No. 142, Original

In The
Supreme Court of the United States

STATE OF FLORIDA,

Plaintiff,

v.

STATE OF GEORGIA,

Defendant.

STATE OF GEORGIA'S PRETRIAL BRIEF

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INTRODUCTION

The Supreme Court places a heavy burden on States like Florida that seek to upset the *status quo* through a common-law equitable apportionment action. As the Court has explained, "the equities supporting the protection of existing economies will usually be compelling," *Colorado v. New Mexico*, 459 U.S. 176, 187 (1982) (*Colorado I*), because the "harm that may result from disrupting established uses is typically certain and immediate, whereas the potential benefits from a proposed diversion may be speculative and remote," *Colorado v. New Mexico*, 467 U.S. 310, 316 (1984) (*Colorado II*). This case begins and ends with these principles: Georgia's existing water uses are compelling, disrupting those uses will cause certain and substantial harm, and Florida's claimed injuries are speculative or not attributable to those uses.

Georgia is home to over 98% of the population and economic activity in the Apalachicola-Chattahoochee-Flint River Basin ("ACF Basin"). ACF waters in Georgia support a city of five million people and a multibillion dollar agricultural industry. And yet, despite those highly beneficial uses, the vast majority of water in the Basin flows through to Florida, both in times of plenty and in times of drought. Florida receives more than 90% of available water under most conditions. And even in the worst drought conditions, the United States Army Corps of Engineers ("Corps") guarantees flows to Florida of at least 5,000 cubic feet per second (cfs) in most cases—an amount Florida itself says is "enough water both to supply approximately 19 million people ***and*** irrigate approximately four million acres of farmland."[1]

Before the Supreme Court will interfere with a sovereign State's decisions on how to use the water within its own borders, the Court requires a plaintiff State to demonstrate an injury caused by another State that is "real and substantial," *Idaho ex rel. Evans v. Oregon*, 462 U.S.

[1]Fla. Mot. *in Limine to* Preclude Expert Testimony by Dr. Philip Bedient and Dr. Sorab Panday at 3 (Sept. 16, 2016) (emphasis in original).

1017, 1028 (1983), and that constitutes "serious damage to her substantial interests and those of her citizens," *Colorado v. Kansas*, 320 U.S. 383, 398 (1943). A plaintiff State, moreover, must prove those injuries by clear and convincing evidence: "Society's interest in minimizing erroneous decisions in equitable apportionment cases requires that hard facts, not suppositions or opinions, be the basis for interstate diversions." *Colorado II*, 467 U.S. at 320-21.

This case fails at the outset because Florida cannot meet its burden of proving real and substantial injury by clear and convincing evidence. As Florida readily admits, this is not a case of economic harm. Rather, Florida attempts to establish a series of ecological harms that it claims must be caused by Georgia's upstream water use. But these harms either do not exist, are based on speculation, or were caused by factors other than Georgia, such as operations of the Corps, uncontrollable forces of nature, or Florida itself. For example, Florida says that Georgia caused its oyster collapse, but Florida's own leading scientists at the University of Florida studied this issue for thousands of hours and "did not find correlations" between Apalachicola River flows and the 2012 oyster collapse. Florida also claims that Georgia's water use has endangered the fat threeridge mussel, but the U.S. Fish and Wildlife Service has estimated that between 6 and 18 million fat threeridge live in the Apalachicola River, ten times prior estimates. And Florida has been forced to concede that it was the Corps (not Georgia) that fundamentally changed the river's habitat when it built Woodruff Dam and dredged the river channel.

The evidence will also show that Georgia's water use is "equitable" by any measure. The Atlanta metro region is a nationally recognized leader in water stewardship. Georgia has spent millions on water conservation in the region, and both per capita and total consumptive water use have ***declined*** in Atlanta over the last twenty years. Tellingly, Florida has dropped the expert it retained to critique Atlanta's water conservation efforts. Moreover, since the late 1990s when scientific evidence first began to suggest that agricultural irrigation could have an impact on streamflows, Georgia has directed significant funds and resources toward agricultural water conservation. Georgia has extensively studied agricultural water use in the ACF Basin, enacted a suite of measures to promote conservation and efficient water use, provided resources to farmers to improve irrigation efficiency, and placed limitations on new irrigations permits in key areas. Those efforts have had real and meaningful impacts and have stabilized water use in the region.

Florida also has not advanced a remedy that is reasonable, proportionate, cost-justified, or that would provide Florida relief in the absence of the United States as a party. Florida proposes draconian reductions in Georgia's water use—cuts that will cost hundreds of millions (if not billions) of dollars and will generate a mere fraction of the water that Florida suggests. In some cases, Florida proposes entirely implausible reductions that would meet or exceed the total amount of water Georgia consumes on a monthly basis. Those dramatic and costly reductions will also yield no benefit to Florida in drought times because of the way the Corps manages dams and reservoirs in the Basin, which involves increasing storage in reservoirs and not supplementing downstream flow until drought conditions have abated. And even if the Corps did allow that additional water to pass into the Apalachicola River, Florida has come forth with no evidence—let alone clear and convincing evidence—that those additional amounts would remedy the ecological harms of which it complains. Accepting Florida's proposed remedies would thus inflict massive economic injury on Georgia's farmers and Atlanta's water supply, without providing any measurable benefit to Florida.

For those same reasons, the evidence has now clearly shown that the United States is a necessary party to this dispute, and that this case cannot be fairly adjudicated in the absence of the United States as a party. Both Georgia ***and Florida's*** experts have determined that reductions in Georgia's consumptive use will not lead to material increases in flow at the state line during dry months and drought years without Corps involvement. Indeed, when Florida's own expert modeled a scenario in which Georgia's agricultural water use was reduced by 50%, there was little to no increase in state line flows during recorded dry months and drought years. These expert analyses prove what Georgia has consistently argued: without Corps involvement, any limitations on Georgia's water use will not provide Florida meaningful relief.

For these reasons, and for those discussed below, Georgia respectfully asks that the Special Master deny Florida's requested relief, which will only serve to jeopardize Georgia's economy and the well-being of its citizens, while providing no corresponding benefit to Florida.

ARGUMENT

I. Florida Must Overcome Substantial Burdens Of Proof.

As the plaintiff in an equitable apportionment action, Florida must prove its case by clear and convincing evidence. *Colorado II*, 467 U.S. at 316. That burden is "much greater" than in an ordinary civil case. *Connecticut v. Massachusetts*, 282 U.S. 660, 669 (1931). This Court imposes that demanding burden because it is "conscious of the great and serious caution with which it is necessary to approach the inquiry whether a case is proved" in an original jurisdiction action. *Kansas*, 320 U.S. at 393-94. Florida is asking the Court to intervene in a dispute between two sovereign States and impose restrictions on one sovereign's internal activities at the behest of another. That is a serious and sensitive task. *Colorado II*, 467 U.S. at 314. Before the Court will take the extraordinary step of intervening in a State's affairs, "the case must be of serious magnitude and fully and clearly proved." *Kansas*, 320 U.S. at 393.

Florida's burden is even higher because it seeks to disrupt substantial and longstanding uses in Georgia. Because "the equities supporting the protection of existing economies will usually be compelling," the Court begins its analysis from the presumption that Georgia's substantial upstream economies should be maintained. *Colorado I*, 459 U.S. at 187. To overcome that presumption and upset the status quo, Florida must prove four things by clear and convincing evidence: (1) that it is suffering "real and substantial injury or damage," *Idaho*, 462 U.S. at 1027; (2) that its injury is proximately caused by Georgia's upstream water use, and is not caused by other factors; (3) that Georgia's upstream water uses are inequitable; and (4) that its proposed remedy will redress its alleged injuries and that the benefits of its proposed remedy "substantially outweigh the harm that might result" to Georgia, *Colorado I*, 459 U.S. at 187.

Relying exclusively on footnote 13 from *Colorado I*, Florida argues that the downstream state need only prove injury and causation, and then the burden shifts to the upstream state to prove that its use is equitable and that a remedy is not justified.[2] That misreads the law. *Colorado I* and *Colorado II* do not distinguish between upstream and downstream states for burden purposes. To the contrary, those cases placed the burden of proof on the state seeking to disrupt the status quo. *Colorado I* made clear that the state seeking to change the status quo must "demonstrate[] by clear and convincing evidence that the benefits of the diversion substantially outweigh the harm that might result." 459 U.S. at 187. And *Colorado II* reiterated the "long-held view" that the "proposed diverter" bears the burden of proof on most issues in equitable apportionment cases. 467 U.S. at 316. Colorado thus bore the burden of proof not because it was the "upstream state," as Florida claims, but because it was the state seeking to disrupt the status quo with a new diversion. *Colorado I*, 459 U.S. at 177. Florida's burden-shifting theory is also inconsistent with other equitable apportionment cases. The Supreme Court has long required states seeking to change the status quo to prove both inequitable upstream use and that a proposed remedy will redress its harms. *See Kansas v. Colorado*, 206 U.S. 46, 117 (1907); *Idaho*, 462 U.S at 1028; *Washington v. Oregon*, 297 U.S. 517, 522 (1936).

[2] *See* Fla. Resp to Ga. Mot. for Extension of Expert Discovery Deadlines at 2-3 (Mar. 15, 2016).

II. Florida Cannot Show Clear And Convincing Evidence Of Substantial Injury Caused By Georgia's Water.

The first two elements of the equitable-apportionment analysis can be addressed together: Unless Florida can prove by clear and convincing evidence that it is suffering substantial injury, and that its injury is caused by Georgia's water use, Florida is not entitled to an equitable apportionment. *Idaho*, 462 U.S. at 1029 (denying relief because "Idaho ha[d] not carried its burden of demonstrating a substantial likelihood of injury"); *Washington*, 297 U.S. at 544 (denying relief because "[i]f any wrong has been done, it is unsubstantial and uncertain"); *Connecticut*, 282 U.S. at 667-69 (denying Connecticut's request to cap Massachusetts' proposed withdrawals because Connecticut had not established injury or causation); *Pennsylvania v. New Jersey*, 426 U.S. 660, 663 (1976) (*per curiam*) ("[A] plaintiff State must first demonstrate that the injury for which it seeks redress was directly caused by the actions of another State").

Florida has no evidence of economic harm in this case.[3] There is no evidence, for example, that Florida has been deprived of water for municipal or industrial purposes, or that it has been left with insufficient water for agricultural irrigation. Nor is there any evidence that any local economy in Florida is being harmed. Instead, Florida relies on a series of speculative ecological harms to try to meet the injury requirement. Discovery has shown, however, that those arguments have no merit and that Florida has failed to carry its burden on injury.

A. Georgia's Water Use Did Not Cause Florida's Oyster Fishery Collapse.

Florida began this case by alleging that it suffered "real and substantial injury" because Georgia's upstream water use caused the oyster fishery in the Apalachicola Bay to collapse in 2012. *See* Compl. ¶¶ 6, 43, 54, 56. This allegation has itself collapsed in discovery, principally on the basis of scientific study and analysis conducted by University of Florida experts.

[3] *See, e.g.*, Sunding Tr. 16:22-17:2; Phaneuf Tr. 25:14-22.

Although the Florida legal team attempted to derail these experts' research, the University of Florida put science ahead of politics and published its findings. And those findings foreclose Florida's attempts to attribute the 2012 oyster collapse to Georgia's water use.

These studies began when Florida Governor Rick Scott requested research on the cause of the 2012 collapse.[4] Professor Karl Havens, an ecological biologist at the University of Florida, assembled a team of experts that came to include oyster biologist and marine fisheries expert, Dr. William Pine, also of the University of Florida. After more than two years and thousands of hours of research, Dr. Pine just last year published a peer-reviewed journal article entitled "The Curious Case of the Eastern Oyster," which remains the definitive analysis concerning the subject of the 2012 Apalachicola Bay oyster collapse. Dr. Pine and his colleagues reached the following unambiguous conclusion:

> ***We did not find correlations*** between Apalachicola River discharge measures ... and our estimated relative natural mortality rate ... or oyster recruitment rates[.] The overall relationships between freshwater flows, drought frequency and severity, oyster recruitment, and harvest dynamics ***remain unclear***, and this is an area of ongoing work.[5]

When asked under oath whether he had seen evidence to support Florida's allegation that "[r]educed freshwater inflows ... precipitated a collapse of the Apalachicola Bay oyster fishery," Compl. ¶ 54, Dr. Pine unflinchingly testified: "No."[6] He also testified that there was no "clear" or "convincing" evidence "of a connection between Apalachicola River flows and oyster mortality."[7] Dr. Havens similarly testified that his team "never found any quantitative linkage between flow from the [Apalachicola] river and the crash with the oysters."[8]

[4] Ex. 1 at UFL_0053544 (12/3/2012 Email from Pine to Havens); Havens Tr. 86:6-14.
[5] Ex. 2 at p.4 (Pine, *Curious Case* article) (emphasis added).
[6] Pine Tr. 308:8-19.
[7] Pine Tr. 291:14–25.
[8] Havens Tr. 175:18-21.

Florida's lawyers in this case understood how devastating these findings were for this case. As Dr. Pine put it: "I was told by my FWC colleague that the attorneys thought the papers should be withdrawn, and if they were published...they could 'make things difficult for me.'"[9] Florida's legal team was "not happy" with Pine's findings.[10] Dr. Pine was told there was concern that his papers "may be disadvantageous to Florida's legal position in the current litigation."[11] And, as he reported contemporaneously, "[a]t issue is the perception that the work I've led undermines the State of Florida's assertion in the ongoing lawsuit that the Apalachicola oyster collapse was caused by water policy in Georgia."[12] Dr. Havens likewise recognized that "[r]esults from some of the [Sea Grant] funded research strongly supports the Georgia case."[13] Florida's lawyers threatened Pine with retaliation precisely because he had found that Florida "can't figure out what caused the collapse because the evidence isn't clear."[14] This led Pine to hire his own attorney to protect his academic independence and represent him in any further dealings with Florida state officials and members of Florida's legal team.[15] This is the opposite of "clear and convincing" evidence that Georgia's water use caused the oyster collapse. Science, not threats and suppression of facts, should prevail, and here the science found no connection between river flow and the health of Apalachicola oysters.

The truth is that Florida's own mismanagement of its oyster fishery had a devastating impact on Apalachicola Bay oyster populations. In September 2012, Governor Scott wrote a letter to the Federal Government seeking federal aid to deal with the oyster situation. Although

[9] Ex. 3 at UFL_00214273 (12/20/2014 Pine email).
[10] *Id.*
[11] Pine. Tr. 363:13-20; Ex. 3 at UFL_00214273 (12/20/2014 Pine email).
[12] Ex. 3 at UFL_00214273 (12/20/2014 Pine email).
[13] Ex. 4 at UFL_00251508 (2/9/2015 Havens email).
[14] Ex. 3 at UFL_00214273 (12/20/2014 Pine email).
[15] *Id.*

he did point to the (later-disproved) theory of low flows from the Apalachicola River as one potential cause, Governor Scott also admitted that

> [h]arvesting pressures and practices were altered to increase fishing effort, as measured in reported trips, due to the closure of oyster harvesting in contiguous states during 2010. This led to overharvesting of illegal and sub-legal oysters further damaging an already stressed population.[16]

This pressure to fish was driven by fear that oil from the Deepwater Horizon oil spill might reach the Bay and harm the oyster habitat.[17] Not long after the Governor's letter, Florida realized that blaming its own conduct could jeopardize its ability to secure federal disaster aid.[18] Florida hastily drafted a report that blamed the collapse on Georgia's upstream water use. It then submitted that report in an attempt to obtain a federal disaster declaration.[19]

But Florida cannot avoid plain facts. In the two years immediately prior to the collapse, oystermen fished at unprecedented and unsustainable levels with regulatory requirements and fishing restrictions eased by the State to encourage it.[20] Florida also tolerated the removal of "sublegal" oysters, which deprived the Bay of the less mature oysters that are necessary to sustain the population.[21] As a report issued by the Florida agency charged with monitoring oysters found:

> The practice of harvesting sub-legal oysters appears to be an extension of a ***'use it or lose it' attitude*** that prevailed during the fall and winter of 2010. … Throughout the period when oil posed an unpredictable threat to the oyster

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[16] Ex. 5 at FL-ACF-02425652 (9/6/2012 Gov. Scott disaster request).

[17]Ex. 6 at FL_SEA_GRANT_40074-75 (FDACS Oyster Resource Assessment Report); Parrish Tr. 110:15-111:1 (stating that the "general consensus" was to harvest the resource in case the oil spill impacted the bay).

[18] Ex. 7 at FL-ACF-02016441 (4/23/2013 Heil email) (NOAA employee flagging over-harvesting concerns associated with Florida's disaster application); Ex. 8 at FL-ACF-01936043 (NOAA official's "initial conclusion was overharvesting"); Ex. 9 at FL-ACF-BERRIGAN-0000198 (4/29/2013 Estes email) (conversation with NOAA official flagging lack of intervention by Florida management and over-fishing concerns).

[19] Ex. 10 at FL-ACF-03475196 (Florida Gulf Coast Oyster Disaster Report).

[20] Ex. 11 (Order No. EO 10-19) (summer oyster bars opened ten days early); Ex. 12 (Order No. EO 10-25) (increased from five to six days); Ex. 13 (Order No. 10-32) (increased from six to seven days; opens winter bars two months early); Ex. 14 at FL-ACF-04088387 (6/17/2010 Press Release).

[21] Ex. 15 at UFL_00233421(2012 Oyster Resource Assessment Report).

> fishery, less effort was directed toward enforcing size limits, perhaps, yielding to the view that it would be more beneficial to harvest the available resource.[22]

Even as the oyster population declined due to intense fishing, Florida refused to close the Bay to allow the oyster population to recover.[23] As Dr. Havens wrote, "the [Fish and Wildlife Commission] won't close the bay to harvesting despite evidence that the bay's population of oysters is almost 100% depleted."[24] All of this fishing had a devastating impact. As Florida's own contemporaneous agency reports found, "the overall condition of many reefs has declined substantially over the past two years as a result of continuous harvesting from Cat Point and East Hole Bars, concentrated and intensive harvesting by the majority of the fishing fleet, and the excessive harvesting of sub-legal oysters."[25]

Florida also failed to take critically needed steps to restore the oyster reefs that its own policies had so badly damaged. Florida officials admit that a process called "re-shelling" is the single most effective method of restoring the oyster resource.[26] Yet re-shelling efforts in the years immediately prior to the collapse decreased to a mere fraction of historical levels, and today Florida no longer independently funds them.[27] Notwithstanding the recommendation of Drs. Pine and Havens that Florida aggressively resume re-shelling,[28] Florida has not undertaken meaningful re-shelling efforts or other efforts to restore the oyster habitat.[29]

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[22] *Id.* at UFL_00233421 (emphasis added); *see also* Berrigan Tr. 151:2-14 (Florida's enforcement of legal size oyster rules was "lax" after the oil spill).

[23] Lipcius Tr. 310:10-311:11; Ex. 16 at 25-31 (Lipcius Rep.).

[24] Ex. 17 at UFL_00248654 (9/2/2014 Havens email).

[25] Ex. 15 at UFL00233420 (2012 Oyster Resource Assessment Report).

[26] *See, e.g.*, Berrigan Tr. 76:5-77:14; 78:25-79:5 ("Restoring habitat [through re-shelling] is an important aspect in restoring reef functionality."); 81:25-82:5 (Re-shelling is the "most cost effective way" to protect oyster resources).

[27] Lipcius Tr. 322:17-324:5; Berrigan Tr. 107:3-111:8 (describing difficulties in securing money for re-shelling).

[28] Ex. 18 at FL_SEA-GRANT_41141(2013 Oyster Situation Report); Ex. 2 at p.4 (Pine, *Curious Case* article).

[29] Lipcius Tr. 322:17-324:5; Berrigan Tr. 107:3-111:8 (describing difficulties in securing money for re-shelling activities from the state legislature during his tenure); Ex. 19 (Oyster_Cultch_time_Series.xlsx); Hartsfield Tr. 123:6-124:12 (noting that as of August 2013, only 2% of areas that needed re-shelling had been re-shelled).

B. Georgia Has Not Caused Substantial Injury To The Apalachicola River.

Florida also attempts to prove "real and substantial injury" by arguing that Georgia's upstream water use has caused harm to various species in the Apalachicola River and its connected floodplain. Florida's river ecology expert, Dr. David Allan, concedes that he did not study most species in the river.[30] Instead, he focused primarily on mussels, Gulf sturgeon and other riverine fish, and Tupelo trees. The evidence shows, however, that the federal dam at the state line and river dredging are largely to blame for any changes to the ecology of the river and that populations for the species Dr. Allen studied are stable or increasing.

Impact of Federal Dam & Dredging. Through its operation of dams and reservoirs, the Corps often provides Florida with more water than it would otherwise receive during dry months or times of drought. But as scientists from federal agencies and the State of Florida have repeatedly concluded, the construction of Woodruff Dam by the Corps has also been the single biggest cause of ecological change to the Apalachicola River. The United States Geological Survey ("USGS") published a paper in 2006 that expressly found that "water-level decline caused by channel change is probably the most serious anthropogenic impact that has occurred so far in the Apalachicola River and floodplain."[31] That "channel change" is the result of the Corps' construction of Jim Woodruff Dam and navigation dredging in the Apalachicola River—not Georgia's water use. As Florida's witness on riverine injury testified: "[w]herever you have a dam…the dam impedes sediment flow down the river. The river is hungry, and as a result, it will scour any material below a dam. And as it scours, it will lower the bed of the river."[32] That same witness acknowledged just what USGS found: "[t]he entrenchment right below the dam

[30] Allan Tr. 216:12-262:5 (no study of birds, amphibians, reptiles, or mammals).
[31] Ex. 20 at 1 (Light, et al., *Water Level Decline* article)
[32] Hoehn 30(b)(6) Tr. 89:23-90:8.

has had an impact on species."[33] And Matthias Kondolf, one of Florida's retained experts, wrote a paper in 2009 that concluded that "the Apalachicola River ecosystem has been severely degraded through a long history of navigational dredging by the U.S. Army Corps of Engineers."[34] Dr. Kondolf also opined that Corps "activities have destabilized and widened the river channel; reduced the river's hydraulic complexity and habitat diversity; smothered and displaced habitat in the river's rich sloughs, floodplains, and channel margins; and altered the river's flow regimes."[35] These are the conclusions of Florida's own scientists and experts.

Mussels. Florida has historically claimed harm to three endangered species of mussels in the Apalachicola River: the fat threeridge, the purple bankclimber, and the chipola slabshell. The United States Fish & Wildlife Service ("USFWS")—the federal agency charged specifically to monitor and protect those species—has repeatedly found that the flow levels established by the Corps are sufficient to protect those species and their habitat. In fact, though Dr. Allan, claims the fat threeridge is somehow in peril, USFWS estimates that there are now between ***6 and 18.6 million*** fat threeridge living in ten times the suitable habitat previously believed to exist.[36] That population is thriving, not failing, and the Government has begun the process of de-listing the fat threeridge from the endangered species list.[37]

Nor are the Chipola slabshell or purple bankclimber impacted by Georgia's upstream consumption. The USFWS found as much in its 2012 and 2016 biological opinions, and

[33] *Id.* at 91:12-13.
[34] Ex. 21 at FL-ACF-03388635 (6/9/2009 Hoehn email); Kondolf Tr. 64:20-65:18.
[35] Ex. 21 at FL-ACF-03388635.; Kondolf Tr. 69:12-70:15; 72:5-73:20.
[36] Ex. 22 at 124 (2016 USFWS Biological Opinion); *see also* Ex. 23 at USFWS0043974 (Smit, *Using Sonar* article) (estimating number of fat threeridge mussels in Apalachicola River at more than 8 million as of August 2013); Ex. 24 at USFWS0088935 (2/3/2015 Zettle email)) (FWS is "moving forward with the reclassification" of the fat threeridge mussel as of February 2015.).
[37] Hoehn Tr. 149-50; Ex. 23 (Smit, *Using Sonar* article); Ex. 25 (6/7/2013 Information Memorandum); Ex. 26 (6/10/2013 Information Memorandum); Ex. 27 (7/30/2013 Kaeser email); Ex. 28 (FDEP 2013 Coordination Act Report); *see also* Ex. 29 at 2-199 (2015 Draft EIS for Water Control Updates) ("Ongoing studies by the USFWS in the Apalachicola River suggest that previous estimates likely underestimated the population of fat threeridge in the middle river reaches.").

Florida's expert admitted that he cannot claim Georgia harmed either species. Like the USFWS found, Dr. Allan conceded that "the Chipola slabshell is not thought to be vulnerable to water-level changes."[38] He also admitted that the purple bankclimber only lives in stretches of the river that have been dramatically altered by Corps activities and therefore any harm to that species cannot be tied to Georgia.[39] And with regard to habitat for all three species, USFWS found in 2012 and again in a report released ***just last week*** that the Corps' reservoir operations and current flow levels "will not destroy or adversely modify designated critical habitat" for those species.[40]

In fact, Florida has admitted it has no evidence of population decline caused by Georgia for ***any*** mussel species. As Dr. Allan testified: "I did not do any population studies on these three species."[41] Florida cannot possibly claim clear and convincing evidence of harm to mussels where Florida has developed ***no*** evidence of population level declines of any mussel species (and, in fact, where at least one species has made a robust recovery); where the evidence shows the mussels are unaffected by Georgia; and where the USFWS has repeatedly concluded that water flows in the Basin are sufficient to maintain these species.

Gulf Sturgeon. Florida officials acknowledge that any harm to historic sturgeon populations is the result of the construction of Woodruff Dam by the Federal Government, not of Georgia's water use. The dam prevents sturgeon from accessing historic spawning areas in Georgia, and it will continue to do so regardless of how much water Georgia uses or does not

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[38] *See* Allan Tr. 418:6-19.
[39] *See id.* at 402:19-25 ("My analysis did not pursue the issue of harm to the purple bankclimber.").
[40] Ex. 30 at ii (2012 USFWS Biological Opinion) (finding all three endangered species stable or increasing under Revised Interim Operating Plan over objection by Florida); *see also* Ex. 22 at 187-89 (2016 USFWS Biological Opinion).
[41] Allan Tr. 423:9-13.

use.[42] Other witnesses in this case agree.[43] Florida also has no evidence that Gulf sturgeon populations have declined in recent years.[44] In fact, population estimates by USFWS in 2012 found that Gulf sturgeon populations are stable or gradually increasing,[45] and in the report released last week USFWS reaffirmed that the population is "stable."[46] Dr. Allan, for his part, testified that he could not offer an opinion on whether the sturgeon population is "increasing, declining or remaining stable"—not exactly clear and convincing evidence of harm.[47]

Tupelo Trees. Florida has also claimed a diminution in Tupelo tree populations. But that species also has been impacted by the channel changes to the river caused by Woodruff Dam and dredging activities of the Corps. By deepening the river channel, those activities led to lower water levels and less inundation even at the same level of flow coming from Georgia.[48] As the USGS has recognized, "[a]s a consequence of this decreased inundation, the quantity and quality of floodplain habitats for fish, mussels, and other aquatic organisms have declined, and wetland forests of the floodplain are changing in response to drier conditions."[49]

C. Florida Cannot Prove Ecological Harm To Apalachicola Bay.

Florida's argument that the ecology of the Apalachicola Bay as a whole is at a "tipping point," is not based on real-world evidence, let alone the clear and convincing sort, and relies on an attenuated causal chain through the entire food web that cannot possibly be sustained. *See*

[42] Ex. 31 at FL-ACF-03393541 (5/32/2013 Hoehn email) ("The [Jim Woodruff Dam] also resulted in reduced access to historically important upstream spawning habitat. . . . Important species most affected include the federally listed Gulf Sturgeon[.]"); Leitman. Tr. 120:5-121:6 (the "population of Gulf sturgeon has declined significantly since Jim Woodruff Dam was constructed, . . . the construction of the dam limited the potential spawning habitat for the sturgeon").
[43] Weller Tr. 54:3-6; Leitman Tr. 120:5-24.
[44] Allan Tr. 193:24-194:12; 515 (admitting no information about change in population of Gulf Sturgeon).
[45] Ex. 32 at 3 (USFWS and NMFS, 2009 Gulf Sturgeon 5-Year Review).
[46] Ex. 22 at 103 (2016 USFWS Biological Opinion).
[47] Allan Tr.194:11-12.
[48] Ex. 21 at FL-ACF-03388635 (6/9/2009 Hoehn email); Ex. 20 at 1 (Light, et al., *Water Level Decline* article).
[49] Ex. 20 at 1 (Light, et al., *Water Level Decline* article).

Aransas Project v. Shaw, 775 F.3d 641, 656 (5th Cir. 2014) (rejecting similar argument under Endangered Species Act on proximate causation grounds).

To begin, there is no evidence of harm to so-called "primary producers"—the phytoplankton and other organisms that make up the lowest level of the food chain.[50] Aquatic vegetation has recovered in the Bay since being devastated by Hurricane Dennis in 2005, and the community structure of plants and animals in the Bay remains strong and dynamic.[51] Florida's expert on these microscopic organisms admitted that she had "no information or data that food availability in the Bay is impaired" or "negatively impacted" for white shrimp, blue crab, or any fish species[52]; and that she had "not done any analysis that would permit [her] to identify minimal flows in the Apalachicola Bay that would be required for the ecosystem not to be harmed or in peril,"[53] rendering the rest of her opinion pure speculation.

Florida also has no evidence of harm to organisms at higher levels of the food chain, such as fish in the Apalachicola Bay. Florida's expert on these organisms—Dr. Jenkins—had exceptional difficulty testifying as to which organisms in the Bay had been harmed.[54] He also testified that he could not "point to a decline in the number of freshwater species among the 12 most abundant species in the bay, from the 1970s to the 2000s."[55] In light of this and similar testimony, Florida dropped Dr. Jenkins from its witness list. Florida's other ecology expert, Dr. Glibert, testified that she had "no data or information indicating any fish species in the Apalachicola Bay has been negatively impacted by impaired food availability," because her

[50] *See* Ex. 33 at 61-63 (Menzie Rep.).
[51] *Id.* at 114.
[52] Glibert Tr. 73:13-18; 73:19-74:2, 75:2-8; 76:17-77:1.
[53] *Id*. at 107:16-22.
[54] Jenkins Tr. 65:18-69:11.
[55] *Id.* at 443.

"analyses did not go into specific fish species."[56] With Dr. Jenkins out of the case, Florida has ***no*** testimony on harm to the fish populations of Apalachicola Bay.

In contrast to this complete lack of evidence about harm to the Bay, Georgia's ecology expert, Dr. Charles Menzie, demonstrated that there is simply no evidence that the Bay is suffering severe ecological harm, much less that it has reached any kind of "tipping point." And Georgia's oyster ecology and marine fisheries expert, Dr. Romuald Lipcius, showed that shellfish in the Bay, such as shrimp and blue crab, have not suffered population declines.[57] Even Dr. Glibert, who is the leading proponent of Florida's misguided "tipping point" theory, admits that "estuaries are dynamic systems,"[58] that "ecosystems can come back from 'tipping points,'"[59] and most tellingly, that even if a "tipping point" had been reached in 2011-2012, recent flow data "is consistent with a trajectory of recovery."[60] Moreover, she admitted that she could not "identify any period, prior to 2011 and 2012, when the Apalachicola Bay estuary did not recover from ecological stress to the estuary."[61]

D. Florida Cannot Create New Legal Definitions Of "Harm" To Compensate For Its Failure to Develop "Clear And Convincing" Evidence.

Realizing it cannot demonstrate clear and convincing evidence of substantial injury caused by Georgia, Florida has attempted to define "harm" so broadly that it includes virtually ***any*** change to ***any*** species for ***any*** reason. Florida believes it has suffered injury "if the species has had anything ranging from death to a disruption of anything regarding its life cycle."[62] Thus, Florida would have this Court define "injury" for equitable apportionment purposes as constituting disruption to any portion of a species' "life cycle" or any action that "disrupt[s]

[56] Glibert Tr. 76.
[57] Ex. 16 at 65-66 (Lipcius Rep.).
[58] Glibert Tr. 288:13-18.
[59] *Id.* at 285:12-286:12.
[60] *Id.* at 706:8-706:22; 707:1-708:4.
[61] *Id.* at 307:16-308:10.
[62] Hoehn 30(b)(6) Tr. 60:18-24.

some part of their needs."[63] For example, one of Florida's experts defined harm as the "reduction of access to optimal feeding habitat,"[64] though he refused to say how far below "optimal" will actually cause a species to suffer harm.[65] And that exposure to sub-optimal feeding habitat, according to Florida, need not even result in the death of a single organism in order to constitute harm.

Florida's definition of harm is indefensible. This Court has never found that mere "disruption" in the life cycles of species—without any evidence of an actual or imminent decline in population—is sufficient to justify the extraordinary remedy of equitable apportionment. To the contrary, this Court will intervene in a dispute between states only when the injury is shown to be "of serious magnitude." *Kansas*, 320 U.S. at 393. That demanding standard requires, at the very least, that Florida prove some actual decline in the species with respect to which it alleges injury. Activities that do not reduce the population of a species, but instead may (or may not) "disrupt" its lifecycle, are not the "hard facts" showing injury this Court demands and are thus not cognizable injuries in equitable apportionment actions. *Colorado II*, 467 U.S. at 320-21.

E. Florida Cannot Show By Clear And Convincing Evidence That Georgia's Water Consumption Is Decreasing Flows At The State Line.

Finally, even if Florida could clear the injury and causation hurdles (and it cannot), Florida's claims would fail at yet another level of the causal chain: Florida does not have clear and convincing evidence that Georgia's consumptive water use has materially reduced the volume of water flowing from Georgia into Florida. This is primarily because the Corps largely controls the amount and timing of flow entering the Apalachicola River at all times of the year through its operation of a complex system of dams and reservoirs in the Basin. No water enters

[63] *Id.* at 62:10-11; *see also id.* 63:3-4 (a species is harmed "if ***any*** parts of [its] life cycle[] are disrupted").
[64] Allan Tr. 509:20-21.
[65] *See id.* at 511:5-9.

the Apalachicola River from either the Chattahoochee or Flint River without passing through the Corps' facilities, including Woodruff Dam located at the Florida-Georgia border.[66] The federal reservoir system offsets natural variability in streamflow in the ACF Basin, which the Corps does by storing water in the reservoirs during high-flow conditions and releasing water to "augment" flows during dry times. This has the effect of "smoothing out" the impact of flow variability, including that resulting from upstream water use, which renders the link between Georgia's water use and state-line flow tenuous.

At the outset, experts on both sides agree that, for the vast majority of months in the vast majority of years, Georgia's consumptive water use has only a *de minimis* impact on streamflows in the ACF Basin.[67] Since 1980, Georgia's total annual water use in the Basin has reduced streamflows in Georgia by less than 1,000 cfs per year.[68] By comparison, that is less than 5% of the average annual flow entering the Apalachicola River.[69] Georgia's water use also has no material impact on state-line flows if the analysis is limited to May to September, the months in which flows are typically at their lowest. In those months, since 1994, total streamflow reductions caused by Georgia's consumptive water use averaged approximately 1,170 cfs, or the equivalent of less than 10% of streamflow in the Apalachicola River during that period (approximately 15,000 cfs).[70] Thus, even when water is generally in its greatest demand and flows are at their lowest, Georgia's water use represents a relatively small percentage as compared to state-line flow. An overwhelming majority of water remains available for Florida.

[66] Ex. 34 (USACE Scoping Report).
[67] Sunding Tr. 281:6-9 ("Virtually all of the discussions that I have had with other Florida experts have focused on dry years. I just haven't heard any issues raised about average or wet year problems.") Dr. Allan, Florida's ecological expert assumes no flow-related harms occur in the riverine ecosystem during the months of October through February. Ex. 35 at 132 (Allan Rep.).
[68] Ex. 36 at 3-4, 36-37 (Bedient Def. Rep.); Ex. 37 (20160223-ACF-GA-total-consumptive-monthly.xlsx); Ex. 38 (USGS Groundwater and Surface Water Data).
[69] Ex. 36 at 3-4.
[70] *Id.* at 4, 37-38 (Bedient Def. Rep.); Ex. 37 (20160223-ACF-GA-total-consumptive-monthly.xlsx); Ex. 38 (USGS Groundwater and Surface Water Data).

Not only does Georgia consume only a limited amount of water in the rivers in Georgia, the fact that the reservoirs redistribute water throughout the ACF Basin has the effect of minimizing the impact of Georgia's consumptive use. During seasonal low-flow and drought periods, the Corps strategically releases water from federal reservoirs to guarantee a minimum flow to Florida. Indeed, during drought periods, actual flows at the state line are often significantly higher than they would be in the absence of Corps operations. Most relevant here, during times of drought, the Corps guarantees flows of at least 5,000 cfs into the Apalachicola River (except in very narrow circumstances when it can be lowered to 4,500 cfs).[71] As a result, Georgia's consumptive use often has no direct effect on flows entering the Apalachicola River, especially during low-flow and drought periods when Florida purports to need water the most.[72]

To the extent Florida asserts it is receiving less water than it did historically, the evidence shows that such decreases are largely due to an increase in the severity and frequency of natural droughts. The past 15 years of record have seen several severe, multi-year droughts, including droughts in 1999-2001, 2006-2008, and 2010-2012.[73] Indeed, according to NOAA, the 24-month period from December 2010 to November 2012 was the driest 24-month period ever recorded for the State of Georgia, and drought conditions for those years were acutely focused on the southwest corner of the State.[74] Georgia's expert hydrologist has found a clear, direct relationship between precipitation and streamflow in the ACF Basin.[75] In fact, Florida's own hydrology expert, Dr. George Hornberger, concluded that flow declines within Florida were attributable to "natural climate variations" resulting from "the dry period in the last roughly 15

[71] Ex. 29 at ES-11 to ES-12 (2015 Draft EIS for Water Control Updates) (explaining that during "drought operations," "the minimum release from Jim Woodruff Lock and Dam is 5,000 cfs [and] any basin inflow above 5,000 cfs may be stored"); *see also id*. at 2-70 to 2-73 (describing RIOP operations); Ex. 39 at 17-23 (Bedient Rep.).
[72] Ex. 36 at 37-38 (Bedient Def. Rep.).
[73] Ex. 40 (US Drought Monitor data).
[74] Ex. 41 (NOAA Drought Annual 2012).
[75] Ex. 36 at 72-76 (Bedient Def. Rep.) (finding a relationship after analyzing over 80 years of precipitation and streamflow data).

years."[76] The evidence thus shows that any lower streamflows into Florida are the result of these multi-year droughts, not Georgia's consumptive use.[77]

There is also some irony in Florida's attempts to blame Georgia for reductions in streamflow. The evidence will show that over the past several decades a material amount of Apalachicola River water has been lost ***entirely within Florida's borders***. Since 1978, Florida's contribution of flows to the Apalachicola River has declined from approximately 5,000-6,000 cfs to approximately 1,000-2,000 cfs.[78] Florida does not contest this long-term decline.[79] And as Florida's percentage "share" of water contributed to the Apalachicola River has been shrinking over time, Georgia's "share" has been increasing.[80] In a very real sense, Florida is asking Georgia to make up for water that Florida has lost in the last 40 years.

III. Florida Cannot Show Clear And Convincing Evidence That Georgia's Water Use Is Inequitable.

Beyond proving injury and causation, Florida must also prove that Georgia's upstream water use is inequitable, which it cannot do. The Court will closely evaluate the nature and value of Georgia's uses, and can "decline[] to grant any relief … on the ground that the great benefit to [the upstream state] outweigh[s] the detriment to [the downstream state]." *Colorado I*, 459 U.S. at 186; *Kansas*, 206 U.S. at 117 (denying relief notwithstanding "perceptible injury" where upstream use "transform[ed] thousands of acres into fertile fields"); *Washington*, 297 U.S. at 523 (denying relief where remedy would injure upstream state with no benefit to downstream state). The evidence shows that Georgia uses water in the ACF Basin for highly beneficial purposes,

[76] Hornberger Tr. 573:3-8; Ex. 42 at 18-19 (Hornberger Def. Rep.).
[77] Ex. 36 at 74-76 (Bedient Def. Rep.).
[78] *Id.* at 76-77.
[79] Fla. Reply in Support of Mot. *in Limine* to Preclude Expert Testimony of Dr. Bedient and Dr. Panday on "Lost Water" at 3-4 (Oct. 7, 2016).
[80] Ex. 36 at 78-79 (Bedient Def. Rep.).

supporting millions of people and billions in economic output. At the same time, Georgia has been a conscientious and effective steward of water resources.

A. Georgia's Water Consumption Is Plainly Equitable.

There can be no dispute that Georgia uses ACF waters for highly beneficial purposes. ACF waters are the principal municipal and industrial water supply for the Atlanta Metropolitan Area, the ninth largest metropolitan area in the United States.[81] Approximately 5.1 million citizens in Georgia rely on the ACF Basin for their daily water supply, including drinking, cooking, cleaning, and other everyday uses.[82] As this Court has noted, "[d]rinking and other domestic purposes are the highest uses of water[,]" and "[a]n ample supply of wholesome water is essential." *Connecticut*, 282 U.S. at 673. ACF Georgia is also home to many industries and businesses for which water is a key input, including manufacturing industries such as poultry processing and aircraft manufacturing, and green industries such as greenhouse production, landscaping, and horticultural services. Together, those industries contribute nearly $13.5 billion to total Gross Regional Product (GRP) and employ nearly 50,000 people.[83]

ACF waters are also the driving force behind Georgia's agricultural industry, which is one of the largest and most productive in the Nation. In 2013 alone, agricultural revenues in ACF Georgia from three key row crops (corn, cotton, and peanuts) were over $1 billion, and total agricultural revenues for the region exceeded $4 billion.[84] ACF Georgia accounts for over 25% of all peanut acreage nationwide, and grows nearly half of all cotton in the State, which is the nation's second largest cotton producer. Within the ACF Basin, substantial economic

[81]Ex. 49 at GA02451835 (Georgia's Comments on Water Control Manual Update).
[82] Ex. 44 at Att. A, p.2 (4/29/2016 Metro District Memo); Ex. 45 at 16 (Mayer Rep.).
[83] Ex. 43 at 28-29 (Stavins Rep.).
[84] *Id.* at 30.

activity also depends on output from the agricultural sector, contributing an additional $687 million per year to GRP.[85]

Farmers must irrigate to ensure the viability of their crops and provide the agricultural commodities on which the State and our nation depend. Without irrigation, farmers lack a reliable source of water for their crops, particularly during dry periods. Even Florida's agricultural irrigation expert agreed that "farmers using dryland farming are at an increased risk of low yields" and "face an increased risk of crop failure compared to farmers who irrigate."[86] Another of Florida's experts explained that crop yield "is extremely responsive to supplemental irrigation"[87] and without irrigation, "complete crop failure" was possible.[88] Crop yield data bears this out: without irrigation, Georgia's farmers would produce 51 percent smaller peanut yields, 78 percent lower cotton yields, and 93 percent lower corn yields during dry years.[89] Even during normal years, both Georgia and Florida experts agree that yields from irrigated fields are significantly greater than yields from non-irrigated fields for all major row crops.[90]

In comparison to the highly beneficial purposes to which Georgia puts the waters in the ACF Basin, Florida's uses are relatively minor. In 2014, the permanent population of the Florida portion of the ACF basin was less than 3% of the total population of the Basin, and ACF Florida accounts for less than 1% of the economic activity in the basin.[91] Florida has relatively little agricultural activity in the ACF Basin.[92] And there is no large metropolitan area in ACF Florida

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[85] Ex. 44 at Att. 2 (4/29/2016 Metro District Memo); Ex. 43 at 30-32 (Stavins Rep.).
[86] Bottcher Tr. 81:8-18.
[87] Hoogenboom Tr. 89:20-23.
[88] *Id.* at 117:20-118:1.
[89] Ex. 43 at 33 (Stavins Rep.) at 33.
[90] Ex. 46 at 16-17 (Irmak Rep.); Ex. 47 at 10 (peanuts), 18-19 (corn), 27-28 (cotton), 36-37 (soybean) (Hoogenboom Rep.).
[91] Ex. 43 at 22 (Stavins Rep.).
[92] Barr Tr. 254:13-15.

that must be supported. Even the oyster industry Florida seeks to protect generates only between $5-8 million in revenue per year.[93]

In light of Georgia's highly beneficial uses, and Florida's comparatively minor uses, Georgia's consumptive water use is exceedingly reasonable. ACF Georgia is home to 98% of the population in the ACF Basin, has 99% of the economic activity in the ACF Basin, 5 times the land area of ACF Florida, 80 times more employees than ACF Florida, 56 times the population than in ACF Florida, and a GRP that is 129 times larger than ACF Florida.[94] Yet, Georgia consumes only a small fraction of the water available in the ACF system, and the vast majority of water flows through to Florida.

What is more, there is no indication that Georgia's water use will substantially increase in the near future. Georgia's projected water supply needs for the entire ACF Basin through 2040 would amount to an increase in Georgia's water use of only 62 cfs.[95] The resulting decrease of streamflow at the state line during low-flow periods resulting from that increase would often be 0 cfs, as a result of the Corp's regulation of water in the Basin.[96] Florida's asserted fears of "ever-increasing" water use by Georgia are therefore unfounded.

B. Georgia Has Made Substantial Efforts To Conserve Water For Municipal And Industrial Purposes.

Florida has struggled to make a case against Atlanta's municipal and industrial conservation practices. Florida has now dropped the sole expert it had retained to critique Atlanta's conservation measures. And for good reason: Georgia has invested heavily in comprehensive efforts to conserve water for municipal and industrial purposes.

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[93] Ex. 48 at 43 (Phaneuf Rep.). Dr. Phaneuf also admits that the total annual revenue from the combined harvest of shrimp, crab, and finfish is only $4.5 million.
[94] Ex. 43 at 18, 22 (Stavins Rep.).
[95] Ex. 36 at 7 (Bedient Def. Rep.).
[96] *Id.* at 54.

To begin, the vast majority of water that Georgia withdraws from the ACF Basin for municipal and industrial purposes is thereafter treated and returned to the system, after which that water is free to flow down the watershed. The Metro Water District[97] returns ***more than 70%*** of the water it withdraws back to the ACF Basin.[98] That is true even in drought years. In 2011, Georgia achieved a return rate of over 70% during one of the worst droughts in State history.[99] Return rates are projected to reach 75% by 2050.[100] Achieving those high return rates has been extraordinarily costly. For example, Gwinnett County spent more than $1 billion to construct a water reclamation facility capable of returning 20 mgd of wastewater back to the Chattahoochee River and 40 mgd to Lake Lanier.[101]

Georgia also has required all water systems and local governments within the Metro Water District to enact some of the most aggressive conservation measures adopted anywhere in the United States. Those mandatory practices include: residential and commercials water audits; replacement of older, inefficient plumbing fixtures; award-winning education and customer outreach programs; low-flow retrofit kits for residential units; high-efficiency toilets in government buildings; multi-family high-efficiency toilet rebates; meters with point-of-use leak detection; and high-efficiency plumbing fixtures in new construction.[102] Georgia requires rigorous water loss audits that must be validated by a third party.[103] Additionally, the Metro Water District and other water providers in the ACF Basin implement increasing block rate,

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[97] The Metro Water District encompasses 15 counties and 92 separate municipalities in the metropolitan Atlanta area and is tasked by statute with preserving and protecting water resources. The Metro Water District develops comprehensive regional and watershed specific water resource plans to be implemented by local governments.
[98] Zeng Tr. 632:7-11; Ex. 45 at 15 (Mayer Rep.); Ex. 49 at GA02451997- GA02451998 (Georgia's Comments on Water Control Manual Update).
[99] Zeng Tr. 523:19-23.
[100] *Id.* at 42:24-44:8.
[101] Ex. 45 at 51 (Mayer Rep.).
[102] *Id.* at 80:4-14, 695:7-18; Ex. 50 at GA02451936 (1/11/2013 Gov. Deal letter); Ex. 45 at 58-59 (Mayer Rep.).
[103] Ex. 45 at 26 (Mayer Rep.).

conservation pricing—an important practice reducing overall water use.[104] These forward-looking measures have been supported by billions of dollars of investment by local governments and water suppliers in the Atlanta metropolitan area.[105]

Georgia has also implemented drought-management rules designed to reduce M&I water use during periods of severe drought. Those rules establish pre-drought mitigation strategies[106] and set forth graduated increases in restrictions based upon the level of severity of a drought.[107] Georgia has not hesitated to utilize these tools. For example, during the 2007-2009 drought, Georgia ordered an almost total outdoor watering ban[108] and mandatorily required all water suppliers in the Atlanta region to reduce their use by 10%.[109] Georgia updated the drought rules in 2015 to incorporate additional pre-drought mitigation strategies; a drought declaration process; a menu of drought response strategies; and a drought response committee.[110]

In 2010, Georgia enacted the Water Stewardship Act, which supplemented the Metro District's water conservation and efficiency programs and was designed "to create a culture of water conservation in the state of Georgia."[111] The Stewardship Act required local governments, public water systems, and state agencies to adopt permanent outdoor water use restrictions, increased block rate pricing for all residential customers, and required sub-metering in all new buildings and annual water loss audits for public water systems statewide.[112]

As a result of these conservation measures, M&I water usage in the Metro Water District has dropped dramatically—both in terms of total consumptive use and per capita use. Total M&I

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[104] Mayer Tr. 231:19-24; Kirkpatrick Metro District 30(b)(6) Tr. 49:10-15; Ex. 45 at 61 (Mayer Rep.).
[105] *See* Ex. 51 at GWNT-DWR0012553 (2009 Summary of Water Conservation).
[106] Ex. 52 (2003 Georgia Drought Management Plan).
[107] Ex. 53 at GA00081536- GA00081539 (Ga. Comp. R. & Regs. R. 391-3-30-.01-08).
[108] Ex. 54 at FL-ACF-02640133 (9/28/2007 Press Release).
[109] Ex. 55 at GA01210159 (10/23/2007 Press Release).
[110] Ex. 53 (Ga. Comp. R. & Regs. R. 391-3-30-.01); Ex. 56 (12/30/2014 Turner memo).
[111] Ex. 57 at § 1 (S.B. 370).
[112] *Id*. at §§ 2-3, 10.

consumptive use ***decreased*** from 1994 to 2013 in the Metro District, even as the population ***more than doubled*** over the same period.[113] Per capita water use in the Metro District has also declined rapidly since 2000—dropping from 155 gallons per capita per day (GPCD) in 2000 to 98 GPCD today.[114] Per capita water use in the Metro District is lower than Florida's per capita rate in the ACF Basin, in Jacksonville, and in Tampa.[115] Florida's own expert, Dr. Dracup, acknowledged in his deposition that "something below a hundred gallons per day per capita" would indicate that "water conservation measures are being appropriately implemented."[116] With per capita use in Atlanta at 98 GPCD, Florida decided not to bring Dr. Dracup to trial.

In light of these efforts, Georgia has emerged as a national leader in public water supply management. In 2012, the Alliance for Water Efficiency gave Georgia the highest score given to any state nationally for water conservation and efficiency, while Florida earned a "C".[117] Georgia also leads the nation in progress on auditing of public water systems,[118] and has been recognized as a leader for its water conservation, education, and customer outreach programs.[119]

C. Georgia Has Made Substantial Efforts To Conserve Agricultural Water Resources.

Georgia also has taken a number of wide-ranging, large-scale, and proactive measures to enhance management and conservation of agricultural water resources. Throughout discovery in this case, Florida has repeatedly cited a number of documents and public statements indicating that Georgia was aware of potential water management issues in the Lower Flint River Basin by the late 1990s. Florida ignores, however, what happened next: Georgia promptly took a series of

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[113] *See* Mayer Tr. 88:12-90:23, 102:12-19.
[114] *Id.* at 95:29-97:9, 101:10-102:6; Ex. 45 at 17-19 (Mayer Rep.).
[115] *See* Mayer Tr. 67:2-23; 74:20-76:19.
[116] Dracup Tr. at 132:12-18.
[117] Ex. 58 (State Scorecard).
[118] Ex. 59 at 45-46 (Water Audits in the United States).
[119] In 2015, the Metro District was awarded the prestigious 2015 EPA WaterSense Excellence in Education and Outreach award. *See* Ex. 60.

proactive and reasonable actions in response to these potential issues and developed a regime of comprehensive and effective water management in the ACF Basin.

In the late 1990s, signs emerged that, during times of extreme drought, agricultural pumping in ACF Georgia could have an impact on water levels in the Flint River. At the time, the evidence was uncertain. Very few scientists had studied the issue; the hydrologic models available were rudimentary; there were no precise studies of the amount of irrigated acreage in the ACF Basin; agricultural water uses were unmetered and estimates of total agricultural water use were often overstated; and the interaction and impacts of groundwater pumping to surface water flows was not fully understood.[120] Nonetheless, Georgia quickly implemented a process to comprehensively and scientifically study agricultural water use in the ACF Basin, while also taking steps to better conserve and manage water resources.

That multi-year process had two primary components. *First*, Georgia's Environmental Protection Division (EPD) placed a moratorium on new agricultural groundwater and surface water permits in the ACF Basin.[121] The moratorium, which prohibited any new permits in areas where streamflow was considered most sensitive to agricultural withdrawals, lasted for over ***six years***. *Second*, Georgia initiated a Sound Science Study to better understand the impact of agricultural irrigation on surface water flows.[122] The Sound Science Study brought together technical experts, policymakers, farmers, environmental groups, and other stakeholders in a collaborative process that lasted several years. Georgia hired contractors to map irrigated acreage; collected data on irrigation application amounts for different crops and climatic conditions; measured distributions of agricultural water use; worked with USGS to study the

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[120] *See* Ex. 61 at USGS-0020249, USGS-0020260-USGS0020265 (Torak, *Water Availability and Competing Demands*) (explaining that the Torak and McDowell (1996) model was outdated but USGS working to fill data gaps and develop model to improve understanding of groundwater and surface-water interaction).
[121] Reheis Tr. 34:8-37:3.
[122] Reheis Tr. 288:19-290:3; Cowie Tr. 473:1-21.

hydrology of the region; commissioned the development of an advanced hydrologic model to study the impact of groundwater pumping on streamflows; and evaluated numerous conservation practices and irrigation efficiency measures.[123]

While the moratorium was in place and the Sound Science Study was underway, Georgia took other steps to improve conservation in the ACF Basin. In 2000, Georgia passed the Flint River Drought Protection Act ("FRDPA"), which empowered the Director of EPD to issue a prediction of "severe drought conditions" by March 1st of each year, and to administer an auction whereby farmers may voluntarily agree not to irrigate in return for monetary payments. EPD conducted auctions pursuant to the FRDPA in both 2001 and 2002, which resulted in the removal of 33,000 and 40,000 acres from irrigation, respectively, at a combined cost of $10 million.[124] Policymakers had mixed views on the effectiveness of the auction process in the FRDPA, and Georgia ultimately amended the Act in 2014 with the goal of improving it. In the meantime, Georgia pursued other, more efficient programs to address conservation.

Building on the FRDPA, in 2003 Georgia passed legislation requiring the installation of flow meters on irrigation withdrawals.[125] Georgia has invested more than $22 million in metering efforts under the Agricultural Water Metering Program, and over 11,000 meters have been installed throughout the state, including over 4,000 in the ACF Basin.[126] In addition to providing a benefit to growers, who can use this knowledge to better plan their irrigation activities, the agricultural metering data has been used for water planning and policymaking.

In 2006, after years of careful study and development, Georgia's Sound Science Study culminated with the Flint River Basin Regional Water Development and Conservation Plan

[123] Ex. 62 at GA00185754-755, GA00185783-792 (2006 Flint River Regional Water Plan).
[124] Ex. 63 at GA00201026 (Summary of FRDPA Auctions).
[125] Ex. 46 at 60-61 (Irmak Rep.).
[126] *See id.*; Ex. 64 at 11 (Torak, *Summary of Georgia Agricultural Conservation and Metering Programs)*); Ex. 65 (USGS, GA Agricultural Water Conservation and Metering Program); Ex. 66 (GSWCC Metering Program).

("FRB Plan"). The FRB Plan divided the Basin into different "zones" based on hydrologic sensitivity to groundwater withdrawals. After the issuance of backlogged permits, applications for new irrigation permits were severely restricted in the most sensitive zones, termed "Capacity Use Areas," and remain so to date. New or modified permits in the remaining zones were required to implement a suite of advanced conservation protections, including end-gun shut-off switches, which prevent center pivot irrigation of non-cropped areas; leak prevention and repair plans; pump-safety shutdown switches; rain-gage shut-off switches; and low-flow protection plans that mandated cessation of irrigation during extreme drought conditions.[127]

Georgia has also implemented mandatory statewide and regional water planning, which requires regional councils—including councils located in the ACF Basin—to devise water management plans and update those plans every five years. Those plans, which are compiled with the support of expert technical consultants and policymakers, seek to identify the amount of water available in a given region, the amount of water that is projected to be required for agricultural or other uses, and management and conservation practices that will help use water resources efficiently. The first state plan was completed in 2008 and the first regional planswere completed in 2011. Currently the regional councils are in the initial five-year process of reviewing and revising their regional water plans.[128]

Georgia has also implemented aggressive efficiency requirements for irrigation equipment in the ACF Basin. As mentioned above, the FRB Plan requires all irrigation systems in Conservation, Capacity, or Restricted Use areas to implement efficiency measures. Georgia has also passed legislation mandating that all center-pivot irrigation systems—by far the most

[127] *See* Ex. 62 at GA00185768-70 (2006 Flint River Regional Water Plan).
[128] Masters Tr. 696:3-24.

common irrigation systems—be at least 80% efficient.[129] These efforts have worked. Currently, farmers in the Lower Flint River Basin use low pressure irrigation systems to irrigate over 90% of the irrigated acreage in the region.[130] In the most hydrologically sensitive areas, farmers use low pressure irrigation systems to irrigate 93% of irrigated acreage.[131]

Georgia also makes numerous resources available to help farmers manage their irrigation systems more efficiently. The State has invested millions in a Mobile Irrigation Lab program, which (at no cost to farmers) audits the uniformity of farmers' center pivot irrigation systems and subsidizes the costs of retrofitting those systems to achieve greater efficiency.[132] Georgia has completed over 460 irrigation system retrofits, covering over 40,000 irrigated acres. Georgia has also funded institutes like the University of Georgia Extension, which has had over 250,000 face-to-face contacts with farmers and overseen 1,740 hours of farmer training;[133] the Georgia Water Planning & Policy Center, which provides technical assistance and educational outreach to farmers and helps them access USDA programs; and the Flint Soil and Water Conservation District, which has has helped farmers implement conservation measures on over 200,000 acres.

Georgia's aggressive agricultural conservation efforts have continued in recent years. Significantly, during the historic 2012 drought, Georgia reinstituted a moratorium on new agricultural water withdrawal permits, including new permits for withdrawals from the Floridan aquifer or from surface waters in critical areas.[134] That suspension is still in effect today, and there is no reasonable prospect of the moratorium being lifted in the future. As a result, irrigated acreage from the Floridan aquifer and surface-water sources in the most-critical areas of the ACF

[129] *See* Ex. 46 at 63 (Irmak Rep.); Cowie Tr. 567:9-25; O.C.G.A. § 12-5-546.1(b).
[130] *See* Ex. 46 at 74 (Irmak Rep.); Ex. 67 (LF Mapping.pptx).
[131] *See* Ex. 46 at 73-74 (Irmak Rep.); Ex. 68 (GWPPC Mapped Pivtos_Flint Basin.xlsx).
[132] *See* Ex. 46 at 64-71 (Irmak Rep.); Eigenberg Tr. 46:20-47:2, 191:15-192:10.
[133] *See* Ex. 46 at 84 (Irmak Rep.).
[134] Ex. 69 at GA00043929 (Suspension Announcement).

Basin are effectively capped going forward, protecting against future growth. Moreover, in 2014 Georgia enacted new legislation creating new efficiency requirements for irrigation systems in the Lower Flint Basin and giving EPD the authority to protect stream flows generated from state-sponsored augmentation projects.[135]

Those efforts have had meaningful impacts on agricultural water use in ACF Georgia. Combined acreage irrigated from surface water and Floridan Aquifer sources in ACF Georgia has declined since 2004; irrigation efficiency has improved; and the streamflow impact of agricultural water use has remained relatively constant. At the same time, crop yields have increased as Georgia farmers have become more efficient users of water resources.[136] Taken together, the initiatives discussed above demonstrate that Georgia has taken a reasonable, responsible, and conscientious approach to agricultural water conservation.

IV. Florida's Proposed Remedies Will Not Redress Its Alleged Harms, Will Impose Extreme Costs, And Cannot Be Imposed Without The United States As A Party.

Even if Florida could prove injury, causation, and inequitable use, it still would bear the burden of proving (1) that its proposed remedies will redress its alleged harms; and (2) that the benefits of its proposed remedies substantially outweigh the harms they will do to Georgia. *See Colorado I*, 459 U.S. at 187. If Florida cannot prove both of these elements by clear and convincing evidence, the Court will deny relief, as it has in past cases. *Kansas*, 320 U.S. at 385-86 (denying relief, in part, because "[b]efore the developments in Colorado consequent upon irrigation were to be destroyed or materially affected, Kansas must show not merely some technical right but one which carried corresponding benefits."); *Washington*, 297 U.S. at 523 (denying WA's requested relief, in part, because "[t]o limit the long established use in Oregon would materially injure Oregon users without a compensating benefit to Washington users").

[135] *See* Ex. 70 at GA00305431 (2014 FRDPA amendments).
[136] Ex. 46 at 145-49 (Irmak Rep.).

Both at trial and in post-trial briefing, Georgia will renew its argument and seek dismissal on the ground that the United States is a necessary and indispensable party that cannot be feasibly joined under Rule 19. In denying Georgia's motion to dismiss on this issue, the Special Master found that Georgia and the United States had made a "persuasive case that the United States is a party required to be joined if feasible" under Rule 19(a),[137] but nonetheless held that the case could proceed "in equity and good conscience" under Rule 19(b) because, at the pleading stage, it was "possible" that Florida could obtain adequate relief through a ***cap*** on Georgia's consumptive water use that would not affect the United States' operations in the ACF Basin.[138] The Court cautioned, however, that Florida would have to meet its burden of proof on that issue at trial: "Having voluntarily narrowed its requested relief and shouldered the burden of proving that the requested relief is appropriate, it appears that Florida's claim will live or die based on whether Florida can show that a consumption cap is justified and will afford adequate relief."[139] Florida cannot make either showing. The consumption caps proposed by Florida are so costly to Georgia, and result in so few benefits to Florida, that they are neither "justified" nor "equitable." And in any event, those caps—without the United States as a party—will not provide Florida meaningful relief from the harms it alleges.

Florida's experts have proposed draconian restrictions on Georgia's water use. Dr. Sunding—Florida's lead economist—has proposed a number of drastic remedy scenarios, including scenarios (using his calculations) that would require Georgia in "dry" years to reduce irrigation of row crops by up to 71% and proposals that require Georgia to reduce outdoor domestic water use from anywhere between 20-75%.[140] Dr. Sunding believes (inaccurately) that

[137] Order on State of Georgia's Motion to Dismiss (June 19, 2015) at 8.
[138] *Id.* at 11-15.
[139] *Id*. at 13.
[140] Ex. 71 at 9, 75, 78 (Sunding Rep.); Ex. 72 at 2, 4 (Sunding Def. Rep.).

those scenarios could generate between 1,000-2,000 cfs in additional streamflow in peak summer months—amounts that sometimes exceed Georgia's ***total consumptive use*** in those months. Indeed, according to Florida's own experts, even completely eliminating ***all*** agricultural irrigation from surface water and groundwater in Georgia could not generate the peak summer flows that Dr. Sunding's claims to achieve.[141] Dr. Flewelling, another Florida expert, has proposed similarly draconian remedial scenarios. He proposes reducing total agricultural irrigation by 50%, eliminating half of all man-made small impoundments, and eliminating ***all*** interbasin transfers.[142] He also proposed a scenario that would require banning irrigation on 150,000 acres in two watersheds that are critical to agricultural productivity in the basin.[143]

Unsurprisingly, the costs of those potential remedies are staggering. Two scenarios proposed by Dr. Sunding, which solely focus on agricultural water use, would cost Georgia between $205-$335 million each time the proposed restrictions are imposed.[144] Combining those agricultural water-use reductions with certain reductions in municipal and industrial water use proposed by Florida would cost Georgia $433 million when restrictions are imposed.[145] And a final scenario proposed by Dr. Sunding—which he suggests would generate 2,000 cfs in streamflow—would cost billions. Dr. Flewelling's scenarios, particularly his proposal to eliminate interbasin transfers, are similarly costly. These staggering impacts would dwarf any potential benefit to Florida, even if they did actually generate the streamflow Florida claims.

But Florida's proposals will not generate nearly the amount of water that Florida believes. Dr. Sunding estimates that three of his scenarios will increase peak summer

[141] Dr. Langseth testified that eliminating all agricultural pumping from surface water in the entire basin and eliminating all groundwater irrigation considered by Dr. Sunding would result in a peak summer streamflow of 1,231 cfs (636 cfs from surfacewater and 595 cfs from groundwater). *See* Langseth Tr. 869:1--870:9, 875:3-16.
[142] Ex. 73 at 38 (Flewelling Rep.).
[143] *Id*. at 39.
[144] *See* Ex. 43 at 52, 54-60 (Stavins Rep.).
[145] *See id.* at 53.

streamflows by 1,000 cfs. Georgia's analysis, however, shows that his measures would increase streamflows by only around 616-682 cfs.[146] Indeed, it would not be possible to generate 1,000 cfs increase in peak summer streamflows even if ***all*** row crop irrigation in ACF Georgia were eliminated in a dry year.[147] Dr. Sunding's purported benefits from M&I conservation are similarly impossible to achieve. Dr. Sunding testified that certain M&I conservation measures could generate 546 cfs in peak summer streamflows.[148] But even Florida's consumptive use expert found that that eliminating ***all*** M&I use throughout the entire ACF basin would have had a maximum impact of 468 cfs in the peak drought month of June 2011.[149]

Florida's proposed remedies also suffer from a much more fundamental problem: They will not lead to material increases in flows at the state line—at least without the Corps participating as a party in this case. Georgia's expert performed hydrologic modeling of 18 potential remedial scenarios using the Corps' ResSim model. That analysis shows that even significant reductions in Georgia's consumptive use would not materially increase state-line flows during many summer and fall months in dry years, because the Corps would offset any increases in Flint River flows with decreased releases from reservoirs on the Chattahoochee River.[150] The same is true with respect to Dr. Sunding's scenarios purporting to generate 1,000 cfs additional streamflow in peak summer months. Even assuming Dr. Sunding's scenarios could generate 1,000 cfs in additional streamflow, given how the Corps manages the integrated system of reservoirs to achieve multiple project purposes, a 1,000 cfs increase in Flint River flows ***would not materially increase*** flows in the state line in peak summer months.[151]

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[146] *See* Ex. 43 at 52-53 (Stavins Rep.).
[147] *Id*. at 78.
[148] Ex. 72 Table 1 at 2 (Sunding Def. Rep.).
[149] Flewelling Tr. 363:17-23.
[150] Ex. 36 at 60-69 (Bedient Def. Rep.).
[151] *Id*.

Florida's expert reached the same conclusion. Dr. Hornberger—Florida's expert on the "hydrological impacts" of Georgia's water use—performed modeling using his modified version of ResSim. That modeling showed that even draconian reductions in Georgia's water use ***would not materially increase*** state-line flows during many low flow months of dry years as a result of the Corps' management of ACF dams and reservoirs.[152] Dr. Hornberger admitted that, when he modeled a scenario in which Georgia's agricultural water use was reduced by ***over 50%***, his results showed multiple months in which state-line flows ***did not increase at all***.[153] Dr. Hornberger decided not to report these results in his expert report, but they were buried in his backup materials and they confirm Georgia's position and undermine Florida's.[154]

These findings are not surprising and, indeed, were presaged by Georgia at the outset of this case: reductions in Georgia's consumptive use do not cause increased flows at the state line in the summer months of dry years because of the significant role the Corps plays in managing water resources in the ACF Basin.[155] Releases from Georgia into Florida are tightly controlled by the Corps according to a precise set of rules and a careful balance of multiple federal project purposes. In dry times, that ensures Florida a 5,000 cfs minimum flow. Under the Corps' protocols, any additional water saved by reductions in Georgia's water consumption (at least during dry times) would be stored in upstream reservoirs and not passed through to Florida.[156]

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[152] Hornberger Tr. 417:11-418:1.
[153] *Id*.
[154] *Id*. at 415:21-416:5.
[155] Ex. 36 at 60-69; 69-71, 101 (Bedient Def. Rep.).
[156] *See, e.g.*, Ex. 74 at ACE-0118072 (12/7/2007 Brandt email) ("Once the determination is made to exercise the trigger, releases from Jim Woodruff Dam would be made to meet the 4,500 cfs minimum flow, and storage of inflows above the 4,500 cfs would occur."); Ex. 75 at ACE-0118126 (explaining that basin inflow "is all stored in W.F. George" during certain times); Ex. 76 at ACE-0118593 (Corps biologist stating that the Corps "intend[s] to store basin flows greater than 5,000 cfs if conditions permit…."[D]ue to the continuing drought we believe it is prudent to recover the storage as opportunities present themselves. Recovery of storage will assist us in continuing to augment flows to meet the 5,000 cfs minimum release requirement at Jim Woodruff Dam in support of listed mussels.").

The only way to deliver reliable or meaningful increases above 5,000 cfs during these times would be to change the Corps' operational protocols—and that cannot happen as long as the United States is not a party to this case. Indeed, when Florida's expert on Corps reservoir operations, who has over 30 years of experience with management of federal reservoir projects, was directly asked whether the Corps would have to be involved in delivering a predictable flow to Florida, he answered: "I don't see how else you would do it."[157] Florida's expert also testified that "because the Corps operates the Woodruff Dam and that's what releases the water into Florida, there would probably need to be some involvement of the Corps."[158] And, like the other Florida experts who acknowledged the truth, Mr. Barton was dropped from Florida's witness list and will not be coming to trial.

To be sure, there are limited circumstances in which, under the Corps' operating rules for the reservoirs, increases in flow entering the reservoir system would lead to some increases in flows at the state line. However, this would almost always occur during high-flow months when water is already plentiful, and even those times are difficult, if not impossible, to predict.[159] There is no evidence that increased flows would occur during dry times or times of drought—when Florida claims to need the water most. For example, under hydrological conditions of 2007 (which was a drought year), Florida would receive no additional state-line flow for 273 days of the year, and the full benefit of any increase in ***only 19 days*** in the summer and fall months.[160] Under the hydrology of 2012 (another drought year), Florida would receive no additional state-line flow for 307 days of the year, and would not receive ***any*** benefit during the

[157] Barton Tr. 205:14-20.
[158] *Id*. at 204:6-16.
[159] Ex. 39 at 26 (Bedient Rep.).
[160] *Id.* at 25.

summer and fall months.[161] Such unpredictable flows do not provide the kind of reliable remedy that equitable apportionment cases demand. Those cases ask whether the plaintiff state can be assured streamflows which are "fairly constant and dependable." *Wyoming v. Colorado*, 259 U.S. 419, 480, 483-84 (1922). Without the United States as a party, however, there is no way to assure Florida a "constant" or "dependable" increase in flow. And there is, moreover, a virtual assurance that Florida will not get a dependable increase in flow—or any increase in flow—during the times that it claims to need it most.

In addition to the infrequency and unpredictability of these impacts, Florida has no evidence—much less clear and convincing evidence—that short-term flow increases across the state line would redress the ecological harms of which it complains. That is true both with respect to the Apalachicola Bay and the Apalachicola River.

Florida has put forth no evidence showing that consumption caps on Georgia's water use would improve the ecology of the Apalachicola Bay. In fact, Florida's own expert found that cutting Georgia's agricultural consumption by ***50%*** and halting ***all*** interbasin transfers would result in only a ***1-3 part per thousand (ppt)*** change in salinity in East Bay (a portion of the Apalachicola Bay),[162] an ecologically insignificant amount.[163] Those same measures would result in ***less than 1 ppt*** change during the drought years of 2007 and 2012, the years in which Florida alleges its oyster industry suffered most.

No evidence proves, or even suggests, that such small changes in salinity levels would increase the population of oysters or in any other species in the bay. Florida's oyster biologist did not attempt to analyze what effect, if any, Florida's proposed remedies would have on overall

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[161] *Id.* at 28.
[162] *See* Greenblatt Tr. 182:1-16.
[163] Ex. 33 at 115 (Menzie Rep.); *id.* App C at C-15.

oyster abundance in the Bay.[164] Instead, his model evaluated only the counter-factual scenario where Georgia consumes ***no water at all***.[165] In addition, Florida's expert on fish species in Apalachicola Bay failed to analyze ***any*** remedy or conservation scenario.[166] Thus, Florida will present no evidence of the effect of realistic reductions in Georgia's water use on the Bay's oyster or fish populations. *Id.* Georgia's experts, in contrast, have determined that even increasing streamflows by 1,000 cfs in peak summer months (as Dr. Sunding proposes) "would not have significant ecological benefits for the Apalachicola Bay."[167] Florida has no evidence to contradict that determination. In fact, Florida's Bay biology expert and one of its state employees admitted that it was impossible to quantify precisely what salinity level would be desirable for any species in Apalachicola Bay.[168]

Florida also has not put forth evidence showing that consumption caps on Georgia's water use would improve the ecology of the Apalachicola River. Florida's riverine expert will offer no opinion on whether any of Florida's proposed remedies would have a material impact on the population of ***any*** species in the Apalachicola River region.[169] And even under Florida's amorphous and expansive concept of "harm," Florida's own expert found that cutting Georgia's agricultural consumption by 50% would improve the number of "flow days" by miniscule

[164] White Tr. 51:24-53:9; Ex. 16 at 57-58 (Lipcius Rep.) (observing that because Florida's oyster experts did not evaluate the proposed remedy scenarios, the State of Florida does not have a "modeled estimate of the effect of practical reductions in water use upon the Apalachicola Bay oyster population").

[165] Ex. 77 at 12 (White Rep.).

[166] Jenkins Tr. 330:21-331:3.

[167] Ex. 33 at 115 (Menzie Rep.); *see also id.* App. C, C-15; Figure C-7 (increasing freshwater inflows into the Bay by 1,000 cfs would have a negligible impact on salinity in Apalachicola Bay and that even that negligible change in salinity is "dwarfed" by natural variability in the system).

[168] *See* Jenkins Tr. 206:7-11 ("Q: And, likewise, you cannot tell me, as you sit here today, what value of salinity change impacts the nursery function for any species in East Bay? A: Precisely. I cannot."); Edmiston Tr. 73:4-12 ("The fish move around to the salinities and habitats they prefer natural variability is so great in the system that is is impossible to set a number.").

[169] Allan Tr. 469:10-21.

amounts (on the average of just a few days per year over 16 years) and in some cases could actually ***increase*** "harm," as Florida defines that concept.[170]

Moreover, for years prior to this litigation, Florida told federal courts that the Corps was the primary cause of the same injuries it alleges in this case, and that changes to the Corps' operating procedures were necessary for those injuries to be fully redressed. For example, Florida told the Supreme Court in a related case that "[w]hen the Corp structures its operations to retain water in Lake Lanier," that has "devastating consequences for the ecology and species of the Apalachicola River and Bay," such as by "eliminate[ing] those water bodies' hydrologic connections to stream and marshland habitats … and increase[ing] salinity in the Bay."[171] In addition, Florida argued to the U.S. District Court of the Middle District of Florida that "the Corps' exercise of discretion was a 'factual cause'" of its alleged injuries, because "the devastation of the listed mussels and the negative impact on the spawning by Gulf sturgeon would not have occurred … ***but for*** the Corps exercising its discretion to hold water in storage in Lake Lanier."[172] Florida has also argued in numerous letters to the Corps that "the Corps' operation of dams, reservoirs and related facilities … currently affects and will continue to affect" natural resources in the Apalachicola Region, and cited the very same injuries Florida alleges here, including harm to oysters, Gulf sturgeon, mussels, river-floodplain animals and vegetation, and Apalachicola Bay fisheries and estuaries.[173] Florida has thus admitted time and again, before multiple federal courts and agencies, that the Corps was the primary cause of its injuries, and that changes to Corps operations are necessary to redress those injuries. Florida cannot walk away from those admissions now because it finds it convenient to do so.

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[170] *Id.* 463:24-464:7; 465:11-466:16.
[171] Ex. 78 at 29 (*Tri-State Water Rights* Cert. Petition).
[172] Ex. 79 at 42 (Fla. Response in *Tri-State Water Rights Litig.*).
[173] *See* Ex. 80 at FL-ACF-02427524 (6/12/2007 Fla. Letter to Corps); *see also* Ex. 81 at FL-ACF-02427485 (Jan. 6, 2005 Fla. Letter to Corps).

In short, Florida has no evidence that any meaningful ecological benefit will result from placing a cap on Georgia's upstream consumption of water. The benefits of Florida's proposed remedies are speculative and uncertain, whereas the costs those remedies would impose on Georgia are certain and substantial.

CONCLUSION

Florida will not be able to prove its case a trial. Discovery has shown that Florida does not have clear and convincing evidence that (1) it is suffering real and substantial ecological injury caused by Georgia's water use; (2) Georgia's water use is inequitable; or (3) its injuries would be redressed by a remedy that is possible without the participation of the Corps as a party, or that is justified in light of the substantial costs it would impose on Georgia. Accordingly, Florida's request for an equitable apportionment must be denied.

Respectfully submitted,

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No. 142, Original

In The
Supreme Court of the United States

STATE OF FLORIDA,

Plaintiff,

v.

STATE OF GEORGIA,

Defendant.

Before the Special Master

Hon. Ralph I. Lancaster

CERTIFICATE OF SERVICE

This is to certify that the STATE OF GEORGIA'S PRETRIAL BRIEF and APPENDIX OF EXHIBITS has been served on this 12th day of October 2016, in the manner specified below:

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No. 142, Original

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APPENDIX OF EXHIBITS TO STATE OF GEORGIA'S PRETRIAL BRIEF

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Exhibit 1	12/03/2012	Email from Pine to Havens re Research Needs for AB - Confidential (UFL_0053543-45)
Exhibit 2	01/01/2015	Pine III, W. E., et al. The curious case of eastern oyster Crassostrea virginica stock status in Apalachicola Bay, Florida, Ecology and Society.
Exhibit 3	12/20/2014	E-mail from Bill Pine to Jack Payne, Eric Hellgren, and Karl Havens (UFL_00214273-24)
Exhibit 4	02/09/2015	Email from Havens to Cammen re Supreme Court Case Florida vs. Georgia (UFL_00251508)
Exhibit 5	09/06/2012	Letter from Gov. Scott to US Department of Commerce requesting Disaster Declaration, Attaching A. Putnam letter and August 2012 Oyster Resource Assessment Report (FL-ACF-02425651-66)
Exhibit 6	08/01/2011	FDACS Oyster Resource Assessment Report (FL_SEA-GRANT_40074-80)
Exhibit 7	04/23/2013	Email from David Heil to Jim Estes re Report with assessment report included (FL-ACF-02016441-54)
Exhibit 8	04/29/2013	Email from J. Estes to N. Wiley re Need some info ASAP on Oysters (FL-ACF-01936042-44)
Exhibit 9	10/09/2012	Email from David Heil to Mark Berrigan forwarding oyster disaster request (FL-ACF-BERRIGAN-0000196-198)
Exhibit 10	08/05/2013	Email from Jim Estes to Roy Crabtree re Oyster Report (FL-ACF-03475195-357) (Excerpts)
Exhibit 11	05/20/2010	Order No. EO 10-19 Early Opening of the Summer Harvest Season for Oysters In Apalachicola Bay Established in Rule 68B-27.019 (1)(a)1, F.A.C.
Exhibit 12	06/04/2010	Order No. EO 10-25 Additional Oyster Harvest Days for Apalachicola Bay
Exhibit 13	06/17/2010	Order No. EO 10-32 Additional Oyster Harvest Days and Areas for Apalachicola Bay
Exhibit 14	06/17/2010	Press Release - Florida Provides for Increased Apalachicola Bay Oyster Production (FL-ACF-04088487-88)
Exhibit 15	01/01/2012	Oyster Resource Assessment Report, Apalachicola Bay 2012 (UFL_00233414-25)
Exhibit 16	05/20/2016	Expert Report of Romuald Lipcius (Excerpts)

Exhibit 17	09/02/2014	Email from Havens to Payne et al., re Apalachicola (UFL_00248654 -56)
Exhibit 18	04/23/2013	Florida Sea Grant Apalachicola Bay Oyster Situation Report (FL_SEA-GRANT_41113-44)
Exhibit 19		Oyster_Cultch_time_Series.xlsx (FL-ACF-04142713)
Exhibit 20	01/01/2006	Light, H.M., K.R. Vincent, M.R. Darst, and F.D. Price. Water-level decline in the Apalachicola River, Florida, from 1954 to 2004, and effects on floodplain habitats: U.S. Geological Survey Scientific Investigations Report 2006-5173.
Exhibit 21	06/09/2009	Email from Ted Hoehn to MaryAnn Poole re meeting(s) with Mike Sole (FL-ACF-03388630-707)
Exhibit 22	09/14/2016	Biological Opinion, Endangered Species Act, Section 7 Consultation on the U.S. Army Corps of Engineers, Mobile District, Update of the Water Control Manual for the Apalachicola-Chattahoochee-Flint River Basin in Alabama, Florida, and Georgia and a Water Supply Storage Assessment
Exhibit 23	05/03/2014	Smit, Reuben. Using sonar habitat mapping and GIS analyses to identify freshwater mussel habitat and estimate population size of a federally endangered freshwater mussel species, Amblema neislerii, in the Apalachicola River, FL. (USFWS0043933-4033)
Exhibit 24	02/03/2015	Email from Brian Zettle to Adam Kaeset and Heather Bulger re Apalachicola - Fat threeridge data (USFWS0088935-65)
Exhibit 25	06/07/2013	Information Memorandum for the Regional Director (USFWS0093993-97)
Exhibit 26	06/10/2013	Information Memorandum for the Regional Director (USFWS0098185)
Exhibit 27	07/30/2013	Email from Adam Kaeser to Donald Imm, Catherine Phillips, Karen Hennington, Channing St. Auibin and Sandra Pursiful re Fat threeridge listing meeting Friday (USFWS0090215-27)
Exhibit 28	01/14/2013	FDEP, Appendix III to February 2011 Addendum for Fish and Wildlife Coordination Act Report (FL-ACF-03404782)

Exhibit 29	10/01/2015	USACE, Draft Environmental Impact Statement (Volumes & Appendices), Update of the Water Control Manual for the Apalachicola-Chattahoochee-Flint River Basin in Alabama, Florida, and Georgia and a Water Supply Storage Assessment
Exhibit 30	05/22/2012	USFWS Biological Opinion on the U.S. Army Corps of Engineers, Mobile District, Revised Interim Operations Plan for the Jim Woodruff Dam and Associated Releases to the Apalachicola River (Excerpts)
Exhibit 31	05/02/2013	Email from Ted Hoehn to Dan Tonmeire, Charlie Mesing, Michael Hill, Graham Lewis and Matt Kondolf re Apalachicola River Restoration field trip with Restoration Plan attachment (FL-ACF-03393537-47)
Exhibit 32	09/01/2009	2009 Gulf Sturgeon 5-Year Review
Exhibit 33	05/20/2016	Expert Report of Charles Menzie (Excerpts)
Exhibit 34	01/30/2009	Final Scoping Report, Environmental Impact Statement, Update of the Water Control Manual for the Apalachicola-Chattahoochee-Flint (ACF) River Basin, in Alabama, Florida, and Georgia
Exhibit 35	02/29/2016	Expert Report of J. David Allan
Exhibit 36	05/20/2016	Defensive Expert Report of Philip Bedient
Exhibit 37		20160223-ACF-GA-total-consumptive-monthly.xlsx
Exhibit 38		USGS Groundwater and Surface water data (http://waterdata.usgs.gov/usa/nwis/)
Exhibit 39	02/29/2016	Expert Report of Philip Bedient (Excerpts)
Exhibit 40		U.S. Drought Monitor
Exhibit 41		NOAA State of the Climate: Drought - Annual 2012, available at https://www.ncdc.noaa.gov/sotc/drought/201213
Exhibit 42	05/20/2016	Defensive Expert Report of George Hornberger (Excerpts)
Exhibit 43	05/20/2016	Expert Report of Robert Stavins (Excerpts)
Exhibit 44	04/29/2016	Memorandum from Metro Water District to Georgia EPD re Chattahoochee-Flint River Basin Population Served.
Exhibit 45	05/20/2016	Expert Report of Peter Mayer (Excerpts)
Exhibit 46	05/20/2016	Expert Report of Suat Irmak (Excerpts)
Exhibit 47	02/29/2016	Expert Report of Gerrit Hoogenboom (Excerpts)
Exhibit 48	02/29/2016	Expert Report of Daniel Phaneuf (Excerpts)

Exhibit 49	01/29/2016	Memorandum from W. Zeng to J. Turner - Technical Evaluation of Georgia's 2015 Updated Water Supply Request
Exhibit 50	01/11/2013	Letter from Governor Deal to Jo Ellen Darcy re State of Georgia Water Supply Request
Exhibit 51	11/12/2009	Summary of Water Conservation, Water Management and Water Efficiency Projects with Special Focus on the Lake Lanier/ Chattahoochee River Users
Exhibit 52	03/26/2003	Georgia Drought Management Plan
Exhibit 53		2015 Drought Management Rule, 391-3-30.01 - .08. (http://rules.sos.ga.gov/nllxml/georgiacodesGetcv.aspx?urlRedirected=yes&data=admin&lookingfor=391-3-28)
Exhibit 54	09/28/2007	Press Release: Citing Historic Drought, Georgia EPD Bans Most Outdoor Water Use in North Georgia
Exhibit 55	10/23/2007	Press Release: Governor Perdue Orders Utilities, Permit Holders to Reduce Water Use by 10 Percent
Exhibit 56	12/30/2014	Memorandum from J. Turner to Board of Natural Resources re Drought Management Rules
Exhibit 57	01/01/2010	Senate Bill 370 - Georgia Water Stewardship Act
Exhibit 58		The Water Efficiency and Conservation State Scorecard: An Assessment of Law and Policies
Exhibit 59	01/01/2015	Water Audits in the United States: A Review of Water Losses and Data Validity
Exhibit 60		http://www3.epa.gov/watersense/partners/winners_2015.html
Exhibit 61	09/12/2003	Torak, Lynn, Water Availability and Competing Demands, Southwest Georgia Sound Science Initiative
Exhibit 62	03/20/2006	Flint River Basin Regional Water Development and Conservation Plan
Exhibit 63		Summary of 2000 and 2001 Flint River Drought Protection Act Auctions
Exhibit 64	01/01/2011	Torak, LJ; Painter, JA.. "Summary of the Georgia Agricultural Water Conservation and Metering Program and Evaluation of Methods Used to Collect and Analyze Irrigation Data for the Middle andLower Chattahoochee and Flint River Basins, 2004–2010." USGS Scientific Investigations Report 2011–5126.
Exhibit 65	01/01/2014	USGS. "Georgia Agricultural Water Conservation and Metering Program." South Atlantic Water Science Center – Georgia (http://ga.water.usgs.gov/projects/agwater)
Exhibit 66	11/09/2015	GSWCC Metering Program
Exhibit 67		LF Mapping.pptx
Exhibit 68		GWPPC Mapped Pivots_Flint Basin.xlsx

Exhibit 69	07/30/2012	Permit Suspension Announcement.
Exhibit 70	03/13/2014	Senate Bill 213
Exhibit 71	02/29/2016	Expert Report of David Sunding (Excerpts)
Exhibit 72	05/20/2016	Defensive Expert Report of David Sunding (Excerpts)
Exhibit 73	02/29/2016	Expert Report of Samuel Flewelling (Excerpts)
Exhibit 74	12/07/2007	Email from Joanne Brandt to G. Carmody & J. Ziewitz re ACF Exceptional Drought Operations - 4,500 cfs Incremental reduction - 7 Dec 2007 Letter to USFWS
Exhibit 75	12/07/2007	EDO Incremental Reduction in Flow to 4,750 cfs - ACF Reservoir Storage Conserved
Exhibit 76	10/25/2007	Email from Cheryl Hrabovsky to J. Ashley, A. Houston et al. re FW Volumetric Balancing
Exhibit 77	02/29/2016	Expert Report of Wilson White (Excerpts)
Exhibit 78	02/01/2012	Petition for a Writ of Certiorari, in *In re MDL-1824 Tri-State Water Rights Litigation* (Filed Feb. 1, 2012)
Exhibit 79	02/10/2010	Response of the State of Florida and the City of Apalachicola to the Non-Federal Parties' Motions for Summary Judgment on Phase 2 Claims, in In re Tri-State Water Rights Litigation, No. 3:07-MD-1-PAM (M.D. Fla.)(filed Feb. 10, 2010)
Exhibit 80	06/12/2007	Draft Management Plan options for Recovery of Oyster Resources in Florida
Exhibit 81	01/06/2005	Letter from Colleen Castille to Col. Peter Taylor re Corps' Operation of Dams, Reservoirs and Related Facilities in the ACF Basin

Exhibit 1

From: Pine, Bill
Sent: Monday, December 03, 2012 9:21 PM
To: Havens,Karl
Subject: RE: research needs for AB - confidential

Here's the thing, I can't find any relationship between flow and effort or landings. Neither can Carl. So we (all of us) read these papers and think flow drives all these things like predation and nutrients etc., so if it does there should be a relationship, with maybe an 18-24 month lag time for the little oysters to grow to harvestable size, between flow and landings. But the landings and trips data since 1986 (post-hurricane and the year the landings data were mandatory and not voluntary) are pretty flat, they don't change that much. So maybe the landings data are completely made up by the dealers (what FDACS seems to think) or there isn't a strong flow-oyster relationship. Maybe Leslie is right, the folks in AB are super politically savvy and know how to play this game to their political advantage. It wouldn't be the first time.

Dr. Bill Pine
Associate Professor
Department of Wildlife Ecology and Conservation and Fisheries and Aquatic Sciences Program University of Florida
http://floridarivers.ifas.ufl.edu

-----Original Message-----
From: Havens,Karl
Sent: Monday, December 03, 2012 9:16 PM
To: Pine, Bill
Subject: Re: research needs for AB - confidential

OK, these are good points -- it is different approach, however, I get it as a greater payoff from the standpoint of effective management.

After reading Livingston's work and papers on predation, I think you can make a pretty good case for both predation and nutrient limitation effects with low flow. The key would be to figure out what kind of flow regime is needed to keep predators in check and maintain sufficient input of P, N and perhaps organic C. I think this is much more challenging than figuring out a harvest rate, AND both are linked.

Karl

Karl Havens, Professor and Director
Florida Sea Grant College Program
University of Florida
Website: flseagrant.org
Office phone: 352-392-5870
Cell phone: 352-284-8558

Sent from my iPad

On Dec 3, 2012, at 9:12 PM, "Pine, Bill" <billpine@ufl.edu> wrote:

> The reason is because I don't think we are seeking a mechanistic understanding of the system in order to manage it better, instead we are seeking to better manage the system, which doesn't require a mechanistic understanding of fine scale biological and physical processes.
>
> We have to ask ourselves first "what can we do?" from a management perspective. If the only thing we can do is regulate harvest (I'm not sure we can do that) then that's what we do focus on. If we can regulate plankton, then we include that. If we can regulate flows we do that.
>
> Dr. Bill Pine
> Associate Professor
> Department of Wildlife Ecology and Conservation and Fisheries and
> Aquatic Sciences Program University of Florida
> http://floridarivers.ifas.ufl.edu
>
>
> -----Original Message-----
> From: Havens,Karl
> Sent: Monday, December 03, 2012 9:04 PM
> To: Pine, Bill; Allen,Micheal S; Kane,Andrew S
> Cc: Payne,Jack M; Hayes,John P; Havens,Karl
> Subject: Re: research needs for AB - confidential
>
> I suggest we include Ed Phlips and Shirley Baker. We have not delved
> into phytoplankton compositional changes, because of lack of funds,
> but Ed and his PhD student have at least thre years of data from AB
> from 2010-2012 and we have not yet looked at direct effects of
> increased salinity, which is documented to have effects on growth of
> oysters -- this is Shirley's area of expertise -- Karl
>
> Karl Havens, Professor and Director
> Florida Sea Grant College Program
> University of Florida
> Website: flseagrant.org
> Office phone: 352-392-5870
> Cell phone: 352-284-8558
>
> Sent from my iPad
>
> On Dec 3, 2012, at 8:04 PM, "Havens,Karl" <khavens@ufl.edu> wrote:
>
>> Bill, Mike and Andy,
>>
>> I was called today by a friend in a senior level position at the FWC, and told that the Governor wants to know what research needs to be done to figure out what happened to the oysters in Apalachicola Bay and what actions need to be taken to prevent it from happening again. It was suggested that we put together a clearly defined list of research needs as quickly as possible to have ready when requested.
>>
>> I suggest that the four of us quickly get our heads around this, and then as part of the discussion we determine if anyone else at UF (or elsewhere) who currently is not working in this issue needs to be involved (my sense is that we have all the bases covered, given that there are not other UF faculty actively working on this -- not from the 'what caused it' perspective anyway).
>>

>> I don't know about including David because he is leaving FSU. Perhaps we can start to informally discuss over dinner and beer when we all are in Apalachicola this Thursday evening, and then have a brainstorming meeting towards the end of next week to come up with a list. Or, just start thinking about research needs in your area and we will do a meeting next week.
>>
>> I think we need to think big and think comprehensively -- 'what is needed to really nail this one down?' It probably will require experiments, a multi-year assessment, and modeling, and my guess is that it will take close to the amount Jack provided us with an additional zero after the end of the number -- $2M anyway. I can tell you that just from the nutrient / trophic dynamics aspect, things are unfolding just like Livingston observed in the 1990s, right down to increased clarity, then increased Chl-a, and ... I don't think we have the relevant biological data on consumers. But, it will be a test to determine how important this is compered to salinity effects on enhancing predation by conchs, sponges and welks, on Perkinsus, and then all of this relative to over-fishing. I also have no idea what the Governor means by finding out how to prevent it from happening again, if the main cause is insufficient water input from the river and that is determined ultimately by what a court decides about a USACE water control manual. Suggest our focus is in the bay and on inflows, and maybe even some prescriptions about seasonal flow pattern and volumes and fishing regulations ... but not on things like how to regulate lakes and groundwater wells in Georgia. In the discussion I had today, it was pretty clear that the FWC folks (at least) understand quite well the importance of groundwater discharges vs. reservoirs.
>>
>> I'm copying Jack and John in case they have caught wind of this and know anything more. It was not specifically said that the idea was for UF to do this research, however, given that we are the only ones actively doing research on the bay right now and will be a good ways towards some answers, it seems logical it would go that way. Jack and John might advise how to work that angle to make sure that if there is money for research it comes to UF and not to the FWC -- we know that the people in the community, for good reason or not, do not trust the agencies, and have been calling for our 'independent' analysis.
>>
>> If this became a reality it would be critical to have the money go through the FWC (25% IDC) and not FDACS (5% IDC), else we will come out at a loss on the money side.
>>
>> For obvious reasons, I'd not share this email or information around just yet, since we don't have all the details.
>>
>> Karl
>>
>> Karl Havens, Professor and Director
>> Florida Sea Grant College Program
>> University of Florida
>> Website: flseagrant.org
>> Office phone: 352-392-5870
>> Cell phone: 352-284-8558
>>
>> Sent from my iPad

Exhibit 2

Pine, W. E., III, C. J. Walters, E. V. Camp, R. Bouchillon, R. Ahrens, L. Sturmer, and M. E. Berrigan, 2015. The curious case of eastern oyster *Crassostrea virginica* stock status in Apalachicola Bay, Florida. *Ecology and Society* 20(3):46. http://dx.doi.org/10.5751/ES-07827-200346

Insight

The curious case of eastern oyster *Crassostrea virginica* stock status in Apalachicola Bay, Florida

William E. Pine III[1], *Carl J. Walters*[2], *Edward V. Camp*[3], *Rachel Bouchillon*[4], *Robert Ahrens*[3], *Leslie Sturmer*[5] *and Mark E. Berrigan*[6]

ABSTRACT. The Apalachicola Bay, Florida, eastern oyster (*Crassostrea virginica*) industry has annually produced about 10% of the U.S. oyster harvest. Today's simple individual-operator, hand-tonging, small-vessel fishery is remarkably similar to the one that began in the 1800s. Unprecedented attention is currently being given to the status of oyster resources in Apalachicola Bay because this fishery has become central to the decision making related to multistate water disputes in the southeastern United States, as well as millions of dollars in funding for restoration programs related to the Deepwater Horizon oil spill. The oyster fishery collapsed in 2012, leading to large economic losses and community concerns over the current and future status of oyster resources, ecosystem health, and local economic opportunities. We used best available data to assess what mechanism(s) may have led to the collapse of the Apalachicola Bay oyster fishery. We then assessed the efficacy of alternative management strategies (e.g., restoration, fishery closure) to accelerate oyster population recovery. Our results suggest that the Apalachicola Bay oyster population is not overfished in the sense that recruitment has been limited by harvest, but that the 2012 collapse was driven by lower-than-average numbers and/or poor survival of juvenile oysters in the years preceding the collapse. This reduction in recruitment not only reduced the biomass of oysters available to harvest, but from a population resilience perspective, likely reduced the amount of dead shell material available as larval settlement area. Although the Apalachicola Bay oyster fishery has proven resilient over its >150-year history to periods of instability, this fishery now seems to be at a crossroads in terms of continued existence and possibly risks an irreversible collapse. How to use the restoration funds available, and which restoration and management practices to follow, are choices that will determine the long-term viability of the Apalachicola Bay oyster fishery.

Key Words: *adaptive management; Apalachicola; harvest management;oysters; restoration*

INTRODUCTION

Eastern oyster (*Crassostrea virginica*) populations are significant components of coastal ecosystems, playing numerous important ecological, cultural, and economic roles. Eastern oyster (hereafter, "oyster") populations often create complex reefs of living oysters of multiple size and age classes living on and among dead oyster shell material known as cultch (Fig. 1). These oyster reefs create key habitat for numerous fish, invertebrate, and bird species, many of which have large recreational and commercial value (e.g., red drum [*Sciaenops ocellatus*], Florida stone crab [*Menippe mercenaria*]) or are species of special concern (e.g., American Oystercatcher [*Haematopus palliatus*]). Oyster reefs also function as barrier islands in many areas, dampening wave action to reduce coastal erosion and protect human coastal communities from storm damage (Borsje et al. 2011), as well as improve coastal water quality (Coen et al. 2007). Globally oyster reef distribution has declined by as much as 85% for a variety of reasons including overharvest, disease, and poor water quality (Beck et al. 2011). Well-known U.S. oyster fisheries such as those in the Chesapeake Bay are much smaller than historic levels (Wilberg et al. 2011). The largest wild oyster fishery in the world currently is in the Gulf of Mexico, which supplies about 50% of the U.S. commercial oyster harvests (Beck et al. 2011).

Florida provides about 10% of the U.S. commercial harvest (MacKenzie 1996), with the majority of oyster landings coming from Apalachicola Bay (Dugas et al. 1997). Apalachicola Bay oysters have traditionally been viewed as a high-quality seafood product, and Apalachicola oysters are marketed by name for their size and flavor qualities. Oyster fisheries and oyster processing are a significant component of the local economy, supporting more than 1000 jobs and about half of the revenues for some coastal counties (Whitfield and Beaumariage 1977, Havens et al. 2013).

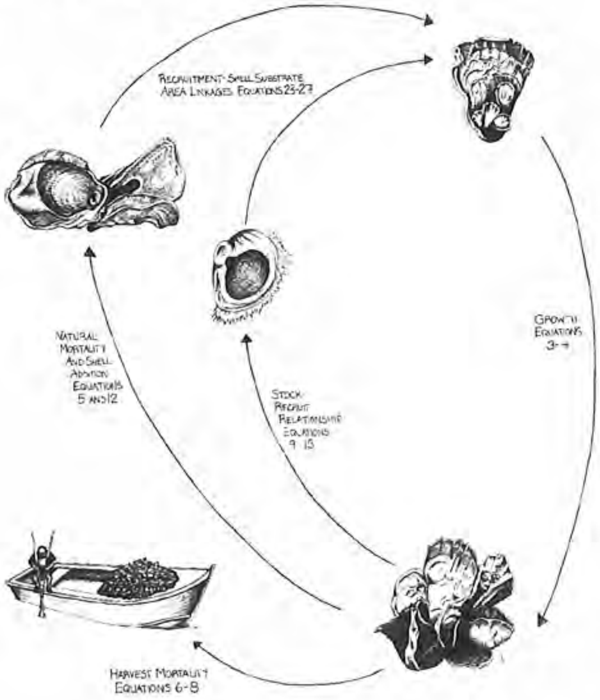
Apalachicola Bay oyster populations have a long research and management history (Fig. 2). In a report of the U.S. Commission of Fishes and Fisheries, as part of a survey of oyster regions of Apalachicola Bay, Florida, Swift (1897) said:

> *The oysters of this bed, especially those found near the 3-foot curve off Cat Point, are of the very finest quality, and it is probable that no better flavored oysters can be found in any part of the country. They are not only exceptionally good in flavor, but are large and fat.* Swift (1897:210)

> *This bed [South Lump], like the others surrounding it on the north side, was formerly very productive, but it, like the others, was so overworked that it became depleted a few years ago. Since that time, these beds have been left to recuperate, and it seems probable that, if left undisturbed, they will soon recover their former productiveness.* Swift (1897:203)

[1]Department of Wildlife Ecology and Conservation, University of Florida, [2]University of British Columbia, [3]Fisheries and Aquatic Sciences Program, School of Forest Resources and Conservation, University of Florida, [4]School of Natural Resources and the Environment, University of Florida, [5]Shellfish Aquaculture Extension Program, School of Forest Resources and Conservation, University of Florida, [6]Applied Aquaculture LLC

Fig. 1. Generalized eastern oyster (*Crassostrea virginica*) lifecycle and equations used in the stock assessment model (Table A2.1 in Appendix 2) developed to assess status and trends in the Apalachicola oyster population.



This is the first of several large declines in Apalachicola oyster populations reported since the late nineteenth century. The most recent occurred in 2012, when Apalachicola Bay experienced large declines in the abundance of harvestable oysters, leading the State of Florida to request a Federal Fisheries Disaster declaration from the National Marine Fisheries Service. This decline resulted in large economic losses in the region, leading to a 2012 community-based review of environmental conditions in Apalachicola Bay (Havens et al. 2013, Camp et al. 2015). This review followed decades of earlier agency and academic research on Apalachicola Bay ecology in the 1970s-2000s (Livingston 1991, 2002, 2015).

Despite the economic importance of the Apalachicola oyster fishery and expanded attention to the ecosystem services provided by oyster populations across their distribution (Coen et al. 2007, Beck et al. 2011, Seavey et al. 2011), the status of oyster populations in quantitative terms, i.e., terms useful for making management and restoration decisions, is not well known in many areas (Wilberg et al. 2011). To inform Apalachicola oyster fishery management and restoration, it is specifically critical to understand (1) the role that fishing effort has played in the current oyster fishery collapse to determine best fishing practices in the future and (2) what specific strategies or scenarios (e.g., shelling of oyster bars, restrictive harvest policies) will lead to the most rapid or most certain recovery of the fishery.

We analyzed available data in a population dynamics model to assess what mechanism(s) likely led to the collapse of the Apalachicola Bay oyster fishery. An original contribution is that our model captures the feedback between natural mortality and the accretion of shell material as substrate for oyster larvae (spat) settlement and growth, and the linkages between harvest (which removes both oyster shell material and live oysters) and recruitment. We then assessed the efficacy of alternative management strategies (e.g., habitat restoration, fishery closures) and scenarios (area for and frequency of adding shell material) to accelerate oyster population and fishery recovery to help inform planning efforts for community-led restoration programs designed to promote resilience in this resource-dependent community (Camp et al. 2015).

Note that we did not study or reach any conclusions about any effect of water withdrawals affecting the Apalachicola River Basin or oyster populations in Apalachicola Bay. This is an area that warrants future research.

STUDY SITE

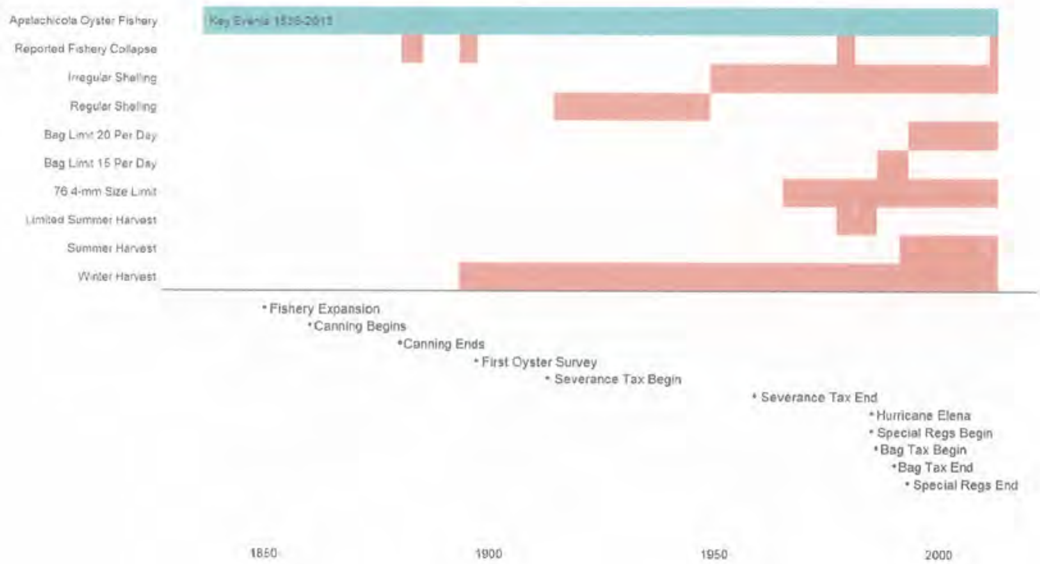
Apalachicola Bay is a shallow estuary (mean depth <3 m) of approximately 63,000 ha enclosed by a series of barrier islands with an east-west orientation. Geologic surveys of the bay suggest that the primary oyster bars are perpendicular to the orientation of the bay along ancient sandy deltas, and these bars became expansive 1200-2400 years ago (Twichell et al. 2010). The primary source of freshwater input into Apalachicola Bay is the Apalachicola River, and river discharge has a strong influence on the salinity, nutrient dynamics, and other aspects of the Apalachicola Bay ecosystem (Livingston et al. 1997).

Fishery overview

The commercial oyster fishery in Apalachicola was first described in the 1880s, and extensive surveys in the 1890s reported established fisheries with commercial canning operations, as well as documentation of oyster bars being "overworked" and no longer producing a commercial harvest (Swift 1897, Dugas et al. 1997; Fig. 2). Oyster landings from Apalachicola Bay in the last half century average between 91,000 and 272,000 kg of meat, or about 90% of Florida's commercial oyster harvest (Dugas et al. 1997; Fig. 3), with the majority of harvest coming from public reefs where oysters are harvested via hand tonging (Whitfield and Beaumariage 1977). As early as 1881, it was recognized by Florida statute that the recycling or placing of oyster shell on oyster reefs to provide substrate for oyster spat (known as "shelling") was important to promote sustainable oyster harvest (Whitfield and Beaumariage 1977). In 1949, a management program was established to replace oyster shell on public reefs, and the amount of material has varied annually depending on funding and availability of material (Whitfield and Beaumariage 1977).

In 1985, Hurricane Elena caused significant damage to oyster resources in Apalachicola Bay, leading to highly restrictive regulations, on-water harvest check stations, and intensive shelling operations on a subset of reefs (Berrigan 1990). Beginning in 1986, a revised landings and effort reporting system was required for all commercially harvested marine species, in contrast to the prior voluntary reporting program in place. Based on data

Fig. 2. Time line of key events and management actions in the Apalachicola Bay, Florida oyster fishery, 1836-2013.



since 1986, the number of Apalachicola Bay oyster harvesters declined from about 1000 in the late 1980s to around 400-600 throughout most of the 1990s and early 2000s, before increasing since 2008 to about 1000 license holders at present (Fig. 3a). The number of oyster fishing trips follows a similar pattern, with about 30,000 trips reported in 1988, declining to about 10,000 trips in the mid-1990s, and then varying between 10,000 and 25,000 trips until 2006, when the number of trips increased to about 40,000 annually in recent years. Large declines in landings were reported beginning in the fall of 2012, and landings and trips declined dramatically in 2013 (Camp et al. 2015). Oyster regulations in Apalachicola Bay are currently managed using a system of seasons, spatial closures, bag limits, and size limits, but on-water check stations and a bag tax to fund research and monitoring programs were ended in the early 1990s (Fig. 2).

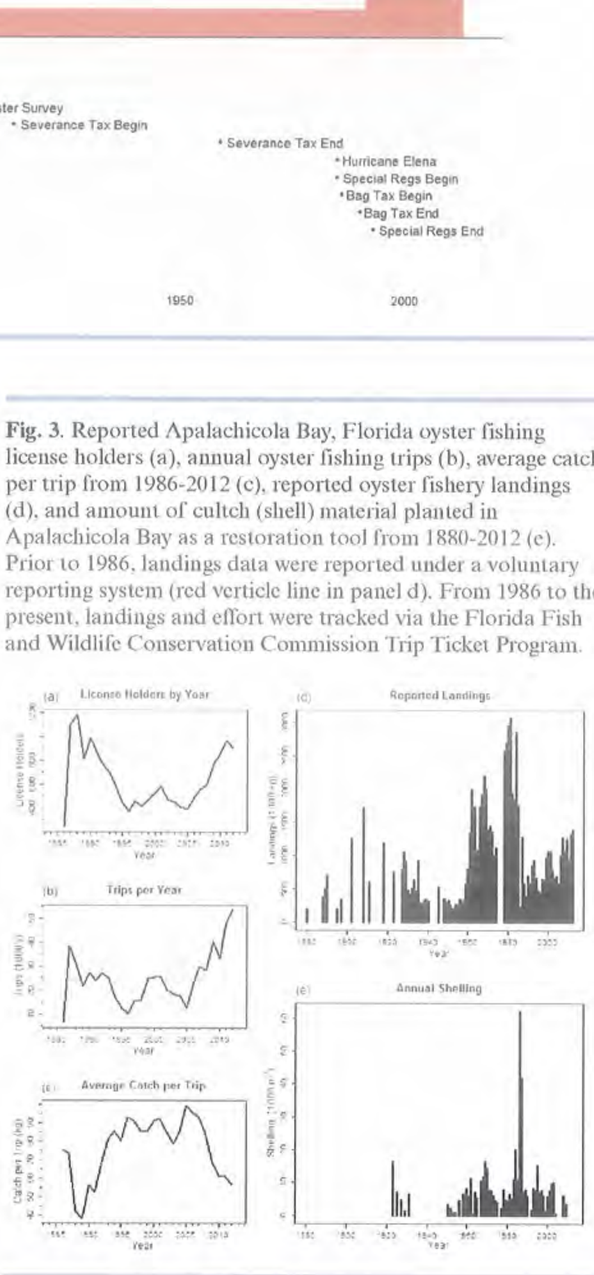
METHODS

Oyster stock assessment model

We developed an age-structured oyster stock assessment model that reconstructs historical abundance patterns and allows for exploration of future alternative management options. The model represents a single oyster population in some area of interest; that region may be some large management area like Apalachicola Bay or some much smaller habitat type or site within a larger region. The model is implemented in an Excel spreadsheet to allow portability and ease of examination of model structure and calculations; an example copy of this spreadsheet is available as a supplemental file (see Appendix 1).

Model population dynamics calculations (growth, survival, recruitment) are made at a monthly time resolution to account for the rapid growth and mortality of oysters, to assist in

Fig. 3. Reported Apalachicola Bay, Florida oyster fishing license holders (a), annual oyster fishing trips (b), average catch per trip from 1986-2012 (c), reported oyster fishery landings (d), and amount of cultch (shell) material planted in Apalachicola Bay as a restoration tool from 1880-2012 (e). Prior to 1986, landings data were reported under a voluntary reporting system (red verticle line in panel d). From 1986 to the present, landings and effort were tracked via the Florida Fish and Wildlife Conservation Commission Trip Ticket Program.



interpretation of seasonal harvesting data, and for evaluation of seasonal harvesting policies, e.g., seasonal closures. Three time-accounting variables are used in the model equations: y for calendar year ($y = 1,...,n_y$), m for month of year ($m = 1,...,12$), and t for month from start of a time simulation ($t = 1,...,12n_y$). The model predicts matrices of oyster numbers $N_{a,t}$ and shell lengths $L_{a,t}$ by month of age. Using monthly fishing efforts $E_{y,m}$, the model predicts monthly catches $C_{y,m}$ for statistical comparison to historic data, while allowing for interannual variations in recruitment, growth, and survival (equation 1 in Table A2.1, Appendix 2). For our Apalachicola Bay case history, observed fishery landings and effort data by month were compiled for 1986-2013 from information provided by the Florida Fish and Wildlife Conservation Commission. We developed a standardized index of oyster recruitment using fisheries-independent survey data of oysters by 5-mm size classes collected by the Florida Department of Agriculture and Consumer Services (DACS) on the major commercial fishing reefs in Apalachicola Bay (available from 1990 through 2013). Full details on our population dynamics model and its application to the Apalachicola Bay case study are available in Appendix 2.

Simulation of management actions

When tuned to the uncertainty in oyster population dynamics in Apalachicola Bay, this model can be used to evaluate future fishery outcomes of alternative management actions. As an example, how harvest or environmental perturbations affect persistence of shell material essential for successful recruitment represents a key uncertainty in managing oyster populations. If shell material is removed from the oyster bars as fishermen cull legal oysters from sublegal sizes and associated shell material, and these sublegal oysters and shell are discarded away from the oyster bar, then this loss rate (discard mortality of both live sublegal oysters and shell material) could be substantial. Such evaluations are a critical part of any adaptive management program designed to learn more about the system (Camp et al. 2015).

We used the model to assess the effect on future oyster fishery landings of a variety of potential management actions under different assumptions about oyster recruitment patterns and processes. We first assumed future average oyster recruitment levels similar to those observed in 2004-2013 and explored four management action scenarios: (1) no management action taken; (2) no management action taken, but assuming a different function form of the recruitment relationship (i.e., assuming a Beverton-Holt recruitment function rather than a Ricker recruitment function); (3) initiating a substantial shell addition program involving restoration of about 50 ha (a little more than the historic average annual shelling) for each of four years (2014-2018); and (4) reducing fishing effort by half (from around 4000 trips/month to 2000) over the next six years (2014-2020). We then evaluated actions 1, 3, and 4 under the alternative assumption that future average oyster recruitment remains low (similar to 2011-2012 levels). Finally, we assessed how a future 20% annual loss rate of shell material would impact oyster population recovery under no action (scenario 1) and reshelling (scenario 3).

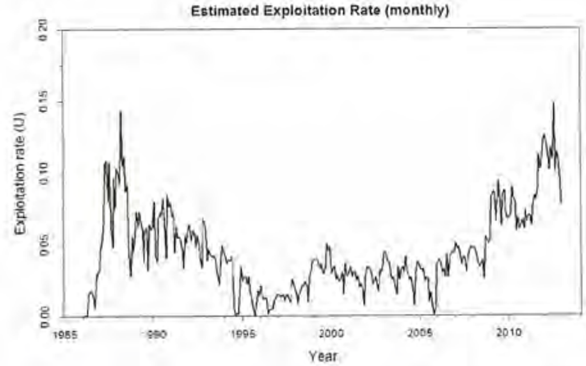
RESULTS

Oyster stock assessment model

The oyster stock assessment model (Appendix 2) appears to represent well the oyster population dynamics in Apalachicola Bay and results in a remarkably good statistical explanation of historical catches and major trends in fisheries-independent survey data. Our assessment results suggest that the Apalachicola Bay oyster population is probably not recruitment overfished; i. e., the observed low recruitments are not anticipated to be strictly because of overharvest of adults. Rather, the 2012 collapse instead was likely driven by lower-than-average abundance or survival of sublegal (juvenile) oysters in the years preceding the collapse. This reduction in recruitment not only reduced the biomass of oysters available to harvest, but from a population resilience perspective, likely reduced the amount of dead shell material available as area for larval settlement.

An important and surprising result of our work was the low estimate of the area of oyster bar needed to produce the estimated abundance of legal-size oysters, in other words, to support the observed harvests (A_{total}, about 500 ha). The low A_{total} estimates would imply very high monthly exploitation rates (U_t), in the range of 0.1-0.15 for recent years. This is much higher than U_t estimated from about 1995-2010 of around 0.05 per month, but similar to the estimates from about 1988-1990 (Fig. 4). This low estimate of A_{total} has multiple potential interpretations: (1) the Apalachicola Bay fishery is being supported by recruits from a very small but productive proportion of the total oyster bar area (total area of oyster habitat including subtidal areas estimated to be about 4800 ha); (2) fishery catches have been grossly under-reported; (3) DACS harvest data are not representative of average oyster densities; (4) the impact of a unit of fishing effort (fishery catchability, q, and hence U_t) has been greatly overestimated; (5) the total oyster bar area has been overestimated based on existing geological (bottom type) and other survey information; and/or (6) the model allows upward bias in exploitation rate estimates by not properly accounting for erosion of size structure at age (selective removal of faster growing individuals).

Fig. 4. Estimated monthly exploitation rate for legal (>76.2 mm) oysters in Apalachicola Bay, Florida.



The basic problem is most likely that the model predictions of sublegal and legal abundances, i.e., size distribution, are not in fact reasonable for such high exploitation rates (interpretation 6). If exploitation rates were in reality as high as predicted, most legal oysters would be removed within a few months of reaching the 76.2-mm legal length, and the size distribution would thus be far more severely truncated than observed; i.e., the legal/sublegal density ratio would be much lower. Instead, the model "allows" very high exploitation rates without erosion in the predicted size structure because it assumes regeneration of the length distributions of sizes each month. The only way to avoid this faulty regeneration assumption would be to use a much more complex model structure involving growth-type groups. However, when we developed growth-type-group models based on five-year periods of time (Appendix 2), these models resulted in similar estimates of A_{total} of around 500 ha, prohibiting a conclusive dismissal of the small A_{total} estimate as an artifact of the model structure.

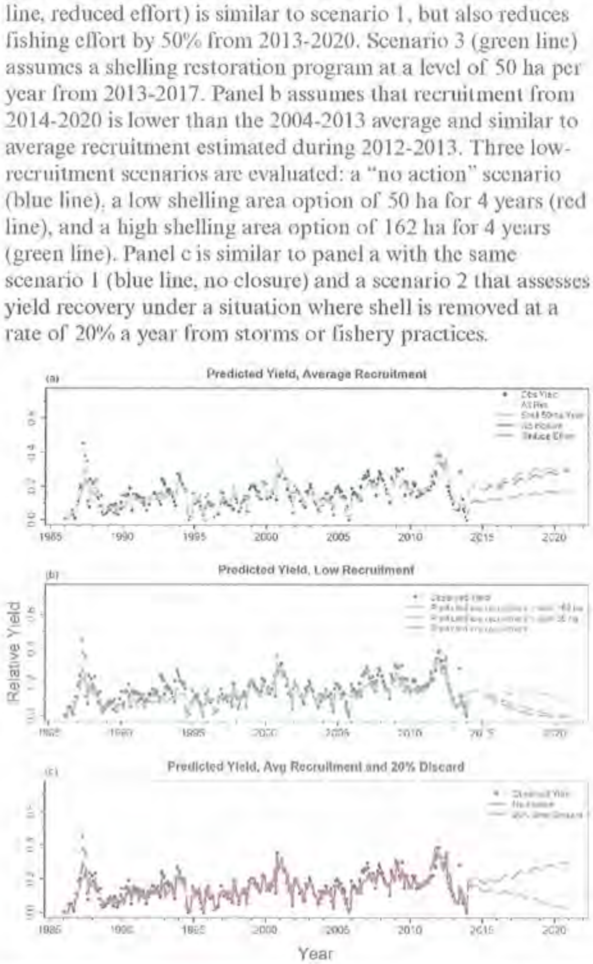
The lack of clarity regarding the area of oyster production, A_{total}, reverberates throughout the model results. If A_{total} is larger than estimated, as implied by the above information, our assessment suggests a large, relatively unproductive oyster population scarcely affected by fishing harvest. Alternatively, if A_{total} is truly small, our assessment would suggest a highly productive population that has been relatively heavily impacted by recent fishing harvest. Therefore, although our best assessments of the available data suggest that the collapse of the Apalachicola Bay oyster fishery was not strictly due to overfishing, the model was unfortunately unable to clearly resolve the historical role that harvest has played or the relative productivity of the oyster population in Apalachicola Bay.

Simulation of management actions

The model predicted that under average "normal" recruitment and mortality rates observed from 2004-2013, oyster populations would recover in 5-10 years, even with no management action (blue lines, Fig. 5a). If recruitment remains equal to the 2004-2013 average, then adding shelling of 50 ha per year for the next 4 years was predicted to increase oyster yields to 2008-2010 levels in about 5 years, even if fishery effort remains high (green lines, Fig. 5a). Interestingly, shelling only provided a small reduction in recovery time compared with the "no action" scenario. With the same assumption of recruitment equal to the 2008-2012 average, reducing effort by half over the next 6 years (2014-2020) would result in increasing yields within 5 years, but such a reduction in effort would obviously reduce overall yield (red lines, Fig. 5a) and likely have deleterious economic effects on the community. The effects of closures or shelling additions were small relative to the effect of assuming a different functional form for the stock recruitment relationship (gray lines, Fig. 5a).

When we ran the model under the assumption that the low oyster recruitment observed in Apalachicola Bay during 2012-2013 would continue into the future, it predicted that oyster fishery recovery was less likely to occur in the absence of management actions (blue lines, Fig. 5b). If recruitment remains at 2012-2013 levels, our model predicted that even with shelling 50 ha per year for four years, the oyster population would continue to decline in 2014-2020 (red lines, Fig. 5b). Even with very high shelling rates (162 ha per year), the low-recruitment oyster population was predicted to increase only slightly (green lines, Fig. 5b) and only during the four years when shell additions take place (green lines, Fig. 5b).

Fig. 5. Observed (black circles) and model predicted (overlapping lines) oyster yields in Apalachicola Bay, Florida from 1986-2013. In panel a, 2013-2020 yield is predicted under three different scenarios based on 2004-2013 average annual recruitment rates. Scenario 1 (blue line, no closure) is a baseline prediction of oyster population yield allowing for average recruitment and based on survival rates and similar effort levels observed in 2004-2008. Scenario 1 also includes results from a "no closure" option assuming the alternative Beverton-Holt stock-recruitment function. Scenario 2 (red line, reduced effort) is similar to scenario 1, but also reduces fishing effort by 50% from 2013-2020. Scenario 3 (green line) assumes a shelling restoration program at a level of 50 ha per year from 2013-2017. Panel b assumes that recruitment from 2014-2020 is lower than the 2004-2013 average and similar to average recruitment estimated during 2012-2013. Three low-recruitment scenarios are evaluated: a "no action" scenario (blue line), a low shelling area option of 50 ha for 4 years (red line), and a high shelling area option of 162 ha for 4 years (green line). Panel c is similar to panel a with the same scenario 1 (blue line, no closure) and a scenario 2 that assesses yield recovery under a situation where shell is removed at a rate of 20% a year from storms or fishery practices.



A central finding is the importance of the protection of shell habitat and the maintenance of a "positive" shell budget. We found that the oyster fishery is unlikely to recover if shell loss, e.g., from storms, culling practices, or ocean acidification, is higher than shell deposition from natural or restoration actions (i.e., if the shell budget is negative). At a 20% annual shell loss rate, our model estimated relatively rapid oyster fishery collapse (red lines, Fig. 5c) compared with the recovery predicted even without management actions (blue lines, Fig. 5c) if no shell loss is assumed.

Overall, the key result from our simulations was identifying the pivotal role that recruitment rates likely play in oyster population recovery. If recruitment levels return to the average observed in 2004-2013, then oyster yields are likely to recover in about five years without any management action. If recruitment rates remain low (similar to 2012-2013), then the likelihood is high for a very slow oyster population recovery or even collapse. There are multiple factors that could lead to low recruitment at present or in the future, including:

1. Changes in A_{total} caused by environmental factors and/or fishing. In this scenario, declines in the total area of oyster habitat would result in overestimates in oyster population levels based on extrapolation from DACS surveys from a small subset of oyster bars.
2. Removal of dead shell during the harvesting process, leading to a negative shell budget (shell losses exceeding deposition) and an overall decline in settlement area.
3. Irreversible increases in estimated relative natural mortality rate (M) because of invasion or expansion in the system of oyster predators or diseases.
4. Nonstationarity in the stock-recruit relationship, meaning that uncorrelated random deviations from the mean stock-recruitment relationship can lead to very misleading assessments, while long-term recruitment trends because of habitat changes (i.e., settlement area, larval food supply) are masked. In traditional fisheries stock assessments, we sometimes attempt to deal with this structural problem by using virtual population analysis methods to back-calculate recruitment without assuming any underlying stock-recruitment relationship; however, we were unable to determine parameters for a virtual population analysis model with oyster populations because we did not know the age structure of the harvested population.

DISCUSSION

Factors contributing to the 2012 oyster population collapse based on available data

What led to the oyster population collapse in Apalachicola Bay in 2012-2013? Our results suggest that the 2012-2013 Apalachicola oyster population collapse was likely due to low recruitment and/or low sublegal survival rates. Our results warn that this decline may have resulted in or resulted from a decrease in larval settlement area (dead shell), which could severely retard population recovery or even send the stock into irreversible decline, depending on future recruitment and shell dynamics. Although the Apalachicola Bay oyster fishery has proven resilient over its >150-year history, this fishery now may be at a crossroads in terms of continued existence, and if recruitment levels remain low, then large-scale restoration programs may be necessary to avoid an irreversible collapse.

Perhaps the most important finding from our work is that none of the available data give superior estimates of historical exploitation rates fishing impacts. The sudden decline in Apalachicola Bay oyster landings in 2012 was preceded by several years of increasing harvest and effort. We initially suspected a case of overfishing led to the collapse of the oyster fishery; however, our analyses suggest a much more complex but classic problem in fish stock assessment: we can generally attribute the observed changes in relative abundance either to fishing or productivity changes, but we can never be sure which was more important without good independent data on absolute exploitation rates over time. With the data currently available for Apalachicola Bay, we cannot be sure whether we are dealing with a small oyster population that has been subject to strong fishing impacts or a larger population that has been subject to strong environmental influences that have impacted the long-term carrying capacity. In the latter case, the population may recover, but, if the long-term carrying capacity is reduced, it may not recover to the same historic levels.

Factors likely not contributing to the 2012 oyster population collapse based on available data

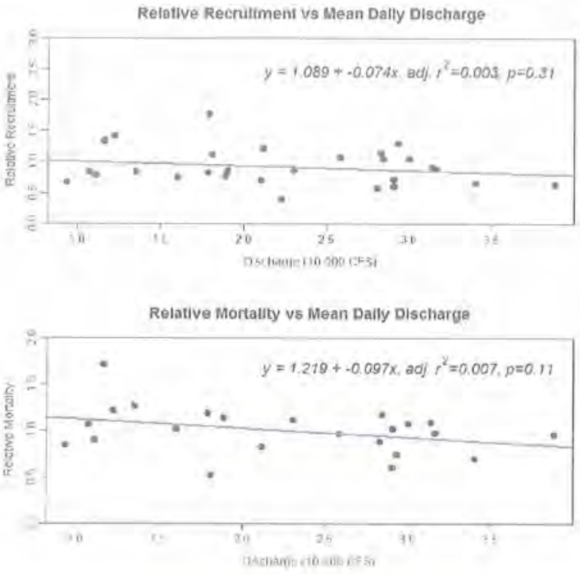
Our results are notable for what they did not find. Within the Apalachicola community there are two widespread hypotheses related to driving forces of the oyster fishery collapse. First, there is widespread concern that the oyster population collapse in 2012 was related to the Deepwater Horizon oil spill that occurred in March 2010. In a related project, a large number of sediment, water, and animal tissue samples were collected in 2012 by the University of Florida and no pollutants were detected (Havens et al. 2013, Camp et al. 2015). This corroborates results from sampling by state and federal agencies immediately after and in the years following the oil spill. Our model results suggest that the decline in sublegal oyster abundance in Apalachicola Bay did not begin until 2012, two years after the oil spill. To the best of our knowledge, the Apalachicola Bay oyster population was not directly impacted by oil or oil dispersants used during the 2010 Deepwater Horizon oil spill.

A second recent concern among the Apalachicola oyster fishing community and resource managers is the impact of low freshwater inputs into Apalachicola Bay from drought conditions within the Apalachicola-Chattahoochee-Flint basin. During 2011-2012, the Apalachicola-Chattahoochee-Flint basin experienced extensive drought (Palmer Drought Severity index of severe to extreme, https://www.drought.gov/drought/regional-programs/acfrb/acfrb-home), leading to low freshwater discharge into Apalachicola Bay and higher than normal salinity measures across several of the historically important oyster harvesting reefs (Havens et al. 2013). A series of previous studies have noted positive correlation between high-salinity drought conditions and oyster disease-related mortality (Petes et al. 2012), as well as complex relationships between estuarine freshwater discharge and oyster harvest (Wilber 1992, Turner 2006, Livingston 2015). We did not find correlations between Apalachicola River discharge measures (average monthly, total annual, total monthly, or coefficient of variation on annual discharge, mean seasonal, or total seasonal) and our estimated relative natural mortality rate (M) or oyster recruitment rates (example Fig. 6). The overall relationships between freshwater flows, drought frequency and severity, oyster recruitment, and harvest dynamics remain unclear, and this is an area of ongoing work.

Management implications: oyster stock rebuilding scenarios

A key finding from simulations of management scenarios is that oyster recruitment likely drives the Apalachicola Bay oyster fishery. We are uncertain as to the extent oyster recruitment can be influenced by management actions. This is seen in the relatively minor effect on fishery recovery time from effort reductions or shelling compared with the effect of differing recruitment averages. This uncertainty is largely because of a lack of understanding of the functional relationships between shelling and recruitment, and the inability of our assessment model to clearly define recent oyster harvest rates.

Fig. 6. Relative monthly recruitment for 1990-2012 (top panel) and relative natural mortality rate (M) for 1990-2012 (bottom panel) versus average monthly Apalachicola River discharge (Q) measured at the U.S. Geological Survey Sumatra gauge (02359170).



Although our model results suggest that the addition of shell as cultch material will have a minor effect on fishery recovery time under average recruitment levels, we conclude that shell addition may still be the best management action to follow. Shelling should not be expected to guarantee recovery of the fishery; but shell addition would be expected to reduce the risk of stock collapse in case low recruitment continues, while allowing for continued harvests. Adding shell material as cultch would be a critical management action if the current shell budget is deficient, with shell losses on existing reefs (from harvest-related discard, environmental disturbances, or other factors) exceeding deposition of new shell from the natural mortality of oysters. Although shell additions may restore settlement sites for oyster recruits, if oyster recruitment remains low for other reasons, then even large amounts of shelling may not lead to rapid oyster population recovery. However, based on our assessment model, shell addition is likely a better management action to achieve stated goals of oyster population and fishery recovery than fishery reductions or closures. Overall our results suggest that shell habitat as cultch should be as carefully managed as the oyster fishery for live oysters and that oyster shell material, in terms of available area, recruitment of new shell, and prevention of shell removal by harvest or storms, should be quantified and tracked.

Although recovery of the Apalachicola Bay oyster fishery may be possible without management actions, this recovery depends upon uncertain community dynamics. One uncertainty is how the fishing industry will respond over this recovery period. If the legal oyster biomass remains low, it is possible that fishers will not be willing to exert high fishing effort given costs associated with a day of fishing and low potential harvests. Such declines (voluntary or otherwise) in effort could hasten recovery; however, oyster prices are currently at near-record high levels, and alternative employment opportunities remain limited in this area. If prices and fishing effort remain high and increase, respectively, the chance of recovery could decrease as recovering oyster stocks are rapidly removed by harvest.

Management implications: policy and research

Our study suggests at least two policy issues that need to be addressed. First, it suggests that intense shelling (162 ha) should be immediately undertaken each year to counter the risk of irreversible fishery collapse, although we are uncertain at what density the shelling should occur to promote larval settlement and persistence of reef material. In 1986-1987, following 1985's Hurricane Elena, about 156 ha of oyster reef in Apalachicola Bay was successfully restored through a combination of restrictive harvest and shelling at a density of about 472 m^3 of shell per hectare (Berrigan 1990). Within 18 months of completing this restoration, these oyster bars supported 587 oysters per m^2 and more than 22 oysters per m^2 of legal size (76.2 mm), leading Berrigan (1990) to conclude that the restoration costs were recovered after one harvest season from this area. Most shelling efforts in Apalachicola Bay have been at various densities and much smaller in scale, usually averaging about 40 ha in size, and these restoration efforts have varied widely in area and frequency in the last 20 years (Fig. 3c). Natural shell deposition occurs following oyster mortality events, which may help to partially explain the rapid oyster recovery in Apalachicola Bay following Hurricane Elena. Other than the Berrigan (1990) study, no oyster restoration efforts have been rigorously evaluated to inform future strategies, such as understanding the trade-off between shelling a small area at a high shell density versus shelling a larger area at a lower shell density. Because restoration costs have increased greatly since Berrigan (1990), this type of information is critical to informing effective restoration projects.

Second, actions (including shelling) should be designed to provide more opportunity for learning about the system (Camp et al. 2015). Uncertainty in shelling density is precisely linked to uncertainty in the total productive area of the current oyster fishery. Swift (1898) estimated the total area of commercially viable oyster bar in Apalachicola Bay to be about 4942 ha, whereas Rockwood et al. (1973, as cited in Whitfield and Beaumariage 1977) estimated about 2023-2428 ha in Apalachicola Bay in the early 1970s. More recent surveys of Apalachicola Bay (Twichell et al. 2010) have focused on the geologic features that support oyster reefs and do not provide density estimates comparable to those of earlier surveys. We assessed available geographic information system layers and estimated that the existing oyster reef area was about 4000 ha, but we do not have a good understanding of how the DACS oyster survey data apply to this area; i.e., we cannot extrapolate density estimates from DACS survey data to this entire area. Determining whether the total area (A_{total}) of commercially viable oysters has changed in Apalachicola Bay is a key area for future work.

It is also uncertain what the impacts of fishery practices are on the persistence of shell material as cultch and sublegal oysters on oyster reefs. Swift (1897) warned of this potential for loss of shell material in his surveys of the Apalachicola Bay oyster fishery and suggested that "it is doubtful whether the law regarding the taking of small oysters and the culling of the oysters, especially the latter, are strictly complied with by the oystermen, yet it is of the greatest importance that they should realize that this law should be strictly obeyed if they wish to maintain the productiveness of the beds and thus insure themselves a livelihood in the future." Whether culling and discarding currently take place on the bars where the tonging occurs or in areas off of the bar is not known, but it is a sensible practice to only cull in the same location that tonging occurs. The key existing uncertainties in informing management actions regarding shelling density, productive fishery area, and availability and persistence of cultch material, as well as current harvest rates and effects of changing environmental conditions, disease, and oyster predator responses, all likely influence oyster recruitment levels that apparently drive the fishery. These uncertainties can be addressed, and their reduction is critical to informing decision making and bolstering the resilience of the Apalachicola Bay oyster fishery (Camp et al. 2015).

CONCLUSION

The Apalachicola Bay oyster fishery is currently at the lowest level observed in recent decades; however, this is not the first oyster population collapse in Apalachicola Bay (Swift 1898, Andree 1983, Berrigan 1990, Havens et al. 2013). For more than 120 years, various reports and workshops have repeated the same key uncertainties for oyster resources in Apalachicola Bay (i.e., unknown total area of oysters, unknown shell budget dynamics) and made the same types of management recommendations to address fundamental fishery practices, such as preservation and cultivation of shell substrate, seasonal closures, and size limits to protect oyster bars from being "overworked" (Table A2.4, Appendix 2). These recommendations often highlight recurring issues related to poor compliance with existing regulations, including high harvest rates of undersized oysters, harvest from closed areas, or culling and discarding that occur off of oyster bars. The results of our stock assessment model suggest that Apalachicola Bay oyster resources will respond positively to management actions, particularly actions that improve availability and area of shell substrate. Our simulation results suggest that if recruitment does not return to some long-term stationary level similar to past averages or if the resilience of the Apalachicola Bay oyster resource changes over time (Camp et al. 2015), then these types of management actions may not be effective.

A variety of state and federal restoration programs totaling more than U.S. $10 million are currently committed to the Apalachicola oyster fishery and community. The oyster industry is likely to play a large role in determining how these funds are spent. The potential exists for restoration to be effective, given the success of prior oyster restoration efforts coupled with intensive fishery management for oyster resources in Apalachicola Bay (Berrigan 1990). Although restoration and management strategies are known, whether or not to follow these practices and how to use available restoration funds are choices to be made by the local community that are likely to determine the long-term viability of the Apalachicola Bay oyster fishery.

Responses to this article can be read online at:
http://www.ecologyandsociety.org/issues/responses.php/7827

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Appendix 1. Age-structured oyster stock assessment model.

Please click here to download file 'appendix1.xlsx'.

Appendix 2

Age-structured population dynamics model development

Growth

In our age-structured model (Appendix 1), growth of oysters is first described using standard von Bertalanffy growth parameters (Walters and Martell 2005). For Apalachicola Bay, we estimated these parameters using incremental growth measurements obtained from oyster growth experiments conducted by the Florida Department of Environmental Protection (DEP) during 2004-2009 (J. Harper, DEP, *personal communication*). We then used the Ford-Brody representation of growth (Equation 2), which is a relatively simple bioenergetics model derived from the von Bertalanffy assumptions that: (1) anabolic (feeding) rates vary as the 2/3 power of body weight, (2) catabolic (metabolic) rates are proportional to body weight, and (3) body length varies as the 1/3 power of body weight. The Ford-Brody α parameter (Equation 3) can be expressed in terms of the asymptotic maximum body length L_∞ (Equation 4). As noted by Walters and Post (1993), L_∞ represents effects of both feeding and metabolic rates, and is likely to vary inversely with population density. Both feeding and metabolic rates are likely to vary with water temperature, but lead to the same L_∞ if both rates vary with the same Q_{10} or Arrhenius power of temperature. Using these relationships, we expect L_∞ to vary with population density but not temperature, and ρ (the slope of the Ford-Brody plot) to vary only with temperature. Hence we assume $\rho_m=e^{-K_m}$ to vary in a sinusoidal pattern; variation in K_m is due to variation in monthly average temperature, and α varies both with density and monthly temperature. In the von Bertalanffy model, feeding or filtering rate is assumed to vary as the square of body length.

The use of monthly time steps in our age-structured model allows for the incorporation of seasonal variation in growth (Appendix Figure A2.1). In Florida, there is wide divergence in reported oyster growth rates with estimated age (a) of recruitment to the legal size (76.4 mm) ranging from about $a = 7$ months (Ingle and Dawson 1952) to $a = 15$ months or more (L. Sturmer, University of Florida, *unpublished information*). Growth has also been reported to be seasonal (Ingle and Dawson 1952; Hayes and Menzel 1981) with average growth rates of about 0.05 mm/day in the winter and 0.15 mm/day in the summer. We examined a large sample of individual Apalachicola Bay oyster growth curves from 2004-2009 (data from J. Harper, DEP, *personal communication*) and did not find evidence for strong seasonality in growth. We fit these growth measurements to the Ford-Brody growth model and found best fit with weak seasonal growth (Appendix Figure A2.1) and constant $L_\infty = 90$ mm and K = 0.1/month. It is unclear from the literature how strong density-dependent effects on oyster growth might be, and our attempts to include density dependent effects on Apalachicola Bay oyster growth did not improve model fit.

Survival

In our population dynamics model, we assume that survival rates $S_{a,t}$ (1 = natural mortality) in Equation 1 were assumed to vary with oyster age and body length, according to the Lorenzen survival function (mortality rate inversely proportional to body length). We assumed a base natural mortality rate (around 0.1/month) for larger oysters that had reached near asymptotic length and applied an annual relative mortality rate scaler (P_y, varying around 1.0) to represent changes in natural mortality rate (e.g., from salinity, predation, disease, etc.). Based on field observations, the net mortality rate of oysters in a dense "clump" may be very low and the oyster populations persist for a long time. This is accounted for in our model in Equation 5 which can predict a "stagnant" high density situation where $L_{\infty,t}$ has been severely reduced through competition when most oysters have reached this length or larger.

We assumed that the vulnerability of oysters to harvesting ($v_{a,t}$ in Equation 1) varies with body length and the legal minimum length for harvest (in Apalachicola Bay, L_{legal} = 76.2 mm) according to a logistic function that represents variation in size at age around the mean length $L_{a,t}$ (Equation 6). Monthly exploitation rates U_t are predicted in our model from fishing efforts using a standard Baranov catch equation (Equation 7; Hilborn and Walters 1992). This catch equation assumes density dependence and variation in vulnerable biomass in catchability (q) according to a type II functional response (Equation 8). Note that Equation 8 can represent combined effects of nonrandom searching for oysters by fishermen, handling and processing time, and caps on daily harvests by regulation or orders from wholesale oyster dealers per oyster license holder.

In the population dynamics model, information on annual oyster recruitment is required to drive initial oyster year class size in each year. For Apalachicola bay, we developed a standardized index of oyster recruitment using fisheries independent survey data of oysters by 5-mm size classes collected by the Florida Department of Agriculture and Consumer Services (DACS) on the major commercial fishing reefs in Apalachicola Bay (available from 1990-2013). As a tong fishery, a fishing trip in Apalachicola Bay consists of a number of oyster tong lifts that each "sweep" some area a_{lift} of the bottom. From our assessment of the fisheries independent survey data, it appears that when fishing effort is measured by the number of oyster fishing trips annually, q varies as predicted by Equation 8. The DACS survey data also provided annual estimates of mean legal oyster biomass per unit area D_{year}. The catch per trip should thus vary as catch-per-unit-effort (CPUE) =a_{lift} x number of lifts per trip x D_{year}. If lifts per trip were constant and lift locations were random with respect to fine-scale variation in oyster densities, CPUE should be proportional to D_{year} (i.e., q measured as a_{lift} x number of lifts per trip should be constant). However, when we plot the observed ratio of CPUE to mean DACS density, we see instead that the apparent q has increased considerably when densities have been low (Appendix Figure A2.2). Apalachicola oyster fishermen have told us that they do indeed stay out longer and make more lifts when oyster abundance is low, and typically end each trip when their catch approaches trip limits imposed by regulations or daily limits based on market orders from dealers.

Recruitment

Monthly recruitment $N_{1,t}$ (Equation 9) to the population is predicted as a function of larval oyster settlement (Equation 10, 10a) and available shell material with a density-dependent mortality function applied during the first month of settlement to match observed survival patterns (Equation 11). We examined an alternative model for larval settlement where base settlement rate was made a power function of the relative spawning biomass index SB_t (Equation 10a).

Shell Accumulation

A key aspect of our population dynamics model is the development of an accounting and prediction system for oyster shell biomass and the explicit linkage in our model between oyster recruitment, oyster mortality rates, and availability of shell material for spat settlement

(Equations 9-13). This is an original contribution. In our model, if shell persistence (shell survival) is high ($S_{shell} = 0.99$) this implies slow deterioration in the shell substrate base available for oyster settlement and recruitment. Under sustainable oyster harvesting regimes, the suitable shell area AS_t is predicted in our shell budget to approach a nonzero equilibrium value (i.e., shell "recruitment" exceeds removals from harvest). However, the possibility of long term deterioration in oyster population carrying capacity would result if abundances $N_{a,t}$ are severely reduced through harvesting, leading to declines in AS_t. This suggests that there is a critical oyster stock size below which the oyster population will tend toward zero unless recruitment onto the oyster bars is assumed to be supported by adult oysters invulnerable to the fishery (the power function for larval settlement LS_t in equation 10a $\beta < 1.0$). Early attempts to fit the model by allowing β to vary always led to $\beta = 0$ (similar to Equation 10), but full use of both oyster harvest and relative abundance information suggests the opposite result: that β is larger and generally approaches the constraint $\beta = 1$. In our model, Equation 12 predicts that on average the ratio of dead shells to total live oysters, AS/N, should be near $(1-S_{live})/(1-S_{shell})$, where S_{live} is the average of $S_{a,t}$ weighted by $N_{a,t}/N$. From field observations we have seen highly variable AS/N, but typically we see ratios near 1.0, where the number of recently dead shells is about equal to the number of live oysters. This implies S_{shell} should be about equal to S_{live}, in the range 0.8-0.9. For our Apalachicola Bay analysis, we assumed a relatively conservative value 0.8 for the analysis. Our model assumes an exponential form of the larval production rate proportional to live biomass, which implies an overall long term Ricker stock-recruitment relationship (Hilborn and Walters 1992) for the population. This allows for depensatory decrease in recruitment at low oyster population stock sizes due to the shell area dynamics factor AS_t (Equation 13).

Parameter Scaling

We used scaling parameters (i.e., k_{growth}) to link oyster and fishery rate processes (growth, catchability, biomass) with oyster abundance as measured by the sum of squared lengths and biomass (Equations 14-15). Appropriate values for these parameters depend on the units of measurement of length, and scaling of overall population size so as to match historical abundance and catch data. This scaling is simplified by specifying an overall average natural recruitment rate R_o and corresponding Botsford incidence functions that sum up age specific quantities weighted by survivorship to age assuming equilibrium (Walters and Martell 2004, Box 3.1, page 56) for natural survivorships to age x natural age-specific quantities (L^2, W; Equations 16-22). In our model, as R_o is varied by the user or by Solver in Excel (Microsoft Corporation, Redmond, Washington), the scaling parameters are varied so as to predict growth and survival rates that will make R_o close to a stable equilibrium value without harvesting. That is, the model predicts base numbers and sizes at age $N_{a,0}$ by assuming $N_{a,0} = R_o l_{a,0}$ where $l_{a,0}$ is natural survivorship to age a, given a base or natural growth curve $L_{a,0}$ with associated base predictions of $M_{a,0}$. These base numbers and sizes are used in the model to predict base values for the sums over ages that appear in the various dynamic equations. The dynamic equations are then solved for the scaling parameters (k) given these base values. Given the season and density effects parameterized in the model and observed in the data, this solution for the k values is not exact but is sufficient to avoid strong transient changes as the model dynamics "spin up" over time.

To further simplify the parameter scaling in our stock assessment model, key quantities like maximum oyster catchability q_{max} and body size $L_{\infty max}$ were assumed as ratios to either base unfished values or to likely values at some sustainable fished equilibrium. We specified a base exploitation rate U_o in which case the population is assumed to have been fished at this rate (and to be near equilibrium with respect to it) for enough time for abundances and sizes to have reached equilibrium. These initial equilibrium values are used to set $N_{a,1}$ (numbers at age in the first simulation month) and catchability scaling parameter k_q that will give a catchability q_o that insures $U_t=U_o$ when effort is at its initial time value E_1.

Alternative Model Formulation to Check Model Assumptions and Predictions
We were concerned that the Ricker functional form for density dependent early survival in our model may have a dome shape, and hence may provide overly optimistic predictions about recruitment changes when oyster stock size is reduced. To check this possibility, we ran the model with an alternative stock-recruitment relationship of Beverton-Holt form (described in Equations 23-25, final form Equation 26). This alternative model was derived by assuming that larval settlement LS_t has a mass-action relationship to both relative egg production (relative spawning biomass index SB_t) and relative effective shell settlement area A_{set}.

Equilibrium Analysis Using Growth Type Group Splitting of Recruitment
We were also concerned that the population dynamics model could give misleading predictions of length distribution patterns if the length distribution predictions are based on treating the length distribution at each age as "regenerating" each month by having constant standard deviation independent of harvesting effects (Walters and Martell 2004). In reality, faster growing individuals from each cohort will reach legal size sooner and be removed by fishing, which progressively distorts the length distribution for each age. The distortion could be represented by dividing each cohort into a set of growth types, and tracking size and survival (natural and fishing) separately for each group. However, this computation would result in extremely complex monthly accounting unless it was used simply to predict average or equilibrium length distributions over periods of stable growth and exploitation rate in a growth type group (GTG) model structure (Walters and Martell 2004, Box 5.3, p. 121). Using this simplified method, equilibrium length frequency predictions were made for five-year periods from 1990-2012.

The equilibrium GTG predictions were constructed by first dividing a typical cohort of N = 1.0 recruits into 21 growth types *g*, each initialized at 1 month age to $N_{g,1} = p(g)$ recruits where p(g) is the proportion of recruits assigned to group *g*. All groups were assumed to have the same von Bertalanffy K value, and distinct maximum lengths $L_\infty(g)$ given by $L_\infty(g) = L_\infty[1+CV\Delta(g-11)]$ where CVL_∞ is the standard deviation of L_∞ among individuals (we assumed CV = 0.1). We also assumed that Δ is the standard normal distribution increment between groups and we set Δ such that the groups vary in L_∞ over two standard deviations from average, with *g* = 11 representing the average group. Applying the von Bertalanffy growth equation by *g* and age results in a 21 x 36 matrix $L_{g,a}$ of predicted lengths at age, we then applied the basic survival equation (Equation 1) to each group over age to predict the 21 x 36 matrix $N_{g,a}$, using the Lorenzen size-dependent survival rate for each $L_{g,a}$ (Equation 5) and vulnerability $v_{g,a}$ to fishing set at 0.0 for predicted lengths at age < 75 mm and at 1.0 for lengths 75 mm and larger (approximate legal size of harvest in Florida). Finally, the equilibrium length distribution was obtained by simply summing all the $N_{g,a}$ by 5-mm length bins, with length bin assignment determined by the $L_{g,a}$ lengths.

Population Dynamics Model Parameter Estimation for Apalachicola Bay

Our basic approach to estimate as many of the model parameters as possible involved (1) estimating oyster growth and recruitment timing parameters from independent data sources and inputting these values, then (2) fitting the model to a set of time series data using a "stock synthesis" approach where the model equations are solved over time given only initial stock structure, effort time series, and relative recruitment and mortality time series. This is a harsh test of the model structure, since the equations could easily diverge greatly from patterns evident in the data if the model parameter values were far off.

Three time series were available for estimation of model parameters for the Apalachicola Bay oyster population: (1) monthly meat weight of oysters landed C_t for 1986-2012, (collected by FWC), (2) monthly fishing efforts (daily fishing trips) E_t for these same months (collected by FWC), and (3) annual survey estimates for 1990-2012 of absolute density of oysters (numbers/m^2) by 5-mm size increments, from 10-40 0.25 m^2 quadrats per year (collected by DACS). We aggregated the DACS survey densities by size to numbers of sublegal (20-75 mm) and legal (> 75 mm) oysters per m^2. The more detailed 5-mm interval length distributions were compared to model-predicted distributions only after fitting, since these detailed distributions are "contaminated" by interannual changes in seasonal timing of recruitment not fully captured in the basic model.

Unfortunately, the DACS data cannot be used directly to estimate total population size, since the total oyster bar area to which the sampled densities apply is not known. Estimates of oyster bar area based on geological sampling (Twichell et al. 2006, 2010) and available GIS layers (Apalachicola National Estuarine Research Reserve; January 2013) suggest a total area A_{total} of at least 40 km^2, whereas the DACS density estimates and fishery catch data imply that the observed catches might be coming from as little as 2-4 km^2 of productive bottom. In directly comparing the DACS data to catches, we noted a useful conversion factor: a DACS legal density (> 75 mm) of 30/m^2 corresponds to a live weight harvestable biomass of 0.45 kg/m^2 (1 lb/m^2), so densities of 30/m^2 represent about 453,492 kg/km^2 (1 million lb/km^2).

Also unfortunately, only a few of the DACS sampling areas have been visited consistently since 1990 (Table 1) and these areas are known only based on the name of the oyster bar and not a specific location on the bar. This creates a need to estimate missing area-year data combinations based on persistent differences among areas and shared temporal patterns (Equation 27). Fishery CPUE (C_t/E_t) has varied less than the DACS legal density estimates DL_y over time (Appendix Figure A2.2), suggesting as indicated above that CPUE has been strongly hyperstable (i.e., CPUE does not decline as fast as abundance).

Based on our growth assessments, the majority of sublegal oysters (DS_y) counted in any year of the DACS survey data probably did not become legal until the next year (average sublegal length was about 40 mm, implying about a year to reach legal length). This suggests that the ratio DL_{y-1}/DS_t is a reasonable estimator of the annual survival rate of sublegal oysters and $M = -\ln(DL_{y+1}/DS_t)/12$ is a reasonable estimator of the monthly natural mortality rate of sublegal oysters. Indeed, we would not even attempt to estimate the annual relative mortality multipliers P_y in Equation 5 if it were not for the direct information about annual carryover rates evident in the DACS data. The most realistic average mortality rates were obtained when the model M_o value was set to 0.1/month (Appendix Table 3).

Population Dynamics Model Estimation Procedure for Apalachicola Bay Oyster Fishery
We maximized a concentrated log likelihood function for the time series data (Equation 28) using Solver, by varying the following parameters:

$$\{R_o, l_o, U_o, q_{max}, M_o, P_{1986}\text{-}P_{2012}, RY_{1986}\text{-}RY_{2012}\}$$

where R_o sets the basic simulated population scale, l_o determines resilience (how low the population can be driven before recruitment fails), base exploitation rates U_o and q_{max} determine average monthly exploitation rate U_t given effort E_t and harvestable biomasses B_t, P_y drives interannual variation in natural mortality rate, and RY_y drives interannual changes in relative recruitment rate. Note that we would not ordinarily try to estimate both fishing (U_o, q_{max}) and natural mortality (M_o) rates at the same time, but having sublegal and legal density estimates from the DACS data makes this possible. As recommended by Walters and Ludwig (1994), SS_{DACS} (Equation 29) is evaluated at the conditional maximum likelihood estimate of q_s. As an alternative to this SS that assumed q_s to be unknown, we note that given the DACS units of measurement (counts/m^2), q_s can be interpreted as $1/A_{total}$, where A_{total} is the total productive area of the fishery. For some fitting trials, we froze A_{total} to various reasonable values, ranging from 2.0 km^2 to 10 km^2. The "penalty" terms for recruitment and survival anomalies (Equations 30 and 31) are the same as assuming RY_y and $PY_y = e^{\xi y}$, where ξ_y is assumed to be normally distributed with mean zero.

The estimation criterion defined by Equation 28 requires an estimate of the four σ^2 variances: catch, survey abundance, recruitment, natural mortality. However, we were unsure how to estimate these variances, or what to assume about their structure. We initially attempted to estimate them as additional unknown parameters [by changing from SS/variance to (n/2)ln(SS) terms in Equation 28, thus evaluating the normal log likelihood terms at their conditional maximum likelihood variance estimates], but this led to unrealistically high estimates of RY_y variation and no variation in P_y, basically "ignoring" evidence of mortality variation in the DACS data in favor of fitting the catch data more precisely. To force the model to better fit the DACS data, we assumed relatively high variance in the catch $\sigma^2_C = 1.0$, and low DACS variance $\sigma^2_{DACS} = 0.04$ based on coefficient of variation of the annual abundance estimates of around 0.2 based on observed variation in densities among bars sampled each year. We also tried various combinations of values for σ^2_{RY} and σ^2_P, generally in the range 0.1-1.0, to represent alternative hypotheses about how much of the observed variation has been due to recruitment versus survival variation.

Age-structured Population Model Results
Model estimates of natural mortality ($M_o = 0.095$/month) and exploitation rates (averaging 5%-10% per month) from our stock assessment model are quite reasonable and the q_s estimate implies a productive area of around 2 km^2. When we used the Beverton-Holt formulation for recruitment (Equation 26), best fits were obtained at unrealistically high unfished recruitments R_o (huge productive area), low productivity (α), and unrealistically low exploitation rates U_t. That is, the Ricker stock-recruitment formulation indicated a small, productive stock while the Beverton-Holt indicated a large, unproductive one.

The DACS data represents the best available information on trends in abundance and oyster size composition of areas fished. Because of uncertainty in the total area (A_{total}) of oysters to which the DACS surveys apply, we systematically varied A_{total} from low to high while allowing all other model parameters in the model to vary. This was done to try and determine whether the fishery was supported from a small highly productive oyster population or a large low-productivity oyster population. It resulted in almost identical fits to the catch and survey data from either the small productive or large unproductive oyster stock scenario (sums of squares based on the catch data or the DACS survey data, Equation 23). For both scenarios (small productive or large unproductive) the best model fits (lowest sums of squares, Equation 23) show a substantial increase in the Apalachicola Bay oyster population from 1990 until about 2000, then a persistent decline (Appendix Figure A2.3). Estimated exploitation rates during this time period of increasing population were lower during the years 1990-2000 than in recent years when oyster populations have declined (Figure 4; Appendix Figure A2.3). How were the same results and model fits found from models with very different A_{total}? For the large, low productivity stock scenario (high values of A_{total}) the best model fit was made by estimating high M_0 and by attributing the patterns in oyster abundance and landings mainly to large recruitment and mortality anomalies (SS_P, SS_{RY} components of the likelihood function, Equation 23). For the small, highly productive stock, the patterns in oyster abundance and landings are attributed by the model more to effects of fishing (i.e., estimating low exploitation rates during the mid-1990s, much higher exploitation rates at present), leading to considerably smaller recruitment and natural mortality anomalies and hence lower SS_P, SS_{RY} in the likelihood function (Equation 23).

We had hoped that close examination of the DACS length frequency data for legal oysters would demonstrate changes in exploitation rate, at least between the lower exploitation period of the mid-1990s compared to the higher exploitation from about 2008-2013, through reduced relative abundance of larger oysters in the high exploitation period (Figures 4 and Appendix Figure A2.3). However, the data show no such pattern; if anything they seem to support the hypothesis that monthly exploitation rates have never been high enough to severely distort the size distribution based on the available data. As an example, a comparison of predicted and observed length frequencies for oysters by year suggests either no change, or possibly that survival rates to larger sizes were lower in the early to mid-1990s than indicated by model estimates of exploitation rates (Appendix Figures A2.4 and A2.5, see 1992-99 as examples where observations are lower than predictions for legal size oysters).

Comparison of the full model length distributions to DACS length frequencies (Appendix Figure A2.5) shows that the model does not correctly predict the observed sublegal (< 75 mm) size distribution in late fall for most years. The model predicts a more pronounced peak in the size distribution near 40 mm (Appendix Figure A2.5, solid line) than was observed in most years (Appendix Figure A2.5, dots), indicating a wider spread in settlement timing than assumed. For recent years the observed length distribution has peaks at smaller sizes (15-20 mm), presumably representing later seasonal timing of successful settlement than assumed in the model. The late settlement years in the DACS data (1993, 1995, 2000, 2002, 2005-2011) are not obviously correlated with any known environmental factor such as Apalachicola River discharge (average monthly, total annual and total monthly, CV on annual discharge, mean seasonal, or total seasonal). We could have forced the model to fit the juvenile patterns more closely by estimating a set of nuisance parameters representing annual recruitment timing variation, but this would not change the model's basic predictions about abundance trends and harvest impacts, and would instead give a false impression about the model's precision in explaining observed data.

Growth Type Group Model Results

The equilibrium GTG model gives average exploitation rates by 5-year period similar to those resulting from fitting the age-structured model with $A_{total} = 5$ km^2 (Appendix Table A2.2), provided the natural mortality parameter M_o is set to 0.1 (M = K assumption, also best M_o from that same age-structured model fit). These fits were obtained by visual comparison of the model and observed legal length proportions (Appendix Figures A2.4 and A2.5). For alternative estimates of the monthly exploitation rate, comparisons based on a binomial likelihood comparison of observed and predicted proportions resulted in somewhat higher exploitation rates, for reasons that are unclear. Unfortunately, the reasonable agreement between the age-structured and GTG model predictions is not good evidence that the monthly exploitation rate is indeed low, since the best GTG estimate of exploitation rate is highly sensitive to the assumed M_o; lower exploitation rates are obtained when M_o is increased and higher rates when it is decreased. Absent independent estimates of M from unexploited populations, the GTG model does not resolve the issue of how large the productive area A_{total} really is.

Table A2.1. Model equations

Accounting equations		
Equation 1	$N_{a+1,t+1}=N_{a,t}S_{a,t}(1-v_{a,t}U_t)$	Oyster population numbers at age *a* and time *t*. $S_{a,t}$ is the monthly natural survival rate of age a oysters in month t, $v_{a,t}$ is the relative vulnerability of age a oysters to harvest, U_t is the monthly exploitation rate of fully vulnerable oysters in month t
Equation 2	$L_{a+1,t+1}=\alpha_t+\rho_m L_{a,t}$	α_t is the Ford-Brody (incremental von Bertalanffy) growth intercept (or size at age 1 month) parameter, and ρ_m is the Ford-Brody metabolic parameter (equal to e^{-K} where K is the monthly von Bertalanffy metabolic parameter for length growth). New recruits $N_{1,t}$ are added to the population each month, at body length α_t
Growth equations		
Equation 3	$\alpha_t=(1-\rho_m)L_{\infty,t}$	Ford-Brody growth intercept
Equation 4	$L_{\infty,t}=L_{\infty max}/(1+k_{growth}\Sigma N_{a,t}L_{a,t}^2)$	$L_{\infty max}$ is the maximum asymptotic length that would be achieved at low population densities, k_{growth} is a scaling constant for effect of population density, and $\Sigma N_{a,t}L_{a,t}^2$ is the sum of numbers at age times L^2 as an index of relative feeding
Survival equations		
Equation 5	$S_{a,t}=\exp\{-P_y M_o L_{\infty,t}/L_{a,t}\}$	Natural survival rates, assumed to vary with age and shell length, M_o base natural mortality rate (around 0.1/month), $L_{\infty,t}$ is the time and possibly density dependent maximum length (equation 4), and P_y is an annual relative mortality rate scaler.
Vulnerability to harvest		
Equation 6	$v_{a,t}=1/(1+\exp\{-(L_{a,t}-L_{legal})/s_a\})$	Vulnerability of oysters to harvesting ($v_{a,t}$) represented by logistic function that represents variation in size at age around mean length $L_{a,t}$, where s_a=CV/1.7 x L_∞ with CV around 0.13 represents variation in length at age. An s_a of around 5 implies length at age near the legal size varying with a standard deviation of around 5/1.7 or 2.9 mm.
Equation 7	$U_t=1-\exp(-q_t E_t)$	Monthly exploitation rates U_t are predicted from fishing efforts E_t
Equation 8	$q_t=q_{max}/(1+k_q B_t)$ where $B_t=\Sigma_a N_{a,t}W_{a,t}v_{a,t}$	$W_{a,t}$=weight at age, q_{max} is maximum catchability (fishing mortality rate per unit effort) at low stock size, and k_q is a scaling constant such that q is reduced to $q_{max}/2$ when

		B_t is half of its unfished level (i.e. k_q=2/B_o where B_o is the predicted average biomass of the stock absent harvesting)
Recruitment and shell accumulation		
Equation 9	$N_{1,t} = LS_t\, AS_t\, SL_t$	$N_{1,t}$ = monthly recruitment where LS_t= annual and seasonally varying larval settlement per unit suitable shell area, AS_t= suitable shell area generated from natural mortality, SL_t= density-dependent survival of pre or post settlement juveniles.
Equation 10	$LS_t = l_o R_y R_m SB_t$ where $SB_t = \Sigma_a N_{a,t} L^3_{a,t}$	LS_t = Larval settlement rate where, l_o = average settlement rate, R_y = interannual variation in larval production estimated from data, R_m monthly variation in spawning and predation rate on larvae and spat, SB_t spawning biomass that is proportion to body weights at age
Equation 10a	$LS_t = l_o R_y R_m (SB_t/SB_o)^{\beta}$	Alternative model for larval settlement assuming a power function of SB_t. Power parameter β represents possible density dependence in larval or early juvenile survival rats, and/or delivery of a substantial proportion of the larvae from non-harvested spawning sources (e.g. intertidal areas where oysters never reach legal size).
Equation 11	R_m=spawning component x predation component	Monthly variation in spawning and predation rate set by user in spreadsheet model to vary seasonally following either a unimodal spat settlement pattern peaking midsummer, bimodal recruitment pattern with high mid-summer predation loss, or unimodal spring or fall peak with high predation rates in spring or fall (patterns similar to Appendix Figure A2.1).
Equation 12	$AS_{t-1} = S_{shell} AS_t + k_{shell} \Sigma_a N_{a,t} (1-S_{a,t}) L_{a,t}^2$	AS_t = Shell area available for recruitment following a balance rate of shell survival $S_{survival}$ (persistence of old shell) and recruitment of new shell due to natural mortality of live oysters 1-$S_{a,t}$. k_{shell} is an arbitrary area scaling constant = 10^{-4} . By summing over ages of numbers, times squares of lengths, this represents age-size variation in shell area per dying oyster
Equation 13	$SL_t = \exp\{-k_{density} \Sigma_a N_{a,t} L_{a,t}^2\}$	Density-dependent effects on larval survival and/or survival over the first month after settlement. $k_{density}$ is a scaling constant for the effect per unit live oyster area present on survival rate.

Scaling parameters

Equation 14	$l_{1,0}=l_{1,fished}=1.0$ $l_{a,0}=l_{a-1,0}S_{a-1,0}$ a >1	Unfished survivorship to age
Equation 15	$l_{a,fished}=l_{a-1,fished}S_{a-1,0}(1-v_{a,0}U_o)$ where a>1	Fished survivorship to age
Equation 16	$\varphi_{L2,0}=\Sigma_a l_{a,0}L_{a,0}^2$	Incidence function, squared lengths
Equation 17	$\varphi_{SH,0}=k_{shell}\Sigma_a l_{a,0}(1-S_{a,0})L_{a,0}^2$	Incidence function, shell production
Equation 18	$\varphi_{B,0}=\Sigma_a l_{a,0}v_{a,0}W_{a,0}$	Incidence function, vulnerable biomass
Equation 19	$\varphi_{E,0}=\Sigma_a l_{a,0}vL^3_{a,0}$	Incidence function, relative spawning biomass, equation 10
Equation 20	$k_{growth}=(L_{\infty,max}/L_{\infty,0}-1)/(R_o\varphi_{L2,0})$	Growth scaling constants based on assuming recruitment R_o, given $\beta=0$
Equation 21	$k_q=(q_{max}/q_o-1)/(R_o\varphi_{B,0})$	Catchability scaling constants based on assuming recruitment R_o, given $\beta=0$
Equation 22	$k_{density}=-\ln[(1-S_{shell})/(l_o\varphi_{SH,0})]/(R_o\varphi_{L2,0})$	Density scaling constants based on assuming recruitment R_o, given $\beta=0$

Beverton-Holt stock recruitment

Equation 23	$LS_t=kSB_tA_{set}$	LS_t = larval settlement at time t related to both relative egg production SB_t and relative effective shell settlement area A_{set} and a constant k
Equation 24	$N_{t+1}=akSB_tA_{set}/(1+bkSB_tA_{set})$	Predicted recruitment following density dependent mortality of spat following settlement
Equation 25	$A_{set}=\xi AS_t/(1+\xi AS_t)$	Equation describing the relationship between effective shell settlement area A_{set} and shell area AS_t, where ξ is a constant that determines the shell area needed to achieve half of the maximum possible effective settlement area ($1/\xi$ is the shell area needed to obtain A_{set}=0.5, ½ of its maximum 1.0)
Equation 26	$N_{1t}=\alpha R_yR_mSB_tAS_t/[1+AS_t(\xi+\beta SB_t]$	Simplified Beverton-Holt stock recruitment function based on relationships in Equations 23-25 after combining constants and including seasonal and annual relative recruitment multipliers (R_y, R_m) where α represents the steepness of the stock-recruitment relationship and β represents density-dependent mortality effects. Other terms as defined previous.
Equation 27	$Ln(D_{x,y})=\mu_x+\tau_y+e_{x,y}$	Log-linear model used to estimate oyster densities for different area-year data combinations. $D_{x,y}$ is the observed mean density for area x in year y, $e_{x,y}$ is combined process and sampling error for that observation, area means μ_x were estimated as the mean density for each

		area x over time, while the year effects τ_y were estimated as the mean of the deviations $D_{x,y}$- μ_x in year y from the overall mean densities for the areas sampled in year y. corrected density estimates $D'x,y=\exp(\mu_x+\tau_y)$ were then averaged using stratum weights equal to estimated bar areas for each x to give weighted density estimates DS_y for sublegal sized oysters and DL_y for legal sized oysters for each year
Estimation procedure		
Equation 28	$\ln L= -0.5[SS_C/\sigma^2_C+SS_{DACS}/\sigma^2_{DACS} + SS_{RY}/\sigma^2_{RY}+SS_P/\sigma^2_P]$	Log-likelihood function for time series data assuming log-normal variation in all observed quantities, recruitment, and mortality anomalies and weighting the sums of squares deviations by assumed variances.
Equation 29	$SS_{DACS}=\Sigma_y[\ln(DS_y/NS_y)-\ln(q_s)]^2+\Sigma_y[\ln(DL_y/NL_y)-\ln(q_s)]^2$	SS_{DACS} calculated by assuming observed values have averages proportional to model sublegal and legal abundances (NS_y and NL_y) obtained by adding abundances over the simulated age structure in an index month (August) each year, with constant of proportionality or survey catchability q_s (q_s is interpreted as the inverse of the number of square kilometers of oyster bar habitat at DACS densities needed to produce the model abundances). The MLE $\ln(q_s)$ is the arithmetic average over all DACS estimates of the $\ln(D_y/N_y)$ ratios.
Equation 30	$SS_{RY} =\Sigma_y \ln^2(R_y)$	Penalty term for recruitment anomalies
Equation 31	$SS_P =\Sigma_y \ln^2(P_y)$	Penalty term for recruitment anomalies

Table A2.2a-d. Estimates of raw and interpolated mean oyster density (number/m^2) for sublegal (20-75 mm shell length) and legal (> 75 mm) oysters from Florida Department of Agriculture and Consumer Services surveys on major oyster bars in Apalachicola Bay.

(a) Raw mean oyster density (number/m^2) for sublegal oysters

	Cat Point	Dry Bar	East Hole	Eleven Mile Bar	Lighthouse Bar	Normans South	Platform Bar	Porters Bar
1990	267.4		166.0		108.1			
1991	220.2	257.4	158.7		244.8		340.9	
1992	274.9	242.0	237.1		315.6			502.4
1993	237.5	151.8	333.4		246.0	298.0		140.8
1994	287.7	305.4	525.2	132.1	214.9	332.8		152.9
1995	180.7	216.8	721.4	119.6	256.8		344.9	
1996	341.6	225.4	293.8		516.9	430.8		
1997	377.7	122.7	460.8	106.4	360.4	329.2		
1998	191.7	105.8	174.1		317.2	320.4		
1999	244.3	562.8	443.6		246.0	192.1		
2000	379.1	199.6	332.8					
2001	266.1	516.8	415.2					138.4
2002	286.4	412.8	211.6	62.5				85.2
2003	353.7	283.2	167.2	164.8				184.8
2004	681.7	144.1	685.8	40.0				657.4
2005	180.3	119.7	184.0					92.9
2006	178.0	500.4	124.4	462.4				42.5
2007	350.5	618.4	158.8	253.6				168.0
2008	148.6	418.6	198.6	200.2	170.0	189.1	256.4	253.3
2009	154.1	261.9	186.1	169.5			229.7	172.7
2010	172.1	242.3	247.2	139.9	309.2	224.1	439.7	
2011	587.9	401.2				297.6		
2012	48.5	80.0	34.5		194.9	219.6		

(b) Interpolated mean oyster density (number/m^2) for sublegal oysters using log-linear model with bar and year effects

	Cat Point	Dry Bar	East Hole	Eleven Mile Bar	Lighthouse Bar	Normans South	Platform	Porters Bar
1990	168.2	170.3	165.9	95.0	172.0	186.8	213.8	113.4
1991	225.1	227.9	222.0	127.1	230.2	250.0	286.2	151.7
1992	325.1	329.2	320.6	183.6	332.5	361.1	413.4	219.1
1993	233.6	236.5	230.3	131.9	238.8	259.4	297.0	157.4
1994	285.5	289.0	281.5	161.2	291.9	317.0	362.9	192.4
1995	272.4	275.8	268.6	153.8	278.5	302.5	346.3	183.6
1996	338.5	342.7	333.8	191.1	346.1	375.9	430.3	228.1
1997	273.8	277.2	270.0	154.6	280.0	304.0	348.1	184.5
1998	199.6	202.0	196.8	112.7	204.1	221.6	253.7	134.5
1999	302.7	306.5	298.5	170.9	309.5	336.2	384.8	204.0
2000	293.2	296.9	289.2	165.6	299.9	325.7	372.8	197.6
2001	329.2	333.3	324.6	185.9	336.6	365.6	418.5	221.9
2002	203.7	206.2	200.9	115.0	208.3	226.2	258.9	137.3
2003	266.4	269.8	262.7	150.4	272.4	295.9	338.7	179.6
2004	341.8	346.0	337.0	193.0	349.5	379.5	434.5	230.3
2005	153.0	154.9	150.9	86.4	156.5	169.9	194.5	103.1
2006	224.7	227.5	221.6	126.9	229.8	249.6	285.7	151.5
2007	329.1	333.2	324.5	185.8	336.5	365.5	418.4	221.8
2008	235.3	238.3	232.1	132.9	240.6	261.3	299.2	158.6
2009	217.0	219.7	214.0	122.5	221.9	241.0	275.9	146.3
2010	245.6	248.7	242.3	138.7	251.2	272.8	312.3	165.6
2011	396.7	401.6	391.2	224.0	405.6	440.5	504.3	267.3
2012	87.2	88.3	86.0	49.3	89.2	96.9	110.9	58.8

(c) Raw mean oyster density (number/m^2) for legal oysters

	Cat Point	Dry Bar	East Hole	Eleven Mile Bar	Lighthouse Bar	Normans South	Platform	Porters Bar
1990	23.4		17.3		11.9			
1991	17.0	16.4	14.8		40.8		45.5	
1992	20.7	22.4	18.2		51.6			49.6
1993	41.9	30.6	63.8		126.8	134.0		24.8
1994	29.7	18.5	83.2	23.9	48.3	98.0		44.9
1995	46.4	45.6	184.4	92.8	74.8		87.9	
1996	31.0	77.8	203.6		133.9	209.2		
1997	56.5	46.9	82.8	51.2	101.6	169.6		
1998	34.8	35.4	58.9		61.6	100.4		
1999	33.7	24.0	34.4		45.6	79.9		
2000	81.0	168.0	93.8					
2001	41.1	59.2	54.4					62.4
2002	24.1	103.6	32.0	32.7				23.6
2003	31.4	45.2	18.0	32.8				17.2
2004	38.6	40.5	40.2	47.2				181.6
2005	29.1	17.3	48.2					55.9
2006	45.0	49.0	23.2	61.6				8.3
2007	37.0	68.7	42.8	36.0				18
2008	36.2	42.1	32.3	59.0	40.4	41.6	48.4	35.9
2009	20.6	18.4	18.5	27.6			18.9	11.5
2010	19.7	24.4	25.6	34.3	33.2	32.7	51.5	
2011	24.3	29.6				75.2		
2012	15.9	20.0	16.3		48.3	40.0		

(d) Interpolated mean oyster density (number/m^2) for legal oysters using log-linear model with bar and year effects

	Cat Point	Dry Bar	East Hole	Eleven Mile Bar	Lighthouse Bar	Normans South	Platform	Porters Bar
1990	13.0	15.4	16.8	17.4	22.1	34.4	18.7	13.0
1991	18.3	21.7	23.5	24.5	31.1	48.3	26.3	18.2
1992	24.2	28.7	31.2	32.4	41.2	64.0	34.9	24.1
1993	41.4	49.1	53.3	55.4	70.4	109.4	59.6	41.3
1994	30.6	36.4	39.5	41.0	52.1	81.0	44.1	30.5
1995	60.2	71.4	77.5	80.5	102.4	159.0	86.7	60.0
1996	72.5	86.0	93.4	97.0	123.3	191.6	104.5	72.3
1997	52.5	62.4	67.7	70.3	89.4	138.9	75.7	52.4
1998	36.6	43.4	47.1	48.9	62.2	96.6	52.7	36.5
1999	27.1	32.2	35.0	36.3	46.2	71.7	39.1	27.1
2000	94.1	111.7	121.3	126.0	160.2	248.8	135.7	93.9
2001	48.2	57.3	62.2	64.6	82.1	127.5	69.5	48.1
2002	31.3	37.2	40.4	41.9	53.3	82.8	45.1	31.2
2003	23.4	27.8	30.2	31.4	39.9	61.9	33.8	23.4
2004	48.3	57.4	62.3	64.7	82.2	127.7	69.6	48.2
2005	30.7	36.5	39.6	41.1	52.3	81.2	44.3	30.6
2006	26.4	31.3	34.0	35.3	44.9	69.8	38.0	26.3
2007	32.2	38.2	41.5	43.1	54.8	85.1	46.4	32.1
2008	29.9	35.5	38.5	40.0	50.9	79.0	43.1	29.8
2009	15.6	18.5	20.1	20.8	26.5	41.2	22.4	15.5
2010	21.0	24.9	27.0	28.1	35.7	55.4	30.2	20.9
2011	25.8	30.6	33.2	34.5	43.9	68.2	37.2	25.7
2012	17.1	20.3	22.0	22.9	29.1	45.2	24.6	17.0

Table A2.3. Estimates of monthly exploitation rate from the age-structured model with $A_{total} = 5$ km^2, compared to estimates from fitting the growth type group model to the average legal size distribution over 5-year periods.

Period	Age model	GTG model
1990-1994	0.067	0.06
1995-1999	0.02	0.04
2000-2004	0.03	0.02
2005-2009	0.045	0.06
2010-2012	0.075	0.05

Table A2.4. Apalachicola Bay oyster resource management recommendations compiled from reports from local symposia or agency assessments.

Swift 1898

- Maintain dredge fishery ban
- Extend harvest closure period to April 15 through October 15 in order to protect early spawning season
- Adhere strictly to laws regarding culling and taking of small oysters
- Improve enforcement of harvest laws and laws protecting oyster planters
- Break up and separate transplanted clusters of overcrowded oysters in order to improve growth
- Use shell as cultch for new planting locations to create productive beds
- Add cultch to depleted beds and allow to recuperate for a year or two
- Improve communication with oystermen to reduce mistrust of planting laws

Whitfield and Beaumariage 1977

- Balance protection of resources and enhancement of product marketability through technological innovation and modernization of industry
- Develop non-destructive mechanical harvesting technology
- Construct state-sponsored oyster fattening plants to allow year-round culture
- Shorten harvest season to November 1 through May 1
    - Refuse demands by oystermen for legislation allowing year-round harvest
- Adhere vigorously to harvest regulations
- Amend anti-leasing laws to encourage private management and reef development
- Continue State-directed construction of new oyster reefs and rehabilitation of existing reefs
- Inform general public on impacts of development and upstream health on coastal economy and food production
- Have resource managers work closely with resource users to implement management plans
- Initiate FDA-sponsored oyster marketing and sanitation inspection program to improve product quality
- Expand sanitary surveillance of harvesting waters
- Discourage further development, channelization, and dam construction on Apalachicola River

Andree 1983

- Environmental effects on productivity of oysters
    - Correlate biological productivity of oysters with rainfall, salinity, density of predators, and other environmental parameters
    - Map substrate bottom types and locations in order to improve oyster cultch planting efforts in suitable locations
    - Examine sedimentation and current scour in relation to oyster spat survival in order to improve reef construction site selection
- Management and regulation of fishery resources
    - Re-examine laws on undersized oyster harvest, oyster transport, and summer harvest to make law enforcement more efficient

- Re-examine potential for submerged bottom leasing in unproductive areas that are not likely to be developed by the state's reef construction program
- Continue Florida Department of Natural Resources oyster reef construction program, but improve site selection, construction methods, and reef monitoring
- Improve communication between state agencies, researchers, and the industry through an annual forum, possibly led by the Apalachicola National River and Estuarine Sanctuary
- Develop better economic guidance for oyster dealers and oystermen
- Create functional long-range resource use plan for oysters

- Maintenance of a quality product for the market
    - Increase cooperation between law enforcement, management agencies, oystermen, and oyster dealers to reduce undersized oyster harvest
    - Establish water quality control procedures in oyster processing houses
    - Develop simple, adequate test for *Vibrio* bacteria in oyster meats in order to avoid costly consumer scares
- Miscellaneous discussion
    - Potential for hybridization and genetic manipulation
    - Exploration of alternative and "non-traditional" seafood products
    - Preliminary oyster "relay" projects highly successful

Arnold and Berrigan 2002

- Florida FWC should closely monitor ACF River Basin Allocation Formula agreements between Florida, Alabama, and Georgia, and should intervene to protect oyster resources in Apalachicola Bay if these freshwater allocations threaten them
- Florida FWC should carefully manage other Florida oyster resources to ensure that alternative sources are available if/when natural or anthropogenic factors result in the collapse of Apalachicola Bay oyster populations

Havens et al. 2013

- Monitoring
    - Continue monitoring oyster landings and expand fisheries independent monitoring program
    - Include oysters in list of species routinely assessed by FWRI
- Management and restoration
    - Improve acceptance and enforcement of rules regarding size limits, spatial restrictions, and seasonal closures
    - Explore oyster leases as possible alternative to open-access fisheries (e.g. Territorial User Rights Fisheries)
    - Evaluate efficacy and cost effectiveness of different shell planting materials and strategies, and expand cultching efforts
    - Involve state agencies and university experts in long-term fishery management process
    - Evaluate "relay" practices and potential for recruitment overfishing
- Research
    - Identify optimal approach for monitoring long-term oyster characteristics
    - Quantify interactions of oyster population dynamics, product quality, and the

fishery with river flow, nutrients, salinity, harvesting intensity, and restoration methods

- Assess oystermen harvesting practices and adaptation to changes in oyster abundance
- Use ECOSPACE model to identify effects of varying flow regimes and flow alternatives on oyster population dynamics and harvest potential

- Outreach and education
  - Develop community-based outreach and education program
  - Involve oyster harvesters and processors in research and restoration projects
- Miscellaneous discussion
  - Exploration of alternative and "non-traditional" seafood products

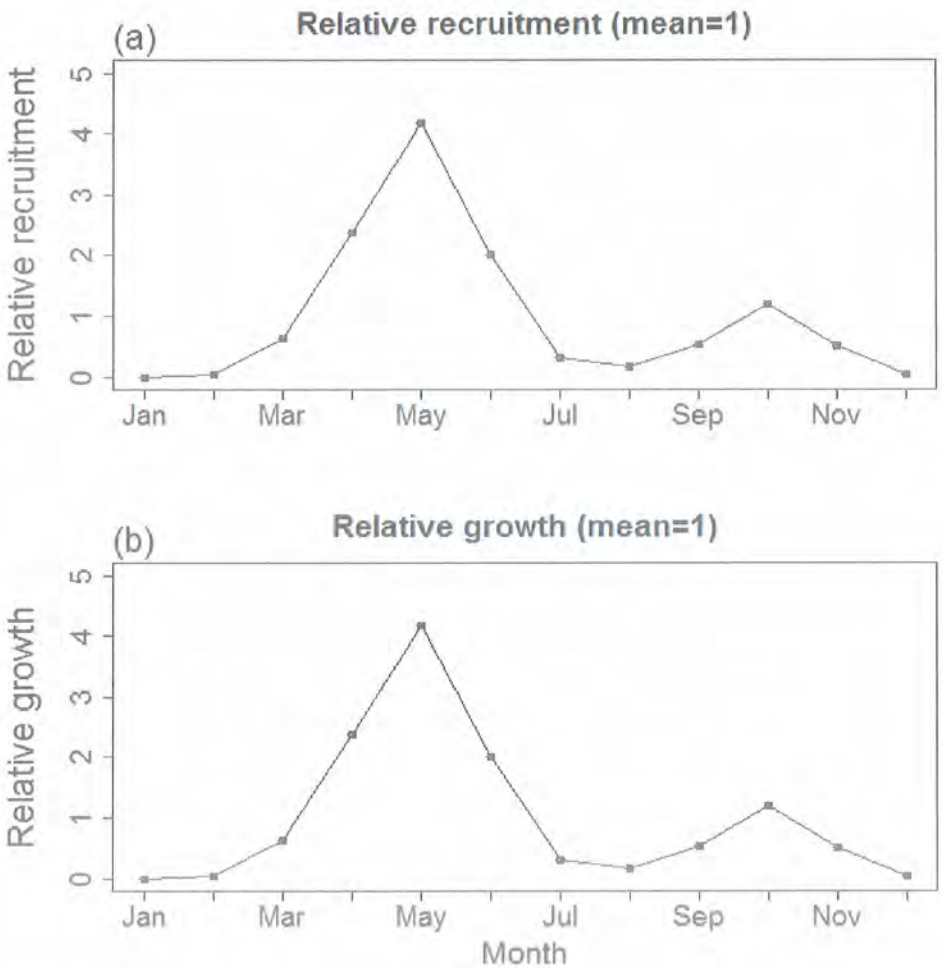

Figure A2.1. Monthly relative recruitment (a) and growth patterns (b) assumed for oysters in Apalachicola Bay, Florida based on empirical assessment of growth patterns and literature review.

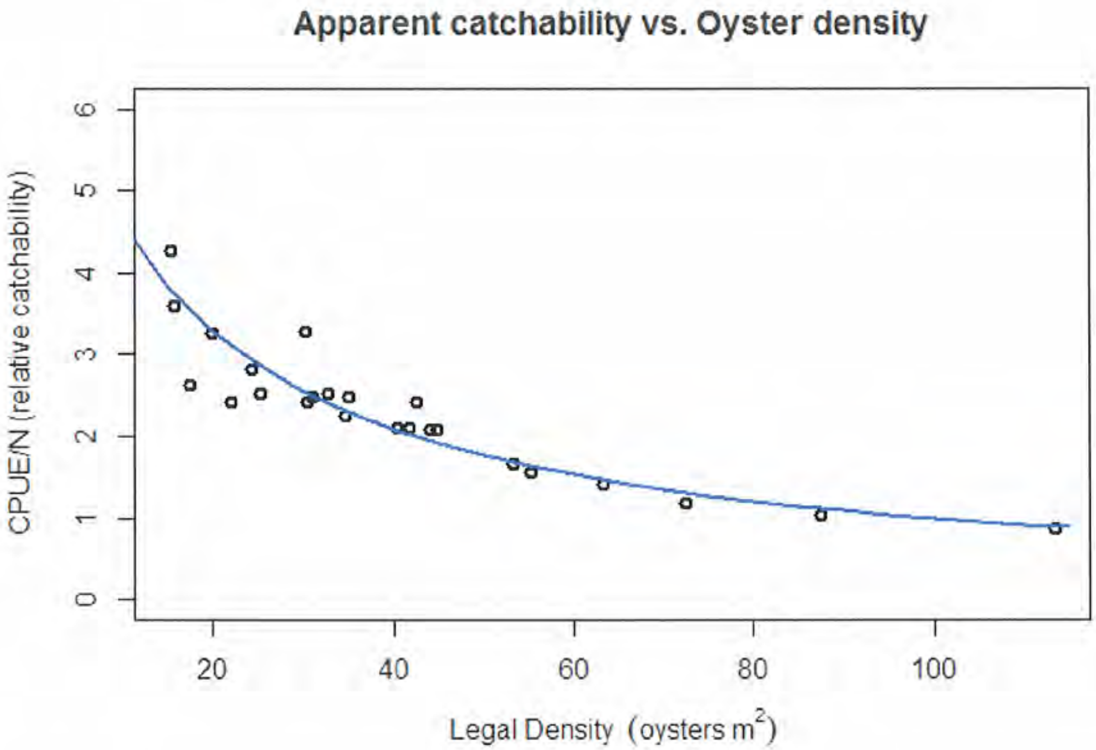

Figure A2.2. Density dependence in relative catchability q as evidenced by variation in mean annual catch per unit effort (CPUE), measured as trips per year divided by mean legal oyster density from DACS surveys. Assuming constant area swept per tong lift, this relationship implies that number of tong lifts per trip increases by a factor of about 4 when densities drop from around 100 legal oysters/m^2 to the observed low of near 10/m^2.

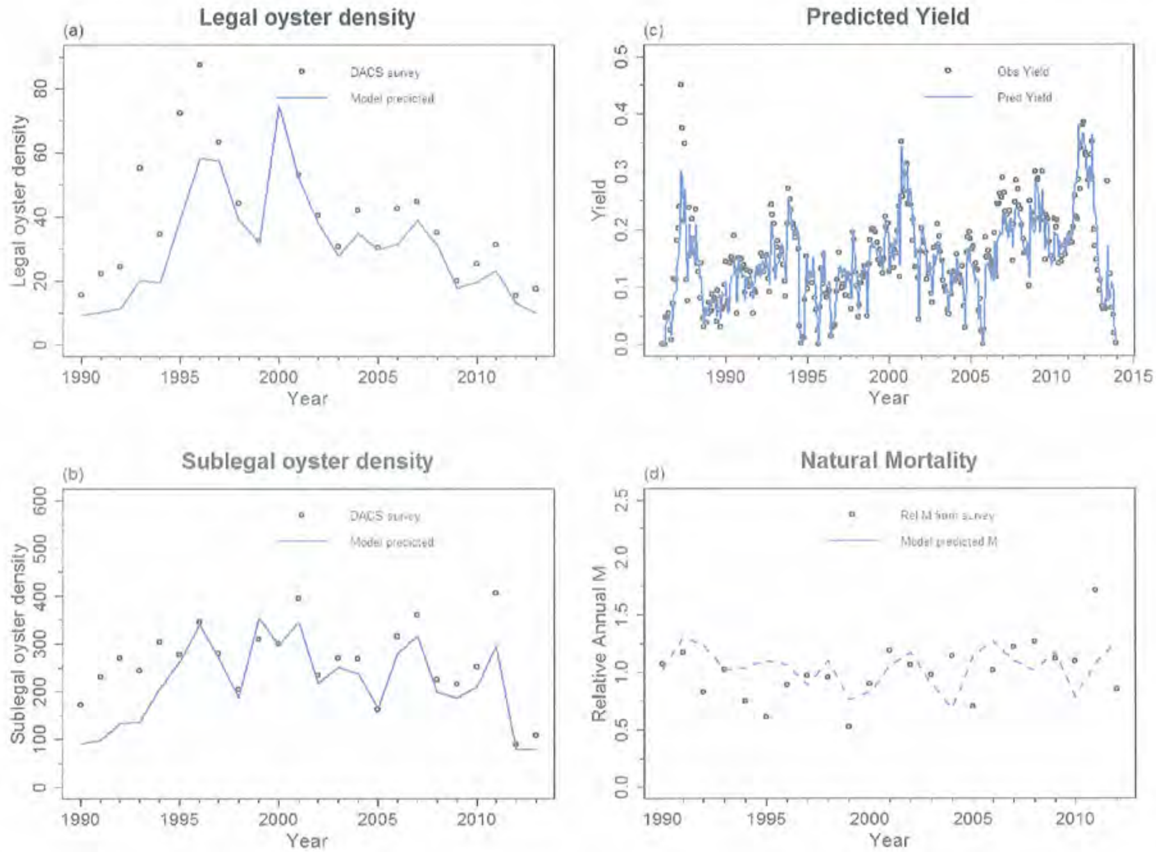

Figure A2.3. Observed (black circles) and model predicted (blue line) trends in legal (> 76.2 mm, panel (a) and sub-legal (b) oyster abundance, predicted oyster fishery yield (c), and estimated natural mortality rate (d) in Apalachicola Bay from 1990-2013. Model prediction results are from applying the parameter estimation procedure assuming balanced impacts of variation in natural mortality rate and recruitment rate. Observed data are from Florida Department of Agriculture and Consumer Sciences (DACS) fisheries independent surveys and predictions are from age-structured model described in this paper for comparison. Note large reduction in recruitment rates for 2012-3 implied by forcing the model to fit the DACS density estimates.

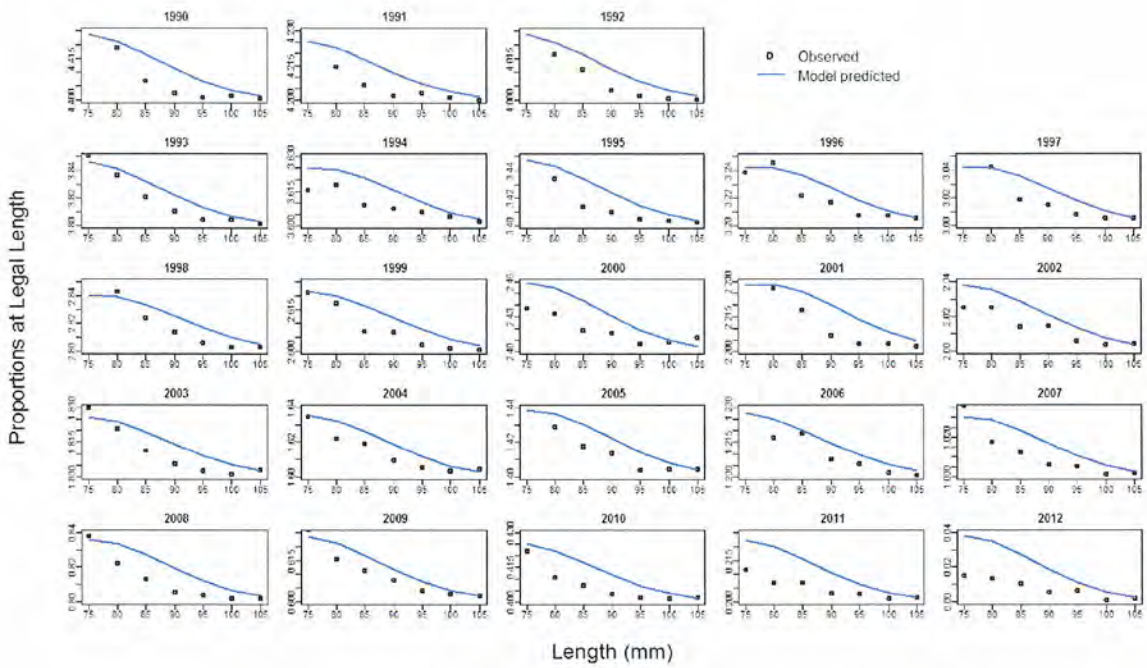

Figure A2.4. Comparison of model-predicted length proportions of legal sized oysters in Apalachicola Bay, Florida during fall (blue line) and observed length proportions of legal size oysters (black circles) in fisheries independent surveys conducted in fall by the Florida Department of Agriculture and Consumer Services.

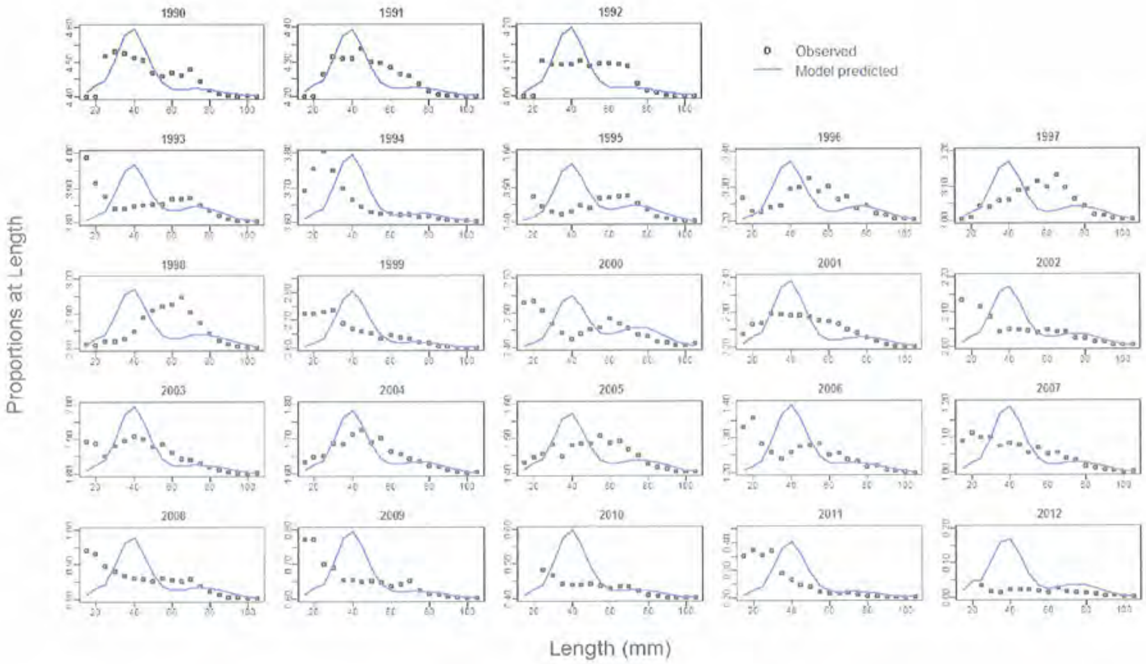

Figure A2.5. Comparison of model predicted length proportions of oysters 15-105 mm in size from Apalachicola Bay, Florida during fall (blue line) and observed length proportions of legal size oysters (black circles) from fisheries independent surveys conducted in fall by the Florida Department of Agriculture and Consumer Services.

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Exhibit 3

From:	Pine, Bill
Sent:	Saturday, December 20, 2014 11:12 AM
To:	Payne,Jack M; Hellgren,Eric C; Havens,Karl
Subject:	Apalachicola: Not for distribution
Importance:	High

Please do not distribute this email

Hello Jack, Eric and Karl:

On Thursday morning I received a call from a colleague at FWC as a "heads up." The purpose of the call was to let me know that following a meeting on Wednesday in Tallahassee with the legal team representing Florida in the Florida vs. Georgia case pending in the US Supreme Court that the lead attorneys were "not happy" with two manuscripts that I have in journal review on oyster populations in Apalachicola Bay. I was told by my FWC colleague that the attorneys thought the papers should be withdrawn, and if they were published that they could "make things difficult for me." When told that the funding for the work was provided by IFAS, the response was that things could be made difficult for IFAS as well. I was told to expect a call from the attorneys to meet with them to explain the papers and the current situation. I have not received that call.

At issue is the perception that the work I've led undermines the state of Florida's assertion in the ongoing lawsuit that the Apalachicola oyster collapse was caused by water policy in Georgia. The papers basically say "we can't figure out what caused the collapse as the evidence isn't clear, but here are some ways to figure it out going forward". But based on my experience with similar issues in the Colorado, Gila, and Sacramento river basins this type of uncertainty doesn't match well with legal maneuverings related to "take" and "loss". I've read the brief(s) filed by Florida and the Georgia response so I am familiar with the points raised by both states. These two papers are part of a group of four manuscripts I've been working on related to this issue. The third paper is basically complete and can be ready for submission with four or five more hours of work. My estimate of my time invested in this project and papers since the fall of 2011 is probably 3000-3500 hours.

Our work in Apalachicola, motivated by the request from Franklin County to IFAS and the oyster recovery task force headed by Karl Havens, predates the current lawsuit under review by the US Supreme Court. All of our state agency players have also been closely involved in this work by sharing data, and in participating in three or four workshops we had in developing the models and manuscripts (in an adaptive ecosystem assessment style at the FWC lab in Cedar Key). So whether the attorneys working on the case like it or not, state of Florida staff have been involved in this work since late 2011 predating the current lawsuit. The state has also had copies of the main paper, reviewed it numerous times, and many of their staff were included as co-authors until very late drafts of the manuscript when they were asked by legal staff to "step off" the paper.

I've watched these types of science-policy-legal conflicts play out in several places now. It usually disintegrates into a "if you don't like the science then attack the scientist" situation. I've seen people almost lose their jobs with FWS (suspended and ultimately reinstated after omnibus review). I've had a friend ultimately quit his job with USGS over the stress associated with repeated intense criticism over his work in various legal proceedings in the Colorado Basin. I do not want to be in this position and hope that it does not evolve into that. I take the veiled threat of this type of environment, if that is what it is, very seriously. I will not work in an environment where I'm attacked personally for doing the job I was asked to do by UF and in a situation where I have been as above board as possible with our agency partners.

EXHIBIT
PENGAD 800-631-6989
33
Pine

I've retained a personal attorney (Ron Kozlowski) at the recommendation of a senior faculty member in the UF law school whom I consulted on the Apalachicola situation and my role as a UF faculty member. My reason for engaging a personal attorney is to try and create what I think of as a "firewall" between the Apalachicola legal issues, my work on the subject as part of my job at UF, and my family and personal well being. At the advice of my attorney I'm sort of laying low for the next little bit and seeing how things shake out. I'm taking Monday off and may take Tuesday off as well. I probably won't be in Gainesville and will be in Cedar Key or somewhere else. Hopefully nobody from FWC gave the attorneys my cell number.

From a legal perspective there is a February 2 deadline for Georgia to provide an updated response to a series of recent filings. At the same time a "special master" (a lawyer from Maine) was appointed by the Supreme Court with the authority to "fix the time and conditions for the filing of additional pleadings, to direct subsequent proceedings, to summon witnesses, to issue subpoenas, and to take such evidence as may be introduced and such as he may deem it necessary to call for." More info and the original appointment of the special master is in the document linked below.

See http://www.scotusblog.com/2014/11/special-master-named-in-river-dispute-2/

Thank you for your time in reading this email. Please do not distribute it to UF counsel or anyone else. Please do not contact Nick Wiley or anyone else with FWC, DEP, other agencies, the legislator, or anyone like this on my behalf or anything related to what I've shared in this email. I will keep you up to date on any developments.

Thanks,
Bill Pine

Exhibit 4

From: Havens,Karl
Sent: Monday, February 09, 2015 8:57 PM
To: Leon.Cammen@noaa.gov
Subject: Regarding Supreme Court Case GA vs FL

Leon,

As you may be aware, there is a pending supreme court case of Florida vs. Georgia, in which the state of Florida is suing Georgia for taking water from the Apalachicola-Chattahoochee-Flint River system for consumptive uses and as a result causing the collapse of the Apalachicola Bay oyster fishery in fall 2012. You may also know that I led the research and outreach team in 2012-present that conducted research, modeling and community outreach after the collapse and identified the (1) likely causal agents, and (2) remedies to establish a more resilient fishery and economy. We now have a $5.4M grant from NFWF with the Florida Fish and Wildlife Commission to do experimental reef restoration work.

So that is all good. The not so good news, and the reason for the email is to inform you that Florida Sea Grant was served with a subpoena on Friday from the State of Georgia that requires us to turn over a large amount of information ... including the research proposals and reviews of two current ongoing Sea Grant projects (and all projects we have funded in that ecosystem since 1975). We have no choice but to comply and are being assisted by the UF Office of Counsel. I just wanted to let you know before you might happen to see a news story indicating that FL SG was subpoenaed in this case.

Results from some of the SG funded research strongly supports the GA case, which will be interesting. The work is very rigorous and already is accepted in peer-reviewed journals.

Karl

Karl E. Havens, Director, Florida Sea Grant
Office Phone: (352) 392-5870, Cell Phone: (352) 284-8558

Sent from my MS Surface Pro 2

EXHIBIT 27
PENGAD 800-631-6989

Exhibit 5

RICK SCOTT
GOVERNOR

September 6, 2012

Ms. Rebecca Blank
Acting Secretary
U.S. Department of Commerce
1401 Constitution Avenue, NW
Washington, D.C. 20230

Dear Secretary Blank:

On behalf of Florida's oyster industry, I respectfully request that you declare a commercial fishery failure due to a fishery resource disaster for Florida's oyster harvesting areas in the Gulf of Mexico, particularly those in Apalachicola Bay, pursuant to Section 312(a) of the Magnuson-Stevens Fishery Management and Conservation Act.

The State of Florida has experienced an unprecedented decline in the abundance of oysters within our coastal estuaries, a direct consequence of which has been a significant loss of income to commercial oyster fishermen, oyster processors and rural coastal communities. Recent oyster resource assessments indicate that the outlook for the 2012/2013 harvesting season is "poor" and unlikely to sustain commercial harvesting levels. I enclose a letter and report from Florida's Department of Agriculture and Consumer Services (FDACS) assessing the current impacts. The FDACS report estimates the dockside value of oyster landed in Franklin County at $6.64 million in 2011, which translates to a larger and significant overall economic impact to the affected communities. After conferring with county leadership, Franklin County estimates the employment impact to affect 2,500 jobs, including commercial oyster fishermen, processors and related coastal economies.

According to the report, observations and sampling of oyster populations on the primary oyster producing reefs in Apalachicola Bay during July 2012 indicated that oyster populations were in poor condition. It is believed that a combination of factors has led to the recent decline in oyster populations.

The Florida Panhandle and Apalachicola Bay, as the drainage basin of the Apalachicola, Flint, and Chattahoochee Rivers, have experienced drought conditions for several years resulting in reduced freshwater input into Apalachicola Bay. This absence

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of freshwater contributes to higher salinity levels adversely affecting oyster populations and contributing to mass natural mortality events and a dramatic increase in oyster predation.

Harvesting pressures and practices were altered to increase fishing effort, as measured in reported trips, due to the closure of oyster harvesting in contiguous states during 2010. This led to overharvesting of illegal and sub-legal oysters further damaging an already stressed population. Other undetermined causes may also have been involved.

Disaster relief funds authorized by the Magnuson-Stevens Act are needed to: 1) further assess the primary and secondary causes of the oyster decline; 2) determine the feasibility of actions to remediate or restore the affected resources; 3) begin actions to prevent and restore affected resources; and 4) provide economic assistance to fishing communities and small businesses, including oyster fishermen affected by the disaster.

The State of Florida is prepared to provide the information necessary for you to properly assess this situation. On behalf of Florida's oyster community, I thank you for your prompt consideration of this urgent request.

Sincerely,

Rick Scott
Governor

FLORIDA DEPARTMENT OF AGRICULTURE AND CONSUMER SERVICES
COMMISSIONER ADAM H. PUTNAM
THE CAPITOL

September 5, 2012

The Honorable Rick Scott
Governor
State of Florida
The Capitol, Plaza Level 05
Tallahassee, Florida 32399

Dear Governor Scott:

I am writing today to advise you of a situation that is quickly becoming a crisis for Florida's coastal communities who rely on a vibrant and healthy oyster population for economic viability. The oyster resources in the state, particularly those in Apalachicola Bay, have been significantly impacted by the prolonged drought that many areas of the state are facing. The drought conditions in the Bay have caused the oyster resources to decrease to a level that will no longer sustain Florida's commercial oyster industry. This situation has been exacerbated by the low level of fresh water coming down the Apalachicola River into the Bay.

As you know, oysters require a delicate balance of both fresh and salt water. If salinity levels in and around oyster reefs get too high, the water is hospitable to marine organisms that prey on oysters such as oyster drills, stone crabs and conchs. In addition, high salinity creates unfavorable conditions for juvenile oyster growth. First with Tropical Storm Debby and followed shortly thereafter by Tropical Storm Isaac, the already scarce resource was further impacted. A recent assessment of the oyster resources in the Bay conducted by the Florida Department of Agriculture and Consumer Service (FDACS) concluded that current oyster resource levels have not been this low since immediately after Hurricane Elena in 1985.

In addition to Apalachicola, we have already begun to hear from oyster harvesters in Wakulla, Dixie and Levy counties that they are also seeing high oyster mortality rates due to the drought. These areas have been closed seasonally to oyster harvesting through the summer and only opened on September 1, 2012. FDACS will conduct assessments on those areas over the next two weeks, however given the situation in Apalachicola Bay, it is likely these areas will also not support a sustained commercial harvest.

On behalf of Florida's oyster harvesters and processors, I respectfully request that you ask United States Department of Commerce Acting Secretary Rebecca Blank to declare a federal fishery disaster for Florida's oyster harvesting areas in the Gulf. I believe the current conditions meet the requirements established in Section 312(a) of the Magnuson-Stevens Fishery Conservation and Management Act and Section 308(b) of the Interjurisdictional Fisheries Act and therefore warrant this request.

To assist in your consideration of this request, I am enclosing the Apalachicola Bay Oyster Resource Assessment Report. Thank you in advance for your support of Florida's commercial oyster industry. Should you need additional information on this situation, please do not hesitate to contact me.

Sincerely,

Adam H. Putnam
Commissioner of Agriculture

Enclosure

Oyster Resource Assessment Report
Apalachicola Bay
August 2012
Department of Agriculture and Consumer Services
Division of Aquaculture

Executive Summary

Observations and sampling of oyster populations on the primary oyster producing reefs in Apalachicola Bay during July 2012 indicated that oyster populations were depleted over most of the reef areas sampled and that surviving oyster populations are severely stressed. Staff of the Department of Agriculture and Consumer Services' Division of Aquaculture conducted assessments of oyster populations after preliminary reconnaissance following the passage of Tropical Storm Debby indicated that oyster populations on Cat Point Bar and East Hole Bar were in poor condition. More detailed sampling and analyses confirmed the condition of oyster resources and suggested that the poor condition was the result of combination of environmental factors and fishery practices. Analyses and observations further suggested that Tropical Storm Debby was only a minor contributing factor to the overall poor condition of oyster resources and confirmed evidence that prolonged drought conditions, continuing low river discharge rates and intensive harvesting were adversely affecting oyster populations in Apalachicola Bay.

This report provides interpretative analyses of sampling data, fisheries data, environmental conditions, fishery practices and other factors to describe the current status of oyster resources and predict oyster fishery trends for the 2012/13 Winter Harvesting Season in Apalachicola Bay. Analyses and observations indicate that a combination of factors have resulted in a cascading effect that has contributed to the depletion of oyster populations and may lead to longer-term debilitation of oyster resources and oyster reef habitats.

Introduction

The Florida Department of Agriculture and Consumer Services (DACS) shares responsibility for managing oyster resources in Apalachicola Bay with the Florida Fish and Wildlife Conservation Commission (FWC); more specifically, the Division of Aquaculture manages oysters from both resource development and public health protection perspectives. This report summarizes information related to oyster resource compiled by the Division of Aquaculture from 2009 through August 2012.

Oyster Fisheries Statistics

Since 1980, reported landings of oysters in Florida ranged from about 1 to 6.5 million pounds of meats: highest landings were reported in the early 1980s, around 6.5 million pounds. Apalachicola Bay accounts for about 90% of Florida's landings and about 9% of the landings from the Gulf of Mexico (2000-2008 average). Reported oyster landings from Apalachicola Bay for 2011 were approximately 2.4 million pounds of meat, representing a slight increase in landings from 2010 (Table 1).

In 2011, oystermen in Franklin County reported landings of 2,380,810 pounds of meats from 39,176 trips. Landings for Apalachicola Bay are higher than reported for Franklin County, because oystermen in neighboring counties may report landings from Apalachicola Bay in those counties.

Table 1. Oyster Landings in Apalachicola Bay, Florida

Year	Pounds (Meats)	Number of Trips Reported	AB Oyster Harvesting Licenses	Bags/ Trip
2000	2,327,402	25,550	958	13.9
2001	2,333,968	25,261	1,135	14.1
2002	1,725,776	20,294	914	13.0
2003	1,449,890	18,467	759	12.0
2004	1,502,056	17,692	719	12.9
2005	1,260,996	12,663	714	15.2
2006	2,127,049	22,644	916	14.3
2007	2,645,359	29,104	1,142	13.9
2008	2,238,482	27,603	1,168	12.3
2009	2,695,701	39,942	1,433	10.2
2010	1,938,059	32,330	1,909	9.1
2011	2,380,810	39,176	1,799	9.3
2012			1,687	

Landings per trip remained relatively stable during 2010 and 2011, ranging from 9.1 to 9.3 bags per trip. Landings per trip continued to trend downward from about 15 bags per trip in 2005 to about 9.3 bags per trip in 2011. Oyster landings and bags per trip do not show a direct correlation with the number of ABOHL sold; there were 1,799 ABHOL sold in 2011 and 1,687 sold in 2012. The dockside value of oyster landed in Franklin County was estimated at $6.64 million in 2011.

Oyster landings appear to be correlated with three primary variables; resource availability, fishing effort, and market demand. Fishing effort has increased while market demand has been highly variable due to economic instability, concerns associated with the Deep Water Horizon (DWH) oil spill incident in 2010, and inconsistent supplies from other Gulf states.

Oyster Resource Assessments

The Division has conducted oyster resource surveys on the principle oyster-producing reefs in Apalachicola Bay since 1982. This information is used by resource managers to reliably predict trends in oyster production; to monitor oyster population dynamics, including recruitment, growth, natural mortality, standing stocks; and to determine the impacts of climatic events such as hurricanes, floods, and droughts on oyster resources. Sampling oyster populations allows resource managers to compare the relative condition of standing stocks over time using a defined sampling protocol. The Standard Oyster Resource Management Protocol (SORMP) provides a calculation to estimate production based on the density of legal size oysters collected during a defined sampling interval. Production estimates exceeding 400 bags of oysters per acre is applied as an indicator of healthy oyster reefs capable of sustaining commercial harvesting.

The Division of Aquaculture conducted oyster resource assessments on the commercially important oyster reefs in Apalachicola Bay during July 2012. Commercially important reefs included Cat Point Bar, East Hole Bar and the St. Vincent Bar and Dry Bar reef complex. Oyster resource assessments were also conducted on three recently rehabilitated reefs, and on shallow and intertidal reefs in St. Vincent Sound.

Production estimates for July 2012 from Cat Point Bar (287 bags/acre) and East Hole Bar (294 bags/acre) were the lowest production estimates reported in the past twenty years prior to the opening of the Winter Harvesting Season. Similarly, production estimates from St. Vincent Bar and Dry Bar (bags per acre) demonstrated depressed production estimates. Estimated oyster population parameters for Cat Point Bar, East Hole Bar and St. Vincent / Dry Bar are below levels generally observed on these reefs prior to opening the Winter Harvesting Season, and suggest that stocks are not sufficiently abundant at this time to support commercial harvesting throughout the Winter Harvesting Season. Factors affecting estimated production parameters on individual reef complexes are discussed later in this report.

Cat Point Bar and East Hole Bar have historically been the primary producing reefs in Apalachicola Bay. These reefs form a contiguous reef system (except for the Intracoastal Waterway) that extends north to south across St. George Sound and separates the sound from Apalachicola Bay. Over the past twenty years, landings from these reefs have been critical to supporting the oyster fishery in the region.

Oyster density and estimated production showed marked declines on Cat Point Bar when compared to 2011. Estimated production declined from 417 bags per acre in August 2011 to 287 bags per acre in July 2012 (Table 2). Oyster densities decreased substantially from 430 to 64 oysters per square meter over the same sampling interval (Table 2). The decrease in oyster density reflects poor recruitment, as well as severely reduced number of oysters in the juvenile size classes, and is indicative of the degraded quality of reef substrate and structure.

Cat Point and East Hole Bar have been subject to a combination of factors that have adversely affected oyster populations, oyster reef habitat, and the oyster fishery. Oyster populations over much of the reef area are depleted and the quality of the substrate is degraded to a point where spat settlement and recruitment have been disrupted. Stress associated with prolonged high salinity, high natural mortality and predation, and intensive fishing effort have markedly reduced standing stocks of juvenile, sub adult and adult oysters.

The Dry Bar and St. Vincent Bar complex is a large contiguous reef system in western Apalachicola Bay. This reef complex provides a substantial portion of the Bay's landings during normal years, but fishing pressure was sporadic during 2011 and 2012. The estimated production for Dry Bar-St. Vincent (Table 2) indicated a substantial reduction from 323 bags per acre in August 2011 to 215 bags per acre in July 2012. Samples were collected from the Little Gully area on Dry Bar, because no live oysters were collected on St. Vincent Bar. St. Vincent Bar, extending from Dry Bar southward was considered to be depleted of marketable oysters. The oyster population on St. Vincent Bar was likely decimated by stress associated with high salinity, disease and predation. Fishing pressure has declined as a result of reduced standing stocks of market-size oysters over the entire reef complex over the past two years. The current condition of oyster resources on Dry Bar is not expected to be at levels that will sustain commercial harvesting through the 2012/13 Winter Harvesting Season.

Estimated production parameters for the reef complexes in the western portion of the Bay and the "Miles" indicate that standing stocks of market size oysters are at various levels. Standing stocks on some reefs will support commercial harvesting, while other reefs show signs of severe stress and depletion. Oyster reefs, including North Spur, Green Point and Cabbage Lumps Plant Sites are in moderately good condition, with standing stocks and production at levels that will support limited commercial harvesting. These plant sites have been planted with processed oyster shell within the last three years, and the substrate remains in good condition; size frequency distributions are typical of healthy oyster populations. However, these reefs are small and overall production will be limited. Also, oysters on these reefs will likely be subject to intense predation from rock snails, while salinity levels remain high. Oyster populations on shallow and intertidal reefs in the 'Miles' (Spacey's Flats, Eleven Mile Bar, Picolene Bar) are also severely stressed, showing signs of intense predation and natural mortality. Bars in northwestern Apalachicola Bay and eastern St. Vincent Sound, including Green Point, North Spur and Cabbage Lumps are more strongly influenced by river flows than bars located further away from the river mouth. Prevailing flows and circulation patterns move plumes of freshwater westward from the river over these reefs before they are dispersed throughout the Bay and St. Vincent Sound.

The Standard Oyster Resource Management Protocol

Continuous monitoring and data analyses have allowed resource managers to develop a scale using defined sampling protocol to determine the relative condition of oyster resources based on estimated production parameters. The Standard Oyster Resource Management Protocol (SORMP) provides that estimated production exceeding 400 bags of oysters per acre is applied as an indicator of healthy oyster reefs capable of sustaining commercial harvesting. Accordingly, oyster populations are 1) capable of supporting limited commercial harvesting when stocks exceed 200 bags/acre, 2) below levels necessary to support commercial harvesting when stocks fall below 200 bags/acre, and 3) considered depleted when marketable stocks are below 100 bags/acre. Generally, production from Cat Point Bar has been the most accurate indicator of oyster production in Apalachicola Bay, but East Hole Bar and St. Vincent Bar are also reliable indicators of the condition of oyster resources throughout the Bay. This scale forms the basis for the Standard Oyster Resource Management Protocol provided in Subsection 68B-27.017, Florida Administrative Code, which has been used as the criteria for setting the number of harvesting days in the Winter Harvesting Season in Apalachicola Bay.

Depletion of Oyster Resources

Standing Stocks and Commercial Production Estimates

Size frequency distributions for oyster standing stocks are strong indicators of the health of oyster populations and are useful for predicting fishery trends. Size distributions among oyster populations are used to evaluate recruitment to the population, recruitment of juveniles to market size, growth, survival and potential production. Accordingly, size frequency distributions can be used to evaluate oyster depletion events. Current analyses of size frequency distributions and oyster standing stocks indicate that oyster populations on the major producing reefs in Apalachicola Bay are experiencing an on-going depletion event.

Oyster populations can be depleted from a number of factors; including climatic conditions, water quality, drought and flood events, catastrophic storms and hurricanes, natural mortality from diseases and predation, and fisheries. Most of the time, depletions occur because of a combination of these factors (multiple stressors).

Data analyses and observations on the major reef complexes showed substantial losses of oyster populations over the past two years, with severe declines in oyster densities, standing stocks and production estimates. Declining populations can be attributed to less than optimal environmental conditions (prolonged drought, reduced river discharge rates, high salinity), storm events (Tropical Storm Debby), and increased predation and natural mortality, weak recruitment, and extensive harvesting on the major reefs. It is evident from divers' observations that many reefs in Apalachicola Bay are showing the negative effects of decreased rainfall and freshwater flow rates from the Apalachicola River over the past two years, including depressed recruitment and increased natural oyster mortality (predation, disease, and stress associated with high salinity regimes). Additionally, the long-term impairment of reef structure (reef elevations, shell matrix, and shell balance) is of serious concern. Each of the factors contributing to oyster depletion in Apalachicola Bay are discussed below.

Prolonged Drought and Elevated Salinity

Adverse environmental conditions can have a devastating effect on oyster populations; and high salinity is among the most detrimental factors. Because oysters are sessile animals, they are not capable of moving when environmental conditions become less than optimal or sometimes lethal. While oysters can tolerate a wide range of salinities, prolonged exposure to less than optimal conditions will adversely impact affected populations. Oysters become physiologically stressed when salinity levels are below or above optimal levels (10-25 ppt) for extended periods, affecting reproductive potential, spatfall, recruitment, growth and survival.

Rainfall and concomitant river discharge are essential for productive oyster populations in Apalachicola Bay, and provide three critical requirements for survival. First, survival depends upon salinity regimes that are suitable for oysters to reproduce, grow and survive. Rainfall in the drainage basin and discharge into the Bay are essential, as productive oyster populations require a combination for fresh water and marine waters. Fluctuating salinity regimes, within the oyster's tolerance limits, is the single most important factor influencing oyster populations in Apalachicola Bay. Second, rainfall, flooding in the flood plain, and river discharge into the Bay are essential for supplying nutrients and detritus necessary to nourish and sustain food webs and trophic dynamics within the estuarine system. And third, rainfall and river discharge is a critical factor driving fluctuations in salinity levels that prevent destructive predators with marine affinities from becoming established in the Bay. The critical influences of rainfall and river discharge were severely diminished during the past two years. The region and much of the drainage basin have been subject to extensive drought during 2011 and 2012, and these conditions have been reflected in low river stages and low river discharge rates.

Although, environmental conditions improved with relatively normal rainfall and river discharge in 2009 and early 2010, and abundant spat fall was reported on Cat Point and East Hole Bars during 2010, oyster resources have not rebounded completely. Conditions began to decline and drought conditions have persisted in the Apalachicola River Basin since August 2010. With drought conditions returning to the region, decreased rainfall and river discharge have contributed to stress on oyster populations in Apalachicola Bay.

The Florida Panhandle and the Apalachicola River (ACF) drainage basin have experienced prolonged drought conditions for several years, and the reduced freshwater input into Apalachicola Bay has seriously affected oyster populations in the Bay. Poor recruitment and poor survival can be directly attributed to prolonged high-salinity environment, which is also confirmed by the presence of marine predators, primarily stone crabs and Florida rock snails (oyster drills). The predators are present in great numbers and are currently overwhelming oyster populations throughout Apalachicola Bay. Petes et al., (2012) and Wilber (1992) investigated the effects of reduced freshwater flows on oyster populations in Apalachicola Bay and reported adverse impacts resulting from low river flows.

Natural Mortality and Predation

The combination of high salinity and high water temperatures are known to severely stress oyster populations and may result in massive mortality events. It is highly likely that these environmental factors have contributed substantially to natural mortality and low recruitment in the Bay. High salinity and high water temperatures also correlate with the increased prevalence and intensity of the oyster parasite, *Perkinsus marinus*. This parasite (dermo) is often associated with oyster mortality in the hotter summer months and is commonly described as 'Summer Mortality Syndrome' in Florida. The Department participates in the Oyster Sentinel Program in the Gulf and monitors the presence and intensity of *P. marinus* in oysters in Apalachicola Bay.

Observations by divers confirmed the presence and abundance of stone crabs, *Menippe mercenaria*, on the primary oyster reefs in Apalachicola Bay. Stone crab burrows are easy to recognize and the appetite of these destructive predators is obvious. Stone crab burrows are surrounded by living and dead oysters; the result of crabs actively foraging and bringing live oysters to their burrows. The shells of devoured oysters are also present and form a ring around burrows. Examining dead oyster shell provides confirmation of the crushing action of stone crabs on the shell of oysters. Stone crabs are considered primary predators of oysters when salinities remain high for extended periods and crab populations become established on oyster reefs.

Observations and sampling confirmed the presence and abundance of the Florida rock snail, *Stramonita haemastoma*, (formerly *Thais haemastoma*), a destructive snail commonly referred to as an oyster drill. Oyster drills are considered as one of the most serious oyster predators along Florida's Gulf Coast, and have become established in Apalachicola Bay over the past two years. Reports from oystermen suggest that drills are more abundant than at any time in recent memory. It appears that drill populations are moving farther into the estuary as oyster populations in the more marine portions of the Bay are depleted. High numbers of drills were found wherever viable oyster populations were observed. The presence and establishment of snail populations correlate with prolonged high salinity waters. It is also disturbing that drills are completing their life cycles within the estuary, since egg cases, juvenile, subadult and adult snails are abundant on oyster reefs.

Additionally, the Florida crown conch, *Melongena corona*, was commonly observed on oyster reefs. These conchs are also known to be serious oyster predators with marine affinities. Mud crabs of various species are also common predators on oyster reefs, generally attacking spat and smaller juvenile oysters.

Increased stress associated with high salinity regimes acts to exacerbate the level and intensity of predation by weakening oysters. Prolonged periods of high salinity result in natural mortality from predation which can have a significant impact on oyster populations and result in serious economic losses to commercial oyster fisheries. The presence and abundance of marine predators on oyster reefs in Apalachicola Bay the long duration of high salinity conditions within the estuary.

<u>Harvesting Pressure</u>

Declining oyster population parameters can be associated with harvesting, as well as environmental influences and natural mortality. Reported oyster landings for Franklin County in 2011 increased marginally over 2010 in both production and bags per trip, but harvesting pressure (as measured in reported trips) increased by about 20 percent. Oyster population parameters for Cat Point Bar and East Hole Bar suggest that oyster abundances and potential production is markedly depressed, possibly reflecting the effects of continuous harvesting, poor harvesting practices, as well as, less than optimal environmental conditions in 2010 and 2011. Over harvesting is most damaging when environmental conditions are less than optimal, recruitment is low, and natural mortality is high.

Resource managers believe that several activities associated with harvesting have had a detrimental impact on standing stocks and oyster resources on the primary producing reefs in St. George Sound in eastern Apalachicola Bay. The standing stocks of juvenile, sub-legal, and market-size oysters suggest that the overall condition of many reefs has declined substantially over the past two years as a result of continuous harvesting from Cat Point and East Hole Bars, concentrated and intensive harvesting by the majority of the fishing fleet, and the excessive harvesting of sub-legal oysters.

Vessel counts during the 2011/12 Winter Harvesting Season show that about 60 percent of the fishing fleet was concentrated on Cat Point and East Hole Bars. Fishing effort often averaged more than 120 vessels per day throughout 2011 and 2012 placing added pressure on Cat Point and East Hole Bars. In response to limiting the number of hours harvest can occur each day to control for *Vibrio vulnificus*, additional harvesting days during 2011 and 2012 were implemented which increased fishing pressure and further deteriorated the condition of the resource. Another contributing factor was the management decision to allow harvesting from these reefs during the summer of 2010 in response to the oil spill event (April, 2010). This resulted in an intense harvesting effort which precluded any recovery time for the resource

Harvesting pressure is usually high on reefs in the eastern portion of the Bay at the beginning of the oyster harvesting season, and in 2011 and 2012 harvesting pressure was almost exclusively directed to Cat Point and East Hole Bars. Harvesting pressure on Cat Point Bar and East Hole

Bar in St. George Sound demonstrated an upward trend in effort over the past two years. This change in fishing effort is not easy to explain, since it does not seem to be strictly associated with resource availability. One plausible explanation may be the proximity of St. George Sound to Eastpoint, where many licensed oystermen reside and sell their oysters.

Some of the decline of legal-size oysters can be attributed to the excessive harvesting of sub-legal oysters. Since 2010, there have been numerous reports of oystermen harvesting oysters below the legal size limit, and observations in the marketplace confirmed that the harvest of small oysters was very common during the DWH oil spill event and has persisted to the present. Excessive harvesting of sub-legal oysters from 2010 through 2012 reduced recruitment among sub-legal size classes to legal size, contributing to declining trends in estimated production in 2012/2013. This situation results from harvesting and culling practices of the fishermen, when sub-legal oysters are not culled and returned to the reef to grow to marketable size.

The practice of harvesting sub-legal oysters appears to be an extension of a "use it or lose it' attitude that prevailed during the fall and winter of 2010. Following the oil spill in April 2010, there was an acknowledged threat to oyster resources in Apalachicola Bay, and management policies were directed toward harvesting available resources in the face of a growing risk of loss. Throughout the period when oil posed an unpredictable threat to the oyster fishery, less effort was directed toward enforcing size limits, perhaps, yielding to the view that it would be more beneficial to harvest the available resource. But unfortunately, many oystermen have continued the same harvesting practices that were allowed during the oil spill threat.

The Division's 2011 *Oyster Resource Assessment Report for Apalachicola Bay* (Division of Aquaculture, 2011) stated that oyster population estimates indicated that recruitment would keep pace with harvesting pressure and sustain production throughout the 2011/12 Winter Harvesting Season: with the caveat that increased harvesting pressure and/or the unabated harvesting of sublegal stocks may alter the production / harvesting balance. In 2011, reports of the harvest and sale of oysters below the legal size limit was still common practice, and it is now clear that there are not sufficient numbers of juvenile and market size oysters to support harvesting throughout the up coming season.

Tropical Storm Debby

Tropical Storm Debby made its closest approach to Apalachicola Bay on June 25, 2012 before moving eastward and making landfall near the mouth of the Suwannee River. Despite the fact that Debby never achieved hurricane strength, it was accompanied by moderate storm surge in the Big Bend region. Maximum surge at Apalachicola was 3.51 feet.

The greatest impacts to oyster reefs were expected to be in St. George Sound and western Apalachicola Bay (St. Vincent Bar) because of the long fetch of open water. Scouring was expected as a result of storm surge and wave action across the Bay. Fortunately, most of the storm surge and strongest wave action occurred during high tides when the reefs are most protected from severe hydrological impacts.

Preliminary reconnaissance following T.S.Debby did not indicate severe disruption of oyster reef structure. Examination of shells and live oysters did not display the effects of severe scouring (ex. polished shell surfaces, abrasion, dead oysters) and observations by divers did not demonstrate extensive disruption of the reef's surface (suspension and deposition of reef shell and sediments, concretion of reef material, or burial of shell and living oysters). Although reef areas were sometimes devoid of live oysters, clusters of oysters were present in adjacent areas that did not indicate severe disturbance. Scouring and wave action may have impacted reef surfaces and oyster resources in some areas, but widespread damage to reef structure was not observed.

Heavy rainfall and coastal flooding may have an adverse impact on oyster reefs closest to the river and distributaries in the river delta, but the sudden influx of freshwater did not appear to cause extensive oyster mortalities on reefs away from the river delta (reefs in the Winter Harvesting Areas). Preliminary reconnaissance and sampling did not identify oyster populations where mass mortalities occurred; it is generally apparent when a mass mortality event occurs from a freshet or poor water quality (low dissolved oxygen concentrations). However, it remains likely that oyster populations in close proximity to the river delta may be subject to prolonged low salinity and associated low dissolved oxygen concentrations, and may suffer mortalities. There have been some reports of recent mortalities (late July) among oysters on reefs in the Summer Harvesting Area (Norman's Lumps).

Fishery Management Implications

The Department of Agriculture and Consumer Services and the Fish and Wildlife Conservation Commission enacted several policies that allowed oystermen a greater opportunity to harvest available oyster resources in Apalachicola Bay in response to the Deepwater Horizon oil spill event and national shellfish program requirements. The Executive Director of the FWCC signed an Executive Order that allowed commercial harvest of oysters from Apalachicola Bay seven days a week beginning September 1, 2011, contingent upon the Standard Oyster Resource Management Protocol (SORMP). On June 1, 2012, the FWCC enacted rule amendments in Chapter 68B-27.017 that allowed harvesting of oysters seven days a week, year round in Apalachicola Bay. This action was taken, in part, to accommodate commercial oyster fishermen for time on the water harvesting that was decreased as a result of recent management practices to enhance public health protection. These practices, consistent with national *Vibrio vulnificus* reduction criteria, imposed more stringent limitations on harvesting times from April through November.

Subsection 68B-27.017(1)(a), Florida Administrative Code, provides that oysters may be harvested for commercial purposes on any day of the week. Subsection (1)(b) provides that - If during the period of November 16 through May 31 DACS establishes that the oyster resources on Cat Point Bar and East Hole Bar can not sustain a harvest of 300 bags per acre (SORMP), then the harvest of oysters for commercial purposes shall be prohibited on Saturdays and Sundays. Results of the current assessment indicated that estimated production on Cat Point Bar and East Hole Bar may not exceed the level provided in the SORMP for DACS to recommend that oyster harvesting for commercial purposes be continued at seven days a week. Oyster resources will be re-assessed in November and recommendations will be forwarded to the Florida Fish and Wildlife Conservation Commission.

Fishery Trends

Analyses of oyster resource assessment data over the past two years indicate several general conclusions regarding oyster resources in Apalachicola Bay.

The outlook for oyster production for the 2012/2013 Winter Harvesting Season in St. George Sound (Cat Point, East Hole, Porters Bar and Platform) is described as "poor". It appears unlikely that oyster populations on Cat Point and East Hole Bars can sustain concentrated harvesting effort throughout the Winter Harvesting Season.

Declining population estimates over the past two years generally indicated that oyster populations are severely stressed. Although oyster population parameters for 2010 and 2011 reflected relatively stable production estimates, declines in 2012 suggest that overall resource availability may not be capable of sustaining current harvesting levels (bags per trip). The number of bags per trip has continued to decline over the past five years.

Prior to 2009, the demand for oysters from Apalachicola Bay was a primary factor limiting harvests, as harvests did not appear to be limited by available stocks. Higher landings in 2009 likely reflected strengthening market demand and increased fishing effort rather than increased resource availability. However, in 2011/2012 demand for Apalachicola Bay oysters increased because of reduced production from historically productive areas in other Gulf states, while oyster resources in the Bay have suffered during the current drought. Consequently, oyster resources may not be adequate to support increased harvesting pressure and meet increased demand throughout the upcoming season.

Table 2. Cat Point Bar Population Estimates: September 2008 to July 2012.

Sample		Oyster	Mean	Density	Oysters				Bags
Date	Quadrat (0.25m)	Number (n)	Leng. (mm)	(/m)	>50mm (%)	>75mm (%)	(/m)	1000x (/ac)	(/ac)
09/08	20	616	55.2	123.2	66.2	17.21	21.2	85.8	381
11/08	10	564	52.0	225.6	55.7	19.33	43.6	176.4	784
12/08	10	333	56.9	133.2	66.1	24.92	33.1	134.3	597
08/09	20	828	50.1	165.6	49.9	15.10	25.0	101.1	449
11/09	10	626	48.2	250.4	50.2	7.83	19.6	79.3	352
04/10	20	969	48.4	193.8	46.7	9.91	19.2	77.7	345
08/10	20	1,043	50.5	208.6	53.9	8.92	18.6	75.3	334
11/10	20	865	52.8	173.0	63.7	12.25	21.2	85.7	381
08/11	15	1,611	48.2	429.6	48.5	5.40	23.2	93.9	417
07/12	10	161	58.8	64.4	67.1	24.84	15.9	64.7	287

Table 2. East Hole Bar Population Estimates: November 2008 to July 2012.

Sample		Oyster	Mean	Density	Oysters				Bags
Date	Quadrat (0.25m)	Number (n)	Leng. (mm)	(/m)	>50mm (%)	>75mm (%)	(/m)	1000x (/ac)	(/ac)
11/08	10	318	57.5	127.2	69.1	22.33	28.4	114.9	510
09/09	20	1,023	49.3	204.6	50.7	9.09	18.5	75.2	334
11/10	10	682	47.0	272.8	48.6	9.38	25.6	103.6	460
07/12	10	127	60.8	50.8	65.3	32.28	16.3	66.3	294

Table 2. Dry Bar Population Estimates: September 2008 to July 2012.

Sample		Oyster	Mean	Density	Oysters				Bags
Date	Quadrat (0.25m)	Number (n)	Leng. (mm)	(/m)	>50mm (%)	>75mm (%)	(/m)	1000x (/ac)	(/ac)
09/08	20	1,467	54.0	293.4	64.1	14.86	43.6	176.4	784
12/08	10	986	47.1	394.4	49.8	7.81	30.8	124.6	554
08/09	20	1,353	46.6	272.6	41.2	6.31	17.2	69.6	309
11/09	10	589	45.6	235.6	41.7	7.13	16.7	67.9	302
08/10	20	877	50.2	175.4	50.5	10.83	18.9	76.8	341
11/10	20	1,313	43.1	262.5	34.4	11.65	30.5	123.8	550
08/11	15	567	47.5	151.2	44.8	11.90	17.9	72.7	323
07/12	10[a]	150	55.0	60.0	66.0	20.0	12.0	48.6	215[a]

a - Samples collected from Little Gully on Dry Bar. No live oysters were collected from St. Vincent Bar

Table 2. North Spur (Plant) Population Estimates: September 2008 - July 2012.

Sample		Oyster	Mean	Density	Oysters				Bags
Date	Quadrat (0.25m)	Number (n)	Leng. (mm)	(/m)	>50mm (%)	>75mm (%)	(/m)	1000x (/ac)	(/ac)
09/08	5	284	52.9	227.2	60.6	10.56	23.9	97.0	431
09/09	10	541	49.5	216.4	49.9	12.75	27.5	111.6	496
04/10	5	1040	48.0	832.0	50.4	5.10	42.4	171.7	763
08/11	5	269	52.9	215.2	58.0	15.99	34.4	139.2	619

07/12	10	362	53.4	144.8	57.5	18.23	26.4	106.8	475

Table 2. Green point (Plant) Population Estimates: September 2008 - July 2012.

Sample		Oyster	Mean	Density	Oysters				Bags
Date	Quadrat (0.25m)	Number (n)	Leng. (mm)	(/m)	>50mm (%)	>75mm (%)	(/m)	1000x (/ac)	(/ac)
09/08	10	482	58.8	192.2	75.9	20.33	39.2	158.6	705
09/09	10	274541	48.2	109.6	44.1	17.52	19.2	77.7	345
09/11	10	510	54.4	204.0	65.5	12.94	26.4	106.5	474
07/12	5	125	59.6	100.0	65.0	28.00	28.0	113.3	503

Exhibit 6

Oyster Resource Assessment Report
Apalachicola Bay 2011
Department of Agriculture and Consumer Services
Division of Aquaculture

Introduction

The Florida Department of Agriculture and Consumer Services (FDACS) shares responsibility for managing oyster resources in Apalachicola Bay with the Florida Fish and Wildlife Conservation Commission (FWC); more specifically, the Division of Aquaculture manages oysters from both resource development and public health protection perspectives. This report summarizes oyster resource surveys conducted by the Division of Aquaculture from 2009 through September, 2011.

Fisheries Statistics

Since 1980, reported landings in Florida ranged from about 1 to 6.5 million pounds of meats: highest landings were reported in the early 1980s, around 6.5 million pounds. Apalachicola Bay accounts for about 90% of Florida's landings and about 9% of the landings from the Gulf of Mexico (2000-2008 average). Reported oyster landings from Apalachicola Bay for 2010 were approximately 1.9 million pounds of meat, representing a decline in landings from 2009 (Table 1). Dockside value for oysters from Apalachicola Bay was about 5.6 million dollars in 2010.

Table 1. Oyster Landings in Apalachicola Bay, Florida

Year	Pounds (Meats)	Number of Trips Reported	AB Oyster Harvesting Licenses	Bags/ Trip
2000	2,327,402	25,550	958	13.9
2001	2,333,968	25,261	1,135	14.1
2002	1,725,776	20,294	914	13.0
2003	1,449,890	18,467	759	12.0
2004	1,502,056	17,692	719	12.9
2005	1,260,996	12,663	714	15.2
2006	2,127,049	22,644	916	14.3
2007	2,645,359	29,104	1,142	13.9
2008	2,238,482	27,603	1,168	12.3
2009	2,695,701	39,942	1,433	10.2
2010	1,916,155	31,984	1,909	9.1

Oyster landings appear to be correlated with three primary variables; resource availability, fishing effort, and market demand. Most recently, fishing effort and market demand have been highly variable due to economic instability and concerns associated with the Deep Water

Horizon (DWH) oil spill incident. In 2010, oystermen reported 31,984 trips and the number of Apalachicola Bay Oyster Harvesting Licenses reached 1,909, the highest number of licenses sold since the license was created. Landings per trip have declined from about 15 bags per trip in 2005 to about 9.1 bags per trip in 2010, and show an inverse correlation with the number of ABOHL sold.

Oyster Resource Assessments

The Division has conducted oyster resource surveys on the principle oyster-producing reefs in Apalachicola Bay since 1982. This information is used by resource managers to reliably predict trends in oyster production; to monitor oyster population dynamics, including recruitment, growth, natural mortality, standing stocks; and to determine the impacts of climatic events such as hurricanes, floods, and droughts on oyster resources.

Continuous monitoring and data analyses have allowed resource managers to develop a scale using defined sampling protocol to determine the relative condition of oyster resources based on estimated production parameters. The Standard Oyster Resource Management Protocol (SORMP) provides that estimated production exceeding 400 bags of oysters per acre is applied as an indicator of healthy oyster reefs capable of sustaining commercial harvesting. Accordingly, oyster populations are 1) capable of supporting limited commercial harvesting when stocks exceed 200 bags/acre, 2) below levels necessary to support commercial harvesting when stocks fall below 200 bags/acre, and 3) considered depleted when marketable stocks are below 100 bags/acre. Generally, production from Cat Point Bar has been the most accurate indicator of oyster production in Apalachicola Bay, but East Hole Bar and St. Vincent Bar are also reliable indicators of the condition of oyster resources throughout the Bay. This scale forms the basis for the Standard Oyster Resource Management Protocol provided in Subsection 68B-27.017, Florida Administrative Code, which has been used as the criteria for setting the number of harvesting days in the Winter Harvesting Season in Apalachicola Bay.

Subsection 68B-27.017(2)(a), Florida Administrative Code, provides that oysters may be harvested for commercial purposes on any day of the week from November 16 to May 31 of each year when the Bay is not closed for public health purposes and when the oyster resources on Cat Point Bar or Easthole can sustain a harvest of 300 bags of oysters per acre. The Executive Director of the FWCC signed an Executive Order that allowed commercial harvest of oysters from Apalachicola Bay seven days a week beginning September 1, 2011, contingent upon the SORMP. Under the protocol, oyster abundance (standing stocks of legal size oysters) must be sufficient to sustain a harvest of 300 bags of oysters per acre on Cat Point and East Hole Bars.

This action was taken, in part, to accommodate commercial oyster fishermen for time on the water harvesting that was decreased as a result of recent management practices to enhance public health protection. These practices, consistent with national *Vibrio vulnificus* reduction criteria, imposed more stringent limitations on harvesting times from April through November.

The Division of Aquaculture conducted oyster resource assessments on the commercially important oyster reefs in Apalachicola Bay during August and September, 2011. Results of these assessments indicated that estimated production on Cat Point Bar (417 bags per acre) exceeded the level provided in the Standard Oyster Resource Management Protocol to open the bay to harvest for seven days per week. Based on this resource assessment data, the Division of Aquaculture can also recommend that oyster harvesting for commercial purposes be continued at seven days a week beginning on November 16, 2010. This recommendation will be assessed after the November sampling interval and forwarded to the Florida Fish and Wildlife Conservation Commission.

Production estimates from Cat Point Bar for September 2011 (417 bags/acre) improved slightly over production estimates for November 2010 (381 bags/acre), but population parameters still suggested that standing stocks of market oysters were stressed. Production estimates from Dry Bar over the same sampling intervals (September 2011; 323 bags/acre and November 2010; 550 bags/acre), showed a decline in standing stocks of market-size oysters. Although production estimates exceeded 300 bags per acre on both reef complexes, estimated oyster population parameters on Cat Point Bar and Dry Bar suggest that stocks are not sufficiently abundant at this time to support intense commercial harvesting throughout the Winter Harvesting Season. Factors affecting estimated production parameters on individual reef complexes will be discussed in this report.

Vessel Counts

The most recent vessel counts indicated that most of the fishing fleet was concentrated on Cat Point and East Hole Bars when the 2011/12 Winter Harvesting Season opened. Vessels counts to monitor fishing pressure showed that oystermen moved their fishing effort from reefs in the western portion of the Bay to reefs in St. George Sound, primarily Cat Point and East Hole Bars in 2011. Fishing effort throughout the winter and spring of 2011 placed added pressure on Cat Point and East Hole Bars, which, in conjunction with fishing effort that was placed on these reefs during the summer of 2010 in response to the oil spill event, resulted in a cumulative increase in harvesting pressure from a relatively limited resource.

Vessel counts during the Summer Harvesting Season confirmed that typical seasonal harvesting efforts returned to bars in the Summer Harvesting Areas, in sharp contrast to the previous summer (2010) when management responses to the Deep Water Horizon (DWH) oil spill contributed to directing fishing effort to bars that are normally closed during the summer harvesting season. Vessel counts showed harvesters moved back to the traditional Summer Harvesting Area and effort was concentrated primarily on Lighthouse Bar and Norman's Bar.

Cat Point Bar and East Hole Bar

Cat Point Bar and East Hole Bar have historically been the primary producing reefs in Apalachicola Bay. These reefs form a contiguous reef system (except for the Intracoastal Waterway) that extends north to south across St. George Sound and separates the sound from Apalachicola Bay. Over the past twenty years, landings from these reefs have been critical to supporting the oyster fishery in the region.

Oyster density and estimated production showed marked increases on Cat Point Bar when compared to 2010. Estimated production increased from 334 bags per acre in September 2010 to 417 bags per acre in September 2011 (Table 2). Oyster densities increased more substantially from 208 to 429 oysters per meter over the same sampling interval. The increase in oyster density reflects strong recruitment, as well as a high number of oysters in the juvenile and sublegal size classes. Nearly 96% of the oyster population sampled on Cat Point were less than three inches (Table 2).

Because harvesting pressure has been relatively intense over the sampling period, population parameters can be associated with harvesting and environmental influences. Oyster population parameters for Cat Point Bar and reported landings over the past three years suggest that oyster abundances and potential production is depressed, reflecting the effects of continuous harvesting, as well as, less than optimal environmental conditions in 2010 and 2011. Excessive harvesting of sub-legal oysters reduced recruitment among sub-legal size classes to legal size, and higher salinity regimes adversely affected recruitment, survival and growth, contributing to stable or declining trends in population dynamics in 2010. Although, environmental conditions improved with relatively normal rainfall and river discharge in 2009 and early 2010, and abundant spat fall was reported on Cat Point and East Hole Bars during 2010, oyster resources have not rebounded completely. Conditions began to decline and drought conditions have prevailed in the Apalachicola River Basin since August 2010. With drought conditions returning to the region, decreased rainfall and river discharge have contributed to stress on oyster populations in Apalachicola Bay.

Dry Bar and St. Vincent Bar

The Dry Bar and St. Vincent Bar complex is a large contiguous reef system in western Apalachicola Bay. This reef complex provides a substantial portion of the Bay's landings during normal years, but fishing pressure was sporadic during 2010 and 2011. The estimated production for Dry Bar-St. Vincent (Table 2) indicated a modest decrease from 341 bags per acre in August 2010 to 323 bags per acre in August 2011, probably reflecting poor recruitment and survival resulting from higher salinity regimes over the past year. Fishing pressure has declined as a result of reduced standing stocks of market-size oysters. The current condition of oyster resources on St. Vincent Bar is somewhat typical during drought periods.

Fishery Trends in Apalachicola Bay

Annual oyster resource surveys showed moderate fluctuations in oyster densities, standing stocks and production estimates. Downward fluctuations can be attributed to less than optimal environmental conditions, increased predation and natural mortality resulting in weak recruitment, and extensive harvesting on some of the major reef complexes. It is evident from divers' observations that many reefs in Apalachicola Bay are showing the negative effects of decreased rainfall and freshwater flow rates from the Apalachicola River over the past year, including decreased recruitment and increased natural oyster mortality (predation, disease, and stress associated with high salinity regimes).

The overall condition of reefs and the abundance of juvenile, sub-legal, and market-size oysters suggest that the overall condition of many reefs has declined over the past two years. Some of the decline of legal-size oysters can be attributed to the excessive harvesting of sub-legal oysters during the fall and winter of 2010, when a "use it or loose it' attitude prevailed. The outlook for oyster production for the 2011/2012 Winter Harvesting Season in St. George Sound (Cat Point, East Hole, Porters Bar and Platform) is described as "moderate", but the short-term outlook is not as dire as the perception currently expressed by the oyster industry. However, it remains uncertain whether oyster populations on Cat Point and East Hole Bars can sustain concentrated harvesting effort for the remainder of the Winter Harvesting Season.

Harvesting pressure is usually high on reefs in the eastern portion of the Bay at the beginning of the oyster harvesting season, but in 2011 harvesting pressure was almost exclusively directed to Cat Point and East Hole Bars. Harvesting pressure on Cat Point Bar and East Hole Bar in St. George Sound demonstrates an upward trend in effort over the past two years. This change in fishing effort is not easy to explain, since it does not seem to be strictly associated with resource availability. One plausible explanation may be the proximity of St. George Sound to Eastpoint, where many licensed oystermen reside.

Estimated production parameters for the minor reef complexes in the western portion of the bay and the "Miles" indicate that standing stocks of market size oysters are at various levels. Standing stocks on some reefs will support commercial harvesting, while other reefs show signs of stress. Oystermen may have to become more intent on searching for reefs where oyster stocks are more abundant, since minor reefs are expected to support an increasing level of harvesting as fishing effort shifts away from Cat Point and East Hole Bars.

Cursory analyses of oyster resource assessment data over the past two years indicate several general conclusions regarding oyster resources in Apalachicola Bay.

The outlook for oyster production for the 2011/2012 Winter Harvesting Season is described as "moderate".

Stable or declining population estimates over the past two years generally indicated that oyster populations are stressed. During 2010 and 2011, oyster population parameters reflected relatively stable production estimates, which when compared to harvesting pressure (number of trips) suggests that resource availability may not be capable of sustaining current harvesting levels (bags per trip). The number of bags per trip has declined each year for the past five years.

Prior to 2009, the demand for oysters from Apalachicola Bay was a primary factor limiting harvests, as harvests did not appear to be limited by available stocks. Higher landings in 2009 likely reflected strengthening market demand and increased fishing effort rather than increased resource availability. However, it is likely that 2011/2012 will bring increased demand for Apalachicola Bay oysters, since landings from many historically productive areas in other Gulf states may decline as the result of various challenges. At the same time, oyster resource availability has not markedly improved during the recent drought. Consequently, oyster resources may not be adequate to support increased harvesting pressure throughout the upcoming season.

Oyster population estimates indicate that recruitment will keep pace with harvesting pressure and sustain production throughout the 2011/12 Winter Harvesting Season. However, substantially increasing harvesting pressure and/or the unabated harvesting of sublegal stocks may alter the production / harvesting balance. Again in 2011, there are reports that the harvest and sale of oysters below the legal size limit is still common practice. However, estimated production parameters indicate that there are sufficient stocks to support harvesting over the short term and that there are sufficient numbers of juvenile oysters to support harvesting throughout the season, if they are returned to the reef and allowed to grow to marketable size.

There were numerous reports of oystermen harvesting oysters below the legal size limit, and observations in the marketplace confirmed that the harvest of small oysters was very common during the DWH oil spill event. This situation resulted from harvesting and culling practices attributed to fishermen responding to the uncertainties that the Bay would be closed and the fishery lost. Throughout the period when oil posed an unpredictable threat to the oyster fishery, less effort was directed toward enforcing size limits, perhaps, yielding to the view that it would be more beneficial to harvest the available resource, a "use-it or loose-it" approach.

Table 2. Cat Point Bar Population Estimates: September, 2008 to September, 2011.

Sample		Oyster	Mean	Density	Oysters				Bags
Date	Quadrat (0.25m)	Number (n)	Leng. (mm)	(/m)	>50mm (%)	>75mm (%)	(/m)	1000x (/ac)	(/ac)
09/08	20	616	55.2	123.2	66.2	17.21	21.2	85.8	381
11/08	10	564	52.0	225.6	55.7	19.33	43.6	176.4	784
12/08	10	333	56.9	133.2	66.1	24.92	33.1	134.3	597
08/09	20	828	50.1	165.6	49.9	15.10	25.0	101.1	449
11/09	10	626	48.2	250.4	50.2	7.83	19.6	79.3	352
04/10	20	969	48.4	193.8	46.7	9.91	19.2	77.7	345
08/10	20	1,043	50.5	208.6	53.9	8.92	18.6	75.3	334
11/10	20	865	52.8	173.0	63.7	12.25	21.2	85.7	381
08/11	15	1,611	48.2	429.6	48.5	5.40	16.7	67.5	417

Table 2. East Hole Bar Population Estimates: November, 2008 to November, 2010.

Sample		Oyster	Mean	Density	Oysters				Bags
Date	Quadrat (0.25m)	Number (n)	Leng. (mm)	(/m)	>50mm (%)	>75mm (%)	(/m)	1000x (/ac)	(/ac)
11/08	10	318	57.5	127.2	69.1	22.33	28.4	114.9	510
09/09	20	1,023	49.3	204.6	50.7	9.09	18.5	75.2	334
11/10	10	682	47.0	272.8	48.6	9.38	25.6	103.6	460

Table 2. Dry Bar Population Estimates: September, 2008 to September, 2011.

Sample		Oyster	Mean	Density	Oysters				Bags
Date	Quadrat (0.25m)	Number (n)	Leng. (mm)	(/m)	>50mm (%)	>75mm (%)	(/m)	1000x (/ac)	(/ac)
09/08	20	1,467	54.0	293.4	64.1	14.86	43.6	176.4	784
12/08	10	986	47.1	394.4	49.8	7.81	30.8	124.6	554
08/09	20	1,353	46.6	272.6	41.2	6.31	17.2	69.6	309
11/09	10	589	45.6	235.6	41.7	7.13	16.7	67.9	302
08/10	20	877	50.2	175.4	50.5	10.83	18.9	76.8	341
11/10	20	1,313	43.1	262.5	34.4	11.65	30.5	123.8	550
08/11	15	567	47.5	151.2	44.8	11.90	17.9	72.7	323

Table 2. North Spur (Plant) Population Estimates: September, 2008 - September, 2011.

Sample		Oyster	Mean	Density	Oysters				Bags
Date	Quadrat (0.25m)	Number (n)	Leng. (mm)	(/m)	>50mm (%)	>75mm (%)	(/m)	1000x (/ac)	(/ac)
09/08	5	284	52.9	227.2	60.6	10.56	23.9	97.0	431
09/09	10	541	49.5	216.4	49.9	12.75	27.5	111.6	496
04/10	5	1040	48.0	832.0	50.4	5.10	42.4	171.7	763
08/11	5	269	52.9	215.2	58.0	15.99	34.4	139.2	619

Exhibit 7

From: Heil, David
Sent: Tuesday, April 23, 2013 11:18 AM
To: Estes, Jim
Subject: RE: Report

And, I sent a needed correction to language I sent NOAA Fisheries Service:

> Note: No size limits, bag limits, gear or any other provision of the oyster rules were deviated or waived for oysters in 2010 (or anytime before 2010 or anytime after 2010). Based on oyster conservation, the Agency (FWC) did not change anything except the several seasonal dates described. Even if FWC would have been requested to change size limits, bag limits, gear, . . . the request would ~~not~~ have been denied.

From: Heil, David
Sent: Tuesday, April 23, 2013 10:16 AM
To: Estes, Jim
Subject: FW: Report

See latest email response below from NOAA Fisheries Service.

I WILL NEED ASSISTANCE TO ADDRESS THIS.

Below are highlighted excerpts from the DACS Report addressing fishery practices, over-harvest and or undersized-harvest:

Oyster Resource Assessment Report
Apalachicola Bay
August 2012
Department of Agriculture and Consumer Services
Division of Aquaculture

Executive Summary

Observations and sampling of oyster populations on the primary oyster producing reefs in Apalachicola Bay during July 2012 indicated that oyster populations were depleted over most of the reef areas sampled and that surviving oyster populations are severely stressed. Staff of the Department of Agriculture and Consumer Services' Division of Aquaculture conducted assessments of oyster populations after preliminary reconnaissance following the passage of Tropical Storm Debby indicated that oyster populations on Cat Point Bar and East Hole Bar were in poor condition. More detailed sampling and analyses confirmed the condition of oyster resources and suggested that the poor condition was the result of combination of environmental factors and fishery practices. Analyses and observations further suggested that Tropical Storm Debby was only a minor contributing factor to the overall poor condition of oyster resources and confirmed evidence that prolonged drought conditions, continuing low river discharge rates and intensive harvesting were adversely affecting oyster populations in Apalachicola Bay.

This report provides interpretative analyses of sampling data, fisheries data, environmental conditions, fishery practices and other factors to describe the current status of oyster resources and predict oyster fishery trends for the 2012/13 Winter Harvesting Season in Apalachicola Bay. Analyses and observations indicate that a combination of factors have resulted in a cascading effect that has contributed to the depletion of oyster populations and may lead to longer-term debilitation of oyster resources and oyster reef habitats.

Introduction

The Florida Department of Agriculture and Consumer Services (DACS) shares responsibility for managing oyster resources in Apalachicola Bay with the Florida Fish and Wildlife Conservation Commission (FWC); more specifically, the Division of Aquaculture manages oysters from both resource development and public health protection perspectives. This report summarizes information related to oyster resource compiled by the Division of Aquaculture from 2009 through August 2012.

Oyster Fisheries Statistics

Since 1980, reported landings of oysters in Florida ranged from about 1 to 6.5 million pounds of meats: highest landings were reported in the early 1980s, around 6.5 million pounds. Apalachicola Bay accounts for about 90% of Florida's landings and about 9% of the landings from the Gulf of Mexico (2000-2008 average). Reported oyster landings from Apalachicola Bay for 2011 were approximately 2.4 million pounds of meat, representing a slight increase in landings from 2010 (Table 1).

In 2011, oystermen in Franklin County reported landings of 2,380,810 pounds of meats from 39,176 trips. Landings for Apalachicola Bay are higher than reported for Franklin County, because oystermen in neighboring counties may report landings from Apalachicola Bay in those counties.

Table 1. Oyster Landings in Apalachicola Bay, Florida

Year	Pounds (Meats)	Number of Trips Reported	AB Oyster Harvesting Licenses	Bags/ Trip
2000	2,327,402	25,550	958	13.9
2001	2,333,968	25,261	1,135	14.1
2002	1,725,776	20,294	914	13.0
2003	1,449,890	18,467	759	12.0
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2005	1,260,996	12,663	714	15.2
2006	2,127,049	22,644	916	14.3
2007	2,645,359	29,104	1,142	13.9
2008	2,238,482	27,603	1,168	12.3
2009	2,695,701	39,942	1,433	10.2
2010	1,938,059	32,330	1,909	9.1
2011	2,380,810	39,176	1,799	9.3
2012			1,687	

Landings per trip remained relatively stable during 2010 and 2011, ranging from 9.1 to 9.3 bags per trip. Landings per trip continued to trend downward from about 15 bags per trip in 2005 to about 9.3 bags per trip in 2011. Oyster landings and bags per trip do not show a direct correlation with the number of ABOHL sold; there were 1,799 ABHOL sold in 2011 and 1,687 sold in 2012. The dockside value of oyster landed in Franklin County was estimated at $6.64 million in 2011.

Oyster landings appear to be correlated with three primary variables; resource availability, fishing effort, and market demand. Fishing effort has increased while market demand has been highly variable due to economic instability, concerns associated with the Deep Water Horizon (DWH) oil spill incident in 2010, and inconsistent supplies from other Gulf states.

Oyster Resource Assessments

The Division has conducted oyster resource surveys on the principle oyster-producing reefs in Apalachicola Bay since 1982. This information is used by resource managers to reliably predict trends in oyster production; to monitor oyster population dynamics, including recruitment, growth, natural mortality, standing stocks; and to determine the impacts of climatic events such as hurricanes, floods, and droughts on oyster resources. Sampling oyster populations allows resource managers to compare the relative condition of standing stocks over time using a defined sampling protocol. The Standard Oyster Resource Management Protocol (SORMP) provides a calculation to estimate production based on the density of legal size oysters collected during a defined sampling interval. Production estimates exceeding 400 bags of oysters per acre is applied as an indicator of healthy oyster reefs capable of sustaining commercial harvesting.

The Division of Aquaculture conducted oyster resource assessments on the commercially important oyster reefs in Apalachicola Bay during July 2012. Commercially important reefs included Cat Point Bar, East Hole Bar and the St. Vincent Bar and Dry Bar reef complex. Oyster resource assessments were also conducted on three recently rehabilitated reefs, and on shallow and intertidal reefs in St. Vincent Sound.

Production estimates for July 2012 from Cat Point Bar (287 bags/acre) and East Hole Bar (294 bags/acre) were the lowest production estimates reported in the past twenty years prior to the opening of the Winter Harvesting Season. Similarly, production estimates from St. Vincent Bar and Dry Bar (bags per acre) demonstrated depressed production estimates. Estimated oyster population parameters for Cat Point Bar, East Hole Bar and St. Vincent / Dry Bar are below levels generally observed on these reefs prior to opening the Winter Harvesting Season, and suggest that stocks are not sufficiently abundant at this time to support commercial harvesting throughout the Winter Harvesting Season. Factors affecting estimated production parameters on individual reef complexes are discussed later in this report.

Cat Point Bar and East Hole Bar have historically been the primary producing reefs in Apalachicola Bay. These reefs form a contiguous reef system (except for the Intracoastal Waterway) that extends north to south across St. George Sound and separates the sound from Apalachicola Bay. Over the past twenty years, landings from these reefs have been critical to supporting the oyster fishery in the region.

Oyster density and estimated production showed marked declines on Cat Point Bar when compared to 2011. Estimated production declined from 417 bags per acre in August 2011 to 287 bags per acre in July 2012 (Table 2). Oyster densities decreased substantially from 430 to 64 oysters per square meter over the same sampling interval (Table 2). The decrease in oyster density reflects poor recruitment, as well as severely reduced number of oysters in the juvenile size classes, and is indicative of the degraded quality of reef substrate and structure.

Cat Point and East Hole Bar have been subject to a combination of factors that have adversely affected oyster populations, oyster reef habitat, and the oyster fishery. Oyster populations over much of the reef area are depleted and the quality of the substrate is degraded to a point where spat settlement and recruitment have been disrupted. Stress associated with prolonged high salinity, high natural mortality and predation, and intensive fishing effort have markedly reduced standing stocks of juvenile, sub adult and adult oysters.

The Dry Bar and St. Vincent Bar complex is a large contiguous reef system in western Apalachicola Bay. This reef complex provides a substantial portion of the Bay's landings during normal years, but fishing pressure was sporadic during 2011 and 2012. The estimated production for Dry Bar-St. Vincent (Table 2) indicated a substantial reduction from 323 bags per acre in August 2011 to 215 bags per acre in July 2012. Samples were collected from the Little Gully area on Dry Bar, because no live oysters were collected on St. Vincent Bar. St. Vincent Bar, extending from Dry Bar southward was considered to be depleted of marketable oysters. The oyster population on St. Vincent Bar was likely decimated by stress associated with high salinity, disease and predation. Fishing pressure has declined as a result of reduced standing stocks of market-size oysters over the entire reef complex over the past two years. The current condition of oyster resources on Dry Bar is not expected to be at levels that will sustain commercial harvesting through the 2012/13 Winter Harvesting Season.

Estimated production parameters for the reef complexes in the western portion of the Bay and the "Miles" indicate that standing stocks of market size oysters are at various levels. Standing stocks on some reefs will support commercial harvesting, while other reefs show signs of severe stress and depletion. Oyster reefs, including North Spur, Green Point and Cabbage Lumps Plant Sites are in moderately good condition, with standing stocks and production at levels that will support limited commercial harvesting. These plant sites have been planted with processed oyster shell within the last three years, and the substrate remains in good condition; size frequency distributions are typical of healthy oyster populations. However, these reefs are small and overall production will be limited. Also, oysters on these reefs will likely be subject to intense predation from rock snails, while salinity levels remain high. Oyster populations on shallow and intertidal reefs in the 'Miles' (Spacey's Flats, Eleven Mile Bar, Picolene Bar) are also severely stressed, showing signs of intense predation and natural mortality. Bars in northwestern Apalachicola Bay and eastern St. Vincent Sound, including Green Point, North Spur and Cabbage Lumps are more strongly influenced by river flows than bars located further away from the river mouth. Prevailing flows and circulation patterns move plumes of freshwater westward from the river over these reefs before they are dispersed throughout the Bay and St. Vincent Sound.

The Standard Oyster Resource Management Protocol

Continuous monitoring and data analyses have allowed resource managers to develop a scale using defined sampling protocol to determine the relative condition of oyster resources based on estimated production parameters. The Standard Oyster Resource Management Protocol (SORMP) provides that estimated production exceeding 400 bags of oysters per acre is applied as an indicator of healthy oyster reefs capable of sustaining commercial harvesting. Accordingly, oyster populations are 1) capable of supporting limited commercial harvesting when stocks exceed 200 bags/acre, 2) below levels necessary to support commercial harvesting when stocks fall below 200 bags/acre, and 3) considered depleted when marketable stocks are below 100 bags/acre. Generally, production from Cat Point Bar has been the most accurate indicator of oyster production in Apalachicola Bay, but East Hole Bar and St. Vincent Bar are also reliable indicators of the condition of oyster resources throughout the Bay. This scale forms the basis for the Standard Oyster Resource Management Protocol provided in Subsection 68B-27.017, Florida Administrative Code, which has been used as the criteria for setting the number of harvesting days in the Winter Harvesting Season in Apalachicola Bay.

Depletion of Oyster Resources

Standing Stocks and Commercial Production Estimates

Size frequency distributions for oyster standing stocks are strong indicators of the health of oyster populations and are useful for predicting fishery trends. Size distributions among oyster populations are used to evaluate recruitment to the population, recruitment of juveniles to market size, growth, survival and potential production. Accordingly, size frequency distributions can be used to evaluate oyster depletion events. Current analyses of size frequency distributions and oyster standing stocks indicate that oyster populations on the major producing reefs in Apalachicola Bay are experiencing an on-going depletion event.

Oyster populations can be depleted from a number of factors; including climatic conditions, water quality, drought and flood events, catastrophic storms and hurricanes, natural mortality from diseases and predation, and fisheries. Most of the time, depletions occur because of a combination of these factors (multiple stressors).

Data analyses and observations on the major reef complexes showed substantial losses of oyster populations over the past two years, with severe declines in oyster densities, standing stocks and production estimates. Declining populations can be attributed to less than optimal environmental conditions (prolonged drought, reduced river discharge rates, high salinity), storm events (Tropical Storm Debby), and increased predation and natural mortality, weak recruitment, and extensive harvesting on the major reefs. It is evident from divers' observations that many reefs in Apalachicola Bay are showing the negative effects of decreased rainfall and freshwater flow rates from the Apalachicola River over the past two years, including depressed recruitment and increased natural oyster mortality (predation, disease, and stress associated with high salinity regimes). Additionally, the long-term impairment of reef structure (reef elevations, shell matrix, and shell balance) is of serious concern. Each of the factors contributing to oyster depletion in Apalachicola Bay are discussed below.

Prolonged Drought and Elevated Salinity

Adverse environmental conditions can have a devastating effect on oyster populations; and high salinity is among the most detrimental factors. Because oysters are sessile animals, they are not capable of moving when environmental conditions become less than optimal or sometimes lethal. While oysters can tolerate a wide range of salinities, prolonged exposure to less than optimal conditions will adversely impact affected populations. Oysters become physiologically stressed when salinity levels are below or above optimal levels (10-25 ppt) for extended periods, affecting reproductive potential, spatfall, recruitment, growth and survival.

Rainfall and concomitant river discharge are essential for productive oyster populations in Apalachicola Bay, and provide three critical requirements for survival. First, survival depends upon salinity regimes that are suitable for oysters to reproduce, grow and survive. Rainfall in the drainage basin and discharge into the Bay are essential, as productive oyster populations require a combination for fresh water and marine waters. Fluctuating salinity regimes, within the oyster's tolerance limits, is the single most important factor influencing oyster populations in Apalachicola Bay. Second, rainfall, flooding in the flood plain, and river discharge into the Bay are essential for supplying nutrients and detritus necessary to nourish and sustain food webs and trophic dynamics within the estuarine system. And third, rainfall and river discharge is a critical factor driving fluctuations in salinity levels that prevent destructive predators with marine affinities from becoming established in the Bay. The critical influences of rainfall and river discharge were severely diminished during the past two years. The region and much of the drainage basin have been subject to extensive drought during 2011 and 2012, and these conditions have been reflected in low river stages and low river discharge rates.

Although, environmental conditions improved with relatively normal rainfall and river discharge in 2009 and early 2010, and abundant spat fall was reported on Cat Point and East Hole Bars during 2010, oyster resources have not rebounded completely. Conditions began to decline and drought conditions have persisted in the Apalachicola River Basin since August 2010. With drought conditions returning to the region, decreased rainfall and river discharge have contributed to stress on oyster populations in Apalachicola Bay.

The Florida Panhandle and the Apalachicola River (ACF) drainage basin have experienced prolonged drought conditions for several years, and the reduced freshwater input into Apalachicola Bay has seriously affected oyster populations in the Bay. Poor recruitment and poor survival can be directly attributed to prolonged high-salinity environment, which is also confirmed by the presence of marine predators, primarily stone crabs and Florida rock snails (oyster drills). The predators are present in great numbers and are currently overwhelming oyster populations throughout Apalachicola Bay. Petes et al., (2012) and Wilber (1992) investigated the effects of reduced freshwater flows on oyster populations in Apalachicola Bay and reported adverse impacts resulting from low river flows.

Natural Mortality and Predation

The combination of high salinity and high water temperatures are known to severely stress oyster populations and may result in massive mortality events. It is highly likely that these environmental factors have contributed substantially to natural mortality and low recruitment in the Bay. High salinity and high water temperatures also correlate with the increased prevalence and intensity of the oyster parasite, *Perkinsus marinus*. This parasite (dermo) is often associated with oyster mortality in the hotter summer months and is commonly described as 'Summer Mortality Syndrome' in Florida. The Department participates in the Oyster Sentinel Program in the Gulf and monitors the presence and intensity of *P. marinus* in oysters in Apalachicola Bay.

Observations by divers confirmed the presence and abundance of stone crabs, *Menippe mercenaria*, on the primary oyster reefs in Apalachicola Bay. Stone crab burrows are easy to recognize and the appetite of these destructive predators is obvious. Stone crab burrows are surrounded by living and dead oysters; the result of crabs actively foraging and bringing live oysters to their burrows. The shells of devoured oysters are also present and form a ring around burrows. Examining dead oyster shell provides confirmation of the crushing action of stone crabs on the shell of oysters. Stone crabs are considered primary predators of oysters when salinities remain high for extended periods and crab populations become established on oyster reefs.

Observations and sampling confirmed the presence and abundance of the Florida rock snail, *Stramonita haemastoma*, (formerly *Thais haemastoma*), a destructive snail commonly referred to as an oyster drill. Oyster drills are considered as one of the most serious oyster predators along Florida's Gulf Coast, and have become established in Apalachicola Bay over the past two years. Reports from oystermen suggest that drills are more abundant than at any time in recent memory. It appears that drill populations are moving farther into the estuary as oyster populations in the more marine portions of the Bay are depleted. High numbers of drills were found wherever viable oyster populations were observed. The presence and establishment of snail populations correlate with prolonged high salinity waters. It is also disturbing that drills are completing their life cycles within the estuary, since egg cases, juvenile, subadult and adult snails are abundant on oyster reefs.

Additionally, the Florida crown conch, *Melongena corona*, was commonly observed on oyster reefs. These conchs are also known to be serious oyster predators with marine affinities. Mud crabs of various species are also common predators on oyster reefs, generally attacking spat and smaller juvenile oysters.

Increased stress associated with high salinity regimes acts to exacerbate the level and intensity of predation by weakening oysters. Prolonged periods of high salinity result in natural mortality from predation which can have a significant impact on oyster populations and result in serious economic losses to commercial oyster fisheries. The presence and abundance of marine predators on oyster reefs in Apalachicola Bay the long duration of high salinity conditions within the estuary.

Harvesting Pressure

Declining oyster population parameters can be associated with harvesting, as well as environmental influences and natural mortality. Reported oyster landings for Franklin County in 2011 increased marginally over 2010 in both production and bags per trip, but harvesting pressure (as measured in reported trips) increased by about 20 percent. Oyster population parameters for Cat Point Bar and East Hole Bar suggest that oyster abundances and potential production is markedly depressed, possibly reflecting the effects of continuous harvesting, poor harvesting practices, as well as, less than optimal environmental conditions in 2010 and 2011. Over harvesting is most damaging when environmental conditions are less than optimal, recruitment is low, and natural mortality is high.

Resource managers believe that several activities associated with harvesting have had a detrimental impact on standing stocks and oyster resources on the primary producing reefs in St. George Sound in eastern Apalachicola Bay. The standing stocks of juvenile, sub-legal, and market-size oysters suggest that the overall condition of many reefs has declined substantially over the past two years as a result of continuous harvesting from Cat Point and East Hole Bars, concentrated and intensive harvesting by the majority of the fishing fleet, and the excessive harvesting of sub-legal oysters.

Vessel counts during the 2011/12 Winter Harvesting Season show that about 60 percent of the fishing fleet was concentrated on Cat Point and East Hole Bars. Fishing effort often averaged more than 120 vessels per day throughout 2011 and 2012 placing added pressure on Cat Point and East Hole Bars. In response to limiting the number of hours harvest can occur each day to control for *Vibrio vulnificus*, additional harvesting days during 2011 and 2012 were implemented which increased fishing pressure and further deteriorated the condition of the resource. Another contributing factor was the management decision to allow harvesting from these reefs during the summer of 2010 in response to the oil spill event (April, 2010). This resulted in an intense harvesting effort which precluded any recovery time for the resource

Harvesting pressure is usually high on reefs in the eastern portion of the Bay at the beginning of the oyster harvesting season, and in 2011 and 2012 harvesting pressure was almost exclusively directed to Cat Point and East Hole Bars. Harvesting pressure on Cat Point Bar and East Hole Bar in St. George Sound demonstrated an upward trend in effort over the past two years. This change in fishing effort is not easy to explain, since it does not seem to be strictly associated with resource availability. One plausible explanation may be the proximity of St. George Sound to Eastpoint, where many licensed oystermen reside and sell their oysters.

Some of the decline of legal-size oysters can be attributed to the excessive harvesting of sub-legal oysters. Since 2010, there have been numerous reports of oystermen harvesting oysters below the legal size limit, and observations in the marketplace confirmed that the harvest of small oysters was very common during the DWH oil spill event and has persisted to the present. Excessive harvesting of sub-legal oysters from 2010 through 2012 reduced recruitment among sub-legal size classes to legal size, contributing to declining trends in estimated production in 2012/2013. This situation results from harvesting and culling practices of the fishermen, when sub-legal oysters are not culled and returned to the reef to grow to marketable size.

The practice of harvesting sub-legal oysters appears to be an extension of a "use it or lose it' attitude that prevailed during the fall and winter of 2010. Following the oil spill in April 2010, there was an acknowledged threat to oyster resources in Apalachicola Bay, and management policies were directed toward harvesting available resources in the face of a growing risk of loss. Throughout the period when oil posed an unpredictable threat to the oyster fishery, less effort was directed toward enforcing size limits, perhaps, yielding to the view that it would be more beneficial to harvest the available resource. But unfortunately, many oystermen have continued the same harvesting practices that were allowed during the oil spill threat.

The Division's 2011 *Oyster Resource Assessment Report for Apalachicola Bay* (Division of Aquaculture, 2011) stated that oyster population estimates indicated that recruitment would keep pace with harvesting pressure and sustain production throughout the 2011/12 Winter Harvesting Season: with the caveat that increased harvesting pressure and/or the unabated harvesting of sublegal stocks may alter the production / harvesting balance. In 2011, reports of the harvest and sale of oysters below the legal size limit was still common practice, and it is now clear that there are not sufficient numbers of juvenile and market size oysters to support harvesting throughout the up coming season.

Tropical Storm Debby

Tropical Storm Debby made its closest approach to Apalachicola Bay on June 25, 2012 before moving eastward and making landfall near the mouth of the Suwannee River. Despite the fact that Debby never achieved hurricane strength, it was accompanied by moderate storm surge in the Big Bend region. Maximum surge at Apalachicola was 3.51 feet.

The greatest impacts to oyster reefs were expected to be in St. George Sound and western Apalachicola Bay (St. Vincent Bar) because of the long fetch of open water. Scouring was expected as a result of storm surge and wave action across the Bay. Fortunately, most of the storm surge and strongest wave action occurred during high tides when the reefs are most protected from severe hydrological impacts.

Preliminary reconnaissance following T.S.Debby did not indicate severe disruption of oyster reef structure. Examination of shells and live oysters did not display the effects of severe scouring (ex. polished shell surfaces, abrasion, dead oysters) and observations by divers did not demonstrate extensive disruption of the reef's surface (suspension and deposition of reef shell and sediments, concretion of reef material, or burial of shell and living oysters). Although reef areas were sometimes devoid of live oysters, clusters of oysters were present in adjacent areas that did not indicate severe disturbance. Scouring and wave action may have impacted reef surfaces and oyster resources in some areas, but widespread damage to reef structure was not observed.

Heavy rainfall and coastal flooding may have an adverse impact on oyster reefs closest to the river and distributaries in the river delta, but the sudden influx of freshwater did not appear to cause extensive oyster mortalities on reefs away from the river delta (reefs in the Winter Harvesting Areas). Preliminary reconnaissance and sampling did not identify oyster populations where mass mortalities occurred; it is generally apparent when a mass mortality event occurs from a freshet or poor water quality (low dissolved oxygen concentrations). However, it remains likely that oyster populations in close proximity to the river delta may be subject to prolonged low salinity and associated low dissolved oxygen concentrations, and may suffer mortalities. There have been some reports of recent mortalities (late July) among oysters on reefs in the Summer Harvesting Area (Norman's Lumps).

Fishery Management Implications

The Department of Agriculture and Consumer Services and the Fish and Wildlife Conservation Commission enacted several policies that allowed oystermen a greater opportunity to harvest available oyster resources in Apalachicola Bay in response to the Deepwater Horizon oil spill event and national shellfish program requirements. The Executive Director of the FWCC signed an Executive Order that allowed commercial harvest of oysters from Apalachicola Bay seven days a week beginning September 1, 2011, contingent upon the Standard Oyster Resource Management Protocol (SORMP). On June 1, 2012, the FWCC enacted rule amendments in Chapter 68B-27.017 that allowed harvesting of oysters seven days a week, year round in Apalachicola Bay. This action was taken, in part, to accommodate commercial oyster fishermen for time on the water harvesting that was decreased as a result of recent management practices to enhance public health protection. These practices, consistent with national *Vibrio vulnificus* reduction criteria, imposed more stringent limitations on harvesting times from April through November.

Subsection 68B-27.017(1)(a), Florida Administrative Code, provides that oysters may be harvested for commercial purposes on any day of the week. Subsection (1)(b) provides that - If during the period of November 16 through May 31 DACS establishes that the oyster resources on Cat Point Bar and East Hole Bar can not sustain a harvest of 300 bags per acre (SORMP), then the harvest of oysters for commercial purposes shall be prohibited on Saturdays and Sundays. Results of the current assessment indicated that estimated production on Cat Point Bar and East Hole Bar may not exceed the level provided in the SORMP for DACS to recommend that oyster harvesting for commercial purposes be continued at seven days a week. Oyster resources will be re-assessed in November and recommendations will be forwarded to the Florida Fish and Wildlife Conservation Commission.

Fishery Trends

Analyses of oyster resource assessment data over the past two years indicate several general conclusions regarding oyster resources in Apalachicola Bay.

The outlook for oyster production for the 2012/2013 Winter Harvesting Season in St. George Sound (Cat Point, East Hole, Porters Bar and Platform) is described as "poor". It appears unlikely that oyster populations on Cat Point and East Hole Bars can sustain concentrated harvesting effort throughout the Winter Harvesting Season.

Declining population estimates over the past two years generally indicated that oyster populations are severely stressed. Although oyster population parameters for 2010 and 2011 reflected relatively stable production estimates, declines in 2012 suggest that overall resource availability may not be capable of sustaining current harvesting levels (bags per trip). The number of bags per trip has continued to decline over the past five years.

Prior to 2009, the demand for oysters from Apalachicola Bay was a primary factor limiting harvests, as harvests did not appear to be limited by available stocks. Higher landings in 2009 likely reflected strengthening market demand and increased fishing effort rather than increased resource availability. However, in 2011/2012 demand for Apalachicola Bay oysters increased because of reduced production from historically productive areas in other Gulf states, while oyster resources in the Bay have suffered during the current drought. Consequently, oyster resources may not be adequate to support increased harvesting pressure and meet increased demand throughout the upcoming season.

Table 2. Cat Point Bar Population Estimates: September 2008 to July 2012.

Sample		Oyster	Mean	Density	Oysters				Bags
	Quadrat	Number	Leng.		>50mm	>75mm		1000x	
Date	(0.25m)	(n)	(mm)	(/m)	(%)	(%)	(/m)	(/ac)	(/ac)
09/08	20	616	55.2	123.2	66.2	17.21	21.2	85.8	381
11/08	10	564	52.0	225.6	55.7	19.33	43.6	176.4	784
12/08	10	333	56.9	133.2	66.1	24.92	33.1	134.3	597
08/09	20	828	50.1	165.6	49.9	15.10	25.0	101.1	449
11/09	10	626	48.2	250.4	50.2	7.83	19.6	79.3	352
04/10	20	969	48.4	193.8	46.7	9.91	19.2	77.7	345
08/10	20	1,043	50.5	208.6	53.9	8.92	18.6	75.3	334
11/10	20	865	52.8	173.0	63.7	12.25	21.2	85.7	381
08/11	15	1,611	48.2	429.6	48.5	5.40	23.2	93.9	417
07/12	10	161	58.8	64.4	67.1	24.84	15.9	64.7	287

Table 2. East Hole Bar Population Estimates: November 2008 to July 2012.

Sample		Oyster	Mean	Density	Oysters			-	Bags
Date	Quadrat (0.25m)	Number (n)	Leng. (mm)	(/m)	>50mm (%)	>75mm (%)	(/m)	1000x (/ac)	(/ac)
11/08	10	318	57.5	127.2	69.1	22.33	28.4	114.9	510
09/09	20	1,023	49.3	204.6	50.7	9.09	18.5	75.2	334
11/10	10	682	47.0	272.8	48.6	9.38	25.6	103.6	460
07/12	10	127	60.8	50.8	65.3	32.28	16.3	66.3	294

Table 2. Dry Bar Population Estimates: September 2008 to July 2012.

Sample		Oyster	Mean	Density	Oysters			-	Bags
Date	Quadrat (0.25m)	Number (n)	Leng. (mm)	(/m)	>50mm (%)	>75mm (%)	(/m)	1000x (/ac)	(/ac)
09/08	20	1,467	54.0	293.4	64.1	14.86	43.6	176.4	784
12/08	10	986	47.1	394.4	49.8	7.81	30.8	124.6	554
08/09	20	1,353	46.6	272.6	41.2	6.31	17.2	69.6	309
11/09	10	589	45.6	235.6	41.7	7.13	16.7	67.9	302
08/10	20	877	50.2	175.4	50.5	10.83	18.9	76.8	341
11/10	20	1,313	43.1	262.5	34.4	11.65	30.5	123.8	550
08/11	15	567	47.5	151.2	44.8	11.90	17.9	72.7	323
07/12	10[a]	150	56.0	60.0	66.0	20.0	12.0	48.6	215[a]

a - Samples collected from Little Gully on Dry Bar. No live oysters were collected from St. Vincent Bar

Table 2. North Spur (Plant) Population Estimates: September 2008 - July 2012.

Sample		Oyster	Mean	Density	Oysters			-	Bags
Date	Quadrat (0.25m)	Number (n)	Leng. (mm)	(/m)	>50mm (%)	>75mm (%)	(/m)	1000x (/ac)	(/ac)
09/08	5	284	52.9	227.2	60.6	10.56	23.9	97.0	431
09/09	10	541	49.5	216.4	49.9	12.75	27.5	111.6	496
04/10	5	1040	48.0	832.0	50.4	5.10	42.4	171.7	763
08/11	5	269	52.9	215.2	58.0	15.99	34.4	139.2	619

07/12	10	362	53.4	144.8	57,5	18.23	26.4	106.8	475

Table 2. Green point (Plant) Population Estimates: September 2008 - July 2012.

Sample		Oyster	Mean	Density	Oysters			-	Bags
Date	Quadrat (0.25m)	Number (n)	Leng. (mm)	(/m)	>50mm (%)	>75mm (%)	(/m)	1000x (/ac)	(/ac)
09/08	10	482	58.8	192.2	75.9	20.33	39.2	158.6	705
09/09	10	274541	48.2	109.6	44.1	17.52	19.2	77.7	345
09/11	10	510	54.4	204.0	65.5	12.94	26.4	106.5	474
07/12	5	125	59.6	100.0	65.0	28.00	28.0	113.3	503

From: Steve Branstetter - NOAA Federal [mailto:steve.branstetter@noaa.gov]
Sent: Tuesday, April 23, 2013 9:22 AM
To: Heil, David
Subject: Re: Report

just remember, your Agriculture report states such harvest did occur.

On Tue, Apr 23, 2013 at 8:54 AM, Heil, David <David.Heil@myfwc.com> wrote:

Understood. Thursday morning, I will send you the orders in Appendix 5 and we can further discuss this issue and any other issue you find. These discussions are very helpful to us.

Note: No size limits, bag limits, gear or any other provision of the oyster rules were deviated or waived for oysters in 2010 (or anytime before 2010 or anytime after 2010). Based on oyster conservation, the Agency (FWC) did not change anything except the several seasonal dates described. Even if FWC would have been requested to change size limits, bag limits, gear, . . . the request would not have been denied.

From: Steve Branstetter - NOAA Federal [mailto:steve.branstetter@noaa.gov]
Sent: Tuesday, April 23, 2013 7:35 AM
To: Heil, David
Subject: Re: Report

You don't include Appendix 5 for our cross-reference, but you do note the following

Florida's Governor issued Executive Order Numbers 10-99, 10-100 and numerous subsequent ones extending these Orders (Appendix 5). The Orders specify that the Governor delegates to agencies: "to deviate from the statutes, rules, ordinances and orders they administer, and I delegate to such agencies the authority to waive or deviate from such statutes, rules and ordinances or orders to the extent that such actions are needed to cope with this emergency."

and then follow it up with descriptions of opening seasons early for all areas. you note landings were down, but like you note, I suspect the lack of product is more related to lack of ability to sell gulf seafood.

Nevertheless, a disaster has to be beyond the scope and control of management. This relaxation of harvest restrictions in 2010 could be a reason for lack of oysters in 2013.

On Mon, Apr 22, 2013 at 10:50 PM, Heil, David <David.Heil@myfwc.com> wrote:

Steve,
I will address. Thanks. There was and is no allowable undersized harvest (above the tolerances allowed by rule). Industry pushes undersized harvest at times and law enforcement responds appropriately. I will make that crystal clear. Again, thank you. Please Keep reviewing, I would rather take care of all misconceptions and explain anything needed before we submit report.
David

Sent from my iPhone

On Apr 22, 2013, at 6:08 PM, "Steve Branstetter - NOAA Federal" <steve.branstetter@noaa.gov<mailto:steve.branstetter@noaa.gov>> wrote:

sorry, hit send too quick.

You state that in 2010 and 2011 the state allowed harvest of undersized oysters and continues to do so. And now in 2013, you have minimal harvestable oysters in the system. Lets see 3 years........ hmmmmmmm.

On Mon, Apr 22, 2013 at 3:21 PM, Heil, David <David.Heil@myfwc.com<mailto:David.Heil@myfwc.com>> wrote:
Attached. Draft is in review and subject to change. Your input would be greatly appreciated.

From: Steve Branstetter - NOAA Federal
[mailto:steve.branstetter@noaa.gov<mailto:steve.branstetter@noaa.gov>]

Sent: Monday, April 22, 2013 3:15 PM
To: Heil, David
Subject: Re: Report

sure

On Mon, Apr 22, 2013 at 3:02 PM, Heil, David <David.Heil@myfwc.com<mailto:David.Heil@myfwc.com>> wrote:
Steve,

Our agency is drafting the Report containing the information in support of the Florida Governors' request for the oyster fishery failure. I anticipate the Report will be sent to Roy on May 1, 2013.

I can send you a draft to you if you think that will help your review and or our strengthen our Report. Just let me know.

Thanks,
David

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Steve Branstetter, Ph.D., Gulf Branch Chief
NMFS, SERO
263 13th Ave. S.
St. Petersburg, FL 33701
727-551-5796

--

Steve Branstetter, Ph.D., Gulf Branch Chief
NMFS, SERO
263 13th Ave. S.
St. Petersburg, FL 33701
727-551-5796

Exhibit 8

From: Estes, Jim
Sent: Monday, April 29, 2013 3:36 PM
To: Wiley, Nick
Cc: McCawley, Jessica
Subject: Re: need some info ASAP on oysters

It does. It clearly states that recruitment overfishing did not occur. However, the original DACS report cited overfishing as one of the culprits. We will add a section to our report explaining that this was not the case, citing UF report rationale.

Sent from my iPhone

On Apr 29, 2013, at 1:00 PM, "Wiley, Nick" <Nick.Wiley@MyFWC.com> wrote:

> Jim. Help me here. I was thinking the UF report would help us.
>
> ---
>
> **From:** McCawley, Jessica
> **Sent:** Monday, April 29, 2013 11:56 AM
> **To:** Wiley, Nick
> **Cc:** Estes, Jim
> **Subject:** Fwd: need some info ASAP on oysters
>
> Sent from my iPhone
>
> Begin forwarded message:
>
>> **From:** "Heil, David" <David.Heil@MyFWC.com>
>> **Date:** April 29, 2013 11:54:59 AM EDT
>> **To:** "McCawley, Jessica" <jessica.mccawley@MyFWC.com>
>> **Subject: RE: need some info ASAP on oysters**
>>
>> The Report to NOAA is FWC's and no one else (we are the resource agency). **Therefore, FWC is the author of this report** (of course, we needed t use DACS, DEP, UF data and information).
>>
>> It is the DACS report that alludes to overharvesting and poor harvester practices. Unless I am missing something, the UF report does not state that overharvesting was not a factor.
>>
>> ---
>>
>> **From:** McCawley, Jessica
>> **Sent:** Monday, April 29, 2013 11:44 AM
>> **To:** Heil, David
>> **Subject:** Fwd: need some info ASAP on oysters
>>
>> Sent from my iPhone

FL-ACF-01936042

Begin forwarded message:

From: "Wiley, Nick" <Nick.Wiley@MyFWC.com>
Date: April 27, 2013 1:48:46 PM EDT
To: "McCawley, Jessica" <jessica.mccawley@MyFWC.com>
Subject: Re: need some info ASAP on oysters

Also if we didn't already, we need to provide details on factors that restricted harvest. We only expanded seasons during the oil spill and harvest during this time was limited because the boats were working for BP. We went back to regular seasons after the spill with time, size, harvest and season restrictions. Who makes the NMFD/NOAA recommendation? Who is the authority on this?

Nick Wiley

On Apr 27, 2013, at 10:16 AM, "McCawley, Jessica" <jessica.mccawley@MyFWC.com> wrote:

> See info. I have asked to review letter before goes to NOAA
>
> Sent from my iPhone
>
> Begin forwarded message:
>
> > **From:** "Heil, David" <David.Heil@MyFWC.com>
> > **Date:** April 26, 2013 6:00:12 PM EDT
> > **To:** "McCawley, Jessica" <jessica.mccawley@MyFWC.com>
> > **Cc:** "Estes, Jim" <jim.estes@MyFWC.com>
> > **Subject: Re: need some info ASAP on oysters**
> >
> > Jessica,
> >
> > Report, Supplement document and suggested transmittal letter on my desk. Jim has reviewed. Amanda reviewed for content. Steve Geiger promised a review this weekend. Target date to send to NOAA St Pete is May 1st. As planned draft was sent to Steve Bransttler (? spelling) to be sure what he needed was there. His initial conclusion was over harvesting. I respectively disagreed. If over harvest or lack of endorsement or judicial ignorance or any other fishery management action or lack of action,

the disaster request will be denied.
Please weigh in with all the influence we have

David

Sent from my iPhone

On Apr 26, 2013, at 5:49 PM, "McCawley, Jessica" <jessica.mccawley@MyFWC.com> wrote:

> Where are we on the disaster declaration? Have we provided all the info that NOAA needs to them? Are we still waiting on data? Didn't we have a meeting with them recently about the data needs?
>
> Nick needs this info
> Thanks
> Jessica
>
> Jessica R. McCawley
> Director, Division of Marine Fisheries Management
> Florida Fish and Wildlife Conservation Commission
> 2590 Executive Center Circle E, Suite 201
> Tallahassee, FL 32301
> Ph: 850-487-0554 (general number)
> **NEW PH**: 850-617-9635 (direct number)
> Fax: 850-487-4847
> jessica.mccawley@myfwc.com

Exhibit 9

Berrigan, Mark

From: Heil, David [David.Heil@MyFWC.com]
Sent: Tuesday, October 09, 2012 3:25 PM
To: Berrigan, Mark
Subject: FW: oyster disaster request

Mark,

FYI. Just got this.

David

-----Original Message-----
From: McCawley, Jessica
Sent: Tuesday, October 09, 2012 3:21 PM
To: Heil, David
Subject: FW: oyster disaster request

Jessica R. McCawley
Director, Division of Marine Fisheries Management Florida Fish and Wildlife Conservation Commission
2590 Executive Center Circle E, Suite 201 Tallahassee, FL 32301
Ph: 850-487-0554 (general number)
NEW PH: 850-617-9635 (direct number)
Fax: 850-487-4847
jessica.mccawley@myfwc.com

-----Original Message-----
From: Roy Crabtree [mailto:roy.crabtree@noaa.gov]
Sent: Tuesday, October 09, 2012 10:43 AM
To: Wiley, Nick
Cc: McCawley, Jessica; Miles Croom; Heather Blough; Steve Branstetter; Phil Steele; Estes, Jim; McRae, Gil; Roberson, Louie; Fauls, Jackie
Subject: Re: oyster disaster request

Nick, I think we can work with survey data if landings are incomplete. Here is some language from the NOAA PolicyGuidance for Disaster Assistance".

"If available scientific information indicates that there has been an unexpected sudden and precipitous decrease in the harvestable biomass or spawning stock size of a fish stock that causes a significant number of persons to lose access to the fishery for a substantial period of time in a specific area, a serious disruption affecting future production will be deemed to have occurred. The Secretary will consider, among other things, most recent trawl surveys and other fishery resource surveys conducted by the National Marine Fisheries Service and/or state officials, as well as most recent stock assessments and other indicators of future production from the fishery.
The same percentage thresholds used to evaluate revenue losses for a commercial fishery failure determination will be applied in making this determination, based on estimated decrease in harvestable biomass or spawning stock size of the fish targeted by the fishery (which is dependent on the fishery resource subject to a fishery resource disaster) compared to the most recent 5-year period."

If your folks can get us with what they have (landings, revenues, surveys etc.) then we can have a discussion about how to proceed. Roy

On Fri, Oct 5, 2012 at 3:15 PM, Wiley, Nick <Nick.Wiley@myfwc.com> wrote:
> Hello Roy. First I want to thank you and your team for taking action on this. This very important to our state and an extremely high priority for FWC. Secondly, Jessica her team, principally Jim Estes, are coordinating our efforts on this. I believe we

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already are compiling the landings data you requested. It is important to note, however, that the local oyster harvesters are now reporting reductions in harvest rates, but this is likely a fairly recent development that may not show up yet in landings data. In fact, beyond recent observations by oyster harvesters, most of the concern about this situation is being driven by the recent oyster survey conducted by Florida Dept. of Agriculture and Consumers Services that projected serious declines in oysters that would be available for the major winter harvest season when most of the commercial crop is harvested. This survey and report indicated that there would not be enough oysters to support any commercial harvest this winter. Jim Estes can provide the report in case you don't have it. Given this and your need to document a decline, I am thinking it will be several months before landings data will be available to make this assessment. Not sure if there is any other way to tackle this and move it forward more quickly. It would be much better if we could somehow get you guys comfortable with the survey data which is based on state experts diving the oyster bars. I know we have at least 5 years of survey data that could be correlated with economic data and then used to calculate the expected economic impact. Is this something we could discuss? We would be glad to help. Let us know. Thanks and have a nice weekend. Nick

>
>
>
>
> Sent from my Verizon Wireless 4G LTE DROID
>
>
> Roy Crabtree <roy.crabtree@noaa.gov> wrote:
>
> Jessica,
>
> Just want to follow up on our phone call of last weekregarding the
> Govenor's disaster request. We need landings and revenues for oysters
> from the affected area for the past five years to evaluate the
> Governor's disaster request. We normally look to see how much
> landings and revenues have declined; so, we need enough to establish a
> baseline and then see how much landings and revenues have declined
> this year. I'm assuming you will be our point of contact, but if
> there is someone else we should go through let me know. If you have
> questions you can either contact me or Steve Branstetter.
>
> Thanks
>
>
> Dr. Roy Crabtree
> Regional Administrator
> Southeast Regional Office
> NOAA Fisheries

--

Dr. Roy Crabtree
Regional Administrator
Southeast Regional Office
NOAA Fisheries

Steve Branstetter

NOT OFFICIALLY TRANSMITTED

USE SURVEY FOR BASELINE INFO

NEED HISTORICAL DATA FOR BASELINE

MINIMUM REDUCTION (35%) - LANDINGS - STANDING STOCKS

AUTOMATIC W/T 80% DECLINE

WILL HAVE TO PROVIDE FISHERY LANDINGS AS THEY COME IN - MAYBE 3-6 MONTHS

MIGHT TAKE A YEAR FOR APPROVAL

DISTINQUISH BETWEEN DROUGHT VS OVERFISHING

A SECOND REPORT MAY BE NEEDED

AMEND INFORMATION — 2ND REPORT

ISSUES — HARVEST OF SUB-LEGAL OYSTERS
MANAGEMENT DID NOT INTERVENE
REVENUE DECLINES (FUTURE LANDINGS) > 35%

FL-ACF-BERRIGAN-0000198

Exhibit 10

From:	Estes, Jim
Sent:	Monday, August 05, 2013 8:07 AM
To:	roy.crabtree@noaa.gov
Cc:	McCawley, Jessica; Heil, David
Subject:	Oyster Report
Attachments:	Letter to Dr Crabtree.pdf; Florida Oyster Disaster Report to NMFS Final 8-2-13.pdf; Supplemental Document for Report to NMFS.pdf

Dr. Crabtree,

Attached you should find three attachments; one is a transmittal letter to you; another is our report describing a commercial fishery failure due to a fishery resource disaster for Florida's oyster harvesting areas in the Gulf of Mexico, particularly those in Apalachicola Bay, pursuant to Section 312(a) of the Magnuson-Stevens Fishery Conservation and Management Act; and a third is a supplemental document of appendices in support of the report. We are also mailing paper copies to you. . We intend on issuing a press release this morning about the document. Please let me know if you have any questions or if any of the documents were removed by one of our servers because of the size.

Jim

Jim Estes
Deputy Division Director, Division of Marine Fisheries Management
Florida Fish and Wildlife Conservation Commission
2590 Executive Center Circle E, Suite 201
Tallahassee, FL 32301
850-617-9622
Fax: 850-487-4847

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Florida Fish and Wildlife Conservation Commission

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Kenneth W. Wright
Winter Park

Executive Staff
Nick Wiley
Executive Director

Greg Holder
Assistant Executive Director

Karen Ventimiglia
Chief of Staff

Office of the
Executive Director
Nick Wiley
Executive Director

(850) 487-3796
(850) 921-5786
FAX

Managing fish and wildlife resources for their long-term well-being and the benefit of people.

620 South Meridian Street
Tallahassee, Florida
32399-1600
Voice: (850) 488-4676

Hearing/speech-impaired:
(800) 955-8771 (T)
(800) 955-8770 (V)

MyFWC.com

August 5, 2013

Dr. Roy Crabtree, Regional Administrator
NOAA Fisheries Service, Southeast Regional Office
263 13th Avenue South
Saint Petersburg, Florida 33701

RE: Florida Commercial Oyster Fishery Failure

Dear Dr. Crabtree:

The Florida Fish and Wildlife Conservation Commission is pleased to provide your office with the enclosed Report and Supplemental Document in support of Florida Governor Rick Scott's request to Secretary Rebecca Blank to declare a commercial fishery failure due to a fishery resource disaster for Florida's oyster harvesting areas in the Gulf of Mexico, particularly those in Apalachicola Bay, pursuant to Section 312(a) of the Magnuson-Stevens Fishery Conservation and Management Act.

This disaster was the result of low water flows due to water management policies which exacerbated the impact of severe drought conditions experienced in the southeast United States. The mechanisms for this disaster have not been quantified, but include increased predators and disease from increased salinities and decreased oyster nutrition from decreased freshwater input.

I want to personally thank you and your staff for taking the time to work with us so that we could provide the information your office needs for review of the Florida request as timely as possible.

Please feel free to contact Jim Estes with our Division of Marine Fisheries Management at 850-487-0554 if you have any questions.

Sincerely,

Nick Wiley
Executive Director

nw/je/lh
Enclosures
cc: The Honorable Rick Scott, Governor
Richard A. Corbett, Chairman

Exhibit 11

STATE OF FLORIDA
FLORIDA FISH AND WILDLIFE CONSERVATION COMMISSION

Order No. EO 10-19 **Early Opening of the Summer Harvest Season for Oysters In Apalachicola Bay Established in Rule 68B-27.019 (1)(a)1, F.A.C.**

The Fish and Wildlife Conservation Commission of the State of Florida, acting under the authority of Article IV, Section 9, of the Florida Constitution, and acting through its Executive Director under Delegations of Authority Paragraph 17 and Paragraph 22, Executive Order of the Governor Number 10-99, dated April, 30, 2010, hereby opens the summer harvest season for oysters in Apalachicola Bay, Franklin County, Florida effective May 21, 2010. This action is taken in order to relieve economic hardships on the commercial fishing industry that may occur in the area due to the BP Deepwater Horizon oil spill. This action is authorized only as follows:

1. All other provisions governing harvest of oysters in Apalachicola Bay remain in effect.

2. This order shall take effect at 12:01 a.m. EDT, May 21, 2010 and shall expire at 12:01 a.m. EDT, June 1, 2010.

Specific Authority: Article IV, Section 9, Florida Constitution

Law Implemented: Article IV, Section 9, Florida Constitution and Executive Order of the Governor Number 10-99, dated April, 30, 2010 and 120.81(5), Florida Statutes

Effective Date: 12:01 a.m. EDT, May 21, 2010

Given under my hand and seal of the Florida Fish

And Wildlife Conservation Commission on this

_20th_ day of May_2010_.

/signed/

Nick Wiley

Executive Director

Attest: /signed/

Agency Clerk

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PENGAD 800-631-6989
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Exhibit 12

STATE OF FLORIDA
FLORIDA FISH AND WILDLIFE CONSERVATION COMMISSION

Order No. EO 10-25 **Additional Oyster Harvest Days for Apalachicola Bay**

The Fish and Wildlife Conservation Commission of the State of Florida, acting under the authority of Article IV, Section 9, of the Florida Constitution, and acting through its Executive Director under Delegations of Authority Paragraph 17 and Paragraph 22, Executive Order of the Governor Number 10-99, as amended, hereby opens the harvest for oysters in Apalachicola Bay, Franklin County, Florida on Saturdays, so long as Apalachicola Bay is not closed for public health purposes. This action is taken in order to relieve economic hardships on the commercial fishing industry that may occur in the area due to the BP Deepwater Horizon oil spill. This action is authorized only as follows:

1. Harvest for oysters in Apalachicola Bay is hereby opened on Saturdays, notwithstanding anything to the contrary in rule 68B-27.017, Florida Administrative Code.

2. All other provisions governing harvest of oysters in Apalachicola Bay remain in effect.

3. This order shall take effect at 12:01 a.m. EDT, June 5, 2010, shall expire August 31, 2010, and shall be limited to when Apalachicola Bay is not closed for public health purposes.

Specific Authority: Article IV, Section 9, Florida Constitution

Law Implemented: Article IV, Section 9, Florida Constitution and Executive Order of the Governor Number 10-99, dated April, 30, 2010 and 120.81(5), Florida Statutes

Effective Date: 12:01 a.m. EDT, June 5, 2010

Given under my hand and seal of the Florida Fish and Wildlife Conservation Commission on this 4th day of June 2010.

________/signed/________

Nick Wiley
Executive Director

Attest______/signed/______
Agency Clerk

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Exhibit 13

STATE OF FLORIDA
FLORIDA FISH AND WILDLIFE CONSERVATION COMMISSION

Order No. EO 10-32 **Additional Oyster Harvest Days and Areas for Apalachicola Bay**

The Fish and Wildlife Conservation Commission of the State of Florida, acting under the authority of Article IV, Section 9, of the Florida Constitution, and acting through its Executive Director under Delegations of Authority Paragraph 17 and Paragraph 22, Executive Order of the Governor Number 10-99, as amended, hereby opens the harvest for oysters in Apalachicola Bay, Franklin County, Florida seven days per week and hereby opens the winter harvesting areas, so long as Apalachicola Bay is not closed for public health purposes. This action is taken in order to relieve economic hardships on the commercial fishing industry that may occur in the area due to the BP Deepwater Horizon oil spill. This action is authorized only as follows:

1. Notwithstanding the prohibition for harvesting on Fridays and Saturdays June through August in rule 68B-27.017, Florida Administrative Code, harvest for oysters in Apalachicola Bay is hereby opened seven days per week.

2. Harvest for oysters in areas approved in rule 5L-1.003(1), Florida Administrative Code for winter harvesting in Apalachicola Bay, are hereby opened for harvest notwithstanding anything to the contrary in rule 68B-27.019, Florida Administrative Code.

3. All other provisions governing harvest of oysters in Apalachicola Bay remain in effect.

4. This order shall take effect at 12:01 a.m. EDT, June 18, 2010, shall expire August 31, 2010, and shall be limited to when Apalachicola Bay is not closed for public health purposes.

Specific Authority:	Article IV, Section 9, Florida Constitution
Law Implemented:	Article IV, Section 9, Florida Constitution and Executive Order of the Governor Number 10-99, dated April, 30, 2010 and 120.81(5), Florida Statutes
Effective Date:	12:01 a.m. EDT, June 18, 2010

Given under my hand and seal of the Florida Fish and Wildlife Conservation Commission on this 17th day of June 2010.

____

Nick Wiley
Executive Director

Attest:______________________
Agency Clerk

PENGAD 800-631-6989
EXHIBIT
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Exhibit 14

FOR IMMEDIATE RELEASE: **FOR MORE INFORMATION**:

June 17, 2010

David Heil: 850 488-5471, or

Terence McElroy: 850 488-3022

Florida Provides for Increased Apalachicola Bay Oyster Production

TALLAHASSEE – Florida Agriculture and Consumer Services Commissioner Charles H. Bronson and Chairman Rodney Barreto of the Florida Fish and Wildlife Conservation Commission (FWC) today announced that both the winter and summer oyster harvesting areas in the Apalachicola Bay System will be opened for harvest seven days per week through August 31, 2010.

Before this action was taken, the summer oyster areas were closed for harvest on Fridays in June, July and August, and the winter oyster areas were closed altogether for harvest during those months. This action marks the first time that the two agencies, which jointly manage oyster resources in Florida, have permitted seven day per week harvest during the summer months opened the winter oyster areas during the summer months.

"We are pleased to support Commissioner Bronson in this effort to help the hard working people in Florida's oyster industry," Barreto said.

Staff of both Agencies will continue to closely monitor Bay water quality, oyster harvest, oyster handling and oyster processing to ensure oysters resources are protected and are safe to consume.

"This action should be viewed by the citizens of Florida and the United States that Gulf of Mexico seafood in restaurants and markets is safe," Bronson said. "With demand for safe Gulf oysters at a peak, this action will benefit both our oyster industry and consumers alike."

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Apalachicola Bay, Franklin County Florida Summer and Winter Oyster Harvesting Areas

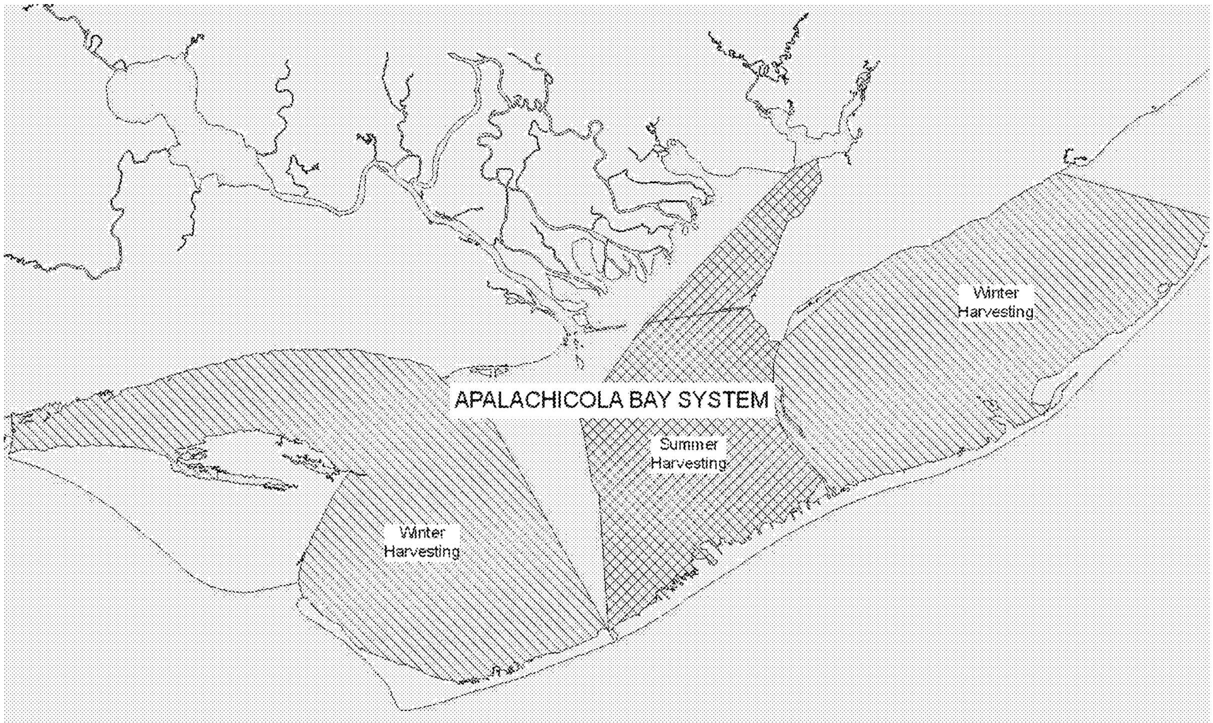


Exhibit 15

Oyster Resource Assessment Report
Apalachicola Bay
August 2012
Department of Agriculture and Consumer Services
Division of Aquaculture

Executive Summary

Observations and sampling of oyster populations on the primary oyster producing reefs in Apalachicola Bay during July 2012 indicated that oyster populations were depleted over most of the reef areas sampled and that surviving oyster populations are severely stressed. Staff of the Department of Agriculture and Consumer Services' Division of Aquaculture conducted assessments of oyster populations after preliminary reconnaissance following the passage of Tropical Storm Debby indicated that oyster populations on Cat Point Bar and East Hole Bar were in poor condition. More detailed sampling and analyses confirmed the condition of oyster resources and suggested that the poor condition was the result of combination of environmental factors and fishery practices. Analyses and observations further suggested that Tropical Storm Debby was only a minor contributing factor to the overall poor condition of oyster resources and confirmed evidence that prolonged drought conditions, continuing low river discharge rates and intensive harvesting were adversely affecting oyster populations in Apalachicola Bay.

This report provides interpretative analyses of sampling data, fisheries data, environmental conditions, fishery practices and other factors to describe the current status of oyster resources and predict oyster fishery trends for the 2012/13 Winter Harvesting Season in Apalachicola Bay. Analyses and observations indicate that a combination of factors have resulted in a cascading effect that has contributed to the depletion of oyster populations and may lead to longer-term debilitation of oyster resources and oyster reef habitats.

Introduction

The Florida Department of Agriculture and Consumer Services (DACS) shares responsibility for managing oyster resources in Apalachicola Bay with the Florida Fish and Wildlife Conservation Commission (FWC); more specifically, the Division of Aquaculture manages oysters from both resource development and public health protection perspectives. This report summarizes information related to oyster resource compiled by the Division of Aquaculture from 2009 through August 2012.

Oyster Fisheries Statistics

Since 1980, reported landings of oysters in Florida ranged from about 1 to 6.5 million pounds of meats: highest landings were reported in the early 1980s, around 6.5 million pounds. Apalachicola Bay accounts for about 90% of Florida's landings and about 9% of the landings from the Gulf of Mexico (2000-2008 average). Reported oyster landings from Apalachicola Bay for 2011 were approximately 2.4 million pounds of meat, representing a slight increase in landings from 2010 (Table 1).

In 2011, oystermen in Franklin County reported landings of 2,380,810 pounds of meats from 39,176 trips. Landings for Apalachicola Bay are higher than reported for Franklin County, because oystermen in neighboring counties may report landings from Apalachicola Bay in those counties.

Table 1. Oyster Landings in Apalachicola Bay, Florida

Year	Pounds (Meats)	Number of Trips Reported	AB Oyster Harvesting Licenses	Bags/ Trip
2000	2,327,402	25,550	958	13.9
2001	2,333,968	25,261	1,135	14.1
2002	1,725,776	20,294	914	13.0
2003	1,449,890	18,467	759	12.0
2004	1,502,056	17,692	719	12.9
2005	1,260,996	12,663	714	15.2
2006	2,127,049	22,644	916	14.3
2007	2,645,359	29,104	1,142	13.9
2008	2,238,482	27,603	1,168	12.3
2009	2,695,701	39,942	1,433	10.2
2010	1,938,059	32,330	1,909	9.1
2011	2,380,810	39,176	1,799	9.3
2012			1,687	

Landings per trip remained relatively stable during 2010 and 2011, ranging from 9.1 to 9.3 bags per trip. Landings per trip continued to trend downward from about 15 bags per trip in 2005 to about 9.3 bags per trip in 2011. Oyster landings and bags per trip do not show a direct correlation with the number of ABOHL sold; there were 1,799 ABHOL sold in 2011 and 1,687 sold in 2012. The dockside value of oyster landed in Franklin County was estimated at $6.64 million in 2011.

Oyster landings appear to be correlated with three primary variables; resource availability, fishing effort, and market demand. Fishing effort has increased while market demand has been highly variable due to economic instability, concerns associated with the Deep Water Horizon (DWH) oil spill incident in 2010, and inconsistent supplies from other Gulf states.

Oyster Resource Assessments

The Division has conducted oyster resource surveys on the principle oyster-producing reefs in Apalachicola Bay since 1982. This information is used by resource managers to reliably predict trends in oyster production; to monitor oyster population dynamics, including recruitment, growth, natural mortality, standing stocks; and to determine the impacts of climatic events such as hurricanes, floods, and droughts on oyster resources. Sampling oyster populations allows resource managers to compare the relative condition of standing stocks over time using a defined sampling protocol. The Standard Oyster Resource Management Protocol (SORMP) provides a calculation to estimate production based on the density of legal size oysters collected during a defined sampling interval. Production estimates exceeding 400 bags of oysters per acre is applied as an indicator of healthy oyster reefs capable of sustaining commercial harvesting.

The Division of Aquaculture conducted oyster resource assessments on the commercially important oyster reefs in Apalachicola Bay during July 2012. Commercially important reefs included Cat Point Bar, East Hole Bar and the St. Vincent Bar and Dry Bar reef complex. Oyster resource assessments were also conducted on three recently rehabilitated reefs, and on shallow and intertidal reefs in St. Vincent Sound.

Production estimates for July 2012 from Cat Point Bar (287 bags/acre) and East Hole Bar (294 bags/acre) were the lowest production estimates reported in the past twenty years prior to the opening of the Winter Harvesting Season. Similarly, production estimates from St. Vincent Bar and Dry Bar (bags per acre) demonstrated depressed production estimates. Estimated oyster population parameters for Cat Point Bar, East Hole Bar and St. Vincent / Dry Bar are below levels generally observed on these reefs prior to opening the Winter Harvesting Season, and suggest that stocks are not sufficiently abundant at this time to support commercial harvesting throughout the Winter Harvesting Season. Factors affecting estimated production parameters on individual reef complexes are discussed later in this report.

Cat Point Bar and East Hole Bar have historically been the primary producing reefs in Apalachicola Bay. These reefs form a contiguous reef system (except for the Intracoastal Waterway) that extends north to south across St. George Sound and separates the sound from Apalachicola Bay. Over the past twenty years, landings from these reefs have been critical to supporting the oyster fishery in the region.

Oyster density and estimated production showed marked declines on Cat Point Bar when compared to 2011. Estimated production declined from 417 bags per acre in August 2011 to 287 bags per acre in July 2012 (Table 2). Oyster densities decreased substantially from 430 to 64 oysters per square meter over the same sampling interval (Table 2). The decrease in oyster density reflects poor recruitment, as well as severely reduced number of oysters in the juvenile size classes, and is indicative of the degraded quality of reef substrate and structure.

Cat Point and East Hole Bar have been subject to a combination of factors that have adversely affected oyster populations, oyster reef habitat, and the oyster fishery. Oyster populations over much of the reef area are depleted and the quality of the substrate is degraded to a point where spat settlement and recruitment have been disrupted. Stress associated with prolonged high salinity, high natural mortality and predation, and intensive fishing effort have markedly reduced standing stocks of juvenile, sub adult and adult oysters.

The Dry Bar and St. Vincent Bar complex is a large contiguous reef system in western Apalachicola Bay. This reef complex provides a substantial portion of the Bay's landings during normal years, but fishing pressure was sporadic during 2011 and 2012. The estimated production for Dry Bar-St. Vincent (Table 2) indicated a substantial reduction from 323 bags per acre in August 2011 to 215 bags per acre in July 2012. Samples were collected from the Little Gully area on Dry Bar, because no live oysters were collected on St. Vincent Bar. St. Vincent Bar, extending from Dry Bar southward was considered to be depleted of marketable oysters. The oyster population on St. Vincent Bar was likely decimated by stress associated with high salinity, disease and predation. Fishing pressure has declined as a result of reduced standing stocks of market-size oysters over the entire reef complex over the past two years. The current condition of oyster resources on Dry Bar is not expected to be at levels that will sustain commercial harvesting through the 2012/13 Winter Harvesting Season.

Estimated production parameters for the reef complexes in the western portion of the Bay and the "Miles" indicate that standing stocks of market size oysters are at various levels. Standing stocks on some reefs will support commercial harvesting, while other reefs show signs of severe stress and depletion. Oyster reefs, including North Spur, Green Point and Cabbage Lumps Plant Sites are in moderately good condition, with standing stocks and production at levels that will support limited commercial harvesting. These plant sites have been planted with processed oyster shell within the last three years, and the substrate remains in good condition; size frequency distributions are typical of healthy oyster populations. However, these reefs are small and overall production will be limited. Also, oysters on these reefs will likely be subject to intense predation from rock snails, while salinity levels remain high. Oyster populations on shallow and intertidal reefs in the 'Miles' (Spacey's Flats, Eleven Mile Bar, Picolene Bar) are also severely stressed, showing signs of intense predation and natural mortality. Bars in northwestern Apalachicola Bay and eastern St. Vincent Sound, including Green Point, North Spur and Cabbage Lumps are more strongly influenced by river flows than bars located further away from the river mouth. Prevailing flows and circulation patterns move plumes of freshwater westward from the river over these reefs before they are dispersed throughout the Bay and St. Vincent Sound.

The Standard Oyster Resource Management Protocol

Continuous monitoring and data analyses have allowed resource managers to develop a scale using defined sampling protocol to determine the relative condition of oyster resources based on estimated production parameters. The Standard Oyster Resource Management Protocol (SORMP) provides that estimated production exceeding 400 bags of oysters per acre is applied as an indicator of healthy oyster reefs capable of sustaining commercial harvesting. Accordingly, oyster populations are 1) capable of supporting limited commercial harvesting when stocks exceed 200 bags/acre, 2) below levels necessary to support commercial harvesting when stocks fall below 200 bags/acre, and 3) considered depleted when marketable stocks are below 100 bags/acre. Generally, production from Cat Point Bar has been the most accurate indicator of oyster production in Apalachicola Bay, but East Hole Bar and St. Vincent Bar are also reliable indicators of the condition of oyster resources throughout the Bay. This scale forms the basis for the Standard Oyster Resource Management Protocol provided in Subsection 68B-27.017, Florida Administrative Code, which has been used as the criteria for setting the number of harvesting days in the Winter Harvesting Season in Apalachicola Bay.

Depletion of Oyster Resources

Standing Stocks and Commercial Production Estimates

Size frequency distributions for oyster standing stocks are strong indicators of the health of oyster populations and are useful for predicting fishery trends. Size distributions among oyster populations are used to evaluate recruitment to the population, recruitment of juveniles to market size, growth, survival and potential production. Accordingly, size frequency distributions can be used to evaluate oyster depletion events. Current analyses of size frequency distributions and oyster standing stocks indicate that oyster populations on the major producing reefs in Apalachicola Bay are experiencing an on-going depletion event.

Oyster populations can be depleted from a number of factors; including climatic conditions, water quality, drought and flood events, catastrophic storms and hurricanes, natural mortality from diseases and predation, and fisheries. Most of the time, depletions occur because of a combination of these factors (multiple stressors).

Data analyses and observations on the major reef complexes showed substantial losses of oyster populations over the past two years, with severe declines in oyster densities, standing stocks and production estimates. Declining populations can be attributed to less than optimal environmental conditions (prolonged drought, reduced river discharge rates, high salinity), storm events (Tropical Storm Debby), and increased predation and natural mortality, weak recruitment, and extensive harvesting on the major reefs. It is evident from divers' observations that many reefs in Apalachicola Bay are showing the negative effects of decreased rainfall and freshwater flow rates from the Apalachicola River over the past two years, including depressed recruitment and increased natural oyster mortality (predation, disease, and stress associated with high salinity regimes). Additionally, the long-term impairment of reef structure (reef elevations, shell matrix, and shell balance) is of serious concern. Each of the factors contributing to oyster depletion in Apalachicola Bay are discussed below.

Prolonged Drought and Elevated Salinity

Adverse environmental conditions can have a devastating effect on oyster populations; and high salinity is among the most detrimental factors. Because oysters are sessile animals, they are not capable of moving when environmental conditions become less than optimal or sometimes lethal. While oysters can tolerate a wide range of salinities, prolonged exposure to less than optimal conditions will adversely impact affected populations. Oysters become physiologically stressed when salinity levels are below or above optimal levels (10-25 ppt) for extended periods, affecting reproductive potential, spatfall, recruitment, growth and survival.

Rainfall and concomitant river discharge are essential for productive oyster populations in Apalachicola Bay, and provide three critical requirements for survival. First, survival depends upon salinity regimes that are suitable for oysters to reproduce, grow and survive. Rainfall in the drainage basin and discharge into the Bay are essential, as productive oyster populations require a combination for fresh water and marine waters. Fluctuating salinity regimes, within the oyster's tolerance limits, is the single most important factor influencing oyster populations in Apalachicola Bay. Second, rainfall, flooding in the flood plain, and river discharge into the Bay are essential for supplying nutrients and detritus necessary to nourish and sustain food webs and trophic dynamics within the estuarine system. And third, rainfall and river discharge is a critical factor driving fluctuations in salinity levels that prevent destructive predators with marine affinities from becoming established in the Bay. The critical influences of rainfall and river discharge were severely diminished during the past two years. The region and much of the drainage basin have been subject to extensive drought during 2011 and 2012, and these conditions have been reflected in low river stages and low river discharge rates.

Although, environmental conditions improved with relatively normal rainfall and river discharge in 2009 and early 2010, and abundant spat fall was reported on Cat Point and East Hole Bars during 2010, oyster resources have not rebounded completely. Conditions began to decline and drought conditions have persisted in the Apalachicola River Basin since August 2010. With drought conditions returning to the region, decreased rainfall and river discharge have contributed to stress on oyster populations in Apalachicola Bay.

The Florida Panhandle and the Apalachicola River (ACF) drainage basin have experienced prolonged drought conditions for several years, and the reduced freshwater input into Apalachicola Bay has seriously affected oyster populations in the Bay. Poor recruitment and poor survival can be directly attributed to prolonged high-salinity environment, which is also confirmed by the presence of marine predators, primarily stone crabs and Florida rock snails (oyster drills). The predators are present in great numbers and are currently overwhelming oyster populations throughout Apalachicola Bay. Petes et al., (2012) and Wilber (1992) investigated the effects of reduced freshwater flows on oyster populations in Apalachicola Bay and reported adverse impacts resulting from low river flows.

Natural Mortality and Predation

The combination of high salinity and high water temperatures are known to severely stress oyster populations and may result in massive mortality events. It is highly likely that these environmental factors have contributed substantially to natural mortality and low recruitment in the Bay. High salinity and high water temperatures also correlate with the increased prevalence and intensity of the oyster parasite, *Perkinsus marinus*. This parasite (dermo) is often associated with oyster mortality in the hotter summer months and is commonly described as 'Summer Mortality Syndrome' in Florida. The Department participates in the Oyster Sentinel Program in the Gulf and monitors the presence and intensity of *P. marinus* in oysters in Apalachicola Bay.

Observations by divers confirmed the presence and abundance of stone crabs, *Menippe mercenaria*, on the primary oyster reefs in Apalachicola Bay. Stone crab burrows are easy to recognize and the appetite of these destructive predators is obvious. Stone crab burrows are surrounded by living and dead oysters; the result of crabs actively foraging and bringing live oysters to their burrows. The shells of devoured oysters are also present and form a ring around burrows. Examining dead oyster shell provides confirmation of the crushing action of stone crabs on the shell of oysters. Stone crabs are considered primary predators of oysters when salinities remain high for extended periods and crab populations become established on oyster reefs.

Observations and sampling confirmed the presence and abundance of the Florida rock snail, *Stramonita haemastoma*, (formerly *Thais haemastoma*), a destructive snail commonly referred to as an oyster drill. Oyster drills are considered as one of the most serious oyster predators along Florida's Gulf Coast, and have become established in Apalachicola Bay over the past two years. Reports from oystermen suggest that drills are more abundant than at any time in recent memory. It appears that drill populations are moving farther into the estuary as oyster populations in the more marine portions of the Bay are depleted. High numbers of drills were found wherever viable oyster populations were observed. The presence and establishment of snail populations correlate with prolonged high salinity waters. It is also disturbing that drills are completing their life cycles within the estuary, since egg cases, juvenile, subadult and adult snails are abundant on oyster reefs.

Additionally, the Florida crown conch, *Melongena corona*, was commonly observed on oyster reefs. These conchs are also known to be serious oyster predators with marine affinities. Mud crabs of various species are also common predators on oyster reefs, generally attacking spat and smaller juvenile oysters.

Increased stress associated with high salinity regimes acts to exacerbate the level and intensity of predation by weakening oysters. Prolonged periods of high salinity result in natural mortality from predation which can have a significant impact on oyster populations and result in serious economic losses to commercial oyster fisheries. The presence and abundance of marine predators on oyster reefs in Apalachicola Bay the long duration of high salinity conditions within the estuary.

<u>Harvesting Pressure</u>

Declining oyster population parameters can be associated with harvesting, as well as environmental influences and natural mortality. Reported oyster landings for Franklin County in 2011 increased marginally over 2010 in both production and bags per trip, but harvesting pressure (as measured in reported trips) increased by about 20 percent. Oyster population parameters for Cat Point Bar and East Hole Bar suggest that oyster abundances and potential production is markedly depressed, possibly reflecting the effects of continuous harvesting, poor harvesting practices, as well as, less than optimal environmental conditions in 2010 and 2011. Over harvesting is most damaging when environmental conditions are less than optimal, recruitment is low, and natural mortality is high.

Resource managers believe that several activities associated with harvesting have had a detrimental impact on standing stocks and oyster resources on the primary producing reefs in St. George Sound in eastern Apalachicola Bay. The standing stocks of juvenile, sub-legal, and market-size oysters suggest that the overall condition of many reefs has declined substantially over the past two years as a result of continuous harvesting from Cat Point and East Hole Bars, concentrated and intensive harvesting by the majority of the fishing fleet, and the excessive harvesting of sub-legal oysters.

Vessel counts during the 2011/12 Winter Harvesting Season show that about 60 percent of the fishing fleet was concentrated on Cat Point and East Hole Bars. Fishing effort often averaged more than 120 vessels per day throughout 2011 and 2012 placing added pressure on Cat Point and East Hole Bars. In response to limiting the number of hours harvest can occur each day to control for *Vibrio vulnificus*, additional harvesting days during 2011 and 2012 were implemented which increased fishing pressure and further deteriorated the condition of the resource. Another contributing factor was the management decision to allow harvesting from these reefs during the summer of 2010 in response to the oil spill event (April, 2010). This resulted in an intense harvesting effort which precluded any recovery time for the resource

Harvesting pressure is usually high on reefs in the eastern portion of the Bay at the beginning of the oyster harvesting season, and in 2011 and 2012 harvesting pressure was almost exclusively directed to Cat Point and East Hole Bars. Harvesting pressure on Cat Point Bar and East Hole

Bar in St. George Sound demonstrated an upward trend in effort over the past two years. This change in fishing effort is not easy to explain, since it does not seem to be strictly associated with resource availability. One plausible explanation may be the proximity of St. George Sound to Eastpoint, where many licensed oystermen reside and sell their oysters.

Some of the decline of legal-size oysters can be attributed to the excessive harvesting of sub-legal oysters. Since 2010, there have been numerous reports of oystermen harvesting oysters below the legal size limit, and observations in the marketplace confirmed that the harvest of small oysters was very common during the DWH oil spill event and has persisted to the present. Excessive harvesting of sub-legal oysters from 2010 through 2012 reduced recruitment among sub-legal size classes to legal size, contributing to declining trends in estimated production in 2012/2013. This situation results from harvesting and culling practices of the fishermen, when sub-legal oysters are not culled and returned to the reef to grow to marketable size.

The practice of harvesting sub-legal oysters appears to be an extension of a "use it or lose it' attitude that prevailed during the fall and winter of 2010. Following the oil spill in April 2010, there was an acknowledged threat to oyster resources in Apalachicola Bay, and management policies were directed toward harvesting available resources in the face of a growing risk of loss. Throughout the period when oil posed an unpredictable threat to the oyster fishery, less effort was directed toward enforcing size limits, perhaps, yielding to the view that it would be more beneficial to harvest the available resource. But unfortunately, many oystermen have continued the same harvesting practices that were allowed during the oil spill threat.

The Division's 2011 *Oyster Resource Assessment Report for Apalachicola Bay* (Division of Aquaculture, 2011) stated that oyster population estimates indicated that recruitment would keep pace with harvesting pressure and sustain production throughout the 2011/12 Winter Harvesting Season: with the caveat that increased harvesting pressure and/or the unabated harvesting of sublegal stocks may alter the production / harvesting balance. In 2011, reports of the harvest and sale of oysters below the legal size limit was still common practice, and it is now clear that there are not sufficient numbers of juvenile and market size oysters to support harvesting throughout the up coming season.

Tropical Storm Debby

Tropical Storm Debby made its closest approach to Apalachicola Bay on June 25, 2012 before moving eastward and making landfall near the mouth of the Suwannee River. Despite the fact that Debby never achieved hurricane strength, it was accompanied by moderate storm surge in the Big Bend region. Maximum surge at Apalachicola was 3.51 feet.

The greatest impacts to oyster reefs were expected to be in St. George Sound and western Apalachicola Bay (St. Vincent Bar) because of the long fetch of open water. Scouring was expected as a result of storm surge and wave action across the Bay. Fortunately, most of the storm surge and strongest wave action occurred during high tides when the reefs are most protected from severe hydrological impacts.

Preliminary reconnaissance following T.S.Debby did not indicate severe disruption of oyster reef structure. Examination of shells and live oysters did not display the effects of severe scouring (ex. polished shell surfaces, abrasion, dead oysters) and observations by divers did not demonstrate extensive disruption of the reef's surface (suspension and deposition of reef shell and sediments, concretion of reef material, or burial of shell and living oysters). Although reef areas were sometimes devoid of live oysters, clusters of oysters were present in adjacent areas that did not indicate severe disturbance. Scouring and wave action may have impacted reef surfaces and oyster resources in some areas, but widespread damage to reef structure was not observed.

Heavy rainfall and coastal flooding may have an adverse impact on oyster reefs closest to the river and distributaries in the river delta, but the sudden influx of freshwater did not appear to cause extensive oyster mortalities on reefs away from the river delta (reefs in the Winter Harvesting Areas). Preliminary reconnaissance and sampling did not identify oyster populations where mass mortalities occurred; it is generally apparent when a mass mortality event occurs from a freshet or poor water quality (low dissolved oxygen concentrations). However, it remains likely that oyster populations in close proximity to the river delta may be subject to prolonged low salinity and associated low dissolved oxygen concentrations, and may suffer mortalities. There have been some reports of recent mortalities (late July) among oysters on reefs in the Summer Harvesting Area (Norman's Lumps).

<u>Fishery Management Implications</u>

The Department of Agriculture and Consumer Services and the Fish and Wildlife Conservation Commission enacted several policies that allowed oystermen a greater opportunity to harvest available oyster resources in Apalachicola Bay in response to the Deepwater Horizon oil spill event and national shellfish program requirements. The Executive Director of the FWCC signed an Executive Order that allowed commercial harvest of oysters from Apalachicola Bay seven days a week beginning September 1, 2011, contingent upon the Standard Oyster Resource Management Protocol (SORMP). On June 1, 2012, the FWCC enacted rule amendments in Chapter 68B-27.017 that allowed harvesting of oysters seven days a week, year round in Apalachicola Bay. This action was taken, in part, to accommodate commercial oyster fishermen for time on the water harvesting that was decreased as a result of recent management practices to enhance public health protection. These practices, consistent with national *Vibrio vulnificus* reduction criteria, imposed more stringent limitations on harvesting times from April through November.

Subsection 68B-27.017(1)(a), Florida Administrative Code, provides that oysters may be harvested for commercial purposes on any day of the week. Subsection (1)(b) provides that - If during the period of November 16 through May 31 DACS establishes that the oyster resources on Cat Point Bar and East Hole Bar can not sustain a harvest of 300 bags per acre (SORMP), then the harvest of oysters for commercial purposes shall be prohibited on Saturdays and Sundays. Results of the current assessment indicated that estimated production on Cat Point Bar and East Hole Bar may not exceed the level provided in the SORMP for DACS to recommend that oyster harvesting for commercial purposes be continued at seven days a week. Oyster resources will be re-assessed in November and recommendations will be forwarded to the Florida Fish and Wildlife Conservation Commission.

Fishery Trends

Analyses of oyster resource assessment data over the past two years indicate several general conclusions regarding oyster resources in Apalachicola Bay.

The outlook for oyster production for the 2012/2013 Winter Harvesting Season in St. George Sound (Cat Point, East Hole, Porters Bar and Platform) is described as "poor". It appears unlikely that oyster populations on Cat Point and East Hole Bars can sustain concentrated harvesting effort throughout the Winter Harvesting Season.

Declining population estimates over the past two years generally indicated that oyster populations are severely stressed. Although oyster population parameters for 2010 and 2011 reflected relatively stable production estimates, declines in 2012 suggest that overall resource availability may not be capable of sustaining current harvesting levels (bags per trip). The number of bags per trip has continued to decline over the past five years.

Prior to 2009, the demand for oysters from Apalachicola Bay was a primary factor limiting harvests, as harvests did not appear to be limited by available stocks. Higher landings in 2009 likely reflected strengthening market demand and increased fishing effort rather than increased resource availability. However, in 2011/2012 demand for Apalachicola Bay oysters increased because of reduced production from historically productive areas in other Gulf states, while oyster resources in the Bay have suffered during the current drought. Consequently, oyster resources may not be adequate to support increased harvesting pressure and meet increased demand throughout the upcoming season.

Table 2. Cat Point Bar Population Estimates: September 2008 to July 2012.

Sample		Oyster	Mean	Density	Oysters				Bags
Date	Quadrat (0.25m)	Number (n)	Leng. (mm)	(/m)	>50mm (%)	>75mm (%)	(/m)	1000x (/ac)	(/ac)
09/08	20	616	55.2	123.2	66.2	17.21	21.2	85.8	381
11/08	10	564	52.0	225.6	55.7	19.33	43.6	176.4	784
12/08	10	333	56.9	133.2	66.1	24.92	33.1	134.3	597
08/09	20	828	50.1	165.6	49.9	15.10	25.0	101.1	449
11/09	10	626	48.2	250.4	50.2	7.83	19.6	79.3	352
04/10	20	969	48.4	193.8	46.7	9.91	19.2	77.7	345
08/10	20	1,043	50.5	208.6	53.9	8.92	18.6	75.3	334
11/10	20	865	52.8	173.0	63.7	12.25	21.2	85.7	381
08/11	15	1,611	48.2	429.6	48.5	5.40	23.2	93.9	417
07/12	10	161	58.8	64.4	67.1	24.84	15.9	64.7	287

Table 2. East Hole Bar Population Estimates: November 2008 to July 2012.

Sample		Oyster	Mean	Density	Oysters			-	Bags
Date	Quadrat (0.25m)	Number (n)	Leng. (mm)	(/m)	>50mm (%)	>75mm (%)	(/m)	1000x (/ac)	(/ac)
11/08	10	318	57.5	127.2	69.1	22.33	28.4	114.9	510
09/09	20	1,023	49.3	204.6	50.7	9.09	18.5	75.2	334
11/10	10	682	47.0	272.8	48.6	9.38	25.6	103.6	460
07/12	10	127	60.8	50.8	65.3	32.28	16.3	66.3	294

Table 2. Dry Bar Population Estimates: September 2008 to July 2012.

Sample		Oyster	Mean	Density	Oysters			-	Bags
Date	Quadrat (0.25m)	Number (n)	Leng. (mm)	(/m)	>50mm (%)	>75mm (%)	(/m)	1000x (/ac)	(/ac)
09/08	20	1,467	54.0	293.4	64.1	14.86	43.6	176.4	784
12/08	10	986	47.1	394.4	49.8	7.81	30.8	124.6	554
08/09	20	1,353	46.6	272.6	41.2	6.31	17.2	69.6	309
11/09	10	589	45.6	235.6	41.7	7.13	16.7	67.9	302
08/10	20	877	50.2	175.4	50.5	10.83	18.9	76.8	341
11/10	20	1,313	43.1	262.5	34.4	11.65	30.5	123.8	550
08/11	15	567	47.5	151.2	44.8	11.90	17.9	72.7	323
07/12	10[a]	150	56.0	60.0	66.0	20.0	12.0	48.6	215[a]

a - Samples collected from Little Gully on Dry Bar. No live oysters were collected from St. Vincent Bar

Table 2. North Spur (Plant) Population Estimates: September 2008 - July 2012.

Sample		Oyster	Mean	Density	Oysters			-	Bags
Date	Quadrat (0.25m)	Number (n)	Leng. (mm)	(/m)	>50mm (%)	>75mm (%)	(/m)	1000x (/ac)	(/ac)
09/08	5	284	52.9	227.2	60.6	10.56	23.9	97.0	431
09/09	10	541	49.5	216.4	49.9	12.75	27.5	111.6	496
04/10	5	1040	48.0	832.0	50.4	5.10	42.4	171.7	763
08/11	5	269	52.9	215.2	58.0	15.99	34.4	139.2	619

07/12	10	362	53.4	144.8	57,5	18.23	26.4	106.8	475

Table 2. Green point (Plant) Population Estimates: September 2008 - July 2012.

Sample		Oyster	Mean	Density	Oysters			-	Bags
Date	Quadrat (0.25m)	Number (n)	Leng. (mm)	(/m)	>50mm (%)	>75mm (%)	(/m)	1000x (/ac)	(/ac)
09/08	10	482	58.8	192.2	75.9	20.33	39.2	158.6	705
09/09	10	274541	48.2	109.6	44.1	17.52	19.2	77.7	345
09/11	10	510	54.4	204.0	65.5	12.94	26.4	106.5	474
07/12	5	125	59.6	100.0	65.0	28.00	28.0	113.3	503

Exhibit 16

State of Florida v. State of Georgia

No. 142 Original

Expert Report
of
Romuald N. Lipcius, Ph.D.

20 May 2016

The contemporaneous data I analyzed indicated that fishing pressure and harvest practices used on the oyster population in Apalachicola Bay were excessive, unprecedented, and unsustainable, and collectively caused the collapse of the Apalachicola Bay oyster population in 2012, as indicated by:

- *fishing effort and landings were at the highest levels of the contemporary reporting period (1986-2014) in the two years immediately preceding the fishery collapse;*
- *the number of oyster fishers licensed by the State of Florida increased considerably from 2009 through 2012 to high values not observed since 1990;*
- *Catch Per Unit Effort (CPUE), a measure of fishing efficiency calculated as oyster landings per fishing trip, began to decline precipitously in 2009, eventually dropping and remaining below historical low values last observed in 1992;*
- *fishery exploitation rates increased spectacularly from 2009 through 2012–monthly rates in 2011 and 2012 were in the top 6% of those in the 336 months from 1986 to 2014, and annual rates exceeded those deemed sustainable in oyster fisheries; moreover, as the population declined through 2012, oyster fishers were catching a higher fraction of oysters, a practice known as depensatory fishing;*
- *population persistence, population recovery, and fishery yield depend critically on habitat quality, such that inadequate consideration of habitat degradation due to oyster harvest practices will lead to fishery collapse, even when a traditional stock assessment deems the fishery stock not to be overfished; and,*
- *removal of shell substrate from the Apalachicola Bay oyster grounds during the period prior to and during 2012 was excessive and not replenished adequately (Section 11.2).*
- ***Thus, unsustainable fishing pressure and harvest practices led to the collapse of the Apalachicola Bay oyster fishery in 2012.***

7.2 Unsustainable Fishing Pressure and Harvest Practices

As noted in Florida Governor Rick Scott's letter to the Department of Commerce requesting that the U.S. government declare a federal fisheries disaster in Florida's Gulf of Mexico fisheries, "[h]arvesting pressures and practices were altered to increase fishing effort, as measured in reported trips, due to the closure of oyster harvesting in contiguous states during 2010. This led to overharvesting of illegal and sub-legal oysters further damaging an already stressed population." (Knickerbocker Ex. 20). Governor Scott also attached the August 2012 FDAC Oyster Resource Assessment Report to his request. This report stated that harvesting pressure contributed to declining stocks of "juvenile, sub-legal, and market-sized oysters" due to "continuous harvesting" of Apalachicola Bay's primary oyster bars, Cat Point and East Hole. (FDACS August 2012 Assessment at p. 7). The report continued that the "excessive harvesting of sub-legal oysters" contributed to declines in legal-size oysters, and that this "excessive harvesting" started after the Deepwater Horizon oil spill event, but then continued through at least August 2012. (FDACS August 2012 Assessment at p. 8) My findings are largely consistent with the findings of the Governor's letter and accompanying report, as detailed below.

Unsustainable fishing pressure by recruitment overfishing (i.e., harvesting too great a fraction of the reproductive segment of the population–spawning stock) can lead to recruitment failure (i.e., too few juveniles entering the fishable segment of the population). This can occur when too few larvae are produced, such as when densities of adults in a habitat are too low or when fertilization efficiency is greatly reduced, or when the requisite substrate (shell) for larval settlement and juvenile survival is inadequate. To reduce the risk of fishery collapse, fishery managers typically attempt to control fishing effort (e.g., number of fishing licenses or trips) or catch (i.e., fishery landings) or both. For example, when a fishery stock is at risk (e.g., abundance declining past a biomass threshhold, or exposed to a natural environmental stress), a risk-averse management approach based on the precautionary principle dictates that fishing effort and catch be capped at current levels, or reduced to allow the fished population to recover from a decline or withstand environmental stress. In the case of exploited populations that are also reliant on habitat, ecosystem-based fishery management approaches are indicated, such as enhanced re-shelling of oyster bars or minimization of harmful fishing practices on oyster bars (i.e., removal of shell). In addition, managers must attempt to eliminate sublegal and illegal fishing practices, which by themselves can deplete a population to fishery collapse. Established measures of fishing pressure, including (i) fishery landings, (ii) fishing effort represented by the number of fishing trips, (iii) fishing effort represented by the number of licensed fishers, and (iv) fishing mortality, were assessed to determine if there was excessive fishing pressure on the Apalachicola Bay oyster population and habitat in the years immediately preceding the fishery collapse.

7.2.1 Fishery Landings

Landings data provide one measure of fishing pressure. Annual landings data for Franklin County reflect harvest of oysters in Apalachicola Bay (Figure 4). These data were downloaded from the FWC website (`https://public.myfwc.com/FWRI/PFDM/ReportCreator.aspx`). This analysis relied on data from 1986-2014 because these were the longest landings time series that were standardized as to the data reporting system. Landings data reporting became mandatory in 1986; prior to 1986 reporting was voluntary. Data prior to 1986 were thus not used because those data could not be compared directly with the data after 1985 due to the change in reporting system. This situation is common in fishery management; the solution is to use standardized data in analyses of fishery performance.

Oyster fishery landings from Franklin County in 2011 and 2012 were the two highest in the time series (Figure 17). In addition, Franklin County landings from 2007-2012 encompassed four of the five highest landings since 1986, and were consistently above the time series average (Figure 17). Accordingly, the level of fishing pressure (as measured by landings) on oysters in Apalachicola Bay in the years preceding the collapse was the highest during the entire contemporary period of record (1986-2014) comprising standardized harvest data. Note that the landings may have been high due to significantly higher oyster abundance, not just excessive fishing pressure. This alternative, though, is not supported by the evidence on population abundance presented in Section 6.

7.2.2 Fishing Effort–Trips and Catch per Unit Effort (CPUE)

Another measure of fishing pressure is derived from fishing effort, which can be estimated by the number of fishing trips and by the number of license holders. The first estimate was calculated as the annual number of fishing trips by Franklin County oyster fishers (Figure 8). Data on fishing trips were downloaded from the FWC website (`https://public.myfwc.com/FWRI/PFDM/ReportCreator.aspx`).

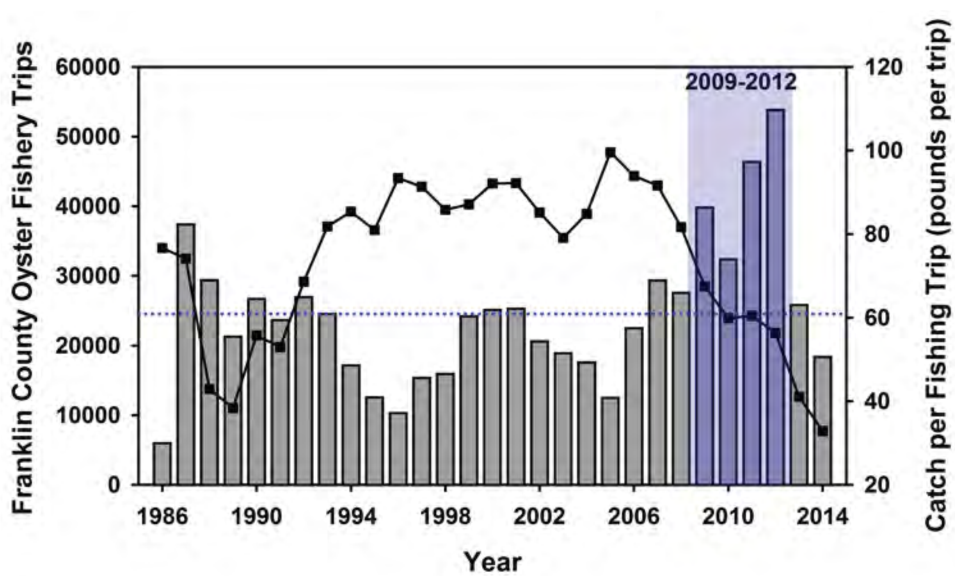


Figure 8: Number of fishing trips per year (grey bars) and CPUE as catch per fishing trip (square symbols connected by line) by the oyster fishery in Franklin County. Catch per trip was calculated as landings divided by trips. The blue shaded rectangle encompasses the three highest numbers of fishing trips (2009, 2011, 2012) in the contemporary historical record from 1986 through 2014. The blue dotted line is the average of the trips time series.

As with Franklin County landings, the number of fishing trips executed by Franklin County oyster fishers in 2011 and 2012 were the two highest in the time series (Figure 8). The third highest value in the time series was in 2009 and fifth highest was in 2010, indicating that fishing pressure (as measured by fishing trips) on oysters in Apalachicola Bay was extreme in the years preceding the collapse.

Fishery efficiency, as estimated by the catch per fishing trip (usually referred to as Catch per Unit Effort–CPUE), began to decline precipitously in 2009, having dropped to a low level last observed in 1992. This drop happened at the same time that the number of fishing trips rose significantly above the time series average (Figure 8). Catch per trip continued to decline below the time series average through 2012, eventually reaching lowest values in 2013 and 2014.

The significant decline in CPUE from 2009 through 2012 along with the very high fishing effort (fishing trips) reflected excessive fishing pressure and inefficient fishing performance, which are warning signs that often precede fishery collapse, and which should have triggered risk-averse management actions for the Apalachicola Bay oyster fishery.

7.2.3 Fishing Effort–Licenses

Another surrogate measure of fishing effort was estimated by the number of licensed oyster fishers in Apalachicola Bay from 1986 through 2012 (Figure 9). The data were derived from document UFL_00088115.xls and were checked against the data in the Oyster Resource Assessment Report, Apalachicola Bay, August 2012 by the Florida Department of Agriculture and Consumer Services, Division of Aquaculture (`http://www.freshfromflorida.com/content/download/5108/90903/`). The number of licensed fishers per year in Apalachicola Bay from 2009-2012, which encompasses the period subsequent to the Deepwater Horizon oil spill and immediately before the fishery collapse, ranged from 774-972 (Figure 9). All of these values were well above the 1986-2012 average of 644 licensed fishers, indicating high nominal fishing effort.

7.2.4 Exploitation Rate

Exploitation rate is the fraction of the fishable population harvested by the fishery per unit time; in this case, it is the fraction harvested per month (Figure 10) or per year (Figure 11) in Apalachicola Bay from 1986 through 2013.

Exploitation rate data were derived from Appendix 1 of Pine III et al. (2015). Of the 336 monthly values depicted in Figure 10, 15 of the highest 20 values occurred in 2011 and 2012, and all exploitation rates since 2009 were above the average exploitation rate. The monthly exploitation rates were used to calculate annual exploitation rates (Figure 11). Annual exploitation rates were at highest levels from 2009 through 2013, ranging from 45-73%, which greatly exceeded the recommended annual exploitation rate (20%) for sustainable exploitation of oyster populations in the Gulf of Mexico (Powell et al., 2012). In addition, extremely high fishing pressure for several years is a key predictor of fishery collapse (Essington et al., 2015), and contemporaneous analyses by official Florida agencies

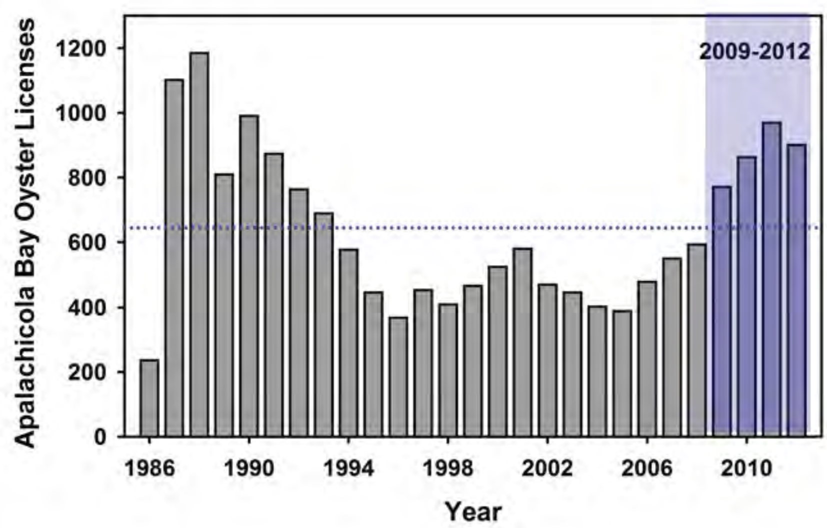


Figure 9: Number of licensed fishers per year in the Apalachicola Bay oyster fishery. Data were derived from document UFL_00088115.xls. The blue shaded rectangle encompasses the period subsequent to the Deepwater Horizon oil spill and immediately before the fishery collapse. The blue dotted line is the average of the time series.

repeatedly documented the fact of extremely high fishing pressure in the years immediately preceding the collapse. For example, in the FDACS 2011 Report, p. 3, it noted that "Fishing effort throughout the winter and spring of 2011 placed added pressure on Cat Point and East Hole Bars, which, in conjunction with fishing effort that was placed on these reefs during the summer of 2010 in response to the oil spill event, resulted in a cumulative increase in harvesting pressure from a relatively limited resource." This observation is consistent with my conclusion that the Apalachicola Bay oyster fishery collapsed due to excessively high exploitation rates in combination with habitat degradation.

7.3 Habitat Degradation and Fishery Collapse

The mechanism by which unsustainable harvest of oysters collapses fisheries involves some combination of recruitment overfishing and degradation or destruction of oyster reef habitat. Recruitment overfishing entails reduction of the spawning stock and its subsequent recruitment of young oysters below a level that allows the population to persist (Pine III et al., 2015). Habitat degradation occurs when the method normally used to harvest oysters (Figure 12) destroys the physical profile of reefs, which places the oysters lower in the water column where water flow is reduced and sediment accumulation rates are highest, thereby suffocating oysters and reducing larval settlement (Lenihan, 1999; Newell, 1988). In contrast, on unexploited high-relief reefs, oyster density and larval recruitment are higher

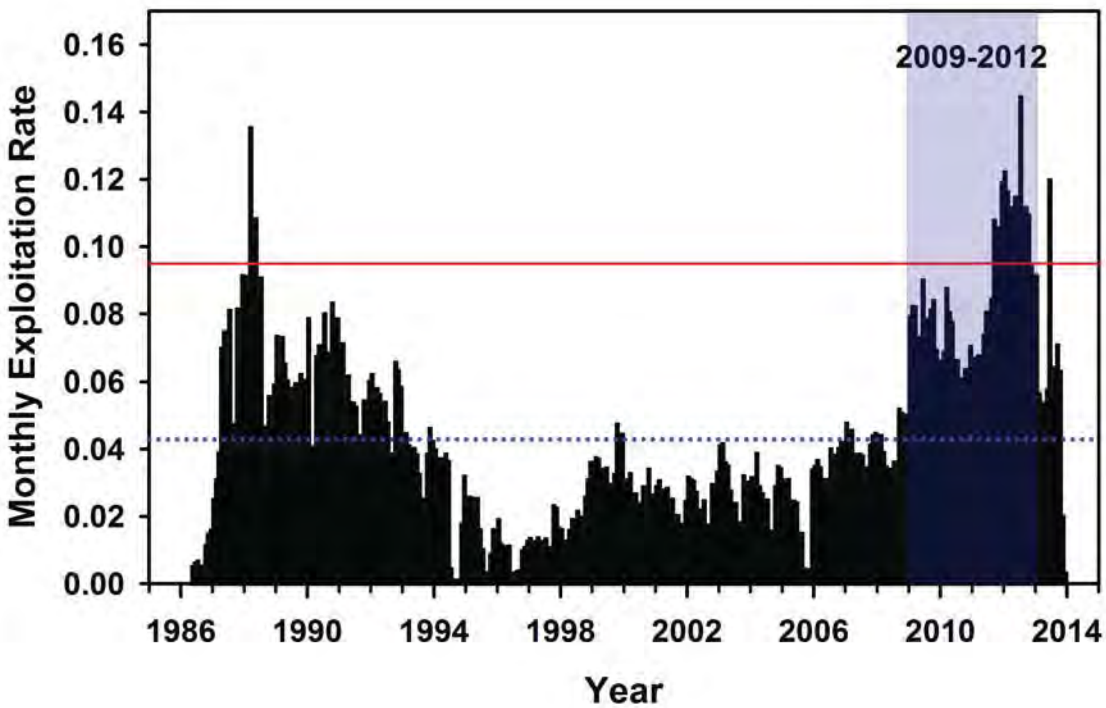


Figure 10: Monthly exploitation rate in Apalachicola Bay from 1986 through 2013. Blue shaded rectangle encompasses 2009-2012, immediately before the fishery collapse. The blue dotted line is the time series average. The red line is a reference to emphasize the high rates in 2011 and 2012.

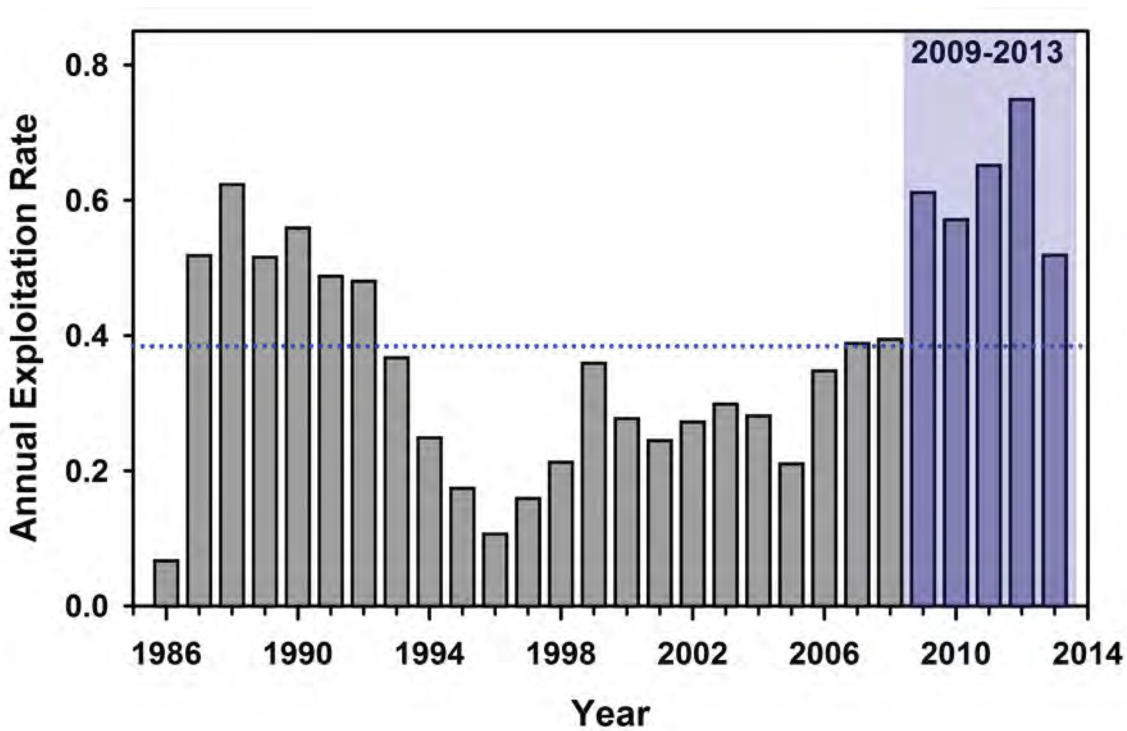


Figure 11: Annual exploitation rate, the fraction of the legal population harvested by the oyster fishery per year, in Apalachicola Bay from 1986 through 2013. The blue shaded rectangle encompasses 2009 through 2013, immediately before and during the fishery collapse. The blue dotted line is the average of the time series.

the 2012 fishery collapse in Apalachicola Bay.

9.3.6 Assessment of White/Kimbro Population Model and Conclusions

The general model used by Dr. White (integral projection model) is an advanced type of population model used widely in studies of population dynamics and conservation (Ellner and Rees, 2006; Rees and Ellner, 2009). In fact, my colleagues and I have a scientific publication in press on the use of an integral projection model with the Pacific oyster *Crassostrea gigas* (Appendix A: Moore, J.L., R.N. Lipcius, B. Puckett and S.J. Schreiber. The demographic consequences of growing older and bigger in oyster populations. *Ecological Applications* in press, doi: 10.1002/eap.1374). However, White's model contains serious errors in the parameterization and assumptions underlying the model, which preclude application of the model results and conclusions to the Apalachicola Bay fishery collapse. Herein I will highlight some of the issues.

The model used FDACS oyster survey data from one oyster bar, Cat Point, to extrapolate to conditions throughout the entire Bay. Such an approach does not capture the unique environment of each oyster reef, as well as the critical distinction between oyster reefs that are harvested and those that are lightly harvested and/or re-shelled, which have dramatically different oyster densities of legal and sublegal oysters, as demonstrated in Section 8.5.

In addition, Dr. White decided to run only Dr. Greenblatt's "unimpacted scenario" to study the changes in Apalachicola Bays oyster biomass. The "unimpacted scenario," however, rests on an assumption that the State of Georgia removes zero water from the Apalachicola-Chattahoochee-Flint River basin. Such an assumption makes Dr. White's model have little practical utility. Dr. White, for instance, did not run any of Dr. Greenblatt's remedy scenarios, which I understand are similar to the restrictions the State of Florida has asked be imposed on the State of Georgia with respect to its water consumption. Thus, there is no modeled estimate of the effect of practical reductions in water use upon the Apalachicola Bay oyster population.

The principal conclusion Dr. White offers in his Expert Report does not provide any specific calculation of the effect of lower water consumption: "High salinity conditions in the Apalachicola Bay due to reductions in flow of the Apalachicola River by Georgia contributed to reductions in oyster biomass in Apalachicola Bay from 2007-2012." Accordingly, this conclusion provides no valid scientific basis that could allow Dr. Kimbro to draw concrete conclusions about the relationship between Georgia water consumption, predation and the collapse of the oyster fishery in 2012.

As an example of mistaken parameterization in the model, I will discuss the function relating larval growth and survival to salinity in Dr. White's model. In the report it was noted that "[oyster larval] recruitment decreased as salinity moved away (higher or lower) from 15 ppt, which was consistent with reported effects of salinity on larval growth and survival (e.g., Davis 1956)." The reference was actually Davis (1958), which was cited correctly in the report's Literature Cited section, but which does not conclude that larval survival and growth are optimal at 15 psu (partial salinity units, previously termed "ppt"). Davis (1958) actually noted that "The salinity range for development of normal straight-hinge larvae...for eggs from oysters conditioned at 26.0-27.0 p.p.t. was from 12.5 to above 35.0 p.p.t." and that the optimum salinity for growth of larvae of oysters from waters at 26-27 psu "was 17.5 p.p.t." in one study and "about 22.5 p.p.t." in another study. Davis (1958) also noted that oysters raised in low-salinity waters will have lower salinity optima, but that is not relevant in the case of Apalachicola Bay oysters during drought conditions. Furthermore, the literature on habitat requirements for larval settlement states "maximal setting at 18 to 22 ppt" in general for the eastern oyster (Cake, 1983). For example, Cake (1983) cites data from 11 years of spatset data from Louisiana, which found "Setting intensities were consistently high...between 16 and 24 ppt with a peak of more than 12 spat/cm between 20 and 22 ppt." Thus, the parameterization for the larval survival function is in error relative to the case in Apalachicola Bay during drought, and raises concerns about the veracity of other parameter and function estimates used in the model.

Hence, I conclude that, as presented, the modeling results and conclusions cannot address the actual situation underlying the Apalachicola Bay oyster fishery collapse in 2012.

9.4 Stone Crab

The Gulf stone crab *Menippe adina* ranges from peninsular Florida through the Gulf of Mexico (Figure 29), and supports a major commercial fishery along the Gulf coast of Florida (Bert and Harrison, 1988), including the counties of Wakulla (Apalachee Bay) and Franklin (Apalachicola Bay) (`http://myfwc.com/media/195801/florida-stone-crab.pdf`). In this region, hybrids of the Gulf stone crab and Florida stone crab *Menippe mercenaria* also occur, but are aggregated with Gulf stone crab in landings data (`http://myfwc.com/media/195801/florida-stone-crab.pdf`).

The Gulf stone crab was implicated in the fishery collapse by Fish and Wildlife Conservation Commission (2013), as follows:

> "Observations by divers confirmed the presence and abundance of stone crabs (*Menippe mercenaria*), on the primary oyster reefs in Apalachicola Bay." and "Stone crabs are considered the primary predators of oysters when salinities remain high for extended periods and crab populations become established on oyster reefs."

The rationale for this is that the stone crab, like the rock snail, prefer higher salinities, and should have increased in abundance to some degree during the drought. Consequently, I examined available data on stone crab landings in both Franklin and Wakulla counties

10 Ecosystem Productivity of Apalachicola Bay

10.1 Rationale and Findings

Relationships between river flow, salinity, and ecosystem productivity of estuaries along the Gulf of Mexico, such as Apalachicola Bay, has been investigated in depth (see Livingston (2014) for a review). In some cases, ecosystem productivity increases with salinity (Livingston et al., 1997), while in others it decreases (Livingston, 2014). Consequently, I examined whether or not CPUE of exploited crustaceans, surrogates for Apalachicola Bay productivity, had dropped significantly during the years of low flow and oyster fishery collapse–2011 through 2013. These data were compared to those for the oyster and stone crab fisheries, which demonstrated conspicuous declines immediately preceding and during the fishery collapses (Figures 8, The findings indicate that, during and immediately after the years of low flow and oyster fishery collapse from 2011 through 2013:

- *CPUE of white shrimp, pink shrimp and blue crab did not exhibit a significant reduction;*
- *landings of these species were either positively correlated or not correlated with river flow at 0 or 1 year time lags;*
- *the patterns in CPUE over time differed significantly from those of oyster and stone crab; and,*
- *CPUE for shrimp species in Apalachicola Bay (white and pink shrimp) did not differ from those of the brown rock shrimp, which inhabits deeper waters outside of Apalachicola Bay.*
- ***Thus, ecosystem production of the blue crab and shrimp during and immediately after the years of low flow and oyster fishery collapse was not low relative to non-drought years, and was also not correlated with river flow.***

I investigated three species that depend on productivity of Apalachicola Bay, the blue crab, pink shrimp, and white shrimp (Figure 33). I also investigated data for brown rock shrimp (Figure 33), even though it is primarily a deep-water species outside of Apalachicola Bay, to assess whether its patterns in CPUE were similar or different from those of the three that are abundant in Apalachicola Bay. CPUE was calculated as (landings/fishing trips) using data for Franklin County derived from the Florida Fish and Wildlife Conservation Commission website (`https://public.myfwc.com/FWRI/PFDM/ReportCreator.aspx`). Blue crab landings were for hard crabs, and did not include landings of soft crabs produced by shedding operations.

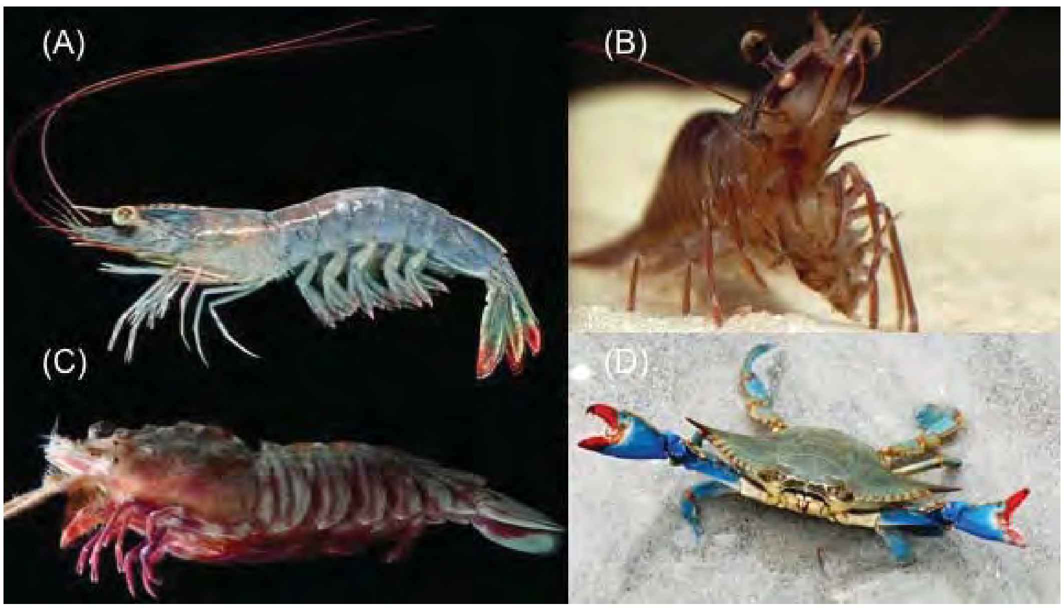


Figure 33: (A) white shrimp Litopenaeus setiferus***, (B) pink shrimp*** Farfantepenaeus duorarum***, (C) brown rock shrimp*** Sicyonia brevirostris***, and (D) blue crab*** Callinectes sapidus***. Photo credits: (A)*** *http://www.ncfishes.com/families/aquatic-invertebrates/litopenaeus-setiferus/*, ***(B)*** *http://voices.nationalgeographic.com/2010/02/01/shrimp_trawl_excluder_cuts_bycatch/*, ***(C)*** *http://naturewatch.org.nz/observations/862824*, ***(D)*** *http://splendidwallpapers.com/blue-crab-wallpapers.html*.

Exhibit 17

From: Havens,Karl
Sent: Tuesday, September 02, 2014 9:31 PM
To: Payne,Jack M; Place,Nick T
Cc: Kane,Andrew S
Subject: Apalachicola

Jack and Nick,

See below from Erik Lovestrand. all that I have heard there may be major politics involved. We will continue to do research, education and outreach however I don't see a clear role for IFAS or Sea Grant or the Oyster Recovery Team to 'act proactively to help' since there may be big politics afoot. The agencies are creating a management plan pretty much behind closed doors [from the perspective of the community] and the FWC won't close the bay to harvesting despite evidence that the bay's population of oysters is almost 100 percent depleted.

I'm available to talk more should there be a desire to do this and Andy could join us as someone with much first hand / in the water knowledge.

This is largely a heads up that when the fall oystering season opens (yesterday) and days go by with no harvest, things could quickly get dire in the community.

My understanding is that there are millions of dollars from Congress to restore the bay ... so the state has federal money to employ oystermen in useful restoration projects. A win-win that is not occurring.

I don't know why this is not happening (though I have an educated guess) .. vs allowing depletion of the tiny remaining amount of oysters, a real collapse of the industry and many people out of work.

Karl

Karl Havens, Ph.D.
Director, Florida Sea Grant
Professor, University of Florida/IFAS

Sent from my iPhone

Begin forwarded message:

> **From:** Andy Kane <kane@ufl.edu>
> **Date:** September 2, 2014 at 5:17:43 PM EDT
> **To:** Karl Havens <khavens@ufl.edu>
> **Cc:** Jack M Payne <jackpayne@ufl.edu>
> **Subject: Fwd: Today's County Commission meeting**
>
> This is what's been brewing, as nicely captured by Erik. It's "winter season" as of September 1st, and it's now a question of who has egg on their face when depletion goes to the point of "worse depletion" that closes the fishery. The option of coming up w the relatively sparse dollars needed to engage the limited number of honest licensed harvesters, whose income is primarily from oyster harvesting, in a closed-bay restoration process, is a win-win alternative to the current (seemingly) one-for-all & all-for-one maelstrom.

EXHIBIT
PENGAD 800-631-6989
21

Hope to hear from Luiz soon. Would you like to chat by phone?

andy

From my iPhone in Portland

_/_/_/_/_/_/_/_/_/_/_/_/_/_/_/
Andrew S. Kane, MS, PhD
Associate Professor of Environmental and Global Health, and Graduate Program Director
College of Public Health and Health Professions
University of Florida

Director, UF Aquatic Pathobiology Laboratories
Emerging Pathogens Institute
KANE@UFL.EDU
(352) 273-9090 - desk
(352) 213-8407 - cell

Begin forwarded message:

> **From:** "Lovestrand,Erik L" <elovestrand@ufl.edu>
> **Date:** September 2, 2014 at 9:18:46 AM PDT
> **To:** "Kane,Andrew S" <kane@ufl.edu>
> **Subject: Today's County Commission meeting**
>
> Hi Dr. Kane,
>
> There was quite a discussion today during the Franklin County Commission meeting regarding the state-of-the-Bay and the lack of information that is forthcoming from the "state agencies" involved in looking into the problem. Mainly, people are getting very nervous regarding the poor condition of the summer bars now and the bleak outlook for what will be available on the winter bars. As often happens in these situations, people are emotionally involved as this affects livelihoods and getting increasingly impatient for answers on what is happening. Comments were even made from the Commission that the "state" doesn't care and that they won't tell the people what they do know. Also, "enough research, we need some communication from these agencies." Most of the negativity is typically aimed at DACS and also the blame for allowing over-harvest when they thought the oil was coming. I think folks are finally at the realization that the more harvest pressure put on the depleted bars, the longer recovery will take and we are in for hard times for a long time if we don't deal with this reality. I'm hearing quite a few people saying we need to shut down oystering (oystermen and dealers even) but no one is willing to do this without an alternative way to pay oystermen, either through a shelling program or via disaster assistance.
>
> The Commission passed a motion to contact the agencies involved and the Governor to see what can be done.
>
> I just wanted to touch base with you and see if you thought the UF Oyster Recovery Team might be able to act proactively in any way to help. The Board is looking for communication mainly so they feel like they know what is going on. I thought I would give a head's-up that this was building.

Erik

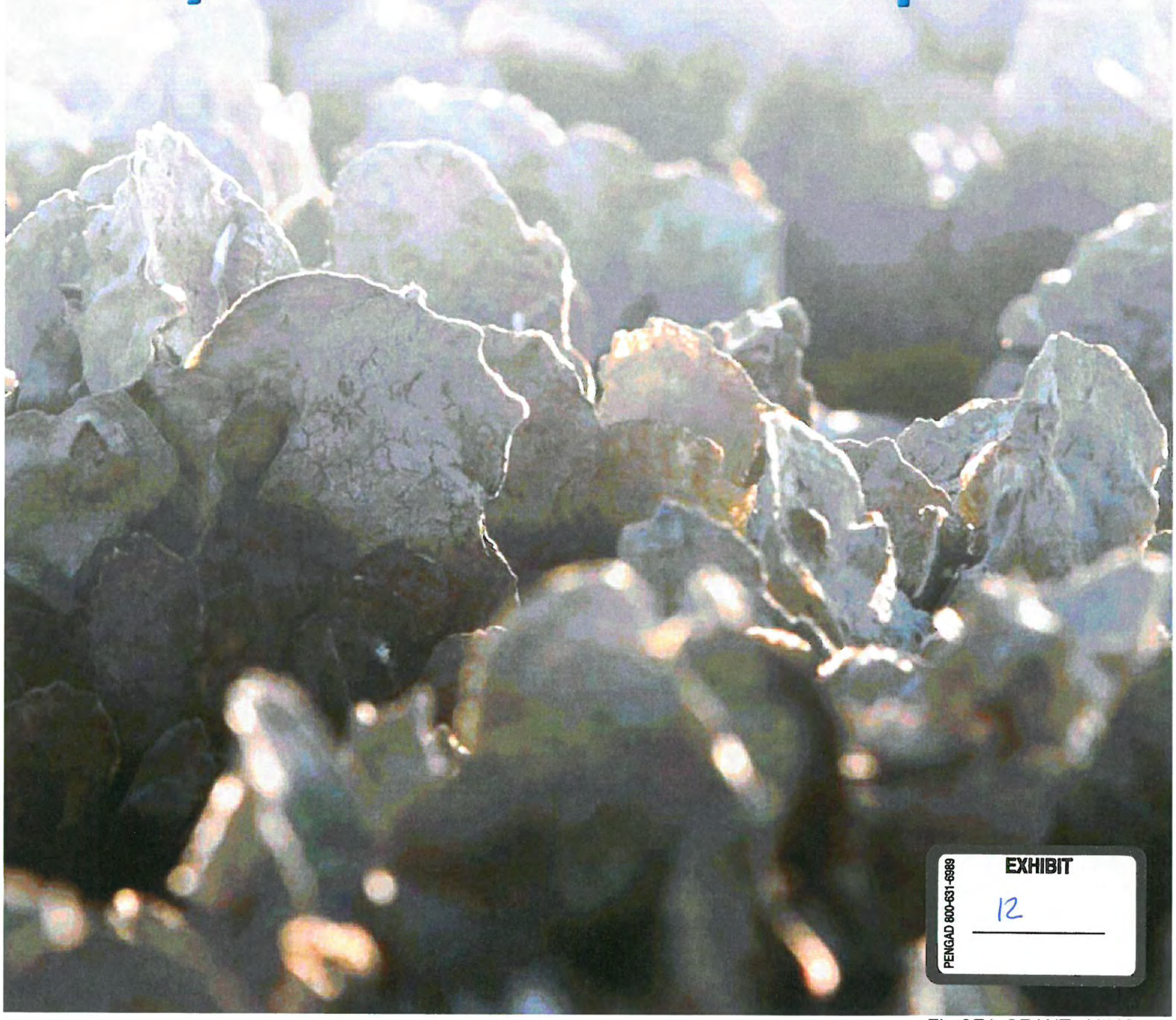
Erik Lovestrand
UF/IFAS Franklin County Extension Director
Sea Grant Regional Specialized Agent II
elovestrand@ufl.edu
(850) 653-9337

Exhibit 18

UF UNIVERSITY of FLORIDA IFAS | Sea Grant Florida | EMERGING PATHOGENS INSTITUTE University of Florida

TP-200

Apalachicola Bay
Oyster Situation Report



Apalachicola Bay Oyster Situation Report

APRIL 24, 2013

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CONTENTS

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Apalachicola Bay Oyster Situation Report

APRIL 24, 2013

EXECUTIVE SUMMARY

This report summarizes efforts conducted through the University of Florida Oyster Recovery Team, in collaboration with various stakeholders, to describe conditions in Apalachicola Bay prior to and after a historic collapse of the oyster fishery. The report characterizes conditions in the bay, reviews possible causes for the fishery collapse, and outlines a plan for future monitoring, research and fishery management. Conclusions in this report are based on analyses of data collected in historical monitoring programs conducted by the Florida Fish and Wildlife Conservation Commission, Florida Department of Agriculture and Consumer Services, Apalachicola National Estuarine Research Reserve (Florida DEP) and Northwest Florida Water Management District, as well as field, experimental, and community data collected by the authors, who are reporting in their capacity as members of the UF Oyster Recovery Team.

Findings

- Apalachicola River discharge levels are strongly influenced by rainfall over the Apalachicola-Chattahoochee-Flint River Basin. The lower part of this basin was frequently classified by the National Integrated Drought Information System as in an 'exceptional drought' during the last three years.
- Water quality data indicate that 2012 was a year of high salinity at all monitoring stations in the bay likely caused by low river flows and limited local rainfall in most months.
- A large decline in oyster landings was reported after August 2012 in the bay, and the number of reported oyster harvesting trips also dropped off each month during the second half of that year.
- The 2012 decline in oyster landings and recruitment of juvenile oysters is unprecedented during the period of data analyzed and has likely involved recruitment failure or high mortality of small oysters.
- Fisheries independent monitoring data, collected by state agencies, indicates a general downward trend in abundance of legal-sized (3 inch or larger) oysters in the bay in recent years and a large decline in sub-legal (smaller than 3 inches) oysters present in 2012.
- Because of the low abundance of sub-legal oysters in 2012 there is a high likelihood that legal-sized oysters will be in low abundance in 2013 and likely in 2014 as well.
- The current size limit of 3 inches appears to be effective at reducing the risk of "growth overfishing" where yield (pounds of meat harvested) is reduced because oysters are harvested at too small a size. However, it is essential that this size limit be accepted by the community, adopted by the industry, and enforced by regulatory agencies and the county judicial system. Substantial future harvesting of sub-legal oysters could have negative effects not only on oyster populations but also a serious impact on the national reputation of Apalachicola oysters as a high-quality seafood product.
- Oysters, white shrimp, brown shrimp, blue crab and multiple finfish species have been analyzed for the presence of oil residue. All samples were either below the limits of detection or below quantifiable limits. Thus, based on analyses conducted so far, there is no evidence of chemical contamination from the Deepwater Horizon oil spill in the seafood sampled from Apalachicola Bay.
- A large percentage of oysters in the bay have some degree of shell parasitism by clams, polychaete worms, sponges or other organisms. This parasitism negatively affects the integrity and aesthetics of the oyster shell, the overall growth and productivity of the oysters, and the economic value of product bound for the half-shell market. There are no historic data to compare degree of shell parasitism observed in 2012-2013.

Recommendations

Monitoring

- There is a need to continue the monitoring of oysters in Apalachicola Bay, both in terms of tracking landings reported by oystermen, and in the sampling done by state agencies.The fisheries independent monitoring program needs to be expanded in its spatial extent to include all of the bay where oyster bars occur, including areas that are closed to fishing, because these may represent important sources of oyster spat.
- Oysters should be included on the list of invertebrate species routinely assessed by Fish and Wildlife Research Institute (FWRI) stock assessment staff. These assessments can identify persistent uncertainties in oyster ecology or population status and help guide research such as the relationship between Apalachicola River flows and juvenile oyster survival rate or culling mortality.

Management and Restoration

- Acceptance by the community and industry, and enforcement and adjudication of rules regarding size limits, spatial restrictions, and weekly and seasonal closures is essential for these measures to be effective in sustaining the oyster population.
- Throughout our work on this project there were persistent reports of high levels of unreported harvest and illegal harvest from closed areas. While tangible evidence of illegal activity is not available, it is clear from our simulation models that lack of compliance with current regulations could greatly reduce the likelihood of Apalachicola Bay oyster populations returning to historic population levels, regardless of management action taken.
- Oyster leases should be explored as a possible alternative to open-access fisheries. The concept of TURF (Territorial User Rights Fisheries) as a lease arrangement could be appealing to oyster fishermen and help promote restoration actions such as re-shelling because the fishermen would benefit directly from the restoration activities they were engaged in by having a "share" of the restored area (the lease) to manage and harvest from.
- The total current area of oyster bar in Apalachicola Bay that is not open to fishing is unknown, and the degree to which this area is the source of the oyster spat for the entire bay also is unknown. If this area is small or declining, then large-scale oyster relay from these closed areas to areas open to fishing may reduce the total spat available throughout Apalachicola Bay, increasing the risk of "recruitment overfishing" where harvests of adults could influence availability of future spat.
- Therefore, the practice of 'relaying' should be carefully evaluated in regard to its short-term benefits versus potential longer-term negative impacts to the fishery—in other words, whether or not it is depleting a substantive portion of the source population of oyster spat.
- Management actions such as shell planting could expedite the recovery of Apalachicola Bay oyster resources. However, a new modeling tool called ECOSPACE, brought forward by the UF Oyster Recovery Team, suggests that shell planting needs to be conducted at a considerably greater scale than current levels to be effective—approximately 200 acres per year for a 5-year period. A very important uncertainty is whether shell planting should concentrate large amounts of shell in small areas to create thick layers of shell or whether shell should be spread over larger areas but not in as thick a shell layer. Restoration should be done in a manner that provides information on efficacy and cost-effectiveness of different shelling strategies, including evaluating different densities of shelling and different kinds of shell material.
- A participatory decision-making process, involving SMARRT (the Seafood Management Assistance Resource and Recovery Team), relevant state agencies and experts from the state university system is needed to support long-term management of the oyster fishery in a more robust manner. The ECOSPACE model could further support members of SMARRT and management agencies to screen different policy or restoration alternatives.

Research

- Research is needed to identify an optimal approach for monitoring long-term settlement, juvenile and adult survival, productivity, health, mortality, oyster diseases, and product quality of oysters. Subsequently this information could be used to inform changes in the oyster monitoring program.
- Research is needed to quantify how oyster population dynamics, product quality and the fishery are affected by interactions between river flow, nutrients, salinity, harvesting intensity and restoration methods.
- There is a need to assess the harvesting practices of the oystermen and how they respond to changes in oyster abundance.
- The ECOSPACE model has additional functionality to identify effects of varying flow regimes and to screen flow alternatives, relative to Apalachicola Bay oyster population dynamics and harvest potential when the model is linked with the Apalachicola Basin River Model currently being used by the Apalachicola-Chattahoochee-Flint River Stakeholders Group.

Outreach and Education

- A community-based outreach and education program is needed to foster actions consistent with supporting a sustainable bay ecosystem and economy.
- Involvement of oyster harvesters and processers in research and restoration projects can aid in educating the entire community about bay stewardship.

The Future

The situation in Apalachicola Bay, as outlined in the pages of this report, highlights a series of interwoven ecologic, fisheries, and community concerns. The bay is a national treasure, and its demise would sever critical links among our modern society, nature and our heritage. Work to date is a starting point toward understanding the processes underlying the current crisis, and includes steps that can and should be taken in initial efforts to restore the bay. However, if we are truly committed to bringing the bay back to a point even close to its former productivity, a great deal of work is still required. These studies and analyses were conducted on a shoestring budget with internal funds from UF/IFAS, and limited support from Florida Sea Grant and from the National Institute of Environmental Health Sciences. If we are truly committed to the restoration of the bay, we can't stop here.There is a critical need for follow-up work, bringing together state and federal agencies, academic researchers, and the community, to look out over a 5-, 10-, and 20-year time scale, to conduct interventions, do the necessary research, and monitor outcomes. This will require a strong leadership structure and it will cost money. The question remains as to whether we, as a society, are willing to make this investment of time, and money, to preserve this priceless natural resource for our lifetime, and the lifetimes of our children.

BACKGROUND

Apalachicola is a heritage fishing community located in the Big Bend Gulf coast region of Florida. For decades, it has been the state's prime production estuary for oysters prized for their outstanding quality and taste. Today this unique oyster fishery may be on the verge of collapse. This collapse is associated with multiple environmental and human factors.

Apalachicola Bay traditionally has been a great place for oysters to grow. Freshwater inflows from the Apalachicola River are retained in Apalachicola Bay by a series of barrier islands fringing the coast. This retention of fresh water lowers the salinity level in Apalachicola Bay creating preferable salinity conditions that favor good oyster growth, survival, and low disease occurrence, but unfavorable conditions for marine predators that feed on oysters such as conchs and whelks. Apalachicola Bay has other natural geologic features such as ancient hard bottom areas that provide nucleation sites for oysters to grow forming oyster bars. In addition to lowering the salinity, fresh water flows from Apalachicola River also deliver nutrients from upstream areas that are essential for the entire Apalachicola Bay ecosystem.

During the last two years, a severe drought in the southeast U.S., including Georgia, where much of the water in the Apalachicola River originates, has dramatically reduced freshwater inflows to Apalachicola Bay. Adding to this problem are withdrawals of water from upstream reservoirs for use by metropolitan Atlanta and water withdrawals in the basin for Georgia and Alabama agriculture. Oystermen and other concerned citizens in the Apalachicola area have pointed to declines in abundance of a wide range of aquatic animals in the bay, including economically and ecologically valuable oysters and other seafood products. This situation could reflect a variety of stressors, including increased disease and predation as salinity in the bay has increased without the typical rate of freshwater inflow, perhaps nutrient limitation of the food web, and a historically high level of oyster harvesting.

The number of oysters harvested and the number of oyster fishermen in Apalachicola Bay has increased in recent years due to several factors including high oyster prices because of reduced oyster availability in other areas following the Deepwater Horizon oil spill in 2010. There also were temporary changes in harvest regulations immediately following the oil spill, due to concerns that oysters might be lost to oil contamination. This led to increased harvest rates - yet the oil did not reach the bay, and no evidence of oil contamination has ever been found in Apalachicola Bay. In 2011 and 2012 oyster prices again remained high and the number of oyster harvesting trips reported by fishermen reached the highest levels observed since the mid-1980s. Additionally, fishermen raised concerns about large harvests of sub-legal (less than 3 inch) oysters over this same time period—all while Apalachicola River flows reached some of their lowest points recorded and salinity levels increased within the bay to higher and higher levels. In essence, the period from 2010 to 2012 may have been a perfect storm for the oyster fishery in Apalachicola Bay with low river flows and higher salinity creating poor environmental conditions and several years of low juvenile survival and naturally low populations. At the same time, oyster demand, prices, and fishing effort, combined with insufficient fishery management enforcement and adjudication, led to a large portion of the oysters being harvested. Unfortunately, the storm may not be over as surveys of juvenile oysters suggest that legal oyster abundance will be low in 2013 and likely 2014 as well. Now is the time to address key long-term uncertainties related to managing and restoring oyster resources in Apalachicola Bay, in order to create and maintain a resilient oyster fishery.

RESPONSE

University of Florida/IFAS responded to this situation in fall 2012, when Senior Vice President Jack Payne formed the UF Oyster Recovery Team, and appointed Karl Havens, director of Florida Sea Grant, to serve as chair. The team includes UF researchers with a broad range of experience and knowledge about oysters and coastal ecosystems in Florida. Also included are researchers from Florida State University and Florida Gulf Coast University, state regulatory agencies, the Northwest Florida Water Management District, and representatives from the oyster industry and other fishing-related businesses in Apalachicola. The work reported here was funded primarily by internal funds from the Institute of Food and Agricultural Sciences at UF, Florida Sea Grant, and with some components funded by the National Institute of Environmental Health Sciences (Grant U19ES020683) as part of the Deepwater Horizon Research Consortium.

The team met in Apalachicola for public meetings in October 2012 and January 2013, and researchers have met with agency scientists on a number of occasions throughout this period to obtain and jointly evaluate historical and contemporary data on oysters, water quality and other features of the bay. The focus of research has been on looking for signs of increased infection, signs of oil or dispersant from the Deepwater Horizon oil spill, evidence of over-harvesting and harvesting of sub-legal oysters, and predation impacts on oysters and how it relates to salinity at different locations in the bay. The team has also worked with members of the industry and community to develop approaches for increased community resiliency, and evaluated options for diversification of seafood products.

While researchers were doing this work, a group of oystermen, oyster dealers and other members of the community formed a citizen action group called SMARRT (Seafood Management Assistance Resource and Recovery Team) that aims to work with the state regulatory agencies to develop a process to ensure that the oyster industry has long-term sustainability. UF/IFAS faculty supported this effort, by developing a process for participatory decision making and by developing a tool (an interactive and visual computer model of the bay) that can be used by SMARRT to screen restoration and policy alternatives.

ABOUT THIS REPORT

This report summarizes the findings of natural and social science research and outreach conducted by members of the UF Oyster Recovery Team since October 2012. It focuses on questions related to "what happened?" in the bay (i.e., research dealing with presence/absence of oil or dispersant, disease, predators, apparent responses to reduced salinity and the effects of fishing of sub-legal oysters on recovery of the population) and "what can be done?"

This is a report of efforts to understand the bay, its ecology, and optimal approaches to protecting its resources. It should be emphasized that this is only a start. Bringing the bay back to a point even close to historical oyster production levels will require restoration actions and long-term research and monitoring, in a second phase plan, to assess the outcome of new programs, and to continually refine our understanding of the bay and its operation. This will need to include further development and implementation of the ECOSPACE model with validation efforts and river flow analyses to determine effects of mitigating management strategies. Future work will also need to include continued oyster health and productivity assessments, and examination of alternative seafood products and seafood product production practices.

RESULTS

Environmental Conditions

To assess physical conditions in the bay during 2012, we examined recent patterns in freshwater inputs, rainfall, water temperature, and dissolved oxygen in Apalachicola Bay using data from U.S. Geological Survey gauge stations on the Apalachicola at Chattahoochee and preliminary 2012 water quality data from the Apalachicola National Estuarine Research Reserve.

Flow patterns in the Apalachicola River

The Apalachicola River is formed by the confluence of the Chattahoochee and Flint Rivers approximately 112 miles upstream of the town of Apalachicola, Fla. This Apalachicola-Chattahoochee-Flint River Basin (ACF) drains a watershed of about 19,500 miles² in three states: Georgia (74% of watershed), Alabama (15%), and Florida (11%). Within this basin, 16 in-stream reservoirs are present which modify and attenuate river flows in various ways. River flows are also modified via surface and subsurface water withdrawals for agricultural, municipal, and industrial use. How these flow modifications alter the hydrology and ecology of the ACF basin and Apalachicola Bay is an area of ongoing debate and research by numerous federal, state, and citizens groups.

The Apalachicola River has seasonally variable flows with the highest flows generally occurring during winter and spring and lowest flows occurring in summer and fall. The Apalachicola River is the primary source of freshwater input into Apalachicola Bay, and as such flows from the river have a very strong influence on the salinity, nutrient dynamics, and other aspects of the Apalachicola Bay ecosystem. We assessed recent flow patterns in the Apalachicola River measured at the Chattahoochee USGS gauge 02358000 by calculating modified box plots of monthly river flows from 1950-2006, as shown in **Figure 1**. These box plots can be interpreted as follows: the x-axis represents the month of the year and the y-axis represents the average daily flow volume for that month from 1950-2006; the thick horizontal line for each month is the median value (middle value for historic daily flows for that month); the box is the interquartile range which spans the first quartile (the 25th percentile) to the third quartile (the 75th percentile); the whiskers extend 1.5 times beyond the interquartile range, and the circles extending beyond the whiskers are the most outlying largest or smallest values. In simplest terms this can be interpreted as saying that in a given month between 1950 and 2006, most of the average daily flows would be observed within the box for each month. We then used colored dots to plot the mean monthly flows in each year from 2007-2012 to assess what the flows over the last 6 years looked like compared to the previous 56 years. This graph demonstrates that for most months over the last 6 years, the flows in the Apalachicola River have been exceptionally low with average daily winter/early spring flows (January–April) generally falling in the lower 25% of measured flows for that month

Apalachicola River @ Chattahoochee Gauge

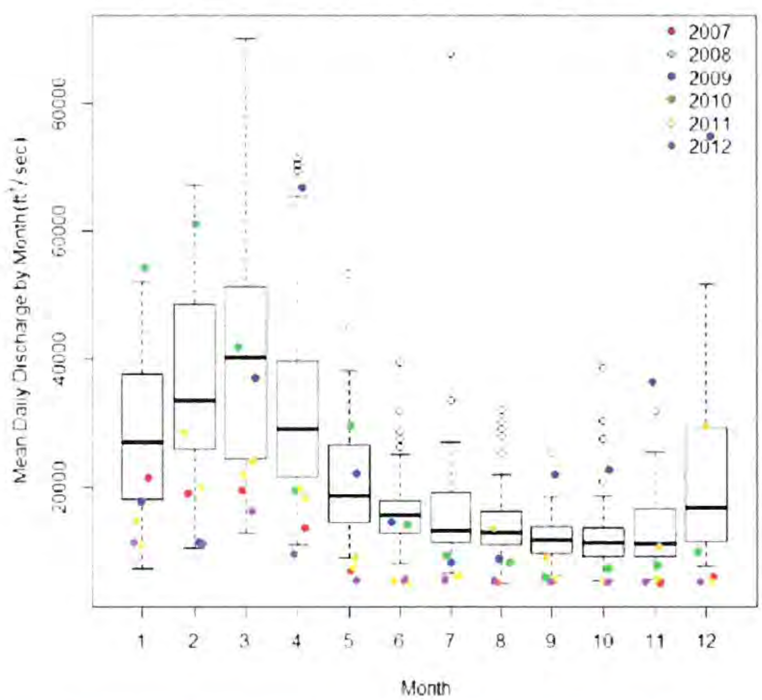

Figure 1 Modified box plot of mean daily discharge (ft³/sec) by month from 1950-2006 (box plots) and from 2007-2012 (individual colored dots by year, see legend) for the Apalachicola River measured at the USGS Chattahoochee gauge.

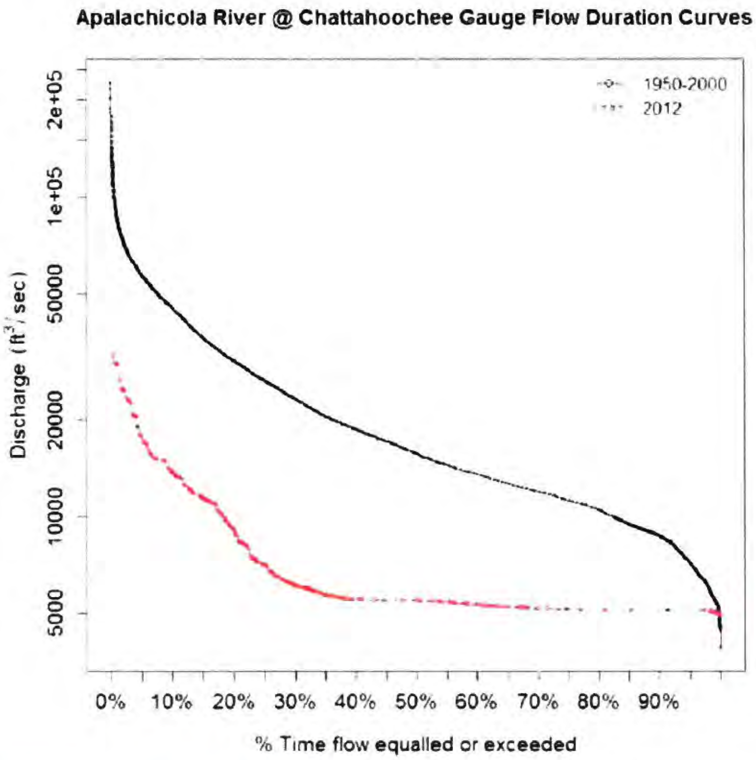

Figure 2 Flow duration curve for the Apalachicola River measured at the USGS Chattahoochee gauge. Black line represents the average flow values that were equal to or exceeded from 1950-2012 and the red line represents the observed 2012 flows.

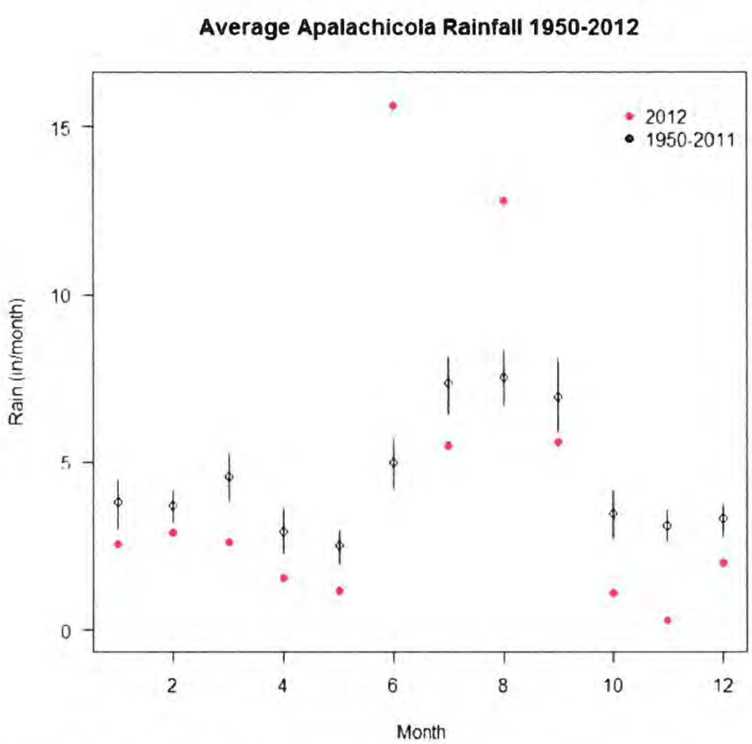

Figure 3 Average monthly rainfall and boot-strapped 95% confidence limits for Apalachicola from 1950-2011 (black circles with error bars) and 2012 (red dots) obtained from the Prism Climate Group [illegible]

and the flows during the rest of the year (May–December) generally at the lowest levels measured for any year during the period of record. The general exception to this pattern over the last six years is 2009 when flows were generally normal through the winter and above normal range during fall and winter.

To more closely examine the river flow for 2012 compared to most of the period of time (1950-2000) we created a river stage duration curve (**Figure 2**) which shows the percent of time the Apalachicola River flow equaled or exceeded a given flow value in a particular year. This graph shows that in 2012 the Apalachicola River mean daily discharge (ft^3/sec) equaled or exceeded a discharge level of about 10000 ft^3/sec about 20% of the time, whereas during the time period between 1950-2000 this same flow level was exceeded more than 80% of the time (**Figure 2**). Combined, **Figures 1 and 2** demonstrate how low the Apalachicola River flows have been in recent years, particularly in 2012 compared to the period of record.

Apalachicola area rainfall

Apalachicola River stage and discharge levels are strongly influenced by rainfall within the Apalachicola-Chattahoochee-Flint River Basin. According to briefings hosted by the National Integrated Drought Information System (NIDIS) and a variety of cooperating agencies and research groups, the lower part of the ACF basin, particularly the Flint River drainage within southwest Georgia has frequently been in "exceptional drought" conditions for much of the past three years (see materials archived at [illegible]) including most of 2012.

At the local level, 2012 rainfall levels in the Apalachicola Bay area show that rainfall during 2012 was well below average (**Figure 3**), even below the lower 95% confidence interval (e.g., rainfall was higher on average 95% of the time based on the 1950-2011 record compared to rainfall observed in 2012). The two exceptions are June and August 2012, both months with significant tropical rain events resulting in above average rainfall.

Apalachicola Bay water quality 2012

We looked for anomalous patterns (high or low events) in the water quality data available from data sondes maintained by the Apalachicola NERR lab (downloads available, [illegible]) for locations at Dry Bar, Cat Point, and a surface and bottom sonde in East Bay. We made plots of temperature (C), salinity (ppt), dissolved oxygen percent saturation (DO%), and dissolved oxygen in milligrams/l. Water quality data suggests that 2012 was a year of generally high salinity (for Apalachicola Bay) at all stations (**Figures 4-7**) likely because of low river flows and limited local rainfall in most months (**Figures 1-3**). Summer conditions of high heat and salinity changed abruptly following large rain events related to Tropical Storm Debby in late June and other rain events in August. While these rain events were locally significant and did cause short-term changes in salinity, temperature, dissolved oxygen, and likely other water quality parameters, these rain events were mostly coastal and were not accompanied by large changes in river flow from basin level inputs.

Nutrient inputs to the bay

In addition to delivering fresh water, the Apalachicola River is a major source of nutrients to the bay, fueling a food web that supports oysters, shrimp, fish and other marine organisms. When flows decline, so do inputs of nutrients, and if this phenomenon lasts for a long period of time, the abundance of all of the organisms mentioned above may decline.

There are no continuous measurements of nutrient input to the bay, only water flow volume. However in the early 2000s the Northwest Florida Water Management District conducted several years of simultaneous measurement of flows, nutrient concentrations and nutrient inputs (loading rate). This was done for three nutrient elements that are important for marine food webs – nitrogen, phosphorus and organic carbon. Regression analysis of those data indicated that concentrations did not vary with flow. This allowed a simple loading model to be developed based simply on the regression of flow vs. load. That model was used to approximate what the loads have been in the more recent years (**Figure 8**). The data clearly show a decline in the inputs of nitrogen, phosphorus and carbon to the bay in the last two years. Low nutrient inputs also occurred in some earlier drought years, including 2006 and 2007. Additional work is required to identify possible linkages between the reduced nutrient inputs and changes in the marine organisms. This relationship is complicated by time lags between loading reduction and biological responses, and the timing of response depends on the life cycle of each organism.

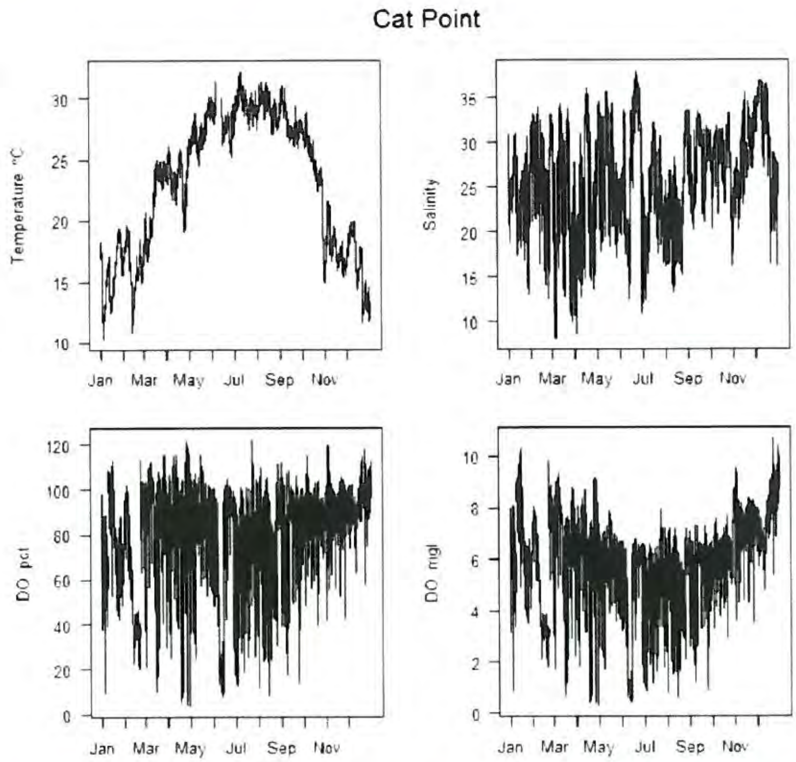

Figure 4 Temperature (C), salinity (ppt), and dissolved oxygen (% saturation, DO_pct and mg/L DO_mgl) for the Cat Point data sonde in Apalachicola Bay maintained by Apalachicola-NERR staff for 2012. Data are considered preliminary until finalized by NERR staff.

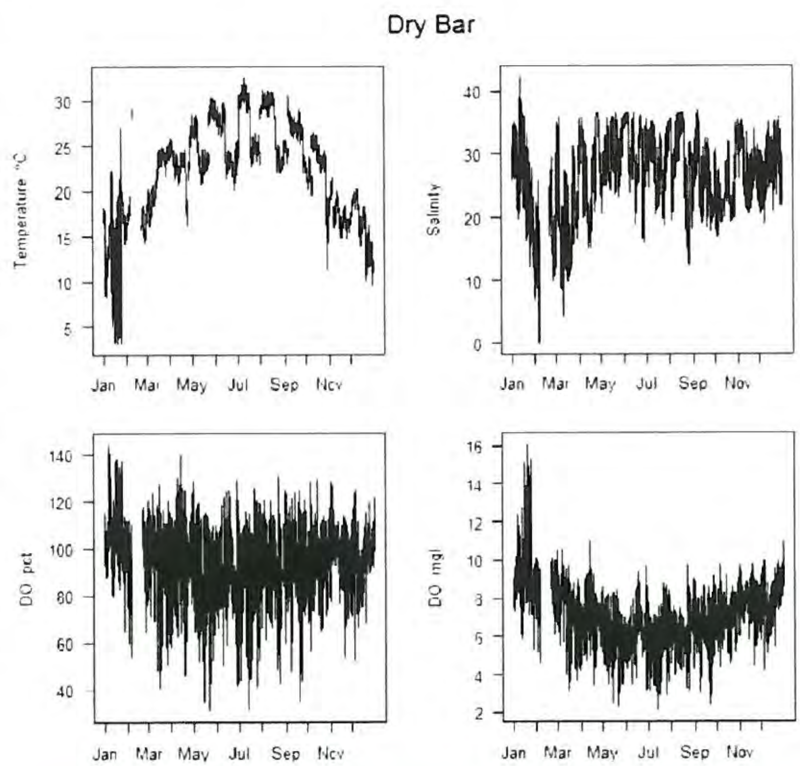

Figure 5 Temperature (C), salinity (ppt), and dissolved oxygen (% saturation, DO_pct; and concentration in mg/L DO_mgl) for the Dry Bar data sonde in Apalachicola Bay, maintained by Apalachicola-NERR staff for 2012. Data are considered preliminary until finalized by NERR staff.

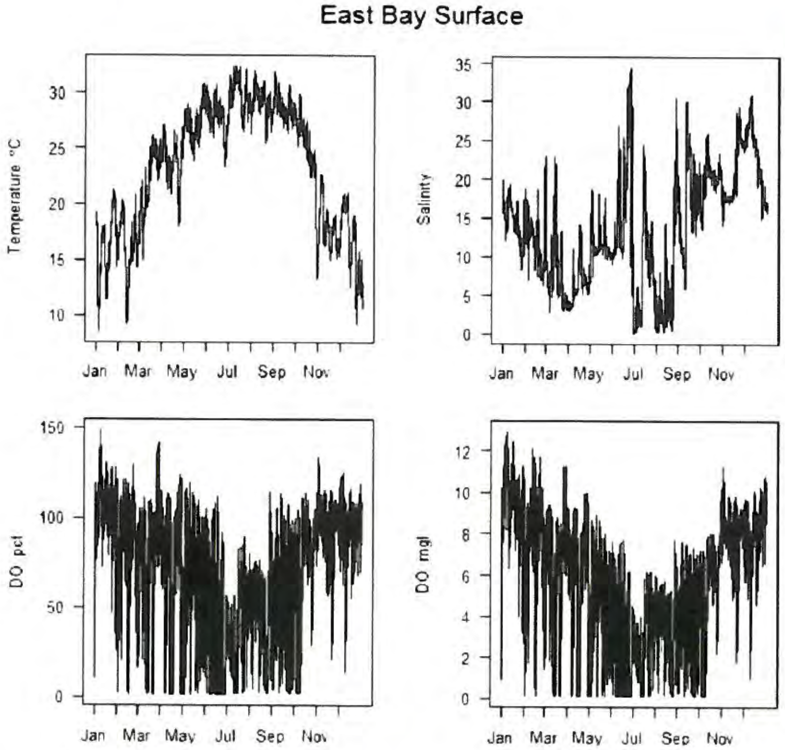

Figure 6 Temperature (C), salinity (ppt), and dissolved oxygen (% saturation, DO_pct and concentration in mg/L, DO_mgl) for the East Bay data sonde near the surface of Apalachicola Bay, maintained by Apalachicola-NERR staff for 2012. Data are considered preliminary until finalized by NERR staff.

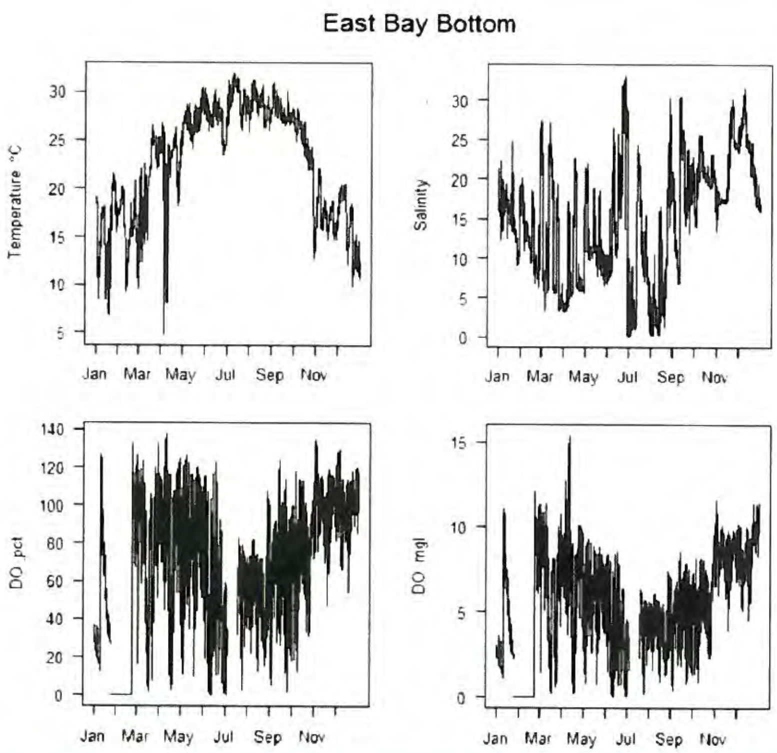

Figure 7 Temperature (C), salinity (ppt), and dissolved oxygen (% saturation, DO_pct and concentration in mg/L, DO_mgl) for the East Bay data sonde maintained at depth in Apalachicola Bay, maintained by Apalachicola-NERR staff for 2012. Data are considered preliminary until finalized by NERR staff.

Future work

The types of variables reported—river flow, rainfall, various water quality metrics—can all be easily (and cheaply) measured via automated equipment. However, our understanding of how these different variables may (or may not) impact oyster populations is not as well known. Various studies have documented that oyster disease and parasite risks increase under high temperature and salinity conditions in lab and field trials. Because of very limited monitoring of disease and pathogens that affect oysters in Apalachicola Bay (and not necessarily their human consumers) we do not have a good understanding of exactly when these types of outbreaks occur, what the outbreaks are, or even whether these outbreaks have population level impacts on oysters in terms of mortality or growth. Similarly, higher salinity environments are thought to support higher abundance of potential oyster predators such as whelks, drills, and conch. However, we do not have data available on trends in these species related to environmental conditions so we do not know what the time lag of any increase in predator populations may be, nor again do we know the population level effects on oysters. Linking water quality and flow monitoring data with information on the occurrence and spatial distribution of key diseases, pathogens, and predators is a key area of future work to develop an understanding of the linkages between environmental conditions and oyster population responses.

Status and Trends in the Oyster Fishery

Mike Allen, Bill Pine, Carl Walters and Ed Camp

We assessed the current status and recent trends in the oyster fishery in Apalachicola Bay. This was done first through simple graphical assessments of fisheries dependent data that are reported by the fishers and dealers to the Florida Fish and Wildlife Conservation Commission, as well as fisheries independent data of surveys of juvenile and adult oysters collected by Florida Department of Agriculture and Consumer Services. We then used these data, along with information on oyster growth rates, spawning patterns, maturity schedules, mortality rates, and other biological data obtained from previous studies to conduct a stock assessment of the Apalachicola oyster fishery. A stock assessment is a compilation of biological and fishery data that is used to determine the status of the "stock" or management unit of interest, in this case, oysters in Apalachicola Bay. In Florida, stock assessments are routinely conducted by FWC for a large variety of fish species such as redfish and gag grouper, but only for a few invertebrates—lobster, stone crab, blue crab and queen conch. No previous stock assessment exists for oysters in Florida. We used an array of mathematical and statistical techniques to develop a variety of models that described the relationship between the oyster population in Apalachicola Bay, observed through the fishery independent data, and the oyster harvests, observed through the fishery dependent data, based on our knowledge of oyster biology. The basic approach in these models is known as a statistical catch-at-age model where we estimated the relative recruitment (spat) and juvenile mortality rates in each month from 1986-2012 that likely would have been required to produce the reported monthly adult oyster landings. The models were developed over a series of three meetings with FWC, FDACS, the Florida Department of Environmental Protection, and Northwest Florida Water Management District personnel. The assessments assume complete reporting of harvest by oystermen over the time frame of the examined data. It is uncertain whether this is a valid assumption, and it should be examined in future work.

Fisheries dependent data summary

We used monthly oyster landings data from FWC with 1986 as our starting year because of uncertainty in the voluntary reporting program prior to 1986. As shown in **Figure 9**, reported oyster landings in Apalachicola Bay have ranged from about 1-2.5 million pounds over this time period with higher catches observed in 1987, and in 2007 and 2009 of 2.7-2.8 million pounds. Low landings occurred in 1995 and 1996 (<1 million pounds each year) and also following Hurricane Elena in 1985 (about 0.5 million pounds) when the bay was closed to harvest for nearly a year. Reported landings for 2012 are still preliminary as not

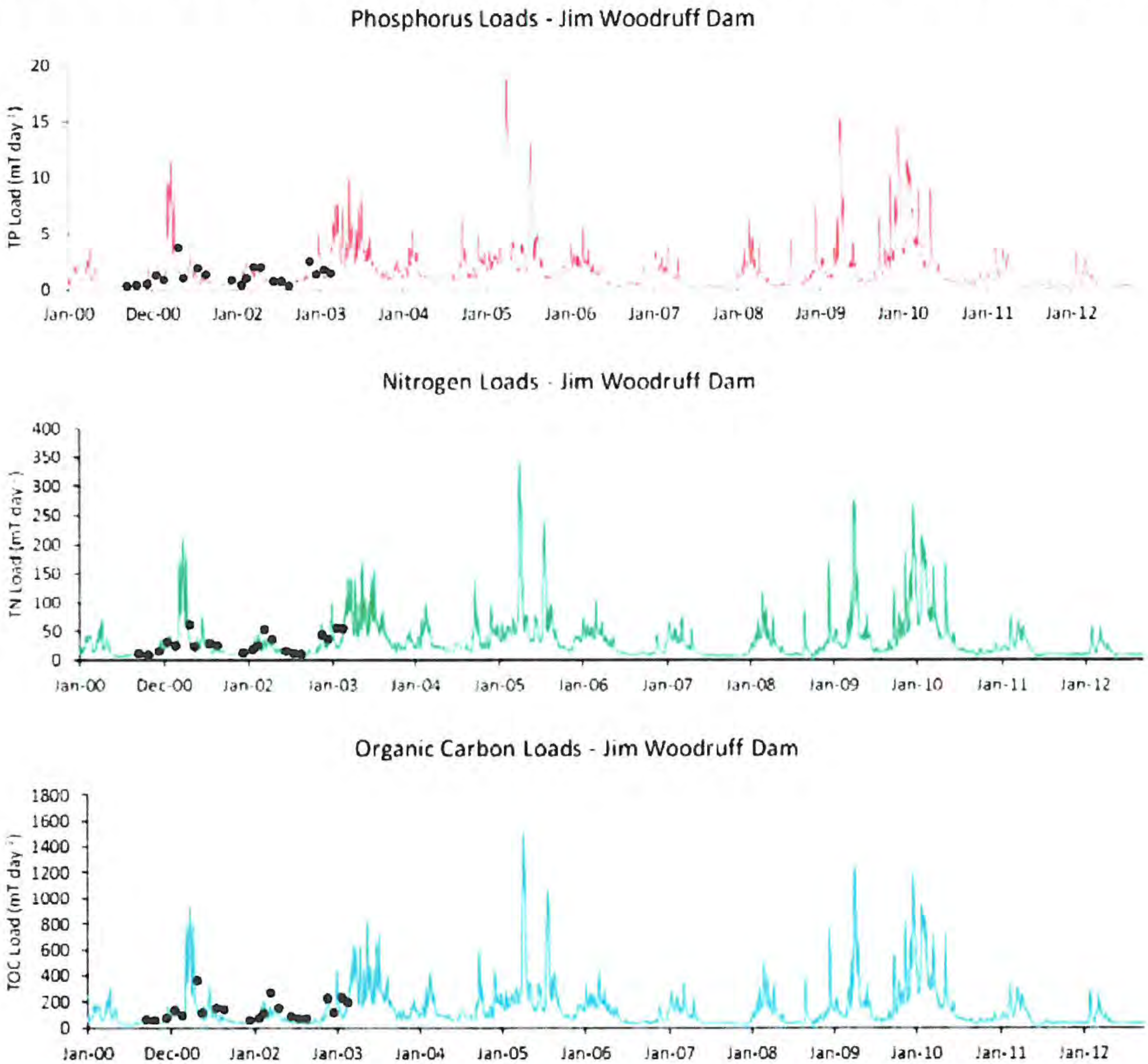

Figure 8 Loading rates of total phosphorus (TP), total nitrogen (TN) and total organic carbon (TOC) at the Jim Woodruff Dam in the Apalachicola River. The black symbols are actual measured loads and the colored lines are estimated loads from the regression model described in the text.

all dealers have reported their final totals from the year. However, total landings for Apalachicola Bay to date are about 2.3 million pounds for 2012. When landings data for each month are analyzed individually, a large decline in reported oyster landings is observed for Apalachicola Bay during 2012. **Figure 10** plots the monthly landings from January 2007-December 2012 and shows the large decline in landings that occurred in August-December 2012.

We then examined trends in Apalachicola Bay (AB) license holders from 1986-2012. The number of license holders peaked in the late 1980s at about 1200 license holders, declined to 400-500 license holders from about 1995-2005, and then begin to increase steadily with about 900 fishermen holding AB licenses in 2012 (**Figure 11**). Reported Apalachicola oyster fishing trips (**Figure 12**) since 1986 have varied widely from about 5,000 trips in 1985 (the year of Hurricane Elena) to more than 40,000 trips reported in 2012 (the highest on record). However, in 2012 most of this effort was during the first half of the year as the number of oyster fishing trips by month since 2007 shows that the number of trips in Apalachicola Bay declined sharply in each month during the second half of 2012 (**Figure 13**).

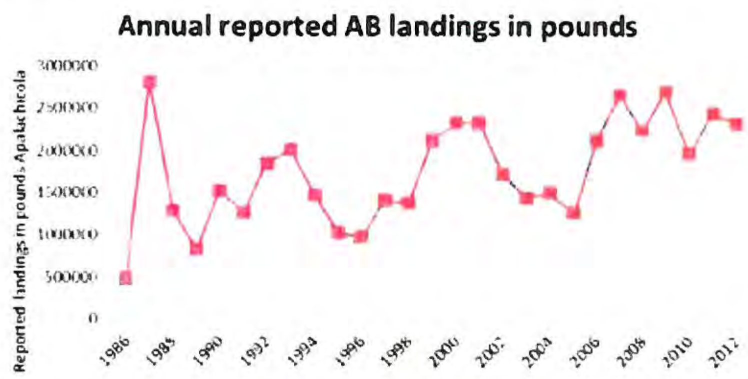

Figure 9 Annual reported oyster landings in pounds provided by FWC from Apalachicola Bay, Florida 1986-2012. Note that 2012 landings are preliminary.

Figure 10 Monthly reported oyster landings in pounds provided by FWC from Apalachicola Bay, Florida 1986-2012. Note that 2012 landings are preliminary.

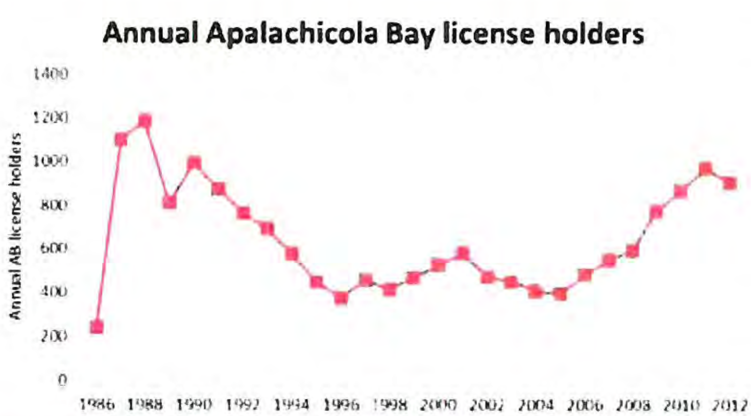

Figure 11 Total number of Apalachicola Bay license holders from 1986-2012 provided by FWC.

Fisheries independent data summary

We obtained surveys of oyster counts by size (sub-legal and legal categories) from FDACS over a wide spatial area of Apalachicola Bay from 1990-present. In general these surveys are completed by counting the number of oysters of different size classes inside standard quadrats on different oyster reefs throughout Apalachicola Bay. We used data on the number of legal and sub-legal oysters from different locations to compile a composite average of oyster abundance throughout the bay through time. These results (**Figure 14**) suggest a slow downward trend in the abundance of legal oysters for harvest in the bay in recent years and a dramatic decline in the number of sub-legal oysters present in 2012. Because of the low abundance of sub-legal oysters in 2012 there is a high likelihood that legal-sized oysters will be in low abundance during at least 2013 and likely 2014 as well.

Stock Assessment Modeling Efforts

Yield-per-recruit analysis

There is concern in the Apalachicola oyster fishing community related to the effects of harvesting sub-legal oysters on the long-term population viability of the Apalachicola oyster fishery. To assess this, we built a simple mathematical model to evaluate the impacts of harvesting oysters at different sizes. A common objective in commercial fisheries is to maximize yield (i.e., pounds per harvest). This objective is generally achieved by a specific combination of harvest rate and size at harvest. If animals are harvested at too small a size, potential gains in yield that would have occurred by allowing animals to grow to a larger size are lost. This situation is referred to as growth overfishing. Similarly, if harvest rates on animals are too high, potential gains in yield that could have occurred by allowing more animals to survive to larger sizes prior

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to harvest are lost. To recommend optimal harvest rates that avoid growth overfishing, the equilibrium yield has to be determined under a range of harvest rates and minimum size limits.

We constructed a simulation model to determine the optimal size at harvest for oysters in Apalachicola Bay and assess how harvest of smaller sizes could increase the risk of growth overfishing and subsequently reduced harvests in terms of smaller yield of oysters harvested. Our model simulates how yield in the fishery would change under different harvest rates and size regulations. This simulation requires estimates of oyster growth, survival, and recruitment which we derived from earlier studies in Apalachicola Bay or from ongoing research. Our findings suggest that the current size limit of oysters (3 inches, 76.2-mm) is quite close to that which would produce maximum yield (**Figure 16**) over a range of harvest rates. The results suggest that a 3-inch minimum size limit would protect against growth overfishing over a relatively large range in harvest rates, and thus, the 3-inch size limit is likely a good minimum size limit for use in Apalachicola Bay. This model is sensitive to the parameters used in the model such as growth such that if growth rates change, then the model should be updated with different growth rates as the optimal minimum size regulation would likely change. Additionally, this assessment assumes that the prices received by fishermen are constant relative to the size of oysters at harvest. If price for larger oysters is substantially higher (due perhaps to sales for the restaurant "on the half shell" market relative to the processing market), the optimal harvest size of oysters would likely be greater and more sensitive to minimum size at harvest (**Figure 17**). These caveats notwithstanding, this assessment shows that the current size limit is generally sufficient for maximizing yield. While our results suggest that this size limit would be effective, there is evidence of harvesting of sub-legal oysters (< 3 inches). If large harvests of sub-legal oysters are occurring, then it is likely that potential yield is being lost to the fishery because of oysters being harvested at too small a size, basically increasing the risk of growth overfishing. Basically the current harvest regulations are only going to be effective if they are accepted by the community and industry, and enforced and adjudicated.

Figure 12 Annual number of reported oyster fishing trips in Apalachicola Bay, Florida from 1986-2012. Note that 2012 numbers are preliminary.

Figure 13 Reported oyster fishing trips by month for Apalachicola Bay from January 2007-December 2012 provided by FWC. Note that 2012 are preliminary.

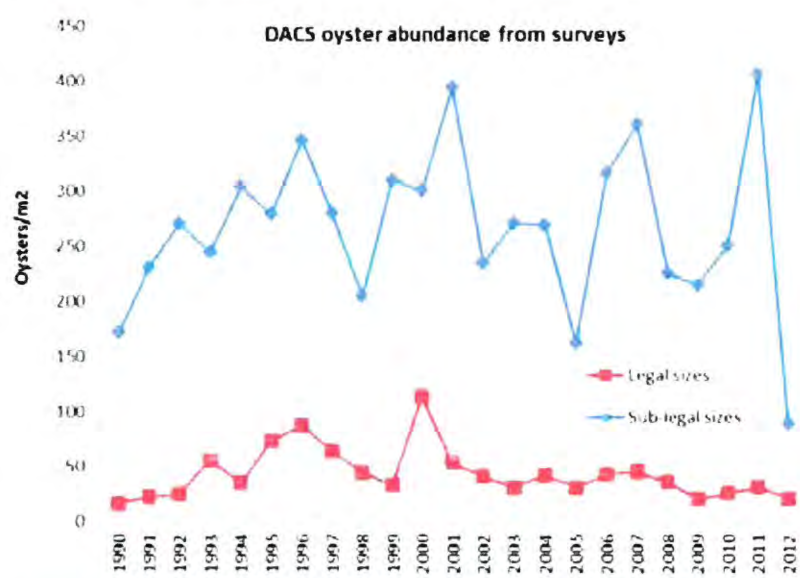

Figure 14 A composite of oyster density per m^2 of habitat in Apalachicola Bay from data collected by FDACS from 1990-2012 across a large number of oyster bars. Legal-sized oysters (> 3") are shown by the red line and sub-legal (< 3") are shown by the blue line.

Statistical Catch-At-Age Model

We developed a detailed population dynamics model to aid in interpretation of past harvest and FDACS survey data for the Apalachicola oyster population, and in particular to determine how natural mortality, recruitment, and exploitation rates have varied since the mid-1980s. Key aims of this work have been to determine whether there has been overharvesting (in particular due to take of sub-legal oysters) and whether we can detect mortality and recruitment effects

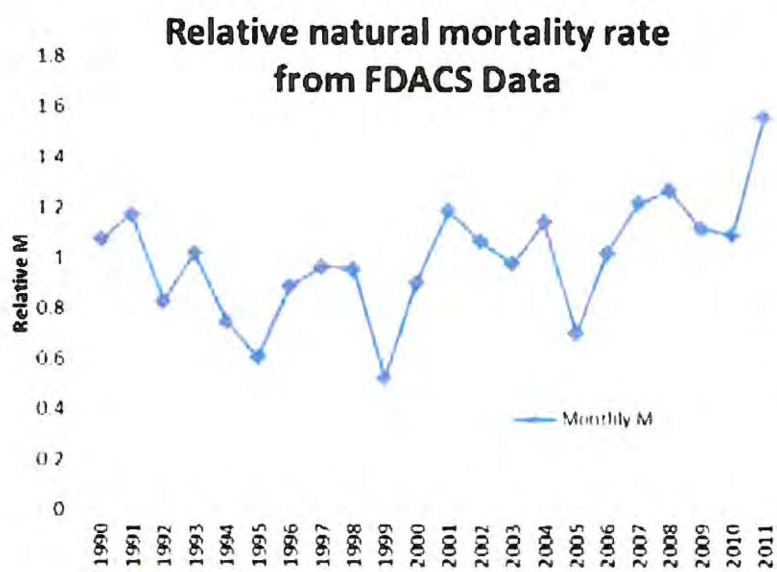

Figure 15 Natural mortality (M) for juvenile oysters in Apalachicola Bay estimated from the stock assessment model based on surveys of juvenile oysters by FDACS.

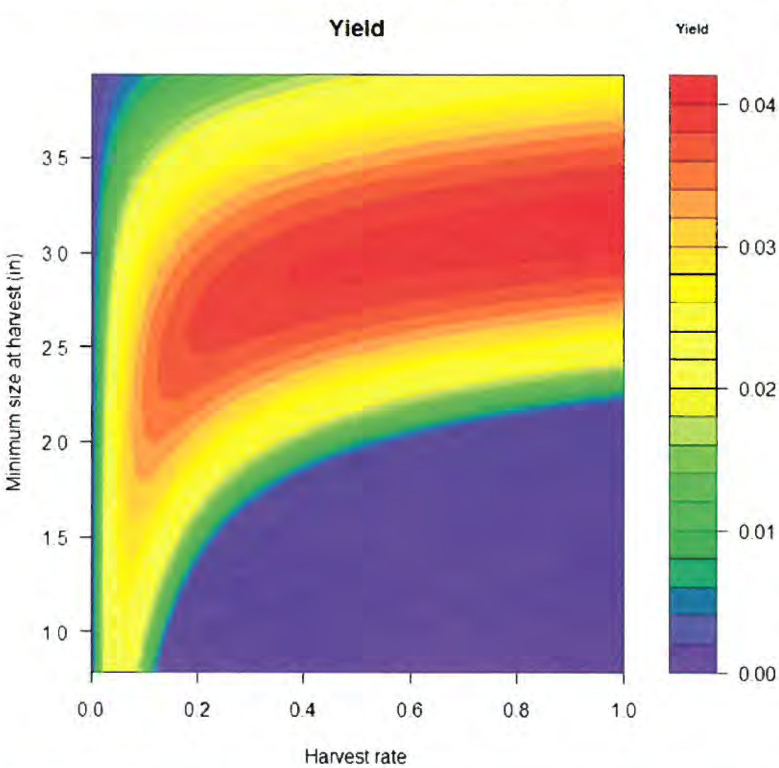

Figure 16 Relative amount of value (represented by colors) of the Apalachicola Bay oyster fishery attained at various harvest rates (x-axis) and minimum size limits (y-axis), when price per pound of oyster increases by two-fold for larger oysters (greater than 3 in), representing potentially greater price paid for larger oysters for the "half shell" market.

of Apalachicola River flow that are not clearly evident in simple comparisons of harvest and flow data.

We calibrated the model by fitting it to reported oyster landings and FDACS survey data. As indicated in **Figure 18**, the model fits the data very well, and indicates complex trends in mortality and recruitment rates over the past two decades. Almost all of the variation in catches can be explained by variation in fishing effort, and there is no indication of a persistent downward trend in abundance of sub-legal oysters preceding the severe decline evident in DACS data for 2012 (**Figure 14**). Declines in harvest of legal-sized oysters the last few months of 2012 are likely due to lack of recruitment from juveniles to the legal-sized because of low abundance of juveniles. However, the decline in sub-legal abundance, sudden as it was, cannot be attributed to reduced spawner abundance (i.e., adult population) and/or larval supply based on the available data we have examined. Without more data, we cannot reach a conclusion about what proximal factor(s) contributed to the decline.

The main findings from the stock assessment model fitting exercise can be summarized by four main points. First, the 2012 decline in landings and juvenile abundance is unprecedented during the period of data we examined (1986-2012 fishery dependent data, 1990-2012 fishery independent data), and has likely involved a recruitment failure that we have not been able to completely explain with the available data. Possible reasons for this recruitment failure include very high natural mortality rate of small oysters from predators or some type of episodic disease or pathogen.

Second, both direct analysis of survival patterns (from sub-legal to legal-sizes, **Figures 19 and 20**) in the FDACS data and the model fitting exercise indicate that natural mortality rates appear to be increasing over time (**Figures 15, 19, 20**). The exact reason is uncertain, but two hypotheses that could be tested through future work include assessing whether natural mortality on juvenile oysters increases during periods of higher salinity from either predators or disease and determining whether the discard mortality rate of culled, sub-legal oysters has potential population level consequences. The role of culling mortality may be different under a range of population sizes (more significant at lower population sizes than high) or that culling mortality may be higher under situations where natural mortality is already high.

Third, the severe decline in sub-legal abundance in 2012 FDACS surveys (**Figure 14)** suggests that the legal harvests in 2013 and possibly 2014 will again be very low and likely not better than the 2012 season. These low abundance levels of legal oysters lead managers to close major fishing areas to protect remaining populations and reef habitat or, alternatively, the populations may be so low that it is not economical for fishermen to harvest from these efforts even without a closure. For example, in response to the FDACS reports, the FWC closed the commercial oyster harvest on weekends from November 16, 2012 to May 31, 2013.

Fourth, there is no evidence that harvest of sub-legal oysters has or would lead to overfishing, if current regulations are followed. It is unlikely that occurrence of sub-legal oysters in the catch has caused the trends we see in the data unless the sub-legal harvest has been unregulated and extremely high.

Restoration actions, caution, and future work

Much uncertainty exists as to what approaches are best for restoration. Modeling efforts suggest linkages between the available shell habitat and recruitment in Apalachicola Bay. If essential shell substrate habitats have been lost in Apalachicola Bay from storm events or reduced production of natural shell (accumulated as oysters grow then die in the bay leaving their shell) then the risk of the oyster fishery having effects on the oyster population likely increases. In oyster populations the carrying capacity of the population could be related to the substrate available for oyster spat to settle and grow. Both substrate and the number of oyster spat available may be influenced by the number of oysters harvested each year. In this way feedbacks are created between the oysters that are harvested, the shell that is available for spat to settle, and the spat that are produced each year. While these feedbacks may not be strong in years with high oyster abundance, in years with low abundance, the interactions between spat, substrate, and adult harvests may be strong. If shell habitat is lost due to high harvest rates, storm events, or other causes, this could reduce the available habitat for juveniles and ultimately reduce adult populations.

One area of uncertainty is our understanding of whether juvenile oyster mortality rates do increase under high salinity conditions and from what cause. This could have policy implications related to a variety of issues such as using techniques adopted from the clam culture industry of using netting to reduce predator abundances (likely only possible on leases) or modifying fishing intensity. Another area of uncertainty is the scale, in terms of size, depth, and spatial location, of any restoration efforts related to shelling. A variety of culching programs have been carried out in Apalachicola Bay over several decades that can provide

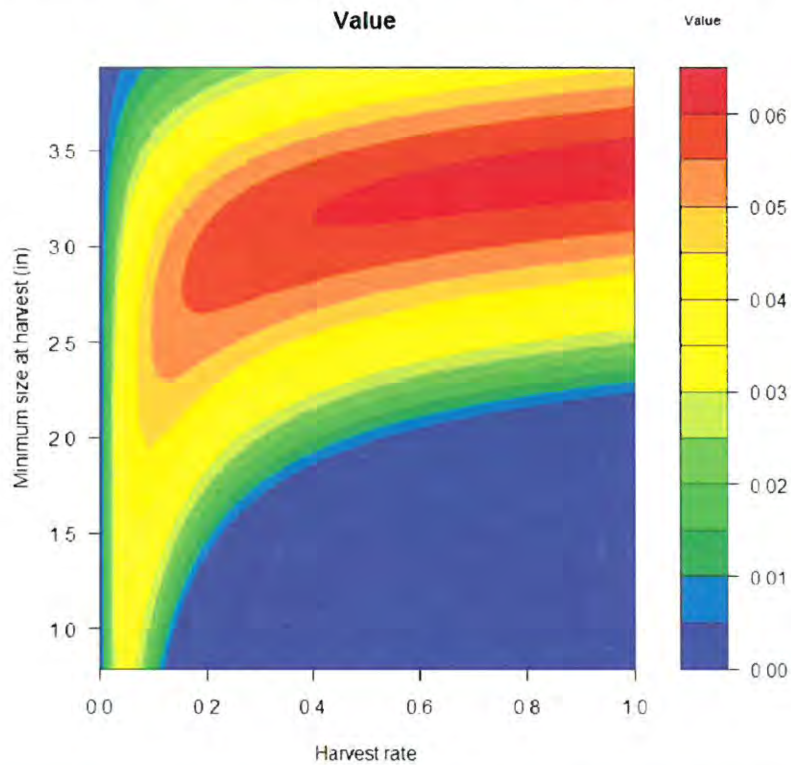

Figure 17 Relative amount of value (represented by colors) of the Apalachicola Bay oyster fishery attained at various harvest rates (x-axis) and minimum size limits (y-axis), when price per pound of oyster increases by two-fold for larger oysters (greater than 3 in), representing potentially greater price paid for larger oysters for the "half shell" market.

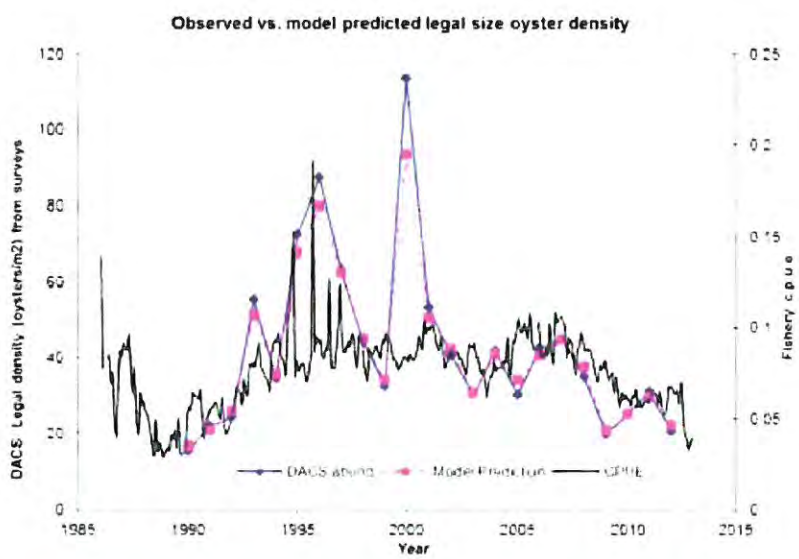

Figure 18 An example of the stock assessment model fit of predicted density of legal-sized oysters (dashed, light blue line) with the observed density of legal oysters from the FDACS data (dark blue solid line) and fishery CPUE (solid black lined, measured on secondary Y-axis) to data from 1986-2012.

some guidance on this activity. However, additional work could be done to better identify the best approach to re-culching oyster bars, particularly under variable flow conditions. In simplest terms, culching as a restoration tool is likely to require large volumes of shell because essentially the culching is trying to replace the shell material that would have been produced naturally by oysters as they grow and die. This shell material is instead transported out of the bay when the oysters are harvested. Given the high costs of culching activities, in terms of buying the shell and planting the shell in the bay, determining the culching strategy that most efficiently helps in restoring oyster bars in Apalachicola Bay is essential.

We are also concerned that the recovery of Apalachicola Bay oyster resources may take longer than many people assume. As an example,

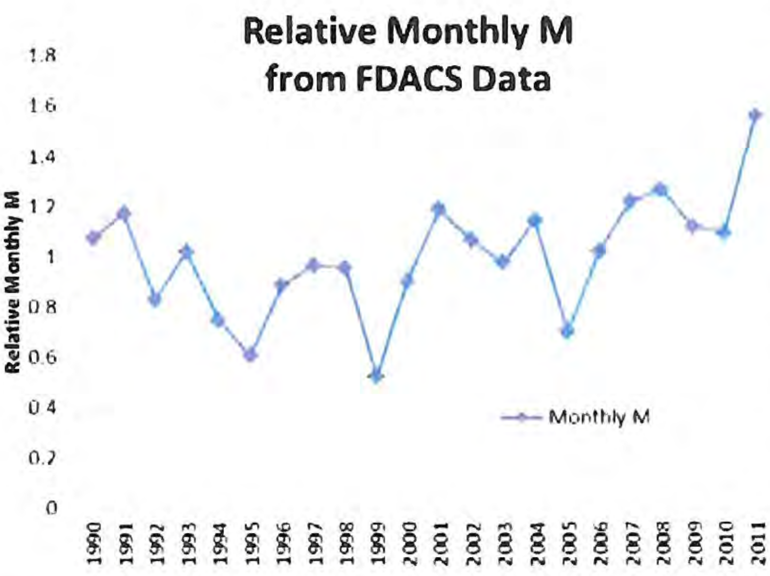

Figure 19 Relative monthly natural mortality rate (M) of juvenile oysters from the FDACS collected in Apalachicola Bay from 1990-2011

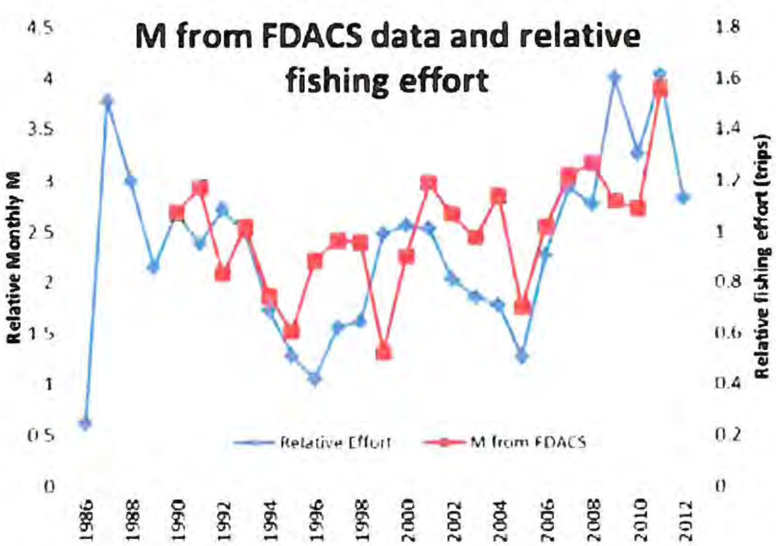

Figure 20 Natural mortality rate (M, red line, primary y-axis) and relative monthly fishing effort (trips, blue line, secondary y-axis) of juvenile oysters from the FDACS collected in Apalachicola Bay from 1990-2011.

to estimate the amount of time it is likely to take Apalachicola Bay oyster reefs to recover, we modified our assessment model to evaluate what the Apalachicola Bay oyster fishery might look like over the next 10 years (until 2023) under different policy options for restoration (**Figure 21**). Under the "no closures" scenario, we assumed that fishing effort (number of trips) would remain at about the same levels as observed in recent years into the future. For the "reduced effort" scenario, we assumed a 50% reduction in effort during 2013-2014 (because of low oyster abundance) and then resumption to the same effort as the no closures level for the remaining years. For the "shelling" scenario we assumed that there is about 1-2 km^2 of productive oyster bar in the bay and evaluated a cultching program that would cover about 40-50 ha (about 100 acres) per year for five years. This simple projection model does not include depensatory predation (higher proportional losses to predators due to low oyster abundance), any disease outbreaks, etc. We evaluated three scenarios and compared the time to recovery for each (**Figure 21**). Our results suggest that even under the best case scenario, recovery is likely to take 3-5 years to reach the harvest levels observed through most of the 1990s and 2000s.

We have also developed preliminary versions of two spatial modeling systems to help identify future impacts of water management on oysters, and management options for the oyster fishery. The FLABAY model simulates hydrodynamics and water chemistry (nutrients and salinity) over Apalachicola Bay, and its results can be written to files as input for the ecological/fishery model, ECOSPACE. The ECOSPACE model is based on an ECOPATH/ECOSIM food web model that simulates changes in primary production, oyster population structure (age-size composition) and growth based on available production, and oyster predator dynamics in responses to changes in oyster abundance and salinity. ECOSPACE has a comprehensive policy interface allowing specification of spatial fishery operations (e.g. seasonal closures) and habitat restoration (cultch planting) policies, and it is also capable of doing economic impact assessments (fishery and regional economic values, employment).

FLABAY uses an extremely simple hydrodynamic model to quickly compute monthly average water movement and mixing rates over a grid of spatial cells (0.6km x0.6km) using river flow, wind, and rainfall data. It can "reconstruct" monthly historical patterns of nutrient loading and salinity for the

1986-2012 period in just a few minutes of personal computer processing time, and can also simulate future scenarios for seasonal and inter-annual variation in Apalachicola River flow. As shown in **Figure 22**, a screen capture from the model interface, the model reconstructed salinities at key locations in the bay (Cat Point, Dry Bar) based on observed river discharge, wind, and rainfall patterns are reasonably close to the measured values from the NERR program, which is critical for predicting salinity-related changes in oyster production (i.e., growth, predation impacts from freshwater-intolerant predators) in the ECOSPACE model. This type of hydrodynamic model can easily be demonstrated and used in workshop settings with fishermen and other interested stakeholders.

As an example of how FLABAY and ECOSPACE can be used for policy comparison and screening, we assessed the amount of time it would take for oyster populations to recover over a 20-year time period (2013-2033) for Apalachicola Bay oysters assuming (1) a decline in 2012 similar to the one observed (2) freshwater flow patterns from 2013-2023 similar to those observed since 2000 (i.e., periods of high, low, and average flows) and (3) reduced oyster fishing effort in 2013 and 2014 (80-90% reduction in 2013, about 50% reduction in 2014). We used the model to compare two different policies, one without cultching and one with cultching, and how the estimated time it takes oyster populations to recovery differed between these. The first policy test of no cultching and reduced fishing effort in 2013 and 2014 (**Figure 23**) the ECOSPACE model predicts disturbingly slow recovery from the 2012 decline, even if fishing effort is severely reduced in 2013 and 2014. The slow recovery time is due to a combination of reduced recruitment due to reduced natural shell (larval settlement substrate) abundance and predicted "depensatory" high impacts of oyster predators on the reduced population (e.g., predators are removing a larger portion of the population than normal because the abundance of oysters is low).

We then evaluated a policy where a large cultching effort of about 200 ha per year from 2013-2017 is implemented to speed up recovery of

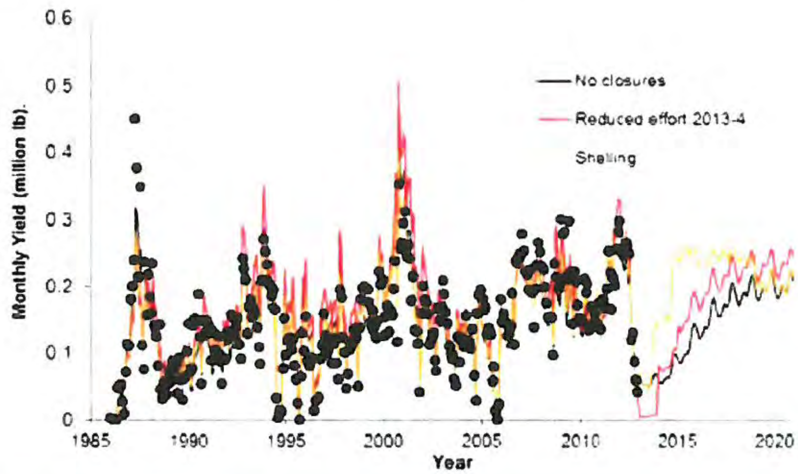

Figure 23 Observed (black dots) and predicted (solid lines, one for each policy evaluated) monthly oyster yield for Apalachicola Bay.

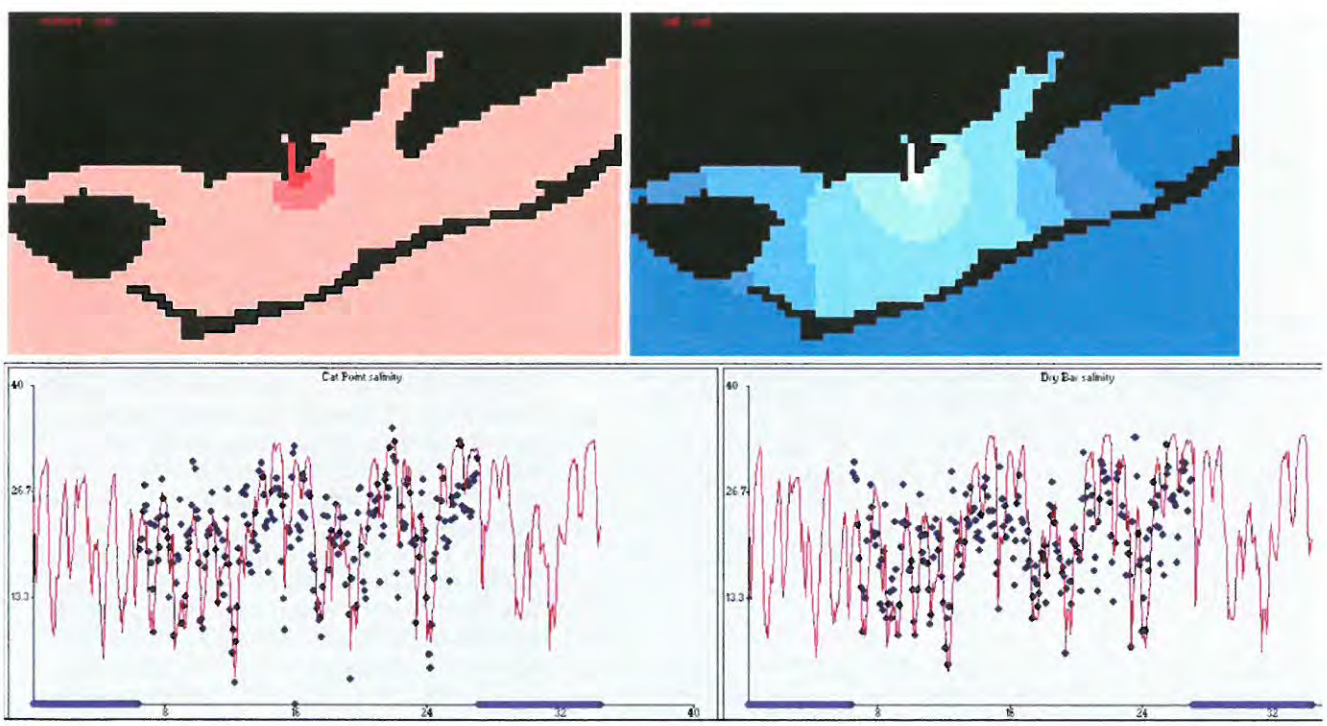

Figure 22 Screenshot from the FLABAY model, showing predicted nutrient and salinity maps for one simulated month, and fit to historical data on mean monthly salinities at Cat Point and Dry Bar

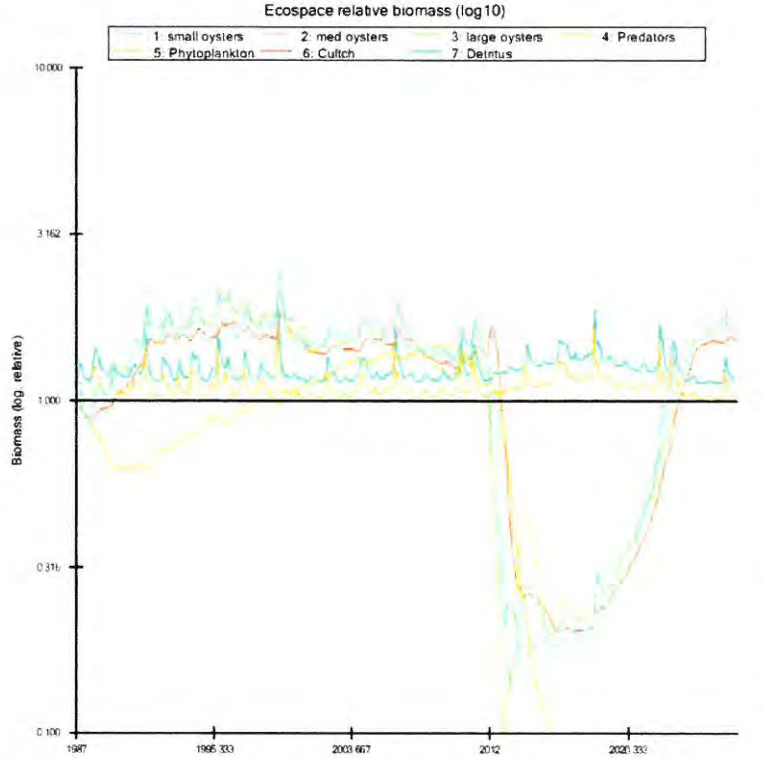

Figure 23 Time plot of simulated relative abundances of ecosystem components using the ECOSPACE model. Note long time predicted for oyster population recovery (about 10-12 years) following decline in 2012, despite reduced fishing effort in 2013 and 2014.

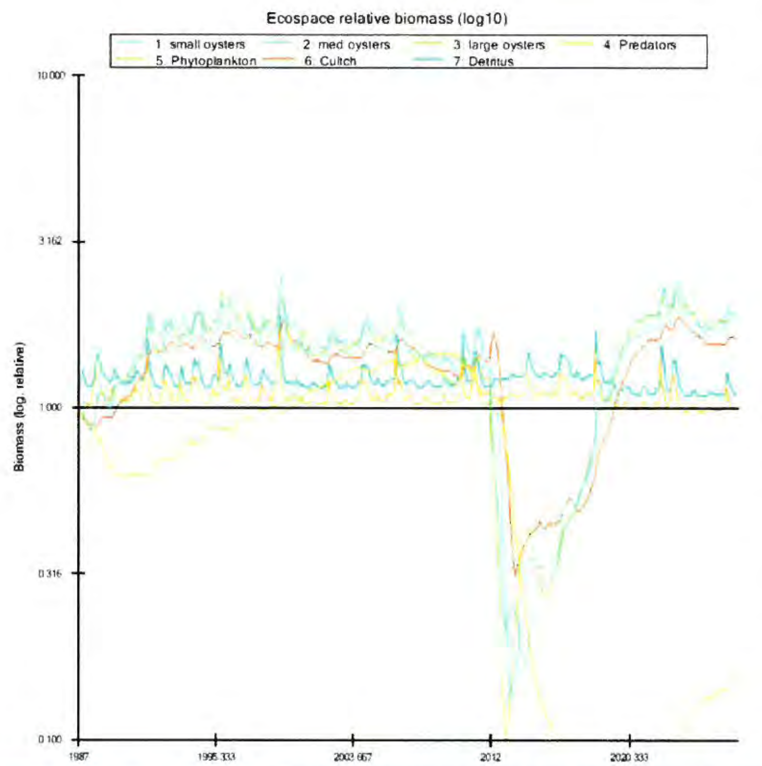

Figure 24 ECOSPACE predicted time trends for oyster recovery for a scenario where 200-ha per year of cultch is added for the 2013-2017 period and fishing effort is reduced during 2013 and 2014. Note more rapid oyster recovery than predicted in the baseline scenario Figure 23 where only effort is reduced.

oyster recruitment and to spread fishing effort over a larger area in addition to the fishing effort reduction evaluated above (**Figure 24**). When compared to the first scenario where no cultching took place, only effort reduction (**Figure 23**), the time to recovery is reduced from 10-12 years (**Figure 23**) to 8-10 years (**Figure 24**).

Note that both **Figures 23 and 24** assume severe reduction in fishing effort for 2013, and moderate (50%) reduction for 2014. Scenarios without these effort reductions lead to even longer recovery periods. Further, the scenarios in **Figures 23 and 24** all assume reasonably favorable Apalachicola River flows, i.e. with some drought years but some wet years as well (a future pattern similar to the flow pattern since 2000). A key concern during oyster population recovery is latent effort response by oyster fishermen. In this situation as oyster populations begin to recover, oyster fishermen may quickly locate these oysters and quickly harvest the recovering population as they begin to rebound. If this happens, it is likely to perpetually keep the oyster populations low and extend the recovery time or keep the oyster population from recovering at all. Therefore, there is a need for new resource management tools, procedures and regulations.

While these models show promise, there is substantial work still required to calibrate the models to available data. We think that a variety of population and ecosystem models should be developed for Apalachicola Bay to help screen policy options that managers are faced with when looking at fishing regulations, restoration approaches or river flow alterations.

There are major uncertainties in any model predictions and it is only through an iterative process of model building, prediction, and rigorous testing in the field that we are able to improve the model's abilities. A key experiment is also naturally occurring right now in that the periods of extremely low Apalachicola flows during 2012 are replaced with high flows during the winter of 2013 and potentially into the spring/summer season of high mortality for juvenile oysters. Are existing monitoring programs able to detect any change in mortality rates during 2013 compared to earlier, low-flow conditions? How will the oyster resources and the oyster fishery respond to the 2012 decline? We do not know whether drought conditions (low river flow) will return following the currently wet winter, nor do we know how rapidly and strongly predator populations will respond to reduced oyster availability, leading to further severe mortality events. Perhaps most important, we do not know the effective productive area of Apalachicola Bay for oysters, and because of this we do not know how much area really needs to be cultched. Additionally, we do not know whether restoration efforts could and should be applied to the much larger bar area that may have supported higher historical catches in the voluntary reporting data prior to 1986. Many of these needs could be addressed through field studies and the results used to update these types of models for assessing trade-offs in policy options.

Contaminants

In response to community concerns about environmental health impacts associated with the Deepwater Horizon oil spill, and concerns about the health of the Apalachicola Bay oyster fishery, studies were initiated to discern the presence of oil spill-related contaminants in Apalachicola Bay seafood products. These costly efforts were incorporated into a larger, ongoing regional study to discern the safety of inshore-harvested seafood, particularly for coastal residents who regularly consume portions of their catches.[1]

Seafood sampling in Apalachicola Bay included oyster, white shrimp, brown shrimp, blue crab and multiple finfish species. Sampling was accomplished with the assistance of the Franklin County Seafood Workers Association, and fishers who were assigned specific tasks to contribute to the effort. Oysters were collected by tonging from four east-west distributed sites in the bay. White and brown shrimp were collected by trawling from two distinct sites in the bay. Blue crab were collected using crab pots from two separate sites in the bay, and finfish were collected by hook and line from multiple bay sites.

Analytical results at the time of this report include oyster PAH, or polycyclic aromatic hydrocarbons data (see **Table 1**). Data focus on PAHs with known relative carcinogenic risk factors, allowing for the development of risk assessment based on: (a) the levels of contaminants present in seafood, (b) and frequency and portion sizes of seafood meals consumed, and (c) consumer body weight. Further, these PAHs are the same chemicals that were analyzed by federal and state agencies throughout the Gulf. Focus on these chemicals, therefore, may also allow for comparison of analytical results throughout the region. Samples processed for additional organic analyses, metal analyses, and seafood types are underway.

Table 1 shows analytical results for sixteen parent PAHs for individual oyster samples collected from AP Bay in 2012. In addition to parent PAHs, alkyl homologues were also analyzed. These data provide quantitative information about the presence and concentrations of these PAHs in oyster meats, as well as inter-individual variability of potential contaminant levels between oysters sampled from the same site. Such variability data is lost when samples are "pooled", i.e., the meats of three to twelve oysters from a site are homogenized together, subsampled, and processed to generate an "average" from those oysters (typical method used by state and federal laboratories). Although sample pooling greatly reduces effort and cost (analyzing one sample rather than

PAH Concentraton, ng/g

wet sample wt. (g)	**5.342**	**5.496**	**4.954**	**5.155**	**5.211**	**5.059**	**5.344**	**5.336**	**5.227**	**4.989**	**5.204**	**5.327**
Sample ID	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**	**12**
Naphthalene	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Acenaphthylene	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Acenaphthene	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Fluorene	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Phenanthrene	0.15	nd	BQL	nd	nd	nd	nd	BQL	nd	nd	BQL	nd
Anthracene	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Fluoranthene	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Pyrene	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Chrysene	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Benz[a]anthracene	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Benzo[b]fluoranthene	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Benzo[k]fluoranthene	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Benzo[a]pyrene	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Indeno[1,2,3-cd]pyrene	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Dibenz[a,h]anthracene	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Benzo[g,h,i]perylene	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd

Table 1 Analytical results for PAHs from 12 Apalachicola Bay oyster samples. The different PAHs analyzed are listed in the left-hand column (labeled "Sample ID"); results for individual PAHs from 12 individual oyster samples are in the next 12 columns to the right. Results are presented in ng/g (nanograms per gram wet weight oyster homogenate; parts per billion); nd=not detected; BQL=below quantifiable limits. Refer to text on next page for additional details.

[1] This study was supported by the National Institutes of Environmental Health Sciences, as part of the Deepwater Horizon Research Consortium. The UF component of the award supports research groups through the University of Florida Emerging Pathogens Institute (Dr. J. Glenn Morris, Principal Investigator). This study, called "Healthy Gulf Healthy Communities," supports three separate projects developed to support Gulf coast community health in the wake of the oil spill. These projects are led by Dr. Lynn Grattan, focusing on individual psychological health and well-being; Dr. Brian Mayer, focusing on community resiliency; and Dr. Andy Kane, focusing on seafood safety. The seafood safety team brings together expertise in aquatic biology and toxicology, analytical toxicology, food science and human nutrition, risk assessment, and risk communication.

12, for example), there is no data to detect animals from a site that can accumulate higher amounts of contaminants that might pose greater risk to consumers.

The data presented in **Table 1** are similar to other oyster data analyzed thus far from Apalachicola Bay. Most results in this table are noted as "nd," meaning not detected (i.e., below level of detection). Several samples are noted as "BQL," meaning Below Quantifiable Limits." The chemical detection limit for most of these PAHs is approximately 1-2 part per billion, and may vary among analytes (chemicals detected). The level of quantification, often close to the level of detection, is based on our ability to confidently provide a numerical value for the concentration present. In the subset of data presented in the table above, there is one result that was quantified, phenanthrene, with a concentration of 0.15 parts per billion.[2] The FDA's level of concern for phenanthrene in oysters is 2,000 parts per million (over 7 orders of magnitude, i.e., 10 million times higher, than was detected in an Apalachicola Bay oyster sample).

Oyster Condition and Health *Andrew Kane*

To address concerns about declining oyster harvests, and the sustainability of the Apalachicola Bay oyster fishery, we have begun to examine environmental parameters that can affect the condition, health and growth of oysters regionally throughout the bay. A variety of environmental stressors can affect the health and growth dynamics of oysters in the Apalachicola Bay system, including sub-optimal water quality, contamination, oyster density, tonging-induced mortality, and the presence of parasites and pathogens. This section outlines the primary efforts contributed through the UF Aquatic Pathobiology Laboratories, with support from the Contaminants and Pathogens Work Group, others contributing to the UF Oyster Recovery Team, and the University of Florida Institute of Food and Agricultural Sciences.

Sampling efforts were initiated to address the questions: "How healthy are Apalachicola Bay oysters?" "What factors might be associated with altered health status?" and "Are there regional differences in condition, health or population dynamics?" To begin answering these questions, oysters were harvested from multiple sites in Apalachicola Bay across an east-west transect of the bay. These sites are shown in **Figure 26**.

Oysters were sampled by tonging using two approaches. One approach allowed for more rapid collection of a larger number of specimens for health assessment that also permitted assessment of relative density, catch per unit effort, and size distribution including spat on cultch (**Figures 27 and 28**). This method closely reflects typical harvesting methods.

The second sampling method used a depletion sampling approach as illustrated in **Figure 29**. Briefly, an area of known size (demarcated by maximally open tong rakes) on an oyster bed is repeatedly sampled in the same spot (depleting that small spot completely, or close to completely). Theoretically, if sufficient samples are randomly taken over a reef, density of harvest-size oysters can be estimated, along with a different metric for catch per unit effort.

Health studies

Oysters have been sampled throughout Apalachicola Bay to discern the condition index of the meat, and the relative condition of the oyster shell based on the degree of shell parasitism associated with boring polychaete worms, boring clams, and boring sponges.

Figure 25 Left photo Technicians process freshly harvested seafood in a field laboratory.

Right photo Starting at sunrise, Shannon Hartsfield tonged for oysters with Andy Kane to make collections for chemical analyses. Multiple watermen provided time and input to facilitate these sample collections. Each waterman collected specimens with data on GPS coordinates, time of collection and species.

[2] Some real-world examples of part per billion comparisons include: one penny in 10 million dollars, 1 second in 32 years, 1 foot of a trip to the moon, a blade of grass on a football field, or one drop of water in an Olympic-size swimming pool.

Meat condition index is related to the overall health and well-being of the animal, and reflects potential impact of multiple environmental stressors such as food availability, parasites and disease, water quality, and reproductive status. The condition index of the oyster meat is particularly important to Apalachicola Bay oysters that are prized for both flavor and appearance (**Figure 30**).

Shell parasites and condition indices analyzed as part of this effort include the prevalence and severity of boring shell parasites. These parasites include the sponge, *Cliona*; the boring clam, *Diplothyra smithii*; and the polychaete worm *Polydora* (**Figure 31**). The presence and severity of these parasites in the oyster shells can have detrimental effects on the well-being of the oysters. Heavy shell parasite infestations divert oyster energy away from growth and health, and shift energetics toward self-preservation and secretion of more nacre to wall-off the invaders from the inside of the mantle cavity. Further, shells that are weakened by shell parasites are less "water tight" and more susceptible to predators such as whelks that use slow, steady pressure to pry open the shell and eat the oyster inside. Shell condition also affects the half-shell appearance of the oyster that is critical for the Apalachicola Bay oyster product.

Shell parasites also affect the internal shell appearance, as parasites bore close to the animal inside. Multiple internal shell indices associated with shell-boring parasites are also being observed and recorded as part of these studies (**Figure 32**). Typically, the vast majority of all Apalachicola Bay oysters has some degree of shell parasitism (i.e., high prevalence) that affects the aesthetics of the shell as well as overall growth of the oyster. The severity of shell parasitism, however, varies greatly among individuals and location. The shell parasite observations described in **Figure 32** contribute to an overall shell rank index (developed as part of this project).

Dermo infections. One of the most widespread diseases that affects American oyster is Dermo. This disease is caused by a microscopic, single-celled parasite that lives within the oyster meat tissues. The scientific name (genus and species) of the parasite is *Perkinsus marinus*. The common name of the disease (Dermo) came from an older genus name, *Dermocystidium marinum*, thought at the time to be a fungus.

Dermo disease is endemic to Apalachicola Bay oyster populations. In other words, it exists historically throughout the bay and

Figure 26 Apalachicola Bay map showing East-West sampling areas outlined in blue. All sites were sampled with replication to discern within-site variability.

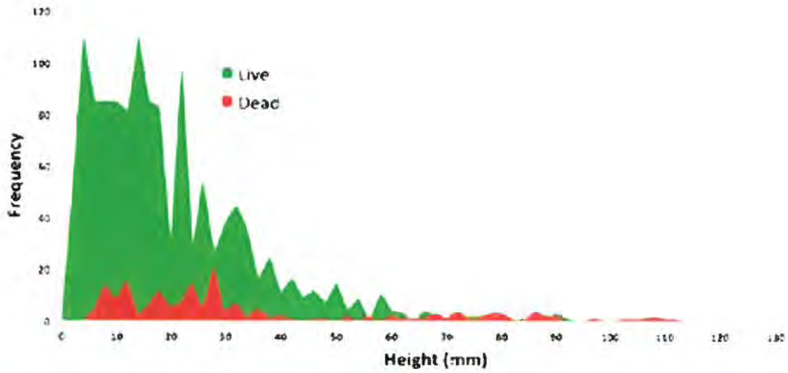

Figure 27 Size distribution (numbers) of live and dead oysters from a single sampling site on an oyster reef. The sampling strategy was to determine the number of tong "licks" and number of minutes it took to collect 32 harvest size (3 inch) oysters. At this site there are numerous spat (although not uncommon, always reassuring to see) analyzed from cultch or intact oysters. The number of live (green) oyster greater than 75 mm height however, is low in this sample. This is associated with environmental, disease or predator factors that thin the 40-60 mm portion of the area's population, and/or removal by harvesters. Replicate sampling sites on the same oyster reef revealed notable variability in abundance and size distribution.

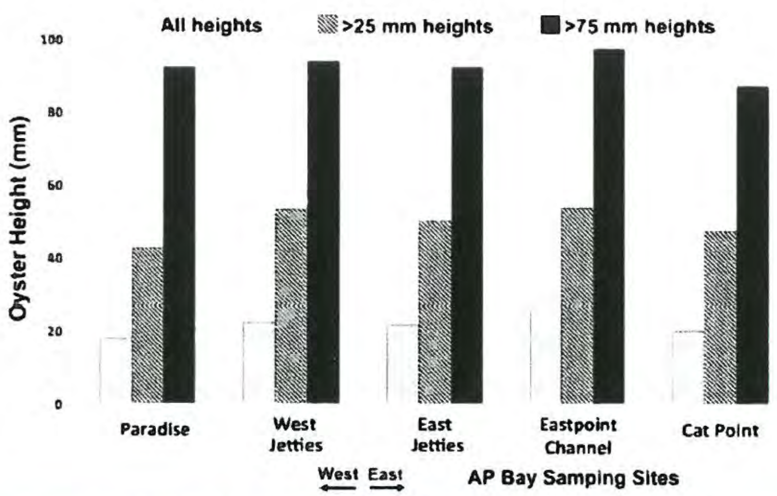

Figure 28 Relative size distribution of oysters sampled in November 2012 from five sites across an east-west transect of Apalachicola Bay. For each site, the light colored bar represents the average oyster height for all oysters examined, including all spat. The middle diagonally hatched bars represent the average height for all oysters greater than 25mm height. The black right-most bar for each site shows the average oyster height for all harvest size oyster. There are no differences in oyster height between sites examined during this sampling period. Approximately 2,000 oysters from each site were evaluated.

Figure 29 Depletion sampling methods to estimate oyster density per square meter.

Left Tongs are carefully lowered down onto the oyster bed, guided by a piece of PVC pipe to maintain location. This allows the same spot to be resampled until the number of oysters depletes close to zero for that spot. From these data, we can determine the number of oysters per square meter. *Right* Water height is determined by the water line on the tong poles. Based on the operator's measured "wing span," the width of the particular tongs, and the water depth, we can determine the area that was sampled on the bottom at each sampling site.

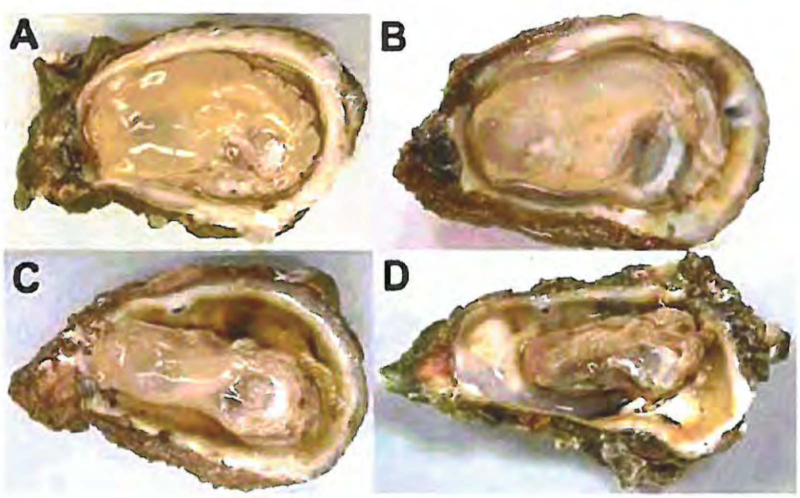

Figure 30 The meat condition index is ranked on a scale of 1-5, where 5 is a "perfect oyster," with plump, not watery or translucent meat that fills out the shell, with a uniform tan-creamy appearance. Images shown in this figure taken from Apalachicola Bay samples show a range of meat ranks. The oyster pictured in image A, had a meat index of 4.5. The oysters in image B, C, and D had indices of 3.5, 2.0 and 1.0, respectively.

is widespread. The severity of the disease, however, is typically relatively low such that it does not commonly overtly harm the oysters. When severe, however, Dermo can devastate and wipe out oyster populations. In general, elevated salinity and temperatures are associated with increased Dermo prevalence (percentage of infected oysters) and infection severity.

This project has initiated monitoring of the prevalence and severity of Dermo at multiple sites across Apalachicola Bay. To do this, tissues from fresh, live oysters are incubated in a special growth medium, and then stained with iodine to visualize the Dermo spores (**Figure 33**). The number and distribution of spores in tissue samples seen under the microscope are used to rank the presence and severity of infection in each oyster examined.

Data from Cat Point (**Figure 34**) and other Apalachicola Bay locations reveal a high prevalence of Dermo in oysters (typically >90% of all oysters sampled are positive for the parasite), albeit with a relatively low infection severity (approximately 1.00 on a scale ranging from 0-5).

Dermo data derived from samples taken in November 2012 and February 2013 indicate that:

- "Early" versus "late" winter samples did not reveal significantly different weighted prevalence of Dermo between these two sampling time points (from animals taken from the same oyster bar);
- Sampling along different oyster bars (Cat Point, East Point Channel, East and West Jetties, Paradise) did not reveal significantly different weighted prevalence of Dermo within bars;
- Dermo infections may be higher throughout the bay now than previously estimated, based on other studies conducted through the Oyster Sentinel program[3] and Petes et al. (2012).[4]

Additional efforts

Continued sampling and analyses for Dermo disease (and other health indices) are planned as part of this study to discern Dermo prevalence and severity in summer months, when infections are typically higher. This type of sampling and data analysis is important in order to discern trends that may be relevant to fishery management strategies that can account for seasonality, oyster density and harvest pressure, water flow, water quality, and other stressors.

Application of additional oyster health indices and analyses to examine associations between environmental conditions and oyster health are also planned. Of great importance will be to discern relationships between Apalachicola Bay conditions, harvest pressure, and the health, condition and distribution of oysters relative to implementation of near- and long-term management strategies.

Outreach and community partnerships

Efforts have also included outreach through the Franklin County Seafood Workers Association, and support for the newly formed SMARRT. Support for SMARRT has been based on developing common goals to support a sustainable and healthy Apalachicola Bay system in partnership with federal and state managers and regulators. To that end, collaborative efforts have also extended to working with other stakeholders including Franklin's Promise Coalition, Gulf Coast Workforce Board, Florida Department of Agriculture and Consumer Services, Florida Fish and Wildlife Conservation Commission, and Apalachicola National Estuarine Research Reserve Service. Thanks are due to the many contributing Apalachicola Bay fishers and all parties engaging in this constructive partnership.

Developing Cost-Effective Monitoring for the Oyster Fishery and an Experimental Assessment of Predator Impacts

David Kimbro

The collapse of the Apalachicola Bay oyster fishery has been detected through the combined efforts of the FDACS monitoring program and the commercial landings records of the FWC. Although these data are adequate to monitor the decline in market size oysters, they do not provide sufficient information to determine the precise cause of this decline. As part of the oyster task force, my team is developing tools to supplement the current FDACS monitoring program so that future data include key demographic information: recruitment, growth, mortality, and size structure. By re-sampling the data we collect, we will determine the minimum sampling effort and operational cost required to obtain reliable demographic predictions.

Using Florida Sea Grant program development funds, we developed a spatially stratified sampling design for reefs in which 16 0.25 m^2 quadrats were collected from 18 different reefs (**Figure 35a**). As the current protocol used by FDACS does, we harvested all material in a quadrat and then processed

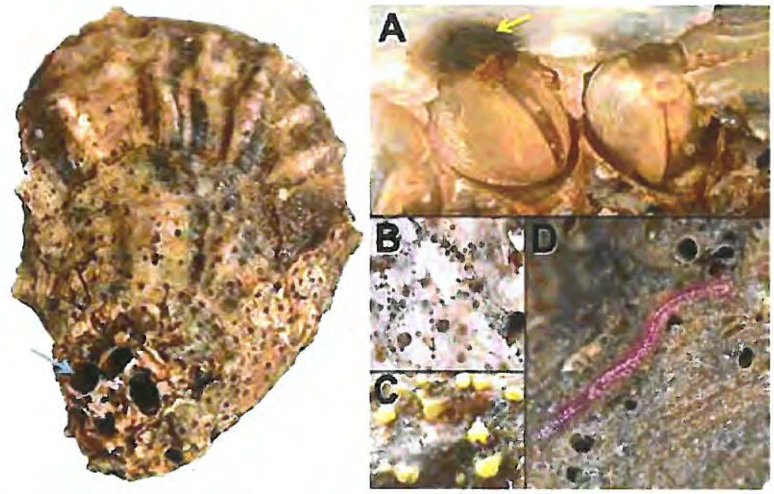

Figure 31 Shell parasites observed in Apalachicola Bay oysters 2012-2013. The whole oyster shell on the left shows evidence of several types of parasite damage. The blue arrow points to one of several larger holes formed by boring clams (*Diplothyra smithii*). Also evident are numerous smaller holes associated with the boring sponge, *Cliona spp*. Panel on the right shows close up images of common Apalachicola Bay oyster shell parasites. Panel A shows two boring clams seen at the edge of a shell that was fractured to reveal the parasites. Note the black spot (yellow arrow) associated with the clam's activity on the inner nacreous layer of the shell. Panel B shows close up of exterior shell holes bored by *Cliona* sponge. In life, this sponge organism is yellow and protrudes from the shell holes (Panel C). Panel D shows one of two types of polychaete worms, *Polydora*. This worm forms tubes within the shell, and can cause the oyster host to wall off this invader by forming mud blisters on the inside of the shell.

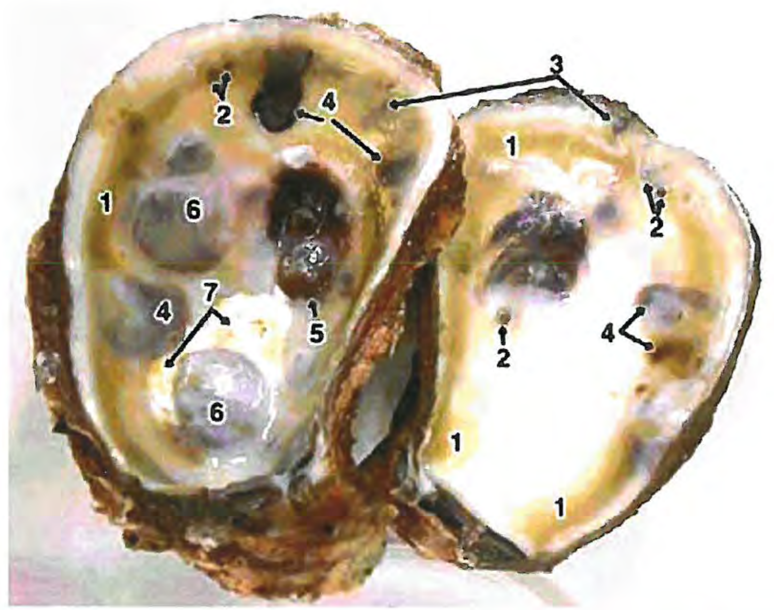

Figure 32 Internal shell observations associated with parasites from Apalachicola Bay oysters. Observations are described by number.
1 Yellowing. This discoloration in the nacreous layer is deposited by the mantle under stressful conditions.
2 Black spots associated with *Diplothyra* clams living within the shell.
3 Burrowing tubes at periphery of shell. These are points of access of boring *Polydora* worms.
4 Enlarged Polydora burrows within shell.
5 Mud blister. This "blister" is formed when *Polydora* worms penetrate the nacreous layer of the shell. The oyster host expends energy to secrete more nacre to wall-off the invader.
6 Long-standing mud blisters with thicker layer of nacre walling off the worm.
7 Chalky deposits. These white deposits are also laid down by the mantle under stressful conditions.

[3] Oyster Sentinel, Ray and Soniat (http://www.oystersentinel.org)
[4] Petes LE, Brown AJ and Knight CR. 2012. Ecol. Evol. 2(7)1712-1724

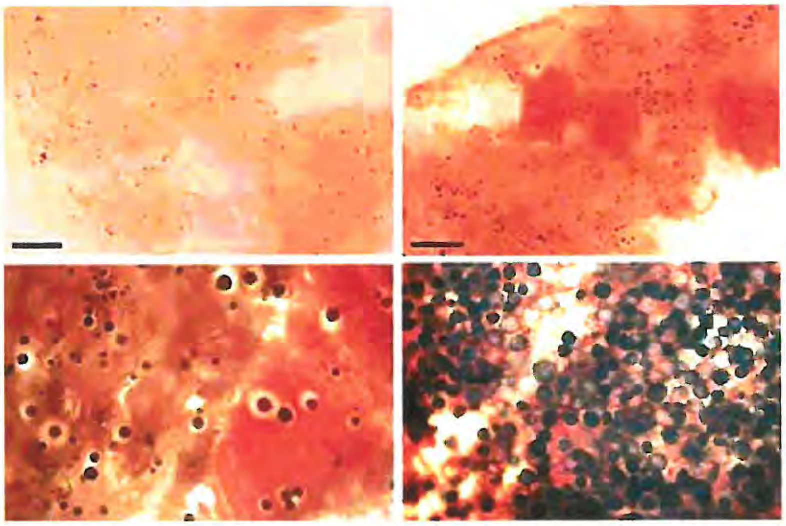

Figure 33 Photomicrographs showing varying degrees of Dermo infection in oyster mantle tissue. The number and distribution of *Perkinsus* spores allows a trained observer to derive a weighted prevalence for a sampling site and time point. The weighted prevalence is based on the percentage of oysters with any detectable Dermo multiplied by the mean severity rank (0-5) on a Mackin Scale.

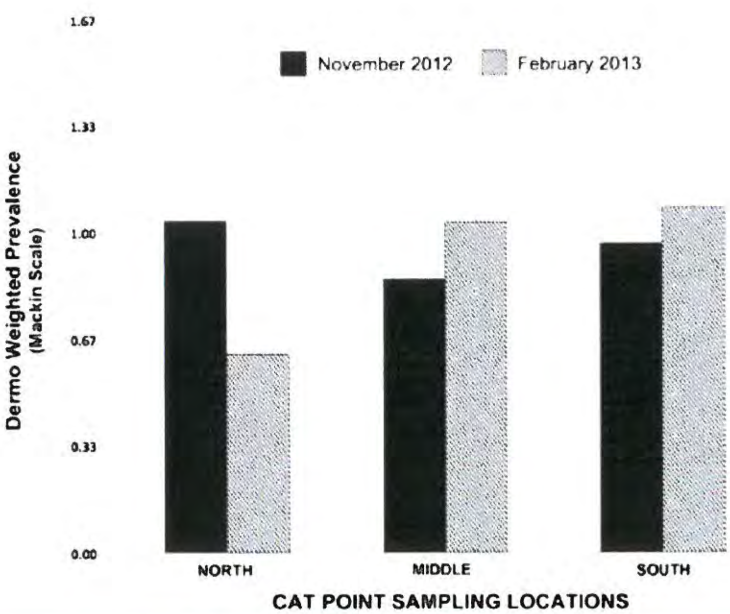

Figure 34 Spatial and temporal distribution of Dermo in oysters sampled along Cat Point bar in November 2012 and February 2013.

it to estimate number, biomass, and size structure of oysters and predatory gastropods and decapods. However, we processed each sample three different ways. Each method differs in quality of data production and operational cost. The first sampling event was completed in January 2013 and involved working with Franklin's Promise to hire local oystermen for vessel transportation ($2,000). Below, we present preliminary findings on the condition of oyster reefs.

Oyster reef structure

Based on model-selection analysis, the amount of reef structure throughout Apalachicola Bay differs in two important ways. First, reefs in east Apalachicola have nearly double the amount of oyster structure when compared to reefs in west Apalachicola (**Figure 35b**). Second, and with respect to eastern reefs, reef structure increases in a linear fashion with distance from freshwater input (**Figure 35c**). In contrast, in the west, reef structure increases minimally from Region 1 to Region 3.

Oyster abundance

According to the same statistical procedures, the abundance of adult oysters (oysters > 25 mm) differs between the east and west portions of Apalachicola Bay (**Figure 36b**). Similar to the pattern of reef structure, adult oysters on eastern reefs increased in abundance with distance from freshwater input. However, the presence of adult oysters is highly variable in Region 3 (i.e., larger error bars). The distribution of juvenile oysters (i.e., individuals < 25 mm) parallels the adult spatial pattern (**Figure 36c**).

Oyster size

In the January 2013 survey, we found that oyster size on eastern reefs decreased with increasing distance from freshwater input. In contrast, oyster sizes collected from western reefs increase with increasing distance from freshwater input (**Figure 37b**). Because spatial differences in the supply of oyster larvae could skew the average size of oysters, we re-plotted these data only for oysters > 25 mm length, thereby minimizing the influence of recruitment variation. This subset of data showed larger oysters sizes on both sides of the bay, yet the spatial patterns from Regions 1-3 mirrored those of the full data set (**Figure 37cv**).

Oyster predator abundance

In January 2013, the primary macro-invertebrate predator was the southern oyster drill (*Stramonita haemostoma*). The abundance of this predator was significantly less than

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the abundances we observed in preliminary sampling during October 2012. But for both the eastern and western portions of Apalachicola, the winter abundance of this predator peaks in Region 2 (**Figure 38b**). Because of the expected effects of the winter season, we found few individuals of crown conchs.

In our pending research, we will:

A. Monitor oyster recruitment and individual growth throughout the bay on a monthly basis beginning in March 2013.

B. Conduct an oyster mortality experiment throughout the bay to assess mortality of adult and juvenile oysters as a function of predation and environmental conditions.

C. Establish correlative relationships between these oyster response metrics by deploying salinity, temperature, and tidal loggers throughout the bay.

D. Collect monthly samples from each reef on nutrient and phytoplankton (Chl-a) concentrations in the water column.

E. Repeat the aforementioned oyster survey in order to characterize the distribution and abundance of oysters and their predators during the summer.

F. Use computerized re-sampling of our data to simulate less intensive sampling effort (e.g., measuring only a fraction of adult oysters in a quadrat) and to determine how much effort is required for reliable model analysis.

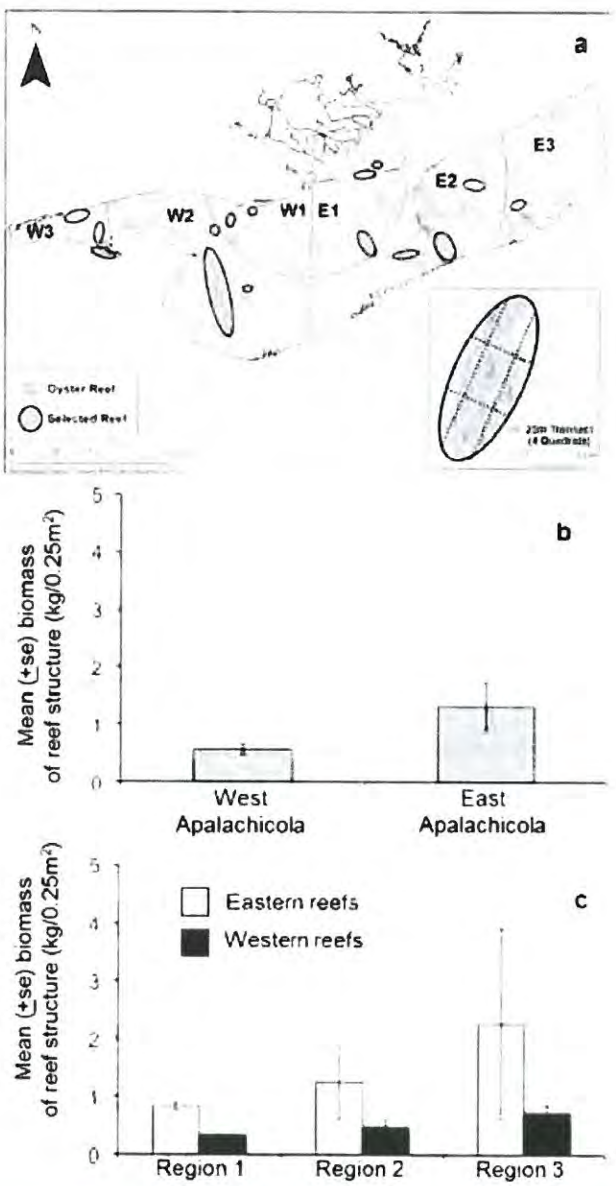

Figure [illegible] Map of oyster reefs in Apalachicola Bay (a), biomass of reef structure in the western and eastern portions of the bay (b) and biomass of reef structure in three different regions of the bay (c).

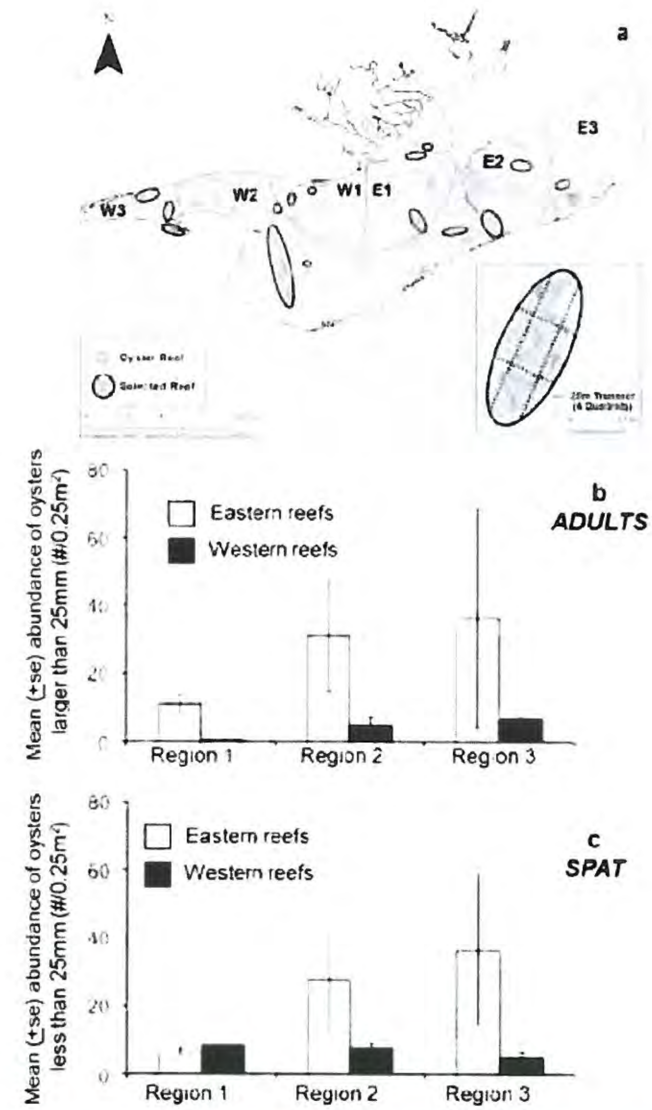

Figure [illegible] Map of oyster reefs in Apalachicola Bay (a), abundance of adult oysters (b) and spat (c) in different regions of the bay.

Fostering Community Resiliency and Stewardship *Traci Irani and Angela Lindsey*

Social vulnerability and resiliency theory are approaches that have been used to look at communities' responses to both natural and man-made disasters. For communities dependent on natural resources for their livelihoods, environmental and natural disasters are particularly salient, since these communities are vulnerable to negative changes in the environment. Social scientists define social vulnerability as a group of factors that make the system more or less able to cope with change. Social vulnerability can be understood as a characteristic within the system that affects how much harm from external factors the system is likely to experience. Within a community system, increasing the resiliency of the community and involving its members in the decision-making process can be an important way to prepare members to handle future disasters and remain strong. In addition, access to more resources helps people adapt to living in an environment with regular environmental vulnerability. Increasing information and awareness is also a strategy to decrease vulnerability and increase resilience. While scientific information is absolutely essential in working through environmental disasters and issues, it should be coupled with knowledge from those communities impacted.

During the past seven years, Franklin County, Fla. has endured hardships, including hurricanes, tropical storms, red tide, the Deepwater Horizon oil spill and drought. Due to these hardships, local resources have been impacted, which has directly impacted the economic and social stability of Franklin County's communities. University of Florida researchers and community outreach specialists have been working with these communities to help mitigate the socio-psychological as well as environmental effects. Through these pre-established relationships with community leaders in Franklin County, UF was able to

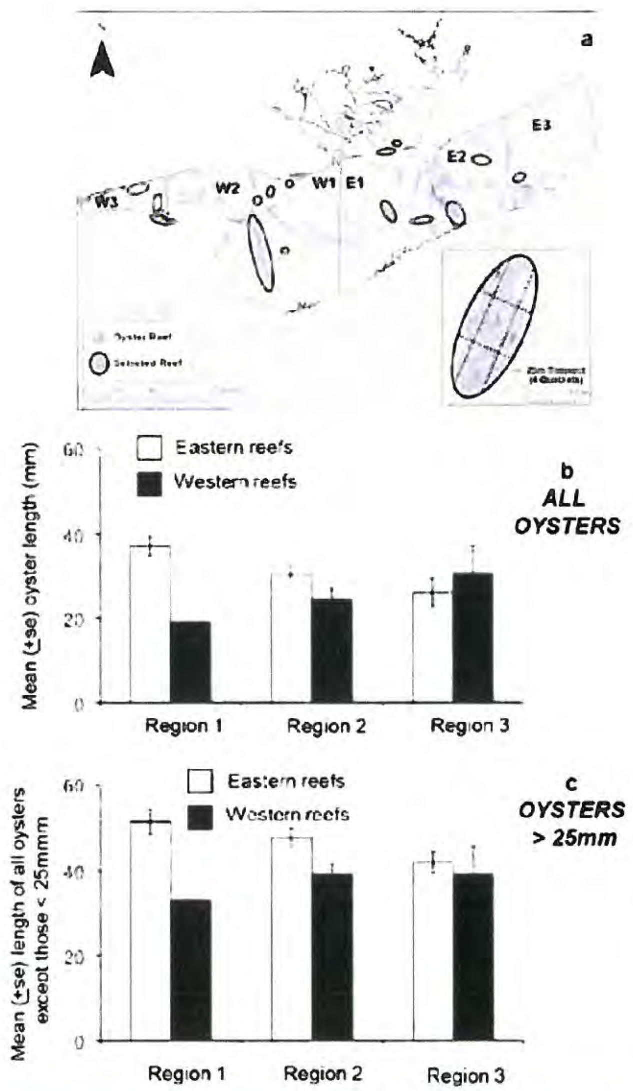

Figure 37 Map of oyster reefs in Apalachicola Bay (a), average length of all oysters (b) and average length of only adult oysters in different regions of the bay (c).

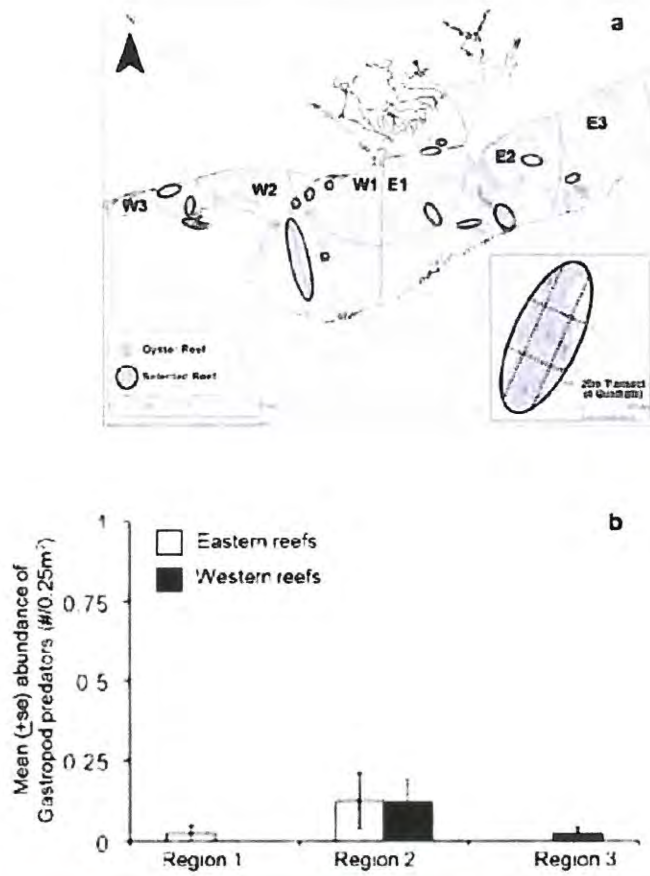

Figure 38 Map of oyster reefs in Apalachicola Bay (a), and abundance of gastropod predators in different regions of the bay (b).

continue to assist with resilient strategies and outreach efforts to combat recent economic downturns caused by the oyster harvesting crisis. These efforts included organizing and guiding community listening sessions and public forums, as well as collaborating with stakeholders on efforts to minimize damage and better prepare for future disasters.

Since the 1990s, there has been a change in development projects and processes in which researchers have focused on community participation as a formative research technique. This shift has brought about a host of different social science research methods, including participatory rural appraisal, appreciative inquiry, and community capitals framework, that all include a focus on more participatory methods when working with the community. Within these approaches, community participation has been used as a way to increase community empowerment and resilience.

Using the community participation method, a listening session and public forum meeting were held to hear the concerns of the community. The goal of these events was to understand community perceptions of the problems facing these communities. The first community meeting was an informal community listening session held on October 9, 2012. The purpose of this session was to bring interested parties together to address the oyster industry decline in Apalachicola Bay, FL. The session was divided in two different phases including: (1) what is happening, and how (are these events) affecting you? And (2) what are potential solutions to the situation? For this event, there were about 30 participants in attendance and these included representatives from the Franklin County Seafood Workers Association, Franklin's Promise Coalition, Florida Sea Grant, UF/IFAS Extension, and the university's Oyster Recovery Task Force. In addition, more than 15 community members were in attendance.

It was during this session that community members described their idea of forming a stakeholder-based community initiative that focuses on the sustainability and resilience of the local seafood industry. The proposed effort, identified as Seafood Management Assistance Resource and Recovery Team (SMARRT), would work collaboratively to tackle current hardships and create sustainable plans that ensure future preparedness. Partners in this program would be about 15 members representing law enforcement/regulators, government officials, seafood businesses, nonprofit organizations, social services and academic institutions. The inclusion of diverse partners and stakeholders was evidence of the goal to develop a sustainable solution for the bay.

The community development of the SMARRT initiative is an example of Empowerment Theory within a community. Empowerment Theory describes how changes in beliefs and attitudes influence changes in behavior leading to social change. It argues that by first developing a critical consciousness about one's (or a community's) situation and abilities, that collective action toward the social or collective good will occur. Empowerment can be considered either a process or an outcome, and can be analyzed at the individual or community level. As a process, empowerment increases power so that actors can take control of and act upon their own situations. Perceived control over the situation can account for varying levels of community participation, with communities who perceive that they have more control over their situations more apt to participate in community meetings and community organizing events.

Following the theory, once the idea of SMARRT was initiated, the community was open to working with UF to further develop the idea and meet the goals. Therefore, once SMARRT was identified and defined, UF began efforts to work with the community to further develop this important initiative. A public forum was subsequently held on October 16, 2012 to identify next steps in the development of the SMARRT Task Force. This forum aimed to support this collaborative effort by bringing community members together with vested stakeholders to discuss potential solutions and action plans to address the challenges of the oyster decline. The sessions focused on stakeholder input regarding the future direction of the SMARRT initiative. Outputs of this meeting included the development of an ad hoc committee to assist in the development. UF was asked to sit on this task force and has since been actively involved in the development of SMARRT.

This meeting provided the opportunity for community members to interact both internally and externally, which can also lead to open communication, higher feelings of empowerment, and resilience. The theory of communicative action explores the role of communication in creating social bonds. This theory argues that for groups to work together they must first understand one another, particularly in their interpretations of the world and social norms. Language, therefore, is a way to understand one another on a deeper level. Open communication, without resorting to power or persuasion, is crucial to reveal truth about situations and issues and is the only way to reach true consensus. It was the aim of these initial meetings to learn from the community and to be thoroughly transparent in efforts in which to assist them. Efforts were therefore developed collaboratively and strategically.

One example of the collaborative effort between the community and UF was the development and presenting of a grant workshop to Franklin County, FL in February 2013. The focus of this workshop was collaboration among community resource organizations in order to have the largest impact within the community. For this event, there were 13 participants from extension and 15 with nonprofit or public organizations. Participants had diverse and overlapping program interests, including gardening, health, nutrition, natural resources, youth, the arts, financial literacy, and disaster preparedness. The grant workshop covered topics including (1) developing the right idea, (2) creating logic models, (3) building a grant writing team, (4) collaborating as a team, (5) creating a budget, and (6) final submission. The overall goal of the workshop was to the increase capacity of community leaders and organizations to collaborate together to secure resources for their programs focused on community development and resiliency.

Moving ahead, UF will continue to look for opportunities to collaborate with the community in order to meet needs.

In addition, we will continue to be active in our efforts to work with the community to further the development of SMARRT. The theory of empowerment discusses new ways of approaching development intervention collaborations. Suggestions have been made on how to facilitate the empowerment process when working with groups. This includes (1) enhancing experience and competence, (2) enhancing group structure and capacity, (3) removing social and environment barriers, and (4) enhancing environmental support and resources. In order to integrate the pieces of empowerment theory into SMARRT, UF will continue to advise SMARRT developers on next steps and organizational structure. We have been present at all meetings and work diligently to become a bridge between the community organization and the resources available at the University of Florida.

The use of participatory methods when working with communities, whether for research or development projects, can be used to open communication lines among people to express concerns and priorities for their communities. This is important in developing new strategies for handling current and future crises and natural disasters in resource-dependent communities like those in Franklin County.

Alternative Seafood Products

A new modest, periodic fishery appears probable and potentially useful in terms of partial predator control. Initial studies are assessing the potential for harvest and utilization of the crown conch, *Melongena corona*, which is one of the primary predators on oysters. These small mollusks can appear in substantial numbers relative to salinity regimes in Apalachicola Bay as well as other similar coastal/estuarine areas about Florida and the Southeast U.S. region. Development of the fishery will proceed with caution due to the lack of information pertinent to a fishery. Preliminary assessments have been favorable regarding necessary processing to recover edible portions and market acceptance of the product in cooked forms. Commercial retail interest is strong mindful of the limited availability of the traditional queen conch, *Strombus gigas*, which currently is under formal consideration as an endangered species (NOAA/2013). Since December 2012, crown conch has been harvested from Florida waters and processed to recover substantial volumes for secondary production of food items. The cooked forms have been successfully evaluated by the seafood sensory expertise at the Food Science and Human Nutrition Department at the University of Florida, and through trials in established retail/food service chains based in Florida. Further work is necessary to assess attributes involving appropriate resource availability and utilization, food safety and quality, including frozen storage and shelf-life, and markets for by-products including empty shells and live crown conch that are too small for processing. As a new seafood item, request for appropriate terminology for product identity and labels as Crown Conch have been formally initiated with the required federal authorities in the Food and Drug Administration and respective resource authorities in the FWC. This work is proceeding with commercial assistance through Florida Sea Grant staff without financial support from grant funds.

SUGGESTIONS FOR MONITORING, MANAGEMENT, RESTORATION AND RESEARCH

Monitoring

- There is a need to continue the monitoring of oysters in Apalachicola Bay, both in terms of tracking landings reported by oystermen, and in the sampling done by state agencies.The fisheries independent monitoring program needs to be expanded in its spatial extent to include all of the bay where oyster bars occur, including areas that are closed to fishing, because these may represent important sources of oyster spat.
- Oysters should be included on the list of invertebrate species routinely assessed by Fish and Wildlife Research Institute (FWRI) stock assessment staff. These assessments can identify persistent uncertainties in oyster ecology or population status and help guide research such as the relationship between Apalachicola River flows and juvenile oyster survival rate or culling mortality.

Management and Restoration

- Acceptance by the community and industry, and enforcement and adjudication of rules regarding size limits, spatial restrictions, and weekly and seasonal closures is essential for these measures to be effective in sustaining the oyster population.
- Throughout our work on this project there were persistent reports of high levels of unreported harvest and illegal harvest from closed areas. While tangible evidence of illegal activity is not available, it is clear from our simulation models that lack of compliance with current regulations could greatly reduce the likelihood of Apalachicola Bay oyster populations returning to historic population levels, regardless of management action taken.
- Oyster leases should be explored as a possible alternative to open-access fisheries. The concept of TURF (Territorial User Rights Fisheries) as a lease arrangement could be appealing to oyster fishermen and help promote restoration actions such as re-shelling because the fishermen would benefit directly from the restoration activities they were engaged in by having a "share" of the restored area (the lease) to manage and harvest from.
- The total current area of oyster bar in Apalachicola Bay that is not open to fishing is unknown, and the degree to which this area is the source of the oyster spat for the entire bay also is unknown. If this area is small or declining, then large-scale oyster relay from these closed areas to areas open to fishing may reduce the total spat available throughout Apalachicola Bay, increasing the risk of "recruitment overfishing" where harvests of adults could influence availability of future spat.
- Therefore, the practice of 'relaying' should be carefully evaluated in regard to its short-term benefits versus potential longer-term negative impacts to the fishery—in

other words, whether or not it is depleting a substantive portion of the source population of oyster spat.

- Management actions such as shell planting could expedite the recovery of Apalachicola Bay oyster resources. However, a new modeling tool called ECOSPACE, brought forward by the UF Oyster Recovery Team, suggests that shell planting needs to be conducted at a considerably greater scale than current levels to be effective—approximately 200 acres per year for a 5-year period. A very important uncertainty is whether shell planting should concentrate large amounts of shell in small areas to create thick layers of shell or whether shell should be spread over larger areas but not in as thick a shell layer. Restoration should be done in a manner that provides information on efficacy and cost-effectiveness of different shelling strategies, including evaluating different densities of shelling and different kinds of shell material.
- A participatory decision-making process, involving SMARRT (the Seafood Management Assistance Resource and Recovery Team), relevant state agencies and experts from the state university system is needed to support long-term management of the oyster fishery in a more robust manner. The ECOSPACE model could further support members of SMARRT and management agencies to screen different policy or restoration alternatives.

Research

- Research is needed to identify an optimal approach for monitoring long-term settlement, juvenile and adult survival, productivity, health, mortality, oyster diseases, and product quality of oysters. Subsequently this information could be used to inform changes in the oyster monitoring program.
- Research is needed to quantify how oyster population dynamics, product quality and the fishery are affected by interactions between river flow, nutrients, salinity, harvesting intensity and restoration methods.
- There is a need to assess the harvesting practices of the oystermen and how they respond to changes in oyster abundance.
- The ECOSPACE model has additional functionality to identify effects of varying flow regimes and to screen flow alternatives, relative to Apalachicola Bay oyster population dynamics and harvest potential when the model is linked with the Apalachicola Basin River Model currently being used by the Apalachicola-Chattahoochee-Flint River Stakeholders Group.

Outreach and Education

- A community-based outreach and education program is needed to foster actions consistent with supporting a sustainable bay ecosystem and economy.
- Involvement of oyster harvesters and processers in research and restoration projects can aid in educating the entire community about bay stewardship.

The Future

The situation in Apalachicola Bay, as outlined in the pages of this report, highlights a series of interwoven ecologic, fisheries, and community concerns. The bay is a national treasure, and its demise would sever critical links among our modern society, nature and our heritage. Work to date is a starting point toward understanding the processes underlying the current crisis, and includes steps that can and should be taken in initial efforts to restore the bay. However, if we are truly committed to bringing the bay back to a point even close to its former productivity, a great deal of work is still required. These studies and analyses were conducted on a shoestring budget with internal funds from UF/IFAS, and limited support from Florida Sea Grant and from the National Institute of Environmental Health Sciences. If we are truly committed to the restoration of the bay, we can't stop here. There is a critical need for follow-up work, bringing together state and federal agencies, academic researchers, and the community, to look out over a 5-, 10-, and 20-year time scale, to conduct interventions, do the necessary research, and monitor outcomes. This will require a strong leadership structure and it will cost money. The question remains as to whether we, as a society, are willing to make this investment of time, and money, to preserve this priceless natural resource for our lifetime, and the lifetimes of our children.

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April 2013

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Exhibit 19

Date	Location	five.year.bin	Cultch Type	Cubic Yards	Acreage	Yd^3/Acre	Actual Yd^3/Acre	Cost	Price/Yd^3	Actual Price/Yd3	Cost/Acre	Actual Cost/Acre	Notes
1970	Apalachicola Bay	1970	Processed Oyster Shell	18,649	74.6	100 - 200	250			$ -		$ -	
1971	Apalachicola Bay	1970	Processed Oyster Shell	10,136	40.5	100 - 200	250			$ -		$ -	
1972	Apalachicola Bay	1970	Processed Oyster Shell	9,675	38.7	100 - 200	250			$ -		$ -	
1973	Apalachicola Bay	1970	Processed Oyster Shell	7,660	30.6	100 - 200	250			$ -		$ -	
1974	Apalachicola Bay	1970	Processed Oyster Shell	5,780	23.1	100 - 200	250			$ -		$ -	
1975	Apalachicola Bay	1975	Processed Oyster Shell	5,055	20.2	100 - 200	250			$ -		$ -	
1976	Apalachicola Bay	1975	Processed Oyster Shell	0						#DIV/0!			
1977	Apalachicola Bay	1975	Processed Oyster Shell	2,751	11	100 - 200	250			$ -		$ -	
1978	Apalachicola Bay	1975	Processed Oyster Shell	10,139	40.6	100 - 200	250			$ -		$ -	
1979	Apalachicola Bay	1975	Processed Oyster Shell	6,258	25	100 - 200	250			$ -		$ -	
1980	Apalachicola Bay	1980	Processed Oyster Shell	5,709	22.8	100 -200	250			$ -		$ -	
1981	Apalachicola Bay	1980	Processed Oyster Shell	8,570	34.3	100 - 200	250			$ -		$ -	PL 88-309
1982	Apalachicola Bay	1980	Processed Oyster Shell	6,501	26	100 - 200	250			$ -		$ -	PL 88-309
1983	Apalachicola Bay	1980	Processed Oyster Shell	14,030	56.1	100 - 200	250			$ -		$ -	PL 88-309
1984	Apalachicola Bay	1980	Processed Oyster Shell	26,164	104.7	100 - 200	250			$ -		$ -	
1985	Apalachicola Bay	1985	Processed Oyster Shell	13,949	55.8	100 - 200	250			$ -		$ -	
1986	Apalachicola Bay		Processed Oyster Shell	24,567	120	250	205	$416,200		$ 16.94		$ 3,468.33	FCSWA
1986	Apalachicola Bay		Dredged Clam Shell	56,470	225	250	251	$918,000	$16.25	$ 16.26	$4,080	$ 4,080.00	CFDA/PL 88-309 (4B)
1986	Apalachicola Bay	1985	Oyst+Clam	81,037									
1987	Apalachicola Bay		Dredged Clam Shell	39,760	160	250	249	$553,950	$13.89	$ 13.93	$3,460	$ 3,462.19	CFDA/PL 88-309 (4B)
1987	Apalachicola Bay		Processed Oyster Shell	14,901	60	250	248	$178,800		$ 12.00	$2,980	$ 2,980.00	
1987	Apalachicola Bay	1985	Oyst+Clam	54,661									
1988	Apalachicola Bay	1985	Processed Oyster Shell	9,104	36.4	100 - 200	250	$109,250		$ 12.00	$3,000	$ 3,001.37	
1989	Apalachicola Bay	1985	Processed Oyster Shell	10,013	40	250	250	$120,000		$ 11.98	$3,000	$ 3,000.00	
1990	Apalachicola Bay	1990	Processed Oyster Shell	7,297	36	200	203	$87,500		$ 11.99	$2,400	$ 2,430.56	
1991	Apalachicola Bay	1990	Processed Oyster Shell	0									
1992	Apalachicola Bay	1990	Processed Oyster Shell	2,100	8.4	100 - 200	250	$25,200		$ 12.00	$3,000	$ 3,000.00	
1993	Apalachicola Bay		Scallop Shell	4,415	22	200	201	$55,200	$0.55	$ 12.50	$2,500	$ 2,509.09	
1993	Apalachicola Bay		Processed Oyster Shell	6,250	25	100 - 200	250	$75,000		$ 12.00	$3,000	$ 3,000.00	
1993	Apalachicola Bay	1990	Oyst+scallop	10,665									
1994	Apalachicola Bay		Processed Oyster Shell	1,440	6	250	240	$17,280		$ 12.00	$2,880	$ 2,880.00	
1994	Apalachicola Bay		Processed Oyster Shell	923	5	200	185	$44,300		$ 48.00	$8,860	$ 8,860.00	EDA/JTPA/FCSWA
1994	Apalachicola Bay		Scallop Shell	7,841	39	200	201	$375,000	$0.55	$ 47.83	$9,600	$ 9,615.38	EDA/JTPA/FCSWA
1994	Apalachicola Bay	1990	Oyst+scallop	10,204									
1995	Apalachicola Bay		Dredged Oyster Shell	8,940	45	200	199	$457,700	$20.00	$ 51.20	$10,170	$ 10,171.11	EDA/JTPA/FCSWA
1995	Apalachicola Bay		Processed Oyster Shell	10,935	43.7	250	250	$131,200		$ 12.00	$3,000	$ 3,002.29	
1995	Apalachicola Bay	1995	dredged+processed	19,875									
1996	Apalachicola Bay	1995	Processed Oyster Shell	9,000	36	250	250	$108,000		$ 12.00	$3,000	$ 3,000.00	
1997	Apalachicola Bay	1995	Processed/Dredged Shell	9,705	39	250	249	$116,460		$ 12.00	$3,000	$ 2,986.15	
1998	Apalachicola Bay	1995	Processed Oyster Shell	1,585	6.5	100 -200	244	$38,040		$ 24.00	$5,850	$ 5,852.31	
1999	Apalachicola Bay	1995	Processed Oyster Shell	1,750	7	250	250	$21,000		$ 12.00	$3,000	$ 3,000.00	
2000	Apalachicola Bay	2000	Processed Oyster Shell	7,316	29.3	100 - 200	250	$87,800		$ 12.00	$3,000	$ 2,996.59	
2001	Apalachicola Bay	2000	Processed Oyster Shell	9,828	40	250	246	$216,200	$12.00	$ 22.00	$5,400	$ 5,405.00	FDOT
2002	Apalachicola Bay	2000	Processed Oyster Shell	12,508	50	250	250	$275,200	$12.00	$ 22.00	$5,500	$ 5,504.00	FDOT
2003	Apalachicola Bay	2000	Processed Oyster Shell	12,744	51	250	250	$280,370	$12.00	$ 22.00	$5,500	$ 5,497.45	FDOT
2004	Apalachicola Bay	2000	Processed Oyster Shell	528	2.1	250	251	$11,600	$12.00	$ 21.97	$5,530	$ 5,523.81	FDOT
2005	Apalachicola Bay	2005	oyster shell	0									
2006	Apalachicola Bay	2005	oyster shell	0									
2007	Apalachicola Bay	2005	oyster shell	0									
2008	Apalachicola Bay	2005	Processed Oyster Shell	7,700	31	100 - 200	248	$169,400	$12.00	$ 22.00	$5,500	$ 5,464.52	EDRP1
2009	Apalachicola Bay, Franklin County	2005	Processed Oyster Shell	4,345	20	100 - 200	217	$95,600	$12.00	$ 22.00	$4,800	$ 4,780.00	EDRP1
2010	Franklin County	2010	Processed Oyster Shell	14,313	57.2	244	250			$ -		$ -	
2011	Franklin County	2010	Processed Oyster Shell	4,880	19.3	253	253			$ -		$ -	
2012	Franklin County	2010	Processed Oyster Shell	8,630	34.6	249	249			$ -		$ -	
2013	Franklin County	2010	Processed Oyster Shell	4,000	16	250	250	$109,375		$ 27.34		$ 6,835.94	
2014	Franklin County	2010	Processed Oyster Shell	20,226	99.63	200	203	$1,803,644	$84.99	$ 89.17	$16,997	$ 18,103.42	
2015	Franklin County	2015	Processed Oyster Shell	26,900	134.5	200	200	$2,010,775	$74.75	$ 74.75	$14,950	$ 14,950.00	
			overall.average	12,077									
			average.before.2010	11,950									

Exhibit 20

Water-Level Decline in the Apalachicola River, Florida, from 1954 to 2004, and Effects on Floodplain Habitats

By Helen M. Light[1], Kirk R. Vincent[2], Melanie R. Darst[1], and Franklin D. Price[3]

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Prepared in cooperation with the

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Northwest Florida Water Management District
Florida Department of Environmental Protection
U.S. Fish and Wildlife Service

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Contents

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Conversion Factors, Acronyms, and Abbreviations

Multiply	By	To obtain
inch (in.)	25.4	millimeter
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
square mile (mi^2)	2.590	square kilometer
river mile* (rm)	1.609	river kilometer
acre	0.4047	hectare
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
cubic yard (yd^3)	0.7646	cubic meter
part per million (ppm)	1.0	milligram per liter

*See Glossary for definition.

Vertical coordinate information is referenced to National Geodetic Vertical Datum of 1929 (NGVD 1929)—a geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called "Sea Level Datum of 1929."

ACF	Apalachicola-Chattahoochee-Flint
AMO	Atlantic Multidecadal Oscillation
FFWCC	Florida Fish and Wildlife Conservation Commission
NWFWMD	Northwest Florida Water Management District
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey

Glossary

Channel change refers to physical changes in a river channel, such as widening, deepening, or changes in slope, which can result in a change in the water level for a given discharge. Channel change can also refer to minor rerouting of the channel locally, such as meander cutoffs or bend easings to straighten bends in the river.

Climate year is an informal term used in this report to define the annual period from April 1 through March 31. This period was used in analysis of low discharges in order to avoid splitting low-flow periods that typically occur in summer and fall. (See water year.)

Equivalent-stage discharge is an informal term used in this report to represent the discharge in the recent period having the same water-surface elevation as a specified discharge had during the pre-dam period. For example, the selected discharge of 15,000 cubic feet per second at the Chattahoochee gage had a pre-dam stage of 49.22 feet, and 25,700 cubic feet per second is the "equivalent-stage discharge" in the recent period that has that same water-surface elevation. Determining equivalent-stage discharge is a necessary first step in determining the decrease in duration of inundation from pre-dam to recent periods.

Gage or streamgage refers to a long-term streamflow gaging station at which a time-series of stage measurements (elevation of river surface) have been recorded, and measurements of instantaneous streamflow discharge may have been made.

High bottomland hardwood forests grow on the higher elevations of the floodplain (levees and ridges) that are usually inundated for 2 to 6 weeks each year. High bottomland hardwoods are dominated by sweetgum and hackberry.

Joining point is an informal term used in this report to indicate the stage or discharge at which pre-dam and recent stage-discharge relations merge. The joining point discharge is a large value at the upstream-most site, and gradually decreases with distance downstream. For any given site, the joining point identifies the stage or discharge above which the proportion of flow moving over the floodplain is large enough that physical changes that occurred in the main river channel at that site have no noticeable effect on river stage.

Lag time is an expression for the time it takes for water passing an upstream gage to reach a downstream location. All lag times used in this report represent average travel times from Chattahoochee to downstream locations. Analyses in this report were based on daily mean values, thus lag times were expressed in whole days, rather than hours. Discharge at Chattahoochee was related to stage 1 day later at Blountstown, 2 days later at Wewahitchka and RM 35, and 3 days later at Sumatra. Methods used to determine lag times are described in the text.

Loop stream is an informal term used by Light and others (1998) to describe a type of floodplain stream or slough in which water diverted from the main river enters at the head of the stream, flows a few miles in the stream channel through the floodplain, and returns to the river at the mouth of the stream. An intermittent stream of this type is fed by the river and receives no direct upland runoff, thus when water levels in the river are too low, the stream stops flowing.

Low bottomland hardwood forests are present on low ridges and flats where continuous flooding averages 2 to 4 months per year. Low bottomland hardwoods are dominated by water hickory, overcup oak, swamp laurel oak, and green ash.

Percent duration of inundation is the percentage of time that a particular location is inundated by water. Percent duration of inundation, which is a term used to describe hydrologic conditions on the floodplain, is numerically equal to percent exceedance in this report; however, that is not always the case in other contexts. Percent duration of inundation in the floodplain can be different than percent exceedance calculated from streamflow data, because some topographic features in the floodplain, such as swamp depressions, may retain water long after flood waters recede. Thus, the reader is cautioned that percent duration of inundation values in this report are based solely on river stage, without any adjustments to account for site-specific variations in floodplain topography. (See percent exceedance.)

Percent exceedance is the percentage of time that a specified streamflow discharge is equaled or exceeded during a given time period. In this report, percent duration of inundation, which is a term used to describe hydrologic conditions on the floodplain, is numerically equal to percent exceedance. (See percent duration of inundation.)

Pre-dam period is an informal term used in this report to refer to the time period before substantial physical changes occurred in the Apalachicola River. This period ends in May 1954, which is when Jim Woodruff Dam was completed and the filling of Lake Seminole was initiated. Riverbed degradation which resulted from the trapping of streambed sediment in the reservoir, was the primary cause of the water-level decline in the upper reach of the river. Beginning in 1956, a variety of other channel-altering activities took place over a period of many years that probably also contributed to the water-level decline, particularly in the nontidal lower reach. Thus, the use of the term "pre-dam" is not intended to imply that scour downstream from the dam as a result of sediment trapping in the reservoir was the only cause of channel change.

Reach refers to a length subdivision of the Apalachicola River. The upper reach begins just below Jim Woodruff Dam at river mile 106.3 and extends about 29 miles downstream to the Blountstown gage at river mile 77.5. The middle reach is the longest reach, about 36 miles long, ending at the Wewahitchka gage at river mile 41.8. The nontidal lower reach is the shortest reach, about 21 miles long, and ends at the Sumatra gage at river mile 20.6. The tidal reach of the river is not discussed in this report. In reality, there is no precise boundary between the tidal and nontidal reaches, but rather a transitional zone in which tidal influence is minimal at the upper end (occuring only at very low flows) and gradually increases downstream. For practical purposes in this report, the boundary between tidal and nontidal was established at the Sumatra gage; however, during low-flow conditions, tidal influence occurs at the Sumatra gage and probably also extends upstream to some undetermined point.

Recent period is an informal phrase used in this report to indicate the decade from October 1, 1994, to September 30, 2004. This period was chosen to be long enough to include a mix of both flood and drought years, but short enough to exclude data from earlier periods during which water levels were still changing.

River mile (rm) refers to a reference frame of distances along the river channel. In this report, river mile values are those depicted on the most recent U.S. Geological Survey quadrangle maps that were available in 2005. These river mile distances are similar to, but not exactly the same as, the most recent navigation mile system used by U.S. Army Corps of Engineers. Slight differences in distance reference frames are to be expected because the river moves and changes length through time in response to various processes, both natural and anthropogenic.

Stage refers to the elevation of water surface of a river at a particular time and place.

Stage-discharge rating refers to a standard U.S. Geological Survey stage-discharge relation based on instantaneous observations of stage and direct measurements of discharge made at a streamflow gaging station. (See stage-discharge relations.)

Stage-discharge relations are defined by best-fit lines or curves in which river stage is related to river discharge. Three types of relations are used in this report: (1) standard U.S. Geological Survey stage-discharge ratings; (2) nonstandard relations in which stage at a downstream gage is related to discharge at the upstream-most gage at Chattahoochee, Florida; and (3) interpolated nonstandard relations in which stage at a between-gage site is related to discharge at the Chattahoochee gage, based on interpolation between relations at the closest upstream and downstream gages. (See stage-discharge rating.)

Streamgage or gage refers to a long-term streamflow gaging station at which a time-series of stage measurements (elevation of river surface) have been recorded, and measurements of instantaneous streamflow discharge may have been made.

Thalweg is the deepest part of the river channel.

Tupelo-cypress swamps are present in the lowest elevations of the floodplain where continuous flooding averages 4 to 9 months per year. Swamps are dominated by water tupelo, bald cypress, and ogeechee tupelo.

Water-level decline, as applied to streamflow, can refer to three situations. This report primarily addresses the situation characterized by a long-term decrease in river stage for a particular streamflow discharge, and a long-term shift in the stage-discharge relation for a site. Such declines result from some type of channel change, which usually occurs over a period of years. Another type of water-level decline, which is also addressed in this report but is not described in as much detail as the first type, refers to a long-term decrease in the amount of water delivered from the upstream watershed. Both of these types of water-level declines cause periods of low water levels to become more frequent and longer in duration. Water-level decline can also refer to short-term fluctuations in stage during the passage of a flood, but this meaning is not used in this report.

Water year is defined as the annual period from October 1 through September 30. This period was used in analysis of high discharges in order to avoid splitting flood events that typically occur in winter and spring. (See climate year.)

Water-Level Decline in the Apalachicola River, Florida, from 1954–2004, and Effects on Floodplain Habitats

By Helen M. Light[1], Kirk R. Vincent[2], Melanie R. Darst[1], and Franklin D. Price[3]

Abstract

From 1954 to 2004, water levels declined in the nontidal reach of the Apalachicola River, Florida, as a result of long-term changes in stage-discharge relations. Channel widening and deepening, which occurred throughout much of the river, apparently caused the declines. The period of most rapid channel enlargement began in 1954 and occurred primarily as a gradual erosional process over two to three decades, probably in response to the combined effect of a dam located at the head of the study reach (106 miles upstream from the mouth of the river), river straightening, dredging, and other activities along the river. Widespread recovery has not occurred, but channel conditions in the last decade (1995–2004) have been relatively stable. Future channel changes, if they occur, are expected to be minor.

The magnitude and extent of water-level decline attributable to channel changes was determined by comparing pre-dam stage (prior to 1954) and recent stage (1995–2004) in relation to discharge. Long-term stage data for the pre-dam period and recent period from five streamflow gaging stations were related to discharge data from a single gage just downstream from the dam, by using a procedure involving streamflow lag times. The resulting pre-dam and recent stage-discharge relations at the gaging stations were used in combination with low-flow water-surface profile data from the U.S. Army Corps of Engineers to estimate magnitude of water-level decline at closely spaced locations (every 0.1 mile) along the river. The largest water-level declines occurred at the lowest discharges and varied with location along the river. The largest water-level decline, 4.8 feet, which occurred when sediments were scoured from the streambed just downstream from the dam, has been generally known and described previously. This large decline progressively decreased downstream to a magnitude of 1 foot about 40 river miles downstream from the dam, which is the location that probably marks the downstream limit of the influence of the dam on bed scour. Downstream from that location, previously unreported water-level declines progressively increased to 3 feet at a location 68 miles downstream from the dam, probably as a result of various channel modifications conducted in that part of the river.

Water-level declines in the river have substantially changed long-term hydrologic conditions in more than 200 miles of off-channel floodplain sloughs, streams, and lakes and in most of the 82,200 acres of floodplain forests in the nontidal reach of the Apalachicola River. Decreases in duration of floodplain inundation at low discharges were large in the upstream-most 10 miles of the river (20–45 percent) and throughout most of the remaining 75 miles of the nontidal reach (10–25 percent). As a consequence of this decreased inundation, the quantity and quality of floodplain habitats for fish, mussels, and other aquatic organisms have declined, and wetland forests of the floodplain are changing in response to drier conditions. Water-level decline caused by channel change is probably the most serious anthropogenic impact that has occurred so far in the Apalachicola River and floodplain.

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This decline has been exacerbated by long-term reductions in spring and summer flow, especially during drought periods. Although no trends in total annual flow volumes were detected, long-term decreases in discharge for April, May, July, and August were apparent, and water-level declines during drought conditions resulting from decreased discharge in those 4 months were similar in magnitude to the water-level declines caused by channel changes. The observed changes in seasonal discharge are probably caused by a combination of natural climatic changes and anthropogenic activities in the Apalachicola-Chattahoochee-Flint River Basin. Continued research is needed for geomorphic studies to assist in the design of future floodplain restoration efforts and for hydrologic studies to monitor changes in the future flow regime of the Apalachicola River as water management and land use in this large tri-state basin continue to change.

Introduction

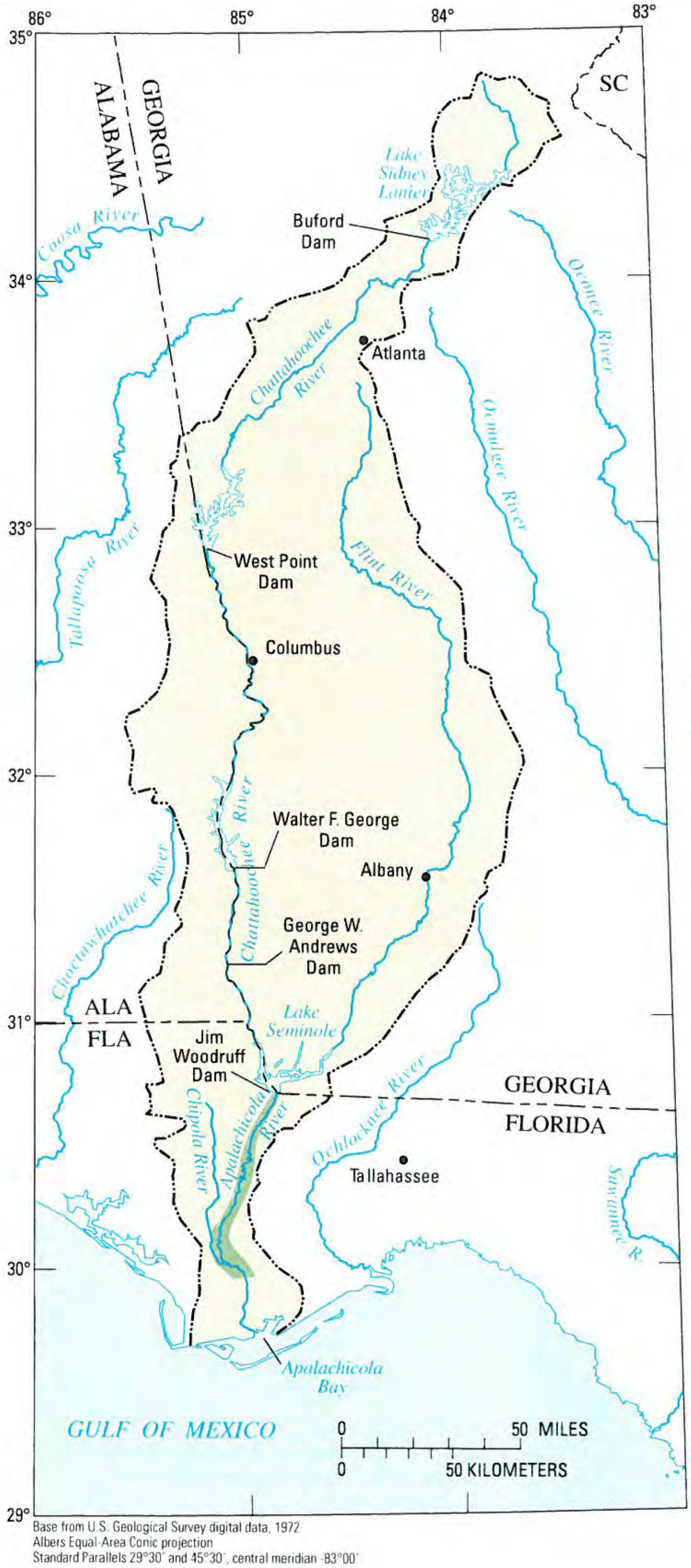
Large coastal plain rivers of the southeastern United States have extensive forested floodplains with a diversity of aquatic and wetland habitats that are strongly influenced by river levels (Wharton and others, 1982; Mitsch and Gosselink, 2000). Streams, sloughs, ponds, lakes, and swamps in the floodplain alternately connect and disconnect as river levels fluctuate. Complex relationships exist between biological communities in floodplain habitats and river levels, with floral and faunal distributions varying spatially, seasonally, and annually as the river rises and falls (Welcomme, 1979; Bayley, 1995; Power and others, 1995).

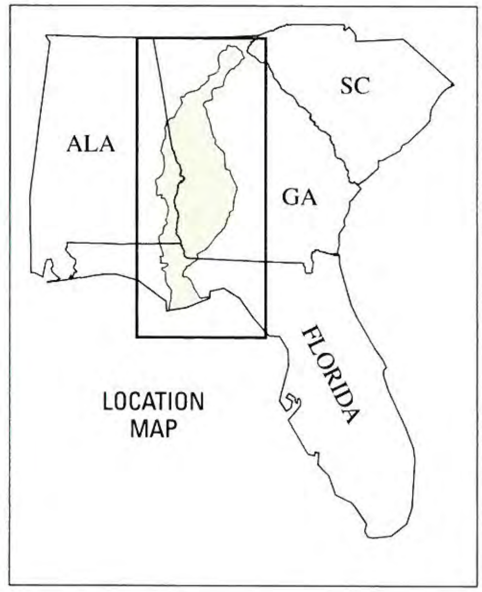
In floodplains along the 86-mi (mile) nontidal reach of the Apalachicola River (figs. 1 and 2), there are more than 200 mi of off-channel floodplain sloughs, streams, and lakes that are directly influenced by river-level fluctuations (Light and others, 1998). These off-channel waterbodies provide extensive habitat for fishes and other aquatic organisms. More than 80 percent of the freshwater and anadromous fish species found in the Apalachicola River are known to spend some part of their life cycle in floodplain habitats (Light and others, 1998; Stephen J. Walsh, U.S. Geological Survey (USGS), written commun., 2006). In addition, tree species richness in 82,200 acres of swamps and bottomland hardwoods bordering the Apalachicola River is among the highest of North American river floodplains (Leitman and others, 1984; Brinson, 1990). Tree composition and recruitment in this vast wetland forest corridor is primarily determined by the flow regime of the river.

Water-level declines caused by channel change in the upper reach of the river, and the impact on floodplain habitats resulting from these declines, are described in previous reports (Simons, Li, and Associates, 1985; Light and others, 1998; U.S. Army Corps of Engineers (USACE), 2001a). Until recently, these declines were thought to be limited primarily to the upper reach and its floodplain, which constitutes about 20 percent of the total floodplain area of the nontidal river. Based on the water-level declines attributable to channel changes in the middle and nontidal lower reaches that are documented in this report, it is now known that water levels in most of the remaining 80 percent of the nontidal floodplain declined at about the same time as water levels declined in the upper reach. As a consequence, almost all of the nontidal river and floodplain is now experiencing longer and more frequent periods of low water levels than prior to 1954, increasing the amount of time that woody substrate along channel banks is exposed; floodplain streams are dewatered, isolated, or not flowing; and swamps and bottomland hardwood forests are dry.

A conceptual diagram illustrating the causes of long-term water-level decline in rivers and the consequences on river-floodplain habitats is presented in figure 3. Two types of changes can potentially decrease long-term water levels: physical changes in the channel or a reduction in the amount of water delivered from upstream. Physical changes in the channel, such as channel enlargement or increased flow velocity, can change stage-discharge relations, resulting in a long-term decrease in river stage (water level) in relation to streamflow discharge (volumetric rate of flow). In contrast, reductions in the amount of water delivered from upstream do not change stage-discharge relations. Temporary changes in water level may occur during droughts or when streambed topography is rearranged during the passage of a flood. Where a water-level decline persists for many years, or the decline increases in magnitude over many years, the decline is probably the result of fundamental changes in either the geomorphology of local channels or the hydrology of the upstream watershed, or both.

Channel widening and deepening has occurred throughout much of the river (USACE, 2001a; Price and others, 2006), and is the apparent cause of the long-term changes in stage-discharge relations documented in this report. A certain amount of channel change is natural in meandering streams (such as the Apalachicola River) as the stream migrates across the floodplain (Gilbert, 1877; Mackin, 1948; Hupp, 2000). Natural channel migration, however, occurs without a change in channel size. Sediment is eroded from the cut-bank on the outside of a bend and deposited on point bars a short distance downstream. As the point bar accretes laterally, the older area of the bar becomes colonized with trees, so that channel width and depth remain relatively constant over time as the channel migrates across the floodplain. Channel enlargement can result from an increase in the magnitude or frequency of peak floods caused by climate change or watershed urbanization (Leopold and others, 2005). There is no evidence, however, that channel changes in the Apalachicola River have been caused by increased flow. Along certain rivers, the channel can widen substantially (but not deepen) during a catastrophic flood, although this widening is followed by gradual narrowing during subsequent decades (Schumm and Lichty, 1963). The Apalachicola River, in contrast, enlarged gradually and has not recovered by narrowing. Therefore, the channel widening and deepening that occurred in the Apalachicola River was probably caused by anthropogenic activities along the river.



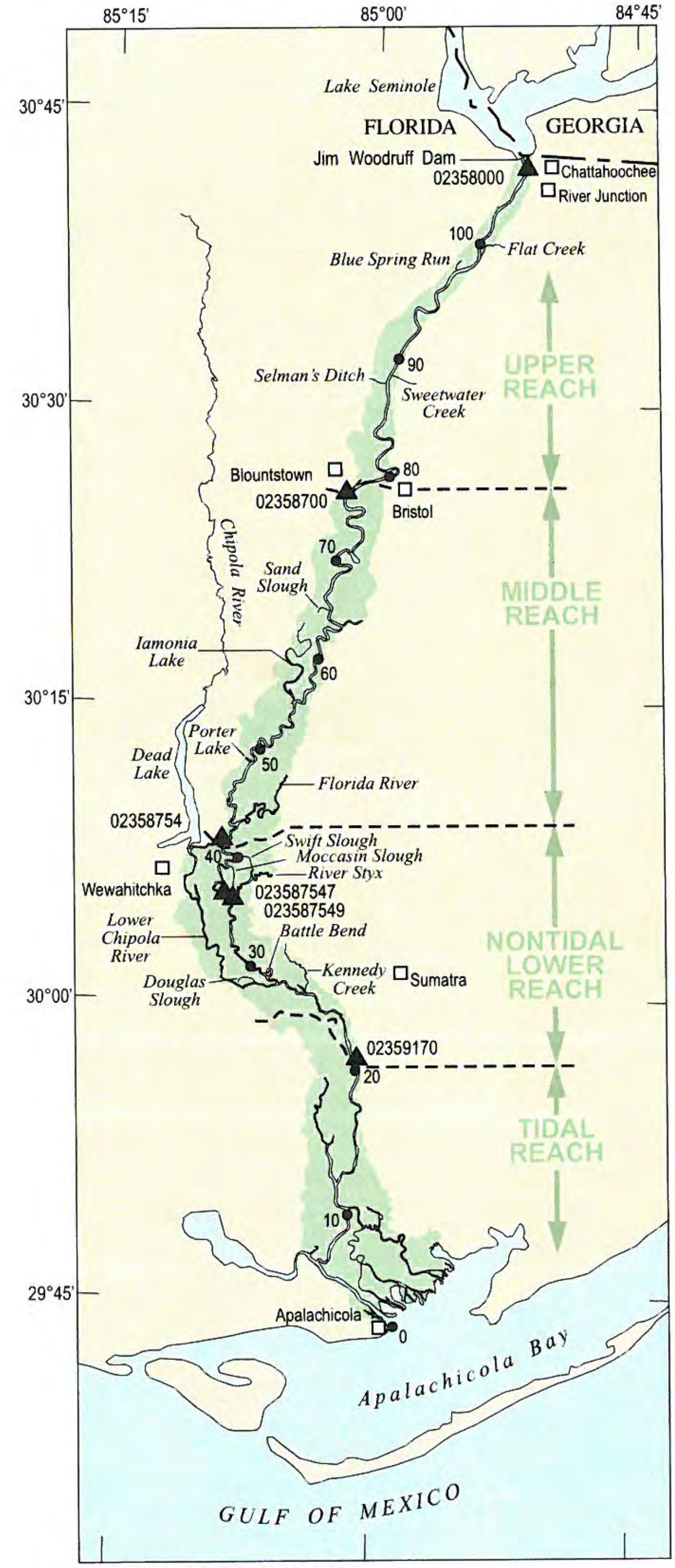


EXPLANATION

DRAINAGE BASIN OF THE APALACHICOLA, CHATTAHOOCHEE, AND FLINT RIVERS

STUDY AREA

Figure 1. Drainage basin of the Apalachicola, Chattahoochee, and Flint Rivers in Florida, Georgia, and Alabama.



EXPLANATION

APALACHICOLA RIVER FLOODPLAIN

02358000 LONG-TERM STREAMFLOW GAGE WITH STATION NUMBER

60 RIVER MILE—Number is distance from mouth in miles

0 5 10 15 MILES
0 5 10 15 KILOMETERS

Base from U.S. Geological Survey digital data, 1972
Albers Equal-Area Conic projection
Standard Parallels 29°30' and 45°30', central meridian -83°00'

Figure 2. Major reaches of the Apalachicola River and location of long-term streamflow gaging stations.

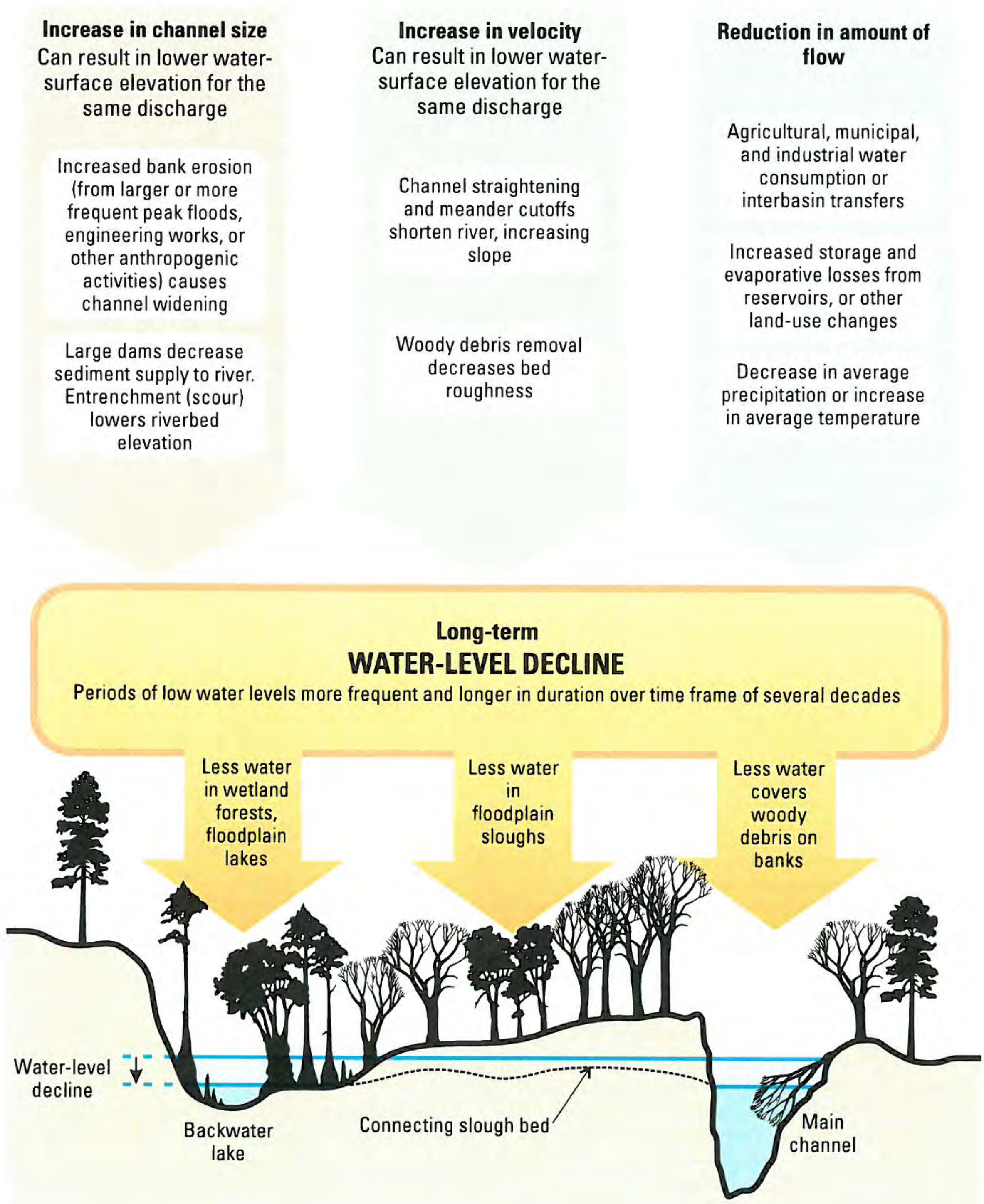


Figure 3. Possible causes of long-term water-level decline in rivers and resulting impacts on river-floodplain habitats.

Channel enlargement began in 1954 and occurred primarily as a gradual erosional process over two to three decades, probably in response to the combined effect of engineering projects along the river. Although various navigational improvements have been conducted on the Apalachicola River since the 1800s, the intensity of those activities greatly increased in the 1950s after Congress mandated that the USACE construct a dam and maintain a 9- by 100-ft (foot) navigation channel. After construction in 1954 of Jim Woodruff Dam at the head of the river (fig. 2), mobile streambed sediment (sand) was trapped in the reservoir created by the dam (Lake Seminole) and deepening of the bed of the Apalachicola River downstream from the dam occurred as a result (Simons, Li, and Associates, 1985). Riverbed degradation, and its consequences in terms of decreased floodplain inundation, has been well documented downstream from dams in other rivers, including low-gradient, sand-bedded rivers similar to the Apalachicola River (Galay, 1983; Ligon and others, 1995). Bends in the Apalachicola River were straightened by excavation of meander cutoffs and bend easings in 1956 and 1969, and river-training dikes were constructed from 1963 to 1970 (USACE, 1986). Dredging in the deepest part of the channel (thalweg), disposal of dredged material, and removal of woody debris over much of the length of the river were conducted annually from 1956 to 2001 (USACE, 2001a). During the 1970s, however, dredged material disposal practices were changed and the amount of annual wood removal was decreased in order to reduce environmental impacts of the navigation project on the river ecosystem.

Regarding the amount of water delivered from upstream, average annual discharge appears relatively unchanged. Minimum flows have decreased, however, and the seasonal distribution of flows has changed. At the streamflow gaging station on the Apalachicola River at Chattahoochee (fig. 2), very low discharges of 5,000 ft^3/s (cubic feet per second) or less occurred in 5 of the last 23 years (1981–2004), but not at all in the previous 53 years (USGS, 2006a). Monthly flow duration analyses indicate that fall and winter discharges have increased, and spring and summer discharges have decreased, based on a comparison of the earliest and latest 30 years in the period of record at this streamgage (1929–2004). Many natural changes and anthropogenic alterations have occurred in this large tri-state basin that could have contributed to changes in flow; however, hydrologic analysis to determine the relative contribution of causal factors has not been conducted.

Recovery of floodplain off-channel aquatic habitats altered by water-level decline in the Apalachicola River has been a long-standing concern of various State and Federal agencies. The restoration of habitats within a complex hydrologic system such as the Apalachicola River, however, is not a simple process. Many difficulties have been encountered in the restoration efforts conducted so far. Understanding the causes and magnitude of the water-level declines and identifying the reaches that have been most affected can help guide future prevention and recovery measures.

Purpose and Scope

This report describes the water-level decline that occurred in the Apalachicola River from 1954 to 2004 as a result of long-term changes in stage-discharge relations. This investigation was conducted by the U.S. Geological Survey (USGS) in cooperation with the Florida Fish and Wildlife Conservation Commission (FFWCC) and other agencies as part of a study to describe and quantify impacts of water-level declines on floodplain habitats of the Apalachicola River to help guide restoration efforts. The specific objectives of this report are to:

(1) Document stage-discharge relations at streamflow gaging stations prior to 1954 and during a recent period (1995–2004). This was done by relating stage data from five streamgages to discharge data from the upstream-most gage at Chattahoochee, Fla., using a procedure involving streamflow lag times.

(2) Estimate stage-discharge relations for the same time periods at closely spaced locations between the streamgages. This was done by using a combination of streamgage records and low-flow water-surface profile data.

(3) Estimate the water-level decline at closely spaced locations along the river and to determine average water-level decline by reach for selected discharges.

(4) Determine the consequence of the water-level decline on duration of inundation of the floodplain.

(5) Describe specific effects of the water-level decline on selected floodplain habitats and general effects on the overall floodplain.

(6) Discuss related issues: (a) changes in water levels attributable to long-term changes in monthly discharge, (b) recovery and restoration efforts, and (c) research needs.

The study area includes the nontidal reach of the Apalachicola River from the Chattahoochee gage at rm (river mile) 105.7 to the Sumatra gage at rm 20.6 (fig. 2). Data analysis was conducted from July 2001 to December 2005. Data in this report came from ongoing data-collection programs within the USGS and USACE that were conducted independent of this study, with the exception of field data collected at selected floodplain sites discussed in objective 5.

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Setting

The Apalachicola River is the largest river in Florida, and the fourth largest river in the southeastern United States, in terms of mean annual discharge (Iseri and Langbein, 1974). The river is formed by the confluence of the Chattahoochee and Flint Rivers, and the drainage basin of all three rivers covers 19,600 mi^2 (square miles) in Florida, Georgia, and Alabama. The Chattahoochee and Flint Rivers drain the upstream-most 90 percent of the basin in Georgia and Alabama (fig. 1). The Apalachicola River and its largest tributary, the Chipola River, lie in the downstream-most 10 percent of the drainage basin, which is primarily in Florida. The Apalachicola River is in the Coastal Lowlands physiographic area (Puri and Vernon, 1964), which is generally low in elevation.

The Apalachicola River is an alluvial, low-gradient, meandering river with an average water-surface gradient of 0.00009 in the nontidal reach. The river surface falls about 41 ft from the head at Jim Woodruff Dam to the Sumatra gage. The sinuosity of the nontidal river (1.44) is moderately high but not "torturous," and falls within the range typical of low-gradient meandering rivers (Knighton, 1984). The Apalachicola River is about 106 mi long; however, the downstream-most 20.6 mi is considered tidal and is not addressed in this report. In reality, there is no precise boundary between the tidal and nontidal reaches, but rather a transitional zone in which tidal influence is minimal at the upper end (occurring only at very low flows) and gradually increases downstream. For practical purposes, the boundary between tidal and nontidal was established at the Sumatra gage (fig. 2); however, during low-flow conditions, tidal influence occurs at the Sumatra gage and probably also extends upstream to some undetermined point. Bed sediments throughout most of the river are sand, except in areas of low velocity on channel margins where finer sediments accumulate, and in high velocity areas of the upper reach where gravel, rock, or limestone bedrock can be found locally (USACE, 2001a; Jerry W. Ziewitz, USFWS, oral commun., 2006).

The Apalachicola River at Chattahoochee, Fla., had an average discharge of 21,900 ft^3/s and a median discharge of 15,900 ft^3/s for the period of record (1929–2004). All discharge values in this report are from the streamflow gaging station at Chattahoochee. Flooding typically occurs in January through April, with low flows in September through November (Leitman and others, 1984). The highest recorded daily mean discharge was 291,000 ft^3/s on March 20, 1929; the lowest was 3,900 ft^3/s on November 15, 1987. A minimum flow of 5,000 ft^3/s has been strictly maintained with reservoir releases by USACE since the summer of 2000. The climate of the Apalachicola River Basin is humid subtropical with a growing season of about 270 days. Average annual rainfall is 56 in. (inches), with the highest monthly averages occurring in the summer and the lowest averages in the fall.

The ACF River Basin has an unusually high diversity of flora and fauna. The Apalachicola River is in one of the Nation's biodiversity hotspots, as recognized by The Nature Conservancy (Stein and others, 2000). More than 70 different species of trees grow in the Apalachicola River floodplain, which is the largest forested floodplain in Florida (112,000 acres of nontidal and tidal freshwater forests). The nontidal floodplain forest (82,200 acres) is predominantly palustrine wetlands according to the wetland classification system of the USFWS (Cowardin and others, 1979; Reed, 1988). The ACF Basin has the highest species density of amphibians and reptiles on the continent north of Mexico (Kiester, 1971), and the largest diversity of fish fauna among the Gulf Coast river drainages east of the Mississippi River (Dahlberg and Scott, 1971). Sixteen fish species have been listed for protection by Federal or State agencies (Couch and others, 1996). Of the western Florida river drainages, the ACF River Basin has the largest number of freshwater gastropod and bivalve species and the largest number of endemic mollusk species (Heard, 1977).

Construction of Jim Woodruff Dam, which impounds Lake Seminole at the head of the Apalachicola River where the Chattahoochee and Flint Rivers join, began in 1950 and was completed in 1954, with filling of the reservoir accomplished from 1954 to 1957. Upstream from Jim Woodruff Dam are 15 other mainstem dams and reservoirs (13 on the Chattahoochee River and 2 on the Flint River) (USACE, 1996). Buford Dam, which impounds the largest reservoir on the ACF system (Lake Sidney Lanier) is located on the upper Chattahoochee River upstream from Atlanta (fig. 1), and was completed in the same year as Jim Woodruff Dam (1954). Three other large Federal dams, Walter F. George,

George W. Andrews, and West Point, were completed in 1963, 1963, and 1974, respectively. Flow regulation is conducted at Federal dams for Congressionally authorized purposes of flood control, hydropower, navigation, fish and wildlife management, recreation, and water supply. Eleven other non-Federal mainstem dams and reservoirs were built for power generation at various times beginning in 1834. Management of non-Federal reservoirs does not affect seasonal distribution of streamflow in the ACF river system.

Methods

The objective of this report, to quantify water-level decline caused by changes in stage-discharge relations, was accomplished by comparing pre-dam stage (prior to 1954) to recent stage (1995–2004) in relation to discharge. For this comparison, it was important for estimates of pre-dam stage to be calculated using the same types of data and the same analytical methods as were used to calculate estimates of recent stage. Two types of data were available from both the pre-dam and recent period: long-term streamflow gage data and low-flow water-surface profile data. Both types of data were combined in this analysis to estimate the magnitude and extent of water-level decline at closely spaced locations along the river.

Description of Basic Data

Long-term streamflow gage records analyzed in this report are summarized in table 1. Analyses of pre-dam and recent data throughout this report were based on data at five of the six streamflow gaging stations present along the nontidal Apalachicola River: Chattahoochee, Blountstown, Wewahitchka, RM 35, and Sumatra. Data from the RM 36 gage were not used except for two daily mean values during the peak of the July 1994 flood that were adjusted for use at the RM 35 gage location. At all gages downstream from Chattahoochee, the only type of data used in this report was daily mean stage. At the Chattahoochee gage, daily mean stage, daily mean discharge, and instantaneous measurements of stage and discharge were used.

The two water-surface profiles used in this report (fig. 4) were computed by USACE for time periods when the discharge was 9,300 ft^3/s at the Chattahoochee gage. The water-surface profile used to represent recent conditions was a provisional, unpublished 1995 water-surface profile for 9,300 ft^3/s at Chattahoochee, which was prepared using HECRAS Version 3.1.2 (USACE, Mobile District, unpublished data, 2005). The profile was computed from survey data collected between May 30, 1994, and January 6, 1995, and represents existing conditions before that season's dredging, as the intention of the surveyors was to stay ahead of the dredging for that year.

Table 1. Streamflow gaging station records used for stage and discharge analyses of the Apalachicola River, Florida.

[A break in the record is indicated only when periods of missing record are greater than 1 year. River miles represent approximate distance upstream from the mouth. USGS, U.S. Geological Survey; USACE, U.S. Army Corps of Engineers]

Station name and number	Abbreviated name	Agency operating the gage	Location, in river miles	Period of record	Type of record used in this report
Apalachicola River at Chattahoochee 02358000	Chattahoochee	USGS	105.7	Oct. 1, 1928 – Sept. 30, 2004[1]	Daily mean stage Daily mean discharge Discharge measurements
Apalachicola River near Blountstown 02358700	Blountstown	USACE	77.5	Oct. 1, 1928 – Sept. 30, 2004	Daily mean stage
Apalachicola River near Wewahitchka 02358754	Wewahitchka	USACE	41.8	Oct. 18, 1955 – Sept. 5, 1957 Oct. 1, 1965 – Sept. 30, 1982 Oct. 1, 1988 – Sept. 30, 1996 Sept. 4, 1998 – Sept. 30, 2004	Daily mean stage
Apalachicola River at River Mile 36 023587547	RM 36	USACE	36.0	Nov. 14, 1991 – Sept. 30, 1996	Daily mean stage
Apalachicola River at River Mile 35 023587549	RM 35	USACE	35.3	Sept. 4, 1998 – Sept. 30, 2004	Daily mean stage
Apalachicola River near Sumatra 02359170	Sumatra	USGS	20.6	May 11, 1950 – Sept. 30, 1959 Sept. 1, 1977 – Sept. 30, 2004	Daily mean stage

[1] Chattahoochee stage data prior to December 16, 1939, were collected at the River Junction gage, which was 0.9 miles downstream from its present location. For discharge data greater than 100,000 cubic feet per second collected at the River Junction site, daily mean stage and stages associated with discharge measurements were adjusted to the present gage location and used in analyses in this report.

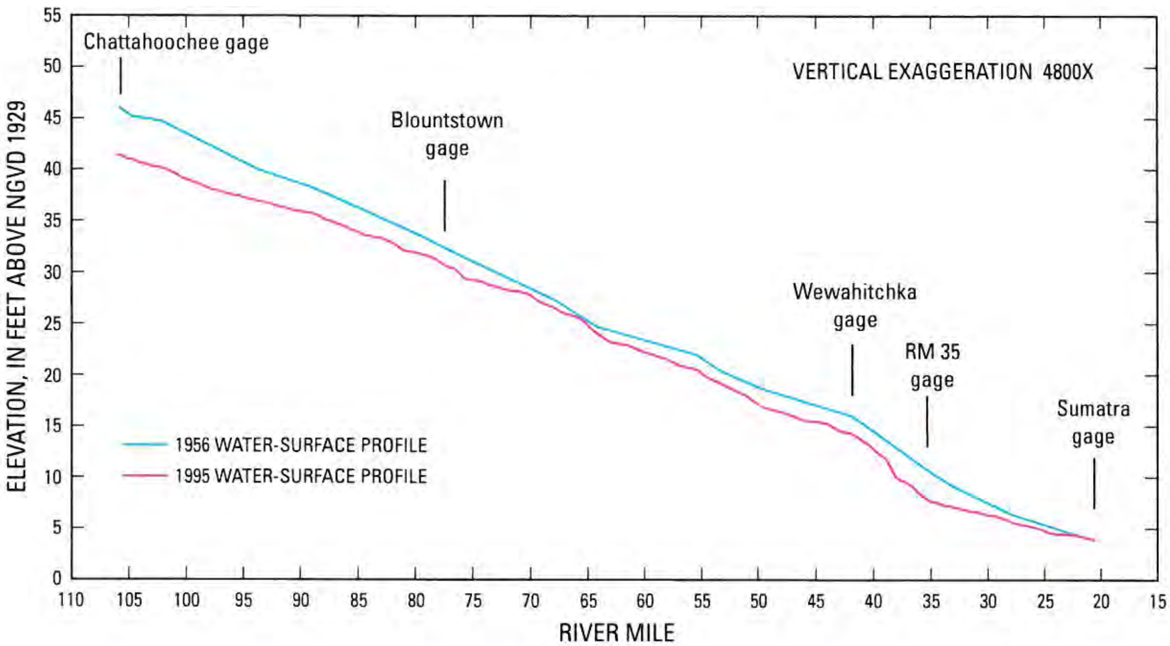

Figure 4. Water-surface profiles developed in 1956 and 1995 for the nontidal reach of the Apalachicola River, Florida, for a discharge of 9,300 ft^3/s at Chattahoochee streamgage. The 1956 water-surface profile is from Plate 43A of Design Memorandum No. 1 (U.S. Army Corps of Engineers, 1955). Design Memorandum No. 1 is dated December 15, 1955 (with transmittal to the Division Engineer December 23, 1955); however, Plate No. 43A is dated March 1956 with the notation: "This Plate is a supplement to Plate No. 43". Apparently computations for this water-surface profile were completed after the report was transmitted and were made an official supplement to the report after-the-fact. The 1995 water-surface profile is provisional (USACE, Mobile District, unpublished data, 2005).

The water-surface profile used to represent pre-dam conditions was developed in March 1956. The profile is entitled "Computed W.S. Profile after dredging, Q=9300 c.f.s." on Plate No. 43A of Design Memorandum No. 1 (USACE, 1955). Original data files for the 1956 profile were not available, so points were manually digitized from the graph. Although the length of the river has changed since 1956, the profile included the locations of eight fixed landmarks (including gage sites). The profile was adjusted between those fixed landmarks to match river locations on the present-day profile.

Dredging was conducted annually, thus profiles called "before dredging" or "after dredging" were intended to represent conditions before or after actual or planned dredging for that season. As mentioned, the 1995 profile was intended to represent conditions prior to that season's dredging. The 1956 profile, in contrast, was labeled "after dredging." A "before dredging" water-surface profile at 9,300 ft^3/s for the earlier timeframe, if it had existed, would have been preferable for our analysis. Fortunately, however, the 1956 "after dredging" profile compares favorably with average pre-dam stage from long-term gage data. Details of this comparison are discussed in the section entitled "Interpolated Stage-Discharge Relations between Streamgages."

Stage-Discharge Relations at Streamgages

Stage decline caused by channel enlargement results in a lower water level for the same amount of discharge. An appropriate method for measuring this type of water-level decline is to analyze changes in stage-discharge relations over time at streamflow gaging stations. Traditionally, this type of analysis is done by examining standard stage-discharge relations that relate stage at a particular streamgage to discharge at the same gage. The traditional method was used in this report to measure the water-level decline at the Chattahoochee gage. At a flow of 10,000 ft^3/s, the decline from pre-dam stage to recent stage at the Chattahoochee gage was 4.8 ft. (This decline was determined by comparing pre-dam and recent stage-discharge relations described in the section entitled "Pre-dam, Recent, and Period-of-Record Stage-Discharge Relations.")

The traditional method could not be used for measuring water-level decline downstream from Chattahoochee, because standard stage-discharge relations were not available for the pre-dam period at most of the downstream gages. Thus, a nonstandard approach was developed in which downstream stage was related to discharge at the upstream-most gage at Chattahoochee. This nonstandard approach allowed water-level declines to be estimated at all gage locations and at between-gage sites by the same method. Also, the ability to compare water-level declines at many different river miles to each other was greatly simplified by calculating stage at all sites in relation to discharge at a single upstream site (Chattahoochee).

Water-level decline estimated by both the traditional and nontraditional methods was compared at one downstream location (Wewahitchka gage), and results were found to be similar. At a discharge of 10,000 ft^3/s, a water-level decline of 1.6 ft was reported by the USACE using the traditional method (USACE, 2001a); a similar decline of 1.5 ft was determined by the USGS in this report using the nonstandard approach.

River stage at a streamgage is a direct result of the discharge at the gage and the channel conditions at or just downstream from that gage. Discharge at a gage also determines the stage at downstream sites, but the correlation is complicated by time-dependent factors, including the travel time of water, changing conditions of water stored on the floodplain, and tributary inflows. Thus, relations of stage at five downstream gages to discharge at the Chattahoochee gage have increasing error with increasing distance downstream. Error analyses are provided for all stage-discharge relations presented in this report so the results can be used with an understanding of their inherent limitations.

Error can be partially reduced by accounting for lag time, which is an expression of the time it takes for water passing Chattahoochee to reach a downstream location. Lag time, which can be measured in various ways, typically varies with discharge. The relation of lag time to discharge in the Apalachicola River is complex, however, because the travel time of flow in off-channel sloughs and overbank flow on the floodplain is different than in the main channel and can be variable depending upon antecedent conditions, rate of rise and fall of flood peaks, or other factors. For practical reasons, a single lag time that was approximately correct for all flows was derived for each gage downstream from Chattahoochee.

Lag times were calculated in whole days because daily mean values were used in all analyses. The most suitable lag time was determined by the following steps:

(1) For each gage, a series of two or three graphs was created in which stage at the downstream gage was related to discharge at Chattahoochee. A different lag time was used for each graph. In the first graph of the Blountstown series, for example, each Chattahoochee discharge value for a particular day was plotted in relation to the stage observed at the Blountstown gage on that same day (lag of 0 days). In the second graph, each Chattahoochee discharge value for a particular day was plotted in relation to the stage observed at the Blountstown gage on the next day (lag of 1 day).

(2) Polynomial curves were fitted to each plot in the series, and the lag time associated with the curve having the lowest root mean squared error was determined to be the most suitable lag time for that gage. The resulting "best" lag times were 1 day for the Blountstown gage, 2 days for both the Wewahitchka and RM 35 gages, and 3 days for the Sumatra gage.

Selection of Pre-dam and Recent Periods

Selection of pre-dam and recent time periods for analysis was based on an examination of the timing of water-level decline at four gages during low-flow conditions. Average annual stage at four gages for a narrow range of low discharges (9,500-10,500 ft^3/s) at Chattahoochee are shown in figure 5. Stages were averaged for each climate year (April 1–March 31) to avoid splitting low-flow periods that typically occur in summer and fall. At the Chattahoochee gage, stage data prior to 1939 are not shown because they were collected at a different location 0.9 mi downstream from the present location (see footnote in table 1). Chattahoochee stage data from 1929 to 1938 were affected by this minor location change because of the water-surface slope of the river. Chattahoochee discharge data during that time period, however, were unaffected by the movement of the gage, because tributary inflow between the two locations was too small to have a measurable effect on river discharge. Thus, stage data at the Blountstown gage from 1929 to 1938 (for Chattahoochee discharges between 9,500 and 10,500 ft^3/s) are included in figure 5, but Chattahoochee stages during that time period are not.

Annual averages in figure 5 are color coded to indicate major drought years and major flood years, based on the drought and flood years listed in tables 2 and 3. Not all of the major flood years listed in table 3 appear in figure 5, because discharges between 9,500 and 10,500 ft^3/s, which are relatively low discharges, did not occur in the following major flood years: 1948, 1949, 1964, 1966, 1973, and 1975.

The data shown in figure 5 indicate a tendency for annual averages to be lower during drought years and higher during flood years, particularly at the Blountstown and Wewahitchka gages. In most cases, the occurrence of lower stage in drought years and higher stage in flood years was probably an artifact of the method in which downstream stage is related to upstream discharge. In major flood years, wetter than normal antecedent conditions result in higher than normal stages downstream for a given Chattahoochee discharge, because water coming out of floodplain storage is added to main channel flow. For the same discharge at Chattahoochee in a drought period, the stage downstream may be lower than normal because of dry antecedent conditions with little or no water contributed from floodplain storage. Even so, a difference in antecedent conditions did not account for the drop in average stage from 1980 to 1981. It is possible that changes in sand scour and deposition patterns during severe drought could temporarily lower the riverbed. This may have occurred when the major drought of 1981 followed an unusually long period of higher than normal flows in the preceding two decades (1960–1980). Previous analyses identified 1958 to 1980 as a period when mean discharge was higher than normal regionally, not only in rivers of the ACF Basin, but also in several other southeastern rivers (Leitman and others, 1984).

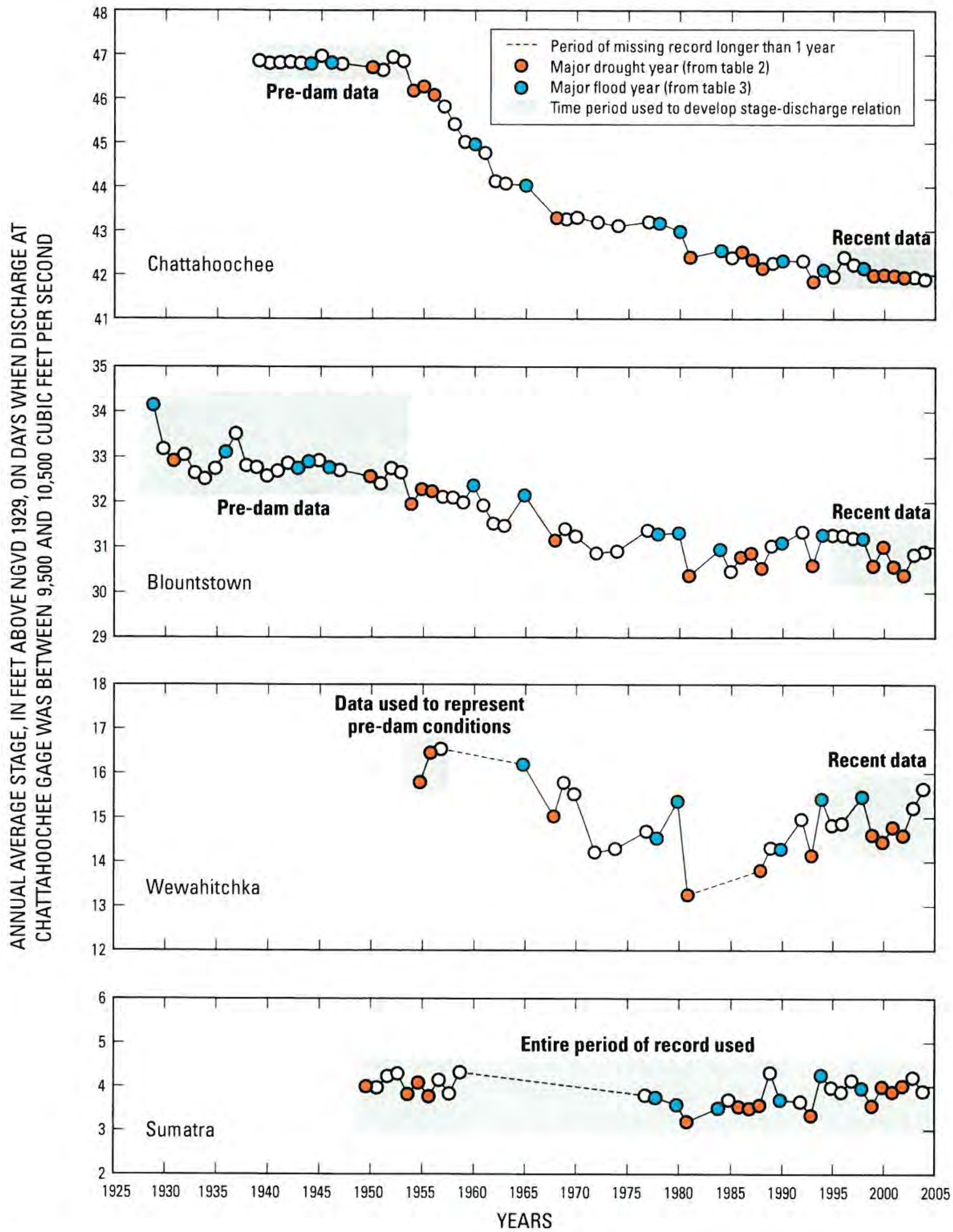

Figure 5. Time series of stage during low-flow conditions in the Apalachicola River, Florida, showing time periods used to develop stage-discharge relations. Lag times, as defined in glossary, were used to relate stage at streamgages to discharge at Chattahoochee streamgage. Annual analysis was based on climate years (April 1–March 31). Stages at Chattahoochee streamgage from 1929 to 1938 are not shown, because they were collected at a different location (see text). Not all of the major flood years listed in table 3 are shown, because discharges between 9,500 and 10,500 ft^3/s did not occur in some of those years.

Table 2. Lowest flow years in the period of record for the Apalachicola River at Chattahoochee, Florida.

[Analysis is based on climate year of April 1 to March 31 to avoid splitting low-flow periods that typically occur in summer and fall. Groups of consecutive years are shaded]

Year	Lowest mean discharge, in cubic feet per second, and rank for consecutive period indicated (rank of 1 is the lowest)					
	1 day		30 days		365 days (annual mean)	
	Discharge	Rank	Discharge	Rank	Discharge	Rank
1931	5,120	7	5,440	6		
1950					13,700	9
1954	5,010	6	5,250	3	11,400	2
1955	5,160	9	5,450	7	12,000	4
1956					13,400	7
1968					13,600	8
1981	4,980	5	5,590	8		
1986	4,430	2	5,260	4		
1987	3,900	1				
1988	4,430	3	4,680	1	11,400	3
1993	5,150	8				
1999			5,700	9	10,200	1
2000	4,530	4	4,700	2	12,900	6
2001			5,890	10	12,100	5
2002	5,250	10	5,420	5	15,100	10

Table 3. Highest flow years in the period of record for the Apalachicola River at Chattahoochee, Florida.

[Analysis is based on water year of October 1 to September 30 to avoid splitting high-flow periods that typically occur in winter and spring. Groups of consecutive years are shaded]

Year	Highest mean discharge, in cubic feet per second, and rank for consecutive period indicated (rank of 1 is the highest)					
	1 day		30 days		365 days (annual mean)	
	Discharge	Rank	Discharge	Rank	Discharge	Rank
1929	291,000	1	175,200	1	35,700	1
1936	144,000	8				
1943	142,000	9				
1944	141,000	10	86,300	6		
1946					29,400	10
1948			77,800	9	33,500	5
1949			75,000	10	35,500	2
1960	154,000	7				
1964			86,700	5	34,600	3
1965					31,100	8
1966	162,000	6	95,000	3		
1973					33,300	6
1975			83,300	7	32,700	7
1978	165,000	5				
1980			79,600	8		
1984					29,400	9
1990	177,000	4				
1994	203,000	3	92,100	4		
1998	227,000	2	97,000	2	34,600	4

Jim Woodruff Dam was completed and filling of Lake Seminole began in May 1954. Water-level decline at the Chattahoochee gage located 0.6 mi downstream from the dam began later that year, presumably as a result of riverbed degradation caused by the trapping of sediment in the lake. Consequently, data prior to May 1, 1954, were selected to represent the pre-dam period at the Chattahoochee and Blountstown gages. Because Wewahitchka had no data prior to 1954, the 2 years of stage data measured shortly afterwards (1955–1957) were used in this report as an estimate of pre-dam stage at Wewahitchka.

The so-called "recent period" was selected as the decade from October 1, 1994, to September 30, 2004. This period includes a mix of both flood and drought years, but excludes data from earlier periods when water levels were still changing (fig. 5). In the 1980s and early 1990s, stages at Chattahoochee continued to decline slightly. At Blountstown, water levels have not changed substantially since the 1970s. At Wewahitchka, data indicate that a partial recovery of the water-level decline may have occurred over the last two decades, although the amount of missing data in the 1980s at this site lends uncertainty to this assumption. Stable water levels at Blountstown and a recovery trend at Wewahitchka may have occurred because of changes that were made in the navigation project in the 1970s to reduce environmental impacts on the river ecosystem.

At the Sumatra gage, pre-dam and recent data were not differentiated, because little difference was observed in average stages between the 1950s and the most recent decade this far downstream (fig. 5). Average stages from 1977 to 1993 were slightly lower than either the earlier or later period, but considering the error associated with the relation of stage at Sumatra to discharge measured 85 mi upstream, it seemed reasonable to conduct analyses of Sumatra data on the entire period of record.

Pre-dam, Recent, and Period-of-Record Stage-Discharge Relations

Stage at multiple gages was related to discharge at Chattahoochee in 14 separate stage-discharge relations developed for the specific time periods and discharge ranges listed in table 4. The relations are shown in a single graph in figure 6, and are enlarged and shown individually in 22 graphs in appendixes I through V. The difference between pre-dam and recent stage is greatest at low flows and decreases with increasing flow. Pre-dam and recent relations come together at a high discharge referred to in this report as the joining point, which varies among the gage sites principally by decreasing discharge in the downstream direction. The joining point represents the discharge above which physical changes that occurred in the main river channel have had no noticeable effect on river stage. Effects of channel change disappear when most of the flow is out of bank and moving over the floodplain. Stage-discharge relations during overbank flows can change in response to changes in floodplain elevation or

Table 4. Time periods, range of discharges, and other information about stage-discharge relations developed from long-term streamgage data for analysis of water-level decline in the Apalachicola River, Florida.

[Stage-discharge relations developed for this report relate stage at all gages to discharge at Chattahoochee gage using lag time as indicated below and as defined in glossary. Relations were developed only for the specific time period and range of discharges indicated. Breaks in the time period are indicated only when periods of missing record are greater than 1 year. Pre-dam and recent ratings merge at a relatively high flow, referred to in this report as the "joining point," which is further described in the text. n, number of values used in relation. ft³/s, cubic feet per second]

River mile location	Name of stage-discharge relation	Daily mean values used (or other data as indicated): Time period	n	Range of discharges for which relation was developed, in ft³/s	Joining point flow, in in ft³/s	Lag time, in days
105.7	Chattahoochee pre-dam	Dec. 1939 – April 1954	5,269	5,000 – 188,000	188,000	0
	Chattahoochee recent	Oct. 1994 – Sept. 2004	3,579	5,000 – 188,000		
	Chattahoochee period of record (for flows greater than 188,000 ft³/s)	Oct. 1928[1] – Sept. 2004	17	188,000 – 291,000		
77.5	Blountstown pre-dam	Oct. 1928 – April 1954	9,313	5,000 – 135,000	135,000	1
	Blountstown recent	Oct. 1994 – Sept. 2004	3,598	5,000 – 135,000		
	Blountstown period of record (for flows greater than 35,000 ft³/s)	Oct. 1928 – Sept. 2004	55	135,000 – 291,000		
41.8	Wewahitchka pre-dam	Oct. 1955 – Sept. 1957	677	5,000 – 65,000	65,000	2
	Wewahitchka recent	Oct. 1994 – Sept. 1996; Sept. 1998 – Sept. 2004	2,517	5,000 – 65,000		
	Wewahitchka period of record (for flows greater than 65,000 ft³/s	Oct. 1955 – Sept. 1957; Oct. 1965 – Sept. 1982; Oct. 1988 – Sept. 1996; Sept. 1998 – Sept. 2004	364	65,000 – 203,000		
35.3	RM 35 estimated pre-dam	Three values from 1951, 1954, and 1956 water-surface profiles (USACE, U.S. Army Corps of Engineers, 1955)		5,000 – 52,000	52,000	2
	RM 35 recent	Sept. 1998 – Sept 2004	2,096	5,000 – 100,000[2]		
	RM 35 estimated high flow	Two daily mean values during peak of July 1994 flood, adjusted from RM 36 gage		100,000 – 203,000		
20.6	Sumatra period of record (for flows less than 100,000 ft³/s)[3]	May 1950 – Sept. 1959; Sept. 1977 – Sept. 2004	12,635	5,000 – 100,000	25,000[4]	3
	Sumatra period of record (for flows greater than 100,000 ft³/s)[3]	May 1950 – Sept. 1959; Sept. 1977 – Sept. 2004	39	100,000 – 227,000		

[1] Stage data collected prior to December 1939 at the River Junction gage site (about 0.9 mile downstream from the present Chattahoochee gage location) were adjusted using methods described in the text, so that data from the record flood of 1929 could be used in development of this relation.

[2] The entire RM 35 recent relation was based on recent data; however, because of a lack of data in other time periods, the part of this relation above the joining point of 52,000 ft³/s was used in analyses to represent the period-of-record relation (which assumes no difference between pre-dam and recent stage above 52,000 ft³/s).

[3] The period-of-record relation at Sumatra was divided into an upper and lower relation because of the difference in sample sizes (n). Error statistics vary widely between the two discharge ranges.

[4] Although no differentiation was made at the Sumatra gage between pre-dam and recent stage, an estimated joining point was needed for calculating interpolated relations between the RM 35 and Sumatra gages.

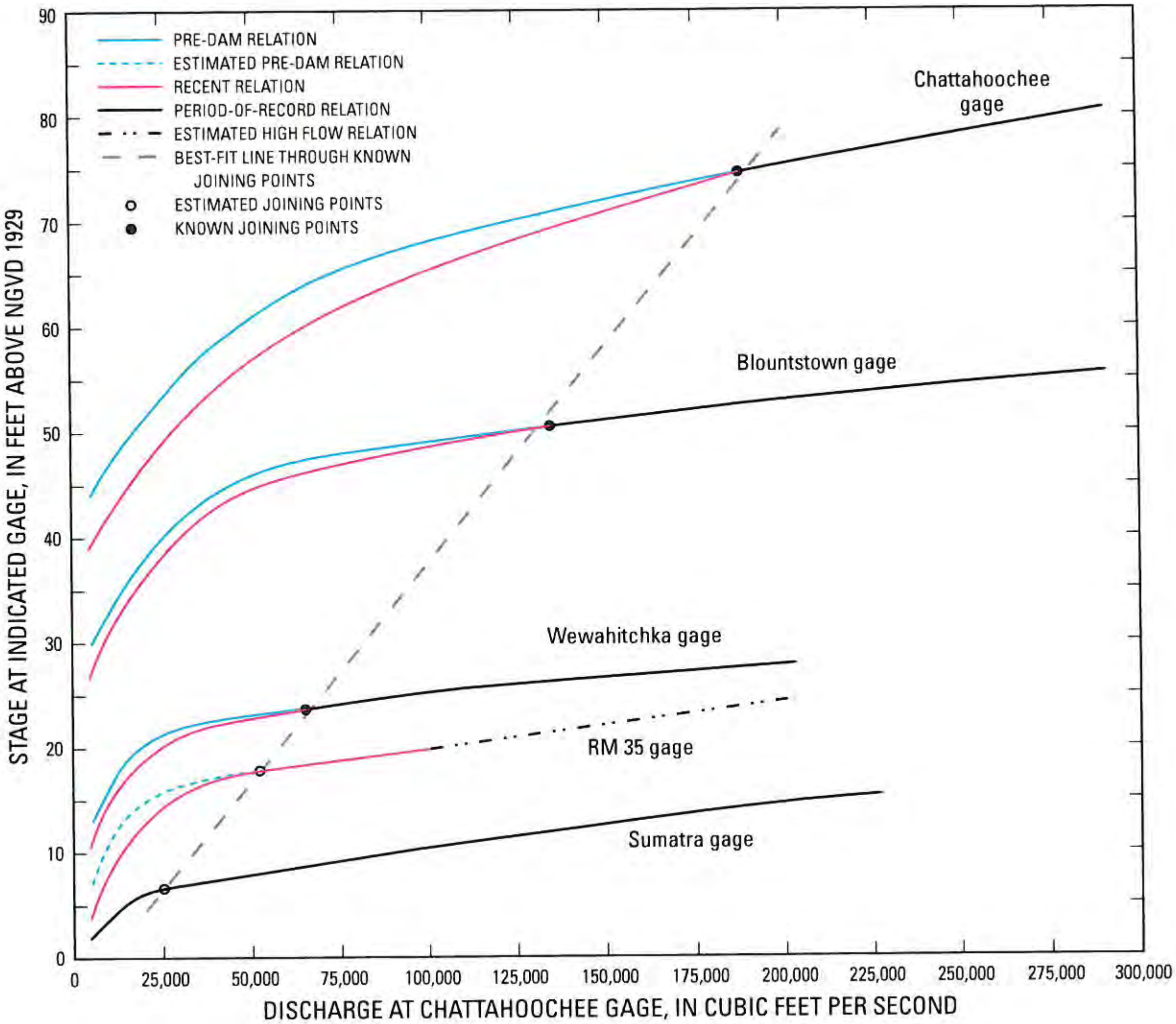

Figure 6. Stage at five streamgages on the Apalachicola River in relation to discharge at Chattahoochee, Florida, with known and estimated joining points for pre-dam and recent relations. Relations at streamgages downstream from Chattahoochee were developed using lag times as defined in glossary. An estimated joining point was needed for Sumatra, even though there is only one curve at that site, so that interpolated pre-dam and recent relations could be developed between RM 35 and Sumatra.

hydraulic roughness (changes in land use, forest maturity, or installation or removal of roadway embankments). These factors, however, have not changed enough along this river in 50 years (1954–2004) to cause a noticeable change in stage at high flow.

Stage-discharge relations at Chattahoochee, Blountstown, and Wewahitchka had joining points determined from actual data that were 188,000, 135,000, and 65,000 ft^3/s, respectively. A best-fit straight line was drawn through these three known points on figure 6 and projected "downward" to estimated joining points at RM 35 and Sumatra, namely where the best-fit line intersected the stage-discharge relation for those two downstream sites. The joining point at RM 35 gage (52,000 ft^3/s) was used to estimate the RM 35 pre-dam relation, which is described later in this section. Although Sumatra had only one relation (for the whole period of record), the joining point at the Sumatra gage (25,000 ft^3/s) was needed for calculating interpolated pre-dam and recent relations between the RM 35 and Sumatra gages, which are discussed in the section entitled "Interpolated Stage-Discharge Relations between Streamgages."

Several factors probably contribute to the magnitude of the joining point flow at any particular location, including the amount of channel enlargement, the elevation of the floodplain, and the ratio of main channel width to floodplain width. Actual and estimated stages at joining points in relation to

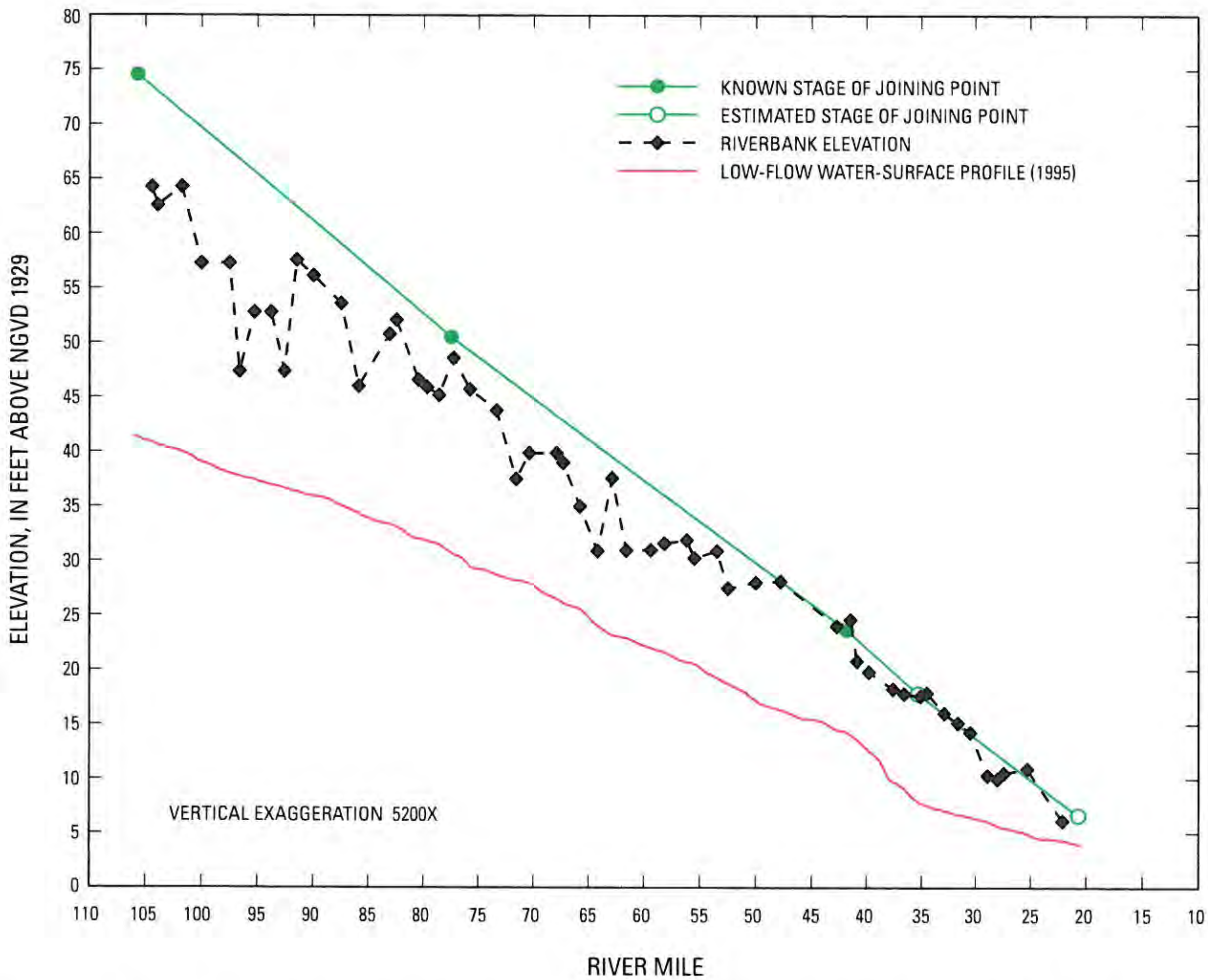

Figure 7. Stage of joining points in relation to riverbank elevation and water surface at low flow in the Apalachicola River, Florida. Procedures for determining joining points (the points at which pre-dam and recent stage-discharge relations merge) are described in the text, and these points are graphically illustrated on figure 6. Riverbank elevations are the top-of-bank elevations on the lowest side of surveyed cross sections (U.S. Army Corps of Engineers, 2001a). The 1995 low-flow water-surface profile was developed for 9,300 ft^3/s at Chattahoochee and is provisional (USACE, Mobile District, unpublished data, 2005).

riverbank heights from 53 main-channel cross-section surveys are shown in figure 7 (USACE, 2001a). Bank heights in any given cross section are typically higher on one side of the river than the other. The bank heights used in figure 7 are the bank elevations of the low side in each cross section.

Figure 7 shows that the joining point stage is 10 ft above bank level in the upper reach and gradually decreases downstream until the joining point stage is essentially the same as bank level in the nontidal lower reach. This progressive lowering of the relative elevation of the joining point stage is probably due to the following reasons. The width of the main channel at Chattahoochee is about 10 percent of the width of the floodplain, whereas the width of the main channel in the nontidal lower reach is only about 1 percent of the width of the floodplain (fig. 2). In addition, in the lower reaches of the river, a substantial amount of river water leaves the main channel and is carried by large side-channel streams even during low-flow conditions. Lastly, the amount of channel enlargement that has occurred is greater at Chattahoochee than in the nontidal lower reach, as evidenced by the difference between pre-dam and recent stage-discharge relations at low flow (fig. 6). Because of these differences, the main channel in the upper reach conveys a relatively large proportion of the discharge during overbank flows and, therefore, water-level decline caused by channel change in the upper reach is still evident when water levels rise well above bank height.

The 22 graphs in appendixes I through V are arranged in pairs with two different scales on the horizontal (discharge) axis. The first graph in each pair has a horizontal axis showing the full range of discharge (from 0 to either 220,000, 240,000, or 300,000 ft^3/s, depending upon data available for that gage). The second graph in each pair has a horizontal axis showing discharges up to 60,000 ft^3/s only. Two pairs of graphs (A–B and C–D) are provided for every gage with an additional third pair of graphs for the Chattahoochee gage (E–F). Graphs A and B show the relations with averages of daily mean values in selected discharge increments. Increment sizes were 1,000 ft^3/s for discharges up to about 30,000 ft^3/s and increased with increasing discharges greater than 30,000 ft^3/s. Increment sizes at the highest discharges were optimized to accommodate small sample sizes. Graphs C and D show the relations with daily mean values.

Graphs E and F in appendix I (Chattahoochee) show the relations developed for this report with individual discharge measurements and with the two USGS ratings used in the recent period for computing published discharges. At gaging stations, discharge measurements are routinely conducted at various times during the year to directly determine the volumetric rate of flow (discharge) of the river. Discharge measurements are the basic data from which standard stage-discharge ratings are created. Graphs E and F are included as a check to show how relations developed for this report compare with the original data that were used to estimate daily mean discharge values at Chattahoochee.

All of the stage-discharge relations (except the pre-dam relation for RM 35) were made by fitting a hand-drawn line through the averages of daily mean values in selected discharge increments (shown in graphs A and B in apps. I–V). The points defining the hand-drawn line were manually digitized, then entered into a curve-fitting software program to generate a formula for the line (app. VI) and error statistics on the fit of the line to the daily mean values (table 5). The average ranges of 95-percent confidence limits for stage-discharge relations are 0.04 ft at 10,000 ft^3/s, 0.10 ft at 50,000 ft^3/s, and 0.44 ft at various high flows ranging from 100,000 to 250,000 ft^3/s (table 5).

Three stage-discharge relations (Chattahoochee pre-dam relation, Chattahoochee period of record relation for high flows, and RM 35 estimated relation for high flows) included some daily mean values that were collected at nearby sites less than a mile away.

(1) The Chattahoochee pre-dam relation was based primarily on stage and discharge data from December 16, 1939, to April 30, 1954, when the Chattahoochee gage was located at the US 90 highway bridge (its present location). From October 1, 1928, to December 15, 1939, the gage was located at the railroad bridge at River Junction, about 0.9 mi downstream from its present location. River Junction daily mean values greater than 100,000 ft^3/s were adjusted to account for the drop in stage from the US 90 bridge to the railroad bridge and were added to the 1939–1954 data to improve the pre-dam relation at higher flows. This correction, which increased with discharge and ranged from 0.89 ft at 100,000 ft^3/s to 1.09 ft at 291,000 ft^3/s, was determined from a comparison of stages at River Junction and the present gage for similar discharges, and from water-surface slope calculations between the Chattahoochee and Blountstown gages.

(2) Adjusted River Junction daily mean values were also added to the data used to create the period of record relation for high flows greater than 188,000 ft^3/s at Chattahoochee. Two discharge measurements made prior to 1939 were adjusted to the present gage location and are included in graph E of appendix I.

(3) The RM 35 estimated relation for high flows was based on two daily values that were adjusted from measured values at the RM 36 gage, which was located 0.7 mi upstream from the RM 35 gage. These two values occurred during the peak of the July 1994 flood.

Methods for estimating the RM 35 pre-dam relation are illustrated in figure 8. The first step involved the development of a pre-dam straight-line distance interpolation relation which was estimated by the following calculation. The river-mile distance from the Wewahitchka gage to the RM 35 gage was divided by the total river-mile distance from the Wewahitchka gage to the Sumatra gage. The resulting proportion was then multiplied by the difference between the Wewahitchka stage and the Sumatra stage for each discharge increment, and subtracted from the Wewahitchka pre-dam stage to yield the straight-line distance interpolation stage for RM 35 for that discharge.

The RM 35 pre-dam straight-line distance interpolation relation, although helpful as a guide, could not be used "as is" because it did not account for the fact that the slope from Wewahitchka to RM 35 is steeper than any other reach of the river. The RM 35 pre-dam relation was estimated at the low end using actual data consisting of three stage values from water-surface profiles developed for Chattahoochee discharges of 5,860 ft^3/s (October 1954), 7,340 ft^3/s (August 1951), and 9,300 ft^3/s (March 1956) (USACE, 1955). At the high end, the relation was drawn through the estimated joining point of 52,000 ft^3/s from figure 6. The remainder of the RM 35 pre-dam relation between 9,300 and 52,000 ft^3/s was visually estimated using the RM 35 recent relation as a lower guide and a RM 35 pre-dam straight-line distance interpolation relation as an upper guide.

Table 5. Error statistics for stage-discharge relations developed from long-term streamgage data on the Apalachicola River, Florida.

[Stage-discharge relations developed for this report relate stage at all gages to discharge at Chattahoochee gage using lag times as defined in glossary. Relations were developed only for the specific range of discharges indicated. Error statistics could not be generated for the RM 35 estimated pre-dam and RM 35 estimated high flow relation, because they were visually estimated from limited data. n, number of daily mean values used to create relation; ft, feet; ft³/s, cubic feet per second]

Name of stage-discharge relation	Range of discharges for indicated relation, in ft³/s	n	Fit of relation to daily mean values			Range of 95-percent confidence limits at selected discharges[2]		
			R^2	Root mean square error[1]	F statistic	Range (+/-), in ft	at	Discharge, in ft³/s
Chattahoochee pre-dam	5,000 – 188,000	5,269	0.998	0.21	568,933	0.01	at	10,000
						0.02	at	50,000
Chattahoochee recent	5,000 – 188,000	3,579	0.997	0.33	173,715	0.02	at	10,000
						0.03	at	50,000
Chattahoochee period of record (for flows greater than 188,000 ft³/s)	188,000 – 291,000	17	0.984	0.26	440	0.18	at	200,000
						0.23	at	250,000
Blountstown pre-dam	5,000 – 135,000	9,313	0.993	0.40	247,816	0.01	at	10,000
						0.03	at	50,000
Blountstown recent	5,000 – 135,000	3,598	0.980	0.74	30,049	0.04	at	10,000
						0.10	at	50,000
Blountstown period of record (for flows greater than 135,000 ft³/s)	135,000 – 291,000	55	0.940	0.39	194	0.21	at	200,000
						0.38	at	250,000
Wewahitchka pre-dam	5,000 – 65,000	677	0.949	0.68	2,491	0.11	at	10,000
						0.29	at	50,000
Wewahitchka recent	5,000 – 65,000	2,517	0.967	0.64	12,354	0.04	at	10,000
						0.12	at	50,000
Wewahitchka period of record (for flows greater than 65,000 ft³/s	65,000 – 203,000	364	0.809	0.40	251	0.12	at	100,000
						0.22	at	150,000
RM 35 recent	5,000 – 100,000	2,096	0.968	0.69	10,524	0.05	at	10,000
						0.16	at	50,000
Sumatra period of record (for flows less than 100,000 ft³/s)	5,000 – 100,000	12,635	0.922	0.49	21,349	0.02	at	10,000
						0.03	at	50,000
Sumatra period of record (for flows greater than 100,000 ft³/s)	100,000 – 227,000	39	0.511	1.46	9	0.97	at	150,000
						1.21	at	200,000
			Averages at selected discharges			0.04	at	10,000
						0.1	at	50,000
						0.44	at	various discharges from 100,000–250,000

[1]Also known as fit standard error.

[2]Because confidence limits vary with discharge, two values were selected for each relation to indicate the typical range.

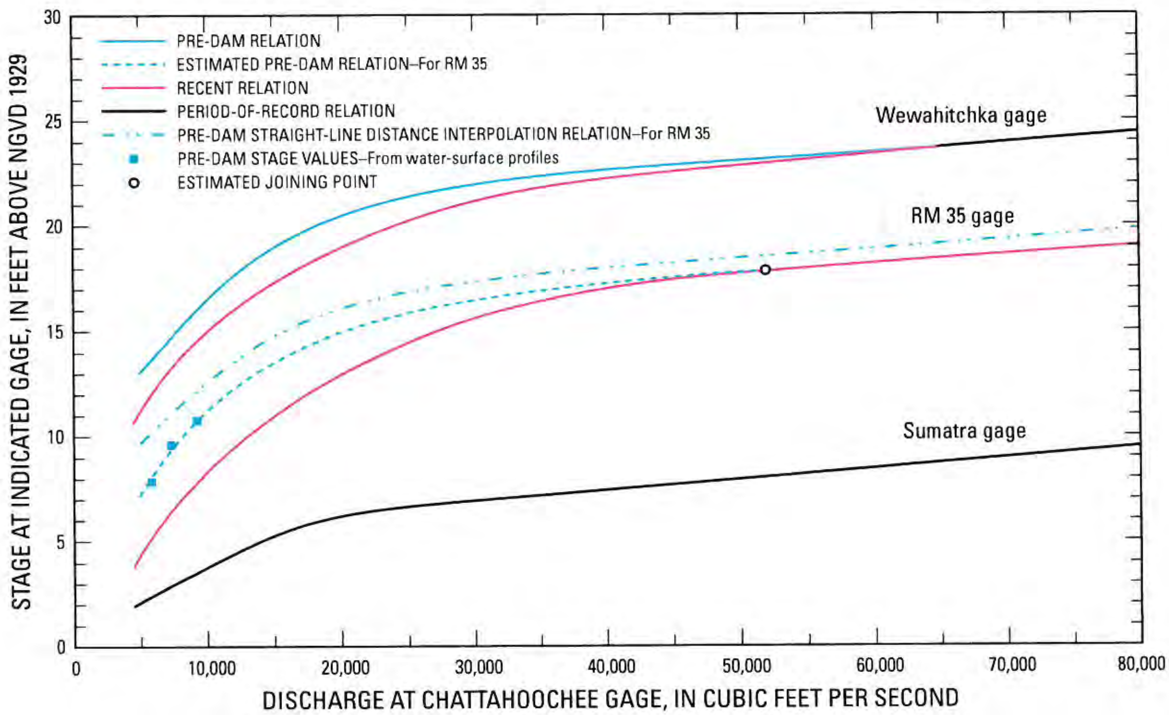

Figure 8. Data used to estimate pre-dam stage at the RM 35 streamgage in relation to discharge in the Apalachicola River at Chattahoochee, Florida. The RM 35 pre-dam stage-discharge relation was drawn through three pre-dam stage values from water-surface profiles, then visually estimated to join the recent relation at the estimated joining point, using the recent relation as a lower guide and the pre-dam straight-line distance interpolation relation (calculated from pre-dam Wewahitchka and Sumatra relations) as an upper guide. The estimated pre-dam relation does not coincide with the pre-dam straight-line distance interpolation relation for reasons discussed in text. Relations were developed using lag times as defined in glossary.

Interpolated Stage-Discharge Relations between Streamgages

Two types of data were combined to produce interpolated stage-discharge relations between the gages. Stage-discharge relations at gages provide detailed information about stages that might be expected at all discharges ranging from lowest to highest, but only near gage locations. Water-surface profiles provide detailed information about stages at all locations, but only for a single discharge (9,300 ft^3/s).

Water-surface profile data and long-term gage data compare favorably at the gage locations (fig. 9). Differences between the two types of data at the gage locations are listed in table 6. The average difference is 0.19 ft after adjusting for an explainable error at Chattahoochee that applies only to a limited distance in the vicinity of that site. The error at Chattahoochee occurred because the pre-dam water-surface profile was developed in 1956 after more than one-half foot of decline had already occurred at the gage from riverbed degradation resulting from the trapping of sediment in Lake Seminole. Adjustments for this local error, shown in parentheses in table 6, were calculated using the following steps:

(1) An adjusted value for pre-dam long-term gage data at the Chattahoochee gage (45.84 ft) was calculated by averaging all stages that occurred at discharges between 8,800 and 9,800 ft^3/s (9,300 ±500 ft^3/s) from 1954 to 1956.

(2) A difference of 0.08 ft for Chattahoochee pre-dam data was determined from the difference between the adjusted value for pre-dam long-term gage data (45.84 ft) and the 1956 water-surface profile data (45.92 ft).

(3) The average of all differences (0.19 ft) was calculated using 0.08 ft for the pre-dam Chattahoochee difference (instead of 0. 57 ft).

Water-surface profiles are compared to straight-line interpolations of stage between all gages except RM 35 in figure 9. Over most of the river's length, the results of the two methods compare favorably. In the nontidal lower reach, however, straight-line interpolation without the benefit of RM 35 data results in large errors in both the actual stage and the magnitude of the water-level decline. The problem is that the two largest changes in water-surface slope in the entire 85 mi of

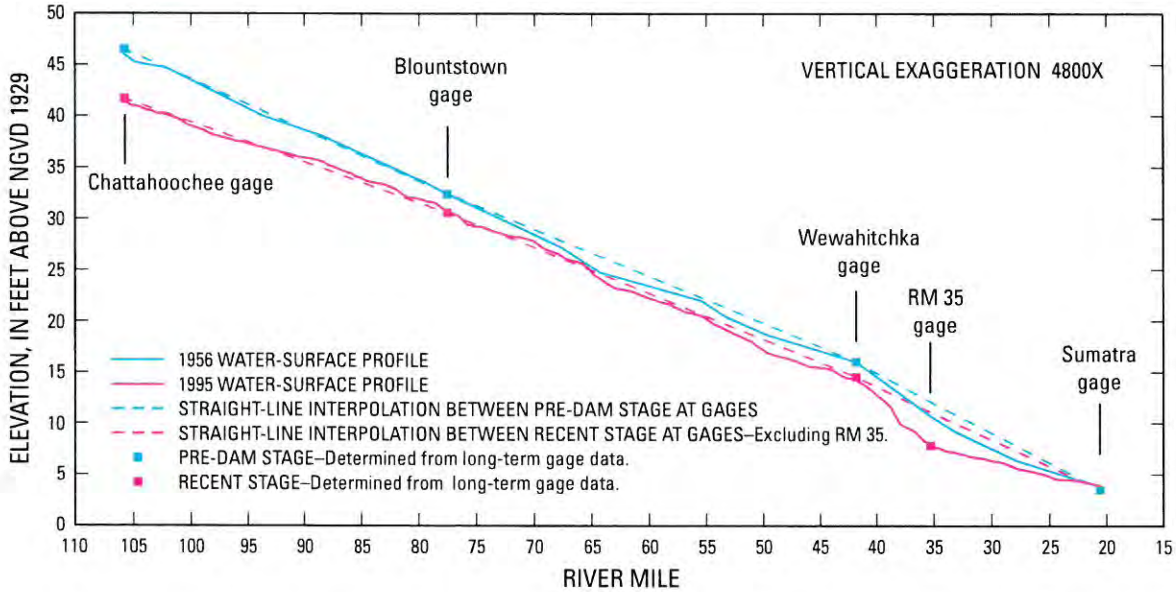

Figure 9. Comparison of water-surface profiles and stage values from long-term streamgage data for the nontidal reach of the Apalachicola River, Florida. All profile and stage data represent water levels at a Chattahoochee flow of 9,300 ft^3/s using approximate lag times defined in glossary. Water-surface profiles were computed by U.S. Army Corps of Engineers (see fig. 4). Pre-dam and recent stages from long-term streamgage data are from stage-discharge relations developed for this report.

Table 6. Comparison of stage in water-surface profiles to stage at long-term streamgages on the Apalachicola River, Florida.

[Stage from long-term gage data were determined using stage-discharge relations developed in this report, except for the values in parentheses, which reflect an adjustment for a local error at Chattahoochee (see discussion in text). Although this local error could not be corrected in the interpolated relations between gages developed for this report, average difference based on the adjusted value in parentheses better represents river-wide error in the water-surface profile data. ft^3/s, cubic feet per second; +/-, plus or minus; USACE, U.S. Army Corps of Engineers]

Gage	Time period	Stage at indicated gage, in feet, for discharge of 9,300 ft^3/s at Chattahoochee gage[1]: From long-term gage data	Stage at indicated gage, in feet, for discharge of 9,300 ft^3/s at Chattahoochee gage[1]: From water-surface profiles[2]	Difference (+/-), in feet
Chattahoochee	Pre-dam	46.49 (45.84)[3]	45.92	0.57 (0.08)[3]
	Recent	41.72	41.33	0.39
Blountstown	Pre-dam	32.38	32.40	0.02
	Recent	30.57	30.72	0.15
Wewahitchka	Pre-dam	16.00	16.00	0.00
	Recent	14.54	14.27	0.27
RM 35	Recent	7.84	7.89	0.05
Sumatra	Pre-dam	3.54[4]	3.85	0.31
	Recent		3.97	0.43
			Average	0.24 (0.19)[3]

[1] Stage at gages downstream from Chattahoochee were determined using lag times as defined in glossary.
[2] Pre-dam profile is from Plate No. 43A of Design Memorandum No. 1 (USACE, 1955). Recent profile is provisional, unpublished data (USACE, written commun., 2005).
[3] Values in parentheses were adjusted for a local error at Chattahoochee based on methods described in text.
[4] Pre-dam and recent periods were not distinguished at Sumatra because they were similar. This value is based on the period of record at this gage.

the nontidal river occur at the Wewahitchka and RM 35 gages. From Wewahitchka to RM 35 is a 6.5-mi reach with the steepest slope in the entire nontidal river, and downstream from RM 35 is a 14.7-mi reach with the lowest slope. For this reason, all available data were used to estimate a pre-dam stage-discharge relation at RM 35 (fig. 8). Admittedly, this estimated relation has considerable uncertainty associated with it; however, figure 9 demonstrates why the use of an estimated pre-dam RM 35 stage-discharge relation, along with its companion for the recent period, is a better method for interpolating stage-discharge relations between Wewahitchka and Sumatra than a method that excludes the RM 35 data.

Interpolated stage-discharge relations for estimating stage at all locations between gages (at every 0.1 rm) in relation to discharge at Chattahoochee were developed using a series of interpolation formulas that varied among three flow ranges (low, intermediate, and high). In the low-flow range (9,300 ft^3/s and less), the interpolation formulas use slope calculations based on stage data in water-surface profiles (app. VII.A). In the high-flow range (joining-point flow and greater), the formulas use slope calculations based on straight-line river-mile-distance interpolations between gages (app. VII.B). In the intermediate-flow range (between 9,300 ft^3/s and the joining-point flow), the formulas generate a mathematically smoothed curve beginning at the water-surface profile stage for 9,300 ft^3/s and ending at the straight-line river-mile-distance interpolated stage (averaged from both pre-dam and recent relations) at the joining-point flow (app. VII.C).

Selected examples of interpolated relations in each reach shown in figure 10 help explain how the formulas in appendix VII operate. Known stage for 9,300 ft^3/s from water-surface profiles are identified in each interpolated rating to show the data upon which the low end of the relation was based (fig. 10). One of the examples in figure 10B, head of Sand Slough at rm 65.2, was chosen to show pre-dam and recent stage at a location where little water-level decline occurred, based on the water-surface profiles in figure 9. Three of the examples, mouth of Flat Creek (fig. 10A), mouth of stream to Porter Lake (fig. 10B), and head of Moccasin Slough (fig. 10C), are discussed further in the "Results and Discussion" section. Although this report does not specifically address water-level decline in the lower Chipola River, two of the relations shown in figure 10C can be used to determine decline at the upper and lower end of that river: (1) at the Wewahitchka gage, located close to the head of the Chipola River Cutoff, which feeds the upper end of the lower Chipola River; and (2) at the mouth of the lower Chipola River at rm 27.9.

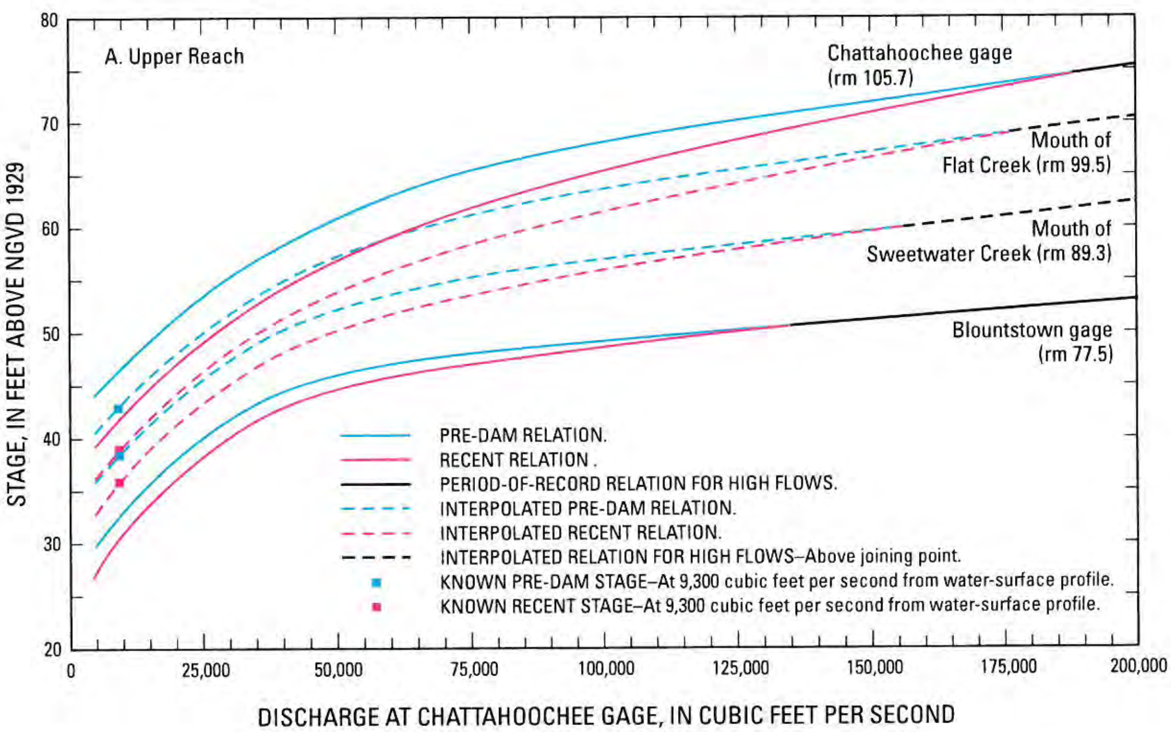

Figure 10. Interpolated stage at selected sites between streamgages in relation to discharge in the Apalachicola River at Chattahoochee, Florida, in (A) upper reach, (B) middle reach, and (C) nontidal lower reach. Relations at streamgages downstream from Chattahoochee were developed using lag times as defined in glossary. Range of stage and discharge shown on axes varies among the three graphs to focus on flows below joining points in each reach.

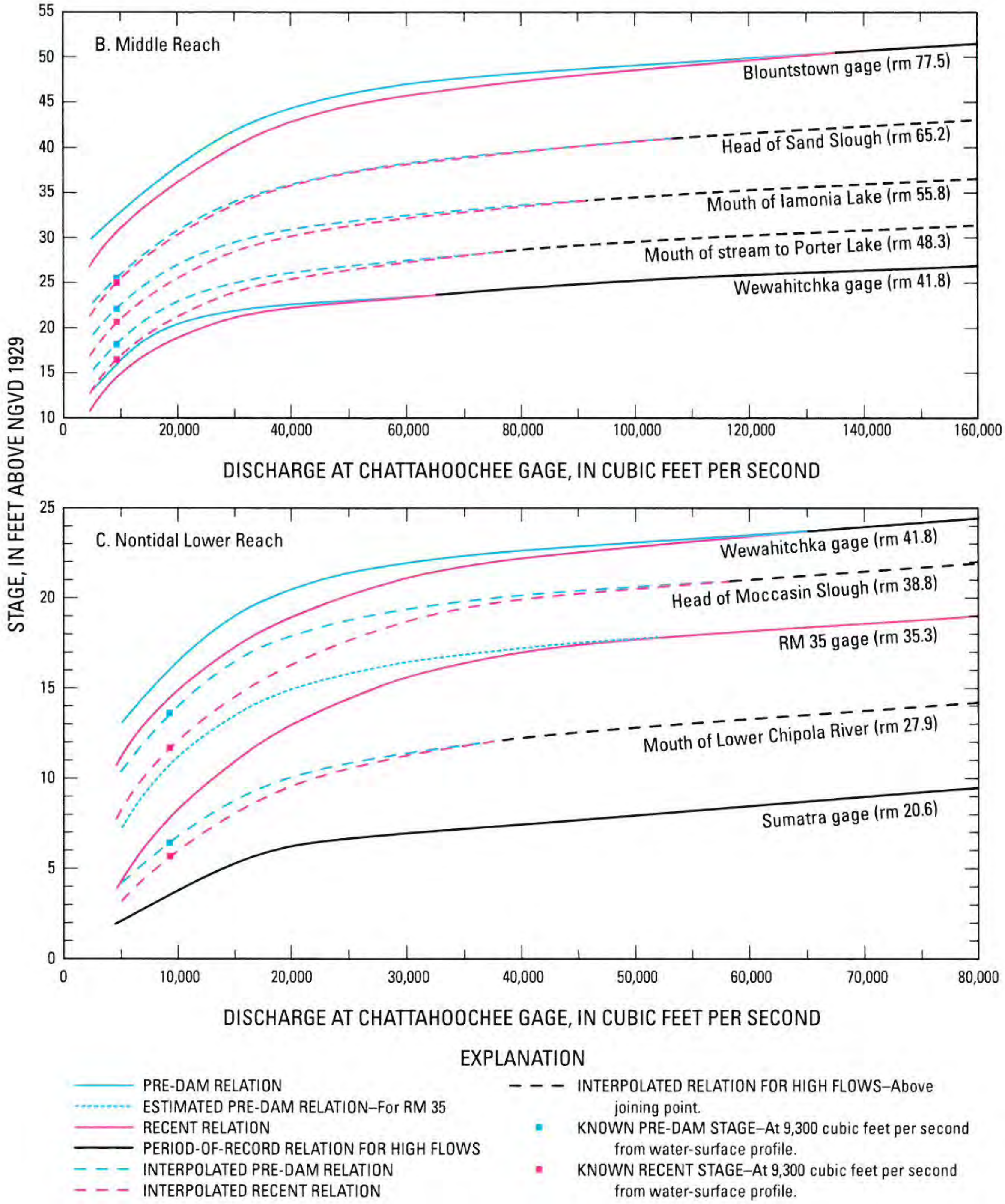

Figure 10. (Continued) Interpolated stage at selected sites between streamgages in relation to discharge in the Apalachicola River at Chattahoochee, Florida, in (A) upper reach, (B) middle reach, and (C) nontidal lower reach. Relations at streamgages downstream from Chattahoochee were developed using lag times as defined in glossary. Range of stage and discharge shown on axes varies among the three graphs to focus on flows below joining points in each reach.

Errors associated with the interpolation methods cannot be quantified, but an additional analysis of the methods used to interpolate between-gage relations shows hypothetical worst-case error in a comparison of test cases (fig. 11). In this figure, stage-discharge relations at three gages based on actual data from long-term records are compared to hypothetical cases in which the gage data were ignored and the relation was developed by the interpolation methods used in this report. At the Blountstown gage site, for example, interpolated stage-discharge relations were developed from data at the Chattahoochee and Wewahitchka gages, ignoring the existing data from the Blountstown gage. Similarly, interpolated stage-discharge relations were developed at the Wewahitchka site using Blountstown and Sumatra gage data, and at the RM 35 site using Wewahitchka and Sumatra gage data.

The departures shown in the hypothetical worst-case tests in figure 11 are greater than would be expected for the between-gage interpolated relations for three reasons:

(1) In two test cases, Blountstown and Wewahitchka, it was assumed that gage data did not exist and interpolations were conducted over long distances, 63.9 and 56.9 rm respectively. The actual distances over which interpolations were made are considerably shorter (28.2, 35.7, 6.5, and 14.7 rm).

(2) In two test cases, Wewahitchka and RM 35, information about the nearby (and large) slope changes on the river are ignored, whereas actual calculations include information that accounts for these slope changes.

(3) Error resulting from the interpolation method approaches zero near the gages, so the departures of the type shown on figure 11 would not apply to the relations for sites close to gages.

Stage-discharge relations defined by a set of paired discharge and stage values are listed in digital table files for each gage site and for each site spaced every 0.1 rm between the gages. These digital files are on the compact disk (CD) in the map pocket of this report and a description of their contents is provided in appendix VIII. The files on the CD contain a total of 1,704 relations (5 pre-dam and 5 recent relations at gages, plus 847 interpolated pre-dam and 847 interpolated recent relations between gages). Each relation is defined by about 500 points at the discharge increments shown in the annotated example in appendix VIII.A. Appendixes VIII.B and C describe the organization of files in EXCEL format and flat file format, respectively.

Developing a list of points that define each relation was determined to be the most practical way to generate and present large numbers of stage-discharge relations that are provided on the CD. Future users of these data can easily convert selected point lists to equations for stage-discharge relations using any curve-fitting software (similar to those listed in app. IV), and can then use those equations to estimate water-level decline at specific locations in the nontidal river for any discharge. The methods presented in this report, and the interpolated (between-gage) stage-discharge relations provided on the CD, were developed primarily for the purpose of making reasonable estimates of the amount of water-level decline that occurred between the pre-dam period and the recent period. The interpolated relations may be useful for other purposes, but the methods and inherent assumptions used to develop the relations should be evaluated before these relations are used for other applications.

Water-Level Decline and Floodplain Effects

The magnitude of water-level decline at a particular location is the difference between the pre-dam and recent stage-discharge relations at that site. An example of this difference using pre-dam and recent relations at the Chattahoochee gage is shown in figure 12. For a given discharge, the recent stage minus the pre-dam stage yields the change in water level at that discharge. At the Chattahoochee gage, the decline is greatest at low discharges and systematically decreases with increasing discharge. This same trend, with a few minor exceptions, occurs at the other gages as well. At all locations, the amount of the decline decreases to zero at the joining point where pre-dam and recent relations merge (not shown in fig. 12). Water-level declines attributable to channel change were calculated at closely spaced locations (every 0.1 rm) for 14 selected discharges to show variation at different locations under different flow conditions.

Approximate Decrease in Duration of Inundation Caused by Channel Change

Impacts of water-level decline on biological habitats and communities in the floodplain cannot be adequately determined from direct measurements of water-level decline alone. Statistics derived from streamflow records, such as changes in the duration or frequency of inundation, are necessary for describing changes in long-term hydrologic conditions on the floodplain. The following methods were used to calculate the approximate decrease in duration of inundation attributable to channel change, which is used in several analyses in this report.

The first step in determining the decrease in duration of inundation is to calculate what is informally referred to as "equivalent-stage discharge." In the example in figure 13, the selected discharge of 15,000 ft^3/s at the Chattahoochee gage had a pre-dam stage of 49.22 ft, and 25,700 ft^3/s is the "equivalent-stage discharge" in the recent period with that same water-surface elevation. Another way of describing this concept is that an additional 10,700 ft^3/s would be required in the recent period to replicate the stage associated with 15,000 ft^3/s during the pre-dam period.

The next step is to determine the percent exceedance for both the initial selected discharge and its corresponding equivalent-stage discharge. "Percent exceedance" is the term commonly used to describe the percentage of time that a specified streamflow discharge is equaled or exceeded during a given time period. Percent exceedance is used to determine "percent duration of inundation," which is the percentage of

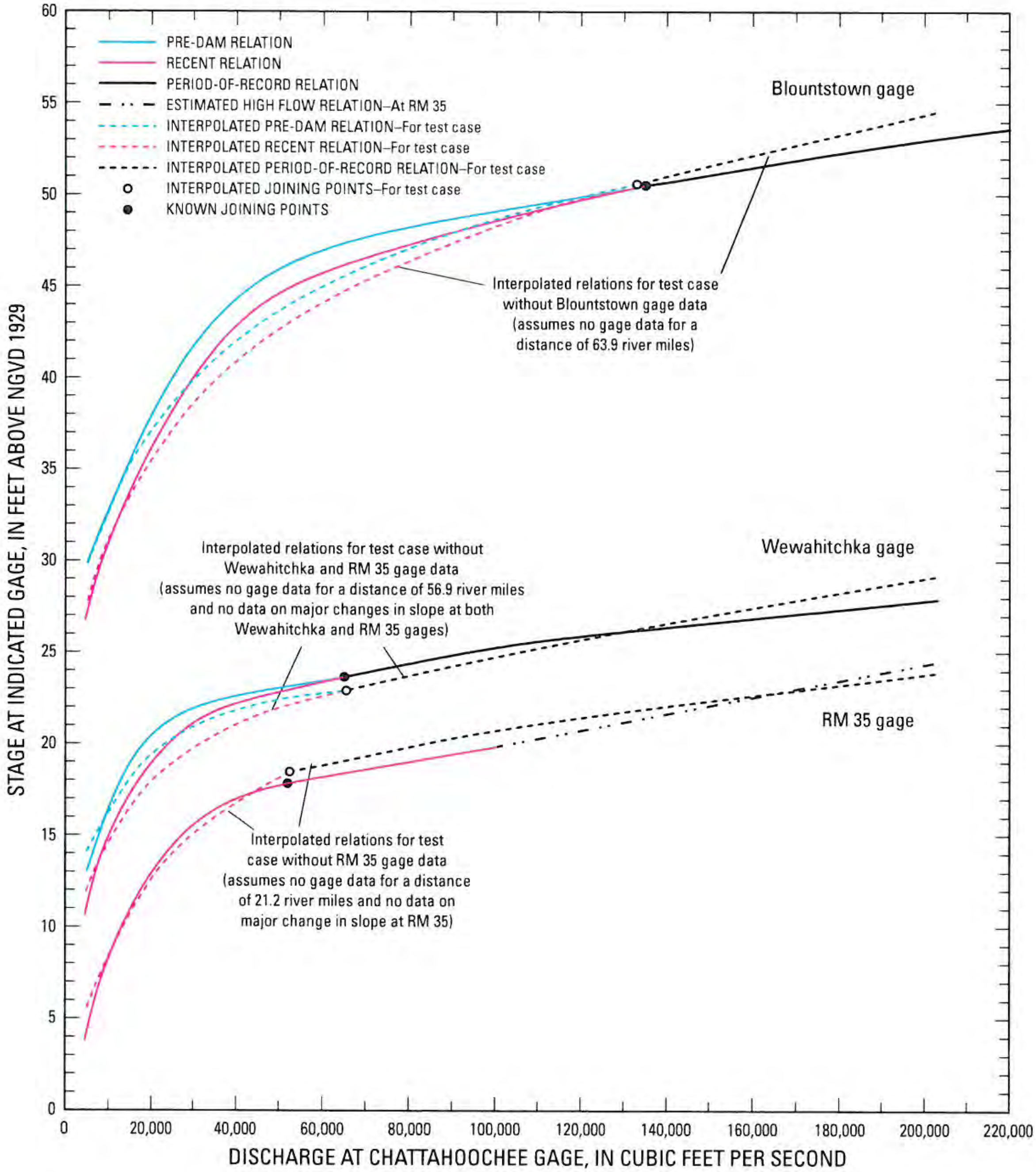

Figure 11. Stage-discharge relations based on long-term records at streamgages on the Apalachicola River, Florida, compared to hypothetical test cases in which streamgage data were ignored and relations were developed by interpolation methods used in this report. The departures shown in these hypothetical worst-case tests are greater than would be expected for the between-gage interpolated relations developed in this report (see discussion in text). Relations were developed using lag times as defined in glossary.

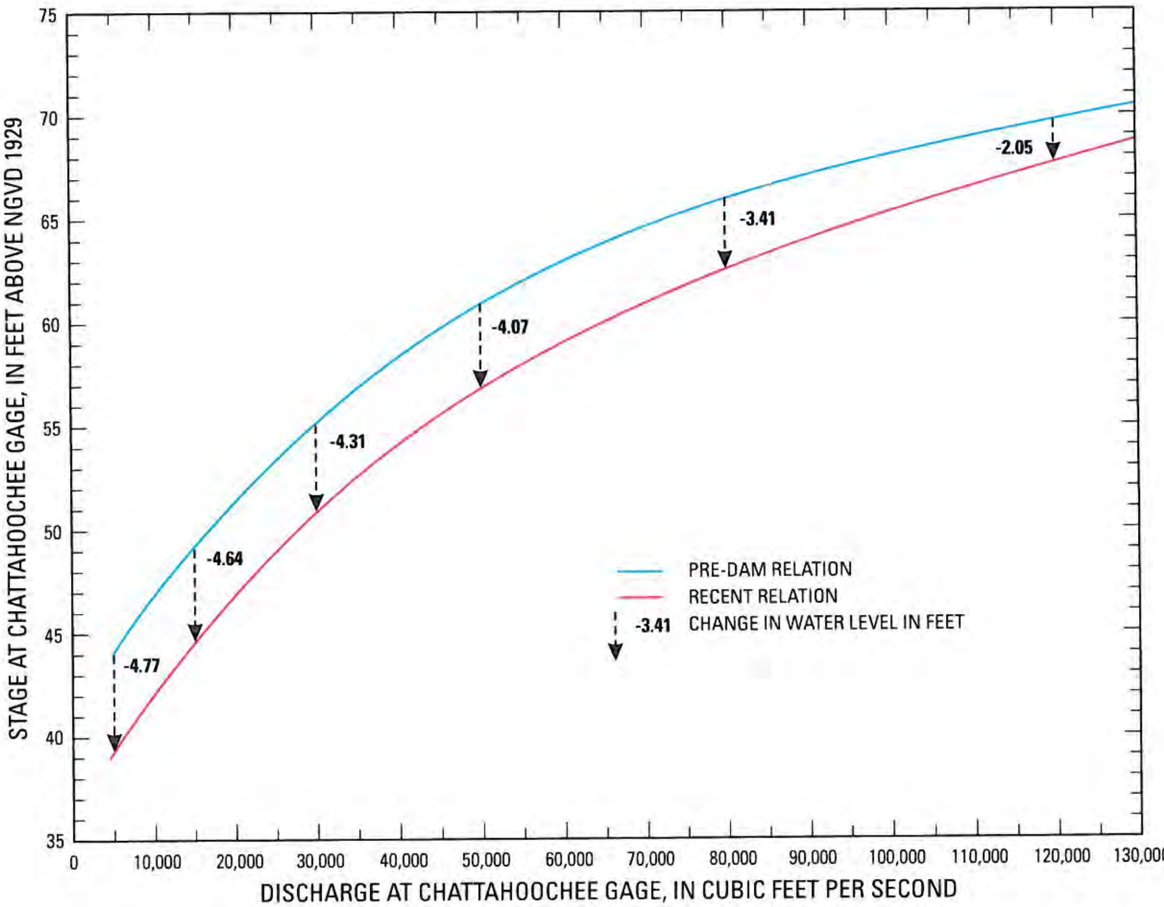

Figure 12. Water-level decline resulting from difference between pre-dam and recent stage-discharge relations at the Chattahoochee streamgage on the Apalachicola River, Florida, for selected discharges. The magnitude of the decline is greatest at low discharges and systematically decreases at higher discharges.

time that a particular location is inundated by water and is the preferred term for describing hydrologic conditions on a floodplain. Percent duration of inundation and percent exceedance can be treated as numerically equal with certain caveats:

(1) The area of inundated floodplain is greatest when river levels are high and decreases with decreasing stage, but there are a few low areas of the floodplain that remain inundated by river water even at minimum flow, such as the beds of permanently connected floodplain streams or very low swamp forests. (Details on the amount of floodplain area that is inundated at various discharges can be found in Light and others, 1998.) All percent exceedance values, even those for very low discharges, can be used to define the percent duration of inundation of some areas of the floodplain, but they may not necessarily apply to the entire floodplain.

(2) Low topographic features of the floodplain with a bowl-like shape, such as swamp depressions, may retain water long after flood waters recede or may refill after heavy rains. Such areas would experience longer periods of inundation than those assumed from river stages. Swamps receiving water from seepage off nearby bluffs or local upland drainage areas can also have water perched above the elevation of the river surface during low water. In these areas, the actual percent duration of inundation is different than percent exceedance calculated from streamflow data. The reader is cautioned that percent duration of inundation values in this report are based solely on river stage, without any adjustments to account for site-specific variations in floodplain topography or other sources of water supplied to the floodplain independent of river flow.

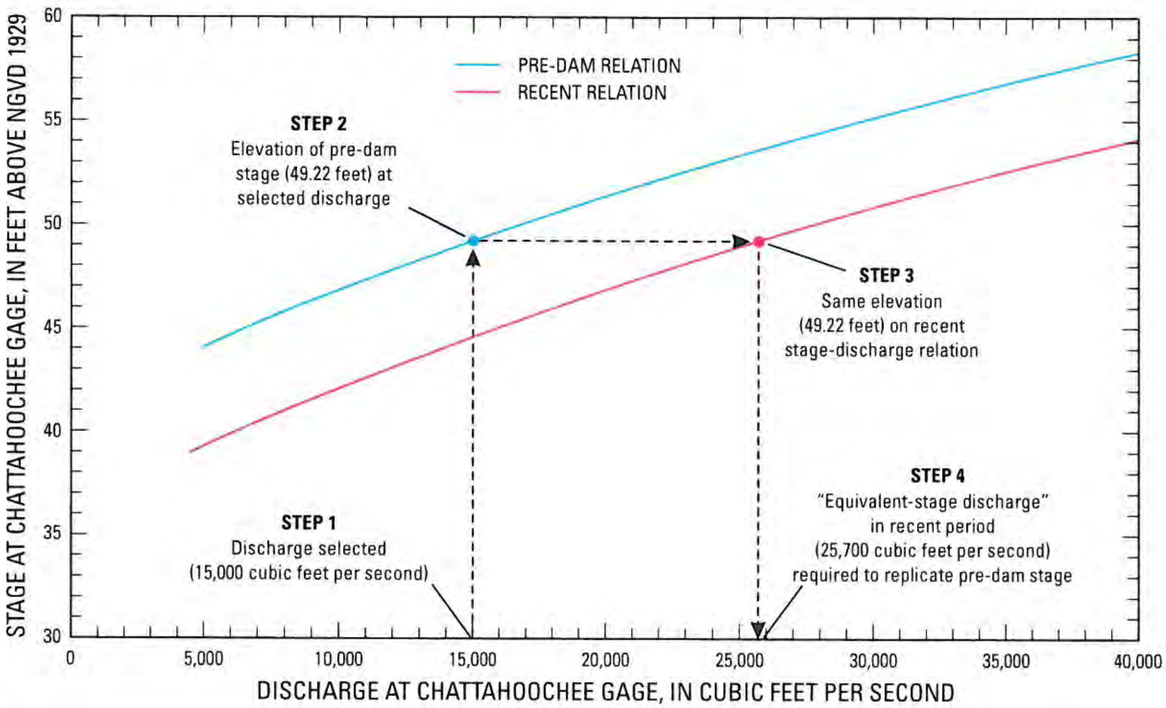

Figure 13. Example of determination of the "equivalent-stage discharge" in the recent period that is required to replicate a pre-dam stage using data for the Chattahoochee streamgage on the Apalachicola River, Florida. Calculation of "equivalent-stage discharge" is a necessary step in estimating changes in long-term flow statistics, such as duration of inundation, that have resulted from changes in stage-discharge relations from 1954 to 2004. In this example, 15,000 ft^3/s at Chattahoochee had a pre-dam stage of 49.22 feet, and 25,700 ft^3/s is the "equivalent-stage discharge" in the recent period that has that same water-surface elevation.

Percent exceedance is calculated from streamflow records for a defined time period, and the results vary depending upon the time period chosen. Selection of the time period is determined by the objective of the analysis. If the objective were to compare actual floodplain inundation in the pre-dam period to that in the recent period, the first step would be to determine equivalent-stage discharges using pre-dam and recent stage-discharge relations. These different discharges for pre-dam and recent conditions, indicative of the physical changes in the channel, would then be used to calculate percent exceedance based on the two different periods of flow records (pre-dam and recent, respectively). The difference in duration of inundation resulting from these calculations would reflect the combined effects of both the physical changes in the channel and changes in discharge between the two periods. Studies addressing the full extent of hydrologic change that has occurred in floodplain habitats should include the combined effects of both of these types of water-level changes. An analysis of this type, however, is not within the scope of this report. Changes in discharge are complex because of substantial seasonal and annual variability, and causes of those changes are unclear. Although a limited description of changes in water levels caused by changes in discharge is addressed for comparison purposes in the section entitled "Long-Term Changes in Monthly Discharge," the primary objective of this report is to present details about the water-level decline caused by channel changes, independent of changes in flow.

If the same time period is used to calculate percent exceedance from pre-dam stage-discharge relations and percent exceedance from recent relations, then the difference between them represents the decrease in floodplain inundation that has occurred as a result of channel changes only (independent of changes in flow). This allows the consequences of channel changes to be determined without the additional complication of flow differences between earlier and later time periods. In most of the analyses in this report, actual conditions in the recent period of 1995 to 2004, reflecting the effects of water-level decline attributable to channel change, were compared to the approximate natural conditions that would have occurred in that same period if this water-level decline had *not* occurred. This comparison shows the approximate difference in duration of floodplain inundation with and without channel change during the recent period.

The recent period was compared to a 30-year contemporary period and two other earlier periods (fig. 14). The recent period should not be assumed to represent average or typical conditions because it is the driest decade of the later period. At discharges less than 30,000 ft^3/s, the recent period is more similar to the driest decade in the early period (1949-58) than to either the earlier or the later 30-year periods. The recent period, however, is an excellent time period for evaluating the effects of water-level decline on biological habitats during extreme low-flow events. Extreme events can be an important factor affecting the species of trees that will colonize or thrive in floodplain forests, the long-term survival of sensitive aquatic species such as endangered mussels, and many other biological processes in the floodplain. If the objective of the analysis is to describe the effects of water-level declines under more typical conditions, however, periods longer than 10 years (preferably 20-30 years or longer) should be used.

Calculations of percent exceedance for the recent period based on both the pre-dam and recent relations are illustrated in the example in figure 15A. The initial selected discharge of 15,000 ft^3/s and its corresponding equivalent-stage discharge of 25,700 ft^3/s in figure 15A are the same values generated by the example steps in figure 13. In the final calculation step in figure 15A, the percent exceedance of the equivalent-stage discharge (20.6) minus the percent exceedance of the initial selected discharge (45.3) yields a change of -24.7 percent. This is the approximate decrease in duration of inundation during the recent period that resulted from water-level decline caused by channel change at the Chattahoochee gage. Figure 15B illustrates the same calculation, which was made separately for the individual years 2000 and 2003, showing large differences in durations from year to year. Because of this annual variability, it is important not to draw conclusions about durations for a multiple-year period, as shown in figure 15A, and apply them to individual years. Biological stress caused by adverse hydrologic conditions may not be evident when examining durations for the 10-year period, but vulnerable species could be extirpated locally by conditions occurring in the driest year of this decade.

Approximate decreases in duration of inundation caused by channel change, as determined from 1995 to 2004 flow durations, were calculated at closely spaced locations (every 0.1 rm) for 14 selected discharges to show variation at different locations and under different flow conditions. Approximate decreases in duration of inundation were also calculated for each year of the 1995 of 2004 period at three example locations selected to show specific effects of water-level decline on biological habitats of the floodplain. At these three locations, duration data were calculated only for the seasons during which hydrologic conditions are important to the organisms utilizing those habitats. Inundation of floodplain forests, for example, has little effect on tree growth and survival during the dormant season, so duration calculations were made only on water-level data during the growing season for that particular case study. Elevation data at these three sites were collected in previous studies or for other purposes in the present study. Sources of the elevation data are cited in each case.

Changes in Seasonal Distribution of Discharge

Long-term changes in the seasonal distribution of discharge were evaluated by comparing monthly discharge in the two 30-year periods shown in figure 14 (1929–1958 and 1975–2004). Both periods included major droughts and large floods (tables 2 and 3) and had similar average discharges. Although anthropogenic effects on runoff and streamflow are not new—some beginning in the 1800s—many anthropogenic activities prevalent in the later period were minimal or nonexistent in the earlier period. For example, the later period begins just after the completion of the last of the five large Federal reservoirs that were constructed from 1954 to 1974 for various flow regulation purposes (USACE, 1996). Large increases in agricultural water use occurred with the advent of center-pivot irrigation systems in southwest Georgia beginning in the 1970s (Pierce and others, 1984). Municipal water use was much greater in the later period, especially in metropolitan Atlanta, which has experienced large increases in population (Marella and others, 1993; Couch and others, 1996; Atlanta Regional Commission, 2006).

To compare these two 30-year periods, the first step involved isolating daily discharge values by month. For example, the daily mean discharge values for every January day in the earliest 30-year period were combined into one dataset having 930 values. Then five selected streamflow duration statistics (10, 25, 50, 75, and 90 percent exceedance) were developed for that "January" dataset. For example, the discharge equaled or exceeded in 10 percent of the days in January (49,780 ft^3/s in the early period) represents the discharge that typically occurred in January during very wet conditions. The discharge equaled or exceeded in 90 percent of the days in January (11,700 ft^3/s in the early period) represents the discharge that typically occurred in January during drought conditions. The same five selected duration statistics were calculated for each month in the later period using the same methods.

In a final analysis, water-level changes caused by changes in monthly discharge were compared to the water-level declines caused by channel changes. Because water-level changes resulting from changes in flow are complex, varying seasonally, annually, and by location along the river, this comparison of both types of water-level declines was made at only one example location (Blountstown gage), and only for median flow conditions (50 percent exceedance) and drought conditions (90 percent exceedance). Water-level changes caused by both channel changes and flow changes were calculated individually, by the following methods, and then combined to show the relative contribution of each to the total long-term change in monthly water levels at the selected site.

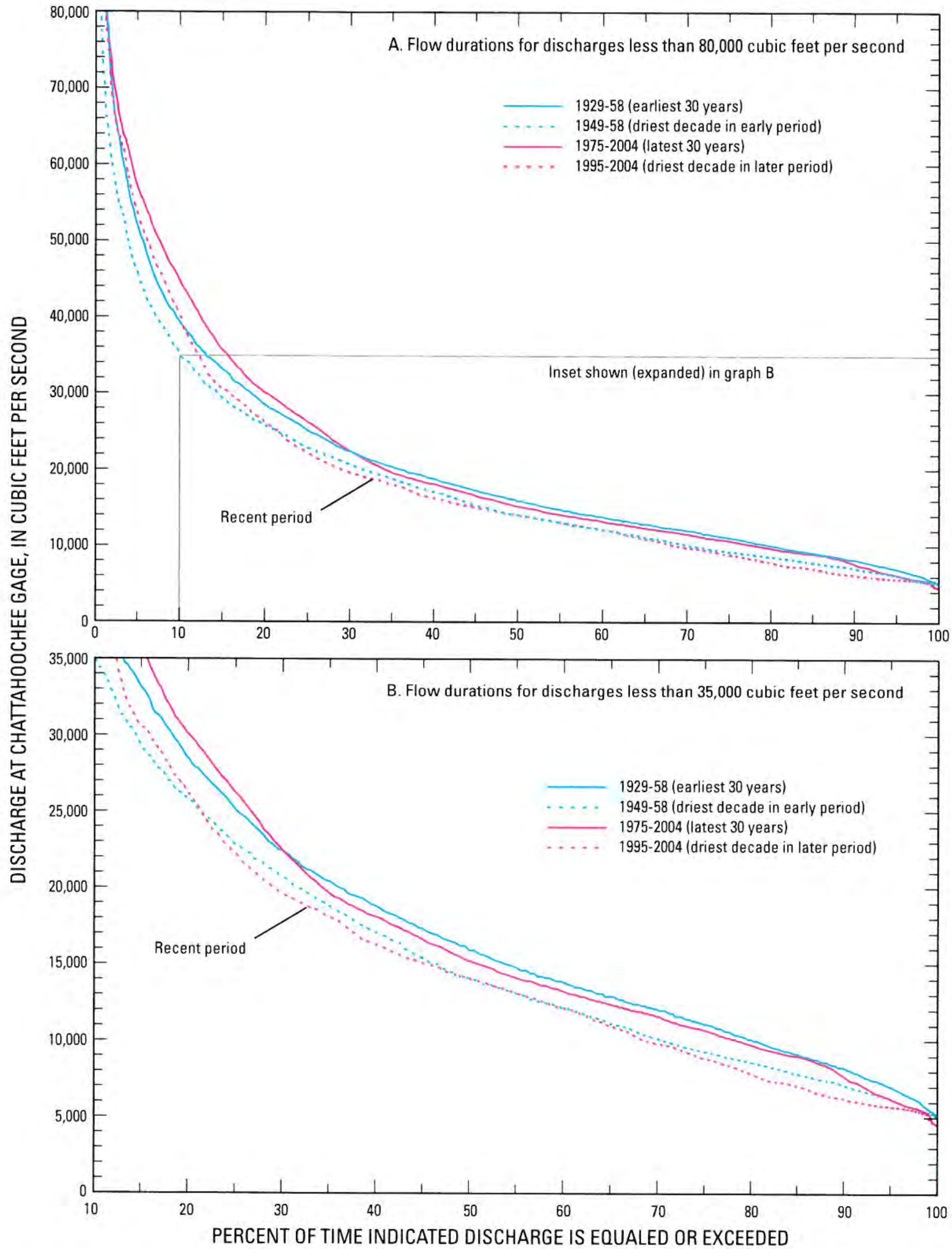

Figure 14. Flow durations for the recent period (1995–2004) compared to three other periods at the Apalachicola River at Chattahoochee, Florida, (A) for discharges less than 80,000 ft^3/s, and (B) for discharges less than 35,000 ft^3/s. With regard to flow durations, the recent decade including the severe drought of 1999–2002 was more similar to the decade including the severe drought of 1954–56 than it was to either of the longer 30-year periods.

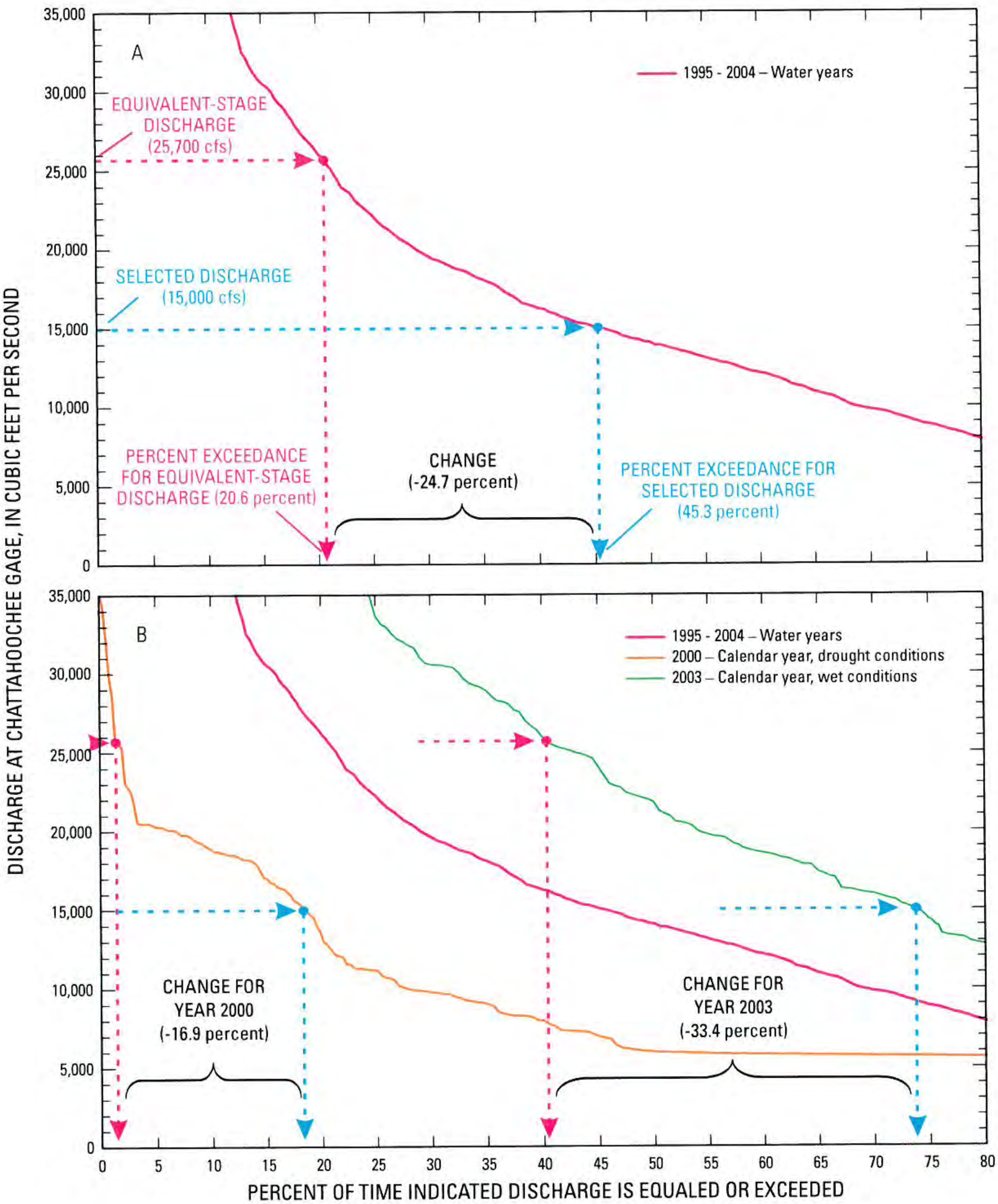

Figure 15. Example of determination of approximate decrease in duration of inundation caused by channel changes using data for the Chattahoochee streamgage on the Apalachicola River, Florida, (A) for the entire recent period (1995-2004), and (B) for one dry year (2000) and one wet year (2003). In graph A, percent exceedance of the equivalent-stage discharge (20.6 percent) minus the percent exceedance of the initial selected discharge (45.3 percent) yields the approximate change in duration of inundation resulting from water-level decline caused by channel change (-24.7 percent). See figure 13 for methods used to determine the equivalent-stage discharge. Graph B shows the same calculations which were made separately for individual years to show an example of annual variability.

(1) To calculate water-level changes attributable to changes in discharge, streamflows from both the early period (1929–1958) and the later period (1975–2004) were converted to stage using the same stage-discharge relation (the recent relation for the Blountstown gage), and then differences in stage between the two periods were determined for each month. The same stage-discharge relation was used for both time periods to isolate the effects of flow changes from the effects of channel changes. These results show the consequences of changes in flow assuming the present channel shape.

(2) To calculate water-level declines attributable to channel changes, streamflows from the later period only (1975-2004) were converted to stage using both the pre-dam (pre-1954) and recent (1995-2004) stage-discharge relations at the Blountstown gage, and the water-level decline was determined from the difference in those two stages. The same time period of flow data (1975-2004) was used to calculate pre-dam and recent stage to isolate the effects of channel changes from the effects of changes in discharge.

Results and Discussion

A summary of the water-level decline that occurred throughout nearly all of the nontidal Apalachicola River as a result of changes in stage-discharge relations from 1954 to 2004 is discussed in this section. The effects of water-level decline on long-term duration of inundation and selected floodplain habitats are also discussed.

Magnitude and Extent of Water-Level Decline

The magnitude of the water-level decline in relation to distance along the river at 14 selected discharges is shown in figure 16. The lowest lines in figure 16 indicate that the largest stage declines occurred at the lowest discharges, which was anticipated in the discussion of figure 12. The 14 lines in figure 16 parallel one another with fairly consistent spacing. This pattern reflects the fact that all stage-discharge relations (apps. I-V) have a generally similar shape. There are minor departures, however, from this general pattern. In the vicinity

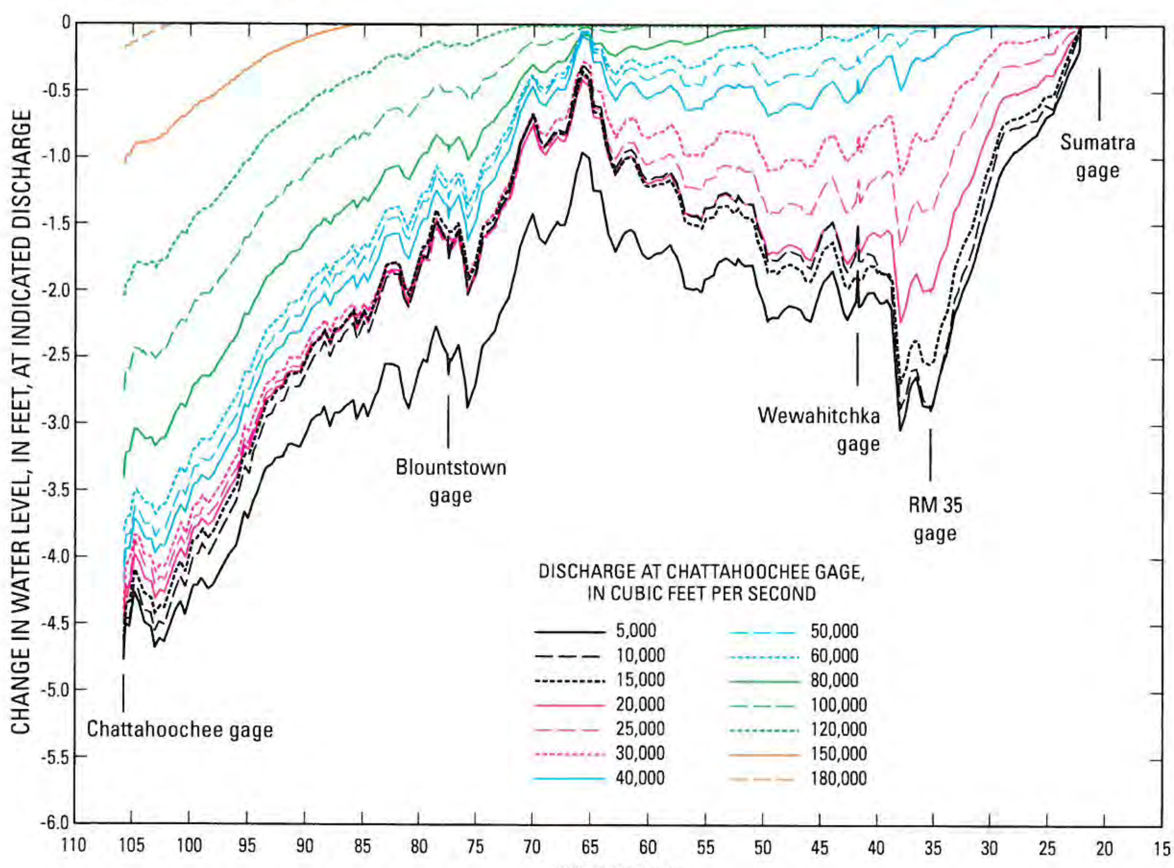

Figure 16. Patterns of water-level decline, at various discharges, that occurred along the nontidal Apalachicola River, Florida, as a result of long-term changes in stage-discharge relations from 1954 to 2004. Physical changes in the river channel caused the changes in stage-discharge relations, thus the decline is greatest at low discharges when all streamflow is contained within the channel, and least at high discharges when much of the runoff is flowing over the floodplain.

of the Wewahitchka gage, for example, the stage decline for 15,000 ft^3/s is slightly greater than the decline for 10,000 ft^3/s, indicating that some aspect of channel change in that vicinity was atypical. If the amount of channel widening at different elevations on the banks did not progressively decrease with increasing stage, crossed lines would occur on figure 16. At Wewahitchka, channel widening at the elevation associated with 15,000 ft^3/s (higher up on the bank) may have been greater than the amount of channel widening that occurred at the elevation associated with 10,000 ft^3/s (lower down on the bank). Considering that dredged material disposal has occurred along the riverbank at this and many other sites (USACE, 2001a), widening could have been atypical in some cases.

The largest water-level decline occurred at rm 105.7, just downstream from Jim Woodruff Dam, and the decline progressively decreased downstream to rm 66. Downstream progressing riverbed degradation is to be expected where a dam traps the sediment (sand in this case) of the streambed (Galay, 1983; Simons, Li, and Associates, 1985; Ligon and others, 1995). Sand in the streambed below the dam is naturally mobilized and transported downstream during large streamflow events. Prior to dam construction, those transported sediments were replaced by sand from upstream sources, but that does not occur now that the dam is in place because sediments are trapped in the reservoir. The consequence is a progressive lowering of the streambed surface, with greater magnitude of bed decline near the dam and lesser magnitude downstream. Other factors could also have contributed to the water-level decline. Dredging permanently removed streambed sediment from the channel environment and lowered the streambed surface when it was accompanied by disposal of dredged material on the floodplain (a common practice prior to 1973), but the relative contribution of this practice to bed lowering has not yet been determined. In addition, channel widening, which was documented using a time series of aerial photographs, has been relatively widespread throughout the entire nontidal river (Price and others, 2006) and probably also contributed to the water-level decline upstream from rm 66.

The near absence of water-level decline at most discharges in the vicinity of rm 66 is anomalous and not easily explained, considering that channel widening, which was relatively widespread along the entire river, occurred in this reach as well. It is telling that the trend toward progressively lessening declines moving downstream from the dam ended at rm 66, with a trend reversal of progressively increasing declines downstream from this location. River mile 66 probably marks the downstream limit of the influence of Jim Woodruff Dam with regard to riverbed degradation, because it is not obvious how the presence of the dam could have contributed to the increasing declines downstream from this location. Water-level declines downstream from rm 66 are likely the result of channel widening and other more localized factors.

The large and abrupt increase in water-level decline in the vicinity of rm 38 is unique within the pattern shown on figure 16. Widespread and repetitive activities (including annual maintenance dredging, disposal, and woody debris removal) probably contributed to this water-level decline, but do not explain why the decline was larger in this particular location. In addition to normal maintenance activities, meander cutoffs and bend easings were excavated in 1957 and 1969 to straighten the lower reach of the river within a few miles upstream and downstream from RM 35. Widening of the river channel was particularly large (50 percent increase in average width) in the vicinity of bend easings upstream from RM 35 (Price and others, 2006). In addition, a substantial amount of channel deepening was measured in cross-section surveys downstream from RM 35 in the vicinity of the two largest meander cutoffs (Price and others, 2006). Upstream-progressing riverbed degradation is a predictable consequence when a river reach is shortened by meander cutoffs (Galay, 1983).

The fact that the water-level decline was negligible near the Sumatra gage site is to be expected. The Sumatra gage is located at the approximate boundary between the nontidal and tidal reaches of the Apalachicola River. Near the mouth of an alluvial river that flows into the sea, the surface of the river must always merge smoothly with sea level irrespective of any channel changes that may take place.

Certain small-magnitude aspects of the pattern of water-level decline (fig. 16) are likely the result of errors. The sharp change in the decline (for all discharges except the very highest) just downstream from the Chattahoochee gage, and the abrupt "uptick" in many of the lines at the Wewahitchka gage are examples. The methods for developing stage-discharge relations at gages and between-gage sites were different. Thus the values in figure 16 at the exact gage locations were determined differently than the values 0.1 rm upstream and downstream from the gages (and at all locations between gages). As explained in the "Methods" section, stage-discharge relations at the five gage sites were developed using only the long-term streamgage records at those sites, whereas a combination of water-surface profile data and streamgage records were used to develop interpolated relations at between-gage sites at closely spaced intervals of 0.1 rm. The interpolated between-gage relations were based primarily on water-surface profile data at low flows, with a gradually increasing use of the long-term gage data in the interpolations at higher discharges. Table 6 and figure 9 show that the water-surface profile data are in general agreement with stages determined from long-term gage records. Minor discrepancies at Chattahoochee and Wewahitchka, however, are large enough to be visible in figure 16. In the first case, the decline shown at the exact Chattahoochee gage location is more accurate than those shown in about the first 3 rm downstream from the gage. This is because the between-gage declines were based on water-surface profiles developed in 1956 after more than 0.5 ft of decline had already occurred at the gage from riverbed degradation resulting from sediment trapping in Lake Seminole. The declines at the exact location of the Wewahitchka gage are also probably more accurate than the between-gage declines. The uptick at Wewahitchka provides an example of the error that is possible in the between-gage declines at the lower discharges, which were based primarily on the water-surface profile data.

The magnitude of the declines at the gage sites is graphically presented in figure 17A (and listed on the left side of app. IX) in relation to 14 selected discharges. The decline at the Chattahoochee gage is more than twice the decline at any other gage at all discharges shown, and exceeds 2 ft even at discharges as high as 120,000 ft^3/s. At discharges in the 25,000 to 100,000 ft^3/s range, the second largest decline is at the Blountstown gage. At the lowest flows, the second largest decline is at the RM 35 gage.

The detailed data shown by river mile in figure 16 is summarized by major reaches of the river in figure 17B (and listed on the right side of app. IX). As expected, the upper reach has the greatest declines at all discharges shown. Declines in the middle reach at discharges of 20,000 ft^3/s and less are relatively similar to those in the lower reach.

Effects of Water-Level Decline on Floodplain Habitats

Effects of the long-term water-level decline on hydrologic conditions in floodplain habitats are described in this report primarily in terms of decreases that have occurred in percent duration of inundation. Actual duration of inundation in the recent period, reflecting the effects of water-level decline, were compared to the approximate natural duration of inundation that would have occurred in that same period if water levels had not declined. Figure 18 shows these approximate decreases in duration of inundation in relation to distance along the river for 14 selected discharges. Approximate decreases in duration of inundation at the gage sites and average decreases for reaches of the river are shown in figure 19 for those same 14 selected discharges.

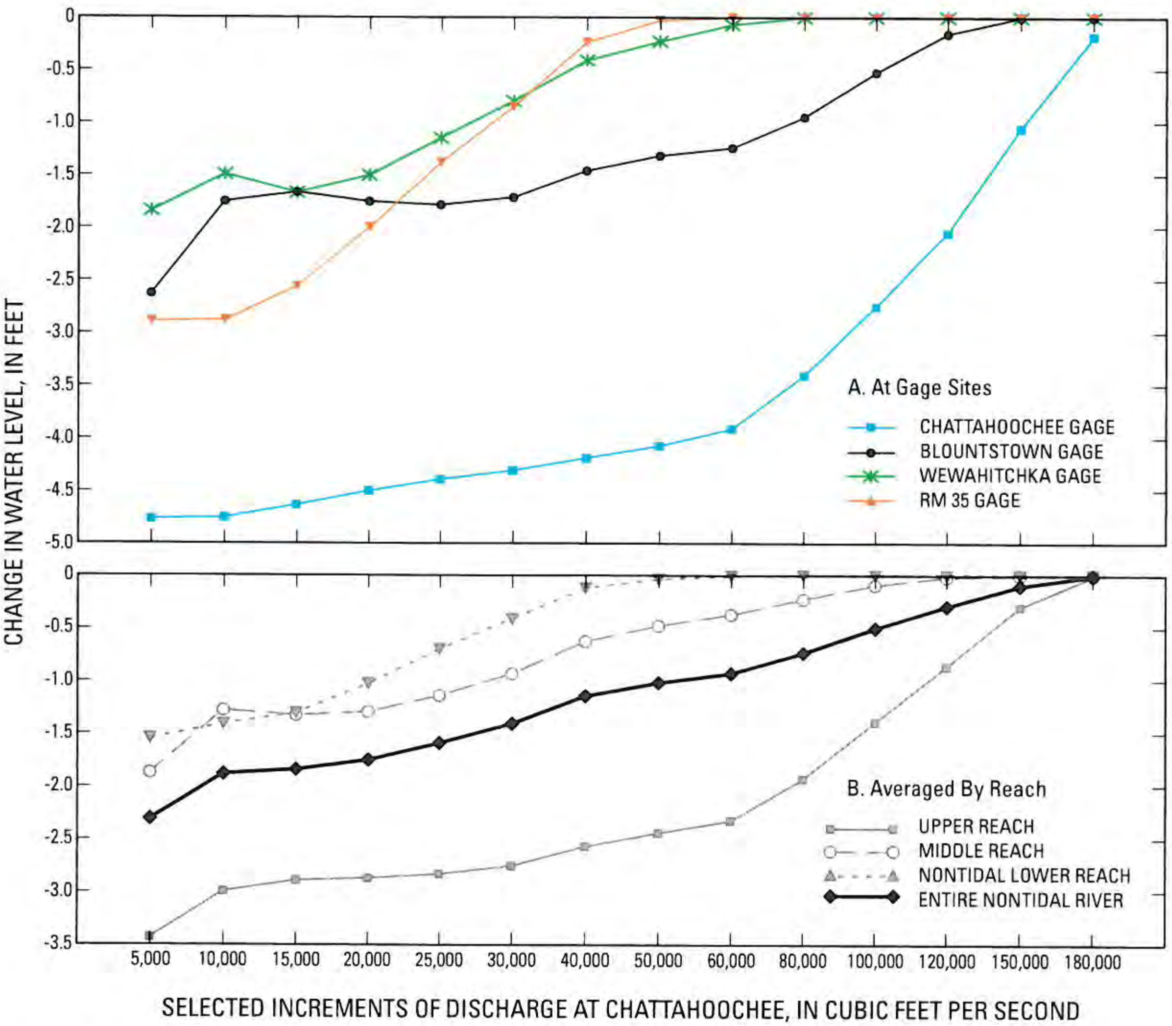

Figure 17. Water-level decline, at various discharges, that occurred along the nontidal Apalachicola River, Florida, as a result of long-term changes in stage-discharge relations from 1954 to 2004 (A) at streamgage sites, and (B) averaged by reach. Physical changes in the river channel caused the changes in stage-discharge relations, thus the decline is greatest at low discharges when all streamflow is contained within the channel, and least at high discharges when much of the runoff is flowing over the floodplain.

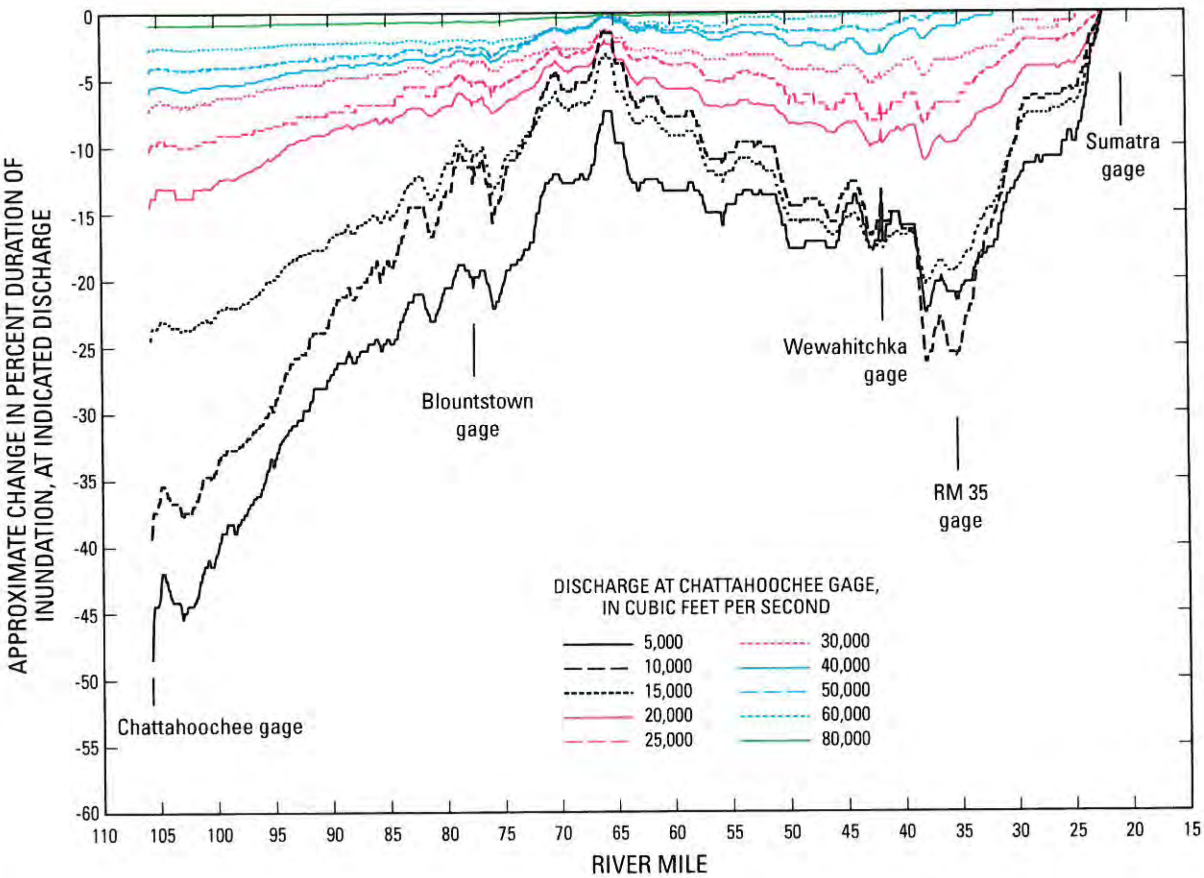

Figure 18. Patterns of approximate decreases in percent duration of inundation, at various discharges, that occurred along the nontidal Apalachicola River, Florida, as a result of long-term changes in stage-discharge relations from 1954 to 2004. These results represent the difference between duration of inundation under actual conditions in the recent period (water years 1995–2004), reflecting the effect of water-level decline, and the duration of inundation that would have occurred in that same period if water levels had not declined. Calculations were made in a series of steps, described in the methods, starting with the pre-dam and recent stage-discharge relations. NOTE: Duration values are dependent on the time period used for calculating them (1995–2004 in this case) and would be different if a different time period were used.

Appendix X lists the values resulting from each step of the calculation process used to generate the results shown in figure 19. This appendix is a three-part table with equivalent-stage discharges shown in part A, the corresponding percent exceedance values in part B, and approximate decreases in duration of inundation in part C. The values in part C of appendix X are the same values as shown in figure 19.

Similar to figure 16, the greatest decreases in inundation shown in figures 18 and 19 occur at the lowest discharges, with minor departures from this general pattern. The reasons for the departures are twofold: (1) some aspect of channel change in that vicinity may have been atypical (as explained in the discussion of fig. 16), and (2) differences in durations can vary depending upon which part of the flow duration curve is involved in the change from the pre-dam discharge to the recent equivalent-stage discharge (as illustrated in fig. 15).

Large decreases in percent duration of inundation of about 20 to 45 percent occurred in the upstream-most 10 mi of the upper reach for discharges of 5,000, 10,000, and 15,000 ft^3/s (fig. 18). As expected, these decreases were greater than at any other location along the river. But for all other discharges, decreases in duration of inundation in the upper reach were relatively similar to decreases in much of the middle and lower reaches. This differs from the results shown in figure 16, in which the magnitude of water-level declines in the upper reach were substantially greater than in the middle and lower reaches for all discharges. Dissimilar results in these two figures are primarily due to differences in floodplain topography between the reaches. In the lower reach, adjacent floodplains are lower in relation to river stage and the floodplain is wider and has lower relief than in the upper reach (figs. 2 and 7). In addition, a substantial amount of river flow

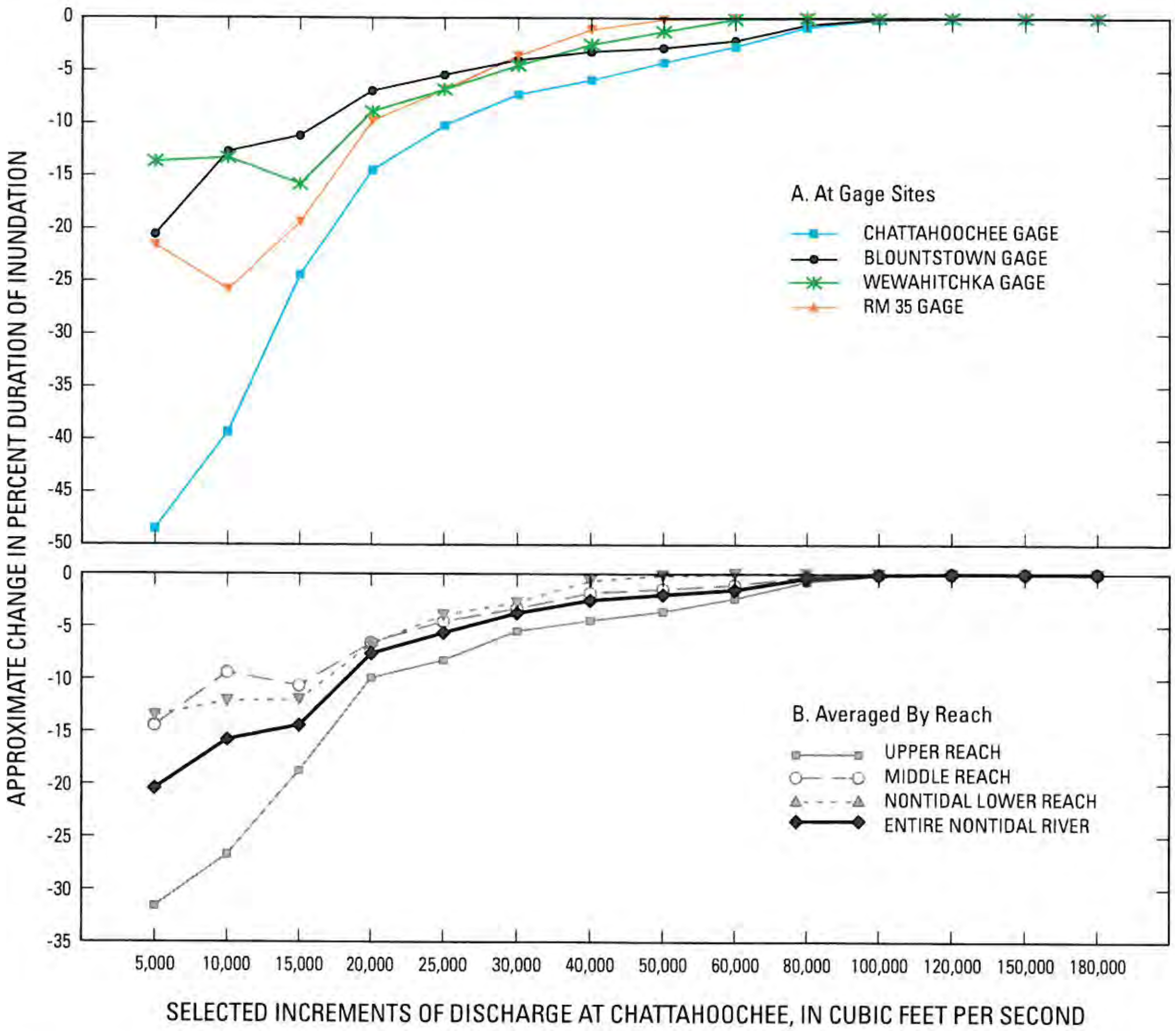

Figure 19. Approximate decreases in percent duration of inundation, at various discharges, that occurred along the nontidal Apalachicola River, Florida, as a result of long-term changes in stage-discharge relations from 1954 to 2004 (A) at streamgage sites and (B) averaged by reach. These results represent the difference between duration of inundation under actual conditions in the recent period (water years 1995–2004), reflecting the effect of water-level decline, and the duration of inundation that would have occurred in that same period if water levels had not declined. Calculations were made in a series of steps, described in the methods, starting with the pre-dam and recent stage-discharge relations. NOTE: Duration values are dependent on the time period used for calculating them (1995–2004 in this case) and would be different if a different time period were used.

leaves the main channel and is carried by large side-channel streams even during low-flow conditions. As a result, a difference in river stage is usually associated with a larger difference in discharge at downstream sites than at upstream sites. For a discharge of 30,000 ft^3/s, for example, the water-level decline shown in figure 17 for the Blountstown gage (1.7 ft) was more than twice the decline that occurred at the Wewahitchka gage (0.8 ft). Yet the equivalent-stage discharge required in the recent period to replicate the pre-dam stage for 30,000 ft^3/s is similar between the two sites (35,500 ft^3/s at Blountstown, 36,500 ft^3/s at Wewahitchka; app. X, part A). Consequently, the approximate decrease in duration of inundation as a result of that water-level decline is slightly greater at Wewahitchka (4.5 percent) than at Blountstown (4.0 percent) (fig. 19) in spite of the substantially smaller water-level decline at Wewahitchka.

Specific Examples of Habitat Alteration

Determining the effects of water-level declines on particular species or biological communities in the floodplain requires an understanding of the seasonal habitat needs of those particular organisms. Decreases in duration of inundation caused by water-level decline in the river are calculated for different seasonal periods in each of the following examples to describe conditions that are important to the organisms that are dependent upon those sites. Although analyses of floodplain effects in this report are based primarily on decreases in duration of inundation, a variety of other types of streamflow statistics can be used to evaluate the effects of water-level decline on floodplain habitats.

Access to cool-water refuges for striped bass.—At one time, the native Gulf Coast race of the striped bass (*Morone saxatilis*) was a commercially and recreationally important species with widespread distribution in most rivers along the Gulf of Mexico. Currently, the last remnant population appears to exist only in the Apalachicola River system (Wooley and Crateau, 1983; Lukens, 1988). Construction of dams and impoundments that have blocked passage to spawning grounds and cool-water refuges, and widespread use of agricultural chemicals have been cited as possible reasons for the rapid decline of the Gulf Coast striped bass, which occurred from about 1940 to 1960 (Wooley and Crateau, 1983; Van Den Avyle and Evans, 1990; Striped Bass Technical Task Force, 2005). Annual stocking is now required to maintain harvestable population levels, because natural reproduction is extremely limited (ACF Striped Bass Technical Committee, 2004).

Adult striped bass, which cannot tolerate the warm ambient water temperatures of rivers and reservoirs, require access to cool-water refuges for summer survival (Moss, 1985; Coutant, 1985 and 1987; Lukens and Barkuloo, 1990; Van Den Avyle and Evans, 1990; Zale and others, 1990). Striped bass typically move into cooler waters in May and remain there through October (Van Den Avyle and Evans, 1990). Adult striped bass larger than 10 pounds are more vulnerable to summer temperature stress than smaller individuals (Wooley and Crateau, 1983). Although individuals up to 48 pounds have been reported from the upper Apalachicola River, they usually do not exceed 25 or 30 pounds (Charles L. Mesing, Florida Fish and Wildlife Conservation Commission, written commun., 2006). To provide adequate access for these large adult fish, cool-water streams probably need to be at least 3 ft deep during the warm season (May-October).

More than a dozen perennial cool-water streams in the upper reach of the Apalachicola River, as well as springfed streams in the lower reach of the Flint River, have been identified as thermal refuges for adult striped bass during the warm season (Lukens and Barkuloo, 1990; Van Den Avyle and Evans, 1990; Charles L. Mesing, Florida Fish and Wildlife Conservation Commission, written commun. 1995). One of these cool-water refuge streams is Flat Creek, which drains 52 mi^2 in an upland area adjacent to and east of the upper reach of the Apalachicola River (fig. 2; Light and others, 1998). The downstream-most 2 mi of Flat Creek flows through the Apalachicola River floodplain before it empties into the main river channel at rm 99.5 (fig. 20). Temperatures in Flat Creek during the summer are cooler than river temperatures because this creek is fed partly by ground water.

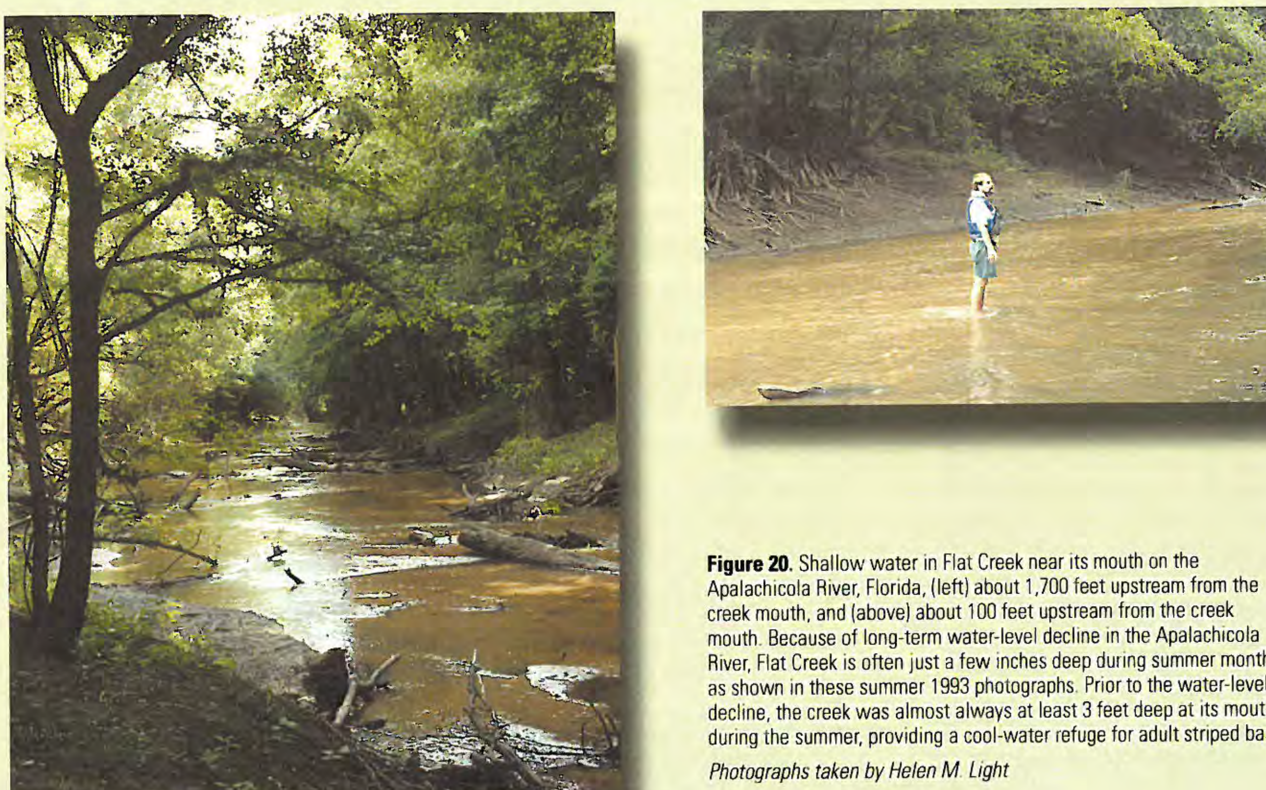

Figure 20. Shallow water in Flat Creek near its mouth on the Apalachicola River, Florida, (left) about 1,700 feet upstream from the creek mouth, and (above) about 100 feet upstream from the creek mouth. Because of long-term water-level decline in the Apalachicola River, Flat Creek is often just a few inches deep during summer months, as shown in these summer 1993 photographs. Prior to the water-level decline, the creek was almost always at least 3 feet deep at its mouth during the summer, providing a cool-water refuge for adult striped bass.

Photographs taken by Helen M. Light

The availability of thermal refuge habitat in Flat Creek and other cool-water streams in the upper reach of the Apalachicola River has been severely reduced by water-level decline since 1954. These streams are often too shallow during summer to provide access for adult striped bass (fig. 20). In the recent period from 1995 to 2004, the percentage of time in May through October that the mouth of Flat Creek was at least 3 ft deep has been reduced by more than half because of water-level decline (fig. 21). If channel changes had not occurred, cool-water refuge would have been available in Flat Creek about 90 percent of the time in the months of May through October during the 10 years of the recent period. Because of water-level decline, however, cool-water refuge was available only about 40 percent of the time during this period. In addition, there was not a single year in the recent period (1995–2004) that Flat Creek was available for adult striped bass continuously throughout the thermal refuge season of May through October (fig. 21). By comparison, if water-level decline had not occurred, availability 100 percent of the time during the thermal refuge season would have occurred in 6 out of 10 years, with more than 70 percent availability in 9 out of 10 years (all years except 2000).

By severely reducing access to critical habitat in cool-water streams, water-level decline in the Apalachicola River probably contributed, in part, to the historical decline and the present low numbers of the Gulf Coast race of striped bass. Water depths in more than a dozen Apalachicola River tributaries known to be thermal refuge streams are no longer sufficient to provide access for adult striped bass when river discharge drops below 8,000 ft^3/s, with the exception of Selman's Ditch, which was artificially dredged and deepened many years ago. Excavation to deepen the mouths of other cool-water refuge streams has provided only short-term benefits (Long, 2004; Striped Bass Technical Task Force, 2005) (see section entitled "Future Trends and Potential for Restoration").

Persistence of flowing-water habitat for listed mussels.—In the past 50 years, a precipitous decline in freshwater mussels appears to have occurred in the ACF Basin, similar to the decline that has occurred throughout the southeastern United States (Brim Box and Williams, 2000). Causes of the decline in the ACF Basin, although not quantitatively documented, probably include construction of dams and impoundments, dredging and channel modifications, excess sedimentation from erosion as a rsult of poor agricultural practices, introduction of the Asian clam (*Corbicula fluminea*), and pollution (Neves and others, 1997; Brim Box and Williams, 2000).

Many species of freshwater mussels, including threatened and endangered species, exhibit high mortality in the absence of flowing water and the ensuing hypoxic conditions (Johnson and others, 2001; USFWS, 2003; Golladay and others, 2004). Perennial flowing streams in the floodplain that have upland drainage areas, such as Flat Creek, are common in the upper reach of the Apalachicola River. Listed mussels, however, have not been found in these streams, with the exception of the Shinyrayed pocketbook (*Lampsilis subangulata*), which was last seen in 1962 and apparently extirpated since then

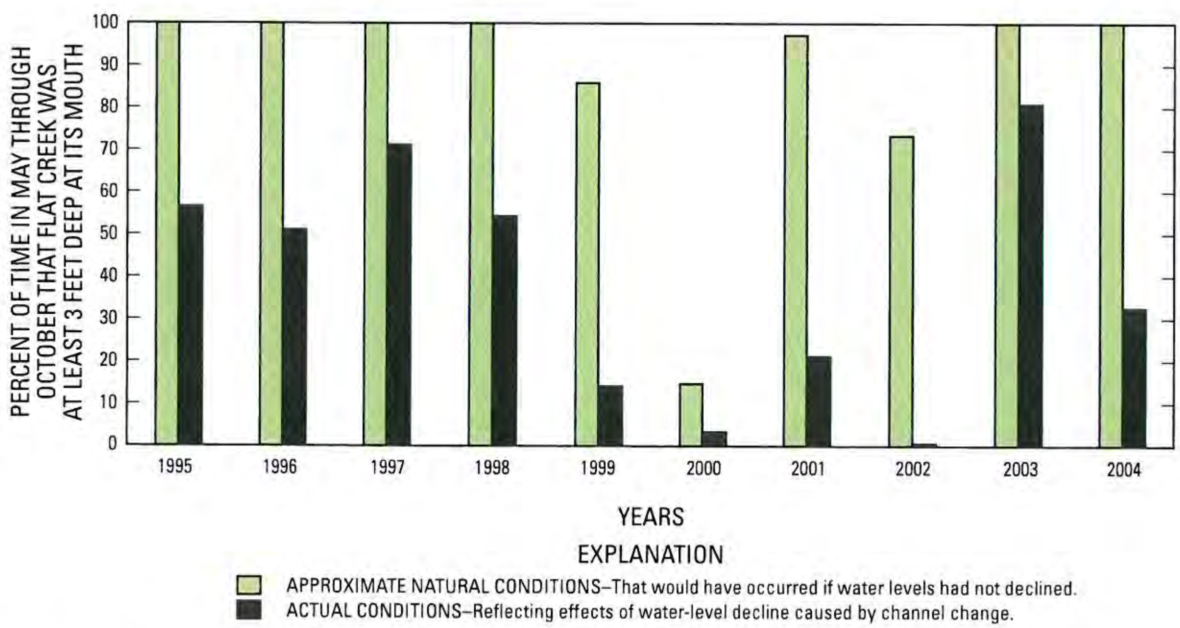

Figure 21. Effects of water-level decline on the availability of thermal refuge habitat for adult striped bass in Flat Creek on the Apalachicola River, Florida, from 1995 to 2004. Water depths at the creek mouth were based on a cross-section survey in 1993 120 feet upstream from the mouth of the creek where it empties into the upper reach of the Apalachicola River at river mile 99.5.

(USFWS, 2003). The absence of rare mussels in floodplain streams of the upper reach could be related to the drastic reductions in mussel populations reported for the mainstem of the upper Apalachicola River, an area that once harbored an abundant and diverse mussel fauna as recently as 50 years ago (Brim Box and Williams, 2000).

Floodplain streams in the middle and nontidal lower reaches of the Apalachicola River are a different type of stream than the perennial streams of the upper reach. Some of the largest off-channel water bodies, like Iamonia Lake and Florida River, may receive minor contributions from upland runoff, but are largely controlled by backwater from the main river channel. Many of the smaller streams and sloughs are what have been informally called "loop streams" by Light and others (1998), where water diverted from the Apalachicola River enters at the head of the stream, flows a few miles along the stream through the floodplain, and returns to the river at the mouth of the stream. Loop streams are fed by the river and receive no direct upland runoff, and can be perennial or intermittent depending on whether or not the streambed elevation is below minimum river levels. An intermittent loop stream stops flowing when the water level of the river is lower than the elevation of the streambed. Some of these streams are dewatered completely when river levels are low; others become a series of stagnant, isolated pools along the streambed (fig. 22). These pools can become hypoxic during extended periods of isolation, especially in warm weather. Further details about streams and sloughs of the Apalachicola River floodplain, including descriptions of their periodic connection and disconnection to the main river channel, and photographs of the major stream types, can be found in Light and others (1998).

Swift Slough and Moccasin Slough, two loop streams in the nontidal lower reach with similar channel widths and lengths, are fed by the Apalachicola River at their heads and empty into the River Styx at their mouths (fig. 2). Moccasin Slough is an intermittent stream that alternately connects and disconnects to the main river channel, depending upon river levels. Moccasin Slough flows when river levels are high enough for the stream to be connected to the main channel, and has small isolated pools along the bed when river levels are too low to enter the stream at its head (fig. 22). In the recent period, Moccasin Slough was disconnected and experienced no flow for extended periods during dry years (fig. 23). Continuous periods of disconnection in the drought years of 1999, 2000, 2001, and 2002 were estimated to be as long as 12, 28, 7, and 7 weeks, respectively. Moccasin Slough was a perennial stream prior to water-level decline in the

Figure 22. Comparison of flowing and nonflowing conditions in Moccasin Slough in the lower reach of the Apalachicola River, Florida. Moccasin Slough is a "loop stream" in which water diverted from the Apalachicola River enters at its head, flows about 2 miles through the floodplain, and returns to the river at the slough mouth. Moccasin Slough was a perennial flowing stream prior to 1954, similar to photograph (left), because river levels were always high enough for water to enter the stream and maintain flowing-water conditions. Because of water-level decline in the river, Moccasin Slough now becomes disconnected for extended periods during dry years, similar to photograph (above), with stagnant, isolated pools along a streambed that is mostly dewatered.

Photographs taken by Helen M. Light

Apalachicola River, and permanent flowing water conditions would have been continuously maintained in Moccasin Slough throughout the recent drought of 1999 to 2002 if water levels in the river had not declined.

Because Moccasin Slough probably has been an intermittent stream since the early 1980s, with nonflowing conditions lasting weeks or months during dry years, the slough has not been suitable habitat for threatened or endangered mussels that depend on continuously flowing water to maintain oxygenation. Consequently, no listed mussels have been found there. Many species of fish are intolerant of hypoxic or nonflowing conditions as well, including fish identified as host species necessary to support the larval phase of mussel reproduction. The blackbanded darter (*Percina nigrofasciata*) has been identified as a potential host species for the endangered fat threeridge (*Amblema neislerii*) (USFWS, 2003). Darters as a group generally inhabit flowing waters and would be unlikely to survive in the isolated pools of intermittent floodplain streams (Kuehne and Barbour, 1983; Leitman and others, 1991).

Swift Slough, by comparison, was a perennial stream until recently (July 2006) and harbored a relatively abundant and diverse mussel fauna, including the largest population of fat threeridge known to inhabit floodplain streams of the Apalachicola River (USFWS, 2003; EnviroScience, Inc., 2006). Swift Slough was observed to be disconnected for the first time on record in late July 2006 (Charles L. Mesing, FFWCC, written commun., 2006), as a result of very low flow in the river (5,100 ft^3/s) in combination with a higher than normal streambed elevation in the first 700 ft of the head of the slough (1.3 ft higher than during the previous observation in August 2000). Sand from a large shoal in the main river channel immediately upstream of the slough may have been deposited in the slough during a longer than normal high water period (exceeding 6 months) in 2003 and a major flood event (maximum daily mean discharge of 158,000 ft^3/s) in 2005.

The only floodplain streams known to have live populations of listed mussels are those with persistent flowing water. Fat threeridge populations were reported in Kennedy Creek (EnviroScience, Inc., 2006) in a location having perennial flow (Light and others, 1998). One live purple bankclimber (*Elliptoideus sloatianus*) was found in River Styx in 2000 (Theodore S. Hoehn, Florida Fish and Wildlife Conservation Commission, written commun., 2006). Flow in River Styx is typically sluggish during low-flow periods, but this backwater slough has not been known to disconnect completely from the Apalachicola River. Dead shells of fat threeridge and purple bankclimber were found in two small unnamed intermittent streams between rm 30.0 and rm 30.3 that flow (when river levels are high enough) from the Apalachicola River to Douglas Slough (Jerry W. Ziewitz, USFWS, written commun., 2000). It is not known if the dead shells washed in from the river or were the remains of live mussels that succumbed to adverse conditions in these streams when the streams stopped flowing. Several fat threeridge and purple bankclimber mussels were found in the main channel of the river

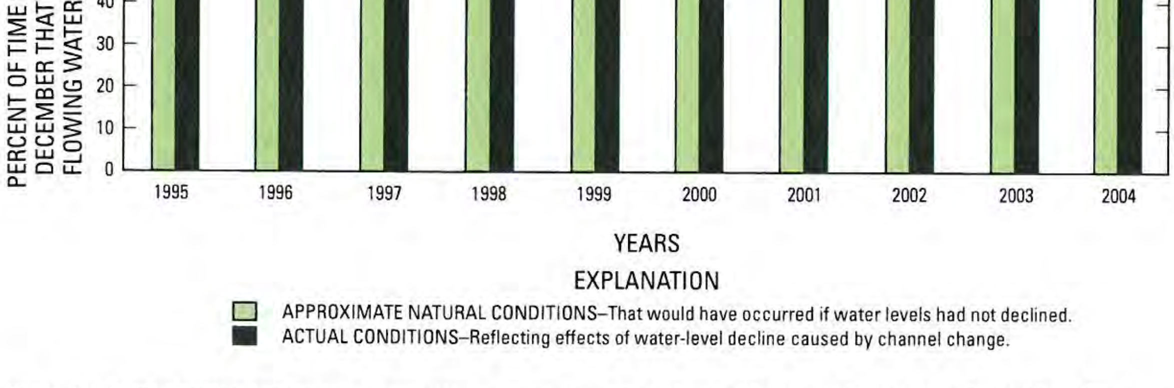

Figure 23. Effects of water-level decline on persistence of flowing-water habitat in Moccasin Slough on the Apalachicola River, Florida, from 1995 to 2004. These results are based on an elevation survey of the streambed in the head of Moccasin Slough and observations of flowing and non-flowing conditions in 2001 and 2002 compared to simultaneous stage measurements at RM 35 streamgage.

at the mouths of these unnamed streams, but no live mussels were found in the streams themselves (Jerry W. Ziewitz, USFWS, written commun., 2001; Payne and Miller, 2002; EnviroScience, Inc. 2006).

It has been hypothesized that floodplain streams in the nontidal lower reach could support mainstem mussel communities by serving as a core reproductive population for these species (James D. Williams, USGS, oral commun., 2006). Water-level decline in the Apalachicola River, however, appears to be an important limiting factor for rare mussels because of its effect on the persistence of flowing water conditions in floodplain streams of the nontidal lower reach.

Duration of inundation in tupelo-cypress swamps.—Tupelo-cypress swamps are found in the lowest elevations of the forested floodplain where the longest periods of inundation occur. Low bottomland hardwood trees grow on slightly higher elevations where inundation periods are shorter. The long duration of inundation and deep flooding that occurs in tupelo-cypress swamps controls forest composition primarily through a process of exclusion, drowning the seedlings of most bottomland hardwood species before they can become established (Hosner, 1960; Light and others, 1993, 2002). The seedlings of water tupelo (*Nyssa aquatica*) and bald cypress (*Taxodium distichum*) are more likely to survive flooding in swamps because they grow tall much faster than bottomland hardwood species (Harms, 1973; Brown, 1984). Solitary individuals of bald cypress grow well at higher elevations in the floodplain, and even do well when planted on upland sites, but natural stands with large numbers of bald cypress trees, as shown in figure 24, occur only where flooding lasts long enough to limit competition from drier habitat species. Limited competition is also a necessary prerequisite for the establishment of water tupelo trees, but unlike bald cypress, water tupelo requires wet conditions to thrive in the seedling stage and will not grow well under drier conditions (Applequist, 1959; Hosner and Boyce, 1962; Dickson and others, 1965). Where flooding has decreased in depth or duration, species of trees most commonly found in bottomland hardwood forests will successfully invade tupelo-cypress swamps, changing the swamps to a drier forest type.

Elevations and tree compositions of sampling points near Porter Lake in the middle reach of the Apalachicola River were surveyed by Leitman and others (1984) and reanalyzed as part of this study to show the effects of water-level decline on swamp forests. Because of its proximity to a stream that connects Porter Lake to the Apalachicola River at rm 48.3, water levels in swamps at the sampling area are directly controlled by river stage. Thus, percent duration of inundation calculated by the methods used in this report can be applied directly without any adjustments for water retention in topographic depressions. Inundation of floodplain forests has little effect on tree growth and survival during the dormant season, so duration calculations were made only on water-level data during the growing season of March 1-November 24 (last and first 32 °F freeze dates at the Quincy, Florida, weather station, 1971-2000).

Figure 24. Tupelo-cypress swamp near Porter Lake in the middle reach of the Apalachicola River, Florida, during a summer low-water period. The trees in this photograph are primarily cypress, with dark, distinct "water lines" on swollen trunks several feet above ground that were formed during the high water season in winter and early spring. Duration of inundation in this swamp is considerably shorter than it was before 1954, because of long-term water-level decline in the Apalachicola River.

Photograph taken by Helen M. Light

During the 10 years of the recent period, duration of inundation in the growing season at the average elevation of the tupelo-cypress swamp at this site was 29 percent, based on actual conditions reflecting the effects of water-level decline caused by channel change (fig. 25). The approximate duration of inundation in the growing season that would have occurred in this swamp if water levels had not declined was 47 percent. Thus, the water-level decline in the river has shortened the duration of inundation in the growing season in the tupelo-cypress swamp at Porter Lake to the extent that hydrologic conditions in the swamp are now more similar to natural conditions associated with the low bottomland hardwood forest (19 percent) than to conditions previously associated with the swamp.

A preliminary assessment of vegetative changes indicates that Porter Lake swamps are shifting to a drier forest composition. Based on a comparison of historical (1979) to present (2005) composition and a comparison of the present canopy to the present subcanopy (using younger trees as an indication of the future canopy), a change has occurred in forest composition of about 10 to 20 percent toward a drier forest type in the Porter Lake tupelo-cypress swamp. Because forest composition changes slowly, the full impact of the hydrologic change may not occur for many more years. Other effects of altered hydrology may be slower growth rates, higher mortality rates, and reduced density. The composition of low and high bottomland hardwood forests may also change in response to drier conditions.

Effects on Floodplain Habitats: An Overview

The specific examples given at Flat Creek, Moccasin Slough, and Porter Lake swamp illustrate the impacts of water-level decline on floodplain habitats. The reduction in availability of cool-water refuge by more than half in Flat Creek, the conversion of the previously perennial Moccasin Slough to an intermittent stream with no flow for weeks or months during dry years, and the alteration of hydrologic conditions in tupelo-cypress swamps near Porter Lake to the extent that tupelo-cypress swamps are changing to a different and drier forest type, represent only a few examples of the impacts that have occurred in floodplain habitats as a result of water-level decline caused by channel change. Water-level declines in the river have substantially changed long-term hydrologic conditions in more than 200 mi of off-channel floodplain sloughs, streams, and lakes and in most of the 82,200 acres of floodplain forests in the nontidal reach of the Apalachicola River (fig. 18; Light and others, 1998). Figure 26 illustrates some of the other effects that decreasing river levels have on floodplain habitats.

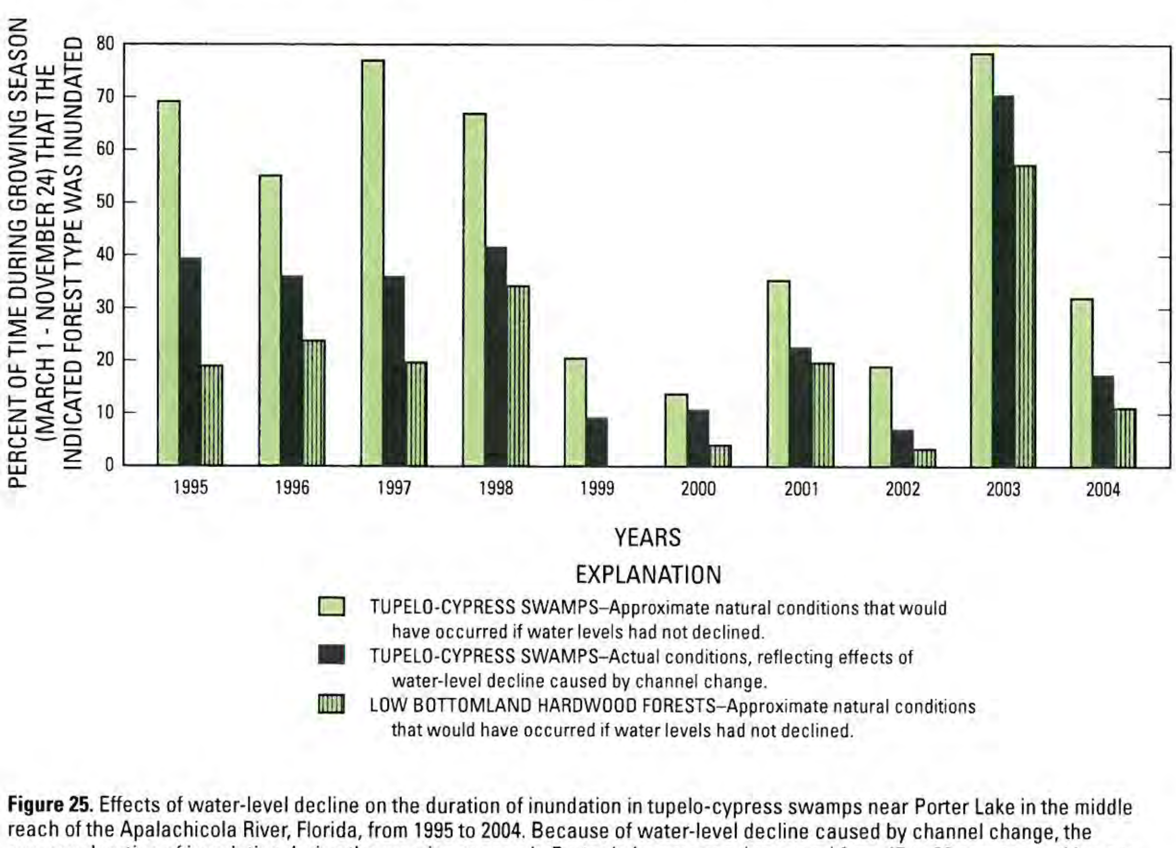

Figure 25. Effects of water-level decline on the duration of inundation in tupelo-cypress swamps near Porter Lake in the middle reach of the Apalachicola River, Florida, from 1995 to 2004. Because of water-level decline caused by channel change, the average duration of inundation during the growing season in Porter Lake swamps decreased from 47 to 29 percent, and is now more similar to the natural conditions associated with low bottomland hardwood forests (19 percent).

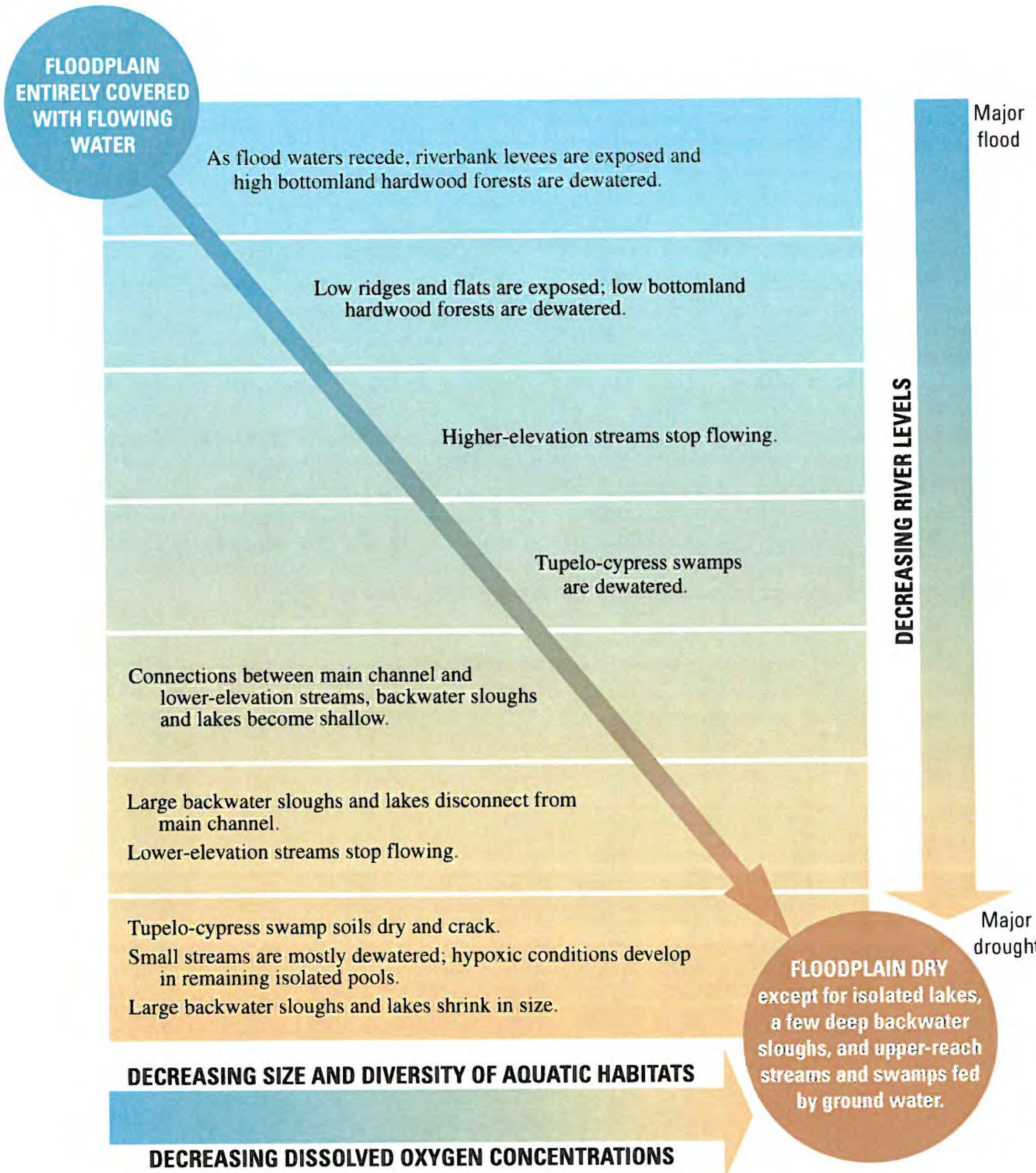

Figure 26. Conceptual relation between conditions in floodplain habitats and decreasing river levels in the nontidal Apalachicola River, Florida. A fluctuating flow regime is a natural characteristic of this river system, and all conditions shown occur naturally at various times in some floodplain habitats. Long-term water-level declines in the river, however, have substantially increased the frequency and duration of nonflowing, disconnected, hypoxic, and dewatered conditions in the floodplain.

Except during the highest floods, when the floodplain is entirely covered with water moving in a downstream direction, the river-floodplain corridor contains a constantly changing mixture of terrestrial and aquatic habitats as water levels fluctuate seasonally and annually between the wet and dry extremes shown in figure 26. The high diversity of habitat types and hydrologic conditions in the Apalachicola River floodplain helps explain the high biological diversity of this system. All of the habitat conditions shown in figure 26 occur periodically in some parts of the floodplain in response to the naturally fluctuating flow regime of this system. The frequency and duration of conditions at the dry end of the spectrum, however, have increased substantially because of long-term water-level declines. Nonflowing, hydrologically disconnected, and dewatered conditions occur much more often as a result of the decline, with important consequences on water quality, particularly dissolved oxygen concentrations. Based on over 900 water-quality measurements made in various floodplain habitats of the Apalachicola River from 2001–2004, mean dissolved oxygen concentrations were 6 ppm (parts per million) in flowing waters, 5 ppm in nonflowing backwaters connected to the main channel, 4 ppm in backwaters that had been isolated from the main channel less than 6 weeks, and less than 2 ppm in backwater areas that had been isolated from the main channel more than 6 weeks (Stephen J. Walsh, USGS, written commun., 2006). Ponds and lakes remaining in the floodplain shrink in size from evaporation and infiltration during extended periods of low water levels, reducing the amount of aquatic habitat connected to the main river channel to 200 acres or less during severe droughts (Light and others, 1998).

Long-term hydrologic changes in floodplain habitats of the Apalachicola River described so far in this report were caused by channel changes only. Changes in the amount of water delivered from upstream were not included in the calculations of decreased duration of inundation presented in figures 18, 19, 21, 23, and 25, because effects of water-level declines caused by changes in stage-discharge relations were calculated independent of changes in flow (see section entitled "Approximate Decrease in Duration of Inundation Caused by Channel Change"). A discussion of additional hydrologic changes that have occurred as a result of changes in flow is necessary in this general overview of the effects of water-level decline on floodplain habitats.

Long-term changes in monthly discharge.—Average discharge in the earliest 30 years (1929–1958) and latest 30 years (1975–2004) in the period of record at the Chattahoochee gage was very similar (21,200 and 21,500 ft^3/s, respectively), but the seasonal distribution of flows has changed. Figure 27 compares monthly streamflow statistics (10, 25, 50, 75, and 90 percent exceedance) in these two periods. During median conditions (fig. 27C), fall and winter discharges increased and spring and summer discharges decreased, with the greatest changes in February (23 percent more discharge) and April (22 percent less discharge). During drought conditions (90 percent exceedance, fig. 27E), discharge decreased in all months except February, with the greatest decreases in April, May, July, and August (28, 24, 26, and 29 percent less discharge, respectively).

Long-term changes in the monthly discharge in the Apalachicola River are probably caused by a combination of natural climatic changes and anthropogenic activities in the ACF Basin, some of which are listed below. Although numerous reports have addressed most of these activities and changes, there is no comprehensive summary describing the degree to which each of the factors have affected streamflow in the Apalachicola River. In the following discussion, the order in which various factors are addressed does not necessarily imply order of importance. Trend analyses relating discharge to climate, which is not within the scope of this report, would be necessary to understand the degree to which anthropogenic effects have contributed to the observed changes in monthly discharge.

Climatic differences may have contributed, in part, to differences in monthly discharge between the earlier and later periods. Large increases in median February and March discharge in the Apalachicola River (fig. 27C), for example, were also observed in two smaller, undammed rivers nearby to the east and west (Suwannee River at Ellaville, Choctawhatchee River near Bruce; USGS, 2006b,c). In many north Florida streams, including the Apalachicola River, winter streamflow increased from 1940–1969 to 1970–1999 (Kelly, 2004). This increase was attributed to a long-term cyclical pattern in Atlantic Ocean sea-surface temperatures called the Atlantic Multidecadal Oscillation (AMO) in which 1940 to 1969 was a warm phase and 1970 to 1999 was a cool phase. In that comparison, the increase in average annual flow in the Apalachicola River during the recent cool phase (1970–1999) was less than all other north Florida streams examined, possibly because streamflow decreased at all Flint River stations during that period—a trend atypical of the southeastern United States in general. It is important to understand the effect of the AMO and other long-term climatic patterns (such as the El Niño Southern Oscillation) on Apalachicola River flow, because these natural cycles can alternately "disguise or accentuate" the effects of anthropogenic activities (Enfield and others, 2001).

Flow regulation is carried out by USACE through the management of reservoir storage and releases at three Federal dams along the Chattahoochee River (Buford, West Point, and Walter F. George; fig. 1) (USACE, 1989; 2006a). Reservoirs impounded by George W. Andrews and Jim Woodruff Dams are essentially run-of-river projects and are not normally used for flow regulation. Although reservoir operations vary from year to year depending upon river levels, climatic conditions, and water management needs, operations generally follow pool-level guidelines called "action zones" to meet project purposes for each reservoir (USACE, 2006a,b). Management for flood control typically includes releases of water in the fall (October-December) to lower reservoir pool levels in advance

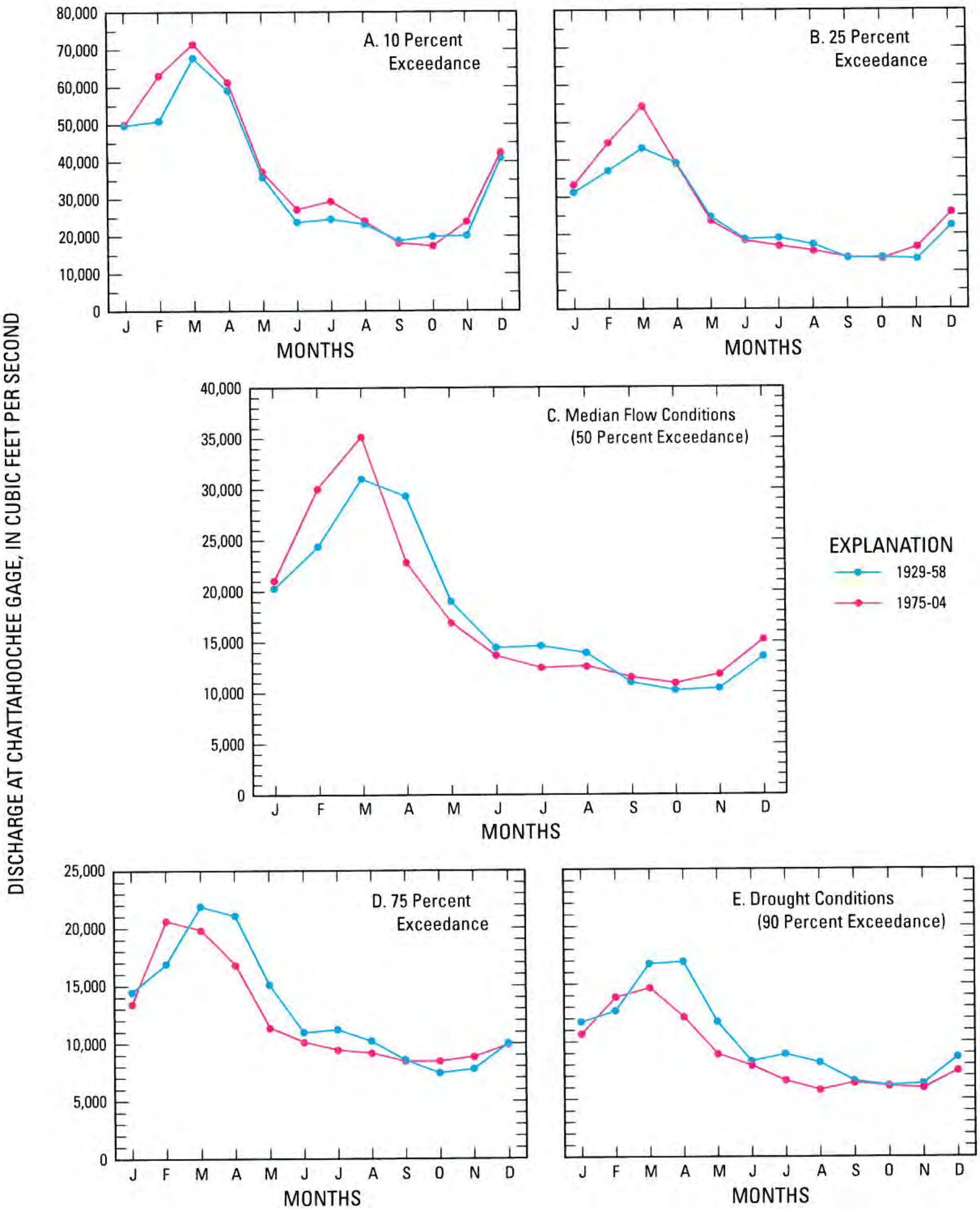

Figure 27. Monthly streamflow statistics for the earliest 30 years (1929–58) and the latest 30 years (1975–2004) in the period of record at the Chattahoochee streamgage on the Apalachicola River, Florida. Discharge values shown were equaled or exceeded, for the percent of time indicated, in the given month of the specified 30-year period. For example, graph A shows discharges that were equaled or exceeded only 10 percent of the time, representing very wet conditions. Graph E shows discharges that were equaled or exceeded 90 percent of the time, representing drought conditions. Note that scales on vertical axes are different on every graph.

of the flood season (January-April). Refilling of the reservoir pools can begin as early as mid-February, but is accomplished primarily in April and May in advance of Memorial Day, the first major holiday of the recreational season (USACE, 2006a,b). Although the amount of water that can be stored in or released from Federal reservoirs is limited relative to the flow of the Apalachicola River, reservoir management may have contributed, in part, to decreased flow in April and May in the Apalachicola River during moderate and dry conditions (fig. 27C, D, and E). Reservoir operation objectives to maintain full reservoir pool levels during the summer recreational season, which ends with the Labor Day holiday (USACE, 2006b), may have affected summer flow in the Apalachicola River. On the other hand, releases from lake storage during summer and fall (June-December) were routinely made in the past to augment flow in the Apalachicola River to support navigation (USACE, 1986). If support of navigation is reduced in the future as a result of recent difficulties encountered by the USACE in obtaining a State permit for maintenance dredging of the navigation channel (Florida Department of Environmental Protection, 2005), the amount of summer flow augmentation may change.

Agricultural water use increased rapidly in the lower Flint River basin during the 1970s with the introduction of center-pivot irrigation systems (Pierce and others, 1984). The irrigation season is typically April through September, with peak irrigation volumes in May through August (Georgia Environmental Protection Division, 2006). Ground water is the primary source of irrigation withdrawals (Marella and others, 1993). Several studies have documented a strong connection between ground-water withdrawals and reduced streamflow in the lower Flint River basin (Hayes and others, 1983; Torak and others, 1996) with modeling results indicating effects on Apalachicola River flows, particularly during droughts (Torak and McDowell, 1996).

Municipal and industrial water use in the ACF Basin has increased substantially since 1970. Municipal water use increased steadily from 1970 to 1990, whereas industrial water use increased from 1970 to 1980 and then leveled off (Marella and others, 1993). Comprehensive compilations of municipal and industrial water withdrawals and wastewater returns in this basin after 1990 have not been published, although estimated values were generated for missing data as part of a recent ACF flow-modeling project (USACE, 2004). Population in urban areas of Georgia has continued to increase, particularly in metropolitan Atlanta (Atlanta Regional Commission, 2006), and preliminary 2000 water-use estimates in the ACF Basin indicate that steady increases in municipal water withdrawals are continuing as well (Fanning, 2003; Richard L. Marella, USGS, written commun., 2006). Considerable seasonal variation can occur in the amount of municipal consumption (withdrawals minus returns). Municipal consumption in the ACF Basin from May through August was about twice that of November through April based on preliminary data for the year 2000.

Reservoir evapoprecipitation (evaporative losses and precipitation gains) results in lower flows in spring, summer, and early fall, when temperatures and evaporation rates are highest, and higher flows in winter, when evaporation rates are low and precipitation on reservoir surfaces adds directly to streamflow without interception by the forests that existed there before the reservoirs were built (USACE, 1996). Estimates of evapoprecipitation effects on streamflow have been made at the four largest Federal reservoirs by the USACE (1995, 1996). Evapoprecipitation is also occurring at the 12 smaller mainstem reservoirs on the Chattahoochee and Flint Rivers, 1,800 reservoirs on mapped tributaries of these two rivers (U.S. Environmental Protection Agency (USEPA), 1998; Alice Lawrence, USFWS, written commun., 2005), and 22,000 additional small reservoirs, including ponds on intermittent streams and isolated ponds used for irrigation and stock watering (Cowie, 2002; Davis, 2003; Georgia Spatial Data Infrastructure, 2006). Little is known about the hydrologic effects of these numerous farm ponds on ACF streamflow. In a detailed hydrologic study conducted in a stream basin with many stock-water reservoirs in an arid region (Wyoming), water losses attributable to reservoirs were about 30 percent of total basin streamflow (Culler, 1961). A similar hydrologic study is needed to determine the effects of reservoirs on streamflow in the humid southeastern United States.

Increases in impervious surfaces from urbanization have occurred in the ACF Basin, with the greatest increases occurring in metropolitan Atlanta. Increases in frequency and magnitude of high flows, and other changes in streamflow characteristics, are known to occur as a result of increased imperviousness (Bledsoe and Watson, 2001; Leopold and others, 2005). In the Upper Chattahoochee River basin, tributary stream basins with the largest percentage of impervious area had the highest peak flood flows (Rose and Peters, 2001) and the lowest baseflows (Calhoun and others, 2003). The degree to which this change in land use has changed mainstem streamflow is unknown. Updated estimates of the percentage of the watershed covered with impervious surfaces are needed, along with a better understanding of the runoff characteristics that existed in those areas prior to urbanization.

As described in figure 3, effects of water-level decline are the same for floodplain habitats regardless of the cause. Thus a comprehensive assessment of the impact of hydrologic alterations on floodplain habitats should address the combined effects of long-term changes in both channel conditions and the amount of water delivered from upstream. Water-level changes resulting from changes in flow, however, are complex because of substantial seasonal and annual variability. In addition, the effect of flow changes on duration of inundation varies with the location along the river, similar to the variability that occurs with channel changes. Although a full description of the effects of flow changes is not within the scope of this study, the combined effects of water-level change attributable to both channel changes and flow changes at one site (Blountstown gage) are presented for comparison purposes in figure 28.

During typical or median conditions (fig. 28A), changes in the seasonal distribution of flows have diminished the effect of channel change in the fall and winter, with large enough increases in February discharges to entirely cancel out the effects of channel change. In the spring and summer, however, decreased flows during median conditions have added to the effect of channel change in 5 consecutive months (April-August). During median conditions, the total water-level decline in April attributable to both channel change and flow changes is 4.3 ft (1.8 ft from channel changes plus 2.5 ft from flow changes).

During drought conditions (fig. 28B), total water-level declines in April, May, July, and August (3.5–4.1 ft) are approximately double the decline caused by channel change alone. Drought conditions in this figure refer to flows that are equaled or exceeded 90 percent of the time, which over the long-term represent conditions that occur on average 1 year out of every 10.

The combined effects of channel changes and fow changes are depicted in figure 28 for only one site (Blountstown gage), so the reader is cautioned that total water-level declines at sites with large channel-change declines can be greater than those

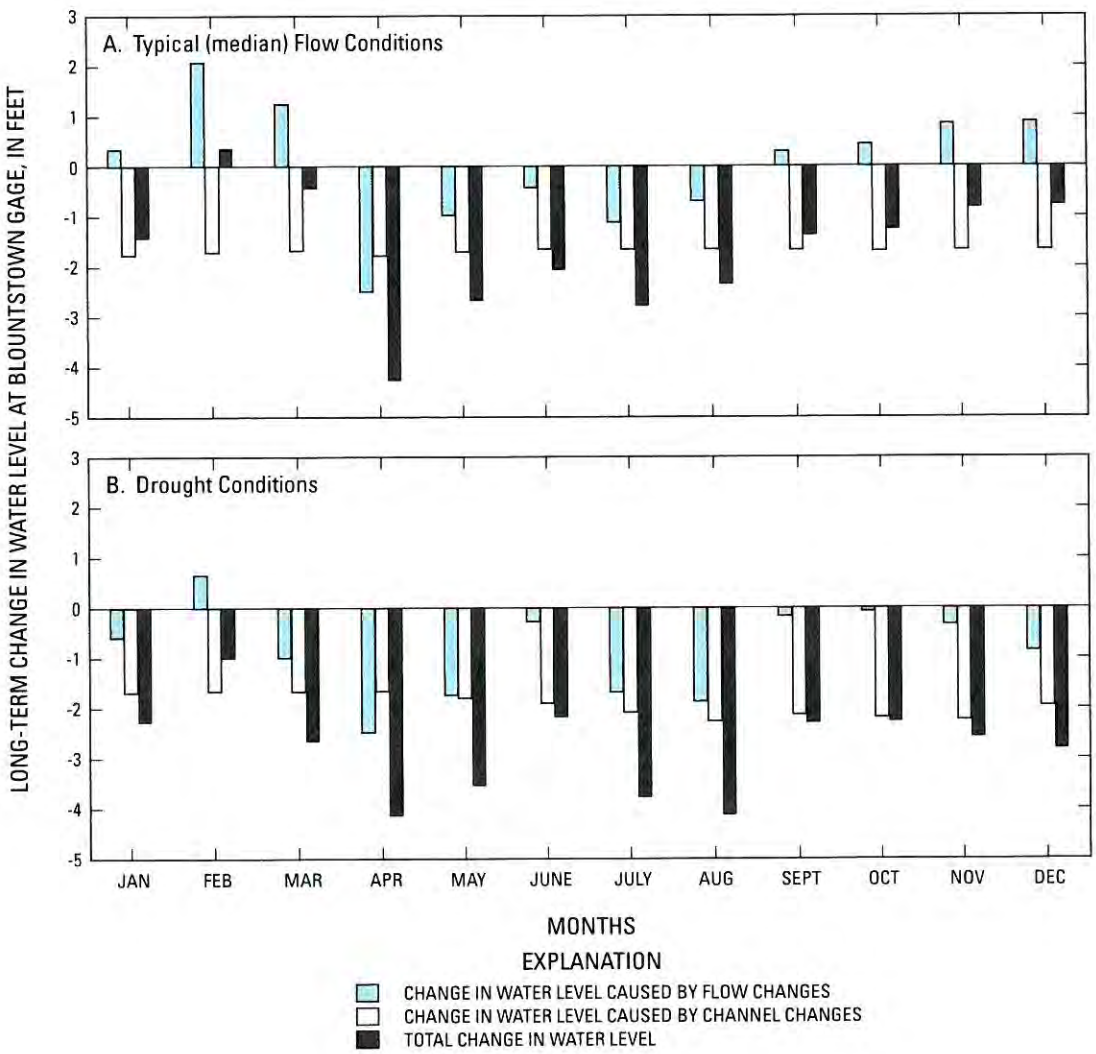

Figure 28. Long-term water-level changes attributable to the isolated effects of flow changes and channel changes, and their combined effect, at the Blountstown streamgage on the Apalachicola River, Florida, during (A) typical (median) flow conditions, and (B) drought conditions. In this figure, drought conditions represent flows that were equaled or exceeded 90 percent of the time. Water-level changes caused by changes in discharge were determined from the difference between earlier (1929–58) and later (1975–2004) discharge data from the Chattahoochee streamgage from figure 27C and E, using the recent Blountstown stage-discharge relation in figure 6. Water-level declines caused by channel changes were determined from the difference between pre-dam (pre-1954) and recent (1995–2004) stage calculations (using Blountstown stage-discharge relations in figure 6) for the 1975–2004 discharges shown in figure 27C and E.

shown. For example, the total water-level decline in April during drought conditions exceeds 5 ft at RM 35 (2.8 ft from channel changes plus 2.3 ft from flow changes) and is about 7 ft at Chattahoochee gage (4.7 ft from channel changes plus 2.3 ft from flow changes).

The observed declines in spring and summer flows are important because water levels influence many important biological processes during that time of year, with sensitive species especially vulnerable during drought conditions in hot weather. Greatest spawning activity for fishes in floodplain habitats of the Apalachicola River occurs in April and May, with high levels of spawning activity continuing for some species throughout the summer (Stephen J. Walsh, USGS, written commun., 2006). The need for cool-water refuge in floodplain streams for striped bass is greatest in the summer months when flows are low and river temperatures are high (Van Den Avyle and Evans, 1990). Low dissolved oxygen concentrations in isolated sloughs are most problematic for fish and mussels during summer for the same reasons (low flow and high temperature). Spring and early summer are the seasons of greatest tree growth (Conner and Day, 1992), and probably also the seasons when flooding has the largest influence on tree composition and recruitment in floodplain forests. Consequently, a better understanding of the causes of decreased spring and summer flow, and the trends in seasonal discharge that might be expected in the future, is critical in determining the full extent of the effects of long-term water-level declines on floodplain habitats and biological communities.

Future trends and potential for restoration.—Water-level decline caused by channel change slowed dramatically at some sites and ceased altogether at other sites about 20 to 30 years ago (fig. 5). At the Chattahoochee gage, streambed lowering is predicted to continue at a slow rate as long as sand continues to be trapped behind Jim Woodruff Dam. In a "worst-case" estimate by USACE, water-level decline was projected to be 1 ft in the next 40 years at the Chattahoochee gage (USACE, 2001a). It is possible that decreased slope in the upper 40 mi of the river, evident in a comparison of the 1956 and 1995 water-surface profiles in figure 4, will serve as a counter-balancing influence to downstream-progressing riverbed degradation. Future water-level decline in this reach may depend on the degree to which this decrease in slope acts to decrease both stream velocities and sand transport, which is unknown.

Partial recovery of the water-level decline at the Wewahitchka gage (fig. 5) may have occurred because of changes that were made in the navigation project in the 1970s to reduce environmental impacts on the river ecosystem. This partial recovery indicates that future channel change (except for minor deepening that may gradually continue because of the presence of the dam) could be minimized by avoiding the channel modification activities that caused the observed changes. Unfortunately, it is not yet clear which activities played the greatest role in channel enlargement, particularly channel widening. If the specific activities responsible for most of the widening could be identified and halted, there is a possibility that the river would narrow by natural processes, allowing a more widespread recovery of the water-level decline by some as yet unknown amount. Prevention efforts will be more effective when the causes of these changes are better understood.

Recovery options to raise water levels in selected reaches of the river could have large potential benefits, with low-water connections and flowing conditions restored to many miles of streams and sloughs, and a more natural flood regime restored to thousands of acres of floodplain forests. Large-scale projects, however, can be expensive, questionable with regard to feasibility, and pose the risk of negative unintended consequences.

One example of a potential large-scale restoration project to raise water levels is the rerouting of the river back through the bendway of the artificial meander cutoff at Battle Bend (fig. 29). The Battle Bend cutoff, which shortened the river by more than a mile, was the largest of seven artificial cutoffs and bend easings excavated by the USACE from 1956 to 1969 along the Apalachicola River, all of which were located in the lower reach. Although the difficulties involved in rerouting a river as large as the Apalachicola could prove to be a major engineering and construction endeavor, restoring the Battle Bend cutoff might reverse the channel deepening that has occurred in this straightened reach of the river, raising water levels for many miles upstream. Meander cutoffs were successfully restored on the Kissimmee River in central Florida, resulting in reflooding of floodplain marshes and rapid recovery of biological communities (Toth, 2005; Williams and others, 2006). Restoration of a meander cutoff of the Apalachicola River, however, may be considerably more difficult than bendway restoration on a smaller, lower gradient stream like the Kissimmee River.

Another example of a large-scale restoration project is a sand bypass or sand recycling project, which could move sand from the reservoir and deposit it in the thalweg of the upper reach of the river or move sand upstream to the upper reach of the river from large dredged material disposal sites in the lower reach. Preliminary evaluations of similar proposals in the Missouri River, however, describe high costs and many difficult logistical issues involved in sand bypass projects (USACE, 2001b; Engineering and Hydrosystems, Inc., 2002).

Local-scale remediation efforts do not raise water levels, but can increase the size and connectivity of limited areas of aquatic habitat by removing sediments and lowering bed elevations in selected sloughs or backwaters. Minor excavation in the mouths of floodplain streams and sloughs has been conducted along the Apalachicola River by the USACE since the 1980s in response to environmental concerns about the damage done to the river-floodplain system as a result of the navigation project. About a dozen small projects have been completed, involving excavation amounts ranging from 200 to 2,500 yd^3 (cubic yards) that were limited to areas in the mouths or heads of streams within 100 ft of the main channel (USACE, written commun., 2003).

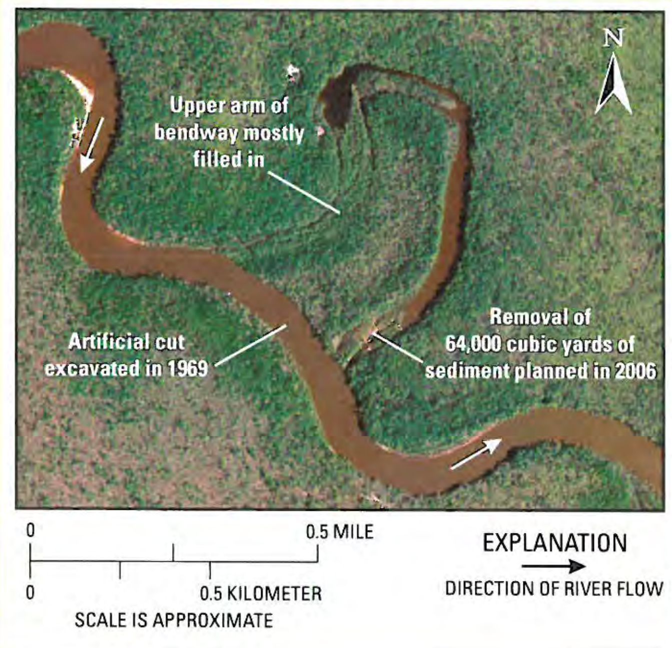

Figure 29. Artificial meander cutoff at Battle Bend in the lower reach of the Apalachicola River, Florida (location shown in fig. 2). This cutoff shortened the river by about 6,000 feet (U.S. Army Corps of Engineers, 1986). Photograph was taken in 2004 (source—Florida Department of Environmental Protection).

One type of local-scale remediation conducted by the USACE involved minor excavation of the mouths of perennial streams, mostly in the upper reach, to create deep pools of cool water for striped bass to use as thermal refuge. The first project of this type was conducted in 1997 in Blue Spring Run (fig. 2). Since then, five other cool-water spring runs and creeks in the upper reach and one stream in the upper part of the middle reach were dredged at their mouths to provide thermal refuge habitat at a discharge of 8,500 ft^3/s (USACE, written commun., 2003). These efforts were temporarily successful, but in most cases, creek mouths began to accumulate sediments within 1 to 3 years (Long, 2004; Striped Bass Technical Task Force, 2005). Excavation of thermal refuge streams is needed on a regular basis to assure long-term benefits (Charles L. Mesing, Florida Fish and Wildlife Conservation Commission, written commun., 2006).

Minor excavation of sediment blockages by the USACE in one middle reach slough and two lower reach sloughs was intended to increase connectivity between interior reaches of the sloughs and the main river channel. This excavation did not increase connectivity to any great extent, however, because additional internal sills continued to control the hydrologic connection to the main channel. Little is known about the mechanisms responsible for sediment blockages in middle and lower reach sloughs. Sand from dredged material disposal was apparently responsible for sediment blockages at some locations. Water-level decline in the middle and lower reach (not generally understood prior to this report) reduced connectivity of streams as well. Streambed elevations probably remained the same when river levels declined, causing many sloughs to be shallowly connected or disconnected from the main channel—a problem that probably cannot be remedied by minor excavation at the slough head or mouth.

FFWCC is currently involved in the final phases of a local-scale project for fisheries enhancement involving excavation of a large volume of sediments (64,000 yd^3) to remove a sill that is obstructing the lower arm of Battle Bend (fig. 29). The project is intended to create backwater habitat that will be connected to the main river channel at the currently maintained minimum flow of 5,000 ft^3/s. FFWCC plans to continue local-scale enhancement of this type and may explore the feasibility of large-scale projects in coming years (Michael J. Hill, Florida Fish and Wildlife Conservation Commission, oral commun., 2006).

In addition to excavation projects, improved conditions in floodplain habitats can also be accomplished by increasing flows in the spring and summer. For long-term changes in flow to occur, management solutions, such as increased water conservation, additional growth-management policies, and changes in reservoir operations, would be needed throughout the basin. Scientific investigations are needed to provide the supporting information necessary to evaluate and prioritize possible management solutions.

Research Needs

Natural conditions and anthropogenic influences are constantly changing in this complex river-floodplain system and in the large tri-state basin of which the Apalachicola is a part. Research needs change as well, both in terms of changing management priorities as well as changing environmental conditions. The following discussion is intended to highlight some of the key issues regarding water-level declines caused by both channel changes and flow changes that, to the authors' knowledge at the time of this writing (2006), have not yet been adequately addressed by the scientific community.

Although it is apparent that channel changes in the Apalachicola River were caused by some combination of various channel modifications (dam construction, meander cutoffs, dredging, dredged material disposal, and woody debris removal), the relative contribution of each of these activities is not known. Additionally, the precise geomorphic mechanisms that caused widespread channel widening are unclear. A geomorphological study, addressing fluid mechanics, sediment transport, bank erosion, and the history of mechanically removed sediment, is needed to determine which of these past actions played the greatest role in channel widening, based on the river's response to past actions. This research would provide a basis for evaluating the potential erosion and sedimentation effects of all future proposals to modify the channel, whether for navigational improvement, restoration, or other purposes. In addition, the study results could be used to develop a plan that details the actions (and inactions) needed to encourage channel narrowing and allows for the recovery of the water-level decline to the greatest extent possible.

A better understanding of geomorphological processes is also needed to answer important practical questions about sedimentation at sites being considered for local-scale remediation. Answers are needed to estimate the time it may take for sediments to accumulate after remediation so that the need for repeated excavation can be more accurately predicted. Where does sedimentation occur and at what rates? What is the travel path of sediment deposited in sloughs? Is sediment delivered to sloughs during high-flood events with water passing over the floodplain or during lower stages with water primarily contained within banks? Is the sediment composed of sand (which could only have been delivered from the main channel during high discharges)? Is it better to open the upstream end, the downstream end, or both ends of a cutoff oxbow in order to reduce subsequent sedimentation rates? Analyzing relevant historical data and monitoring sedimentation in sloughs is needed to address these questions.

The long-term changes in monthly discharges depicted in figure 27, and the resulting water-level changes shown in figure 28, provide useful preliminary information about trends in flow; however, this analysis is limited in scope and provides little information about the causes of the flow changes. A more comprehensive statistical analysis of flow-climate relations in the ACF Basin, based on observed discharges at the Chattahoochee gage in relation to meteorological data throughout the upstream watershed, is needed to understand the relative contribution of various natural and anthropogenic causes. A baseline flow-climate model could be developed by determining the amount of water that historically was delivered from the upstream watershed under a specified set of meteorological conditions. Such a model could be used to calculate differences between expected and observed flows in recent periods under similar meteorological conditions. Departures from expected streamflow could be compared to data on flow regulation, water use, and other anthropogenic influences to determine the relative contribution of nonclimatic (anthropogenic) factors to streamflow changes. The model could be used to estimate future changes in flow, based on potential changes in reservoir operation practices, changes in water use, or other changes. The model also could be used as a future real-time monitoring tool, with the potential to detect flow deficits that may not have been expected. Research based on flow-climate relations could complement recent work accomplished by USACE to reconstruct natural flows by making adjustments of observed flows based on known human influences (USACE, 1996, 2004), with each type of model serving as a cross-check for the other.

An equally critical research need that would help elucidate causes of decreased spring and summer flow is to update the comprehensive basinwide database of ACF water use that was last conducted using 1990 data (Marella and others, 1993). In that report, agricultural, municipal, and industrial water-use data collected every 5 years from 1970 to 1990 were presented to provide data on current water use at the time (1990) and to describe historical trends in water use for the 20 years leading up to that time. This time series data for water use has been helpful for documenting the history of anthropogenic influences in the basin and for providing trends upon which future projections of water consumption can be based. Up-to-date water-use data for the three most recent 5-year cycles, 1995, 2000, and 2005, are needed, particularly in light of the large increases in population that have occurred in the basin since 1990, and the large future increases projected for metropolitan Atlanta (Atlanta Regional Commission, 2006).

Continued research is needed to address the causes of hydrologic alterations and to better understand their effects on biological communities of the Apalachicola River floodplain. If declining populations of floodplain species are detected early, investigations of causal factors and possible solutions might lead to timely preventative measures. An understanding of biological responses to hydrologic change can help guide the design and prioritization of restoration efforts on the river, and will be needed to monitor the health of aquatic organisms and forest communities over time, as changing priorities for flow regulation and basinwide changes in land and water use influence the future flow regime of the river.

Summary and Conclusions

This report describes the magnitude and extent of the water-level decline that occurred in the nontidal Apalachicola River from 1954 to 2004 as a result of long-term changes in stage-discharge relations. In the upper reach of the river, which starts at Jim Woodruff Dam at the head of the river 106.4 mi (mile) upstream from the mouth and extends to rm (river mile) 77.5, the water-level decline has been known and generally described in previous reports and is described in more detail in this report. The magnitude and extent of the water-level decline in the middle reach (rm 41.8 to rm 77.5) and nontidal lower reach (rm 20.6 to rm 41.8), which is presented in detail in this report, has not been reported previously.

Channel widening and deepening, which occurred throughout much of the river, apparently caused the water-level decline. The channel enlargement occurred primarily as a gradual erosional process over two to three decades, probably in response to the combined effect of the dam, river straightening, dredging, dredged material disposal, woody debris removal, and other activities along the river. Although navigational improvements have been made on the Apalachicola River since the 1800s, channel modifications were conducted with greatest intensity from 1954 to the 1970s.

Periods of low water levels are now more frequent and longer in duration than prior to 1954, resulting in longer periods during which floodplain streams are dewatered, isolated, or not flowing, and swamps and bottomland hardwood forests are dry. Protection and restoration of biological habitats and communities was the primary motivation for this research, which was conducted in cooperation with the Florida Fish and Wildlife Conservation Commission to assist in fisheries enhancement of off-channel aquatic habitat of the Apalachicola River floodplain. Understanding how much water-level decline has occurred, which reaches of the river have been most affected, and why the decline has occurred were necessary first steps in finding solutions to the problems created by declining water levels.

The magnitude of water-level decline caused by channel changes was determined by comparing pre-dam stage (prior to 1954) and recent stage (1995–2004) in relation to discharge. Long-term stage data for the pre-dam and recent periods from five streamflow gaging stations were related to discharge data from the upstream-most gage at Chattahoochee, Florida, using a procedure involving streamflow lag times. Differences between pre-dam and recent relations are greatest at low flows, and gradually decrease with increasing discharge to a point at which the two relations merge, informally called the "joining point." This point is the stage or discharge above which the proportion of flow moving over the floodplain is large enough that physical changes that occurred in the main river channel at that site have no noticeable effect on river stage. The joining point is 10 ft (feet) above the top of the natural riverbank levee at the upstream-most site where the floodplain is about 10 times the width of the main channel, and gradually decreases with distance downstream until it is nearly the same height as the natural riverbank levee in the nontidal lower reach where the floodplain is about 100 times the width of the main channel.

The pre-dam and recent stage-discharge relations at the streamgage locations were used in combination with low-flow water-surface profile data from the U.S. Army Corps of Engineers to estimate magnitude of water-level decline at closely spaced locations (every 0.1 mi) along the river. Data included in digital files on a compact disk attached to this report can be used to calculate the water-level declines for any discharge at any of the closely spaced locations.

Water-level decline varied with location along the river, with the largest stage declines occurring at low flows. The largest water-level decline, 4.8 ft, occurred at rm 105.7, just downstream from Jim Woodruff Dam, and water-level declines progressively decreased downstream to 1 ft at rm 66. The large water-level decline downstream from the dam was caused primarily by the dam, because sediment trapped in the reservoir was not available to replace sand naturally scoured from the bed and transported downstream by the river. This process acted to lower the elevation of the riverbed, and was probably exacerbated by dredging of streambed sediment to improve navigation. River mile 66 probably marks the downstream limit of the influence of Jim Woodruff Dam with regard to riverbed degradation. Downstream from rm 66, the trend reversed and the decline progressively increased to 3 ft at rm 38. Although annual maintenance dredging, disposal, and woody debris removal occurred along the entire river and probably contributed to the relatively widespread channel widening and water-level declines throughout most of the river, these activities alone do not explain the large declines (2–3 ft) that occurred in the lower reach between rm 33 and rm 39. Declines in this vicinity may have been caused, in part, by channel straightening activities (meander cutoffs and bend easings) accomplished in and downstream from this 6-mi reach. Water-level decline decreased downstream from rm 33, and was negligible at the approximate upstream boundary of the tidal influence of the Apalachicola River at rm 20.6, which is to be expected.

Water-level declines in the river have substantially changed long-term hydrologic conditions in more than 200 mi of off-channel floodplain sloughs, streams, and lakes and in most of the 82,200 acres of floodplain forests in the nontidal reach of the Apalachicola River. Approximate decreases in duration of floodplain inundation that occurred as a result of water-level decline were estimated based on an analysis of daily mean discharge at the Chattahoochee gage from 1995 to 2004. Decreases in duration of floodplain inundation were greatest at low discharges at all sites. For discharges of 5,000 to 15,000 cubic feet per second, large decreases in percent duration of inundation occurred in the upstream-most 10 mi of the upper reach (20–45 percent), with decreases that were nearly as large continuing throughout most of the remaining 75 mi of the nontidal reach (10–25 percent).

The nature and magnitude of the hydrologic alterations of biological habitats on the floodplain that occurred as a result of the water-level declines were described using specific examples at three locations. Access to thermal refuge for striped bass was reduced by more than half in Flat Creek, a cool-water floodplain stream in the upper reach. Moccasin Slough, a perennial floodplain stream in the lower reach was converted to an intermittent stream with no flow for weeks or months during dry years. At a third site in the middle reach of the river near Porter Lake, tree composition in a tupelo-cypress swamp shifted to a drier mix of species, and the swamp could change to a different and drier forest type over time. Many other types of biological habitats have been affected by an increase in frequency and duration of nonflowing, hydrologically disconnected, hypoxic, and dewatered conditions in the floodplain.

Water-level decline caused by physical changes in the channel is probably the most serious anthropogenic impact that has occurred so far in the Apalachicola River and floodplain. This decline has been exacerbated, however, by long-term reductions in spring and summer flow, especially during drought periods. Although no trends in total annual flow volumes were detected, long-term decreases in discharge for April, May, July, and August were apparent, and water-level declines during drought conditions resulting from decreased discharge in those 4 months were similar in magnitude to the water-level declines caused by channel changes. These changes in monthly flows have large impacts on floodplain biota, because many important biological processes are influenced by floodplain inundation in spring and summer. Further research on flow-climate relations, linking discharge in the river to the meteorological conditions in the basin, is needed to understand the relative contribution of natural and anthropogenic causes of the observed declines in spring and summer flow.

Channel restoration to raise water levels could have large benefits for many miles of floodplain streams and thousands of acres of floodplain forest; however, restoration projects of this type typically are major engineering interventions that are expensive and logistically difficult to conduct. Restoration of floodplain streams and sloughs conducted so far have been small, local-scale excavation projects with relatively short-lived benefits (1–3 years). Geomorphic evaluations of proposed excavation projects for restoration, navigational improvements, or other purposes, are needed to optimize the success of such activities and to avoid unintended consequences that could lead to further water-level declines. Scientific studies aimed at understanding the precise geomorphic mechanisms that caused the channel widening, which remain unclear, are needed to assess the possibility of recovery by channel narrowing. Understanding the processes that deliver and deposit sediment in sloughs and other floodplain channels, which as yet is poorly known, will improve the success of future projects designed to enhance fisheries habitat. Continued research on biological communities in the floodplain is needed to assist in design and prioritization of restoration, and to monitor the health of aquatic organisms and forest communities as changes in water management and land use in this large tri-state basin affect the future flow regime of the Apalachicola River.

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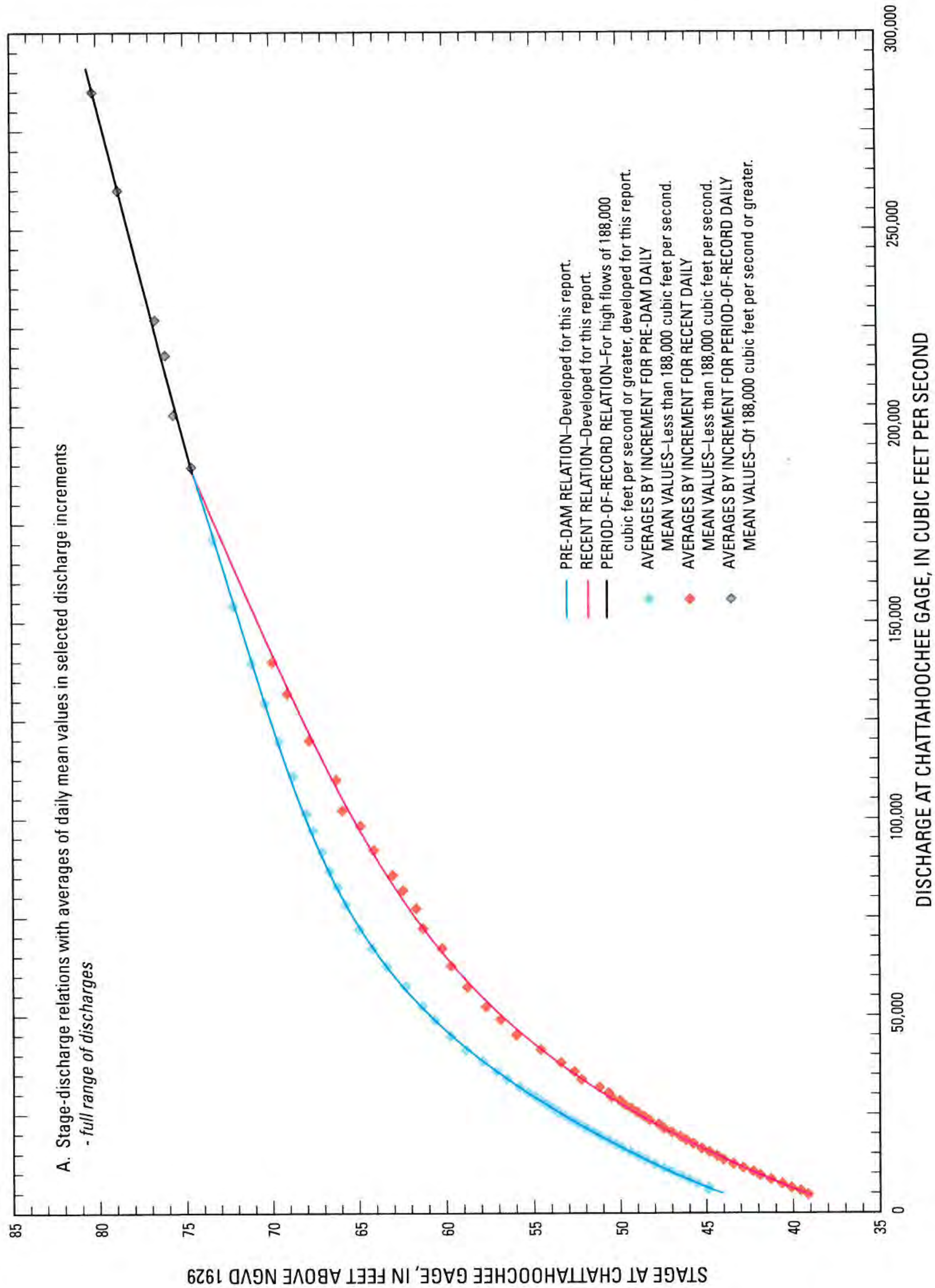
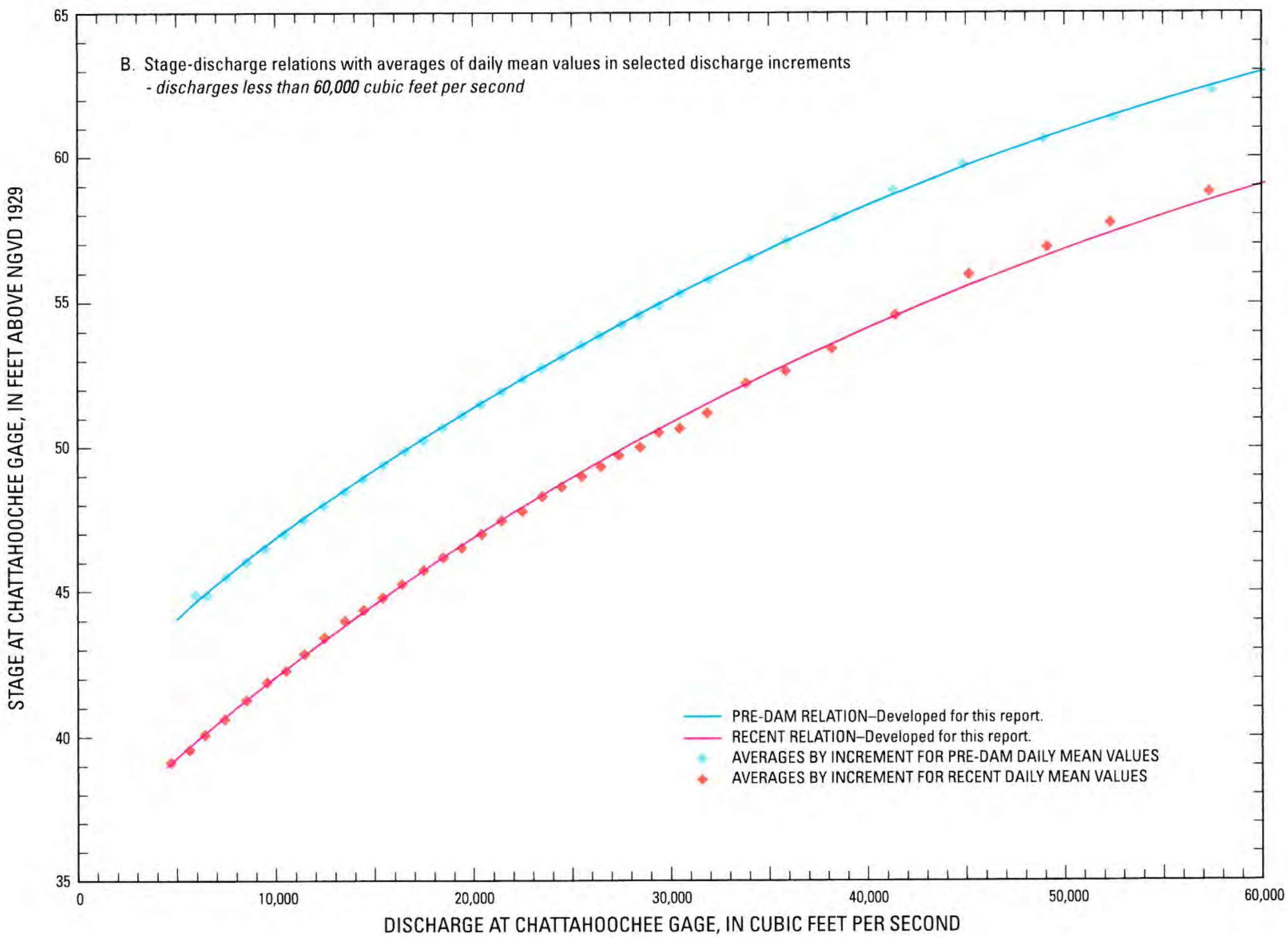
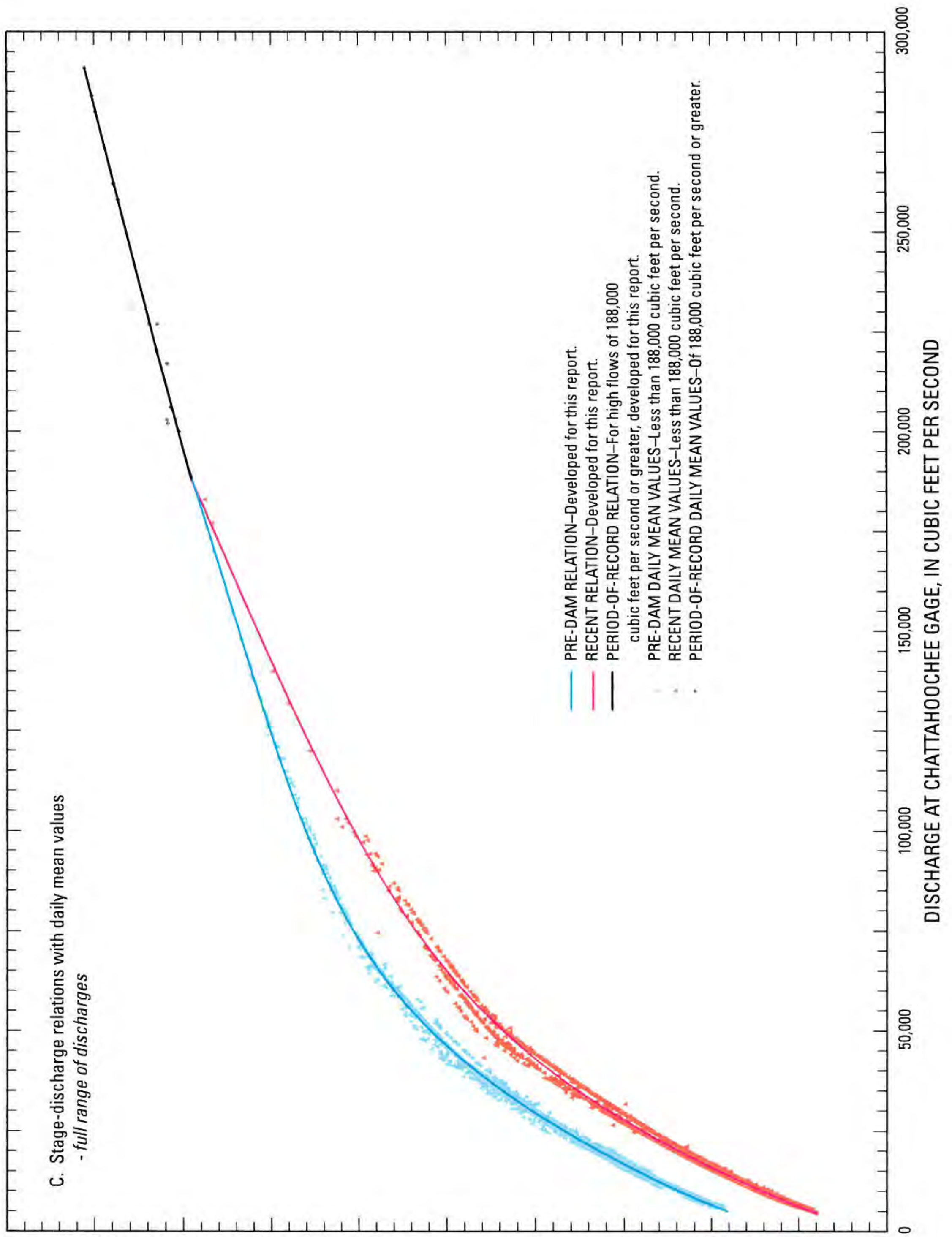
Appendixes I–X



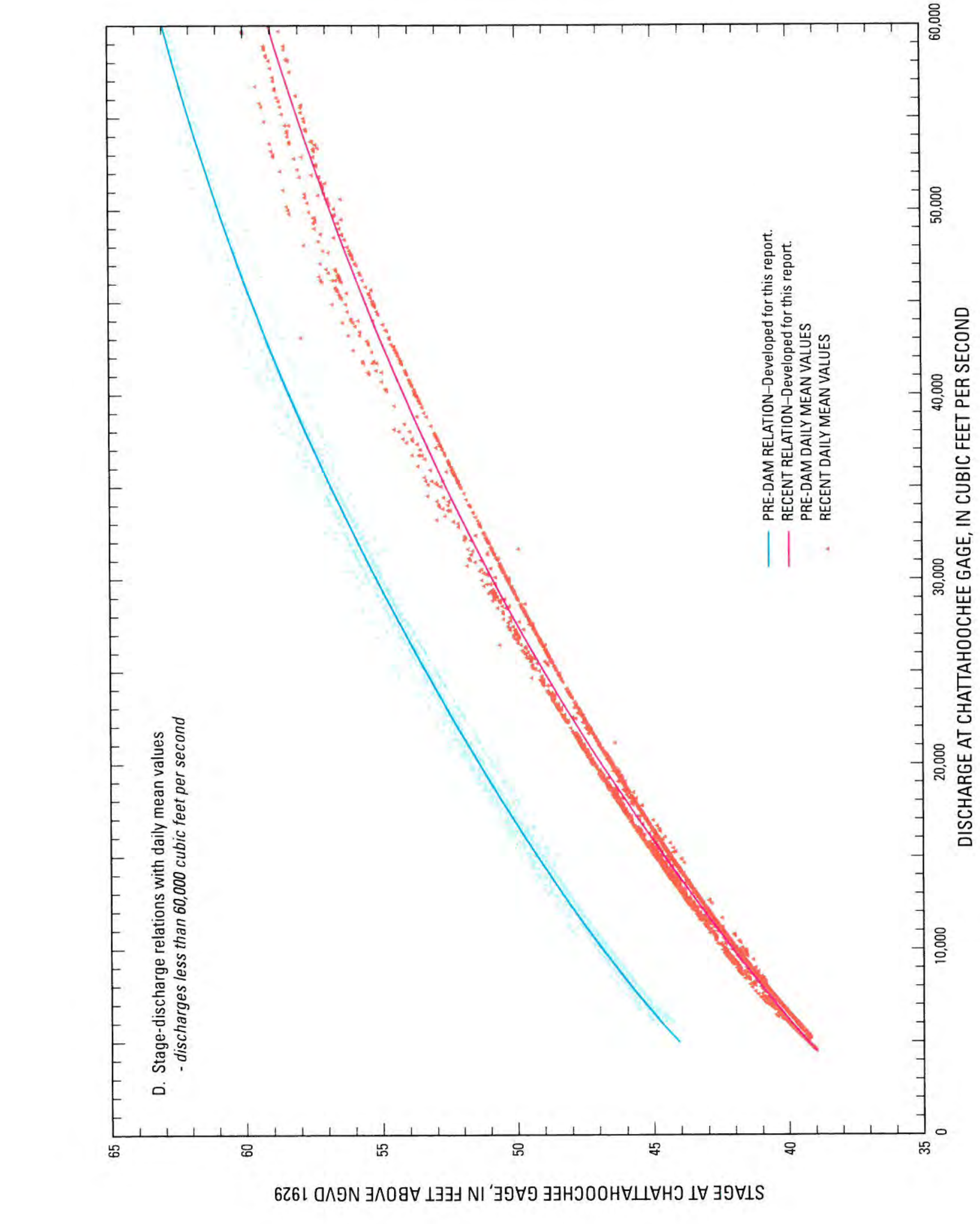
Appendix I. Stage-discharge relations at the Chattahoochee streamgage in the Apalachicola River, Florida.



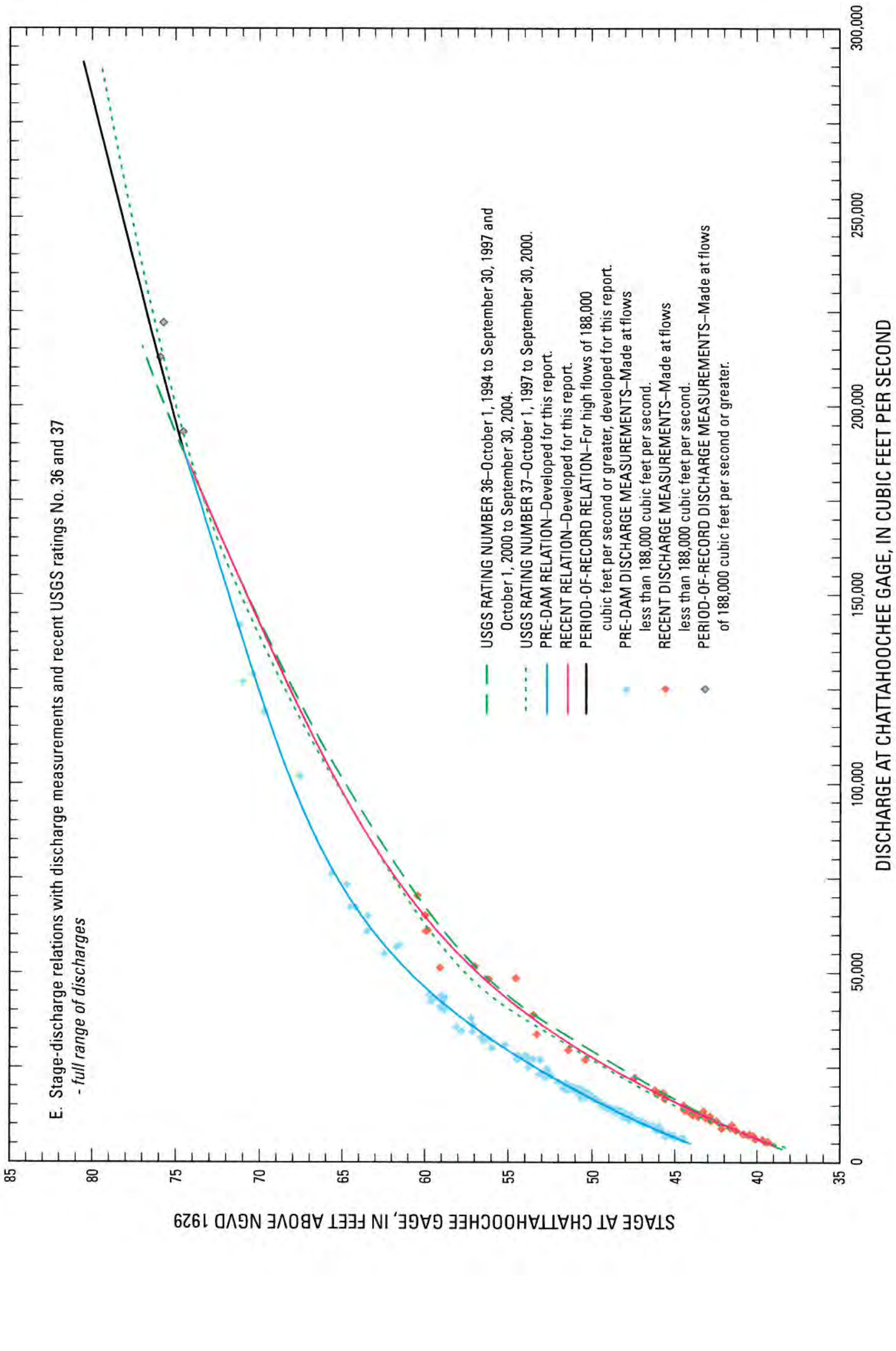
Appendix I. (Continued) Stage-discharge relations at the Chattahoochee streamgage in the Apalachicola River, Florida.



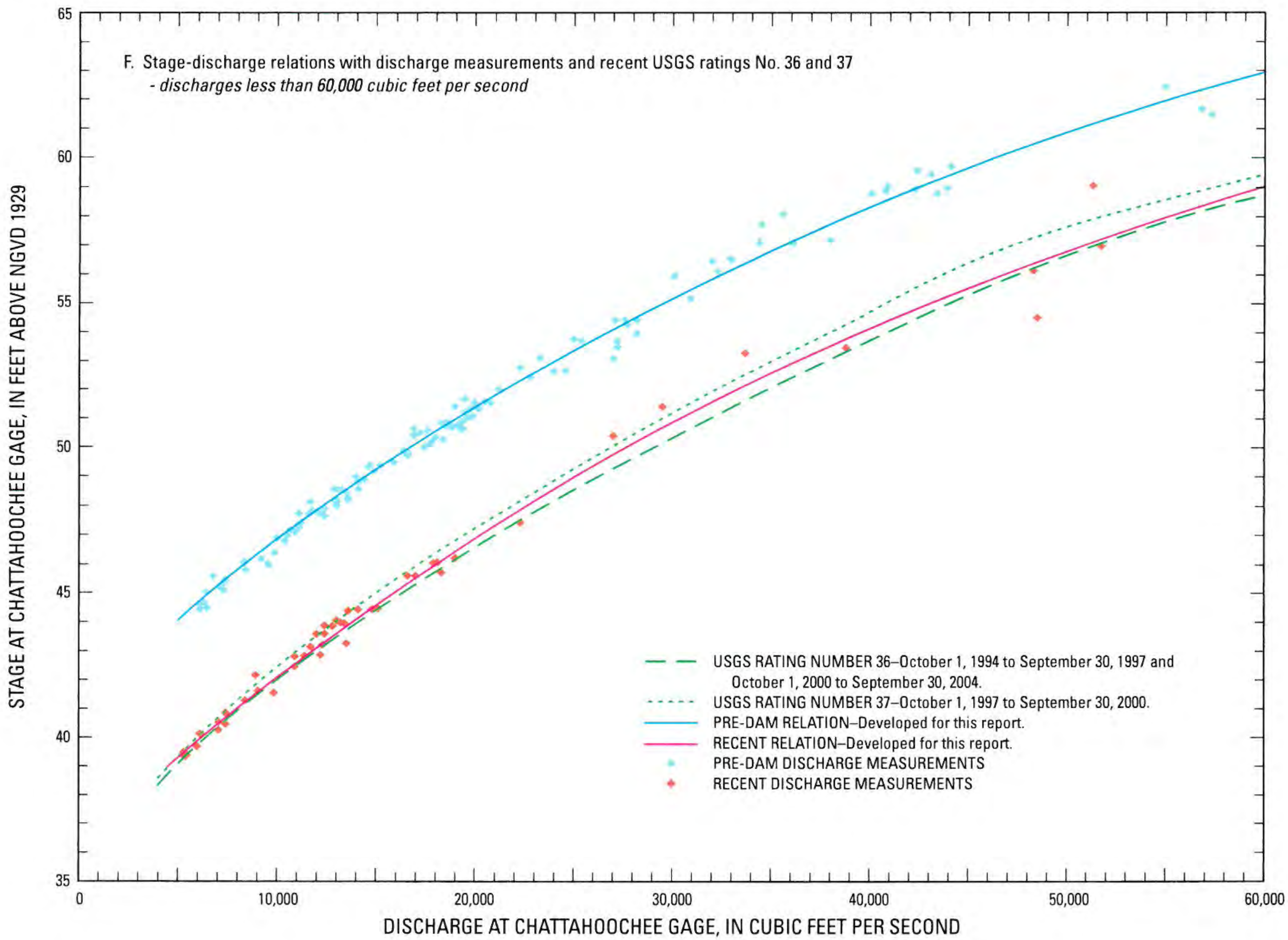
Appendix I. (Continued) Stage-discharge relations at the Chattahoochee streamgage in the Apalachicola River, Florida.



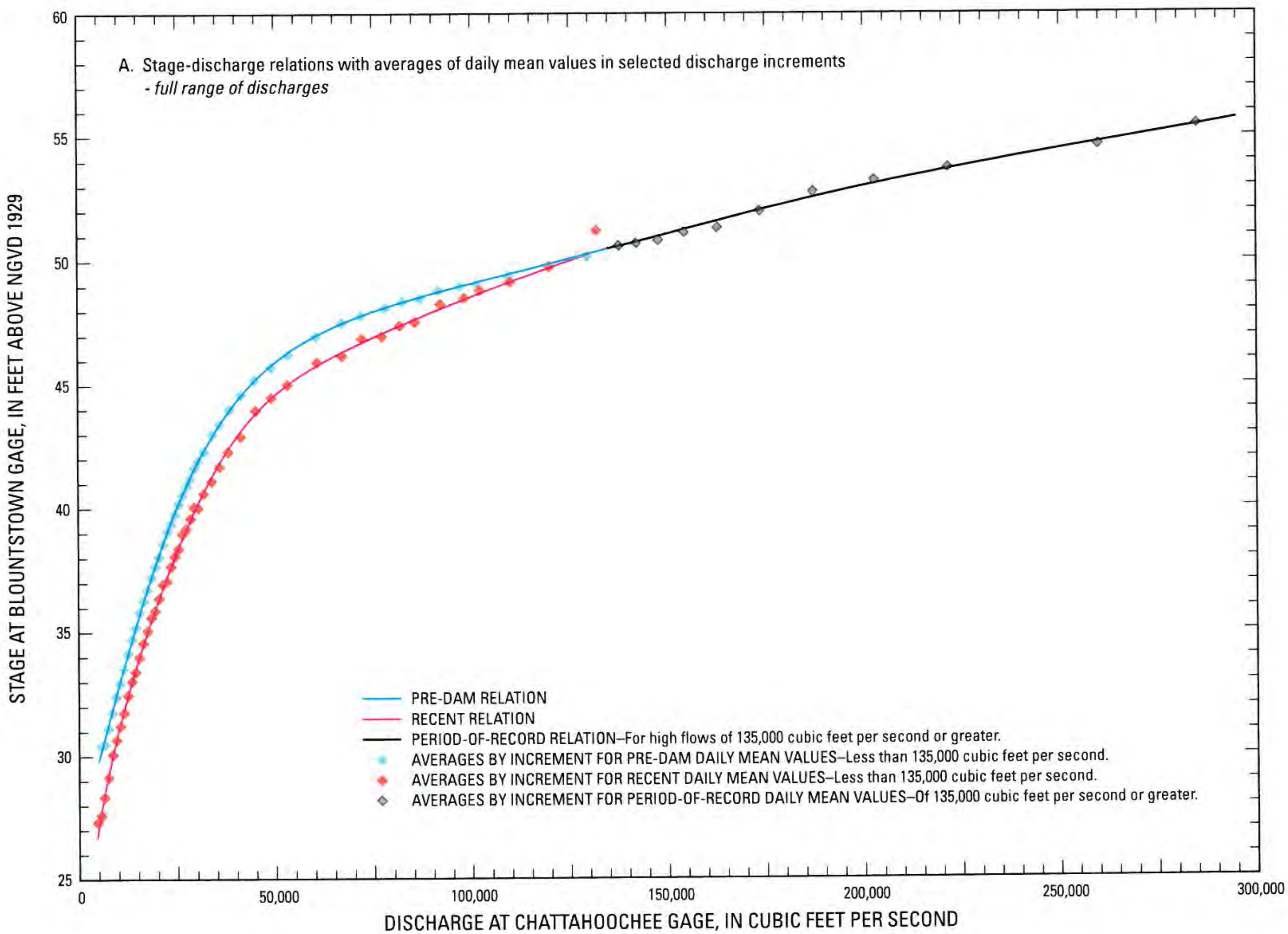
Appendix I. (Continued) Stage-discharge relations at the Chattahoochee streamgage in the Apalachicola River, Florida.



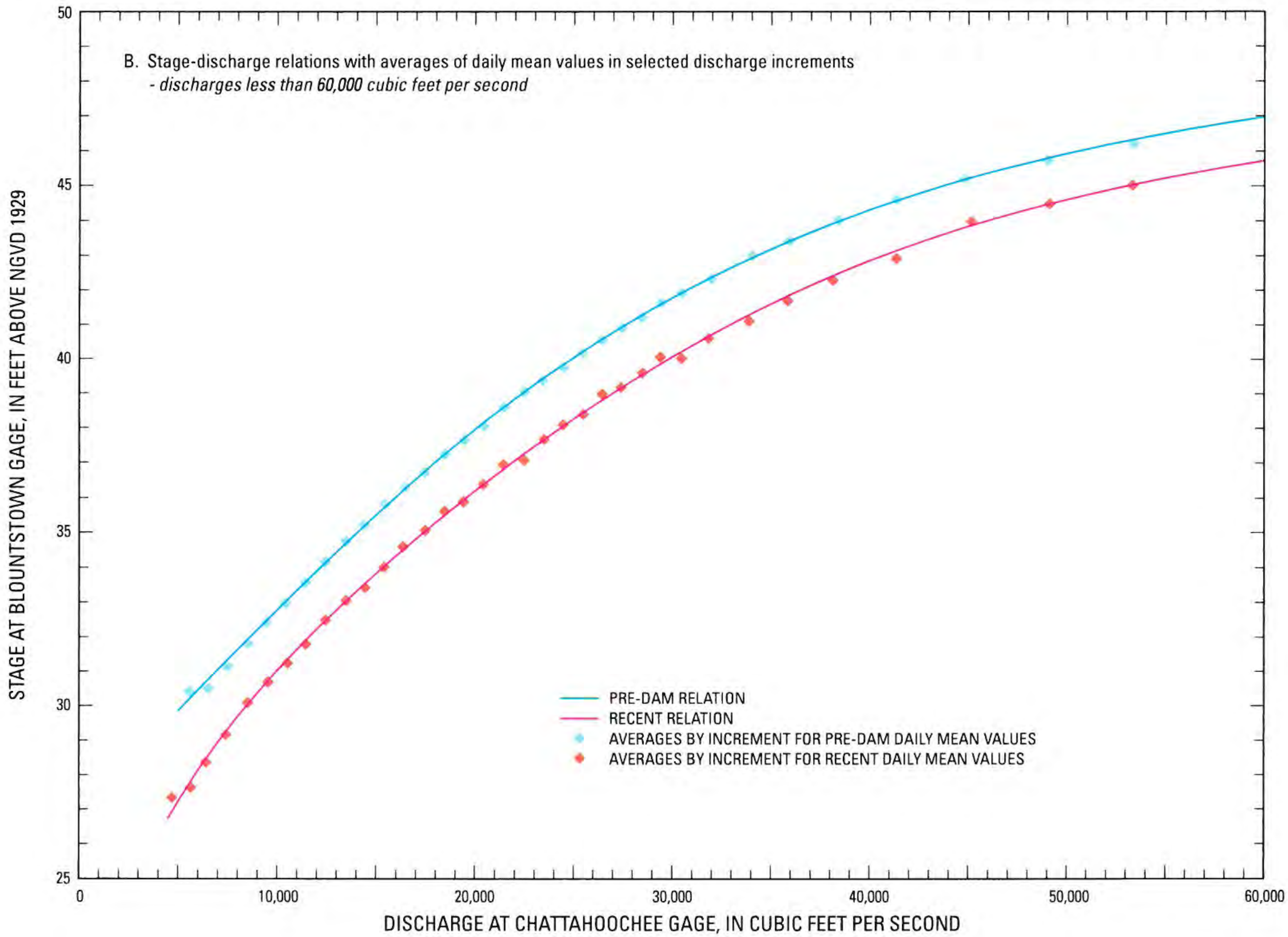
Appendix I. (Continued) Stage-discharge relations at the Chattahoochee streamgage in the Apalachicola River, Florida.



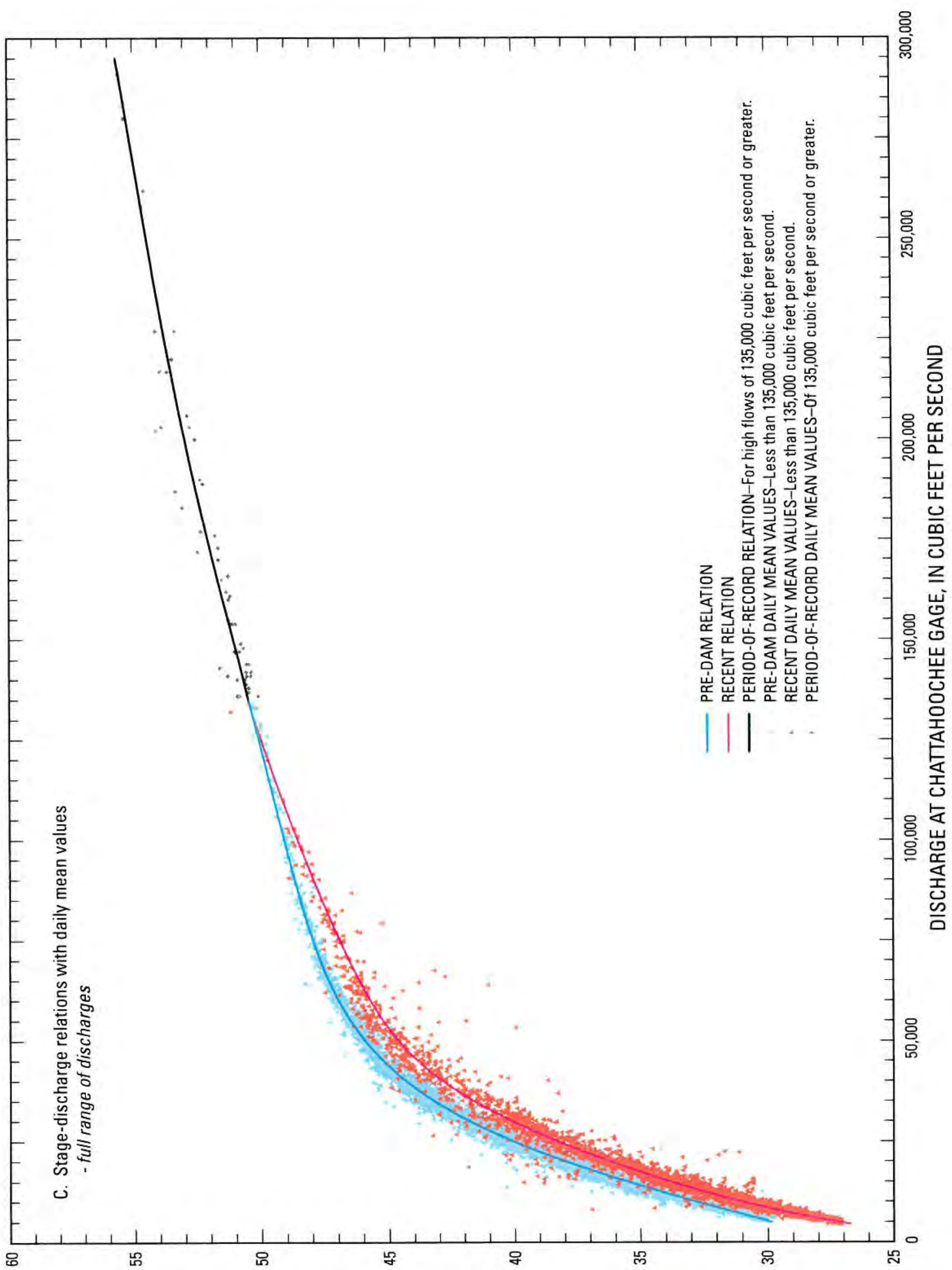
Appendix I. (Continued) Stage-discharge relations at the Chattahoochee streamgage in the Apalachicola River, Florida.



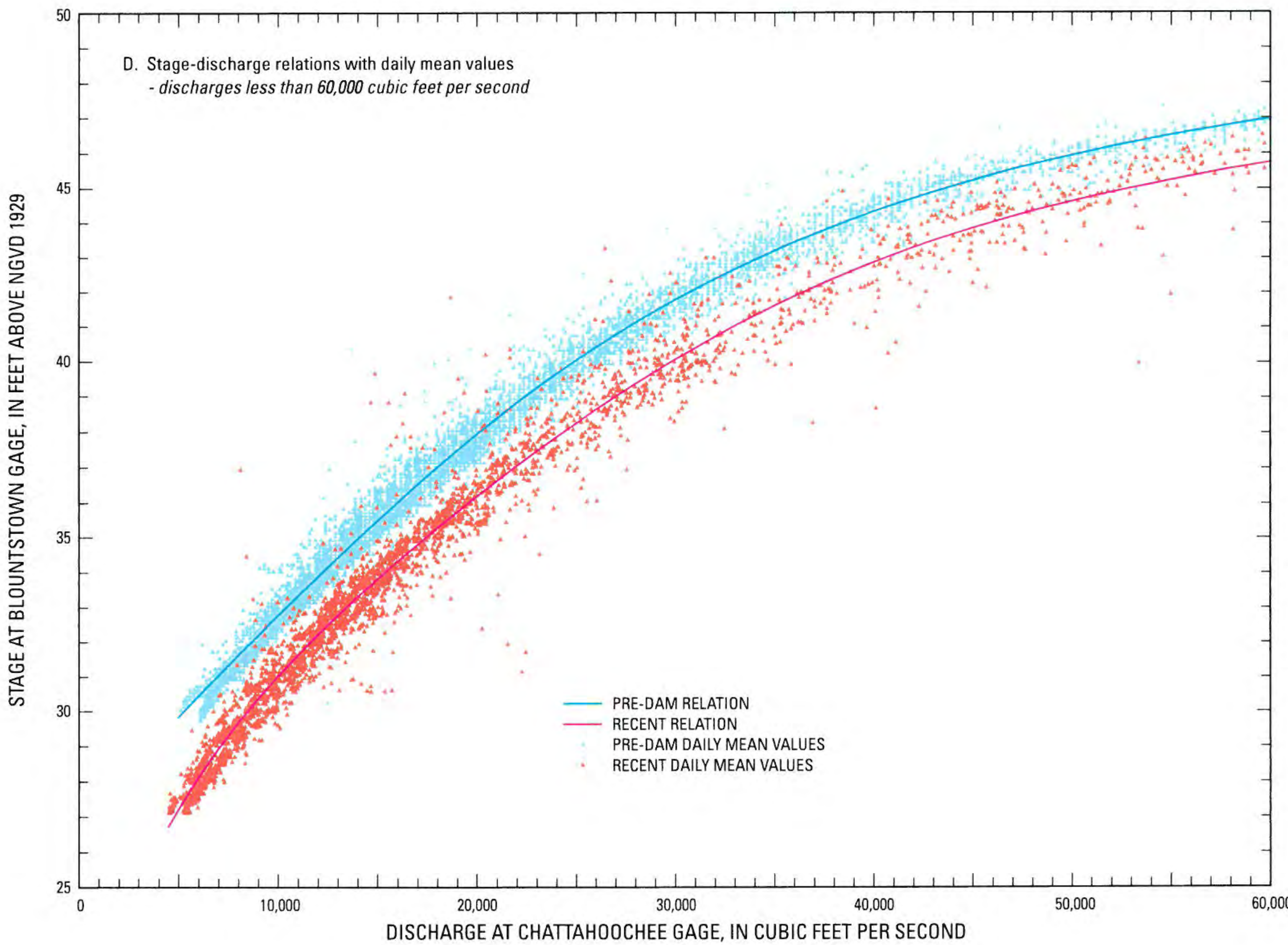
Appendix II. Stage at the Blountstown streamgage in relation to discharge at the Chattahoochee streamgage in the Apalachicola River, Florida. Relations were developed using a lag time of 1 day, as defined in glossary.



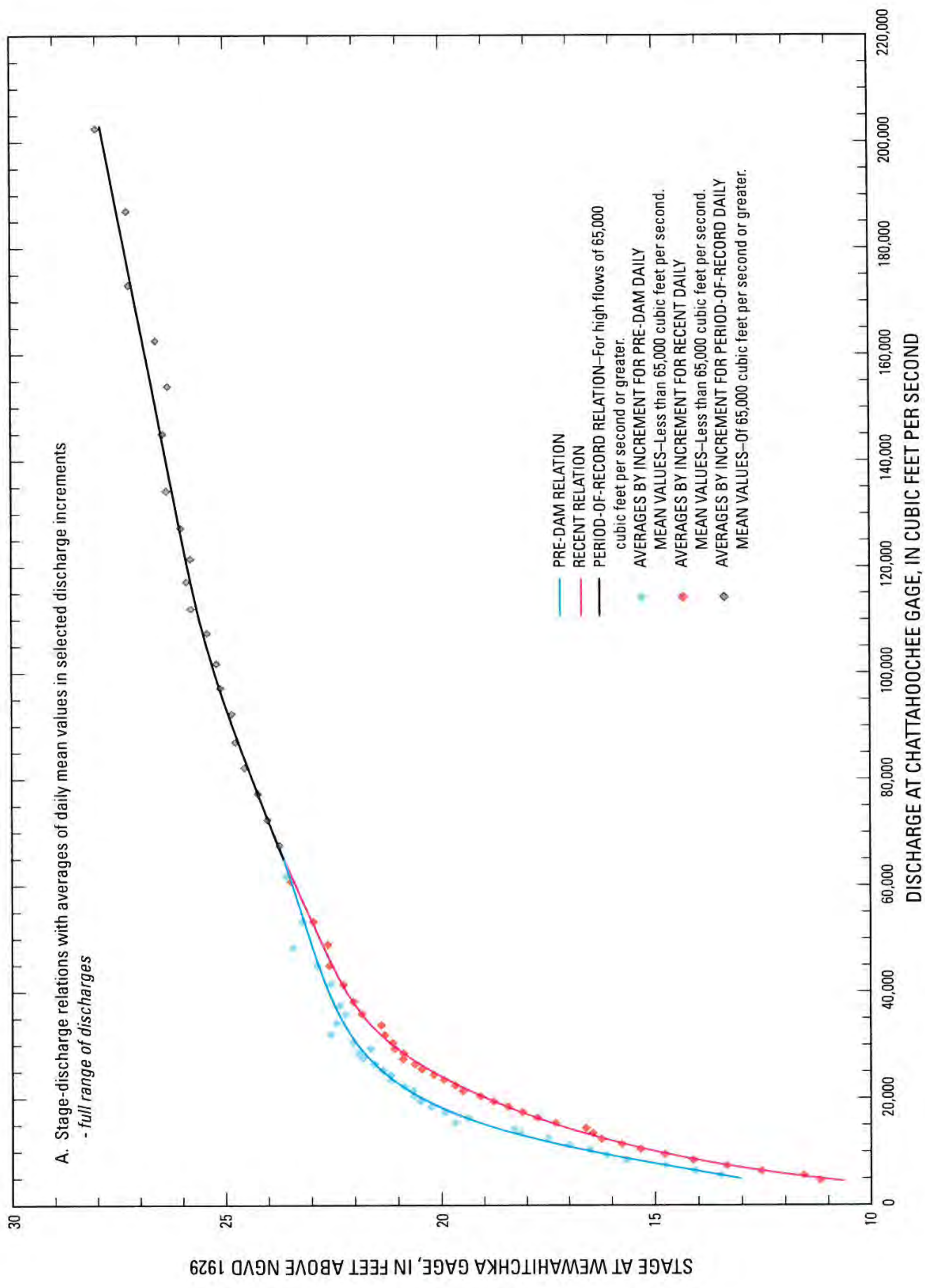
Appendix II. (Continued) Stage at the Blountstown streamgage in relation to discharge at the Chattahoochee streamgage in the Apalachicola River, Florida. Relations were developed using a lag time of 1 day, as defined in glossary.



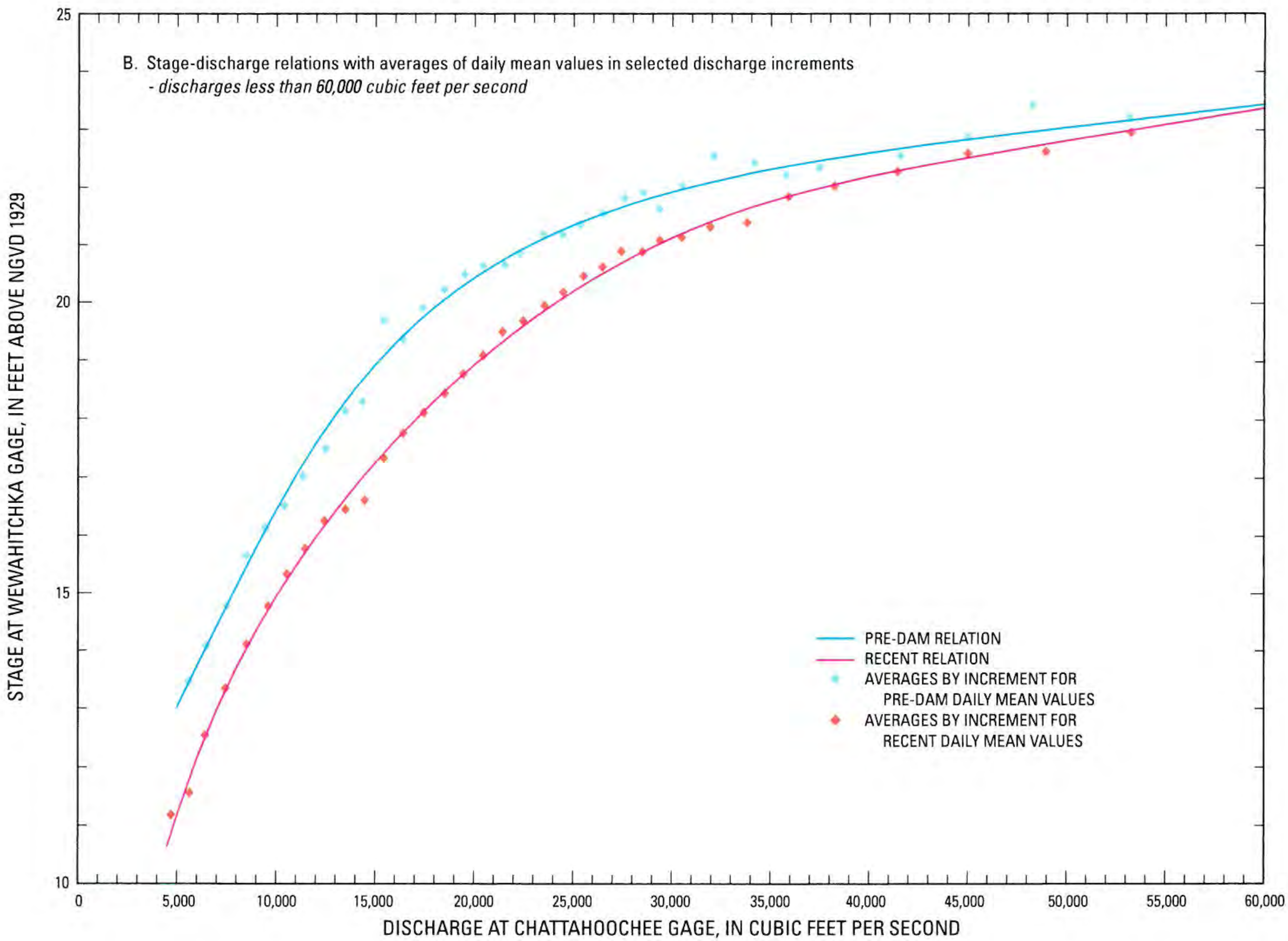
Appendix II. (Continued) Stage at the Blountstown streamgage in relation to discharge at the Chattahoochee streamgage in the Apalachicola River, Florida. Relations were developed using a lag time of 1 day, as defined in glossary.



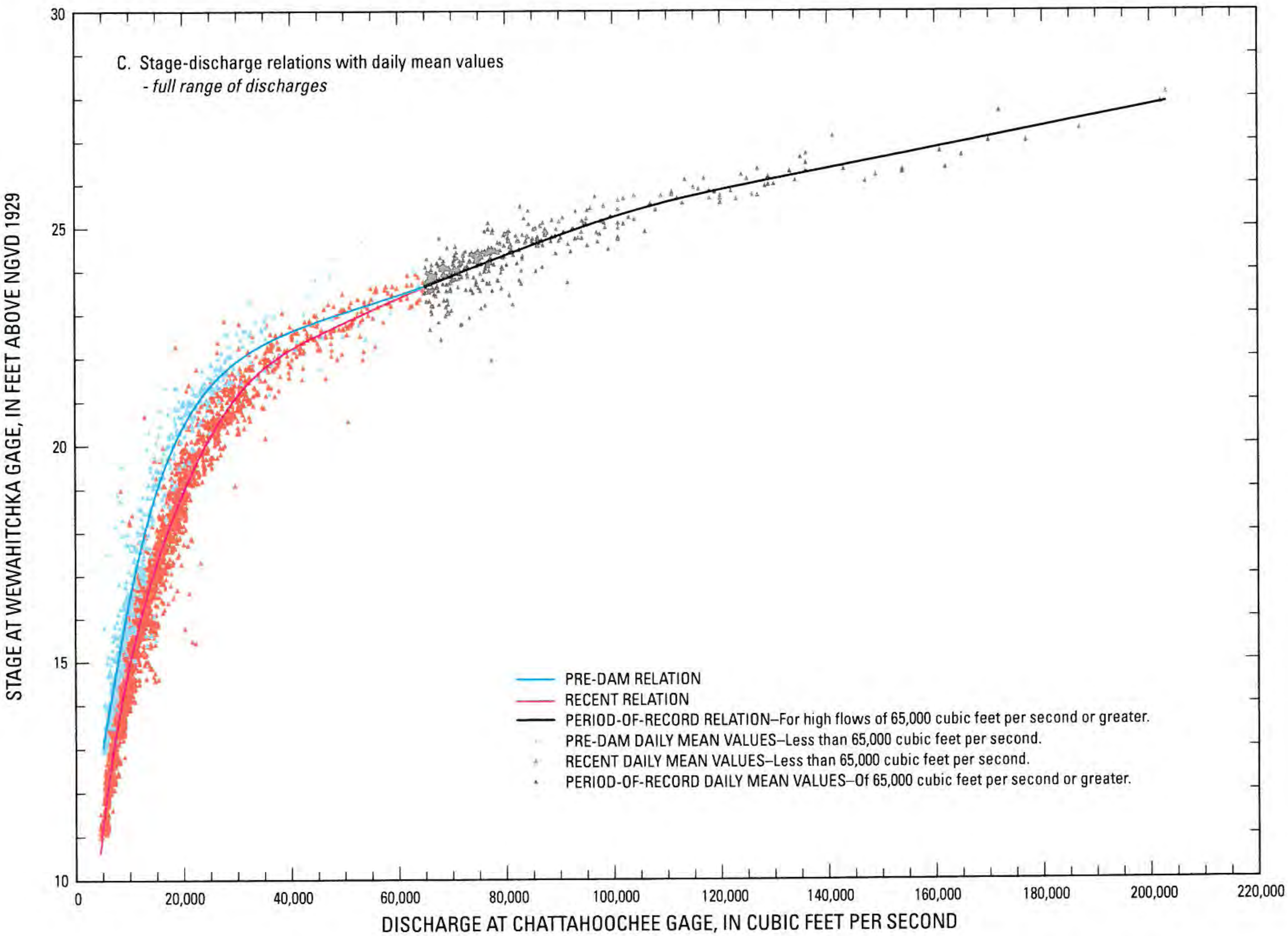
Appendix II. (Continued) Stage at the Blountstown streamgage in relation to discharge at the Chattahoochee streamgage in the Apalachicola River, Florida. Relations were developed using a lag time of 1 day, as defined in glossary.



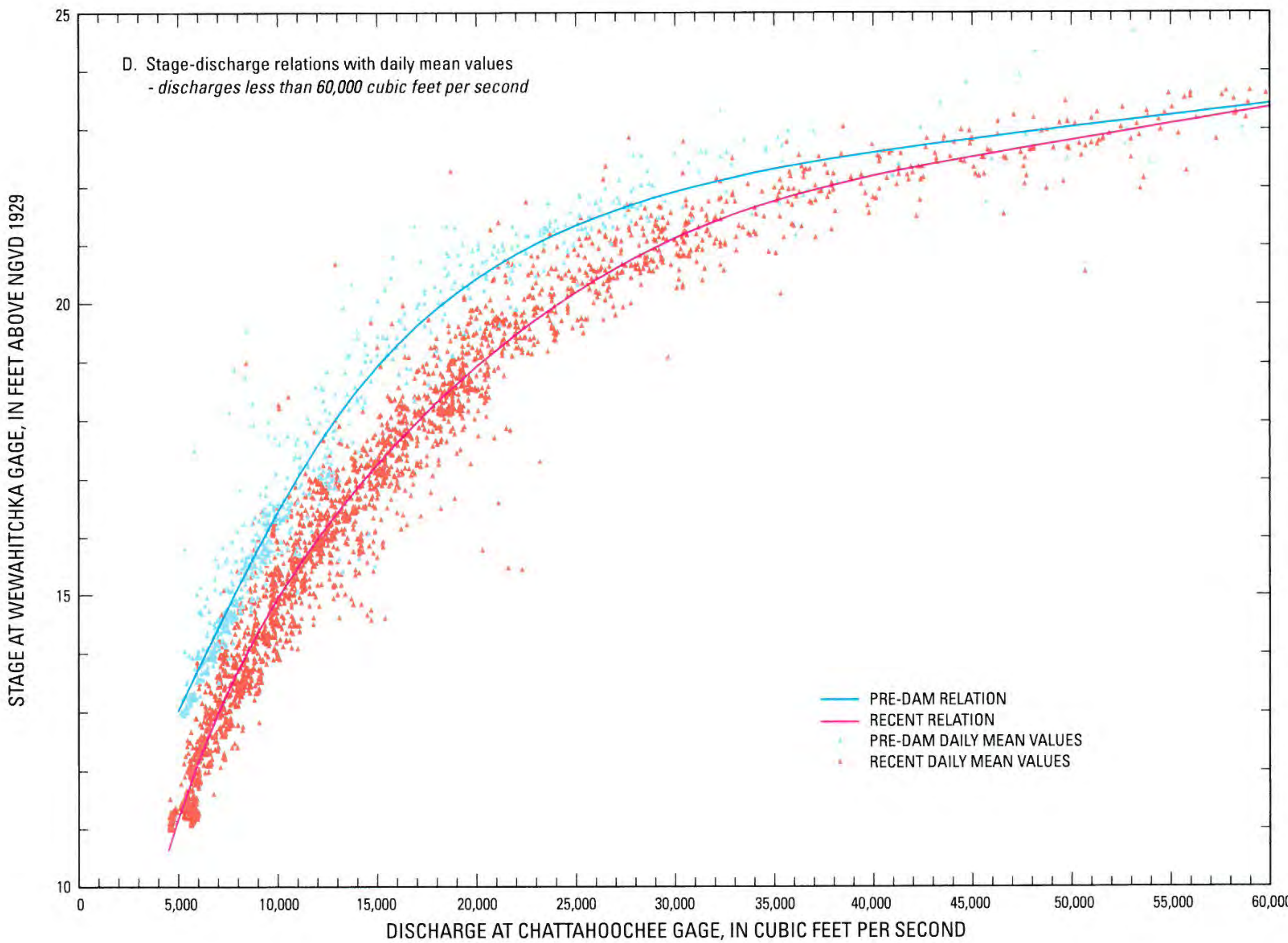
Appendix III. Stage at the Wewahitchka streamgage in relation to discharge at the Chattahoochee streamgage in the Apalachicola River, Florida. Relations were developed using a lag time of 2 days, as defined in glossary.



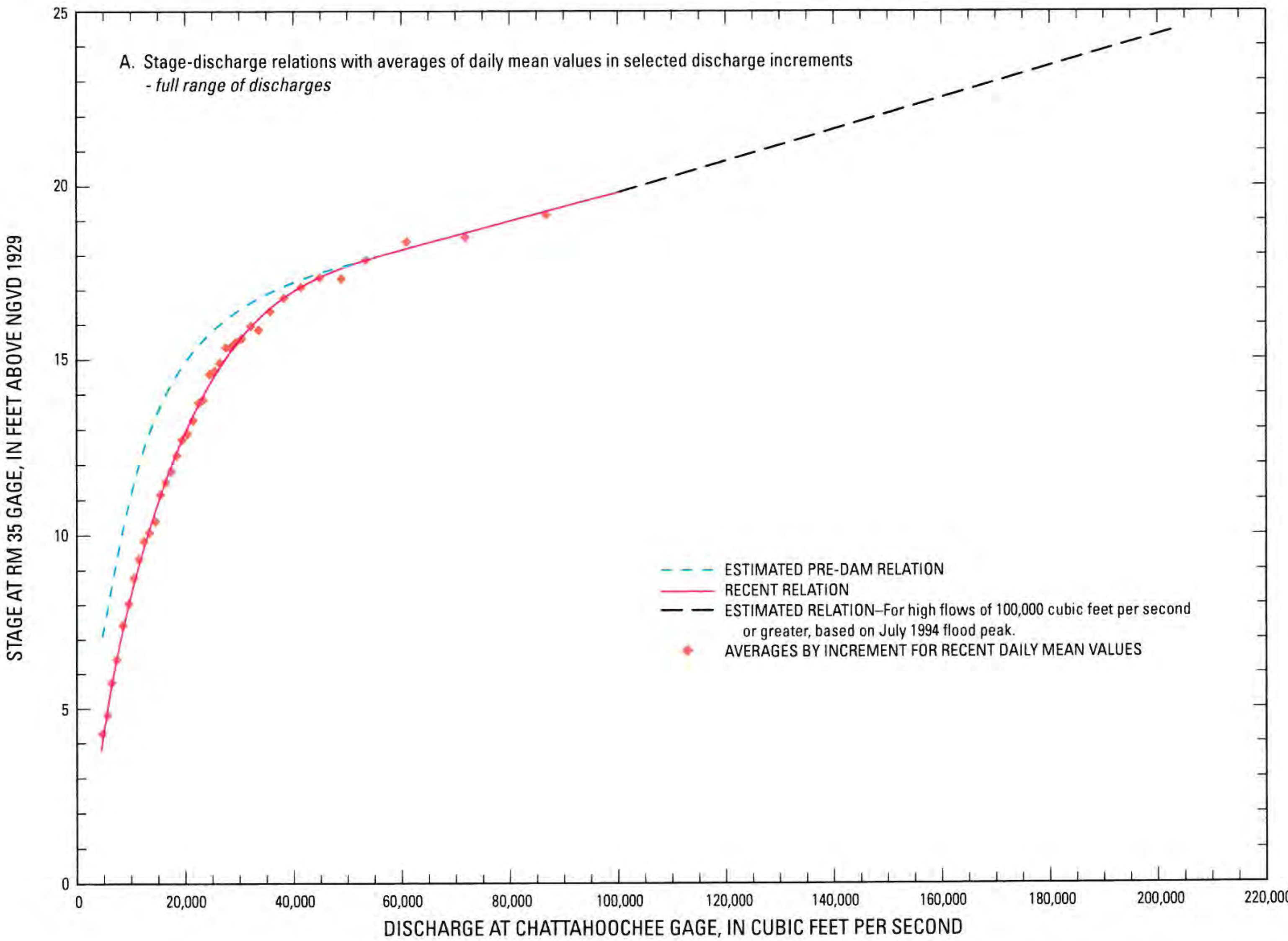
Appendix III. (Continued) Stage at the Wewahitchka streamgage in relation to discharge at the Chattahoochee streamgage in the Apalachicola River, Florida. Relations were developed using a lag time of 2 days, as defined in glossary.



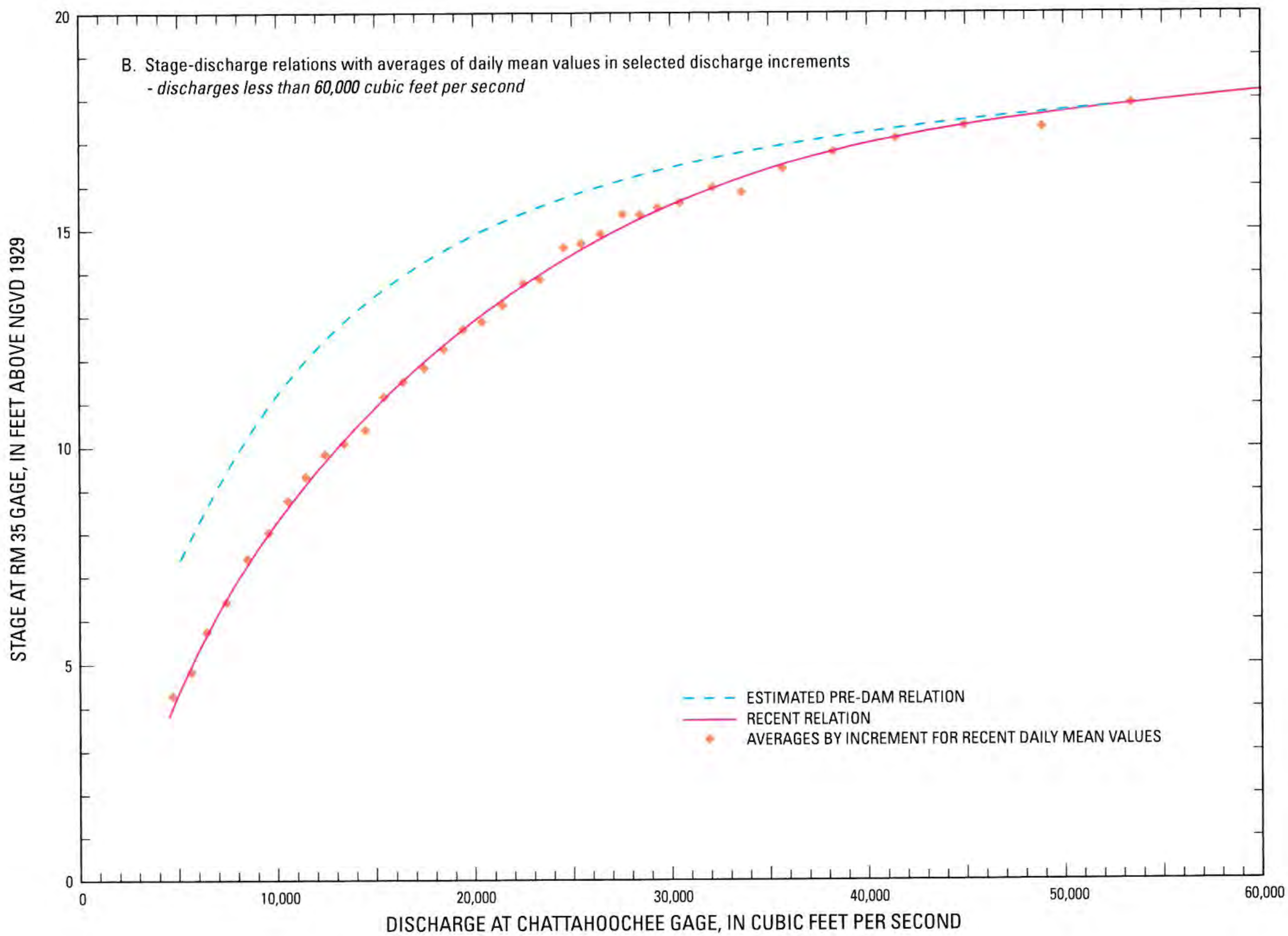
Appendix III. (Continued) Stage at the Wewahitchka streamgage in relation to discharge at the Chattahoochee streamgage in the Apalachicola River, Florida. Relations were developed using a lag time of 2 days, as defined in glossary.



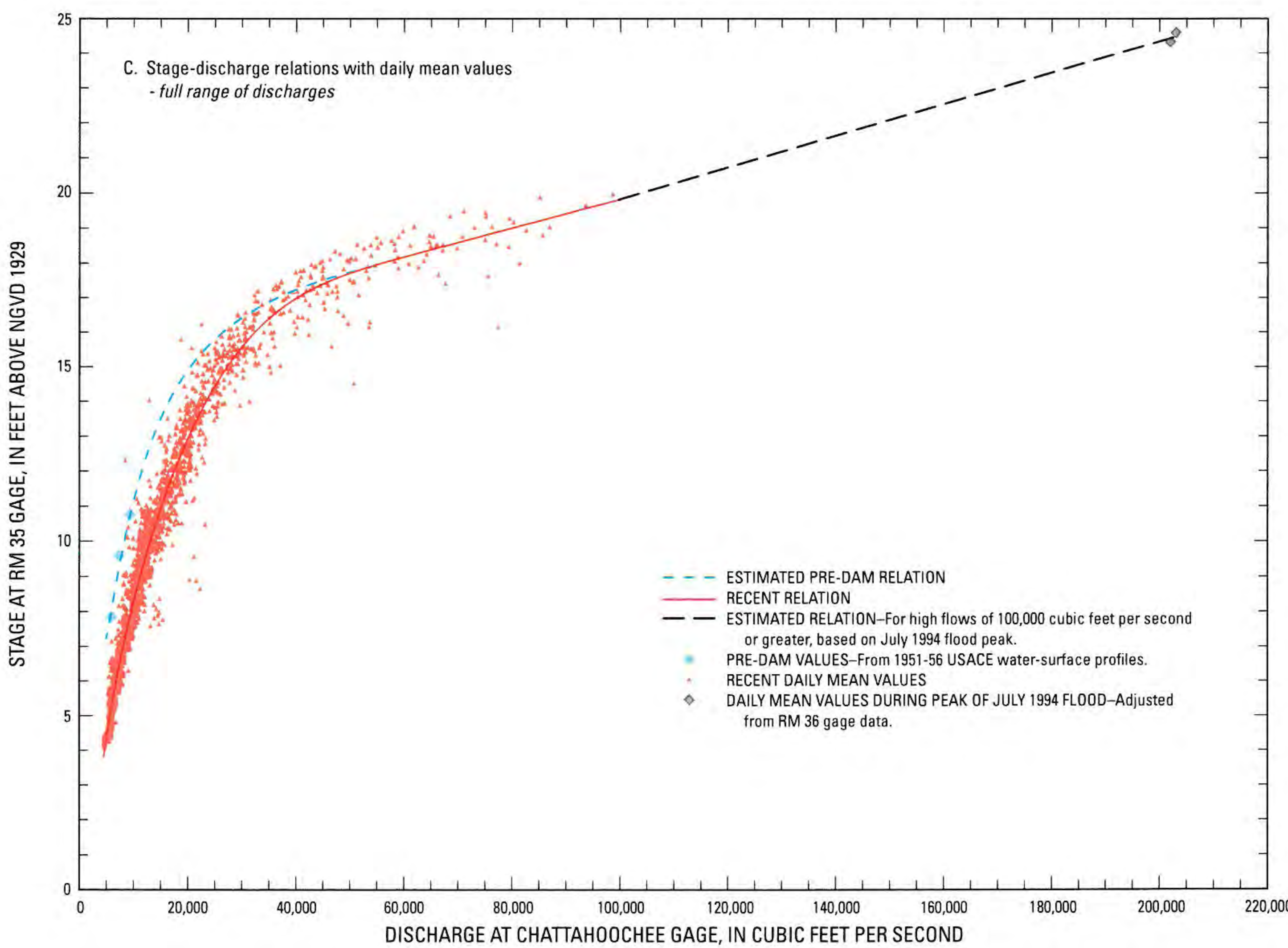
Appendix III. (Continued) Stage at the Wewahitchka streamgage in relation to discharge at the Chattahoochee streamgage in the Apalachicola River, Florida. Relations were developed using a lag time of 2 days, as defined in glossary.



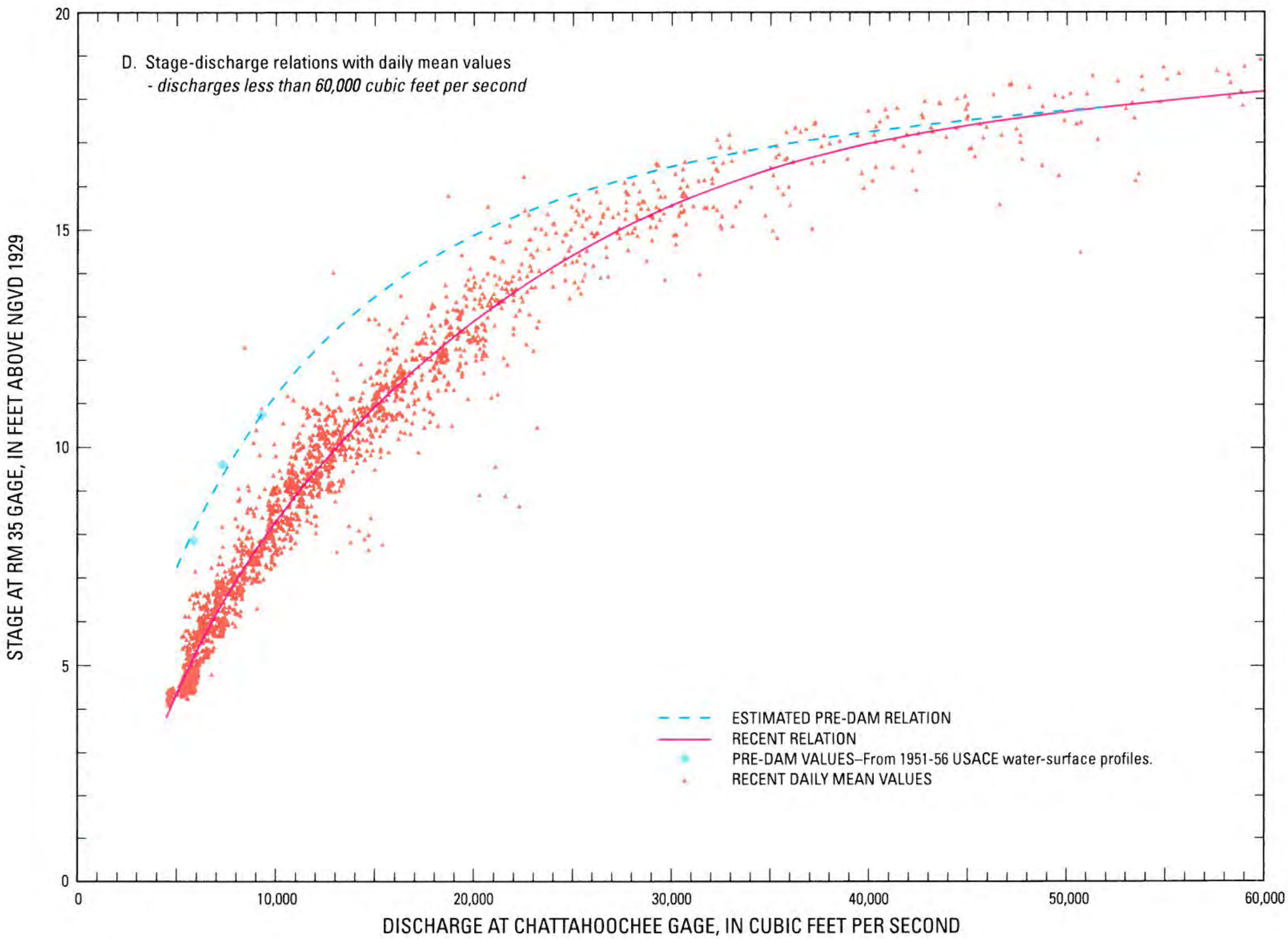
Appendix IV. Stage at the RM 35 streamgage in relation to discharge at the Chattahoochee streamgage in the Apalachicola River, Florida. Relations were developed using a lag time of 2 days, as defined in glossary.



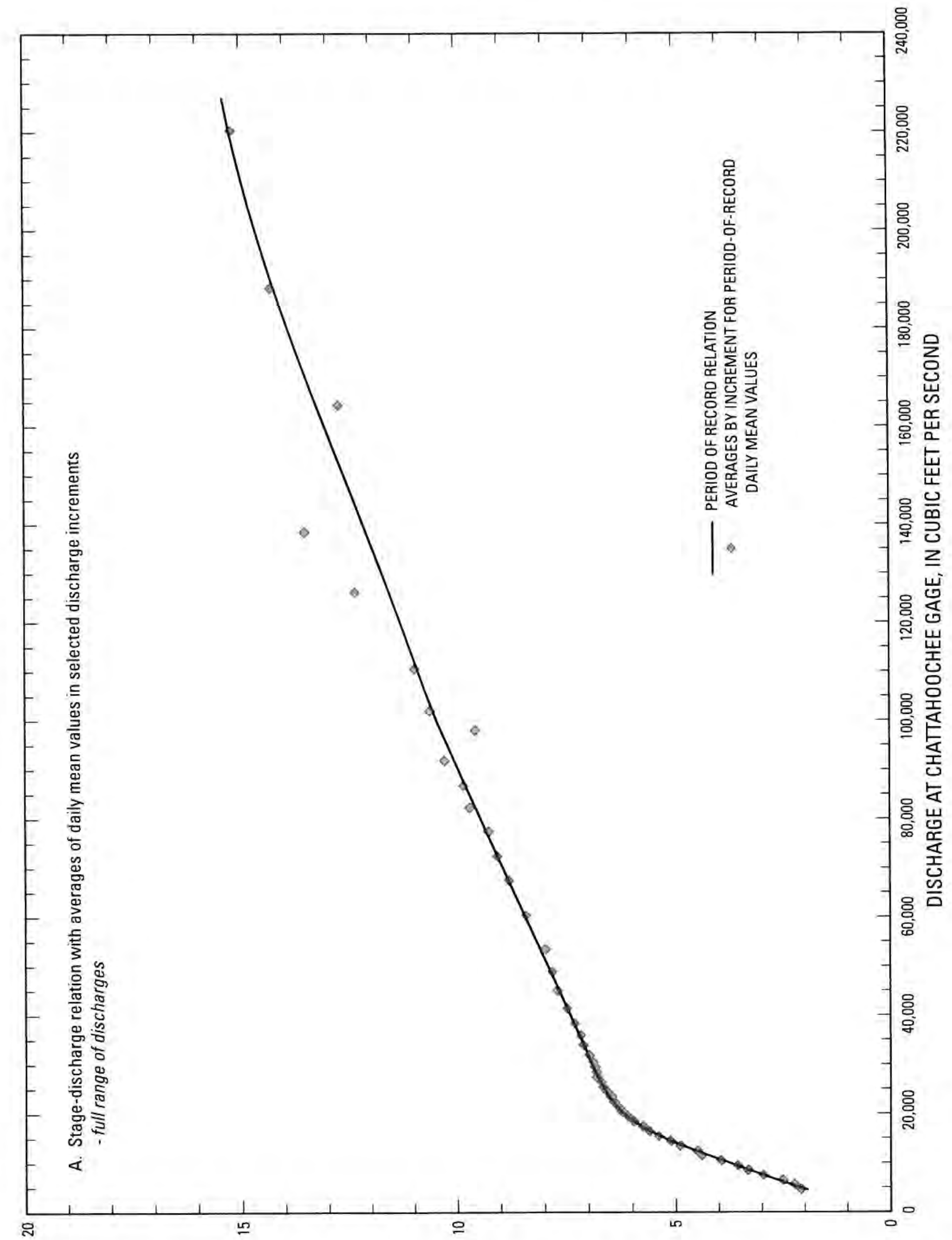
Appendix IV. (Continued) Stage at the RM 35 streamgage in relation to discharge at the Chattahoochee streamgage in the Apalachicola River, Florida. Relations were developed using a lag time of 2 days, as defined in glossary.



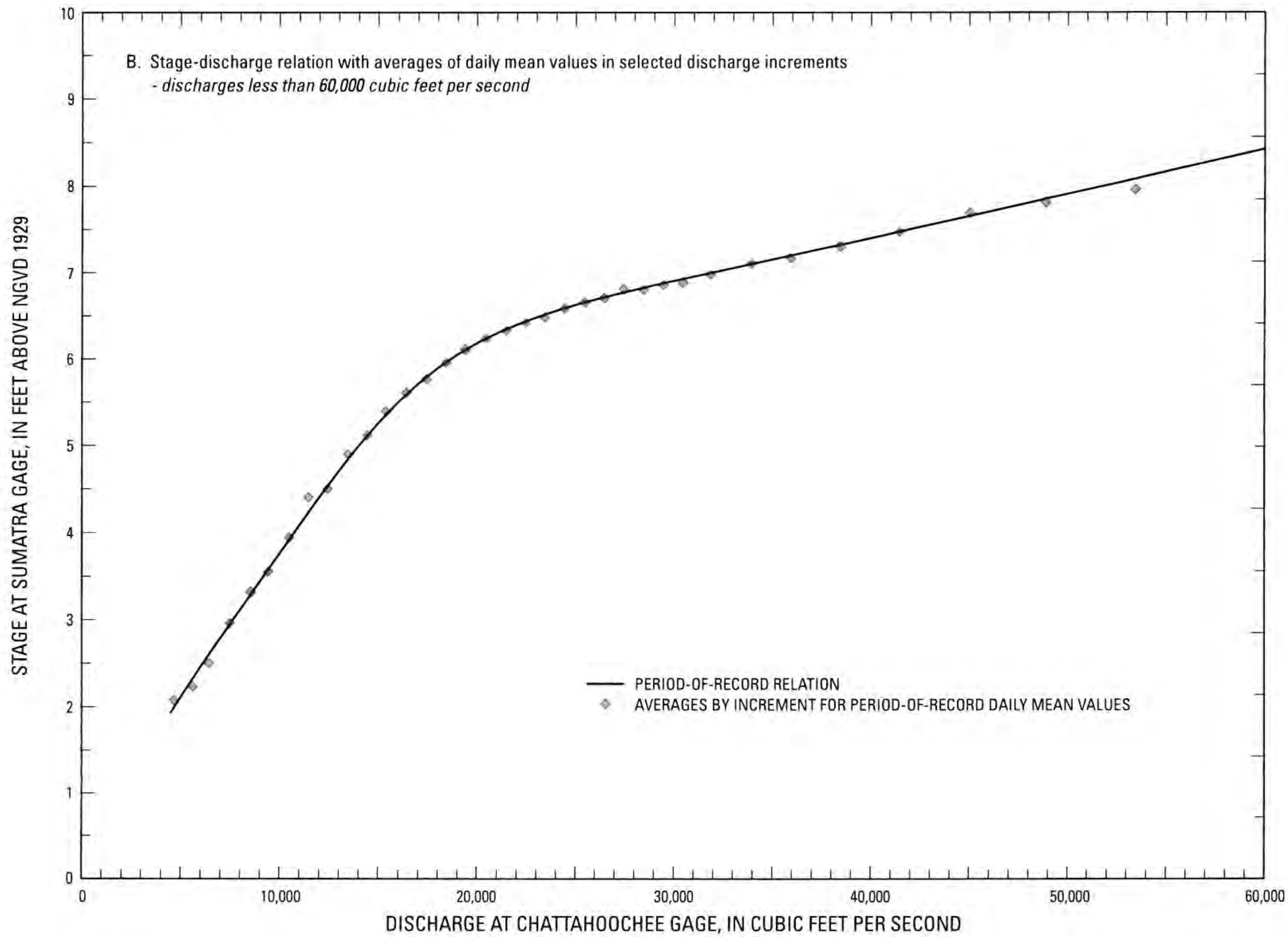
Appendix IV. (Continued) Stage at the RM 35 streamgage in relation to discharge at the Chattahoochee streamgage in the Apalachicola River, Florida. Relations were developed using a lag time of 2 days, as defined in glossary.



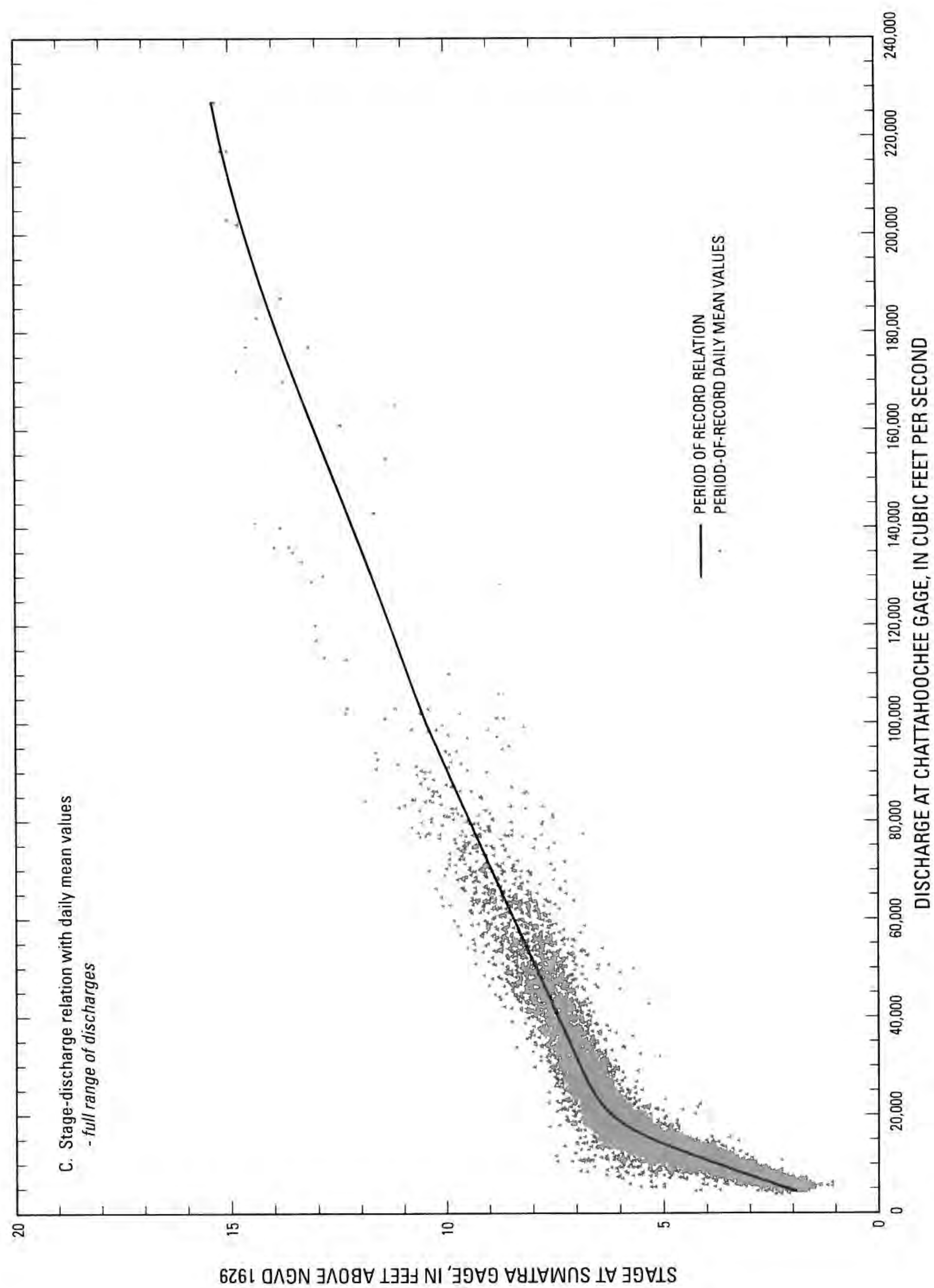
Appendix IV. (Continued) Stage at the RM 35 streamgage in relation to discharge at the Chattahoochee streamgage in the Apalachicola River, Florida. Relations were developed using a lag time of 2 days, as defined in glossary.



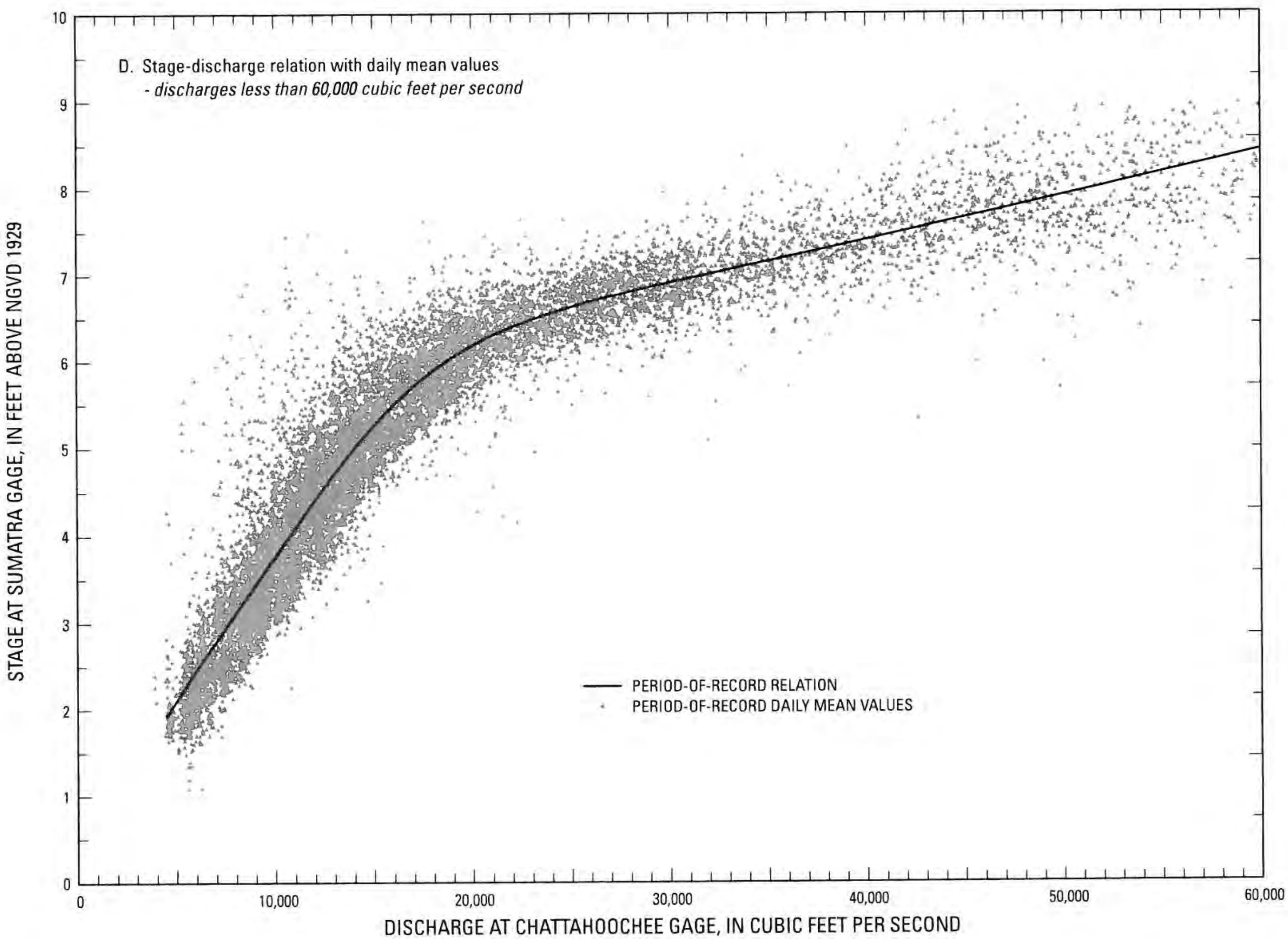
Appendix V. Stage at the Sumatra streamgage in relation to discharge at the Chattahoochee streamgage in the Apalachicola River, Florida. Relations were developed using a lag time of 3 days, as defined in glossary.



Appendix V. (Continued) Stage at the Sumatra streamgage in relation to discharge at the Chattahoochee streamgage in the Apalachicola River, Florida. Relations were developed using a lag time of 3 days, as defined in glossary.



Appendix V. (Continued) Stage at the Sumatra streamgage in relation to discharge at the Chattahoochee streamgage in the Apalachicola River, Florida. Relations were developed using a lag time of 3 days, as defined in glossary.



Appendix V. (Continued) Stage at the Sumatra streamgage in relation to discharge at the Chattahoochee streamgage in the Apalachicola River, Florida. Relations were developed using a lag time of 3 days, as defined in glossary.

Appendix VI. Formulas defining stage-discharge relations developed from long-term streamgage data on the Apalachicola River, Florida.

[Stage-discharge relations developed for this report relate stage at all gages to discharge at Chattahoochee gage using lag times as defined in glossary. A hand-drawn line was fitted through the averages of daily mean values in selected discharge increments (shown in graphs A and B of appendixes I-V). The points defining the hand-drawn line were entered into a curve-fitting software program to generate the formulas shown here. NOTE: Relations were developed only for the specific range of discharges indicated. Symbols used in formulas: y, stage at gage site; x, discharge at Chattahoochee; LN, natural logarithm of; ^, raised to the power of; *, times; /, divided by; SQRT, square root of. ft^3/s, cubic feet per second]

Name of stage-discharge relation	Range of discharges for indicated relation, in ft^3/s	Formula that defines indicated relation (first formula, in bold italics, emphasizes form of equation and depicts coefficients using letters a through h; second formula includes appropriate numeric values for coefficients; other symbols explained in header)
Chattahoochee pre-dam	5,000 to 188,000	***y=(a+cLNx+e(LNx)^2+g(LNx)^3)/(1+bLNx+d(LNx)^2+f(LNx)^3)*** y=(36.46419+-8.759358*LN(x)+ 0.7013277*LN(x)*LN(x)+-0.01857202*(LN(x))^3)/(1+-0.2476923*LN(x)+0.0205087*LN(x)*LN(x)+-0.0005656828*(LN(x))^3)
Chattahoochee recent	5,000 to 188,000	***y=(a+cLNx+e(LNx)^2+g(LNx)^3)/(1+bLNx+d(LNx)^2+f(LNx)^3)*** y=(32.70129+-7.959521*LN(x)+ 0.6462684*LN(x)*LN(x)+-0.01726782*(LN(x))^3)/(1+-0.2506587*LN(x)+0.0210629*LN(x)*LN(x)+-0.0005899609*(LN(x))^3)
Chattahoochee period of record (discharges greater than 188,000 ft^3/s)	188,000 to 291,000	***y=a+bx^(1.5)+cLNx/x^2*** y=71.502+0.000000063368*x*SQRT(x)+-6145800000*LN(x)/(x*x)
Blountstown pre-dam	5,000 to 135,000	***y=(a+cx^(0.5)+ex)/(1+bx^(0.5)+dx+fx^(1.5))*** y=(25.7675+-0.169116*SQRT(x)+0.000707624*x)/ (1+-0.00795382*SQRT(x)+0.0000301019*x+-0.0000000195457*x*SQRT(x))
Blountstown recent	5,000 to 135,000	***y=(a+cx^(0.5)+ex+gx^(1.5))/(1+bx^(0.5)+dx+fx^(1.5))*** y=(16.2468+0.0838415*SQRT(x)+-0.00158704*x+ 0.00000505012*x*SQRT(x))/(1+-0.00602802*SQRT(x)+-0.0000013423*x+0.0000000613884*x*SQRT(x))
Blountstown period of record (discharges greater than 135,000 ft^3/s)	135,000 to 291,000	***y=a+bx+c/x^(0.5)+dLNx/x+e/x*** y=-319.484+0.000164829*x+452543/SQRT(x)+-38552700*LN(x)/x+336092000/x
Wewahitchka pre-dam	5,000 to 65,000	***y=a+b/LNx+c/(LNx)^2+d/(LNx)^3+e/(LNx)^4+f/(LNx)^5*** y=36019.307+-1730956/LN(AI3)+33161881/(LN(AI3))^2+ -316295790/(LN(AI3))^3+1501669600/(LN(AI3))^4+-2839282900/(LN(AI3))^5
Wewahitchka recent	5,000 to 65,000	***y=(a+cx^(0.5)+ex+gx^(1.5))/(1+bx^(0.5)+dx+fx^(1.5))*** y=(-6.04395+0.407601*SQRT(x)+-0.00355355*x+ 0.00000911464*x*SQRT(x))/(1+-0.000205626*SQRT(x)+-0.0000679837*x+0.000000255263*x*SQRT(x))
Wewahitchka period of record (discharges greater than 65,000 ft^3/s	65,000 to 203,000	***y=(a+cLNx+e(LNx)^2+g(LNx)^3)/(1+bLNx+d(LNx)^2+f(LNx)^3)*** y=(14.23322839+-3.115040943*LN(x)+0.2199988079*LN(x)*LN(x)+-0.004930216433*(LN(x))^3)/ (1+-0.2360226768*LN(x)+0.0184113499*LN(x)*LN(x)+-0.0004736537139*(LN(x))^3)
RM 35 estimated pre-dam	5,000 to 52,000	***y=a+bx+cx^2+dx^2lnx+ex^(2.5)*** y=-0.041366+0.0021784*x+-0.00000072654*x*x+0.000000071414*x*x*LN(x)+-0.0000000003694*x*x*SQRT(x)
RM 35 recent	5,000 to 100,000	***y=(a+cx^(0.5)+ex+gx^(1.5))/(1+bx^(0.5)+dx+fx^(1.5))*** y=(-9.0383+0.28127*SQRT(x)+-0.0018663*x+ 0.0000042952*x*SQRT(x))/(1+-0.0033541*SQRT(x)+-0.000020966*x+0.00000011465*x*SQRT(x))
RM 35 estimated high flow	100,000 to 203,000	***y=a+bx*** y=15.307+0.000045139*x
Sumatra period of record (discharges less than 100,000 ft^3/s)	5,000 to 100,000	***y=(a+cx^(0.5)+ex+gx^(1.5))/(1+bx^(0.5)+dx+fx^(1.5)+hx^2)*** y=(-2.03362+0.0956435*SQRT(x)+-0.00105982*x+0.00000394975*x*SQRT(x))/ (1+-0.00806881*SQRT(x)+-0.0000393046*x+0.000000489282*x*SQRT(x)+-0.000000000548872*x*x)
Sumatra period of record (discharges greater than 100,000 ft^3/s)	100,000 to 227,000	***y=a+bx+c/LNx+d/x+e/x^(1.5)*** y=2317.753+-0.0003114299*x+-29250.1/LN(x)+42348710/x+-5028014000/(x*SQRT(x))

Appendix VII. Formulas used to interpolate stage between gages in relation to discharge at the Chattahoochee gage in the Apalachicola River, Florida.

Acronyms used in formulas

Location-related terms:

BGS (between-gage site for which interpolated stage-discharge relation is being calculated)
BGSStg (stage at BGS)
USG (closest upstream gage to between-gage site)
USGStg (stage at USG derived from stage-discharge relations based on long-term gage records)
DSG (closest downstream gage to between-gage site)
DSGStg (stage at DSG derived from stage-discharge relations based on long-term gage records)
RM (river mile)

Terms related to slope proportions:

WSP (water-surface profile)
WSPP (slope proportion calculated from stage in WSP)
WSPPStg (stage calculated using WSPP)
DISTP (slope proportion based on straight-line RM distance)
DISTPStg (stage calculated using DISTP)

Other terms:

JP (joining point flow)
JPS (stage at JP)
AVGP&R (average of pre-dam and recent)
DIFF9300 (Difference between DISTPStg and WSPPStg at 9,300 ft^3/s)

A. Calculation of BGSStg in low flow range (Chattahoochee flows of 9,300 ft^3/s or less)

Step 1.
Pre-dam WSPP for BGS =
((USGStg at 9,300 ft^3/s) - (BGSStg at 9,300 ft^3/s derived from 1956 WSP)) /
((USGStg at 9,300 ft^3/s) - (DSGStg at 9,300 ft^3/s))

Step 2.
Recent WSPP for BGS =
((USGStg at 9,300 ft^3/s) - (BGSStg at 9,300 ft^3/s derived from 1995 WSP)) /
((USGStg at 9,300 ft^3/s) - (DSGStg at 9,300 ft^3/s))

Step 3 (final step for pre-dam stage).
Pre-dam WSPPStg at BGS for given discharge = (pre-dam USGStg at given discharge) -
((pre-dam WSPP for BGS) x ((pre-dam USGStg at given discharge) - (pre-dam DSGStg at given discharge)))

Step 4 (final step for recent stage).
Recent WSPPStg at BGS for given discharge = (recent USGStg at given discharge) -
((recent WSPP for BGS) x ((recent USGStg at given discharge) - (recent DSGStg at given discharge)))

B. Calculation of BGSStg in high flow range (Chattahoochee flows greater than or equal to JP)

Step 1.
DISTP for BGS = ((RM of USG) - (RM of BGS)) / ((RM of USG) - (RM of DSG))

Step 2.
Pre-dam DISTPStg at BGS for given discharge = (pre-dam USGStg at given discharge) -
((DISTP at BGS) x ((pre-dam USGStg at given discharge) - (pre-dam DSGStg at given discharge)))

Step 3.
Recent DISTPStg at BGS for given discharge = (recent USGStg at given discharge) -
((DISTP at BGS) x ((recent USGStg at given discharge) - (recent DSGStg at given discharge)))

Step 4 (final step).
AVP&R DISTPStg at BGS for given discharge =
((pre-dam DISTPStg at BGS for given discharge) + (recent DISTPStg at BGS for given discharge)) / 2

Appendix VII. (Continued) Formulas used to interpolate stage between gages in relation to discharge at the Chattahoochee gage in the Apalachicola River, Florida.

C. Calculation of BGSStg in intermediate flow range (Chattahoochee flows between 9,300 ft^3/s and JP)

Step 1. (same as B.1.)

DISTP for BGS = ((RM of USG) - (RM of BGS)) / ((RM of USG) - (RM of DSG))

Step 2.

Pre-dam DISTPStg at BGS for 9,300 ft^3/s = (pre-dam USGStg at 9,300 ft^3/s) -
((DISTP at BGS) x ((pre-dam USGStg at 9,300 ft^3/s) - (pre-dam DSGStg at 9,300 ft^3/s)))

Step 3.

Recent DISTPStg at BGS for 9,300 ft^3/s = (recent USGStg at 9,300 ft^3/s) -
((DISTP at BGS) x ((recent USGStg at 9,300 ft^3/s) - (recent DSGStg at 9,300 ft^3/s)))

Step 4.

Pre-dam DIFF9300 at BGS =
(pre-dam DISTPStg at BGS for 9,300 ft^3/s) - (pre-dam BGSStg for 9,300 ft^3/s derived from 1956 WSP)

Step 5.

Recent DIFF9300 at BGS =
(recent DISTPStg at BGS for 9,300 ft^3/s) - (recent BGSStg for 9,300 ft^3/s derived from 1995 WSP)

Step 6.

Pre-dam JPS at BGS = (pre-dam JPS at USG) - ((DISTP at BGS) x ((pre-dam JPS at USG) - (pre-dam JPS at DSG)))

Step 7.

Recent JPS at BGS = (recent JPS at USG) - ((DISTP at BGS) x ((recent JPS at USG) - (recent JPS at DSG)))

Step 8.

AVGP&R JPS at BGS = ((pre-dam JPS at BGS) + (recent JPS at BGS)) / 2

Step 9.

JP for BGS = (JP at USG) - ((DISTP for BGS) x ((JP at USG) - (JP at DSG)))

NOTE: Our calculations were made for selected discharge increments. Therefore, this step includes a process similar to rounding, in which a lookup formula selects the largest discharge increment that is less than or equal to the resulting discharge from this formula

Step 10. (final step for pre-dam stage)

Pre-dam BGSStg for given discharge (smoothed from pre-dam BGSStg at 9,300 ft^3/s from 1956 WSP to AVGP&R JPS) =
pre-dam DISTPStg at BGS for given discharge -
(((JP for BGS - given discharge)/(JP for BGS - 9300)) x (pre-dam DIFF9300 at BGS)) -
(((given discharge - 9300)/(JP for BGS - 9300)) x ((pre-dam JPS at BGS) - (AVGP&R JPS at BGS)))

Step 11. (final step for recent stage)

Recent BGSStg for given discharge (smoothed from recent BGSStg at 9,300 ft^3/s from 1995 WSP to AVGP&R JPS) =
recent DISTPStg at BGS for given discharge -
(((JP for BGS - given discharge)/(JP for BGS - 9300)) x (recent DIFF9300 at BGS)) -
(((given discharge - 9300)/(JP for BGS - 9300)) x ((recent JPS at BGS) - (AVGP&R JPS at BGS)))

NOTE: A minor adjustment was made in the 1995 WSP data in a 1.5 rm reach from rm 22.2 to 20.7. In that reach (just upstream of Sumatra gage), stage in the 1956 WSP was slightly less than the stage in the 1995 WSP. The differences ranged from 0.02 to 0.11 feet. At the Sumatra gage, both the 1956 and 1995 WSP's were higher (by about 0.3 or 0.4 ft) than the stage at 9,300 ft^3/s that was determined from long-term gage data. Because the 1956 water-surface profile more closely matched the long-term gage data, it was assumed to be more accurate at that location, and 1995 WSP data were adjusted to match the 1956 values in this 1.5 rm reach.

Appendix VIII. Description of attached digital files of stage-discharge relations at all streamgages and between gage sites on the Apalachicola River, Florida.

A. Annotated example of contents of contents of attached digital files.

[Tables below show example data from pre-dam files for two subreaches. Relations were developed using lag times as defined in glossary. rm, river mile; Chatt, Chattahoochee; Blount, Blountstown; Q, discharge; ft³/s, cubic feet per second. Separate pre-dam and recent files were created for each of the following subreaches (file size in parentheses includes some duplicate relations at gages)]

Upper1 - rm 105.7-91.7 (141 relations with 506 points each)
Upper2 - rm 91.6-77.5 (142 relations with 506 points each)
Middle1 - rm 77.5-59.7 (179 relations with 488 points each)
Middle2 - rm 59.6-41.8 (179 relations with 488 points each)
Lower1 - rm 41.8-35.3 (66 relations with 488 points each)
Lower2 - rm 35.3-20.6 (148 relations with 488 points each)

ChattQ, in ft³/s

Column headings are river miles at 0.1 increments

Upper1_Pre-dam

ChattQ 105.7	Chatt gage 105.7	105.6	. . .	91.8	91.7	Chatt Q
4,500						4,500
4,600						4,600
4,700						4,700
4,800						4,800
4,900						4,900
5,000	44.07	43.41	. . .	36.76	36.72	5,000
5,100	44.13	43.48	. . .	36.83	36.79	5,100
⋮	⋮	⋮		⋮	⋮	⋮
29,900	55.13	54.56	. . .	48.25	48.22	29,900
30,000	55.17	54.59	. . .	48.29	48.25	30,000
30,500	55.34	54.76	. . .	48.45	48.41	30,500
⋮	⋮	⋮		⋮	⋮	⋮
99,500	67.99	67.62	. . .	58.44	58.38	99,500
100,000	68.03	67.67	. . .	58.47	58.41	100,000
101,000	68.13	67.76	. . .	58.54	58.48	101,000
⋮	⋮	⋮		⋮	⋮	⋮
187,000	74.45	74.37	. . .	63.64	63.56	187,000
188,000	74.52	74.45	. . .	63.70	63.62	188,000
190,000	74.68	74.60	. . .	63.81	63.73	190,000
195,000	74.99	74.91	. . .	64.05	63.98	195,000
⋮	⋮	⋮		⋮	⋮	⋮
285,000	80.19	80.11	. . .	67.97	67.88	285,000
290,000	80.48	80.39	. . .	68.18	68.09	290,000
291,000	80.54	80.45	. . .	68.22	68.14	291,000

Relations start at 5,000 ft³/s for pre-dam and 4,500 ft³/s for recent

Discharge increments, in ft³/s (total of 506 discharge values in upper reach files): 100; 500; 1,000; 5,000

Upper1 stops here and Upper2 picks up 0.1 rm downstream

Values in body of table are stage, in feet

ChattQ repeated at end of each file to accommodate EXCEL's lookup formula

The first and/or last relation in each reach file is at a gage

Upper2_Pre-dam

ChattQ 105.7	91.6	91.5	. . .	77.6	Blount gage 77.5	Chatt Q
4,500						4,500
4,600						4,600
4,700						4,700
4,800						4,800
4,900						4,900
5,000	36.68	36.64	. . .	29.93	29.85	5,000
5,100	36.75	36.71	. . .	29.99	29.91	5,100
⋮	⋮	⋮		⋮	⋮	⋮
29,900	48.18	48.14	. . .	41.81	41.74	29,900
30,000	48.21	48.17	. . .	41.84	41.77	30,000
30,500	48.38	48.34	. . .	42.00	41.93	30,500
⋮	⋮	⋮		⋮	⋮	⋮
99,500	58.32	58.25	. . .	49.16	49.08	99,500
100,000	58.35	58.29	. . .	49.18	49.10	100,000
101,000	58.42	58.35	. . .	49.22	49.14	101,000
⋮	⋮	⋮		⋮	⋮	⋮
187,000	63.48	63.41	. . .	52.60	52.52	187,000
188,000	63.54	63.47	. . .	52.64	52.56	188,000
190,000	63.66	63.58	. . .	52.71	52.63	190,000
195,000	63.90	63.82	. . .	52.88	52.80	195,000
⋮	⋮	⋮		⋮	⋮	⋮
285,000	67.79	67.71	. . .	55.48	55.40	285,000
290,000	68.00	67.92	. . .	55.62	55.53	290,000
291,000	68.05	67.96	. . .	55.65	55.56	291,000

Blank spaces from 4,500 to 4,900 ft³/s in pre-dam file allow for row-to-row comparisons with recent file.

B. Organization of files in EXCEL format (1 file with 12 worksheets named as follows)

1. Upper1_Pre-dam
2. Upper1_Recent
3. Upper2_Pre-dam
4. Upper2_Recent
5. Middle1_Pre-dam
6. Middle1_Recent
7. Middle2_Pre-dam
8. Middle2_Recent
9. Lower1_Pre-dam
10. Lower1_Recent
11. Lower2_Pre-dam
12. Lower2_Recent

C. Organization of files in flat file format (12 separate files named as follows)

1. Upper1_Pre-dam
2. Upper1_Recent
3. Upper2_Pre-dam
4. Upper2_Recent
5. Middle1_Pre-dam
6. Middle1_Recent
7. Middle2_Pre-dam
8. Middle2_Recent
9. Lower1_Pre-dam
10. Lower1_Recent
11. Lower2_Pre-dam
12. Lower2_Recent

NOTE: Pre-dam and recent relations in this appendix include values above the joining point that were derived from period-of-record data. Thus all points above the joining point flow in each pair of pre-dam and recent files in this appendix give exactly the same stage.

Appendix IX. Water-level decline, at various discharges, that occurred at streamgages and within reaches along the nontidal Apalachicola River, Florida, as a result of long-term changes in stage-discharge relations from 1954 to 2004.

[Data in this table are the same as shown in figure 17. Physical changes in the river channel caused the changes in stage-discharge relations; thus, the decline is greatest at low discharges when all streamflow is contained within the channel, and least at high discharges when much of the runoff is flowing over the floodplain. ft^3/s, cubic feet per second]

Selected discharge, in ft^3/s	Change in water level, in feet, at selected discharge								
	At gages					Averaged by reach			
	Chatta-hoochee	Blounts-town	Wewa-hitchka	RM 35	Sumatra	Upper reach	Middle reach	Nontidal lower reach	Entire nontidal river
5,000	-4.8	-2.6	-1.8	-2.9	0.0	-3.4	-1.9	-1.5	-2.3
10,000	-4.8	-1.8	-1.5	-2.9	0.0	-3.0	-1.3	-1.4	-1.9
15,000	-4.6	-1.7	-1.7	-2.6	0.0	-2.9	-1.3	-1.3	-1.8
20,000	-4.5	-1.8	-1.5	-2.0	0.0	-2.9	-1.3	-1.0	-1.8
25,000	-4.4	-1.8	-1.1	-1.4	0.0	-2.8	-1.1	-0.7	-1.6
30,000	-4.3	-1.7	-0.8	-0.9	0.0	-2.8	-0.9	-0.4	-1.4
40,000	-4.2	-1.5	-0.4	-0.2	0.0	-2.6	-0.6	-0.1	-1.1
50,000	-4.1	-1.3	-0.2	0.0	0.0	-2.4	-0.5	0.0	-1.0
60,000	-3.9	-1.2	-0.1	0.0	0.0	-2.3	-0.4	0.0	-0.9
80,000	-3.4	-0.9	0.0	0.0	0.0	-1.9	-0.2	0.0	-0.7
100,000	-2.7	-0.5	0.0	0.0	0.0	-1.4	-0.1	0.0	-0.5
120,000	-2.1	-0.2	0.0	0.0	0.0	-0.9	0.0	0.0	-0.3
150,000	-1.1	0.0	0.0	0.0	0.0	-0.3	0.0	0.0	-0.1
180,000	-0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Appendix X. Equivalent-stage discharges, corresponding percent exceedance values, and approximate decreases in percent duration of inundation, at various discharges, calculated at gages and within reaches along the nontidal Apalachicola River, Florida, as a result of long-term changes in stage-discharge relations from 1954 to 2004.

[This is a three-part table with the first two parts (A and B) providing data upon which the final data in part C are based. Data in part C are the same as shown in figure 19. Equivalent-stage discharges are provided in part A and corresponding percent exceedance values for those discharges are listed in part B. Steps for determining equivalent-stage discharge are illustrated in figure 13. Percent exceedance is the percent of time a specified discharge is equaled or exceeded during a given time period. Percent duration of inundation is numerically equivalent to percent exceedance in this report (see discussion in text). The time period used to calculate exceedance values in part B and approximate decreases in duration of inundation in part C is the recent period 1995-2004 (October 1, 1994 – September 30, 2004). ft^3/s, cubic feet per second]

A. Equivalent-stage discharge that would be required in the recent period to replicate pre-dam stage

Selected discharge, in ft^3/s *This is the discharge in step 1 of figure 13 used to determine pre-dam stage*	Equivalent-stage discharge, in ft^3/s *This is the discharge in step 4 of figure 13 that would be required in the recent period to replicate the pre-dam stage of a selected discharge.*								
	At gages					Averaged by reach			
	Chatta-hoochee	Blounts-town	Wewa-hitchka	RM 35	Sumatra	Upper reach	Middle reach	Nontidal lower reach	Entire nontidal river
5,000	13,900	8,200	7,100	8,400	5,000	10,300	7,100	7,000	8,100
10,000	19,900	13,000	13,000	15,500	10,000	15,700	12,300	12,800	13,600
15,000	25,700	18,500	20,000	21,700	15,000	21,300	18,200	18,600	19,400
20,000	31,500	24,200	26,100	26,900	20,000	27,000	23,900	24,000	24,900
25,000	37,500	29,900	31,500	31,500	25,000	32,700	29,100	28,500	30,100
30,000	43,500	35,500	36,500	35,000	30,000	38,600	34,100	32,600	35,200
40,000	56,500	48,000	46,500	42,500	40,000	51,300	44,400	41,400	45,900
50,000	70,000	62,000	54,000	50,500	50,000	64,700	54,700	50,500	57,000
60,000	82,500	75,500	61,500	60,000	60,000	77,400	64,500	60,000	67,700
80,000	105,000	94,500	80,000	80,000	80,000	98,000	83,400	80,000	87,400
100,000	124,000	109,000	100,000	100,000	100,000	114,300	101,400	100,000	105,300
120,000	139,000	123,000	120,000	120,000	120,000	129,000	120,000	120,000	123,000
150,000	161,000	150,000	150,000	150,000	150,000	153,000	150,000	150,000	151,000
180,000	182,000	180,000	180,000	180,000	180,000	179,000	180,000	180,000	180,000

B. Percent exceedance in recent period (1995-2004) for selected and equivalent-stage discharge values

Selected discharge, in ft^3/s	Percent exceed-ance for selected discharge	Percent exceedance for equivalent-stage discharge listed in part A								
		At gages					Averaged by reach			
		Chatta-hoochee	Blounts-town	Wewa-hitchka	RM 35	Sumatra	Upper reach	Middle reach	Nontidal lower reach	Entire nontidal river
5,000	99.1	50.6	78.5	84.7	77.5	99.1	67.5	84.6	85.6	78.7
10,000	68.6	29.3	55.3	55.3	42.8	68.6	41.9	59.2	56.5	52.8
15,000	45.3	20.6	33.7	29.0	25.7	45.3	26.4	34.5	33.1	30.7
20,000	29.0	14.1	22.0	20.1	19.2	29.0	19.1	22.4	22.3	21.4
25,000	21.4	10.9	16.0	14.1	14.1	21.4	13.2	16.8	17.4	15.8
30,000	15.9	8.6	11.9	11.4	12.3	15.9	10.5	12.6	13.2	12.2
40,000	10.2	4.3	6.8	7.3	9.0	10.2	5.7	8.3	9.5	7.6
50,000	6.2	1.9	3.3	4.9	6.0	6.2	2.6	4.7	6.0	4.2
60,000	3.7	1.0	1.5	3.5	3.7	3.7	1.3	2.6	3.7	2.2
80,000	1.1	0.3	0.5	1.1	1.1	1.1	0.4	0.9	1.1	0.8
100,000	0.4	0.2	0.3	0.4	0.4	0.4	0.2	0.3	0.4	0.3
120,000	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
150,000	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
180,000	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

Appendix X. (Continued) Equivalent-stage discharges, corresponding percent exceedance values, and approximate decreases in percent duration of inundation, at various discharges, calculated at gages and within reaches along the nontidal Apalachicola River, Florida, as a result of long-term changes in stage-discharge relations from 1954 to 2004.

[This is a three-part table with the first two parts (A and B) providing data upon which the final data in part C are based. Data in part C are the same as shown in figure 19. Equivalent-stage discharges are provided in part A and corresponding percent exceedance values for those discharges are listed in part B. Steps for determining equivalent-stage discharge are illustrated in figure 13. Percent exceedance is the percent of time a specified discharge is equaled or exceeded during a given time period. Percent duration of inundation is numerically equivalent to percent exceedance in this report (see discussion in text). The time period used to calculate exceedance values in part B and approximate decreases in duration of inundation in part C is the recent period 1995-2004 (October 1, 1994 – September 30, 2004). ft^3/s, cubic feet per second]

C. Approximate decrease in percent duration of inundation as a result of long-term changes in stage-discharge relations

Selected discharge, in ft^3/s	Percent exceed-ance for selected discharge	Approximate change in percent duration of inundation (Percent exceedance for equivalent-stage discharge minus percent exceedance for selected discharge)								
		At gages					Averaged by reach			
		Chatta-hoochee	Blounts-town	Wewa-hitchka	RM 35	Sumatra	Upper reach	Middle reach	Nontidal lower reach	Entire nontidal river
5,000	99.1	-48.5	-20.6	-14.4	-21.6	0.0	-31.6	-14.4	-13.5	-20.4
10,000	68.6	-39.3	-13.3	-13.3	-25.8	0.0	-26.7	-9.4	-12.1	-15.8
15,000	45.3	-24.7	-11.6	-16.3	-19.6	0.0	-18.9	-10.8	-12.2	-14.6
20,000	29.0	-14.9	-7.0	-8.9	-9.8	0.0	-9.9	-6.6	-6.7	-7.6
25,000	21.4	-10.4	-5.4	-7.3	-7.3	0.0	-8.2	-4.5	-3.9	-5.6
30,000	15.9	-7.3	-4.0	-4.5	-3.6	0.0	-5.4	-3.3	-2.7	-3.7
40,000	10.2	-5.9	-3.4	-2.8	-1.1	0.0	-4.4	-1.8	-0.7	-2.5
50,000	6.2	-4.3	-2.8	-1.3	-0.2	0.0	-3.6	-1.5	-0.2	-2.0
60,000	3.7	-2.7	-2.2	-0.2	0.0	0.0	-2.3	-1.1	0.0	-1.5
80,000	1.1	-0.9	-0.7	0.0	0.0	0.0	-0.7	-0.2	0.0	-0.4
100,000	0.4	-0.2	-0.1	0.0	0.0	0.0	-0.1	0.0	0.0	-0.1
120,000	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
150,000	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
180,000	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Exhibit 21

From:	Hoehn, Ted [/O=FLA FISH AND WILDL CONSERV COMM/OU=TALLAHASSEE/CN=RECIPIENTS/CN=FWC/CN=OFFICE OF ENVIRONMENTAL SERVICES (OES)/CN=TED.HOEHN]
Sent:	6/9/2009 8:46:30 PM
To:	Poole, MaryAnn [/O=FLA FISH AND WILDL CONSERV COMM/OU=TALLAHASSEE/CN=RECIPIENTS/CN=MARYANN.POOLE]
BCC:	Poole, MaryAnn [/O=FLA FISH AND WILDL CONSERV COMM/OU=TALLAHASSEE/CN=RECIPIENTS/CN=MaryAnn.Poole]
Subject:	FW: Meeting(s) with Mike Sole
Attachments:	Apalachicola Restoration Prospects_June 2009_Final.pdf; American Rivers Restoration Paradigm_Meeting Request FINAL 4.doc
Importance:	High

Here is the info that we discussed earlier today.

Ted Hoehn
Florida Fish and Wildlife Conservation Commission
Division of Habitat and Species Conservation
Habitat Conservation Scientific Services
620 S. Meridian Street, MS 2A
Tallahassee, FL 32399-1600
(850)410-0656 ext 17336; Cell 850-519-3106
Fax (850) 921-1847

From: Wiley, Nick
Sent: Tuesday, June 09, 2009 2:07 PM
To: Hoehn, Ted; Sanders, Scott
Cc: Breault, Tim
Subject: FW: Meeting(s) with Mike Sole
Importance: High

Ted and Scott. Can you help me determine if we have enough key staff available this Friday afternoon to host the referenced meeting? Not sure who all needs to be there, but I know it needs to be more than just me. I do believe Ted is an essential participant. Thanks. Nick

From: Haddad, Ken
Sent: Tuesday, June 09, 2009 1:49 PM
To: dan@apalachicolariverkeeper.org
Cc: Wiley, Nick; Ventimiglia, Karen
Subject: FW: Meeting(s) with Mike Sole
Importance: High

Dan, I am not here but certainly some of the staff you list below can be there and perhaps Nick Wiley our assistant executive director. Via this email I am asking him to coordinate if it is feasible. Regards Ken

Ken Haddad, Executive Director
Florida Fish and Wildlife Conservation Commission
620 South Meridian, Tallahassee, Fl. 32399
850 487 3796
visit our web at MyFWC.com

From: Haddad, Kenneth
Sent: Monday, June 08, 2009 5:39 PM
To: Haddad, Ken

EXHIBIT 3
PENGAD 800-631-6989

Executive Summary

The Apalachicola River system is of exceptional ecological importance. It has been designated by the United Nations as an International Biosphere Reserve, by the United States as a National Estuarine Research Reserve, and by the State of Florida as an Outstanding Florida Water. The river harbors the most diverse assemblage of freshwater fish in Florida, the largest number of species of freshwater snails and mussels, and the most endemic species in western Florida. The river basin is home to some of the highest densities of reptile and amphibian species on the continent. The Apalachicola's waters and floodplain are the biological factory that fuels the Apalachicola Bay, one of the most productive estuaries in the northern hemisphere.

Despite its enormous ecological value, the Apalachicola River ecosystem has been severely degraded through a long history of navigational dredging by the U.S. Army Corps of Engineers (Corps), impoundment of water by upstream reservoirs, and consumptive use of water upstream. These activities have destabilized and widened the river channel; reduced the river's hydraulic complexity and habitat diversity; smothered and displaced habitat in the river's rich sloughs, floodplains, and channel margins; and altered the river's flow regimes. By enlarging the channel, navigation dredging has also lowered water levels for the same flows from upstream. Decreased water levels in the river have caused the Apalachicola's floodplains and sloughs to dry out, with severe ecological effects.

In an attempt to mitigate some of the impacts of its navigation dredging (and as required by its state dredging permit), the Corps implemented a number of small-scale mitigation projects designed to recreate or reconnect habitats. These projects did not attempt to restore the river's fluvial processes, have not been sustainable, and have not reversed habitat losses caused by the Corps' dredging. At best they may have been marginally effective for a limited period of time, while also producing additional ecological harm. There has been little or no monitoring of these projects to optimize learning to benefit future restoration efforts.

After putting a stop to the Corps' navigational dredging in October 2005, the State of Florida carried out a larger-scale restoration project at Battle Bend. Originally planned by the Corps, this project involved dredging to restore a connection between the Apalachicola River and the Battle Bend Oxbow.

Exhibit 22

Biological Opinion

Endangered Species Act
Section 7 Consultation

on the

U.S. Army Corps of Engineers
Mobile District

Update of the Water Control Manual for the Apalachicola-Chattahoochee-Flint River Basin in Alabama, Florida, and Georgia and a Water Supply Storage Assessment

Prepared by:
U.S. Fish and Wildlife Service
Panama City Field Office, Florida
September 14, 2016

USFWS Log No: 04EF3000-2016-F-0181

As discussed above, designated critical habitat for the Gulf sturgeon in the action area includes the Apalachicola River unit, and the Apalachicola Bay unit. In the effects analysis, we discussed how the WCM may affect four of the PCEs of sturgeon critical habitat: 1) food items in both the riverine and estuarine environments; 2) riverine spawning areas; 3) flow regime, and 4) water quality. Of the effects of WCM, hydropeaking has the potential to affect food resources in the river for young (5-day old) sturgeon larvae and the reduction in floodplain inundation in the fall and winter has the potential to further reduce food resources for juvenile sturgeon overwintering for the first time in the bay and estuary. Spawning areas may be affected by the sub-daily flow and velocity changes from hydropeaking. The flow regime may be altered by operations under the WCM by changing floodplain inundating flows and sub-daily fluctuations from hydropeaking. The water quality, especially salinity, in the distributary rivers may affect the ability to effectively forage by young of year and juveniles in the winter. However, the WCM would not appreciably change the quantity or quality of the PCEs to the extent that it would appreciably diminish the habitat's capability to provide the intended conservation role.

7.3 Determination

After reviewing the current status of the listed species and designated critical habitat, the environmental baseline for the action area, the effects of the proposed action, and the cumulative effects, it is the USFWS' biological opinion that the proposed action: 1) will not jeopardize the continued existence of the Gulf sturgeon; and 2) will not destroy or adversely modify designated critical habitat for the Gulf sturgeon.

The WCM is intended to apply until a new WCM is adopted. Given the USACE's current timeline, the findings of this BO shall apply for five years until September 14, 2021, or until amended through a reinitiation of consultation or superseded with a new opinion for a new proposed action.

8 MUSSELS - STATUS OF THE SPECIES

8.1 Species Description

Fat threeridge

The fat threeridge (*Amblema neislerii*) is a medium-sized, heavy-shelled mussel that reaches a length of about 100 millimeters (mm) (4.0 inches (in)). Large specimens are highly inflated. The dark brown to black shell is oval to quadrate and strongly sculptured with seven to nine prominent horizontal parallel plications (ridges). The umbo (the raised, rounded portion near the shell hinge) is in the anterior quarter of the shell. The inside surface of the shell (nacre) is white to bluish white. As typical of the genus, no sexual dimorphism is displayed in shell characters (Williams and Butler 1994, Williams et al. 2008).

Purple bankclimber

and habitat mapping using side-scan sonar throughout the known range in the ACF Basin have increased our knowledge of the population size of fat threeridge (Smit 2014, Smit and Kaeser *in press*). The sonar mapping approach identified twice as many patches and ten times the quantity of suitable habitat than identified using traditional approaches and SCUBA sampling identified high densities of mussels. Fat threeridge was the most abundant mussel in terms of frequency collected of the 18 mussel species detected during surveys (Smit 2014, Smit and Kaeser *in press*). During these 2012-2015 surveys, 7,454 individuals were collected from the lower Chipola River and lower and middle Apalachicola River (Table 9.1, 9.2, 9.3). Recent surveys all reported evidence of fat threeridge recruitment in the Apalachicola River based on size class information (Gangloff 2011, Smit 2014, Smit and Kaeser *in press*).

The highest densities of fat threeridge occur in the lower Chipola River and between RM 27-50 of middle Apalachicola River with mean densities ranging from 2.1 to 11.2 individuals/sq. m, but densities ranged up to 19.5 individuals/sq. m in optimal habitat in the lower Chipola River. Densities varied with habitat class and IRZ, ORZ, and POB generally having the highest densities (Table 9.5). Based on these densities and the area of habitat mapped in each river reach, current estimates of the population size of fat threeridge in the action area range from about 6,009,000 to 18,650,000 individuals, with a mean of approximately 12,167,000. According to the 2015 Annual Report for USACE, incidental take monitoring began under the current RIOP conditions, there has been a cumulative take estimate of 8,374 fat threeridge. For the fat threeridge this represents a total of approximately 0.07% of the population.

Table 9.5 Population estimates based on densities sampled in each habitat (Smit 2014, Smit and Kaeser *in press*).

River	Habitat Class	Mapped area (m^2)	Mean Density	lower 95% CI	upper 95% CI	Population Estimate	lower 95% CI	upper 95% CI
Middle Apalachicola River	IRZ	270,698	4.6	2.0	6.9	1,239,797	527,861	1,867,816
	ORZ	157,183	4.8	3.0	6.4	754,478	474,693	1,007,543
	POB	1,043,241	2.1	1.0	3.0	2,169,941	1,084,971	3,077,561
	PB	505,010	0.1	0.0	1.3	30,301	0	656,513
	MC	4,985,217	0.0	0.0	0.0	0	0	0
	River Total	6,961,349				4,194,517	2,087,524	6,609,433
Lower Apalachicola River	SBA	681,500	0.9			599,720		
Lower Chipola River	SBA	381,803	11.2	6.9	15.6	4,276,195	2,618,406	5,953,074
	POB	281,579	11.0	2.5	19.5	3,097,370	703,948	5,488,539
	MC	1,265,849	0.2	0.0	0.5	202,536	0	632,925
	River Total	1,929,231				7,373,564	3,322,353	11,441,613
Total		9,572,080				12,167,801	6,009,598	18,650,766

10.4 Interrelated and Interdependent Actions

We must consider along with the effects of the action the effects of other federal activities that are interrelated to, or interdependent with, the proposed action (50 CFR sect. 402.02). By definition, interrelated actions are part of a larger action and depend on the larger action for their justification. Interdependent actions have no independent utility apart from the proposed action. At this time, the USFWS is aware of only one action that satisfy the definitions of interrelated and interdependent actions that will not themselves undergo section 7 consultation in the future, or that are not already included in the Baseline or our representations of flows under the WCM. This action will undergo section 7 consultation in the future, but is worthy of mention because they address possible reasonable and prudent measures and terms and conditions for addressing effects of hydropeaking. The USACE contract with Southeast Power Administration and Duke Energy will undergo section 7 in the future. This contract controls hydropower production and hydropeaking.

11 MUSSELS - CUMULATIVE EFFECTS

Cumulative effects for mussels are anticipated to be similar to those for Gulf sturgeon.

12 MUSSELS - CONCLUSION

The proposed action provides both beneficial and adverse effects to the species and their designated critical habitats. To the extent that the consumptive use assumptions are accurate, differences between the Baseline and the simulated flows of the WCM are due to differences in reservoir operations, as the model is driven by the observed hydrology. Therefore, we attribute all differences between the Baseline and WCM simulated flow regime to the USACE's discretionary operations. Differences between the Baseline and WCM are summarized for each of the species below (for more details, see section 10).

Most of these effects, both beneficial and adverse, derive from relatively minor differences between the WCM and Baseline. Generally, it appears that USACE would store water more often and augment flows less often under the WCM than has occurred under current management. The WCM uses some of this stored water to maintain a minimum flow of 5,000 cfs, but the frequency of flows less than 10,000 cfs and less than 7,500 cfs is increased. Additionally, floodplain inundation during spring and summer is reduced. The remainder of this section summarizes and consolidates our findings in the previous sections for each listed species and critical habitat in the action area.

12.1 Fat threeridge

Based on best available information, we believe the population of fat threeridge in the action area is stable and possibly increasing. The population appears to be doing well despite the principal effects to the fat threeridge in the action area that we described in section 8, Mussels -

Environmental Baseline. The inter-annual frequency and the intra-annual duration of low flows in the pre-Lanier period substantially increased in the post-West Point period. Flows under the WCM will further increase the frequency and duration of low flows. Flows less than 5,000 cfs were not recorded in the pre-Lanier period. The WCM supports a minimum flow of 5,000 cfs, which benefits the fat threeridge, except when drought operations are triggered that provide for minimum-flow support of 4,500 cfs. Supporting a minimum flow of 5,000 cfs in the future with less basin inflow as demands increase would require greater storage releases from the reservoirs, which could trigger the 4,500 cfs minimum flow provision of the WCM more frequently. The results of an earlier PVA indicated that the population can sustain reductions of 1-2%, and this magnitude of population reduction occurred in the past at a probability less than expected in the WCM. However, the PVA also indicates that increasing the frequency of such events results in a greater impact to long-term population viability, and the WCM increases the probability from once to twice in 74 years. As such, we need to continue to monitor the frequency and severity of these events. If the events occur with greater frequency, it may be necessary to reinitiate consultation.

Therefore, our analysis indicates that the WCM would have a negative, but not appreciable, impact on the survival and recovery of the fat threeridge due to mortality and other adverse effects if flows are reduced to 4,500 cfs or if additional recolonization and subsequent mortality occurs at flows above 5,000 cfs. Further, the WCM would have a negative, but not appreciable, impact on the survival and recovery of the fat threeridge due to reduced recruitment if flows inundate the floodplain for less than 30 consecutive days between March and August.

12.2 Purple bankclimber

The core of the known population of purple bankclimbers in the action area is at the Race Shoals (the limestone shoal at RM 105), but the species is apparently rare in the rest of the river and may be experiencing poor recruitment. Little recent information in the action area is available on the species with only 31 individuals collected during 2012-2015 surveys and 40 detected during take monitoring, but the species is much more detectable and probably much more abundant in other parts of its range, such as the Flint River and the Ochlockonee River. A whole river population estimate is not available, but the population at Race Shoals was estimated to be 30,000. The principal effects to the purple bankclimber in the action area are those we described in section 8, Mussels - Environmental Baseline. Channel morphology changes may have contributed to a decline of the species in the upstream-most 30 miles of the river, although the species is still found in this reach in relatively high numbers at Race Shoals. Flow regime alterations discussed above for the fat threeridge apply also to purple bankclimber with the exception that purple bankclimbers are rarely found at stages greater than 4,500 cfs in the Apalachicola River. We have observed limited mortality of the population during low flows from 2008-2015 with 39 individuals in 2011 when flows were inadvertently reduced below 5,000 cfs and 40 individuals detected during USACE take monitoring.

Therefore, our analysis indicates that the WCM would have a negative, but not appreciable, impact on the survival and recovery of the purple bankclimber. This impact is due to mortality and other adverse effects if flows are reduced to 4,500 cfs or if additional recolonization and subsequent mortality occurs at flows above 5,000 cfs.

12.3 Chipola slabshell

Surveys from 1990 to present have documented many occurrences but found that the species generally occurs in relatively low abundance. We have no evidence that these populations are currently declining, and we consider the Chipola slabshell status to be stable. Many of the effects we described in section 8, Mussels - Environmental Baseline do not apply to the Chipola slabshell, as its known range within the action area is almost entirely limited to the Chipola River downstream of the Chipola Cutoff. Most of the species range is in the Chipola River upstream of the action area. Channel morphology appears less altered in the Chipola River than the Apalachicola River. Flow regime alterations discussed for the fat threeridge apply also to the Chipola slabshell, but probably to a lesser extent in the narrower channel and higher bank slopes of the Chipola River. No Chipola slabshell mortality was documented during the low flows of 2006-2008 and 2010-2011, but there has been a cumulative take estimate of 24 Chipola slabshell under USACE take monitoring. We also expect the mortality of the Chipola slabshell to be less than the expected for the fat threeridge or purple bankclimber because of its expected higher mobility.

Therefore, our analysis indicates that the WCM would have a negative, but not appreciable, impact on the survival and recovery of the Chipola slabshell due mortality and other adverse effects if flows are reduced to 4,500 cfs or if additional recolonization and subsequent mortality occurs at flows above 5,000 cfs. Further, the WCM would have a negative, but not appreciable, impact on the survival and recovery of the Chipola slabshell due to reduced recruitment if flows inundate the floodplain for less than 30 consecutive days between March and August.

12.4 Critical Habitat

Designated critical habitat for the fat threeridge and purple bankclimber in the action area includes most of the Apalachicola River unit, and the downstream-most part of the Chipola River Unit. Designated habitat for the Chipola slabshell only occurs within the downstream-most part of the Chipola River Unit. In the effects analysis, we discussed how the WCM may affect the three of the five PCEs of the mussel critical habitat: 1) permanently flowing water; 2) water quality; and 3) fish hosts.

The WCM increased the probability of reducing flows <5,000 cfs, although this is still a very infrequent event (3 of 74 years in the record). This would occur under drought operations, and droughts substantially change the nature of all of these PCEs compared to normal flows. At higher flows inundating the floodplain, the WCM is expected to have slightly negative effects for mussel growth and fecundity during the late growing season compared to the baseline. Although these are also rare events in the record (1 of 74 years in the record), one less pulse of nutrients may provide less carbon and consequently primary productivity to the main channel of the river to the majority of the mussel population. Additional data on the effects of up to 1.8 ft sub-daily

Exhibit 23

Using sonar habitat mapping and GIS analyses to identify freshwater mussel habitat and estimate population size of a federally endangered freshwater mussel species, *Amblema neislerii,* in the Apalachicola River, FL

by

Reuben B. Smit

A thesis submitted to the Graduate Faculty of
Auburn University
in partial fulfillment of the
requirements for the Degree of
Master of Science

Auburn, Alabama
May 3, 2014

Keywords: sonar habitat mapping, freshwater mussels, species distribution model, *Amblema neislerii,* fat threeridge, Apalachicola River

Approved by

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Abstract

Identification and quantification of freshwater mussel habitat in large turbid rivers is challenging. Sonar habitat mapping offers a low cost and time efficient means to identify and quantify benthic habitats over large spatial extents. I used sonar to classify freshwater mussel habitat across a 700 hectare reach of the Apalachicola River, FL, and used sonar imagery collected before and after a 10-year flood event to assess habitat stability. GIS-derived metrics and survey data were used to develop predictive models of presence/absence and abundance for the federally endangered freshwater mussel, *Amblema neislerii*. Strong associations were identified between habitats representing flow refugia, as well as deep water habitats. I validated predicted abundances with data from an independent, quantitative study. Suitable *A. neislerii* habitat as revealed by this approach was much larger than identified in previous studies, as was the resulting reach-wide population estimates of 7-8 million individuals.

Acknowledgements

I must thank many people of highest quality that made this manuscript possible, and those who contributed greatly to the lessons learned during the process. Each of my committee members collaborated a great deal and greatly improved my understanding of the scientific discipline and writing. Adam Kaeser has taught me everything I know about sonar habitat mapping, and his creativity, enthusiasm, and critical thinking made this project successful. Mike Gangloff sampled technically challenging habitats for the ground-breaking benefit of this study, and contributed greatly to this study through provision of data and encouragement. Jim Stoeckel provided patient guidance through the complicated world of academia. Steve Sammons and Elise Irwin gave essential comments that improved my writing significantly. I would like to give a shout-out to my Auburn University labmates Michael Hart, Tyler Mosely, and Ian Palmer for help with fieldwork, as well as for many intelligent discussions and welcomed diversions that made my experience in Auburn meaningful. Also, the USFWS crew in Panama City, Florida deserves recognition for outstanding field assistance, support, and friendship.

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I. Using side scan sonar to delineate freshwater mussel habitat and assess habitat stability in a meandering Coastal Plain river.

Introduction

Classifying and quantifying freshwater mussel habitat in large rivers is challenging. Large rivers impose a variety of logistical hurdles when attempting to access and measure physical or biological components of the benthic environment. The investigation of habitat associations over large spatial extents requires that practitioners strive to balance feasibility and effectiveness when conducting research and conservation activities.

Freshwater mussel habitat has been broadly linked to landscape-scale factors such as land-use, catchment size, and stream power (DiMaio & Corkum 1995; Arbuckle & Downing 2001; McRae 2004), and to micro-habitat characteristics such as substrate type, particle size, food availability, and the presence of fish hosts (Brainwood et al. 2008; Hastie et al. 2000; Brim Box et al. 2002; Vaughn & Taylor 2000). Micro-scale measurements of depth, particle size, and current velocity used in complex hydraulic modeling and assessments of sediment stability have provided compelling evidence that mussel beds occur in areas where substrate remains stable during base flow and high-discharge events (Morales et al. 2006; Steuer et al. 2008; Zigler et al. 2008; Allen & Vaughn 2010).

Identifying how ecological processes function across spatial scales is becoming a key area in ecological research (Levin 1992), and clearly identifying the spatial scale and associated factors in which the phenomenon of interest is occurring is essential for any study of freshwater mussel ecology (Newton et al. 2008). Fausch et al. (2002) identified the importance of intermediate-scale processes to the ecology of stream fishes, and noted that they provide important ecological details that may be overlooked when only micro and landscape scales are considered. Intermediate (meso-scale) habitat classifications have been shown to be practical and effective when applied to biological habitat assessments across wide geographic boundaries (Newson and Newson 2000). With the preponderance of freshwater mussel habitat studies occurring at the landscape and micro scales, the science of freshwater mussel ecology might be advanced by studies conducted at the meso-scale.

Micro-scale assessments of substrate stability can be used to calibrate meso-scale models that predict hydraulically stable habitats across larger spatial extents than is feasible with micro-scale studies alone (Parasiewicz et al. 2012). Although metrics such as relative substrate stability are assessed at a fine scale through integration of particle size and shear velocity measurements, hydraulically stable habitats often occur and can be identified as patches at a higher spatial scale (Morales et al. 2006). Patch units are commonly used in landscape ecology as classes of predominant habitat within a spatial context, and occur at intermediate spatial scales (Newson and Newson 2000). Areas of hydraulic refuge in streams represent patches of suitable habitat for many organisms, increasing the richness, diversity, and abundance of aquatic species (Townsend et al. 1989; Garcia et al. 2012), including freshwater mussels (Strayer et al. 1999). Thus, incorporating meso-scale information such as patch-level habitat data in studies may advance understanding of freshwater mussel ecology in large rivers.

The close relationship between the hydraulic habitat needs of freshwater mussels and the spatial extent at which these habitat units exist suggests that study of freshwater mussel habitat at the meso-scale and patch level may provide useful information for the conservation of these imperiled benthic animals. However, measurement and derivation of complex hydraulic components to predict substrate stability requires expensive equipment and significant time, effort, and expertise, which may limit the widespread adoption of this approach. Although complex hydraulic variables are clearly useful and important to identify stable habitat for freshwater mussels, aquatic resource managers could benefit from low-cost tools and approaches to identify and accurately quantify suitable, stable mussel habitat within the logistical constraints imposed by time, money, and scale.

Remote sensing of benthic features using side scan sonar provides detailed information on benthic habitat in hard to access environments. Sonar habitat mapping and geographic information system (GIS) techniques can be integrated to classify and quantify benthic habitats in large rivers (Strayer et al. 2006; Nitsche et al. 2007), and riverine habitat features such as woody material and substrates have been accurately mapped using relatively low cost sonar equipment (Kaeser & Litts 2008; 2010; Kaeser et al. 2012). Sonar imaging techniques have been used to track sedimentation processes and bedform in riverine environments (Amina et al. 2007; Nitsche et al. 2007; Manley and Singer 2007). Bedforms that represent turbulent, unstable hydraulic conditions might therefore be discriminated from those associated with more stable conditions by sonar imaging.

Large meandering rivers are shaped by sediment transport forces and exhibit hydraulic patterns that support the formation of stable habitat patches in predictable locations across the river channel (Klienhans et al. 2010; Garcia et al. 2012). In alluvial rivers, variability in hydraulic forces due to meandering flow dramatically influence the shape and conditions of the river channel, and support the formation of large sand dunes that migrate downstream during action stages of river flows (Deitrich et al. 1979). In sonar imagery, dune bedform features can be easily recognized (Elliot et al. 2004), and are associated with the high shear stresses regions of the channel (Arcement and Schnieder 1989; Zigler et al. 2008; Garcia et al. 2012). As large rivers change direction around a meander bend, the scouring erosional forces of river flows separate from the bank and create secondary backwater/eddy flow environments and recirculation zones, that occur both upstream and downstream of point bars and adjacent to the river bank (Ferguson et al. 2003). These areas are used as hydraulic refuge by benthic organisms including freshwater mussels during flood disturbances (Strayer 1999; Morales 2006; Steuer et al. 2008; Zigler et al. 2008; Garcia et al. 2012). Flow refugia are also used by a variety of fish species that may serve as hosts for mussels, thereby increasing chances of glochidial deposition in these areas.

The Apalachicola River in northwest Florida is a large, alluvial river that is home to a variety of endemic species, including several imperiled freshwater mussels (Brim Box and Williams 2000). The fat threeridge, *Amblema neislerii,* is a federally endangered species, and is most abundant in the middle reach of the Apalachicola as well as the lower Chipola River, an adjacent tributary (Gangloff 2012). Quantification of *A. neislerii* habitat throughout the Apalachicola River was identified as a high priority by the U.S. Fish and Wildlife Service (USFWS) for conservation and recovery of the species (USFWS Recovery Plan 2010). A map of potential mussel habitat is needed to stratify mussel sampling, and to provide data for modeling the distribution and abundance of *A. neislerii* throughout the river.

Preliminary sonar imaging of known mussel beds in the Apalachicola River revealed distinct, observable differences in characteristics of the sandy bottom (A. Kaeser 2012, unpublished data). In particular, a smooth bedform was observed in locations of known mussel beds. This flat, plane bedform extended some distance away from the bank of the river and ended abruptly at a boundary of distinctive sand dune and ripple bedforms. Smooth bedforms were found both upstream and downstream of sandy point bars throughout a meandering reach of the

Apalachicola River known to support a high diversity and abundance of freshwater mussels, including *A. neislerii* (Brim Box & Williams 2000). Variations in bedform observed in the sonar imagery were interpreted as indicators of the hydraulic conditions at the water/sediment interface during the bed-forming, action stages of river discharge, and were further suspected to correspond to differences in habitat suitability for mussels. Bedform topology has been used for meso-scale habitat classification (Frissel et al. 1986), and the hydraulic conditions of meander bends are responsible for the spatial arrangement of bedforms within the channel, further suggesting the phenomena of interest could be described well at the meso-scale of study (Newson & Newson 2000; Garcia et al. 2012). I hypothesized that low-cost, sonar habitat mapping would enable the classification of suitable mussel habitat at the meso-scale.

My first goal was to identify and implement a classification scheme for benthic mesohabitats units that would represent functional habitat for freshwater mussels in a large, coastal plain river. In order to assess temporal consistency of mesohabitat boundaries, I also used sonar imagery to quantify the areal change that occurred to the mesohabitat classes after a 10-year flood event. Thus, my objectives were to: (1) validate the use of low-cost, sonar habitat mapping for classifying and quantifying area of mesoscale habitat patches based on bedform features, and (2) assess the stability of mesohabitat units suspected to function as flow refugia for mussels using pre and post-flood sonar imaging and areal change analysis within a GIS platform.

Methods

Study Area

The Apalachicola River is a large alluvial river formed at the confluence of the Chattahoochee River and the Flint River, and since impoundment begins below Jim Woodruff

Lock and Dam, a navigation and hydropower facility, at the Georgia/Florida state boundaries (Figure 1). The Apalachicola River drains 50,800 km^2 of eastern Alabama, west and central Georgia, and portions of northwestern Florida making it the largest river in Florida and ranking it 21^{st} in mean annual discharge in the United States (Light et al. 1998). The Apalachicola River is currently regulated to maintain a minimum flow of 141.5 m^3s^{-1} (5,000 f^3s^{-1}) during low flow periods of the year (USFWS 2012).

Below the Jim Woodruff Lock and Dam the Apalachicola River flows unimpeded for 174 km to the Gulf of Mexico. Along its course trends in channel morphology allow division of the river into Upper, Middle, and Lower-Non Tidal reaches (Light et al. 2006). The Upper section exhibits a relatively straight channel of coarse sand and gravel with scattered limestone outcroppings that occur downstream until river kilometer (rkm) 130, the point at which the surrounding geology drops from the Tallahassee Hills to the Coastal Lowlands (Harvey 2007). At this point channel geomorphology begins to exhibit a strong meandering characteristic and sediment composition changes to primarily coarse and fine sand. At rkm 67, the main channel exhibits a natural anabranch diversion known as the Chipola cut-off, which connects the Apalachicola River to the Chipola River, a large tributary. The Chipola cut-off marks the end of the Middle Reach and the beginning of the Lower-Non Tidal Reach. The Lower-Non Tidal Reach exhibits repeating meander bends until rkm 57. Thereafter the river assumes a less sinuous course, and continues toward Apalachicola Bay, whose tidal influences from the Gulf of Mexico begin to influence the shape and chemistry of the channel.

In this study, I focused on the Middle Reach and an upstream portion of the Lower Non-Tidal Reach of the Apalachicola River (rkm 104-54; river mile (RM) 65-35; Figure 1), because these portions are known to hold the highest abundance and diversity of freshwater mussels and a majority of the *A. neislerii* Apalachicola River population (Brim Box & Williams 2000; Gangloff 2012).

Sonar Survey and Image Processing

Sonar imagery of the entire study area was collected using a Humminbird® 1198c side-imaging sonar unit during the first two weeks of March 2012 (3/2, 3/7, 3/15, and 3/16) and a 17-foot skiff equipped with a custom, front-mounted sonar transducer (Kaeser and Litts 2011). River flows of 566 m^3s^{-1} (15,000 f^3s^{-1}) or greater were targeted for the survey, as the river channel is fully inundated at these discharges (Figure 2). The middle reach of the river often exceeded 100 m in width at the target flows, thus, a 3-pass, multi-transect approach was required to maintain high image resolution across the entire channel. One survey pass (i.e., transect) was made within close proximity of each bank of the river, using a sonar range setting of 26 m per side. A third pass was made along the middle of the river channel using a sonar range setting of 45.7 m per side to image the gap between the two bankside transects. I opted to use a lower range setting during bank passes to provide higher image resolution in areas known to harbor mussel beds. Slant range correction, an option referred to as "water contour mode" in the Humminbird® side imaging system, was not activated during bank passes. Slant range correction is a processing feature that removes the water column representation from sonar images, but I determined this feature performed poorly when imaging areas containing large quantities of submerged wood. Slant range correction was enabled, however, during scanning of the middle transect because it was largely devoid of wood. An operating frequency of 455 kHz was used during all sonar survey passes. In addition to sonar imagery, depth observations were recorded at 3-second intervals along all survey routes.

Sonar image geoprocessing was conducted according to methods described in Kaeser and Litts (2011). Once processed, the sonar image maps (SIMs, i.e., rectified image raster datasets) were loaded into an ESRI ArcGIS workspace to provide a spatially continuous, 2-dimensional representation of the river bottom across the entire study area.

Habitat Mapping

A mesohabitat classification scheme was developed through a review of literature associated with large river habitat classifications and discussions with biologists familiar with the Apalachicola River and with mussel sampling in the system. Five distinct habitat classes were identified as occurring within the main river channel: Point Bar, Inner Recirculation Zone, Outer Recirculation Zone, Mid-Channel, and Pool/Outer Bank. Garcia et al. (2012) provided technical explanations of the hydrological conditions likely to be occurring within each of these mesohabitat classes. Mesohabitat classes and their associated definitions are summarized in Table 1, and a visual representation of the geospatial context and general hydraulic conditions of each class within a meander bend is portrayed in Figure 3.

Mesohabitat classes were delineated using a heads-up, manual digitization approach during inspection of the sonar image map (SIM) layers (Kaeser and Litts 2011). River banks were first digitized as an outer boundary for the mesohabitat class delineation. Banks were kept within view on-screen during near-bank survey passes and were digitized as the apparent boundary of the sonar signal reflectance. Following bank digitization, boundaries between bank-attached, plane (i.e., smooth) bedforms and rippled/dune patterns were drawn.

Since slant range correction was not applied during near-bank passes, a standardized approach to digitizing features that appeared near to, and/or crossing the dark band of pixels representing the water column in the middle of resulting images was necessary. Whenever the water column is incorporated in a sonar image, objects or features that exist directly beneath the boat during the survey are both compressed and displaced to either side of the water column to some extent. As such, the water column does not represent missing data, but its inclusion does introduce some positional error and feature distortion. My approach to digitizing boundary features in such imagery was to trace the boundary as it appeared in the SIMs until the boundary intersected the water column pixels. At this point, the actual boundary was located directly beneath the survey vessel, so I digitized the boundary as a line that crossed the water column and followed the center of the image until the boundary feature was again visible on the opposite side of the water column. When visible, the boundary would be drawn across the water column and proceeding along the apparent position of the feature in the SIMs (Figure 4). This approach provided a consistent and repeatable method for digitizing features when the water column was displayed, but may have introduced some positional error associated with features that occurred near the boat path.

After the bank-attached, smooth bedform regions of the channel were separated from the rippled and duned channel regions, the Inner and Outer Recirculation Zones were dissected from the Pool/ Outer Bank. Since three mesohabitats exhibited smooth bedform in the SIMs, alternate features were used for this delineation. The downstream extent of the Inner Recirculation Zone was generally recognizable in the SIMs by the appearance of large pieces of submerged wood, a change in substrate tone from dark to light, and a change in the appearance of the bank edge from a dull-toned, less discrete edge to a bright, solid edge indicating a steepening of the bank slope (Figure 5). The Outer Recirculation Zone was delineated from the Pool/Outer Bend with similar sonar features as the Inner Recirculation Zone. At this transition, a darkening of image tone was often apparent, likely due to the deposition of finer particles (i.e., silt and mud). Also apparent at this transition was a change in the bank signature from bright and narrow to fuzzy and broad, indicating a reduction of the bank slope (Figure 5). The quantity of large woody material appeared to be similarly abundant in both mesohabitats and was not a useful characteristic for discriminating the Pool/Outer Bank from the Outer Recirculation Zone. To interpret the transition between the Pool/Outer Bank and the Outer Recirculation Zone, I also identified an inflection point at which the depth of water along the Pool/Outer Bank began to decrease, indicating the beginning of the pool tail-out and a change in the flow environment along the river margin.

Delineation of the Point Bar from the Mid-Channel required incorporation of aerial imagery and knowledge of deposition patterns around meander bends. At action stages, when the bed is formed, the point bar is submerged and shows no clear separation in terms of bedform from the Mid-Channel in sonar imagery. However, once flows recede seasonally the shallowest portions of point bars become exposed and can be clearly seen in aerial imagery. To delineate a portion of the point bar that remained inundated at seasonally low flow levels, a narrow (~10 m wide) portion of the Mid-Channel surrounding the exposed point bar was separated from the Mid-Channel using 2010 National Agricultural Inventory Program (NAIP) aerial imagery collected during a period of low flow (141.5 m^3s^{-1}/ 5,000 f^3s^{-1}). The resulting area of shallow, inundated river channel adjacent to point bars was classified as the Point Bar mesohabitat. The Point Bar mesohabitat was assigned a unique class on the basis that it might differ from the Mid-Channel mesohabitat class in terms of physical habitat conditions.

The Apalachicola River is currently regulated to maintain a minimum flow of 141.5 m^3s^{-1} (5,000 f^3s^{-1}) during low flow periods of the year (USFWS 2012). To identify the extent of habitat inundated at this low flow level, and subsequently map only the habitat that is available to mussels during such conditions, I digitized the river bank and the edge of exposed sand bars using recent (Summer 2010) National Agricultural Inventory Program (NAIP) aerial imagery captured during a period of stable, low flow (141.5 m^3s^{-1}/5000 f^3s^{-1}). This boundary was incorporated in the habitat map and used to define the extent of habitat available to mussels during low flow conditions. Sloughs and other off-channel, inundated areas were not included in the habitat classification scheme and therefore were not mapped in this study.

In order to investigate habitat composition trends across the longitudinal extent of the study area, the final habitat map was decomposed into consecutive sites containing representatives of all mesohabitat classes. A site was defined as a single meander bend containing at least one representative of each mesohabitat class. I extracted areal values for all mapped mesohabitats and summarized both the overall and relative composition of each site to illustrate trends in habitat composition. To investigate river gradient as a factor potentially associated with the geomorphology of these sites, I extracted water surface elevation values derived from a LIDAR-based survey along the river course at 0.16 km intervals. Water surface elevation was plotted against rkm to illustrate trends in water surface slope occurring throughout the study reach.

Assessing mesohabitat consistency between pre and post flood sonar imagery

Side scan sonar has been used to track changes in river bedforms after flood events (Anima et al. 2007). In March 2013 the Apalachicola River experienced a 10-year flood event where discharge recorded at the USGS gauge in Chattahoochee, FL exceeded 2,832 m^3s^{-1} (100,000 f^3s^{-1}) (Figure 2). This flood followed a high discharge event where flow peaked above

2,265 m^3s^{-1} (80,000 f^3s^{-1}). Recognizing an opportunity to assess changes occurring to the areal extent of mapped mesohabitats associated with a flood (i.e., habitat stability), I rescanned a 32 km portion (67%) of the study area on May 22, 2013 when river discharge at Chattahoochee was 623 m^3s^{-1} (22,000 f^3s^{-1}). This post-flood sonar dataset was processed and mesohabitats were digitized and classified according to previously described methods.

To assess change, the post-flood May 2013 mesohabitat map was superimposed on the original March 2012 map; each map was converted to a raster dataset with a 1 m^2 pixel (cell) grid. To quantify differences between the two maps, I used the Raster Calculator tool in the ArcToolbox; this tool provides a rapid algorithm for quantifying differences in pixel values between two raster datasets. Differences in pixel values were interpreted as areal changes, and were summarized and organized in a matrix to aid in interpretation (Congalton & Green 2008). I refer to the results of this GIS-based analysis as "raw change". To calculate the percentage of change that occurred to each mesohabitat I divided the change in area within each class by the total area of the class prior to the flood (i.e., the March 2012 map). Areas where bedform had changed from smooth/plane to rippled or duned after the flood were interpreted as unstable, and not likely to be suitable habitat for mussels.

A certain amount of positional error is inherent in any sonar-based habitat map due to GPS accuracy experienced during the sonar survey (Kaeser and Litts 2010; 2012). Moreover, when rescanning a reach of river, it is likely the boat will follow a path that deviates slightly from that taken during a previous survey. Since the path of the boat determines the position of the water column and, therefore, the aforementioned displacement of features within the imagery, it is possible that feature boundaries delineated in imagery from two separate surveys could produce variable results in a change detection framework. In this study, I define areal differences between two maps attributable solely to navigation and GPS positioning as "mapping error". I recognized the influence of mapping error on the quantification of post-flood, raw areal changes, and deemed it necessary to estimate these error rates.

To estimate mapping error, sonar image datasets collected during identical field conditions were required. Two simultaneous surveys were conducted along a 15 km portion (30.9%) of the study area on August 8th, 2013 at discharges of 566 m^3s^{-1} (20,000 f^3s^{-1}) using two survey vessels equipped with separate Humminbird 1198c sonar systems. This approach ensured that the field conditions (i.e., bedforms and depths) that each sonar system experienced were identical, and therefore any differences between the resulting maps would be due solely to mapping error. Each sonar image set was processed and classified by the author resulting in two classified polygon layers representing the same mesohabitat classes observed during identical field conditions. The total area of each mesohabitat class measured from the first map was divided by the total area of each mesohabitat class measured from the second map in order to calculate the net proportion of change in habitat area between the two maps. The percentage of change in area that occurred in each mesohabitat between the two maps was calculated and interpreted as a net range of percent error (Congalton & Green 2008). The range of percent error per mesohabitat class was compared to the net percent change in area that occurred between the pre and post flood habitat maps.

In addition to the mapping error assessment, areas identified as having changed after the flood were visually inspected to verify whether bedform had truly changed, or apparently changed simply due to variation in how the boundary lines were drawn. If a physical change in bedform was evident in an area of change, the polygon representing the area was classified as having passed visual inspection. Areas of change occurring as a result of boundary line alignment (i.e., mapping error) were classified as having failed visual inspection. A matrix summarizing all verified physical changes (i.e., "verified change") was prepared to compare to results from the GIS-based analysis (i.e., raw change) and the mapping error assessment.

Results

The resulting, classified mesohabitat map encompassed approximately 7,000 ha of river channel inundated at a low flow of 141.5 m^3s^{-1} (5,000 f^3s^{-1}). The map contained 203 mesohabitat patches distributed among 50 consecutive meander bends (i.e., sites). With few exceptions, each site contained one representative of each mesohabitat class (Table 2; Figure 6; Figure 7). The smallest mesohabitats on average were the Inner and Outer Recirculation Zone (mean area per site = 5,500 and 3,400 m^2, respectively), while the Pool/Outer Bank habitat units averaged 20,000 m^2 in area. Together, the Inner and Outer Recirculation Zones represented 6.2% of the total habitat area, while Point Bar and Mid-Channel mesohabitat classes composed 77.9% of the total area. Pool/Outer Bank mesohabitats represented the remaining 15.0% within the study area.

In terms of relative composition, the habitat classes associated with smooth bedforms typically represented between 15% and 25% of the total area of each site (Figure 9). Sites 28-39 located between rkm 67 and 80 (i.e., RM 41.8 to 50) appeared to be geomorphically different from other sites. These sites occupied smaller areas and contained larger proportions of smooth bedform habitat (>25%) compared to other sites throughout the study reach. Sites 28-39 are also associated with a section of the study reach that had the lowest water surface slope (Figure 10).

Results of the mesohabitat change analysis revealed a majority of the mapped areas remained unchanged after a 10-year flood event (Table 3). Largest areas of raw change detected occurred between Mid-Channel habitat boundaries. The net percent raw change of smooth bedform substrate within Inner and Outer Recirculation Zone mesohabitats increased in area post flooding, whereas the percent in Pool/Outer Bank mesohabitats decreased (Table 4).

Ranges of percent change due mapping error were greater than the net percent raw change detected from pre and post flood maps for all mesohabitats except the Pool/Outer Bank. Net percent mapping error showed highest variability in the Inner and Outer Recirculation Zones (15.9% and 15.6%, respectively; Table 4). Pool/Outer Bank exhibited a range of percent error of +/- 1.2, while the Mid Channel (+/- 0.02) had the lowest percent mapping error.

Area of verified post-flood changes to bedforms exceed mapping error only within the Pool/Outer Bank mesohabitat class. All other mesohabitat classes had smaller percentages of verified change than their associated mapping error. The largest verified changes occurred at the Mid-Channel and Pool/Outer Bank interface (Table 5) with a decrease of 4.9% in total Pool/Outer Bend habitat area due to Mid-Channel encroachment. Verified percent decreases in the Inner and Outer Recirculation Zone mesohabitat areas due to Mid-Channel encroachment were -1.5% and -4.1%, respectively (Table 6). Inner Recirculation Zone habitat was verified to increase by 0.76%. A small percentage (0.9%) of the Inner Recirculation Zone was changed to Point Bar habitat, and 0.4% of the Mid-Channel exhibited change to the Pool/Outer Bank habitat.

Discussion

The results of the sonar based mapping effort show that this habitat classification for freshwater mussels exhibited distinct repeatable units across the entire 700 ha study area. Moreover, the bedform-based classification system aligned with their average mesohabitat areas delimited during this study (Frissel et al. 1986; Newson and Newson 2000).

Additional features contributed to the identification of mesohabitat boundaries among adjacent habitats exhibiting similar smooth bedforms. In particular, submerged large woody debris served as a reliable indicator of active bank erosion and the beginning of the Pool/Outer Bank mesohabitat class, and dark image tones indicating fine particle deposition were useful for distinguishing the Inner and Outer Recirculation zones from the Pool/Outer Bank. Dark tones indicative of fine sediments were often variable within the Inner and Outer Recirculation mesohabitats, indicating that these mesohabitats likely contained heterogeneous surface substrates. Tonal heterogeneity within Inner and Outer Recirculation Zones suggests that a map based solely on substrate classification would look considerably different than a map based on fluvial geomorphology and river bedform patterns.

Previous mussel studies in the Apalachicola River have assumed that Inner and Outer Recirculation Zones are stable during high flow conditions (Beidenharn, 2007; Miller and Payne, 2007; Harvey 2007), but the degree of stability remained un-assessed. The results of both the raw and verified areal change analyses confirmed that mesohabitat bedforms remain mostly unchanged after flood events and provide stable refuge habitat for freshwater mussels during flood events. Smooth bedforms associated with these flow refugia were observed to extend often > 10 m from the bank even after the flood event. These boundaries suggest potentially stable freshwater mussel habitat in the Apalachicola River actually extends quite a bit further from the bank than previous studies have measured using consecutive, unoccupied quadrats as indication of habitat boundaries (Gangloff 2012). A sonar based mesohabitat mapping approach as presented in this study may provide more complete information on the extent of suitable freshwater mussel habitat, however sampling for mussels within these mapped mesohabitats is required to confirm mussel presence in these areas.

The areal extent of the Pool/Outer Bank was the second largest in total and average patch size of the five mesohabitat classes, and sonar imaging indicated a smooth/plane bed characteristic. The plane bedform in the Pool/Outer Bank was likely caused by flow velocity at the bed transitioning between the velocities that cause the characteristic dunes and ripples of the Mid Channel and Point Bar and higher velocities that form plane bedforms (Arcement and Schneider 1989; Julien and Raslan 1998). Despite encroachment of the sand dunes and ripples of the Mid Channel environment across the Pool/Outer Bank boundary, a large majority of the smooth bedform of the Pool/Outer Bank mesohabitat class remained intact after the flood disturbance. Studies of meander bend hydrodynamics suggests that high shear stress in this environment during high flows leads to sediment transport, scouring, and deepening of this habitat (Garcia et al. 2012; Leopold and Wolman 1960), and hydraulic conditions occurring on the outer bank in the Pool/Outer Bank mesohabitat class during floods are erosive and powerful, causing the felling of large trees growing close to the bank. Large aggregations of submerged woody debris were clearly imaged in the Pool/Outer Bank mesohabitat class, with some aggregations > 100 m in length and extending > 20 m into the channel. Extensive aggregations of large woody debris may deflect flow during floods (Abbe and Montgomery 1996), and possibly create favorable refuge conditions for mussels during high flows within the Pool/Outer Bank mesohabitat.

In previous studies, Kaeser and Litts (2008, 2010) examined the classification or thematic accuracy of sonar-based habitat maps. In this study I assumed that my ability to differentiate smooth from rippled or duned bedforms was highly accurate, as these characteristics were highly observable and boundaries between the two bedform types were highly distinct throughout the study area. Verification of boundaries as discrete transitions between zones of differing hydrologic conditions by empirical measurement of hydrologic variables was beyond the scope of this study. Verification of boundaries by direct underwater observation was, likewise, logistically unfeasible. Moreover, I would not expect boundaries to remain static between a sonar survey occurring at higher flows and the execution of a groundtruthing operation that required divers and lower flow conditions. Such temporal shifts in the position of boundaries between adjacent mesohabitats may lead to co-registration error, and confound an assessment of classification accuracy (Congalton and Green 2008). Rather than attempt a traditional, classification accuracy assessment of mesohabitats, I conducted an assessment of mapping error rates, a type of error I defined previously as resulting from both survey navigation and GPS positional error.

Observed changes in habitat after the 10-year flood event could have been due in part to mapping error. The results of the mapping error assessment allowed me to infer levels of variation associated with areal estimates in the map. For example, estimates of Inner Recirculation Zone area varied by 15.9% between two maps of the same area and conditions. Therefore, the estimate of total available Inner Recirculation Zone habitat in the study area (207,733 m^2) may vary by as much as +/- 33,030 m^2. However, the net change in Inner Recirculation Zone area I observed between pre and post flood habitat maps was only 13,805 m^2, leading to the conclusion that net changes detected in the pre and post flood maps might be largely attributed to mapping error, highlighting the need to verify stability by visually inspecting sonar imagery.

Both change due to mapping error and actual changes to the bedforms were incorporated in the results of the raw change analysis. I deemed it necessary to determine the extent of these two potential sources of change by visually inspecting the sonar imagery to confirm the change was due to either mapping error or a visible change in bedform pattern, and results indicated that even less habitat change actually occurred in the Inner and Outer Recirculation Zone mesohabitats. Indeed, most of the verified changes to bedform occurred due to encroachment of the Mid Channel into smooth bedform habitats that could possibly be suitable for mussels. Even though some new Inner and Outer Recirculation Zone mesohabitats were verified to form after the flood, these habitats likely experienced higher rates of change and were likely not yet occupied by mussels. Therefore, newly formed smooth bedform does not necessarily represent quality, suitable habitat for mussels. A portion (4.9%) of the Pool/Outer Bank mesohabitat was verified to change from smooth bedform to ripple and dune that typically occurred along the Mid Channel boundary line, and often involved large aggregations of woody material being covered by a mass of sand dune and ripples (Figure 11).

The success of using complex hydraulic variables to predict freshwater mussel distribution and abundance strongly suggest temporal fluctuations in river flow dynamics play an integral part of the persistence of freshwater mussel populations (Strayer 1999, Morales 2006, Steuer et al. 2008, Allen and Vaughn 2010). Parasiewicz et al. (2012) used an intensive survey of hydraulic characteristics across a large spatial extent and over variable flow conditions to calibrate a mesohabitat-scale predictive model of optimal freshwater mussel habitat for one species. This kind of extrapolation includes the spatial extent considerations and temporal variability needed for management of freshwater mussels at the meso-scale, but there is still a need to develop cost effective and efficient strategies for gathering such data across larger spatial extents and other riverine systems in order to identify, quantify, and quickly preserve critical habitat of these imperiled species. The approach taken in this study facilitated a rapid classification of large, turbid river habitats and confirmed the bedform stability associated with 3 of 5 habitat units.

The high repeatability of this mesohabitat classification could be applied to rivers of similar meandering geomorphology and alluvial sediment transport characteristics as boundaries between the presented mesohabitat classes were easily identified in sonar imagery in predictable locations, and were also supported by research of hydrologic patterns occurring around meandering river bends (Garcia et al. 2012). The results of this study suggested that time-lapse sonar imaging may provide a cost-effective, alternative means of assessing habitat stability for freshwater mussels in sand-bed rivers. To the best of my knowledge, this is the first time low-cost side-scan sonar mapping has been used detect and quantify reach-level changes in benthic habitat conditions in a large river system over a wide spatial extent.

II. Predicting the distribution and abundance of the freshwater mussel *Amblema neislerii* in a middle reach of the Apalachicola River, Florida

Introduction

Mapping and modeling the distribution and abundance of freshwater mussel species in large turbid rivers is challenging. Large rivers frequently include deep-water habitats that are difficult to access, and sampling across large spatial extents is logistically demanding. In some cases this leads to surveys that are limited in scope and inference. However, because many freshwater mussel taxa are endangered, threatened or of special concern in the United States and Canada (Williams et al. 1993), development of practical, efficient techniques to reveal their distribution and monitor population trends remains a high priority.

Species distribution models (SDMs) are increasingly being used to predict suitable habitat for organisms over large spatial extents (Guisan and Zimmerman 2000). Advances in geographic information systems (GIS), remote sensing, and computer processing have contributed to the success of SDMs in the management of species habitat, modeling of species distribution for conservation planning, and assessment of management actions (Guisan and Thuiller 2006). SDMs applied to freshwater mussel ecology have been used to guide conservation activities (Prie et al. 2012), and can be useful to explain the distribution of mussels across multiple scales of study (Newton et al. 2008).

Sampling of freshwater mussels is often limited by time and funding constraints. In spite of the aforementioned challenges associated with sampling mussels in large rivers, accurate habitat data are required for use of SDMs (Guisan and Thuiller 2005). Recent work in the upper Mississippi River used historical data and hydraulic modeling to explain the distribution and abundance of freshwater mussels with high accuracy across a 30-km reach (Morales et al. 2006; Steuer et al. 2008; Zigler et al. 2008; Allen & Vaughn 2010). This work suggested that freshwater mussel distribution and abundance was controlled by the stability of benthic conditions during flood disturbances. However, deriving the complex hydraulic variables necessary for such predictions require technical expertise and resources that may limit the widespread adoption of this approach. Therefore, the development of low-cost, less technical approaches to model freshwater mussel distribution in large turbid rivers remains a worthy goal toward advancing the conservation of this imperiled group of organisms.

The Apalachicola River in northwest Florida is a large alluvial river of the Southeast Coastal Plain that is recognized as a biodiversity hotspot (Blaustein 2008), and has drawn considerable conservation attention due to intensive demands on its water resources (Light et al. 2002). The river supports a high diversity and abundance of freshwater mussels, including the federally endangered Fat Threeridge *(Amblema neislerii)* (Brim Box and Williams 2000). A restricted range, perceived threats associated with channel modifications and water management, and patchy habitat distribution were cited as factors contributing to *A. neislerii*'s listing as endangered under the Endangered Species Act in 1998 (Federal Register 1998). Efforts led by the U.S. Fish and Wildlife Service (USFWS) to recover the species have been guided by strategies outlined in the Service's Recovery Plan (USFWS 2003). Recent survey work has provided estimates of *A. neislerii* population size in the Apalachicola River (EnviroScience 2006a; Miller and Payne 2007; Gangloff 2012), but estimates vary considerably among studies that are likely due to differences in sampling methodology that, in turn, influence perspectives on abundance and habitat associations. Current perspective of *A. neislerii* distribution and abundance suggests most mussels are living in shallow waters, however there has been no concerted effort to systematically sample deep water habitats in the Apalachicola River (EnviroScience 2006a; Miller and Payne 2006; Gangloff 2012; USFWS 2012).

Dense aggregations of *A. neislerii*, and other freshwater mussels, have consistently been located along river margins directly downstream of point bars in several Apalachicola River studies (Brim Box & Williams 2000, EnviroScience 2006a; Gangloff 2012). These habitats are described as moderately depositional and remaining stable during floods (Miller and Payne 2007; Harvey 2007; Beidenharn 2007; Chapter 1). Although commonly targeted during surveys, only the upstream and downstream boundaries of these habitats have been mapped. Mapping of moderately depositional habitats using review of aerial photographs and field reconnaissance to identify riparian features such as point bars, willow stands, and bank slope inflection points to delimit habitat boundaries was conducted by the USFWS in 2008 (Gangloff 2012). Prior my investigation, however, the actual underwater boundaries of these habitats remained unknown. Deep water habitats in the Apalachicola River, including the Pool/Outer Bank and Mid Channel mesohabitats (Chapter 1) have not been heavily sampled in past survey work, due to the hazards associated with deep water, swift currents and numerous submerged trees (EnviroScience 2006b; Miller and Payne 2007). These critical data gaps limit the reliability of current *A. neislerii* population estimates as well as the perception that this species primarily occupies shallow, moderately sloping, near-bank habitats (EnviroScience 2006a; Gangloff 2012; USFWS 2012).

A recent study designed to assess the impact of water-level drawdown on *A. neislerii* populations in moderately depositional habitats yielded *A. neislerii* population estimates for these habitats throughout the Apalachicola River and the lower Chipola River, a large tributary (Gangloff 2012). Abundance estimates were intended to be minimum population estimates for the system, and inferences regarding the potential impacts to *A. neislerii* populations associated with river level management by the U.S. Army Corps of Engineers (USACE) were incorporated in a recent Biological Opinion produced by the USFWS (2012). Both Gangloff (2012) and other recent studies (EnviroScience 2006a) reported *A. neislerii* in deep-water habitats, suggesting a more comprehensive survey of *A. neislerii* distribution and abundance in the Apalachicola River is needed for accurate population estimates to guide flow management and species recovery.

Sonar habitat mapping of benthic features in the Apalachicola River identified patches of stable habitat that were larger and more numerous than prior understanding of suitable *A. neislerii* habitat had indicated (Chapter 1). Habitat classification revealed that some habitat classes corresponding to previously known *A. neislerii* aggregations may be more extensive as well and revealed similarities between moderately depositional and poorly-surveyed deep-water habitats. Here I use that habitat classification map to guide a stratified, quantitative survey of *A. neislerii* across a 50 km reach of the Apalachicola River. I develop predictive species distribution models of *A. neislerii* presence/absence as well as abundance using habitat boundaries and variables derived from my sonar-based map.

Methods

Study Area

The Apalachicola River is a large alluvial river formed by the confluence of the Chattahoochee and the Flint Rivers at river navigation mile 106 directly below the Jim Woodruff Lock and Dam Reservoir at the Georgia/Florida state boundaries (Figure 1). Below Jim Woodruff Lock and Dam the Apalachicola River flows unimpeded for 170 km to the Gulf of Mexico. Along its course the channel geomorphology changes considerably allowing clear dissection of the river into upper, middle, and lower-non tidal zones (Light et al. 2006). The upper section is a relatively straight channel composed predominantly of coarse sand and gravel with scattered limestone outcroppings that occur downstream until river kilometer (rkm) 130, the point at which the surrounding geology drops from the Tallahassee Hills to the Coastal Lowlands (Harvey, 2007; Florida Geological Survey). At this transition into the middle reach, the channel geomorphology begins to exhibit a strong meandering characteristic with elevated sinuosity, and sediment composition changes to primarily coarse and fine sand. At rkm 67, a side channel known as the Chipola cut-off connects the Apalachicola River to the Chipola River, a large tributary, and serves as a landmark to the beginning of the lower non-tidal reach.

I chose the section of the Apalachicola River with the greatest sinuosity and most repetitive meandering pattern as my study area, beginning at rkm 104 and ending with an observable straightening of the channel at rkm 56, just below "Sand Mountain", a large aggregation of sand spoils visible on the bank created from historical dredging. This area includes most of the middle reach as defined by Light et al. (2006) and Gangloff (2012), as well as an upstream portion of the lower-non tidal reach.

Freshwater Mussel Survey

Sampling Approach

A sonar-based mesohabitat map produced for the study area was used to stratify the sampling of freshwater mussels (Chapter 1). Mesohabitat classes of this map represented patches of common geomorphology, flow, and bedform characteristics occurring in meander bends. Several classes suspected to support freshwater mussel populations were identified as stable during a post-flood change analysis, while other classes represented depositional and/or turbulent environments commonly associated with large alluvial rivers. Stratification is highly recommended for freshwater mussel surveys in which a priori habitat information is available (Strayer & Smith 2003), and is also useful when allocating limited time and monetary resources across broad spatial extents with costly sampling techniques such as SCUBA. In this study, a stratified approach served to quantitatively asses hypothesized mussel/habitat associations within the meandering, middle reach of the Apalachicola River and perhaps elucidate the factors contributing to the high density of *A. neislerii* populations in this reach.

Rather than randomly selecting sampling locations from mesohabitats throughout the entire study area, I decomposed the study area into a series of 50 consecutive study sites using reference boundaries drawn between the downstream end of each Inner Recirculation Zone and the downstream end of the Outer Recirculation Zone on the opposite side of the channel. With few exceptions, each site was composed of one representative of each mesohabitat class, or five mesohabitats. Six of these sites were selected for sampling by first grouping the 50 sites into six groups of approximately equal numbers of consecutive sites (i.e., eight or nine sites per group), and then using a random number generator to select one sampling site from each of the six groups. This approach ensured that sampling sites would be distributed throughout the 50 km reach.

Next, I assigned 10 sampling points to each mesohabitat class occurring in each of the six sampling sites using the Generalized Random Tessellated Stratification (GRTS) sampling algorithm found in the spsurvey package (Kincaid and Olsen 2013) for the R software platform. This algorithm randomly generates a set of points that are distributed in a spatially balanced manner within a user-defined extent, thereby decreasing probabilities of bias and auto-correlation (i.e., clumping of points). The GRTS points are ordered, and consecutively distributed in a way that preserves the spatial balance of the set, so that if one point cannot be sampled, the sampling crew can target the next ordered point in the set; this point will be spatially balanced among the rest.

Sampling points were located in the field with a Garmin GPSmap 760CSx GPS unit and immediately marked with an anchored buoy. A set of geographic coordinates representing the actual sampling location was recorded, and a 1.78-m length of metal cable representing the radius of a 10-m^2 sampling plot was attached to a piece of rebar inserted vertically into the river bed at the center of the sampling plot (Ghent et al. 1978, Gregoire and Valentine 2007). The radial cable was used to delimit the extent of the sampling plot, and tactile searches were conducted by 2-5 crew members to remove all mussels present in the plot. All freshwater mussels were identified to species and enumerated; a measurement along the longest axis of any *A. neislerii* <50 mm was recorded. The depth at the center of the plot, and a classification of the predominant substrate type within the plot was recorded. Predominant substrate was classified as either 1) coarse sand, 2) fine sand, 3) a mixture of fine sand, silt, and mud, or 4) other. Due to preponderance of unoccupied sites in the Mid-Channel mesohabitat class and the hazardous nature of SCUBA sampling in this high velocity and unstable substrate environment, I reduced the number of plots sampled in this mesohabitat from 6 to 3 plots per site.

Data Analysis

One-way ANOVA was used to test for differences between *A. neislerii* counts and mesohabitat classes. Two species distribution models were developed for *A. neislerii*. The first was a presence/absence model based on a multiple logistic regression with a binomial distribution, and the second was a count model using multiple generalized linear model (GLM) regression. I used a negative binomial error distribution (log link) to model counts per sampling plot because *A. neislerii* counts were not normally distributed (Davis et al. 2013). I fit the models in R 3.1 (R Development Core Team 2012) using the MASS package (Venables & Ripley 2002) function glm() for the presence/absence models and the glm.nb() function for the count models. A set of candidate models was developed using different combinations of six explanatory variables that represented alternate hypotheses regarding factors that influence *A. neislerii* presence/absence or abundance in the Apalachicola River. I considered the following explanatory variables: mesohabitat class, rkm, distance to the 141.5 m^3s^{-1} (5,000 f^3s^{-1}) river bank, distance to nearest unstable mesohabitat (i.e. shortest distance to Point Bar or Mid-Channel), water depth, and substrate type.

To derive explanatory variables, GPS coordinates of the sampled locations were loaded into the ArcGIS 10.2 (ESRI 2013) software platform and metrics were generated using analysis tools in ArcToolbox. The mesohabitat map was used to associate each sampling location with the mesohabitat class in which the plot occurred (Chapter 1). For each sampling location, the shortest distance to the 141.5 m^3s^{-1} river bank, and the distance to nearest unstable habitat were calculated using the NEAR analysis tool in ArcToolbox. Each sampling location was associated with the nearest tenth of a river kilometer. Data obtained from the field survey, including mussel counts, sampling plot depth, and predominant substrate type were integrated with the resulting table of habitat metrics, and this composite database was exported as a comma separated value (.csv) file. The data table was loaded into the R software platform for statistical analysis and model development.

To determine which variables or sets of variables were most important in explaining *A. neislerii* presence/absence and counts per sampling plot I used an information-theoretic (IT) model selection approach (Kullback and Leibler 1951; Kullback 1959). The IT approach is an evidence-based model selection technique useful for investigating complex ecological hypotheses (Anderson 2008). Performance of models was ranked according to the Akaike information criterion corrected for small sample size (AIC_c) along with model weights, and model summaries were reported for the presence/absence as well as abundance models with the lowest AIC_c value. The area under the curve (AUC) metric was computed for the best performing presence/absence model as a measure of accuracy. Specificity (true negative) and sensitivity (true positive) rates were also computed for the best performing presence/absence model and plotted with estimated probabilities of occurrence in order to find the optimal probability (i.e., the 'cutpoint') in which both rates are maximized. Predicted probabilities greater than or equal to the optimal cutpoint were considered presences and all observations with probabilities less than the optimal cutpoint were considered absences.

When developing the count model, I decided to parse all sampling points in the Point Bar and Mid Channel mesohabitat classes based on the very low probabilities associated with *A. neislerii* occurrence in these two habitats. The fit and accuracy of the most informative abundance model was assessed by calculating the regression coefficient (R^2) from a linear regression between observed and predicted counts of *A. neislerii* at the sampling plot level (Pineiro et al. 2008), and points were tested for correlation using a Pearson correlation test. Residuals were plotted to assess fit.

To generate an estimate of the total abundance of *A. neislerii* in the middle reach using the predictive capacity of most informative count model, I first overlaid a raster grid on the study area with a cell size equal to the actual mussel sampling area used in this study (10 m^2). A point was assigned to the centroid of each cell in the grid, and each point was attributed unique values for each of the habitat variables included in the most informative abundance model. Because the

Point Bar and Mid-Channel observations were not included in the development of the count model, all points of the grid located within the Mid-Channel and Point Bar mesohabitats were removed from the dataset, leaving ~150,000 points covering the Inner and Outer Recirculation Zone and the Pool/Outer Bank mesohabitat classes. The point data table was imported in R, and the prediction function of the MASS package was used to predict the abundance of *A. neislerii* at each point using the most informative count model. The sum total of predicted abundances provided a raw estimate of the number of *A. neislerii* occurring across the entire study area.

When predicting abundance across a landscape, practitioners should consider the ranges associated with predictor variables, and exercise caution when attempting to predict outside of the range of values inherent in the model (Guisan and Thuiller 2006). In other words, a model should not be used to extrapolate beyond the information used to build it. When examining preliminary results of predicted abundance in specific regions of the map, particularly those associated with areas close to the river banks in the Pool/Outer Bend mesohabitat, I noticed unrealistically high values (>1,000 mussels/m^2). These values exceeded the maximum level of abundance observed during the field survey, and were associated with the predictor "nearest distance to unstable habitat" that exceeded the range of values in the sample set used to develop the model. Therefore, I removed all GIS-generated prediction points with values outside the range of model set variables. The remaining predictions at each point across the landscape were summed to provide an "adjusted" reach wide population estimate of *A. neislerii*.

Verifying the accuracy of predicted abundance

Although it was beyond the scope of this study to conduct additional field sampling to evaluate the accuracy of abundance model predictions, an independently-derived data set was available from recent sampling conducted by Gangloff (2012) in my study area. These data enabled me to compare and contrast density and abundance estimates made using two different, quantitative approaches at both site and reach scales, and to identify primary factors associated with differences in abundance estimates. This sampling approach involved 5-6 transects originating at, and oriented perpendicular to, the bank at each sampling site (Gangloff 2012). A suction dredge was used to excavate consecutive, 0.25-m^2 quadrats along each sampling transect. The use of a suction dredge, although time-consuming, is considered both quantitative and highly effective at capturing mussels present within a sampling frame (Strayer and Smith 2003). Sites sampled by Gangloff (2012) were randomly selected from a set of suitable mussel sites whose upstream and downstream boundaries had been defined prior to this investigation. Gangloff's (2012) set of suitable sites were located within the Inner and Outer Recirculation Zone mesohabitat classes mapped in this study.

The spatial data associated with the previous sampling sites, in combination with reported transect measurements, allowed me to generate and overlay polygons in the habitat map representing the approximate areas sampled by Gangloff (2012). I used these polygons to extract my model-based estimates of abundance at each of the sampling sites for an analysis of congruency between the two estimates at the site scale. Gangloff (2012) provided a reach-wide estimate of *A. neislerii* abundance by multiplying the total length of all available mussel sites by the average number of mussels estimated to occur per longitudinal meter of sampled sites. To derive a comparable, reach-wide estimate from the count model, I used the coordinates of all available mussel sites and the average length of all transects sampled by Gangloff within my study area to generate a set of equivalent polygons, and used these polygons to extract the corresponding model-based estimates from my abundance map.

Results

I sampled a total of 164 radial plots each 10 m^2 for a total area sampled of 1640 m^2. A total of 3958 individual *A. neislerii* were collected. *Amblema neislerii* was the 3rd most abundant mussel among species collected, comprising 34.5% of the total mussels collected. Juvenile *A. neislerii* $\leq$ 30 mm represented 5.4% of the total collection, and 2.2% of *A. neislerii* were $\leq$ 20 mm.

Significant differences ($P < 0.0001$) were found between mesohabitat classes and *A. neislerii* counts per sample plot (Figure 12). Nearly all (99.3%) *A. neislerii* were found in 21% of the study area, all of which consisted entirely of smooth bedform signatures in sonar imagery (Inner and Outer Recirculation Zones, Pool/Outer Bank; Table 8). *Amblema neislerii* were notably absent from sampling locations in the ripple and dune bedform mesohabitats. Approximately 80% of the sampling plots were unoccupied within the Point Bar mesohabitat class and only 1 sampling plot was occupied in the Mid Channel. *Amblema neislerii* was found at a maximum depth of 8.5 m, and a maximum of 37.1 m from the edge of the 141.5 m^3s^{-1} bank. The maximum *A. neislerii* density observed was 43.4 mussel/m^2.

A dramatic increase was observed in site-level *A. neislerii* density from 0.5 mussels/m^2 at site 19 (rkm 85), to 5.3 mussels/m^2 at site 29 (rkm 75). Site density remained relatively high at the two sites downstream (rkm 68 and 60; Figure 9). Although observed maximum densities among the different mesohabitat classes peaked at different sites, the trend in mean density of the Outer Recirculation Zones closely resembled the overall average site density trend across the study area (Figure 9).

Of the six top ranking presence/absence models, there was strong support for the model that included the explanatory variables of mesohabitat class, rkm, and distance to low flow bankline (Table 9). Two models comprising a small proportion of AIC weight included the additional variables of distance to unstable habitat and water depth. The AUC of the top ranked presence/absence model was 0.939, with an optimal cutoff probability for predictions occurring at 0.7 (Figure 14). No observations within the Point Bar and Mid Channel habitats (n=62) had greater than a 70% chance of *A. neislerii* occurrence. Coefficient estimates of the top ranked presence/absence model indicated that all smooth bedform mesohabitat classes were positively associated with the presence of *A. neislerii* (Table 10). The Mid Channel mesohabitat class was negatively associated with the species presence. Model coefficients for rkm and distance to low-flow bankline indicated that habitats located further upstream, or further from the bank had lower likelihoods of *A. neislerii* occurrence. The probability of *A. neislerii* occurrence ($\hat{\pi}_i$) was represented by the most informative multiple logistic regression model in the following equation:

$$\hat{\pi}_i = \frac{\exp(\beta_0(Point\ Bar) + \beta_1(Inner\ Recirculation\ Zone) + \beta_2(Outer\ Recirculation\ Zone) + \beta_3(Pool\ Outer\ Bank) + (-\beta_4(Mid\ Channel)) + (-\beta_5(rkm)) + (-\beta_6(Distance\ to\ low\ flow\ bank)))}{1 + (\exp((Point\ Bar) + \beta_1(Inner\ Recirculation\ Zone) + \beta_2(Outer\ Recirculation\ Zone) + \beta_3(Pool\ Outer\ Bank) + (-\beta_4(Mid\ Channel)) + (-\beta_5(rkm)) + (-\beta_6(Distance\ to\ low\ flow\ bank))))}$$

The count model set showed the top ranked model to be the single most parsimonious model with a model weight of 0.99 (Table 11). The top ranked model contained variables of mesohabitat class, rkm, distance to low-flow bankline, and distance to unstable habitat, while models that included variables of substrate type and water depth had little support (Table 11). For the top ranked abundance model, rkm and distance to low-flow bankline had a negative relationship with *A. neislerii* counts, whereas distance to unstable habitat had a positive effect on

A. neislerii counts (Table 12). The number of *A. neislerii* per $10m^2$ sampling point was represented by the most informative count model in the following equation:

$$\ln(\#\,\widehat{A.neislerii_i}) = \begin{array}{c} \beta_0(Inner\ Recirculation\ Zone) + \beta_1(Outer\ Recirculation\ Zone) + \\ \beta_2(Pool\ Outer\ Bank) + (-\beta_3(rkm)) + \\ (-\beta_4(Distance\ to\ low\ flow\ bankline) + (-\beta_5(Distance\ to\ unstable\ habitat)) \end{array}$$

Observed and predicted numbers were significantly correlated ($P < 0.001$). The regression coefficient (R^2) between the observed number and predicted number from the highest ranked count model was 0.34, and the slope of the regression line equaled 0.85 (Figure 15). The scatterplot of residuals between observed versus predicted *A. neislerii* contained normal variability. Two outliers were identified in the plot; one outlier involved an observation of 434 mussels and a model prediction of 86 mussels, and the other outlier involved a prediction of 351 mussels relative to an observation of 230 mussels (Figure 15).

Amblema neislerii population estimate

The most informative count model generated an estimate of 8,687,083 *A. neislerii* within the 700 ha study reach. This included an estimated 1,178,708 mussels in the Inner and Outer Recirculation Zones combined, and an estimated 7,508,375 mussels in the Pool/Outer Bank mesohabitat class. The area of prediction included only the Inner and Outer Recirculation Zone area, and 89.7 % of the Pool/Outer Bank mesohabitat class. The excluded portion of the Pool/Outer Bank (118,020 m^2) represented areas primarily near the river banks that fell outside of the range of predictor variables used to build the model.

Comparisons with an independent dataset

The average *A. neislerii* density observed in this survey within Inner and Outer Recirculation Zone mesohabitat classes was 4.1 mussels/m^2, while the average *A. neislerii* density sampled previously was 4.9 mussels/m^2 across 12 Inner and Outer Recirculation Zone sites within my study area (Gangloff 2012). At the site level, I found no correlation between *A. neislerii* abundance estimates from the count model and corresponding estimates made by Gangloff (2012; Figure 11). The count model over-estimated the number of *A. neislerii* estimated by Gangloff (2012) at several sites, but also underestimated the number existing at a few sites by a greater magnitude. This trade-off resulted in a total estimated number of *A. neislerii* occurring within Gangloff (2012) sampling sites of 81,907 mussels, a number somewhat lower than estimated by Gangloff (n= 86,335; 2012). Likewise, when examining only the exact same areas considered by Gangloff (2012) as 'potential' habitat that fell within my study area, my reach wide estimate of numbers of *A. neislerii* (n= 175,124) was lower than Gangloff's (2012) estimate of 199,679 mussels.

Area of potential *A. neislerii* habitat varied widely between what I identified with sonar mapping and what Gangloff (2012) identified (Figure 13). Gangloff's (2012) potential habitats covered 46,455 m^2 over 43 sites within my study area, while the sonar habitat map of Inner and Outer Recirculation Zones covered 429,880 m^2 across 101 mesohabitat patches (Table 10), thus the sonar habitat mapping approach identified twice as many sites and ten times more area than previously identified by field reconnaissance and inspection of areal imagery (Figure 12). Gangloff's (2012) maximum sampled depth was reported as 2.25 m, and maximum transect length (distance from bank) was 15.0 m, while I sampled to a maximum depth of 4.6 m and a maximum distance to the bank of 22.4 m within Inner and Outer Recirculation Zone mesohabitats. In these habitats, *A. neislerii* was collected in 12 of 12 sampling plots occurring at depths greater than the maximum sampled by Gangloff (2012), and in 4 of 7 plots occurring at greater distances to the bank than sampled by Gangloff (2012).

Species distribution map

The results of predicted probabilities of *A. neislerii* occurrence and abundance when displayed in a spatial context revealed highest probabilities and abundances occurring near and parallel to the bank (Figure 18; Figure 19). Predicted probabilities of < 0.7 were notably located within the Inner and Outer Recirculation Zones and the Pool/Outer Bank mesohabitat classes, and were located near the edge adjacent to the Mid Channel (Figure 18; Figure 20). Points with predicted probabilities of < 0.7 were considered unoccupied areas, composing 20% of the smooth bedform mesohabitat areas. The Pool/Outer Bank mesohabitat class displayed a larger area of high (> 100 mussels per 10-m^2 cell) predicted abundances than in the Inner and Outer Recirculation Zones (Figure 21).

Discussion

The results of this study profoundly alter existing paradigms of *A. neislerii* distribution in the middle reach of the Apalachicola River. The species had been previously described as primarily inhabiting shallow, near bank habitats where stable substrates existed (EnviroScience 2006a; Beidenharn 2007; Harvey 2007; Miller and Payne 2007; USFWS 2012). This association raised major concerns for population-level impacts due to stranding and mortality associated with river level fluctuations (i.e., manipulated draw down rates; EnviroScience 2006a; USFWS Biological Opinion 2012), and motivated additional research to assess levels of vulnerability

(Gangloff 2012). With respect to the inner and outer recirculation zones traditionally surveyed for *A. neislerii*, I have determined that these stable mesohabitats are not only larger and more numerous than previously described, but that *A. neislerii* can be found in greater depths and further distances from the bank in this reach of the Apalachicola River. I mapped nearly 10 X the amount of suitable inner and outer recirculation zone habitat than was previously considered when Gangloff (2012) estimated abundance in the study reach.

Amblema neislerii is not restricted to shallow water and channel margin habitats as previously thought, and therefore populations may be more resilient to reductions in water level. EnviroScience (2006a) reported most *A. neislerii* sampled quantitatively were found at depths ≤ 1 m, and Miller and Payne (2007) found *A. neislerii* to depths of 2.7 m, while the USFWS Biological Opinion (2012) reported *A. neislerii* sampled up to a depth of 5 m in moderately depositional as well as moderately erosional habitats, but stated that a majority of the population occurred at depths of 1 m. In contrast, 56% of the total *A. neislerii* collected in this study occurred at depths ≥ 1.0 m. *Amblema neislerii* was found in five sampling points with depths greater than 5 m, and to a maximum depth of 8.5 m. In addition to greater depths, *A. neislerii* was also found in greater distances from the bank than other studies. Gangloff (2012) found *A. neislerii* to a distance of 22.4 m from the bank, whereas the maximum distance from the bank of a sample containing *A. neislerii* was 37.1 m in this study.

Furthermore, large numbers of *A. neislerii* were regularly documented in a habitat not well sampled in past studies- the Pool/Outer Bank mesohabitat class. Little is known about *A. neislerii* populations living in this habitat, and the high rate of occupancy observed in the Pool/Outer Bank habitat was unexpected. *Amblema neislerii* was found at depths between 2.3-8.5 meters in the Pool/Outer Bank, and the average density in this habitat was nearly equal to the densities of the Inner and Outer Recirculation Zones. Because the Pool/Outer Bank mesohabitat class covers such a large area, the potential number of *A. neislerii* existing in this mesohabitat class is substantial. The total habitat area of the Pool/Outer bank may have been underestimated due to the 2-dimentional nature of sonar habitat mapping. The steep bank slope of the Pool/Outer Bank habitat exists as a 3-dimentional environment, and consequently the 2-D sonar habitat map did not quantify the 15-30ft vertical face of the outer bank. Interestingly, EnviroScience (2006a) reported that upper portions of moderately-erosional, steep banks adjacent to deep (~20 ft) water were 1 of 3 primary habitats where *A. neislerii* were found in highest abundance. The authors also noted the occurrence of the species in deep water adjacent to steep banks, but suggested mussels occurred there because they were dislodged from the upper bank. The vertical wall of the outer bank was not properly quantified in the map, and no sampling points were randomly assigned to the bank wall, causing a portion of *A. neislerii* habitat area to be excluded from this study.

Hydrodynamic forces occurring within the Pool/Outer Bank habitat in meander bends may explain how *A. neislerii* is able to survive embedded in the bank material. As water flows around a steeply banked meander bend, secondary flow patterns develop close to the bank that decrease the sheer stress acting on the upper portions of the vertical face that effectively decrease scouring forces and stabilize erosion (Bathurst et al. 1979; Blanckaert 2011; Garcia et al. 2012). Meanwhile the lower portions and the horizontal bed experience mostly primary flows causing greatest shear stresses that are responsible for the erosional nature and smooth plane bedform used to classify the Pool/Outer Bend. However, 1/3 of observations in the Pool/ Outer Bank reported fine particle substrate types (Figure 22), which suggest the hydrodynamic conditions within the Pool/Outer Bank habitat area are not uniformly erosional and that deposition of fine particles does occur at many locations within this habitat at some point in the hydrodynamic cycle. Research on seasonal variation in hydrodynamic conditions in thalweg environments suggests that these environments may experience a shift from erosional at higher flows to depositional at slower flows (Keller 1971; Thompson et al. 1999; MacWilliams et al. 2006). The effect of large woody material may also be responsible for local deposition of finer sediments observed in many Pool/Outer Bank sampling points (Figure 23). Large woody material can deflect flows during floods, cause deposition of sediments, stabilize banks, and provide habitat for many aquatic organisms (Mutz, 2000; Abbe and Montgomery, 1996; Thompson 1995; Gurnell et al. 1995). EnviroScience (2006a) found *A. neislerii* living next to large woody material located 20-30 m from the bank, and many Pool/Outer Bank observations in this study reported large woody material occurring within the sampling point area. Although I did not attempt to quantify the amount of large woody material in the study area, large aggregations of woody material are easily identified in sonar imagery (Figure 24). Indeed, large woody material aggregation were sometimes too dense to sample with SCUBA safely, causing some sampling points to be aborted, and possibly causing bias towards sampling areas with less woody material. Juvenile mussels were also located in this habitat, including the largest collection of juvenile *A. neislerii* among any sampling point (38 < 20 mm). The high occupancy rates of the sampling points in the Pool/ Outer Bank habitat class (26 of 29) strongly suggests this habitat class contains suitable habitat conditions for *A. neislerii*.

Unsuitable habitats were identified with ease. The rippled and duned bedform patterns used to define the Point Bar and Mid Channel mesohabitats are indications of turbulent nearbed flow conditions and high bedform mobility, and are easily discernable in sonar imagery (Deitrich et al. 1979; Elliot et al. 2004; Manley and Singer, 2007; Zigler et al. 2008). Sampling results are consistent with the assumed unsuitable nature of the Point Bar and Mid Channel mesohabitat classes, as a very small portion of sampling points within these classes were found to contain only a few individuals. The small numbers of *A. neislerii* occurring in the Point Bar mesohabitat class is not surprising due to the close proximity and upstream location of adjacent habitat classes that held large numbers of *A. neislerii* (Outer Recirculation Zone, Pool/Outer Bank). Mussels could be displaced or move short distances from the upstream habitats across boundaries to the Point Bar once flow conditions subside after floods. One observation in the Mid Channel habitat contained 9 *A. neislerii*, but this sampling location was < 1 m from an Outer Recirculation Zone boundary. GPS or mapping error alone (3 – 5 m) could have resulted in displacement of the sample point slightly outside of the mesohabitat actually sampled in the survey causing misidentification when assigning the mesohabitat class variable to the point dataset in the map. Although fewer points were sampled in the Mid Channel than other habitat types, only one sampling point contained *A. neislerii*, and additional sampling in the Mid Channel is unlikely to detect mussels in this unsuitable habitat.

The increase in total suitable habitat area estimated by this study resulted in an increased estimate of population abundance in middle reach of the Apalachicola River. By simply multiplying habitat area by the average *A. neislerii* density sampled per habitat class (Gangloff 2012), the number of *A. neislerii* in this study was estimated to be an order of magnitude greater than previous estimates. However, this simple estimate does not address the variability likely occurring within habitat classes and among sites, and a more comprehensive model would provide a more accurate total population estimate.

The species distribution models developed in this study used relatively simple and easily derived habitat metrics obtained from sonar-based habitat maps and GIS software, and provide more detail on factors associated with *A. neislerii* distribution and abundance in the Apalachicola River. Distance to the 141.5 m^3s^{-1} (5,000 f^3s^{-1}; "low flow") bank, distance to unstable habitat, and rkm were all generated post survey, and the inclusion of these variables in the most informative models suggests these metrics represent relevant ecological phenomena controlling *A. neislerii* distribution and abundance.

Distance to the low flow bank was found in the most informative of both presence/absence and abundance models, suggesting that as distance to the water's edge at low flow increases, the likelihood of mussel occurrence and abundance decreases. Previous studies have also reported a decline in *A. neislerii* occurrence and abundance as distance to the wetted edge increases (EnviroScience 2006a; Gangloff 2012). Relationships between *A. neislerii* occurrence and abundance and distance to low flow bank measured in this study were important in the most informative models primarily because I conducted all sampling during a period of 141.5 m^3s^{-1} (5,000 f^3s^{-1}) river flow conditions that represent the minimum water level currently allowed in the Apalachicola River. If the wetted edge of the river had been defined at higher flows and sampled during a period of greater discharge, the distance to bank relationship may not be as strong as measured in this survey. Receding flows force mussels residing near the water's edge to relocate to lower elevations or face desiccation, and consecutive periods of seasonally low flows would eventually shift the distribution to lower elevations. Surveys that do not consider the history of flows with respect to the location of mussels in the channel might falsely conclude mussels don't exist or are at lower densities in locations near the bank if sampling occurs in areas that were exposed during recent hydraulic periods.

Distance to unstable habitat as an influential habitat metric effecting *A. neislerii* abundance is supported by the most informative abundance model. Results of the areal change analysis performed in Chapter 1 provide evidence to explain why this variable is significant within stable habitats. The Mid Channel habitat is composed of migrating sand dunes and was observed to shift to some extent across the boundaries of smooth bedform and stable habitats (Inner and Outer Recirculation Zone, Pool/Outer Bank) after a 10-year flood event. Mussels residing near such a boundary could face dislodgement, burial, or be forced to migrate when boundaries between stable and unstable bed conditions change. Guisan and Thuiller (2005) identified distance to disturbances as a main influence on species distribution in general, and recommended such metrics to be included in SDMs if statistically supported.

The inclusion of rkm in the most informative of both presence/absence and abundance models reflected a longitudinal trend on riverine habitat and *A. neislerii* distribution and abundance, with *A. neislerii* densities remaining relatively low in the three most upstream sample sites (sites 8, 12, and 19) and then increasing dramatically at the remaining downstream three sites (site 29, 38, 46; Figure 13). The trend of total *A. neislerii* density per sampling site (i.e., rkm) shows a spike at rkm 75 (site 29; river navigation mile 46). Gangloff (2012) observed a similar increase in *A. neislerii* density between rkm 75 - 67 (river navigation mile 46-39). To some extent, increases in abundance in downstream directions is consistent with river ecology theory such as the river continuum concept (Vannote et al. 1980). If the meandering characteristic of the river supports the formations of stable, suitable habitat (Garcia et al. 2012), and the cumulative availability of such habitat increases in the downstream direction, then the factors responsible for increased *A. neislerii* density within this portion of the middle reach could be attributed to slower water velocities due to a flattening of elevation gradient that would increase concentration and retention time of nutrients in recirculating environments as distance down river increases. A decrease in gradient would slow water velocities and decrease the distance required for water to change direction around a meander bend, resulting in smaller sites. This is supported with lower than average mesohabitat areas occurring at a similar location on the river as a marked flattening of gradient (Figure 8; Figure 10), and a shortening of meander bend length is visible in the map of the study area (Figure 1). Locations of lower gradient and slowed water velocities could also increase the settlement of glochidia entrained in the transport mechanism of fine particulates (Morales et al. 2006).

Large slough-like embayments also appear at this section of the study area, which could provide a substantial amount of biological enrichment to downstream and adjacent habitats. Off-channel habitats such as sloughs and tributary mouths were not sampled because they were not included in the sonar habitat map, however, past studies have encountered *A. neislerii* living in slough and off-channel environments (Payne and Miller, 2002; EnviroScience 2006a).

Water depth and substrate type provided no additional explanatory power in the most informative models, suggesting *A. neislerii* presence/absence and abundance is only weakly related to these commonly-measured parameters. In contrast to previous reports of a significant association between water depths and abundances (EnviroScience 2006a; Gangloff 2012), *A. neislerii* was found across a range of depths and model AIC_c values support the hypothesis that water depth is less of an important factor in controlling *A. neislerii* distribution and abundance than previously reported. Like water depth, *A. neislerii* was found in a variety of substrate types. These findings indicate that an attempt to characterize suitable mussel habitat using substrate alone would not have succeeded in this river reach (Strayer and Ralley 1993; Brim Box et al. 2002; Strayer 2004). The model results show that mesohabitat class was a stronger explanatory measure than substrate type, and all occupied classes exhibited a heterogeneous substrate composition (Figure 23).

Using the explanatory variables I derived with sonar and GIS analysis tools to develop models for predicting *A. neislerii* occurrence and abundance across our study area was a primary objective of this study. The most informative presence/absence model predicted 18% of the study occupied, all of which was located within smooth bedform mesohabitat classes. Although the abundance model only included the smooth bedform mesohabitat classes, not all areas within the smooth bedform mesohabitat classes were predicted to contain at least one mussel, and a map of predicted abundances clearly indicated variation across mesohabitats. Predicted abundances exhibited an increasing trend with increasing study site, and therefore also with distance downstream (Figure 22). This longitudinal trend is most likely due to effect of rkm on estimates of abundance at downstream study sites, and indicates rkm describes longitudinal variation in *A. neislerii* density. A marked increase in estimated abundance for all sites downstream of the site with highest observed average density exemplified the effect of rkm on predicted *A. neislerii* abundance (Figure 22). No significant increase in suitable habitat areas occurred at lower study sites (Figure 8), further suggesting the rkm variable is largely responsible for the trend in predicted abundances.

Assessments of within model performance revealed strengths and some weaknesses of the models developed in this study. The most informative presence/absence model contained low type I and II error when predicting occurrences (Figure 14), and therefore provided a statistically accurate predictive species distribution model for *A. neislerii* presence/absence at the 10 m^2 scale in this reach of the Apalachicola River. Regression analysis between predicted abundances by the most informative count model and the observed counts from the survey were significantly correlated, however a R^2 of 0.34 suggests the accuracy of the count model needs improvement.

The geospatial map of abundance that resulted from the population estimate procedure allowed me to validate the count model predictions with data collected from an independent study conducted by Gangloff (2012). Predicted abundances estimated to occur within equal areas of Gangloff (2012) sampling sites showed a lack of correlation in regression analysis between site level abundance estimates (Figure 16), suggesting variables not included in the model influenced abundance at the sub-mesohabitat or site level. This is not surprising as I focused on using only a few, simple, easily measured variables to model abundance across the large spatial extent of the study area. Abundance estimates on a site by site basis showed the count model consistently predicted greater abundances than Gangloff's 2012 estimate. However, the count model predicted lower abundance by a larger degree at three points, causing estimates from each study to be similar when totaled across Gangloff (2012) sample sites. Population estimates between the two methodologies were also similar when comparing a reach-wide estimate to habitat areas identified by Gangloff in 2012. This indicates the variation observed between estimates at the site level balances at the reach scale.

The lack of correlation between my site-level estimates and the site-level estimates of an independent survey (Gangloff 2012) could be the result of unexplained variation due to explanatory variables not included in the model. Alternate variables such as slope, sinuosity, or radius of curvature may improve the accuracy of estimates made at the scale used to develop the count model (10 m^2), and therefore may result in more accurate estimates at the higher, site-level scale. For example, *A. neislerii* densities have been shown to be highest between rkm 75 – 67, and this area exhibits distinctly less gradient (Figure 10), shorter site length (Figure 8), and contains a greater proportion of smooth bedform area per site than sites upstream and downstream (Figure 9). Using hydrogeomorphic variables associated with these observations could be incorporated in future count models.

A closer inspection of where the count model estimated greater numbers of *A. neislerii* than M. Gangloff revealed four of these sites were occurring below a natural side channel known as the Chipola Cutoff at rkm 65. Gangloff (2012) observed decreased *A. neislerii* density at several sites below this feature. Further investigation revealed dredging activities for navigation channel maintenance conducted by the USACE was heavily concentrated in several areas directly below the Chipola Cutoff until a moratorium in 2001 (USACE Dredging Report 2001, unpublished data). However, even though the single site sampled below the Chipola Cutoff contained less *A. neislerii* than sites sampled upstream, the observed decrease in *A. neislerii* density was not great enough to be represented in the count model and consequently caused predicted abundance to steadily increase below the Chipola Cutoff (Figure 23). The combination of Gangloff's (2012) data, USACE dredging locations, and knowledge of shallow channel bathymetry led to removal of study sites 41, 42, 48, and 50 below the Chipola Cutoff from the population estimate. This removed nearly 1,500,000 mussels from the initial population estimate for a final adjusted estimate of 7,132,332 *A. neislerii* potentially living in the study area.

Although my final population estimate greatly exceeds previous estimates, this estimate can be considered conservative. In addition to fully excluding four sites, 118,020 m^2 of the Pool/Outer Bank habitat was removed from prediction. Furthermore, the tactile sampling technique used in this survey may have missed some of the smallest individuals. Gangloff (2012) sampled 4.5x as many juvenile *A. neislerii* less than 30mm using a suction dredge as found using tactile searches alone in this study, and therefore observed densities in this study may be slightly lower. However, searching with tactile methods in this study still uncovered 221 *A. neislerii* less than 30mm in length, representing 5.6% of the total population sampled, and leads to the conclusion that the sampling method used in this study was still effective at estimating percent juveniles and detecting recruitment.

Population estimates from M. Gangloff (2012) and this study were similar, but I estimated dramatically higher numbers of *A. neislerii* in recirculation habitats when using the full extent of suitable habitat area identified with side scan sonar. The discrepancy in population estimates is primarily due to the difference in estimated suitable habitat area between the studies. All of Gangloff's (2012) sample sites that occurred in my study area were in the Inner and Outer Recirculation Zones. However, I quantified total Inner and Outer Recirculation Zone habitat area to be an order of magnitude greater than that of Gangloff (2012), and consequently the total number of *A. neislerii* estimated in recirculating habitats was also an order of magnitude greater (Table 13).

The paradigm shift in *A. neislerii* habitat use and population sizes occurring as a result of this study provides an example of how differences in study methodology can significantly change estimates of population size and critical habitat. Peterson et al. (2001) reviewed three independent studies that assessed the magnitude of environmental degradation to coastal habitats from a large oil spill, and found that differences in sampling approaches were responsible for polarized conclusions of the extent of damage to natural resources. Sonar habitat mapping was employed in this study to identify extent of difficult-to-access habitats and this information was used to stratify sampling efforts for an endangered freshwater mussel. Results show that this population may be less prone to extinction than previously thought, and it is possible that an integrated, sonar-based study approach could identify previously unrecognized habitat for other freshwater mussel populations in systems similar to the Apalachicola River.

The sonar-based habitat classification employed in this study corresponds to areas of stable habitat as measured by complex hydraulic variables in other large alluvial river systems. Zigler et al. (2008) created a geospatial model with estimates of substrate stability in a 30-km reach of the Upper Mississippi River and found areas of the mid channel that contained large sand dunes exhibited high sediment mobility rates and therefore were unstable and shifting, while channel margins in sinuous reaches were identified as areas with high probabilities of mussel presence and high abundance. Past studies have shown a high degree of correlation between stable habitats and mussel abundance (Strayer 1999; Morales et al. 2006; Steuer et al. 2008; Allen & Vaughn 2010), and large meandering rivers support the formation and maintenance of stable habitats adjacent to the bank at the inflection points of meander bends (Klienhans et al. 2010). Stable habitats that provide flow refuge from flood disturbances have been associated with high probability of juvenile settlement, whether through presence of fish hosts (Vaughn and Taylor 2000) or depositional hydrology (Morales et al. 2006), and correspond directly to the Inner and Outer Recirculation Zones identified in this study. Areas where flow recirculates increases residence time of nutrients that can contribute to higher benthic invertebrate diversity and richness (Garcia et al. 2012; Townsend et al. 1989; Vannote et al. 1980), and can also increase the residency time of fish hosts and food required for freshwater mussel populations to persist (Strayer 2004).

To my knowledge, this is the first study to use side scan sonar to classify potential mussel habitat across a large river reach, and then use map-derived variables to model distribution and abundance at this scale. The entire 700 ha study area was scanned, mapped, and sampled for freshwater mussels within one year, further supporting the utility of this study's methodology for limited budget and time constricted situations. A similar approach involving mapping potential habitat first, stratifying samples accordingly, and modeling with the resulting data might also alter ecological perspectives on other freshwater mussel species in large rivers as this study has done with *A. neislerii*.

Conclusion

Identifying the spatial extents of freshwater mussel habitats with side scan sonar habitat mapping has considerably altered previous perspectives on Fat Threeridge (*Amblema neislerii*) freshwater mussel populations in the Apalachicola River. Using bedforms to delineate habitats at the mesoscale and using time lapse sonar image analysis to confirm their stability provided a low cost, efficient approach to focus sample efforts of *A. neislerii* across this 50 km reach of the Apalachicola River. The sampling approach taken in this study revealed *A. neislerii* residing in undistinguished habitats and occupying greater extents than previously recognized, and sonar-based and GIS-derived habitat variables were sufficient to develop species distribution models to estimate population size over large spatial extents. The information gained from this study has identified previously unrecognized suitable habitat, and provided a more comprehensive perspective of *A. neislerii* distribution and abundance. I believe the integration of low-cost, sonar habitat mapping, stratified mussel surveys, and species distribution modeling may help fill a critical gap in information necessary to study and manage these imperiled organisms in a variety of other river systems.

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Tables

Table 1. Descriptions and features of the mesohabitat classification scheme.

Mesohabitat unit	Flow conditions	Bed stability & depositional pattern	Bedform pattern	Location in channel	Sonar features
Point Bar	Turbulent	Unstable; Highly depositional of coarse particles	Ripples/Dunes	Inner bend bank attached	Bright image tone, dunes and ripples
Inner Recirculation Zone	Recirculation/flow separation eddy	Stable; Moderately depositional of finer particles and organic matter	Smooth plane	Bank attached downstream of Point Bar inner bend	Smooth texture; darker image tone; moderate bank slopes-dull sonar return from edge
Outer Recirculation Zone	Recirculation/flow separation eddy	Stable; Moderately depositional of finer particles and organic matter	Smooth plane	Bank attached downstream of Pool/Outer Bend	Smooth texture; darker image tone; moderate bank slopes-dull sonar return from edge; large woody material
Mid-Channel	Turbulent	Unstable; Transport of coarse particles	Ripples/ Dunes	Center of channel	Bright image tone, dunes and ripples
Pool/Outer Bend	Unidirectional secondary flow	Stable at low flow; Erosion at high flow; Deposition of coarsest particles and submerged wood	Smooth plane	Bank attached outer portion of meander bend	Smooth texture; bright image tone; steep/verticle bank-bright sonar return from edge; large woody material

Table 2. Results of the mesohabitat classification across the study area.

Mesohabitat Unit	Total Number of units	Average Area Per unit (ha)	Total Area (ha)	% of Total Habitat
Point Bar	49	1.03	50.6	7.3
Inner Recirculation Zone	49	0.55	27.1	3.9
Outer Recirculation Zone	49	0.34	15.7	2.3
Mid-Channel	50	10.0	498.6	71.6
Pool/Outer Bank	50	2.1	104.3	15.0

Table 3. Area in hectares and percent change occurring to each mesohabitat class after a 10 year flood event. The mesohabitat classes listed vertically on the left column correspond to the mesohabitat classes that existed preflood, and the horizontally listed mesohabitat classes on the top column correspond to the mesohabitats that existed post flood. For example, the inner recirculation zone exhibited a 3.8% change in area to the Point Bar mesohabitat after the flood event. Shaded boxes represent area of no change.

		Post-flood data				
		Point Bar	Inner Recirculation Zone	Outer Recirculation Zone	Mid-Channel[a]	Pool/Outer Bank
Pre-flood data	Point Bar	264.9 (80.3%)	2.7 (0.8%)	2.0 (0.6%)	60.2 (18.3%)	0 (0%)
	Inner Recirculation Zone	8.0 (3.8%)	167.1 (80.4%)	0 (0%)	16.7 (8.0%)	15.9 (7.7%)
	Outer Recirculation Zone	1.7 (1.5%)	0 (0%)	85.3 (71.0%)	25.5 (21.2%)	7.5 (6.2%)
	Mid-Channel	66.8 (2.1%)	38.9 (1.2%)	21.4 (0.6%)	3,023.9 (93.5%)	84.9 (2.6%)
	Pool/Outer Bank	0 (0%)	11.6 (1.5%)	11.8 (1.5%)	118.8 (15.6%)	618.8 (81.2%)

Table 4. Comparisons of the % net change between pre and post flood sonar habitat maps, and the % change that was measured from two sonar habitat maps representing identical field conditions presented here as a measure of % mapping error. The % net change that occurred between all mesohabitats except the Pool/Outer Bank fell inside the range of % error that could simply be due to differences in GPS error and path of the survey vessel.

Mesohabitat Class	Pre-flood Area (m^2)	Post-flood Area (m^2)	% Net Change	Range of % mapping error
Point Bar	329849	341760	3.6	(+/-) 5.0
Inner Recirculation Zone	207733	220818	6.3	(+/-) 15.9
Outer Recirculation Zone	120113	125915	4.8	(+/-) 15.6
Mid Channel	3235962	3245683	0.3	(+/-) 0.02
Pool/Outer Bank	760920	724421	-4.8	(+/-) 1.2

Table 5. Results of manually selecting polygons associated with a visually noticeable change in bedform pattern. Numbers are percentage of mesohabitat class on the left, vertical column that exhibited visually noticeable change in bedform to the mesohabitat class on the right, horizontal column.

		Post-flood data				
		Point Bar	Inner Recirculation Zone	Outer Recirculation Zone	Mid-Channel	Pool/Outer Bank
Pre-flood data	Point Bar		0.28	0.19	0	0
	Inner Recirculation Zone	0.95		0	1.45	0
	Outer Recirculation Zone	0	0		4.13	0
	Mid-Channel	0	0.28	0		0.44
	Pool/Outer Bank	0	0	0	4.94	

Table 6. Results of the raw change analysis for suspected stable habitat units and the Pool/Outer Bank habitat. Decrease in area due to Mid-Channel expansion is defined as the percent change that occurred from each of these habitats to the Mid Channel habitat found in Table 5 above.

Mesohabitat Unit Pre Flood	Mesohabitat unit post flood	Unverified (raw) decrease in area due to mid-channel expansion (%)	Observed percent mapping error	Verified physical area decrease due to mid-channel expansion (%)
Inner Recirculation Zone	Mid-Channel	7.6	15.9	1.5
Outer Recirculation Zone	Mid-Channel	20.8	15.6	4.1
Pool/Outer Bank	Mid-Channel	15.6	1.2	4.9

Table 7. Description and support for variables used in modeling procedure.

Variable Name	Description	Scale	Support	Source
River Kilometer	Longitudinal variable representing coarse resolution phenomena	Landscape	(Vannote et al. 1980) River Continuum Concept; Distribution of species changes from headwaters to mouths of rivers due to geomorphological and resource distribution	Point shapefile with navigation data of the Apalachicola River provided by USACE
Mesohabitat Class	Categorical variable with 5 levels representing spatially defined habitat types within the river channel	Meso	(Garcia et al. 2012) Meander bends support the formation of hydraulic refuge from flood disturbances	Sonar image maps (SIMs) and classified polygon shapefile representing mapped mesohabitats
Distance to Bank	Continuous variable representing distance to wetted edge during low flow conditions in the Apalachicola River	Meso	(Gangloff 2012) A majority of *A. neislerii* were found within short distances (<=~1 meter) of the bank	Polyline shapefile generated by digitizing edge of water from aerial photography collected during a period of low flow in the Apalachicola River
Distance to Unstable Habitat	Continuous variable representing distance to unstable migrating sand ripples and dunes associated with turbulent hydraulic conditions	Meso	(Guisan and Thuiller 2005) Distance to disturbances represents a main influence on species distribution	SIMs and mesohabitat layers representing benthic environments exhibiting a sand ripple and dune bedform
Depth	Continuous variable representing water depth of the sample point during survey	Micro	Gangloff 2012; EnviroScience 2006a found significant correlation between depths and *A. neislerii* counts	Survey data
Substrate Type	Categorical variable with 4 levels representing predominate substrate composition within each sampling plot during survey	Micro	*A. Neislerii* historically associated with substrate compositions of mixtures of fine sand and silt	Survey data

Table 8. Summary of *A. neislerii* and mesohabitat data.

Mesohabitat Class	Areal coverage within study area (m^2)	% of study area	Average *A. neislerii* density (mussels/m^2)	# of sample plots occupied/ # of plots sampled	Range of *A. neislerii* sampled per plot	*A. neislerii* count total	Average *A. neislerii* density x Area (crude estimate)	*A. neislerii* abundance model estimate
Main Channel	4,985,217	71.6	0.03	1/27	0-9	9	149,835	NA
Point Bar	505,010	7.3	0.09	7/35	0-17	30	47,961	NA
Inner Recirculation Zone	270,697	3.9	4.6	29/35	0-244	1602	1,290,186	890,246
Outer Recirculation Zone	157,183	2.3	3.7	37/38	0-434	1419	595,826	288,462
Pool/Outer Bank	1,043,241	15.0	3.1	26/29	0-230	907	3,319,052	7,508,375
Total	6,961,348			100/164		3958	5,402,860	8,687,083

Table 9. Summary of small sample size Akaike information criterion (AIC_c) ranking of *A. neislerii* presence/absence logistic models.

Rank	Variables						Δ_i	K	w_i
1	rkm	Mesohabitat Class	Distance to low flow bankline				0.0	7	0.7
2	rkm	Mesohabitat Class	Distance to low flow bankline	Distance to unstable habitat			2.2	8	0.2
3	rkm	Mesohabitat Class	Distance to low flow bankline	Distance to unstable habitat	Water depth		3.9	9	0.1
4	rkm	Mesohabitat Class					18.73	6	0.0
5		Mesohabitat Class					20.6	5	0.0
6	rkm				Water depth	Substrate Type	40.4	6	0.0

Table 10. Model summary for the AIC_c top-ranked *A. neislerii* presence/absence logistic model.

Coefficient	Estimate	SE	*Z*	*P*
(Intercept)	3.001	1.870	1.609	0.108
Inner Recirculation Zone	3.309	0.747	4.432	<0.0001
Outer Recirculation Zone	3.171	0.792	4.003	<0.0001
Pool/Outer Bank	4.600	0.937	4.907	<0.0001
Mid Channel	-0.298	1.222	-0.244	0.807
River Kilometer	-0.039	0.023	-1.706	0.088
Distance to Low Flow Bankline	-0.141	0.040	-3.574	0.0004

Table 11. Summary of small sample size Akaike information criterion (AIC_c) ranking of the *A. neislerii* abundance models.

Rank			Variables				Δ_i	K	w_i
1	rkm	Mesohabitat Class	Distance to low flow bankline	Distance to unstable habitat			0.0	6	0.99
2	rkm	Mesohabitat Class	Distance to low flow bankline	Distance to unstable habitat		Substrate Type	10.6	7	0.01
3	rkm	Mesohabitat Class	Distance to low flow bankline				21.6	5	0.0
4	rkm	Mesohabitat Class					32.5	4	0.0
5			Distance to low flow bankline	Distance to unstable habitat	Water depth	Substrate Type	46.2	7	0.0
6						Substrate Type	58.4	4	0.0
7					Water depth	Substrate Type	60.6	5	0.0
8					Water depth		62.6	8	0.0
9		Mesohabitat Class					64.47	3	0.0
10		Mesohabitat Class			Water depth		66.52	4	0.0

Table 12. Model summary for the AIC_c top-ranked *A. neislerii* abundance model using the GLM procedure with a negative binomial distribution.

Coefficient	Estimate	SE	*Z*	*P*
(Intercept)	9.750	0.809	12.05	<0.0001
Outer Recirculation Zone	-0.420	0.305	-1.38	0.167
Pool/Outer Bank	0.943	0.330	2.88	0.0040
River Kilometer	-0.082	0.009	-8.70	<0.0001
Distance to Low Flow Bankline	-0.118	0.022	-5.41	<0.0001
Distance to Unstable Habitat	0.058	0.015	3.982	<0.0001

Table 13. Comparison and contrast between M. Gangloff's 2012 sampling and study results with those from this study.

Sampling Comparisons

Methodology	Average density sampled in inner and outer recirculation zones (mussels/m^2)	Area of potential inner and outer recirculation zone habitat in study area (m^2)	Max depth sampled in inner and outer recirculation zones (m)	Max distance from bank sampled in inner and outer recirculation zones (m)
M. Gangloff	4.9	46,455	2.25	15.0
This study	4.1	427,880	4.6	22.4

Population Estimate Comparisons

Methodology	# *A. neislerii* estimated within M. Gangloff's identified potential habitat area	# *A. neislerii* estimated in inner and outer recirculation zone mesohabitat class area	# *A. neislerii* estimated within pool/outer bank mesohabitat class area	# *A. neislerii* estimated across 700 ha study area
M. Gangloff	199,679	199,679	N/A	199,679
This study	175,124	1,178,708	7,508,375	8,687,083

Figures

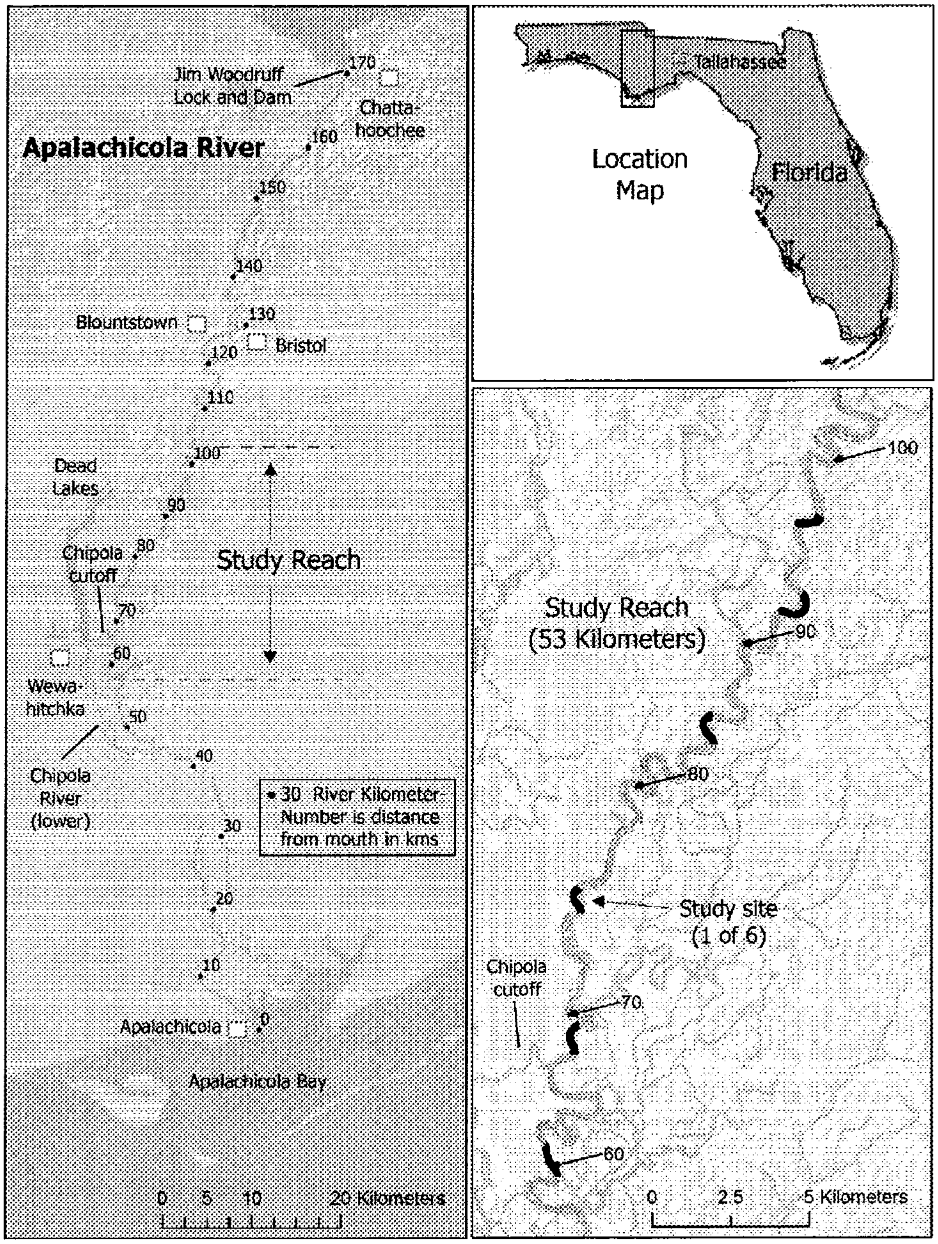

Figure 1. Study area.

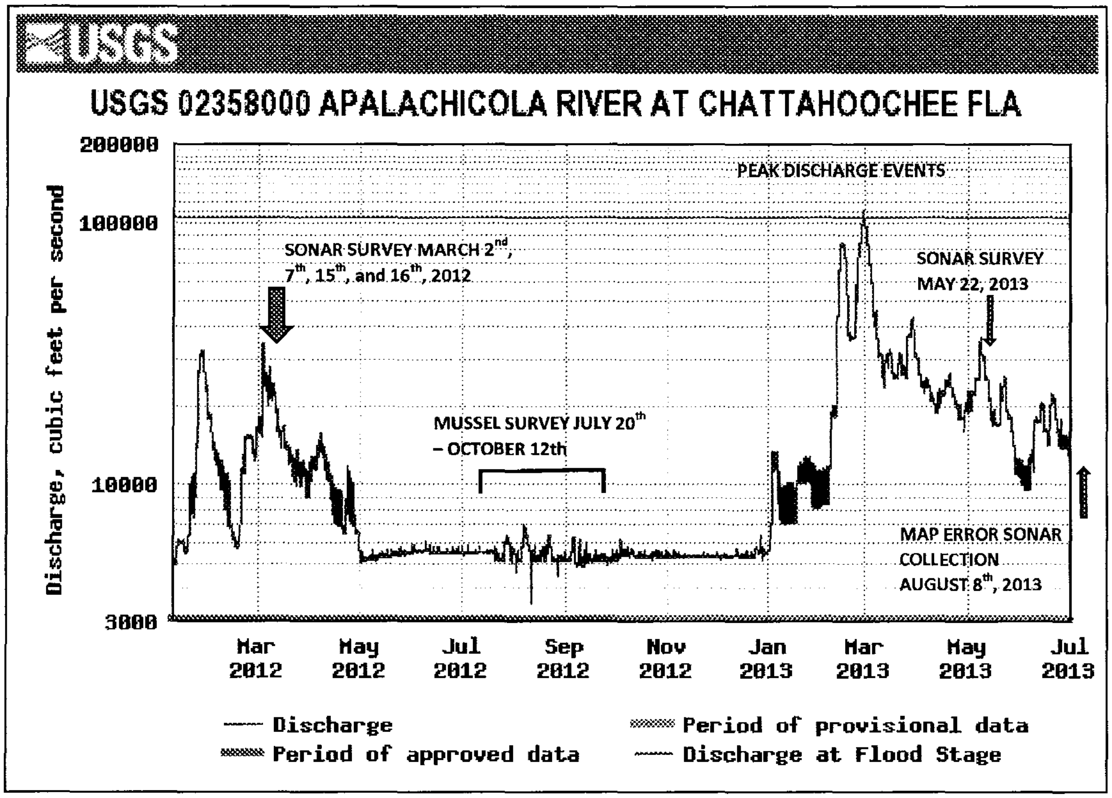

Figure 2. Dates of sonar data collection and associated discharges at the Jim Woodruff Lock and Dam USGS water gauge. Note the >100,000 cfs flood event occurring in March 2013, and the following sonar data collection used for the habitat change analysis.

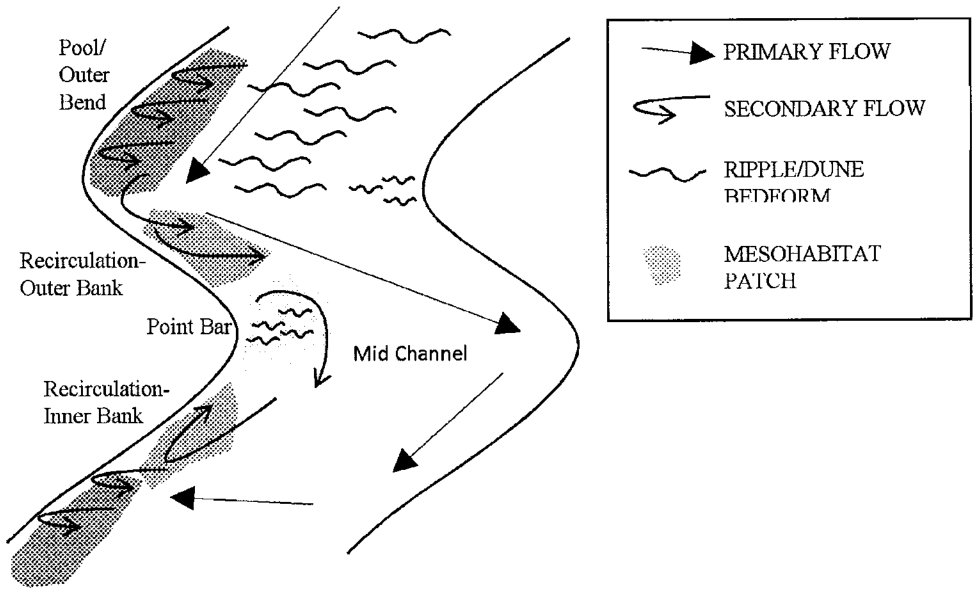

Figure 3. Conceptual illustration of the primary and secondary flow environments around a meander bend and associated habitat units used for this classification. Adapted from Garcia et al. 2012.

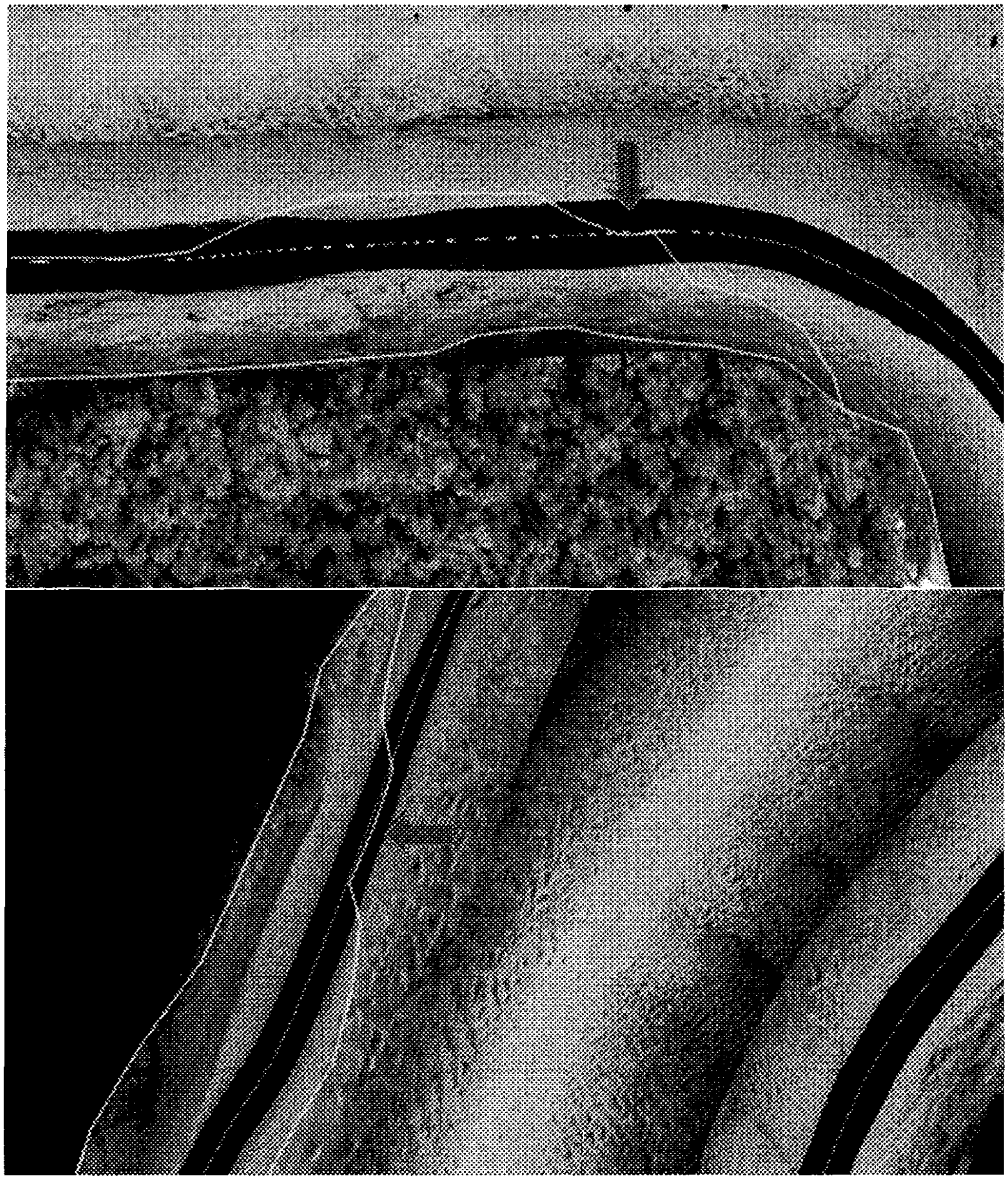

Figure 4 - Two examples of the standardized approach used to delineate boundaries, in this case the boundaries between recirculation zones and mid channel mesohabitats, when such boundaries crossed a region of the sonar image occupied by the water column (i.e., the dark band of pixels).

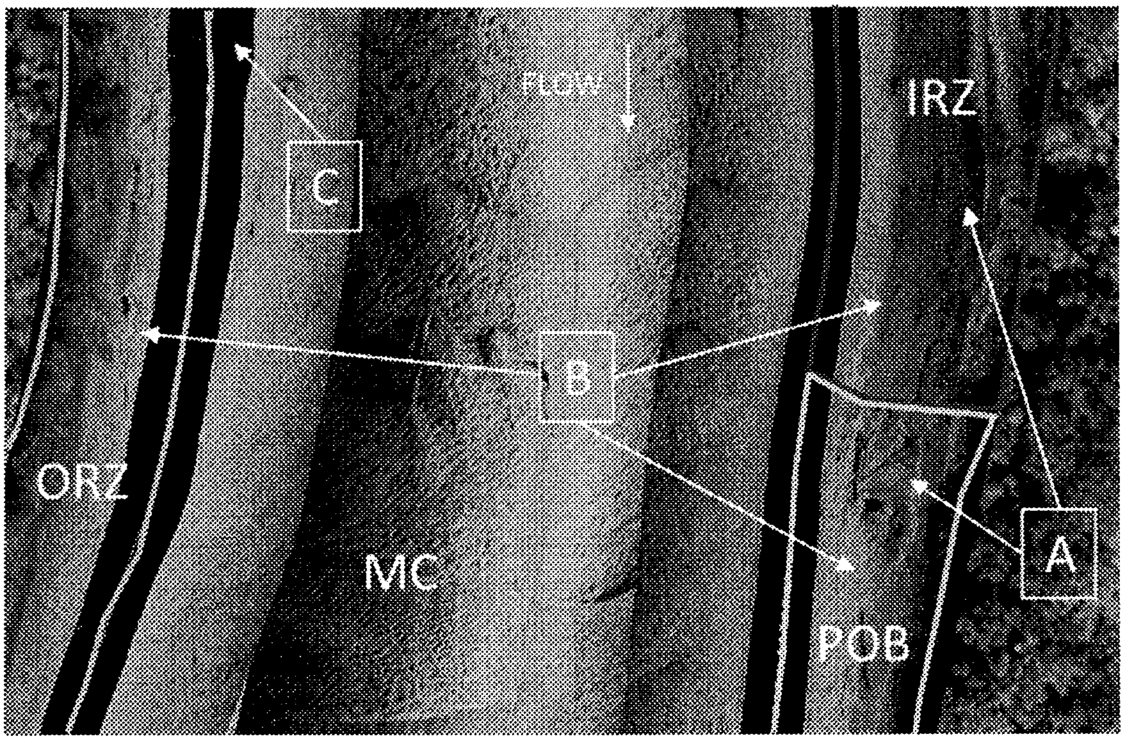

Figure 5-Detail of features used to distinguish the Inner and Outer Recirculation Zones from the Pool/Outer Bank and Mid-Channel habitats during mapping. A.) Using the dark tonal shift and appearance of large woody debris to delineated the IRZ from the POB. B.) Using the bedform variation from sand duned and rippled to smooth bedform to delineate the POB, IRZ, ORZ from the Mid-Channel. Bedform patterns inspected at a much finer map-scale during mapping (~1:300) than shown in this figure. C.) Dark band of pixels representing water depth. In this example, the boat passed directly over the smooth and duned bedform boundary during the time of collection, so the delineation proceeded across the center of the image.

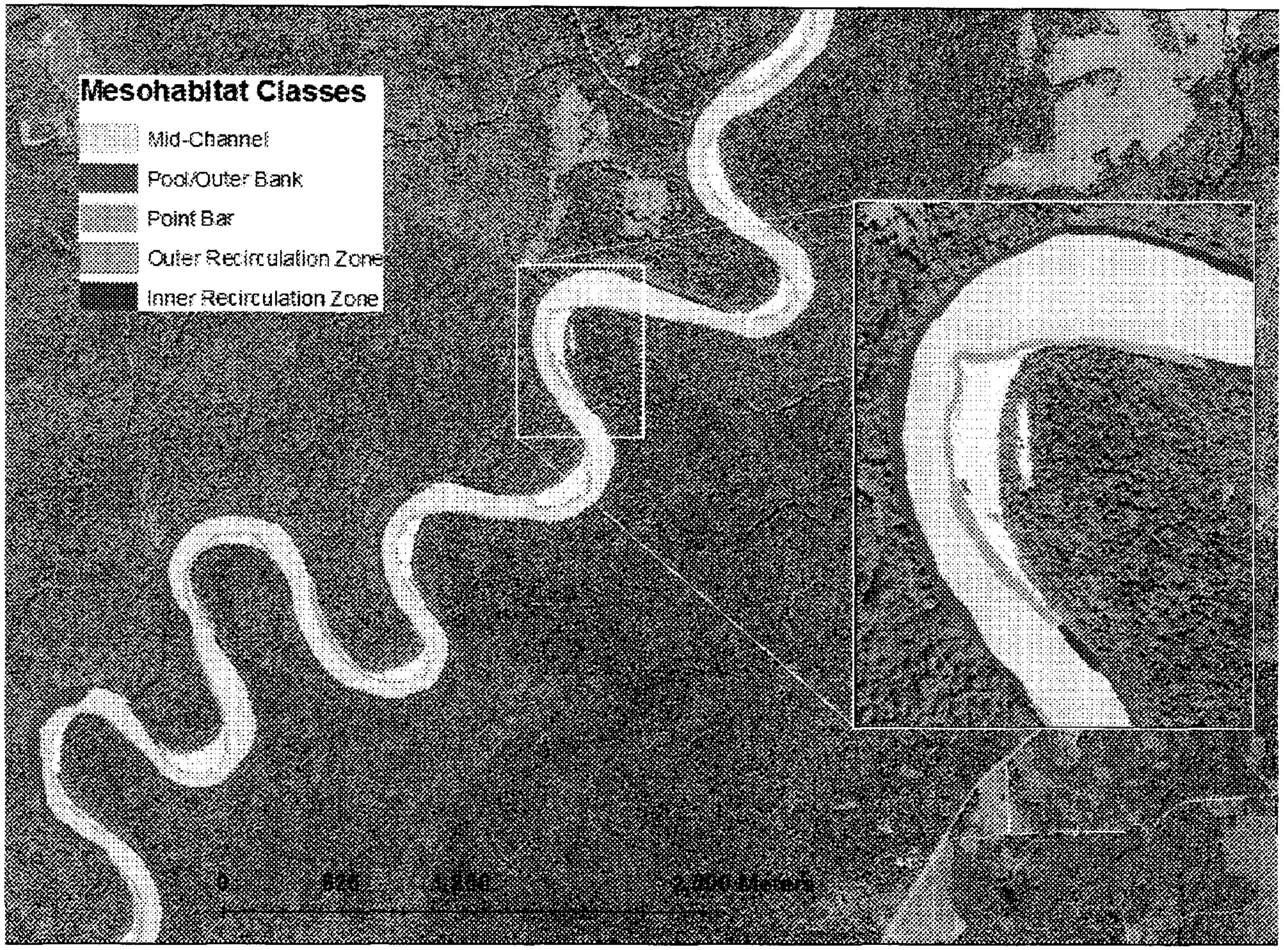

Figure 6 - A section of the completed mesohabitat classification map. Inset shows the consecutive, repeating nature of the mesohabitat classes around a typical meander bend.

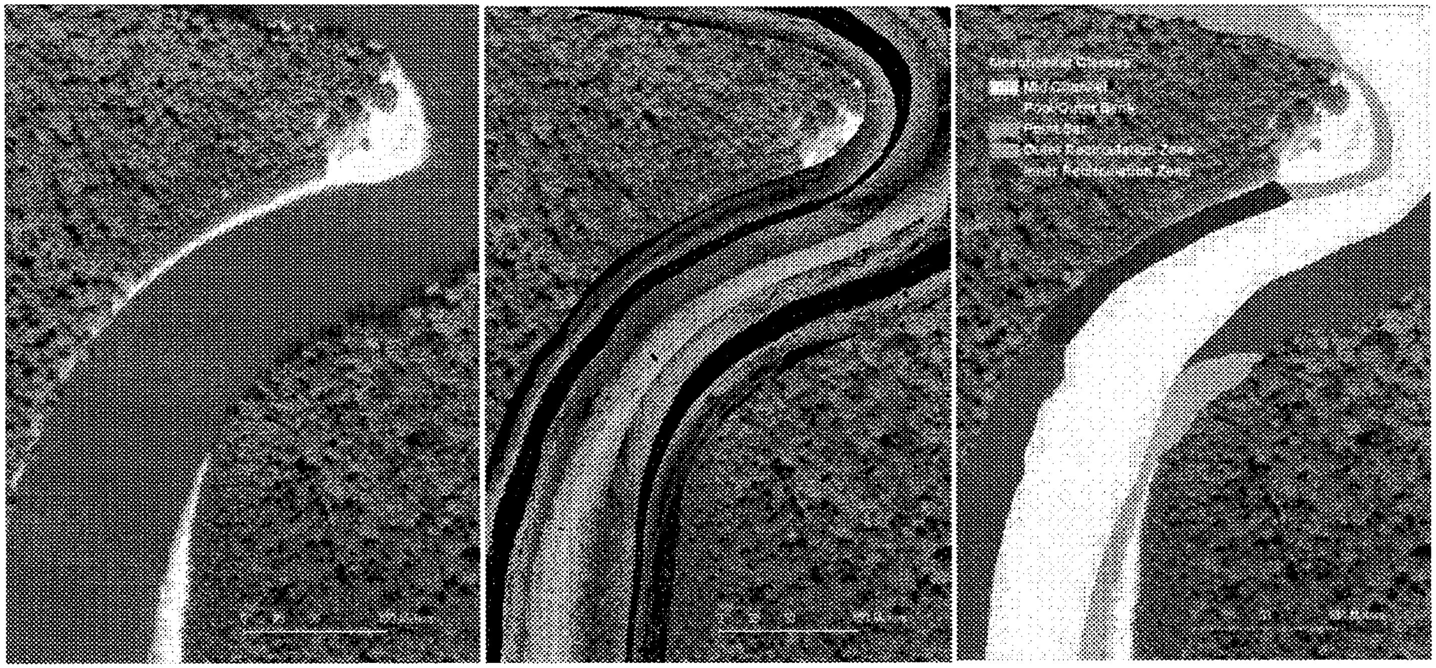

Figure 7- Panels illustrating the 2010 NAIP aerial imagery, sonar image map layers, and the classified mesohabitat map for a bend in the Apalachicola River.

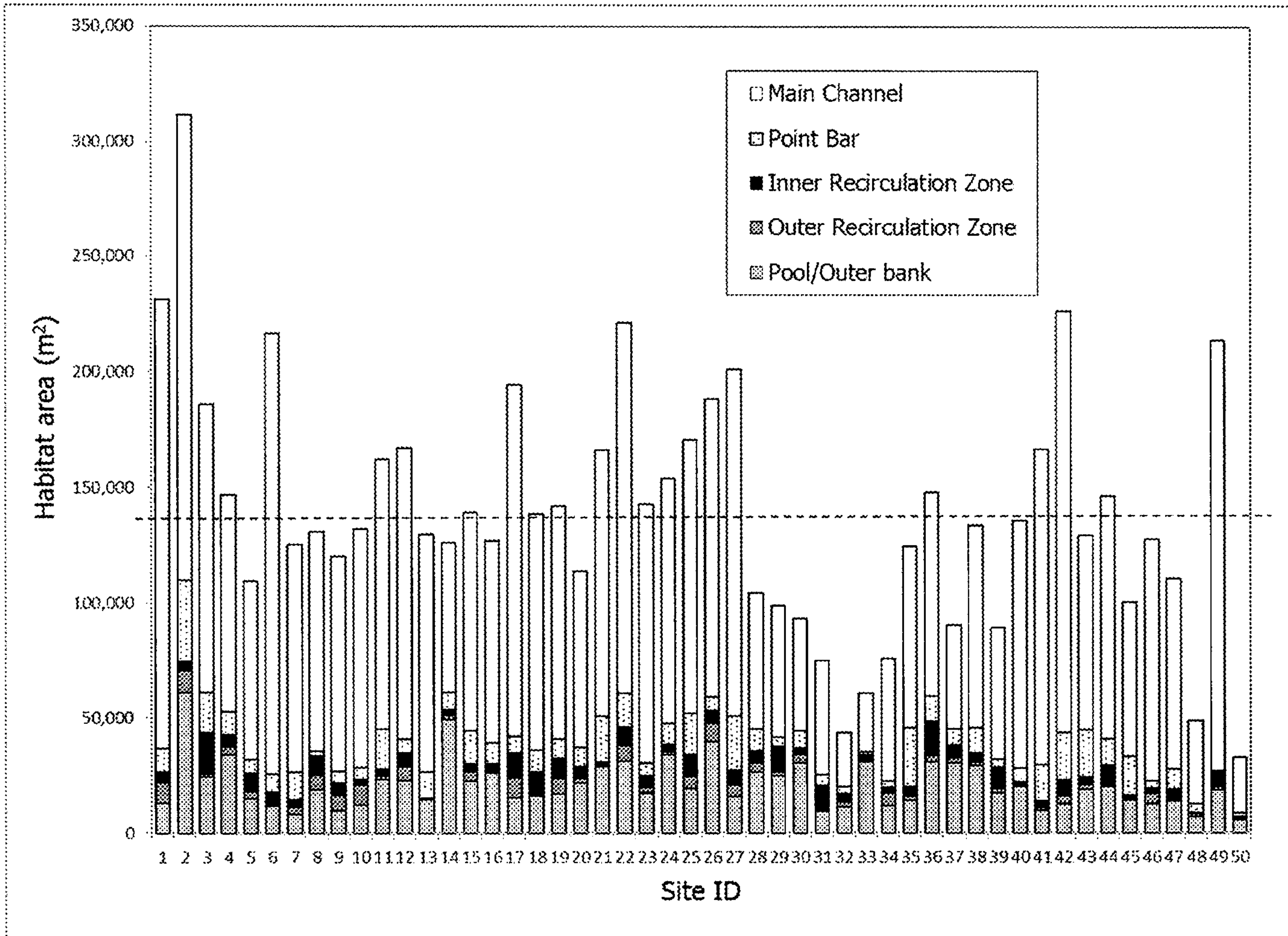

Figure 8. Breakdown of habitat area per site, where each site contains at least one of each mesohabitat type. Site ID number increases with distance downstream, so site 1 is the upstream extent of the study area and site 50 is the downstream extent. The dotted line represents the mean site area across all sites. Note sites 27 -34 hold consecutively smaller site areas.

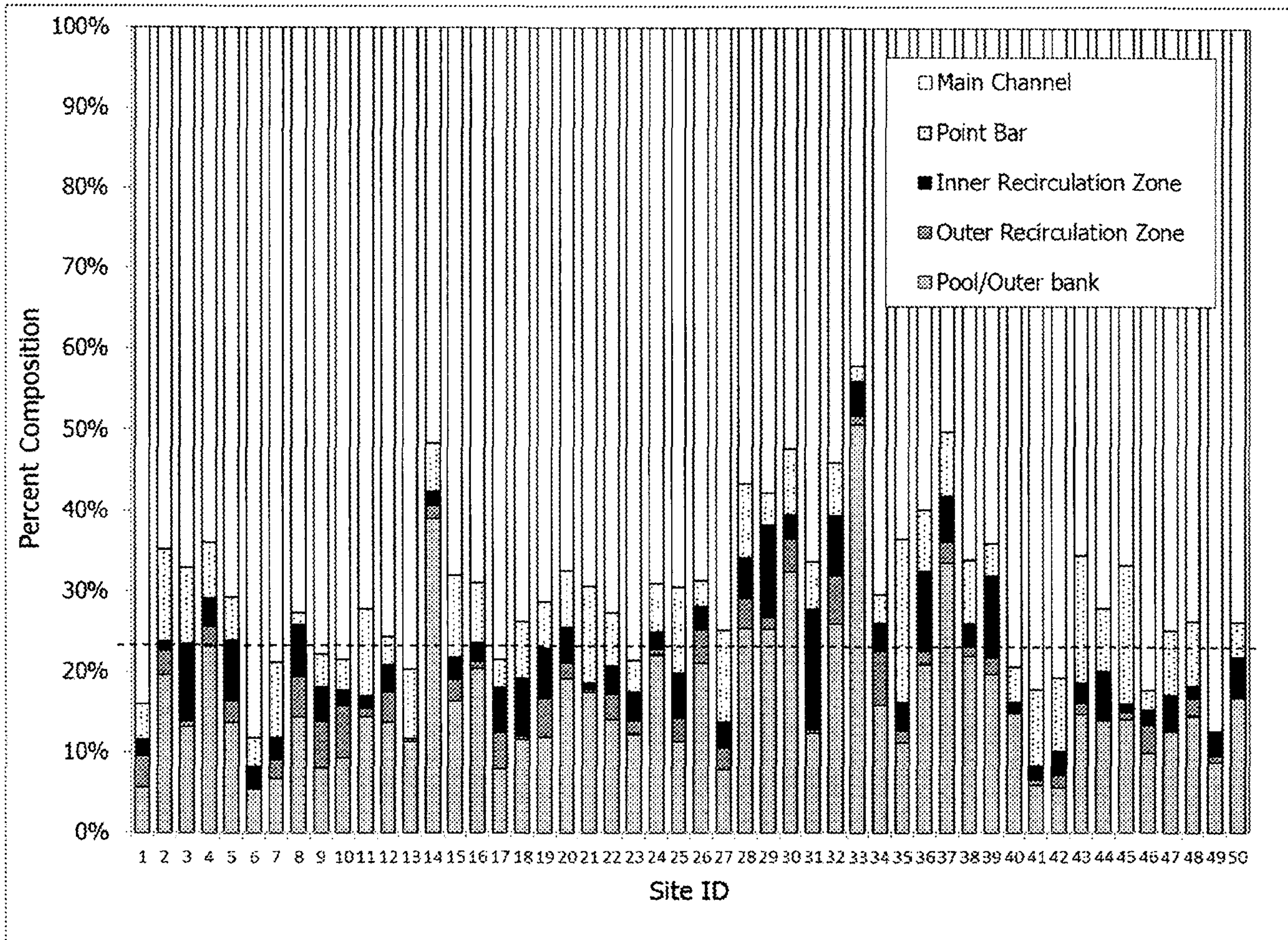

Figure 9. Proportion of area covered by each mesohabitat class per site. Note sites 27 to 39 show greater proportions of smooth bedform mesohabitats (IRZ, ORZ, POB) than all other sites.

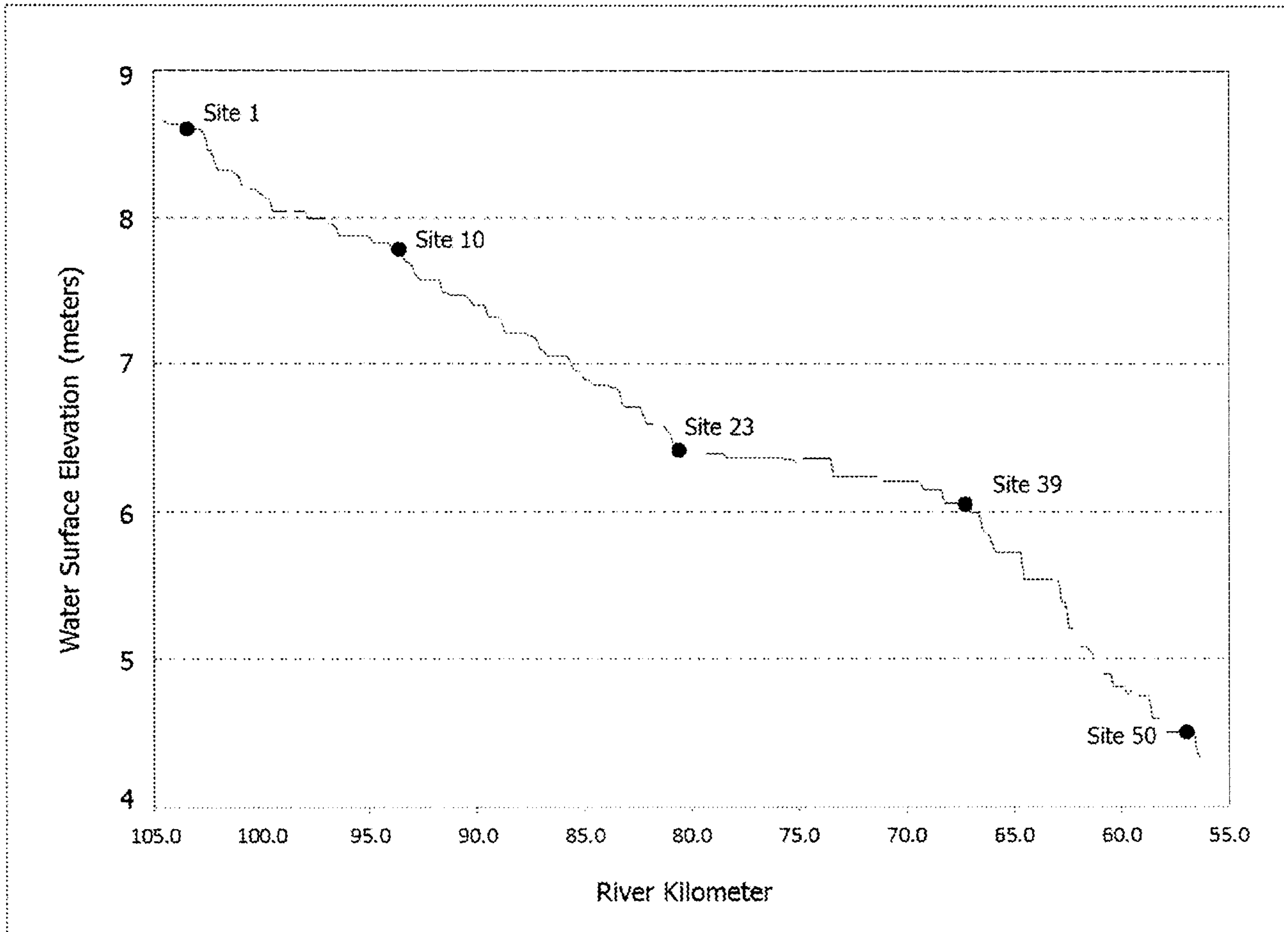

Figure 10. Gradient of the Apalachicola River across the study area. Note the change of gradient occurring from site 23 to 39.

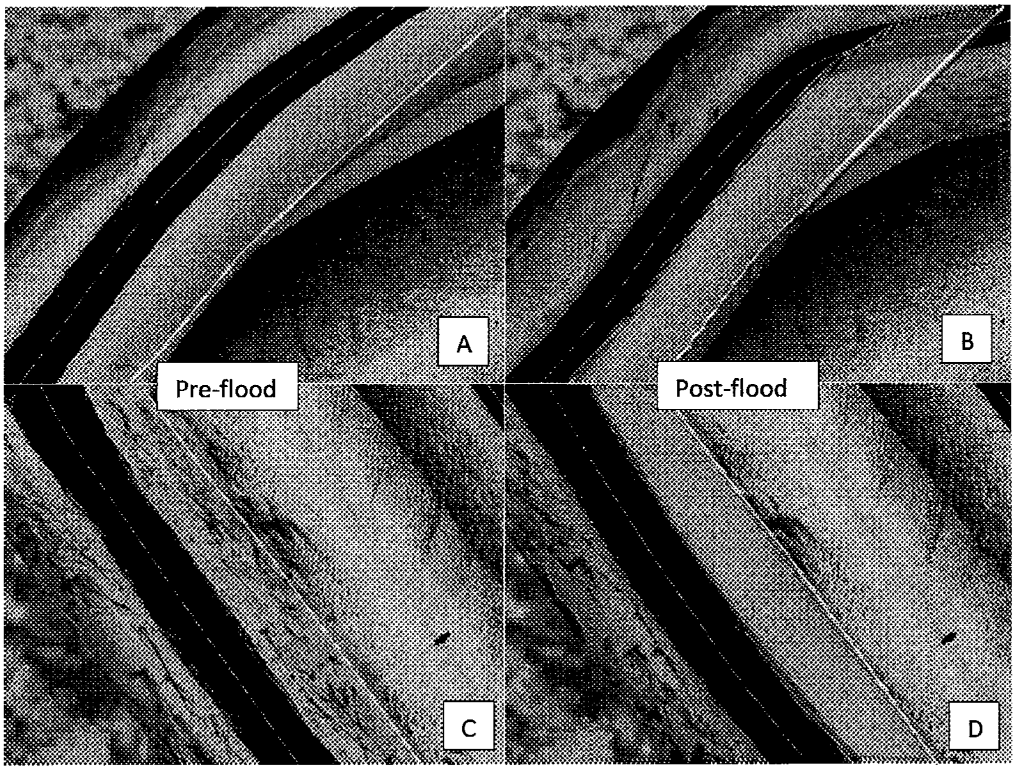

Figure 11. Example of sand dune and ripple bedform encroachment into smooth bedform habitats. Smooth bedforms in Recirculating-Inner Bank (A) and Pool/Outer Bank (C) experienced migration of sand ripples and dunes (B) and covering of large aggregations of woody debris (D). The yellow line represents the outer boundary of the smooth bedforms before the flood as they would be digitized in ArcGIS, while the red line indicates the boundary digitized after the flood. The area quantified as a decrease in habitat is the shaded portion in between the two boundaries, as analyzed using the raster calculator tool in ArcGIS. In A and B note the bedform and image tone remains consistent before and after the flood event, and in C and D, note the persistence of the large woody debris aggregations close to the bank.

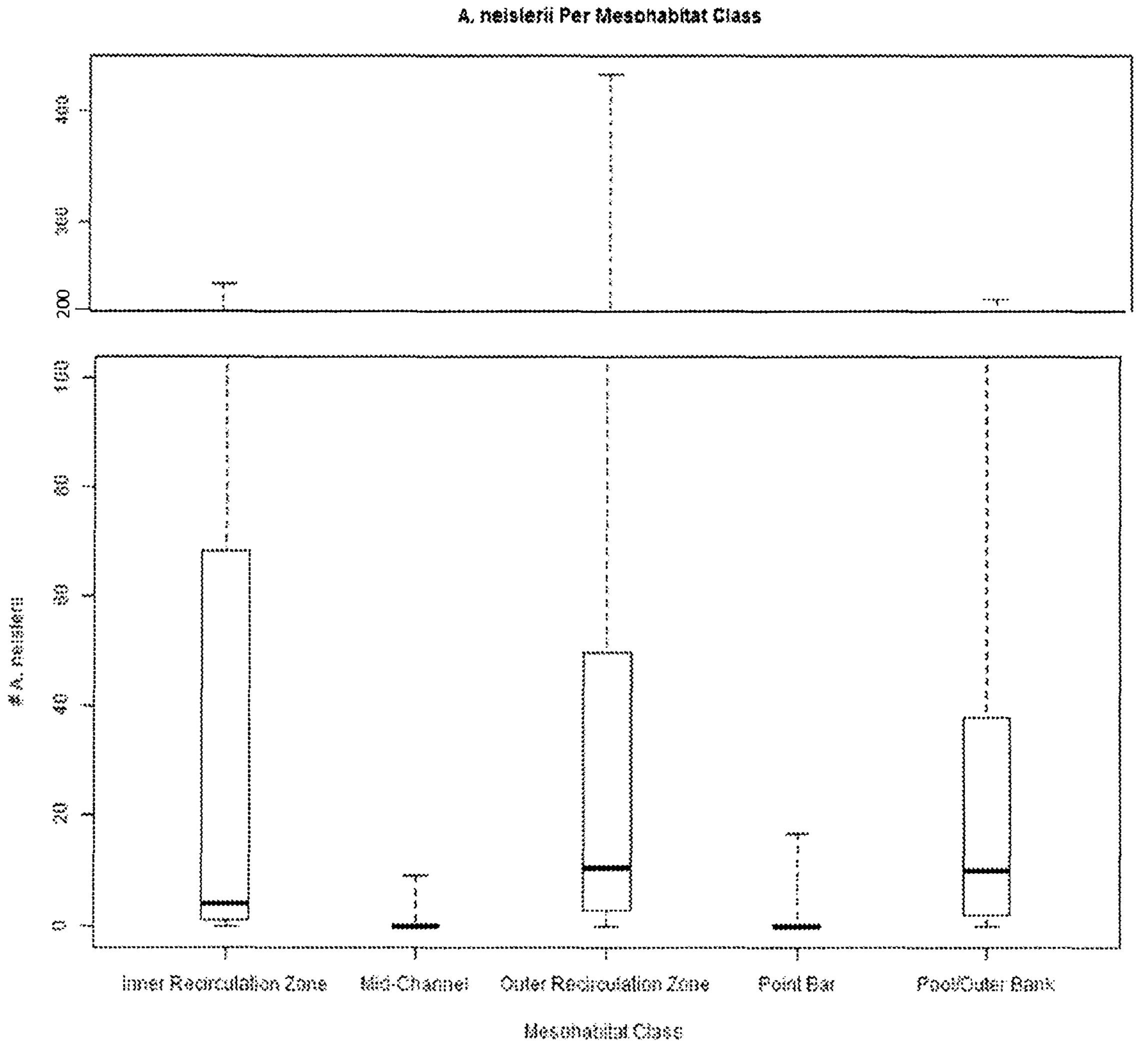

Figure 12. Range of *A. neislerii* counts sampled within each mesohabitat class. Boxes represent inner quartiles, and the solid horizontal black lines represent the median count. Dotted dashed lines represent the entire range of counts observed. Counts can be converted to density by dividing by the sampling area ($10m^2$).

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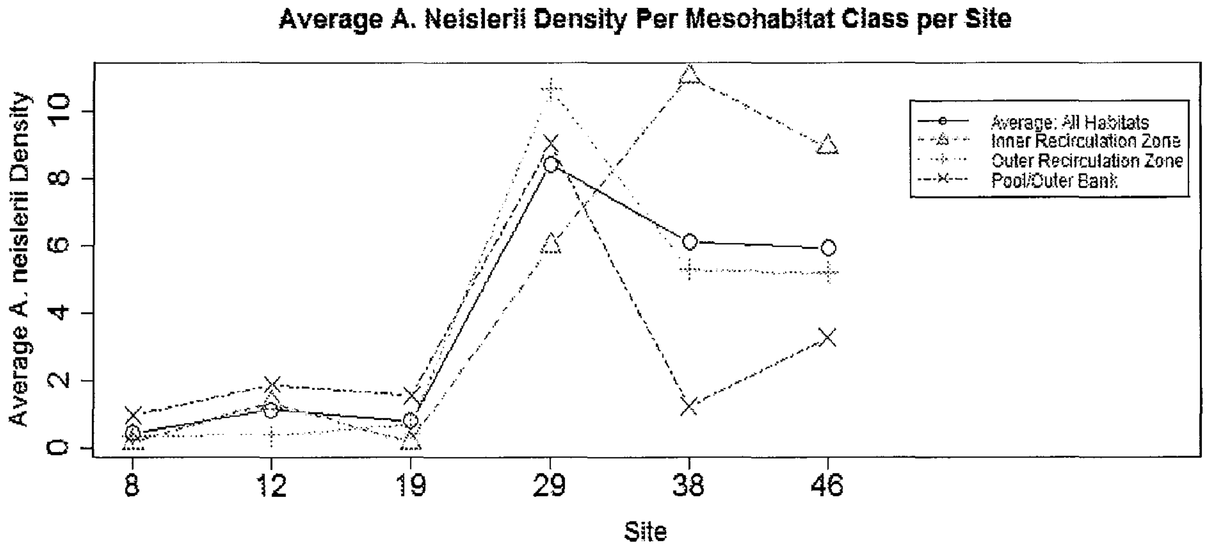

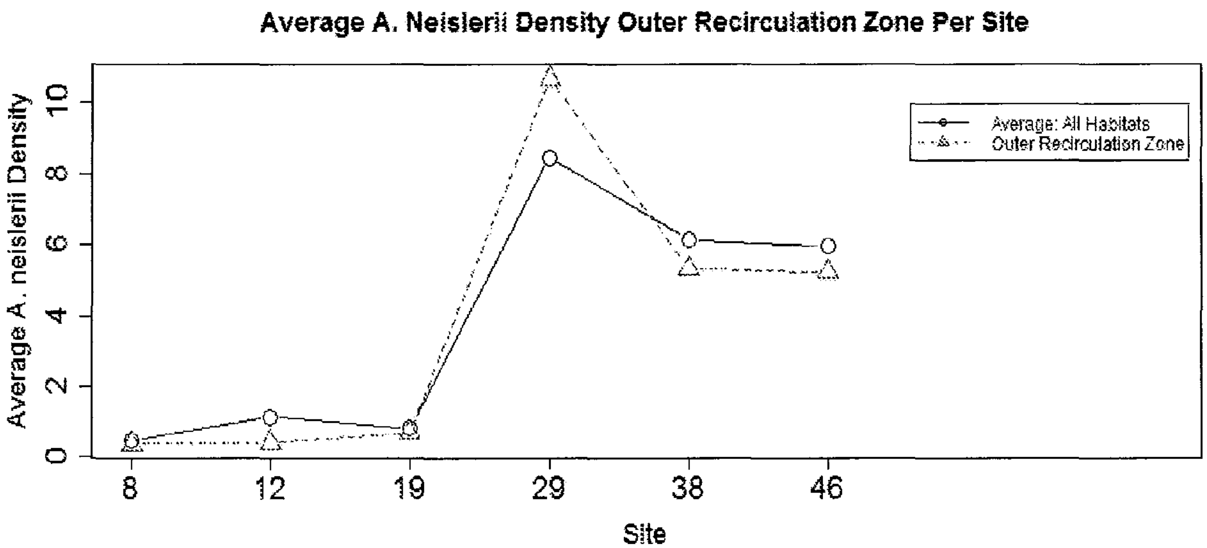

Figure 13. Trends in mean *A. neislerii* density between all mesohabitat classes (upper panel) and the Outer Recirculation Zone mesohabitat (lower panel) compared to average mean density across all mesohabitat classes for each sampling site. Sampling site number increases consecutively downstream. Note the large increase in average *A. neislerii* density at site 29 (river kilometer 75), and the congruency between average *A. neislerii* in the Outer Recirculation Zone mesohabitat class and average *A. neislerii* density across all samples.

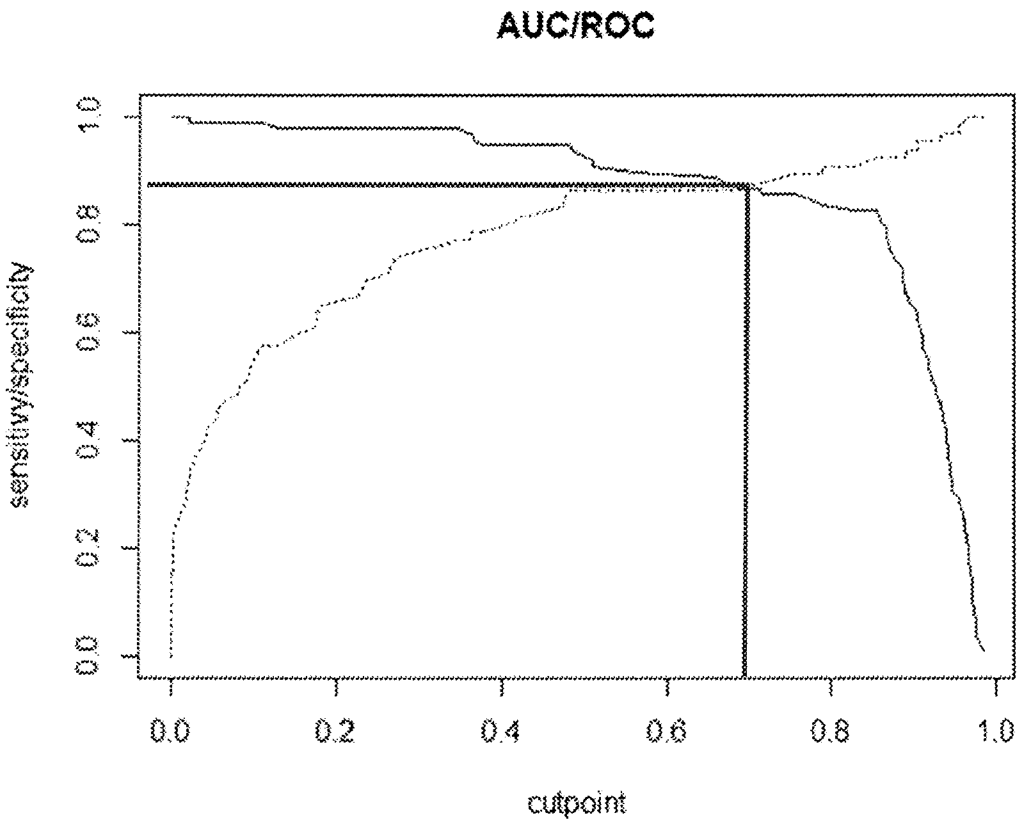

Figure 14. Plot of sensitivity versus specificity of the top ranking presence/absence logistic model. The plot revealed an optimal prediction probability to fall at 0.7 (vertical red line on the x-axis), and the AUC was found to equal 0.939 (horizontal red line on the y-axis).

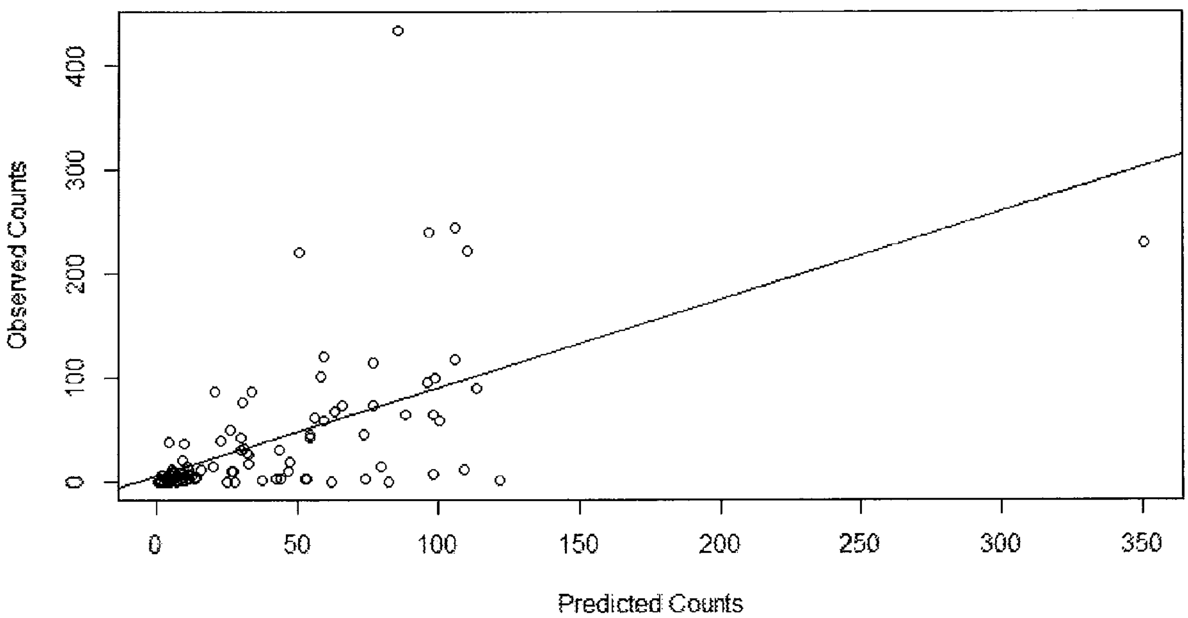

Figure 15. Observed *A. neislerii* counts from the survey vs. predicted counts from the top AIC_c ranked negative binomial generalized linear count model. Correlation coefficient (R^2) between points was found to equal 0.34, and the slope of the regression line was found to equal 0.85. N = 102.

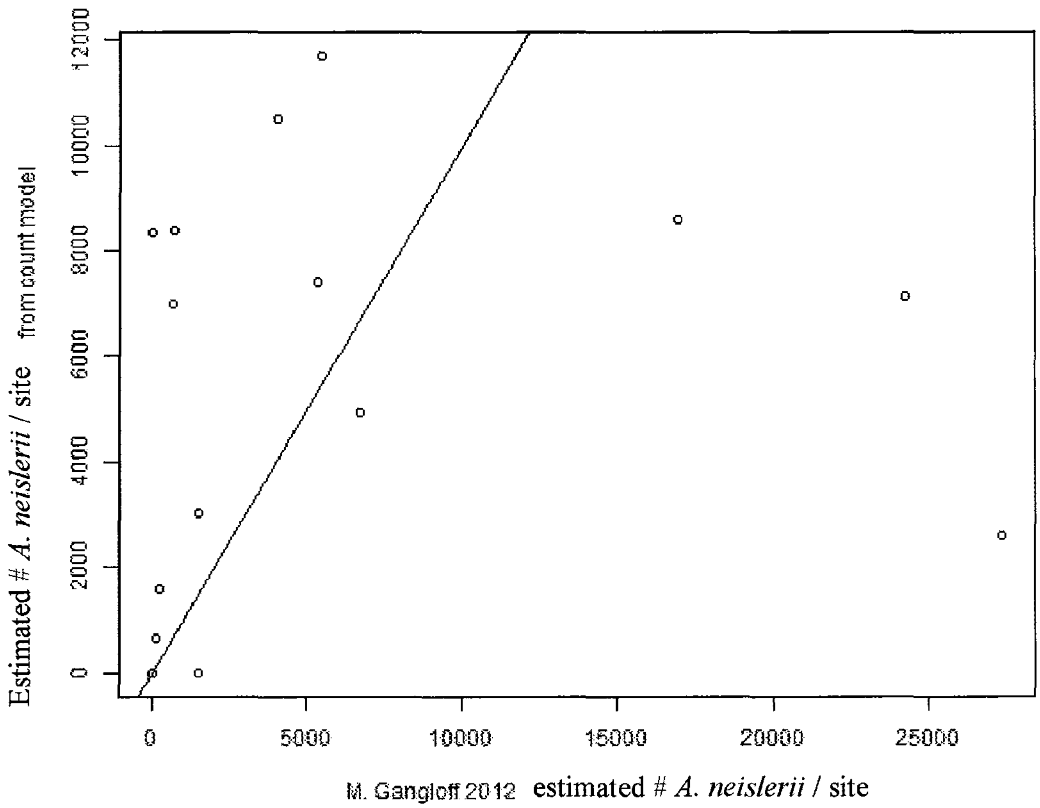

Figure 16. Site level comparisons of *A.* neislerii estimates between M. Gangloff's study in 2012 and the count model predictions estimated from within equal areas sampled by M. Gangloff in 2008, 2010, and 2011. $R^2 = 0.02$, and the slope of the regression line is equal to 1.12. Line visible on the plot corresponds to a slope of 1:1.

Figure 17. Example of differences in sampling site area between M. Gangloff's 2012 study and the habitat extent identified with side scan sonar mapping of submerged bedform features. Polygons in each study represent habitat patches occurring at the meso-scale resolution of study.

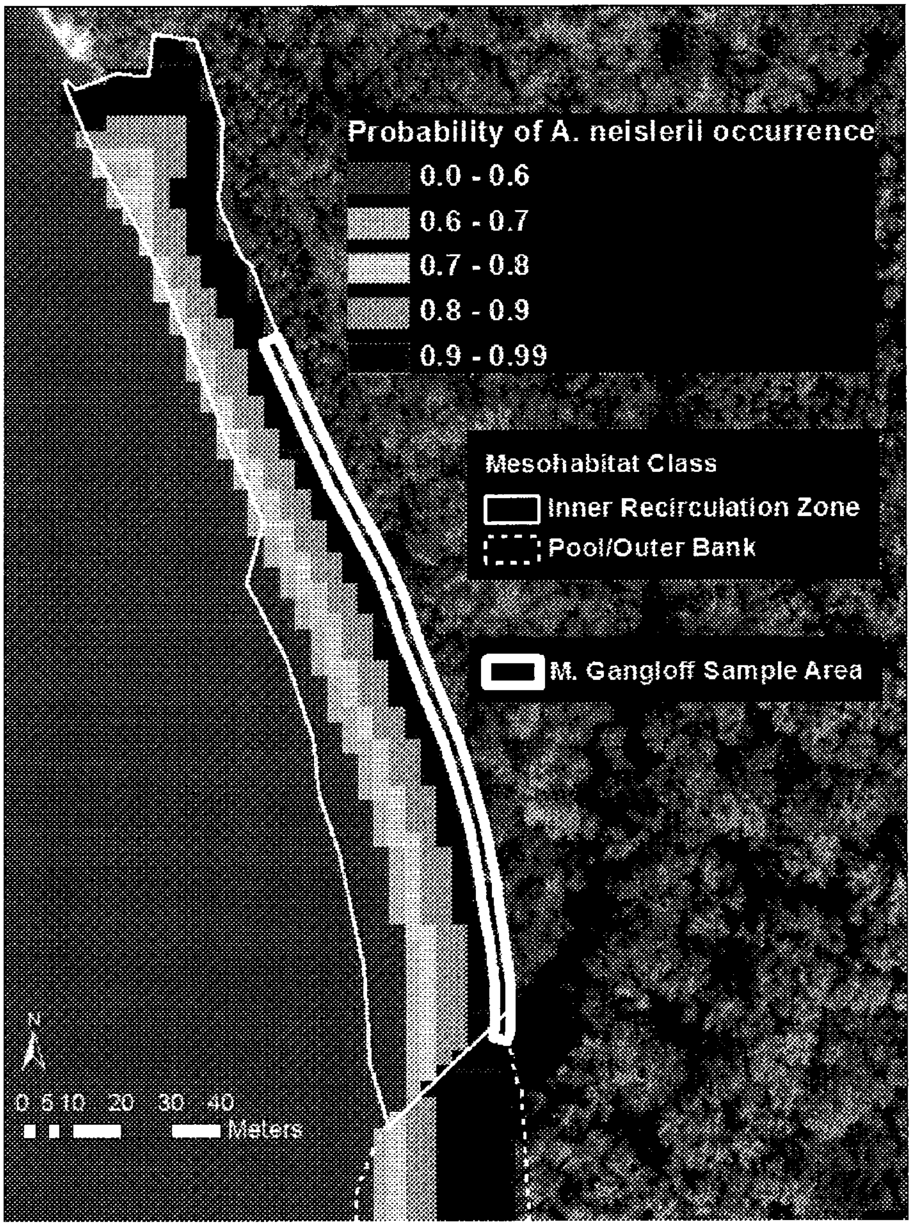

Figure 18. Geospatial species distribution model of presence/absence probabilities for *A. neislerii*. Probabilities of ≥0.7 were associated with the presence of at least 1 *A. neislerii* in a 10 m2 cell. Of note, the outer edge of the downstream portion of this Inner Recirculation Zone mesohabitat was predicted to have a low probability of *A. neislerii* occurrence. Gangloff's sampling area at this site represented a small fraction of the total mesohabitat area, but was located in an area of the highest predicted probability of *A. neislerii* occurrence.

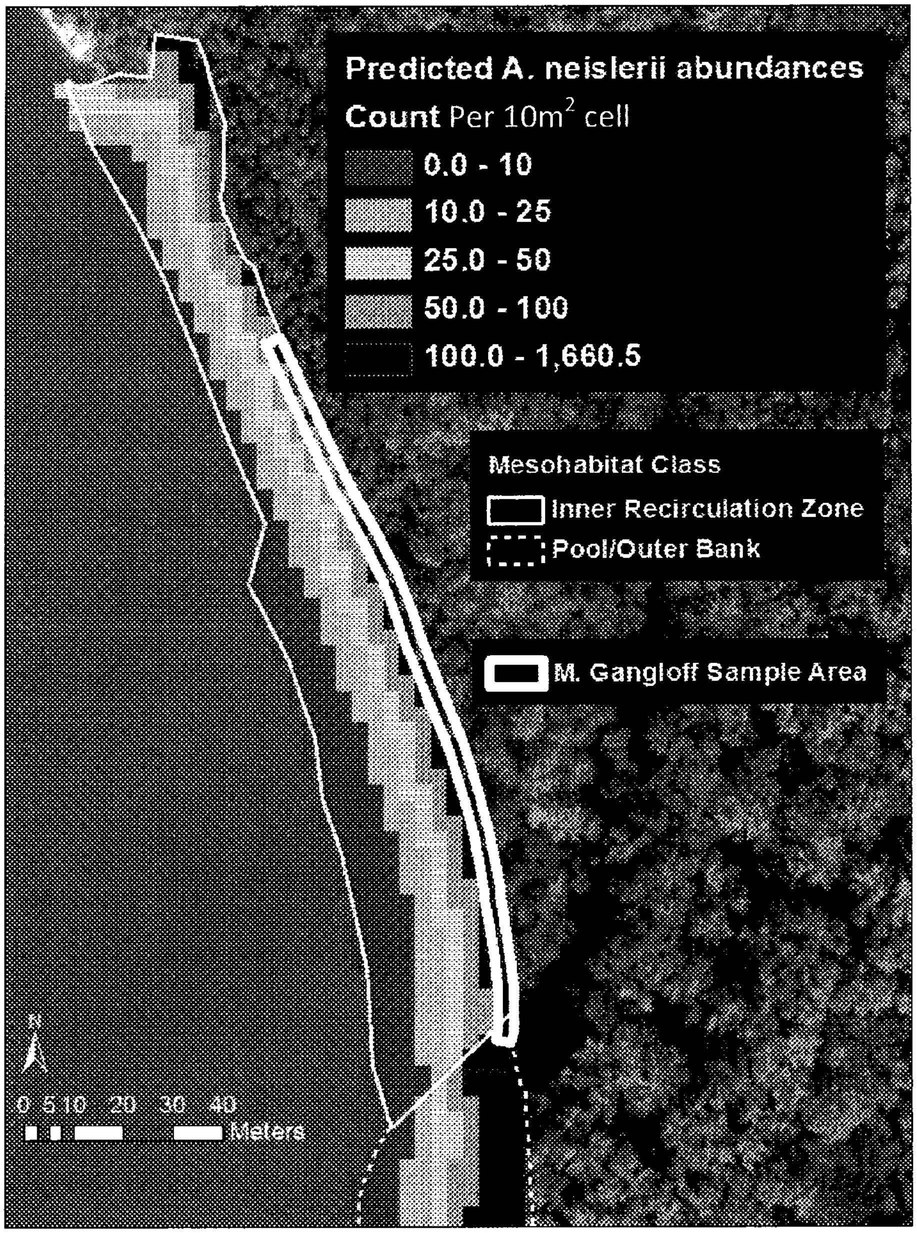

Figure 19. Geospatial species distribution model of abundance. Note area of M. Gangloff's sample site to be restricted to areas predicted to have the highest abundance. The total estimated abundance within the Inner Recirculation Zone mesohabitat shown here was 20901.3 mussels. Gangloff (2012) estimated that 5358.7 mussels inhabited the portion of this mesohabitat defined as the M. Gangloff sample area

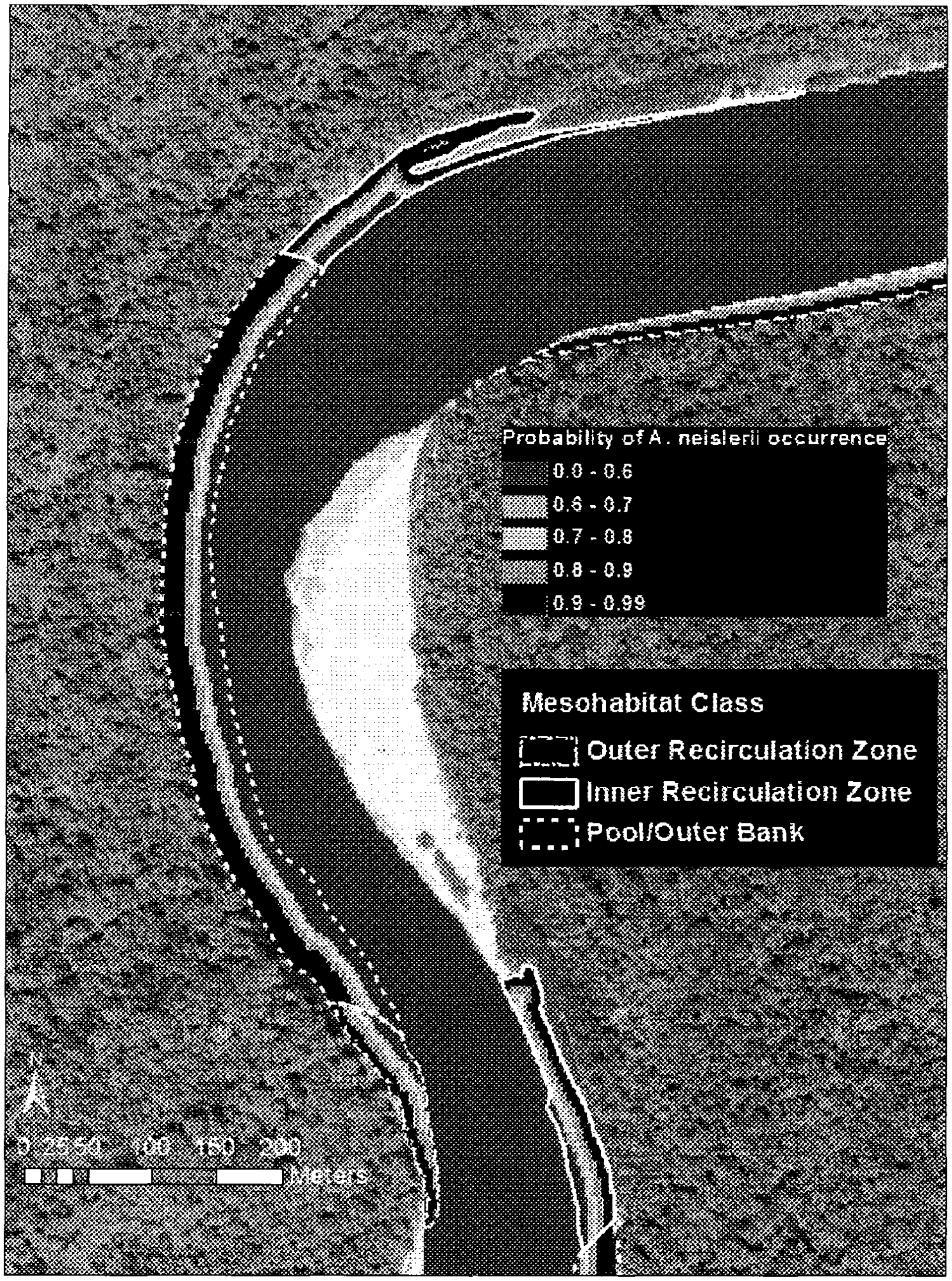

Figure 20. Site-level view of predicted probabilities of *A. neislerii* occurrence

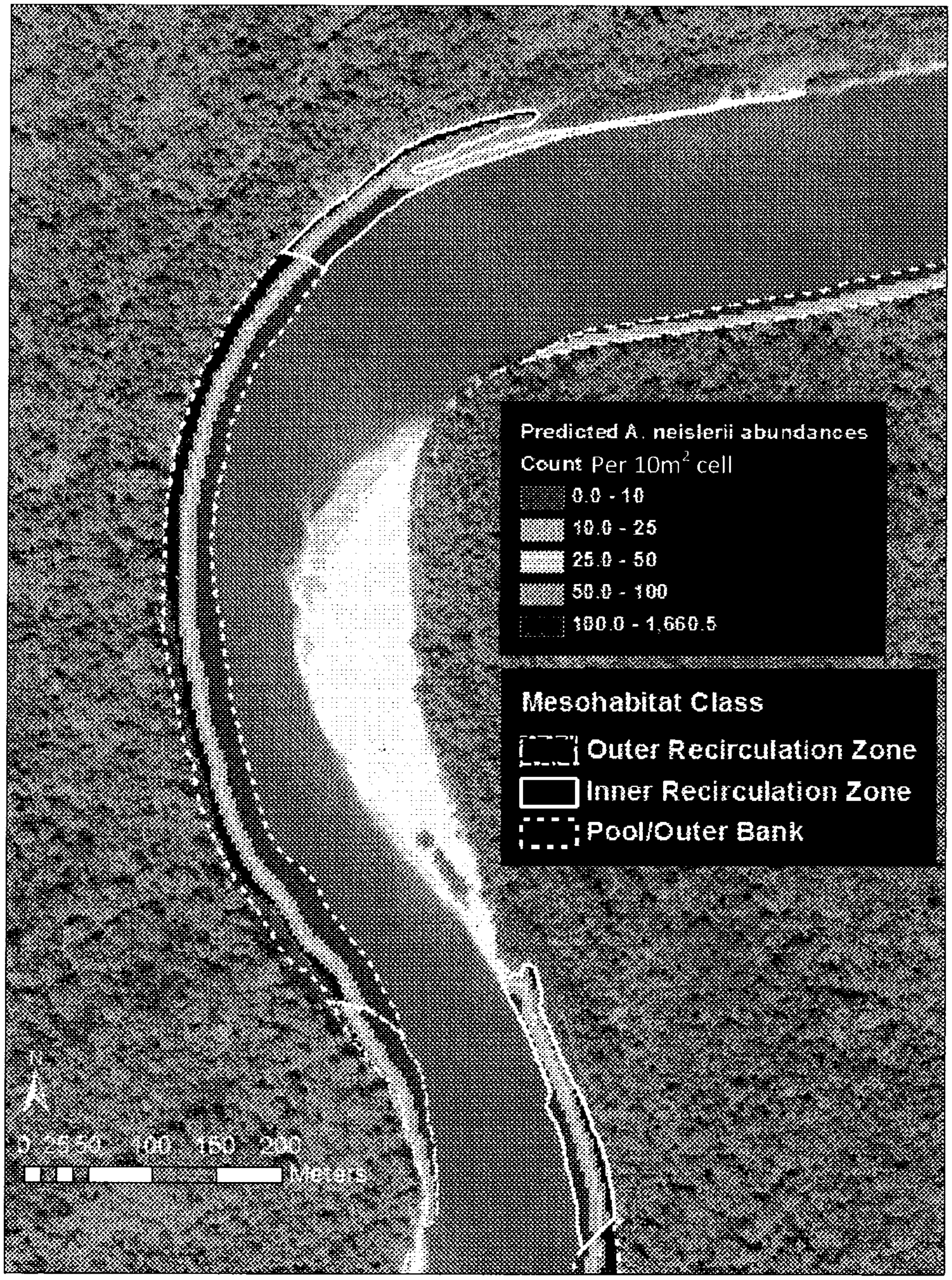

Figure 21. Site-level view of predicted *A. neislerii* abundance

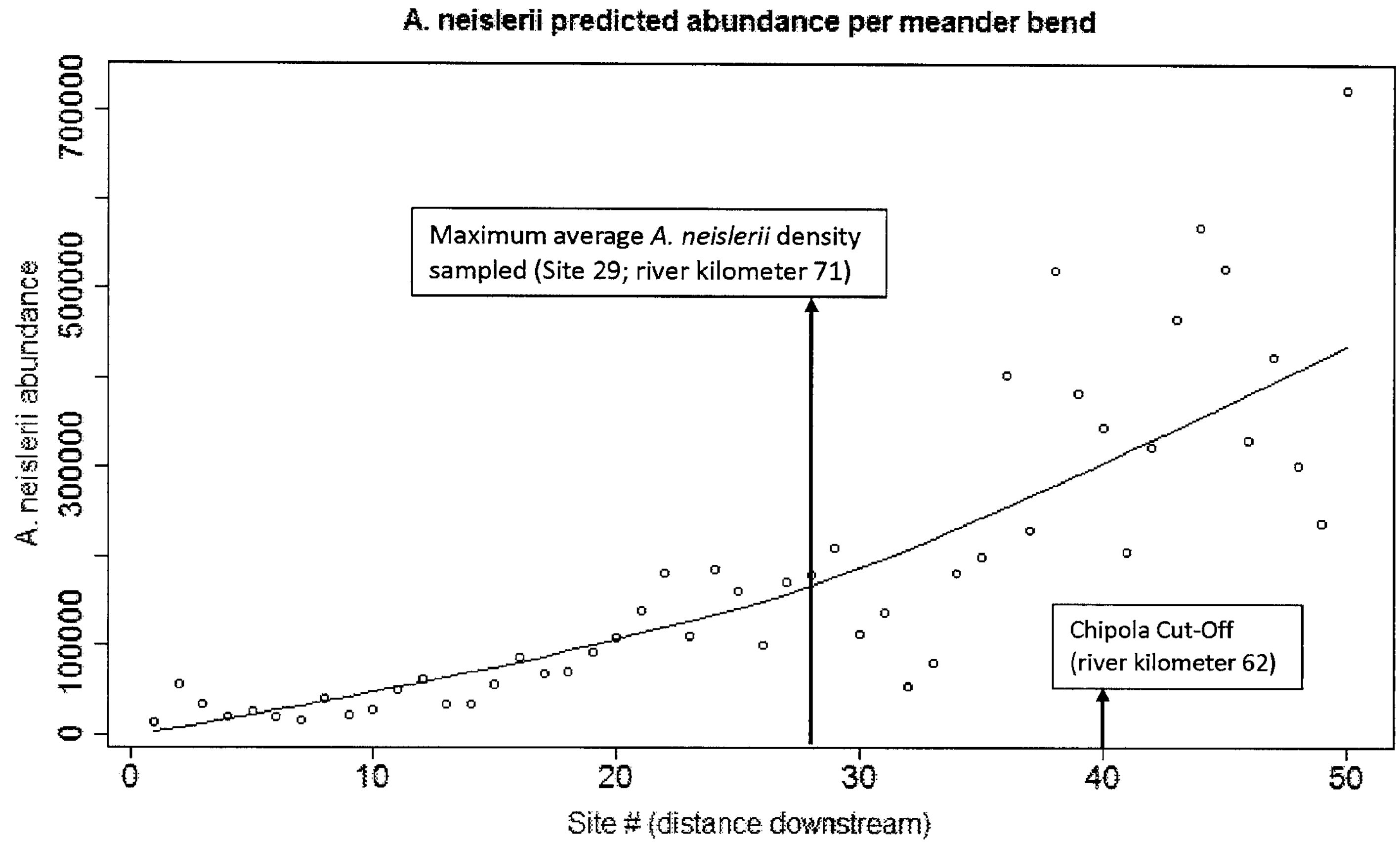

Figure 23. Trends in predicted number of *A. neislerii* per site. Sites correspond to the length of a single meander bend that contains at least one of each mesohabitat class for a total of 50 consecutive sites occurring from the upstream to downstream extent of the study area

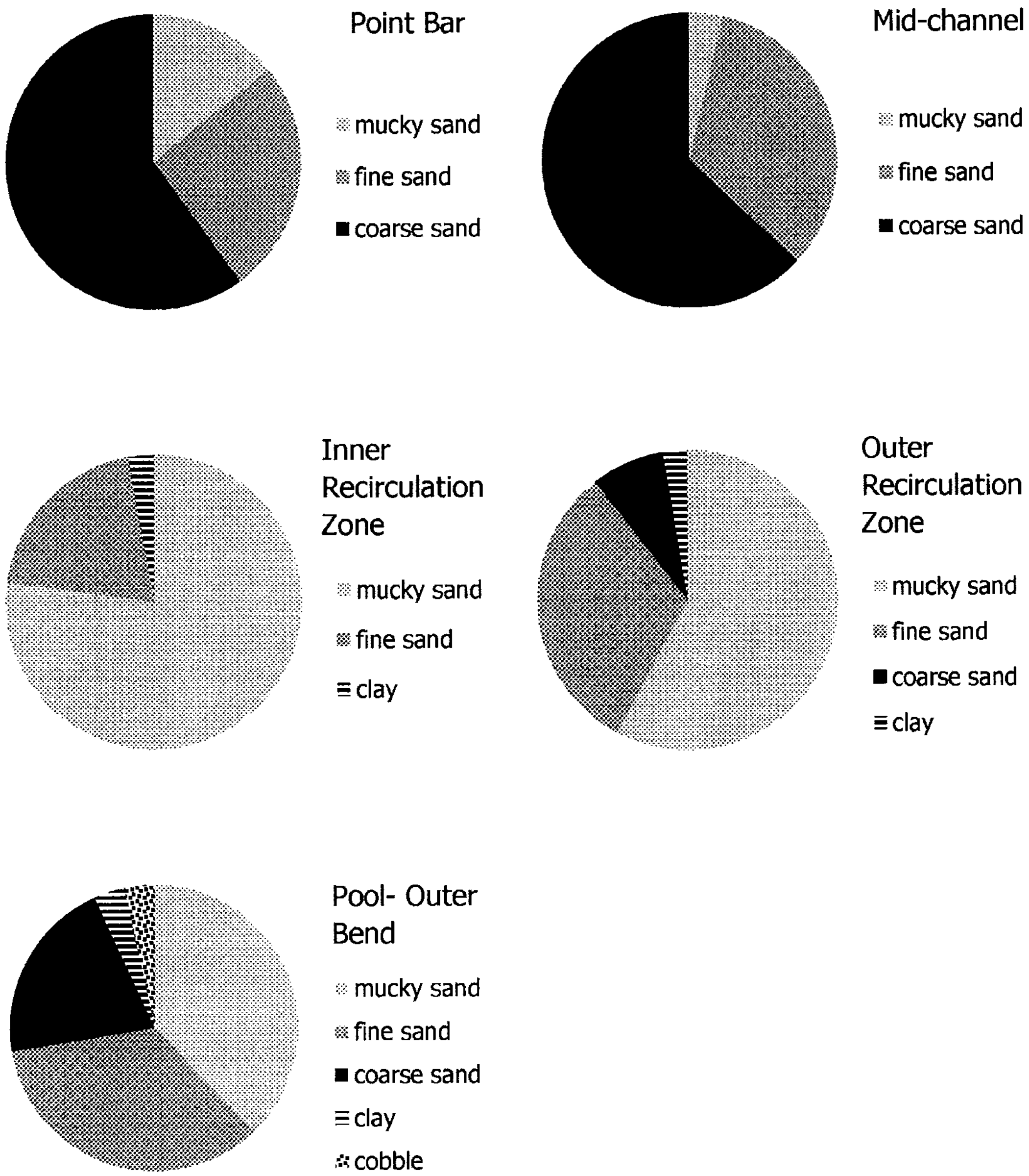

Figure 22. Composition of predominate substrate type of each sampling point per mesohabitat class. Mucky Sand = Combination of silt and finest sand particles.

Figure 24. Associations between large aggregations of woody debris and counts of *A. neislerii*. Note the adjacent samples inside the sand ripples/dunes bedforms containing 0, while the samples located next to large woody debris structures contain 10, 96, and 230 *A. neislerii*.

Exhibit 24

From: "Zettle, Brian A SAM"
To: "Kaeser, Adam" , "Bulger, Heather P SAM"
Date: Tue Feb 03 2015 04:18:29 GMT+0530 (IST)
Subject: RE: [EXTERNAL] Apalachicola - Fat threeridge data (UNCLASSIFIED)

Classification: UNCLASSIFIED
Caveats: NONE

Adam,

I'm glad to hear you guys are moving forward with the reclassification. The assessment you describe regarding dredging locations is something that our navigation folks would routinely conduct when there was funding to support the ACF navigation project. I will talk to our Operations Division guys and see if this has already been done for the most recent survey data. If it has, I think we can share that information with you. If it hasn't, they may be able to produce it quickly rather than you trying to work it out. Let me see what I can find out. I'll see what data I have on dredging and mussels. I know some studies have been done at various locations throughout the District over the years with regards to dredging (disposal) and mussels. If you want it specific to fat threeridge, then it will be limited to the old work we did on the Apalachicola River. USFWS should have access to all of those reports and many others up through 2008 in the Administrative record for the RIOP litigation. Jerry Ziewitz should be able to provide a copy if it is not available on a shared server or something. If he no longer has it, let me know. Once we know what period the USFWS administrative record covers, then I can try to help with documents after that period. I'll try to follow up later this week on the dredging locations analysis. Thanks.

Brian Zettle
Biologist
Chief, Inland Environment Team
U.S. Army Corps of Engineers, Mobile District
(251) 690-2115

-----Original Message-----
From: Kaeser, Adam [mailto:adam_kaeser@fws.gov]
Sent: Monday, February 02, 2015 8:22 AM
To: Zettle, Brian A SAM; Bulger, Heather P SAM
Cc: Grant Webber; Sandra Pursifull; Catherine Phillips
Subject: [EXTERNAL] Apalachicola - Fat threeridge data

Hi Brian,
We are moving forward with early phases of the fat threeridge reclassification process. As discussed during our last meeting, one part of the process involves an assessment of the threats identified in the recovery plan for the species.

One of the threats commonly discussed is dredging. I'm working on an assessment of this threat that will incorporate several complementary approaches. To begin, we've decided to attempt to identify all locations in the channel that might require dredging (under a scenario that dredging would be authorized and funded) using the best available data. I have what I believe is the most recent bathymetric data from the survey you (ACOE) conducted in the river. I have to look the date up on the survey but I believe it was within the last 10 years. What I'm thinking of doing is taking the criteria you use to classify areas in need of dredging, and using these criteria to identify areas of the channel that might need deepening. The criteria I think are at play are 1) minimum depth of channel at a specific flow (e.g., 8 feet deep at flows of 10,000 cfs or greater) 2) and minimum width of channel exhibiting these conditions (e.g., 200 feet wide). To conduct this assessment I'm in need of these specific criteria. Alternatively, would you (ACOE) like to conduct this assessment and provide us with a georeferenced data set indicating areas that might need dredging? If you are comfortable with USFWS conducting this part of the assessment (which of course you can review and QA/QC) then I am willing to do so.

On the topic of dredging and mussels, any information that you have and would like to contribute that might be used to conduct an assessment of the potential impact of dredging on fat threeridge habitat and/or populations I would be glad to receive at this time.

My third request has to do with compiling all of the past data/reports concerning take monitoring work. I have a few spreadsheets on my computer from recent years, but I'm hoping you have a folder with all of the past analyses/spreadsheets and reports to USFWS. I realize that Karen might have been the recipient of these reports in the past, but I would like to establish a complete archive with Grant Webber in our office at this time. We (USFWS) will need to have all of these data together to work on an assessment of the threat of low-water drawdown on stranding and mortality of fat threeridge.

Anything I can do to help clarify the needs, or if interested in discussing these assessments further please let me know.

Thanks,
Adam

--

Adam J. Kaeser, Ph.D.
Aquatic Ecologist
U.S. Fish and Wildlife Service
Panama City Fish and Wildlife Conservation Office
1601 Balboa Avenue
Panama City, Florida 32405
(850) 769-0552 ext. 244
(850) 348-6496 (cell)
adam_kaeser@fws.gov
http://www.fws.gov/panamacity/sonarhabitatmapping.html

Classification: UNCLASSIFIED

Caveats: NONE

From: "Kaeser, Adam"
To: "Zettle, Brian A SAM"
Date: Tue Feb 03 2015 19:58:44 GMT+0530 (IST)
Subject: Re: [EXTERNAL] Apalachicola - Fat threeridge data (UNCLASSIFIED)

Thanks Brian. My first choice would be for you guys to conduct the assessment of areas of the channel that could theoretically require dredging. Such work is your area of expertise. That said, with the criteria in hand I think I can also complete an assessment. Just let me know. Either way, we probably will want to have those criteria spelled out (min depth, flow, and width) to include in the assessment documentation.

Regarding literature and documented effects of dredging- some of the details that would be of high relevance include the area of impact around a dredged area of channel. For example, if an area is dredged in a river like the Apalachicola, how far would the effects of channel destabilization extend in the upstream and downstream directions? We could use this info to assess degree of impact to resident mussels. We have a lot of data on mussel distribution. What we don't have a lot of is details that would facilitate some type of defensible, scientific and quantitative assessment of potential dredging impacts (at least not yet anyway). That's what we're working towards. Any assistance is greatly appreciated.

Thanks,
Adam

On Mon, Feb 2, 2015 at 4:48 PM, Zettle, Brian A SAM <Brian.A.Zettle@usace.army.mil> wrote:

> Classification: UNCLASSIFIED
> Caveats: NONE
>
> Adam,
>
> I'm glad to hear you guys are moving forward with the reclassification. The assessment you describe regarding dredging locations is something that our navigation folks would routinely conduct when there was funding to support the ACF navigation project. I will talk to our Operations Division guys and see if this has already been done for the most recent survey data. If it has, I think we can share that information with you. If it hasn't, they may be able to produce it quickly rather than you trying to work it out. Let me see what I can find out. I'll see what data I have on dredging and mussels. I know some studies have been done at various locations throughout the District over the years with regards to dredging (disposal) and mussels. If you want it specific to fat threeridge, then it will be limited to the old work we did on the Apalachicola River. USFWS should have access to all of those reports and many others up through 2008 in the Administrative record for the RIOP litigation. Jerry Ziewitz should be able to provide a copy if it is not available on a shared server or something. If he no longer has it, let me know. Once we know what period the USFWS administrative record covers, then I can try to help with documents after that

period. I'll try to follow up later this week on the dredging locations analysis. Thanks.

Brian Zettle
Biologist
Chief, Inland Environment Team
U.S. Army Corps of Engineers, Mobile District
(251) 690-2115

-----Original Message-----
From: Kaeser, Adam [mailto:adam_kaeser@fws.gov]
Sent: Monday, February 02, 2015 8:22 AM
To: Zettle, Brian A SAM; Bulger, Heather P SAM
Cc: Grant Webber; Sandra Pursifull; Catherine Phillips
Subject: [EXTERNAL] Apalachicola - Fat threeridge data

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Classification: UNCLASSIFIED
Caveats: NONE

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From: "Pursifull, Sandra"
To: Adam Kaeser , Grant Webber
Date: Tue Feb 03 2015 20:47:09 GMT+0530 (IST)

Subject: Fwd: [EXTERNAL] Apalachicola - Fat threeridge data (UNCLASSIFIED)

Anything docs cited in the Woodruff Dam BO, we should have and I can probably find.

---------- Forwarded message ----------
From: **Zettle, Brian A SAM** <Brian.A.Zettle@usace.army.mil>
Date: Mon, Feb 2, 2015 at 4:48 PM
Subject: RE: [EXTERNAL] Apalachicola - Fat threeridge data (UNCLASSIFIED)
To: "Kaeser, Adam" <adam_kaeser@fws.gov>, "Bulger, Heather P SAM" <Heather.P.Bulger@usace.army.mil>
Cc: Grant Webber <grant_webber@fws.gov>, Sandra Pursifull <sandra_pursifull@fws.gov>, Catherine Phillips <catherine_phillips@fws.gov>

Classification: UNCLASSIFIED
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Adam,

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Sent: Monday, February 02, 2015 8:22 AM
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Cc: Grant Webber; Sandra Pursifull; Catherine Phillips
Subject: [EXTERNAL] Apalachicola - Fat threeridge data

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Classification: UNCLASSIFIED
Caveats: NONE

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Sandy Pursifull
US Fish and Wildlife Service
1601 Balboa Avenue
Panama City, FL 32405
850-769-0552 ext. 240
850-763-2177 Fax
sandra_pursifull@fws.gov
www.fws.gov/panamacity/mussels

From: "Kaeser, Adam"
To: "Zettle, Brian A SAM"
Date: Mon Feb 09 2015 22:16:22 GMT+0530 (IST)
Subject: Re: [EXTERNAL] Apalachicola - Fat threeridge data (UNCLASSIFIED)

Hi Brian,
Just following up to keep the topics and requests current. If you can try to determine whether you have the dredging channel assessment work complete, or can tackle it in house, by the end of the week that would be helpful. With the proper criteria, I can try to tackle it myself alternatively. We have set some timelines for phases of our assessment work which is motivating me to keep this ball rolling.

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Thanks!
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Sent: Monday, February 02, 2015 8:22 AM
To: Zettle, Brian A SAM; Bulger, Heather P SAM
Cc: Grant Webber; Sandra Pursifull; Catherine Phillips
Subject: [EXTERNAL] Apalachicola - Fat threeridge data

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http://www.fws.gov/panamacity/sonarhabitatmapping.html

Classification: UNCLASSIFIED
Caveats: NONE

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http://www.fws.gov/panamacity/sonarhabitatmapping.html

From: "Phillips, Catherine"
To: "Kaeser, Adam"
Date: Mon Feb 09 2015 22:43:13 GMT+0530 (IST)
Subject: Re: [EXTERNAL] Apalachicola - Fat threeridge data (UNCLASSIFIED)

Yup. It will be the 25th at the lock. You are welcome to be there.

Catherine T. Phillips, PhD
Project Leader
Panama City Field Office
1601 Balboa Avenue
Panama City, Florida 32405
850-769-0552 ext.242
850-348-6497 (cell)

On Mon, Feb 9, 2015 at 10:46 AM, Kaeser, Adam <adam_kaeser@fws.gov> wrote:

> Hi Brian,
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From: "Zettle, Brian A SAM"
To: "Kaeser, Adam"
Date: Tue Feb 10 2015 00:31:31 GMT+0530 (IST)
Subject: RE: [EXTERNAL] Apalachicola - Fat threeridge data (UNCLASSIFIED)

Classification: UNCLASSIFIED
Caveats: NONE

Adam,

I have discussed with Operations Division and we believe we can produce the information you are requesting. However, I'd like to set up a call with the relevant parties so we all understand what is needed. Are you available for a quick call later today or tomorrow?

Brian Zettle
Biologist
Chief, Inland Environment Team
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Adam J. Kaeser, Ph.D.

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Classification: UNCLASSIFIED
Caveats: NONE

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From: "Kaeser, Adam"
To: "Zettle, Brian A SAM"
Date: Tue Feb 10 2015 00:34:17 GMT+0530 (IST)
Subject: Re: [EXTERNAL] Apalachicola - Fat threeridge data (UNCLASSIFIED)

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Chief, Inland Environment Team
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(251) 690-2115

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Sent: Monday, February 09, 2015 10:46 AM
To: Zettle, Brian A SAM
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From: "Webber, Grant"
To: "Kaeser, Adam"
Date: Tue Feb 10 2015 01:29:19 GMT+0530 (IST)
Subject: Re: [EXTERNAL] Apalachicola - Fat threeridge data (UNCLASSIFIED)

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><((((o>....... ><((((o>......><((((o>.......><((((o>

Grant Webber

Fish and Wildlife Biologist
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Sent: Monday, February 09, 2015 10:46 AM
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Date: Tue Feb 10 2015 01:33:17 GMT+0530 (IST)
Subject: RE: [EXTERNAL] Apalachicola - Fat threeridge data (UNCLASSIFIED)

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Sure. Let's talk now. The operations guys are not available, but hopefully I can remember what they wanted to know. Call my office once you have all assembled. Thanks.

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Sent: Monday, February 09, 2015 1:59 PM
To: Kaeser, Adam
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Subject: Re: [EXTERNAL] Apalachicola - Fat threeridge data (UNCLASSIFIED)

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From: "Zettle, Brian A SAM"
To: "Kaeser, Adam" , "Webber, Grant"
Date: Tue Feb 10 2015 02:06:51 GMT+0530 (IST)
Subject: FW: [EXTERNAL] Apalachicola - Fat threeridge data (UNCLASSIFIED)

Classification: UNCLASSIFIED
Caveats: NONE

FYI.

Brian Zettle
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(251) 690-2115

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Caveats: NONE

Exhibit 25

June 7, 2013

INFORMATION MEMORANDUM FOR THE REGIONAL DIRECTOR

FROM:

CC:

SUBJECT: Apalachicola-Chattahoochee-Flint (ACF) Basin

TOPIC: **Downlisting the Endangered Fat Threeridge Mussel (*Amblema neislerii*)**

I. INTRODUCTION

The fat threeridge is a species endemic to the ACF that has figured prominently in the politics of ACF water management. The USFWS has both expressed concern and devoted resources to assessing the effects of Corps drought operations (i.e., water level drawdown) and stranding and mortality of fat threeridge in shallow, river margin habitats. To fully evaluate the magnitude of such risks a more thorough and comprehensive assessment of the distribution and abundance of fat threeridge mussels in the ACF is necessary.

II. BACKGROUND

A full-scale river habitat mapping and mussel sampling initiative in the Apalachicola River was launched in 2012 with the assistance of a graduate student (Reuben Smit, Auburn University) under the direction of Adam Kaeser (USFWS). Side scan sonar imagery was used to decompose and classify the wetted river channel into 5 primary mesohabitat classes, and quantitative mussel sampling was conducted in all classes including deep water habitats accessible only by diving. To date, work has been completed for the middle reach only (30 of 170 miles). Fat threeridge were commonly found in 3 of the 5 mesohabitats. Although more sophisticated approaches to modeling abundance are being evaluated, we currently estimate that <u>4.8 million fat threeridge</u> occur in the middle reach of the river alone. This estimate is 40X greater than recent estimates by Gangloff (2011) for the middle reach, a result that we attribute primarily to sampling design. Furthermore, Gangloff reported that 75% of the fat threeridge population existed in the lower Chipola River, a river we have not yet sampled with this new approach. The abundance of fat threeridge, and the occupancy of previously unsampled, deep water habitats provides a new perspective on the ecology of this species. These results, and Gangloff's prior work, provide the necessary support to pursue revising the conservation status of this species in the ACF. Options for downlisting and ultimately delisting the species are under consideration. In the upcoming months we anticipate the initiation of this process.

PENGAD 800-631-6989 EXHIBIT 14

III. POSITION of INTERESTED PARTIES

Several stakeholder groups including the Corps and the state of Florida are aware of the ongoing research, and have been informed that preliminary results are indicating much higher abundances of the species than previously described. The USFWS has not discussed changing the conservation status of the species with stakeholders, thus, it is unclear at this time how these groups will react.

IV. CURRENT STATUS

Reuben Smit will be completing analysis of results from the middle reach of the river for his MS thesis by the end of year. Two manuscripts will thereafter be submitted for peer-review publication.

TOPIC: **The Southeast Native Black Bass Initiative in the Chipola River Watershed**

I. INTRODUCTION

In an effort to focus and coordinate actions to support the long-term persistence of endemic black bass populations, the Southeast Aquatic Resources Partnership (SARP) joined with the National Fish and Wildlife Foundation to form the Southeast Native Black Bass Keystone Initiative. The Initiative provides regional conservation strategies, objectives and targets to restore and preserve functional processes in priority watersheds that support natural habitat conditions and sustainable populations of endemic black bass and native aquatic communities. The Chipola River, a tributary to the Apalachicola River, has been identified as a priority watershed in the Keystone Initiative. This river harbors a reproducing, genetically-secure population of shoal bass (*Micropterus cataractae*), an imperiled species endemic to the ACF.

The primary threat to self-sustaining populations of shoal bass in the upper Chipola River is habitat degradation. The watershed is rapidly being converted from forest to agricultural land, resulting in increased sedimentation and nutrient inputs, and altered hydrologic flow regimes.

II. BACKGROUND

Conservation planning in the Chipola watershed will follow strategies identified in the NFWF Southeast Native Black Bass Keystone Initiative Business Plan, the Southeast Aquatic Habitat Plan (i.e., SARP Strategic Plan), and the State Wildlife Action Plan of Florida. Analysis of habitat integrity, native species population integrity, non-native species distributions, and other factors relevant to the persistence of shoal bass, other native fishes and mussels, and their associated habitats will be conducted to prioritize sites for protection and restoration. Conservation delivery in the Chipola River under the Keystone Initiative will involve multiple stakeholder groups including the USFWS, Florida Fish and Wildlife Commission, NRCS, FDEP, ALDCNR, USGS, and local partners working to develop networks of willing landowners interested in implementing coordinated landscape conservation actions in the Chipola River watershed. Restoration actions implemented by these networks (e.g., brush management, grasslands restoration, spring and riparian fencing, improved road/bridge crossings) will promote the restored function of spring, riparian and stream systems, and emphasize the conservation of native fish and mussel communities and supporting habitats. Habitat protection and restoration projects will be coordinated through FWC Wildlife Legacy Initiative and USFWS Partners for Fish and Wildlife Program, all of which have successful track records in working cooperatively with landowners to implement fish and wildlife conservation projects on private lands.

Specific degradation issues that will be addressed through this Initiative include livestock access in riparian zones and unpaved roads and river crossings which have contributed to increased sedimentation in areas of critical spawning habitats for shoal bass, thermal refugia for Gulf of Mexico populations of Striped Bass (adjacent to springs), and beds of imperiled mussels. Coordinated, watershed-scale conservation actions are needed to restore and preserve habitat conditions in the Chipola River.

III. CURRENT STATUS

Several restoration projects are underway that involve USFWS staff at the Panama City field office. Additional grant funding opportunities are being pursued through partnership efforts.

June 7, 2013

INFORMATION MEMORANDUM FOR THE REGIONAL DIRECTOR

FROM: Leopoldo Miranda, ARD ES

CC: Sandy Tucker, Field Supervisor, Georgia ES
Don Imm, Field Supervisor, Panama City Field Office

SUBJECT: Gulf Sturgeon Fish Passage Research in the ACF Basin

I. INTRODUCTION

The Jim Woodruff Lock and Dam (JWLD) on the Apalachicola River currently impedes access to historic spawning habitat for anadromous fishes in the Apalachicola-Chattahoochee-Flint (ACF) Basin. Recent research indicates that spawning and/or rearing habitat in the Apalachicola River may be limiting recovery of the Alabama shad. Since fish passage was implemented in 2005, Alabama shad populations have increased over four-fold. Microchemistry analysis of adult shad collected below the dam shows 97 percent were spawned upstream of the dam. This is a clear indication that fish passage can contribute to the recovery of Alabama shad in the ACF, and potentially other anadromous species such as the threatened Gulf sturgeon.

II. BACKGROUND

The Panama City Field Office has a cooperative agreement with The Nature Conservancy (TNC) for fish passage research and coordination activities at JWLD. As a result of successful Alabama shad passage, we provided $70,000 for TNC to contract with the University of Georgia to evaluate the potential ecological benefits of passage for Gulf sturgeon. The goals of the project are to determine if: 1) Gulf sturgeon will migrate to/from suitable habitat upstream of JWLD and 2) anadromous fishes are primary hosts for rare mussels. Ten adult male Gulf sturgeon will be moved upstream of JWLD. We anticipate they will eventually pass downstream through the lock or dam gates. The researchers will attempt to net and transport any fish that do not move downstream on their own. Any fish that remain will likely perish by starvation or as a result of high summer temperatures and low oxygen levels in the reservoir.

III. POSITION of INTERESTED PARTIES

The GA-DNR, Service, NMFS, FWC, Corps, and TNC signed a MOU in 2012 that formalized the JWLD Fish Passage Partnership. The MOU facilitates collaboration and implementation of a strategy to provide migratory fish passage at JWLD, including Gulf sturgeon. The GA-DNR Wildlife Resources Division (WRD) has been supportive of this work since 2005 and had proposed completing the same project in 2007. FWC issued permits for the work, including the release of Gulf sturgeon into Florida waters of Lake Seminole above JWLD.

Despite reviewing the project in Fall 2012 without any objection, GA-EPD decided in late April that GA-DNR would not issue a permit to release Gulf sturgeon into the State of Georgia until assurances are made that no additional flow regulation would be required if Gulf sturgeon passage were to occur in the future. EPD is aware this project is the first step in determining if Gulf sturgeon passage is feasible. Many years of research and evaluation would be needed before the FWS would have data to judge the benefit of passage to sturgeon. EPD is also aware this project would not result in the establishment of a Gulf sturgeon population in the Flint River.

IV.CURRENT STATUS

The TNC agreement expires in July 2014. UGA already has a graduate student on staff for this project. In an attempt to salvage the project, we are coordinating with TNC and UGA to see if the mussel work can proceed and related tasks added. An alternative project has recently been initiated in the lower Apalachicola River that involves capture and telemetry of juvenile Gulf sturgeon to study habitat associations of this life stage (INCLUDE?). Additionally, the USFWS has completed an informal, desktop assessment of the availability of potentially suitable spawning habitat in the lower Flint River under a worst-case, extreme low flow scenario. This assessment used published, sonar-based habitat mapping data generated in 2008 by the GA-DNR. This assessment indicated that access to the lower Flint River would increase the availability of spawning habitat by a factor of 5, or greater, relative to current habitat availability in the Apalachicola River. An assessment report was provided to GA-EPD in support of the project, yet the agency has decided to initiate additional work on the Flint River to assess habitat availability using a hydrologic approach that employs river cross sections. GA-EPD will be surveying approximately 15-25 cross-sections at locations identified with the assistance of the USFWS to conduct their own in-house analyses. The hydrologic analysis may be completed sometime this fall. We expect these result will agree with the USFWS assessment. In previous discussions, GA-WRD agreed to fund this project for an additional year if EPD can be convinced that the risk of flow regulation is slight. A decision should be at hand following EPD's hydrologic analysis.

We are discussing the assurances issue with Mike Harris, Chief of the Nongame Conservation Section of GA-WRD. We are sorting through the nuances of a HCP versus an experimental population rule versus a 4(d) rule. The Gulf sturgeon already has a 4(d) rule for conservation efforts. Once we have a better understanding of the options and data regarding potential spawning habitat, we intend to approach EPD with the information in hopes of garnering their support to move the project forward next year.

Exhibit 26

June 10, 2013

INFORMATION MEMORANDUM FOR THE REGIONAL DIRECTOR

FROM: Leopoldo Miranda, ARD ES

CC: Don Imm, Field Supervisor, Panama City Field Office
Sandy Tucker, Field Supervisor, Georgia ES

SUBJECT: Potential to Downlist the Endangered Fat Threeridge Mussel

I. INTRODUCTION

The fat threeridge is a species endemic to the ACF that has figured prominently in the politics of ACF water management. The Service has both expressed concern and devoted resources to assessing the effects of Corps operations on stranding and mortality of fat threeridge in shallow, river margin habitats. To fully evaluate the magnitude of such risks a more comprehensive assessment of the distribution and abundance of fat threeridge mussels in the ACF is necessary.

II. BACKGROUND

A full-scale river habitat mapping and mussel sampling initiative in the Apalachicola River was launched in 2012 with the assistance of a graduate student from Auburn University under the direction of Adam Kaeser of the Service's Panama City FWCO. Side scan sonar imagery was used to classify the river into 5 primary mesohabitat classes, and quantitative mussel sampling was conducted in all classes including deep water habitats accessible only by diving. To date, work has been completed for the middle reach only (30 of 170 miles). Fat threeridge were commonly found in 3 of the 5 mesohabitats. We currently estimate that 4.8 million fat threeridge occur in the middle reach of the river alone, which is forty times greater than recent estimates that only included observations from shallow, near-bank habitat. Furthermore, 75% of the fat threeridge population was believed to occur in the lower Chipola River where we have not yet sampled with this new approach. The abundance of fat threeridge, and the occupancy of previously unsampled, deep water habitats provides a new perspective on the ecology of this species. These results and previous work provide the necessary support to pursue reclassifying the status of this species. Options for downlisting and ultimately delisting the species are under consideration, and we anticipate the initiation of this process in FY14.

III. POSITION of INTERESTED PARTIES

Several stakeholder groups including the Corps and the state of Florida are aware of the ongoing research, and have been informed that preliminary results are indicating much higher abundances of the species than previously described. The USFWS has not discussed changing the conservation status of the species with stakeholders, thus, it is unclear at this time how these groups will react.

Exhibit 27

From: "Kaeser, Adam"
To: Donald Imm , Catherine Phillips , Karen Herrington , "Channing St. Aubin" , Sandra Pursifull
Date: Tue Jul 30 2013 18:43:05 GMT+0530 (IST)
Subject: Fat threeridge listing meeting Friday

Attached is a draft of the fat threeridge downlisting/delisting synopsis that Don asked I prepare. Sandy and Cathy have viewed the document, and Sandy has provided some comments that I have not had the time to incorporate. My intent with the document was to summarize the content of the recovery plan with respect to the criteria necessary for downlisting and/or delisting the fat threeridge, then incorporate some of the existing information that would factor into such decisions, and also to raise relevant questions that pertaining to the subject.

I figured I might start the meeting with a few data slides from the ongoing Apalach mussel study to highlight some of the new findings that expand our knowledge base on threeridge distribution and abundance. This info is lacking in the synopsis. Also weak is the section on threats. It seems likely a lot of the discussion will focus on threats, and here we can use the meeting to flesh this section out more. I envision the meeting leading to a much enhanced version of this synopsis with input from all...and then it might serve future efforts at developing the downlisting/delisting package. At the very least, I hope this doc helps to get a productive discussion going Friday. I'm available all day Friday. Should we start at 9am CT?

Adam

--
Adam J. Kaeser, Ph.D.
Aquatic Ecologist
U.S. Fish and Wildlife Service
Panama City Fish and Wildlife Conservation Office
1601 Balboa Avenue
Panama City, Florida 32405
(850) 769-0552 ext. 244
(850) 348-6496 (cell)
adam_kaeser@fws.gov
http://www.fws.gov/panamacity/sonarhabitatmapping.html

From: "Herrington, Karen"
To: "Kaeser, Adam"
Date: Tue Jul 30 2013 21:21:41 GMT+0530 (IST)
Subject: Re: Fat threeridge listing meeting Friday

Thanks, Adam. I can do 9 AM, but we may want to start sooner if Sandy is available because I have to be at the airport at 1 on Friday.

Karen Herrington

Aquatic Species Consultation & Recovery
Panama City Field Office
U.S. Fish and Wildlife Service
(850) 348-6495
karen_herrington@fws.gov

On Tue, Jul 30, 2013 at 8:13 AM, Kaeser, Adam <adam_kaeser@fws.gov> wrote:

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(850) 348-6496 (cell)
adam_kaeser@fws.gov
http://www.fws.gov/panamacity/sonarhabitatmapping.html

From: "Pursifull, Sandra"
To: "Herrington, Karen"
Date: Tue Jul 30 2013 21:34:14 GMT+0530 (IST)
Subject: Re: Fat threeridge listing meeting Friday

How 'bout start at 8:15?

On Tue, Jul 30, 2013 at 10:51 AM, Herrington, Karen <karen_herrington@fws.gov> wrote:

Thanks, Adam. I can do 9 AM, but we may want to start sooner if Sandy is available because I have to be at the airport at 1 on Friday.

Karen Herrington
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Panama City Field Office
U.S. Fish and Wildlife Service
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Sandy Pursifull
US Fish and Wildlife Service
1601 Balboa Avenue
Panama City, FL 32405
850-769-0552 ext. 240
850-763-2177 Fax
sandra_pursifull@fws.gov
www.fws.gov/panamacity/mussels

From: "Kaeser, Adam"
To: "Herrington, Karen"
Date: Tue Jul 30 2013 21:56:19 GMT+0530 (IST)
Subject: Re: Fat threeridge listing meeting Friday

I can start at 7 am, or 730.

On Tuesday, July 30, 2013, Herrington, Karen wrote:

> Thanks, Adam. I can do 9 AM, but we may want to start sooner if Sandy is available because I have to be at the airport at 1 on Friday.
>
> Karen Herrington
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Sent from Gmail Mobile

From: "St. Aubin, Channing"
To: "Kaeser, Adam"
Date: Tue Jul 30 2013 22:35:26 GMT+0530 (IST)
Subject: Re: Fat threeridge listing meeting Friday

Let's do 8 am?

On Tue, Jul 30, 2013 at 11:26 AM, Kaeser, Adam <adam_kaeser@fws.gov> wrote:
I can start at 7 am, or 730.

On Tuesday, July 30, 2013, Herrington, Karen wrote:
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Sent from Gmail Mobile

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Channing St. Aubin

Environmental Contaminants
US Fish and Wildlife Service
Panama City, FL
(850) 769-0552 ext 248

From: "Herrington, Karen"
To: "St. Aubin, Channing"
Date: Tue Jul 30 2013 22:45:44 GMT+0530 (IST)
Subject: Re: Fat threeridge listing meeting Friday

8:15 works for me

Karen Herrington
Aquatic Species Consultation & Recovery
Panama City Field Office
U.S. Fish and Wildlife Service
(850) 348-6495
karen_herrington@fws.gov

On Tue, Jul 30, 2013 at 12:05 PM, St. Aubin, Channing <channing_staubin@fws.gov> wrote:

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(850) 769-0552 ext 248

From: "Imm, Donald"
To: "Herrington, Karen"
Date: Tue Jul 30 2013 23:29:36 GMT+0530 (IST)
Subject: Re: Fat threeridge listing meeting Friday

I'll look at my calendar and get back with you. By COB

On Tuesday, July 30, 2013, Herrington, Karen wrote:

8:15 works for me

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Sent from Gmail Mobile

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Channing St. Aubin

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US Fish and Wildlife Service
Panama City, FL
(850) 769-0552 ext 248

From: "Imm, Donald"
To: "Herrington, Karen"
Date: Wed Jul 31 2013 01:28:07 GMT+0530 (IST)
Subject: Re: Fat threeridge listing meeting Friday

8:15 works for me ..

On Tue, Jul 30, 2013 at 12:59 PM, Imm, Donald <donald_imm@fws.gov> wrote:

I'll look at my calendar and get back with you. By COB

On Tuesday, July 30, 2013, Herrington, Karen wrote:

8:15 works for me

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Channing St. Aubin

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US Fish and Wildlife Service
Panama City, FL
(850) 769-0552 ext 248

From: "Kaeser, Adam"
To: Reuben Smit
Date: Fri Aug 02 2013 02:13:40 GMT+0530 (IST)
Subject: Fwd: Fat threeridge listing meeting Friday

---------- Forwarded message ----------
From: **Kaeser, Adam**
Date: Tuesday, July 30, 2013
Subject: Fat threeridge listing meeting Friday
To: Donald Imm <donald_imm@fws.gov>, Catherine Phillips <catherine_phillips@fws.gov>, Karen Herrington <karen_herrington@fws.gov>, "Channing St. Aubin" <channing_staubin@fws.gov>, Sandra Pursifull <sandra_pursifull@fws.gov>

Attached is a draft of the fat threeridge downlisting/delisting synopsis that Don asked I prepare. Sandy and Cathy have viewed the document, and Sandy has provided some comments that I have not had the time to incorporate. My intent with the document was to summarize the content of the recovery plan with respect to the criteria necessary for downlisting and/or delisting the fat threeridge, then incorporate some of the existing information that would factor into such decisions, and also to raise relevant questions that pertaining to the subject.

I figured I might start the meeting with a few data slides from the ongoing Apalach mussel study to highlight some of the new findings that expand our knowledge base on threeridge distribution and abundance. This info is lacking in the synopsis. Also weak is the section on threats. It seems likely a lot of the discussion will focus on threats, and here we can use the meeting to flesh this section out more. I envision the meeting leading to a much enhanced version of this synopsis with input from all...and then it might serve future efforts at developing the downlisting/delisting package. At the very least, I hope this doc helps to get a productive discussion going Friday. I'm available all day Friday. Should we start at 9am CT?

Adam

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Exhibit 28

Document Produced in Native Format

Appendix III.A. Caddisfly Species Recorded from the Apalachicola River (and Chipola River below Dead Lakes) that are "flow dependent"

List compiled by A.K. Rasmussen, Ph.D, Aquatic Entomologist, Research Associate in the Center for Water and Air Quality, Florida A&M University
This is a partial list; comprehensive ecological inventories of caddisflies have not been performed.

Hydropsychidae
- Cheumatopsyche burksi
- Cheumatopsyche campyla
- Cheumatopsyche edista
- Hydropsyche incommoda
- Hydropsyche rossi
- Macrostemum carolina
- Potamyia flava

Hydroptilidae
- Hydroptila berneri
- Hydroptila waubesiana
- Neotrichia minutisimella
- Neotrichia vibrans

Leptoceridae
- Ceraclea cancellata
- Ceraclea flava
- Ceraclea maculata
- Ceraclea ophioderus
- Ceraclea protonepha
- Cereclea tarsipunctata
- Cereclea transversa
- Nectopsyche candida
- Nectopsyche pavida
- Nectopsyche spiloma
- Oecetis cinerascens
- Oecetis inconspicua
- Oecetis nocturna
- Oecetis persimilis
- Triaenodes ignitus
- Triaenodes milnei

Philopotamidae
- Chimarra moselyi
- Chimarra obscura

Polycentropodidae
- Cernotina calcea
- Cernotina spicata
- Cyrnellus fraternus
- Neureclipsis crepuscularis

Phryganeidae
- Ptilostomis postica

Psychomyiidae
- Lype diversa

Appendix III.B. Mussels in the Apalachicola River and floodplain

List compiled by James D. Williams, Gainesville, FL

Species	Apalachicola River	Lower Chipola River	Apalachicola Floodplain	Federal listing status
Alasmidonta triangulata	X	X		Candidate petitioned for Federal listing
Amblema neislerii	X	X	X	E
Anodonta heardi	X	X	X	Candidate petitioned for Federal listing
Elliptio arctata	X	X	X	Candidate petitioned for Federal listing
Elliptio chipolaensis	X	X		T
Elliptio crassidens	X	X	X	
Elliptio fraterna	X	X		
Elliptio fumata	X	X		
Elliptio pullata	X	X	X	
Elliptoideus sloatianus	X	X	X	T
Glebula rotundata	X	X	X	
Lampsilis floridensis	X	X	X	
Lampsilis straminea	X	X		
Medionidus penicillatus	X			
Megalonaias nervosa	X	X		
Pyganodon grandis	X	X	X	
Quadrula infucata	X	X	X	
Toxolasma parvum	X			
Toxolasma paulum	X	X	X	
Uniomerus columbensis	X	X	X	
Utterbackia imbecillis	X	X	X	
Utterbackia peggyae	X	X	X	
Villosa lienosa	X	X		
Villosa vibex	X	X	X	
Villosa villosa	X	X	X	
Plus one additional species reported by USFWS:				
Anodontoides radiatus	X	X		Candidate petitioned for Federal listing

Appendix III.C. Snails in the Apalachicola River

List compiled by Leigh Brooks, NWFWMD

Scientific Name	Common Name	Notes
Elimia albanyensis	Black-crested Elimia	FNAI tracking. A shoal species living in shallow water flowing over rock substrates. In Florida confined to the shoal immediately below the Jim Woodruff Dam.
Elimia doolyensis (Syn. *E. curvicostata*)	Graphite Elimia	
Ferrissia mcneilli	Hood Ancylid	Limpet. Confined to small creeks in the area around Mobile Bay east to the Apalachicola system.
Lioplax pilsbryi pilsbryi	Choctaw Lioplax	
Pomatiopsis lapidaria	Slender Walker	In Florida, it is found only in the Apalachicola River system.
Somatogyrus sp.	Apalachi Pebblesnail	Known only from the shoals below Jim Woodruff Dam on the Apalachicola River, where it occurs on the limestone substrata.
Tarebia granifera	Quilted Melania	Abundant in some springs and small streams in Florida. May colonize many types of habitats and may reach very high densities especially in rocky streams and artificial ponds and lakes. Observed by Leigh Brooks in the upper Apalachicola River at shoals, 9/15/2012
Viviparus georgianus	Banded Mysterysnail	

Information from NatureServe and Thompson, Fred G.2004. An Identification Manual for the Freshwater Snails of Florida. Florida Museum of Natural History, Gainesville.

Appendix III. D. Entire list of benthic macroinvertebrate species from FDEP SBIO database – Apalachicola River and floodplain sites only

This list includes all the flow-dependent species listed in Worksheet E, plus several hundred additional species that are primarily lentic species.
This is a partial list based on limited monitoring. Comprehensive ecological inventories of benthc macroinvertebrates in the Apalachicola River have not been conducted.
Caution: This list has not been edited for taxonomic consistency.

Ablabesmyia
Ablabesmyia americana
Ablabesmyia aspera
Ablabesmyia janta
Ablabesmyia mallochi
Ablabesmyia parajanta
Ablabesmyia peleensis
Ablabesmyia rhamphe grp.
Ablabesmyia tarella
Acariformes
Acerpenna pygmaea
Acroneuria
Acroneuria arenosa
Acroneuria arenosa/evoluta
Aedes
Aeshnidae
Agarodes
Agnetina
Amnicola
Amphipoda
Ancylidae
Ancyronyx
Ancyronyx variegatus
Anomalagrion hastatum
Apedilum elachista
Apocorophium
Apocorophium lacustre
Argia
Argia apicalis
Argia fumipennis
Argia moesta
Argia sedula
Argia tibialis
Argia translata
Arrenurus
Asellus
Asheum beckae
Astacidae
Atherix variegata
Athripsodes
Atractides
Atrichopogon
Attenella attenuata
Aulodrilus
Aulodrilus pigueti
Aulodrilus pluriseta
Axarus
Baetidae
Baetis
Baetis australis
Baetis ephippiatus
Baetis frondalis
Baetis intercalaris
Baetis propinquus
Baetis spinosus
Balanus
Belostoma
Belostoma lutarium
Belostomatidae
Berosus
Berosus striatus
Bezzia
Bidessonotus
Bivalvia
Boyeria
Boyeria vinosa
Brachycercus
Branchiura sowerbyi
Bratislavia unidentata
Bryozoa
Caecidotea
Caenis
Caenis amica
Caenis diminuta
Caenis hilaris
Caenis punctata
Callibaetis
Callibaetis floridanus
Callibaetis pretiosus
Callinectes sapidus
Calopterygidae
Calopteryx
Cambaridae
Campeloma
Campeloma geniculum

Cardiocladius
Cardiocladius obscurus
Cassidinidea lunifrons
Cecidomyia
Centroptilum
Centroptilum hobbsi
Centroptilum triangulifer
Centroptilum viridocularis
Ceraclea
Ceraclea diluta
Ceraclea maculata
Ceratopogonidae
Cernotina
Chaoborus
Chaoborus punctipennis
Chauliodes
Cheumatopsyche
Chimarra
Chironomidae
Chironomini gen. a roback
Chironomus
Chironomus attenuatus
Chironomus decorus
Choroterpes
Chrysomelidae
Cladopelma
Cladotanytarsus
Cladotanytarsus sp. f epler
Climacia areolaris
Clinotanypus
Clinotanypus pinguis
Coelotanypus
Coelotanypus concinnus
Coelotanypus scapularis
Coenagrionidae
Coleoptera
Collembola
Conchapelopia
Conchapelopia fasciata
Coptotomus
Corbicula
Corbicula fluminea
Corbicula manilensis
Corixidae
Corophiidae
Corophium
Corophium lacustre
Corophium louisianum
Corydalidae
Corydalus
Corydalus cornutus
Corynoneura
Corynoneura celeripes
Corynoneura lobata
Coryphaeschna
Coryphaeschna ingens
Crangonyx
Cricotopus
Cricotopus bicinctus
Cricotopus bicinctus grp.
Cricotopus or orthocladius
Cricotopus politus
Cricotopus remus
Cricotopus reversus grp. epler
Cricotopus sylvestris grp.
Cricotopus trifasciatus
Cryptochironomus
Cryptochironomus blarina
Cryptochironomus fulvus
Cryptochironomus parafulvus
Cryptotendipes
Culicidae
Culicoides
Curculionidae
Cybister fimbriolatus
Cymellus
Cymellus fraternus
Cymellus marginalis
Dannella simplex
Dasyhelea
Decapoda
Demicryptochironomus
Dero
Dero botrytis
Dero digitata complex
Dero flabelliger
Dero furcata
Dero lodeni
Dero pectinata
Dero vaga
Desserobdella phalera

Dicrotendipes
Dicrotendipes incurvus
Dicrotendipes leucoscelis
Dicrotendipes lobus
Dicrotendipes lucifer
Dicrotendipes modestus
Dicrotendipes neomodestus
Dicrotendipes nervosus
Dicrotendipes simpsoni
Dicrotendipes thanatogratus
Dineutus
Dineutus discolor
Diplectrona
Diplocladius
Diptera
Dixidae
Dromogomphus
Dromogomphus spinosus
Dubiraphia
Dubiraphia vittata
Dugesia tigrina
Dytiscidae
Eclipidrilus
Ectoprocta
Einfeldia
Einfeldia natchitocheae
Elimia
Elimia albanyensis
Elimia floridensis
Elliptio
Elliptio lanceolata
Elmidae
Empididae
Enallagma
Enallagma signatum
Enchytraeidae
Endochironomus
Endochironomus nigricans
Endochironomus subtendens
Endotribelos hesperium
Ephemerella
Ephemerella trilineata
Ephemerellidae
Ephemeroptera
Ephydridae
Epiaeschna heros
Epicordulia princeps
Epicordulia princeps regina
Epoicocladius
Erythemis
Erythemis simplicicollis
Eukiefferiella
Eupera cubensis
Eurylophella
Eurylophella doris
Eurylophella temporalis
Ferrissia
Ferrissia rivularis
Forcipomyia
Gammarus
Gammarus fasciatus
Gammarus mucronatus
Gastropoda
Gerridae
Gerris
Gloiobdella elongata
Glossiphoniidae
Glyptotendipes
Glyptotendipes amplus
Glyptotendipes lobiferus
Glyptotendipes meridionalis
Glyptotendipes seminole
Glyptotendipes sp. b epler
Glyptotendipes testaceus
Goeldichironomus
Goeldichironomus amazonicus
Goeldichironomus fluctuans
Goeldichironomus holoprasinus
Gomphidae
Gomphus
Gomphus pallidus
Gomphus plagiatus
Goniobasis
Gyraulus
Gyraulus parvus
Gyretes
Gyretes iricolor
Gyrinidae
Gyrinus
Haber speciosus
Habrophlebia vibrans

Haemonais waldvogeli
Haitia
Haliplidae
Harnischia
Helichus
Helisoma
Helobdella elongata
Helobdella fusca
Helobdella stagnalis
Helobdella triserialis
Helodidae
Hemerodromia
Heptagenia
Heptagenia flavescens
Heptageniidae
Hetaerina
Hetaerina titia
Heteroptera
Heterotrissocladius
Hexagenia
Hexagenia munda marilandica
Hippolyte pleuracantha
Hirudinea
Hyalella azteca
Hydra
Hydrobaenus
Hydrobiidae
Hydrocanthus
Hydrocanthus oblongus
Hydrochus
Hydrodroma
Hydroporus
Hydropsyche
Hydropsyche incommoda
Hydropsychidae
Hydroptila
Hydroptilidae
Hygrobates
Ischnura
Ischnura credula
Isonychia
Isonychia pictipes
Isonychia sicca
Isopoda
Kiefferulus
Koenikea
Labiobaetis
Labrundinia
Labrundinia johannseni
Labrundinia pilosella
Labrundinia sp. a epler
Laevapex
Lampsilis
Larsia
Larsia lurida
Lebertia
Lepidoptera
Leptocella
Leptoceridae
Leptohyphidae
Leptophlebia bradleyi
Leptophlebia intermedia
Leptophlebiidae
Lethocerus
Libellula
Libellulidae
Limnephilidae
Limnochironomus
Limnodrilus
Limnodrilus hoffmeisteri
Limnodrilus profundicola
Limnophila
Limonia
Liodessus flavicollis
Lioporeus
Lioporeus pilatei
Lirceus
Lopescladius
Lumbriculidae
Lumbriculus
Lumbriculus variegatus
Lymnaeidae
Maccaffertium
Maccaffertium exiguum
Maccaffertium mexicanum integrum
Maccaffertium smithae
Macromia
Macromia illinoiensis
Macromia taeniolata
Macronema
Macronema carolina

Macronemum carolina
Macronychus
Macronychus glabratus
Macropelopia
Macrostemum
Macrostemum carolina
Megalonaias
Megaloptera
Merragata
Mesovelia
Mesovelia mulsanti
Metriocnemus lundbecki
Microcylloepus pusillus
Micromenetus
Micromenetus dilatatus
Microsporidae
Microtendipes pedellus grp.
Mideopsis
Molanna tryphena
Monocorophium
Mooreobdella
Muscidae
Mysidacea
Mysidae
Mysidopsis bigelowi
Mytilopsis leucophaeata
Naididae
Nais communis
Nais communis complex
Nais simplex
Nais(animal)
Nanocladius
Nanocladius alternantherae
Nanocladius alternatherae
Nanocladius distinctus
Nasiaeschna pentacantha
Nectopsyche
Nectopsyche candida
Nectopsyche exquisita
Nectopsyche pavida
Nematoda
Nematomorpha
Nemertea
Neoperla
Neoperla clymene
Neoporus
Neoporus mellitus
Neotrichia
Nerltina reclivata
Neumania
Neureclipsis
Neureclipsis crepuscularis
Neureclipsis melco
Neurocordulia
Neurocordulia alabamensis
Neurocordulia molesta
Nigronia
Nilotanypus
Nilotanypus fimbriatus
Nilothauma
Notonecta
Notonectidae
Nyctiophylax
Nymphula
Odonata
Odontomyia
Oecetis
Oecetis cinerascens
Oecetis georgia
Oecetis nocturna
Oecetis parva
Oecetis persimilis
Oecetis sp. a floyd
Oecetis sp. e floyd
Oligochaeta
Omisus sp. a epler
Ora/scirtes
Orconectes
Oribatei
Orimarga mirabilis
Orthocladiinae
Orthocladius
Orthocladius annectens
Orthotrichia
Oxyethira
Pachydiplax
Pachydiplax longipennis
Palaemonetes
Palaemonetes kadiakensis
Palaemonetes paludosus
Palpomyia

Palpomyia tibialis
Palpomyia/bezzia grp.
Panopeus
Parachironomus
Parachironomus carinatus
Parachironomus directus
Parachironomus frequens
Parachironomus pectinatellae
Paracladopelma
Paragnetina
Paragnetina kansensis
Parakiefferiella
Parakiefferiella sp. a epler
Parakiefferiella sp. c epler
Paralauterbomiella nigrohalterale
Paralimnophyes
Parametriocnemus
Paranyctiophylax
Parapoynx
Parapsyche
Paratanytarsus
Paratanytarsus sp. c epler
Paratendipes
Paratendipes connectens
Pectinatella
Pectinatella magnifica
Pelecypoda
Pelocoris
Pelocoris femoratus
Peltodytes
Peltodytes sexmaculatus
Pentagenia
Pentaneura
Pentaneura carnea
Pentaneura inconspicua
Pentaneura inculta
Pentaneura monilis
Pericoma
Perithemis tenera
Perlesta placida
Perlesta placida complex
Perlidae
Phaenopsectra punctipes grp.
Phoridae
Phylocentropus
Physa
Physa pumilia
Physella
Physella heterostropha
Physidae
Piona
Pisidiidae
Placobdella
Placobdella parasitica
Placobdella translucens
Planaria
Planariidae
Planorbella
Planorbidae
Platyhelminthes
Polycentropodidae
Polycentropus
Polycentropus interruptus
Polychaeta
Polypedilum
Polypedilum aviceps
Polypedilum beckae
Polypedilum convictum
Polypedilum convictum grp.
Polypedilum fallax
Polypedilum flavum
Polypedilum halterale
Polypedilum halterale grp.
Polypedilum illinoense
Polypedilum illinoense grp.
Polypedilum ontario
Polypedilum scalaenum
Polypedilum scalaenum grp.
Polypedilum trigonus
Polypedilum tritum
Pomacea
Porifera
Potamyia flava
Pristina
Pristina aequiseta
Pristina leidyi
Pristina synclites
Pristinella jenkinae
Pristinella sima
Probezzia
Procambarus

Procladius
Procladius (holotanypus)
Procladius bellus
Procloeon
Prostoma
Prostoma rubrum
Psammoryctides convolutus
Psectrocladius
Psectrocladius vernalis
Pseudochironomus
Pseudochironomus fulviventris
Pseudocloeon
Pseudocloeon alachua
Pseudocloeon ephippiatum
Pseudocloeon frondale
Pseudocloeon parvulum
Pseudocloeon propinquum
Pseudocloeon punctiventris
Pseudosuccinea
Pseudosuccinea columella
Psychodidae
Psychomyiidae
Pycnopsyche
Pyralidae
Ranatra
Rhagovelia
Rhagovelia choreutes
Rhantus calidus
Rheocricotopus
Rheocricotopus robacki
Rheosmittia arcuata
Rheotanytarsus
Rheotanytarsus distinctissimus grp.
Rheotanytarsus exiguus
Rheotanytarsus exiguus grp.
Rheotanytarsus pellucidus
Rheumatobates
Rhynchocoela
Robackia
Robackia claviger
Saetheria
Scirtes
Scirtidae
Sialis
Simuliidae
Simulium
Siphloplecton
Sisyra
Slavina appendiculata
Smittia
Sperchon
Sphaeriidae
Sphaeriidae(mollusca)
Sphaerium
Sphaeroma destructor
Spirosperma
Stelechomyia perpulchra
Stempellina
Stempellina sp. a epler
Stempellinella
Stempellinella fimbriata
Stenacron
Stenacron floridense
Stenacron interpunctatum
Stenelmis
Stenelmis antennalis
Stenochironomus
Stenochironomus hilaris
Stenonema
Stenonema exiguum
Stenonema integrum
Stenonema interpunctatum
Stenonema proximum
Stenonema smithae
Stephensoniana trivandrana
Stictochironomus
Stictochironomus caffrarius grp.
Stictochironomus devinctus
Stylaria lacustris
Symbiocladius
Sympotthastia
Synclita
Synurella
Tabanidae
Taeniopteryx
Taeniopteryx nivalis
Tanaidae
Tanypus
Tanypus punctipennis
Tanytarsus
Tanytarsus sp. a epler

Tanytarsus sp. c epler
Tanytarsus sp. e epler
Tanytarsus sp. f epler
Tanytarsus sp. g epler
Tanytarsus sp. j epler
Tanytarsus sp. l epler
Tanytarsus sp. m epler
Tanytarsus sp. o epler
Tanytarsus sp. p epler
Tanytarsus sp. s epler
Tanytarsus sp. t epler
Tanytarsus sp. v epler
Tendipes decorus
Tetragoneuria
Thermonectus
Thienemanniella
Thienemanniella lobapodema
Thienemanniella similis
Thienemanniella sp. a epler
Thienemanniella sp. b epler
Thienemanniella xena
Thienemannimyia grp.
Tipula
Tipulidae
Tortopus
Triaenodes
Triaenodes perna
Triaenodes perna/helo
Tribelos
Tribelos fuscicornis
Tribelos jucundum
Trichocladius
Trichocladius extatus
Trichocladius robacki
Trichocorixa
Trichoptera
Tricorythodes
Tricorythodes albilineatus
Trombidiformes
Tropisternus
Tubificidae
Turbellaria
Tvetenia discoloripes grp.
Tvetenia vitracies
Uniomerus caroliniana
Unionicola
Unionidae
Uranotaenia
Veliidae
Viviparidae
Viviparus
Wormaldia
Xenochironomus
Xenochironomus taenionotus
Xenochironomus xenolabis
Xestochironomus
Zavreliella marmorata
Zygoptera

Appendix III.E. Flow dependent benthic macroinvertebrate species from FDEP SBIO database – Apalachicola River and floodplain sites only

List compiled by Donald H. Ray, Stream Ecologist, Florida DEP, Northwest District, Pensacola, FL
This list is restricted to flow-dependent (lotic) species.
This is a partial list based on limited monitoring. Comprehensive ecological inventories of benthic macroinvertebrates in the Apalachicola River have not been conducted.
Total of 127 species, 15 of which are duplicated in the caddisfly list in another worksheet. Excluding duplications, total is 112 species.

Species	Notes regarding duplication
Acerpenna pygmaea	
Acroneuria arenosa/evoluta	
Agarodes	
Agnetina (annulipes from Berner 1949)	
Ancyronyx variegatus	
Argia apicalis	
Argia moesta	
Argia sedula	
Argia tibialis	
Atherix variegata	
Attenella attenuata	
Baetis ephippiatus	
Baetis frondalis	
Baetis intercalaris	
Baetis propinquus	
Baetis spinosus	
Boyeria vinosa	
Brachycercus	
Calopteryx	
Campeloma geniculum	
Centroptilum hobbsi	
Centroptilum triangulifer	
Centroptilum viridocularis	
Ceraclea diluta	
Ceraclea maculata	Duplication – See caddisfly list from A. Rasmussen
Cernotina	Duplication – See caddisfly list from A. Rasmussen
Cheumatopsyche	Duplication – See caddisfly list from A. Rasmussen
Chimarra	Duplication – See caddisfly list from A. Rasmussen
Choroterpes	
Corydalus cornutus	
Cyrnellus fraternus	Duplication – See caddisfly list from A. Rasmussen
Dannella simplex	
Diplectrona	
Dromogomphus spinosus	
Dubiraphia vittata	
Elimia albanyensis	
Elimia floridensis	
Elliptio	
Elliptio lanceolata	
Ephemerella	
Eukiefferiella	
Eurylophella doris	
Gomphus vatus	
Arigomphus pallidus	
Stylurus plagiatus	
Helichus	
Heptagenia flavescens	
Hetaerina titia	
Hydropsyche	Duplication – See caddisfly list from A. Rasmussen
Hydropsyche incommoda	Duplication – See caddisfly list from A. Rasmussen
Hydroptila	Duplication – See caddisfly list from A. Rasmussen
Isoperla	FSBH 1961
Isonychia pictipes	
Isonychia sicca	
Lampsilis	
Leptoceridae	Duplication – See caddisfly list from A. Rasmussen
Leptophlebia bradleyi	
Leptophlebia intermedia	
Maccaffertium exiguum	
Maccaffertium mexicanum integrum	
Maccaffertium smithae	
Macromia illinoiensis	
Macromia taeniolata	
Macronychus glabratus	
Macrostemum carolina	Duplication – See caddisfly list from A. Rasmussen
Microcylloepus pusillus	
Molanna tryphena	
Nectopsyche candida	Duplication – See caddisfly list from A. Rasmussen
Nectopsyche exquisita	
Neoperla carlsoni (FAMU Ravine Study)	
Neoperla clymene	
Neotrichia	Duplication – See caddisfly list from A. Rasmussen
Neureclipsis crepuscularis	Duplication – See caddisfly list from A. Rasmussen
Neureclipsis melco	
Neurocordulia alabamensis	
Neurocordulia molesta	
Nigronia	
Nyctiophylax	
Oecetis georgia	
Oecetis persimilis	Duplication – See caddisfly list from A. Rasmussen
Oecetis sp. a floyd	
Orthotrichia	
Paragnetina (fumosa FAMU Ravine Study)	

Paragnetina kansensis
Pentagenia
Perlesta placida complex
Phylocentropus
Polycentropus interruptus
Potamyia flava — Duplication – See caddisfly list from A. Rasmussen
Procloeon
Pseudocloeon alachua
Pseudocloeon ephippiatum
Pseudocloeon frondale
Pseudocloeon parvulum
Pseudocloeon propinquum
Pseudocloeon punctiventris
.Psychomyiidae
Pycnopsyche
Rheocricotopus robacki
Rheosmittia arcuata
Rheotanytarsus
Rheotanytarsus distinctissimus grp.
Rheotanytarsus exiguus
Rheotanytarsus exiguus grp.
Rheotanytarsus pellucidus
Robackia claviger
Saetheria
Simulium
Siphloplecton
Stelechomyia perpulchra
Stenacron floridense
Stenacron interpunctatum
Stenelmis
Stenelmis antennalis
Symbiocladius
Sympotthastia
Taeniopteryx
Tortopus
Triaenodes (helo FAMU Ravine Study)
Triaenodes perna
Trichocladius
Tricorythodes albilineatus
Tvetenia vitracies
Viviparus
Wormaldia
Xenochironomus xenolabis
Xestochironomus

Total number of species	127
Number of duplicated caddisfly species	15
Total number, less duplications	112

Appendix III.F. Plant Species of the Apalachicola River and Floodplain

Total of 342 species, 165 of which occur at relatively low elevations affected by flows in the 5,000-20,000 cfs range.

Compiled by Helen Light based on species list in Gholson (1985), unless otherwise indicated. This is a partial list because no comprehensive survey of floodplain plants has been conducted to date.
Synonomy from USDA (2013); National Wetland Inventory (NWI) categories from Lichvar (2012) and USDA (2013) for Atlantic Gulf Coastal Plain (AGCP)

Species	Authorship	Synonym	Common Name	NWI category (AGCP)	Source: Gholson (1985) except as indicated below	Evidence of occurrence at low elevations of floodplain from NWI unless otherwise indicated
Acalypha rhomboidea	Raf.		Common Three-Seed-Mercury	FAC		
Acer negundo	L.		Ash-Leaf Maple	FAC		Found in swamps (Darst & Light, 2008)
Acer rubrum	L.		Red Maple	FAC		Found in swamps (Darst & Light, 2008)
Acer saccharinum	L.		Silver Maple	FAC		
Acmella repens	(Walt.) L.C. Rich.	Spilanthes americana; Acm	Opposite-Leaf Spotflower	FACW		FACW
Ageratina altissima	(L.) King & H.E. Robir	Eupatorium rugosum	White Snakeroot	FACU		
Alnus serrulata	(Ait.) Willd.		Brookside Alder	FACW		FACW
Alternanthera philoxeroides	(Mart.) Griseb.		Alligator-Weed	OBL		OBL
Ambrosia artemisiifolia	L.		Annual Ragweed	FACU		
Ammannia coccinea	Rottb.		Valley Redstem	OBL		OBL
Amorpha fruticosa	L.		False Indigo-Bush	FACW		FACW
Ampelaster carolinianus	(Walt.) Nesom	Aster carolinianus	Climbing-Aster	OBL		OBL
Ampelopsis arborea	(L.) Koehne		Peppervine	FAC		
Ampelopsis cordata	Michx.		Heart-Leaf Peppervine	FAC		
Amsonia tabernaemontana	Walt.		Eastern Bluestar	FACW		FACW
Andropogon glomeratus	(Walt.) B.S.P.		Bushy Bluestem	FACW		FACW
Andropogon gyrans	Ashe		Elliott's Bluestem	FAC		
Apios americana	Medik.		Groundnut	FACW		FACW
Arisaema dracontium	(L.) Schott		Greendragon	FACW		FACW
Aristolochia tomentosa	Sims	Isotrema tomentosum	Wooly Dutchman's pipe	FAC		
Arundinaria gigantea	(Walt.) Muhl.		Giant Cane	FACW		FACW
Asclepias perennis	Walt.		Aquatic Milkweed	OBL		OBL
Asplenium platyneuron	(L.) B.S.P.		Ebony Spleenwort	FACU		
Axonopus furcatus	(Flueggé) A.S. Hitchc.		Big Carpet Grass	OBL		OBL
Baccharis glomeruliflora	Pers.		Silverling	FACW		FACW
Baccharis halimifolia	L.		Groundseltree	FAC		
Berchemia scandens	(Hill) K. Koch		Alabama Supplejack	FAC		
Betula nigra	L.		River Birch	FACW		FACW
Bidens discoidea	(Torr. & Gray) Britt.		Small Beggarticks	FACW		FACW
Bignonia capreolata	L.		Crossvine	FAC		
Boehmeria cylindrica	(L.) Sw.		Small-Spike False Nettle	FACW		FACW
Boltonia diffusa	Ell.		Small-Head Doll's Daisy	FAC		
Botrychium biternatum	(Sav.) Underw.		Sparselobe grapefern	FAC		
Brunnichia ovata	(Walt.) Shinners	Brunnichia cirrhosa	American Buckwheatvine	FACW		FACW
Bulbostylis barbata	(Rottb.) C.B. Clarke		Water-Grass	FAC		
Callicarpa americana	L.		American Beauty-Berry	FACU		
Calycocarpum lyonii	(Pursh) Gray		Cupseed	FACW		FACW
Campsis radicans	(L.) Seem. ex Bureau		Trumpet-Creeper	FAC		
Cardamine pensylvanica	Muhl. ex Willd.		Quaker Bittercress	FACW		FACW
Carex abscondita	Mackenzie		Thicket Sedge	FACW		FACW
Carex cherokeensis	Schwein.		Cherokee Sedge	FACW		FACW
Carex joorii	Bailey		Cypress-Swamp Sedge	OBL		OBL
Carex louisianica	Bailey		Louisiana Sedge	OBL	Leitman (1978)	OBL (Natl Wetland Inventory)
Carex tribuloides	Wahlenb.		Blunt Broom Sedge	FACW		FACW
Carpinus caroliniana	Walt.		American Hornbeam	FAC		Found in swamps (Darst & Light, 2008)
Carya alba	(L.) Nutt.		Mockernut hickory		Darst & Light (2008)	
Carya aquatica	(Michx. f.) Nutt.		Water Hickory	OBL		OBL
Carya cordiformis	(Wangenh.) K. Koch		Bitter-Nut Hickory	FAC		
Carya glabra	(P. Mill.) Sweet		Pignut Hickory	FACU		
Catalpa bignonioides	Walt.		Southern Catalpa	UPL		
Celtis laevigata	Willd.		Sugar-Berry	FACW		FACW
Cephalanthus occidentalis	L.		Common Buttonbush	OBL		OBL
Chamaesyce humistrata	(Engelm. ex Gray) Small		Spreading Sandmat	FACW		FACW
Chamaesyce maculata	(L.) Small		Spotted Sandmat	FACU		
Chasmanthium latifolium	(Michx.) Yates		Indian Wood-Oats	FAC		
Chasmanthium sessiliflorum	(Poir.) Yates		Long-Leaf Wood-Oats	FAC		
Chenopodium ambrosioides	L.		Mexican tea	FACU		
Cinnamomum camphora	(L.) J. Presl		Camphortree	UPL		
Clematis crispa	L.		Swamp Leather-Flower	FACW		FACW
Clematis glaucophylla	Small		White-Leaf Leather-Flower	FAC		
Clethra alnifolia	L.		Coastal Sweet-Pepperbush	FACW		FACW
Cocculus carolinus	(L.) DC.		Carolina Coralbead	FAC		
Colocasia esculenta	(L.) Schott		Coco-Yam	FACW		FACW
Commelina diffusa	Burm. f.		Climbing Dayflower	FACW		FACW
Commelina virginica	L.		Virginia Dayflower	FACW		FACW
Conoclinium coelestinum	(L.) DC.	Eupatorium coelestinum	Blue Mistflower	FAC		
Conradina canescens	Torr. & A. Gray ex Benth.) A. Gray		False rosemary			
Conyza canadensis	(L.) Croquist		Canadian horseweed	FACU		
Cornus amomum	P. Mill.		Silky Dogwood	FACW		FACW
Cornus foemina	P. Mill.		Stiff Dogwood	FACW		FACW
Crataegus marshallii	Eggleston		Parsley Hawthorn	FAC		
Crataegus spathulata	Michx.		Little-Hip Hawthorn	FAC		
Crataegus viridis	L.		Green Hawthorn	FACW		FACW
Crinum americanum	L.		Seven-Sisters	OBL		OBL
Crotalaria spectabilis	Roth		Showy Rattlebox	FACU		
Cynodon dactylon	(L.) Pers.		Bermuda Grass	FACU		
Cyperus iria	L.		Ricefield Flat Sedge	FACW		FACW
Cyperus odoratus	L.		Rusty Flat Sedge	FACW		FACW
Cyperus squarrosus	L.	Cyperus aristatus	Awned Flat Sedge	OBL		OBL
Cyperus surinamensis	Rottb.		Tropical Flat Sedge	FACW		FACW
Cyrilla racemiflora	L.		Swamp Titi	FACW		FACW

Decumaria barbara	L.		Woodvamp	FACW		FACW
Desmodium paniculatum	(L.) DC.		Panicled-Leaf Tick-Trefoil	FACU		
Dichondra carolinensis	Michx.		Carolina Pony's-Foot	FAC		
Dicliptera brachiata	(Pursh) Spreng.		Branched Foldwing	FACW		FACW
Digitaria ciliaris	(Retz.) Koel.		Southern Crab Grass	FACU		
Digitaria serotina	(Walt.) Michx.		Dwarf Crab Grass	FAC		
Diodia teres	Walt.		Poorjoe	FACU		
Diodia virginiana	L.		Virginia Buttonweed	FACW		FACW
Diospyros virginiana	L.		Common Persimmon	FAC		Found in swamps (Darst & Light, 2008)
Ditrysinia fruticosa	(Bartr.) Govaerts & F	Sebastiania fruticosa	Gulf Sebastian-Bush	FAC		
Duchesnea indica	(Andrews) Focke		Indian strawberry			
Echinochloa crus-galli	(L.) Beauv.		Large Barnyard Grass	FACW		FACW
Echinodorus cordifolius	(L.) Griseb.		Creeping Burrhead	OBL		OBL
Eclipta prostrata	(L.) L.	Eclipta alba	False Daisy	FACW		FACW
Eichhornia crassipes	(Mart.) Solms		Common Water-Hyacinth	OBL		OBL
Elephantopus carolinianus	Raeusch.		Carolina Elephant's-Foot	FACU		
Eleusine indica	(L.) Gaertn.		Indian Goose Grass	FACU		
Elymus virginicus	L.		Virginia Wild Rye	FAC		
Endodeca serpentaria	(L.) Raf.	Aristolochia serpentaria	Virginia-Snakeroot	FACU		
Eragrostis elliottii	S. Wats.		Elliot's Love Grass	FACW		FACW
Eragrostis hypnoides	(Lam.) B.S.P.		Teal Love Grass	OBL		OBL
Eragrostis japonica	(Thunb.) Trin.	Eragrostis glomerata	Japanese Love Grass	FAC		
Eragrostis pectinacea	(Michx.) Nees ex Jedw.		Purple Love Grass	FAC		
Erechtites hieraciifolia	(L.) Raf. Ex DC.		American burnweed	FAC-		
Eupatorium capillifolium	(Lam.) Small		Dog-Fennel	FACU		
Eupatorium compositifolium	Walt.		Yankeeweed	FAC		
Eupatorium serotinum	Michx.		Late-Flowering Thoroughwort	FAC		
Euthamia caroliniana	(L.) Greene ex Porte	Euthamia minor	Slender Goldentop	FAC		
Fagus grandifolia	Ehrh.		American Beech	FACU		
Fimbristylis vahlii	(Lam.) Link		Vahl's Fimbry	OBL		OBL
Fleischmannia incarnata	(Walt.) King & H.E. Robins.		Pink Slender-Thoroughwort	FACU		
Forestiera acuminata	(Michx.) Poir.		Eastern Swamp-Privet	OBL		OBL
Fraxinus caroliniana	P. Mill.		Carolina Ash	OBL		OBL
Fraxinus pennsylvanica	Marsh.		Green Ash	FACW		FACW
Fraxinus profunda	(Bush) Bush ex Britt.		Pumpkin Ash	OBL		OBL
Galactia volubilis	(L.) Britt.		Downy Milk-Pea	FACU		
Galium aparine	L.		Sticky-Willy	FACU		
Gelsemium rankinii	Small		Rankin's Trumpet-Flower	FACW		FACW
Gelsemium sempervirens	(L.) Ait. f.		Evening Trumpet-Flower	FAC		
Gleditsia aquatica	Marsh.		Water-Locust	OBL		OBL
Gratiola floridana	Nutt.		Florida Hedge-Hyssop	OBL		OBL
Halesia diptera	Ellis		Two-Wing Silverbell	FAC		
Helenium autumnale	L.		Fall Sneezeweed	FACW		FACW
Heliotropium indicum	L.		Indian Heliotrope	FAC		
Heterotheca subaxillaris	(Lam.) Britt. & Rusby		Camphorweed	UPL		
Hibiscus laevis	All.	Hibiscus militaris	Halberd-Leaf Rose-Mallow	OBL		OBL
Hibiscus moscheutos	L.		Crimson-Eyed Rose-Mallow	OBL		OBL
Hydrocotyle umbellata	L.		Many-Flower Marsh-Pennywort	OBL		OBL
Hydrolea quadrivalvis	Walt.		Waterpod	OBL		OBL
Hygrophila lacustris	(Schlecht. & Cham.) Nees		Gulf Swampweed	OBL		OBL
Hymenocallis occidentalis	(Le Conte) Kunth		Carolina Spider-Lily	OBL	Leitman (1978)	OBL (Natl Wetland Inventory)
Hypericum galioides	Lam.		Bedstraw St. John's-Wort	OBL		OBL
Hypericum hypericoides	(L.) Crantz		St. Andrew's-Cross	FAC		
Hypericum mutilum	L.		Dwarf St. John's-Wort	FACW		FACW
Hypericum tubulosum	Walt.	Triadenum tubulosum	Lesser St. John's-Wort	OBL		OBL
Hypericum virginicum	L.	Triadenum virginicum	Virginia St. John's-Wort	OBL		OBL
Hypericum walteri	J.G. Gmel.	Triadenum walteri	Greater St. John's-Wort	OBL		OBL
Hypoxis curtissii	Rose	H. leptocarpa	Curtiss' Yellow Star-Grass	FACW		FACW
Hyptis mutabilis	(A. Rich.) Briq.		Tropical bushmint	FAC		
Ilex amelanchier	M.A. Curtis ex Chapman		Sarvis Holly	OBL	Darst & Light (2008)	OBL (Natl Wetland Inventory)
Ilex cassine	L.		Dahoon	FACW		FACW
Ilex decidua	Walt.		Deciduous Holly	FACW		FACW
Ilex glabra	(L.) Gray		Inkberry	FACW		FACW
Ilex opaca	Ait.		American Holly	FAC		
Ilex verticillata	(L.) Gray		Common Winterberry	FACW	Darst & Light (2008)	FACW (Natl Wetland Inventory)
Ilex vomitoria	Ait.		Yaupon	FAC		
Ipomoea hederifolia	L.		Scarlet-Creeper	FACW		FACW
Ipomoea lacunosa	L.		Whitestar	FAC		
Ipomoea pandurata	(L.) G.F.W. Mey.		Man-of-the-Earth	FACU		
Iris virginica	L.		Virginia Blueflag	OBL		OBL
Itea virginica	L.		Virginia Sweetspire	FACW		FACW
Iva annua	L.		Annual Marsh-Elder	FAC		
Jacquemontia tamnifolia	(L.) Griseb.		Hairy Clustervine	FACU		
Juglans nigra	L.		Black Walnut	UPL		
Juniperus virginiana	L.	*Juniperus silicicola*	Eastern Red-Cedar	FACU		
Justicia ovata	(Walt.) Lindau		Loose-Flower Water-Willow	OBL		OBL
Lagerstroemia indica	L.		Crape-Myrtle	UPL		
Lechea mucronata	Raf.		Hairy pinweed			
Leersia lenticularis	Michx.		Catchfly Grass	OBL		OBL
Leersia virginica	Willd.		White Grass	FACW		FACW
Leitneria floridana	Chapman		Corkwood	OBL	FSU Herbarium specimens (Godfr	OBL (Natl Wetland Inventory)
Leonotis nepetifolia	(L.) R. Br. ex Ait. f.		Christmas-Candlestick	FACU		
Ligustrum japonicum	Thunb.		Japanese Privet	FAC		
Ligustrum lucidum	W.T. Aiton		Glossy privet			
Lindera benzoin	(L.) Blume		Northern Spicebush	FACW		FACW
Lindernia dubia	(L.) Pennell		Yellow-Seed False Pimpernel	OBL		OBL
Liquidambar styraciflua	L.		Sweet-Gum	FAC		Found in swamps (Darst & Light, 2008)
Liriodendron tulipifera	L.		Tuliptree	FACU		
Lobelia amoena	Michx.	Lobelia georgiana	Southern Lobelia	OBL		OBL
Lobelia cardinalis	L.		Cardinal-Flower	FACW		FACW

Lonicera japonica	Thunb.		Japanese Honeysuckle	FAC		
Ludwigia decurrens	Walt.		Wing-Leaf Primrose-Willow	OBL		OBL
Ludwigia palustris	(L.) Ell.		Marsh Primrose-Willow	OBL		OBL
Lycopus americanus	Muhl. ex W. Bart.		Cut-Leaf Water-Horehound	OBL	Leitman (1978)	OBL (Natl Wetland Inventory)
Lycopus virginicus	L.		Virginia Water-Horehound	OBL		OBL
Lygodium japonicum	(Thunb. ex Murr.) Sw.		Japanese Climbing Fern	FAC		
Magnolia grandiflora	L.		Southern Magnolia	FAC		
Magnolia virginiana	L.		Sweet-Bay	FACW		FACW
Malus angustifolia	(Alton) Michx.		Southern crab apple			
Matelea gonocarpos	(Walt.) Shinners		Angular-Fruit Milkvine	FACW		FACW
Mecardonia acuminata	(Walt.) Small		Axil-Flower	FACW		FACW
Melia azedarach	L.		China-Berry	UPL		
Melothria pendula	L.		Guadeloupe-Cucumber	FAC		
Micranthemum umbrosum	(J.F. Gmel.) Blake		Shade Mudflower	OBL		OBL
Microstegium vimineum	(Trin.) A. Camus		Japanese Stilt Grass	FAC		
Mikania scandens	(L.) Willd.		Climbing Hempvine	FACW		FACW
Mimulus alatus	Ait.		Sharp-Wing Monkey-Flower	OBL		OBL
Mitchella repens	L.		Partridge-Berry	FACU		
Mitreola petiolata	(J.F. Gmel.) Torr. & G	Cynoctonum mitreola	Lax Hornpod	FACW	Leitman (1978)	FACW (Natl Wetland Inventory)
Mollugo verticillata	L.		Green Carpetweed	FAC		
Morella cerifera	(L.) Small	Myrica cerifera	Southern Bayberry	FAC		
Morus alba	L.		White Mulberry	FACU		
Morus rubra	L.		Red Mulberry	FACU		
Muhlenbergia schreberi	J.F. Gmel.		Nimblewill	FAC		
Myriophyllum aquaticum	(Vell.) Verdc.		Parrot's-Feather	OBL		OBL
Nandina domestica	Thunberg.		Sacred bamboo			
Nyssa aquatica	L.		Water Tupelo	OBL		OBL
Nyssa biflora	Walt.	Nyssa sylvatica var. biflora	Swamp Tupelo	OBL		OBL
Nyssa ogeche	Bartr. ex Marsh.		Ogeechee Tupelo	OBL		OBL
Nyssa sylvatica	Marsh.	Nyssa sylvatica var. sylvatic	Black Tupelo	FAC		
Oldenlandia corymbosa	L.	Hedyotis corymbosa	Flat-Top Mille-Graines	FAC		
Onoclea sensibilis	L.		Sensitive Fern	FACW		FACW
Oplismenus hirtellus	(L.) Beauv.	Oplismenus setarius	Long-Leaf Basket Grass	FAC		
Osmunda spectabilis	Willd.	Osmunda regalis var. spect	Royal Fern	OBL		OBL
Ostrya virginiana	(P. Mill.) K. Koch		Eastern Hop-Hornbeam	FACU		
Oxalis dillenii	Jacq.		Slender Yellow Wood-Sorrel	FACU		
Packera glabella	(Poir.) C. Jeffrey	Senecio glabellus	Cress-Leaf Groundsel	OBL		OBL
Panicum anceps	Michx.		Beaked Panic Grass	FAC		
Panicum dichotomiflorum	Michx.		Fall Panic Grass	FACW		FACW
Panicum repens	L.		Torpedo Grass	FACW		FACW
Panicum rigidulum	Bosc ex Nees		Red-Top Panic Grass	FACW		FACW
Parthenocissus quinquefolia	(L.) Planch.		Virginia-Creeper	FACU		
Paspalum distichum	L.		Jointed Crown Grass	OBL		OBL
Paspalum notatum	Flueggé		Bahia Grass	FACU		
Paspalum setaceum	Michx.		Slender Crown Grass	FAC		
Paspalum urvillei	Steud.		Vasey's Grass	FAC		
Passiflora lutea	L.		Yellow passionflower			
Peltandra virginica	(L.) Schott		Green Arrow-Arum	OBL		OBL
Perilla frutescens	(L.) Britt.		Beefsteak plant	FAC		
Persea palustris	(Raf.) Sarg.		Swamp Bay	FACW		FACW
Persicaria glabra	(Willd.) M. Gómez	Polygonum densiflorum	Smooth Smartweed	OBL		OBL
Persicaria hydropiperoides	(Michx.) Small	Polygonum hydropiperoide	Swamp Smartweed	OBL		OBL
Persicaria maculosa	S.F. Gray	Polygonum persicaria	Lady's-Thumb	FACW		FACW
Persicaria pensylvanica	(L.) M. Gómez	Polygonum pensylvanicum	Pinkweed	FACW		FACW
Persicaria punctata	(Ell.) Small	Polygonum punctatum	Dotted Smartweed	OBL		OBL
Persicaria virginiana	(L.) Gaertn.	Polygonum virginianum	Jumpseed	FAC		
Phanopyrum gymnocarpon	(Ell.) Nash	Panicum gymnocarpon	Savannah-Panic Grass	OBL		OBL
Phegopteris hexagonoptera	(Michx.) Fée	Thelypteris hexagonoptera	Broad Beech Fern	FACU		
Phoradendron leucarpum	(Raf.) Reveal & M.C. Johnst.		Oak mistletoe			
Phragmites australis	(Cav.) Trin. ex Steud.		Common Reed	FACW		FACW
Phyllanthus caroliniensis	Walt.		Carolina Leaf-Flower	FAC		
Phyllanthus urinaria	L.		Chamber-Bitter	FAC		
Physalis angustifolia	Nutt.		Coastal groundcherry			
Physalis pubescens	L.		Husk-Tomato	UPL		
Phytolacca americana	L.		American Pokeweed	FACU		
Pilea pumila	(L.) Gray		Canadian Clearweed	FACW		FACW
Pinus glabra	Walt.		Spruce Pine	FACW		FACW
Pinus taeda	L.		Loblolly Pine	FAC		
Piptochaetium avenaceum	(L.) Parodi	*Stipa avenacea*	Black-Seed Spear Grass	UPL		
Planera aquatica	J.F. Gmel.		Planertree	OBL		OBL
Plantago major	L.		Great Plantain	FAC		
Platanus occidentalis	L.		American Sycamore	FACW		FACW
Pleopeltis polypodioides	(L.) Andrews & Wind	Polypodium polypodioides	Resurrection Fern	FAC		
Pluchea camphorata	(L.) DC.		Plowman's-Wort	FACW		FACW
Polygonella polygama	(Vent.) Engelm. & A. Gray		October flower			
Polygonum cespitosum	Blume var. longisetum (Bruijn) A.N. Steward		Oriental lady's thumb			
Polygonum scandens	L.		Climbing false buckwheat	FAC-		
Polypogon monspeliensis	(L.) Desf.		Annual Rabbit's-Foot Grass	FACW		FACW
Polypremum procumbens	L.		Juniper-Leaf	FACU		
Pontederia cordata	L.		Pickerelweed	OBL		OBL
Populus deltoides	Bartr. ex Marsh.		Eastern Cottonwood	FAC		
Populus heterophylla	L.		Swamp Cottonwood	OBL		OBL
Portulaca oleracea	L.		Little-Hogweed	FACU		
Prunus americana	Marsh.		American Plum	UPL		
Prunus caroliniana	Ait.		Carolina Laurel Cherry	FACU		
Prunus serotina	Ehrh.		Black Cherry	FACU		
Prunus umbellata	Elliott		Hog plum			
Pseudognaphalium obtusifolium	(L.) Hilliard & B.L. Bu	Gnaphalium obtusifolium	Rabbit-tobacco			
Ptelea trifoliata	L.		Common Hoptree	FACU		
Pyrrhopappus carolinianus	(Walter) DC.		Carolina desert-chicory			

Quercus hemisphaerica	Bartr. ex Willd.		Darlington's Oak	FACU		
Quercus laurifolia	Michx.		Laurel Oak	FACW		FACW
Quercus lyrata	Walt.		Overcup Oak	OBL		OBL
Quercus michauxii	Nutt.		Swamp Chestnut Oak	FACW		FACW
Quercus nigra	L.		Water Oak	FAC		
Quercus pagoda	Raf.	Quercus falcata var. pagod	Cherry-Bark Oak	FACW		FACW
Quercus virginiana	P. Mill.		Live Oak	FACU		
Rhapidophyllum hystrix	(Pursh) H. Wendl. & Drude ex Drude		Needle Palm	FACW		FACW
Rhus copallinum	L.	Rhus copallina	Winged Sumac	UPL		
Richardia scabra	L.		Rough Mexican clover			
Rosa palustris	Marsh.		Swamp Rose	OBL		OBL
Rotala ramosior	(L.) Koehne		Lowland Toothcup	OBL		OBL
Rubus argutus	Link		Saw-Tooth Blackberry	FAC		
Rubus cuneifolius	Pursh		Sand Blackberry	FACU		
Rubus trivialis	Michx.		Southern Dewberry	FACU		
Ruellia caroliniensis	(J.F. Gmel.) Steud.		Carolina Wild Petunia	FACU		
Sabal minor	(Jacq.) Pers.		Dwarf Palmetto	FACW		FACW
Sabal palmetto	(Walt.) Lodd. ex J.A. & J.H. Schultes		Cabbage Palmetto	FAC		
Saccharum baldwinii	Spreng.	Erianthus strictus	Narrow Plume Grass	OBL		OBL
Sagittaria latifolia	Willd.		Duck-Potato	OBL		OBL
Salix nigra	Marsh.		Black Willow	OBL		OBL
Sambucus nigra	L.	Sambucus canadensis	Black Elder	FACW		FACW
Samolus valerandi	L.	Samolus parviflorus	Seaside Brookweed	OBL		OBL
Sanicula canadensis	L.		Canadian Black-Snakeroot	FACU		
Sassafras albidum	(Nutt.) Nees		Sassafras	FACU		
Saururus cernuus	L.		Lizard's-Tail	OBL		OBL
Scoparia dulcis	L.		Licorice-Weed	FAC		
Scrophularia marilandica	L.		Carpenter's-Square	FACU		
Senna marilandica	(L.) Link	Cassia marilandica	Maryland Wild Sensitive-Plant	FAC		
Senna obtusifolia	(L.) Irwin & Barneby	Cassia obtusifolia	Coffeeweed	FACU		
Sesbania punicea	(Cav.) Benth.		Purple River-Hemp	FAC		
Sicyos angulatus	L.		One-Seed Burr-Cucumber	FACW		FACW
Sida spinosa	L.		Prickly Fanpetals	FACU		
Sideroxylon lanuginosum	Michx.	Bumelia lanuginosa	Gum Bully	FACU		
Sideroxylon lycioides	L.	Bumelia lycioides	Buckthorn Bully	FAC		
Sideroxylon thornei	(Cronquist) T.D. Penn.		Georgia bully		Melanie Darst, USGS field notes	Found on low riverbanks by Melanie Darst
Smilax bona-nox	L.		Fringed Greenbrier	FAC		
Smilax glauca	Walt.		Sawbrier	FAC		
Smilax hispida	Muhl. ex Torr.	Smilax tamnoides	Chinaroot	FAC		
Smilax rotundifolia	L.		Horsebrier	FAC		
Smilax smallii	Morong		Lance-Leaf Greenbrier	FACU		
Smilax walteri	Pursh		Coral Greenbrier	OBL		OBL
Solanum carolinense	L.		Carolina Horse-Nettle	FACU		
Solidago altissima	L.		Tall Goldenrod	FACU		
Spermacoce assurgens	Ruiz & Pav.	Borreria laevis (Lam.) Grise	Woodland false buttonweed			
Spiranthes cernua	(L.) L.C. Rich.		White Nodding Ladies'-Tresses	FACW		FACW
Spiranthes ovalis	Lindl.		October Ladies'-Tresses	FAC		
Staphylea trifolia	L.		American Bladdernut	FAC		
Stylisma humistrata	(Walter) Chapm.		Southern dawnflower			
Styrax americanus	Lam.		American Snowbell	FACW		FACW
Symphyotrichum lateriflorum	(L.) A.& D. Löve	Aster lateriflorus, Aster vin	Farewell-Summer	FAC		
Symplocos tinctoria	(L.) L'Hér.		Horsesugar	FAC		
Taxodium distichum	(L.) L.C. Rich.		Southern Bald-Cypress	OBL		OBL
Thelypteris dentata	(Forssk.) E.P. St. John		Downy maiden fern	FACW		FACW
Thelypteris hispidula	(Dcne.) C.F. Reed	Thelypteris quadrangularis	Rough-hairy maiden fern	FACW	Leitman (1978)	FACW (Natl Wetland Inventory)
Thelypteris kunthii	(Desv.) Morton	Thelypteris normalis	Kunth's Maiden Fern	FACW		FACW
Tillandsia usneoides	(L.) L.		Spanish-Moss	FAC		
Toxicodendron radicans	(L.) Kuntze	Rhus radicans	Eastern Poison-Ivy	FAC		
Trachelospermum difforme	(Walt.) Gray		Climbing-Dogbane	FACW		FACW
Tradescantia fluminensis	Vell.		Small-Leaf Wandering-Jew	FAC		
Triadica sebifera	(L.) Small		Chinese Tallowtree	FAC	Darst & Light (2008)	
Ulmus alata	Michx.		Winged Elm	FACU		Found in swamps (Darst & Light, 2008)
Ulmus americana	L.		American Elm	FAC		Found in swamps (Darst & Light, 2008)
Ulmus rubra	Muhl.		Slippery Elm	FAC	Darst & Light (2008)	
Verbena brasiliensis Vell.	Vell.		Brazilian vervain	FAC-		
Verbena rigida	Spreng.		Tuberous vervain			
Verbesina alternifolia	(L.) Britt. ex Kearney		Wingstem	FAC		
Verbesina occidentalis	(L.) Walt.		Yellow Crownbeard	FACU		
Verbesina virginica	L.		White Crownbeard	FACU		
Vernonia gigantea	(Walt.) Trel. ex Branner & Coville		Giant Ironweed	FAC		
Viburnum dentatum	L.		Southern Arrow-Wood	FAC		
Viburnum obovatum	Walt.		Small-Leaf Arrow-Wood	FACW		FACW
Viola affinis	Le Conte		Sand Violet	FACW		FACW
Vitis aestivalis	Michx.		Summer Grape	FACU		
Vitis palmata	Vahl		Catbird Grape	FACW		FACW
Vitis rotundifolia	Michx.		Muscadine	FAC		
Vitis vulpina	L.		Frost Grape	FAC		
Wisteria frutescens	(L.) Poir.		American Wisteria	FACW		FACW
Xanthium strumarium	L.		Rough Cockleburr	FAC		
Yeatesia viridiflora	(Nees) Small	Dicliptera halei	Yellow Bractspike	FACW		FACW
Zizaniopsis miliacea	(Michx.) Doell & Aschers.		Marsh-Millet	OBL		OBL

Exhibit 29

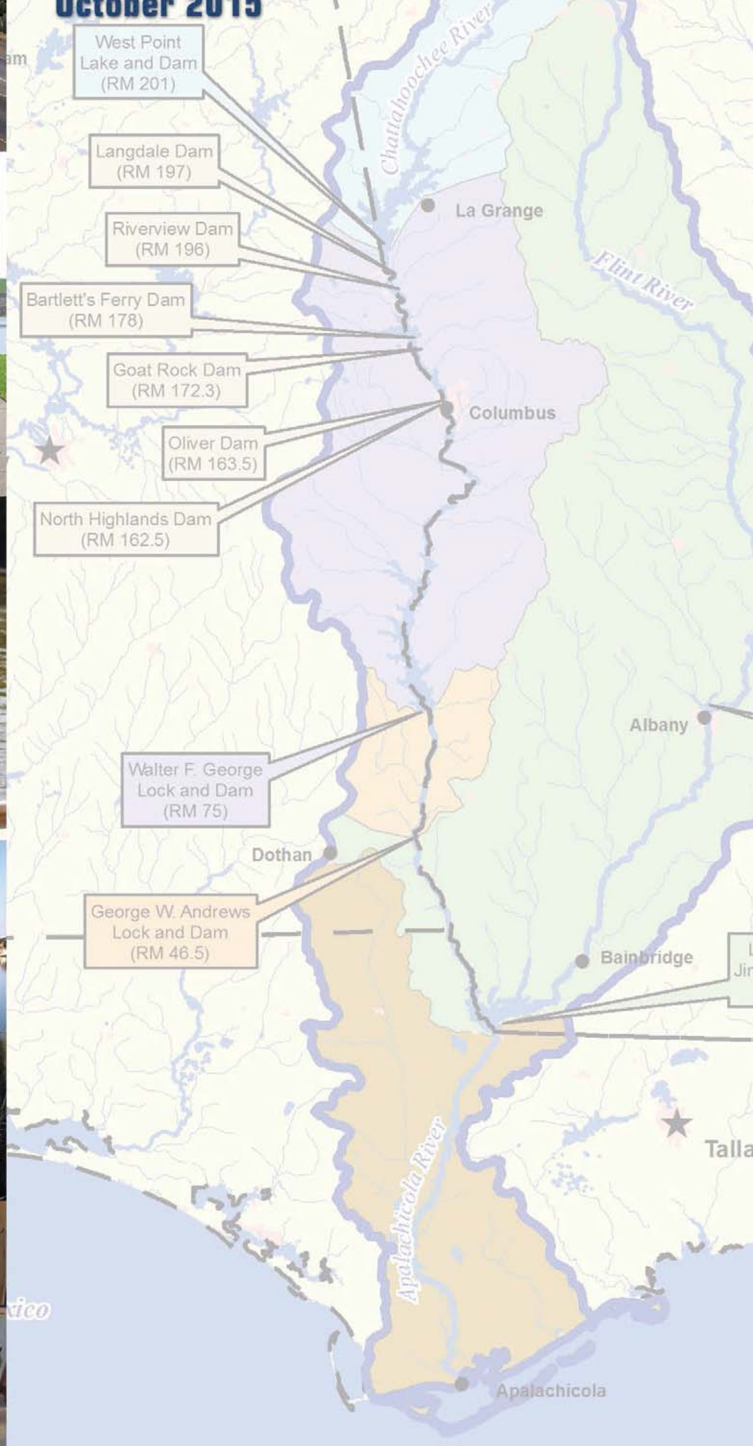
Volume 1

DRAFT

Environmental Impact Statement

Update of the Water Control Manual for the Apalachicola-Chattahoochee-Flint River Basin in Alabama, Florida, and Georgia and a Water Supply Storage Assessment

October 2015



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Water Management Measures Eliminated from Consideration (First Screening)

Water management measures that did not pass the screening criteria or were found to be outside the scope of the EIS were eliminated from consideration. The following sentences include examples of proposed measures eliminated from consideration. Because navigation is one of the congressionally authorized purposes in the ACF Basin, any recommendations to eliminate navigation as a project purpose were not considered. Management measures that suggest use of flood storage for purposes other than flood storage were not considered. Recommendations for studies to determine the allocation of water among Alabama, Florida, and Georgia were also not carried forward for further consideration. USACE did not carry forward management measures that change minimum releases or minimum flows, ensuring other entities meet their future federal compliance requirements. USACE recognizes existing minimum flow requirements in the system but is not authorized to operate its projects to meet requirements for which others parties are responsible. Setting minimum flow targets to ensure compliance with water quality standards is the responsibility of states, not USACE. Changes to the existing head at dams in the ACF Basin could increase the risk to the structural integrity of the projects. Therefore, measures that would change the existing head limits for projects in the ACF Basin were eliminated from consideration. Management measures that suggest structural modifications to the ACF project or other USACE projects do not meet the purpose and need of this EIS. Accordingly, suggestions such as repairing and reversing channel degradation in the Apalachicola River or halting or limiting the current diversion of fresh water caused by the Chipola Cutoff were not carried forward for further consideration. Separate authorities that may be pursued to address some of those issues include Section 216 of the River and Harbor and Flood Control Act of 1970 (Review of Completed Projects); Section 1135 of the Water Resources Development Act (WRDA) 1986, as amended (Project Modifications for Improvement of the Environment); and Section 206 of WRDA 1996, as amended (Small Aquatic Ecosystem Restoration Projects). The latter two authorities have specific limits on federal funds that can be expended on each project ($10 million).

Water Management Measures Considered for Further Evaluation

Potential management measures that passed the screening criteria were considered in the formulation of alternatives. The following provides a general description of the measures considered, each of which was considered individually and refined iteratively.

Revised Guide Curves and Action Zones

USACE considered redefining guide curves and action zones at federal projects in the ACF Basin. A guide curve is the seasonally variable desired pool elevation in a reservoir, and is normally defined as the elevation at the top of the conservation storage. Action zones are partitions of a reservoir's conservation storage, as defined in the reservoir water control plan, to guide reservoir managers in meeting project purposes under a wide variety of hydrologic conditions. In the *1989 draft ACF WCM*, four action zones were first defined for Lake Lanier, West Point Lake, and Walter F. George Lake storage projects in the ACF Basin. The action zones were originally developed by USACE based on past experience in water management, considering the time of year, the relationship of historic pool levels and water releases, operational limits for conservation storage, and recreational impact levels. Each of the four action zones has a set of specific operational rules or guidelines that govern water management operations for the reservoir when the pool elevation lies within that zone. The following specific guide curve/action zone measures were considered: *maintain existing guide curves*; *modify guide curves* at West Point Lake and Walter F. George Lake; *modify action zones* at Lake Lanier, West Point Lake and Walter F. George Lake.

Drought Operations

Under *current drought operations*, a minimum release from Jim Woodruff Dam is specified and the other minimum release and maximum fall rate provisions of the May 2012 RIOP are temporarily suspended until composite conservation storage within the basin is replenished to a level that can support them. "Composite conservation storage" equals the cumulative daily conservation storage values by action zone for the ACF Basin reservoirs (Lanier, West Point, and Walter F. George). Composite conservation storage and the associated zones are discussed in more detail in sections 2 and 4 of the EIS. The minimum discharge is determined in relation to composite conservation storage and not average basin inflow. The drought plan is *triggered* when composite conservation storage falls below the bottom of zone 3 into zone 4. At that time, all the composite conservation storage zone 1-3 provisions are suspended and management decisions are based on the provisions of the drought plan. While composite conservation storage is in zone 4, the minimum release from Jim Woodruff Lock and Dam is 5,000 cfs any basin inflow above 5,000 cfs may be stored. Below composite storage zone 4 is the drought zone (roughly equivalent to the inactive storage in Lake Lanier, West Point Lake, and Walter F. George Lake plus zone 4 storage in Lake Lanier). When composite conservation storage falls into the drought zone, the minimum release from Jim Woodruff Dam is 4,500 cfs and any basin inflow above 4,500 cfs may be stored. When transitioning from a minimum release of 5,000 to 4,500 cfs, maximum fall rates are limited to 0.25 ft/day. The 4,500 cfs minimum release is maintained until composite conservation storage returns to a level above the top of the drought zone, at which time the 5,000 cfs minimum release is reinstated. Per the May 2012 RIOP, the drought plan provisions remain in place until the composite conservation storage reaches a level above the top of zone 2 (i.e., within zone 1). At that time, the drought plan provisions are suspended and all other provisions for normal operations are reinstated.

Revised drought operations would incorporate two potential revisions into the drought plan. Under revised operations, the drought plan would be *triggered* when composite conservation storage falls below the bottom of Zone 2 into Zone 3. The drought plan provisions would remain in place until composite conservation storage reaches a level above the top of Zone 2 (i.e., within Zone 1). If recovery conditions are not achieved in February, drought plan provisions will not be suspended until April, provided composite conservation storage remains above Zone 4.

Minimum Flows at Peachtree Creek

Three measures have been considered regarding minimum flows at Peachtree Creek: *current operations* (maintain continuous net minimum flow of 750 cfs for water quality purposes); *revised minimum flow* (reduce continuous minimum flow to 650 cfs from November through April); *monthly varying flow* (specify a variable minimum flow for each month depending on the reservoir composite storage zone).

Hydropower

Four specific measures were considered for operations of hydroelectric power generation: *current schedule* at Buford Dam, West Point Dam, and Walter F. George Lock and Dam; *modified schedule* at Buford Dam, West Point Dam, and Walter F. George Lock and Dam (variable schedule in zone 1); *reduced hydroelectric power* under drought operations; and *modified schedule with reduced hydroelectric power* under drought operations.

Navigation

The lack of dredging and routine maintenance has led to inadequate depths in the Apalachicola River navigation channel, and commercial navigation is possible only seasonally when flows in the river are naturally high, with flow support for navigation suspended during drier times of the year. Specific navigation operations occur on a case-by-case basis, with limited releases for navigation being made for special shipments when a determination can be made that other project purposes will not be significantly affected and any fluctuations in reservoir levels or river stages will be minimal. Measures considered by USACE for navigation included: continuing the *current operations* in support of navigation; *periodic navigation* based upon the number of opportunities during the year when sufficient flows would be available

GADNR operates a fish hatchery on the Chattahoochee River immediately below Buford Dam. USACE coordinates project operations with the fish hatchery staff. For more information, see section 2.5.5.2.

Endangered Species Conservation Downstream of Jim Woodruff Lock and Dam. Historically, no minimum flow release rate for fish and wildlife purposes was established for the Apalachicola River downstream of Jim Woodruff Lock and Dam. Reservoir releases (varying seasonally) produced from normal operations for hydroelectric power generation and navigation typically provided conditions in the river suitable for fish and wildlife purposes.

On March 7, 2006, USACE, Mobile District initiated formal consultation with USFWS, pursuant to section 7 of the ESA, regarding the effects of existing operations at Jim Woodruff Lock and Dam and releases to the Apalachicola River on federally listed threatened and endangered species and federally designated critical habitat. Specific species/critical habitat affected include the threatened Gulf sturgeon (*Acipenser oxyrinchus desotoi*) and critical habitat for the Gulf sturgeon; and the endangered fat threeridge mussel (*Amblema neislerii*), the threatened purple bankclimber mussel (*Elliptoideus sloatianus*), the threatened Chipola slabshell mussel (*Eliptio chipolaensis*), and the critical habitat associated with these mussel species. The Interim Operation Plan (IOP) that resulted from the section 7 consultation process was implemented in October 2006. Minimum flow provisions for Jim Woodruff Lock and Dam were part of the overall plan established in the IOP to avoid and minimize impacts on the listed species.

On the basis of further consultation between USACE and USFWS and increasingly severe drought conditions in 2007 and 2008, the IOP was modified twice. The revised IOP (RIOP) was implemented in June 2008. The principal water management objective under the IOP (and subsequent modifications) has been to minimize adverse effects to federally listed threatened and endangered species and adverse modification of designated critical habitat in the Apalachicola River. The objective makes allowances for increased storage opportunities and/or reductions in demand for storage to provide continued support to project purposes, minimize impacts to other water users, and provide greater assurance of future sustained flows for federally listed species and other users during a severe multiyear drought.

USACE continued to coordinate with USFWS through 2009 and into 2010 regarding the implementation of the Reasonable and Prudent Measures (RPM), and formal consultation under ESA section 7 was reinitiated between USACE and USFWS in September 2010 to address new information relative to endangered mussel species. That formal consultation was completed in May 2012 when USFWS issued a new Biological Opinion for the RIOP for Jim Woodruff Lock and Dam, requiring some minor operational adjustments to the 2008 RIOP. The following summary of the RIOP is based on the description provided in the May 2012 USACE environmental assessment for the updated RIOP (USACE 2012).

The May 2012 RIOP is governed by two basic parameters applicable to daily releases from Jim Woodruff Lock and Dam: 1) a minimum discharge in relation to average basin inflows (measured as daily average in cfs) and 2) a maximum fall rate (vertical drop in river stage [ft/day]). The RIOP places limitations on refill of upstream reservoirs, but it does not require a net drawdown of composite conservation storage (discussed in more detail below) unless basin inflow is less than 5,000 cfs.

- **Minimum discharge**. The RIOP varies minimum discharges from Jim Woodruff Lock and Dam by basin inflow and by month, and the releases are measured as a daily average flow in cfs at the Chattahoochee gage. Table 2.1-5 shows minimum releases from Jim Woodruff Lock and Dam prescribed by the RIOP and shows when and how much basin inflow is available for increasing reservoir storage. Except when basin inflow is less than 5,000 cfs, the minimum releases are not required to exceed basin inflow. The RIOP defines additional basin inflow threshold levels that vary by three seasons: spawning season (March–May), nonspawning season (June–November), and winter (December–February). The RIOP incorporates composite conservation storage thresholds that factor into minimum release decisions. Composite conservation storage is calculated by combining the conservation storage of Lake Lanier, West Point Lake, and Walter F. George Lake. Conservation storage in each of the individual reservoirs consists of four zones, which are determined by the operational guide curve for each project. The composite conservation storage also uses the 4-zone concept (i.e., Zone 1 of the composite conservation storage represents the combined storage available in Zone 1 for each of the three storage reservoirs). Figure 2.1-40 illustrates the ac-ft of storage available for composite Zones 1 through 4 throughout the year.

Table 2.1-5.
May 2012 RIOP for Jim Woodruff Lock and Dam, Apalachicola River Minimum Discharge from Woodruff Lock and Dam by Month and by Basin Inflow (BI) Rates

Months	Composite conservation storage zone	Basin inflow (BI) (cfs)	Releases from Jim Woodruff Lock and Dam (cfs)	BI available for storage[a]
March–May	Zones 1 and 2	≥ 34,000 ≥ 16,000 and < 34,000 ≥ 5,000 and < 16,000 < 5,000	≥ 25,000 ≥ 16,000+50% BI > 16,000 ≥ BI ≥ 5,000	Up to 100% BI>25,000 Up to 50% BI>16,000
	Zone 3	≥ 39,000 ≥ 11,000 and < 39,000 ≥ 5,000 and < 11,000 < 5,000	≥ 25,000 ≥ 11,000+50% BI > 11,000 ≥ BI ≥ 5,000	Up to 100% BI>25,000 Up to 50% BI>11,000
June–November	Zones 1, 2, and 3	≥ 22,000 ≥ 10,000 and < 22,000 ≥ 5,000 and < 10,000 < 5,000	≥ 16,000 ≥ 10,000+50% BI > 10,000 ≥ BI ≥ 5,000	Up to 100% BI>16,000 Up to 50% BI>10,000
December–February	Zones 1, 2, and 3	≥ 5,000 < 5,000	≥ 5,000 (Store all BI> 5,000) ≥ 5,000	Up to 100% BI > 5,000
At all times	Zone 4	NA	≥ 5,000	Up to 100% BI > 5,000
At all times	Drought Zone	NA	≥ 4,500[b]	Up to 100% BI > 4,500

Sources: USACE, Mobile District 2012; USFWS 2012
Notes:
[a] Consistent with safety requirements, flood risk management purposes, and equipment capabilities.
[b] Once composite conservation storage falls below top of Drought Zone, ramp-down to 4,500 cfs will occur at a rate of 0.25 ft/day.

The RIOP operations and thresholds from March through May are intended to support Gulf sturgeon spawning activities. The 16,000 cfs minimum release is also based on evaluation of spawning and rearing needs for the host fish necessary for mussel reproduction. The RIOP operations from June through February are intended to support the federally protected mussels, host fish for mussels, and young sturgeon.

During spawning season (March–May), two sets of four basin-inflow thresholds and corresponding releases exist according to the composite conservation storage (Table 2.1-5). In accordance with RPM 2008-4 of the 2008 RIOP BO (USFWS 2008a), the spawning season also includes a special fall rate provision in order to avoid take of larval Gulf sturgeon. When the composite conservation storage is in Zones 1 and 2, a less conservative operation is in place. When the composite conservation storage is in Zone 3, a more conservative operation is in place while still avoiding or minimizing impacts on federally listed species and designated critical habitat in the river. When the composite conservation storage falls below the bottom of Zone 3 into Zone 4, the drought contingency operations are triggered, representing the most conservative operational plan. The spawning season fall rate provision is in place under normal and drought operations. Drought contingency operations are summarized below.

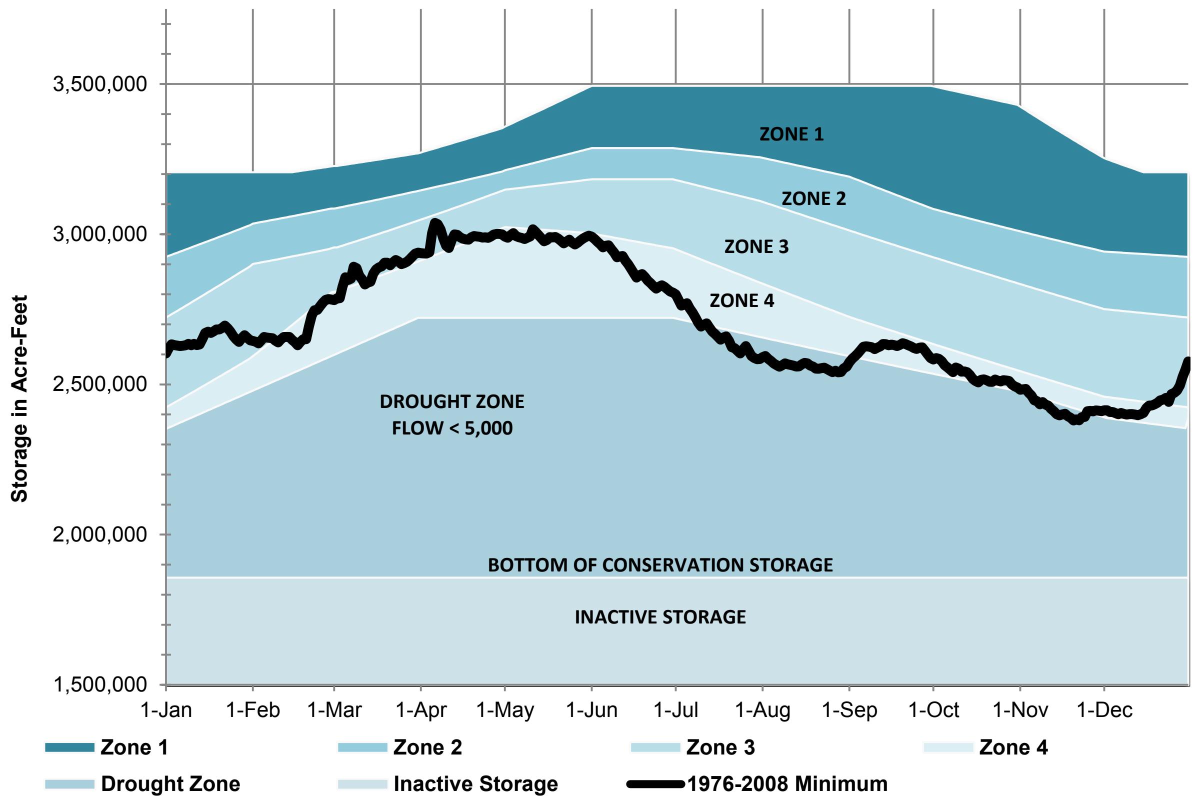

Figure 2.1-40. Basin Composite Conservation Storage and Associated Action Zones (in ac-ft)

During spawning season, the composite conservation storage is monitored daily to determine water management operations. Recently experienced climatic and hydrologic conditions and meteorological forecasts are used in addition to composite conservation storage values when determining the appropriate basin inflow thresholds in support of water management operations.

During nonspawning season (June – November), one set of four basin inflow thresholds and corresponding releases exists according to composite conservation storage in Zones 1 through 3. When composite conservation storage falls below the bottom of Zone 3 into Zone 4, the drought contingency operations are triggered.

During the winter season (December – February), there is only one basin inflow threshold and corresponding minimum release (5,000 cfs) while in composite conservation storage Zones 1 through 3. There are no basin inflow storage restrictions as long as this minimum flow is met under these conditions. When composite conservation storage falls below the bottom of Zone 3 into Zone 4, drought contingency operations are triggered.

The flow rates included in Table 2.1-5 prescribe minimum, not target, releases for Jim Woodruff Lock and Dam. During a given month and basin inflow rate, releases greater than the minimum releases in Table 2.1-5 may occur consistent with the maximum fall rate schedule, described below, or as needed to achieve other project purposes, such as hydroelectric power generation or flood risk management.

- **Maximum Fall Rate.** The fall rate, also called the down-ramping rate, is the vertical drop in river stage (water surface elevation) that occurs over a given period. Fall rates are expressed in units of feet per day (ft/day), and they are measured at the Chattahoochee gage as the difference between the daily average river stage of consecutive calendar days. Rise rates are not addressed. Table 2.1-6 lists the maximum fall rates. The maximum fall rate schedule is suspended when composite conservation storage is in Zone 4 and drought contingency operations are implemented. Unless otherwise noted, fall rates under the drought contingency operation would be managed to match the fall rate of the one-day basin inflow. Matching the one-day basin inflow fall rate during drought operations facilitates quicker recovery and a faster return to normal operations.

  Managing fall rates to conform to Table 2.1-6 values is a challenging undertaking at Jim Woodruff Lock and Dam when flow rates exceed the release capacity of the powerhouse (about 16,000 cfs). Releases greater than 16,000 cfs require the use of the spillway gates in addition to the powerhouse and require an operator to open or close the gates using a rail-mounted crane on the crest of the dam. The water discharge openings of the gates are not fully adjustable, and inclement weather, floating debris, and other factors may complicate the procedure of opening and closing the gates. Fall rates are more manageable when releases are less than 16,000 cfs and controlled by the powerhouse, but this control is not a precise operation. For these reasons, a lower and upper maximum fall rate is provided in Table 2.1-6 for each specific release range. When conditions allow, fall rates will generally conform to the more gradual (lower) rate in each range, consistent with safety requirements, flood risk management purposes, and equipment capabilities.

Table 2.1-6.
RIOP for Jim Woodruff Lock and Dam: Apalachicola River Maximum Fall Rate for Discharge from the Lock and Dam by Release Range for Composite Conservation Storage Zones 1, 2, and 3 [a,b]

Approximate release range (cfs)	Maximum fall rate (ft/day)
> 30,000 [a]	Fall rate is not limited [c,d]
> 20,000 and ≤ 30,000 [b]	1.0 to 2.0 [d]
Exceeds Powerhouse Capacity (~ 16,000) and ≤ 20,000 [b]	0.5 to 1.0 [d]
Within Powerhouse Capacity and > 10,000 [b]	0.25 to 0.5
Within Powerhouse Capacity and ≤ 10,000 [b]	0.25 or less

Sources: USACE, Mobile District 2012; USFWS 2012
Notes:
a. Consistent with safety requirements, flood risk management purposes, and equipment capabilities.
b. The maximum fall rate schedule is suspended in composite Zone 4.
c. For flows greater than 30,000 cfs, it is not reasonable and prudent to attempt to control the down-ramping rate, and no ramping rate is required.
d. Maximum fall rates must be less than 8 ft in a consecutive 14-day period when flows are less than 40,000 cfs in March, April, and May in order to avoid take of Gulf sturgeon eggs and larvae.

- **Drought Contingency Provisions in the RIOP.** The RIOP includes a drought contingency operation (referred to as a *drought plan*). The drought plan specifies a minimum release from Jim Woodruff Lock and Dam and temporarily suspends other minimum release and maximum fall rate provisions until composite conservation storage in the basin is replenished to a level that can support them. Under the drought plan, minimum discharge is determined in relation to the composite conservation storage and not average basin inflow. The drought plan is triggered when composite conservation storage falls below the bottom of Zone 3 into Zone 4. At that time, all the

2.5.3.1.1 Large River Habitat

The Apalachicola River flows freely from Jim Woodruff Lock and Dam and represents the only unimpounded large-river habitat remaining in the ACF Basin. This habitat is not pristine, however, because streamflow is regulated by upstream impoundments and dredging through the 1990s. The USFWS compared preimpoundment and postimpoundment hydrologic regimes in the Apalachicola River using the Range of Variability Approach (RVA) (Richter et al. 1997) to characterize existing altered flow conditions. The assessment showed significant postimpoundment hydrologic alterations, including increased February mean flow, decreased July mean flow, decreased duration of high flow pulses, and alterations in the rate and frequency of change in water conditions (Richter et al. 1997).

The main channel of the Apalachicola River and its tributaries provide important habitat for fish and mussels. Ninety-five species of fish are known to occur, including the anadromous Gulf sturgeon, striped bass (*Morone saxatilis*), and Alabama shad (*Alosa alabamae*) (Appendix H, Table H-5; USGS 1996). Critical habitat has been federally designated recently for Gulf sturgeon (USFWS 2003a) and four mussel species: fat threeridge, Chipola slabshell (*Elliptio chipolaensis*), Gulf moccasinshell (*Medionidus penicillatus*), and shiny-rayed pocketbook (*Hamiota subangulata*) (USFWS 2007a). Ongoing studies by the USFWS in the Apalachicola River suggest that previous estimates likely underestimated the population of fat threeridge in the middle river reaches (Zettle 2014, personal communication).

Integral habitat features of the Apalachicola River extend beyond the main channel to include tributaries, backwaters (oxbow lakes, sloughs), and the floodplain (Light et al. 1995; Sparks 1995). At least 80 percent of the fish species found in the main channel also occupy floodplain habitats, especially for spawning and foraging from April through July (Light et al. 1995; USFWS 1998). Striped bass are reported to use at least 12 tributary streams in the upper reach of the river as cool-water thermal refugia from May through November (Light et al. 1998; USFWS 1998). At least 45 species are known to use the Apalachicola River floodplain for spawning and nursery habitats based on larval trap collections from 2002 to 2007. Fish community research at the Apalachicola River indicates that floodplain connection and inundation are important for fish communities in this river system (Dutterer et al. 2012).

Entrenchment of the Apalachicola River channel, which occurred after construction of Jim Woodruff Lock and Dam up until about 1981, has lowered river stages and decreased the accessibility of tributary streams to fishes in the main channel (Light et al. 1998). As measured at the Chattahoochee gage, a flow of about 11,000 cfs is required to provide sufficient depths at tributary mouths for fish to move between the tributaries and main channel, compared to a flow of about 5,500 cfs before impoundment (Light et al. 1998). Under present conditions, the extent of connected aquatic floodplain habitat increases substantially with flows exceeding 29,000 cfs.

2.5.3.1.2 Subsystems with Unregulated Flow

A second group of river segments have unregulated flow and maintain significant portions of native species assemblages. These systems and subsystems mostly occur in the upper-most portions of the drainages, and, in some cases, represent refugia for species eliminated from downstream segments by impoundments. The upper and middle Flint River system and the uppermost Chattahoochee River system, along with some tributary systems to the Flint and Chattahoochee rivers, are known to support significant remnants of the native riverine faunal communities (Yerger 1977; Barkuloo et al. 1987; Dahlberg and Scott 1971; Gilbert 1969). Unimpeded flow from the Piedmont to the Coastal Plain ecoregion contributes significantly to natural resource value in the Flint River system because river continuity between the distinct habitats above and below the Fall Line facilitates the natural flow of water, energy, and nutrients to downstream habitats and allows the potential exchange of individuals among populations experiencing different habitat regimes. Connectivity to tributary streams is valuable for the same reasons. In all cases,

Exhibit 30

Biological Opinion on the U.S. Army Corps of Engineers, Mobile District, Revised Interim Operating Plan for Jim Woodruff Dam and the Associated Releases to the Apalachicola River

Prepared by:
U.S. Fish and Wildlife Service
Panama City Field Office, Florida
May 22, 2012

EXECUTIVE SUMMARY

The action evaluated in this consultation is the Corps' Revised Interim Operating Plan (RIOP) for Jim Woodruff Dam, which describes releases from the dam to the Apalachicola River. Consultation on the RIOP was completed in 2008 and reinitiated in 2010, because of new information on the distribution and mortality of fat threeridge mussels. Substantial numbers of fat threeridge mussels recolonized habitats at elevations above the minimum 5,000 cfs flow, and many were subsequently exposed and killed when flows declined in September 2010. The Corps determined that the proposed RIOP may adversely affect the fat threeridge, purple bankclimber, and Chipola slabshell, and may affect but would not likely adversely affect (NLAA) the Gulf sturgeon or designated Gulf sturgeon or mussel critical habitat. The Service concurred with the Corps' determination of NLAA for the Gulf sturgeon and its designated critical habitat. Mussel effects were addressed in this biological opinion (BO).

The current version of the RIOP is very similar to the 2008 RIOP. It does not address operational specifics at the four federal reservoirs upstream of Woodruff. The RIOP addresses two specific parameters of the daily releases from Woodruff Dam into the Apalachicola River: a minimum discharge in relation to average basin inflows (i.e., the actual amount of water flowing into all of the Corps projects during a given time period) and maximum fall rate (vertical drop in river stage per day). These two parameters vary by basin inflow, composite conservation storage level and by month. Except when basin inflow is less than 5,000 cfs and during some down-ramping periods, the minimum releases are not required to exceed basin inflow. The Corps proposed five modifications to the 2008 RIOP to minimize impacts to listed species: 1) volumetric balancing is eliminated; 2) minimum flow releases will match basin inflow between 5,000 and 10,000 cubic feet per second (cfs) from June through November (except during drought contingency operations); 3) drought contingency operations are not suspended until composite conservation storage has recovered above Zone 2 into Zone 1; 4) when releases are less than 10,000 cfs, the maximum fall rate is limited to 0.25 ft/day; and 5) river stage declines of 8 feet or more will not occur in less than 14 days when river flows are less than 40,000 cfs during the spawning season (March-May) under both normal and drought operations.

The current status of the three mussel species and their critical habitat is discussed in detail in the BO. Notable mortality of the purple bankclimber and fat threeridge has occurred during recent droughts in 2006-2008 and 2010-2012, but no Chipola slabshell mortality has been observed. The Chipola slabshell population is stable but generally occurs in relatively low abundance. The purple bankclimber is rare and occurs at low abundance in the Apalachicola River (with the exception of one location), and it appears to be experiencing poor recruitment. The fat threeridge population appears stable and may be increasing in size. They are abundant in the middle reach of the Apalachicola River and the lower Chipola River, the population is relatively large, and there is evidence of recruitment.

Fat threeridge are likely moving in response to changing water levels to maintain an optimal depth or associated habitat parameter. At the time of the 2008 BO there were no listed mussels at river stages greater than 5,000 cfs due to the drought of 2006-2008. Although we noted that take may occur when individuals occupy stages greater than 5,000 cfs, we did not anticipate take under this scenario because it was considered an anomaly related to very high flows in 2005. However, based on recent data, it appears that fat threeridge readily recolonize higher bank elevations at flows greater than 5,000 cfs, where they could be at risk of stranding and mortality when flows decline. Mortality during these events was highest in the middle reach of the Apalachicola River where the main channel populations are the most abundant and slopes are shallow. Some mortality occurred in the Chipola River, but it appears to be limited. Mortality estimates from all of these events range from <1% to 2% depending on preceding hydrologic conditions, fall rates, habitat condition, and the size of the population in Swift Slough and unsurveyed deep-water habitats.

Relative to the Baseline period (1975-2008), the proposed RIOP provides both beneficial and adverse effects to the species and designated critical habitats we have assessed. Many of these effects derive from relatively minor differences between the RIOP and Baseline; however, we attribute these differences to changes in reservoir operations and not consumptive water use. Generally, it appears that the Corps would store water more often and augment flows less often under the RIOP than has occurred historically. The RIOP uses some of this stored water to augment basin inflow in order to maintain a minimum flow of 5,000 cfs, but the frequency and duration of flows less than 10,000 cfs is increased.

Lower flows for longer durations will negatively impact all three mussel species. We expect impacts to Chipola slabshell to be minimal because it occurs almost entirely within the Chipola River where movement is facilitated by higher bank slopes and the species' probable tendency to move. Impacts to the purple bankclimber will also likely be minimized because this species appears to occur more often in deeper portions of the stream channel, which is likely why we have observed limited mortality during recent low flows. The results of the fat threeridge population viability analysis (PVA) indicate that the population can sustain reductions of 1-2% (estimated have occurred during recent droughts) if flows are reduced to 5,000 cfs and 4,500 cfs with currently projected probabilities. However, the PVA also indicates that increasing the frequency of such events results in a greater impact to population viability. The RIOP may affect three of the five primary constituent elements (PCEs) of mussel critical habitat: 1) permanently flowing water; 2) water quality; and 3) fish hosts. It does not appear to reduce the amount of important floodplain habitat available to fish hosts. Droughts substantially change the nature of all of these PCEs, but the RIOP would not appreciably change the quantity or quality of the PCEs to the extent that it would appreciably diminish the habitat's capability to provide the intended conservation role. Therefore, it is the Service's biological opinion that the proposed action: 1) will not jeopardize the continued existence of the fat threeridge, purple bankclimber, and Chipola slabshell; and 2) will not destroy or adversely modify designated critical habitat for the fat threeridge, purple bankclimber, and Chipola slabshell.

The Incidental Take Statement issued exempts the Corps from "take" under the Endangered Species Act. During each of these events (flow reduction to 4,500 cfs, and exposure at stages > 5,000 cfs following recolonization), a maximum the following may be exposed: 30 purple bankclimbers (60 total); three Chipola slabshell (six total); and 9,150 fat threeridge (18,300 total). Three mandatory reasonable and prudent measures are also included: 1) adaptive management; 2) maintenance of the Chattahoochee gage; and 3) monitoring.

This BO is effective for five years (May 22, 2017). No further consultation is needed unless the Corps operates Woodruff Dam in a way that is different from the RIOP, new information indicates that the RIOP may affect listed species to an extent not considered in the BO, or if more mussels or Gulf sturgeon are "taken" under the Corps' operations than anticipated.

Exhibit 31

From:	Hoehn, Ted <ted.hoehn@MyFWC.com>
Sent:	Thursday, May 02, 2013 12:47 PM
To:	Dan Tonsmeire; charlie.mesing@myfwc.com; Hill, Michael; Graham Lewis
Cc:	Matt Kondolf
Subject:	RE: Apalachicola River Restoration field trip
Attachments:	Restoration Plan -Graham-long.doc

Going back through my electronic files, here are some things that we had already developed. This would need to be updated since we know a few more things about how some of the slough's hydrology function (example Kennedy Creek). Before we go out, I suggest that we have some plan of what we want to look at. While I do not have a problem with getting out on the river, it should be productive and have a set purpose.

Ted Hoehn
Florida Fish and Wildlife Conservation Commission
Division of Habitat and Species Conservation
620 S. Meridian Street, MS 5B5
Tallahassee, FL 32399-1600
(850) 488-8792; Cell 850-519-3106
Fax (850) 922-5679
"Many men go fishing all their lives without knowing that it is not the fish they are after."- Henry David Thoreau

From: Dan Tonsmeire [mailto:dan@apalachicolariverkeeper.org]
Sent: Thursday, May 02, 2013 11:20 AM
To: Hoehn, Ted; charlie.mesing@myfwc.com; Hill, Michael; Graham Lewis
Cc: 'Matt Kondolf'
Subject: Apalachicola River Restoration field trip

Ted, Rick, Charlie, Michael and Graham: Everyone except Graham can make a trip on the Apalachicola for Friday May 17th. Please plan on that trip to begin at 10 AM Eastern Time and get off the river no later than 2:00 PM. I can carry everyone in my boat if that is OK with you.

My suggestion is for us to put in at Wewahitchka and run up and down the river from there, but certainly willing to put in somewhere else that you think is more important to look at. Please make a suggestion if you have one.

Matt Knodolf will not be able to participate due to prior commitments, but we can try to catch up with him before and after the trip by teleconference.

Please reply with a confirmation of your participation, suggestions for a put in other than Wewa, and any sites you would like to visit.
Thanks,

Dan

Dan Tonsmeire
Apalachicola RiverKeeper
Box 8
232B Water Street
Apalachicola, Florida 32320

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PENGAD 800-631-6989 EXHIBIT 13

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Draft Restoration Program for the Apalachicola River System

Natural History

The Apalachicola River basin forms the lower part of the larger Apalachicola-Chattahoochee-Flint (ACF) River system. The ACF basin covers the north-central and southwestern part of Georgia, the southeastern part of Alabama, and the central part of the Florida panhandle. The basin drains an area covering approximately 19,600 square miles. The Chattahoochee River flows 436 miles from its source in the Blue Ridge Mountains of northern Georgia, drains a land area of 8,650 square miles, and has 13 dams located on the river. The Flint River flows 350 miles from its source south of Atlanta, drains a land area of 8,494 square miles, and contains 2 dams. The Apalachicola River is formed by the confluence of the Chattahoochee and Flint Rivers below the Jim Woodruff Dam, flows 107 miles to Apalachicola Bay, and drains a land area of approximately 2,400 square miles.

The Apalachicola River is the largest in Florida and ranks 21st in the United States in terms of flow. The importance of the Apalachicola River to the productivity of the bay cannot be overemphasized. It also accounts for 35 percent of fresh water flow on the western coast of Florida. This freshwater plume, containing seasonally high nutrient and chlorophyll concentrations, has been observed extending up to 250 km into the Gulf of Mexico and may play an important role in the productivity of the northeast Gulf..

The floodplain of the Apalachicola River is the largest in Florida and one of the larger floodplains on the Gulf Coast. Floodplains in the southeastern United States are in many instances the last refuge for rare and endangered flora and fauna. Fifteen listed plant species occur within the 100-year floodplain alone, including 6 species at lower elevations in the 1 to 10 year floodplain. The floodplain forest has also been cited as being one of the most important wildlife habitats in northwest Florida. Four species of amphibians and reptiles, four species of mammals, and eleven species of birds have been listed as Threatened, Endangered, or Species of Special Concern from the Apalachicola River floodplain. The largest stand of tupelo trees in the world is found in the lower Apalachicola River floodplain.

More than 1,300 plant species have been identified within the Apalachicola drainage basin with 103 of them listed as threatened or endangered. The Apalachicola River drainage basin contains approximately 46 species of amphibians and 83 species of reptiles. This is the highest species density of these amphibians and reptiles on the continent north of Mexico. More than 50 species of mammals, including the threatened Florida black bear, the endangered West Indian manatee, the Indiana bat, and the gray bat are found in the Apalachicola Basin.

The Apalachicola River and Bay and surrounding drainage basin are among the most important bird habitats in the southeastern United States. This area lies on the eastern fringe of the Mississippi Flyway, thus receiving large numbers of birds from both the Midwest and Atlantic seaboard during migratory periods. The list totals more than 300 species with 22 designated as Endangered, Threatened or Species of Special Concern by the Florida Fish and Wildlife Conservation Commission.

The ACF basin is home to one of the largest number of fish species among Gulf Coast drainages, east of the Mississippi River, and the largest assemblage of fresh water fish in Florida. Over 180 species of fish have been documented from the river and bay system. These include fresh water, estuarine, and salt water species which utilize the estuary during part or all of their life cycle. The Apalachicola River basin also has the largest number of species of freshwater gastropods and bivalves, the most molluscan endemic species, and greatest proportion of endemics to total molluscan fauna among western Florida drainages. The high biological diversity and productivity of the system has resulted in designations as a United Nations International Biosphere Reserve, National Estuarine Research Reserve, Outstanding Florida Water, and Florida Aquatic Preserve.

Navigation Channel

The ACF Waterway is a federally authorized navigation project, whose basic authority is the 1945 River and Harbor Act. The overall project consists of a navigation channel, three locks, 5 federal dams and their associated reservoirs. The primary focus of the project in Florida is the 9- by 100- foot navigation channel whose dimensions are to be provided by "dredging, cutoffs, training dikes, or other open-river methods; a series of locks and dams; and flow regulation from upstream reservoirs." The dams and reservoirs on the upstream rivers were built from the 1950's to the mid 1970's while the Apalachicola River segment of the navigation channel was first dredged in 1958. Training works, cutoffs, and rock removal have been accomplished on numerous occasions since the 1950's. The navigation channel in Florida covers the 106.3 miles of the Apalachicola River from its inception below the Jim Woodruff Dam to the river's terminus in Apalachicola Bay.

Federal navigation channels typically have a goal of providing channel dimensions at least 95% of the time. The Apalachicola Waterway has never been able to attain this goal over the long-term and due to drought during the last 4 years has been unavailable almost 100% of the time. The primary reason for non-attainment over the years has been the amount of water available in the basin. When the project was authorized it was thought that the channel could be provided at a flow of 9,300 cfs and that this flow would be available 95% of the time. Since then it has been found that, even with all of the structural modifications made to the river, over 15,000 cfs is needed to provide the authorized channel and the flow available 95% of the time is only about 7,000 cfs. In 1986, studies conducted by the US Army Corps of Engineers, determined that even with dredging and numerous proposed modifications to the river the channel would be available less than the 95% goal. A Government Accounting Office (GAO) study recently estimated that the Apalachicola Navigation Channel was the most expensive navigation channel in the country, based on a cost per ton-mile. In recent years the cost effectiveness of the channel, decreased traffic, and significant environmental damage to the river system have made the channel undesirable to the State of Florida. In 2002 the Governor and Cabinet went on record calling for the cessation of dredging on the Apalachicola River.

Impacts from the Navigation Project on the Apalachicola River System

The construction of the dams, in particular the Jim Woodruff Lock and Dam at the confluence of the Chattahoochee and Flint Rivers in 1955, caused the upper third of the Apalachicola River to entrench. This streambed entrenchment (degradation) caused the exposure of rock outcrops, the reduction of access to cold-water refuges, the loss of connections to important backwater habitats, the loss of riverine habitat, and the movement of tremendous quantities of sand. The dam also resulted in reduced access to historically important upstream spawning habitat as well as upstream sources of sand for the Apalachicola River. Evidence suggests that this streambed degradation continues today. Important species most affected include the federally listed Gulf Sturgeon and striped bass. Other impacts from the dams and bed entrenchment include increased channel widening and lowered river stage resulting in the loss of slough habitat as well as a decrease in floodplain forest inundation. These impacts have resulted in changes in floodplain forest composition, increases in exotic species, and a decrease in aquatic habitat during overbank flooding.

Structural modifications that have occurred as part of the project in the past include training works (dike fields), bend easings, and cutoffs. These modifications have resulted in an increase in the movement of sand downstream and shortening the length of the river, and may have contributed to further instability in the river channel by increasing erosion, increasing the width of the channel, and decreasing the depth of the river. Although dike fields initially created good fish habitat most of these benefits have been lost due to spoil disposal on these sites over time. Numerous other dam projects, bank stabilization projects, cutoffs, and sills have been proposed over the years but never approved or implemented due to the lack of justification of success, cost, or environmental concerns.

Snagging operations, to relocate logs and trees, have been necessary since the inception of the project. The relocation of these snags has resulted in the loss of valuable habitat for fish and their food over the years. Modification of the program in the 1980's resulted in a more selective snagging program as well as placement of the snags back in the river to maintain their ecological value. This has resulted in reduced loss of habitat but continues to be a concern. Bank erosion from boat wakes also continues to be a problem in some parts of the river, particularly in the middle reaches.

The dredge and disposal operation continues to be the largest cause of environmental problems, as well as the most controversial project on the river. Rock removal in the upper river below the dam, necessitated by streambed entrenchment and river meandering, has been a controversial part of the project and although not necessary lately, remains an environmental concern due to its effects on habitat of the Gulf sturgeon and striped bass. Dredging has also contributed to channel widening and lowered river stages in the middle and lower river.

While the actual dredging of sand in the river remains a concern, the disposal of the sand material has had severe environmental impacts. Early in the program most spoil disposal occurred in the floodplain and resulted in the loss of aquatic and floodplain habitat by burial, blockage of sloughs, and unseasonal flooding of backswamps. In an effort to reduce this habitat loss most spoil disposal now occurs at within bank sites along the river shoreline. This type of disposal has resulted in an increase of approximately 25 miles of additional sand habitat on the river, which is the least productive habitat found in the system. Some of the most productive aquatic habitat in the river, including steep natural bank and gently sloping natural banks, has been buried as a result of continued sand disposal along the river. It has also resulted in the blockage of sloughs through the movement of material downstream of these disposal areas, as well impacting many sloughs with sediment deposition that smothers productive aquatic habitat. Slough blockages affect even larger backwater aquatic habitats by causing their disconnection from the riverine system. These habitat losses further impact riverine fisheries due to the loss of invertebrate substrate (food) and potential spawning areas.

The process of floodplain and within bank spoiling has resulted in the loss of floodplain and aquatic habitat, alterations to forest composition, opportunities for invasive species, forest mortality, and elevation and water inundation changes. The increasing use of within bank sites appears to have exacerbated opposite bank erosion, causing additional loss of habitat, downstream sediment deposition and habitat loss, as well as contributing to channel widening, all of which leads to increased dredging to maintain the navigation channel.

Other impacts resulting from the maintenance and use of the navigation channel include increased erosion from boat wakes, loss of shoreline vegetation due to tying up of barges, and the loss of fisheries due to the use of navigation windows. Navigation windows became popular in the 1990's as a way to open up the channel for short periods of time, usually 10-14 days, during periods when there was not enough flow for barges and tugs. The U.S. Army Corps of Engineers would store water in the upstream reservoirs and release this to increase the depth in the Apalachicola Channel. This resulted in the creation of a "navigation window" that could be utilized by barges to move material upriver for a short period of time. Unfortunately this mechanical driven rise in the river caused fish to leave the channel and move into historic areas for feeding and spawning purposes. The subsequent rapid drop in elevation in the river caused by the cessation of the releases resulted in fish being trapped in the floodplain in isolated water bodies. These isolated water bodies eventually dried up or developed water quality problems from the stagnant conditions that occurred.

<u>Potential Restoration Projects on the Apalachicola River</u>

Because of the length of time the navigation channel has been in existence and the activities that have taken place to maintain this channel during the last 50 years there is a large list of potential restoration activities that could be undertaken. Some of these restoration alternatives have been studied in the past and could be done immediately while others would need a more detail analysis as to their costs, benefits, and possibilities for success. The list of potential projects includes:

- Removal of sediment from disposal sites that are at or near capacity;
    - The Corley Slough area, river mile 35 through 38, includes numerous floodplain disposal areas, disposal areas 38, 38A, 39, and 40, that are at or above capacity. Restoring disposal areas 38, 38A, and 39 would mitigate for some of the loss of floodplain habitat. Rejuvenation of site 40 would alleviate the need for additional within banks sites in the future. Continued riverbank erosion threatens all four of these sites in the future.

- Within bank and point bar disposal areas (particularly areas 43, 45A, 47A, 48A, and 58) which are found between river mile 36 and 45 also need restoration activities due to their size and potential impacts on opposite bank erosion. Other within bank sites, which may be causing erosion problems or are nearing capacity, should also be investigated. Part of the investigation should include their future use and potential elimination if necessary.
- The size of many point bars could be reduced by sediment removal, followed by reshaping and re-vegetation, to allow natural plant succession thereby restoring natural river meandering to occur and potentially reducing channel widening.

- Reopening or restoration of large sloughs that have been impacted (most of these projects would need further analysis of their costs benefits, and impacts before proceeding);
  - The Poloway Cutoff, at river mile 71, is a very productive backwater that should be reconnected to the main channel at low water. As part of this project the upstream within bank sites, disposal areas 104A and 105, should be investigated for their impacts on sediment deposition within the mouth of this slough.
  - Restoring the Virginia Cut, river mile 35, would increase flowing water habitat of high quality for fish and invertebrates.
  - The Iamonia Lake area is a very large and productive backwater with sediment deposition problems at the mouth of the slough. The area is used heavily by fishing and hunting clubs, therefore, any sand removal options would need to address the potential effects of lowered lake levels at low river levels on the backwater area.
  - A sandy sill in the mouth of the River Styx area, river mile 35, should be removed. At low water many miles of backwater habitat would be reconnected to the main channel and could have very large benefits.
  - The sediment at the mouth of Kennedy Creek, river mile 25, should be removed, restoring a large drainage and connection back to its natural condition.
  - The connection between the East River, river mile 14, and the Apalachicola River should be stabilized and sediment removed from the aquatic zone. Restoring the connection permanently may involve determining the impacts of the upstream within bank disposal areas on sedimentation in the East River.
  - The opening up and restoration of access to the lower end of Battle Bend cutoff should be accomplished.
- Smaller sloughs could also be restored with benefits to the system. The above list includes the larger sloughs that are more expensive and could provide more benefits. However, before additional slough openings are attempted, the potential for long-term success and downstream impacts should be thoroughly considered. This analysis would also include any sloughs that could be opened easily with benefits to the system.

- The restoration of old cutoffs such as Battle Bend as a method to lengthen the river and reduce its erosion rate should be investigated.
- The beneficial artificial aquatic habitat that was created as part of constructing dike fields could be enhanced by removing the sediment that was disposed on top of the fields. These artificial rock and wood substrates are beneficial to invertebrates as well as habitat for fish, both feeding and spawning.
- In the upper river, primarily in the 5 miles directly below the Jim Woodruff Dam, streambed entrenchment has resulted in the exposure and isolation of rock habitat and the loss of access to historic cool water refuges during low flows. Methods to mitigate the impacts on the gulf sturgeon and striped bass should be investigated. These could include the restoration of these habitats or stocking of these important species.
- Increasing fish passage above and below the dam would allow species, especially the gulf sturgeon and striped bass, passage to their historic spawning grounds upstream. This could involve construction of fish ladders, fish lifts or even modification of the existing locks to allow for fish passage. An analysis of a fish passage structure and costs for the Claiborne Dam on the Alabama River has been undertaken. The potential for a similar project should be investigated the Jim Woodruff Dam on the Apalachicola River.
- Better operation of upstream reservoirs to provide a flow regime that is consistent with the ecological needs of the Apalachicola River system. The Corps of Engineers will be proposing a Water Control Plan to define management of the federal storage reservoirs in the ACF basin in the coming year and this will provide an opportunity to revise reservoir operations as necessary to protect the flow regime.
- A detailed hydro-geomorphic assessment into the current rate of river channel widening should be undertaken. This problem could have tremendous impacts on the navigation channel, the amount of dredging required, as well as the unique natural resources of the river and its floodplain. Its causes and effects are currently not well understood but may play a major role in the future.

Restoration Program for the Apalachicola River

In order to reduce, eliminate, and mitigate the impacts on the Apalachicola River system during the last 50 years of providing a navigation channel it will be necessary to develop a restoration program. This program should have specific and definable goals which allow for:

- reduction or elimination of continuing and future impacts due to sand migration and erosion caused by maintenance of the navigation channel;
- restoration of the natural functioning of the river by re-establishing the integrity of the Apalachicola River basin ecosystem (including restoration of bendways, interconnecting waterways, sloughs, watersheds, associated land areas, and fish and wildlife habitat);
- supporting and sustaining a balanced, integrated, adaptive community of organisms having species composition, diversity, and functional organization comparable to those of the natural habitat of the Apalachicola River; and

- monitoring and assessing the biota, habitats, and water quality of the Apalachicola River basin to assess restoration activities, their benefits, and impacts.

In order to accomplish the Apalachicola River Restoration Program it is recommended that a multi-agency team be put together to develop a long-term comprehensive plan, rank the restoration alternatives, work to acquire permits, contract and supervise the individual restoration activities and monitor the progress and results of the work. This team should include at a minimum the U.S. Army Corps of Engineers, U.S. Fish and Wildlife Service, U.S. Geological Survey, Florida Department of Environmental Protection, Florida Fish and Wildlife Conservation Commission, Northwest Florida Water Management District, as well as other stakeholders in the region such as citizens and non-government organizations. A process that allows the multi-agency committee to control the funds, oversee the prioritization and completion of the restoration activities as well as the monitoring needed to assess the benefits and impacts of the projects. In order to accomplish this task a full-time position must be provided for these activities rather than relying on the efforts of other agency employees, who have other commitments and cannot devote 100% time to the project. The restoration program would be accomplished over a ten-year period with the following components:

1. Year 1 - A working Comprehensive Plan would be developed and adopted that identifies and prioritizes obvious areas, including those listed above, for restoration that have the greatest benefits and chances for success. Any studies that were necessary to understand the system and how it responds to these restoration activities as well as other activities associated with the maintenance of the navigation channel would be detailed. Some specific restoration projects, which have been already been authorized would begin as soon as final cost estimates, plans, and permits are secured.
2. Year 2 - Designs, scopes of work, cost estimates, permits, and contracts would be developed for the second ranked priorities in the plan as well as any required studies.
3. Year 3 - Work on the second ranked priority projects would begin along with the establishment of a monitoring program to measure the impact of restoration activities on biota, habitats, and water quality as well as a focused identification of cause and effect relationships.
4. Year 4 through 8 - Work would continue on restoration activities in the plan. The monitoring information, causes and effects, potential negative impacts from restoration activities, as well as new projects that might be undertaken to restore the system would be evaluated. The working comprehensive plan would be updated during this phase to take advantage of lessons learned, successes, new cost analysis, and monitoring information obtained during the early years of the program.
5. Year 9 through 10 - All restoration activities accomplished would be evaluated with regard to conserving and restoring fish and wildlife and natural habitat. A final report, along with recommendations on restoration activities that could be utilized in other impacted riverine systems would also be prepared.

It is difficult to estimate the actual dollar costs of a restoration program for the Apalachicola River without a comprehensive plan or a detailed analysis of individual projects. However, initial cost estimates for potential projects listed in the last section are between $50 and $70 million. This would include the development of the plan, cost estimates for individual projects, permitting, restoration activities, monitoring studies, and a final report. This estimate does not include the cost of a regional disposal facility nor any costs associated with the final disposition of the material such as beach renourishment or offshore disposal options. It is conceivable that these costs could change depending on the actual projects selected for implementation during the development of the restoration plan.

Comprehensive Restoration Plan for the Apalachicola River

Any comprehensive plan developed by the multi-agency committee must address and include the following issues:

1. How to include and take advantage of restoration actions, results, and studies already authorized by Congress. These include:
   - An investigation of sloughs or tributaries in need of restoration that was authorized by Section 306 of theWater Resources Development Act of 1986. The study was completed, but the report requesting authorization for restoration activities and construction outside the boundaries of the navigation has not been submitted or approved by the Corps of Engineers (COE).
   - An investigation of the restoration of Poloway Cutoff that was authorized by the Water Resources Development Act of 1986. Authorization for construction and restoration has not been requested by the COE.
   - Specific funding that was authorized and appropriated, by the 2001 Energy and Water Appropriations, for the restoration of sloughs as required by the 1999 State of Florida Water Quality Certification to the COE.
   - The restoration or rejuvenation of Disposal Areas 38, 38A, 40, 43 and other within bank disposal areas, provided they can be used for continued disposal practices, were authorized and initial funds were appropriated by the 2002 Energy and Water Appropriations legislation.
2. Authorization for slough, tributary restoration activities outside or beyond the boundaries of the navigation should be provided by any restoration legislation. This may be as much as 1 mile beyond the navigation project boundaries. Authorization for the restoration of disposal areas should be provided without a requirement that they be available for continued use, with the exception of Disposal Area 40.
3. As part of this plan a large regional disposal sand storage facility must be identified and approved to store material in until its final disposition and removal from the system is accomplished. This would allow projects that only involve the removal of material to proceed without delay.
4. The restoration of the Apalachicola River should address the two primary causes for the entrenchment of the river channel and the significant increases in bank erosion; construction of the Jim Woodruff Dam and continued dredging of the river; and specific actions to correct or mitigate impacts associated with both.

5. Because of previous studies, authorizations, or information already available the scopes of work, cost estimates, permits, monitoring requirements, and contracting for some priority projects should be initiated during the first year of the program, even while the plan is undergoing development. These projects include the restoration of disposal areas 38, 39, 43, 45A, 47A, 48A, and 58; the opening up of the lower ends of Poloway and Battle Bend cutoffs, and the continued rejuvenation of disposal area 40. These are currently the highest ranked projects of those listed earlier.
6. During the first year of the development of a restoration plan, a study should be initiated that investigates the increases in channel-widening, channel- instability, and bank erosion rates. This study would:
    - Describe the probable causes and specific problems, by reach or section, and possible solutions to stop or reverse the instability or erosion rates.
    - Identify areas where restoration will naturally occur if maintenance activities change on the river.
    - Identify areas, i.e. point bars and slough openings, where minimal restoration activities will result in lasting benefits
    - Identify areas where major restoration activities will be required to correct identified problems or past disposal activities.
    - Identify areas where restoration is not possible
7. Further prioritization of the remaining projects, not mentioned above, as well as the addition of other needed projects would occur during the development of the plan. The plan would be updated continually during the program based on new information collected, monitoring studies, and lessons learned from restoration projects.
8. Information accumulated, restoration successes, and lessons learned would be utilized in the permitting process to help reduce impacts from the navigation channel as well as speed up the permitting process in the future.

Exhibit 32

GULF STURGEON (*Acipenser oxyrinchus desotoi*)

5-Year Review:
Summary and Evaluation

U.S. Fish and Wildlife Service
Southeast Region
Panama City Ecological Services Field Office
Panama City, Florida

National Marine Fisheries Service
Southeast Region
Office of Protected Resources
St. Petersburg, Florida

September 2009

GULF STURGEON (*Acipenser oxyrinchus desotoi*)
5-YEAR REVIEW

I. GENERAL INFORMATION

1.1. Methodology used to complete the review

A public notice initiating this review and requesting information was published on April 16, 2008, with a 60-day response period (73 FR 20702). The public notice was supplemented with a request for information by postcard dated April 17, 2008, mailed directly to 130 entities (individuals, natural resources agencies, conservation organizations) that could likely have information pertinent to this review. One (1) set of comments/data was received in response to the public notice and postcards, which was incorporated as appropriate into this 5-year review.

The lead recovery biologists for the NMFS and the FWS gathered and synthesized information regarding the biology and status of the Gulf sturgeon. Our information sources included:

- the Gulf Sturgeon Recovery/Management Plan (1995);
- peer-reviewed scientific publications;
- grey literature (annual reports);
- information presented at annual Gulf sturgeon meetings;
- ongoing field survey results and information shared from Gulf sturgeon researchers (both Service and State biologists);
- the final rule listing the Gulf sturgeon as threatened (56 FR 49653) (September 30, 1991); and
- the final rule designating critical habitat for the Gulf sturgeon (68 FR 13370) (March 19, 2003).

We submitted a peer-review draft of this document to 16 professional biologists with expertise on the Gulf sturgeon and its habitats. We provided written guidance to ensure that we relied upon the best available information and that we made sound conclusions based upon this information. Appendix B details how we addressed all comments received from peer reviewers.

All literature and documents used for this review are on file at the FWS Panama City Field Office and at the NMFS SERO.

1.2. Reviewers

1.2.1. NMFS

1.2.1.1. SERO (Southeast Regional Office)

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1.2.2.3. Regional Office
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1.2.3. Peer Reviewers
Jim Clugston, U.S. Geological Survey (retired)
Jared Flowers, North Caroline Cooperative Fish and Wildlife Research Unit
Dewayne Fox, Delaware State University
Alan Huff, Florida Fish and Wildlife Conservation Commission (retired)
Phil Kirk, U.S. Army Corps of Engineers
Bill Pine, University of Florida
Todd Slack, U.S. Army Corps of Engineers
Ken Sulak, U.S. Geological Survey

1.3. Background

1.3.1. FR Notice announcing initiation of this review:

April 16, 2008, 73 FR 20702

1.3.2.

1.3.3. Species status

1.3.3.1. NMFS

NMFS currently considers the status of the Gulf sturgeon as stable.

1.3.3.2. FWS

FY2009 recovery data call: stable. Seven riverine systems have evidence of reproducing populations, some variability in population size has been noted: 1) The Suwannee River population appears to be slowly increasing; 2) population size in the Escambia River system may have declined following a hurricane event; and, 3) hurricane effects to the populations within the Pearl and Pascagoula Rivers are unknown as research has been extremely limited in those systems since Hurricanes Ivan (2004) and Katrina (2005).

1.3.4. Recovery achieved

FWS assigns Gulf sturgeon a 2 out of 4 indicating 26-50% of recovery objectives have been achieved.

1.3.5. Listing history

Original Listing: 56 FR 49653
Date listed: September 30, 1991
Entity listed: subspecies
Classification: threatened

1.3.6. Associated rulemakings

The Services designated critical habitat for the Gulf sturgeon on March 19, 2003 (68 FR 13370).

1.3.7. Review history

This is the first 5-year review completed for the Gulf sturgeon. The Services completed a Recovery Plan in 1995. The FWS has internally responded to "Recovery Data Calls" (most recently in 2009). The Services have participated in exercises to review recovery progress in conjunction with annual Gulf sturgeon workshops since 1998.

1.3.8. Species' recovery priority number at start of review:

1.3.8.1. NMFS

NOAA Fisheries issued guidelines in 1990 (55 FR 24296) for assigning listing and recovery priorities. Three criteria are assessed to determine a species' priority for recovery plan development, implementation, and resource allocation: 1) magnitude of threat; 2) recovery potential; and 3) existing conflict with activities such as construction and development. NOAA Fisheries has fewer priority categories than FWS.

NMFS has assigned a recovery priority number of 8 out of 12 (a moderate degree of threat, low to moderate potential for recovery, and little conflict with economic activities) to the Gulf sturgeon. Additional rationale for this recovery number is provided in the 2006-2008 Biennial Report to Congress on the Recovery Program for Threatened and Endangered Species.

1.3.8.2. FWS

FWS has assigned a recovery number of 12 out of 18 (a subspecies with a moderate degree of threat and a low recovery potential) to the Gulf sturgeon (48 FR 43098).

The different priority rankings (NMFS and FWS) reflect FWS consideration of taxonomic criteria (genus, species, subspecies).

1.3.9. Recovery plan

Name of plan: Gulf Sturgeon (*Acipenser oxyrinchus desotoi*) Recovery/Management Plan.
Date issued: September 22, 1995 (this plan was signed by the NMFS, FWS, and Gulf States Marine Fisheries Commission).

2. REVIEW ANALYSIS

2.1. Application of the 1996 Distinct Population Segment (DPS) policy

2.1.1. Is the species under review a vertebrate?

Yes.

2.1.2. Is the species under review listed as a DPS?

No.

2.1.3. Is there relevant new information for this species regarding the application of the DPS policy?

Yes. Based on the best available information, the Services believe the current listing is valid. However, we have new information that indicates an analysis and review of the species should be conducted in the future to determine if the application of the Distinct Population Segment (DPS) policy could be appropriate for the Gulf sturgeon.

The 1995 Recovery Plan was completed before policies were issued by the Services on the treatment of DPSs under the Act (61 FR 4722; February 7, 1996). Currently there is a lack of information to separate the species into population segments in accordance with the DPS policy across various genetic/geographic subdivisions. However, the Services believe that additional data from ongoing genetics analyses and tagging studies may allow us to determine whether Gulf sturgeon DPSs are identifiable.

2.2. Recovery Criteria

2.2.1. Does the species have a final, approved recovery plan containing objective, measurable criteria?

Yes.

2.2.2. Adequacy of recovery criteria

2.2.2.1. Do the recovery criteria reflect the best available and most up-to date information on the biology of the species and its habitat?

No (see discussion in section 2.2.3).

2.2.2.2. Are all of the 5 listing factors that are relevant to the species addressed in the recovery criteria?

No. Although the tasks outlined in the 1995 Recovery Plan address threats relative to listing factors (e.g., habitat modification, overutilization, etc.), the Plan lacks criteria that would measure progress towards reducing these threats. The Services should develop such criteria in a revised recovery plan. We summarize new information about threats and progress towards reducing threats in section 2.3.2.

2.2.3. List the recovery criteria as they appear in the recovery plan and discuss progress.

1. ***Short-term Objective*** *– to prevent further reduction of existing wild populations of Gulf sturgeon within the range of the subspecies. This objective will apply to all management units within the range of the subspecies. Ongoing recovery actions will continue and additional actions will be initiated as needed.*

Criteria
A. Management units will be defined using an ecosystem approach based on river drainages. The approach may also incorporate genetic affinities among populations in different river drainages.

The criteria have been partially met through the Services' designation of Gulf sturgeon critical habitat in 2003 (68 FR68 13370). In the critical habitat rule we recognized seven extant reproducing populations that are associated with seven river drainages (Pearl, Pascagoula, Escambia, Yellow, Choctawhatchee, Apalachicola, and Suwannee). We noted that conservation of all seven populations was necessary to minimize the potential for inbreeding, to retain potentially important selective pressure at the margins of the species' range, and to provide a rescue effect between adjacent populations in the event of a local extirpation or a decline to extremely low numbers. We determined that physical and biological features within specific habitats occupied by these seven populations (seven riverine units and seven adjacent estuarine/marine units) are essential for the conservation of the species. Our current understanding of the biology of the Gulf sturgeon is still consistent with the findings of the critical habitat rule, but we realize that tagging and genetics data may provide a biological basis for dividing the Gulf sturgeon into two or more discrete population segments.

B. A baseline population index for each management unit will be determined by fishery independent catch-per-unit-effort (CPUE) levels.

This criteria has not been met. Recognizing the problems inherent with CPUE as a recovery monitoring metric in the years following completion of the 1995 Recovery Plan, the Services did not establish baseline CPUE indices as proposed in the Recovery Plan's recovery criteria. Researchers have instead gravitated towards mark-recapture models and age-structured population models (Morrow et al. 1999, Sulak and Clugston 1999, Pine et al. 2001, Pine and Allen 2005, Flowers 2008, Pine and Martell 2009). Researchers confirmed that high variability in CPUE was due to differences in the spatial distribution, sampling gear, deployment methods, and environmental conditions that affected sampling efficiency (e.g., tides, currents, bottom snags, floating debris, and winds), and sampling crew experience (K. Sulak, USGS, pers. comm.). We review the information that has emerged from these and other studies in section 2.3.1. This information suggests that some Gulf sturgeon populations are likely stable or slowly increasing, and that the Suwannee population is more rapidly increasing. The status of some Gulf sturgeon populations, particularly in the western portion of their geographic range, is unknown due to lack of recent survey.

C. Change from the baseline level will be determined by fishery independent CPUE over a three to five year period. This time frame will be sufficient to detect a problem and to provide trend information. The data will be assessed annually.

Currently, seven rivers are known to support reproducing populations of Gulf sturgeon. No population estimate has been made that would satisfy the recovery criteria of evaluating a change from baseline within statistically valid limits over a three to five year period. However, surveys continue on rivers throughout the range and population estimates have been developed using criteria other than CPUE as listed in Appendix A.

D. The short-term objective will be considered achieved for a management unit when the CPUE is not declining (within statistically valid limits) from the baseline level.

Gulf sturgeon researchers have recommended that population parameters estimated from mark-recapture methods be used instead of CPUE to monitor Gulf sturgeon recovery. Morrow et al. (1999) and Flowers (2008) both recommended incorporating a minimum population size into revised recovery criteria in addition to a stable or increasing population size trend.

2. ***Long-term Objective A*** *– to establish population levels that would allow delisting of the Gulf sturgeon by management units. Management units could be delisted by 2023 if required criteria are met. While this objective will be sought for all management units, it is recognized that it may not be achievable for all management units.*

Notably, management units are not listed entities under the ESA and therefore they cannot be de-listed. Rather, management units allow the Services to develop geographically specific recovery tasks that are appropriate to address unique threats to units smaller than the listed entity.

Criteria
A. The timeframe for delisting is based on known life history characteristics including longevity, late maturation, and spawning periodicity.

These criteria are still valid. New data support the previous conclusions that Gulf sturgeon are slow to recolonize areas that it formerly occupied, live long lives, have slow growth, and a high age at maturity. Restoration of the population age-structure will take many more years than previously thought.

B. A self-sustaining population is one in which the average rate of natural recruitment is at least equal to the average mortality rate over a 12-year period (which is the approximate age at maturity for a female Gulf sturgeon).

Currently, seven rivers are known to support reproducing populations of Gulf sturgeon. No population estimate has been made that would satisfy the recovery criteria to determine if the average rate of natural recruitment is at least equal to the average mortality rate over a 12-year period.

C. This objective will be considered achieved for a management unit when the population is demonstrated to be self-sustaining and efforts are underway to restore lost or degraded habitat.

The demographic recovery criteria in the 1995 Recovery Plan relied upon catch-unit-effort (CPUE) data, which has proven too variable to serve as a practical monitoring metric. Demographic parameters estimated from mark-recapture studies appear better suited for this purpose. Using the mark-recapture data, general estimates of population size at a riverine scale have recently been calculated (Appendix A). New information shows a roughly stable or slightly increasing population trend in eastern (Florida) river systems. The number of Gulf sturgeon in the Escambia River system may have recently declined due to hurricane impacts. The Suwannee River population appears to be slowly increasing. Due to lack of research since Hurricanes Ivan and Katrina, no data are available to determine the current size of the Gulf sturgeon populations in the western portion of the geographic range (i.e., Pearl and Pascagoula Rivers) of Gulf sturgeon.

3. *Long-term Objective B –* *to establish, following delisting, a self-sustaining population that could withstand directed fishing pressure within management units. Note that the objective is not necessarily the opening of a management unit to fishing, but rather, the development of a population that can sustain a fishery. Opening a population to fishing will be at the discretion of state(s) within whose jurisdiction(s) the management unit occurs. As with Long-term Objective A, the objective may not be achievable for all management units, but will be sought for all units.*

Criteria:
A. All criteria for delisting must be met.

This criteria remains valid; however, the delisting criteria need to be revised to accommodate a different method to determine demographic recovery criteria as CPUE is too variable of a metric.

B. This objective will be considered attained for a given management unit when a sustainable yield can be achieved while maintaining a stable population through natural recruitment.

Flowers (2008) describes how the historic overexploitation of Gulf sturgeon led to a change in the age-structure of the populations that reduced annual reproductive output. Given Gulf sturgeon life history characteristics such as long life, slow growth, and high age at maturity, restoration of the population age-structure will take many more years than previously thought.

C. Particular emphasis will be placed on the management unit that encompasses the Suwannee River, Florida, which historically supported the most recent stable fishery for the subspecies.

The Suwannee River population appears to be slowly increasing and may be regaining a semblance of its pre-exploitation age structure, with a shift from 10% mature individuals in 1996 to 40% in 2007 (presentation by K.Sulak, USGS at the 2008 Annual Gulf sturgeon meeting).

However, as previously noted, the ESA specifies that only species included on the list published in the Federal Register can be removed from such list (ESA Section 4(c)(2). Because the Gulf sturgeon as a species is on the published list (50 CFR 17) only that unit, and not the management unit, may be considered for de-listing.

2.3. Updated Information and Current Species Status

The 2003 rule designating critical habitat represents our most recent comprehensive review of information relevant to the conservation and status of the Gulf sturgeon. Therefore, the following is based largely upon data and literature compiled since 2003.

2.3.1. Biology and Habitat

2.3.1.1. New information on the species' biology and life history

Brooks and Sulak (2004 and 2005) described the distribution of Gulf sturgeon food resources in the Suwannee River estuary. They found that benthic infauna biomass was greater in the summer than in the winter, and that the spatial distribution of likely prey items was patchy (high in certain areas and low in others).

Additional studies examining Gulf sturgeon prey have been conducted based on Heard et al.'s (2000) assessment of the benthic macro invertebrate assemblages in Choctawhatchee Bay suggesting that ghost shrimp, *Lepidophthalmus louisianensis,* was an important food for Gulf sturgeon greater than 1 m in length. McLelland and Heard (2004, 2005) later analyzed the benthic macro-invertebrate assemblages from two sites off the northern Gulf of Mexico coast of Florida and Alabama where Gulf sturgeon were located by telemetry and believed to be foraging during winter. They reported in 2004 that annelids comprised the main group of organisms collected at both sites and with the exception of the high density of tube building polychaetes collected at the Alabama site, little difference in the benthic invertebrate populations was noted between the two sites. The density of benthic organisms did not substantially differ from 2004 to 2005. However, McLelland and Heard (2005) noted there were a few shifts in population structure: 1) an absence of the tube dwelling polychaete, *Hobsonia florida,* at the Alabama site that was predominate in 2004 and was replaced by the polychaete, *Mediomastusa ambiseta*; and 2) an increase in the number of mollusks with a decrease in arthropods at the Florida site. They speculated that the possible changes in the macro-invertebrate structure could reflect a response to increased nutrient loading from runoff or perhaps a physical shift due to the effects of Hurricane Ivan that made landfall in eastern Alabama in August 2004.

Edwards et al. (2003) tracked the movements of Gulf sturgeon in the Suwannee River estuary using ultrasonic tags and a fixed array of receivers. Tagged individuals displayed a pattern of directed slow, steady travel over several kilometers followed by periods of randomly directed travel. This pattern is consistent with a foraging strategy that is adapted to a patchy distribution of food resources by an animal that lacks advance knowledge of the location of the patches or an ability to detect the patches from afar. If applicable, this strategy may help to explain the regular detection of telemetry-tagged Gulf sturgeon from different natal river systems in the same marine foraging areas such as the nearshore islands. It is also possible that adults can learn the location of optimal foraging areas and revisit year after year. In a follow-up paper reporting results of satellite pop-up archival tags, Edwards et al. (2007) discussed mixing of Gulf sturgeon from different populations and overlap of winter habitat utilization. Similarly, in a multi-year study Ross et al. (2009) found Gulf sturgeon from both the Pascagoula and Pearl Rivers broadly overlap and use the shallow water along the Gulf barrier islands as foraging grounds in the winter. These marine habitats utilized by the Gulf sturgeon were all less than 7 m deep, generally well oxygenated, and with relatively clear water; bottom substrates were mostly coarse sand and shell fragments or fine sand (Ross et al. 2009). Also, Gulf sturgeon tagged in seven Florida panhandle river systems were monitored from Carrabelle, FL to Mobile Bay, AL during the winter period in the coastal waters of the Gulf of Mexico. Gulf sturgeon from different river systems were located occupying the same area of marine habitat.

Harris et al. (2005) also tracked the movements of Gulf sturgeon in the Suwannee River estuary using ultrasonic tags and sampled benthic infauna. Locations of tagged Gulf sturgeon were associated with sandy substrates and high abundances of known prey items. Gulf sturgeon individuals appeared to use different portions of the estuary in fall compared to spring.

Randall and Sulak (2007) estimated yearly recruitment of Gulf sturgeon using 19 years of mark-recapture data for the Suwannee River population. Recruitment was positively correlated with high flows in September and December. They suggested that higher survival of age-0 sturgeon may be related to increased availability of lower-salinity estuarine feeding habitats in wet years.

Similar to shortnose sturgeon, Randall and Sulak (2007) found some evidence to suggest a Gulf sturgeon fall spawning event in the Suwannee River. Limited data on both adult migration patterns and back-calculation to determine age of small fish indicate that a second spawning event may be occurring.

Flowers et al. (in-review) utilized field data from the Suwannee and Apalachicola Rivers to assess bioenergetics of Gulf sturgeon. Using length-at-age incremental growth data from mark-recapture studies, similar bioenergetic parameter estimates were found, except for slight differences in growth between males from the Suwannee River. Given the common homogenous near-shore foraging areas utilized by the Gulf sturgeon, similarities in energy uptake and metabolism across the species are not unexpected.

2.3.1.2. Abundance, population trends, demographic characteristics

Currently, seven rivers are known to support reproducing populations of Gulf sturgeon. No population estimate has been made that would satisfy the recovery criteria of evaluating a change from baseline within statistically valid limits over a three to five year period or an assessment to determine if the average rate of natural recruitment is at least equal to the average mortality rate over a 12-year period. The demographic recovery criteria in the 1995 Recovery Plan relied upon catch-unit-effort (CPUE) data, which has proven too variable to serve as a practical monitoring metric. Demographic parameters estimated from mark-recapture studies appear better suited for this purpose. Using the mark-recapture data, general estimates of population size can be calculated. Although variable, most populations appear relatively stable with a few exceptions (Appendix A). The number of Gulf sturgeon in the Escambia River system may have recently declined due to hurricane impacts, and the Suwannee River population appears to be slowly increasing. Due to lack of research since Hurricanes Ivan and Katrina, no data are available to determine the current size of the Gulf sturgeon populations within the Pearl and Pascagoula Rivers.

Research on Gulf sturgeon population characteristics in the past 5 years has been limited to the eastern five populations. The FWS Panama City Field Office has annually monitored one or more of the four Florida Panhandle rivers (Escambia, Yellow, Choctawhatchee, and Apalachicola) since 2003 (fiscal year annual reports USFWS 2003-2008). USGS researchers completed the first assessment of the Yellow River population (Berg 2004, Berg et al. 2007). Advances in modeling population dynamics have been made, especially for the Apalachicola and Suwannee River populations (Flowers 2008, Pine and Martell 2009).

Results of surveys to assess abundance of Gulf sturgeon within the 7 river drainages with known reproducing populations are summarized in Appendix A. Estimates listed refer to numbers of individuals greater than a specified size, which varies depending on sampling gear, and in some cases, to numbers of individuals that use a particular portion of the river (e.g., a summer holding area or one migratory pathway among several). Therefore, the estimates are not a reliable source to determine trends as frequently studies and years are not directly comparable due to key differences in methods and assumptions. Multiple estimates for a single year and river result from the application of multiple models or represent updated results incorporating additional data. Recently, new studies have been initiated in the western range of the species (Pearl and Pascagoula Rivers), but results are not yet available for this review.

Mark-recapture studies have confirmed the general fidelity of individual Gulf sturgeon returning to particular rivers (NOAA and USFWS 2003), presumably their natal rivers. Gulf sturgeon reproduction is not known to currently occur in several basins (e.g., Mobile Basin) where it most likely occurred historically. A recent survey collected two Gulf sturgeon in Mobile Bay near Fairhope, AL (Mettee et al. 2009) after intensive netting. In addition to slowly recolonizing its former range, insights have emerged from population models in recent years suggesting that Gulf sturgeon life history characteristics also render the species slow to recover in abundance within its current range. Working with data from the Suwannee River population, Pine et al. (2001) identified three parameters (i.e., egg-to-age-1 mortality, the percentage of females that spawn annually, and adult mortality) as those most sensitive in determining the trajectory of population size. Pine et al. (2001) predicted that slight increases in estimated annual adult mortality (from 16% to 20%) would shift the population from an increasing trend into a decline. Flowers (2008) used an age-structured model to conclude that the Apalachicola population is probably slowly recovering, but still needs many years before returning to anywhere near its pre-exploitation abundance. Sulak (2008 Gulf sturgeon workshop) reported an analysis of mark-recapture data for the Suwannee River that suggests this population is regaining a semblance of its pre-exploitation age structure, with a shift from 10% mature individuals in 1996 to 40% in 2007.

Given the variety in methods, Gulf sturgeon population estimates are relatively imprecise, with more than half of the confidence intervals reported (Appendix A) exceeding 65% of the value reported in the third column. This is perhaps owing to the low capture/recapture probabilities associated with sampling this species, which was estimated to be < 10% using closed-system models by Zehfuss et al. (1999), although another researcher argues that recapture rates for Gulf sturgeon are consistently high (K. Sulak, USGS, peer review comments on draft of this document). Although the trends may not be statistically significant, these surveys indicate a roughly stable or a slowly increasing trend in number of individuals at a riverine population scale. It is not necessary in this review to compare and contrast the methods of these various studies; however, the many differences suggest a need to standardize data reporting so that a clearer picture of range-wide status becomes possible. Along similar lines, an online reference database including tag numbers and telemetry frequencies for all researchers would facilitate the rapid recognition of inter-river movements and the rapid notification of interception.

Flowers (2008) describes the rapid decline in Gulf sturgeon landings as likely reflective of rapid erosion of the population age-structure of the large, older, highly fecund individuals being removed which led to a rapid change in the age-structure of the population and thereby reducing annual reproductive output and population recovery. Using several formulations (varying key input parameters, such as annual natural mortality) of an age-structured mark-recapture model (ASMR), Pine and Martell (2009) analyzed all available Gulf sturgeon sampling data collected since the late 1970's for the Apalachicola and Suwannee Rivers. For the Apalachicola River data, the models generally estimated population sizes (age 1+ Gulf sturgeon) of less than 500 individuals in the early 1980's, which increased to about 2,000 fish in 2005. These estimates are substantially higher than for other non-age-structured models. This is partly because estimates from Pine and Martell (2009) include younger age-classes than those included in Zehfuss et al. (1999). Despite key differences in input data and model assumptions, a general trend of gradually increasing abundance is apparent in the Apalachicola River. Similarly, for the Suwannee River data, the ASMR models estimated abundance in the early 1980's of about 3,000 age 1+ sturgeon, increasing to about 10,000 in 2004. These estimates are higher than the abundance estimates from Chapman or Sulak, for similar reasons as in the Apalachicola River analyses. Pine et al. (2001) found a positive population growth of about 5% annually for adults within the Suwannee River Gulf sturgeon population, and therefore in number to about 10,000 individuals in 2004.

2.3.1.3. Taxonomic classification or changes in nomenclature

No changes.

2.3.1.4. Spatial distribution, trends in spatial distribution

Historically, Gulf sturgeon occurred from the Mississippi River east to Tampa Bay. Sporadic occurrences were recorded as far west as the Rio Grande River in Texas and Mexico, and as far east and south as Florida Bay (Wooley and Creteau 1985, Reynolds 1993). The sub-species' present range extends from Lake Pontchartrain and the Pearl River system in Louisiana and Mississippi respectively, east to the Suwannee River in Florida. The species is anadromous: feeding in the winter months in the marine waters of the Gulf of Mexico including bays and estuaries, migrating in the spring up freshwater rivers to spawn on hard substrates, and then spending summers in the lower rivers before emigrating back out into estuarine/marine waters in the fall.

Researchers have conducted telemetry studies in all seven river systems. These studies have substantially advanced our understanding of Gulf sturgeon locations during their migrations between riverine, estuarine, and marine habitats. Gulf sturgeon travel great distances to use specific areas for spawning in the spring, for "holding" in the summer and fall, and for feeding in the winter. With the deployment of fixed-location telemetry receivers in the estuarine and marine environments, a picture of the behavior of age 3+ Gulf sturgeon is emerging of individual fish traveling relatively quickly between areas where they spend an extended period of time (Edwards et al. 2003, Edwards et al. 2007, Randall 2008). To date, published research directed at age 0-2 individuals has been limited to the Suwannee River population by Sulak and Clugston (1998 and 1999). Young-of-year (YOY) individuals have been found to disperse widely downstream of spawning sites, while sometimes traveling upstream of known spawning sites (Clugston et al. 1995, Sulak and Clugston 1999), and eventually arriving in estuarine feeding areas in winter months.

Sub-adult and adult Gulf sturgeon overwintering in Choctawhatchee Bay were generally found to occupy the sandy shoreline habitat at depths of 2-3 m (Fox *et al* 2001, Parauka *et al* 2001).

The 1995 Recovery Plan devotes a paragraph to the possible importance of springs and other cool water refugia to Gulf sturgeon within the riverine environment. Sulak et al. (2007) examined temperature, prey availability, and summer movements of Gulf sturgeon in the Suwannee River and concluded that temperature and prey availability did not explain Gulf sturgeon selection of summer holding areas. Hightower et al. (2002) also found that water temperatures in holding areas where Gulf sturgeon were repeatedly found in the Choctawhatchee River were similar to temperatures where sturgeon were only occasionally found elsewhere in the river. While the factor responsible for concentrating Gulf sturgeon within small areas is unknown, it may be refuge from high-velocity currents.

Many researchers have improved our knowledge of sturgeon movement and habitat use. Rogillio et al. (2007) and Ross et al. (2009) both documented use of barrier-island passes in Mississippi Sound and the Chandeleur Islands for winter feeding. Spawning and associated movement patterns in the Pascagoula River were described by Heise et al. (2004, 2005). The FWS discovered near-shore areas of concentrated feeding activity for adults from multiple riverine systems in the waters near Tyndall Air Force Base/Panama City Beach , FL, and Perdido, FL to Gulf Shores, AL (USFWS 2002, 2003, 2004, 2005, and 2006). Spawning sites were verified by egg collection on the Apalachicola River, FL (USFWS 2006a, Pine et al. 2006, Scollan and Parauka 2008), and the Yellow River, FL (Kreiser et al. 2008). Juvenile movements in the Apalachicola River, and Apalachicola Bay, FL were traced by Randall (2008). In June 2009, the U.S. Army Corps of Engineers (Corps) collected three YOY Gulf sturgeon in the Brothers River, a tributary to the Apalachicola River (P. Kirk, USCOE, pers. com.). Adult Gulf sturgeon were observed in a previously unreported tributary, the Withlacoochee River, FL (Suwannee River tributary), in the fall of 2005 (E. Nagid, FFWC, November 2005 Gulf sturgeon Workshop) and in May 2006 (G. Warren, FFWC Apalachicola, pers. com.). Trophic habitat in the estuary of the Suwannee River, FL was described by Sulak et al. (2009). Juveniles (estimated age 8-9 months) were collected in the Santa Fe River, FL in December 2006 (Flowers and Pine 2008); this observation is significant, because the Santa Fe is not known to support spawning and it is not known if the juveniles were spawned there or searching for habitat. Additional information was gained on feeding habits and movements in the estuary of the Suwannee River, FL (Harris 2003, Harris et al. 2005). Parkyn et al. (2007) described overall seasonal movements in the Suwannee River, FL drainage.

Reproducing populations continue to be evident in seven river systems. At a riverine scale, no estimate of the number of Gulf sturgeon has been calculated that would satisfy the recovery criteria to consider a change from the threatened listing status. Most population estimates have a high degree of statistical uncertainty (i.e., large confidence intervals) and many do not provide data over the three to five year period required to determine if the average rate of natural recruitment is at least equal to the average mortality rate over a 12-year period. Further, the demographic recovery criteria in the 1995 Recovery Plan relied upon catch-unit-effort (CPUE) data, which has proven too variable to serve as a practical monitoring metric. The Services believe that demographic parameters estimated from mark-recapture studies appear better suited for this purpose as general estimates of population size can be made. Although population size of Gulf sturgeon is variable across their range, most populations appear to be relatively stable in number (Appendix A).

2.3.2. ESA Definitions/Listing Determinations

The ESA provides the following definitions:

"endangered species" is defined as "any species which is in danger of extinction throughout all or a significant portion of its range."

"threatened species" is defined as "any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range."

The process for determining whether a species (as defined above) should be listed is based upon the best available scientific and commercial information. The status is determined from an assessment of factors specified in section 4 (a)(1) of the ESA that may be contributing to decline, including:
(A) The present or threatened destruction, modification, or curtailment of its habitat or range;
(B) Overutilization for commercial, recreational, scientific, or educational purposes;
(C) Disease or predation;
(D) Inadequacy of existing regulatory mechanisms; or
(E) Other natural or manmade factors affecting the continued existence of the species.

Based on the information in the preceding section, the Services believe the Gulf sturgeon continues to meet the definition of a threatened species given: 1) the highly variable abundance estimates limited to riverine populations in the east of the sub-species' range, coupled with the unknown status of western populations; 2) results of population modeling that indicate slight increases in annual mortality would quickly shift trends from increasing to decreasing; 3) the unknown age-structure of all but two populations; 4) their long-lived, slow growing and late maturing life history characteristics; and 5) unknown population bottlenecks and overwintering habitats.

The best available information does not indicate that Gulf sturgeon are currently in danger of extinction. The geographic range of the species is not known to have been truncated. Seven riverine systems continue to have evidence of reproducing populations. New information shows a roughly stable or slightly increasing population trend in the eastern (Florida) systems; however, population size and structure of some populations, particularly in the western part of the range, is unknown due to lack of recent survey.

2.3.3. Five-Factor Analysis

Under each factor, we note the impacts and threats that were analyzed in the 1991 listing rule, followed by observations about new threats and progress at relieving threats.

2.3.3.1. Present or threatened destruction, modification or curtailment of its habitat or range

The 1991 listing rule cited the following impacts and threats:

- Dams on the Pearl, Alabama, and Apalachicola rivers; also on the North Bay arm of St. Andrews Bay.
- Channel improvement and maintenance activities: dredging and de-snagging.
- Water quality degradation.
- Contaminants.

New observations:

2.3.3.2. Habitat – dams

All of the dams noted in the listing rule continue to block passage of Gulf sturgeon to historical spawning habitats and thus either reduce the amount of available spawning habitat or entirely impede access to it. Since Gulf sturgeon were listed, several new dams have been proposed on rivers that support Gulf sturgeon (Table 1). Effects of these dams on Gulf sturgeon and their habitat continues to be investigated as well as potential mitigating factors, including assessing the effects of dam operations, on downstream habitats. A short summary of these efforts follows.

Biologists from Clemson University, Georgia Department of Natural Resources, FWS, NMFS, and the Corps are investigating the feasibility of fish passage at Jim Woodruff Lock and Dam on the Apalachicola River (Isely et al. 2005 – workshop presentation). While Gulf sturgeon do not appear to enter the lock, Alabama shad and striped bass have utilized the lock to pass upstream. At this time, it is still unclear whether upstream sturgeon passage through the lock is feasible and if passage would result in a conservation benefit to the Gulf sturgeon. A study using hatchery-reared Gulf sturgeon tagged and released above the Dam into Lake Seminole found that some fish passed downstream into the Apalachicola River, possibly through the navigation lock, while others remained in the reservoir (Weller 2002). None of the tagged fish were observed to travel upstream to areas of potential spawning habitats.

Two dams, Pools Bluff and Bogue Chitto Sills, also impact Gulf sturgeon movements in the Pearl River drainage. Upstream passage is likely possible over these structures during some flow conditions, but the extent to which passage occurs is still unknown. New studies to survey the Pearl River for Gulf sturgeon and track movements began in summer 2009 (S. Bolden, NMFS, pers. com).

The effects on Gulf sturgeon from the Corps' operation of Federal dams and reservoirs in the Apalachicola River basin were assessed in recent biological opinions (USFWS 2006a, 2007, and 2008). The latest of these opinions concluded that some lethal take of Gulf sturgeon eggs or larvae could occur under certain circumstances of rapidly declining river stages during the spawning season. Based on further analysis of flow records and operational practices, the Corps determined that it appears feasible to operate the system in a manner that would avoid take of eggs and larvae in most, if not all, circumstances (USACE 2009). Flowers et al. (in press) examined the possibility of reduced recruitment associated with low flows in the Apalachicola River system and suggested that decreased spawning habitat availability could prolong population recovery or reduce population viability.

Except for the proposed dams on the Pearl River and the Yellow River, the dams listed in Table 1 would be constructed upstream of both designated Gulf sturgeon critical habitat and areas known to be inhabited by Gulf sturgeon. However, if constructed these dams/reservoirs could alter flow, channel morphology, and water quality well downstream and within designated critical habitat.

Table 1. Summary of dams proposed within the geographic range of the Gulf sturgeon by river drainage.

Drainage Basin	State	Stream	Notes
Pearl	MS	Mainstem	Proposed LeFleur Lakes reservoir near Jackson, MS, in vicinity of possible sturgeon spawning area.
Escambia/Conecuh	AL	Murder Creek	Proposed reservoir site is on a tributary that joins the Conecuh River near a known summer resting area for sturgeon.
Escambia/Conecuh	AL	Big Escambia Creek	Proposed reservoir site is on a tributary that joins the Escambia River near the FL/AL border.
Choctawhatchee	AL	Little Choctawhatchee River	Proposed reservoir site is on a tributary that joins the Choctawhatchee River upstream of known spawning sites.
Yellow	FL	Mainstem	Feasibility study completed by Corps for proposed site near Milligan, FL. Dam would impede passage to known spawning site upstream in AL.
Apalachicola	GA	Various	There have been various proposals for new water supply reservoirs, all upstream of the Jim Woodruff Dam on the FL/GA border.

In summary, access to historic Gulf sturgeon spawning habitat continues to be blocked by existing dams and the ongoing operations of these dams also effect downstream habitat. Several new dams are being proposed that would increase these threats to the Gulf sturgeon and its habitat. Dams continue to impede access to upstream spawning areas, and continue to adversely affect downstream habitat including both spawning and foraging areas.

2.3.3.3. Habitat – dredging

Riverine, estuarine, and coastal navigation channels are often dredged to support commercial shipping and recreational boating. Dredging activities can pose significant impacts to aquatic ecosystems by: 1) direct removal/burial of organisms; 2) turbidity/siltation effects; 3) contaminant re-suspension; 4) noise/disturbance; 5) alterations to hydrodynamic regime and physical habitat; and 6) loss of riparian habitat (Chytalo 1996, Winger et al. 2000). The direct lethal effects to Gulf sturgeon resulting from interaction with dredges is discussed later in Section 2.3.3.12.

Dredging operations may also destroy benthic feeding areas, disrupt spawning migrations, and re-suspend fine sediments causing siltation over required substrate in spawning habitat. Because Gulf sturgeon are benthic omnivores, the modification of the benthos affects the quality, quantity, and availability of prey.

Maintenance dredging for the navigation channel on the Apalachicola River last occurred in 2001. Although the channel is still authorized as a Federal navigation project, the State of Florida denied the Corps' application for water quality certification in 2005 (letter dated October 11, 2005 from FDEP Secretary Colleen Castille to Curtis Flakes, USACE). It appears unlikely that periodic or routine dredging in the inland waterway would resume in the foreseeable future. However, occasional maintenance dredging near the mouth of the Apalachicola River still occurs for that segment, which is part of the Gulf Intra-Coastal Waterway.

Maintenance dredging occurs regularly in numerous navigation channels that traverse the bays, passes, and river mouths of all seven river drainages that are used by Gulf sturgeon. Most of this dredging occurs within designated Gulf sturgeon critical habitat and may modify foraging habitat as well as causing injury or killing Gulf sturgeon.

In summary. dredging and disposal to maintain navigation channels, and removal of sediments for beach renourishment occurs frequently and throughout the range of the Gulf sturgeon and within designated Gulf sturgeon habitat annually. This activity has, and continues to threaten the species and affect its designated critical habitat.

2.3.3.4. Habitat – point and non-point discharges

Evaluations of water and sediment quality in Gulf Sturgeon habitat on the northern Gulf of Mexico coast, have consistently shown elevated pollutant loading. This has been observed in both tidal coastal rivers of the type that the sturgeon use in the spring and summer (Hemming et al. 2006, 2008). Perhaps better understood is the widespread contamination throughout the overwintering feeding habitat of the Gulf sturgeon (Brim 1998, 2000, NWFWMD 1997, 1998, 2000, 2002, Hemming 2002, 2003a, 2003b, 2004, 2007). Although the specific effects of these widely varied pollutants on sturgeon in their various life stages is not clearly understood, there is ample evidence summarized below to show potential deleterious effects to Gulf sturgeon and their habitat.

Sulak et al. (2004) suggest that successful egg fertilization for Gulf sturgeon may require a relatively narrow range of pH and calcium ion concentration. These parameters vary substantially along the length of the Suwannee River. Egg and larval development are also vulnerable to various forms of pollution and other water quality parameters (e.g., temperature, dissolved oxygen (DO)).

Potential threats to Gulf sturgeon critical habitat were documented in the upper Choctawhatchee and lower Pea Rivers (Popp and Parauka 2004, Newberry and Parauka in press). Potential habitat threats were identified based on degraded habitat characteristics, such as erosion, riparian condition, presence of unpaved roads, and presence of agriculture.

Pollution from industrial, agricultural, and municipal activities is believed responsible for a suite of physical, behavioral, and physiological impacts to sturgeon worldwide (Karpinsky 1992, Barannikova 1995, Barannikova et al. 1995, Khodorevskaya et al. 1997, Bickham et al. 1998, Khodorevskaya and Krasikov 1999, Billard and Lecointre 2001, Kajiwara et al. 2003, Agusa et al. 2004). Although little is known about contaminant effects on Gulf Sturgeon, a review estimating potential reactions has been performed (Berg 2006). It was found that loss of habitat associated with pollution and contamination has been documented for sturgeon species (Verina and Peseridi 1979, Shagaeva et al. 1993, Barannikova et al. 1995). Specific impacts of pollution and contamination on sturgeon have been identified to include muscle atrophy, abnormality of gonad, sperm and egg development, morphogenesis of organs, tumors, and disruption of hormone production (Graham 1981, Altuf'yev et al. 1992, Dovel et al. 1992, Georgi 1993; Romanov and Sheveleva 1993, Heath 1995, Khodorevskaya et al. 1997, Kruse and Scarnecchia 2002). The extreme of this situation can be observed in the Caspian Sea, likely the most polluted sturgeon habitat in the world. Researchers there have suggested that nearly 90% of sturgeon suffer from organ pathologies and decreased physiological condition associated with sub-lethal levels of pollution (Veshchev 1995, Akimova and Ruban 1996, Luk'yanenko et al. 1999, Kajiwara et al. 2003). In addition, nearly 20% of the female sturgeon experience some impact to egg development. Although there has been a reduction in pollution export into the Caspian Sea, the severity of past pollution and nature of the pollutants ensure their presence in the sediments, water column, and tissues of organisms will continue.

More recently, pharmaceuticals and other endocrinologically active chemicals have been found in fresh and marine waters at effective concentrations (reviewed in Fent *et al.* 2006). These compounds enter the aquatic environment via wastewater treatment plants, agricultural facilities, and farm runoff (Folmar et al. 1996, Culp et al. 2000, Wildhaber et al. 2000, Wallin et al. 2002). These products are the source of both natural and synthetic substances including, but not limited to, polychlorinated biphenyls, phthalates, pesticides, heavy metals, alkylphenols, polycyclic aromatic hydrocarbons, 17β-estradiol, 17α-ethinylestradiol, and bisphenol A (Pait and Nelson 2002, Aguayo et al. 2004, Nakada et al. 2004, Iwanowicz et al. 2009, Björkblom et al. 2009). The impact of these exposures on Gulf sturgeon is unknown, but other species of fish are affected in rivers and streams. For example, one major class of endocrine disrupting chemicals, estrogenic compounds, have been shown to affect the male to female sex ratio in fish in streams and rivers via decreased gonad development, physical feminization, and sex reversal (Folmar et al. 1996). Settlement of these contaminants to the benthos may affect benthic foragers to a greater extent than pelagic foragers due to foraging strategies (Geldreich and Clarke 1966).

Several characteristics of the Gulf sturgeon (i.e., long lifespan, extended residence in riverine and estuarine habitats, benthic predator) predispose the species to long-term and repeated exposure to environmental contamination and potential bioaccumulation of heavy metals and other toxicants. Chemicals and metals such as chlordane, DDE, DDT, dieldrin, PCBs, cadmium, mercury, and selenium settle to the river bottom and are later incorporated into the food web as they are consumed by benthic feeders, such as sturgeon or macroinvertebrates. Some of these compounds may affect physiological processes and impede the ability of a fish to withstand stress, while simultaneously increasing the stress of the surrounding environment by reducing DO, altering pH, and altering other water quality properties.

While laboratory results are not available for Gulf sturgeon, signs of stress observed in shortnose sturgeon exposed to low DO included reduced swimming and feeding activity coupled with increased ventilation frequency (Campbell and Goodman 2004). Niklitschek (2001) observed that egestion levels for Atlantic and shortnose sturgeon juveniles increased significantly under hypoxia, indicating that consumed food was incompletely digested. Behavioral studies indicate that Atlantic and shortnose sturgeon are quite sensitive to ambient conditions of oxygen and temperature: in choice experiments juvenile sturgeons consistently selected nomoxic over hypoxic conditions (Niklitschek 2001). Beyond escape or avoidance, sturgeons respond to hypoxia through increased ventilation, increased surfacing (to ventilate relatively oxygen-rich surficial water), and decreased swimming and routine metabolism (Nonnette et al. 1993, Crocker and Cech 1997, Secor and Gunderson 1998, Niklitschek 2001).

The majority of published data regarding contaminants and sturgeon health are limited to reports of tissue concentration levels. While these data are useful and allow for comparison between individuals, species, and regions, they do not allow researchers to understand the impacts of the concentrations. There is expectation that Gulf sturgeon are being negatively impacted by organic and inorganic pollutants given high concentration levels (Berg 2006). Gulf sturgeon collected from a number of rivers between 1985 and 1991 were analyzed for pesticides and heavy metals (Bateman and Brim 1994); concentrations of arsenic, mercury, DDT metabolites, toxaphene, polycyclic aromatic hydrocarbons, and aliphatic hydrocarbons were sufficiently high to warrant concern. More recently, 20 juvenile Gulf sturgeon from the Suwannee River, FL, exhibited an increase in metals concentrations with an increase in individual length (Alam et al. 2000).

Federal and state water quality standards are protective of most taxa in many habitats. However, impacts of reduced water quality continue to be realized at species-specific, and habitat-specific scales and magnification through the trophic levels continues to be assessed. The result is that current water quality standards are not always protective of federally listed species (Augsburger et al. 2003, Augsburger et al. 2007). To compound the issue, many previously identified water quality problems as realized through violation of state water quality standards are addressed through the necessarily slow and deliberate process of regulated point, and non-point source, pollutant load reductions (Total Maximum Daily Loads, TMDLs) for chemicals that have specific quality criteria. Because there are thousands of chemicals interacting in our natural environment, many of them of human design, many do not have Federal or state water quality standards associated with them. Further, effects of most of these chemicals on the Gulf sturgeon or other protected species are poorly understood. For these reasons point and non-point discharges to the Gulf sturgeon's habitat continue to be a threat.

2.3.3.5. Habitat – climate change

Climate change has potential implications for the status of the Gulf sturgeon through alteration of its habitat. The Intergovernmental Panel on Climate Change (IPCC 2007) concluded that it is very likely that heat waves, heat extremes, and heavy precipitation events over land will increase during this century. Warmer water, sea level rise and higher salinity levels could lead to accelerated changes in habitats utilized by Gulf sturgeon. Saltwater intrusion into freshwater systems could negatively impact freshwater fish and wildlife habitat (FWC 2009) resulting in more saline inland waters that may eventually lead to major changes in inland water ecosystems and a reduction in the amount of available freshwater. Changes in water temperature may alter the growth and life history of fishes, and even moderate changes can make a difference in distribution and number (FWC 2009). Freshwater habitats can be stressed by changes in both water quality and levels because of anticipated extreme weather periods as mean precipitation is expected to decrease along with an increase in precipitation intensity. Both droughts and floods could become more frequent and more severe, which would affect river flow, water temperature, water quality, channel morphology, estuarine salinity regimes, and many other habitat features important to the conservation of Gulf sturgeon.

A rise in water temperature may create conditions suitable for invasive and exotic species. Higher water temperatures combined with increased nutrients from storm runoff may also result in increased invasive submerged and emergent water plants and phytoplankton which are the foundation of the food chain (FWC 2009). New species of freshwater fishes may become established with warmer water temperatures (FWC 2009). The rate that climate change and corollary impacts are occurring may outpace the ability of the Gulf sturgeon to adapt given its limited geographic distribution and low dispersal rate.

2.3.3.6. Overutilization for commercial, recreational, scientific, or educational purposes

All directed fisheries of Gulf sturgeon have been closed since 1972 in Alabama, 1974 in Mississippi, 1984 in Florida, and 1990 in Louisiana (USFWS 1995). Overutilization due to directed harvest is no longer a threat. Although confirmed reports are rare, it is still a common opinion among Gulf sturgeon researchers that possibly significant Gulf sturgeon mortality occurs as bycatch in fisheries directed at other species. Berg et al. (2004) noted finding a dead juvenile Gulf sturgeon on a trot line in the Blackwater River. We discuss the bycatch issue in greater detail under section 2.3.2.8 as a regulatory issue.

2.3.3.7. Disease or predation

No additional information regarding the threat of disease or predation is available.

2.3.3.8. Inadequacy of existing regulatory mechanisms

Direct take of Gulf sturgeon is still prohibited in all four states within the current range of the species. However, fisheries directed at other species that employ various trawling and entanglement gear in areas that sturgeon regularly occupy pose a risk of incidental bycatch. One such fishery is directed at gars (family Lepisosteidae) in southeast Louisiana, where Gulf sturgeon mortality in entanglement gear has been observed (D. Walther, USFWS, pers. comm.). Louisiana Wildlife and Fisheries Commission staff proposed a ban on commercial netting freshwater areas of southeast Louisiana (the Florida Parishes which include East Baton Rouge, East Feliciana, West Feliciana, Livingston, St. Helena, St. Tammany, Tangipahoa, and Washington) in September 2006. The ban was intended to reduce the incidental bycatch of Gulf sturgeon. The resolution was not adopted.

Relocation trawling associated mostly with channel dredging and beach nourishment projects, which was initially intended to remove sea turtles in close proximity to dredges, has successfully moved several Gulf sturgeon in recent years. Between January 2005 and April 2006 relocation trawling captured and successfully moved two Gulf sturgeon near Mobile Bay, AL: 5 near Gulf Shores, AL, 1 near Destin, FL, and 8 near Panama City Beach, FL. These captures in near-shore waters illustrate the relative vulnerability of Gulf sturgeon to incidental bycatch in fisheries that use trawls. Bycatch in shrimp trawls has been documented but has likely been mitigated by sea turtle and fish excluder devices. However, informal conversations with shrimpers suggest that Gulf sturgeon are commonly encountered in Choctawhatchee Bay during nocturnal commercial fishing (D. Fox. Delaware State Univ., pers. com.).

Amendment Three of the Florida Constitution, known as the net ban, was approved by voter referendum in November 1994 and implemented in July 1995. The amendment was implemented in July 1995 and made unlawful the use of entangling nets (i.e., gill and trammel nets) in Florida waters. Other forms of nets (i.e., seines, cast nets, and trawls) were restricted, but not totally eliminated. For example, these types of nets could be used only if the total area of net mesh did not exceed 500 square feet. Implementation of the net ban has likely benefited sturgeon as they are residents of near-shore waters during much of their life span.

Florida's net ban has likely benefited or accelerated Gulf sturgeon recovery. Gulf sturgeon commonly occupy estuarine and coastal habitats where entangling gear was commonly used. Capture of small Gulf sturgeon in mullet gill nets was documented by state fisheries biologists in the Suwannee River fishery in the early 1970s. Large mesh gill nets and runaround gill nets were the fisheries gear of choice in historic Gulf sturgeon commercial fisheries. Absence of this gear in Florida eliminates it as a potential source of mortality of Gulf sturgeon.

Although a number of steps have been taken to reduce the potential for Gulf sturgeon to be incidentally caught by anglers or commercial operations, existing regulatory mechanisms are inadequate to prevent take of adult Gulf sturgeon due to fishing bycatch. Because the loss of a few reproducing adults directly affects population size and growth, inadequately regulated bycatch continues to be a threat.

2.3.3.9. Other natural or manmade factors affecting its continued existence

The 1991 listing rule cited the following impacts and continuing threats:

- Life history characteristics make the species slow to recolonize areas from which extirpated.
- Threat of hybridization with white sturgeon (*A. transmontanus*).

2.3.3.10. Life history characteristics and population growth

As described in Section 2.3.1.2, all new data support the previous conclusion that Gulf sturgeon are slow to recolonize areas where it was formerly found such as the Mobile River system. In addition, population growth has been shown to be very slow. Sulak (2008 Gulf sturgeon workshop) reported that it has taken nearly 100 years for the Suwannee River population to regain a semblance of its age structure prior to exploitation (early 1900's), with a shift from 10%

mature individuals in 1996 to 40% in 2007. However, recent population models for the Suwannee River population (Pine et al. 2001) predicted that slight increases in estimated annual adult mortality (from 16% to 20%) would shift the population from an increasing trend into a decline. Using an age-structured model, (Flowers 2008) concluded that the Apalachicola River population is probably slowly recovering, but will take in excess of 100 years from the time of fishery closure to reach is pre-exploitation abundance. Although we are learning more about the population structure, there continues to be a number of uncertainties requiring additional research.

2.3.3.11. Dredging

Hydraulic dredges (e.g., hopper) can lethally harm sturgeon directly by entraining sturgeon in dredge drag arms and impeller pumps. Mechanical dredges have also been documented to kill shortnose, Atlantic, and Gulf sturgeon (Dickerson 2005). Potential impacts from hydraulic dredge operations may be avoided by imposing work restrictions during sensitive time periods (i.e., spawning, migration, staging, feeding) when sturgeon are most vulnerable to mortalities from dredging activity. When possible, it is best to schedule dredging when sturgeon are not likely to be in the project area.

Dickerson (2005) summarized observed takings of 24 sturgeon from dredging activities conducted by the Corps and observed between 1990 and 2005 (2 Gulf; 11 shortnose; and 11 Atlantic). Of the three types of dredges included (hopper, clam and pipeline) in the report, hopper dredges captured the most sturgeon. Notably, reports include only those limited trips when an observer was on board to document capture and does not include sturgeon purposefully removed from the project area prior to dredging activities.

To reduce take of listed species, relocation trawling may be utilized to capture and move sea turtles and sturgeon. In relocation trawling, a boat equipped with nets precedes the dredge to capture sturgeon and sea turtles and then releases the animals out of the dredge pathway, thus avoiding lethal take. Relocation trawling has been successful and routinely moves sturgeon in the Gulf of Mexico. Seasonal in-water work periods, when the species is absent from the project area, also assists in reducing incidental take.

2.3.3.12. Hurricanes

Mortality of Gulf sturgeon as a result of hurricanes has occurred in the Escambia River following Hurricane Ivan in 2004 (USFWS 2005) and in the northern Gulf of Mexico following Hurricane Katrina in 2005. The impacts of Katrina to the population in the Pearl River are largely unknown, because few large sturgeon have been intercepted post-hurricane in the Pearl River, but it is thought many were killed (T. Ruth, LADFW, pers. com.). Reports from conservation officers on rescue and recovery in Pascagoula the first few days after Katrina reported at least eight dead Gulf sturgeon (Mike Beiser, MSDEQ, pers. com.).

2.3.3.13. Collisions with boats

Collisions between jumping Gulf sturgeon and fast-moving boats on the Suwannee River and elsewhere are a relatively recent and new source of sturgeon mortality and pose a serious public safety issue as well. The FFWC reported that in 2006, nine people were injured by direct strikes and two were injured after swerving to avoid a jumping Gulf sturgeon while boating on the Suwannee River. Nine people were also involved in incidents with jumping sturgeon during 2007, including a fatal incident: two people were ejected from their boat while turning abruptly to avoid a jumping sturgeon and one subsequently drowned. FFWC documented three collisions in the Suwannee River in 2008, and one incident as of this writing in 2009. As a result of these incidents, FFWC now maintains a public awareness campaign about the risk to the boating public with the message "Go slow on the Suwannee." Placards have been posted and distributed along the Suwannee River in areas where Gulf sturgeon are frequently spotted jumping and in areas of high boat traffic. Gulf sturgeon factsheets, large signs, and stickers provide life history information and warn boaters to proceed at slow speeds in the spring and summer. USFWS, USGS, and NMFS have collaborated with FFWC in the information campaign to alert boaters to the collision hazard and urging slower speeds.

The reason why sturgeon jump and expend energy is unknown; one hypothesis is that jumping is a form of group communication that serves to maintain group cohesion (Sulak et al. 2002). Edwards et al. (2007) note that sturgeon jump in marine waters as well.

Ship strikes may be an emerging threat to Gulf sturgeon; ship strikes are a documented threat to Atlantic sturgeon (Assrt 2007). FFWC personnel pulled a live juvenile Gulf sturgeon (< 1 m TL) with a partially severed tail from the Apalachicola River immediately following the passage of a barge tow at river mile 3.5 on September 29, 2004 (E. Lovestrand, pers. comm. 2004). The individual died within an hour after being rescued.

Public outreach and education is improving to alert boaters to slow down in areas where Gulf sturgeon are known to jump. However, the number of boating trips has been and is likely to continue increasing. Combined with the potential of extended droughts in the southeast that result in lowering the water level and subsequently concentrates both sturgeon and boaters into a smaller riverine cross-section, this threat is likely to increase. Boating collisions along with the potential mortality of adult Gulf sturgeon will threaten the stability of these small populations.

2.3.3.14. Red tide

Red tide is the common name for a harmful algal bloom (HAB) of marine algae (*Karenia brevis*) that can make the ocean appear red or brown. *K. brevis* is one of the first species ever reported to have caused a HAB and is principally distributed throughout the Gulf of Mexico, with occasional red tides in the mid- and south-Atlantic United States. *K. brevis* naturally produces a brevetoxin that is absorbed directly across the gill membranes of fish or through ingestion of algal cells.

While many HAB species are nontoxic to humans or small mammals, they can have significant effects on aquatic organisms. Fish mortalities associated with *K. brevis* events are very common and widespread. The mortalities affect hundreds of species during various stages of development. Intoxication begins with binding of PbTx to specific receptor sites in fish excitable tissues (Baden and Mende 1982). Signs of intoxication in fish include violent twisting and corkscrew swimming, defecation and regurgitation, pectoral fin paralysis, caudal fin curvature, loss of equilibrium, quiescence, vasodilation, and convulsions, culminating in death due to respiratory failure. Mortality typically occurs at concentrations of 2.5×10^5 *K. brevis* cells/L, which is often considered to be a lethal concentration. However, it is known that fish can die at lower cell concentrations and can also apparently survive in much higher concentrations (at 3 million cells/L). In some instances, mortality from red tide is not acute but may occur over a period of days or weeks of exposure to subacute toxin concentrations.

Since the 1990's the blooms of red tide have been increasing in frequency; the most recent outbreak occurred in 2007 and 2008. Red tide was the probable cause of death for at least 20 Gulf sturgeon in Choctawhatchee Bay in 1999 (USFWS 2000). Dead and dying Gulf sturgeon were reported to the FWRI Fish Kill Hotline in January 2006 attributed to post-bloom exposure (http://research.myfwc.com/features). More frequent or prolonged algal blooms may result from longer growing seasons predicted with climate change (FWC 2009). Red tides will likely continue to increase in frequency. Based on the best available information, toxins associated have likely killed Gulf sturgeon at both the juvenile and adult life stages. Because the loss of a small number of reproducing adults can have a significant overall effect on the status and trend of the population red tide is a threat to the Gulf sturgeon.

2.3.3.15. Aquaculture

In 2001, Florida Department of Agriculture's Division of Aquaculture (Department) established requirements for sturgeon aquaculture in the State. An application and permitting procedure requires sturgeon aquaculture producers to adhere to best management practices (BMPs), as provided by Chapter 597, Florida Statutes. Aquaculture producers obtain an aquaculture certificate of registration (http://www.floridaaquaculture.com). Chapter 9 of the Statute describes BMPs for sturgeon culture acknowledging that sturgeon aquaculture is a high-risk effort that requires holding of sturgeon for five to eight years before product is available for market. The manual also states that Florida sturgeon culture is currently limited to native Atlantic sturgeon and a few nonnative species. The sturgeon BMPs were developed after the threats or risks of hybridization from aquaculture activities were assessed in a risk assessment workshop sponsored by the Department, FFWC, and Mote Marine Laboratory in April 2000. The sturgeon BMPs require site selection and facility design to prevent the escape of all life stages, reporting of imports, health and escape, and minimum standards for protecting and maintaining offsite water quality and wildlife habitat. Failure to comply with the BMPs can result in a misdemeanor of the first degree, and is subject to a suspension or revocation of certification. The Department may, in lieu of, or in addition to the suspension or revocation, impose on the violator an administrative fine in an amount not to exceed $1,000 per violation per day.

Although BMPs have been issued for Florida, and the Department monitors farms with sturgeon onsite, the risk of hybridization and escapement still occurs. The best screening of water pipes to ensure fish do not escape via irrigation systems does not guarantee that full containment, especially for fish of smaller sizes. Effects of wind and rain associated with hurricanes and unusual weather events can cause overflow of tanks, impacts to irrigation systems, and result in unintended escape of fish. The geographic location of many farms nearby streams and rivers would allow easy entry of farmed fish into sturgeon habitat. As many farms use spring-fed wells as a their source for irrigation, sturgeon raised in farms have likely acclimated to local water temperatures and would presumably survive in local rivers. While effects of intra-specific competition between native and non-natives sturgeons are unknown, it is likely that habitat overlapping would occur as well as a potential for introduction of disease. Other states within the geographic range of the Gulf sturgeon have not implemented similar licensing, monitoring or BMPs.

Therefore, while Florida has issued BMPs and monitors sturgeon farms, the threat of introduction of captive fish into the wild, and potential hybridization continues.

2.4. Synthesis

In the 1995 Recovery Plan, recovery criteria were formulated anticipating the delineation of "management units" for delisting decisions. While this concept pre-dates the Services' 1996 Distinct Population Segment (DPS) policy, it is consistent with the DPS policy and some evidence in this review could contribute to a DPS determination. However, further evidence is necessary to establish the discreteness and significance of two or more river-based DPSs for the Gulf sturgeon.

The demographic recovery criteria in the 1995 Recovery Plan relied upon catch-unit-effort (CPUE) data, which has proven too variable to serve as a practical monitoring metric. Demographic parameters estimated from mark-recapture studies appear better suited for this purpose. Possible parameters to better estimate population status include total number of individuals, age structure (proportions of individuals in various age classes), sex ratio, genetic effective population size, and spawning success.

Mortality rate is a critical aspect in any population. Pine et al (2001) reported that Gulf sturgeon population models are especially sensitive to small increases in mortality affecting the populations. Flowers (2008) describes the historic overexploitation of Gulf sturgeon led to a change in the age-structure of the populations that reduced annual reproductive output. Given Gulf sturgeon life history characteristics such as long life, slow growth, and high age at maturity, restoration of the population age-structure will take many more years as characterized by Sulak for the Suwannee River. Care should be taken to eliminate mortality from anthropogenic sources including indirect mortality from sampling programs, fishery bycatch, mortalities from dredging operations, point and non-point sources, and boater collisions.

Abundance numbers (Appendix A) indicate a roughly stable or slightly increasing population trend over the last decade in the eastern river systems (Florida), with a much stronger increasing trend in the Suwannee River and a possible decline in the Escambia. Populations in the western portion of the range (Mississippi and Louisiana) have never been nearly as abundant, and their current status is unknown as comprehensive surveys have not occurred in the past five years. The life history characteristics of the species make current status of all the future generations vulnerable to threats. Any decline in population number would have chronic impacts and be realized via fewer progeny over many future generations.

The 1995 Recovery Plan did not include measurable criteria relative to reducing the impacts of the five listing factors of the Act that are necessary to monitor progress towards recovery. Data are not yet available to determine if population recovery is limited by factors affecting recruitment (e.g., spawning habitat quantity or quality), adult survival (e.g., incidental catch in fisheries directed at other species), or the late-maturing, intermittent reproductive characteristics of the species. It seems probable that riverine populations are being affected by various factors operating in concert and synergistically on a river-specific scale.

Direct impacts to the Gulf sturgeon and its habitat continue to affect its continued existence through: 1) present or threatened destruction, modification or curtailment of its habitat or range; 2) inadequacy of existing regulatory mechanisms; and 3) other natural or manmade factors. These factors include impacts to habitats by dams, dredging, point and nonpoint discharges, climate change, bycatch, red tide, and collisions with boats. Additional threats may include ship strikes and potential hybridization due accidental release of non-native sturgeon. The juvenile stage of Gulf sturgeon life history is the least understood, and perhaps the most vulnerable as this cohort remains in the river for the first years of its life and is therefore exposed to most of the threats faced by the species and its habitat. Further, the species long-lived, late-maturing, intermittent spawning characteristics make recovery a slow process. This review has found that the current recovery criteria are not adequate. Therefore, we are not recommending reclassification.

3. RESULTS

3.1. Recommended Classification

Based on the best available information, we believe that the Gulf sturgeon continues to meet the definition of a threatened species. While some riverine populations (e.g., Suwannee and Choctawhatchee; see Appendix A) number in the thousands, abundance of most populations is in the hundreds. Loss of a single year class could be catastrophic to some riverine populations with low abundance. Further, while directed fisheries no long occur, many threats continue and new ones are arising. New information should be available in the near future to better inform an analysis and review of the Gulf sturgeon relative to the DPS policy.

3.2. New Recovery Priority Number

No change (NMFS 8, USFWS 12).

4. RECOMMENDATIONS FOR FUTURE ACTIONS

4.1. Recovery Plan Updating

We have preliminary information that may support an analysis and review of the species regarding application of the DPS policy. The 1995 Recovery Plan was completed before policies were issued by the Services on the treatment of DPSs under the Act (61 FR 4722; February 7, 1996). Currently there is a lack of information to separate the species into population segments in accordance with the DPS policy across various genetic/geographic subdivisions. Once the ongoing genetic analysis investigating potential population structure is complete, the Services will determine if data support application of the DPS policy to the Gulf sturgeon.

The demographic recovery criteria of the 1995 plan do not reflect the best available and most up-to date information on the biology of the species. The 1995 criteria rely upon monitoring trends in catch per unit effort (CPUE) as an index to population abundance, but CPUE is too highly variable for assessing population trends. Further, the 1995 criteria do not directly address the five statutory listing/recovery factors. Five-factor-based criteria are necessary for measuring progress towards reducing threats and for determining when the protections of the Act are no longer necessary for the taxon. New criteria in a revised recovery plan should use demographic parameters that can be estimated from mark-recapture studies, including population abundance, and other appropriate metrics organized according to the statutory five factors. Since the 1995 Recovery Plan, the Services issued new guidance in 2006 regarding development of recovery planning. The new requirements include public participation, and focus on species-specific recovery programs that accommodate the unique biological capabilities and needs of the species while addressing the specific circumstances of its endangerment. An updated Gulf sturgeon Recovery Plan would need to take this new guidance into consideration.

Although the criteria of the 1995 Recovery Plan require substantial revision, the plan's outline of recovery actions has proven a useful conservation tool. Most of the progress to date towards improving our understanding of Gulf sturgeon biology and reducing threats to its survival has come from projects and studies predicated on actions formulated in the Recovery Plan, including substantial new information on migratory movements and habitats used for spawning and adult feeding, population models, population monitoring, and genetics. Despite this progress, it is still unclear whether habitat-related factors are slowing or precluding an increase in some sturgeon populations, or whether this relatively long-lived, late-maturing species will simply require additional decades of protection. A revised Recovery Plan should focus explicitly on identifying and then relieving possible limiting factors and on improving the monitoring methods that will demonstrate whether these efforts are successful.

4.2. Research

Two recent papers have highlighted the precarious position of sturgeons. The Endangered Species Committee of the American Fisheries Society (AFS) indicated that 88% of the Acipenseridae family in North America is imperiled (Jelks et al. 2008). Of the eight North American species, AFS considers four endangered (shortnose sturgeon, *A. brevirostrum*, white sturgeon, *A. transmontanus*, pallid sturgeon, *Scaphirhyncus albus*, and Alabama sturgeon, *S. suttkusi*), one threatened (Gulf sturgeon; *A. oxyrinchus desotoi)*, and two vulnerable (lake sturgeon, *A. fulvescens* and Atlantic sturgeon, *A. oxyrinchus oxyrinchus*). On the other hand, Munro et al. (2007) indicated that two major types of management measures that increase the hope for recovery of anadromous sturgeons have been implemented: 1) fishing has been banned for nearly all populations; and 2) consideration of the importance of habitat restoration has been renewed.

Standardization of survey and monitoring protocols needs to be established in order to assess the status of Gulf sturgeon populations across the range. Specific sampling metrics need to be set for inter-basin comparison of population trends. Emerging technologies that would allow remote sensing or counting of sturgeon as they migrate into rivers should be explored. Care should be taken when determining a sampling protocol to allow ample opportunity to the researcher to conduct unique investigations along with census. Results of these surveys should be reported in a standard fashion to the Services so that population trends can be determined and monitored. Posting of data to an on-line database may be considered as well as location information on chart/maps. Some metric of spawning success should be developed to allow analysis of this factor relative to population dynamics.

A better understanding of some basic life history characteristics (habitat needs, energetics, and pollution impacts) would greatly assist in predicting impacts of threats, and understanding population dynamics. Surveys across the geographic range to update population estimates, particularly in the western portion of the geographic range would assist in determining species status and population trends.

Early life stage survival has emerged as a relatively sensitive variable in the age-structured population models developed for the Gulf sturgeon (2001), but no studies have yet attempted to measure it in the field. Developing methods that would estimate annual survival rates from egg to age 3 could contribute information vital to understanding limiting factors and facilitating recovery.

Communication with individual states responsible for issuing Gulf sturgeon research permits should improve. The states have permitting authority (56 FR 49658; September 30, 1991) and no annual reporting to the Services is required. Summary information regarding permits granted, along with a description of the action would greatly assist the Services in tracking research and recovery. Adding Gulf sturgeon to ESA Section 6 agreements with the states would facilitate such annual reporting while providing potential funding for state research and management activities.

Additional analyses to determine genetic structure are essential to understand population structure. Archived tissue samples need to be analyzed and additional samples need to be collected to ensure adequate representation of each river with a known reproducing population. Genetic data along with tagging returns need to be analyzed to determine distinctiveness and effective population structure of Gulf sturgeon.

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U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of GULF STURGEON (*Acipenser oxyrinchus desotoi*)

Current Classification: Threatened
Recommendation resulting from the 5-Year Review: **No change is needed**

Review Conducted By:

Jerry Ziewitz, U.S. Fish and Wildlife Service

Dr. Stephania Bolden, National Marine Fisheries Service

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service

Approve Gail A. Carmody Date 8/24/09

REGIONAL OFFICE APPROVAL:

Acting
Lead Regional Director, Fish and Wildlife Service

Approve Aaron L Valenta Date 9-22-09

NATIONAL MARINE FISHERIES SERVICE

5-YEAR REVIEW of GULF STURGEON (Acipenser oxyrinchus desotoi)

Current Classification: Threatened
Recommendation resulting from the 5-Year Review: **No change is needed**

Review Conducted By:

Jerry Ziewitz, U.S. Fish and Wildlife Service

Dr. Stephania Bolden, National Marine Fisheries Service

APPROVAL:

Lead Assistant Regional Administrator for Protected Resources, National Marine Fisheries Service

Approve ____________ Date 9/30/09

REGIONAL OFFICE APPROVAL:

Lead Regional Administrator, National Marine Fisheries Service
for

Approve James E. Weaver Date 9/30/2009

APPENDIX A

Gulf sturgeon abundance estimates, with confidence intervals (CI), for the seven known reproducing populations.

Note: Estimates refer to numbers of individuals greater than a certain size, which varies between studies (source column) depending on sampling gear, and in some cases, to numbers of individuals that use a particular portion of the river (e.g., a summer holding area or one migratory pathway among several). Estimates are sorted by river, then by researcher and year, because estimates are not necessarily comparable between researchers due to key differences in methods and assumptions. Multiple estimates for a single year and river result from the application of multiple models or represent updated results incorporating additional data. Refer to original publication for details.

River	Year of data collection	Abundance Estimate	Lower Bound 95% CI	Upper Bound 95% CI	Source
Pearl	1993	67	28	not reported	Morrow et al. 1996
	1994	88	59	171	Morrow et al. 1996
	1995	124	85	236	Morrow et al. 1996
	1996	292	202	528	Morrow et al. 1998
	2001	430	323	605	Rogillio et al. 2001
Pascagoula	1999	162	34	290	Ross et al. 2001
	1999	193	117	363	Ross et al. 2001
	1999	200	120	381	Ross et al. 2001
	2000	181	38	323	Ross et al. 2001
	2000	206	120	403	Ross et al. 2001
	2000	216	124	429	Ross et al. 2001
Escambia	2003	558	83	1,033	USFWS 2004
	2004	573	402	745	USFWS 2004
	2006	451	338	656	USFWS 2007
Yellow	2001	566	378	943	Berg et al. 2007
	2002 spring	500	319	816	Berg et al. 2007
	2002 fall	754	408	1,428	Berg et al. 2007
	2003 spring	841	487	1,507	Berg et al. 2007
	2003 fall	911	550	1,550	Berg et al. 2007
Choctawhatchee	1999	3,000	not reported	not reported	USFWS 2000
	2000	2,500	not reported	not reported	USFWS 2001
	2001	2,800	not reported	not reported	USFWS 2002
	2007	2800	not reported	not reported	USFWS 2008
	2008	3314	not reported	not reported	USFWS 2009
Apalachicola	1983	282	181	645	Wooley and Crateau 1985
	1984	103	62	299	Barkuloo 1988
	1985	96	74	138	Barkuloo 1988
	1986	60	37	157	Barkuloo 1988
	1987	111	64	437	Barkuloo 1988
	1988	131	84	305	Barkuloo 1988
	1980	500	not reported	not reported	Pine and Martell 2009[a]

River	Year of data collection	Abundance Estimate	Lower Bound 95% CI	Upper Bound 95% CI	Source
	2005	2,000	not reported	not reported	Pine and Martell 2009 [a]
	1990	108	75	196	USFWS 1990
	1998	270	135	1,719	USFWS 1998
	1999	321	191	1,010	USFWS 1999
	2004	350	221	648	USFWS 2004
	1983	149	115	208	Zehfuss et al. 1999
	1983	111	76	146	Zehfuss et al. 1999
	1984	87	59	150	Zehfuss et al. 1999
	1984	119	87	150	Zehfuss et al. 1999
	1985	101	87	127	Zehfuss et al. 1999
	1985	117	92	142	Zehfuss et al. 1999
	1986	65	47	105	Zehfuss et al. 1999
	1986	108	92	142	Zehfuss et al. 1999
	1987	116	70	225	Zehfuss et al. 1999
	1987	103	78	128	Zehfuss et al. 1999
	1988	109	81	164	Zehfuss et al. 1999
	1988	88	69	107	Zehfuss et al. 1999
	1989	62	37	131	Zehfuss et al. 1999
	1989	91	61	120	Zehfuss et al. 1999
	1990	112	88	155	Zehfuss et al. 1999
	1990	218	114	321	Zehfuss et al. 1999
	1991	95	35	406	Zehfuss et al. 1999
	1991	144	83	205	Zehfuss et al. 1999
Suwannee	1992	2,285	1,887	2,683	Carr et al. 1996
	1987	2,473	2,002	2,944	Chapman et al. 1997
	1988	2,144	1,865	2,423	Chapman et al. 1997
	1989	3,055	2,650	3,460	Chapman et al. 1997
	1990	3,049	2,677	3,421	Chapman et al. 1997
	1991	2,097	1,779	2,415	Chapman et al. 1997
	1992	2,832	2,283	3,381	Chapman et al. 1997
	1993	5,312	3,588	7,036	Chapman et al. 1997
	1994	2,898	2,250	3,546	Chapman et al. 1997
	1995	3,370	1,807	4,933	Chapman et al. 1997
	1996	4,295	1,703	6,887	Chapman et al. 1997
	1982	3,000	not reported	not reported	Pine and Martell 2009 [a]
	2004	10,000	not reported	not reported	Pine and Martell 2009 [a]
	1987	2,059	1,490	2,890	Randall 2008
	1988	1,895	1,544	2,349	Randall 2008
	1989	2,118	1,777	2,543	Randall 2008
	1990	2,473	2,166	2,839	Randall 2008
	1991	2,923	2,516	3,409	Randall 2008
	1992	3,379	2,855	4,011	Randall 2008
	1993	4,273	3,442	5,321	Randall 2008
	1994	3,508	2,821	4,376	Randall 2008
	1995	3,579	3,122	4,119	Randall 2008
	1996	5,525	3,524	8,684	Randall 2008

River	Year of data collection	Abundance Estimate	Lower Bound 95% CI	Upper Bound 95% CI	Source
	1997	4,061	3,310	4,998	Randall 2008
	1998	7,606	5,983	9,702	Randall 2008
	1999	4,944	4,075	6,017	Randall 2008
	2000	4,217	3,149	5,660	Randall 2008
	2001	5,021	3,771	6,706	Randall 2008
	2002	5,220	3,805	7,185	Randall 2008
	2005	1,817	1,303	2,544	Randall 2008
	2006	9,728	6,487	14,664	Randall 2008
	1991	7,650	not reported	not reported	Sulak and Clugston 1999
	1998	7,650	not reported	not reported	Sulak and Clugston 1999
	2007	14,000	not reported	not reported	Sulak 2008

[a] The primary author cited characterizes these as "preliminary estimates" in reviewing this document.

* Juveniles not included in 2007 estimate.

+ Juveniles, subadults and adults included in 2008 estimate.

APPENDIX B
Summary of peer review for the 5-year review of
GULF STURGEON (*Acipenser oxyrinchus desotoi*)

A. Peer Review Method

See "B" below.

B. Peer Review Charge

On June 1, 2009, we sent out a letter and the "**Policy for Peer Review in Endangered Species Act Activities (59 FR 34270)"** through email to 16 professional biologists with expertise on the Gulf sturgeon and its habitats. The letter requested a critical review of the scientific information and data presented and asked them to identify missing literature or other relevant information. The letter was sent to the following individuals. We received comments from eight of these, which are summarized in section "C" below.

Steve Carr, Caribbean Conservation Corporation
Frank Chapman, University of Florida
Jim Clugston, U.S. Geological Survey (retired)
Jared Flowers, North Carolina Cooperative Fish and Wildlife Research Unit
Dewayne Fox, Delaware State University
Joe Hightower, North Carolina Cooperative Fish and Wildlife Research Unit
Alan Huff, Florida Fish and Wildlife Conservation Commission (retired)
Phil Kirk, U.S. Army Corps of Engineers
Scott Mettee, Alabama Geological Survey
Daryl Parkyn, University of Florida
Bill Pine, University of Florida
Howard Rogillio, Louisiana Department of Wildlife and Fisheries (retired)
Steve Ross, Eco-Consulting Services
Tim Ruth, Louisiana Department of Wildlife and Fisheries
Todd Slack, U.S. Army Corps of Engineers
Ken Sulak, U.S. Geological Survey

C. Summary of Peer Review Comments/Report

Jim Clugston, U.S. Geological Survey (retired), Gainesville, FL. Dr. Clugston's comments:

1. Overall assessment of the Gulf sturgeon is realistic based on the available data.
2. The Services did a good job at pointing out the shortcomings of the data in specific systems and the problems with using CPUE as a recovery metric. The "Recommendations for Future Actions" appear reasonable.
3. He suggested that the section on waterborne contaminants (pg. 18) could be expanded to say more about basic nutrient increases and the subtle effect on food chains, etc., as that is a big concern in the Suwannee River.
4. He inquired about the threat of hybridization with white sturgeon and suggested it be included in the aquaculture section.

Jared Flowers, North Carolina Cooperative Fish and Wildlife Research Unit, Raleigh, NC. Mr. Flowers expressed general support for the review. He was pleased with the discussion in which we recommended discontinuing our reliance upon CPUE as a monitoring metric as described in the 1995 Recovery Plan. He recommended that the Services consider genetic effective population size as an alternative metric, and provided references for its use. He offered numerous wording recommendations (e.g., substituting the word "individuals" for "fish").

Dewayne Fox, Delaware State University, Dover, DE. Dr. Fox found the status review well written and had mostly minor editorial comments. Suggested that we provide additional information on the following topics:

1. A table listing the year and location of the annual Gulf sturgeon workshops.
2. Gulf sturgeon bycatch in the commercial shrimp fishery.
3. Additional references and scientific names; clarification of some references.

Alan Huff, Florida Fish and Wildlife Conservation Commission (retired), St. Petersburg, FL. Dr. Huff supported our assessment that Gulf sturgeon are stable or increasing He noted that it would be a very positive thing to work through the DPS process. He suggested improving the red tide discussion and provided a copy of the FWC Summit Report on climate change. He suggested changing the term summer "resting" to summer "holding" throughout the document. He provided grammatical edits and identified several inconsistencies in formatting.

Phil Kirk, U.S. Army Corps of Engineers, Vicksburg, MS. Dr. Kirk agreed that more research on the biology and survival of age 0-to age-3 fish is needed. He did not recommend changes to the document.

Bill Pine, University of Florida, Gainesville, FL. Dr. Pine provided a copy of an in-press paper: "Spawning site selection and potential implications of modified flow regimes on viability of Gulf sturgeon populations". He provided minor editorial suggestions and posed several questions about the intended meaning of statements in the draft review.

Todd Slack, U.S. Army Corps of Engineers, Vicksburg, MS. Mr. Slack suggested grammatical and style edits and provided new information via recently published papers and e-mails. He clarified results of genetics analyses to which he had contributed. He suggested a modification to the Table 1 heading to clarify its contents. He provided an update on coastal restoration efforts post-hurricanes, requested clarification of relocation trawling efforts and observed takings of sturgeon by dredges. Lastly, he suggested that the anticipated increase in storm activity as a result of climate change would increase frequency of fish kills.

Ken Sulak, U.S. Geological Survey, Gainesville, FL. Dr. Sulak provided many comments:

- The draft review relied too much upon a few recent papers and he recommended additional information for our use.
- He objected to our statement that juvenile Gulf sturgeon (not young-of-the-year) "possibly" use the riverine environment for feeding.
- He noted that Gulf sturgeon from different populations mix in the riverine environment as well as the marine environment.

- He characterized as premature our statement that the species apparently no longer reproduces in the Mobile River drainage.
- He noted that several researchers have archived tissue samples that could be used for genetics analysis of population structure.
- He believes that the Suwannee population is increasing more rapidly than our characterization of "most populations are stable or slowly increasing".
- He urged us to cite several oral presentations made by him and various colleagues at recent sturgeon symposia.
- He disagreed with our characterization of Gulf sturgeon population estimates as "imprecise".
- He objected to our mention of an observation of a young-of-year sturgeon in the Santa Fe River without an accompanying reference to his work and that of others that previously documented upstream movements.
- He believes the Suwannee population meets the criteria for delisting and should be delisted.

D. Response to Peer Review

Jim Clugston, U.S. Geological Survey (retired), Gainesville, FL. We added language about waterborne contaminants, and about potential hybridization with white sturgeon.

Jared Flowers, North Carolina Cooperative Fish and Wildlife Research Unit, Raleigh, NC. We accepted all of Mr. Flowers' editorial and terminology recommendations. We added genetic effective population size to the list of parameters that might substitute for CPUE as a recovery monitoring metric in a revised recovery plan.

Dewayne Fox, Delaware State University, Dover, DE. We accepted all of Dr. Fox's editorial and terminology recommendations, added additional references where suggested, clarified language he identified as problematic, cited his review as a personal communication about potential Gulf sturgeon bycatch in commercial fisheries in and near Choctawhatchee Bay, and added language describing potential gaps in distribution to highlight the importance of the western stocks.

Alan Huff, Florida Fish and Wildlife Conservation Commission (retired), St. Petersburg, FL. We accepted all of Dr. Huff's editorial and terminology recommendations, and we enhanced the red tide and climate change sections.

Phil Kirk, U.S. Army Corps of Engineers, Vicksburg, MS. No modifications required.

Bill Pine, University of Florida, Gainesville, FL. We accepted all of Dr. Pine's editorial and terminology recommendations. We used the "in-press" manuscript that he provided in our discussion of potential impacts of flow alterations to the Gulf sturgeon. We added a footnote to his citations in Table 1 indicating the "preliminary" nature of his population estimates in Pine and Martel 2009. We clarified and expanded upon several sections where he had questions about our intended meaning.

Todd Slack, U.S. Army Corps of Engineers, Vicksburg, MS. We accepted all of Mr. Slack's editorial and terminology recommendations and incorporated the new information provided (Ross et al. 2009) into the review. We agreed that an increase in hurricanes could result in additional fish kills and added that to our climate change section. We clarified the text in the genetics section regarding intra-drainage differences and low assignment rates as he suggested.

Ken Sulak, U.S. Geological Survey, Gainesville, FL. We responded to Dr. Sulak's comments as follows:

- Where pertinent, we cited the additional references he provided. We could not rely upon the oral presentations at recent sturgeon symposia that he listed, because these were not available to us.
- We removed our reference to the "possibility" of riverine feeding by age 1+ juvenile Gulf sturgeon.
- We recognized that Gulf sturgeon from different populations mix in the riverine environment as well as the marine environment.
- We rewrote our statements pertaining to an apparent extirpation from the Mobile River system to instead acknowledge that we have no direct evidence of current Gulf sturgeon reproduction in this river system.
- Additional genetic analyses are underway. Dr. Sulak will be contacted on potential tissue samples.
- We acknowledge that the Suwannee population appears to be increasing more rapidly than all others.
- Because the oral presentations Dr. Sulak mentions are not available to us, we cannot rely upon them.
- We restated our characterization of population estimates as "imprecise", explaining that the confidence intervals are relatively broad (more than half are plus or minus 30 percent or more around the estimates). We acknowledge that recapture probabilities for Gulf sturgeon in his mark-recaptures studies are higher than reported by Zehfuss et al. (1999).
- We reduced our emphasis on the observation of a young-of-year sturgeon in the Santa Fe River and added reference to previous studies that have documented upstream movements.
- River-based populations would need to meet the criteria for Distinct Population Segments for the Service to delist any separately from the rest of the taxon. Based on existing information at this time, we do not recommend changing the listing status of the Gulf sturgeon.

Exhibit 33

Exponent®

Expert Report of
Charles A. Menzie, Ph.D.

1509456.000 - 8917

A system is considered nutrient-limited when there is an abrupt decline in phytoplankton biomass attributable to decreased availability of a particular nutrient (usually a form of nitrogen or phosphorus). Chlorophyll-a is a specific chemical pigment used in photosynthesis, and its concentration is considered a surrogate for phytoplankton biomass. In order to better understand relationships between flow, nutrients, and chlorophyll-a, data collected by the NERRS were analyzed along with United States Geological Service (USGS) discharge measurements at the Sumatra gage (i.e., gage nearest to Apalachicola Bay). Monthly grab sample chlorophyll-a and dissolved nutrient concentrations (collected 2002-2014 at 10 different locations in Apalachicola Bay) were matched to discharge at the USGS Sumatra gage on the day of collection (see Appendix C for details). Dissolved nitrite + nitrate concentrations were found to increase with flow at all locations, except in the Apalachicola River and at Sikes Cut in the Gulf of Mexico. The River displayed an inverted U-shaped relationship, where nitrite + nitrate concentrations increased with flow until about 25,000 cfs and then decreased with increasing flows at the highest flows. However, chlorophyll-a concentrations exhibited the opposite pattern with flow. In contrast to dissolved nitrite + nitrate concentrations, chlorophyll-a concentrations were higher at lower flows for the seven locations closest to the River (Figure 21). The fact that higher flow is associated with higher nitrite + nitrate concentrations but lower chlorophyll-a concentrations suggest a temporal de-coupling between dissolved nutrient delivery and phytoplankton productivity in the Apalachicola Bay ecosystem. If higher primary productivity is occurring during times of lower dissolved nutrient input, then either there are other nutrient sources available in the Bay (organic or particulate), or nutrient input during low flow is sufficient to drive productivity, or both. This is supported by the fact that there does not appear to be a clear relationship between dissolved nutrient concentrations and chlorophyll-a (see Appendix C for details). The key observation from the available data throughout the Bay is that chlorophyll-a levels are sustained and that food for grazers such as zooplankton and oysters is readily available during the important growing season regardless of the lower flows (Figure 22).

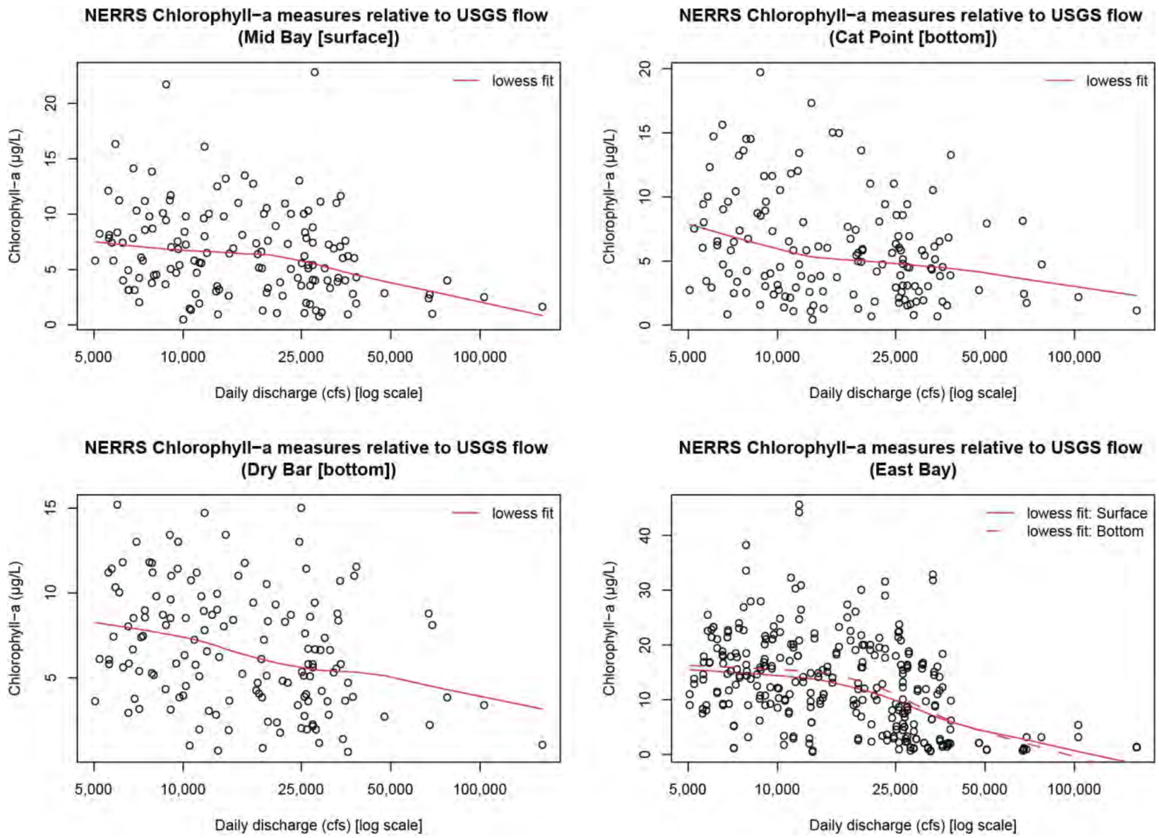


Figure 21. Chlorophyll-a concentrations are higher at lower flows. Across the full range of flows, locally weighted scatterplot smoothing (lowess) curves show a negative relationship between chlorophyll-a and flow.

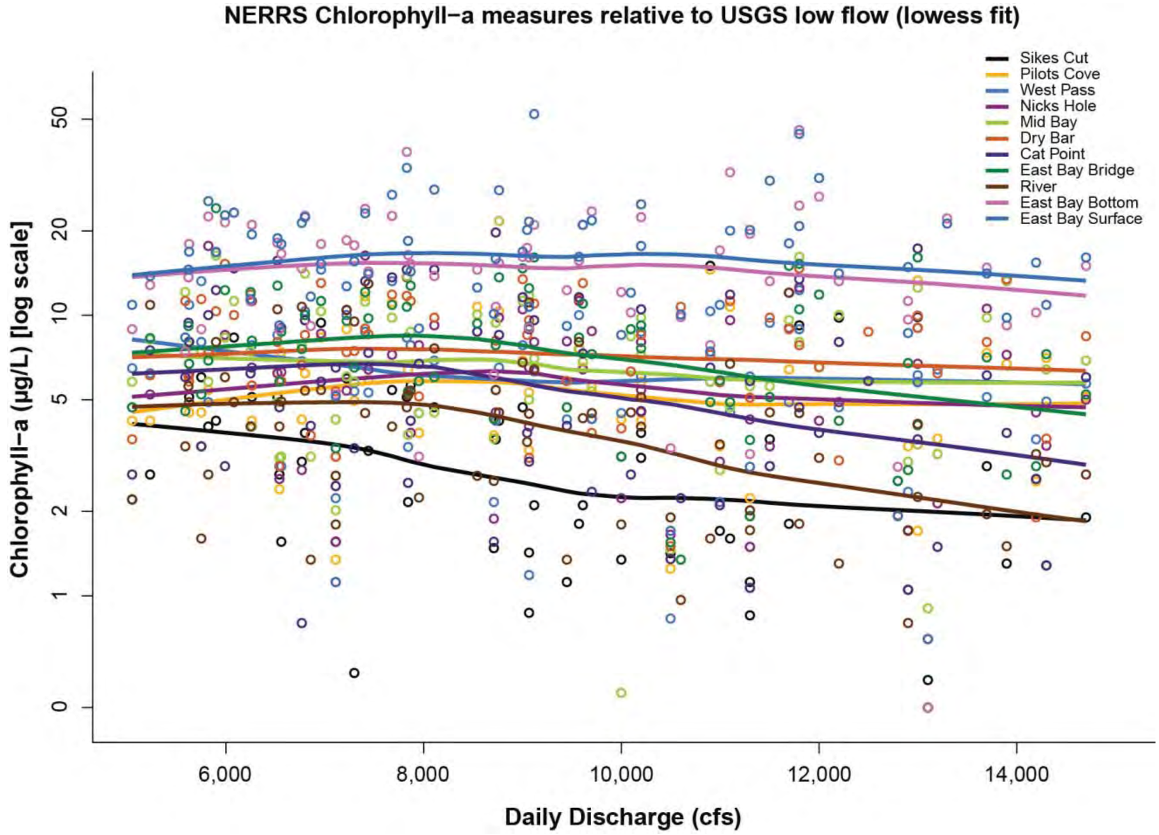


Figure 22. Chlorophyll-a concentrations at Apalachicola Bay stations at lower flow

I was especially interested in what occurs at the lowest measured flows. Does productivity fall off due to nutrient limitation or are there undesirable blooms of algae due to lower flushing? To explore this I plotted the available data on measured chlorophyll-a at Apalachicola Bay stations for river flows at Sumatra between <5,000 cfs to 14,000 cfs (Figure 22). With regard to the Bay as a whole, there are no discernible patterns of sharply increasing or decreasing levels of chlorophyll-a concentrations with decreasing flow at these lowest flows. Most importantly for the productivity of the Bay, there is not a drop-off in phytoplankton primary production, as judged by the presence of chlorophyll-a. Nor is their indication of undesirable algal blooms. This finding, that chlorophyll-a (and associated primary production) increases or remains stable at low flows, is consistent with the 2008 to 2009 study of Viveros Bedoya (2014).[44]

Two factors contribute to sustaining primary production within Apalachicola Bay at low river flows: longer residence time and increase in light penetration. Residence time of water in the Bay is inversely related to flow (see Appendix C for analyses). Longer residence time supports

[44] Viveros Bedoya, P. 2014. Phytoplankton biomass and composition in Apalachicola Bay, a subtropical river dominated estuary in Florida. Dissertation, University of Florida, FL.

Information in subsequent opinions demonstrates that reduced flows have fundamentally altered the long-term fish community structure away from many freshwater-oriented species in the 1970s–1980s as salinities increased In recent years, it has become an ecosystem under chronic stress, transitioning from a stable river-fed estuary toward a lower-flow, higher salinity type estuary with a more marine-like character.

The common theme of "tipping point" used by Florida's three ecological experts creates an ominous but a false impression about the nature of this system. However, it is completely lacking in any form of quantification. No information is presented by any of Florida's experts as to the nature of the tipping point, thresholds that may be crossed that result in irreversible changes, or the proximity of the system to such thresholds. Instead, it is a vague conceptual argument devoid of supporting evidence and inconsistent with what is known about the Apalachicola Bay system. My analyses presented in Sections 4, 5, and 6 of this report demonstrate that the system(s) are not at some theoretical tipping point. In fact, the opposite is the case: (1) productivity is being sustained at all trophic levels; (2) community structure of plants and animals remain representative of a dynamic estuarine system; (3) predominant fish observed in the 1970s and 1980s continue to be the predominant fish species in recent years; (4) SAV has recovered in East Bay following Hurricane Dennis in 2005; and (5) the system continues to experience natural environmental variations comparable to what has been experienced over the past several hundred years.

In Appendix C of my report, I discuss the variability and resilience of estuaries such as the Apalachicola Bay system. Variability is an inherent feature of estuaries, and these ecological systems exhibit resilience in the face of changes. The species that make use of estuaries have evolved an extensive array of adaptive strategies for living within these systems, and it is scientifically insupportable to consider such ecosystems as static and easily toppled as conditions vary. The opposite is the case. That said, none of Florida's experts deny that the systems are in fact resilient. Florida's ecological experts all indicate that the Apalachicola ecosystems would respond "positively" to increases in freshwater flow, and this is completely counter to the notion that an irreversible tipping point is being crossed or has been crossed:

Restoration of flow will provide meaningful benefit to the system and will help to restore ecosystem health. The reinforcing nature of these feedbacks also means that should a positive trajectory be established, through decreased upstream consumption, a reinforcement of the positive feedback trajectory will be established, leading to further improvements once they are initiated.[151]

[151] Glibert, P.M. 2016. Expert report in the matter of State of Florida v. State of Georgia. Apalachicola Bay: An estuary undergoing rapid ecological deterioration. Prepared for Florida Department of Environmental Protection. February 29, 2016.

> *Given the already stressed state the Apalachicola River ecosystem is in, it is my opinion that increases in flow will remedy existing harm, prevent future harm, and allow the ecosystem to slowly recover.*[152]
>
> *This shift in species composition depending upon the amount of freshwater flow suggests that there is potential for the ecosystem to halt the transition toward a more marine-like ecosystem and return closer to its original, more freshwater nature by increasing flows from the Apalachicola River into the Bay.*[153]

Florida's experts' view that the status of the ecosystem will remain permanently pushed into a different status seems to be based in large part on their false assumptions concerning the causes of variations in the Apalachicola River flow. Variations they attribute to water consumption are instead primarily associated with climatic variations. This is readily seen in Figure 5 - Figure 7 in Section 4 of my report. There can be no dispute that the post 2000 period experienced a natural increase in years of drought. However, despite this occurrence, productivity was sustained within Apalachicola Bay at all tropic levels. And, as I demonstrate in Section 4 of my report, these drought conditions are not unprecedented but part of a long record of drier and wetter periods experienced by the Apalachicola Bay system.

Finally, the conservation scenario proposed by Dr. Sunding would not overwhelm the influence of natural climatic variations and yield a measurable benefit relative to current conditions. Florida's experts do not specifically reference Dr. Sunding but instead refer back to the expert report of Dr. Hornberger who incorporates remedy scenarios in his evaluation of how Georgia's water consumption influences river flow. Although none of Florida's ecological experts quantify the benefits of this conservation scenario on biological conditions in the Bay, I have examined the ecological implications of this scenario. The estimated reductions in consumption amount to up to 1,000 cfs during the summer months. As with the results presented in Sections 5 and 6 of my report, these reductions would not have significant ecological benefits for the Apalachicola Bay (see Appendix E for details). I discuss the implications of the Sunding conservation scenario further in Sections 9 and 10 of my report.

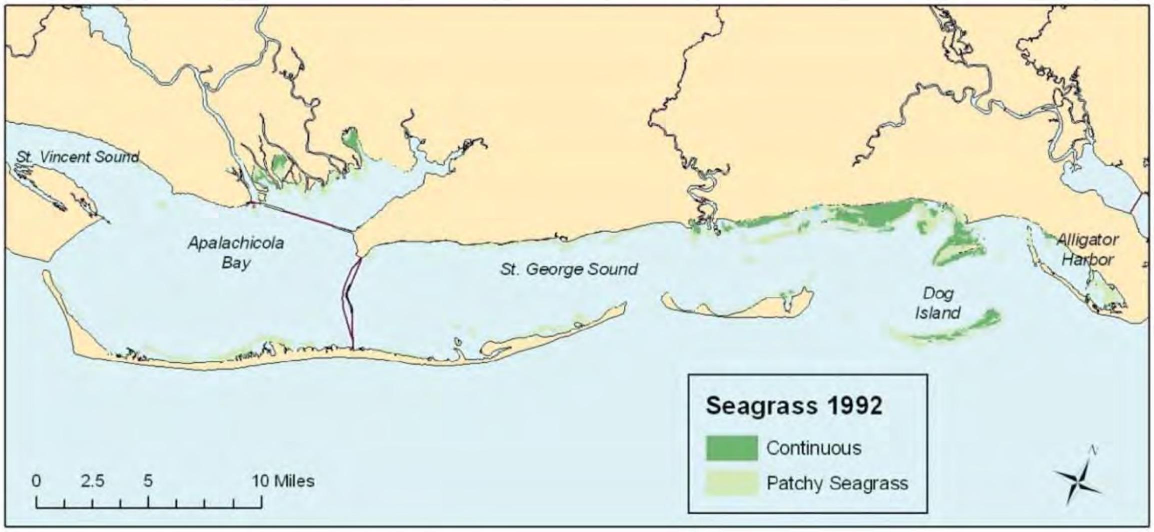
In summary, the tipping point opinion advanced by Florida's experts is unsubstantiated and these experts have provided no reliable evidence that this tipping point actually exists or is about to be crossed. Further, they provide no analysis that indicates a conservation scenario would reduce the risk of crossing the theoretical tipping point. In contrast to the opinion(s) of Florida's experts, I have provided evidence that the Apalachicola Bay ecosystems are resilient, have experienced changes in freshwater flows and salinity throughout their evolutionary history, and have been sustained through the most recent period of naturally occurring drought years.

[152] Allan, J.D. 2016. Expert Report in the matter of Florida v. Georgia, No. 142 Orig. in the United States Supreme Court. Prepared for Florida Department of Environmental Protection. February 29, 2016.

[153] Jenkins, K. 2016. Expert report in the matter of Florida v. Georgia. Prepared for Florida Department of Environmental Protection. February 29, 2016.

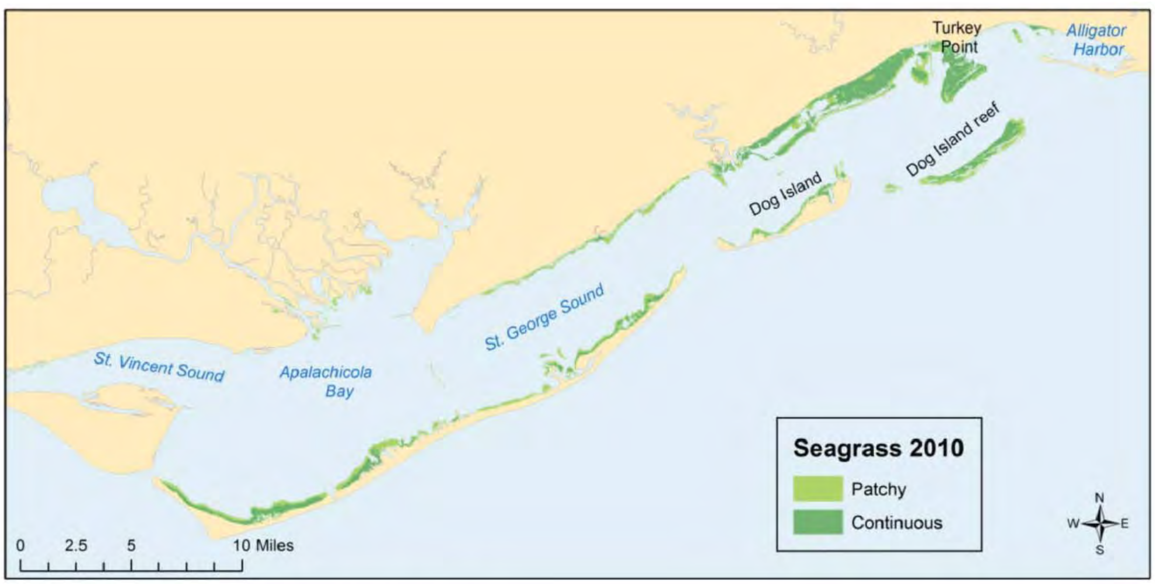
Appendix C

Productivity in Apalachicola Bay



Source: Fish and Wildlife Research Institute (2011)

Figure C- 1. SAV coverage in Apalachicola Bay, 1992[36]



Source: Fish and Wildlife Research Institute (2014)

Figure C- 2. SAV Coverage in Apalachicola Bay, 2010[37]

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[36] Reproduced from FFWCC. 2011. Seagrass integrated mapping and monitoring for the State of Florida: Mapping and monitoring report no. 1. L.A. Yarbro and P.R. Carlson, Jr. (Eds.). Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute, St. Petersburg, FL. Available at http://myfwc.com/media/1591147/fullsimm1.pdf.

[37] Reproduced from FFWCC. 2014. Summary report for Franklin County Coastal Waters in Seagrass integrated mapping and monitoring report no. 1.1, FWRI Technical Report TR-17. L.A. Yarbro and P.R. Carlson, Jr. (Eds.).

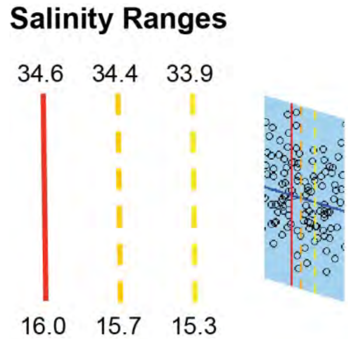


Figure C-8. Salinity ranges (95% prediction intervals) at Cat Point at 10,000 cfs, 10,400 cfs, and 11,000 cfs (reflecting the additions of 400 and 1,000 cfs of freshwater)

Collectively, these analyses indicate that the salinity changes associated with Georgia's water consumption since 1992 are very small and are largely lost in the natural variation in salinity within the Bay. My comparison of weekly average salinities at Cat Point predicted from Dr. Bedient's simulated 1992 withdrawals and 2011 withdrawals showed an average difference of 0.2‰. The addition of another 400 cfs at the Sumatra gage changed salinity by 0.06 – 0.5‰. If flows at the Sumatra Gage increased by 1000 cfs, I calculate that salinity would change by 0.15 – 1.2‰. These small changes are dwarfed by the natural variation in salinity, which fluctuates by 18.6‰ at a given flow (range of 95% prediction intervals calculated from my flow-salinity regression analysis).

Evaluating the Ecological Implications of Salinity Variations Associated with Georgia's Incremental Water Consumption

Different species of freshwater, estuarine, and marine SAV have different optimal and tolerated salinity ranges. Table C- 4 lists SAV salinity tolerance ranges from the literature for species of freshwater, estuarine, and marine SAV. Comparing these tolerance ranges to the variability of salinity ranges at each of the flows considered above, any salinity-driven ecological effects associated with incremental water consumption by Georgia since 1992 are likely negligible.

Exhibit 34

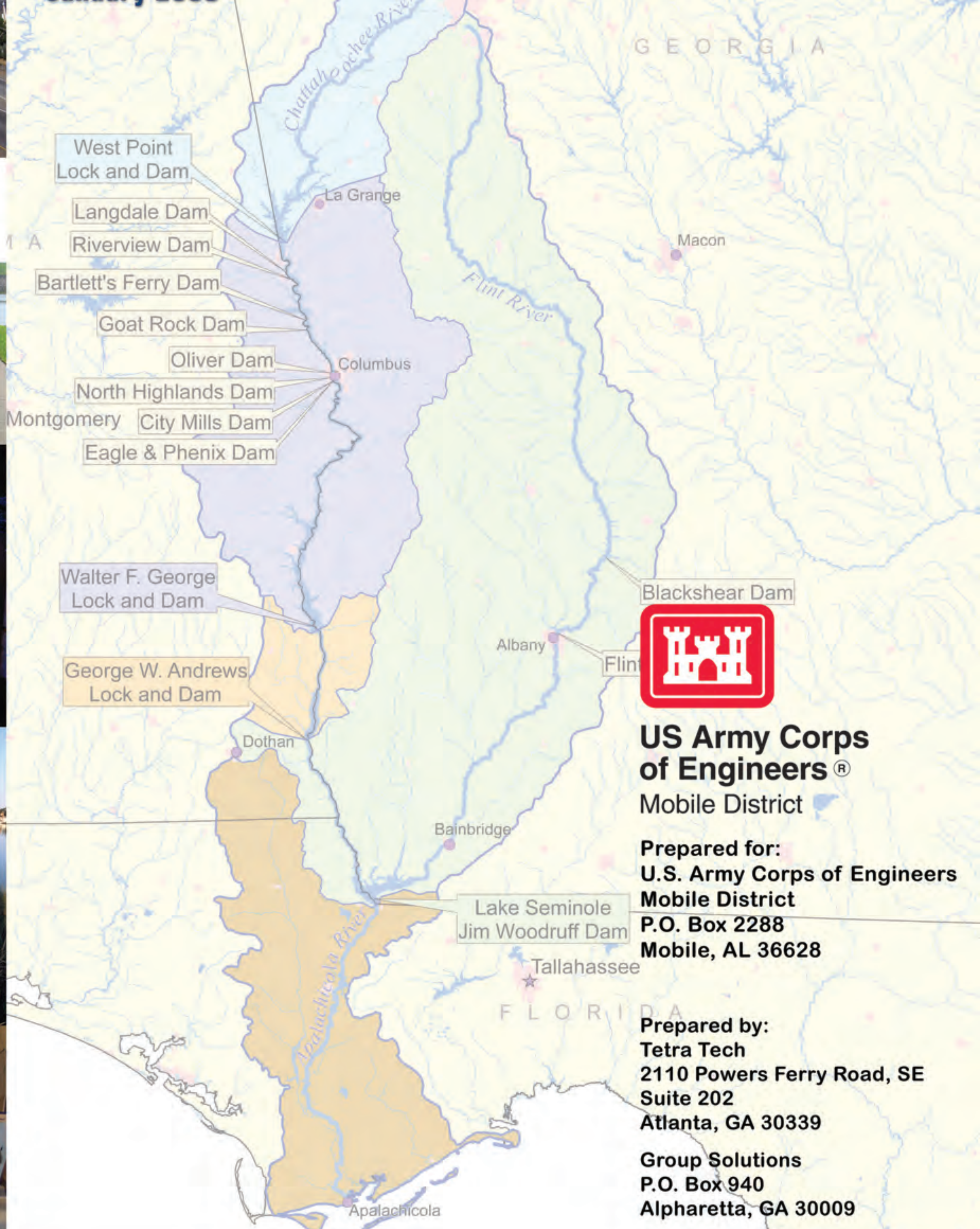





FINAL SCOPING REPORT
Environmental Impact Statement

Update of the Water Control Manual for the Apalachicola-Chattahoochee-Flint (ACF) River Basin, in Alabama, Florida, and Georgia

January 2009



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Contents

Appendices

Executive Summary

The U.S. Army Corps of Engineers (USACE or Corps), Mobile District, conducted public scoping in fall 2008 to initiate preparation of an Environmental Impact Statement (EIS) regarding implementation of an updated *Master Water Control Manual for the Apalachicola-Chattahoochee-Flint (ACF) River Basin* (Master Manual) in Alabama, Florida, and Georgia. A Notice of Intent to prepare an EIS was released February 22, 2008, and a *Federal Register* notice to announce public scoping meetings was published September 19, 2008. An interagency meeting was held October 9, 2008, and public scoping meetings were held at five strategic locations within the ACF River Basin between October 20 and 29, 2008. Native American Indian tribal leaders with interests in the ACF River Basin were also contacted as part of the scoping efforts. The formal scoping period ended November 21, 2008.

The purpose of scoping is to determine the range of issues to be addressed and to identify the significant issues to be analyzed in depth with respect to the proposed action. The process also helps to deemphasize insignificant issues, thereby narrowing the scope of the EIS process. Through the scoping process the Corps will identify the range of actions, alternatives, and impacts to be considered in the EIS for the update of the Master Manual for the ACF River Basin.

This scoping report provides background regarding the Corps' role in managing the ACF River Basin and the need to update the ACF Master Manual (Section 1); describes the scoping activities conducted by the Corps (Section 2); categorizes the issues raised in the scoping comments (Section 3); summarizes the comments submitted by federal, state, and governmental agencies (Section 4); and provides the framework for preparing an EIS to address the potential for significant impacts on the human and natural environment resulting from implementation of an updated Master Manual (Section 5).

The appendices to this report contain copies of all of the Corps' public communication and documentation about the scoping process; copies of all comments received during scoping in their original format; and a report containing all the comments, broken down into segments and categorized by issues.

A total of 1,018 stakeholders participated in the 5 public scoping meetings. Table ES-1 shows a breakdown of participation by meeting location.

Table ES-1. Participants by Scoping Meeting Location

Date	Location	Attendance
October 20, 2008	Apalachicola, Florida	135
October 21, 2008	Dothan, Alabama	24
October 22, 2008	LaGrange, Georgia	365
October 23, 2008	Marietta, Georgia	93
October 29, 2008	Gainesville, Georgia	401
	Total	*1,018*

A total of 2,269 comments were received from 643 individuals, organizations, and agencies during the formal scoping period, which ended November 21, 2008. The agencies included federal, state, and local governments. Federal agencies that submitted comments included the U.S. Environmental Protection Agency Region 4, the Southeastern Power Administration, and the U.S. Fish and Wildlife Service. Leaders from the Georgia and Florida congressional delegations submitted comments, along with the Georgia State House of Representatives. The three states—Alabama, Georgia, and Florida—submitted comments from their associated state agencies. Other local governmental agencies, including the Metropolitan North Georgia Water Planning District; Atlanta Regional Commission; Franklin County, Florida; Hall County, Georgia; Troup County, Georgia; Gwinnett County, Georgia; and the City of LaGrange, Georgia, submitted comments as well.

Two petitions were received during the scoping process. One was from the West Point Lake Advisory Council Needs Your Show of Support and signed by 2,809 individuals. The second petition received were comments on the Potential for the Turkey Run

Landfill to Pollute Groundwater and Surface Waters in Violation of Georgia Environmental Protection Division Solid Waste Management Rules and Landfill Permit and signed by 58 individuals.

All the comments from scoping were reviewed, analyzed, and organized into the 12 categories shown in Table ES-2. The table also shows the number of comments by category. Figure ES-1 shows the distribution of comments by category.

Table ES-2. Distribution of Comments

Category	Number of Comments
Water Management Recommendations	868
Socioeconomics and Recreation	404
Biological Resources	284
Drought Operations	191
Water Quality	155
Water Supply	117
National Environmental Policy Act	79
Data, Studies, and Analytical Tools	56
Other Resources	52
Navigation	28
Hydropower	26
Flood Risk Management	9
Total	*2,269*

As shown in Table ES-2 and Figure ES-1, most of the comments (868) were related to water management recommendations, which include the seven authorized project purposes and the Corps' ability to balance needs throughout the ACF River Basin. Other comments in this category addressed alternatives to consider (or mitigation), demand projections as they relate to downstream and future needs, and overall water conservation in the basin.

Issues and concerns regarding socioeconomics and the tie between water levels, recreation, and regional economics received the second largest number of comments (404). Most of the comments received in this category pertained to the adverse socioeconomic impacts that have occurred in the northern portions of the ACF River

Basin due to extremely low water levels in Lake Lanier, and low or inconsistent water levels in West Point Lake. Similar comments were made by stakeholders in the middle and lower reaches of the basin, who attributed adverse economic conditions to low water flows. Comments were also made regarding the need to address adverse impacts on low-income and minority populations resulting from low lake levels; the potential for collapse of the seafood and fishing industry in the Apalachicola Bay region; safety hazards due to low water levels; concerns regarding property values, aesthetics, and quality of life; and a myriad other concerns over the direct and indirect impacts of basin water management practices on socioeconomics. The primary message stakeholders have conveyed is that the Corps should fully assess in the EIS the socioeconomic impacts of water management practices at the individual projects and in the overall system.

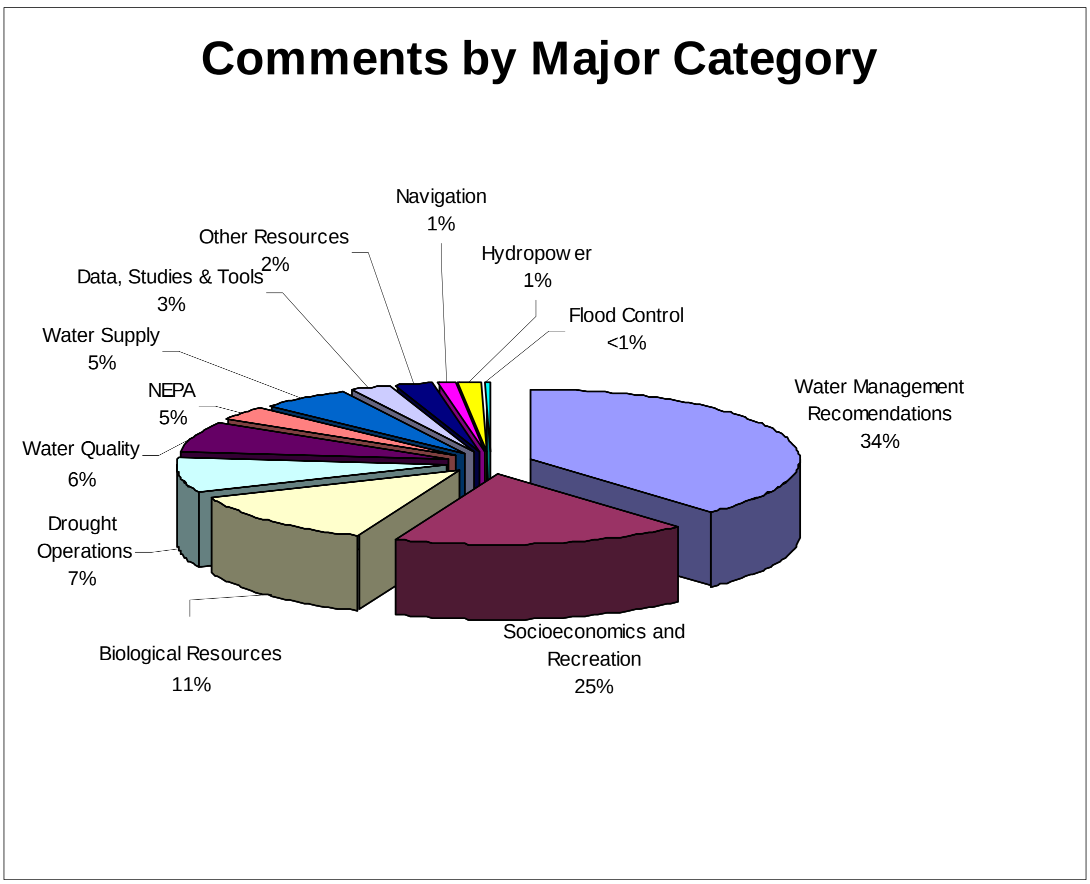

Figure ES-1. Distribution of comments by major category.

The next three categories were biological resources (284), drought operations (191), and water quality (155). Biological resources comments pertained to fisheries, threatened and endangered species, flow concerns for Apalachicola Bay, and other biological issues such as habitat, research, and monitoring. The drought operation comments usually referenced drought conditions in the Lake Lanier watershed over the past decade. Some comments suggested that during periods of extreme drought conditions, the Corps needs to redirect and optimize its operational practices to balance project purposes by establishing management triggers, conservative reservoir operations, emergency drought measures, and water supply conservation measures and/or by prioritizing reservoir purposes. Water quality concerns were related to wastewater dilution, recreational uses, impacts of low lake levels and low flows, reevaluation of low-flow requirements, salinity in Apalachicola Bay, monitoring, effects of population growth, industrial discharges, maintaining existing minimum flows, the effect of the Revised Interim Operating Plan, and Total Maximum Daily Loads.

Water supply (117 comments) and the *National Environmental Policy Act*, or NEPA, (79 comments) were the next two categories. The water supply comments pertained to importance compared to downstream uses, public water supply, real-time monitoring at the City of Atlanta's intake, concern over future availability, consideration of the Metropolitan North Georgia Water Planning District;'s plans, lack of congressional authority, cumulative effects, population growth, and monitoring of the use of storage. NEPA-related comments discussed public involvement, the schedule, the baseline, the proposed action and alternatives, mitigation measures, compliance with other regulations, and cooperating agencies. The remaining comment categories, with a total of 171 comments, were data, studies, and analytical tools; other resources; navigation; hydropower; and flood risk management.

Throughout this process, the public can obtain information on the status of updating the Master Manual and the EIS by checking the USACE Mobile District website (www.sam.usace.army.mil). The scoping report will be posted at www.acf-wcm.com and it can be downloaded with or without the appendices.

1.0 Introduction

In fall 2008 the U.S. Army Corps of Engineers (USACE or Corps), Mobile District, conducted public scoping for preparation of an Environmental Impact Statement (EIS) regarding implementation of an updated *Master Water Control Manual for the Apalachicola-Chattahoochee-Flint (ACF) River Basin* (Master Manual) in Alabama, Florida, and Georgia. The purpose of scoping, in accordance with the requirements of the *National Environmental Policy Act* of 1969 (NEPA), is to solicit input from other agencies and the public to help identify all the relevant issues and alternatives that should be addressed in an EIS. The EIS will provide supporting documentation for a decision on implementing a Master Manual update, as well as for updating reservoir-specific water control plans to be included as appendices to the Master Manual.

This scoping report provides background regarding the Corps' role in managing the ACF River Basin and the need to update the Master Manual (Section 1); describes the scoping activities conducted by the Corps (Section 2); categorizes the issues raised in the scoping comments (Section 3); summarizes the comments submitted by federal, state, and local government agencies (Section 4); and provides the framework for preparation of an EIS to address the potential for significant impacts on the human and natural environment resulting from implementation of an updated Master Manual (Section 5). The appendices to this report contain copies of all of the Corps' public communication and documentation about the scoping process; copies of all comments received during scoping in their original format; and a report containing all the comments, broken down into segments and categorized by issues.

1.1 Background

The ACF River Basin drains 19,800 square miles in parts of southeastern Alabama, northwest Florida, and central and western Georgia. About 74 percent of the ACF River Basin lies in Georgia, 15 percent in Alabama, and the remaining 11 percent in Florida. The basin extends approximately 385 miles from the Blue Ridge Mountains to the Gulf of Mexico and has an average width of approximately 50 miles. The basin covers 50 counties in Georgia, 8 in Florida, and 10 in Alabama. The headwaters of the Chattahoochee River are in north Georgia, and the river flows along the Georgia-Alabama state line. The Chattahoochee joins the Flint River at Lake Seminole. Downstream of the lake, the Apalachicola River ultimately flows into the Gulf of Mexico via Apalachicola Bay in Florida. (Figure 1).

The ACF River Basin is a dynamic hydrologic system characterized by interactions between aquifers, streams, reservoirs, floodplains, and estuaries. Water resources in the basin have been managed to serve a variety of purposes, including navigation, hydroelectric power, flood risk management, water supply, and recreation. There are 16 reservoirs on the mainstems of the Apalachicola, Chattahoochee, and Flint Rivers (5 federal and 11 non-federal projects), which have altered the natural streamflow and provided water supply improvements and recreational opportunities for the public in these resource areas. The interrelationship between operation of the dams and the resulting river flows has resulted in a highly regulated system over much of the basin. The principal rivers, particularly in the lower half of the basin, receive a substantial contribution of water from groundwater baseflow during dry times (Comprehensive Water Resources Study Partners, 1995).

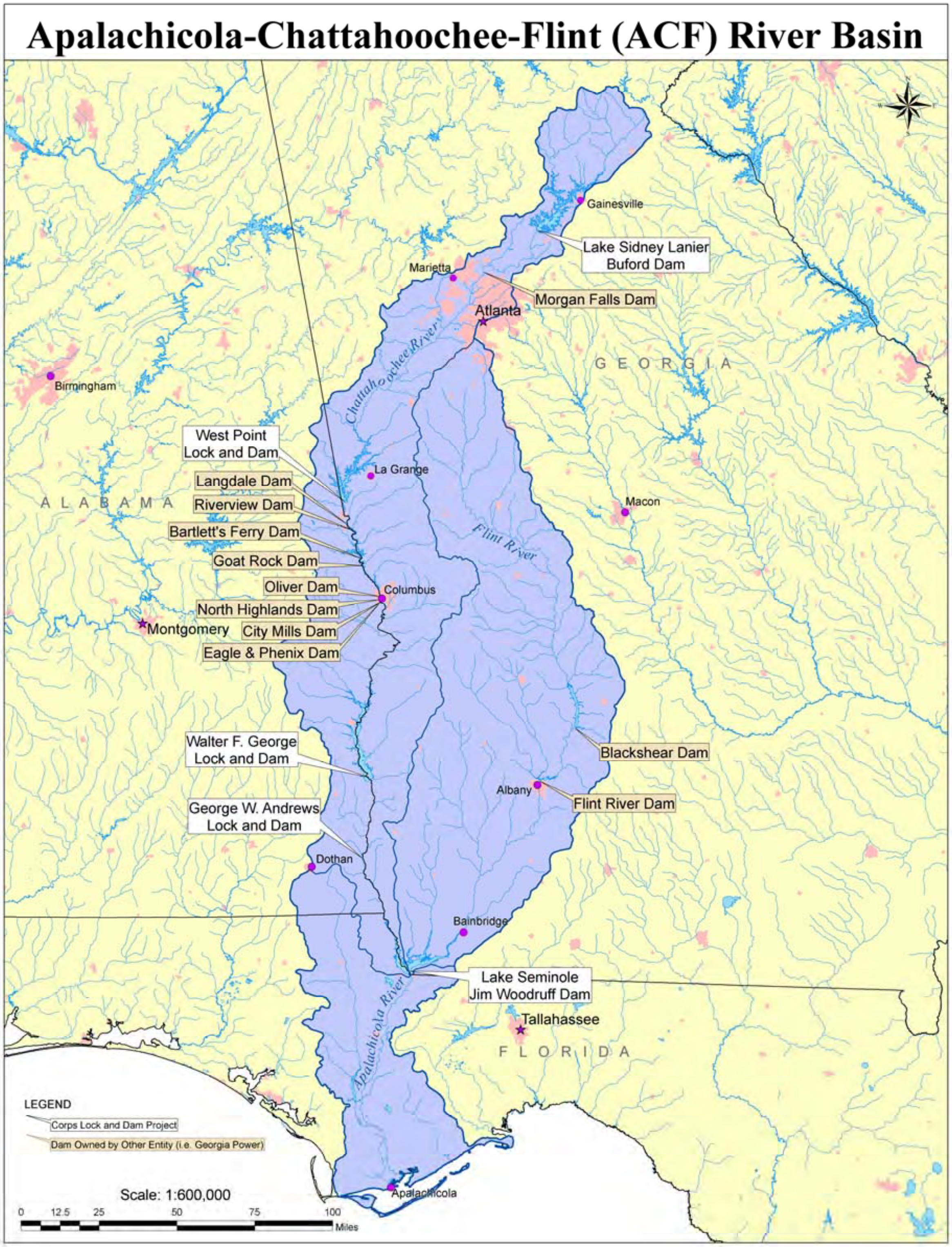

Figure 1. Apalachicola-Chattahoochee-Flint (ACF) River Basin.

1.2 Federal Authorizations

Several pieces of authorizing federal legislation affect the ACF River Basin. Section 2 of the *River and Harbor Act of 1945* (Public Law [P.L.] 79-14) approved the general plan recommended in House Document 342, 76th Congress, for development of the Apalachicola, Chattahoochee, and Flint Rivers, Georgia and Florida, for the multiple purposes of navigation, hydroelectric power generation, and flood risk management. A modification to the 1945 general plan was authorized by Section 1 of the *River and Harbor Act of 1946* (P.L. 79-525), in accordance with the report of the Chief of Engineers dated May 13, 1946 (House Document 300, 80th Congress), to include Buford multipurpose reservoir (Lake Lanier), the Fort Benning Lock and Dam, and the Upper Columbia and Jim Woodruff multipurpose developments. The navigation feature of the project was to be provided by dredging, channel contraction works, construction of a series of locks and dams, and flow regulation by the upstream reservoirs. In the Apalachicola River portion of the project, the 1946 amendment provided that "…local interests furnish free of cost to the United States, as and when required, all rights-of-way, spoil-disposal areas, easements and other lands required for the provision and maintenance of a navigation channel in the Apalachicola River…." Further modifications authorized by Congress in 1953 (House Committee Public Works Resolution adopted May 19, 1953) substituted the now George W. Andrews and Walter F. George Locks and Dams for the Upper Columbia multipurpose project and Fort Benning Locks and Dam. The *Flood Control Act of 1962* authorized West Point Lake in accordance with House Document No. 570, 87th Congress.

Other ancillary project purposes were added to these congressionally authorized projects by laws that apply generally to all Corps reservoirs. These other laws are the *Flood Control Act of 1944* (P.L. 78-534), which provides the authority to add recreation as a purpose and to contract for use of surplus water for domestic purposes; the *Water Supply Act of 1958* (P.L. 85-500, Title III), which provides the authority to include storage for municipal and industrial water supply; the *Fish and Wildlife Coordination Act of 1958* (P.L. 85-624). which provides the authority to modify projects to conserve fish and wildlife; the *Federal Water Pollution Control Act Amendments of 1972* (P.L. 92-500), known as the *Clean Water Act*, which establish the goal to restore and maintain the quality of the Nation's waters; and the *Endangered Species Act of 1973* (P.L. 93-205), which provides the authority for operating projects to protect threatened or endangered fish and wildlife.

1.3 Corps Projects in the ACF River Basin

The Corps operates five dams in the ACF River Basin (in downstream order): Buford, West Point, Walter F. George (George), George W. Andrews (Andrews), and Jim Woodruff (Woodruff). All but one is located wholly on the Chattahoochee River arm of the basin. The exception is the downstream-most dam, Woodruff, which is immediately below the confluence of the Chattahoochee and Flint Rivers and marks the upstream extent of the Apalachicola River. Andrews is a lock and dam without any appreciable water storage behind it, but Buford, West Point, George, and Woodruff dams are reservoirs (Lakes Lanier, West Point, George, and Seminole, respectively) with a combined conservation storage capacity (relative to the top of each reservoir's full summer pool) of about 1.6 million acre-feet. Because Jim Woodruff Dam/Lake Seminole is operated as a run-of-river project, only very limited storage is available to support project purposes. The Corps projects in the ACF River Basin and their authorized project purposes are described in more detail in the following subsections.

1.3.1 Lake Sidney Lanier and Buford Dam

The Corps' Buford Dam on the Chattahoochee River is a multipurpose project for flood risk management, hydroelectric power generation, navigation, recreation, water quality, water supply, fish and wildlife conservation. Section 2 of the *River and Harbor Act of 1945* (P.L. 79-14) approved the general plan recommended in House Document 342, 76th Congress, for development of the Apalachicola, Chattahoochee, and Flint Rivers, Georgia and Florida, for the multiple purposes of navigation, hydroelectric power generation, and flood risk management. A modification to the 1945 general plan was authorized by Section 1 of the *River and Harbor Act of 1946* (P.L. 79-525), in accordance with the report of the Chief of Engineers dated May 13, 1946 (House Document 300, 80th

Congress), and it included Buford multipurpose reservoir (Lake Sidney Lanier or Lake Lanier).

The authorized project provides for a rolled-earth dam 1,630 feet long with crest at elevation 1,106 feet National Geodetic Vertical Datum of 1929 (NGVD), or about 192 feet above streambed elevation; three earthen saddle dikes with a total length of 5,406 feet; a chute spillway with crest at elevation 1,085 feet; a powerhouse in a deep cut, with steel penstocks in tunnels and concrete intake structure at the upstream end of the tunnels; and a flood control sluice tunnel paralleling the power tunnels.

Lake Lanier has a total storage capacity of 2,554,000 acre-feet at elevation 1,085 feet. Of this, 1,049,400 acre-feet (at elevation 1,070) is usable for power generation, 637,000 acre-feet is reserved for flood risk management, and 867,600 acre-feet is inactive storage. The minimum power pool elevation is 1,035 feet, and the maximum power pool (maximum conservation pool) elevations are 1,071 feet in the summer and 1,070 feet in the winter. Lake Lanier has a surface area of 38,024 acres at elevation 1,070 feet. The power installations consist of one generating unit of 6 megawatts (MW) and two units of 50 MW each, or a total of 106 MW. The 6-MW unit runs continuously to assist in meeting the minimum flow requirements at Peachtree Creek.

Minimum flow requirements from Buford Dam have evolved over the period since project completion. The current plan, referred to as the “Short-Term Plan,” was developed in 1986. It established the “River Management System” agreement under which the Corps, when possible and practical, endeavors to make only those releases specifically required for water supply and to maintain the 750-cubic-foot-per-second (cfs) minimum in-stream flow at Peachtree Creek. Georgia Power Company agreed to continue to use Morgan Falls reservoir to reregulate the Buford releases.

1.3.2 West Point Lock and Dam

The Corps' West Point Dam and Lake were authorized by the *Flood Control Act of October 23, 1962* (P.L. 87-874). The authorized project purposes for the reservoir are flood risk management, hydroelectric power generation, navigation, recreation, water quality, water supply, and fish and wildlife conservation.

The authorized project provides for a gravity-type concrete dam 896 feet long with earthen embankments at either end 1,111 feet long on the east end and 5,243 feet long on the west end. The total length of the dam and spillway is 7,250 feet. The main dam consists of a concrete non-overflow section, 185 feet long on the west side, and an earthen embankment retaining wall on the east side, as well as a gravity concrete spillway 390 feet long, including piers and abutments, with six tainter gates, each 50 feet by 41 feet. A monolith intake-powerhouse section and erection bay 321 feet long is constructed directly west of and adjacent to the spillway.

At the full pool elevation of 635 feet NGVD, the reservoir provides a total storage of 605,000 acre-feet, of which 307,000 acre-feet is usable. Flood risk management storage of 85,200 acre-feet is provided between pool elevations 635 feet and 641 feet. During the critical flood season, the reservoir is operated with a maximum power pool elevation of 625 feet to provide additional flood risk management storage of 221,000 acre-feet. West Point Lake has a surface area of 25,900 acres at an elevation of 635 feet. The power installations consist of one generating unit of 3 MW and two units of 42 MW each, or a total of 87 MW.

West Point Dam provides a continuous minimum release of 675 cfs to the Chattahoochee River. It operates in a peaking mode, generating power between two and six hours during normal operations each weekday depending on the conservation pool elevation. Weekend generation may occur if required to meet customer needs. Lake levels vary only during high inflows to the basin and during flood storage drawdown in the winter. Flood flows captured in the reservoir are generally released slowly over the subsequent weeks, unless additional flood flows are expected. Power releases during the low-flow season augment flows at the Georgia Power Company projects along the Chattahoochee River. The releases also provide water for municipal and industrial needs in the Columbus, Georgia, area and for navigation on the Apalachicola River below Jim Woodruff Lock and Dam during the winter.

1.3.3 Walter F. George Lock and Dam

Walter F. George Lake, also known as Lake Eufaula, is created by the Walter F. George Lock and Dam on the Chattahoochee River about 183 miles upstream of Apalachicola Bay. The authorized project purposes include hydroelectric power generation, navigation, recreation, water quality, water supply, and fish and wildlife conservation. The existing project provides for a concrete dam, gated spillway, and single-lift lock, with earthen embankments at either side. The non-overflow section of the dam includes a powerhouse and an intake structure. The gated spillway is 708 feet long with a fixed crest at elevation 163 feet NGVD. The two earthen embankments, almost equal in length, have a total length of 12,128 feet, with crest elevation at 215 feet and a maximum height of about 68 feet. The non-overflow section of the concrete dam is 200 feet long, with the deck of the powerhouse section at elevation 208 feet. The lock, which has usable chamber dimensions of 82 feet by 450 feet, has a lift of 88 feet with the normal upper pool elevation at 190 feet. Depths are 13 feet over the lower sill and 18 feet over the upper sill at normal pool elevation.

At the full pool elevation of 190 feet, the reservoir provides a total storage of 934,600 acre-feet, of which 244,400 is reserved for power production. Walter F. George Lake is the largest reservoir in the ACF River Basin; it has a surface area of 45,180 acres at elevation 190 feet. The power installation at the lake is being rehabilitated. When the rehabilitation is complete, the installation will consist of four generating units of 42 MW, for a total of 168 MW. A lock 82 feet wide and 450 feet long, along with a 9-foot-deep, 200-foot-wide navigation channel extending to Columbus, Georgia, is authorized for navigation use.

1.3.4 George W. Andrews Lock and Dam

The George W. Andrews Lock and Dam is a single-purpose navigation project on the Chattahoochee River, 154 miles upstream of Apalachicola Bay. The authorized project purposes include navigation, recreation, and water quality. It consists of a concrete fixed-crest spillway 340 feet long extending into the right bank with crest at elevation 102 feet NGVD, a concrete gate spillway adjacent to the lock 280 feet long with crest at elevation 82 feet NGVD, a single-lift lock with usable chamber dimensions of 82 feet by 450 feet, and a maximum lift of 25 feet. Depths are 13 feet over the lower sill and 19 over the upper sill at a normal pool elevation of 102 feet. The Andrews project reregulates inflows caused by peaking power operations at Walter F. George powerhouse.

1.3.5 Lake Seminole and Jim Woodruff Dam

The Jim Woodruff Lock and Dam is on the Apalachicola River 107.6 miles above its mouth, about 1,000 feet below the confluence of the Chattahoochee and Flint Rivers and 1.5 miles northwest of Chattahoochee, Florida. The reservoir, Lake Seminole, extends about 46.5 miles upstream along the Chattahoochee River to the vicinity of Columbia, Alabama, and about 47 miles upstream along the Flint River, or 17 miles above Bainbridge, Georgia. The authorized project purposes include hydroelectric power generation, navigation, recreation, water quality, water supply, and fish and wildlife conservation.

The existing project provides for a concrete open-crest spillway 1,634 feet long on the right bank, with crest at elevation 79 feet NGVD; a single-lift lock with usable chamber dimensions of 82 feet by 450 feet constituting a portion of the dam; an earthen section 506 feet long, with a maximum lift of 33 feet and a depth over the sills of 14 feet; a gated spillway 766 feet long with the bridge at elevation 107 feet NGVD, or about 67 feet above the streambed elevation; a powerhouse with an intake section constituting a portion of the dam; an earthen section 506 feet long to accommodate the switchyard and substation; and an overflow dike section 2,130 feet long on the left bank, with crest at elevation 85 feet. At the normal pool elevation of 77 feet, the reservoir has a total capacity of 367,320 acre-feet and a surface area of 37,500 acres. The power installation consists of three units of 14.45 MW, or a total of 43.35 MW. The reservoir level is normally maintained near elevation 77 feet. Pondage of one-half foot above and below this elevation is used to reregulate flows into the reservoir from upstream projects that operate as peaking plants. Because there is no flood risk management storage at this project, the reservoir level is maintained at elevation 77 feet by passing inflows through the spillway gates or through the powerhouse.

Table 1. Projects in the ACF River Basin

Basin/River/Project Name	Owner/State/ Yr. Initially Completed	Drainage Area (Sq. Mi.)	Reservoir Size (Ac.)	Total Storage (Ac-Ft.)	Conservation Storage (Ac-Ft.)	Power Capacity (kW)	Normal (Summer) Lake Elev (Ft.)	Authorized Purposes for Corps-Owned Projects
Chattahoochee River		*8,770*						
Buford Dam/Lake Lanier	COE/GA/1957	1,040	38,542	1,957,000	1,087,600	86,000	1,071	FRM, HP, NAV, REC, WQ, WS, FW
Morgan Falls Dam	GPC/GA/1903	1,340	580	2,450	NA	16,800	866	
West Point Dam and Lake	COE/GA/1975	3,440	25,900	604,520	306,100	82,200	635	FRM, HP, NAV, REC, WQ, WS, FW
Langdale Dam	GPC/GA/1860	3,600	152	NA	NA	401	548	
Riverview Dam	GPC/GA/1902	3,600	75	NA	NA	480	531	
Barletts Ferry Dam	GPC/GA/1926	4,260	5,850	181,000	NA	129,300	521	
Goat Rock Dam	GPC/GA/1912	4,500	965	11,000	NA	68,100	404	
Oliver Dam	GPC/GA/1959	4,630	2,280	32,000	NA	60,000	337	
North Highlands Dam	GPC/GA/1900	4,630	131	1,500	NA	29,600	269	
City Mills Dam*	City Mills/GA/1863	4,630	110	684	NA	740	226	
Eagle and Phenix Dam*	Consolidated Hydro/GA1834	4,640	NA	260	NA	4,260	215	
W. F. George Lock and Dam and Lake (Lake Eufaula)	COE/GA/1963	7,460	45,180	934,400	244,400	130,000	190	HP, NAV, REC, WQ, WS, FW
George W. Andrews Lock and Dam and Lake	COE/GA/1963	8,210	1,540	18,180	NA	None	102	NAV, REC, WQ
Flint River		*8,460*						
Blackshear Dam and Lake*	Crisp Co./GA1930	3,800	8,700	144,000		13,000	237	
Flint River Dam/Lake Worth	GPC/GA/1920	5,310	1,400	NA		5,400	182	
Apalachicola River		*19,600*						
Jim Woodruff Lock and Dam/ Lake Seminole	COE/FL/1954	17,230	37,500	367,320	NA	30,000	77	HP, NAV, REC, WQ, WS, FW

Legend: FRM=Flood Risk Management; HP=Hydroelectric Power Generation; NAV=Navigation; REC=Recreation; WQ=Water Quality; WS=Water Supply; FW=Fish and Wildlife Conservation; NA=Not Available; *Currently Inoperative

1.4 Non-Corps-Owned Dams in the ACF River Basin

There are 11 additional dams within the ACF River Basin that are not owned and operated by the Corps. Brief descriptions of the dams are provided below. Table 1 provides an overview of all the dams (Corps and non-Corps) within the ACF River Basin. The Morgan Falls project is on the Chattahoochee River 30 miles below Buford Dam at river mile 312.6. The dam impounds a 7-mile reservoir that has a surface area of 580 acres at elevation 866 feet. The total reservoir storage volume is about 2,450 acre-feet, of which about 2,250 acre-feet is usable. The maximum generating capacity of the project is 16.8 MW. Georgia Power operates the Morgan Falls Project as a modified run-of-river project to reregulate peaking flows from the Corps' upstream Buford Dam for power generation, drinking water supply, and assimilation of treated wastewater in the Atlanta region.

Below West Point Dam are a series of eight hydropower dams along approximately 32 miles of river. Six of these dams are part of Georgia Power's Middle Chattahoochee Hydro Group; they are known individually as Langdale, Riverview, Bartlett's Ferry, Goat Rock, Oliver, and North Highlands. The first two, Langdale Dam and Riverview Dam, have very small reservoirs that are unnamed. The larger projects at Bartlett's Ferry, Goat Rock, Oliver, and North Highlands are described below. The Middle Chattahoochee projects operate in a run-of-river-with-pondage mode, based on the outflow from the Corps' West Point Dam upstream.

- Bartlett's Ferry Dam is on the Chattahoochee River upstream of Columbus, Georgia. The dam impounds Lake Harding, which has a surface area of 5,850 acres at elevation 521 feet. The project includes a powerhouse composed of six units, which have a total generating capacity of 173 MW.
- Goat Rock Dam is at mile 172.2 on the Chattahoochee River. It impounds Goat Rock Lake, which has a surface area of 965 acres at elevation 404 feet. The powerhouse consists of six units with a total generating capacity of 40 MW. The project provides an instantaneous target minimum flow release of 800 cfs, or inflow, whichever is less, downstream of the dam.

- Oliver Dam, which impounds Lake Oliver, is at mile 163.5 on the Chattahoochee River downstream of Goat Rock Dam. The lake has a surface area of 2,280 acres at elevation 337 feet. The powerhouse consists of three 18-MW generating units and one small 6-MW generating unit, for a total capacity of 60 MW. The project provides an instantaneous target minimum flow release of 800 cfs, or inflow, whichever is less, downstream of the dam
- The North Highlands project is at mile 162.5 on the Chattahoochee River downstream of Oliver Dam. The impoundment has a water surface area of 131 acres at elevation 269 feet. It has four units with a total generating capacity of 29.6 MW. The project is operated in a run-of-river-with-pondage mode, based on the outflow from the West Point Dam upstream. It provides an instantaneous target minimum flow release of 800 cfs, or inflow, whichever is less, downstream of the dam; a daily average target minimum flow of 1,350 cfs, or inflow, whichever is less, downstream of the project; and a weekly average target minimum flow of 1,850 cfs, or inflow, whichever is less, downstream of the project.

Lake Blackshear Dam, owned and operated by the Crisp County Power Commission, impounds the Flint River near Warwick, Georgia, at river mile 134.7. The power plant consists of four units with a total licensed capacity of 15.2 MW. The project consists of two earthen dams, each 30 feet high. The North dam is 3,400 feet long, and the South dam is 650 feet long. The drainage basin is approximately 3,764 square miles and begins at Hartsfield Airport just south of Atlanta, Georgia. The normal full pool elevation is 237 feet above mean sea level (msl).

Lake Worth is formed by the Lake Worth Dam on the Flint River, at its confluence with Muckalee Creek and Kinchafoonee Creek. The Georgia Power Company owns and operates the project. The lake covers 1,400 acres and has 36 miles of shoreline. It is in Dougherty County just upstream of Albany, Georgia. The power installation consists of three units with a capacity of 5.4 MW.

1.5 The ACF Master Manual

In January 2008 Secretary of the Army Pete Geren directed the Corps to update the *Master Water Control Manual for the Apalachicola-Chattahoochee-Flint River Basin.* The current Master Manual was completed in 1958, and consequently it does not include water control manuals for West Point Dam, Walter F. George Lock and Dam, and George W. Andrews Lock and Dam.

In 1989 proposals by the Corps to reallocate storage to municipal and industrial water supply at three reservoirs in the Alabama, Coosa, Tallapoosa (ACT) and Apalachicola, Chattahoochee, Flint (ACF) River Basins—Lake Lanier, Lake Allatoona, and Carters Lake—and by the State of Georgia to develop a regional reservoir near the Alabama state line (West Georgia Regional Reservoir) caused controversy between water user groups, the states of Alabama and Florida, and various federal agencies. A draft Reallocation and Post-Authorization Report and draft Environmental Assessment (EA) had been prepared for the Lake Lanier proposal. A draft *Apalachicola-Chattahoochee-Flint Basin Water Control Plan*, dated October 1989, was included as an appendix to the post-authorization change report. The State of Alabama filed a lawsuit against the Corps in June 1990 to halt these proposed actions. As a result of the litigation, the proposed revisions to the water control manual were deferred while the parties negotiated. The Corps has been operating under the Draft 1989 Master Water Control Manual pending the update of the Master Manual and individual project water control plans.

After a period of negotiation, the governors of Alabama, Florida, and Georgia and the Assistant Secretary of the Army/Civil Works addressed the issues of concern by signing a Memorandum of Agreement (MOA) on January 3, 1992. The MOA specified that a comprehensive study of the water resources of the basins would be conducted, in partnership among the states and the Corps, to develop the needed water resources data and to investigate the feasibility of implementing an interstate coordination mechanism (compacts) for resolving water resources issues in the ACT and ACF River Basins. The MOA contained a “live and let live” provision for water use in the basins while the ACT/ACF Comprehensive Study and negotiations were conducted. This approach permitted existing water users to reasonably increase water withdrawal amounts for the period necessary to negotiate a solution to the water issues. The MOA also specified that the Corps would operate the federal reservoirs in the ACT and ACF River Basins, within its statutory and contractual obligations, to maximize water resource benefits to the basins as a whole while taking into account the needs of existing water users and the need to maintain the historic flow regime in the rivers within the basins.

Subsequent supplemental MOAs extended the term of these agreements and continued to include the “live and let live” provisions. The Comprehensive Study partners recommended river basin compacts between the states as the mechanism for negotiation of water allocation formulas and management of the basins. The “live and let live” provisions were incorporated into the Interstate River Basin Compacts for each basin, signed into law by the President in November 1997; the MOAs were allowed to expire in September 1998.

It was envisioned that the Comprehensive Study would recommend, among other things, a conceptual plan for management of water resources in the ACT and ACF River Basins, including management of the federal and non-federal reservoirs within the basins; an assessment of existing and future water resource needs; the extent of water resources available within the basins to serve such needs; and an appropriate mechanism to implement management of the basins. The Comprehensive Study reports were never finalized, although much useful data on water resource needs and availability was generated and assessment and modeling tools were developed to assist in resource assessment and management of the basins.

Compact negotiations began in early 1998, with a December 31, 1998, deadline for reaching agreement on the water allocation formulas. By mutual agreement and in accordance with the provisions of the Compacts, the states extended the deadline numerous times. Nevertheless, the State Commissioners (governors of each state) were unable to reach an agreement on an equitable apportionment of the waters in either basin, and the Compacts were allowed to expire in August 2003 (ACF River Basin) and in July

2004 (ACT Basin). Upon expiration of the ACT and ACF Compacts, Alabama and Florida reactivated their previous litigation and filed new litigation, resulting in a stay of any action by the Corps related to implementation of any new water supply contracts or changes in reservoir storage or water control operations. The states asserted in this litigation that water control operations in the ACF River Basin are not being conducted in accordance with approved water control plans, Corps regulations, and federal law. The ACF Claims have been consolidated as Multiple District Litigation to be heard by one judge with proceedings to be held in the District Court for the Middle District of Florida.

Court-ordered mediation between the parties was initiated in March 2006 for both the ACT and ACF litigation. It expired in March 2007 (ACF River Basin) and in September 2007 (ACT Basin). On January 30, 2008, Secretary Geren directed the Corps to proceed with updating the water control plans for the ACF River Basin. The Mobile District published the Notice of Intent (NOI) to prepare an Environmental Impact Statement (EIS) for the ACF water control manual update in the *Federal Register* on February 22, 2008.

Water supply issues in the ACF River Basin were also the subject of litigation in the Federal District Court for the District of Columbia (D.C. Court) in December 2000, when the Southeast Federal Power Customers, Inc. (SeFPC) sued the Corps of Engineers, alleging that use of water from Lake Lanier for water supply was not authorized and that the power customers were not receiving appropriate credit for hydropower losses. A Settlement Agreement in that lawsuit between the Corps and the SeFPC and Lake Lanier Water Supply Providers was reached in January 2003, and it was approved by the D.C. Court on February 8, 2004. The Settlement Agreement includes a proposal for the Corps to enter into interim water storage contracts at Lake Lanier for several municipalities and local governments, with the potential for the interim water storage contracts to roll over to permanent reallocation storage contracts in the future. Efforts to implement the Agreement, however, could not proceed because of an injunction obtained by the State of Alabama in another federal court. That injunction was dismissed, and on December 21, 2005, the SeFPC filed a motion with the D.C. Court to stay proceedings in the case pending completion of the NEPA process contemplated by the Settlement Agreement.

In January 2006, the D.C. Court issued an order granting the stay and specifically stating that the stay of the litigation would not release the Corps from its existing legal obligation to implement the settlement agreement as expeditiously as practicable. On June 16, 2006, the Mobile District published in the *Federal Register* an NOI to prepare an EIS to address the proposed interim storage contracts. Public scoping meetings were held in November 2006, and a final Scoping Report was published in February 2007. The States of Alabama and Florida appealed the SeFPC D.C. Court decision to the D.C. Circuit, and arguments were heard in November 2007. On February 5, 2008, the D.C. Circuit held the Settlement Agreement invalid because it constituted a water allocation of more than 20 percent without congressional consent, in violation of the *Water Supply Act of 1958*. The State of Georgia filed a petition for a writ of certiorari with the Supreme Court on the decision by the D.C. Circuit. The petition was denied by the Supreme Court on January 12, 2009.

On November 1, 2007, the governors of Alabama, Florida, and Georgia met with Executive branch leaders (Secretary of the Department of the Interior, Chairman of the Council on Environmental Quality [CEQ], Chief of Engineers) to discuss strategies for developing solutions to the decades-long "Water Wars" between the three states. The resulting discussions focused primarily on the ACF system and the need for the states to agree on a drought water-management plan. The mutually agreed-upon deadline was March 1, 2008. The negotiations did not reach an agreement and ended on the agreed-upon deadline date.

The appendices to the Draft 1989 Master Water Control Manual include federal-reservoir-specific water control plans that outline the regulation schedules for each of the five projects, including operating criteria, guidelines, rule curves, and specifications for storage and releases from the reservoirs.

The reservoirs in the ACF system are operated to provide for the authorized purposes of flood risk management (previously referred to as flood control), fish and wildlife conservation, navigation, hydroelectric power generation, water supply, water quality, and recreation. To provide the authorized project purposes of navigation, certain fish and wildlife needs, hydroelectric power, certain water supply needs, recreation, and water quality, flow must be stored during wetter times of each year and released from storage during drier periods. Traditionally, this means that water is stored in the lakes during the spring and released for authorized project purposes in the summer and fall. In contrast, some authorized project purposes such as lakeside recreation, water supply, and lake fish spawning are achieved by retaining water in the lakes throughout the year or during specified periods. The conflicting water demands require that the Corps operate the system in a balanced operation in an attempt to meet all the authorized purposes while continuously monitoring the total system's water availability to ensure that minimum project purposes can be achieved during critical drought periods.

To help do this, the Corps has defined four Action Zones in each of the major ACF storage projects—Buford, West Point, and Walter F. George. Action Zone 1, the highest in each lake, defines a reservoir condition where all authorized project purposes should be met. As lake levels decline, Action Zones 2 through 4 define increasingly critical system water shortages and guide the Corps in reducing flow releases as pool levels drop as a result of drier-than-normal or drought conditions. The Action Zones also provide a guide to the Corps to help balance the remaining storage in each of the three major storage reservoirs.

Corps regulations require developing a water control plan for each reservoir project, as well as basin water control manuals for the coordinated operation of multiple projects within a river basin. They also require that these manuals be updated or revised as necessary to conform with changing requirements due to developments in the project area and downstream, improvements in technology, new legislation, and other relevant factors, provided such revisions comply with existing federal regulations and established Corps policy. The water control plans for the Corps reservoir projects in the ACF River Basin are out-of-date and need to be updated. The last approved *Apalachicola River Basin Reservoir Regulation Manual* is dated 1959. Although separate water control plans for each federal reservoir project in the ACF River Basin have been prepared, many of them need to be updated. As stated previously, the Master Manual for the ACF River

Basin was updated in 1989, but never finalized. Although the 1989 draft plan was never finalized, the Corps has continued to operate the ACF in accordance with it, making small changes or adjustments as circumstances required. Coordination and consultation under the *Endangered Species Act* has been accomplished for project operations as the need arose, although formal consultation for the basin-wide manual operations has not been completed.

The Corps now intends to proceed with updating those water control plans and the basin manual for the ACF. The proposed updates of the water control plans and manual are intended to reflect current operations as they have evolved due to changing conditions in the basins and would fully comply with agency regulations and federal laws. The states and other stakeholders would be involved in developing the plans. The process of updating the water control plans, subject to the availability of funds, is estimated to take approximately three years. It would include public involvement and analysis under the *National Environmental Policy Act* (NEPA) and consultation under the *Endangered Species Act*. Updating the water control plans and manuals would provide a baseline from which future studies or reallocations would be based, and it would provide a way to capture the Corps' current operating environment.

2.0 Scoping Process Summary

The *National Environmental Policy Act* is a "full disclosure" law, providing for public involvement in the NEPA process. All persons and organizations that have a potential interest in major action proposed by a federal agency—including other federal agencies, state and local agencies, federally recognized Native American Indian tribes, interested stakeholders, and minority, low-income, or disadvantaged populations—are encouraged to participate in the NEPA process.

The CEQ regulations implementing NEPA direct federal agencies that have decided to prepare an Environmental Impact Statement (EIS) to engage in a public scoping process. The purpose of scoping is to determine the range of issues to be addressed and to identify the significant issues to be analyzed in depth with respect to the proposed action and alternatives.

Following the decision to prepare an EIS for implementation of an updated Master Water Control Manual for the ACF River Basin, the Corps initiated the scoping process. The Corps' objectives for scoping were to identify public and agency concerns; clearly define the environmental issues and alternatives to be examined in the EIS, including the elimination of nonsignificant issues; identify related issues that originate from separate legislation, regulations, or Executive Orders (e.g., endangered species or environmental justice concerns); identify state and local agency requirements that must be addressed; and identify available sources of data, studies, or tools that could provide information valuable in preparing the EIS.

The Corps' overall scoping process consisted of the following elements.

- Publishing a Notice of Intent (NOI) to prepare an EIS in the *Federal Register*.
- Publishing an announcement of the dates and locations of five public scoping meetings in the *Federal Register*.
- Updating the existing mailing list by means of an initial postcard requesting accurate contact information.
- Distributing a newsletter and a public notice announcing public scoping meetings

and locations to federal, state, and local agencies and officials; stakeholders; and other interested parties.

- Preparing and launching a Web site that described the NEPA process and all the public involvement activities planned during EIS preparation and served as a tool for collecting public comments and updating the project mailing list.
- Distributing a press release to media outlets.
- Sending agency scoping and tribal consultation letters by email.
- Sending agency scoping and tribal consultation letters by the U.S. Postal Service.
- Holding a federal agency meeting and web conference to inform the agencies and solicit comments.
- Hosting a Stakeholder's Workshop to share the new and improved version of reservoir simulation software called HEC-ResSim with all stakeholders groups involved with water management issues in the basin.
- Holding five public scoping meetings to inform the public about the proposed action and to solicit oral and written comments on the issues that should be addressed in the EIS.
- Reviewing and evaluating the oral and written comments received during the open comment period.
- Publishing the scoping report on a Web site at www.acf-wcm.com.
- Distributing a newsletter announcing publication of the scoping report to federal, state, and local agencies and officials; stakeholders; tribes and other interested parties.

2.1 Initiating Scoping: Notice of Intent

On February 22, 2008, the Corps published in the *Federal Register* an NOI to prepare an EIS for the proposed implementation of the updated ACF Master Manual. On September 19, 2008, a supplement to the NOI was published in the *Federal Register* to invite the public to participate in the NEPA scoping process. The supplemental NOI provided details on the dates and locations of the five open-house-style public scoping meetings scheduled at various locations throughout the ACF River Basin, as well as information explaining the various methods to be used to collect comments from the public for consideration in preparing the Draft EIS. The notice listed Mr. Brian Zettle (USACE Mobile District) as the point of contact for questions regarding the manual update or the NEPA process. Copies of the *Federal Register* notices are provided in Appendix A.

2.2 Public Notices

A press release summarizing the proposed action and the dates, times, and locations of the public scoping meetings (Appendix B) was posted on the USACE Web site at www.sam.usace.army.mil. It was also delivered to newspapers and radio and television stations throughout the basin (Tables 2 and 3). In addition to providing information on the USACE Web site, the Corps also launched a project-specific Web site, www.acf-wcm.com, to provide another avenue for communicating information to stakeholders about the EIS and Master Manual update, as well as to provide for Web-based comment submission during the scoping period.

A newsletter containing the same information as the press release (Appendix C) was sent to more than 3,800 stakeholders, including federal agencies, state agencies, appropriate federally recognized Native American Indian tribes, local agencies and officials, public interest groups, private organizations, individuals, and other interested parties. The newsletter was distributed through the U.S. Postal Service and electronically, if an email had been provided.

Table 2. Newspapers that Received Press Releases

Publication	Location
Abbeville Herald	Abbeville, Alabama
Albany Herald	Albany, Georgia
Atlanta Journal Constitution	Atlanta, Georgia
Columbus Ledger-Enquirer	Columbus, Georgia
The Decatur Daily	Decatur, Alabama
Dahlonega Nugget	Dahlonega, Georgia
Dothan Eagle	Dothan, Alabama
Eufaula Tribune	Eufaula, Alabama
Forsyth County News	Cumming, Georgia
Georgia Outdoor News	Madison, Georgia
Gainesville Times	Gainesville, Georgia
Gulf County Breeze	Gulf Breeze, Florida
Gwinnett Daily Post	Gwinnett County, Georgia
Jackson County Floridian	Marianna, Florida
LaGrange Daily News	LaGrange, Georgia
Lanette Valley Times	Lanette, Alabama
Montgomery Advertiser	Montgomery, Alabama
Mundo Hispanico	Atlanta, Georgia
Opelika Auburn News	Opelika, Alabama
Pensacola News Journal	Pensacola, Florida
Tallahassee Democrat	Tallahassee, Florida

Table 3. Television and Radio Stations that Received Press Releases

Name	City
WRBL TV (Channel 3, CBS)	Columbus, Georgia
WSB TV (Channel 2, ABC)	Atlanta, Georgia
WTVM TV (Channel 9, ABC)	Columbus, Georgia
WXIA TV (Channel 11, NBC)	Atlanta, Georgia
WGCL TV (Channel 46, CBS)	Atlanta, Georgia
WDUN (550 AM)	Gainesville, Georgia
WMJE (102.9 FM)	Gainesville, Georgia
WGST (640 AM)	Atlanta, Georgia
WSB Radio (98.5 FM)	Atlanta, Georgia

The project mailing list was developed from an existing Corps-maintained database of stakeholders with an interest in activities within the ACF River Basin. A postcard was sent to stakeholders to give them an opportunity to update their information to include an email address, provide an alternative contact's email address, state whether they would like to continue to receive mail through the U.S. Postal Service, or remove their name from the mailing list.

At this time, there are more than 4,500 stakeholders on the mailing list. As other interested parties are identified, they have been added to the mailing list, which will be updated continually throughout the development and finalization of the EIS. Anyone requesting information or notice regarding the EIS will be added to the mailing list. Participants in the public and interagency scoping meetings have been added to the project mailing list as well.

2.3 Native American Indian Tribal Consultation

Government-to-government tribal consultation notices (Appendix D) were sent electronically October 1, 2008, and through the U.S. Postal Service on October 15, 2008, to 26 federally recognized Native American Indian tribes in the United States. The consultation letters contained information regarding the update of the Master Manual, as well as announcements of the interagency and public scoping meetings. The letters also requested a response with respect to interest in participating in a consultation meeting regarding the EISs for both the ACF and ACT River Basins. The meeting was planned for November 13, 2008, in Spanish Fort, Alabama, outside Mobile. Mr. Tommy Birchett, an archaeologist with the Mobile District, was identified as the point of contact for responses.

Seven tribes of the 26 responded to the initial electronic mailing, several of which mentioned schedule conflicts. Ultimately, only the Choctaw Nation of Oklahoma expressed interest in attending the meeting November 13, 2008.

A final mailing was sent electronically as a follow-up to ensure that no other tribes were interested in participating in government-to-government consultation at the time. Given the limited response, the Corps chose to coordinate with the tribes through email for the time being and referred the tribes to the various resources available online to find out more about the proposed Corps action.

2.4 Federal Agency Web Conference

On September 26, 2008, the Corps sent an electronic invitation to attend a federal agency web conference to the points of contact previously identified in the ACF River Basin. A follow-up announcement was distributed October 6, 2008, to remind agencies of the meeting and request their participation in a pre-meeting agenda planning tool. An online survey was created to collect input from the agencies, and it was later used to establish the web conference agenda. The web conference was held October 9, 2008, at the Mobile District office in Mobile, Alabama. The purpose of the meeting was to provide background information on and an open discussion about updating the Master Manual. The meeting was also used to gather existing data and additional information that can be used in developing the Draft EIS.

Thirty representatives from 11 federal agencies participated in the web conference. In addition to presenting background information on the update of the Master Manual, the Corps provided information on the NEPA process and discussed the resource areas that would likely be considered in the EIS. A summary of the issues raised during the web conference is provided in Section 4.6 of this report. The meeting agenda and presentation are in Appendix E.

2.5 HEC-ResSim Technical Modeling Workshop

The Hydrologic Engineering Center (HEC) has developed a new and improved version of reservoir simulation software called HEC-ResSim. In recognition of HEC-ResSim's sophisticated computational abilities and maturity as a generalized model, the Mobile District began working with HEC to modernize its ACT and ACF reservoir modeling applications using HEC ResSim. The more powerful system modeling functions and ability to incorporate custom logic into water management decisions proved improved capability to actual operations and allow greater flexibility for evaluating alternatives.

In the interest of transparency and cooperation, the Mobile District and HEC hosted a workshop to share the new tools and data with all stakeholders groups involved with water management issues in the basin. The workshop took place at Jim Woodruff Lock &

Dam from 30 September – 2 October 2008, and focused entirely on technical topics. A total of twenty-eight modelers attended the workshop representing three federal agencies, three state agencies, one university, and five private consultants representing the stakeholders.

The session proved very successful regarding it objectives:

- Introduce the participants to the HEC-ResSim software.
- Initiate technology transfer by providing the participants with a copy of the software and ACT/ACF Models; walk the participants through the model; and answer questions.
- Foster relationships by continuing long standing technical working relationships with stakeholders.

A copy of the workshop announcement and agenda is provided in Appendix F. Mobile District and HEC continue to refine the HEC-ResSim models of the ACF system, with an informed stakeholder group.

2.6 Public Scoping Meetings

Public scoping meetings for the ACF River Basin were held on the following dates at the times and locations noted:

- Monday, October 20, 2008: Franklin County Courthouse, Apalachicola, Florida, 5:00 p.m.–8:00 p.m.
- Tuesday, October 21, 2008: Dothan Convention Center, Dothan, Alabama, 5:00 p.m.–8:00 p.m.
- Wednesday, October 22, 2008: Callaway Center at West Georgia, LaGrange, Georgia, 5:00 p.m.–8:00 p.m.
- Thursday, October 23, 2008: Cobb County Government Civic Center, Hudgins Hall, Marietta, Georgia, 4:00 p.m.–7:00 p.m.
- Wednesday, October 29, 2008: Georgia Mountain Center, Gainesville, Georgia, 5:00 p.m.–8:00 p.m.

The venues were chosen on the basis of accessibility to the public throughout the ACF River Basin. An open house format was used at each meeting, and information stations with displays (Appendix G) and handouts (Appendix H) were available for viewing. Subject matter experts from the Corps and environmental contractors staffed each station, where information about the following was provided:

- The Water Control Manual for the ACF River Basin
- Water management and federally authorized project purposes
- Modeling tools
- The NEPA process and EIS development
- Environmental resources
- Socioeconomics

In addition, a welcome station, media station, written comments station, and court reporter were available to provide information and accept oral and written comments. A total of 1,018 stakeholders participated in the 5 public scoping meetings. A breakdown of participation by meeting location is shown in Table 4.

Table 4. Participants by Scoping Meeting Location

Date	Location	Attendance
October 20, 2008	Apalachicola, Florida	135
October 21, 2008	Dothan, Alabama	24
October 22, 2008	LaGrange, Georgia	365
October 23, 2008	Marietta, Georgia	93
October 29, 2008	Gainesville, Georgia	401
	Total	*1,018*

Following sign-in, a brief presentation was offered to introduce participants to the format of the public scoping meeting and to clarify the purpose of the meeting. Corps experts and environmental contractors were available at stations to answer questions and accept comments. Laptop computers were set up to accept comments electronically through the project Web site. A staff member was on hand to help participants to use the computers. Comment forms were also available at the written comments station. Also, a court reporter was available at each meeting to accept oral comments. Appendix I contains the oral comment roster. Transcripts of the oral comments are included in Appendix J, which contains all the comments the Corps received during scoping.

2.7 Scoping Comments

A total of 2,269 comments were submitted by 643 individuals, organizations, and agencies during the formal scoping period, which ended November 21, 2008. Comments were submitted to the Corps through all available options—U.S. Postal Service, email, Web site, fax, verbal transcription, or in person at one of the scoping meetings. Copies of all the public and agency comments received during the scoping process are presented in Appendix J.

Scoping continues throughout the preparation of an EIS. The Corps will accept and consider all comments regardless of when they are submitted. However, comments submitted after November 21, 2008, are not represented in this scoping report.

3.0 Scoping Comment Analysis

The scoping process for the EIS for implementation of an updated *Master Water Control Manual for the Apalachicola-Chattahoochee-Flint River Basin*) resulted in the submission of comments from 643 individuals, organizations, and agencies and two petitions. As described in Section 2 of this report, the Corps received oral and written comments by U.S. Postal Service, email, on Web site forms, and at public scoping meetings. In the next stages of the EIS process, these comments will be used to determine the scope and content of the Draft EIS. Note that the Corps does not endorse or validate the content of the comments received.

The 2,269 comments received were categorized into 12 comment areas categories: Water Management Recommendations; Socioeconomics and Recreation; Biological Resources; Drought Operations; Water Quality; Water Supply; National Environmental Policy Act; Data, Studies, and Analytical Tools; Navigation; Hydropower; Flood Risk Management; and Other Resources. Some of the categories were further divided into subcategories to present the stakeholders' issues and recommendations more clearly. Table 5 provides the total number of comments by category. Appendix K contains all of the comments received sorted by issue area.

When considering the numbers represented in Table 5, it is important to note that some comments might be defined by more than one category. Also important to note is that some of the comments received were submitted by entities or organizations representing a specifically identified number of individuals. These letters are accounted for in the same manner as correspondence received from elected officials written on behalf of their constituents. They are counted as one submission. Statistically, the petitions were accounted for separately as presented in Section 3.13.

Table 5. Comments Categorized by Segment

Category	Number of Comments
Water Management Recommendations	868
Socioeconomics and Recreation	404
Biological Resources	284
Drought Operations	191
Water Quality	155
Water Supply	117
National Environmental Policy Act	79
Data, Studies, and Analytical Tools	56
Other Resources	52
Navigation	28
Hydropower	26
Flood Risk Management	9
Total	*2,269*

3.1 Water Management Recommendations

The Corps operates federal reservoirs in the ACF River Basin to satisfy the following congressionally authorized project purposes; fish and wildlife conservation, flood risk management, hydroelectric power generation, navigation, recreation, water supply, and water quality. Eight hundred sixty-eight comments were related to the management of project purposes and Corps operations of the ACF River Basin. These comments were further divided into six subcategories: (1) Existing Water Management Practices, (2) Water Management Suggestions, (3) Demands and Needs, (4) Conservation, (5) Alternatives, and (6) Other. Figure 2 presents the distribution of comments regarding water management recommendations.

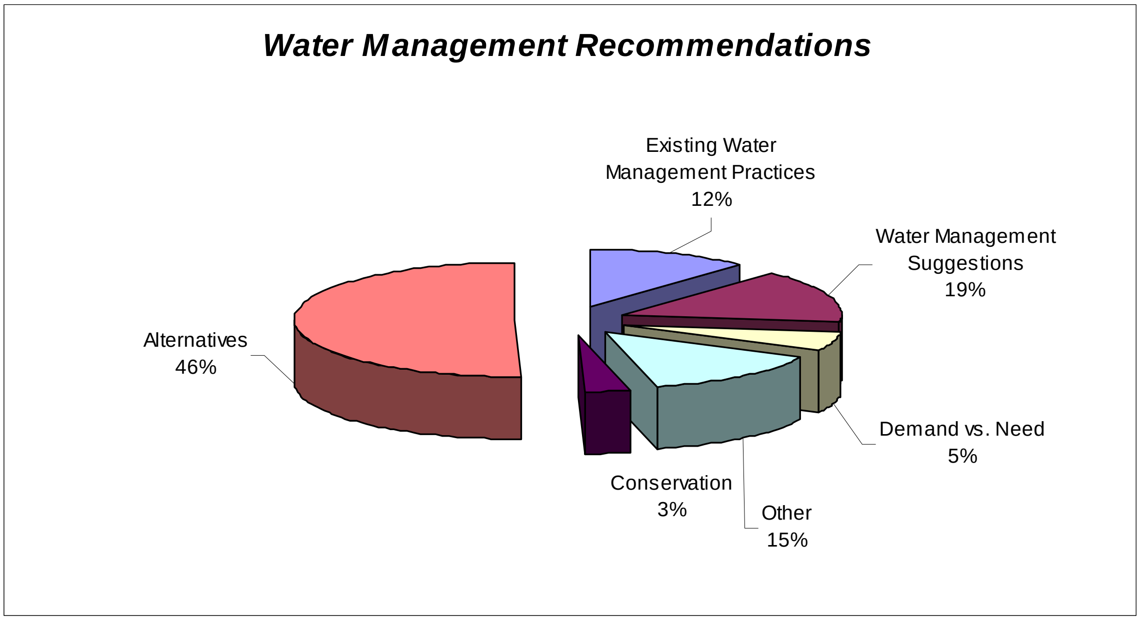

Figure 2. Distribution of comments among Water Management Recommendations subcategories.

3.1.1 Existing Water Management Practices

The Corps received 103 comments critiquing the manner in which the water management activities in the ACF River Basin are carried out. The comments regarding Lake Lanier addressed the low lake levels and their effects on recreation, safety, property values, the environment, and aesthetics. One commenter stated, "Sometimes it's embarrassing. I have relatives that call from all over the United States and make jokes about do I have water in my lake." Another said, "We also had dead mussels on the dry land at our house when the water was down." Others called attention to a gauge error that occurred in 2006, citing the error as a contributor to the low lake levels that followed. Some questioned the Corps' decisions to make releases from Lake Lanier at the beginning of the drought, given the small drainage area upstream and the known difficulty in refilling. Others questioned why water continues to be released from Lake Lanier even when the pool elevation is 22 feet below normal. A few commenters expressed their perception of preferential treatment of upstream users to the detriment of downstream users. A representative of Gwinnett County, citing paragraph 6d of Engineer Regulation (ER) 1110-2-240, stated, "We do not believe that the present Interim Operations Plan and its modifications follow this COE rule." Another commenter stated that downstream lakes have recovered from their low levels, but continued releases from Lake Lanier in excess of inflow have not allowed its recovery.

Those commenting about West Point Lake complained primarily of low lake levels and the impact on recreation and recreational safety. One commenter stated that "[c]onditions of a low pool are extremely hazardous to those who use the lake for recreation and as a means of daily sustenance." Others questioned whether the Corps is operating West Point Lake in accordance with the congressional authorization. The West Point Lake Coalition, for example, stated that "the Corps operates West Point Lake specifically and the ACF system in general in a way that ignores the original, PRIMARY congressional authorizations as a group and focuses extensively on flood risk management as well as downstream and upstream demands that do not meet the purposes set forth by Congress. It appears that the Corps has established the flood risk management authorization as THE primary purpose…." Some suggested that the Corps needs to take a more proactive approach to the creeks that feed into the lake by dredging them to prevent flooding of low-lying areas.

Some commenters were concerned about flows in the open-river sections downstream of the reservoirs. Some, such as the Alabama Department of Conservation and Natural Resources (ADCNR), expressed concern that "the water management policies of the past have often resulted in a degradation of the ecological integrity of a river ecosystem, which in the case of wildlife has led to a decrease in biodiversity and species sustainability." ADCNR added, "To protect ecological integrity, we need to mimic components of natural flow variability, taking into consideration the magnitude, frequency, timing duration, rate of change and predictability of flow, and sequencing of such conditions." Others were concerned that growth in the Atlanta regions will cause the Corps to modify its operations of Lake Lanier to the detriment of the downstream uses of water supply and waste assimilation. The Columbus Water Works expressed concern that current operations do not pay adequate attention to Chattahoochee River flows in the middle stretch of the river and the minimum flow obligations of Georgia Power Company projects operating under a Federal Energy Regulatory Commission (FERC) license. A number of commenters were concerned that current operations favor endangered species (mussels) over people.

3.1.2 Water Management Suggestions

A total of 132 comments provided suggestions regarding potential modifications to current water management practices and water control manuals. The comments from federal, state, regional, and local agencies are discussed in more detail in Section 4. The U.S. Environmental Protection Agency (EPA) identified a number of issues for inclusion in the updated water control manuals, including a discussion of how operations have changed historically, drought contingency operations, compliance with new environmental requirements for water quality and endangered species, use of real-time data, and streamlining data exchange between agencies. The U.S. Fish and Wildlife Service (USFWS) provided a number of suggestions for consideration in updating the water control manuals. The USFWS requested that the Corps develop a summary of the current operating rules for each project, an explanation of their basis in congressional authorization, and a description of the Corps' discretion to change the operating rules. The USFWS recommended a comprehensive process for determining how ecological and social benefits could be increased by modifying the operation of the federal projects and suggested that the Corps consider the impacts of increasing consumptive demands in the ACF River Basin.

The Alabama Office of Water Resources (AOWR) stated that "[u]nless the Corps undertakes the revision to the Water Control Manuals in a manner that is consistent with federal law, including the recent decision of the United States Court of Appeals for the D.C. Circuit, the current effort will not help resolve the long-running controversy over the ACF River Basin." AOWR further suggested that the update of the water control manuals focus on authorized purposes by assessing whether any changes in baseline conditions are necessary to comply with existing laws and regulations. The Florida Department of Environmental Protection (FDEP) stated, "The master manual must clearly describe not only the relative priorities of each of the ACF reservoirs, but also how those priorities and additional uses and demands will be accommodated." FDEP also suggested that the NEPA process evaluate Corps operations throughout the ACF River Basin. The Georgia Environmental Protection Division (GAEPD) stated that "[i]t should be noted that the issuance of water withdrawal permits from Lake Lanier and the withdrawal and consumption of water from the ACF River Basin are state and local actions, not federal actions, and therefore should not be addressed within the scope of connected, cumulative, and similar federal actions." The Atlanta Regional Commission suggested that the Corps consider all reasonable alternatives; operate the ACF projects in accordance with their congressionally authorized purposes; and address the needs of the middle and lower portions of the basin. Hall County, Georgia, suggested that the updated manuals rely on the most up-to-date factual information examining new and different ways of operating the ACF projects.

The Students of River Basin Management at Florida State University provided several suggestions, including potentially revising the Action Zones, incorporating the Revised Interim Operating Plan (RIOP) into the updated manuals, defining the process of balancing the reservoirs, and incorporating adaptive management. One commenter was concerned that net local inflow accounts for not only streamflow into the reservoir but also consumptive depletions and evaporation from the reservoirs, which could adversely affect the computed inflows used in the RIOP. Another commenter encouraged further revision of the RIOP to limit the adverse effect on Lake Lanier. One commenter encouraged the use of HEC-ResSim to assist in developing new operating rules for the ACF projects and suggested that the water control plan consider effects on the Apalachicola River and Bay. The West Point Lake Coalition requested that the "winter drawdown" be no lower than elevation 633 feet.

One commenter suggested that the Corps' updated Master Manual can be a critical tool in achieving joint agreement in interstate water management. Some commenters suggested that the updated manuals must be scientifically based and establish an equitable distribution of the waters of the ACF River Basin. One commenter suggested reducing releases from Lake Lanier when rain occurs in downstream portions of the ACF River

Basin. Another commenter observed that the Flint River has not been developed in accordance with the original comprehensive plan for the ACF River Basin and that additional reservoirs would be helpful in solving the interstate water issues.

The Association of County Governments of Georgia (ACCG) stated, “Updating the plan should include new methods of forecasting runoff and modeling to ensure that the Corps ACF reservoirs, particularly Lake Lanier, are allowed to reach full pool no later than June 1st of each year and are as full as practical during drought conditions while still meeting downstream, legally-required flows.” Numerous other commenters agreed with the idea of refilling Lake Lanier by June 1 of each year. Sixty-six comments encouraged balancing of project purposes. They indicated that all interests should be considered and evaluated and that upstream and downstream needs are equally important. One commenter suggested that “[t]here is sufficient water in the basin to meet reasonable needs for municipal and industrial water supply without causing harm to the environment or to other users if, but only if, the reservoirs are managed wisely.”

Fifteen comments encouraged a reduction in dependence on West Point Lake for meeting downstream needs. The Mayor of LaGrange, the West Point Lake Coalition, and the Troup County Chamber of Commerce all stated that “the project has been used as, using the Corps terms, ‘the workhorse’ of the basin. Nowhere in the Congressional authorization does Congress empower the Corps to take the resources at West Point and to use them exclusively for purposes other than those set by Congress.” A similar sentiment was expressed by 12 other commenters. One commenter suggested that faster reaction to changing conditions is needed and that there is no time for “lots of studies.” Five comments regarding monitoring were received. EPA suggested that “employing this same type of concept [referring to GAEPD’s process for monitoring water quality] in other areas would greatly enhance the ecological sustainability of the aquatic systems affected by construction, maintenance and operation of federal projects within the ACF watershed basin.” Another commenter suggested real-time monitoring for river flows in the Atlanta area to tailor releases to exactly what is needed. ACCG urged that “any new Water Control Plan not simply tweak or replicate the Corps existing operations. Instead, alternative operating plans must be developed using modern inflow forecasting and modeling to meet the agreed upon performance measures that will manage our shared water resources much more effectively both now and into the future."

There were five comments regarding sharing the effects of drought throughout the ACF River Basin. One commenter expressed the opinion that "[a]ll communities benefiting from the Lanier withdrawals should be on the same water restrictions as those at Lake Lanier even if they have sufficient water while we are in a draught [sic]!" Another commenter described this notion as "sharing the pain." Two comments encouraged conservative operations of the reservoirs to maintain higher pool levels. Seventeen commenters suggested conserving storage by reducing releases and withdrawals during drought times. One commenter stated, "Too much water has been allowed to flow downstream. Lake Lanier has been adversely affected by the drought and excessive outflow of lake water." Another commenter suggested that releases above natural river flows should not be made when the lakes are in Action Zones 2–4. All 17 commenters shared the view that releases should be reduced until Lake Lanier has recovered.

3.1.3 Demands and Needs

Forty-six comments fell into the Demands and Needs category. Of these, 31 comments expressed concern regarding the ability of the federal projects in the ACF River Basin to meet downstream needs. Among the needs identified were minimum flow needs in the middle Chattahoochee portion of the basin; the needs of industry, such as the Farley Nuclear Plant; and ecosystem needs in the Apalachicola River and Apalachicola Bay. Some commenters believed that upstream needs for water supply and recreation should receive greater emphasis than downstream needs. Others were concerned that the Apalachicola River and Apalachicola Bay should be protected with adequate water flow. Twelve commenters were concerned about the adequacy of water resources to meet future water needs. One commenter stated, "The new Water Control Plan should be designed to accommodate withdrawals consistent with projections contained in the Metropolitan North Georgia Water Planning Districts Water Supply and Conservation Plan." Another commenter suggested, "Consideration should be given looking at future population projections and water demands from the river." Three comments addressed the subject of growth management. One commenter observed that "[t]he man made problems of uncontrolled development which requires more water than is available without the least bit of concern for others in continuing development is more than we should or can be expected to swallow." Another commenter asked "future growth and development in Atlanta to demonstrate where water supply will come from to support planned growth."

3.1.4 Conservation

The Corps received 27 comments related to water conservation. One commenter observed that conservation measures in the Atlanta area were effective. Another suggested that the region through the "Metropolitan North Georgia Water Planning District is far ahead of the rest of the basin in these efforts and is currently revising its Water Supply and Conservation Plan to be even more aggressive." Several commenters encouraged implementation of basin-wide conservation measures. Another commenter suggested that conservation measures should be developed for water uses in addition to water supply. According to one commenter, conservation measures should be incorporated into the Master Manual update.

3.1.5 Alternatives

There were 440 comments that suggested alternatives to be considered as part of the update of the Master Manual. A large portion of the comments received were associated with maintaining or raising full pool water levels at Lake Lanier and West Point Lake. Specifically, commenters would like Lake Lanier to remain at 1,071 feet or to be raised to 1,073 feet. Comments regarding West Point Lake requested eliminating the winter drawdown and maintaining the lake at between 633 and 635 feet. Other commenters suggested adopting "management triggers" for Lake Lanier, stating that "[t]he new WCP should incorporate specialized provisions for managing Lake Lanier that reflect its distinctive characteristics and management needs. Without them, Lake Lanier is destined to be disproportionately impacted by draw-downs for downstream management, without an ability to remain near full pool or to refill."

Twenty-four commenters suggested construction of additional reservoirs to meet future water supply and other water resources needs. Five commenters encouraged restoring a historic flow regime to the Apalachicola River. One commenter suggested that some control of inter-basin transfers is needed. Four commenters suggested desalination as a potential source for future water supply, and four suggested a pipeline to bring Tennessee River water to the Atlanta area as a potential solution. Three commenters suggested that closing Bob Sikes Cut should be part of a solution to salinity problems in Apalachicola Bay.

Many of the alternatives suggested are outside the existing authority of the Corps and could not be implemented without additional congressional authority. Suggestions that are outside the existing Corps authority may be considered by conducting a feasibility study and making appropriate recommendations to Congress for their authorization. One authority for conducting such a feasibility study is Section 216 of the *Flood Control Act of 1970*, which authorizes studies to review the operation of completed federal projects and recommend project modifications "when found advisable due to significantly changed physical or economic conditions ... and for improving the quality of the environment in the overall public interest." Such studies are conducted under the General Investigation program and require cost-sharing from a local sponsor.

3.1.6 Other

There were 119 comments regarding water management that did not clearly fall within other subcategories and therefore were categorized as Other. These comments were wide-ranging and cannot be easily summarized. A couple of commenters encouraged the Corps to conduct a thorough update, stating that "[o]nly the most thorough study and vetting resulting in a cultural change in the Corps understanding and management of the system will assure a basin that meets the needs for future generations." Another commenter expressed frustration with the time required to update the Master Manual. Other commenters described the scoping process as a waste of time and money.

3.2 Socioeconomics and Recreation

A total of 404 comments were categorized under Socioeconomics—the study of the relationship between economic activity and social life—and Recreation. Following review, the comments were further sorted into six subcategories: (1) Economics and Recreation; (2) Safety Hazards; (3) Environmental Justice; (4) Population Growth; (5) Shoreline Management; and (6) General Socioeconomic Issues. The percentage of comments assigned to each subcategory is shown in Figure 3.

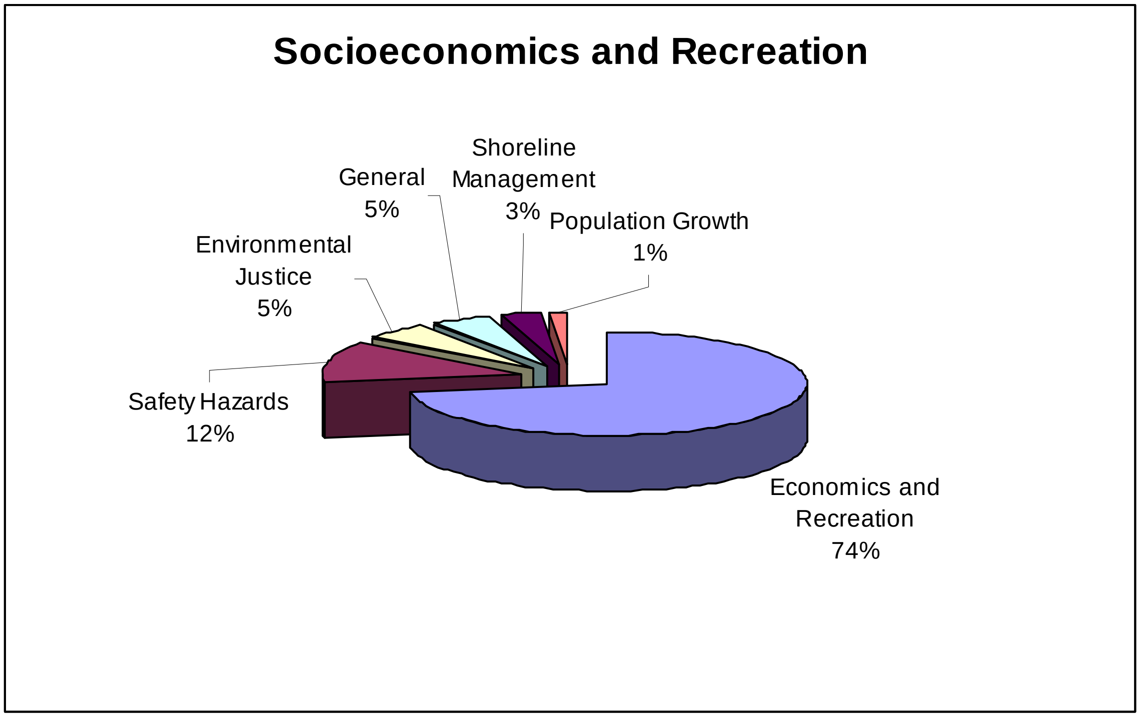

Figure 3. Distribution of comments among Socioeconomics and Recreation subcategories.

It is important to note that concerns regarding socioeconomics—employment, lost revenue, economic growth, property values, recreation, environmental justice, public safety—are the underlying message in far more than the 404 comments directly attributed to this category. Though more comments were assigned to the Water Management Recommendations category than to this category, a large percentage of those recommendations were centered on achieving more favorable socioeconomic conditions for stakeholders throughout the ACF River Basin. Summaries of the issues raised, by subcategory, are provided in the following subsections.

3.2.1 Economics and Recreation

Recreation is a major economic driver for many of the communities in the ACF River Basin. In fact, recreation and economics are so closely intertwined in the comments provided by stakeholders that the two topics could not be disentangled. Of the 293 comments assigned to this subcategory, about 80 percent regarded the effects of low water levels in Lake Lanier and West Point Lake; the remaining 20 percent addressed the effects of low water flows in the Chattahoochee River south of West Point Dam. Stakeholders in Georgia raised numerous issues regarding the adverse impacts that prolonged low and inconsistent water levels in lakes Lanier and West Point have had on the local, regional, and state economies. The issues raised include job and income losses for water-dependent and recreation/tourism-based businesses, sharp declines in property values, lost recreation opportunities and declining quality of life, and lost opportunities for economic growth. Many contended that the Corps has failed to take socioeconomic impacts into account in its water management practices. Several comments expressed a belief that the Corps is knowingly managing its dams to meet the downstream water flow needs of natural resources without regard for socioeconomic impacts on the people of Georgia. Many of the comments were submitted on behalf of large organizations or associations that represent the concerns of thousands of stakeholders.

More than 30 comments were submitted by stakeholders in the middle and lower regions of the ACF River Basin and regarded the adverse economic and recreation impacts of low river flows in the Chattahoochee River south of West Point Dam. Alabama stakeholders raised issues regarding downstream flow requirements to meet hydropower project purposes and industrial users—critical components of the regional and state economy. Recreation is also a large economic driver in the eastern regions of the state, and low reservoir levels and river flow have affected the economy and quality of life for Alabamians. Florida stakeholders expressed great concern for the future of their seafood- and fishing-based economy, as well as the businesses that support that economy, including tourism, if adequate water flow into Apalachicola Estuary and Bay is not maintained. Florida stakeholders expressed grave concerns that if minimum flows for the survival of the Apalachicola estuarine ecosystem are not maintained, the economy of the Apalachicola Bay region will collapse, with no possibility for recovery.

Stakeholders offered an extensive list of basin-wide recommendations and actions that they believe the Corps should consider in updating the Master Manual and supporting EIS. The recommendations include the following:

- Develop an economic study on the impact of various water levels on each region of the ACF River Basin.
- Update the reservoir fisheries performance measures developed for the 1998 draft EIS for ACF water allocation (based on the findings of Ryder et al. [1995]) in light of any new information developed in the past 10 years, and use them to evaluate the relative impacts on reservoir sport fisheries of alternative operating plans.
- Fully analyze the relationship between recreational use of the lakes and the direct and induced economic impacts.
- Show scientific and economic facts to support flow requirements for downstream hydropower, endangered species habitat, and health of the seafood/oyster industry.

Recommendations regarding Lake Lanier include the following:

- Assess the negative impact of questionable water supply on future economic development efforts in Atlanta.
- Provide federal assistance to lake property owners affected by cove erosion due to low lake levels.
- Consider all options for alleviating adverse economic impacts on water-dependent businesses in Lake Lanier/Atlanta region.
- Develop a new water control plan that ensures the best and highest use of Lake Lanier to protect the regional economy.

Recommendations regarding West Point Lake include the following:

- Do not consider use of West Point Lake to support downstream navigation in any alternative operation plans without adequate study of the environmental and socioeconomic damages that could occur due to fluctuating water levels in the lake.
- Include the results of the West Point Lake independent economic study in the EIS as support for developing alternative water control operations at the lake.
- Restore and maintain all Corps-owned and -operated recreational facilities at West Point Lake.
- Maintain West Point Lake at full pool during peak recreational times.
- Perform a risk/benefit analysis of economics versus flood control for West Point Dam management practices.
- Change the start of winter drawdown of West Point Lake from November to January to improve the economic situation.

Recommendations regarding economic and recreation issues in the middle and lower reaches of the Chattahoochee River and Apalachicola Bay include the following:

- Monitor boating access sites and strive to maintain water levels for recreational boating access.
- Consider the positive socioeconomic and environmental benefits to Apalachicola River and Bay that would result from maintaining flows in the Chattahoochee River to support navigation.
- Include in the EIS an analysis of the economic value of the vast ecosystem services and cultural values provided by adequate flow to Apalachicola Bay.
- Conduct a comprehensive analysis of the economic, environmental, and social and cultural impacts tied to the loss of the traditional livelihoods of rural riparian counties and communities.
- Examine the irreversible adverse economic impacts of the loss of the oyster fishery due to low river flows.

The following comments were also offered for the Corps' consideration:

- Install mooring balls in West Point Lake for overnight fishing or camping as another source of revenue for the Corps. Lease the areas where mooring balls are located to local marinas to develop this resource.
- Charge market-based fees for the use of Corps-owned recreational facilities and retain the revenues to fund project operation and maintenance.

3.2.2 Safety Hazards

Stakeholders submitted about 50 comments regarding the safety hazards encountered by recreational users when reservoir levels are not maintained at adequate levels. Commenters point out that low water levels result in exposed or near-surface objects that pose great danger to boaters, as well as damage to recreational equipment. Some commenters also state that low water levels are to blame for drowning due to sudden drop-offs or changes in terrain. Commenters recommend that the Corps keep the reservoirs at full pool to avoid recreational safety hazards. One commenter suggest that the Corps "[p]ermit dredging and removal of hazardous shallows/shoals in the primary thoroughfares, thereby adding additional water capacity to the lake and making the lake safer for navigation."

3.2.3 Environmental Justice

Approximately 25 comments regarding socioeconomic impacts on low-income and minority populations were submitted. Individuals and organizations in and around West Point Lake expressed concern for the low-income and minority populations and communities that rely on the lake for recreation as well for supplemental sustenance. Comments from the non profit organization 100 Black Men of West Georgia states "[a]ctions which result in lower elevations of West Point Lake represent a potential or threat of denial of access to recreational resources for minority and low income populations in the West Georgia and East Alabama." The organization further states that the Corps is ignoring the original authorized purpose of recreation, '[a]nd the needs and expectations of minority and lower income households in west Georgia and east Alabama

They ask the Corps "[e]ngage far more intensely and with a great deal more thoroughness in addressing environmental justice issues at West Point Lake. The West Point Lake Advisory Council requests that the Corps ensure recreational access for low-income families. One commenter contends that the "[i]ssue of ensuring recreational access for low income and minority families that the West Point Lake Advisory Council is attempting to push is ridiculous." The comment goes on to say that the population affected are those wealthy enough to own a house with boat dock on the lake, not the poor, and the rich are trying to use the Environmental Justice issue to help themselves. Several comments were also made regarding the loss of income for many low-income families that rely directly on the lakes and rivers for their income. Concerns were raised that decreased water flow in the middle regions of the ACF River Basin and in Apalachicola Bay could have severe economic impacts for entire low-income or minority communities.

3.2.4 Other Socioeconomic Issues

Population Growth. Six commenters addressed the issue of future population growth as a factor the Corps must consider in the Master Manual and supporting EIS. Commenters want the Corps to factor population projections into any consideration of alternative operational practices and as a factor in management of the ACF River Basin as a whole.

Shoreline Management. Thirteen comments were submitted by individual stakeholders requesting that the Corps consider revisions to dock permitting policies, better manage shoreline debris, perform annual shoreline allocations reviews, and provide for better enforcement of existing shoreline management policies.

General Comments. About 20 comments addressed socioeconomics but did not clearly fit into the other subcategories. These comments include a number of statements regarding the personal enjoyment of living on the water, the importance of ensuring that the resources in the ACF are protected for future generations, and the disappointment and anger many stakeholders feel about the current low water levels in Lake Lanier and West Point Lake.

3.3 Biological Resources

The 305 comments in the Biological Resources category were divided into four subcategories: Fisheries, Threatened and Endangered Species, Flow Concerns for Apalachicola Bay, and Other Biological Issues. Figure 4 illustrates the distribution of comments categorized as Biological Resources.

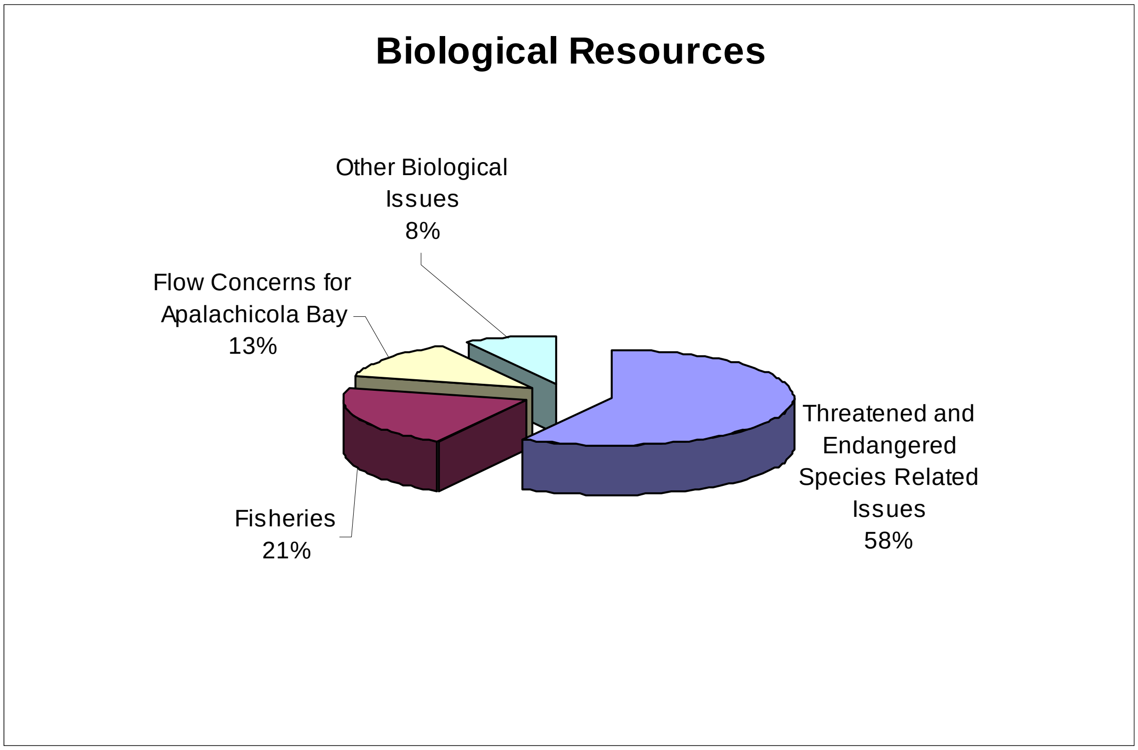

Figure 4. Distribution of comments among Biological Resources subcategories.

3.3.1 Threatened and Endangered Species

The Corps received 165 comments related to threatened and endangered species. Commenters noted that water availability for people should be considered a priority over the protection of mussels and that Lake Lanier should not be drawn down to provide for this species. Navigation should be abandoned as a project purpose because of its detrimental effect on endangered species. Commenters stated that the IOP and RIOP are "flawed" because of a lack of studies on the endangered species at West Point Lake. Some commenters said that more research needs to be conducted on endangered wildlife in the ACF River Basin. EPA recommended that the Corps address and fully document the effects of any proposed actions on threatened and endangered species when considering alternatives for the EIS.

Comments with recommendations for threatened and endangered species in the ACF River Basin include:

- Revisit the list of threatened and endangered species periodically during the planning process and verify the accuracy of the species/habitats list when beginning to prepare a Biological Assessment.
- Participate with the USFWS and other federal and state agencies in efforts to locate and monitor extant populations in the remaining unimpounded portions of the Chattahoochee River and its tributaries.
- Conduct an EIS to determine the amount of water needed for mussels and other endangered species downstream to survive.
- Address the same *Endangered Species Act*-protected resources for the Master Manual update as for the RIOP—the Gulf sturgeon (*Acipenser oxyrinchus desotoi*), fat three ridge (*Amblema neislerii*), Chipola slabshell (*Elliptio chipolaensis*), and purple bankclimber mussel (*Elliptoideus sloatianus*), all of which have designated critical habitat within the action area.
- Ensure that a sufficient quality and quantity of water is provided in such a manner as to resemble the natural riverine flow regime. This flow regime should provide aquatic habitat conditions that support a diversity of endemic aquatic species (including fish, plants, mussels, and other invertebrates) and their life-cycle requirements. As a function of the natural flow regime, both intra- and inter-annual variations of flows should be implemented to sustain biological diversity and a balanced community of organisms.

3.3.2 Fisheries

The 60 fisheries comments were further divided into the following subcategories: wildlife and fisheries, improvement of lake fisheries, commercial fisheries, and the facilitation of migratory fish passage. Most comments about fisheries in the ACF River Basin were related to the drawdown of freshwater throughout the entire system. Commenters noted that at Lake Lanier, fish, clams, mussels, and the like are suffering because of the low water levels. At West Point Lake, bald eagles and other wildlife are being injured because of the low water levels. Trees and fish habitat in the lower Apalachicola River and Bay are being affected by low water flow and an increase in salinity, which could cause long-term ecological damage. Commercial fisheries are in a decline, and mortality rates could be directly related to a reduction of freshwater inflow.

The USFWS commented that when considering alternatives for an EIS, the Corps should consider the major wildlife presence at Eufaula National Wildlife Refuge and all migratory species inhabiting that area during certain seasons. Recreational users commented that critical recreational species directly affected by changes in water level, as well as by potential water allocation changes, should be identified when evaluating alternatives in the EIS. Commenters noted that trout fisheries, which are not part of the natural habitat of the ACF River Basin, should not be accommodated by releasing water out of the lake to maintain a specific water temperature. Commercial fisheries, such as oysters, crab, shrimp, pinfish, and the like, should be protected when addressing freshwater needs in an EIS, and impacts on these species should be taken into careful consideration.

Commenters strongly encouraged fish passage operations at Jim Woodruff Lock and Dam. ADCNR recommended that the Corps establish a goal to develop a fish passage plan for all Corps locks and dams in the ACF River Basin. A fish passage plan should identify key species that need upstream and downstream movement. A lock passage program similar to the one currently employed by the Corps at Woodruff Lock and Dam would be a good starting point. Potential impacts on migratory fishes related to Corps operations should also be considered.

Recommendations for fisheries in the ACF River Basin included the following:

- Conduct an assessment alongside the EIS to study the effects of low water flows on fisheries in the ACF River Basin.
- The USFWS suggested that the Corps apply a spatially explicit hydrodynamic model of the Apalachicola Bay to assess the effects of alternative operations on salinity regimes and, in turn, on the relative distribution of salt marshes, submerged grass beds, and oyster beds in the bay.
- ADCNR suggested that the Corps conduct monitoring studies to determine the present state of aquatic life and to develop new water control manuals that reflect the wildlife conservation actions identified in Alabama's Comprehensive Wildlife Conservation Strategy (CWCS).
- Coordinate with wildlife agencies from Alabama, Georgia, and Florida to explore ways to incorporate the draft Standard Operating Procedures with new alternatives.
- Conduct an assessment with the EIS to evaluate species reductions in crab, shrimp, and oyster populations in Apalachicola Bay.

3.3.3 Flow Concerns for Apalachicola Bay

Thirty-six comments were related to flow concerns for Apalachicola Bay. Salinity in the bay has increased and is affecting the species in the bay, allowing saltwater predators to move into the estuary. Commenters noted that contributions of the Apalachicola estuary to the commercial seafood industry are significant and should be protected. Sustained minimum flows, as defined by the RIOP, will not sustain the commercial seafood industry in Apalachicola Bay. Dredging and shipping interests have created more avenues for salt water to enter the estuary. Statistical data are available through the Florida Fish and Wildlife Service showing reduced landings of crab, shrimp, oysters, pinfish, and the like, and the data should be taken into consideration when considering alternatives for the EIS.

Comments related to the impact of flows on biological resources in the Apalachicola Bay in the ACF River Basin include the following:

- The EIS should include a discussion on major biological characteristics, including impacts from flows on aquatic species. The evaluation of the various alternatives should describe their impact on the sustainability of the aquatic environment and related human benefits.
- The Corps should review existing data and conduct monitoring studies to determine the present state of aquatic wildlife in the river reaches below Corps projects. Using an adaptive process, the Corps should evaluate various modeled flows for its projects to mimic a natural flow regime throughout the ACF River Basin.
- Develop a scientific consensus of environmental flow needs of the ACF River Basin.

3.3.4 Other Biological Issues

Twenty-three comments were categorized as Other Biological Issues. The potential impact of increased municipal and agricultural withdrawals for future management of the reservoirs should also be included in the EIS. The Corps must avoid operations that will violate or lead to violations of water quality standards. The Corps should ensure that even under drought conditions, sufficient flow is maintained below each dam so that water quality standards and endangered species are protected. The Corps should coordinate with the USFWS, EPA, and appropriate state agencies in Alabama, Florida, and Georgia to ensure that the water control manuals are compliant with the *Endangered Species Act* and the *Clean Water Act*.

Comments with recommendations for other biological resource areas in the ACF River Basin include the following:

- The EIS should include a discussion on secondary effects (actions that happen later in time) on major water chemical, physical, and biological characteristics. The discussion on the chemical characteristics could relate both the water velocity and volumes to, at least, temperature, dissolved oxygen, and conductivity. Detailed discussions on major physical characteristics could include the frequency of riparian habitat inundation, the distribution or redistribution of sediment particles based on sediment particles and flow energy (size/load related to velocity), and maintenance of benthic habitat.

- Include a Biological Assessment of effects on these species and their designated critical habitats, as required by the implementing regulations (at Title 50 of the *Code of Federal Regulations* [CFR], section 402.12) for Section 7 of the *Endangered Species Act*.
- Noxious growths of various exotic species, such as hydrilla and Eurasian milfoil, have become a constant management concern at the ACF federal reservoirs, especially at Lake Seminole and Lake Eufaula. The Corps should investigate the feasibility of occasional drawdowns for controlling aquatic plants.
- The Corps should evaluate the effects of past and proposed project operations on flood durations and floodplain habitats.
- ADCNR recommended the development of a new water control manual for the ACF that reflects the wildlife conservation actions identified in Alabama's CWCS where appropriate.
- ADCNR recommended that the Corps establish a goal to develop a fish passage plan for all Corps locks and dams in the ACF. The fish passage plan should identify key species that need upstream and downstream movement. With those species in mind, the evaluate viable fish passage methods. A lock passage program similar to the one employed by the Corps at Woodruff Lock and Dam would be a good starting point. This would greatly benefit adult migratory fish such as striped bass, Alabama shad, American eel, Gulf sturgeon, and many other fish species.

3.4 Drought Operations

Management of water resources during the current drought conditions—specifically, the operation of water releases to balance project purposes at the potential expense of other projects—is of major concern to the commenters throughout the ACF River Basin. Current drought conditions in the Lake Lanier watershed, along with drought conditions in previous years throughout the basin, make the allocation of water difficult. The Corps received 191 comments related specifically to drought operations. The commenters made the following recommendations applicable to the basin:

- Prioritize reservoir purposes during extreme drought events by defining which project purposes are most important.
- Update the critical yield analysis with an opportunity for public input.
- Use conservative reservoir operations during drought by reducing releases to a minimum (inflow equal to outflow).
- Include in the Master Manual emergency drought measures that provide for reducing releases during drought.
- Water supply conservation measures are necessary during drought.
- In extreme drought, let the flow of the river determine flows into Apalachicola Bay. Do not support Apalachicola River flows by releases from reservoirs above the inflows.
- Some recommendations were specific to Lake Lanier:
- Establish and use management triggers (pool elevations at which predetermined actions would be taken) during drought, especially at Lake Lanier.
- Draw down Lake Lanier last when drought occurs, recognizing the small drainage area supplying the lake.
- During drought, reduce the releases from Lake Lanier in the winter to meet the reduced flow target at Peachtree Creek, 650 cfs.

Commenters in the headwaters maintained that to protect Lake Lanier during droughts to preserve its utility for water supply and recreation, the lake should be disengaged from the current practice of operating with all reservoirs as part of a system. Commenters in the lower portion of the basin, on the other hand, stated that too much water is being retained upstream and that natural flows are not being adequately mimicked to protect species and the Apalachicola Bay. There were six comments regarding sharing the effects of drought. Some suggested that water conservation measures, such as water use restrictions, should be implemented throughout the ACF River Basin so that the effects of drought are not focused on one region or part of the basin.

EPA encouraged the development of an adaptive management plan to address the uncertainty associated with in-stream flow. The need to evaluate future changes in climate was specifically referenced in eight of the comments received. Commenters asked that the Corps recognize that the dry weather patterns that the Southeast has experienced in recent years will likely continue in the future and that management of water systems within the ACF River Basin must take that into account. One commenter recommended that predictions for both increased drought and increased heavy rain events be factored into the Corps' Master Manual planning process. The USFWS recommended that the Corps consider how climate change may affect ACF flow regimes and how to best adapt reservoir operations to the most likely foreseeable changes. The effects of a given set of operating rules will vary depending on whether the basin's climate becomes drier, wetter, more variable, or less variable. In particular, it is vitally important to adapt the level set as the top of conservation (TOC) pool to the long-term hydrology of the basin and the essential purposes the projects serve. The Corps already practices this concept with occasional variances from the rule curves to store water above the TOC elevation during dry periods. We recommend that the Corps explicitly address climate-based operational flexibility in the WCM update and in the analyses of the EIS.

3.5 Water Quality

The Corps received 155 comments addressing water quality issues in the ACF River Basin. Drinking water throughout the entire basin is an extreme concern to citizens and to local, state, and federal government agencies. Comments from citizens near West Point Lake stated that "[w]ater quality has suffered greatly as a result of frequent fluctuations in West Point Lake, which supplies water to the City of LaGrange." Record low water levels at West Point Lake were also cited as causing algae blooms due to high nutrient levels in the water. The need for improved sewerage treatment from the City of Atlanta to prevent polluting waters downstream and to ensure that water quality standards are met was also expressed in the comments received. These concerns are associated with the need to maintain water quality for recreational activities, such as swimming and fishing. There is also a concern that reductions in streamflow would result in MeadWestvaco's shutting down operations to avoid violations of its National Pollutant Discharge Elimination System (NPDES) permit. Commenters also expressed concern regarding poor water quality from raw sewage being released from houseboats directly into the river. Above all, citizens expressed the need for the Corps to avoid operations that will violate or lead to violations of water quality standards. Specifically, they recommended the following:

- Examine the effects of reservoir operations on water quality, at projects and in the tailrace, in the Master Manual update, including ongoing and potential future effects on dissolved oxygen, temperature, pH, conductivity, nutrient and organic material dynamics, and various industrial and municipal discharges.
- ADCNR recommended that the Corps maintain water quantity stations above and below all dams, and support flow stations below each lock and dam.
- The Corps should adjust West Point Lake operations to ensure adequate inflow of water and lake elevations to dilute nutrient loading into the lake.
- Adopt a permanent water quality minimum flow of 650 cfs at Peachtree Creek, where the Corps has already granted this flow reduction based on water quality data and assurances from GAEPD.

3.6 Water Supply

Water supply from Corps reservoirs is in litigation, but withdrawals for water supply are occurring at Lake Lanier, as well as at other Corps lakes and unimpounded river portions between the lakes. A number of suppliers of municipal and industrial water supply rely on operations throughout the ACF River Basin to meet their water supply needs. The Corps received 117 comments regarding water supply within the ACF River Basin.

Nineteen commenters expressed the opinion that water supply is more important than downstream uses. These commenters tended to live in the upstream portions of the ACF River Basin. They depend on a reservoir or river flow for their drinking water, and they pointed out that there are no alternative sources of supply. These commenters considered drinking water for human consumption and survival of greater importance than fish and wildlife concerns.

Thirty of the comments received discussed the socioeconomic importance of water supply to the Atlanta region. These commenters, who live in the upstream portion of the basin, expressed concern for future economic development efforts if water supplies are uncertain. Sixteen comments related to concerns over the future availability of water supply in the Atlanta region were received. GAEPD, for example, pointed out that water supply options are limited almost exclusively to surface water. Others who live in the lower portions of the basin expressed the opinion that continued population growth in the Atlanta region should not occur if adequate water supplies are not available. Commenters also called for the Corps to consider the water conservation measures that can be taken or have already been taken, as well as to include considerations from the Metropolitan North Georgia Water Planning District's Water Supply and Water Conservation Plan. Four commenters pointed out that water supply is not an authorized purpose for Lake Lanier and that only Congress may change the original authorized purposes. One of the comments received expressed concern over contaminates (oil) in the water supply due to piping water during times of drought.

Some alternatives for water supply other than Lake Lanier were suggested:

- Adding storage capacity on the Flint River, which would increase the total water storage capacity in the ACF River Basin
- Desalination
- Additional groundwater
- Tennessee River

Two comments on water supply were received from the LaGrange area. They stated that releasing water from West Point Lake to supplement lost or reduced flows from agricultural demands in the Flint River Basin is not a congressionally authorized function of West Point Lake.

3.7 National Environmental Policy Act

The Corps received 79 comments related to the NEPA process. The comments were further sorted into the following subcategories: (1) Scoping and Public Involvement, (2) Baseline Conditions, (3) Proposed Action and Alternatives, (4) Mitigation, (5) Schedule, (6) Other Applicable Regulations, (7) Cooperating Agencies, and (8) General. The percentage of comments assigned to each subcategory is shown in Figure 5.

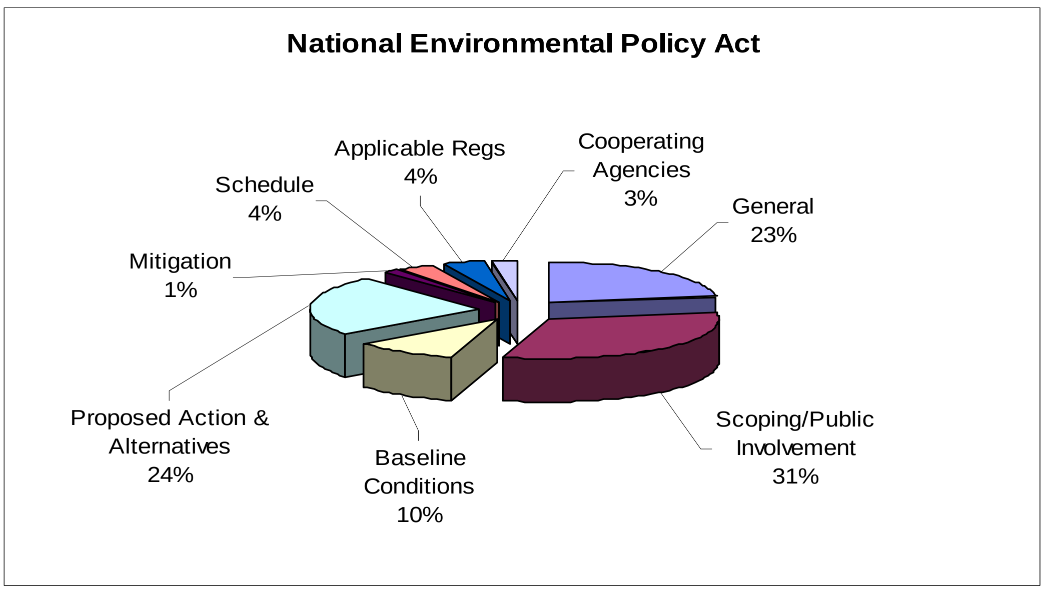

Figure 5. Distribution of comments among NEPA subcategories.

3.7.1 Scoping and Public Involvement

Twenty-five comments focused on issues related to the scoping process and public involvement opportunities were submitted. Several stakeholders said they welcomed the opportunity to work with the Corps. Opinions concerning the single scoping meeting in Florida were mixed: some commenters expressed dissatisfaction with the size of the meeting facility (too crowded to allow interaction with Corps representatives), whereas others were grateful for the opportunity to gain more information about the ACF River Basin and NEPA process. One commenter noted that many people in the Apalachicola Bay area feel there is a bias in favor of upper-basin needs. Some commenters expressed dissatisfaction with the scoping meeting format (no opportunity for public hearing-type comments); others found the meetings informative and professionally conducted. One commenter expressed dissatisfaction with the Web-based comment tool. Several stakeholders criticized the Corps for not providing more information to the public at the scoping stage, claiming that the paucity of details about the proposed action, alternatives, and identified issues hampered meaningful opportunity to provide input. Some commenters asserted that the scoping process conducted by the Corps has been inadequate and does not meet the guidelines for scoping under NEPA, the public participation requirements of the *Water Resources Development Act* (WRDA), or the Corps' own implementing regulations for either act. (Refer to agency comment summaries in Section 4.0.)

Stakeholders offered the following recommendations that the Corps should consider to provide more meaningful communication and cooperation between the Corps and stakeholders as the project moves forward:

- Provide a clear statement of the purpose of and need for the proposed action.
- Provide a summary of the current operating rules for each project, an explanation of their basis in congressionally authorized purposes, and a description of how much discretion the Corps has to change the rules. Post the summary on the District’s Web site for use by other agencies and the public early in the Master Manual update work schedule.
- Develop a flowchart or some other form of audit trace to demonstrate the influence of the stakeholder concerns on the Master Manual.
- Hold a joint meeting with all stakeholders to discuss the findings of the scoping process.
- Implement scoping and alternatives development procedures similar to those used by the Corps to update the water control manuals in the Missouri River Basin.

- Provide for a more formalized stakeholder process to work through the goals of the basin study and alternatives to be considered.
- Provide a third-party mediator at future public meetings.
- Establish a Lake Lanier "crisis team" of Corps employees who are clearly available to stakeholders.

3.7.2 Baseline Conditions

Eight comments pertained to establishing a "baseline" set of conditions against which the Corps will analyze the proposed action and alternatives in the EIS.

The FDEP believes that the 1958 water control manual should be used as the baseline (as opposed to the 1989 draft manual or current existing operations) and that the NEPA process must evaluate all changes in the Corps' reservoir operations and their impacts since that time. This opinion was echoed in the comments provided by Representative Allen Boyd, as well as the Apalachicola River Keepers.

The Alabama Office of Water Resources (AOWR) asserted that the Corps must use the currently approved water control manuals for each reservoir to establish a baseline. The commenter stated that "draft manuals, the use of action zones or other proposed operations that have never been subject to the public scrutiny demanded under NEPA and the Corps' implementing regulations should not be used as a starting point of the Corps' review or effort to update the manuals." Similar comments were made by Georgia Power and on behalf of the Southeast Federal Power customers.

Comments submitted on behalf of West Point Lake stakeholders contend "that the Corps cannot select the Interim Operating Plan, the Revised IOP, or designate any baseline year as the foundation for development of the new WCMs and associated EIS." They recommend that the Corps begin the Master Manual process with a "clean slate."

3.7.3 Proposed Action and Alternatives

Nineteen comments were assigned to this subcategory, but the proposed action and alternatives to be considered were at the heart of a vast number of comments assessed in other categories. Comments regarding the proposed action were somewhat general in nature, with most of the comments focused on the alternatives to be considered. Comments provided by several Georgia stakeholders (GAEPD, Atlanta Regional Commission, Association of County Commissioners of Georgia, Metropolitan North Georgia Water Planning District, Hall County Government Board of Commissioners, and one individual) expressed concern that the revised water control manuals and EIS would merely document existing operations and not consider potentially viable alternatives. One commenter pointed out that the Corps must show that the EIS informed decision-making, rather than simply using the EIS to justify a decision already made. GAEPD expressed opposition to making any version of the IOP and RIOP part of the proposed action; rather, there should be a range of reasonable and feasible alternatives for the continued operation of the federal reservoirs.

Comments provided by Tri-Rivers Waterway Development District and MeadWestvaco urged the Corps to include in its environmental documentation "a clear explanation of the federal 'action' which the Corps is evaluating for purposes of NEPA" and that the proposed action "should be defined as the operation of ACF reservoirs according to their authorized purposes." The FDEP reminded the Corps to "clearly describe all decisions, particularly in the water control plans and their reservoir regulation schedules, so that all parties can easily understand the Corps' proposed action and that action can be reasonably evaluated under NEPA."

The issue of what alternatives the Corps should consider is complex, as demonstrated by the very wide array of comments and recommendations made by stakeholders at every level of state and local government, public interest groups and organizations, private citizens, and other federal agencies. Many of the comments and recommendations were captured in Section 3.1, Water Management Recommendations. In addition, summaries of the detailed comments and recommendations made by federal, state, and local government agencies with regard to the proposed action and alternatives are also provided in Section 4 of this report. The following discussion addresses the comments categorized under NEPA during the comment-sorting process.

Some of the more general comments made regarding alternatives included requests that the Corps consider alternative operating plans to balance water supply needs and economic impact with downstream needs. The Cobb Chamber of Commerce urged the Corps to consider making changes to improve the balance among project purposes, even if doing so requires congressional approval. Another commenter urged that the Corps not limit itself to considering alternatives believed to be within its current authority because doing so could overlook alternatives that would achieve the highest and best use of the federal projects. Several comments urged the USACE not to limit alternatives to only those that mimic the manner of operations of the RIOP. One organization suggested that the Corps prioritize reservoir purposes during extreme drought events, the protection of wildlife being the top priority.

FDEP recommended that the Corps assess an alternative based on true basin inflow, an alternative that uses the entire conservation pool in Lake Lanier, a strong water conservation alternative, and a species recovery-based alternative.

GAEPD recommended consideration of separate alternatives based on reallocation of storage for water supply, rule curve changes at all projects in the ACF River Basin, different methods for optimizing the ACF system, and optimal operations for meeting endangered species needs other than those in the RIOP. They also reminded the Corps that the "no-action" alternative should be interpreted to mean "no change" from the current management direction or level of management intensity; consequently, it would be “a useless academic exercise” to consider as the no-action alternative returning a resource to its earlier, unaltered state.

The USFWS would like the Corps to consider changes to minimum releases and winter drawdown windows for the benefit of downstream species; an alternative that addresses increases in consumptive water demands in the basin; ways that standard operating procedures for fish spawning could be included among the mix of alternatives; and an alternative that allows Lake Eufaula (Walter F. George Lake) to behave more like a river and then compare these with the existing operating regime and other alternatives.

Comments submitted on behalf of West Point Lake stakeholders asked that the Corps assess a full-pool (633–635 feet msl) "run of the river" alternative; an alternative that eliminates or significantly reduces Action zones at West Point Lake; and an operations alternative that ensures that water quality standards are met and that the standards are at proper levels for the project. The stakeholder also stated that the Corps should not consider any alternative that uses the water in West Point Lake to provide minimum flows for waste assimilation or municipal or industrial needs downstream, or support downstream navigation without an adequate study of the ecological and environmental damages caused by lake fluctuations to support that activity.

Tri-Rivers Waterway Development District and MeadWestvaco noted that the Corps should begin by "setting forth a set of operations that fulfills the authorized purposes of the reservoirs, according to the primary legal authorities." They added that [a]ny alternative that differs from optimal operation of the reservoirs for primary authorized purposes should be clearly identified as such; the need and/or legal basis to deviate from operation of the reservoirs for optimal fulfillment of the primary authorized purposes should be clearly explained; and that the Corps should clearly explain applicable limitations on any deviation from operations for primary project purposes, such as a time limit and the circumstances under which the Corps will restore primary operating parameters.

3.7.4 Additional NEPA Topics

Mitigation. FDEP stated that key mitigation elements must include conservation and water transfers.

Schedule. The Corps received three comments regarding the timeline for completing the

Master Manual update and the accompanying EIS. The commenters stressed that time is of the essence, and one added that the EIS cannot be “all things to all people.”

Compliance with Other Regulations. Three comments were made regarding the requirement that the Corps meet all applicable laws in its water management operations. Specific laws mentioned include the *Coastal Zone Management Act*, *Clean Water Act*, and *Endangered Species Act*.

Cooperating Agencies. A comment from the Apalachicola River Keepers suggested that the Corps consider engaging EPA as lead agency—with the U.S. Geological Survey (USGS), the National Oceanic and Atmospheric Administration (NOAA), the National Marine Fisheries Service (NMFS), USFWS, the Corps, and others in cooperating roles—all overseen by the National Research Council. A comment from Representative Boyd encouraged the Corps to continue working with the National Research Council as this project moves forward.

General NEPA Comments. Eighteen of the comments submitted addressed NEPA but did clearly not fit within the defined NEPA subcategories. Some of the comments were included in the general introductory language provided as a lead-in to more specific comments that have been addressed elsewhere in this report. Several commenters thanked the Corps for the opportunity to participate in process or offered their assistance as the project moves forward. Some comments were pleas to the Corps to help their communities, “do the right thing,” and ensure the protection of both the human and natural environment for future generations. A few commenters expressed doubt that the long-standing battle over water can be resolved, admonished politicians and “big government;” or conveyed an overall tone of disappointment or disgust with management of the ACF River Basin.

3.8 Data, Studies, and Analytical Tools

Fifty-six comments were assigned to the category Data, Studies, and Analytical Tools. The highest number of comment submissions called for impact analysis and studies to be conducted for the ACF River Basin. The Corps' EIS should address the accumulation of scientifically based data on the available water and current water withdrawals along the ACF system. The EIS should quantify the relationship between increasing consumptive demands in the ACF River Basin and the benefits from various project purposes. In assessing the cumulative impacts associated with the operation of the ACF Basin, the Corps needs to consider the amount of water that may be lost from the basins through inter-basin transfers and consumptive uses and should consider appropriate limitations on any such losses, particularly under drought conditions. Any raw data input should be measured using modern technology.

Commenters asked that a clear discussion and delineation of the pertinent water management responsibilities of federal and state agencies be included as a part of the EIS. The Corps has no authority to make decisions on matters of water supply planning and must defer to the states on such issues. However, commenters saw the need for the Corps to examine water supply withdrawals (or the lack thereof), and the consequences of them, as impacts of the proposed federal action. Furthermore, the EIS should document the volume of storage that has been contracted for water supply or has been proposed in each project and any limitations due to the hydrologic conditions of meeting the contracts.

Commenters asked that when compiling an EIS, the Corps use the new ResSim model software to the maximum advantage in developing new operating rules and that data from other modeling software be accepted or rejected but not ignored. Commenters also asked the Corps to examine the location of water withdrawals and discharges to ensure their location along the Chattahoochee River; “The HEC-ResSim model places certain water withdrawal and wastewater discharge points in the wrong location along the Chattahoochee River. Because of these errors, the predicted release from Lake Lanier necessary to meet the 750 cfs flow requirement at Peachtree Creek is less that what is actually needed.”

Additional studies and analysis recommended to the Corps by commenters include the following:

- Interagency technical workgroups could would assist the Corps in compiling the information necessary to craft a balanced set of alternatives and to analyze their effects on resources.
- The National Research Council should be permitted to do a study of all basins throughout the three states so that science, rather than politics, can dictate appropriate water policy.
- An assessment of water availability, supply options, demand-management alternatives, and socioeconomic factors that influence uses in the ACF system would be useful.
- EPA encouraged including in the EIS a discussion that connects management plans to reallocation of water storage. Of special interest are the effects of management plans on discharge rates (including velocities) and river elevations (including volume).
- The Corps should evaluate the effects on Apalachicola Bay and Estuary salinity and nutrient composition (to evaluate salt marshes, submerged grass beds, oyster, floodplain habitats, channel morphology, and bank erosion).
- A thorough evaluation of project-related flow regime alterations and the potential benefits of restoring features of the pre-project flow regimes, specifically the approach described by Richter and Thomas (2007), should be conducted.

3.9 Navigation

The response to Corps operations for hydropower was echoed in the 28 comments on navigation—equal numbers of those in favor and those opposed. One comment also focused on the environmental impacts of dredging in the Apalachicola River. The following is a summary of the comments regarding navigation:

- Navigation is no longer a high priority and might be altering the natural environment.
- Navigation is no longer a viable means of transportation.
- Revisions to the manual must recognize navigation as a primary project purpose

and reflect the statutory intent to support downstream communities by resuming channel maintenance in the Apalachicola River acceptable to the FDEP and by providing adequate flow to support navigation.

- Navigation is an important economic driver in this region, but releases should not be made from Lake Lanier to support navigation.
- The Corps is responsible for operating and maintaining the authorized navigation channel. Commenters urged the Corps to "explain in its revised manual and the accompanying environmental documentation how it intends to provide for the needs of the communities and industries located in the middle and lower portions of the ACF River System."

The Tri-Rivers Waterway Development Association and industries located on the Chattahoochee River, such as MeadWestvaco, encouraged the Corps to continue to support navigation on the system by pursuing water quality certification from FDEP for maintenance dredging and by managing reservoir releases to support navigation. Such commenters cite the original congressional authorization as the basis for their position. Those who do not support continued support of navigation point to the lack of navigation traffic on the system and the adverse environmental effects of dredging in the Apalachicola River. One such commenter suggested that the Corps abandon navigation as a function of the ACF system.

3.10 Hydropower

The Corps generates power at dams on the Chattahoochee River and markets the power through the Southeastern Power Administration. Of the 26 comments received related to management for hydropower, the number of comments that called for hydropower production as a priority was the same as the number that called for hydropower production to be reduced in times of drought conditions. The following is a summary of the comments made regarding hydropower:

- Hydropower customers are willing to forego their authorized storage as long as proper compensation is provided.

- Hydropower is one of the original authorized project purposes for Lake Lanier, and it provided the economic justification for the project.
- Any changes in the plan that creates operational restrictions, or redistributes project benefits, should be accompanied by a reallocation of project costs and compensation to the affected purpose.

The commenters that favored hydropower operations at the ACF projects tended to be marketers or users of power, such as the Southeastern Power Administration (SEPA), power cooperatives, Georgia Power Company, or industries. These commenters cited the original congressional authorization, together with the fact that sale of hydropower repays a portion of project costs, as justification for their position. According to SEPA, "[a]ny change in the plan which creates operational restrictions, or redistributes project benefits, should be accompanied by a reallocation of project costs and compensation to the impacted purpose." A representative of the Southeast Federal Power Customers suggested that "the hydropower customers are willing to forego their authorized storage at the projects as long as there is proper compensation. Those commenters who did not favor hydropower operations at the ACF projects believe that other purposes, such as water supply, are of higher priority. Those holding this viewpoint tended to reside in the upstream portion of the basin.

3.11 Flood Risk Management

In cases of extreme wet-weather conditions, the Corps manages operations at federal reservoirs to reduce damage caused by flooding. Given the current drought conditions, only a limited number (nine) of the comments received were related to flood risk management. Comments regarding flood risk management came primarily from residents near West Point Lake. The flood risk management operation of this lake involves lowering the pool level during the winter months to provide additional flood storage. There were comments on both sides of this issue. Those residing on the lake or using it for recreation generally supported reductions in the drawdown of the reservoir in winter to provide flood risk management in the future. The West Point Lake Association and the City of LaGrange, for example, supported drawing West Point reservoir no lower than elevation 633, as opposed to the current operation of drawing down to 628. The larger response associated with flood damage reduction requested the removal of this project purpose in favor of higher water levels to support recreation citing the greater perceived economic impact associated with recreation as compared to flood damage reduction. Those residing downstream, however, predictably held a different viewpoint, citing their dependence on West Point Lake for flood protection. These commenters point out that flood risk management was an original purpose for constructing the reservoir and that downstream residents still rely on that protection.

3.12 Other Resources

Fifty-two additional comments were received that related to other resource areas; air quality, cultural resources, geology and soils, and hazardous, toxic, and radioactive waste.

3.12.1 Air Quality

Three comments were related to air quality. They noted that the Corps should address and fully document the effects of proposed actions on air quality. Trees are dying due to drought conditions. This can significantly impact the natural cycle, which can chemically break down air pollution. More water would ensure the ecological balance that is needed for better air quality.

3.12.2 Cultural Resources

Seven comments regarding cultural resources were submitted. According to the commenters, Florida’s historical heritage is at risk due to declining environmental conditions and the toll taken on the commercial fisheries industry for which the Apalachicola River is known. The community of Franklin County is dependent on the Apalachicola River and the Apalachicola Bay for its livelihood and culture. Commenters ask that the Corps consider the loss of the cultural heritage of the Apalachicola oysterman if river flows are too low to maintain the fishery at adequate levels to make it economic for oyster harvesting to continue, and should provide a better guide for protecting cultural resources in the Master Manual.

3.12.3 Geology and Soils

Twenty-nine of the comments received were related to geology and soils. Commenters expressed concern about bank erosion at Lake Lanier, and how it could diminish the future storage capacity of Lake Lanier. Some commenters pointed out that bare soil near the banks will eventually wash into the nearby creeks and tributaries, creating a water quality issue. A few commenters feel that development should be limited around Lake Lanier to prevent erosion and to control the drawdown of the lake for drinking water.

Other comments point out that West Point Lake has severely eroded along the shoreline and caused silt buildup near private docks. The commenters feel the Corps could minimize erosion and soil deposition in the lake by keeping lake levels at or above 633 feet msl.

3.12.4 Hazardous, Toxic, and Radioactive Waste

The Corps received 13 comments regarding the recently permitted Turkey Run Landfill that will be constructed near a tributary that feeds into West Point Lake. Commenters expressed concern that contaminants from the proposed landfill could leach into West Point Lake and groundwater supply source, polluting their drinking water. Commenters also point out that recreation on West Point Lake could be adversely impacted, if the landfill were to affect the water quality and cleanliness of the lake.

3.13 Petitions

Two petitions were received:

1. West Point Lake Advisory Council Needs Your Show of Support (SOS)
2. Comments on the Potential for the Turkey Run Landfill to Pollute Groundwater and Surface Waters in Violation of Georgia Environmental Protection Division Solid Waste Management Rules and Landfill Permit

The West Point Lake Advisory Council submitted a petition signed by 30 persons at the LaGrange public meeting and later mailed in an additional 2,779 signatures. The petition calls for all levels of government to ensure that five concerns are heard:

1. Maintain a minimum lake level of 633–635 feet msl.
2. Maximize positive economic impact.
3. Return to managing the lake consistent with congressionally authorized purposes.
4. Restore and maintain recreational facilities.
5. Ensure recreational access for low-income and minority families.

These comments were also received in conjunction with other comments and were categorized appropriately in previous sections of this report.

The second petition, related to the Turkey Run Landfill, had been signed by 58 persons. The area of concern is adjacent to West Point Lake, and the comments indicate a need to address adverse water quality impacts on the City of LaGrange's water supply that might occur because of the landfill. Although the landfill is not within the Corps' regulatory authority for the Master Manual, under the NEPA process it may be considered in various aspects of documenting activities within the area of influence of the Corps' reservoirs. Copies of the petitions are provided in Appendix L.

4.0 Federal, State, and Local Agency Responses

This section summarizes the comments that federal, state, and governmental agencies submitted through letters to the USACE Mobile District. Comments from the federal agencies (the U.S. Environmental Protection Agency [EPA], the Southeastern Power Administration [SEPA], and the Department of the Interior's U.S. Fish and Wildlife Service [USFWS]) are summarized first, followed by state agency comments (in alphabetical order), and finally local government input. Copies of all the public and agency comments received during the scoping process are provided in Appendix J.

4.1 Federal Agencies

4.1.1 EPA Region 4

Comments from EPA Region 4 were received December 8, 2008, in a letter signed by Mr. Heinz Mueller. EPA noted that it understands that the updated Master Manual will identify all constraints, including authorized project purposes, power contract commitments, hydrologic and climatologic factors, downstream lake and basin-wide conditions, and potential threats of flood and drought, and will include the resultant lake levels required to satisfy all of these various requirements.

In comments regarding the *manual update*, EPA suggested that manual include sections on current project operations and a historical review; operational changes necessitated by drought contingency requirements and data supporting such changes; updated data reflecting current basin conditions; proposed new environmental requirements for meeting water quality standards; how compliance with endangered species law/fish spawning needs will be accomplished; procedures for capturing/using real-time data provided by additional gauges; results of recent computerized modeling; and proposed improved streamlining of data exchange between agencies.

With respect to *NEPA*, EPA noted that adverse impacts from any proposed action should be avoided, minimized, and/or mitigated. Specifically,

- Address and fully document effects on threatened or endangered species, cultural resources, air quality, and wetlands. Ensure that the proposed action complies with Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations. Fully document that no unacceptable adverse cumulative or secondary impacts will result.

- Address and fully document effects of the proposed action on water quality, including effects on Total Maximum Daily Load (TMDL) implementation and impaired waters. Include information on the impairment status and TMDLs of all ACF system waterbodies.
- Consider the consequences of any major changes to conservation storage at Lake Lanier, West Point, and Walter F. George.
- Make the best management practices that will be implemented to control sediment runoff and manage stormwater at the lakes part of the Master Manual.
- *Water chemical, physical, and biological* comments from EPA noted that the EIS should:
- Include discussion connecting management plans to reallocation of water storage. Of special interest are effects of management plan changes on discharge rates and river elevations. Discuss secondary effects on major water chemical, physical, and biological characteristics.
- Discuss major biological characteristics, including potential alterations to aquatic species that require flow in their habitat. In evaluating alternatives, describe their impact on the sustainability of the aquatic environment and related human benefits.
- Discuss ACF adaptive management plans (AMPs), which should address the uncertainty associated with in-stream flow prescriptions and should include conservation and resource-protective flow standards based on available information; identify monitoring programs; and identify an effective revision procedure.
- Employ in the ACF Basin a concept similar to that described in the GAEPD request for flow reductions in the Chattahoochee River, which relies on a series of predictive models. Monitor identified flow-related sensitive endpoints and use a notification procedure when certain conditions that require flow change exist.

4.1.2 SEPA

SEPA provided comments received on November 21, 2008, in a letter signed by Mr. Herbert R. Nadler. The comments included the following points:

- Project repayment costs were developed and assigned based on authorized purposes receiving certain benefits from the projects. Such costs are to be repaid by the purposes through the use of project features, such as available storage.
- Plan changes that create operational restrictions or redistribute project benefits should be accompanied by reallocating project costs and compensating the affected purpose. It is not fair or equitable to expect an authorized purpose to be responsible for costs that do not correspond to the level of benefits received. Reduction in the availability of power affects SEPA's preference customers.
- Municipalities and cooperatives that benefit from project generation depend heavily on their government allocation of capacity and energy to meet their peak loads. Reductions in the level of benefits available should be accompanied by appropriate compensation.

4.1.3 USFWS

Comments from USFWS were received November 21, 2008, in a letter signed by Ms. Gail A. Carmody. Regarding the Master Manual, USFWS requested a summary of the current operating rules for each project, an explanation of their basis in congressionally authorized purposes, and a description of how much discretion the Corps has to change the rules. USFWS recommended posting the summary on the District's Web site.

Regarding resources, USFWS recommended the following:

- *Threatened and endangered species.* Address the same ESA-protected resources for the manual update as for the RIOP. The EIS should include a Biological Assessment of effects on these species and their designated critical habitats. Contact the states directly and obtain current lists of resources of concern to the state fish and wildlife agencies that could be affected by project operations. Participate with USFWS and other federal and state agencies in efforts to locate and monitor extant populations in the unimpounded portions of the Chattahoochee

River and its tributaries.

- *Reservoir fisheries.* USFWS cooperated with the Corps for the 1998 draft EIS for ACF water allocation to develop a reservoir fisheries performance measure. USFWS recommends that the Corps update this performance measure and use it to evaluate the relative impacts of alternative operating plans on reservoir sport fisheries.
- *Fish passage*. Continue to support and facilitate research on fish passage at Woodruff Dam, and at other ACF federal dams as appropriate, with a goal of identifying and implementing operations that would allow riverine species to travel their historic migratory pathways. Incorporate such procedures into the manual, as appropriate.
- *Water quality*. In the manual, closely examine the effects of reservoir operation on water quality, including ongoing and potential future effects on dissolved oxygen, temperature, pH, conductivity, nutrient and organic material dynamics, and various industrial and municipal discharges.
- *Invasive aquatic plants*. Investigate the feasibility of occasional drawdowns for controlling aquatic plants as part of the manual update.
- *Floodplain habitats.* Evaluate the effects of past and proposed project operations on flood durations and floodplain habitats.
- *Apalachicola Bay habitats and fisheries.* Apply a spatially explicit hydrodynamic model of the bay to assess the effects of alternative operations on salinity regimes and, in turn, on the relative distribution of salt marshes, submerged grass beds, and oyster bars in the bay.

With respect to the alternatives, USFWS recommended the following:

- *Minimum releases*. Use the Master Manual update to comprehensively evaluate storage options in the context of the impacts of altered flow regimes at the ACF dams and the benefits of restoring more natural patterns to the monthly, daily, and instantaneous releases from the ACF dams. Consider how providing windows of more stable flows during critical periods might increase the abundance and diversity of native fishes and other aquatic resources in tailwaters.

- *Winter drawdown*. Consider the potential risks and benefits of reducing the magnitude of the autumn drawdown and/or of beginning the spring refill earlier, especially during dry periods. Consider other alternatives to achieving flood protection.
- *Climate change*. Consider how climate change might affect ACF flow regimes and how to best adapt reservoir operations to the most likely foreseeable changes. Address climate-based operational flexibility in the manual update and in the analyses of the EIS.
- *Consumptive water demands*. Consider the impacts of increasing consumptive water demands in the basin.
- *Fisheries management*. With USFWS and the wildlife agencies of the three states, explore ways to incorporate the draft standard operating procedures into the mix of alternatives evaluated in the manual update.
- *National wildlife refuge*. Use an annual pattern cycling between the highest levels in the late winter and early spring to the lowest levels in the late summer. Consider how the benefits and impacts of such a scheme compare with the existing operating regime and other alternatives.

In addition, USFWS strongly supports the idea of organizing interagency technical workgroups that would assist the Corps in compiling the information necessary to craft a balanced set of alternatives and to analyze their effects. It is willing to participate in such workgroups.

4.2 Political Entities

4.2.1 U.S. Congress: Georgia Delegation

Representatives Tom Price, John Linder, Paul Broun, and Nathan Deal submitted a letter September 18, 2008, to Secretary John Paul Woodley. The letter states the following:

- Water quality and supply should be an expressed priority of the Corps in this process.
- The Master Manual should be made current, taking into account the water supply

shortage many Georgia communities face. Consider a plan that accounts for the complex dynamics of the 3.5 million people in Metro Atlanta that depend on Lake Lanier for drinking water, and keep in mind that Lake Lanier provides the bulk of the storage for the entire ACF River Basin.

- The Corps should conduct a thorough analysis of operations of the ACT and ACF basins, looking for alternative methods to improve water management of these precious water resources.

4.2.2 U.S. Congress: Florida Delegation

Senator Bill Nelson and Representative Allen Boyd from Florida submitted comments in a letter received November 21, 2008. The comments included the following:

- The EIS must be truly comprehensive and must affect the Master Manual.
- The CEQ’s guidance states that real problems should be identified early and properly studied. Appropriate related analyses should be identified and considered. The scoping process should consider all aspects of the “affected environment” in the ACF.
- The updated manual must establish a scientifically based and equitable distribution of the waters of the ACF system. Accumulate data on the available and current water withdrawals.
- In-stream flow requirements should be sufficient to fulfill authorized uses. Assess the impact of variations of freshwater flow on the ecology of the Apalachicola River and downstream coastal ecosystems. In the assessment, compare the unimpaired flow regime, historical flow records, and flows imposed in the current RIOP.
- Assess water availability, supply options, demand-management alternatives, and socioeconomic factors.
- Continue working with the National Research Council to facilitate a complementary study to the Corps’ EIS.

4.2.3 Georgia House of Representatives

Mr. Carl Von Epps of the Georgia House of Representatives submitted comments in a letter received June 2, 2008. His comments focused on Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations, and included the following:

- Lowering lake levels at West Point Lake represents a potential for denial of access to recreational resources for minority and low-income populations in West Georgia and East Alabama. Potential impacts on "consistent consumption of fish and wildlife" also must be considered. A significant amount of shoreline used for recreational activities has been affected. Mr. Von Epps questioned the magnitude of the study and the management of the project in a manner that would ensure minimal impact on the affected communities.
- West Point Lake was assigned a cost allocation of 44.3 percent of its allocated investment to recreation and sportfishing and wildlife development. This is the highest cost allocated to any of the congressional purposes authorized for the lake.
- The Corps uses West Point Lake "as its workhorse" to provide for other demands throughout the river basin, while ignoring the original authorized purpose of recreation as well as the needs and expectations of minority and low-income residents.
- The Corps is required to determine the effects on minority and low-income populations, to coordinate research and data collection, to conduct public meetings, and to develop inter-agency model projects.
- The Corps should reconsider and fully address the impacts that have resulted thus far under the Interim Operations Plan, especially during summer of 2006 and 2007.
- The project should be managed so usable winter and summer pool elevations more closely approximate the initial recreational impact level of 632.5 feet msl, ensuring recreational use of the lake.

4.3 State Agencies

4.3.1 Alabama Office of Water Resources

Mr. Brian Atkins, director of the Alabama Office of Water Resources, on behalf of the State of Alabama, submitted comments by email November 21, 2008. The comments included the following:

- To satisfy the Corps' obligations under federal law, including NEPA, the Corps must focus on the authorized purposes of Lake Lanier (hydropower, navigation, and flood control) and establish a scope for the manual update that addresses five objectives:

1. The Corps should determine the critical yield of each reservoir using the most current hydrologic and climatic conditions.
2. The Corps should establish the baseline for any proposed changes to the water control or master manuals, and the baseline should be based on authorized project purposes.
3. The Corps should use the agreed-upon HEC-5 model developed during the Comprehensive Study or develop a new model that is agreed upon by the Corps and the states.
4. The Corps should assess whether any changes in the baseline conditions are necessary to comply with existing laws and regulations, including those designed to protect the environment.
5. The Corps should analyze any proposed modifications to the baseline and other legal requirements to develop the proposed operations for Lake Lanier, West Point Lake, and Lake Walter F. George.

Each objective is critical to the update process, and the order in which the steps are completed is significant. It is impossible to evaluate and assess proposed changes to the water control manuals unless the critical yields have been calculated and the baseline is established. Refusing to undertake a complete review and assessment of these objectives will ensure that valid water control manuals will never be developed and that additional conflicts over the Corps' operations of the federal reservoirs in the ACF River Basin will follow.

4.3.2 Florida Department of Environmental Protection

The FDEP submitted a letter received November 20, 2008, signed by Ms. Janet Llewellyn. The comments are summarized below:

- Florida contends that the Corps' current process is inconsistent with federal laws and inadequate for both NEPA and the *Water Resources Development Act* (WRDA).
- The ongoing litigation, and subsequent judicial determinations, between the Corps and the States of Florida, Alabama, and Georgia and various stakeholders must be incorporated into the manual revision process.
- For NEPA analysis the Corps must use the appropriate environmental baseline, which is the 1958 Master Manual prepared for the ACF, not the 1989 draft water control plan or existing conditions. The draft manual established Action Zones and the 5,000-cfs flow "requirement" to the Apalachicola River, both of which the Corps unilaterally adopted without compliance with the *Flood Control Act*, its own regulations, NEPA, or the *Endangered Species Act*. NEPA does not allow the Corps to "grandfather" changes in water control operations that have not been subject to final NEPA review. All changes in reservoir operations since that time and their environmental impacts must be analyzed under NEPA as part of the proposed action.
- Effective scoping requires a more detailed proposal from the Corps.
- The Corps must provide a meaningful opportunity to obtain informed public comments. The scoping meetings did not provide meaningful participation or the ability to answer direct questions. The current process does not meet the general guidelines for scoping under NEPA. The Corps has failed to provide fundamental information that is critical to the scoping process. For example, the Corps must include a Drought Contingency Plan.
- Effective scoping requires a revised scope for the proposed action. The Master Manual must clearly describe all decisions so all parties can easily understand the proposed action, and it must be evaluated under NEPA.
- Alternatives that should be considered include an alternative based on true basin inflow, an alternative that uses the entire conservation pool in Lake Lanier, a

strong conservation alternative, and a recovery-based alternative.

- Impacts that should be analyzed include effects on Apalachicola Bay salinity and nutrient composition, and the corresponding economic impact on Apalachicola Bay and surrounding region; effects on Apalachicola River floodplain habitats; effects on the Apalachicola River's channel morphology due to altered flows and changes in operation; and relevant cumulative impacts.
- Potential mitigation measures to be explored must include measures within and outside the Corps' jurisdiction. The key mitigation measures must include conservation and water transfers.
- With respect to compliance with the *Coastal Zone Management Act*, Corps actions that affect the Apalachicola River and Bay must be consistent to the maximum extent practicable with the Florida Coastal Management Plan. The *Coastal Zone Management Act* further obligates the Corps to provide Florida with a consistency determination before undertaking activities that affect the state's coastal resources, including implementation of the new Master Manual.

4.3.3 Georgia Department of Natural Resources, Environmental Protection Division

Comments from the Georgia Department of Natural Resources, Environmental Protection Division, were received November 21, 2008, in a letter signed by Dr. Carol Couch. The letter noted the following:

- GAEPD recommends strongly that the Corps not make the IOP, including the RIOP, the proposed action. The Corps should analyze a range of reasonable and feasible alternatives.
- Issuing water withdrawal permits is a state and local action, and therefore it should not be addressed within the scope of connected, cumulative, and similar actions. The Corps has no authority to make decisions on water supply and must defer to the State of Georgia on such issues. Water supply withdrawals should be examined as an impact of the proposed federal action.
- The Corps is required only to examine reasonable and feasible alternatives.
- The No Action Alternative should be interpreted to mean no change from current

management operations. Operating according to water supply needs in the past would require a new action and thus would not constitute “no action.”

- The Corps should coordinate with state and local interests to analyze water demands at Lake Lanier over the past several years for current water supply.
- The RIOP is interim until the Master Manual is updated and is not the appropriate choice for the No Action Alternative. The Corps must conduct a detailed study on the RIOP’s long-term effects.
- Limiting the scope of the Master Manual and EIS because of budget constraints will be in direct conflict with NEPA and the regulations in the Master Manual.
- The Corps should not limit alternatives to only its own authorities.
- The Corps should obtain the necessary authority to operate with the best use of resources. Georgia believes the Corps has the authority to operate Lake Lanier to meet the 2030 projected municipal and industrial needs.
- The RIOP is not the only alternative. Georgia provides several possible alternative options to be considered: reallocation of storage for water supply, rule curve changes at all projects in the ACF (different configurations), different methods for optimizing the system, and optimal operations for meeting endangered species’ needs.
- The HEC-ResSim model is inconsistent with the established HEC-5 Existing Conditions model. The Corps must explain discrepancies and correct apparent errors. For example, Atlanta’s water intake is upstream of Peachtree Creek, but the model has it downstream; Cobb County/Marietta Water Authority has two wastewater returns below Peachtree Creek, but the model has them upstream. Consequently, ResSim’s prediction of flow at Peachtree Creek is greater than what would actually occur; the Lake Lanier levels would actually be lower than those predicted by the model. There are discrepancies between HEC-5 and HEC-ResSim regarding certain physical characteristics of some of the projects in the ACF River Basin.

4.4 Local Agencies

4.4.1 Metropolitan North Georgia Water Planning District

Ms. Kathryn Dunlap of the Metropolitan North Georgia Water Planning District (MNGWPD) submitted comments in a letter received October 28, 2008. She hopes that the Corps will truly update the Master Manual and not just replicate existing operations that have caused concern over the sustainability of Lake Lanier. She also noted the following:

- The Corps must consider alternative operating plans to balance water supply needs and economic impact with downstream needs before adopting a new Master Manual.
- The Corps should consider the water supply needs of the region as identified in the MNGWPD's long-range plans.
- The net amount of water withdrawn for water supply (in Lake Lanier and the river downstream) is 1 percent of the flows at the Florida line in normal years and 2 percent in drought years.
- Lake Lanier's recreational value should also be an important consideration. The lake receives 8 million visitors a year, resulting in $5.5 billion annually.

4.4.2 Atlanta Regional Commission

Mr. Charles Krautler of the Atlanta Regional Commission submitted comments in a letter received November 21, 2008. He noted the following:

- *Proposed action and alternatives*. The Corps has not adequately defined the proposed action or alternatives. It must consider all reasonable alternatives. The new water control plan must be based on facts and sound science. Historical operations are not realistic or reasonable alternatives. The alternatives must include water supply for metro Atlanta; Metro Atlanta relies on Lake Lanier, and there are no alternative sources. The alternatives should not be constrained by perceived limits on the Corps' authority.
- *Flow requirements*. Flow requirements should be optimized, flexible, and tied to actual needs, and operating plans should recognize Lake Lanier's unique

character.

- *Curve rule changes*. The Corps should consider and analyze potential rule curve changes to maximize the available storage and optimize operations for all purposes.
- *Head limits*. The Corps frequently cites head limits as the controlling reason for excess releases from Woodruff Dam. Rampdown restrictions compound this problem by requiring releases from storage to artificially slow the Apalachicola River's rate following these excess releases. In combination, these factors often result in releases greater than 1,000 cfs, more than Georgia's entire average consumptive water use in the ACF Basin.
- *Hydropower scheduling*. The Corps should also consider alternative mechanisms for developing hydropower generation schedules. Currently, it uses relatively rigid power generation schedules that assume a certain number of hours of generation when a project is in a certain zone. By incorporating into its operating plans more flexible, forecast-based mechanisms that anticipate energy spot market prices, the Corps could maximize the value of the hydropower produced while making storage available to serve other project purposes. This approach has had great success in other projects and is employed in the Sustainable Release Rule.
- *Sikes Cut*. The Corps should consider alternatives that mitigate the salinity increases in other ways. The Corps should consider alternatives that reduce or eliminate saltwater inflow through Sikes Cut, a major salinity contributor.
- *Channel degradation*. The Corps should be concerned about the areal extent of flooding or the inundation and connectivity of certain habitat. It must acknowledge that the real causes of these problems have more to do with channel degradation than with the quantity of flow in the river.
- *Hydrological forecasting*. A large body of literature on forecasting techniques has been developed. The U.S. Geological Survey (USGS) has been using such methods for decades. The Corps should consider alternative operating plans that use these tools, with appropriate margins of error, to optimize reservoir operations.

4.4.3 Franklin County, Florida, Board of County Commissioners

Mr. Noah Lockley of the Franklin County Board of County Commissioners submitted comments in a letter received October 17, 2008. The Board believes that the Master Manual is fundamentally flawed because it does not adequately take into account the freshwater needs of Apalachicola Bay. The Board requests that the EIS include the ecosystem of the bay. Specifically,

- The EIS should include the harvestable resources, including shrimp, blue crab, mullet, and oysters. All these resources have seen their landings plummet over the past few years because of the lack of freshwater reaching the bay.
- The state has spent millions of dollars protecting the bay, and now the Master Manual needs to be expanded to protect this environmental resource.

4.4.4 Hall County, Georgia, Board of Commissioners

Mr. Tom Oliver, Mr. Billy Powell, Mr. Deborah Mack, Mr. Bobby Banks, and Mr. Steve Gailey of the Hall County Government Board of Commissioners submitted comments in a letter received November 14, 2008. They noted the following:

- Lanier will be at an all-time record low in the coming months.
- The Board is confident that the river system can be managed such that all needs are met. The Board believes there is sufficient water for both upstream and downstream environmental, economic, and human needs.
- Sound science and engineering study must prevail to determine how best to operate the river system. The system operations cannot use an antiquated management plan with simple documentation of existing trends. Updated conditions should be considered.
- Alternative methods of creating water quality in downstream basins should be considered (that is, not taking Lake Lanier flows to enhance downstream estuaries).

4.4.5 Troup County, Georgia, Board of Commissioners

Mr. Richard Wolfe, Mr. Richard English, Jr., Mr. Buck Davis, Mr. Kenneth Smith, Sr., Mr. Julian Morris Jones III of the Troup County Board of Commissioners submitted comments in a letter received November 24, 2008. Noting that their past requests had seemingly "been ignored," they asked the Corps to consider the following:

- Consider six critical issues, identified through study groups, that are vital to West Point Lake: maintain a minimum lake level of 633–635 feet msl, maximize positive economic impact, return to managing the Lake consistent with congressionally authorized purposes, restore and maintain recreational facilities, ensure recreational access for low-income and minority families, and protect water quality.
- Low lake levels adversely affect economic opportunities.
- The Action Zones established by the Corps are not in keeping with and were not part of the original authorization by Congress.
- The Corps should fill and stabilize West Point Lake as a "run of the river lake" with flows that mirror a more natural flow during drought and flood conditions.
- The Corps has not funded or maintained many of the recreational areas paid for or established by Congress.
- Action Zones are much worse than other Corps projects and make recreational use quite difficult, if not impossible, to achieve.
- Rapid and frequent fluctuations in lake levels cause issues of compliance with the *Clean Water Act*, which affects the quality of recreation.

4.4.6 City of LaGrange, Troup County, Georgia

Mr. Jeff Brown of Troup County and Mr. Jeff Luken, mayor of the City of LaGrange, submitted comments in identical letters received October 28, 2008, and October 30, 2008, respectively. A summary of the comments follows:

- Congress established five specific *primary* authorized uses for this project: hydropower, sportfishing and wildlife development, general recreation, navigation, and flood control.

- New influences have taken over and control the environmental and socioeconomic factors related to utilization of the lake. Many factors have not been addressed or have been ignored by the Corps in its operations. These include massive urbanization and growth of the area and counties surrounding the lake, industrial development, and growth of the Fort Benning complex and its contingent of citizens and soldiers, who often rely on West Point Lake's facilities for recreation and sportfishing and wildlife.
- The Corps operates the lake and the system in its own way, which ignores the original *primary* congressional authorizations. Recreation and sportfishing and wildlife development are sacrificed—almost in their entirety—to meet the purpose of a lower winter pool of 625–628 feet msl.
- The Corps arbitrarily assigned to the lake Action Zones that were not set up in the enabling legislation. This needs to be corrected, and a maximum drawdown level of 633 feet msl for winter pool and a stable 635-foot summer pool must be established.
- It is the responsibility of the downstream wastewater treatment discharge permit holders to design and operate their discharge systems in a manner that ensures compliance with water quality standards without using the limited waters available.
- Raise the lake levels and stabilize them at the 633–635-foot level. The low lake levels and aesthetic damage caused by winter drawdowns have a *direct* correlation with the low number of visitors. The lake level should never be lower than 633 feet msl, except in dire emergencies.
- Stakeholders in the area have observed massive kills of native mussels in the project boundaries when the Corps operates the dam to provide massive rapid drawdowns for downstream flows.
- The Corps' compliance with the *Clean Water Act* under current operations is at best highly questionable, if in fact it is being achieved. The chlorophyll level is set at an artificially high level of 27 mg/L. Total nitrogen south of the Franklin exceeds the standards with a reading of 6 mg/L.
- Demographics, development patterns, climate changes, and other factors have

brought forth an entirely new reality the Corps must contemplate and address in a new Master Manual for the basin.

4.4.7 Gwinnett County, Georgia, Board of Commissioners

Mr. Charles Bannister of the Gwinnett County Board of Commissioners submitted comments in a letter received October 20, 2008, noting the following:

- The IOP and modifications have not resulted in the most efficient operation of the system to serve its designated use and the public interest. The Board believes that a more conservative and equally effective operation of the ACF system could have saved millions of gallons of storage in Lake Lanier and still met the downstream requirements throughout this prolonged drought.
- The COE EM 1110-2-3600, Section 3-3 b.(I), states, "Furthermore, for many projects that have been operational for a number of years, the water control plans and water control manual are out-of-date, and there is a need for revising them to make them applicable to current conditions."
- The water control plans and the water control manual need to address the current conditions, in which some 3 million people in the Metropolitan Atlanta area rely on the ACF Basin for drinking water for their health and safety.
- The droughts of 1988 and 2001 and the present drought should surely suggest that the Corps should make every effort to conserve storage in the uppermost lake in the system to the maximum extent to enable the system to meet its downstream requirements in times of severe drought. Composite storage for the entire system should not be used to justify releases from Lake Lanier; Lake Lanier represents almost half of the storage for this basin as its uppermost reservoir, but that reservoir has only 6 percent of the basin's drainage area and controls only 9 percent of the flow in the basin.
- The Board highly recommends that the Corps use the methods of hydrological forecasting developed by USGS and recommended to the Corps by the Atlanta Regional Commission.
- An Atlanta Regional Commission letter titled "Proposed Modifications to Interim Operations Plan for ACF Reservoirs" is attached. The Board suggests that

keeping Lake Lanier as full as possible meets these goals and helps protect the environment and the economy of north Georgia. It does not believe that the Mobile District's Interim Operations Plan and its modifications meet these goals as required by the Corps' rules. Had the rules been followed in developing the Interim Operations Plan, the Corps could have met the downstream needs and preserved the storage in lake Lanier to a much greater extent than has been done in the last two years.

- The Board believes that the technical expertise exists to enable the Mobile District to craft a water control plan that meets all the needs of the basin and allows the reservoirs to be full or near full each spring in order to allow the system to be able to provide drought sustainability when needed. Such conservation of storage serves the public interest and sustains the environment and population dependent on this vital resource.
- The Board strongly urges the Mobile District to seriously consider the methodologies suggested by the Atlanta Regional Commission and its consultant, Hydrologics, Inc., for alternative methods of operating the system. Hydrologics has shown that alternative operating scenarios can meet all downstream requirements and at the same time maximize reservoir storage during the wet season to ensure the maximum storage in the spring of each year, particularly in Lake Lanier, to provide for water conservation, drought contingency, and the needs of fish and wildlife, recreation, and environmental improvement/protection of Lake Lanier and the downstream basin.

4.5 Tribal Response

The tribal response indicated an interest in being informed about the updated Master Manual and Draft EIS as more information becomes available. After the development of the alternatives and proposed action, tribal leaders should be contacted and provided another opportunity for government-to-government consultation.

4.6 Federal Interagency Response

The pre-meeting planning agenda tool allowed the Corps to focus discussions on topics of interest to the federal agencies represented on the call—drought operations, water quality, biological resources, and water management. Additional issues identified for discussion included minimum base flows, agricultural water use, reservoir flows, buoy tender and use of channel survey data, water quality impacts, alternative analysis, rule curve alternatives, and a timeline for decisions. These areas can be better defined by (1) those related to the Master Manual update and (2) those related to the NEPA process.

- *Master Manual update***.** Agencies questioned whether substantial changes would be considered in the *Master Manual*. The USACE is currently authorized only to update the Master Manual to current operations; additional authorizations would require congressional authority. The Corps did confirm that the evaluations of alternatives will look at impacts throughout the ACF River Basin. For example, the evaluations will consider how releases at Lake Lanier affect the Apalachicola River and Estuary. Questions were asked regarding changes to minimum flows. States would have to modify their procedures for these types of changes to occur, as has been considered in the RIOP.
- *NEPA process***.** The selection of baseline conditions and alternatives was a concern for the USFWS. The Corps let the agencies know that the scoping process is being used to determine which alternatives will be considered in the EIS, including different levels of water withdrawal.

5.0 Summary of Public Scoping

The Corps has completed the first phase of the scoping process for the EIS regarding implementation of an updated *Master Water Control Manual for the Apalachicola-Chattahoochee-Flint River Basin* in Alabama, Florida, and Georgia. The Corps, however, will continue to give due consideration to all relevant input received throughout the development of the EIS because scoping is an ongoing process. Coordination with regulatory agencies and the public will continue. Following finalization and publication of this scoping report, the draft EIS will be completed and is scheduled to be made available for review and comment in 2010.

The objective of this preliminary scoping phase was to notify regulatory agencies and the public of the proposed action. This phase provided an opportunity for the Corps to learn as much as possible about all concerns, issues, and other significant actions completed, under way, or proposed in the region that could be affected by implementing the proposed action. It also provided an opportunity to gather available information and tools to assist in developing and evaluating the proposed action and alternatives. Such information is essential to ensure that the EIS adequately addresses the effects of the proposed action and alternatives.

Specific requirements of scoping include the following:

- Determining the scope (40 CFR 1508.25) and the significant issues to be analyzed in depth in the EIS.
- Identifying and eliminating from detailed study the issues that are not significant or that have been covered by prior environmental review (40 CFR 1506.3), narrowing the discussion of these issues in the statement to a brief presentation of why they would not have a significant effect on the human environment, or providing a reference to their coverage elsewhere.
- Indicating any public environmental assessments and other environmental impact statements that are being or will be prepared and are related to but are not part of the scope of the impact statement under consideration.

- Identifying other environmental review and consultation requirements so the USACE can prepare other required analyses and studies concurrently with, and integrated with, the EIS as provided in 40 CFR 1502.25.
- Considering how the proposed action might affect resource areas cumulatively; that is, whether the resources, ecosystems, and human communities of concern have already been affected by past or present activities and whether other agencies or the public has plans that could affect the resources in the future.

During the formal scoping period, which ended November 21, 2008, the Corps received 2,269 comments from 643 individuals, organizations, and agencies. The agencies included federal, state, and local governments. Federal agencies that submitted comments were the EPA Region 4, the SEPA, and the USFWS. Political leaders from the Georgia and Florida U.S. congressional delegation submitted comments along with members of the Georgia House of Representatives. The three states—Alabama, Georgia, and Florida––submitted comments from their associated state agencies. Other local governmental agencies, including the MNGWPD; the ARC; Franklin County, Florida; Hall County, Georgia; Troup County, Georgia; Gwinnett County, Georgia; and the City of LaGrange, Georgia, submitted comments as well.

All the comments were reviewed and organized into 12 categories, as discussed in Section 3 of this report:

- Water Management Recommendations: 34 percent
- Socioeconomics and Recreation: 25 percent
- Biological Resources: 11 percent
- Drought Operations: 7 percent
- Water Quality: 6 percent
- Water Supply: 5 percent
- National Environmental Policy Act: 5 percent
- Data, Studies, and Analytical Tools: 3 percent
- Navigation: 1 percent
- Hydropower: 1 percent

- Flood Risk Management: less than 1 percent
- Other Resources: 2 percent

The majority (70 percent) of the comments were related to water management recommendations, socioeconomics, and biological resources.

5.1 Recommendations

In January 2008 Secretary of the Army Pete Geren directed the Corps to update the *Master Water Control Manual for the Apalachicola-Chattahoochee-Flint River Basin*. The current Master Manual was completed in 1958, and consequently it does not include water control plans for West Point Dam, Walter F. George Lock and Dam, and George W. Andrews Lock and Dam. An updated Master Manual that includes water control plans for all the projects in the ACF River Basin is required by Engineer Regulation 1110-2-240. The Master Manual needs to describe project operations for congressionally authorized and general statutory project purposes in the basin while balancing private, community, social, and economic needs and sound environmental stewardship. The purpose of the proposed action is to update the Master Manual to include current project operations under the existing congressional authorizations, taking into account changes in basin hydrology and consumptive demands due to years of growth and development, new or rehabilitated structural features, and environmental issues.

On the basis of the stakeholder comments received during scoping, it is clear that issues of greatest concern are the potential for significant impacts to socioeconomics, water resources, and biological resources. These three topics should be emphasized in the EIS and should be the recommended alternative in the Master Manual.

Stakeholders also recommended a number of alternative scenarios for various projects in the ACF River Basin that do not fall under the current authority of this proposed action. The Corps recognizes that there are scenarios that will need to be considered as part of the analysis that are outside the current authority. Such scenarios might include modifications to the pool elevations and rule curves. All the actions taken by the Corps in updating the Master Manual must meet the congressionally authorized project purposes at all the reservoirs except where doing so is legally or physically impracticable.

5.2 EIS Schedule

Completing the EIS and updating the Master Manual will take approximately three years. A Notice of Availability will be published in the *Federal Register* when the Draft EIS is available for public review (currently anticipated in spring 2010). Public meetings will also be held following publication of the NOA to solicit comments on the Draft EIS. Each comment and the corresponding response will be incorporated into the EIS. The Final EIS and Record of Decision are currently anticipated for publication in late 2011.

The scoping report is posted at www.acf-wcm.com and can be downloaded with or without the appendices.

6.0 Literature Cited

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7.0 Acronyms and Abbreviations

ACCG	Association of County Governments of Georgia
ACF	Apalachicola-Chattahoochee-Flint River Basin
ACT	Alabama-Coosa-Tallapoosa River Basin
ADCNR	Alabama Department of Conservation and Natural Resources
AOWR	Alabama Office of Water Resources
ARC	Atlanta Regional Commission
BMPs	Best Management Practices
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
cfs	cubic-foot-per-second
COE	U.S. Army Corps of Engineers
Corps	U.S. Army Corps of Engineers
CWCS	Comprehensive Wildlife Conservation Strategy
D.C. Court	Federal District Court for the District of Columbia
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
ER	Engineer Regulation
ESA	Endangered Species Act
FDEP	Florida Department of Environmental Protection
FERC	Federal Energy Regulatory Commission
GAEPD	Georgia Environmental Protection Division
HEC	Hydrologic Engineering Center
IOP	Interim Operating Plan
Master Manual	*Master Water Control Manual for the Apalachicola-Chattahoochee-Flint River Basin*
mg/L	milligrams per liter
MNGWPD	Metropolitan North Georgia Water Planning District
MOA	Memorandum of Agreement
msl	mean sea level
MW	Megawatts
NEPA	National Environmental Policy Act
NGVD	National Geodetic Vertical Datum
NMFS	National Marine Fisheries Service
NOA	Notice of Availability
NOAA	National Oceanic and Atmospheric Administration
NOI	Notice of Intent
NPDES	National Pollutant Discharge Elimination System
P.L.	Public Law
RIOP	Revised Interim Operating Plan
SeFPC	Southeast Federal Power Customers, Inc
SEPA	Southeastern Power Association

SOS	West Point Lake Advisory Council Needs Your Show of Support (name of organization)
TMDLs	Total Maximum Daily Loads
TOC	top of conservation pool
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WCM	Water Control Manual
WRDA	Water Resources Development Act

Exhibit 35

Expert Report of
J. David Allan, Ph.D.

In the matter of *Florida v. Georgia*, No. 142 Orig. in the United States Supreme Court

Prepared for
Florida Department of Environmental Protection

Prepared by

J. David Allan, Ph.D.

Professor Emeritus
School of Natural Resources & Environment
The University of Michigan
Ann Arbor Michigan 48109

February 29, 2016

APPENDIX D: RESULTS OF METRICS MODELING

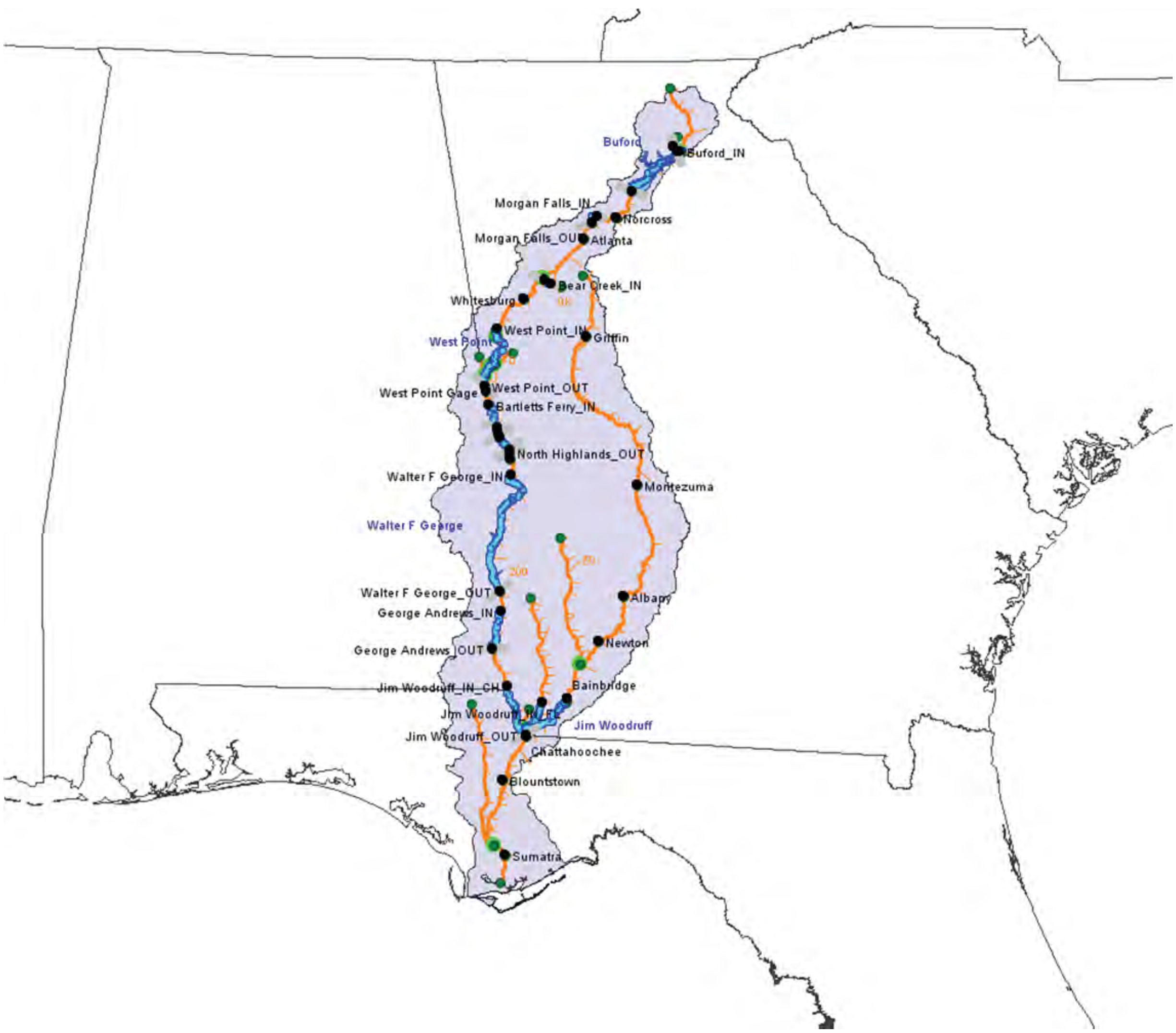
I. LIST OF METRICS

Metric name	Species and habitat				Hydrologic criteria for harm: Harm occurs when flow stays below flow threshold for duration and season indicated		
	Species	Habitat type	Habitat location		Flow threshold (cfs)	Duration, in days (T=total; C=consecutive)	Season
			Reach	River mile			
Muss-MC-6k	Mussel assemblage	Main channel margins	Mid riv, low riv	21-78	6,000	7 (C)	Jun 1-Sept 30
Muss-MC-8k	Mussel assemblage	Main channel margins	Mid riv, low riv	21-78	8,000	7 (C)	Jun 1-Sept 30
Muss-MC-10k	Mussel assemblage	Main channel margins	Mid riv, low riv	21-78	10,000	7 (C)	Jun 1-Sept 30
Muss-Slu-Swf	Mussel assemblage	Floodplain sloughs	Site in low riv	40.2	5,700	30 (C)	Jun 1-Sept 30
Muss-Slu-Hog	Mussel assemblage	Floodplain sloughs	Site in low riv	40.0	7,600	30 (C)	Jun 1-Sept 30
Fish-InunFor60	Fish assemblage	Inundated forests	Mid riv, low riv, upper tidal	14-78	14,000	60 (T)	Mar 1-Sept 30
Fish-InunFor120	Fish assemblage	Inundated forests	Mid riv, low riv, upper tidal	14-78	14, 00	120 (T)	Mar 1-Sep 30
Fish-LgSlu-Ken	Fish assemblage	Large floodplain sloughs (Lower Kennedy Creek)	Site in low riv	26.0	12,000	30 (C)	Jun 1-Sept 30
Fish-SmSlu-Swf	Fish assemblage	Small floodplain sloughs (Swift Slough)	Site in low riv	40.2	5,700	5 (C)	Jun 1-Sep 30
Fish-SmSlu-Mry	Fish assemblage	Small floodplain sloughs (Mary Slough)	Site in mid riv	58.7	9,900	5 (C)	Jun 1-Sep 30
Sturg-YOY60	Gulf sturgeon	Tidal distributaries	Lower tidal	0-10	7,000	60 (T)	May 1-Sept 30
Sturg-YOY120	Gulf sturgeon	Tidal distributaries	Lower tidal	0-10	7,000	120 (T)	May 1-Sept 30
Tupelo-10%	Tupelo & other swamp species	Lowest 10% of inundated swamps	Mid riv, low riv, upper tidal	14-78	14,100	90 (C)	Mar 20 -Sep 22
Tupelo-30%	Tupelo & other swamp species	Lowest 30% of inundated swamps	Mid riv, low riv, upper tidal	14-78	16,100	90 (C)	Mar 20 -Sep 22
Tupelo-50%	Tupelo & other swamp species	Lowest 50% of inundated swamps	Mid riv, low riv, upper tidal	14-78	18,000	90 (C)	Mar 20 -Sep 22

Exhibit 36

STATE OF FLORIDA V. STATE OF GEORGIA
NO. 142 ORIGINAL

DEFENSIVE EXPERT REPORT OF
PHILIP B. BEDIENT, PH.D., P.E.



May 20, 2016

II. SUMMARY OF OPINIONS

As a result of my analysis and my expertise in hydrology and civil engineering, I offer the following opinions and conclusions:

- **Contrary to claims by Florida, Georgia's consumptive water use in the ACF Basin has not materially reduced flows into the Apalachicola River, in part because Georgia's consumptive water use represents a relatively small fraction of total streamflow in the Basin, even when water is in its greatest demand and flows are at their lowest.**
  - Georgia's "consumptive water use"[2] for municipal and industrial ("M&I"[3]) needs and agricultural ("Ag") needs has always averaged less than 1,000 cfs per year. This amounts to less than 5% of the water annually flowing across the Georgia-Florida state line and entering the Apalachicola River, an average of approximately 20,000 cfs (see Figure 1).

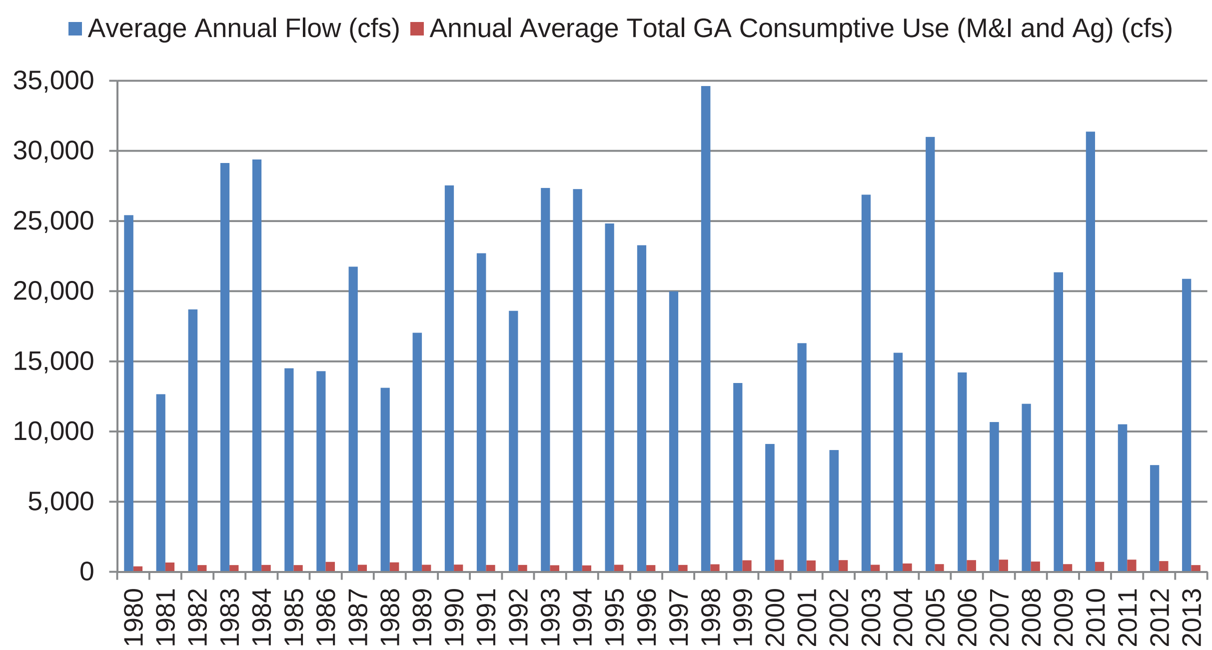


Figure 1. Average Annual Flow at Georgia-Florida State Line vs. Georgia's Average Annual Consumptive Use (1980-2013) (Sources: 20160203-ACF-summary-GA-water-use-1980-2013.xlsx; Expert Report of Peter Mayer, P.E. (May 20, 2016); Expert Report of Suat Irmak, Ph.D. (May 20, 2016))

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2 In this expert report, I use the term "consumptive water use" to refer to the total reduction in surface water streamflow resulting from net water withdrawals from the system.

3 As explained in the Expert Report of Peter Mayer, P.E. (May 20, 2016), and as defined by the USGS (water.usgs.gov/watuse/wuglossary.html), M&I withdrawals are categorized separately from thermoelectric withdrawals. For the purposes of this report and ease of presentation, however, we combine these three uses as "M&I."

- Since 1994, Georgia's total consumptive water use (M&I and Ag) has averaged less than 1,500 cfs for any given month, equivalent to less than 10% of the average monthly streamflow in the Apalachicola River (see Figure 2). These monthly average numbers confirm that even when water is in its greatest demand and flows are at their lowest, Georgia's consumptive use represents a relatively small percentage as compared to state-line flow.

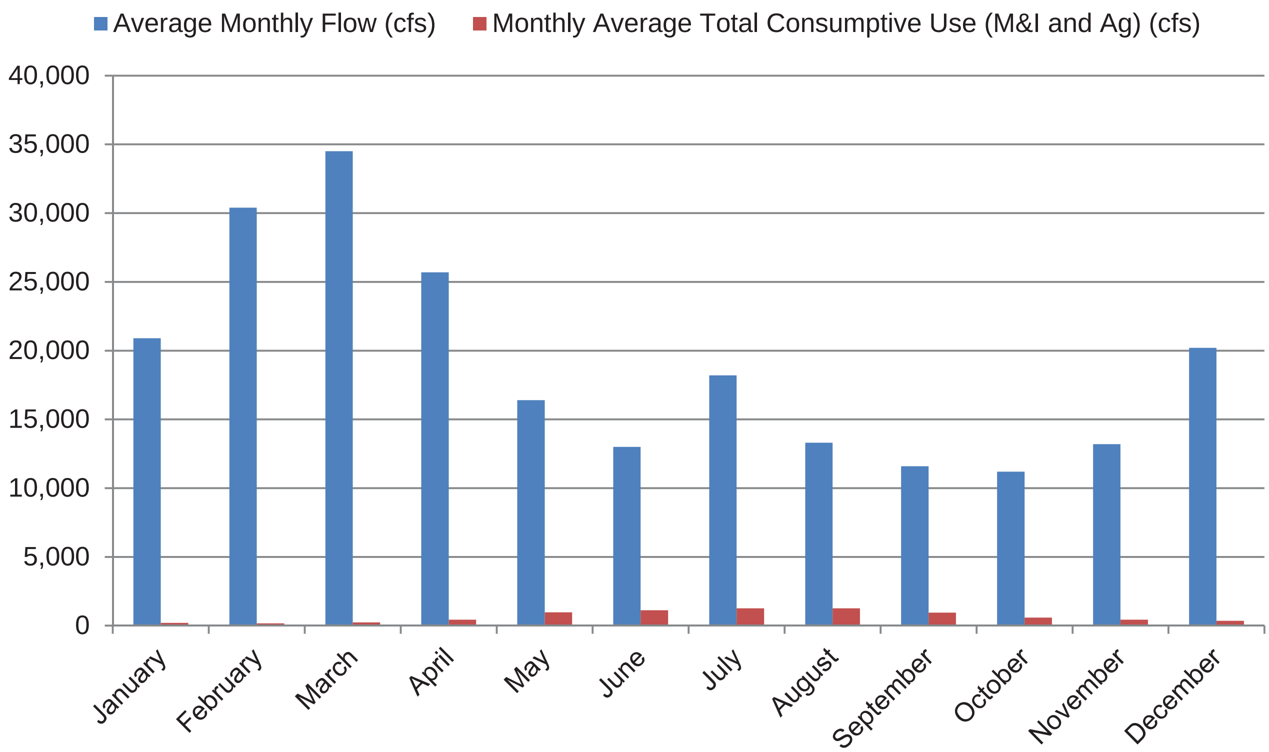

Figure 2. Average Monthly Flow at Georgia-Florida State Line vs. Georgia's Average Monthly Consumptive Use (1994-2013) (Sources: 20160223-ACF-GA-total-consumptive-monthly.xlsx; Expert Report of Peter Mayer, P.E. (May 20, 2016); Expert Report of Suat Irmak, Ph.D. (May 20, 2016); USGS)

- **The USACE's reservoir system in the ACF Basin moderates—and at times fully negates—the impact of Georgia's consumptive water use on state-line flows during low-flow and drought periods.**
  - The impact of Georgia's consumptive water use from the ACF Basin on state-line flow, during lower-rainfall periods, is moderated—and at times fully negated—by the USACE's storing of water in its reservoirs in times of relative excess and releasing it in times of relative scarcity as needed. These strategic releases of water from the USACE's reservoirs are part of the USACE's overall management and regulation of water in the ACF Basin to serve multiple federal project purposes.

- Georgia's projected water supply needs for the entire ACF Basin through 2040 for a typical dry year would amount to an increase in net consumptive water use of about 62 cfs, or less than a 10% increase in Georgia's highest recorded levels of water use (2011).

- The resulting decrease of streamflow at the state line during low-flow periods resulting from Georgia's projected incremental increase in consumptive water use would often be 0 cfs, as a result of the USACE's regulation of water in the Basin.

- When the small increase in Georgia's projected 2040 consumptive water use is coupled with the additional water that will flow into the ACF river system due to increased runoff from land use changes in Georgia, there would continue to be a net <u>increase</u> in the streamflow crossing the state line and into the Apalachicola River as Georgia's population and water needs increase.

- **Reducing Georgia's consumptive water use would not materially increase flows across the Georgia-Florida state line, especially during low-flow or drought periods.**

  - Reducing Georgia's consumptive use by as much as 30% of its most recent highest rates—or even down to its 1992 rates—would provide little to no increase in the amount of water crossing the state line. This is due both to the minimal amount of water consumed in Georgia relative to streamflow in the ACF Basin as well as to USACE operations in redistributing water entering the Basin as it travels towards and into Florida.

  - This is especially true during low-flow periods, given the manner in which the USACE operates its reservoirs and dams. The USACE releases stored water in its reservoirs to supplement low flows in the river downstream, which results in the lowering of these reservoir pool levels. During times of drought, water conserved as a result of hypothetically reduced consumptive use by Georgia will not immediately translate into increased flows at the state line, which are maintained at 5,000 cfs by the USACE. Instead, under USACE reservoir operating procedures, any additional water that might be added to the river system during such times will effectively be offset by the USACE not releasing as much stored water from its reservoirs, and thus the benefit of this added water will not be immediately realized downstream at the state line.

  - Even with a reduction in Georgia's water use by almost half (down to its 1992 rates), low flows at the state line during the dry summer and fall months that were averaging about 5,000 cfs generally would not increase at all due to the USACE reservoir operating procedures (see Figure 5).

IV. Georgia's Consumptive Water Use in the ACF Basin Has Not Materially Reduced Flows into the Apalachicola River

Contrary to Florida's claims, Georgia's total consumptive water use in the ACF Basin has not materially reduced flows crossing the state line and into the Apalachicola River in Florida, in part due to the relatively small amount of Georgia's consumptive water use as compared to the flows at the state line. In addition, the USACE's reservoir system and its operating procedures help to moderate—and at times fully negate—the impact of Georgia's consumptive water use in the ACF Basin by redistributing water throughout the ACF Basin, especially during drought and low-flow periods. Finally, the impact of Georgia's consumptive water use on flows crossing the state line and into the Apalachicola River has been more than offset by the increase in runoff that is generated by land use changes in Georgia.

A. Georgia's Total Consumptive Water Use Is Relatively Small In Comparison to Total State-Line Flow into the Apalachicola River

One metric that is helpful to understand the potential impact of Georgia's consumptive water use on streamflow in the ACF Basin is the magnitude of Georgia's consumptive water use compared to overall streamflow in the Basin.

In Figure 23, Georgia's total consumptive water use from 1980-2013 is compared to streamflow for the same period. As can be seen, Georgia's total consumptive water use is a very small amount of water compared to the annual average flows in the ACF Basin entering Florida.

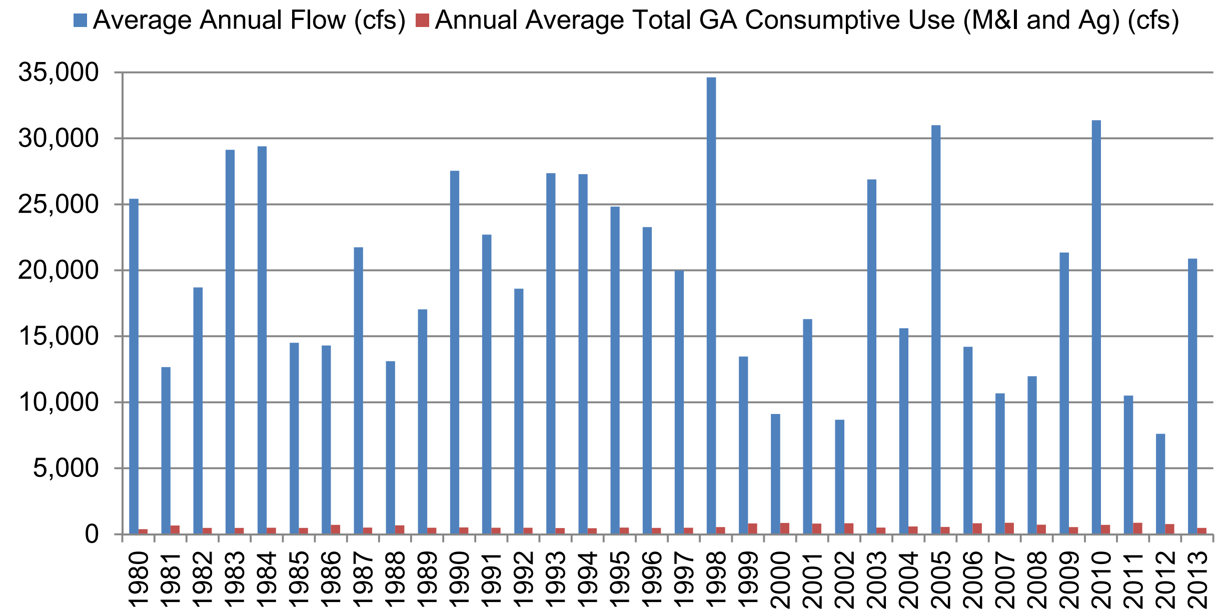

Figure 23. Average Annual Flow At Georgia-Florida State Line vs. Georgia's Consumptive Use (1980-2013) (Source: GAEPD, USGS)

Georgia's total consumptive water use for M&I and Ag increases during lower rainfall periods, typically the summer and fall months of May–September. At the same time, streamflow is typically lower. As can be seen in Figure 24, on average, Georgia's consumptive water use during the months of May–September averages about 1,170 cfs per month, with the months of July and August having the highest use of about 1,330 cfs. This compares to the average monthly flow crossing the state line during May–September of about 15,000 cfs, or less than 10% of that streamflow. Although higher than the annual consumptive water use, these monthly and seasonal numbers confirm that even when water is in its greatest demand, Georgia's total consumptive water use represents a small percentage of water as compared to the amount of streamflow that crosses the state line.

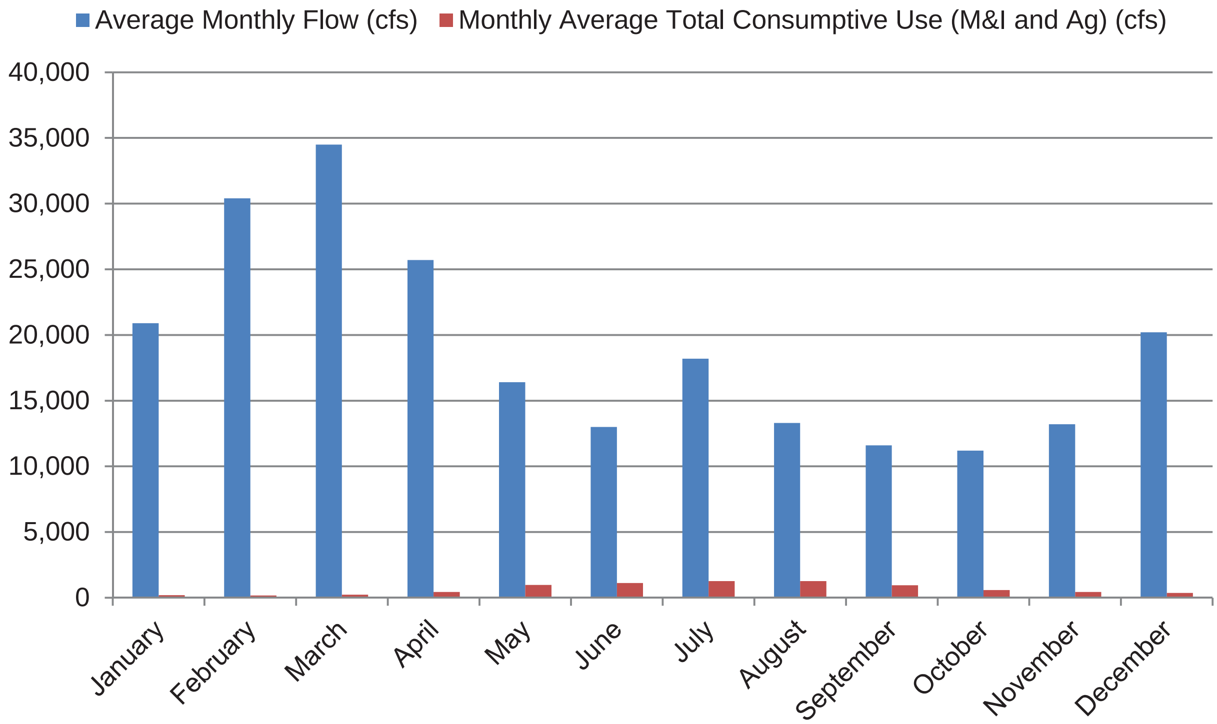

Figure 24. Average Monthly Flow at Georgia-Florida State Line vs. Georgia's Consumptive Use (1994-2013) (Source: GAEPD, USGS)

As can be seen in Figure 25, from 1989-1998, Georgia's total consumptive water use was approximately 500 cfs on an annual average basis, which is small compared to the total streamflow of almost 25,000 cfs crossing the state line on an annual average basis during this same time period (about 2%). This was also a period of above-normal rainfall that was producing above-normal streamflow at the state line. During the drought period of 1999-2002, both M&I and Ag consumptive water use increased. M&I consumptive water use averaged over 300 cfs while the Ag consumptive water use averaged about 500 cfs. During the severe drought of 2006-2007, M&I consumptive water use averaged almost 400 cfs while the Ag consumptive water use averaged about 450 cfs. With the ongoing implementation of conservation measures, Georgia has been able to reduce its M&I consumptive water use such that during the extreme drought period of 2011-2012, it averaged about 300 cfs, with the total consumptive water use averaging about 800 cfs (about 9% of the average annual flow at the state line during this 2-year drought period).

The numbers in Figure 33 are only consumptive water use numbers under Baseline 2011 and Scenario 2040; they do not reflect the state line flow impacts (if any) when those numbers are run through the ResSim model. This figure reflects all consumptive water uses above the Florida state line, which includes both Georgia and Alabama's consumptive water use. However, for comparison purposes, Alabama's consumptive water use values were held constant at 2007 levels, and the difference reflects the projected increase in Georgia's water demands in the Basin from Baseline 2011 to Scenario 2040.[17]

The Scenario 2040 increase in consumptive water use is about 62 cfs on an annual average basis over the entire ACF Basin. This is representative of a typical dry year and therefore does not have as much Ag use as was seen in the Baseline 2011 condition, which was an extreme drought year.[18] The largest increase was in the M&I use in the Metro Atlanta area, averaging 71 cfs for the year. Figure 33 shows the monthly distribution of the total consumptive water use above the state line for these two scenarios that were simulated in ResSim to compare the results to see what impact, if any, an increase in Georgia's projected consumptive water use would have at the state line.

D. Georgia's Projected Future Increases in Consumptive Water Use Would Not "Lead to Substantial Additional Streamflow Depletions"

Annual, seasonal, and monthly average flows were obtained from the ResSim computer model for the period 1975-2011 at the state line based on Georgia's current (2011) consumptive water use for both M&I and Ag as the "Baseline 2011" condition. To understand the impact of changes in consumptive water uses during low flow, summer, and fall periods on flows at the state line, analyses using ResSim of seasonal and monthly impacts of the increase in projected consumptive water use were undertaken for normal, wet, and dry years (2003, 2007, 2009, and 2011). 2003 characterizes a wet year, while 2009 characterizes a normal year with respect to annual rainfall. Both 2007 and 2011 characterize dry years with significantly below normal levels of rainfall.

Figures 34-37 show the results of these ResSim model simulations in comparing flows at the state line between Baseline 2011 and Scenario 2040 levels of consumptive use for hydrologic conditions of selected years. Note that the increase in Georgia's projected consumptive use under Scenario 2040 results in no change in the streamflow crossing the state line during the low flow months (i.e., June, July, August, September, October, November) of the dry years of 2007 and 2011, while in other months and in other years there are both increases and decreases in the state-line flows. These changes in the monthly state-line flows from the increase in Georgia's projected future consumptive use will eventually average out to equate to the 62 cfs average annual increase that has been projected.

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[17] For Scenario 2040, Alabama's consumptive use was increased by 15% over 2007 levels.
[18] See Expert Report of Suat Irmak, Ph.D. (May 20, 2016).

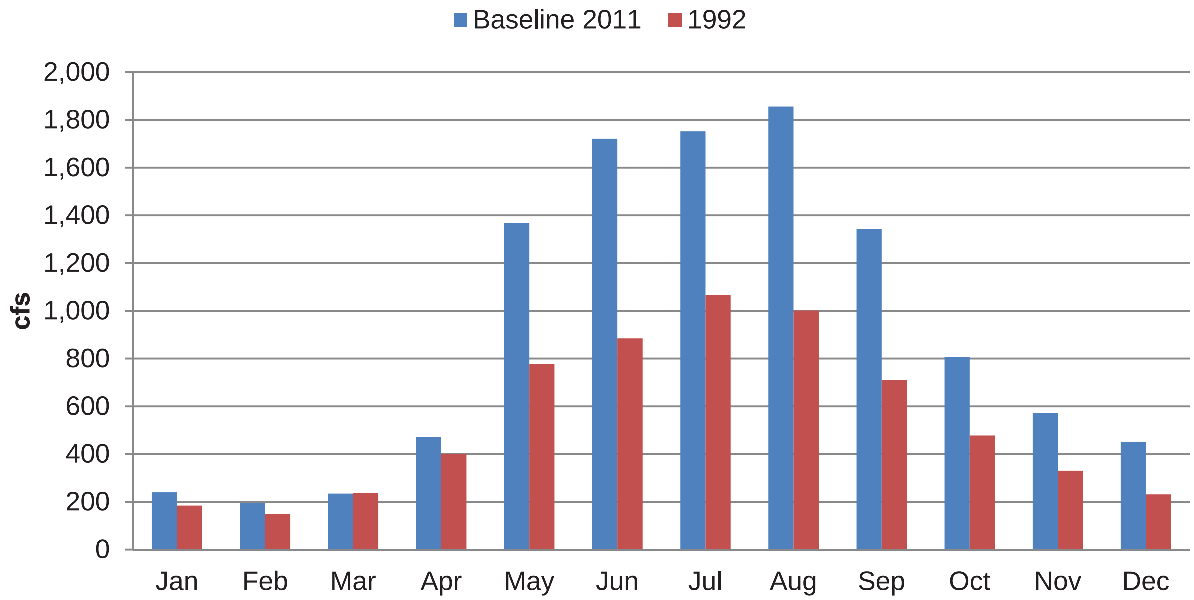


Figure 38. Monthly Consumptive Use Above State Line (Georgia and Alabama) for Baseline 2011 and 1992 Condition (Source: 20160223-ACF-GA-total-consumptive-monthly.xlsx; Expert Report of Peter Mayer, P.E. (May 20, 2016); Expert Report of Suat Irmak, Ph.D. (May 20, 2016))

B. Comparison of Baseline (2011) and Hypothetical Reduction Scenarios

All consumptive water use scenarios were modeled using the Res-Sim computer model of the ACF Basin, and their results compared against the "Baseline 2011" scenario. The following figures show a sample of the results from the model simulations. The full set of results is provided in **Appendix E**. As shown in these figures, the impact on flows at the state line from reducing Georgia's consumptive water use in the ACF Basin under various percent caps, or even to 1992 levels, is minimal.

Figures 39 and 40 show the difference in the monthly and seasonal flows at the state line between the various scenarios for 2003, a wet year. As can be seen, there is very little difference between the flows crossing the state line between the various consumptive water use scenarios, especially during the summer months when there is no difference in the flows. The same can be seen for Figures 41 and Figure 42, which show the difference in monthly and seasonal flows at the state line between the various scenarios for 2007, a dry year. Figures 43 and 44 and Figures 45 and 46 show the difference in the monthly and seasonal flows at the state line between the various scenarios for the 2009 and 2011, respectively, reflecting another example of a wet and dry year.

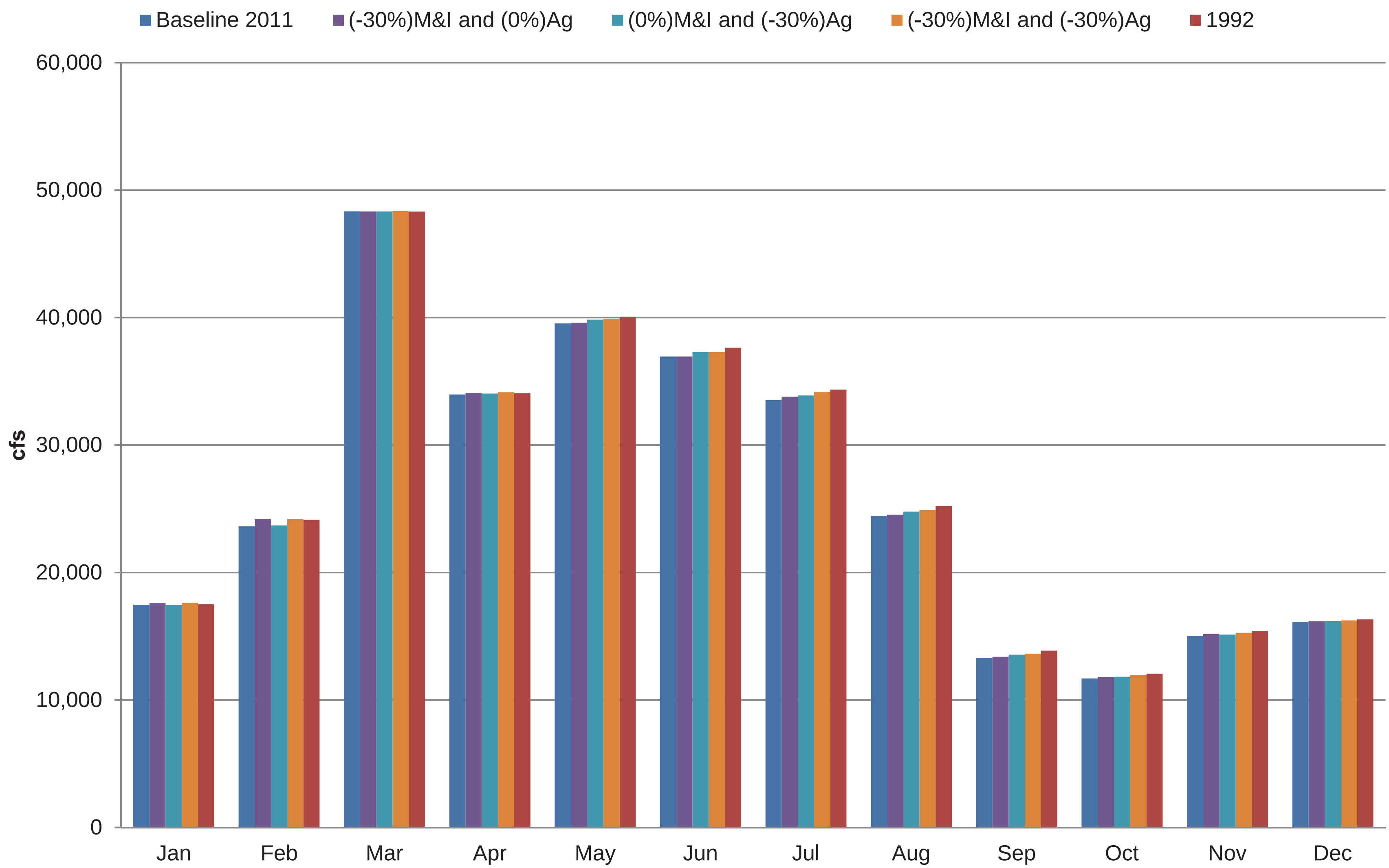


Figure 39. Average Monthly Flows at State Line for Wet (2003) Conditions Comparing Baseline 2011 to 1992 and Several Reduction Scenarios

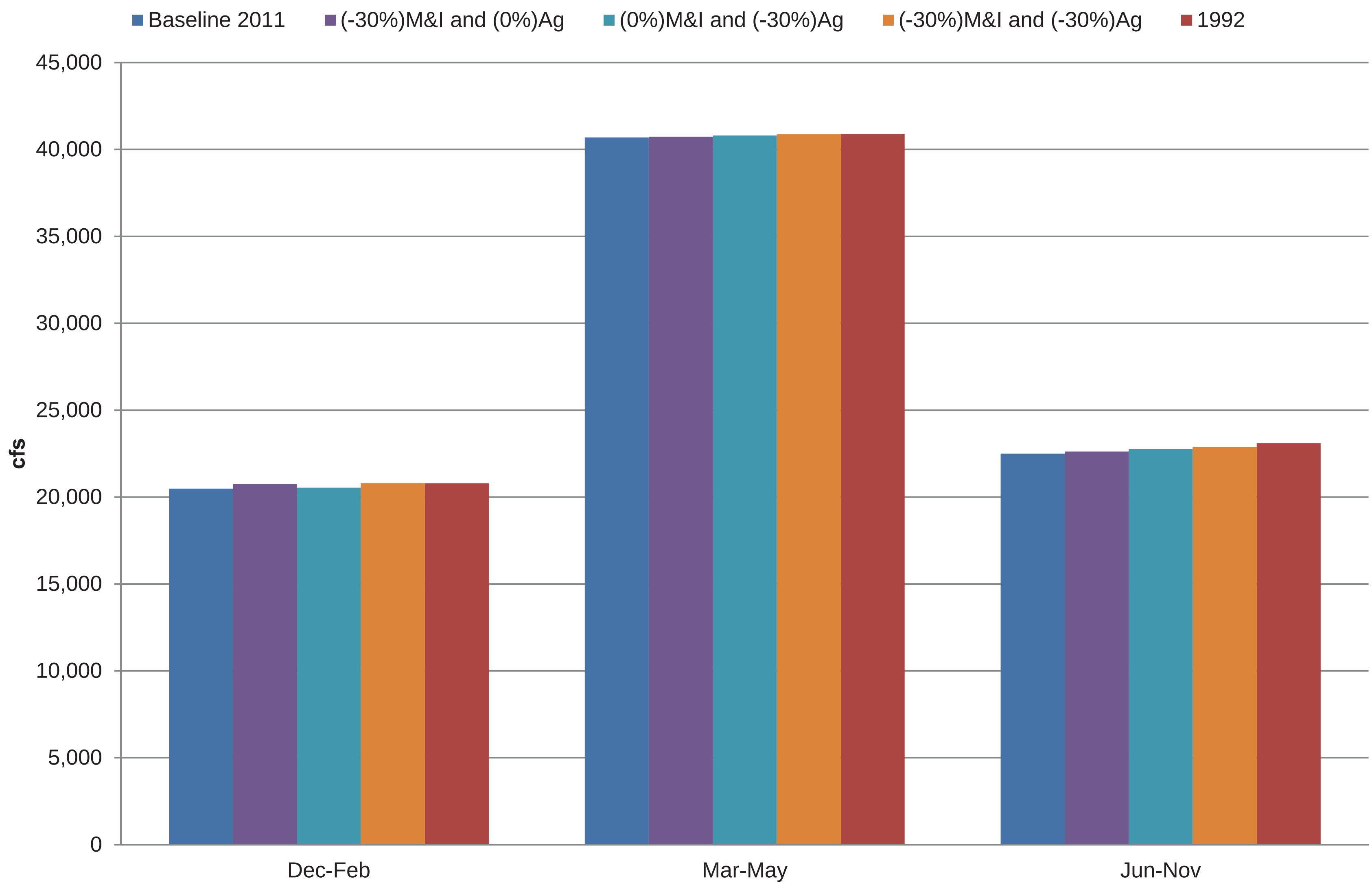


Figure 40. Average Seasonal Flows at State Line for Wet (2003) Conditions Comparing Baseline to 1992 and Several Reduction Scenarios

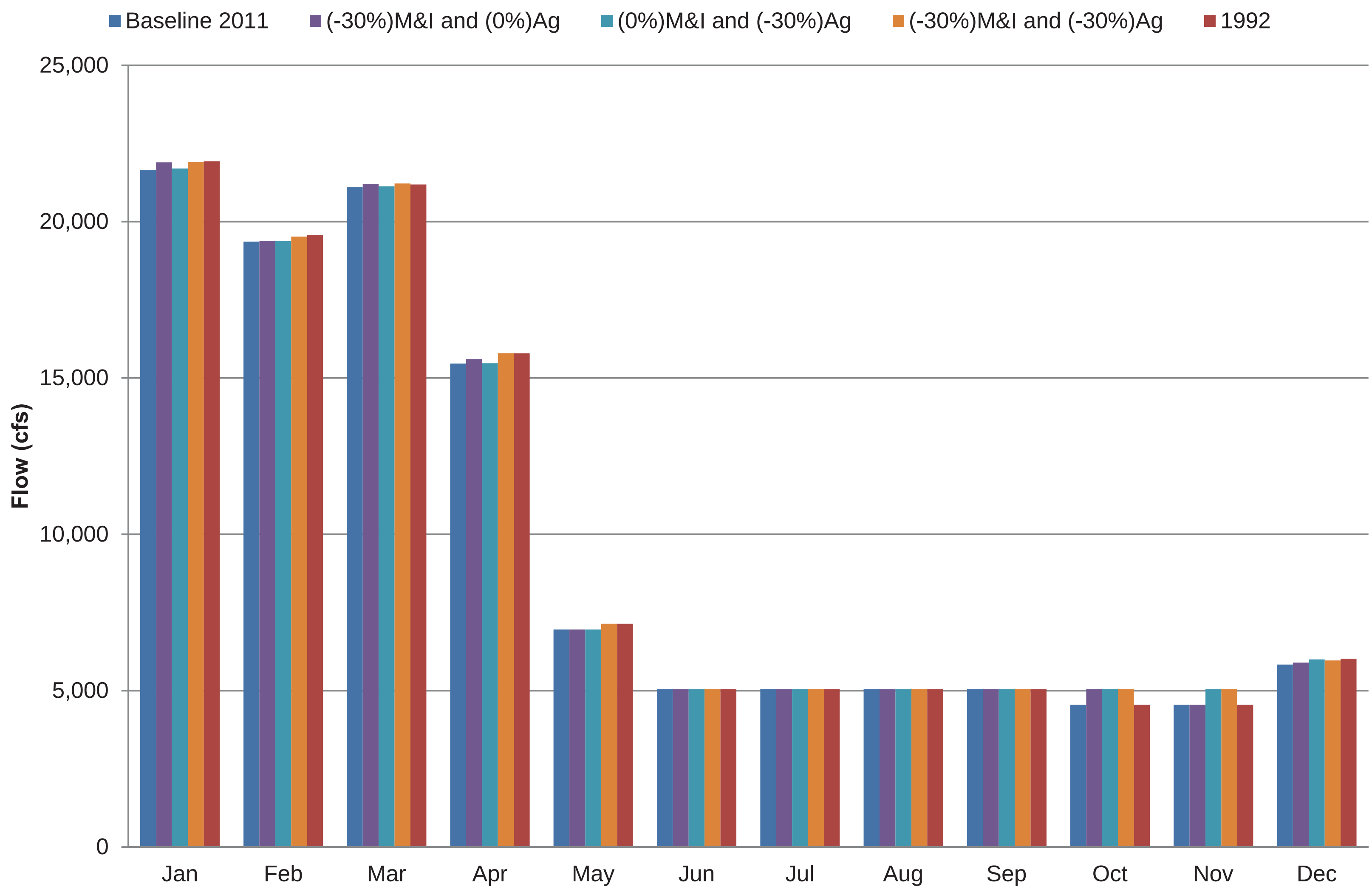


Figure 41. Average Monthly Flows at State Line for Dry (2007) Conditions Comparing Baseline 2011 to 1992 and Several Reduction Scenarios

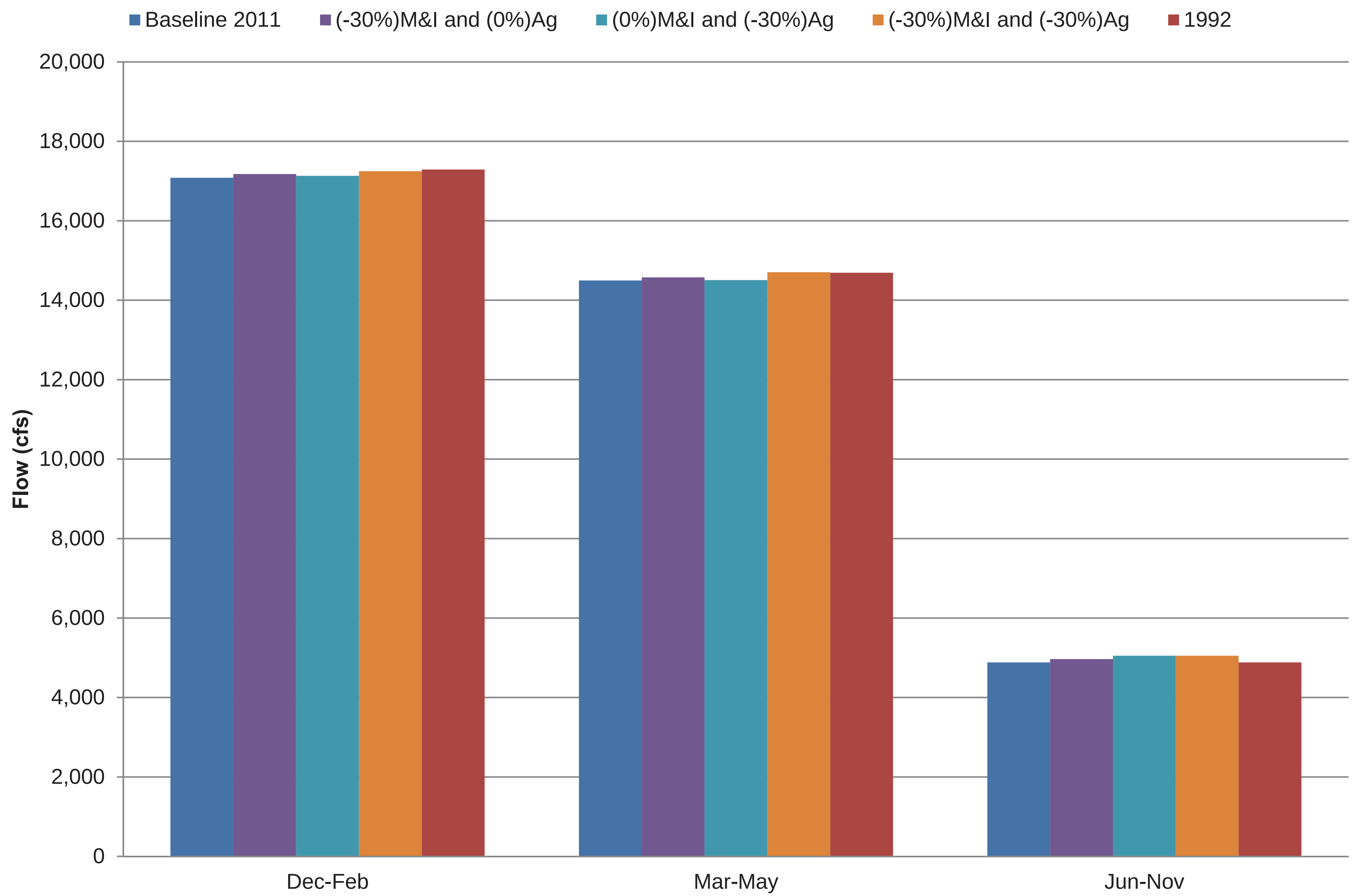


Figure 42. Average Seasonal Flows at State Line for Dry (2007) Conditions Comparing Baseline to 1992 and Several Reduction Scenarios

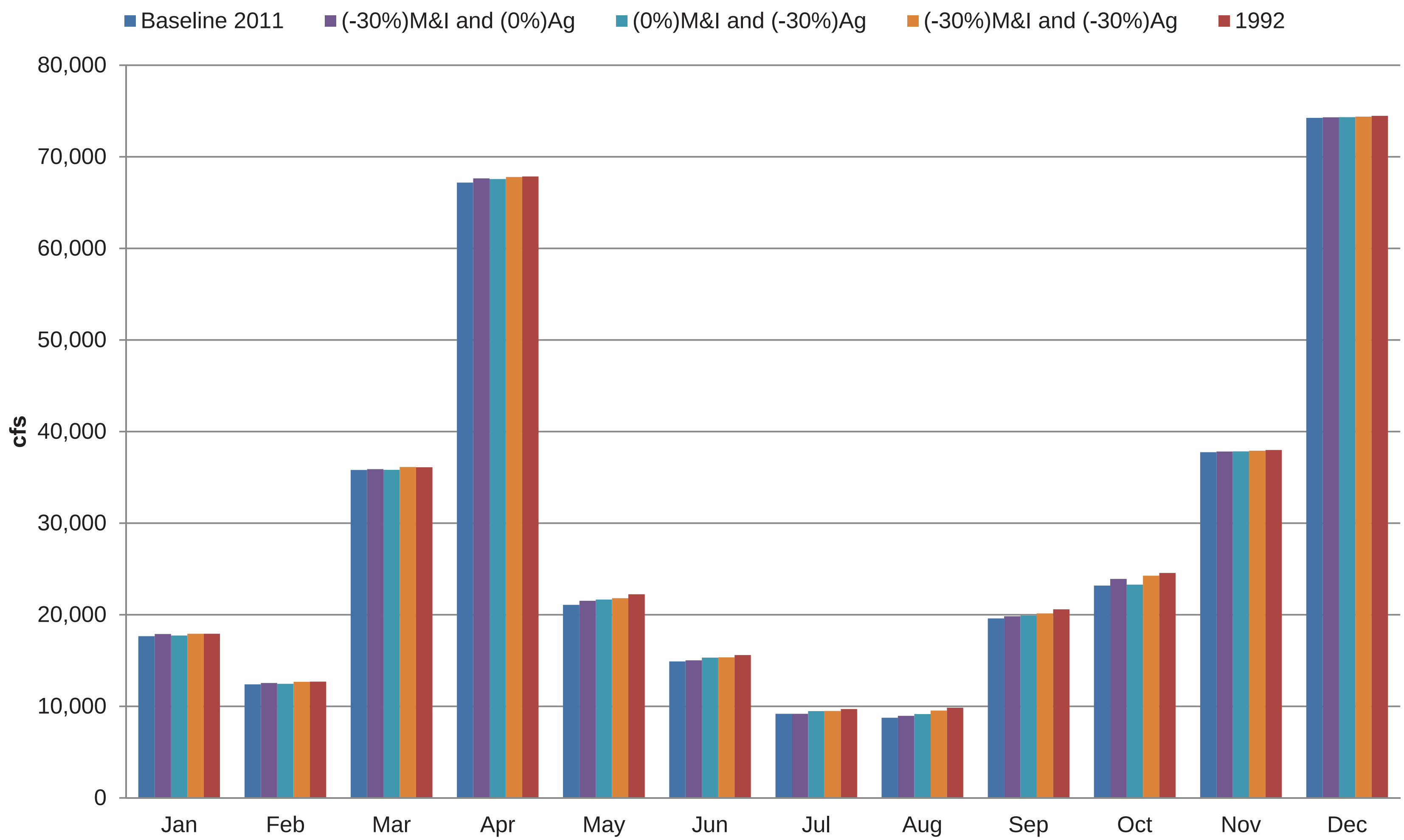


Figure 43. Average Monthly Flows at State Line for Wet (2009) Conditions Comparing Baseline 2011 to 1992 and Several Reduction Scenarios

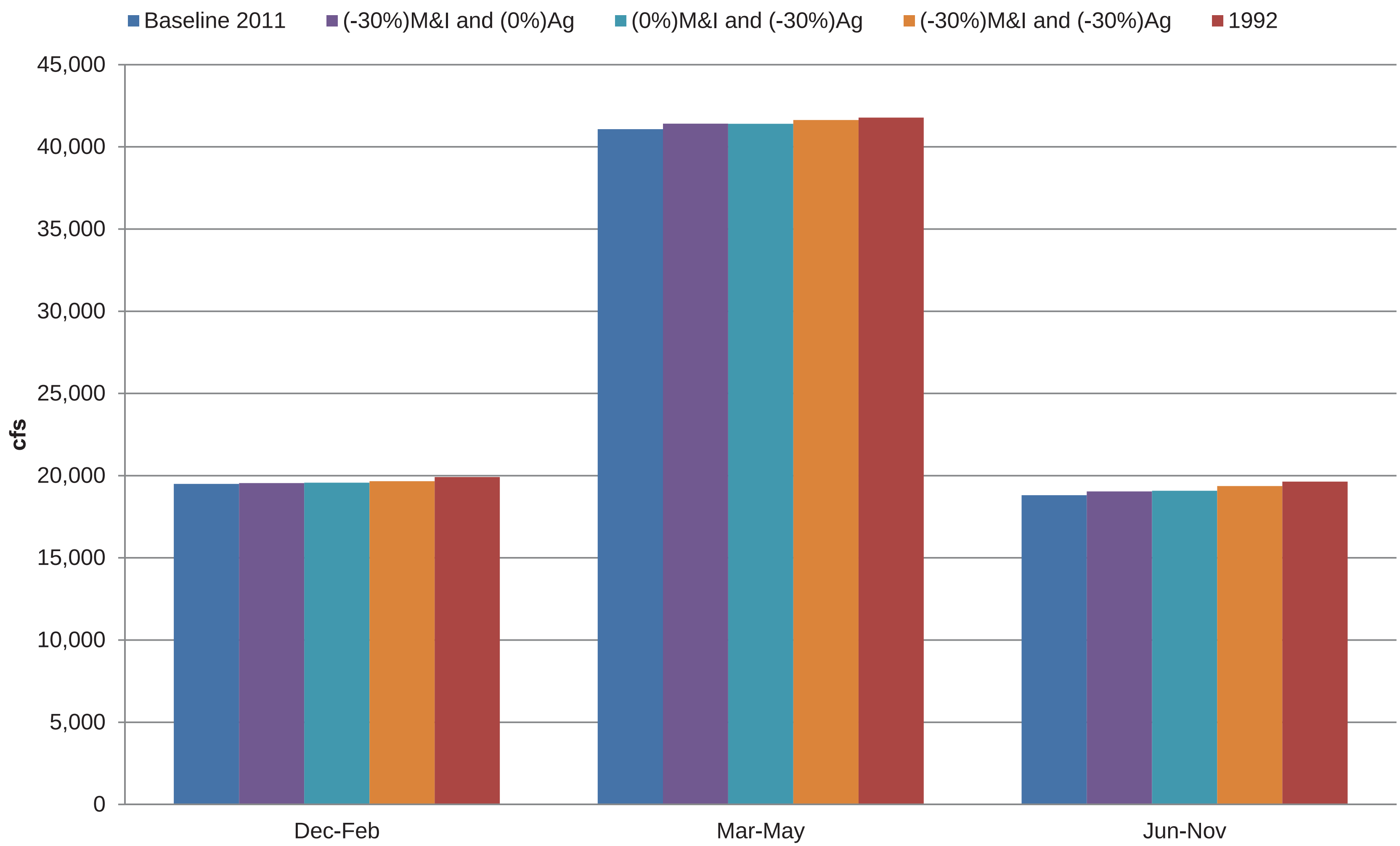


Figure 44. Average Seasonal Flows at State Line for Wet (2009) Conditions Comparing Baseline to 1992 and Several Reduction Scenarios

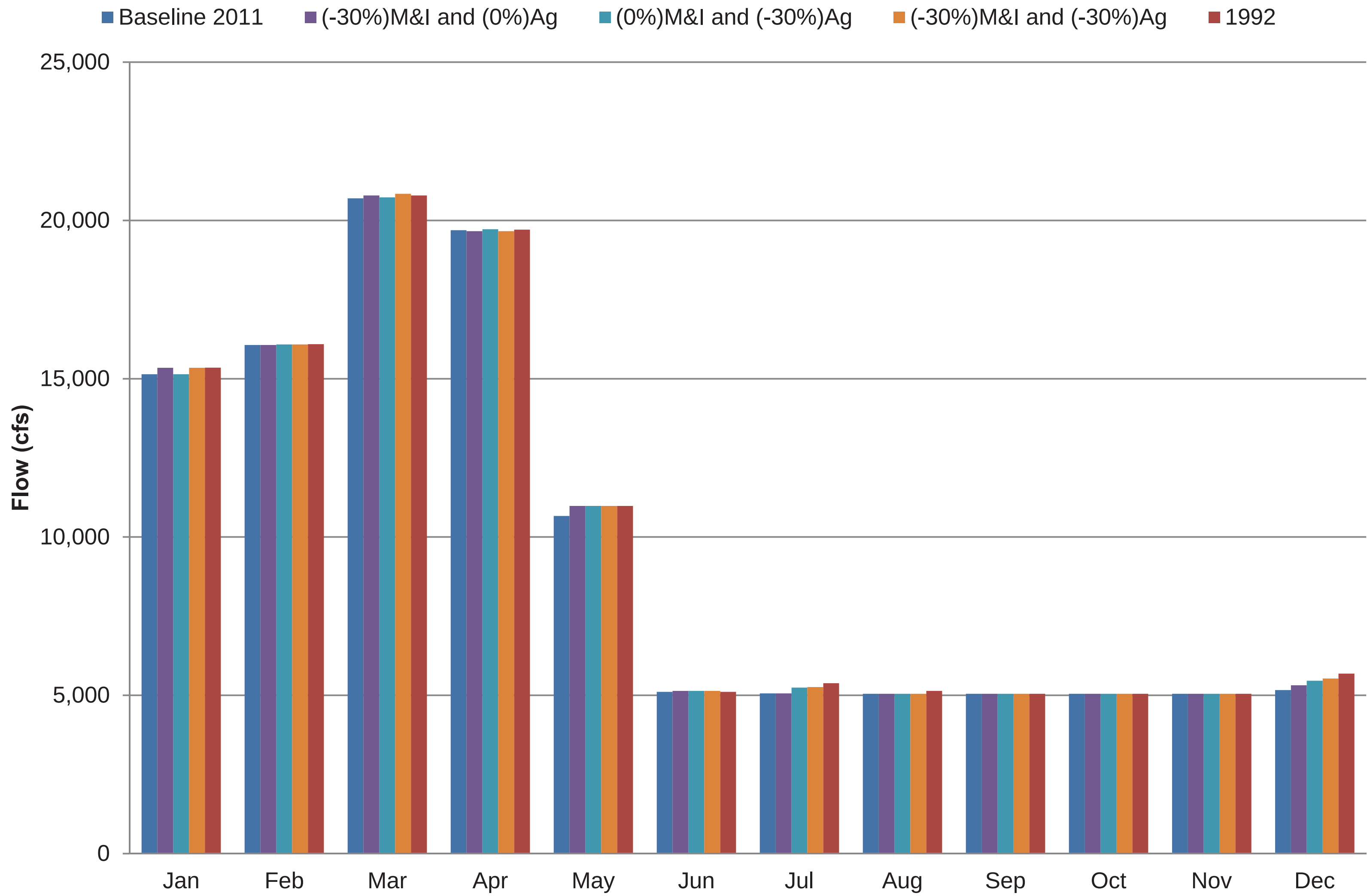


Figure 45. Average Monthly Flows at State Line for Dry (2011) Conditions Comparing Baseline 2011 to 1992 and Several Reduction Scenarios

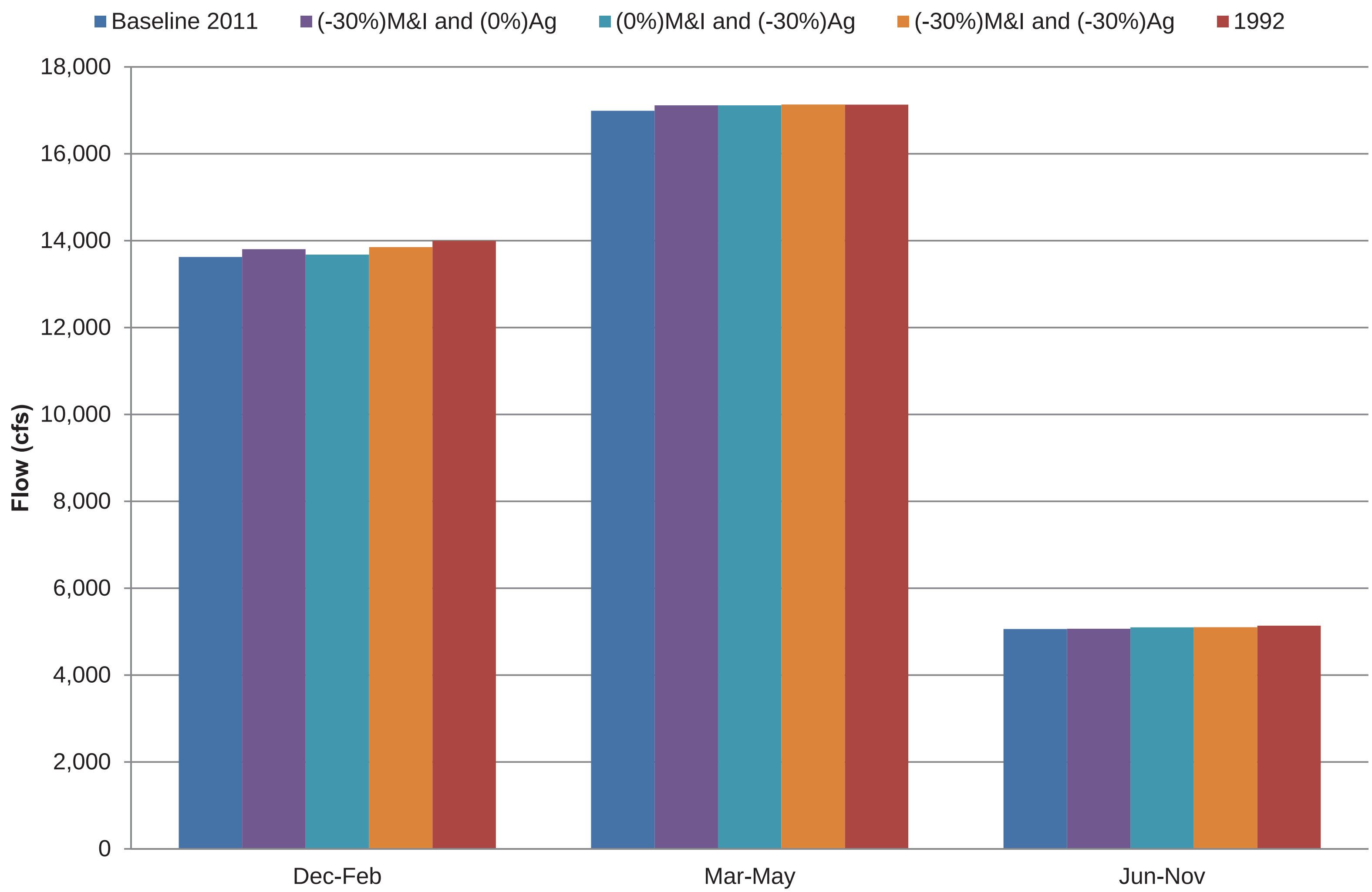


Figure 46. Average Seasonal Flows at State Line for Dry (2011) Conditions Comparing Baseline to 1992 and Several Reduction Scenarios

As the above figures show, there is minimal difference in baseline flows on both a monthly and seasonal basis from significant hypothetical reductions in Georgia's consumptive use. This is especially true for dry years (e.g., 2007 and 2011). In dry years like 2007 and 2011, significant reductions in Georgia's consumptive use would lead to virtually no change in state-line flows during the low-flow months (e.g., June, July, August, September). All of these figures and tables show the importance and significance of the USACE and its reservoir operations in affecting the amount of water flowing across the state line and into the Apalachicola River. This is especially important to understand when changes to Georgia's consumptive use are being considered, whether they be an increase or a decrease. Such changes have been shown to not automatically translate to a comparable change at the state line and into Florida. This is due to the nature of the USACE operations that will hold water in its reservoirs to meet certain project purposes and then release this water at a later time to meet other authorized project purposes.

Table 6 shows the difference between the average annual flow at the state line for the Baseline 2011 condition and the 1992 condition. Again, the difference in flow at the state line varies from the 379 cfs difference in consumptive water use between these two scenarios, and is explained by the change in storage in the USACE reservoirs. For example, in drought years 2000, 2007, and 2011, the average increase in state line flows is far less than the 379 cfs increase in flow contribution to the ACF Basin from this hypothetical reduction in Georgia's consumptive use. This is due to the USACE storing more water in its reservoirs than it would otherwise without this additional inflow to the system. This extra stored water is released during later years, such as 2009, when the average annual increase is more than 379 cfs.

Table 6. Annual Flow, Change in Storage, and Consumptive Use Difference (cfs) Comparison Between Baseline 2011 and 1992 Condition (2000–2011)

Year	Baseline Flow	1992 Flow	Difference in Flow	Difference in Δ Storage	Difference in Flow + Δ Storage	Difference in Consumptive Use
2000	9318	9520	201	180	382	379
2001	16127	16567	441	-58	383	
2002	11031	11465	434	-52	381	
2003	26204	26615	410	-25	385	
2004	17058	17443	385	-2	382	
2005	28884	29264	380	-2	378	
2006	13079	13403	323	57	380	
2007	9921	10110	189	187	376	
2008	14392	14749	357	21	378	
2009	28542	29196	654	-266	388	
2010	22139	22505	366	17	383	
2011	9777	9914	137	234	370	
Average	**17206**	**17563**	**356**	**24**	**380**	**379**

water being released from Woodruff Dam and flowing into the Apalachicola River Florida.

VII. APALACHICOLA RIVER AND BAY INFLOWS HAVE DECLINED IN RECENT YEARS AS A RESULT OF CLIMATOLOGIC AND HYDROLOGIC FACTORS—NOT GEORGIA'S CONSUMPTIVE WATER USE

USGS streamflow records for the Chattahoochee Gage on the Apalachicola River, just downstream of Woodruff Dam, show that flows crossing the state line and entering into the Apalachicola River have declined in recent years. It is also clear from analyzing rainfall records for the ACF Basin from NOAA and others that these reduced flows are primarily a result of the reduced rainfall over the Basin, especially during the three significant drought periods in the last 15 years or so, and not Georgia's consumptive water use.

A. Apalachicola River at Chattahoochee, Florida (1929–2014)

An initial analysis of the average annual streamflow in the ACF Basin crossing the state line was performed using over 80 years of data from the Chattahoochee, Florida USGS stream gage on the Apalachicola River, and comparing it to the corresponding rainfall over the ACF Basin above the state line, as was shown previously in Figure 17. Figure 47 below shows the correlation between the annual average rainfall to streamflow at the state line, having a correlation coefficient of 0.6209 (a value of 1.0 would represent a perfect match).

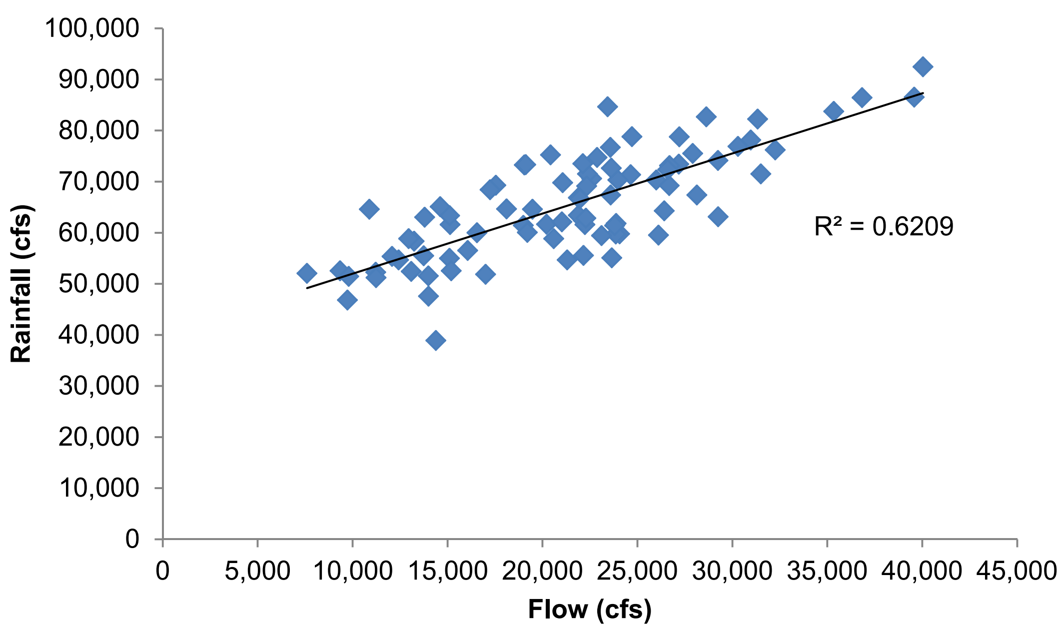


Figure 47. Correlation of Rainfall to Streamflow on Apalachicola River at Gage Near Chattahoochee, FL (1929 - 2014) (Source: NOAA; USGS)

This annual average streamflow and rainfall data clearly show a correlation between the amount of rainfall over the ACF Basin and the corresponding streamflow at the state line. However, given the influence that the USACE reservoir operations have on smoothing out and redistributing inflows into the ACF river system, even over a period longer than a year (as was shown in the previous Tables 5 and 7), analyzing flows at the state line as compared to rainfall might better be correlated by using the two-year running average values rather than the annual average value.

As shown in Figure 48, the correlation between rainfall and streamflow at the state line becomes even closer when analyzing the two-year running average values, which has a correlation coefficient of 0.729.

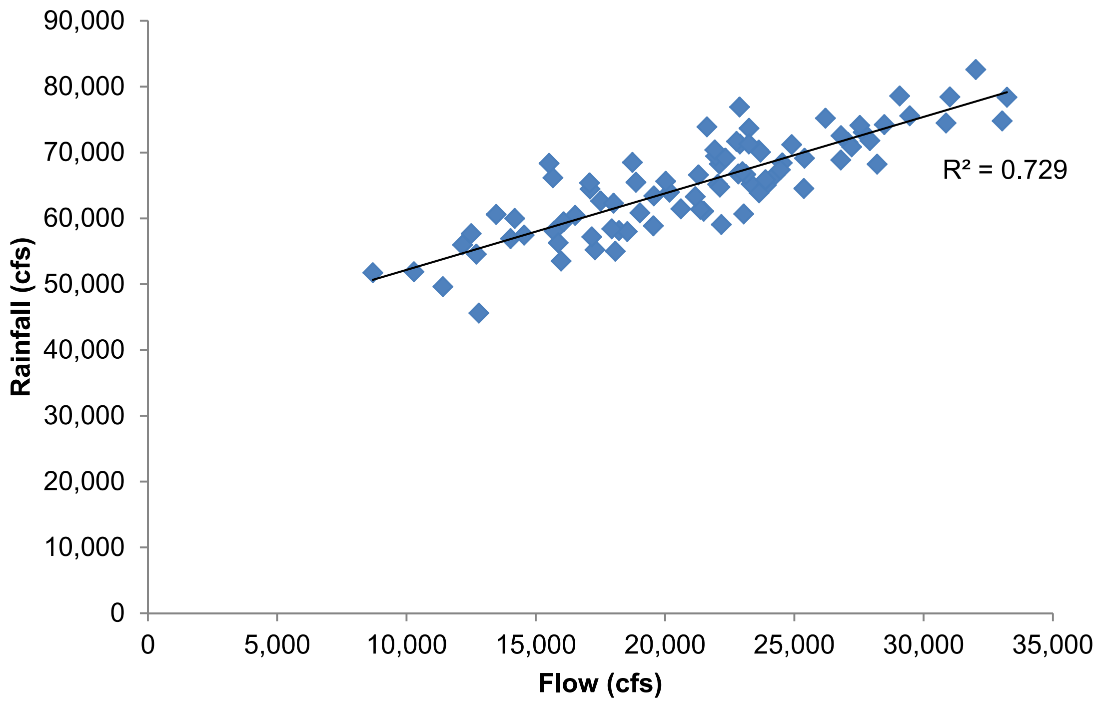


Figure 48. Correlation of Two-Year Running Average Rainfall to Streamflow on Apalachicola River at Gage Near Chattahoochee, FL (1929 - 2014) (Source: NOAA; USGS)

As the two figures above show, the two-year running average rainfall and streamflow data show a better correlation to each other than the one-year average values. This is due to the USACE reservoir storage and release operational procedures that tend to dampen and moderate changes in runoff entering the river and reservoir system of the ACF Basin that can extend the impact from any such changes beyond a year or so. The two-year running average rainfall and streamflow data at the state line were plotted for the Chattahoochee gage's period of record from 1929-2014, as shown in Figure 49. This figure shows the general pattern and trend of the two-year running average streamflow crossing the state line, along with the corresponding rainfall which generally follows the same pattern and trend as the streamflow. It is important to note that in the last 15 years of this period of record, there have been 3 significant drought periods, more so than in any other portion of this data record. Rainfall amounts were significantly lower during these recent drought periods, as were the corresponding streamflow at the state line. This is more evident by analyzing this data using two-year running average values rather than annual and decadal values of streamflow and rainfall.

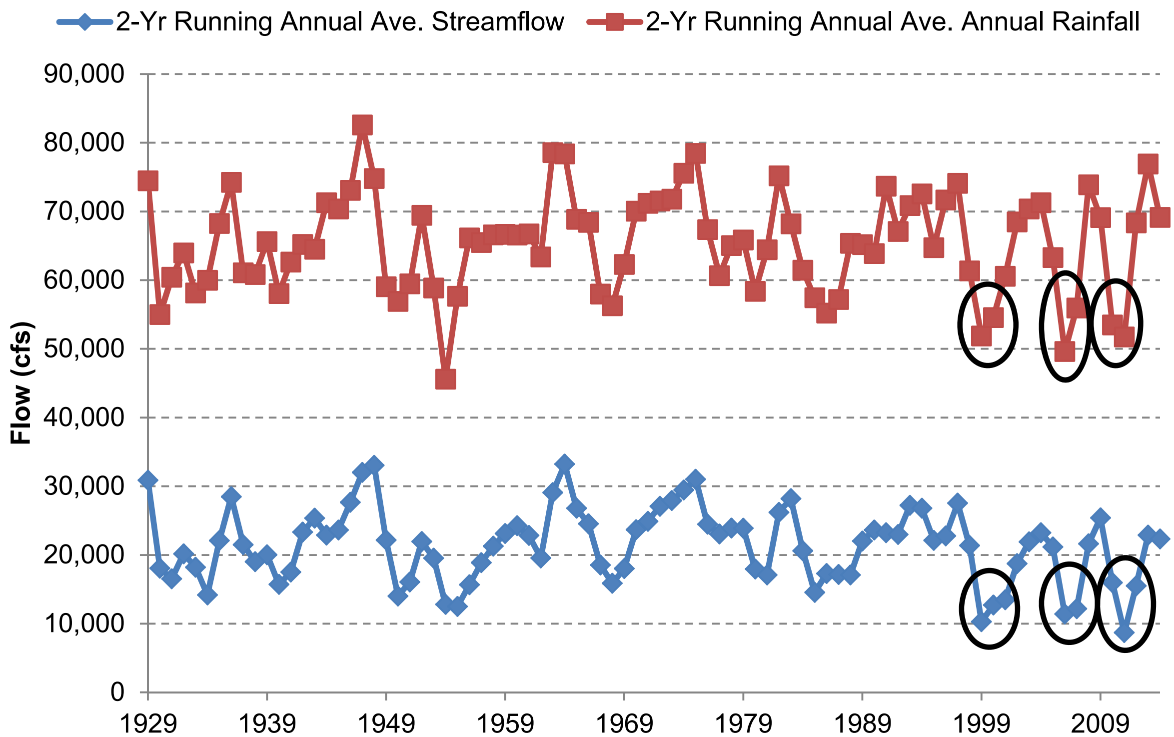


Figure 49. Two-Year Running Average Rainfall and Streamflow on Apalachicola River at Gage Near Chattahoochee, Florida (1929-2014) (Source: NOAA; USGS)

Figure 49 shows the extent and severity of the three drought periods since 1998 (1999-2001, 2006-2008, 2010-2012) as compared to the earlier periods. Figure 49 shows that the three multi-year, low rainfall drought periods correspond to the three multi-year, low flow periods observed in the past 15 years. This is clear indication that the recent periods of low streamflow seen at the state line are primarily caused by correspondingly low rainfall.

Besides rainfall, there are other factors that affect the amount of water flowing across the state line in more recent years. For example, since 1970, the amount of Georgia's consumptive water use has increased, but the total amount of such use has never been over 1,000 cfs on an annual average basis (at about 300 cfs for M&I and 500 cfs for Ag). This represents about 10% of the total annual average flow across the state line during most of the severe drought years of this recent period. A closer analysis of the effect of such consumptive water use on the streamflow crossing the state line is presented in Section IV. That section of the report also explains that urban development in the ACF Basin increases the annual average streamflow by an estimate of over 1,200 cfs and more than offsets the corresponding decrease in streamflow caused by Georgia's consumptive water use.

Thus, while there has recently been a reduction in the amount of water annually crossing the state line, the primary cause is the recent drought periods of reduced rainfall that result in an even greater reduction in the corresponding streamflow. Consumptive water use in the ACF Basin by Georgia contributes to the reduction in the amount of water crossing the state line, but to a much lesser degree. Increased runoff due to land use changes increases the amount of water crossing the state line and more than offsets the associated consumptive water use as the population grows.

B. Apalachicola River at Sumatra, Florida (1978–2014)

Streamflow, and the corresponding rainfall, have been analyzed at the USGS stream gage near Sumatra, Florida on the Apalachicola River (19,200 mi^2 of drainage area) to understand the historic flows entering into the Apalachicola Bay from the ACF Basin over the same time period. The Sumatra Gage is the best available estimate of the amount of water entering the Apalachicola Bay from the Apalachicola River.

First, annual mean flows and decadal mean flows at the USGS gage near Sumatra, Florida, from 1978-2014 were analyzed and compared to the corresponding rainfall over the ACF Basin, as shown in Figure 50. This analysis again shows a strong relationship between rainfall and streamflow, with a similar pattern of higher rainfall and streamflow during the earlier portion of the period as compared to the later portion. This would be expected since about 90% of the ACF watershed at the Sumatra Gage location lies above the state line (17,200 mi^2 out of 19,200 mi^2). Thus, the pattern of streamflow to rainfall that was observed at the state line when analyzing the data at the Chattahoochee Gage should also be prevalent at the Sumatra Gage, since only about 10% of additional drainage area in Florida contributes to the streamflow in the Apalachicola River at the Sumatra gage.

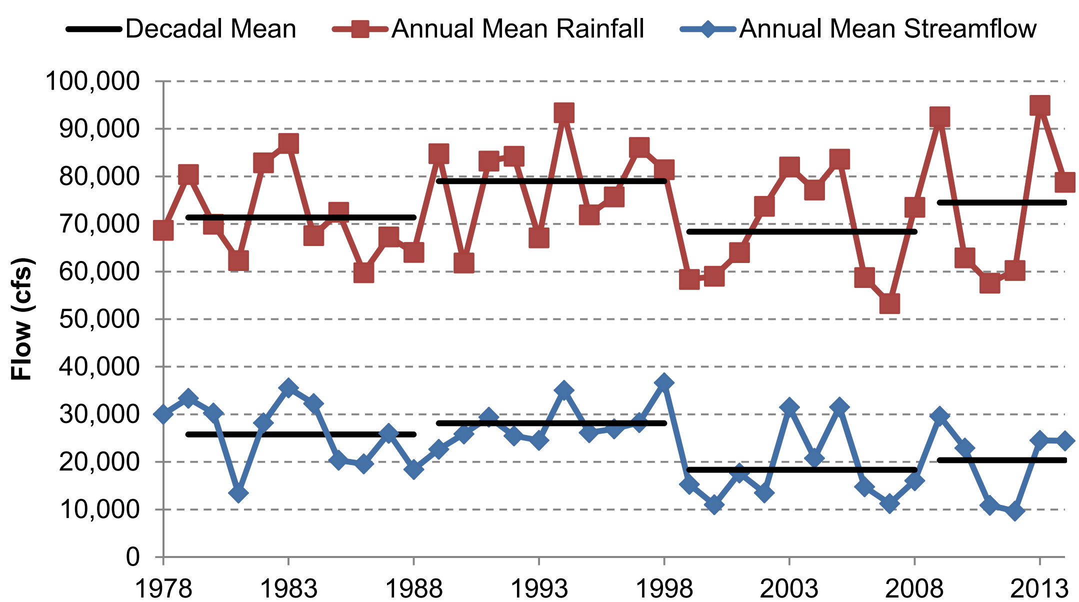


Figure 50. Average Annual and Decadal Rainfall and Streamflow for ACF Basin at Gage Near Sumatra, Florida (1978-2014) (Source: NOAA; USGS)

Therefore, the more recent reduction of streamflow entering the Apalachicola Bay from the Apalachicola River is primarily due to the reduced rainfall over this same period, where a number of years of low rainfall resulted in low flows recorded at the Sumatra Gage. Again, the amount of Georgia's consumptive use played an even lesser role in affecting the amount of water that entered the Bay as compared to what was crossing the state line, since more water enters into the river below the state line as it flows through Florida on its way to Apalachicola Bay.

C. Florida's Contribution to Flows into Apalachicola Bay Has Decreased in Recent Years

As part of my streamflow and rainfall analysis, I also considered the portion of the ACF Basin below the state line that contributes to flows into the Apalachicola Bay. As shown in Table 7 below, a drainage area of about 2,000 mi^2, or 10% of the ACF Basin lies between the state line and the Sumatra Gage in Florida (an additional 400 mi^2 of area drain into this ACF Basin between the Sumatra Gage and Apalachicola Bay).

Table 7. Non-Florida and Florida Portions of the Drainage Area for the ACF Basin at Sumatra, Florida

	Drainage Area (mi^2)	Percent (%) of ACF Basin
Non-Florida Portion	17,200	90%
Florida Portion	2,000	10%
Total	**19,200**	**100%**

To understand the specific portion of flows that Florida contributes to the total flows within the ACF Basin, the difference between flows along the Apalachicola River at the Chattahoochee Gage and the Sumatra Gage were analyzed (see Figure 12 for location of these gages). The flows reported at the Chattahoochee Gage for the Apalachicola River equate to the flows from both the Chattahoochee and Flint Rivers and resulting releases from the Jim Woodruff Dam; whereas flows seen at the Sumatra Gage equate to these flows as well as flows being added or subtracted as the Apalachicola River flows through Florida. By subtracting the flows at the Chattahoochee Gage from the flows at the Sumatra Gage this incremental flow contribution from Florida to the streamflow in the Apalachicola River and ultimately into the Apalachicola Bay can be determined.

The contributions of the gaged flows from the non-Florida and Florida portions of the ACF Basin, as shown in Figure 51, show that the Florida portion of the ACF Basin had a fairly consistent contribution of roughly 5,000 cfs from 1978 to 1998. After 1998, however, the average contribution of the Florida portion of flows to the ACF Basin generally declined to roughly 1,000 to 2,000 cfs, much lower than in earlier years.

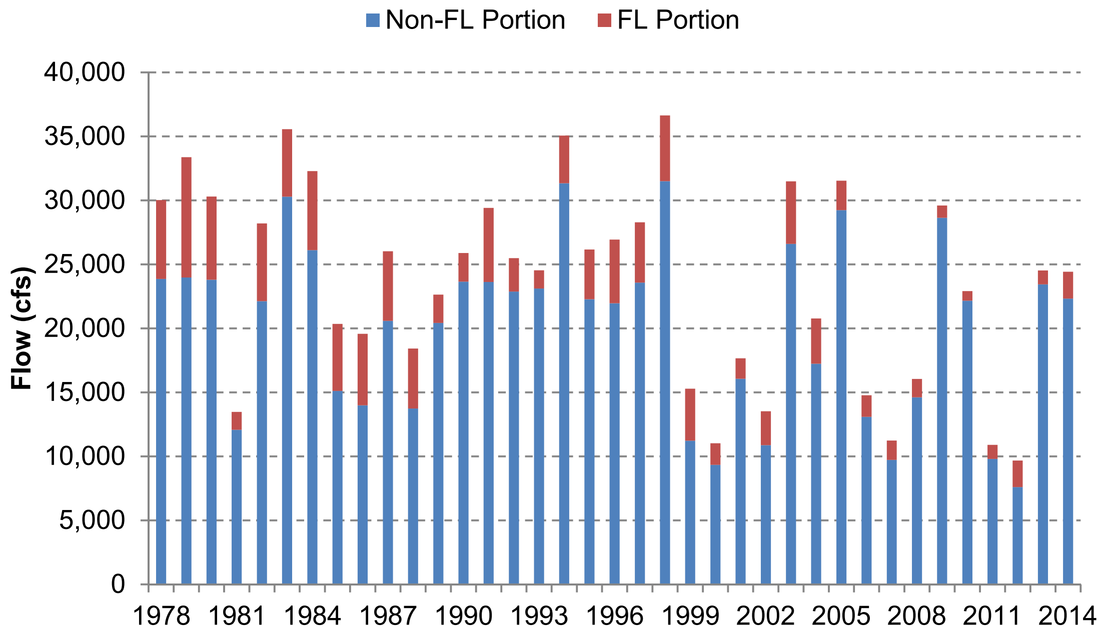


Figure 51. Average Annual Flow Contributions of Non-Florida and Florida Portions of ACF Basin at Gage Near Sumatra, Florida (1978-2014) (Source: USGS)

Next, an analysis was done of how Florida's portion of flows (annual mean and decadal mean) compared to rainfall occurring over the Florida portion of the ACF Basin from 1978 to 2014, as shown in Figure 52, to determine if this trend of reduced contributions of flow from Florida was correlated with reduced rainfall. The decadal mean flows as shown in this figure indicate a consistent decline in flow from almost 6,000 cfs for 1979-1988 to under 2,000 cfs for 2006-2013, while the corresponding rainfall does not show such a consistent decline, but rather follows the pattern previously seen for the entire ACF Basin. The declining trend in the percentage of the streamflow being contributed by the Florida portion of the ACF Basin, as seen in Figure 53, differs from the trend in percentage of streamflow being contributed from the non-Florida portion of the ACF Basin seen in previous figures. Likewise, the strong relationship between rainfall and streamflow that has been seen at the state line does not appear in the data shown for the Florida portion of the ACF Basin. This suggests that there is some other reduction in streamflow occurring in the Apalachicola River entirely within Florida that is not directly attributable to rainfall or to the flows crossing the state line.

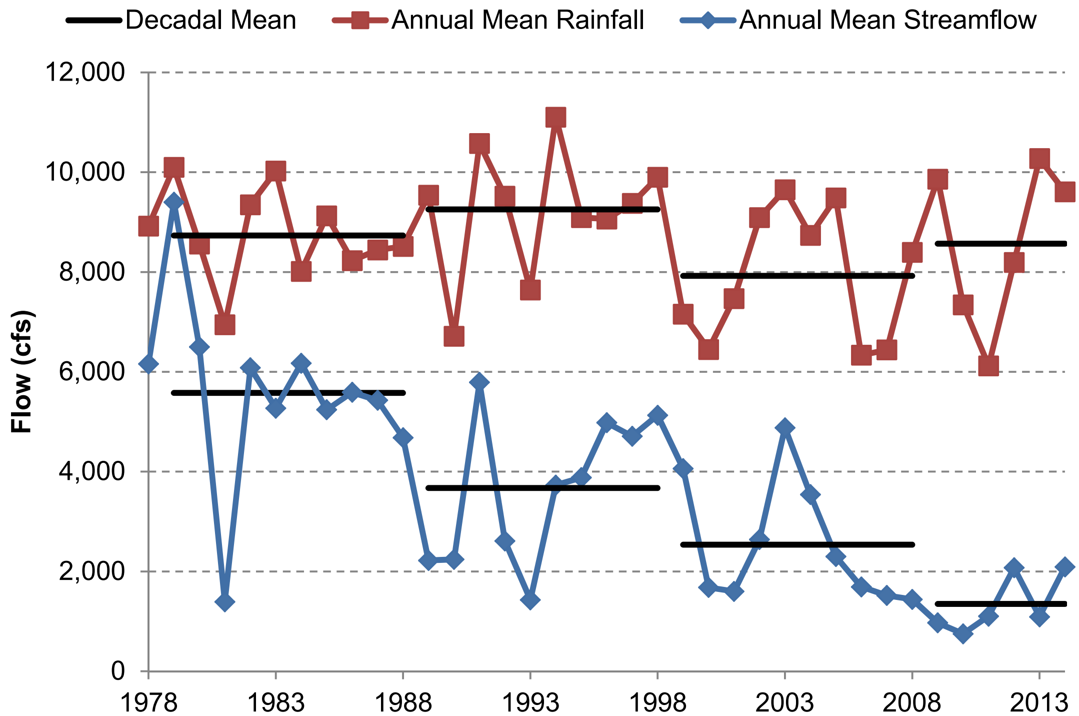


Figure 52. Average Annual Flow and Rainfall for Florida Portion of ACF Basin (1978-2014) (Source: NOAA; USGS)

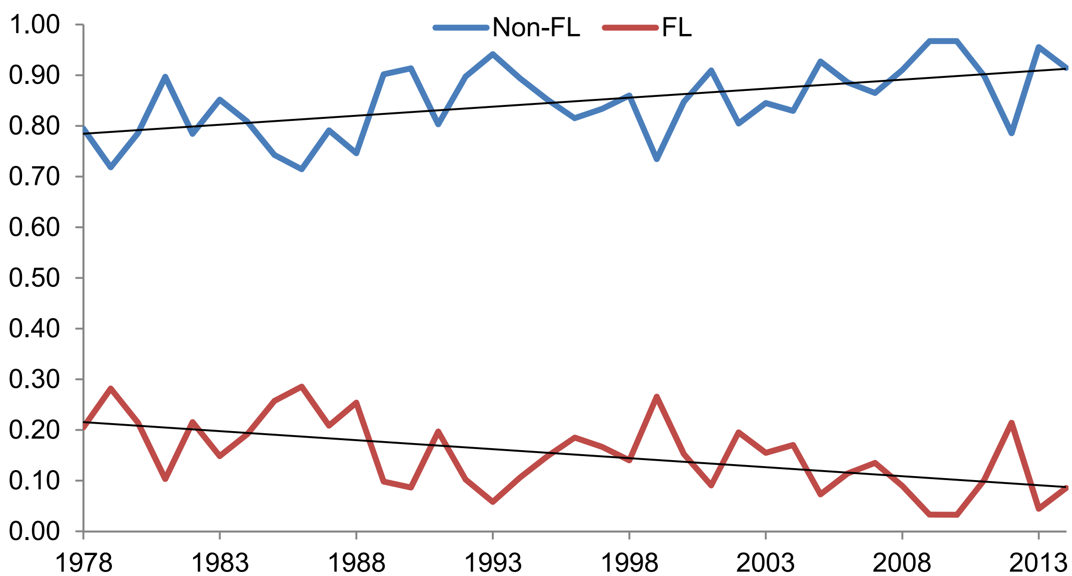


Figure 53. Percentage of Flow Contribution from Non-Florida and Florida Portions of ACF Basin (1978-2014) (Source: NOAA; USGS)

By analyzing the ratio of flow-to-rainfall for Florida's portion of the ACF Basin, as shown in Figure 54, it is observed that the percentage of rainfall that becomes streamflow in the Florida portion of the ACF Basin has also been consistently dropping.

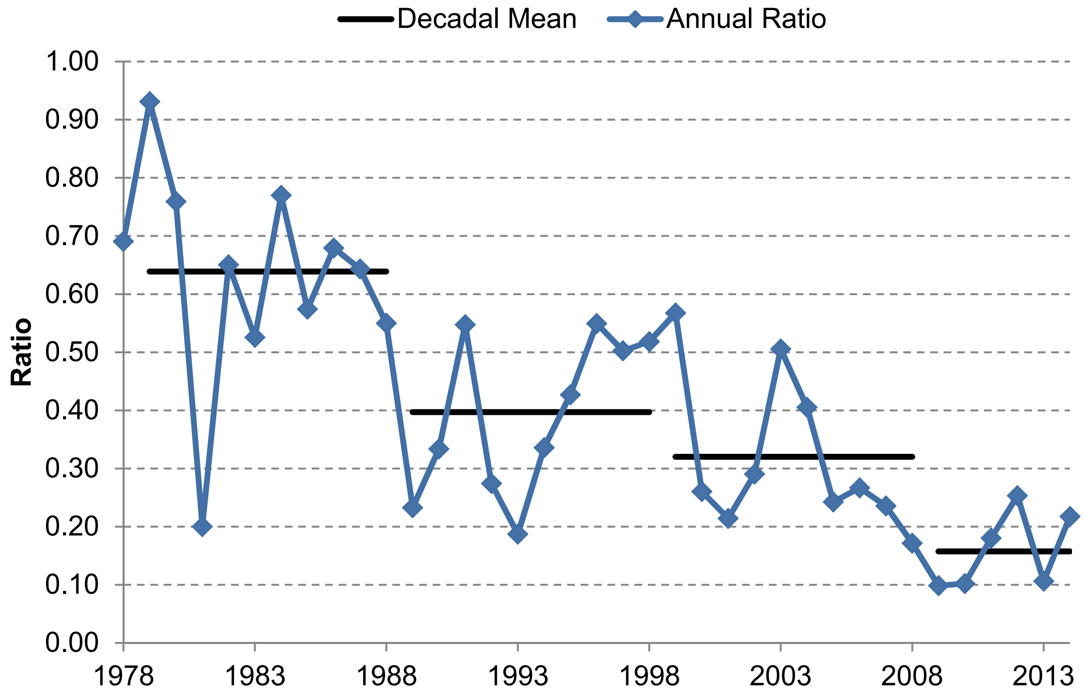


Figure 54. Ratio of Flow vs. Rainfall for Florida Portion of ACF Basin (1978-2014) (Source: NOAA; USGS)

It is not clear why Florida's portion of flow into the ACF Basin has continued to consistently drop even when rainfall has been generally constant, but it is clear that Florida's relative contribution to flow in the ACF Basin has been decreasing. In other words, for the same relative amount of rainfall, the amount of streamflow being contributed from the Florida portion of the ACF Basin and entering into the Apalachicola River and Bay has been decreasing.

summer months is relatively small, if not negligible. Again, this lack of benefit to Florida from hypothetical cutbacks on Georgia's consumptive use during these low flow periods is due to the USACE and its reservoir operating procedures, which will offset additional inflow from the Flint River with less releases from storage on the Chattahoochee River. The results of this ResSim modeling is an example of the minimal impact on streamflow at the state line from such a "conservation scenario," especially during the low flow months and for a low-flow year.

B. Responses to Dr. Shanahan & Mr. Barton

1. Contrary to Dr. Shanahan and Mr. Barton, USACE Operations and Policy Confirm that Additional Inflow from the Flint River from Reductions in Georgia's Consumptive Use Would Be Offset by Storage in the USACE Upstream Reservoirs

Dr. Shanahan's key opinion is that the "stated policy" of the USACE is to store water in its reservoirs during the spring and release stored water from its reservoirs during the summer and fall, and that the USACE's "actual operations" confirm this stated policy. In fact, the USACE's policy regarding reservoir storage is directly contrary to Dr. Shanahan's opinion: the USACE's express goal is to keep the reservoirs as full as possible during the summer and early fall months. Dr. Shanahan further opines that if reductions in Georgia's consumptive use created additional inflows to Lake Seminole from the Flint River, the USACE reservoirs would not be operated so as to offset this additional inflow, since this would be contrary to USACE stated policy of "increasing storage" in the summer and fall, and that the reservoirs have not been historically operated in such a way. In addition to misstating the USACE's policy, Dr. Shanahan misinterprets and mischaracterizes how the USACE has operated its reservoirs, which show that inflow from the Flint River to Lake Seminole is directly correlated with reservoir storage in the ACF Basin. This confirms that increased flow from the Flint River translates to increased storage in the reservoirs. Furthermore, results from the USACE's ResSim model show that such an offset would occur.

2. Dr. Shanahan's Opinion Regarding the USACE's "Stated Policy" Against Reservoir Storage Is Not Supported by Any Evidence

Dr. Shanahan mistakenly opines that "the stated policy of the Corps of Engineers is to store water in reservoirs during the spring and to release storage during the summer and fall." This is contrary to the USACE's statement that they try to keep their reservoir lake levels as high as possible during the summer and fall months. His mistaken understanding of the USACE policy is based on incorrect citations to the USACE's DEIS that involve its flood management policies rather than its normal operations in dealing with the reservoirs' conservation storage pools. Dr. Shanahan also misinterprets historic releases during the summer and fall as being consistent with his interpretation of USACE policy, rather than the fact that the USACE needs to release water during the summer and fall at times to meet certain project purposes, but

Exhibit 37

20160223-ACF-GA-total-consumptive-monthly.xlsx

(File Provided Natively)

Exhibit 38

USGS Groundwater and Surface water data

(http://waterdata.usgs.gov/usa/nwis/)

Exhibit 39

STATE OF FLORIDA v. STATE OF GEORGIA
NO. 142 ORIGINAL

INITIAL EXPERT REPORT OF
PHILIP B. BEDIENT, PH.D., P.E.

Source: 2015 USACE DEIS 1-2, Figure 1.1-1

February 29, 2016

Woodruff Dam Flow Requirement for Apalachicola River

Because these reservoir projects altered the pre-reservoir flow regime of the river system downstream, there is also a need to ensure that fish and wildlife and other water quality issues are being considered when developing the reservoir regulation plan or manual. Releases from Woodruff Dam under normal operations have typically provided conditions in the river suitable for fish and wildlife purposes. However, following recent droughts, the USACE initiated consultation with the U.S. Fish and Wildlife Service ("USFWS") regarding the effects of existing operations at Woodruff Dam on threatened and endangered species and federally designated critical habitat, especially during drought conditions and spawning periods. An interim operating plan ("IOP") was implemented in 2006 following this consultation, with minimum flow provisions becoming part of the overall plan to avoid and minimize impacts on the listed species (2015 USACE DEIS, p. 2-70). Based on further consultation with the USFWS following the increasingly severe drought conditions in 2007–2008 and in 2011–2012, the USACE revised the IOP twice (in 2008 and in 2012). Today, releases from Woodruff Dam to the Apalachicola River are governed by the 2012 revision, termed the Revised Interim Operating Plan ("RIOP").[2] In both 2008 and 2012, the USFWS confirmed that the USACE's minimum releases from Woodruff Dam under the RIOP were acceptable under the USFWS's Biological Opinions and were found not to lead to jeopardy of threatened or endangered species (USFWS 2012 BiOp, p. 143-44; USFWS 2008 BiOp, p. 178-79).

The Corps' drought contingency plan specifies a 5,000 cfs release rate from Woodruff Dam into the Apalachicola River in the event of drought conditions. This drought condition is determined based on the composite storage present in the upstream reservoirs. The drought plan is triggered if the total composite conservation storage falls below Zone 3 and into Zone 4,[3] which varies based on the time of year to account for seasonal variability in basin inflow. When the drought plan is triggered, the flow release from Woodruff Dam is 5,000 cfs, even if the inflow to Lake Seminole is less than that amount. If drought conditions worsen and composite storage falls into the Drought Zone, the plan dictates that the system is in Extreme Drought Operation, and the release is lowered to 4,500 cfs.[4] Once inflows increase and storage levels fully recover (i.e., to Zone 1), the Corps will discontinue drought plan provisions for

[2] In late 2015, as part of its process for revising its Water Control Manual for the ACF Basin, the USACE published a Proposed Action Alternative ("PAA"), which is a set of reservoir operations that would replace the 2012 RIOP. However, until the PAA is formally adopted by the USACE, the RIOP continues to govern releases from Woodruff Dam. For more information regarding the history of USACE reservoir operations in the ACF Basin, see **Appendix D**.

[3] The PAA would initiate drought operations when composite storage falls below Zone 2 into Zone 3, rather than into Zone 4.

[4] Since 2006, when the Corps initiated its modified operating procedures to address minimum flows crossing the state line, the only time that the Corps knowingly allowed the flow at the state line to fall below 5,000 cfs was during a portion of November 2007, when the Corps lowered the minimum threshold flow rate to 4,750 cfs during what was considered to be an extreme drought; later that month, additional rainfall within the ACF Basin allowed the Corps to return to the 5,000 cfs minimum flow requirement (USFWS 2012 BiOp, p. 53). During June 2011, flows fell slightly below 5,000 cfs due to inaccurate recorded gage data (USFWS 2012 BiOp, p. 57).

supplementing low flows to maintain these flow requirements at the state line (2015 USACE DEIS, p. 2-74). It is only when the reservoirs return to Zone 1 will any water entering the USACE's reservoir facilities over and above 5,000 cfs be permitted to flow downstream into the Apalachicola River. Until then, any additional water entering the USACE's reservoir facilities goes to storage (i.e., filling up the reservoirs).

The USACE's drought operations are determined by reservoir storage levels, rather than precipitation, streamflow, or the amount of water entering the reservoir facilities (basin inflow). Reservoir storage is more stable and is a better indicator of overall basin health than these factors, which are far more subject to short-term fluctuations. Thus, it is possible for USACE reservoirs to be in drought operations when basin inflow is above 5,000 cfs, and similarly it is possible for USACE reservoirs not to be in drought operations when basin inflow is below 5,000 cfs. This also means that if there are short-term increases in basin inflow over and above 5,000 cfs during drought operations, this would not automatically lead to additional state-line flow; the USACE would not alter its 5,000 cfs flow requirement at Woodruff Dam unless and until total reservoir storage recovers to Zone 1.

V. ANALYSIS OF THE IMPACT OF THE USACE'S RESERVOIR OPERATIONS ON FLOWS CROSSING THE GEORGIA-FLORIDA STATE LINE

Under the 2012 RIOP, which governs the USACE's reservoir operations in the ACF Basin, the amount of water stored in the USACE's reservoirs or released at Woodruff Dam into the Apalachicola River is a function of three key factors:

1. season;
2. reservoir pool level (i.e., drought vs. non-drought operations); and
3. **basin inflow (BI)**, or the total amount of water calculated to be entering the USACE's reservoir facilities at a particular time.

In consideration of each of these factors, the USACE developed a complex series of rules governing the amount and timing of storages and releases in the ACF Basin, as reflected in Table 1 below.

Table 1. 2012 RIOP for Apalachicola River Minimum Discharge from Woodruff Dam by Month and by Basin Inflow (Source: 2015 USACE DEIS p. 2-71, Table 2.1-5)

Months	Composite conservation storage zone	Basin inflow (BI) (cfs)	Releases from Jim Woodruff Lock and Dam (cfs)	BI available for storage[a]
March–May	Zones 1 and 2	≥ 34,000 ≥ 16,000 and < 34,000 ≥ 5,000 and < 16,000 < 5,000	≥ 25,000 ≥ 16,000+50% BI > 16,000 ≥ BI ≥ 5,000	Up to 100% BI>25,000 Up to 50% BI>16,000
	Zone 3	≥ 39,000 ≥ 11,000 and < 39,000 ≥ 5,000 and < 11,000 < 5,000	≥ 25,000 ≥ 11,000+50% BI > 11,000 ≥ BI ≥ 5,000	Up to 100% BI>25,000 Up to 50% BI>11,000
June–November	Zones 1, 2, and 3	≥ 22,000 ≥ 10,000 and < 22,000 ≥ 5,000 and < 10,000 < 5,000	≥ 16,000 ≥ 10,000+50% BI > 10,000 ≥ BI ≥ 5,000	Up to 100% BI>16,000 Up to 50% BI>10,000
December–February	Zones 1, 2, and 3	≥ 5,000 < 5,000	≥ 5,000 (Store all BI> 5,000) ≥ 5,000	Up to 100% BI > 5,000
At all times	Zone 4	NA	≥ 5,000	Up to 100% BI > 5,000
At all times	Drought Zone	NA	≥ 4,500[b]	Up to 100% BI > 4,500

Season

The RIOP defines threshold levels for storage and releases by three seasons: "winter refilling season" (December–February), "spawning season" (March–May), and "non-spawning season" (June–November).

- **Winter Refilling Season (December–February):** During the winter refilling season, the USACE's priority is refilling the reservoirs, which are typically low in storage by late November or early December, especially in drier years, because stored water is typically released each year to support the 5,000 cfs flow requirement at Woodruff Dam. During this season, the USACE maintains the 5,000 cfs flow requirement into Apalachicola River at all times, and any additional basin inflow above 5,000 cfs is stored in the reservoirs until the system is full. Thus, unless the reservoirs are full, Florida would not receive any additional state-line flow as a result of any reductions that might be made in Georgia's water use during this 90-day "refilling" period. Furthermore, even if additional flows would be allowed to materialize at the state line during this season, water is typically more abundant in the winter than in the summer and fall months, and thus there is less of a need throughout the basin for supplementing flows.

- **Spawning Season (March–May) and Non-Spawning Season (June–November):** During the spawning and non-spawning seasons, the USACE's operational rules provide for reservoir releases at Woodruff Dam based on reservoir pool levels and basin inflow, as depicted in the table above.

Reservoir Pool Level

The amount of storage in the USACE reservoirs (reservoir pool level), as described by the composite conservation storage levels and associated action zones reflected in Figure 5, triggers two different operational regimes: drought operations and non-drought operations.

- **Drought Operations:** Under the RIOP, drought operations are triggered as soon as composite reservoir levels dip into Zone 4. During drought operations, the USACE will only release a guaranteed 5,000 cfs minimum flow across the state line at Woodruff Dam. Drought operations will continue as needed and will not conclude, even as precipitation and basin inflow increase, until all reservoir levels are raised and the composite storage in the reservoirs returns to Zone 1, the top layer of the reservoir system storage. Thus, for the entire period that the USACE is in drought operations, the Apalachicola River will receive only 5,000 cfs crossing the state line. From the moment the reservoir pools dip into Zone 4 until they recover to Zone 1, any additional water entering the system will go to filling the reservoirs, even if basin inflow exceeds 5,000 cfs during that time. This is true even if basin inflow experiences short-term increases above 5,000 cfs, such as during a flash precipitation event. In other words, regardless whether basin inflow is less than, equal to, or greater than 5,000 cfs, if the USACE reservoirs are in drought operations, the flow requirement at Woodruff Dam is 5,000 cfs, and Florida would not receive any additional state-line flow as a result of any reductions that might be made in Georgia's water use.

- **Normal (Non-Drought) Operations:** During non-drought operations, the USACE has established rules for determining how much water to store vs. how much water to release downstream into the Apalachicola River based on threshold levels of basin inflow. As a result, when the USACE is in non-drought operations and basin inflow exceeds 5,000 cfs (but is below a higher threshold that varies by season) some or all of this basin inflow will materialize as additional state-line flow, according to the USACE's threshold release levels described in the next section.

Thus, reducing Georgia's consumptive use would only produce this additional water in the Apalachicola River when the USACE is in non-drought operations and basin inflow is above 5,000 cfs but is below a higher threshold that varies by season. If the reservoir system is still in drought operations, then regardless whether basin inflow is at, above, or below 5,000 cfs, Florida would still receive 5,000 cfs at the state line, and any basin inflow above 5,000 cfs would be stored to available storage capacity, and would not be passed down to Florida.

Basin Inflow

Finally, in determining how much water to store or release in the ACF Basin, the USACE takes into account basin inflow, or the amount of water calculated to be entering the USACE's reservoir facilities at any given time, as depicted in Table 1 above. Four "BI zones" representing threshold levels of basin inflow dictate how much water will be stored in the reservoirs or released into the Apalachicola River when the system is not in drought operations. Figure 6 below graphically represents an example of these four "BI zones" for a reservoir pool level being in Zone 1 and the associated rules for storage vs. release. I refer to these four zones as the "Augmentation Zone," "No-Storage Zone," "Half-Storage Zone," and "All-Storage Zone."

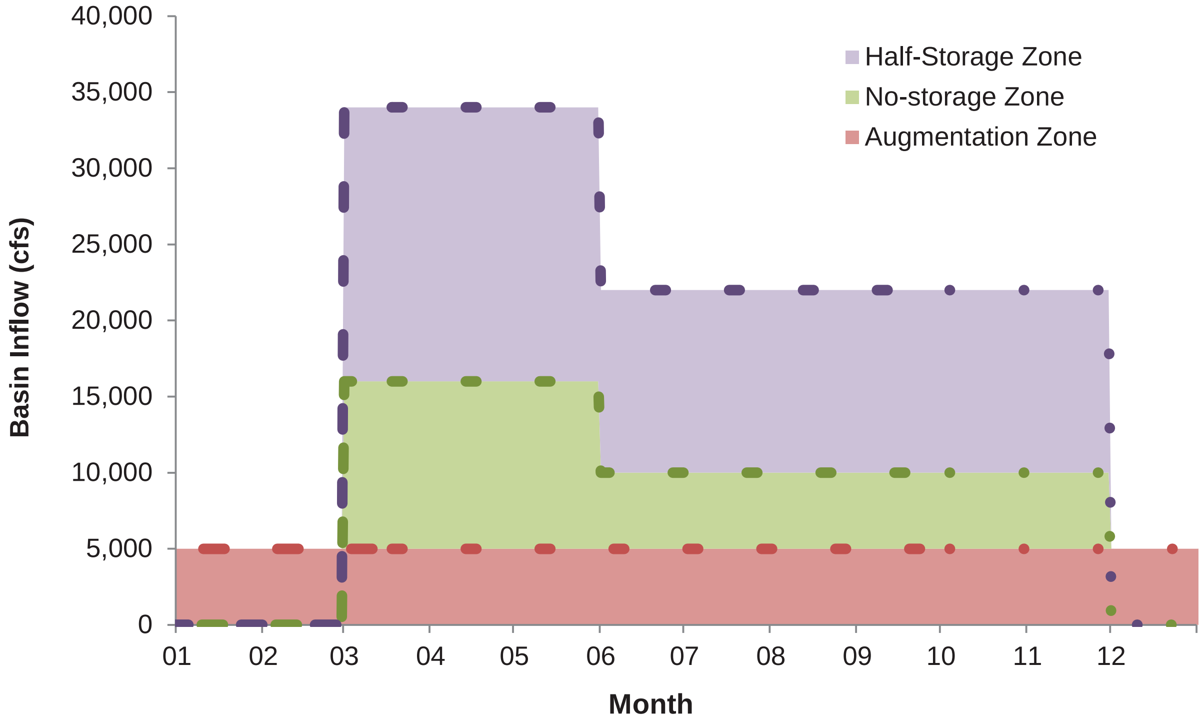


Figure 6. Seasonal Reservoir Operational Thresholds for 2012 RIOP

Again, this graph represents a portion of the seasonal operational procedures that assumes that the reservoir system is not in drought operations and the reservoirs are at prescribed levels of storage demonstrating healthy reservoir status.

The four "BI zones" are as follows:

- **Augmentation Zone (red):** The Augmentation Zone reflects a range of basin inflow (<5,000 cfs) whereby flow augmentation is needed to maintain the threshold of 5,000 cfs at Woodruff Dam. During this time period, regardless how far basin inflow is below the 5,000 cfs threshold level, the USACE's reservoir operations provide for releases of 5,000 cfs at Woodruff Dam (except for extreme drought conditions, when this threshold can be lowered to 4,500 cfs). In other words, during this period, the USACE is "augmenting" flows to satisfy the 5,000 cfs flow requirement. When basin inflow is in the Augmentation Zone, Florida would not receive any additional state-line flow as a result of any reductions that might be made in Georgia's water use.
  - For example, if basin inflow were 4,000 cfs, the USACE would release 1,000 cfs from storage to maintain the 5,000 cfs flow into the Apalachicola River. If Georgia's consumptive use were hypothetically cut in a way that produced an additional 250 cfs, resulting in 4,250 cfs entering the system, the USACE would simply release 750 cfs from storage (instead of 1,000 cfs) to maintain the 5,000 cfs target. Florida

would not receive 5,000 cfs plus the incremental 250 cfs; that 250 cfs would instead be placed in storage under USACE's operating plan and would not flow through to the Apalachicola River. Florida would not receive any additional flows at that time as a result of Georgia's reduced water use.

- Even if the basin inflow were more than 5,000 cfs, and the USACE reservoir system were in or recovering from drought operations, any additional water entering the system would not be released but rather would be stored in the USACE reservoirs. For instance, if 6,000 cfs were entering the system, all 1,000 cfs would go to storage if the reservoirs were still recovering from depleted levels. Florida would not receive any additional flows at that time as a result of Georgia's reduced water use.[5]

- **No-Storage Zone (green):** The No-Storage Zone reflects a range of basin inflow between 5,000 cfs and a higher threshold that varies by season:

  - During the spawning season (March–May), the No-Storage Zone is between 5,000 and 16,000 cfs.

  - During the non-spawning season (June–November), the No-Storage Zone is between 5,000 and 10,000 cfs.

  When basin inflow is in the Non-Storage Zone, the RIOP calls for the USACE to release the equivalent of basin inflow at Woodruff Dam so long as the reservoir system is not in drought operations and all the reservoirs have fully recovered from drought operations (i.e., system composite storage has returned to Zone 1). Only if such conditions are satisfied would Florida receive any incremental increase in the amount of basin inflow above 5,000 cfs when basin inflow is in the No-Storage Zone. However, as explained below, the total amount of time during a drier or drought year during which basin inflow is in this zone and the reservoirs are not in drought operations is not predictable, and can be infrequent.

- **Half-Storage Zone (purple):** The Half-Storage Zone reflects a range of basin inflow (>10,000 or 16,000 cfs and <22,000 or 34,000 cfs depending on the

[5] Florida has likewise acknowledged that additional basin inflow over 5,000 cfs does not automatically materialize as additional state-line flow, and instead would often be stored in the USACE reservoirs under the USACE's operational rules. FL-ACF-01457637 ¶ 131 (Florida's 2d Amended & Supplemented Compl. for Declaratory & Injunctive Relief, *In re Tri-State Water Rights Litig.*, M.D. Fla., 3:07-cv-00250-PAM-JRK (filed Jan. 10, 2008) ("FL 2d Am. *Tri-State* Compl.") (noting that "[USACE's drought operations] allow[] the Corps to store 100% of the water that would otherwise flow to the Apalachicola from the Chattahoochee River") (emphasis added); Barr Dep. Ex. 3 at FL-ACF-02290908 (July 20, 2012 Letter from Douglas Barr, Executive Director NWFWMD, to Dr. Donald Imm, USFWS (produced at FL-ACF-02290903) ("[T]here is no requirement to share the added storage with Florida to provide increased flow during the spring spawning period or for low flow augmentation in the summer and early fall.").

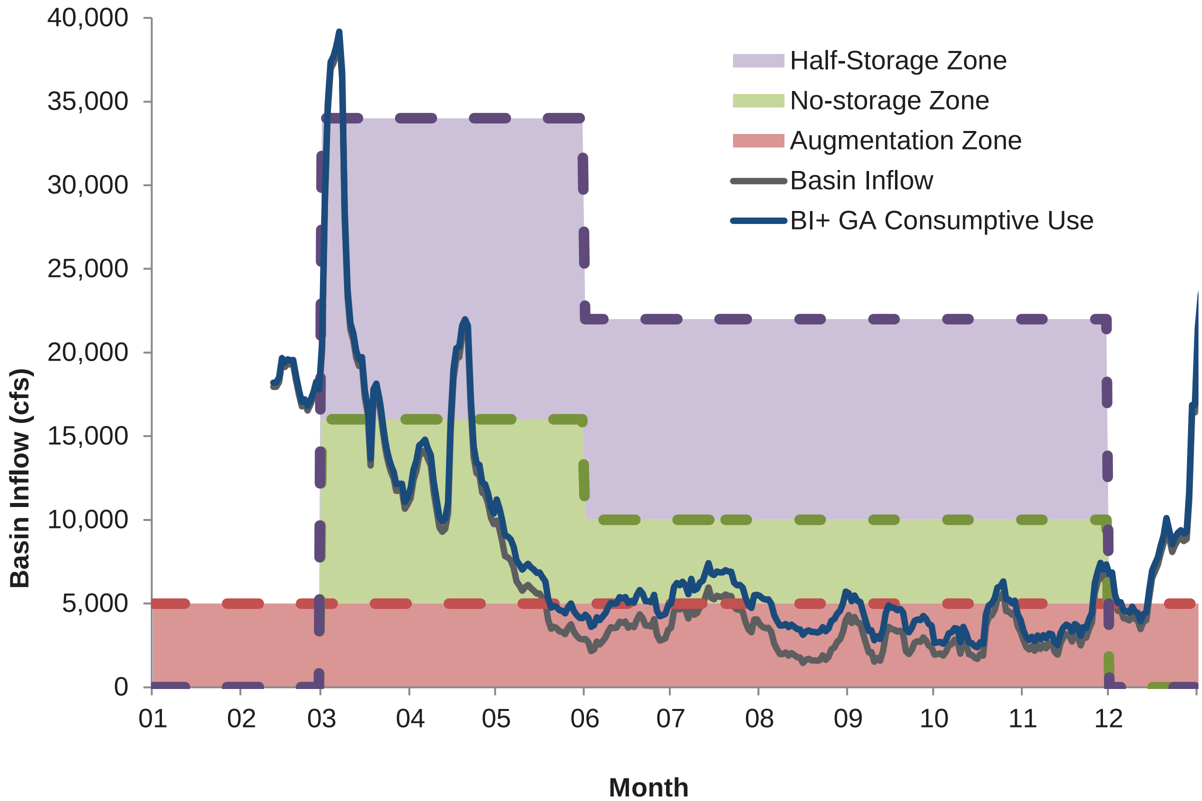


Figure 7. RIOP's Seasonal Reservoir Operational Thresholds & Basin Inflow (BI) for 2007 (Drought Year)

As Figure 7 shows, in 2007 basin inflow starts at about 18,000 cfs in mid-February and peaks in early March at almost 40,000 cfs, followed by a general decline into the summer and fall months before again increasing in December. 2007 basin inflow passes through all four zones. Starting in May and continuing through November, basin inflow was generally below 5,000 cfs (i.e. in the Augmentation Zone). If 2007's basin inflow were repeated today,[6] and assuming the system would not be in drought operations at any time, a simple calculation shows that there would be approximately:

- **273 total days** when Florida would receive <u>no</u> additional state-line flow that would result from any reductions of Georgia's water use. This reflects the total number of days when basin inflow is within the Augmentation Zone (in both the non-spawning and spawning seasons), the total number of days when basin inflow would be in the All-Storage Zone in the spawning season, and the total number of days of the refilling season.

[6] The RIOP did not exist until April 2008, and thus did not govern USACE reservoir operations in 2007.

- **21 total days** when Florida would receive only 50% of any additional state-line flow that would result from any reductions of Georgia's water use (because basin inflow would be in the Half-Storage Zone); and

- **71 total days** when Florida would receive the full benefit of any additional state-line flow that would result from reductions of Georgia's water use (because basin inflow would be in the No-Storage Zone). In other words, any additional basin inflow produced by a reduction in Georgia's consumptive use would materialize as additional state-line flow for a total of 71 days—or approximately 19% of the year. **Only 19 of these 71 days would occur during the summer and fall months, when streamflows were at their lowest.** The majority of days during this 71-day period would occur when water in the ACF Basin is relatively plentiful.

Again, the above analysis assumes the reservoirs do not enter drought operations at any time. If drought operations do occur, which is often the case when basin inflow falls below the 5,000 cfs threshold, this would further limit the number of days where Florida would not receive the benefit of any reduction in Georgia's consumptive use.

The number of days during which the system might be in drought operations can be estimated using reservoir simulation modeling, which provides additional support for the above analysis.[7] Reservoir simulation modeling performed by the USACE as part of its 2015 Water Control Manual ("WCM") revision process shows that the ACF system would indeed fall into a drought operation by November 2007 (Source: 2015 USACE DEIS). This means the 5 days at the end of November 2007 with basin inflow above 5,000 cfs might no longer be considered as days when excess basin inflow is passed downstream. This consideration would change the three numbers above to 278 days when Florida would not receive additional flow, 21 days when Florida would receive only half of additional flow, and 66 days when Florida would receive the full benefit of additional flow from any reductions in Georgia's consumptive water use.

Figure 8 below shows recorded basin inflow (solid gray line) for 2009, a normal year of basin inflow. The 2008 RIOP governed USACE reservoir operations in 2009. Figure 8 provides an example of the relationship between recorded basin inflow and USACE reservoir operations during a higher precipitation year. As shown, basin inflow began around 20,000 cfs, peaked near 120,000 cfs in April, dropped down to between 5,000 and 20,000 cfs for most of the summer and fall, and eventually increased to around 110,000 cfs by year's end. In 2009, the basin inflow never dropped below the minimum threshold of 5,000 cfs to enter into the Augmentation Zone; thus, the USACE reservoirs presumably would have not released any water during this normal year of inflows to maintain the flow requirement at the state line of 5,000 cfs. This is because

[7] Reservoir simulation modeling can also provide further information on the potential system response under the USACE reservoir operating plan by depicting the extent to which reductions in consumptive use influence basin inflow levels, and thereby influence the number of days where the Apalachicola River would benefit from increased flows. My analysis using the USACE's reservoir simulation model is presented in Section VI, below.

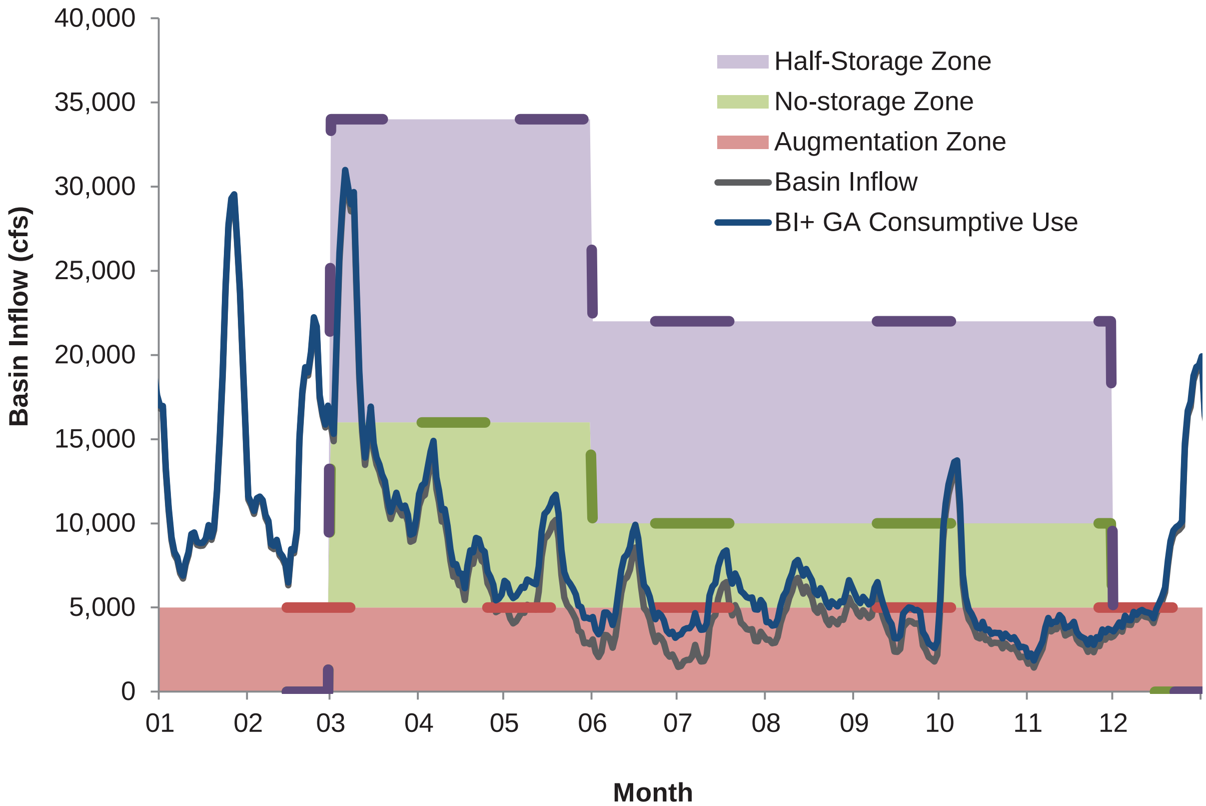


Figure 9. RIOP's Seasonal Reservoir Operational Thresholds & Basin Inflow (BI) for 2012 (Drought Year)

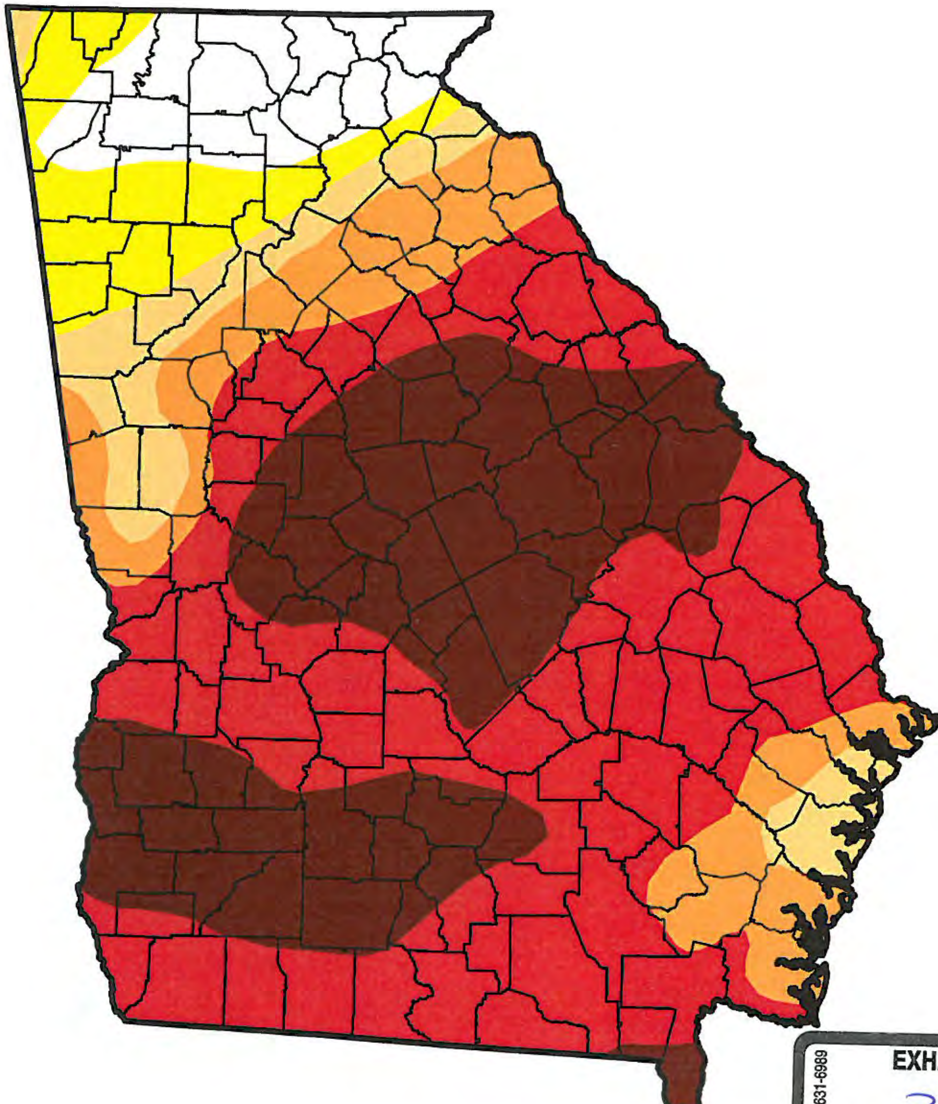
As Figure 9 shows, basin inflow was above 5,000 cfs during January and February, and entered March at about 15,000 cfs, rose to 30,000 cfs before declining into the summer and fall months to a flow of generally less than about 10,000 cfs, with flows again increasing starting in December. Therefore, 2012 resulted in:

- **307 total days** when Florida would receive no additional state-line flow that would result from any reductions of Georgia's water use. This covers the period of time from May 1, 2012, through the end of the year, during which the USACE was actually in drought operations. This also covers the 60 days during the 2012 portion of the 2011–2012 refilling season (January and February 2012), and in late April when basin inflow was in the Augmentation Zone. During this entire period, the USACE was only required by the RIOP to release 5,000 cfs from Woodruff Dam.

- **10 total days** when Florida would receive 50% of any additional state-line flow that would result from any reductions of Georgia's water use (because basin inflow would be in the Half-Storage Zone); and

Exhibit 40

U.S. Drought Monitor
Georgia



May 22, 2012
(Released Thursday, May. 24, 2012)
Valid 7 a.m. EST

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	7.54	92.46	86.05	79.30	67.95	28.31
Last Week *5/15/2012*	7.54	92.46	86.05	80.85	69.35	28.44
3 Months Ago *2/21/2012*	12.83	87.17	83.12	77.55	69.01	30.35
Start of Calendar Year *1/3/2012*	12.07	87.93	85.36	81.00	63.92	0.00
Start of Water Year *9/27/2011*	5.62	94.38	90.72	85.56	78.76	0.00
One Year Ago *5/24/2011*	8.95	91.05	76.99	65.86	13.28	0.00

Intensity:

- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

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USDA National Drought Mitigation Center

http://droughtmonitor.unl.edu/

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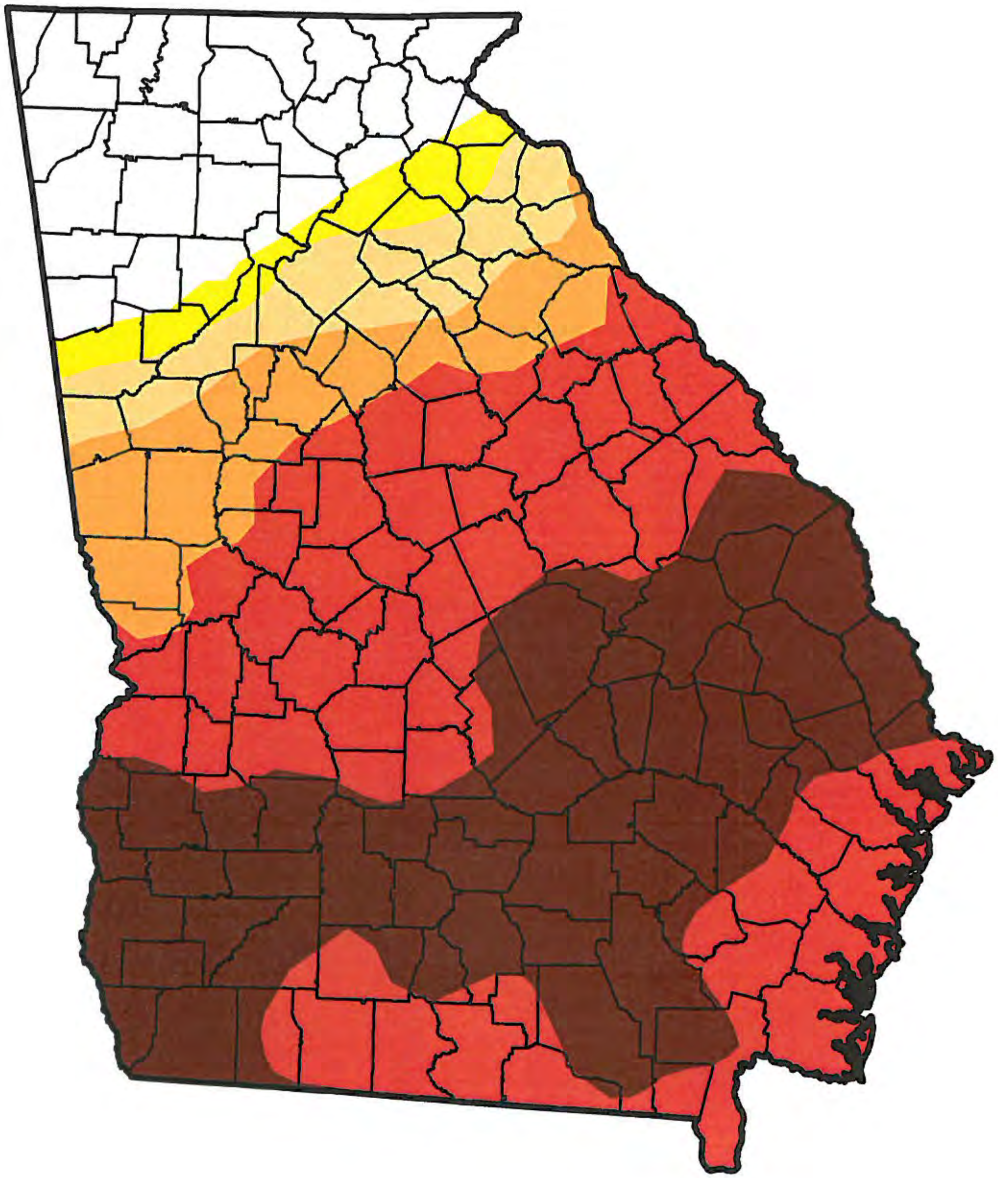
Georgia



February 14, 2012
(Released Thursday, Feb. 16, 2012)
Valid 7 a.m. EST

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	13.88	86.12	83.12	77.55	69.01	34.06
Last Week *2/7/2012*	14.41	85.59	83.07	77.55	68.97	29.54
3 Months Ago *11/15/2011*	4.77	95.23	91.50	85.16	64.61	0.00
Start of Calendar Year *1/3/2012*	12.07	87.93	85.36	81.00	63.92	0.00
Start of Water Year *9/27/2011*	5.62	94.38	90.72	85.56	78.76	0.00
One Year Ago *2/15/2011*	0.00	100.00	76.22	21.87	6.18	0.00

Intensity:

- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

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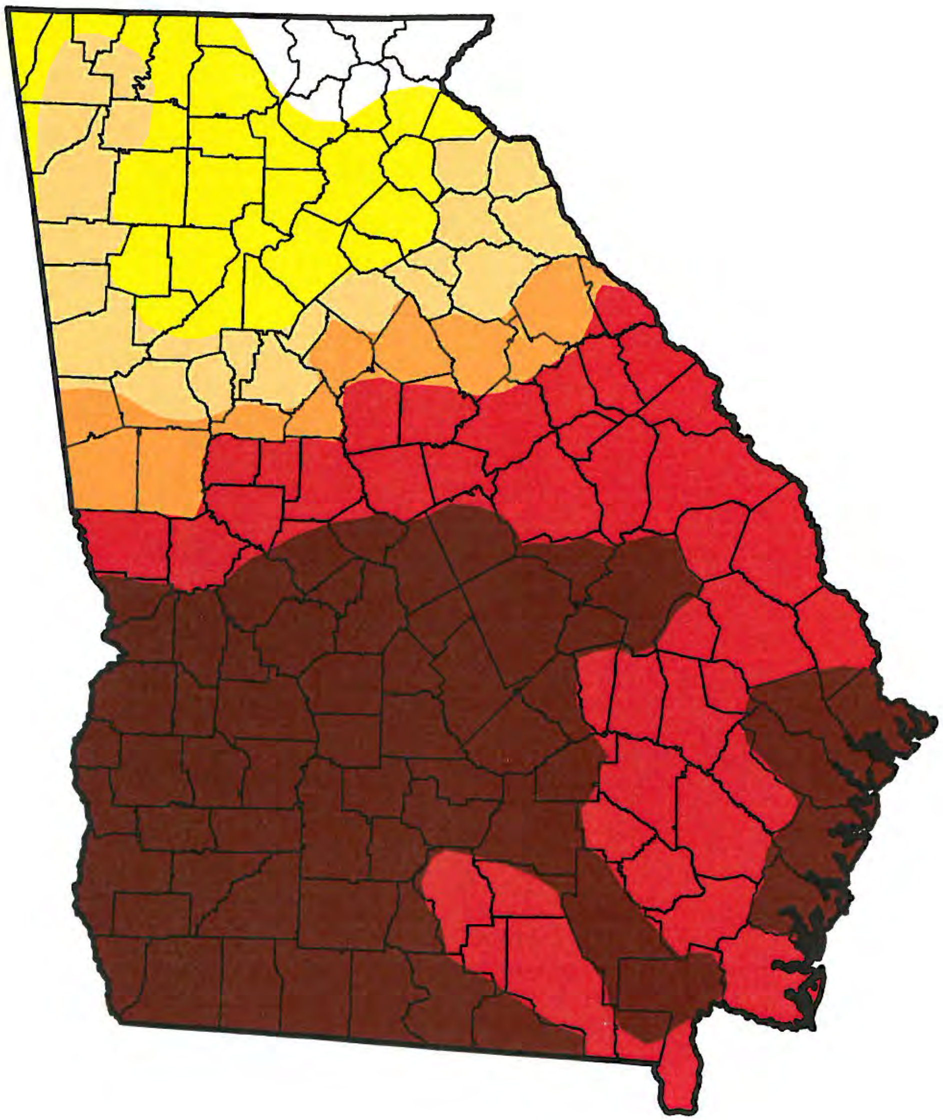
U.S. Drought Monitor
Georgia



July 5, 2011

(Released Thursday, Jul. 7, 2011)

Valid 7 a.m. EST

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	2.58	97.42	85.51	74.91	68.91	40.45
Last Week *6/28/2011*	2.58	97.42	85.51	74.91	68.91	41.18
3 Months Ago *4/5/2011*	23.01	76.99	72.91	18.75	6.94	0.00
Start of Calendar Year *1/4/2011*	2.40	97.60	85.33	40.34	6.49	0.00
Start of Water Year *9/28/2010*	4.80	95.20	39.24	5.11	0.00	0.00
One Year Ago *7/6/2010*	97.31	2.69	0.00	0.00	0.00	0.00

Intensity:

- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

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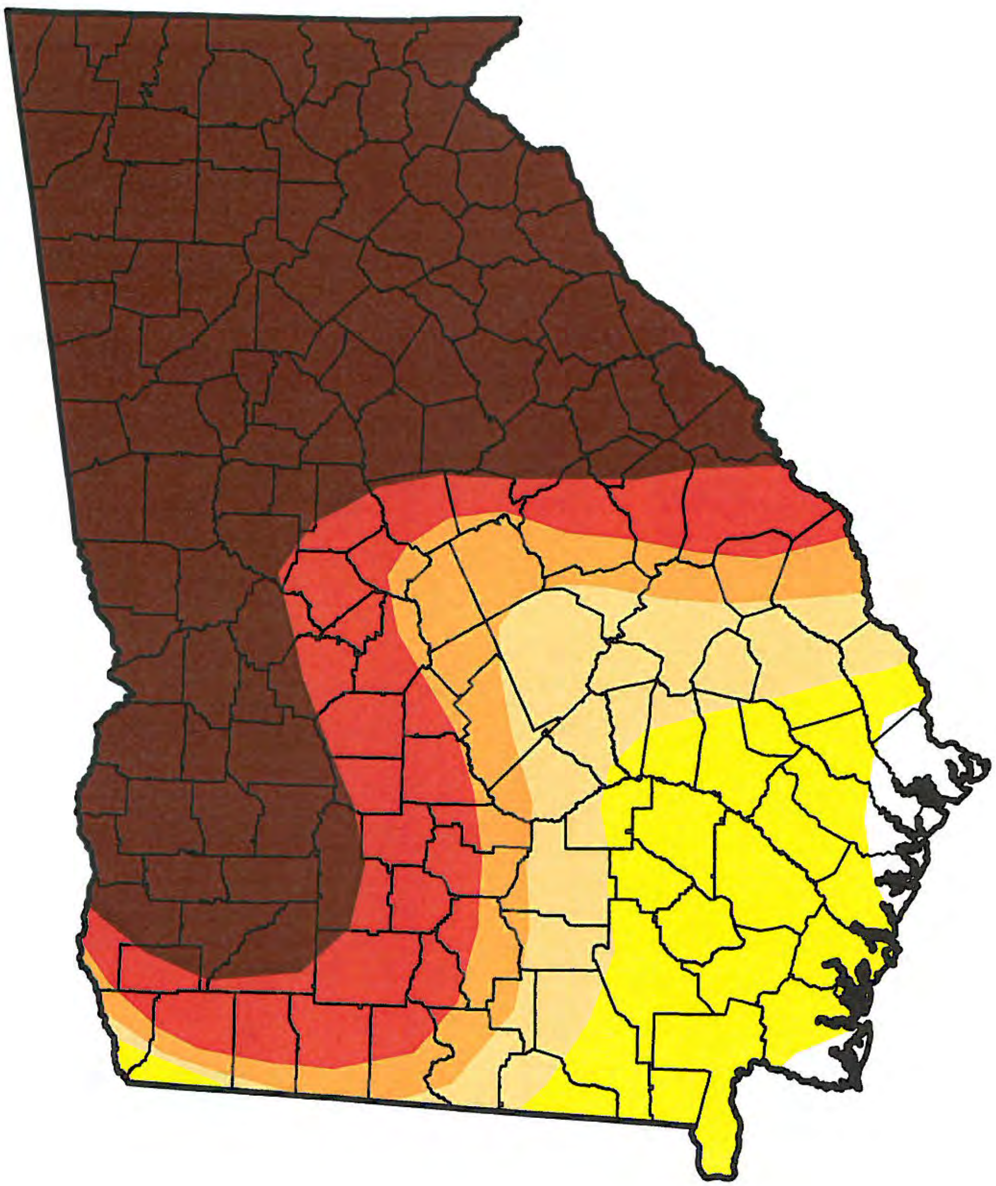
U.S. Drought Monitor
Georgia



December 25, 2007
(Released Thursday, Dec. 27, 2007)
Valid 7 a.m. EST

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	2.01	97.99	83.36	73.08	64.36	49.86
Last Week *12/18/2007*	0.39	99.61	87.94	74.34	64.39	49.86
3 Months Ago *9/25/2007*	24.19	75.81	64.21	52.59	39.36	27.00
Start of Calendar Year *1/2/2007*	12.16	87.84	3.66	0.10	0.00	0.00
Start of Water Year *9/25/2007*	24.19	75.81	64.21	52.59	39.36	27.00
One Year Ago *12/26/2006*	12.16	87.84	7.66	0.08	0.00	0.00

Intensity:

- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

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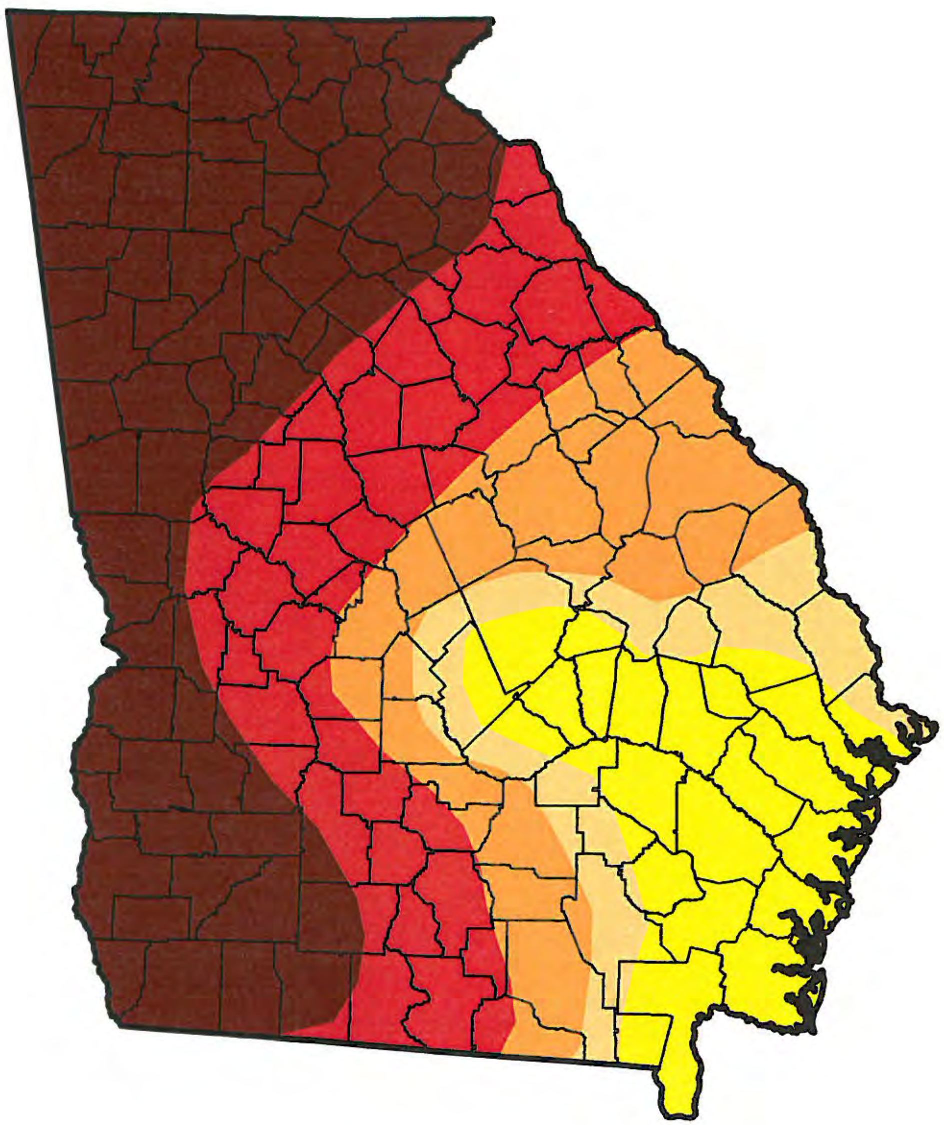
U.S. Drought Monitor
Georgia



August 21, 2007
(Released Thursday, Aug. 23, 2007)
Valid 7 a.m. EST

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	0.00	100.00	84.34	76.38	60.93	39.11
Last Week *8/14/2007*	0.00	100.00	85.68	67.76	52.27	26.87
3 Months Ago *5/22/2007*	0.00	100.00	100.00	93.20	42.77	0.00
Start of Calendar Year *1/2/2007*	12.16	87.84	3.66	0.10	0.00	0.00
Start of Water Year *9/26/2006*	0.05	99.95	46.73	0.00	0.00	0.00
One Year Ago *8/22/2006*	0.24	99.76	93.02	45.11	0.00	0.00

Intensity:

- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

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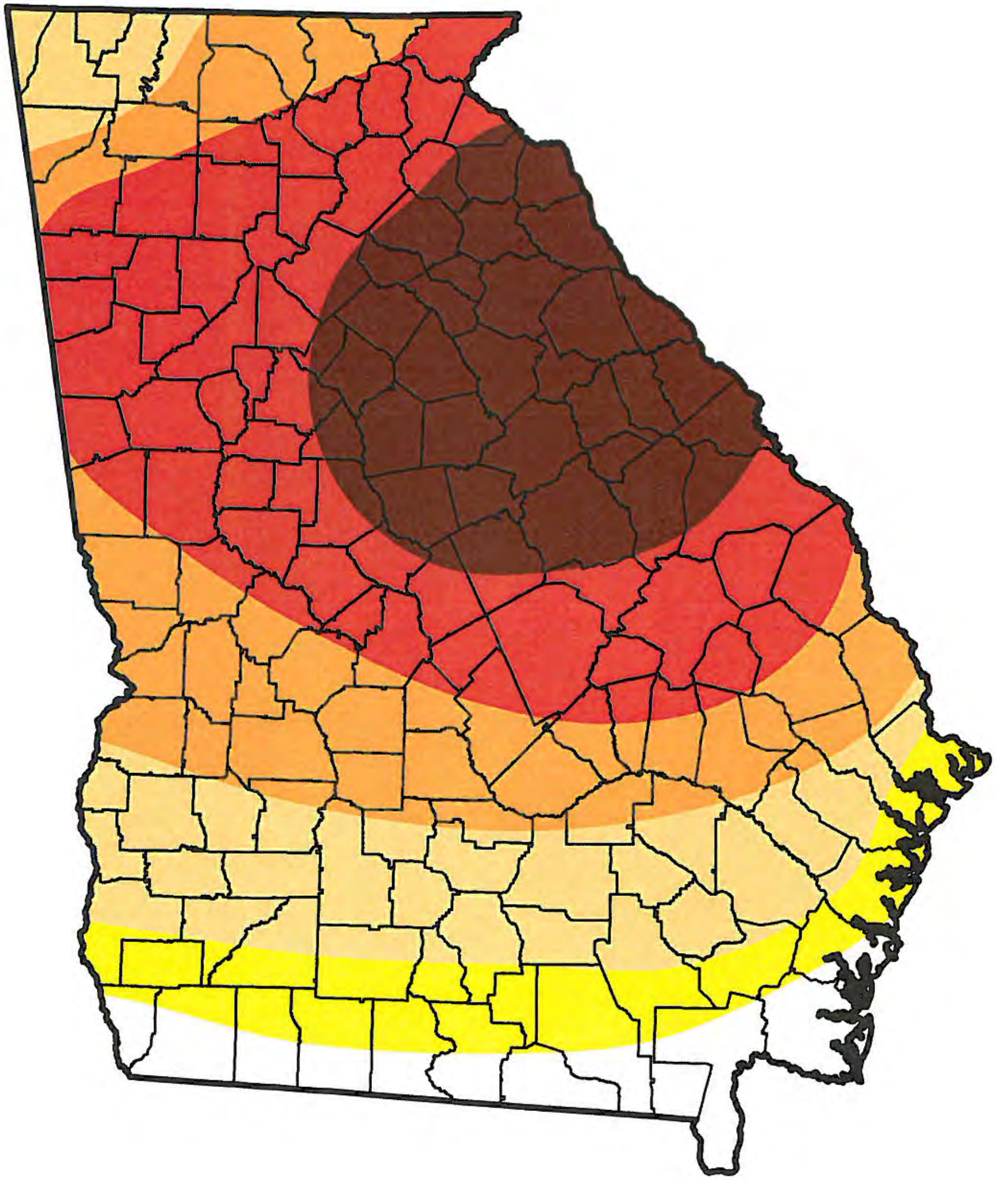
U.S. Drought Monitor

Georgia



September 3, 2002

(Released Thursday, Sep. 5, 2002)

Valid 7 a.m. EST

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	6.76	93.24	84.08	65.70	46.35	17.91
Last Week *8/27/2002*	3.58	96.42	84.85	67.26	34.55	14.09
3 Months Ago *6/4/2002*	0.10	99.90	94.03	82.87	39.14	0.00
Start of Calendar Year *1/1/2002*	2.56	97.44	93.61	67.09	23.65	0.00
Start of Water Year *9/25/2001*	61.50	38.50	0.00	0.00	0.00	0.00
One Year Ago *9/4/2001*	92.92	7.08	0.00	0.00	0.00	0.00

Intensity:

- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

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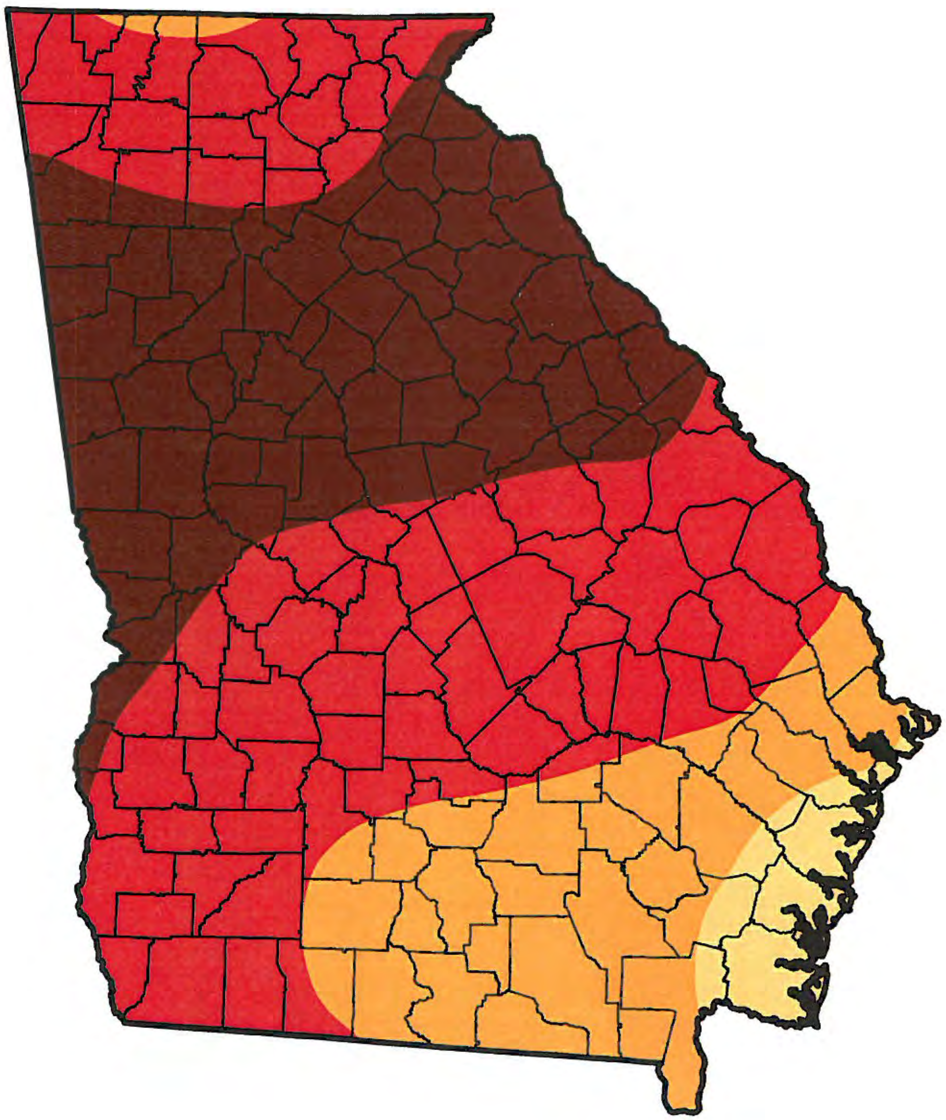
U.S. Drought Monitor
Georgia



July 25, 2000
(Released Thursday, Jul. 27, 2000)
Valid 7 a.m. EST

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	0.00	100.00	100.00	95.86	76.24	32.02
Last Week *7/18/2000*	0.00	100.00	100.00	99.27	86.02	35.28
3 Months Ago *4/25/2000*	0.17	99.83	95.10	54.10	0.00	0.00
Start of Calendar Year *1/4/2000*	100.00	100.00	100.00	68.52	0.00	0.00
Start of Water Year	-	-	-	-	-	-
One Year Ago	-	-	-	-	-	-

Intensity:

- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

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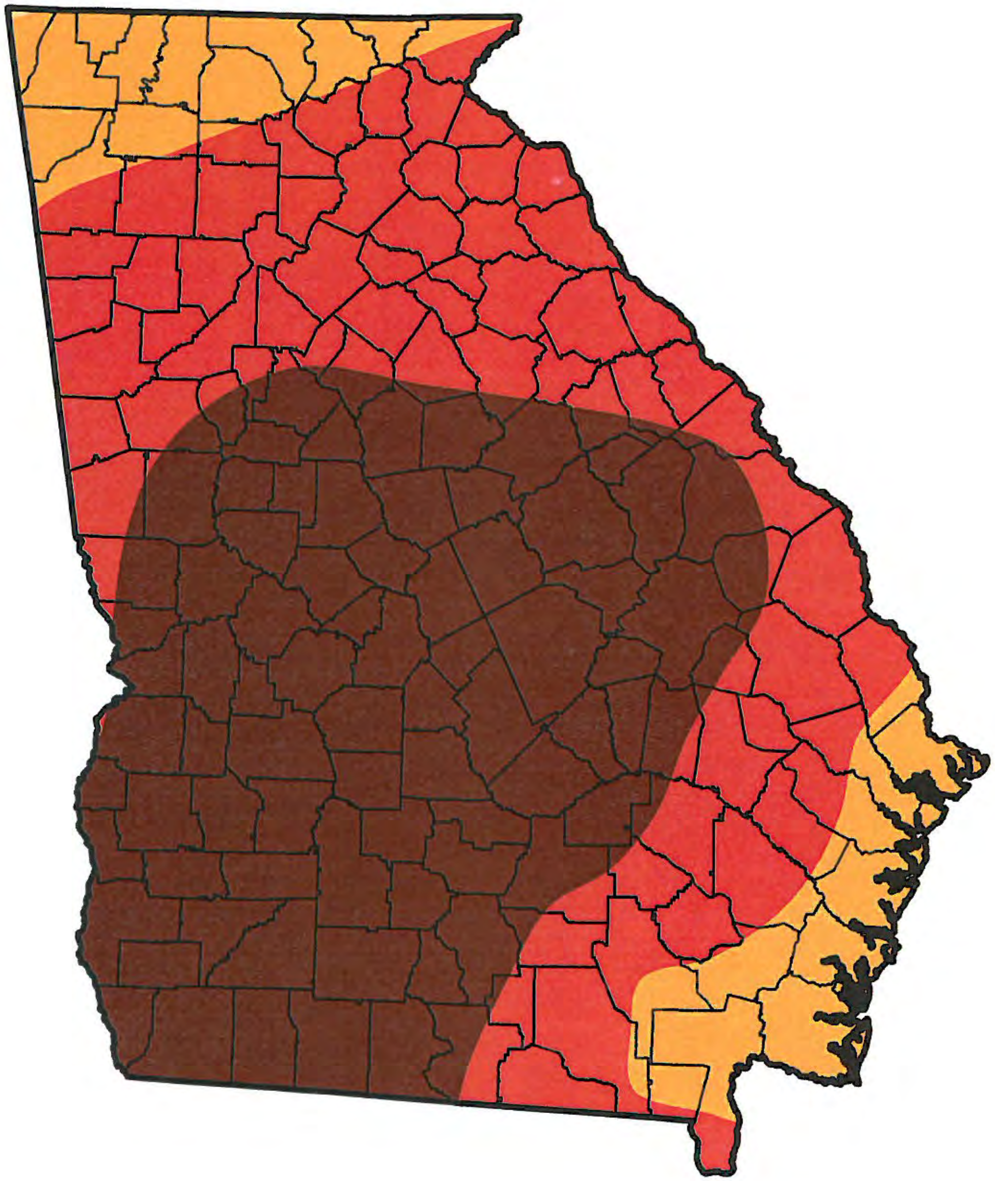
U.S. Drought Monitor
Georgia



June 27, 2000
(Released Thursday, Jun. 29, 2000)
Valid 7 a.m. EST

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	0.00	100.00	100.00	99.97	86.01	48.85
Last Week *6/20/2000*	0.00	100.00	100.00	99.87	88.92	47.88
3 Months Ago *3/28/2000*	0.00	100.00	100.00	57.53	0.00	0.00
Start of Calendar Year *1/4/2000*	100.00	100.00	100.00	68.52	0.00	0.00
Start of Water Year	-	-	-	-	-	-
One Year Ago	-	-	-	-	-	-

Intensity:

- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

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Exhibit 41

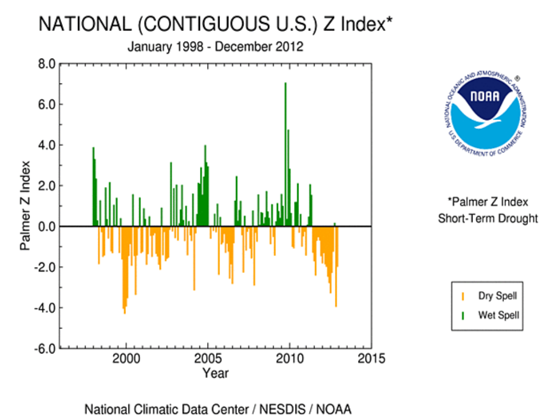
Drought - Annual 2012

NCEI added Alaska climate divisions to its nClimDiv dataset on Friday, March 6, 2015, coincident with the release of the February 2015 monthly monitoring report. For more information on this data, please visit the Alaska Climate Divisions FAQ.

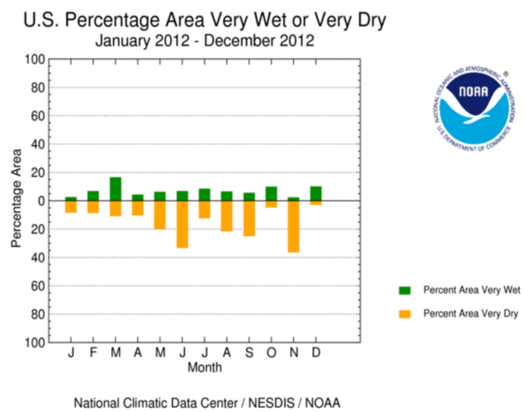
Issued 8 January 2013

The data presented in this drought report are preliminary. Ranks, anomalies, and percent areas may change as more complete data are received and processed.

Contents Of This Report:



National Drought Overview



On a month-by-month basis, 2012 was characterized by large areas of dry and, earlier in the year, large areas of wet weather. Eight months (all except January, February, October, and December) had ten percent or more of the country experiencing very dry (at the tenth percentile of the historical record or drier) precipitation anomalies, with five months (May, June, August, September, and November) having more than a fifth (20 percent) of the country very dry. June and November had a third of the country very dry. The percent area very wet (monthly precipitation totals at the 90th percentile of the historical record or wetter) stayed under ten percent for all but one of the months in the year, with March having the largest percent area very wet (16%). When averaged together, the wet and dry anomalies resulted in the 20th driest February, 23rd driest May, 10th driest June, 22nd driest July, and 8th driest November, nationally, in the 1895-2012 record. Large areas of the country also experienced unusually warm conditions. Ten percent or more of the contiguous U.S. was very warm (monthly temperatures at the 90th percentile of the historical record or warmer) during every month except October. More than a fourth (25%) was very warm during eight months, with July (60%) and March (75%) having more than half of the country very warm. This persistent and anomalous heat resulted in the warmest month ever (July 2012), ranked 2012 as the warmest year on record, and (especially during the growing season) increased evaporation and intensified local drought conditions.

An important feature of the weather conditions in 2012 was the persistence of the areas of dryness and warm temperatures, the magnitude of the extremes, and the large area they encompassed. Dry weather affected parts of the West almost every month, especially the Intermountain Basin during April-July, the Southwest during April-June and October-November, and the Rockies during March-November. The Central Great Plains were plagued by dryness much of the year (especially March-

November), with dryness especially acute during the summer across the Plains (June-August). Dry weather dominated across the Central Plains to Midwest agricultural areas during the critical May-July growing season, but the dryness lasted longer in parts of this region (for example, the Midwest during February-July). August-September saw very dry weather from the Pacific Northwest, across the Northern Rockies and Central to Northern Plains, and into the western Great Lakes. Dry weather afflicted the eastern U.S. early in the year, with the Southeast dry during January-April and the Northeast during February-April. Large areas of the country were very dry during May-June (from the West Coast to the Ohio and Tennessee valleys), August-September (from the Pacific Northwest to the western Great Lakes), and November (from the Southwest and Southern Plains to the Northeast and Southeast).

The hot temperatures exacerbated the impact of the dry weather. When maps of the dryness (Standardized Precipitation Index [SPI]) are compared to maps of the Palmer Z Index (which incorporates the effects of both dryness and heat), larger areas of monthly drought are evident on the Z Index maps for March (SPI, Z Index), April (SPI, Z Index), May (SPI, Z Index), July (SPI, Z Index), and November (SPI, Z Index).

2012 Standardized Precipitation Index maps:	2012 Standardized Temperature Index maps:	2012 Palmer Z Index maps:
January,	January,	January,
February,	February,	February,
March,	March,	March,
April,	April,	April,
May,	May,	May,
June,	June,	June,
July,	July,	July,
August,	August,	August,
September,	September,	September,
October,	October,	October,
November,	November,	November,
December.	December.	December.

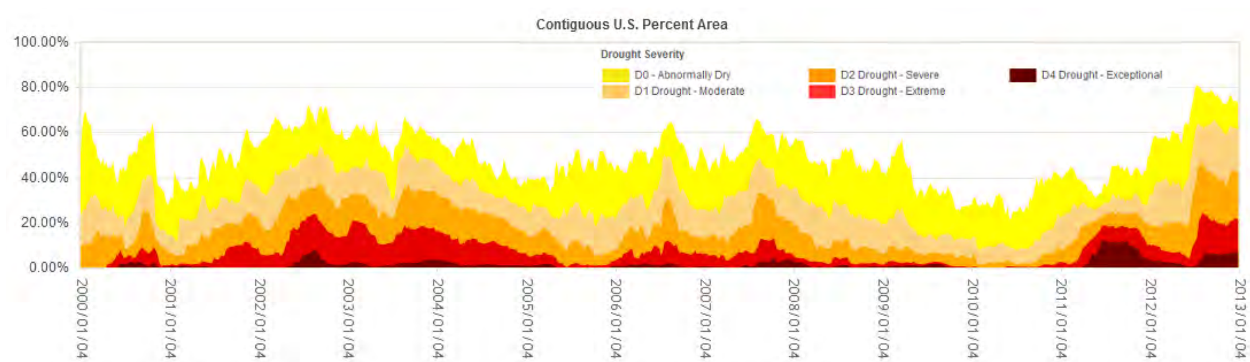
2012 U.S. Drought Monitor maps:	2012 Palmer Drought Severity Index maps:
January,	January,
February,	February,
March,	March,
April,	April,
May,	

The year started out with 31.9 percent of the contiguous U.S. in moderate to exceptional drought (based on the U.S. Drought Monitor [USDM]) manifested in two drought

- June,
- July,
- August,
- September,
- October,
- November,
- December.

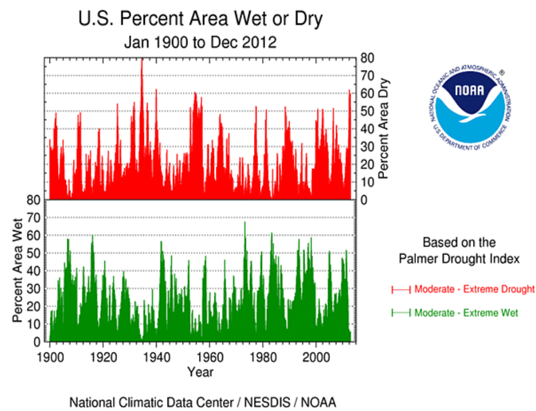
- May,
- June,
- July,
- August,
- September,
- October,
- November,
- December.

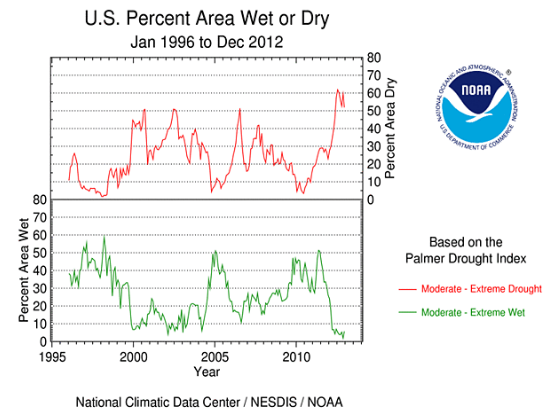
epicenters — areas of moderate to exceptional drought in the Southern Plains and moderate to extreme drought in the Southeast — with areas of moderate to severe drought in the Upper Mississippi Valley and moderate drought in the Far West. As the year progressed, the western drought expanded to link with the Southern Plains drought area and new drought areas developed along the East Coast, pushing the national drought area to 38.2 percent by May 1. Dryness during the late spring began to take its toll in the agricultural heartland by summer as drought intensified and expanded to cover much of the country from the Central Rockies to the Ohio Valley, and the Mexican border to the Canadian border, by the end of August. This solid mass of drought, which stretched from border to border and (by now) West Coast to Mississippi River, persisted through the fall. The percentage area in drought peaked at about 65.5 percent on September 25 (a new high in the 1999-2012 USDM record) and ended the year at 61.1 percent. The percent area of the contiguous U.S. in the worst drought categories (D3-D4, extreme to exceptional drought) peaked at 24.1 percent on August 7, which is also a record.



The percent area* of the contiguous U.S. experiencing moderate to extreme drought (based on the Palmer Drought Index) started the year at about 22.9 percent, grew steadily to a peak of about 61.8 percent during the summer, then contracted slightly during the fall, ending the year at about 51.8 percent. The

Palmer Drought Index data go back 113 years.

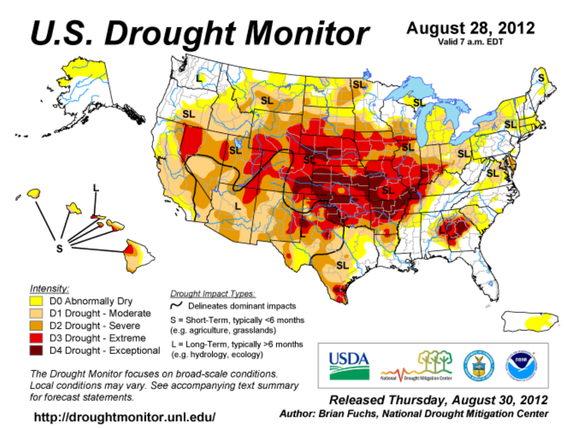




*This drought statistic is based on the Palmer Drought Index, a widely used measure of drought. The Palmer Drought Index uses numerical values derived from weather and climate data to classify moisture conditions throughout the contiguous United States and includes drought categories on a scale from mild to moderate, severe and extreme.

[top]

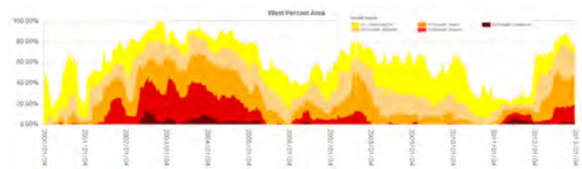
Regional Drought Overview



The year began with drought epicenters in the Southern Plains, Southeast, Upper Midwest, Far West, and Hawaii. As winter ended and spring began, dryness in the West spread to join the Plains and West drought areas while the Southeast drought crept up the East Coast. The spring months were quite dry with drought spreading or pockets of drought developing in several regions. The summer months were extremely dry across a large part of the central U.S., with the result being a merging of the drought epicenters in the West, Plains, and Midwest into one large drought area stretching from the West Coast to the Great Lakes. Beneficial autumn rains helped portions of the Midwest recover from drought, but dryness continued in the Plains where drought intensified. By the end of 2012, three drought epicenters remained — Hawaii, the Southeast, and one large area of drought stretching from the southern California coast across the West and Great Plains to the Midwest, with the worst drought conditions focused on the Plains states.

The dry weather (which lowered moisture supplies), coupled with intense spring and summer heat (which increased evapotranspiration and, thus, moisture demand), depleted soil moisture, lowered streamflow (May, June, July, August), reservoir and stock pond levels, and ravaged crops and livestock. By year's end, low river levels threatened commerce on the vital Mississippi River shipping lanes.

West:

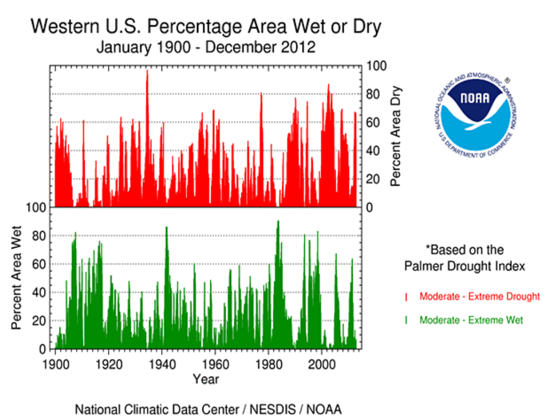


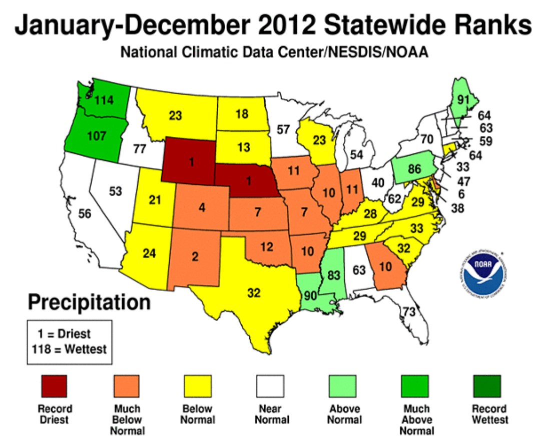
The percent area of the West in moderate to exceptional drought steadily grew during 2012, peaking at 77% in October.

The West began the hydrologic year (water year, October-September) on a dry note, with below-normal precipitation and snowpack water content. As the wet season (October-April) ended, the southern portions of the West had significant precipitation and snow water content deficits, while the northern areas were not as bad off. Continued dryness and intense heat during the spring and summer caused numerous wildfires to break out, with Colorado especially hard hit. Record heat and near-record dryness occurred in the state, with April-June 2012 ranking as the hottest and third driest April-June on record. Wyoming was record dry for several time scales, including June-August, April-August, March-August, June-September, May-September, April-September, and several others. Utah was record dry in June and April-June. A total of four states (Colorado, Nevada, Utah, Wyoming) ranked in the top ten driest category for April-June, six states were in the top ten driest for January-June, and three for January-November, including Colorado and Wyoming (which were record dry) and New Mexico (second driest). The weather pattern shifted during summer and early autumn, bringing much-needed precipitation to the southern areas but drying out the northern states. Five western states (Idaho, Montana, Oregon, Washington, Wyoming) ranked in the top ten driest category for July-September, with Montana having the driest August-September and July-September on record. When last year's dryness is combined with this year's dryness, the last two years (December 2010-November 2012) in New Mexico ranked as the driest such 24-month period on record. For January-December 2012, three states (Wyoming [driest], New Mexico [second driest], Colorado [fourth driest]) ranked in the top ten driest category and three other states (Arizona, Montana, Utah) ranked in the driest third of the historical record.

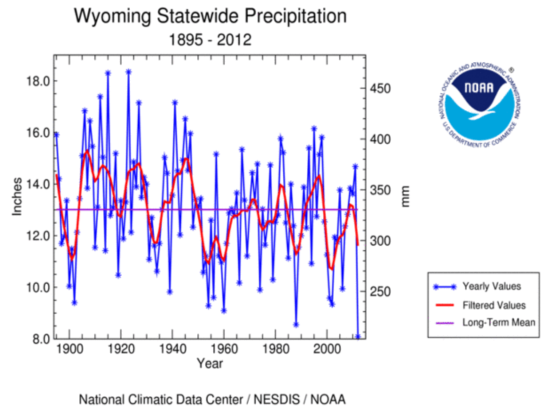
The percent area of the West in moderate to exceptional drought, as measured by the USDM, steadily grew during 2012, peaking at about 77.2 percent in October. Based on the Palmer Drought Index, which goes back to the beginning of the 20th century, moderate to extreme drought peaked at about 67.2 percent of the West during June. Both of these numbers were surpassed by the 2002-2003 drought and (for the Palmer index) earlier droughts.

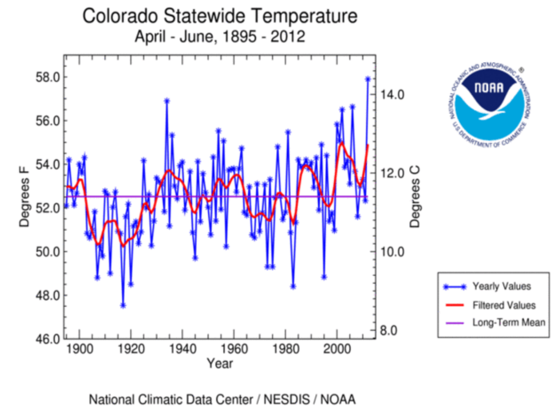
Great Plains and Midwest:

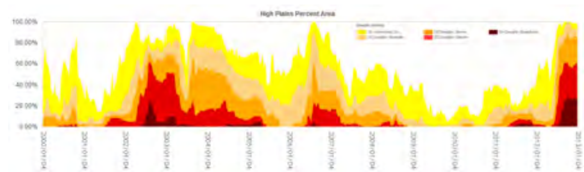




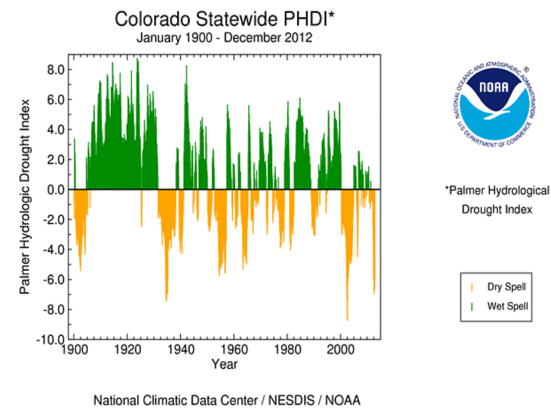
Last year, drought was centered in the







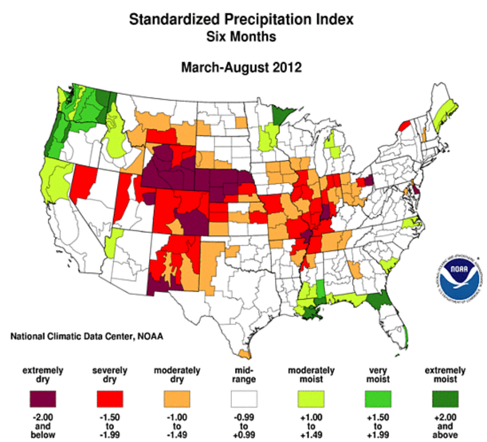
The percent area of the High Plains (Kansas to North Dakota) in moderate to exceptional drought skyrocketed during summer 2012, covering nearly the entire High Plains region by October.

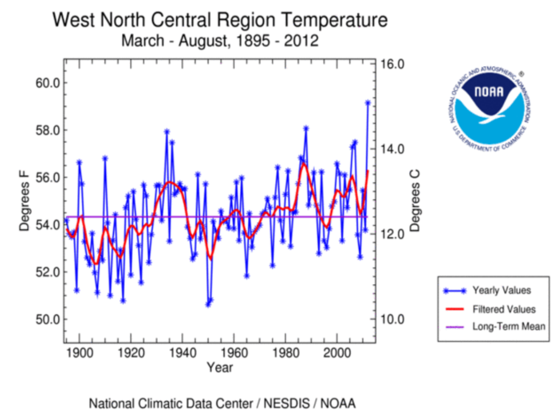


Southern Plains. This year, the entire Plains region was afflicted by drought with a significant part of the Midwest sharing the misery. Dryness affected the Northern Plains during March, the Southern Plains during April, and the Southern to Central Plains during May, with different portions of the Midwest affected during each of those months. But that was just a prelude to even worse conditions. The entire Plains and Midwest were baked and moisture-starved during June and July. Beneficial rains came to parts of the Midwest and Southern Plains during August and September, and to the Northern Plains and Midwest in October, but widespread dry conditions returned in November.

Record dryness occurred for several states in August and September. The persistence of drought gave several states record dry seasons, including Arkansas (April-June and other seasons), Kansas (May-July), Nebraska (June-August and other seasons), and South Dakota (July-September). Six states in the Plains and Midwest (Arkansas, Indiana, Iowa, Kansas, Missouri, Nebraska) ranked in the top ten driest category for January-November, with Nebraska having the driest January-November on record. For January-December 2012, five Great Plains and Midwest states ranked in the top ten driest category, including Nebraska which had the driest year on record.

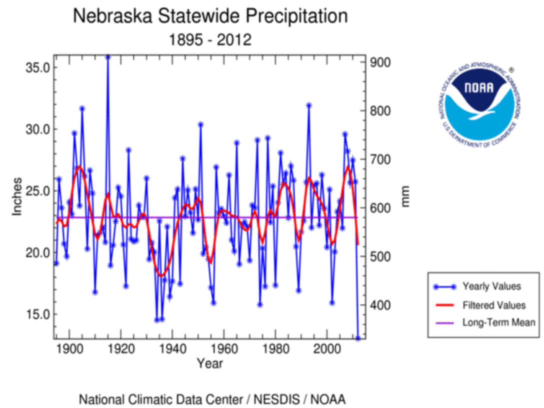
The percent area of the Great Plains and Midwest in moderate to exceptional drought, as measured and defined by the USDM regions, rapidly increased during 2012. Nearly all of the Northern Plains was enveloped in drought by October, which is a record in the 13-year USDM history. Drought coverage also rapidly increased in the Midwest, peaking at about 73.7 percent in July, which is also a USDM record. In early 2012, the Southern Plains was recovering from the 2011 drought. The percent area in moderate to exceptional drought decreased to a low of about 32.3 percent in May 2012 before expanding again to peak at about 73.7 percent in July.

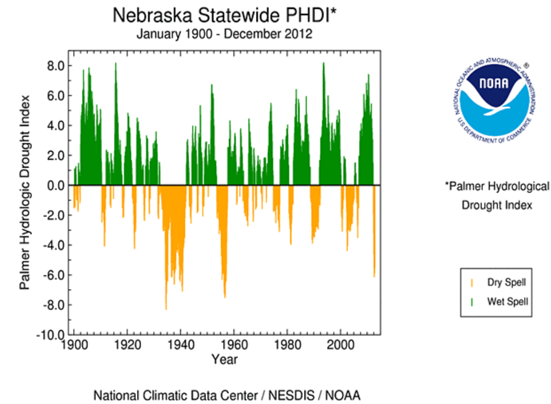




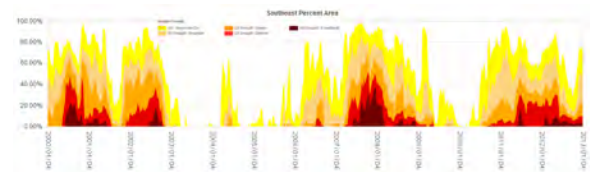
Southeast to Northeast:

The precipitation pattern for the eastern U.S. fluctuated between wet and dry during 2012. The Southeast started the year on the dry side, with January-February ranking in the driest third of the historical record for several states. February-April was dry for the Northeast, with Connecticut having the driest February-April on record and most other states ranking in the top ten driest category. Three



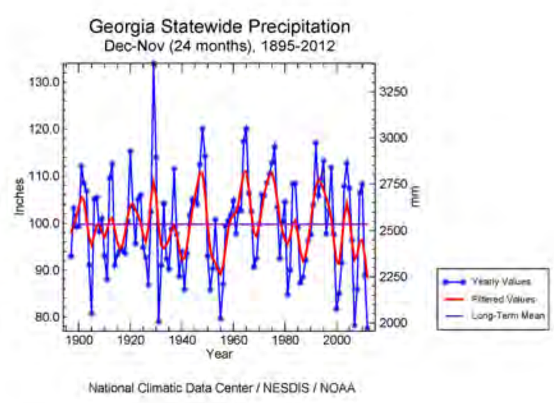


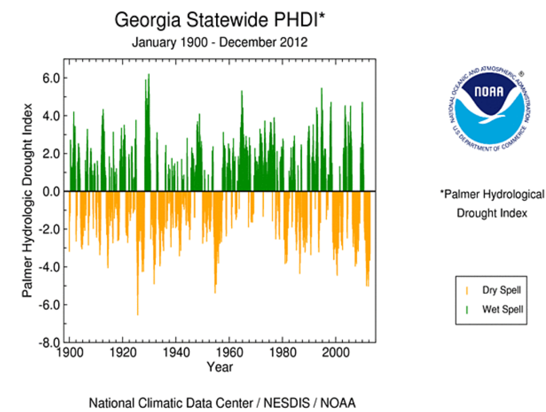
southeastern states (Alabama, Georgia, and Tennessee) ranked in the top ten driest category for April. The weather patterns, which brought drought to the Great Plains and Midwest during the late spring and summer, doused many of the eastern states with beneficial rainfall during this time. Although helpful, the rains were not enough to erase several years' of deficits in the Southeast. November was dry for all eastern states, with most ranking in the top ten driest category. The cumulative impact of the 2012 precipitation deficits gave Delaware the fourth driest January-November and Georgia, the epicenter of the Southeast drought, the eighth driest January-November. For the year (January-December), several states along the eastern seaboard were drier than normal, with Georgia ranking tenth driest and Delaware having the sixth driest year on record. The prolonged dryness in parts of the Southeast gave Georgia the driest December-November 24-month period (December 2010-November 2012) on record.



The percent area of the Southeast in moderate to exceptional drought oscillated up and down during 2012.

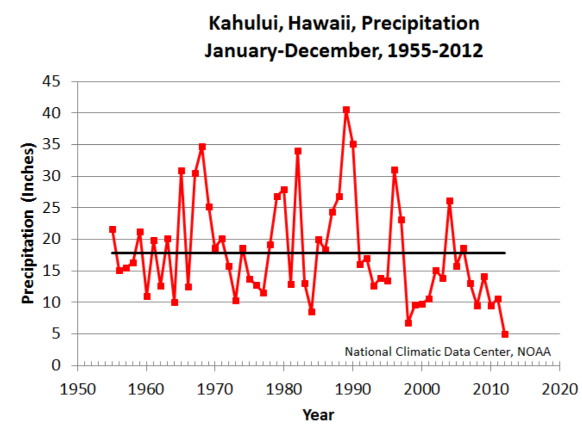
Parts of the Southeast have been in drought for the last two years. The percent area of the Southeast in moderate to exceptional drought, as measured by the USDM, hovered around 50 to 65 percent during the first five months of the year, then contracted during the summer and fall before expanding again at the end of the year. It peaked at about 69 percent at the beginning of May.



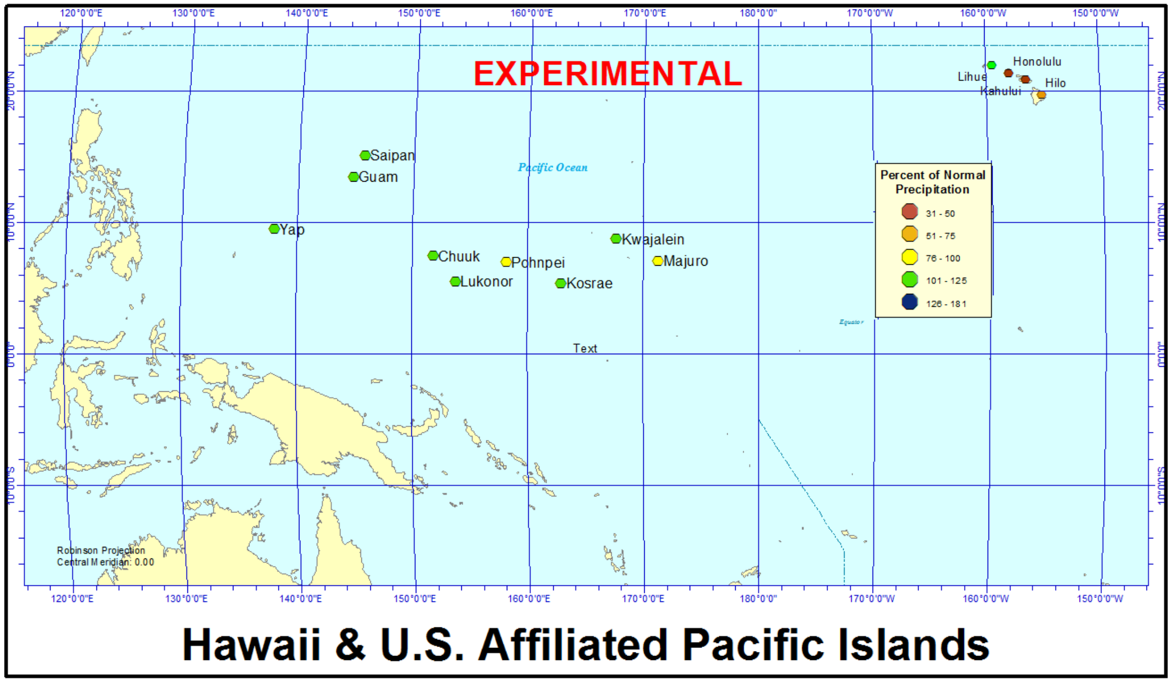


Hawaii and other Pacific Islands:

Drought in Hawaii was resurgent in 2012, with 47.4 percent of the state affected by moderate to exceptional drought on January 3, growing to 73.2 percent by December 4. The state has been in drought for the last four years, with the December 4, 2012 peak approaching the peaks of 2008-2010. Several locations had record to near-record dry conditions in 2012, with Kahului recording the lowest rainfall for the year based on data from 1955-2012, and Honolulu having the fifth driest and Hilo eighth driest year in their 1950-2012 records. Annual rainfall at other U.S.-affiliated Pacific Island stations during 2012 was near or above normal.

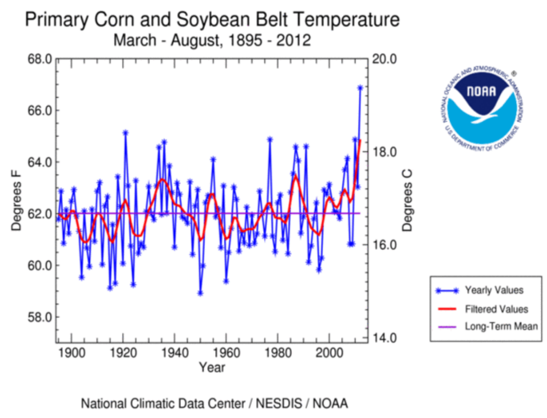


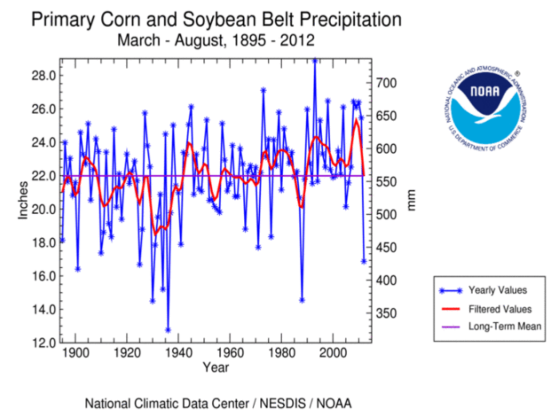
January-December 2012 Precipitation (Percent of Normal)

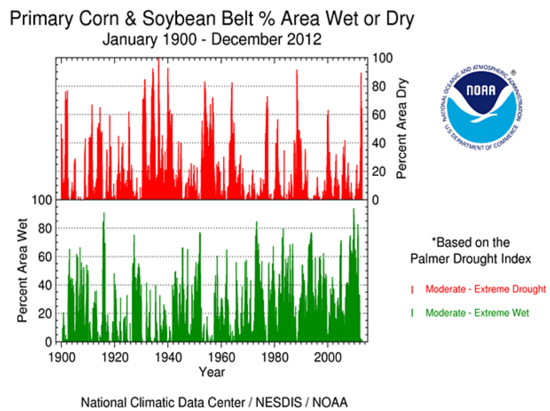


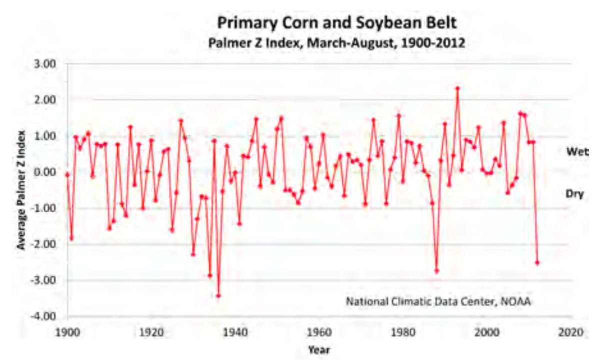
Agricultural Belts:

The spatial pattern of drought this year closely overlaid the agricultural area of the U.S. heartland, and the excessive temperatures and lack of rain during the critical growing season severely reduced corn and soybean crop yield. The Primary Corn and Soybean agricultural belt, collectively, experienced the warmest and seventh driest March-August in 2012, resulting in the fourth most severe Palmer Z Index for the season (behind 1936, 1934, and 1988). The extreme severity of the dryness and evapotranspiration demand over the growing season resulted in a rapid increase in the percent area of this agricultural belt experiencing moderate to extreme drought (as defined by the Palmer Drought Index) and moderate to exceptional drought (for the Midwest and High Plains as defined by the USDM). By August 2012, about 89.3 percent of the Primary Corn and Soybean Belt was experiencing moderate to extreme drought (based on the Palmer Drought Index), surpassing all previous droughts except those in 1988 and the 1930s. The August-October rains in the eastern part of this region were beneficial and helped reduce the intensity of the drought there, but they did little to shrink the overall drought area for the entire region, with the value down to only 54.9 percent by the end of the year. By year's end, January-December 2012 ranked as the tenth driest year on record.

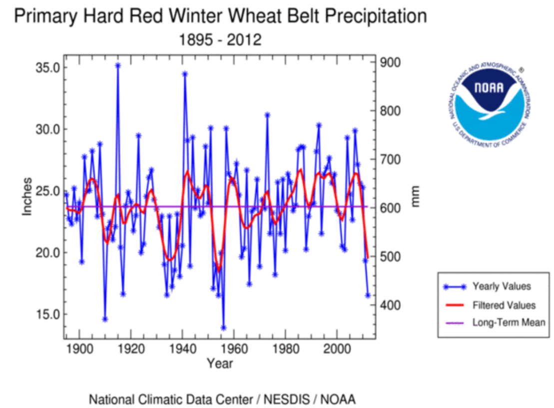




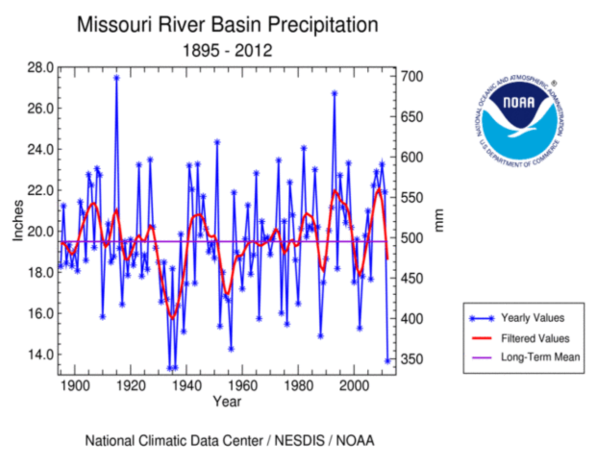


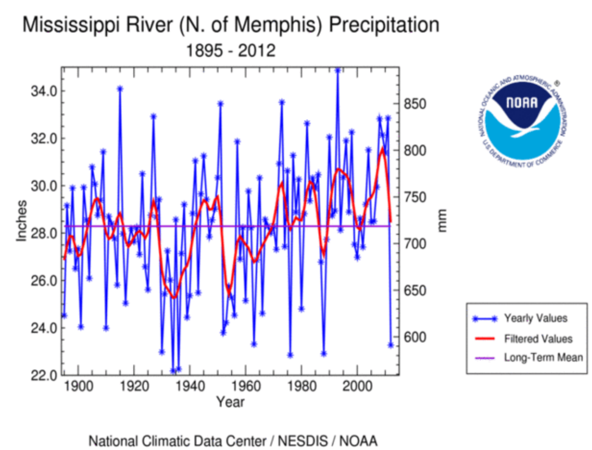


The growing season (October-April) has started out on a dry note for much of the Winter Wheat agricultural belt. October-December 2012 ranked as the 27th driest October-December in the 1895-2012 record, with November 2012 ranking as the 13th driest November. For the smaller Primary Hard Red Winter Wheat belt, November 2012 ranked 23rd driest and October-December tenth driest. By year's end, January-December 2012 ranked as the ninth driest year on record for the Winter Wheat belt and third driest for the Primary Hard Red Winter Wheat belt.



River Basins:





Several river basins have experienced unusually dry

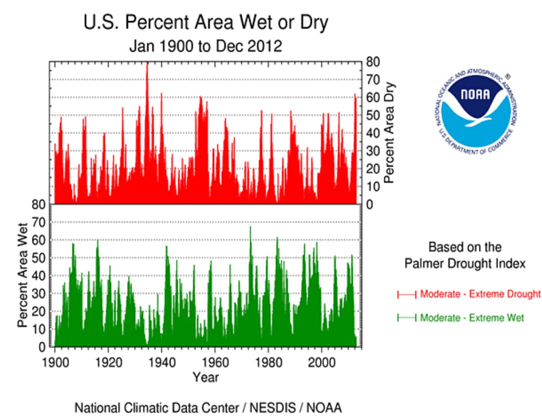
2012 Precipitation Ranks (out of 118 years) for the Major River Basins in the Contiguous U.S.: Calendar conditions during 2012, with the Upper Colorado having the driest year in the 1895-2012 record. As noted by the Midwest Regional Climate Center, drought has contributed to low water issues from the Great Lakes to the Missouri and Mississippi rivers, with navigation on the Mississippi River continuing to be a concern through December. The Missouri River basin had the third driest year in 2012 (behind 1934 and 1936), the Arkansas-White-Red River basin had the ninth driest year, and the Upper Mississippi and Rio Grande both ranked tenth driest. For the Mississippi River and all of its tributaries north of Memphis, Tennessee, 2012 ranked as the sixth driest year on record (behind 1934, 1936, 1976, 1988, and 1930). The aggregate PDSI for the Missouri basin reached the lowest value since the 1950s, while the aggregate PDSI for the broader Mississippi and its tributaries was the lowest since only 1988.

Year (January-December) and Water Year to Date (October-December)

RIVER BASIN	JAN-DEC	OCT-DEC
Pacific Northwest	11th wettest	10th wettest
California	56th driest	36th wettest
Great Basin	41st driest	35th wettest
Lower Colorado	24th driest	33rd driest
Upper Colorado	driest	29th driest
Rio Grande	10th driest	5th driest
Texas Gulf Coast	41st driest	4th driest
Arkansas-White-Red	9th driest	11th driest
Lower Mississippi	48th driest	35th driest
Missouri	3rd driest	37th driest
Souris-Red-Rainy	35th driest	31st wettest
Upper Mississippi	10th driest	59th driest
Great Lakes	54th driest	26th wettest
Tennessee	38th driest	59th driest
Ohio	27th driest	55th wettest
South Atlantic-Gulf	53rd driest	46th driest
Mid-Atlantic	46th driest	37th wettest
New England	38th wettest	38th wettest

Historical Analogs:

As seen in the National Drought Overview section, the percent area of the contiguous U.S. experiencing moderate to exceptional drought (based on the USDM) reached 65.5 percent in September, a record in the 13-year USDM history. The percent area of the contiguous U.S. experiencing moderate to extreme drought, based on the Palmer Drought Index (which goes 113 years), peaked at about 61.8 percent in July. This is only slightly larger than the peak percent area values of the 1950s drought decade and is the largest value since December 1939. So, in terms of total area covered by drought, the 2012 drought closely resembles the 1950s droughts.



The geographical pattern (location and intensity of dryness) of the 2012 drought can be compared to the patterns of previous droughts by using statistical tools such as the correlation coefficient and mean absolute difference. In the two tables below, the 2012 climate conditions (Palmer Z Index, Palmer Hydrological Drought Index [PHDI], temperature [Temp], precipitation [Precip]) were compared two different ways. In the table to the left, each month (January-December) of 2012 was compared individually to the previous years (1900-2011) to find the year with the closest match to each individual month (January closest match to January 2012, and February closest match to February 2012, and March closest match to March 2012, etc.). In the table to the right, the 2012 annual average values were compared to the annual average values for each of the previous years. No consistent pattern in historical analogs can be found in the monthly comparison (left-hand table) due to normal month-to-month variability (climatic noise). However, when the month-to-month variability is averaged out (by computing annual values as in the right-hand table), a consistent pattern becomes evident — the drought years 1955 and 1956 are the closest historical analogs to the geographical pattern of drought in 2012, and 1998 (the second warmest year on record) and 2006 (third warmest year on record) are the closest historical analogs to 2012 for the spatial temperature pattern.

Top 5 Analog Years to 2012 (each month January-December compared individually)

Rank*	Z Index	PHDI	Temp	Precip
1	1966	**1955**	1991	1904
2	1974	**1956**	2006	1901
3	1901	1920	1921	1917
4	2002	1918	1946	1931
5	1988	1963	1990	1974

* Rank: 1 = most similar to 2012.

Top 5 Analog Years to 2012 (annual value compared)

Rank*	Z Index	PHDI	Temp	Precip
1	**1955**	**1955**	1998	**1955**
2	**1956**	**1956**	2006	1966
3	1988	2000	1921	**1956**
4	1933	2006	1999	1980
5	1939	1981	1931	1988

* Rank: 1 = most similar to 2012.

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Contacts & Questions

For additional, or more localized, drought information, please visit:

- The U.S. Drought Portal

Citing This Report

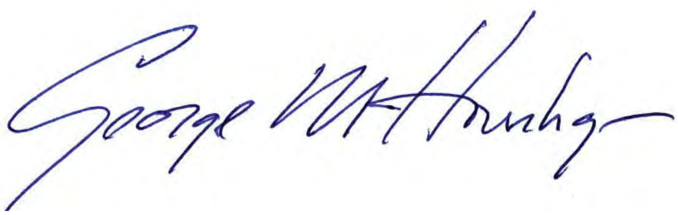
NOAA National Centers for Environmental Information, State of the Climate: Drought for Annual 2012, published online January 2013, retrieved on September 13, 2016 from http://www.ncdc.noaa.gov/sotc/drought/201213.

Exhibit 42

Measurement of Water Discharge in the Apalachicola River Between the Gages at Chattahoochee and at Sumatra, Florida

Defensive Expert Report in the matter of *Florida v. Georgia*, No. 142 Orig.

Prepared by:



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Dr. George M. Hornberger

Prepared for
Florida Department of Environmental Protection

May 20, 2016

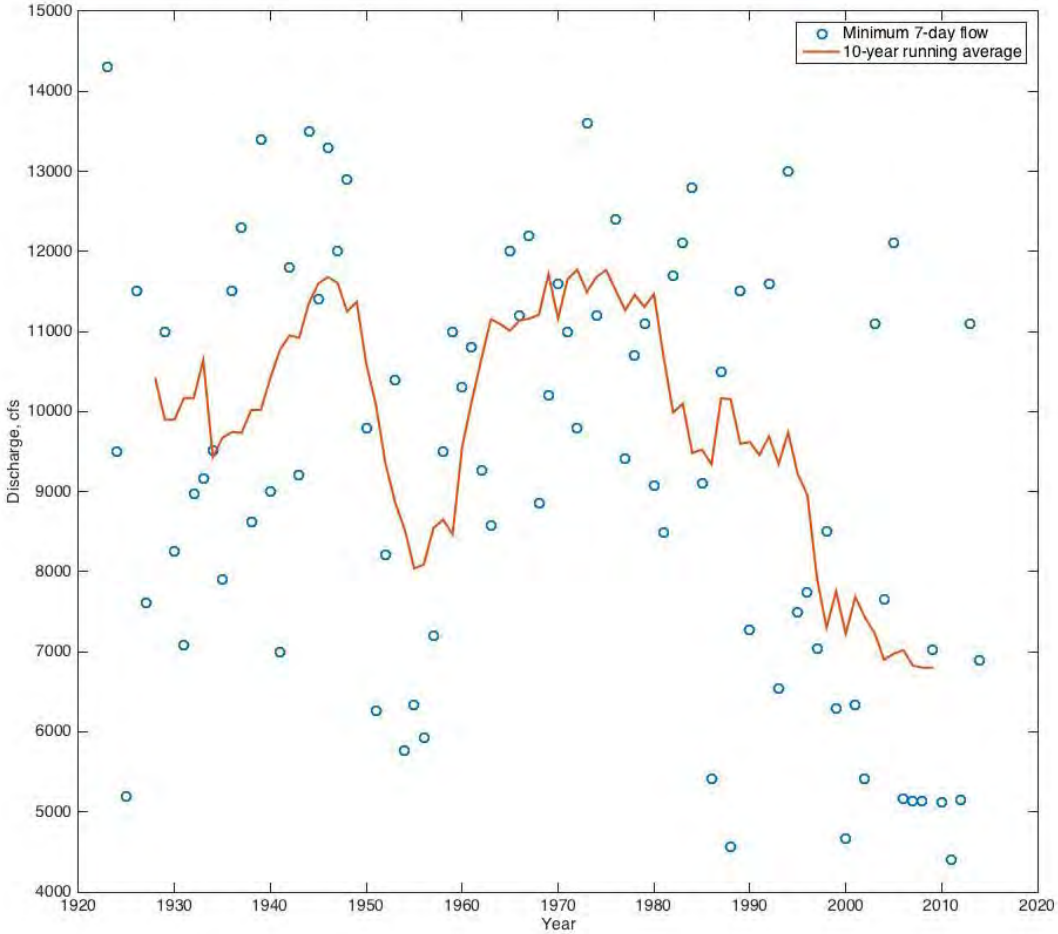


Figure 5 Minimum 7-day Low Flows for Each Year in the Apalachicola at Chattahoochee, FL

Another way to examine the changes in the 7-day low flow is to estimate probabilities that flows will be less than or equal to a given value. For the period from 1922 to 1980, the 7-day minimum flows are approximately normal (*i.e.*, they fall on a "bell-shaped curve" which translates to a straight line on a probability plot) and a flow of 6000 cfs or lower for seven consecutive days has a probability of occurring of about 0.03 indicating that it would be expected on average to occur once every 33 years (Figure 6). A low flow of 5000 cfs or lower for seven consecutive days is associated with a probability of 0.01, so 5000 cfs is the hundred-year 7-day low flow.

If the years from 1981 through 2013 are included, the picture changes considerably. The extreme low flows recorded tend to tilt the curve, making 6000 cfs about the 6-year low flow (probability of about 0.15) instead of the 33-year low flow (Figure 7). Furthermore, even with the tilted curve, the expectation for a flow of 5000 cfs or less to be reached is an occurrence frequency of one year in 10 (a probability of 0.1 indicated by the red line in Figure 7) but in fact occurred 7 years in the last ten years alone (see the cluster of recent years in blue in the lower left corner of Figure 5). In other words, very low flow events have become much more frequent in recent years with Georgia's increase in consumptive use.

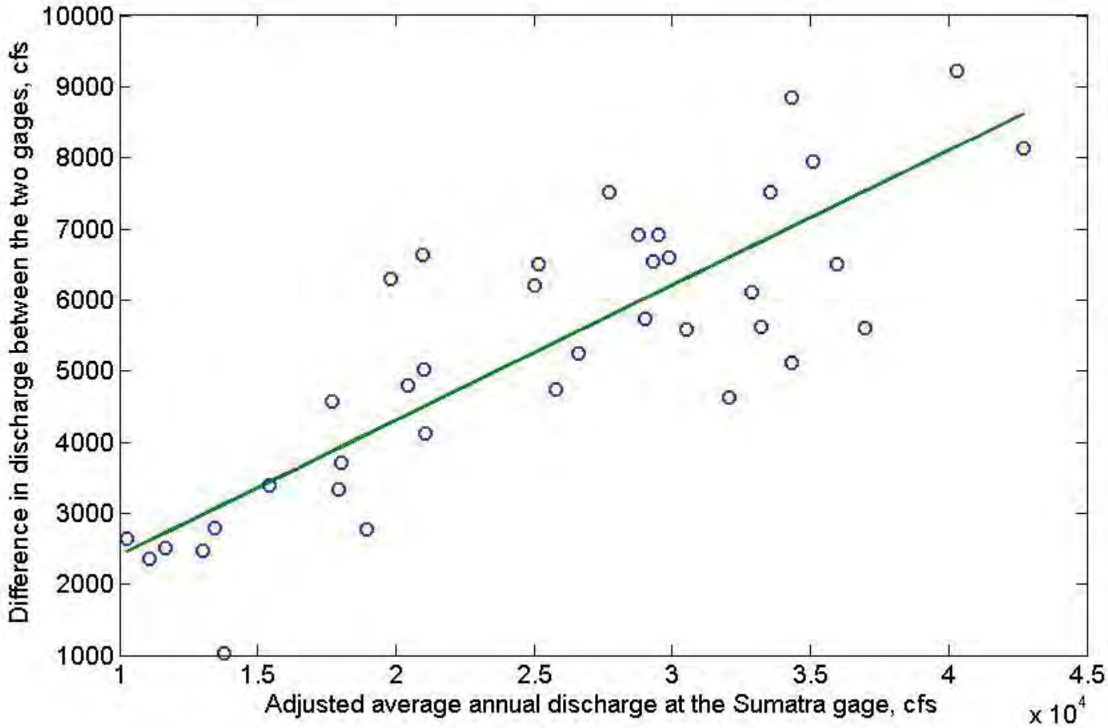


Figure 12. The difference between the adjusted flow at Sumatra and the flow at Chattahoochee is correlated with the adjusted flow at Sumatra.

Part of the apparent decline in differences in average annual discharge in the Apalachicola River between the Chattahoochee and Sumatra gages is simply due to natural climate variations over this limited period that Georgia selected in Figure 1 (1978 – 2014) (annual Sumatra gage discharge data is available from USGS from 1978 to the present). For the most part, the late 1970s featured wetter years and very recent years included more dry and drought years. The record of precipitation for the basin over the past century shows no consistent trend, just climate variability with wet periods and dry periods sporadically interspersed (Lettenmaier Expert Report, Feb. 29, 2016; Lettenmaier Expert Report, May 20, 2016).

The way to take into account the dependence of the flow difference on flow itself is to look at how observed variations are predicted using the flow dependence in Figure 12; this calculation shows that much of the observed variability is due to flow dependence (Figure 13, top panel). The question of whether there is a remaining unexplained trend is reduced to looking at residuals between the observed flow difference and that predicted by the trend in the relative proportion of wet and dry years across the record. There is no trend in these residuals (Figure 13, bottom panel). That is, there is no indication that water has been "lost" between the Chattahoochee and Sumatra gages (Figure 13). Rather, there is an expected greater flow difference in wet years than in dry years that accounts for the underlying data.

Exhibit 43

Expert Report of

ROBERT N. STAVINS, PH.D.

Submitted in the matter of

Florida v. Georgia

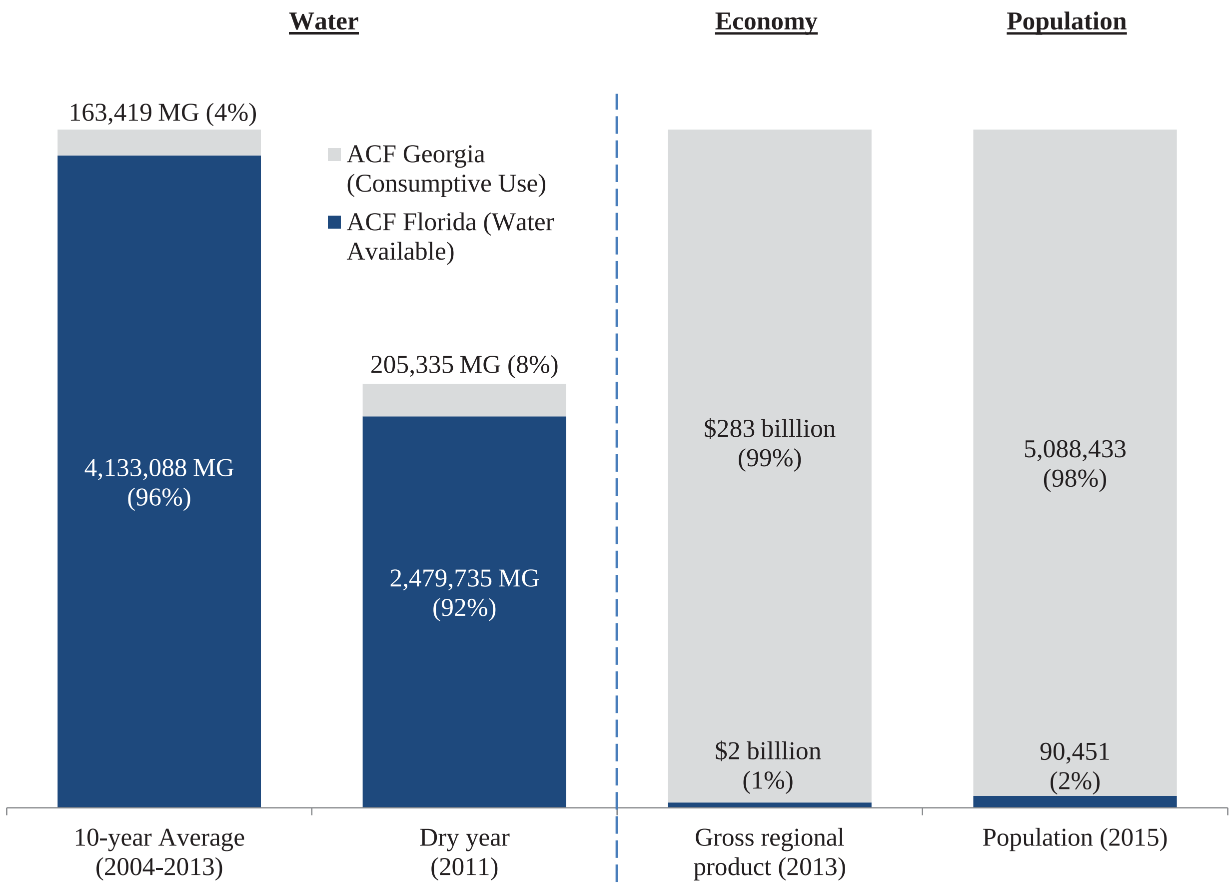
Supreme Court of the United States, No. 142, Original

May 20, 2016

In geographic terms, ACF Georgia is substantially larger than ACF Florida. As shown in Exhibit 2, compared with ACF Florida, ACF Georgia covers five times the land area and supports 56 times the population. Likewise, in demographic terms, ACF Georgia is substantially larger than ACF Florida. ACF Georgia includes five major metropolitan areas, including Atlanta, while ACF Florida has none. In 2015, the total population of ACF Florida was approximately 90,500. In contrast, the population in ACF Georgia was more than 56 times larger, with approximately 5.1 million people.

The magnitude of economic activity within ACF Georgia is also substantially greater than economic activity in ACF Florida. According to data from the Metro North Water Planning District ("Metro Water District"), there are 80 times more employees in ACF Georgia than in ACF Florida. Moreover, the GRP of ACF Georgia – approximately $283 billion in 2013 – was 129 times the GRP of ACF Florida.

Exhibit 3: Comparison of Water Use/Availability and Economic Activity
Average and Dry Year Conditions
ACF Georgia and ACF Florida



Notes & Sources: Bedient Report and materials cited therein ("20160203-ACF-summary-GA-water use-1980-2013.xlsx"); USGS Surface Water Annual Statistics; Zitsch (2006); and IMPLAN.

1. Municipal and Industrial Sectors in the ACF Basin

a) Overview of the Municipal and Industrial Sectors

Differences in the scale of the M&I sectors in Florida and Georgia are substantial. While populations and level of commerce in ACF Florida are relatively small, ACF Georgia has large populations and extensive commerce. Moreover, as described by Peter Mayer in his report, Georgia has long recognized the importance of water to its own economy and to other regions, and it has reflected this value in its statewide long-term planning efforts, as well as in the individual efforts of utilities.[24] According to Mr. Mayer, Georgia is a national leader in many water conservation programs, and M&I consumers in Atlanta face some of the highest water prices in the nation.[25]

Exhibit 4 illustrates the total output of counties in the ACF Basin by industrial sector.[26] Sectoral contributions to GRP in ACF Georgia are many multiples larger than the corresponding sectoral contributions in ACF Florida, ranging from 13 times (“13x”) larger for Mining to more than 100x larger in a range of commercial and industrial sectors, including Finance (127x), Transportation (174x), Wholesale Trade (299x), Manufacturing (359x) and other Services (190x).

The ACF Basin in Georgia is home to several major metropolitan areas, including Atlanta. These cities represent some of the most important and significant economic centers of the Southeast and the United States as a whole. Atlanta is the tenth largest metropolitan area in the United States by GRP.[27] Fifteen Fortune 500 companies are headquartered in the area.[28] In 2014, Atlanta metropolitan area GRP was $325 billion, which was comparable to the State of Indiana (the 15th largest state by rank of state domestic product).[29] As described below, water is a key input to these economies, and restrictions on water use would entail substantial economic costs.

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24 *See* Expert Report of Peter Mayer, P.E. (May 20, 2016) (hereafter, “Mayer Report”).

25 *See* Mayer Report.

26 I used the North American Industry Classification System (NAICS) maintained by the United States Census Bureau to categorize IMPLAN sectors into industry categories. IMPLAN reports GRP at the county level. I scale county level measures by the relative size of the ACF population within each county.

27 Bureau of Economic Analysis, Regional Economic Accounts: 2009-2014, accessed May 15, 2016.

28 Metro Atlanta Chamber of Commerce, “Fortune 500 and Fortune 1000 Headquarters,” available at http://www.metroatlantachamber.com/business/data/fortune-500-1000-hq.

29 Bureau of Economic Analysis, Regional Economic Accounts: 2009-2014. accessed May 15, 2016.

Within the ACF Basin, there are many industries and businesses for which water is a key input. Exhibit 6 lists some of the most water intensive manufacturing industries within the Upper Chattahoochee, which includes large portions of the Atlanta metropolitan region. Here, I define "water intensive" industries based on total water expenditures.[42] For each sector, the exhibit shows total output, water expenditures, and employment in 2013. Even this relatively narrow look at water dependent industries illustrates the size of economic activity in the basin. These industries contribute more than $12.8 billion to GRP and employ more than 35,000 people.

Exhibit 6 also includes two "green" industries that do not purchase water directly from water utilities or other suppliers, but instead rely on their customers' water supply to irrigate lawns and gardens. A reduction in water use by residential customers will tend to reduce consumer spending on water-related services such as landscaping and gardening.[43] These two sectors generated approximately $660 million and employed more than 14,000 people in the Upper Chattahoochee Region in 2013.

Combined, these industries contribute $13.5 billion to total GRP and employ nearly 50,000 people.

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42 Similarly, these industries also tend to have the highest ratios of total water expenditures to economic output among all large industries (that is, with total economic output greater than $500 million). Economic output refers to the total quantity of final sales by all industries in the economy. This includes the intermediate sale of goods between sectors, known as the cost of goods sold.

43 I discuss this in greater detail in Section IV.

Exhibit 6: Economic Metrics for Water-Intensive Industries in the Upper Chattahoochee (2013)

	Contribution to GRP ($millions, $2013)	Output ($millions, 2013)	Total Water Expenditure ($millions, $2013)	Total Employees
Top 10 Manufacturing Industries				
Flavoring syrup and concentrate manufacturing	$9,159	$16,303	$8.0	4,153
Poultry processing	$393	$2,729	$3.9	11,042
Other basic organic chemical manufacturing	$75	$696	$3.5	349
Pharmaceutical preparation manufacturing	$577	$1,397	$1.7	1,017
Other basic inorganic chemical manufacturing	$234	$634	$1.1	608
Bottled and canned soft drinks & water	$224	$1,191	$1.0	1,492
Plastics material and resin manufacturing	$108	$623	$0.9	416
Aircraft manufacturing	$1,036	$3,805	$0.8	5,299
Printing	$682	$1,432	$0.8	8,393
Paperboard container manufacturing	$352	$1,182	$0.7	2,514
Subtotal	$12,840	$29,991	$22.3	35,283
Green Industries				
Landscape and horticultural services	$621	$910	$0.0	13,810
Greenhouse, nursery, and floriculture production	$37	$54	$0.0	527
Subtotal	$658	$964	$0.0	14,337
Total	**$13,498**	**$30,955**	**$22.4**	**49,620**

Notes & Sources: Totals include all counties included in the Upper-Chattahoochee, deemed to draw on water from the ACF-Georgia. *See* Exhibit 1. Total water expenditure consists of expenditures on water and sewerage (IMPLAN Code 51). Green Industries follows definition provided by Hall et al. (2005). Data accessed from IMPLAN.

2. Agriculture in the ACF Basin

Irrigation water is a critical input to a substantial portion of the total agricultural acreage in ACF Georgia, resulting in higher yields during both average and dry years. In this section, I first provide an overview of the agricultural sector, and then describe the role of water as a key input to production.

a) Overview of the Agricultural Sector

The ACF Basin supports a substantial agricultural sector, with the vast majority of this activity occurring in the State of Georgia. Exhibit 7 shows the commercial value of all agriculture products that are produced in ACF Georgia.[44] In 2013 (the most recent year with reported data), total agriculture revenues were $4.7 billion, with $1.3 billion coming from row and forage crops, the majority of which came from three crops: cotton, peanuts, and corn. Most of this agricultural activity takes place within the Lower Flint watershed.[45]

ACF Georgia is also one of the largest and most productive agricultural regions in the United States. Georgia farmers planted almost 50 percent of all peanut acreage nationwide,[46] with ACF Georgia accounting for approximately 54 percent ($478 million) of total peanut sales in 2012.[47] Georgia is also the nation's second largest producer of cotton, producing more than $1.3 billion in sales in 2012, with ACF Georgia contributing roughly 47 percent ($618 million) of this production.

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[44] Agricultural statistics are reported at the county level. In this calculation, I define ACF Georgia as all counties overlapping the Local Drainage Areas (LDAs) identified by Dr. Sunding to be in the ACF River Basin. I use National Environmentally Sound Production Agriculture Laboratory ("NESPAL") dataset that has irrigated acreage to determine county-LDA overlaps.

[45] As described in the Flint River Basin Regional Water Development and Conservation Plan, the highest concentration of irrigation in the Flint River Basin is in the lower Flint River and Spring Creek sub-basins. *See* Couch, Carol A., and R. J. McDowell, "Flint River Basin Regional Water Development and Conservation Plan," Georgia DNR-EPD (2006) ("Flint River Plan").

[46] National commodity production by state was provided by the United States Department of Agriculture (USDA) National Agriculture Statistics Survey. Data available through the USDA quick stats tool.

[47] Crop commercial values were provided by the University of Georgia Farm Gate data (UGA_00130458); According to the Georgia Cotton Production Guide, Georgia was the second largest producer of cotton in 2014 ("2015 Georgia Cotton Production Guide," The University of Georgia Cooperative Extension, January 2015.).

Exhibit 7: ACF Georgia Agricultural Commercial Value Output in 2013 ($2012 billions)

Crop	Commercial Value in 2013 ($2012 billion)
Row and Forage Crops	
Cotton	$0.6
Peanuts	$0.3
Corn	$0.3
Other row and forage crops	$0.2
Subtotal	$1.3
All Agriculture Commodities	
Row and forage crops	$1.3
Poultry and Eggs	$1.5
Livestock	$0.5
Vegetables	$0.4
Nuts and fruits	$0.3
Other	$0.6
Total	**$4.7**

Notes & Sources: Row and Forage crops includes Georgia's three largest crops (corn, cotton, and peanuts) as well as barley, hay, oats, rye, silage, sorghum, soybeans, straw, tobacco, wheat, and other. *See* University of Georgia Farm Gate data, (UGA_00130458). ACF Georgia includes all counties with irrigated acreage drawing from the ACF River Basin as identified in the Sunding Report.

Exhibit 8: Select Industries that Rely on Regional Farm Products, Georgia ACF Basin

Description	Contribution to GRP ($2013 million)	Employment	Purchases of Georgia ACF Basin Farm Output ($2013 million)
Fiber, yarn, and thread mills	$127	1,698	$40.1
All other food manufacturing	$62.6	909	$10.3
Breweries	$303	791	$10.7
Other animal food manufacturing	$69.0	481	$49.9
Roasted nuts and peanut butter manufacturing	$68.3	362	$10.7
Soybean and other oilseed processing	$54.3	272	$33.0
Fats and oils refining and blending	$2.3	17	$0.3
Total	**$687**	**4,531**	**$155**

Notes & Sources: "GRP" is Gross Regional Product. IMPLAN.

Within the ACF Basin, there is also substantial economic activity dependent on output from the agricultural sector, such as food processing. Exhibit 8 shows the economic activities in ACF Georgia that use row crops (corn, cotton, peanuts, and soybeans) and other agricultural commodities as inputs to production. These sectors contributed more than $687 million to GRP and purchased as inputs more than $155 million of raw agricultural commodities from farmers within the region. A restriction in water use that led to reduced and variable farm output could lead to shifts in the location of this economic activity or diminished capital investment in the region.

The importance of agriculture to the region is also reflected in the many institutions devoted to agriculture, including those with a particular focus on water use by the agricultural sector. The University of Georgia has a campus in Tifton, with much of its activities focused on agricultural research, education, and extension, particularly within the Lower ACF Basin. The Georgia Water Planning and Policy Center ("GWPPC"), located at Albany State University, focuses on water use in the agricultural sector, providing research, education, and policy support. The GWPPC has played an important role in promoting and leading long term water planning and conservation efforts.[48] For example the GWPPC has supported three regional water councils (Upper Flint, Lower Flint-Ochlockonee, and Middle Chattahoochee) in the development of their regional water plans. The GWPPC has also been instrumental in the use of

48 *See* Expert Report of Suat Irmak, Ph.D. (May 20, 2016). (hereafter, "Irmak Report").

Geographic Information System (GIS) data analysis to both map irrigated acreage parcels and implement the Agricultural Water Metering Program. These resources allow the GWPPC, in collaboration with other stakeholders and agencies, to monitor, implement, and evaluate total water use in the Basin.

b) Water Use in the Agricultural Sector

Water is an essential input to agricultural production. Water comes from two primary sources. One source is natural precipitation, which varies both across geographies and over time given natural weather variability. The other potential source of water is irrigation. Irrigation systems provide a means for farmers to supplement natural precipitation to maintain yields above levels that would occur absent irrigation. Irrigation systems typically provide farmers with a means of controlling the quantity and timing of water that is applied to crops, thus permitting them to optimize crop yields and total production. Georgia is also a leader in promoting irrigation conservation programs which further refine and optimize the quantity and timing of applications to maximize efficiency and reduce water use.[49]

Irrigation is essential to the productivity of the agricultural sector in ACF Georgia. Given the natural variability of rainfall, irrigation provides a means of insuring against diminished yields or possibly entire crop losses during periods of limited precipitation.[50] Absent irrigation, yields can drop substantially, potentially leading to a loss of most or all crops. This impact is greatest during dry years. Exhibit 9 shows the differences in yields on irrigated and non-irrigated land during average and dry years from multiple data sources, including Dr. Sunding's model. These data illustrate that during dry years, the differences in yields between irrigated and non-irrigated farms is substantial.[51] For example, farmers would be expected to produce 51 percent smaller peanut yields without irrigation than with irrigation during a dry year. Corn farmers could fare even worse: expected yields without irrigation are 68 percent lower during average years and 93 percent lower during dry years.

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[49] Increases in irrigation efficiency have been achieved in the ACF Basin through a comprehensive suite of programs, including conversion of high pressure center pivot sprinklers to more efficient systems, and extensive outreach and pilot programs. These programs are described at length in the Irmak Report. I discuss the implications of increased irrigation efficiency in relation to Dr. Sunding's conservation costs in Section IV.

[50] *See*, for example, Deposition of Adelbert (Del) Bottcher, May 12, 2016, p. 81 ("Q: And farmers using dryland farming also face an increased risk of crop failure compared to farmers who irrigated, right? A: That's correct.")

[51] *See also*, Irmak Report.

Exhibit 14: Summary of Benefits and Costs of Water Conservation Scenarios

	Sunding Report		Stavins Report		
	Claimed Increase in Peak Summer Stream Flow (cfs)	Claimed Benefits (+) or Costs (-) per Dry Year ($ million)	Increase in Peak Summer Stream Flow (cfs)	Benefits (+) or Costs (-) per Dry Year ($ million)	Notes
Irrigation Reduction Only (Sunding Scenario 1)					
Sunding Conservation Measure					
Deficit Irrigation of Rotation Crops	1,000	-$191	678	-$335	Section IV.B.1
Impact on Florida					
Impact on Natural Resources, Ecosystem		*not evaluated*		*de minimis*	Section V
Total Peak Summer Streamflow	1,000		678		
Net Benefit (Benefits minus Costs)		*not evaluated*		-$335	
Agriculture Only (Sunding Scenario 2)					
Sunding Conservation Measure					
High-Value Crops to Deeper Aquifers	337	-$41	-	-	Not evaluated because potential reductions and costs are uncertain / speculative, Section IV.B.3
Center Pivot Efficiency Improvements	111	-$3	13	-$0.1	Reflects incremental reductions beyond existing regulations & overlap with deficit irrigation; no changes to Sunding costs, Section IV.B.2
Deficit Irrigation of Rotation Crops	552	-$56	603	-$205	Section IV.B.1
Impact on Florida					
Impact on Natural Resources, Ecosystem		*not evaluated*		*de minimis*	Section V
Total Peak Summer Streamflow	1,000		616		
Net Benefit (Benefits minus Costs)		*not evaluated*		-$205	

Exhibit 14 – *cont'd*: Summary of Benefits and Costs of Water Conservation Scenarios

	Sunding Report		Stavins Report		
	Claimed Increase in Peak Summer Stream Flow (cfs)	Claimed Benefits (+) or Costs (-) per Dry Year ($ million)	Increase in Peak Summer Stream Flow (cfs)	Benefits (+) or Costs (-) per Dry Year ($ million)	Notes
Agriculture and M&I (Sunding Scenario 4)					
Sunding Conservation Measure					
30% Reduction in Municipal Outdoor Use	150	-$121	75	-$228	Section IV.B.5
Full Municipal Leak Abatement	95	-$7	48	-$34	Reflects incremental reductions beyond existing leak abatement efforts, Section IV.B.5
Center Pivot Efficiency Improvements	111	-$3	16	-$0.1	Reflects incremental reductions beyond existing regulations & overlap with deficit irrigation; no changes to Sunding costs, Section IV.B.2
Deficit Irrigation of Rotation Crops	519	-$49	542	-$170	Section IV.B.1
Reduced Early Season Pecan Irrigation (Scenario 4)	125	0	-	-	Not evaluated because potential reductions and costs are uncertain / speculative, Section IV.B.4
Impact on Florida					
Impact on Natural Resources, Ecosystem		*not evaluated*		*de minimis*	Section V
Total Peak Summer Streamflow	1,000		682		
Net Benefit (Benefits minus Costs)		*not evaluated*		-$433	
Sunding Scenario 3: Other Conservation Measures and Differences from Scenario 4					
High-Value Crops to Deeper Aquifers (Scenario 3)	337	-$41	-	-	Not evaluated because potential reductions and costs are uncertain / speculative, Section IV.B.3
Measures for Municipal Outdoor Water Use, Municipal Leak Abatement and Deficit Irrigation differ in intensity; Reduced Early Season Pecans is not included					

Note: In my scenarios, the assumed quantity of peak summer streamflow increases for Deficit Irrigation is determined by a process in which discrete quantities of irrigated acreage of equal connectivity (of which there are twelve) are incrementally removed (from highest to lowest connectivity) until streamflow increases are large enough to meet or exceed the streamflow increases in Dr. Sunding's scenarios. When removing irrigation, I assume that all acreage at a given connectivity level is removed if it is required to meet Dr. Sunding's assumed streamflow increases. As a result, in the Agriculture Only and Agriculture and M&I scenarios, streamflow increases exceed those assumed by Dr. Sunding.

C. Proposals by Dr. Sunding to restrict water use in ACF Georgia would have substantial, broad impacts on affected sectors and regions in Georgia

With any policy or mandate, such as the proposed restrictions on water use, the distribution of economic consequences is likely to vary across regions, sectors, and populations.

1. Analysis of the economic distribution of the proposed remedy shows substantial impacts to affected sectors and regions in Georgia

The relative impacts of Dr. Sunding's proposed scenarios can first be considered by comparing their impact on production within the two states. As I described above, irrigated agricultural production accounts for large shares of many crops produced in the region. The elimination of irrigation would have substantial effects on productivity within the region. By comparison, Florida's expert Dr. Jenkins estimates that elimination of *all consumptive use* by Georgia would have increased oyster and blue crab harvests by 12 percent and 10 percent, respectively.[86] The stark difference between Georgia and Florida in these relative impacts has much to do with the relative proportion of Georgia's current use of water and the amount available to Florida, as shown in Exhibit 3.

Using economic models, I have evaluated the regional economic impacts of the reduction in economic activity in the agricultural sector under Dr. Sunding's Scenario 1, in which all reductions in water use are achieved through deficit irrigation. The economic impacts of his other scenarios would differ, because of reliance on reductions from different types of economic activity.[87] Exhibits 15 to 18 summarize my findings. Results are estimated using the IMPLAN model (Exhibits 15 and 16) and the REMI model (Exhibits 17 and 18).[88] These models differ in a number of different dimensions, including

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86 Expert Report of Dr. Kenneth Jenkins Report, February 29, 2016 (hereafter, "Jenkins Report").

87 I discuss the potential economic impacts from a reduction in water use within the M&I sectors in Section IV.B.

88 IMPLAN stands for "IMpact analysis for PLANning." I use IMPLAN version 3.1 software, and the 536 sectoring scheme for my analysis, which provides a highly detailed representation of the Georgia and Florida economies. These 536 sectors are based on the 6 digit North American Industry Classification Standards (NAICS). Additional information on IMPLAN can be found at http://www.implan.com/. REMI stands for Regional Economic Models, Inc. I used a seven region, seventy industry sector, REMI PI+ v.1.7 model for my input-output analysis. "PI+ is a structural economic forecasting and policy analysis model… [that] integrates input-output, computable general equilibrium, econometric and economic geography methodologies." Additional information on REMI can be found at http://www.remi.com/.

collateral.[100] Both of these developments would likely make it more difficult for farmers to obtain short- and long-term loans on the same terms as before.

Evidence I have reviewed suggests that these are not merely theoretical concerns. For example, in a study of risk management in farming, Crane et al. interviewed 38 farmers in southern Georgia, including some from the ACF Basin.[101] One farmer interviewed stated that "one needs to have at least 50% of landholdings under irrigation to make a profit or *even to secure a loan from the bank*."[102] In addition, in a letter dated April 7, 2016, Richard S. Monson, the CEO of the largest agricultural lender in the region, Southwest Georgia Farm Credit, stated:

> "Loss of a readily available and consistent source of water would likewise have the compounding effect of not only decreasing loan repayment capacity; it would also translate into deteriorating farm real estate values. … From a financing proposition this becomes somewhat of an untenable situation. Aside from problematic cash flows, row crop farmers would have weakening collateral and equity positions, making it all the more difficult to obtain constructive financing."[103]

2. Dr. Sunding fails to accurately characterize the potential impacts of his proposed reductions to the affected industries and local economies

While Dr. Phaneuf describes the Florida economy's reliance on the region's natural resources, Dr. Sunding downplays the reliance of ACF Georgia on water, particularly agriculture in the Flint River Basin. In summarizing his findings, he compares the economic costs of one water reduction scenario ($35 million for his Scenario 2) to the state's overall economic activity, finding that the cost is "*one-hundredth of a percent*" of Georgia's annual state product.[104] As an initial matter, Dr. Sunding fails to apply his own approach to Florida. For example, in Section V, I estimate the annual economic benefits of

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100 For example, *see* "Comptroller's Handbook Safety and Soundness Agricultural Lending," Office of the Comptroller of Currency, May 2014, p. 18 ("Real estate, machinery, and equipment should be reevaluated whenever market conditions or other information leads the lender to believe that the collateral's original assigned value may have significantly decreased.").

101 Crane, T.A. et al., "Seasonal Climate Forecasts and Risk Management Among Georgia Farmers," *Southeast Climate Consortium Technical Report Series*, 2008 (hereafter "Crane et al. (2008)"), p. 38.

102 Crane et al. (2008), pp. 39-40. Emphasis added.

103 Letter from Richard S. Monson, dated April 7, 2016.

104 Sunding Report, p. 7.

Exhibit 44

Metropolitan North Georgia Water Planning District
40 Courtland Street NE | Atlanta, Georgia 30303

MEMORANDUM

Date: **April 29, 2016**

To: **Jud Turner, Director, Georgia Environmental Protection Division**

From: **Katherine Zitsch, Director**

RE: **Chattahoochee-Flint River Basin Population Served**

As requested, the Metropolitan North Georgia Water Planning District (Metro Water District) has estimated the population served by utilities within the Metro Water District that withdraw water from the ACF Basin or are partially located within the ACF Basin. This includes water systems in Cherokee, Clayton, Cobb, Coweta, DeKalb, Douglas, Fayette, Forsyth, Fulton, Gwinnett, Hall, Henry and Paulding Counties.[1]

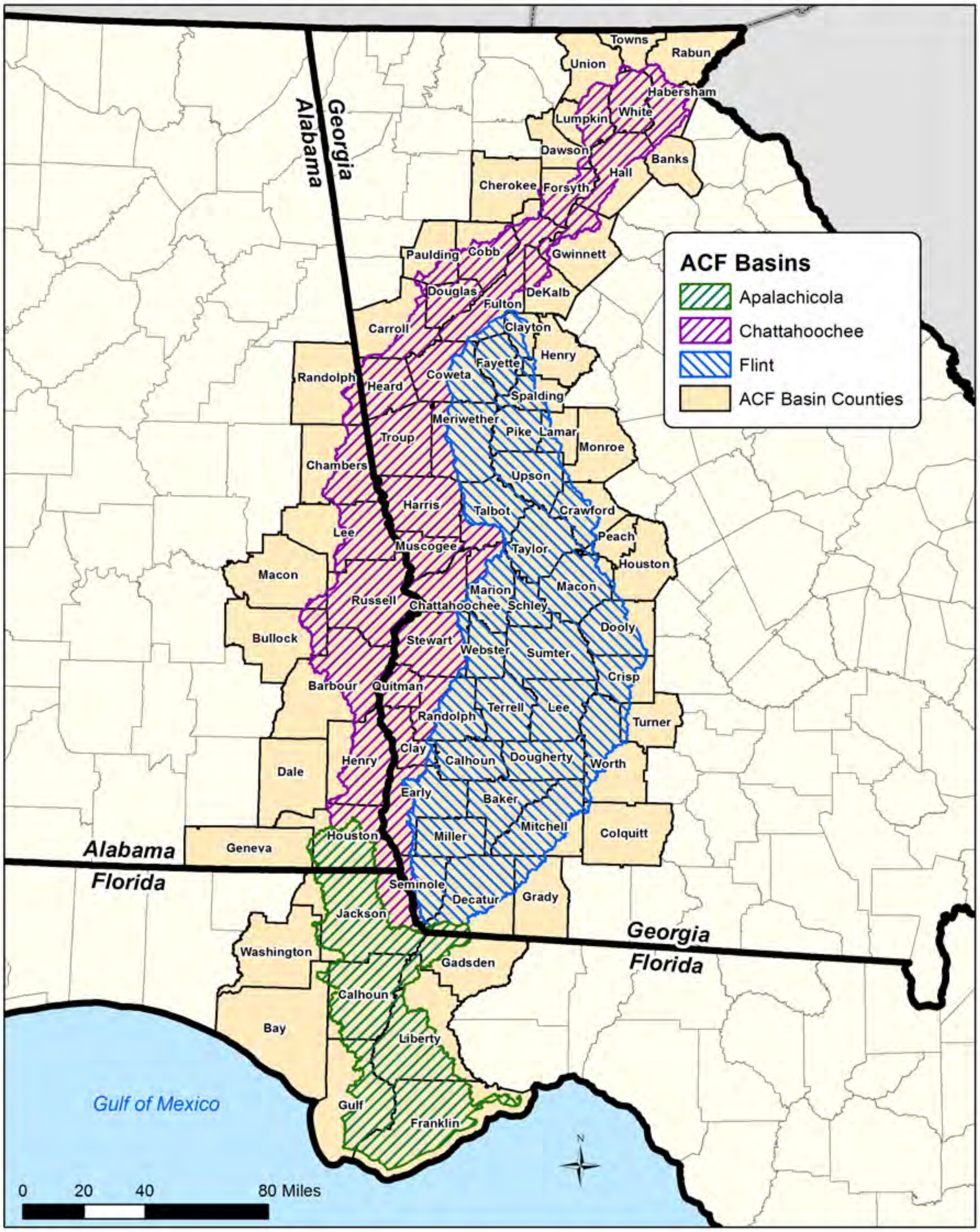
The Atlanta Regional Commission prepared detailed estimates of the population residing in the Apalachicola-Chattahoochee-Flint (ACF) Basin in five-year intervals from 1995 through 2015. These estimates are provided in Attachment A. Estimates of basin residents do not capture the full population that depend on the ACF Basin to meet municipal and industrial water supply needs, however. This is because some water systems in the Metro Water District utilize the ACF Basin as a water supply source and also deliver water to the population residing within the respective county but outside of the ACF Basin boundary (see Figure 1 for basin and county boundaries). Thus, basin boundaries are not reliable estimates for determining the Metro Water District population that relies upon the surface waters of the ACF Basin for water supply.

In general, the population in the Metro Water District dependent on ACF surface water supplies is represented as follows:

> ACF Dependent Population = Total County Population – Self-Supplied Population – Population Supplied by Public Groundwater – Population Supplied from Other Non-ACF Sources

[1] This does not include Bartow and Rockdale Counties because, although they are located with the Metro Water District, they don't rely on ACF for water supply and also don't have any land area within the ACF basin.

Figure 1: ACF River Basins and County Boundaries



Self-Supplied Groundwater

In order to calculate the population served by public water supply systems (either groundwater or surface water), the Metro Water District first estimated the population served through individual groundwater wells. As part of the Metro Water District's 2016 plan update, CH2M Hill, as contractor to the Metro Water District, estimated the self-supplied population in Metro Water District counties for the period from 2001 through 2015 as well as the corresponding water use by the self-supplied population. These estimates are provided in Attachment B.

Next, the population within each county served by public water supply sources was calculated by subtracting the self-supplied population for each county (from Attachment B) from the total county population (from Attachment A).[2] The results of this analysis are presented in Table 1 below. The corresponding calculation of total water supplied in each county by public water supplies is presented in Attachment B.

Table 1
Population Dependent on Public Water Supplies
Metro Water District Counties within ACF Basin

County	1995	2000	2005	2010	2015
Cherokee	87,160	116,617	156,309	195,628	244,299
Clayton	209,157	236,517	247,949	259,424	266,759
Cobb	527,597	607,753	647,816	688,078	735,818
Coweta	43,727	63,923	85,311	106,624	132,179
DeKalb	605,973	665,841	678,811	691,893	727,685
Douglas	81,703	92,331	112,359	132,403	152,534
Fayette	60,092	75,978	85,040	94,061	98,152
Forsyth	57,152	86,057	126,285	166,388	212,597
Fulton	721,006	805,830	858,930	912,244	1,030,359
Gwinnett	470,608	588,458	696,823	805,321	928,590
Hall	77,993	103,365	126,895	150,279	185,722
Henry	69,093	101,177	145,116	188,997	214,033
Paulding	54,796	75,401	106,341	137,322	170,101

[2] ARC utilized GeoLytics as the data source for historic population due to the availability of data at the block group level for the period needed. Therefore, total county population in this memo may vary slightly from US Census Bureau estimates.

Population Served by Municipal Groundwater and non-ACF Surface Water Supply

Based on available data, the population served by either public groundwater sources or surface water sources outside of the ACF-basin was estimated using 2014 withdrawal amounts. Table 2 presents the amount of water supplied by these non-ACF basin sources.[3]

Table 2
Chattahoochee and Flint River Public Water Supply Analysis
(mgd-AADF)

County	Public Water Supply[4]	2014 Public Groundwater and non-ACF Surface Water Withdrawals	Percent Public Groundwater and non-ACF Surface Water Supply	Percent ACF Surface Water Supply
Clayton	24.0	0.02	0.1%	99.9%
Coweta	11.6	0.16	1.4%	98.6%
DeKalb	71.0	0	0.0%	100.0%
Douglas	13.0	0.484[5]	3.7%	96.3%
Fayette	10.1	0.64	6.3%	93.7%
Forsyth	21.2	0	0.0%	100.0%
Fulton	138.4	0.11	0.1%	99.9%
Gwinnett	82.0	0.45	0.5%	99.5%
Hall	18.4	0.867[6]	4.7%	95.3%

[3] This table does not include Cobb County because this information is provided separately below. There are no permitted groundwater wells or groundwater withdrawals in Cobb County in 2014. The tables also do not include Cherokee, Henry or Paulding Counties because they are not served by water from the Chattahoochee or Flint River Basins.

[4] From Table B-3

[5] Douglas County is mainly supplied by water from the Chattahoochee River basin. However, the City of Villa Rica is within both Douglas County and Carroll County and supplies water to citizens from groundwater and surface water from the Alabama-Coosa-Tallapoosa Basin. In 2014, 40% of the population of Villa Rica was in Douglas County. Therefore, 40% of the surface water and groundwater usage is assumed to serve Douglas County citizens. Villa Rica did not report withdrawals from each water supply source separately, so 0.484 mgd includes 40% of total withdrawals from both the Alabama-Coosa-Tallapoosa basin and groundwater.

[6] Includes 0.167 in actual groundwater use for the City of Lula. 2014 actual groundwater usage for the City of Flowery Branch was not available, so permitted (0.7 mgd average month) was used instead.

Cobb County

Cobb County is currently served by two water sources: Allatoona Lake in the Alabama-Coosa-Tallapoosa (ACT) River Basin and the Chattahoochee River. Therefore, the relative share of each source of supply was estimated, as described in Attachment C. After adjusting for out-of-county sales, the Chattahoochee River supplied between 51% and 65% of the water sales within Cobb County for each five-year period for which population estimates are being produced. The fraction of the Cobb County population served by ACF Basin sources is shown in Table 3.

Table 3
Percent of Cobb County Served by Chattahoochee River

Year	Percent of County Served
1995	53%
2000	51%
2005	54%
2010	62%
2015	65%

Population Relying on ACF Basin Surface Water

Using the information above, the relative share of population that depends on surface water from the ACF Basin was calculated for each county. The results of this analysis are summarized in Table 4.[7] Attachment D provides summaries of population estimates for the year 2015 based on the population that lives in the ACF basin versus population served by ACF surface water supplies. Although not evaluated as part of this process, a similar increased proportion of additional employment in these counties is also served by the Chattahoochee and Flint water supply sources.

[7] Because permitted amounts exceed actual withdrawals, using permitted groundwater withdrawals results in a larger estimate of the population utilizing groundwater, and thus a lower estimate of population served by surface water from the ACF Basin. Using permitted groundwater would decrease population served by the ACF basin by about 50,000 people in 2015. However, using actual groundwater usage more accurately reflects current conditions.

Table 4
Population Served by Chattahoochee and Flint Sources

County	**1995**	**2000**	**2005**	**2010**	**2015**
Cherokee	0	0	0	0	0
Clayton	208,983	236,320	247,742	259,208	266,537
Cobb	279,626	309,954	349,821	426,608	478,282
Coweta	43,125	63,044	84,137	105,157	130,360
DeKalb	605,973	665,841	678,811	691,893	727,685
Douglas	78,661	88,893	108,176	127,474	146,855
Fayette	56,302	71,186	79,677	88,129	91,962
Forsyth	57,152	86,057	126,285	166,388	212,597
Fulton	720,432	805,189	858,247	911,518	1,029,539
Gwinnett	468,025	585,229	692,999	800,902	923,494
Hall	74,321	98,498	120,921	143,203	176,978
Henry	0	0	0	0	0
Paulding	0	0	0	0	0
Subtotal - Metro Water District Served by ACF Water Supply Sources	**2,592,602**	**3,010,212**	**3,346,817**	**3,720,479**	**4,184,289**
Georgia ACF Population outside Metro Water District[8]	804,531	847,032	876,349	906,973	904,144
Georgia ACF Dependent Population	**3,397,133**	**3,857,244**	**4,223,166**	**4,627,452**	**5,088,433**

[8] From Attachment A

Attachment A
ARC Population and Employment Memo

ATLANTA REGIONAL COMMISSION
40 Courtland Street, NE
Atlanta, Georgia 30303
atlantaregional.com

M E M O R A N D U M

Date: **April 29, 2016**

To: **Katherine Zitsch, Metropolitan North Georgia Water Planning District**

From: **Mike Carnathan, Research & Analytics Division**

Subject: **Historical Population & Employment Estimates for the ACF Basin**

As requested, the ARC Research & Analytics Division (RAD) has developed historical estimates of population and employment for the Apalachicola-Chattahoochee-Flint (ACF) River Basin in Georgia, Florida, and Alabama for the years 1995, 2000, 2005, 2010, and 2015. This memorandum summarizes the methodology RAD used to compile the required data and to produce the population and employment estimates for the ACF Basin. A summary of the resulting estimates RAD developed is also included below.

ACF Basin Population Estimates

RAD utilized census block data to estimate population within the ACF Basin. Census blocks are the smallest unit of geography for which the United States Census Bureau reports data. Census block data were acquired from GeoLytics, a private sector provider of demographic data. GeoLytics utilized census block population from the United States Census Bureau for 2000 and 2010; GeoLytics developed census block population estimates for 1995, 2005 and 2015.

RAD used GIS software to estimate the fraction of the population reflected in the census block data that resides in the ACF Basin. RAD overlaid the 2010 census block geography onto shapefiles of the ACF Basin to identify those census block segments for which any part is located in the ACF Basin area. The "centroid method" was used to assign census blocks to the ACF Basin. Census block segments for which the centroid was located within the ACF Basin boundaries were assigned to the ACF Basin and used in the population estimates; census blocks for which the centroid was outside the ACF Basin boundaries were excluded from the estimates. Population estimates for the entire ACF Basin and for each individual state were then obtained by summing the population of all ACF Basin census blocks.

Table 1 provides a summary of the total population in the ACF basin for Alabama, Florida and Georgia calculated using the GIS methods described above. Table 2 presents the percentage of total population in the ACF basin within each of the three states. For comparison purposes, relative land area in the ACF basin is presented in Tables 3 and 4. Attachment 1 provides population estimates for each of the counties within the ACF Basin based on the GeoLytics data for these same years.

Table 1. Total Population Within the ACF Basin

Year	Alabama	Florida	Georgia	Total ACF Basin Population
1995	195,080	75,405	2,717,731	2,988,216
2000	207,750	80,863	3,046,091	3,334,704
2005	216,662	84,624	3,287,201	3,588,487
2010	225,978	88,505	3,530,442	3,844,925
2015	235,908	90,451	3,839,829	4,166,188

Table 2. Population Percentages Within the ACF Basin

Year	Alabama	Florida	Georgia
1995	6.5%	2.5%	90.9%
2000	6.2%	2.4%	91.3%
2005	6.0%	2.4%	91.6%
2010	5.9%	2.3%	91.8%
2015	5.7%	2.2%	92.2%

Table 3. Land Area within the ACF Basin

	Square Miles within Basin			Percent of Basin's Land Area			
State	Apalachicola Basin	Chattahoochee Basin	Flint Basin	Apalachicola Basin	Chattahoochee Basin	Flint Basin	Total ACF
Alabama	264.96	2565.81	0.00	8.3%	29.5%	0.0%	13.9%
Florida	2884.58	181.48	0.05	90.4%	2.1%	0.0%	15.1%
Georgia	41.47	5959.61	8454.63	1.3%	68.4%	100.0%	71.0%
Total	3191.01	8706.90	8454.68	100%	100%	100%	100.0%

Table 4. Metropolitan North Georgia Water Planning District
Land Area within the ACF Basin (square miles)

County Name	Land Area in Chattahoochee Basin	Land Area in Flint Basin	Total Land Area in ACF Basin
Bartow County, Georgia	0.00	0.00	0.00
Cherokee County, Georgia	1.65	0.00	1.65
Clayton County, Georgia	0.14	85.75	85.89
Cobb County, Georgia	232.36	0.00	232.36
Coweta County, Georgia	243.36	202.41	445.76
DeKalb County, Georgia	84.41	0.00	84.41
Douglas County, Georgia	201.00	0.00	201.00
Fayette County, Georgia	0.00	199.29	199.29
Forsyth County, Georgia	175.14	0.00	175.14
Fulton County, Georgia	410.36	47.74	458.10
Gwinnett County, Georgia	113.95	0.00	113.95
Hall County, Georgia	272.54	0.00	272.54
Henry County, Georgia	0.00	20.95364	20.95
Paulding County, Georgia	88.12	0.00	88.12
Rockdale County, Georgia	0.00	0.00	0.00
TOTAL – MNGWPD	**1823.03**	**556.13**	**2379.16**

Employment Estimates

RAD also developed estimates of ACF Basin employment, which includes employment in establishments that are subject to the unemployment insurance tax paid, and would not include self-proprietors such as self-employed agricultural workers. These employment estimates were derived using the United States Bureau of Labor Statistics' Quarterly Census of Employment and Wages (QCEW) and the United States Census Bureau's Quarterly Workforce Indicators (QWI).

QWI data are the only small-area employment data available at the census block level across all three states. Therefore, QWI estimates of employment by census block were used for 2005 and 2010, which are the identified years for which QWI data are available. Estimates of employment in the ACF Basin were derived for years for which QWI data are not available (1995, 2000 and 2015) by scaling state-level QCEW data based on the best available QWI data for a given year. This allowed RAD to maintain a consistent time-series of employment data across the period of analysis.

This was completed using a multi-step process:

1) First, QWI data were used to estimate the employment within the ACF Basin using the census block "centroid method" described above. This analysis was performed for Georgia, Florida, and Alabama, respectively, for the years 2005, 2010 and 2014.

2) The calculated total basin employment was then divided by the total QWI employment for each the three states during these same years. This produced a percentage of employment within the basin for each of the three states, thus representing each state's "employment share" in 2005, 2010, and 2014, respectively.

3) Each state's "employment share" was then multiplied by the total QCEW employment for that state to estimate ACF Basin employment for the suite of requested years. The shares derived from QWI data were then used to estimate employment during the relevant period as follows:

   a. The 2005 QWI employment share was utilized for 1995, 2000 and 2005.

   b. The 2010 QWI employment share was utilized for 2010.

   c. The 2014 QWI employment share was utilized for 2015.

Total employment estimates from QWI and QCEW were compared for the requested years to validate this employment share method. Across all three states, total employment for the three subject years ranged from 4% different (2005) to 0.4% different (2014).

Table 5 provides a summary of the total employment in the ACF Basin for Alabama, Florida and Georgia. Table 6 presents the percentage of total employment in the ACF Basin within each of the three states.

Table 5. Total Employment Within the ACF Basin

Year	Alabama	Florida	Georgia	Total ACF Basin Population
1995	61,262	20,277	1,611,195	1,692,734
2000	65,647	24,016	1,888,507	1,978,170
2005	66,072	26,100	1,891,409	1,983,581
2010	61,989	24,793	1,836,176	1,922,958
2015	60,300	25,867	2,057,639	2,143,806

Table 6. Employment Percentages Within the ACF Basin

Year	Alabama	Florida	Georgia
1995	3.6%	1.2%	95.2%
2000	3.3%	1.2%	95.5%
2005	3.3%	1.3%	95.4%
2010	3.2%	1.3%	95.5%
2015	2.8%	1.2%	96.0%

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Attachment 1

GeoLytics Population Estimates for the ACF Basin

	1995		
State and County	**Inside ACF Basin**	**Outside ACF Basin**	**Grand Total**
Alabama	**195080**	**249504**	**444584**
Barbour County, Alabama	17376	9794	27170
Bullock County, Alabama	801	10490	11291
Chambers County, Alabama	30052	6626	36678
Dale County, Alabama		49283	49283
Geneva County, Alabama	242	24391	24633
Henry County, Alabama	11641	4163	15804
Houston County, Alabama	46666	38284	84950
Lee County, Alabama	35954	65194	101148
Macon County, Alabama	349	24085	24434
Randolph County, Alabama	3899	17177	21076
Russell County, Alabama	48100	17	48117
Florida	**75405**	**208574**	**283979**
Bay County, Florida	627	136830	137457
Calhoun County, Florida	11942	27	11969
Franklin County, Florida	9115	824	9939
Gadsden County, Florida	7045	35976	43021
Gulf County, Florida	5521	6866	12387
Jackson County, Florida	38594	5425	44019
Liberty County, Florida	2103	4168	6271
Washington County, Florida	458	18458	18916

	1995		
State and County	**Inside ACF Basin**	**Outside ACF Basin**	**Grand Total**
Georgia	**2717731**	**1703754**	**4421485**
Baker County, Georgia	3810		3810
Banks County, Georgia	148	12147	12295
Calhoun County, Georgia	5643		5643
Carroll County, Georgia	20045	59252	79297
Chattahoochee County, Georgia	15883		15883
Cherokee County, Georgia	337	115659	115996
Clay County, Georgia	3356		3356
Clayton County, Georgia	137892	71265	209157
Cobb County, Georgia	395032	132565	527597
Colquitt County, Georgia	142	39131	39273
Coweta County, Georgia	71427		71427
Crawford County, Georgia	4840	5897	10737
Crisp County, Georgia	19258	1689	20947
Dawson County, Georgia	3260	9381	12641
Decatur County, Georgia	21838	4974	26812
DeKalb County, Georgia	252877	353096	605973
Dooly County, Georgia	6846	3840	10686
Dougherty County, Georgia	96175		96175
Douglas County, Georgia	81703		81703
Early County, Georgia	12079		12079
Fayette County, Georgia	76833		76833
Forsyth County, Georgia	55540	15666	71206
Fulton County, Georgia	616330	115836	732166
Grady County, Georgia	843	21077	21920
Gwinnett County, Georgia	106851	363757	470608
Habersham County, Georgia	29761	1916	31677
Hall County, Georgia	82217	35138	117355
Harris County, Georgia	20692		20692
Heard County, Georgia	9391	417	9808
Henry County, Georgia	3624	85448	89072
Houston County, Georgia	72	99793	99865
Lamar County, Georgia	4044	10405	14449
Lee County, Georgia	20476		20476
Lumpkin County, Georgia	14882	2867	17749
Macon County, Georgia	12836	721	13557
Marion County, Georgia	6336		6336
Meriwether County, Georgia	22428		22428
Miller County, Georgia	6324		6324
Mitchell County, Georgia	17761	4337	22098
Monroe County, Georgia	257	19134	19391
Muscogee County, Georgia	182737		182737
Paulding County, Georgia	32537	28955	61492
Peach County, Georgia	130	22279	22409

	1995		
State and County	**Inside ACF Basin**	**Outside ACF Basin**	**Grand Total**
Georgia (continued)			
Pike County, Georgia	11921		11921
Quitman County, Georgia	2394		2394
Randolph County, Georgia	7883		7883
Schley County, Georgia	3667		3667
Seminole County, Georgia	9170		9170
Spalding County, Georgia	34011	22414	56425
Stewart County, Georgia	5419		5419
Sumter County, Georgia	31668		31668
Talbot County, Georgia	6478		6478
Taylor County, Georgia	8216		8216
Terrell County, Georgia	10800		10800
Towns County, Georgia	2	8006	8008
Troup County, Georgia	57099		57099
Turner County, Georgia	79	9001	9080
Union County, Georgia	70	14522	14592
Upson County, Georgia	26812	144	26956
Webster County, Georgia	2301		2301
White County, Georgia	16461		16461
Worth County, Georgia	7787	13025	20812

	2000		
State and County	**Inside ACF Basin**	**Outside ACF Basin**	**Grand Total**
Alabama	**207750**	**260815**	**468565**
Barbour County, Alabama	18250	10788	29038
Bullock County, Alabama	785	10840	11625
Chambers County, Alabama	29950	6630	36580
Dale County, Alabama		49129	49129
Geneva County, Alabama	267	25501	25768
Henry County, Alabama	12109	4201	16310
Houston County, Alabama	47880	40904	88784
Lee County, Alabama	44603	70562	115165
Macon County, Alabama	352	23748	24100
Randolph County, Alabama	3882	18501	22383
Russell County, Alabama	49672	11	49683
Florida	**80863**	**224596**	**305459**
Bay County, Florida	800	147417	148217
Calhoun County, Florida	13000	17	13017
Franklin County, Florida	9657	1400	11057
Gadsden County, Florida	6693	38394	45087
Gulf County, Florida	6534	6798	13332
Jackson County, Florida	41268	5485	46753
Liberty County, Florida	2407	4614	7021
Washington County, Florida	504	20471	20975

	2000		
State and County	**Inside ACF Basin**	**Outside ACF Basin**	**Grand Total**
Georgia	**3046091**	**1992530**	**5038621**
Baker County, Georgia	4074		4074
Banks County, Georgia	166	14242	14408
Calhoun County, Georgia	6320		6320
Carroll County, Georgia	23044	64224	87268
Chattahoochee County, Georgia	14882		14882
Cherokee County, Georgia	426	141497	141923
Clay County, Georgia	3357		3357
Clayton County, Georgia	155214	81303	236517
Cobb County, Georgia	442056	165697	607753
Colquitt County, Georgia	159	41887	42046
Coweta County, Georgia	89215		89215
Crawford County, Georgia	5240	7255	12495
Crisp County, Georgia	20152	1844	21996
Dawson County, Georgia	4374	11613	15987
Decatur County, Georgia	23195	5044	28239
DeKalb County, Georgia	276579	389262	665841
Dooly County, Georgia	7186	4338	11524
Dougherty County, Georgia	96065		96065
Douglas County, Georgia	92331		92331
Early County, Georgia	12354		12354
Fayette County, Georgia	91263		91263
Forsyth County, Georgia	78137	20254	98391
Fulton County, Georgia	691623	124397	816020
Grady County, Georgia	912	22748	23660
Gwinnett County, Georgia	138725	449733	588458
Habersham County, Georgia	33758	2149	35907
Hall County, Georgia	94571	44733	139304
Harris County, Georgia	23694		23694
Heard County, Georgia	10566	446	11012
Henry County, Georgia	3980	115439	119419
Houston County, Georgia	97	110668	110765
Lamar County, Georgia	4421	11491	15912
Lee County, Georgia	24757		24757
Lumpkin County, Georgia	17476	3504	20980
Macon County, Georgia	13314	759	14073
Marion County, Georgia	7144		7144
Meriwether County, Georgia	22534		22534
Miller County, Georgia	6383		6383
Mitchell County, Georgia	19530	4402	23932
Monroe County, Georgia	243	21515	21758
Muscogee County, Georgia	186291		186291
Paulding County, Georgia	44939	36576	81515
Peach County, Georgia	126	23543	23669

	2000		
State and County	**Inside ACF Basin**	**Outside ACF Basin**	**Grand Total**
Georgia (continued)			
Pike County, Georgia	13688		13688
Quitman County, Georgia	2598		2598
Randolph County, Georgia	7791		7791
Schley County, Georgia	3766		3766
Seminole County, Georgia	9369		9369
Spalding County, Georgia	35922	22498	58420
Stewart County, Georgia	5252		5252
Sumter County, Georgia	33200		33200
Talbot County, Georgia	6499		6499
Taylor County, Georgia	8816		8816
Terrell County, Georgia	10970		10970
Towns County, Georgia	5	9314	9319
Troup County, Georgia	58779		58779
Turner County, Georgia	97	9407	9504
Union County, Georgia	85	17212	17297
Upson County, Georgia	27441	156	27597
Webster County, Georgia	2390		2390
White County, Georgia	19956		19956
Worth County, Georgia	8594	13380	21974

	2005		
State and County	**Inside ACF Basin**	**Outside ACF Basin**	**Grand Total**
Alabama	**216662**	**270097**	**486759**
Barbour County, Alabama	17588	10614	28202
Bullock County, Alabama	714	10531	11245
Chambers County, Alabama	28950	6400	35350
Dale County, Alabama		49605	49605
Geneva County, Alabama	335	25887	26222
Henry County, Alabama	12536	4240	16776
Houston County, Alabama	50825	44262	95087
Lee County, Alabama	50347	77316	127663
Macon County, Alabama	324	22407	22731
Randolph County, Alabama	3780	18828	22608
Russell County, Alabama	51263	7	51270
Florida	**84624**	**237974**	**322598**
Bay County, Florida	849	157546	158395
Calhoun County, Florida	13763	39	13802
Franklin County, Florida	10479	793	11272
Gadsden County, Florida	6901	38791	45692
Gulf County, Florida	7888	6707	14595
Jackson County, Florida	41683	6559	48242
Liberty County, Florida	2538	5148	7686
Washington County, Florida	523	22391	22914

	2005		
State and County	**Inside ACF Basin**	**Outside ACF Basin**	**Grand Total**
Georgia	**3287201**	**2258807**	**5546008**
Baker County, Georgia	3754		3754
Banks County, Georgia	215	16190	16405
Calhoun County, Georgia	6502		6502
Carroll County, Georgia	27148	71710	98858
Chattahoochee County, Georgia	13060		13060
Cherokee County, Georgia	433	177673	178106
Clay County, Georgia	3254		3254
Clayton County, Georgia	161167	86782	247949
Cobb County, Georgia	461028	186788	647816
Colquitt County, Georgia	176	43530	43706
Coweta County, Georgia	108204		108204
Crawford County, Georgia	5203	7347	12550
Crisp County, Georgia	20646	2075	22721
Dawson County, Georgia	4997	14130	19127
Decatur County, Georgia	23442	4565	28007
DeKalb County, Georgia	284693	394118	678811
Dooly County, Georgia	8141	5048	13189
Dougherty County, Georgia	95278		95278
Douglas County, Georgia	112359		112359
Early County, Georgia	11656		11656
Fayette County, Georgia	98876		98876
Forsyth County, Georgia	109032	27877	136909
Fulton County, Georgia	744750	123404	868154
Grady County, Georgia	911	23346	24257
Gwinnett County, Georgia	163737	533086	696823
Habersham County, Georgia	37195	2261	39456
Hall County, Georgia	104210	55216	159426
Harris County, Georgia	27820		27820
Heard County, Georgia	10931	485	11416
Henry County, Georgia	5548	156079	161627
Houston County, Georgia	86	125163	125249
Lamar County, Georgia	4565	12520	17085
Lee County, Georgia	26514		26514
Lumpkin County, Georgia	20364	5104	25468
Macon County, Georgia	13602	783	14385
Marion County, Georgia	7925		7925
Meriwether County, Georgia	22230		22230
Miller County, Georgia	6242		6242
Mitchell County, Georgia	19222	4464	23686
Monroe County, Georgia	227	23853	24080
Muscogee County, Georgia	188058		188058
Paulding County, Georgia	56815	55060	111875
Peach County, Georgia	120	25556	25676

	2005		
State and County	**Inside ACF Basin**	**Outside ACF Basin**	**Grand Total**
Georgia (continued)			
Pike County, Georgia	15760		15760
Quitman County, Georgia	2549		2549
Randolph County, Georgia	7738		7738
Schley County, Georgia	4379		4379
Seminole County, Georgia	9025		9025
Spalding County, Georgia	38247	22987	61234
Stewart County, Georgia	5632		5632
Sumter County, Georgia	32997		32997
Talbot County, Georgia	6664		6664
Taylor County, Georgia	8836		8836
Terrell County, Georgia	10132		10132
Towns County, Georgia	2	9881	9883
Troup County, Georgia	62909		62909
Turner County, Georgia	95	9097	9192
Union County, Georgia	110	19175	19285
Upson County, Georgia	27196	159	27355
Webster County, Georgia	2578		2578
White County, Georgia	23517		23517
Worth County, Georgia	8499	13295	21794

	2010		
State and County	**Inside ACF Basin**	**Outside ACF Basin**	**Grand Total**
Alabama	**225978**	**280057**	**506035**
Barbour County, Alabama	16979	10478	27457
Bullock County, Alabama	649	10265	10914
Chambers County, Alabama	28007	6208	34215
Dale County, Alabama		50251	50251
Geneva County, Alabama	410	26380	26790
Henry County, Alabama	13003	4299	17302
Houston County, Alabama	53884	47663	101547
Lee County, Alabama	56124	84123	140247
Macon County, Alabama	296	21156	21452
Randolph County, Alabama	3682	19231	22913
Russell County, Alabama	52944	3	52947
Florida	**88505**	**251780**	**340285**
Bay County, Florida	896	167956	168852
Calhoun County, Florida	14560	65	14625
Franklin County, Florida	11352	197	11549
Gadsden County, Florida	7126	39263	46389
Gulf County, Florida	9242	6621	15863
Jackson County, Florida	42118	7628	49746
Liberty County, Florida	2671	5694	8365
Washington County, Florida	540	24356	24896

	2010		
State and County	**Inside ACF Basin**	**Outside ACF Basin**	**Grand Total**
Georgia	**3530442**	**2526620**	**6057062**
Baker County, Georgia	3451		3451
Banks County, Georgia	264	18131	18395
Calhoun County, Georgia	6694		6694
Carroll County, Georgia	31279	79248	110527
Chattahoochee County, Georgia	11267		11267
Cherokee County, Georgia	443	213903	214346
Clay County, Georgia	3183		3183
Clayton County, Georgia	167129	92295	259424
Cobb County, Georgia	480124	207954	688078
Colquitt County, Georgia	194	45304	45498
Coweta County, Georgia	127317		127317
Crawford County, Georgia	5192	7438	12630
Crisp County, Georgia	21140	2299	23439
Dawson County, Georgia	5632	16698	22330
Decatur County, Georgia	23742	4100	27842
DeKalb County, Georgia	292832	399061	691893
Dooly County, Georgia	9118	5800	14918
Dougherty County, Georgia	94565		94565
Douglas County, Georgia	132403		132403
Early County, Georgia	11008		11008
Fayette County, Georgia	106567		106567
Forsyth County, Georgia	139987	35524	175511
Fulton County, Georgia	798127	122454	920581
Grady County, Georgia	919	24092	25011
Gwinnett County, Georgia	188760	616561	805321
Habersham County, Georgia	40660	2381	43041
Hall County, Georgia	113943	65741	179684
Harris County, Georgia	32024		32024
Heard County, Georgia	11314	520	11834
Henry County, Georgia	7116	196806	203922
Houston County, Georgia	78	139822	139900
Lamar County, Georgia	4716	13601	18317
Lee County, Georgia	28298		28298
Lumpkin County, Georgia	23255	6711	29966
Macon County, Georgia	13927	813	14740
Marion County, Georgia	8742		8742
Meriwether County, Georgia	21992		21992
Miller County, Georgia	6125		6125
Mitchell County, Georgia	18954	4544	23498
Monroe County, Georgia	217	26207	26424
Muscogee County, Georgia	189885		189885
Paulding County, Georgia	68721	73603	142324
Peach County, Georgia	114	27581	27695

	2010		
State and County	**Inside ACF Basin**	**Outside ACF Basin**	**Grand Total**
Georgia (continued)			
Pike County, Georgia	17869		17869
Quitman County, Georgia	2513		2513
Randolph County, Georgia	7719		7719
Schley County, Georgia	5010		5010
Seminole County, Georgia	8729		8729
Spalding County, Georgia	40594	23479	64073
Stewart County, Georgia	6058		6058
Sumter County, Georgia	32819		32819
Talbot County, Georgia	6865		6865
Taylor County, Georgia	8906		8906
Terrell County, Georgia	9315		9315
Towns County, Georgia	0	10471	10471
Troup County, Georgia	67044		67044
Turner County, Georgia	96	8834	8930
Union County, Georgia	135	21221	21356
Upson County, Georgia	26990	163	27153
Webster County, Georgia	2799		2799
White County, Georgia	27144		27144
Worth County, Georgia	8419	13260	21679

	2015		
State and County	**Inside ACF Basin**	**Outside ACF Basin**	**Grand Total**
Alabama	**235908**	**288031**	**523939**
Barbour County, Alabama	15979	9652	25631
Bullock County, Alabama	610	9438	10048
Chambers County, Alabama	25494	5231	30725
Dale County, Alabama		48976	48976
Geneva County, Alabama	402	24587	24989
Henry County, Alabama	12324	3937	16261
Houston County, Alabama	57769	53267	111036
Lee County, Alabama	63326	95545	158871
Macon County, Alabama	266	19363	19629
Randolph County, Alabama	3541	18033	21574
Russell County, Alabama	56197	2	56199
Florida	**90451**	**261329**	**351780**
Bay County, Florida	824	172327	173151
Calhoun County, Florida	14942	61	15003
Franklin County, Florida	12279	117	12396
Gadsden County, Florida	7245	42144	49389
Gulf County, Florida	8541	5678	14219
Jackson County, Florida	43154	8122	51276
Liberty County, Florida	2860	6019	8879
Washington County, Florida	606	26861	27467

	2015		
State and County	**Inside ACF Basin**	**Outside ACF Basin**	**Grand Total**
Georgia	**3839829**	**2797333**	**6637162**
Baker County, Georgia	2560		2560
Banks County, Georgia	287	19268	19555
Calhoun County, Georgia	6544		6544
Carroll County, Georgia	34166	86357	120523
Chattahoochee County, Georgia	8478		8478
Cherokee County, Georgia	526	259847	260373
Clay County, Georgia	2795		2795
Clayton County, Georgia	172999	93760	266759
Cobb County, Georgia	512353	223465	735818
Colquitt County, Georgia	172	47075	47247
Coweta County, Georgia	150884		150884
Crawford County, Georgia	4698	7301	11999
Crisp County, Georgia	20328	2215	22543
Dawson County, Georgia	6540	19145	25685
Decatur County, Georgia	22891	3686	26577
DeKalb County, Georgia	318627	409058	727685
Dooly County, Georgia	8299	5194	13493
Dougherty County, Georgia	94193		94193
Douglas County, Georgia	152534		152534
Early County, Georgia	8941		8941
Fayette County, Georgia	109457		109457
Forsyth County, Georgia	176153	44278	220431
Fulton County, Georgia	904920	132975	1037895
Grady County, Georgia	828	23335	24163
Gwinnett County, Georgia	213796	714794	928590
Habersham County, Georgia	45318	2598	47916
Hall County, Georgia	131636	80666	212302
Harris County, Georgia	34879		34879
Heard County, Georgia	11156	510	11666
Henry County, Georgia	7952	219572	227524
Houston County, Georgia	75	151027	151102
Lamar County, Georgia	4708	13646	18354
Lee County, Georgia	29622		29622
Lumpkin County, Georgia	25748	7836	33584
Macon County, Georgia	12434	744	13178
Marion County, Georgia	8277		8277
Meriwether County, Georgia	19874		19874
Miller County, Georgia	5364		5364
Mitchell County, Georgia	18677	4178	22855
Monroe County, Georgia	183	27792	27975
Muscogee County, Georgia	189387		189387
Paulding County, Georgia	83848	90775	174623
Peach County, Georgia	112	29510	29622

	2015		
State and County	**Inside ACF Basin**	**Outside ACF Basin**	**Grand Total**
Georgia (continued)			
Pike County, Georgia	19722		19722
Quitman County, Georgia	2414		2414
Randolph County, Georgia	6700		6700
Schley County, Georgia	5489		5489
Seminole County, Georgia	7671		7671
Spalding County, Georgia	42849	24434	67283
Stewart County, Georgia	5192		5192
Sumter County, Georgia	30774		30774
Talbot County, Georgia	5606		5606
Taylor County, Georgia	7705		7705
Terrell County, Georgia	7362		7362
Towns County, Georgia	0	10734	10734
Troup County, Georgia	70775		70775
Turner County, Georgia	67	7049	7116
Union County, Georgia	131	22580	22711
Upson County, Georgia	25055	155	25210
Webster County, Georgia	2371		2371
White County, Georgia	28983		28983
Worth County, Georgia	7744	11774	19518

Attachment B
Self-Supplied Population, Self-Supplied Water Usage and Public Water Supply Calculations

Table B-1
Self-Supplied Population

County	1995[9]	2000	2005	2010	2015
Cherokee	28,836	25,306	21,797	18,718	16,074
Clayton	0	0	0	0	0
Cobb	0	0	0	0	0
Coweta	27,700	25,292	22,893	20,693	18,705
DeKalb	0	0	0	0	0
Douglas	0	0	0	0	0
Fayette	16,741	15,285	13,836	12,506	11,305
Forsyth	14,054	12,334	10,624	9,123	7,834
Fulton	11,160	10,190	9,224	8,337	7,536
Gwinnett	0	0	0	0	0
Hall	39,362	35,939	32,531	29,405	26,580
Henry	19,979	18,242	16,511	14,925	13,491
Paulding	6,696	6,114	5,534	5,002	4,522

[9] Population served by self-supplied groundwater provided by CH2M for 2001-2015 as prepared for the 2016 Metro District Plan update. Population served by self-supplied groundwater estimated for 1995 and 2000 based upon the trendline from 2001-2005 for each county.

Table B-2
Self-Supplied Water Usage
(Average of Baseline Years[10])

County	mgd-AADF
Cherokee	1.20
Clayton	0
Cobb	0
Coweta	1.37
DeKalb	0
Douglas	0
Fayette	0.85
Forsyth	0.78
Fulton	0.64
Gwinnett	0
Hall	1.59
Henry	0.88
Paulding	0.31

[10] Baseline water use includes available data for the years 2010, 2011, 2012 and 2014. Self-supplied water use is the average of water usage over these same four years.

Table B-3
Public Water Supply Calculations

County	Baseline Water Use (AADF)[11]	Self-Supplied Ground-water (AADF)	Public Water Supply (AADF)
Cherokee	19	1.20	17.8
Clayton	24	0.00	24.0
Cobb	70	0.00	70.0
Coweta	13	1.37	11.6
DeKalb	71	0.00	71.0
Douglas	13	0.00	13.0
Fayette	11	0.85	10.1
Forsyth	22	0.78	21.2
Fulton	139	0.64	138.4
Gwinnett	82	0.00	82.0
Hall	20	1.59	18.4
Henry	23	0.88	22.1
Paulding	12	0.31	11.7

[11] Letter from Judson Turner, Director, Georgia Environmental Protection Division, to Col. Chytka, District Commander, Mobile District, U.S. Army Corps of Engineers, regarding Updated Water Demand Projections (September 14, 2015).

Attachment C
Cobb County Analysis

The Cobb County-Marietta Water Authority (CCMWA) withdraws and treats water for Cobb County customers from two water sources – Allatoona Lake and the Chattahoochee River. CCMWA sells this water on a wholesale basis to the Cobb County Water System and several other entities within Cobb County: the City of Austell, the City of Kennesaw, Lockheed Martin, the City of Marietta, the City of Powder Springs, the City of Smyrna and Southern Polytechnic State University (now Kennesaw State University). In addition, CCMWA supplies water – or has historically supplied water – to several wholesale customers outside of Cobb County. These customers are summarized in Table C-1 below along with the water supply source that serves each customer.[12]

Table C-1
CCMWA Wholesale Customers Outside of Cobb County

Wholesale Customer	Water Supply Source
Cherokee County	Allatoona Lake (Wyckoff Water Treatment Plant)
City of Woodstock	Allatoona Lake (Wyckoff Water Treatment Plant)
City of Mountain Park	Chattahoochee River (Quarles Water Treatment Plant)
Douglas County	Chattahoochee River (Quarles Water Treatment Plant)
Fulton County	Allatoona Lake (Wyckoff Water Treatment Plant)
Paulding County	Allatoona Lake (Wyckoff Water Treatment Plant)

Table C-2 provides the total annual withdrawals from each of these water supply sources for the period from 1990-2015, the total water supplied for outside of county sales from each of these water supply sources, the amount of Cobb County sales from each water supply source, the percentage sold from the Chattahoochee River and a five-year average of that percentage.[13]

[12] Information provided by CCMWA included water withdrawn from each facility, water sold to wholesale customers, and information on which plant primarily serves each outside-of-county wholesale customer.

[13] System losses reflecting differences between the amount withdrawn and the amount sold are assumed to occur within Cobb County.

Table C-2
Total CCMWA Withdrawals and Sales from Each Water Supply Source
(in million gallons)

Year	Allatoona Lake (Wyckoff WTP)				Chattahoochee River (Quarles WTP)				
	Total Withdrawals	Outside of County Sales	Sales Inside Cobb County	Percent of Total Cobb County Sales	Total Withdrawals	Outside of County Sales	Sales Inside Cobb County	Percent of Total Cobb County Sales	Five Year Average Cobb County Sales
1991	12,490	2,578	9,912	46%	12,000	357	11,643	54%	
1992	11,982	1,977	10,005	46%	12,377	483	11,894	54%	
1993	14,636	2,226	12,410	51%	12,418	400	12,018	49%	
1994	14,375	2,396	11,979	46%	14,562	692	13,870	54%	
1995	14,938	2,339	12,599	48%	14,116	532	13,584	52%	53%
1996	15,406	2,640	12,766	49%	13,719	183	13,536	51%	
1997	15,719	2,658	13,061	49%	14,042	212	13,830	51%	
1998	17,059	2,844	14,215	49%	15,427	620	14,807	51%	
1999	18,350	2,847	15,503	50%	15,943	693	15,250	50%	
2000	18,296	3,115	15,181	48%	17,085	726	16,359	52%	51%
2001	17,768	2,960	14,808	49%	15,692	87	15,605	51%	
2002	18,218	3,096	15,122	49%	15,844	22	15,822	51%	
2003	17,092	3,192	13,900	48%	15,227	20	15,207	52%	
2004	16,126	3,277	12,849	43%	17,130	19	17,111	57%	
2005	16,213	3,804	12,409	42%	17,153	35	17,118	58%	54%
2006	15,498	4,479	11,019	38%	17,998	99	17,899	62%	
2007	16,834	4,447	12,387	41%	19,056	957	18,099	59%	
2008	12,935	3,871	9,064	36%	15,996	23	15,973	64%	
2009	13,132	4,192	8,940	36%	15,900	28	15,872	64%	
2010	14,644	4,307	10,338	40%	15,802	22	15,780	60%	62%
2011	13,969	4,221	9,747	37%	16,488	60	16,428	63%	
2012	12,371	4,305	8,067	31%	18,062	202	17,860	69%	
2013	11,189	4,094	7,095	30%	16,472	16	16,457	70%	
2014	13,432	4,191	9,241	37%	15,566	85	15,481	63%	
2015	14,074	4,336	9,738	39%	15,425	23	15,402	61%	65%

Attachment D
2015 Population Comparisons

County	Total County Population	Population that Lives within the ACF Basin	Population Dependent on ACF Basin Surface Water Supply Sources	Difference vs Population that Lives within the ACF Basin
Cherokee	260,373	526	0	*-526*
Clayton	266,759	172,999	266,537	*93,538*
Cobb	735,818	512,353	478,282	*-34,071*
Coweta	150,884	150,884	130,360	*-20,524*
DeKalb	727,685	318,627	727,685	*409,058*
Douglas	152,534	152,534	146,855	*-5,679*
Fayette	109,457	109,457	91,962	*-17,495*
Forsyth	220,431	176,153	212,597	*36,444*
Fulton	1,037,895	904,920	1,029,539	*124,619*
Gwinnett	928,590	213,796	923,494	*709,698*
Hall	212,302	131,636	176,978	*45,342*
Henry	227,524	7,952	0	*-7,952*
Paulding	174,623	83,848	0	*-83,848*
TOTAL	**5,204,875**	**2,935,685**	**4,184,289**	***1,248,604***

Exhibit 45

State of Florida v. State of Georgia
No. 142 Original

Expert Report of

PETER MAYER, P.E.

May 20, 2016

24. The expert reports of Drs. Dracup, Flewelling, and Sunding suggest that Georgia's management and stewardship of water resources in the ACF Basin has been inadequate, that municipal and industrial water use is not properly reported in Georgia, and that municipal and industrial water use should be further reduced through a variety of measures in order to benefit downstream flows in Florida. Contrary to the conclusions in the Florida Reports, however, Georgia is a good steward of water resources in the ACF Basin and its use of water for municipal and industrial purposes is reasonable and efficient.

2. Georgia's municipal and industrial water use in the ACF Basin is reasonable, responsible and efficient.

2.1. The Flewelling Report erroneously relies on comparisons of the total volume and relative share of each state's respective water use in the ACF Basin.

25. The Flewelling Report cites the total volume and the relative share of water used in Georgia's portion of the ACF Basin in comparison to Florida (and Alabama).[14] For example, Dr. Flewelling reports that Georgia is the "dominant consumer of water in the basin," and that "Georgia accounted for over 90% of the total non-thermoelectric water use."[15] From this, Dr. Flewelling appears to suggest that Georgia's use is somehow unreasonable or inequitable simply because it is larger.

26. Dr. Flewelling's superficial observations shed no light on whether Georgia's municipal and industrial water use is reasonable or efficient. The population within the ACF Basin is overwhelmingly located in Georgia. As of 2015, fully 92.2 percent of the ACF Basin's population resided in Georgia, while just 2.2 percent resided in Florida.[16] To put this in perspective, the population of Fulton County that depends on the ACF Basin for water supply — which is just one county in the 15-county Metro Water District — is about 11.4 times larger than the population of the entire State of Florida within the ACF Basin. More broadly, almost 5.1 million citizens in Georgia rely on the ACF Basin daily for water supply, while just 90,000 people reside in the ACF Basin in Florida.[17]

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[14] Flewelling Report, at p. 32.

[15] Flewelling Report, at p. S-1.

[16] Apr. 29, 2016 Memorandum from K. Zitsch to J. Turner re: Chattahoochee-Flint River Basin Population Served at Attachment A, p. 2.

[17] Apr. 29, 2016 Memorandum from K. Zitsch to J. Turner re: Chattahoochee-Flint River Basin Population Served at Attachment A, p. 2.

27. Economic activity in the ACF Basin is also overwhelmingly located in Georgia. In 2015, for example, Georgia accounted for 96 percent of the non-farm employment in the ACF Basin. In contrast, only 1.2 percent of the ACF Basin's non-farm employment is in Florida.[18]

28. Given the distribution of population and employment in the ACF Basin, it is not surprising that Georgia is the largest water user in the ACF Basin. Any scientifically valid comparison of relative water uses, therefore, must be standardized to account for such a disproportionate distribution of population and economic activity. Dr. Flewelling's failure to do so, and his reliance instead on coarse and non-standardized comparisons using values such as the total amount of water withdrawn or the relative amounts of water used in each state, are unreliable and of no value in evaluating the reasonableness of Georgia's water use or its value relative to water uses in Florida.

2.2. Per capita water use in Georgia is lower than per capita water use in northern Florida.

29. The Florida Reports criticize water reporting and management in Georgia, but offer no useful comparisons or evaluations of the reasonableness or efficiency of Georgia's use. It is possible to draw meaningful conclusions about the reasonableness and efficiency of municipal and industrial water use in Georgia, however, by comparing the intensity of the water use in Georgia against similarly situated regions in Florida on a daily per capita basis.

30. Using a standard method to calculate per capita use adopted by the State of Florida, per capita water use in the Metro Water District was compared to two reasonably similar water management districts in northern Florida: (a) the Northwest Florida Water Management District, which covers Tallahassee and includes Florida's portion of the ACF Basin; and (b) the St. Johns River Water Management District, which borders Georgia and includes the City of Jacksonville, Florida, the largest metropolitan area in North Florida. [19]

31. This analysis shows that per capita water use in the Metro Water District has been consistently lower than both of the water management districts in Florida. Furthermore, per capita water use in the Metro Water District has declined at a faster rate than in either of the Florida water management districts.

32. As shown in Figure 3, per capita water use in the Metro Water District was lower than either Florida water management district in every year from 2000 – 2013 for which

[18]Apr. 29, 2016 Memorandum from K. Zitsch to J. Turner re: Chattahoochee-Flint River Basin Population Served at Attachment A, p. 2.

[19] Further details regarding the methods applied in this analysis are attached as Appendix A. It is important to note that there are multiple valid methods for calculating per capita water use. Because I have applied the method adopted by the State of Florida to ensure a valid comparison between the water management districts, the calculated per capita water use for the Metro Water District in this report may differ from values included in other reports.

comparable data are available.[20] Over this 14-year period, Metro Water District average per capita use was 126 gpcd, while the average in the Northwest Florida Water Management District (which includes Florida's portion of the ACF Basin) was 144 gpcd, and the average in the St. Johns River Basin was 149 gpcd. In 2013, the final year of the analysis, gross per capita water use in the Metro Water District was 98 gpcd.[21] By comparison, per capita use in 2013 the Northwest Florida Water Management District was 132 gpcd and 126 gpcd in the St. Johns River Water Management District, approximately 30-percent higher than in the Metro Water District in Georgia.

33. Furthermore, as can also be seen in Figure 3, per capita use across all three districts was reasonably similar at the outset of the period, differing by approximately 9 and 13 gpcd, respectively. Over the period of comparison, however, per capita water use in the Metro Water District declined at a steeper rate than per capita water use in either the Northwest Florida Water Management District or the St. Johns River Water Management District. Thus, at the end of the period, the difference in per capita water use in the Metro Water District and the St. Johns River Water Management District had more than doubled to 28 gpcd. The difference between the Metro Water District and the Northwest Florida Water Management District had grown by an even larger amount, increasing from 9 gpcd to 34 gpcd.

[20] In contrast to the St. Johns River Water Management District, the Northwest Florida Water Management District failed to report per capita use information in many years between 2000 and 2010. The dashed line in Figure 3 represents years in which the Northwest Florida Water Management District failed to make data publicly available.

[21] As discussed below, Dr. Dracup acknowledged in his deposition that "something below a hundred gallons per capita per day" would be indicative that "water conservation measures are being appropriately implemented." (Dracup Dep. at 132:12-18.)

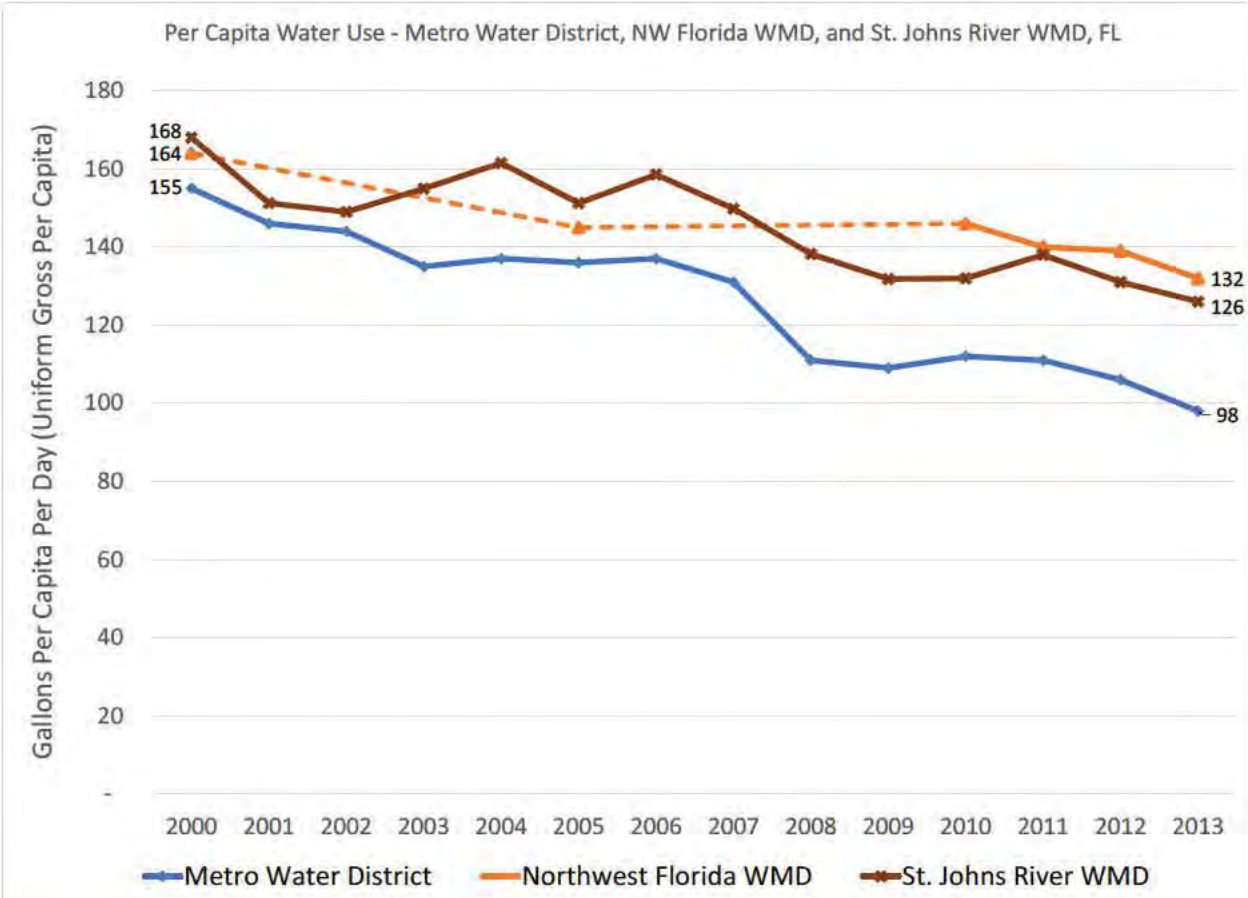

Figure 3: Per Capita Water Use – Metro Water District (GA), and Northwest Florida and St. Johns River Water Management Districts (FL)

34. In comparison with these Florida water management districts, the Metro Water District's use of municipal and industrial water in the ACF Basin is reasonable and efficient.

2.3. Georgia's *total* consumptive use of water from the ACF Basin for municipal and industrial purposes has not increased over the past 20 years.

35. Florida's complaint in this case alleges that "[l]arge, and ever-increasing, amounts of water" are "consumed upstream for municipal [and] industrial" purposes in Georgia.[22] However, an analysis of Georgia's municipal and industrial water use over the past two decades shows that this is incorrect. In fact, Georgia's overall municipal and industrial water consumption has remained essentially stable since 1994, despite the substantial growth in population Georgia has experienced.[23]

[22] Florida Complaint at p. 3.

[23] Florida's complaint makes reference to 1992 levels of consumptive use. In preparing my report, I carefully reviewed Georgia's consumptive use database and have concluded that the data prior to 1994 are incomplete and

permitting only the sale of high-efficiency toilets and fixtures,[29] thus ensuring all new construction — and eventually all buildings in Georgia — will be equipped with high performing, high-efficiency fixtures.

54. My opinion is consistent with other recent, independent assessments of Georgia's water conservation and planning efforts as compared to other states, including the State of Florida. For example, Georgia ranked very high — and substantially above Florida — in a 2012 report on water efficiency by the Alliance for Water Efficiency and the Environmental Law Institute.[30] This report was prepared to "identify and assess state-level laws and policies related to water efficiency and conservation" in an effort to "bring attention to exemplary policies that may be used as models for other states to emulate."[31] Of the 50 states evaluated, Georgia tied for fourth in the nation, behind only the arid states of Texas, California, and Arizona. The State of Florida, in contrast, received a "C grade" and tied for nineteenth in the country. [32]

55. Similarly, a recent report by the US Environmental Protection Agency and the Water Research Foundation entitled, *"Water Audits in the United States: A Review of Water Losses and Data Validity,"*[33] confirmed that Georgia is a national leader in the area of universal water loss auditing of public water systems. Indeed, that report found that Georgia was one of only 5 entities in the nation that required water loss audits in accordance with the American Water Works Association/International Water Association Water Loss Audit standards.[34] Furthermore, Georgia was the only state to require that its water audits be validated by a third party, and, due in part to its training programs, it had the highest data quality of any of the entities.[35] In contrast, Florida does not require water audits in accordance with American Water Works Association's best practices, and it is not mentioned in the Water Research Foundation report.

56. Information on Georgia's significant water conservation and water planning actions is summarized below to convey the scope and effectiveness of Georgia's efforts and to respond to suggestions in the Florida Reports that Georgia's efforts are lacking. Additional

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[29] 2010 Water Stewardship Act, S.B. 370.

[30] The Water Efficiency and Conservation State Scorecard: An Assessment of Laws and Policies, available at http://www.allianceforwaterefficiency.org/WorkArea/linkit.aspx?LinkIdentifier=id&ItemID=8306

[31] The Water Efficiency and Conservation State Scorecard: An Assessment of Laws and Policies at p. 4.

[32] The Water Efficiency and Conservation State Scorecard: An Assessment of Laws and Policies at p. 16.

[33] Sturm, R., K. Gasner, and L. Andrews, 2015, *Water Audits in the United States: A Review of Water Losses and Data Validity,* Water Research Foundation and the US Environmental Protection Agency, Report #4372b, ISBN 978-1-60573-224-4, available at http://waterrf.org/PublicReportLibrary/4372b.pdf

[34] Water Audits in the United States: A Review of Water Losses and Data Validity, at p. xix, 35. For example, audits in the State of California were excluded based on data quality considerations at more than twice the rate of audits in Georgia.

[35] Water Audits in the United States: A Review of Water Losses and Data Validity, at p. 35.

3.5.1. Indirect Potable Reuse Projects.

149. Dr. Dracup opines that Georgia should consider utilizing "indirect potable reuse" as a means to expand municipal and industrial water supplies in metropolitan Atlanta. This opinion is puzzling for at least two reasons.

150. First, any method of water reuse (e.g. indirect, direct potable, or non-potable) would not increase downstream flows to Florida. Indirect potable reuse is a technique whereby highly treated wastewater is returned to a water supply source so that it can be withdrawn and used again in the future. As applied in metropolitan Atlanta, this means taking highly treated wastewater that would have been returned to the Chattahoochee River and that would have otherwise flowed downstream to Florida, and directing those returns upstream of Atlanta for reuse.

151. While indirect potable reuse can be an important strategy to address local water supply needs, it does nothing to increase the amount of water that Florida would receive. This is because it does not change the ultimate water supply needs of the metropolitan Atlanta area – it merely diverts water that is returned and flows downstream today, and uses that water to meet water supply needs in the region. Although reservoir storage may increase with the return flows, the same levels of withdrawals are still occurring. As a result, reservoir releases must instead be made to "replace" the return flows that would otherwise flow downstream.

152. Second, Dr. Dracup is apparently unaware that indirect potable reuse has been an important aspect of the Metro Water District's water supply and water conservation planning since the first plan was issued in 2003. It is therefore not surprising that indirect potable reuse is already practiced in metropolitan Atlanta on a very large scale. For example, Gwinnett County is widely recognized as a national leader in water reuse. It has spent more than $1 billion to construct and operate the F. Wayne Hill Water Resources Center, which is a state-of-the-art water reclamation facility that returns highly treated wastewater to Lake Lanier for indirect potable reuse.[124] The facility is currently permitted by the State of Georgia to return 40 MGD to Lake Lanier, and this amount is projected to increase to 60 MGD by 2050.[125]

153. There are many other indirect potable reuse examples across the Metro Water District. The City of Gainesville returns treated wastewater to Lake Lanier, which is the primary

[124] Nov. 12, 2009 Summary of Water Conservation, Mgmt., and Efficiency Projects (GWNT-DWR0012553) at 5. Gwinnett County also incurs substantial also costs to operate this facility because it requires Gwinnett County to pump treated wastewater uphill so that it can be discharged to Lake Lanier for reuse.

[125] Comments on Draft Environmental Impact Statement: Update of the Water Control Manual for the Apalachicola-Chattahoochee-Flint River Basin in Alabama, Florida, and Georgia and a Water Supply Storage Assessment dated Jan. 30, 2016, available at www.atlantaregional.com/File%20Library/Environment/Tri-State%20Water%20Wars/Water-Supply-Providers-Comments---Final.pdf

177. In his deposition, Dr. Dracup conceded that he did not do any work to analyze the environmental impacts, evaporative losses, construction time, and impact on flows at the Georgia/Florida border of any of the reservoir projects discussed in his report. At the same time, it has been estimated these small reservoir projects (Glades Farm, Dog River, South Fulton Bear Creek) could cost Georgia from $2.63 billion to $4.74 billion in 2010 dollars over the lifetime of the projects.[151]

178. In conclusion, none of these projects would materially reduce impacts to Florida, and their construction would do little if anything to address the harms Florida has asserted. The criticisms in the Florida Reports regarding Georgia's failure to construct these projects are accordingly misplaced.

3.5.5. Water Conservation.

179. Dr. Dracup states, "A robust conservation program is a reasonable conservation measure that should be implemented by the Metro North Georgia Water Planning District."[152] As I describe, however, the Metro Water District and the State of Georgia have already adopted a comprehensive suite of water conservation and efficiency measures, which they continue to refine and improve.

180. As noted above, the Metro Water District released its first Water Supply and Conservation plan in 2003, requiring Metro Water District utilities to implement a conservation program that included an array of water efficiency and conservation measures. These measures were supplemented with the release of the first update to the Water Supply and Conservation Plan (2009) as well as with subsequent conservation measure amendments in December 2010.

181. The suite of water efficiency and conservation measures includes 14 specific requirements that must be implemented by all utilities within the Metro Water District:[153]

- Conservation Pricing
- Replacing Older, Inefficient Plumbing Fixtures
- Pre-rinse spray valve retrofit education program
- Rain Sensor Shut-Off Switches on New Irrigation Systems
- Requiring Sub-Meters in New Multi-Family Buildings
- Assessing and reducing water system leakage
- Conducting Residential Water Audits
- Low-flow retrofit kits for residential users
- Conducting Commercial Water Audits

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[151] 2009 Task Force Report, Appendix III.

[152] Dracup Report, p. 8.

[153] May 2009 Water Supply and Water Conservation Management Plan at ES-6, 5-1 to 5-21.

- Implementing Education and Public Awareness Plan
- Installing High Efficiency Toilets and High Efficiency Urinals in Government Buildings
- Requiring New Car Washes to Recycle Water
- Implementing a Water Waste Policy to reduce outdoor water waste
- High efficiency plumbing fixtures consistent with state legislation

182. It also includes five additional measures that must be implement by utilities within the Metro Water District that withdraw water from the Chattahoochee River or Lake Lanier within the ACF system:[154]

- Expediting existing programs to identify and reduce both real and apparent water losses
- Multi-Family High-Efficiency Toilet Rebates
- Installing Meters with Point of Use Leak Detection
- Requiring private fire lines to be metered
- Maintaining a Water Conservation Program

183. The Metro Water District's 2009 planning effort was followed by passage of the 2010 Georgia Water Stewardship Act. As discussed in Section 2.1.4.3, this groundbreaking legislation imposed a suite of water conservation and efficiency measures, including mandatory outdoor landscape irrigation restrictions, low-flow fixture requirements, and mandatory water loss audits by water providers. This is one of the most progressive examples of statewide water conservation legislation anywhere in the United States. As I also discuss in Sections 2.4 and 3.6, Georgia has required water rate reform to increase the use of conservation pricing, and committed significant financial resources to water supply, water conservation, and water loss reduction efforts.

184. Dr. Dracup fails to analyze or evaluate any of these efforts. Dr. Dracup fails to mention that the Metro Water District maintains one of the strongest suites of mandatory water conservation measures of any region in the nation. He provides no specifics regarding additional water conservation measures that he believes the Metro Water District or the State of Georgia should adopt. And he does not analyze either the water savings that could be achieved through these additional unnamed conservation measures or the cost of their implementation.

185. In his deposition, however, Dr. Dracup conceded that metropolitan Atlanta has a comprehensive and effectively implemented water conservation and efficiency program. Dr. Dracup identified per capita water use as an appropriate metric of the effectiveness of conservation and efficiency measures. When asked what level of per capita water use

[154] Amendments to the Water Supply and Water Conservation Management Plan. This includes all of the water systems in Cobb, DeKalb, Forsyth, Gwinnett, and Hall Counties and those systems in Fulton County except for the cities of Palmetto, College Park, and East Point.

3.6. Expanded Use of Conservation Pricing.

190. Dr. Sunding underestimates the prevalence of conservation pricing and tiered block rates, and incorrectly suggests that utilities in the Georgia ACF Basin should achieve additional water savings through increased use of these measures. In fact, 100% of customers within the Metro Water District and over 90% of customers in the entire ACF Basin are served by utilities with increasing block rate structures. Therefore, Dr. Sunding has also overstated the feasibility of significant additional savings through the implementation of conservation pricing.

191. Relying on survey data from the University of North Carolina, Dr. Sunding estimates that only 44% (2011) and 50% (2013) of water utilities in the ACF used an increasing block rate.[159] He further estimates that, within the Metro Water District, only 83% (2011) and 86% (2013) used an increasing block rate structure, while the remaining providers in each of the years used a uniform rate.

192. I have reviewed the survey data Dr. Sunding considered. Contrary to Dr. Sunding's conclusions, however, the data show that 100% of the systems in the Metro Water District in the ACF Basin used an increasing block rate structure in 2011 and 2013. I do not understand how Dr. Sunding came to his conclusion based on the data available, but his opinions regarding the number of systems in the ACF that use conservation pricing are incorrect.

193. More importantly, it appears that Dr. Sunding uses an improper metric for evaluating the prevalence of conservation pricing in the Georgia ACF Basin. Dr. Sunding considers only the raw number of systems that utilize conservation pricing, without regard to their size or how many people they serve. This creates an incorrect impression that conservation pricing is underused in Georgia, and that there are significant opportunities to expand the practice to achieve substantial water savings. Neither is correct.

194. Table 3 relies on the same data used by Dr. Sunding, but provides a much more accurate picture concerning the use of conservation pricing in the Georgia ACF Basin. As can be seen, 100% of the residential customers in the Metro Water District are served by water providers that utilize conservation pricing. Likewise, more than 90% of the residential customers in the whole of the Georgia ACF Basin are served by water providers that utilize conservation pricing. Further, under the 2015 Drought Management Rule, those public water systems in Georgia with retail customers that do not already impose conservation pricing must develop a drought surcharge program by August 4, 2016 as a temporary price incentive for customers to reduce water demand during a declared drought.[160]

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[159] Sunding Report, p. 67.

[160] Ga. Comp. R & regs. 391-3-30-.07(4)(d).

Exhibit 46

State of Florida v. State of Georgia,
No. 142, Original

Expert Report of
SUAT IRMAK, PH.D.

Prepared for:
The State of Georgia

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greater than the non-irrigated soybean grain yields in 1988, 1998, 2002, 2008, and 2012, respectively.

It is important to note that these are statewide average yields, and thus include crop production from regions with heavy deep fine-textured soils that require far less irrigation than those soils found in the Flint River Basin. Therefore, the irrigated and non-irrigated yield differences in the Flint River Basin for these four major crops would be expected to be much greater than those reported in Figure 3 and Figure 4.

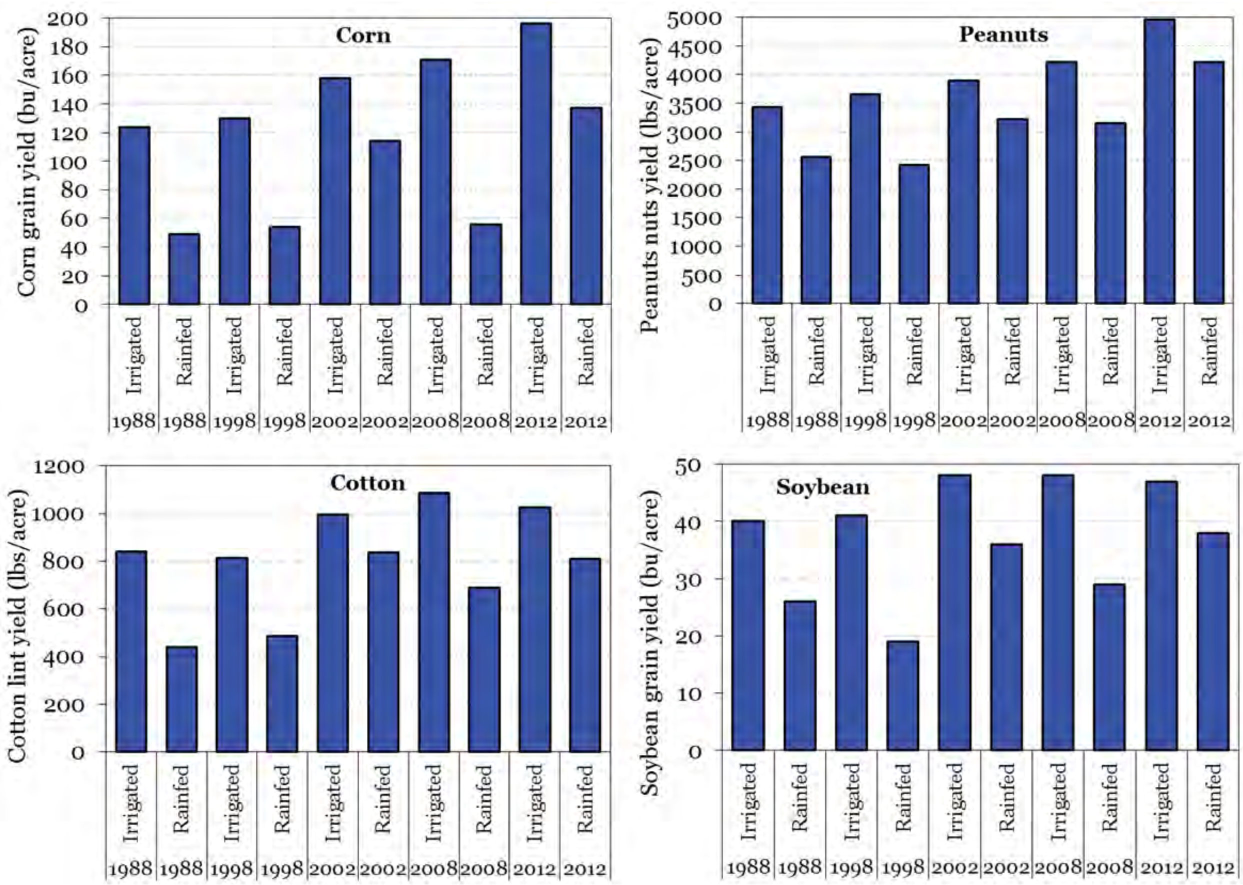

Figure 3. Statewide average irrigated and rainfed yield for corn, peanuts, cotton and soybean in 1988, 1998, 2002, 2008 and 2012 in Georgia (Source: USDA-NASS) (Source: Figure 3_IRR vs Rainfed Yields.xlsx).

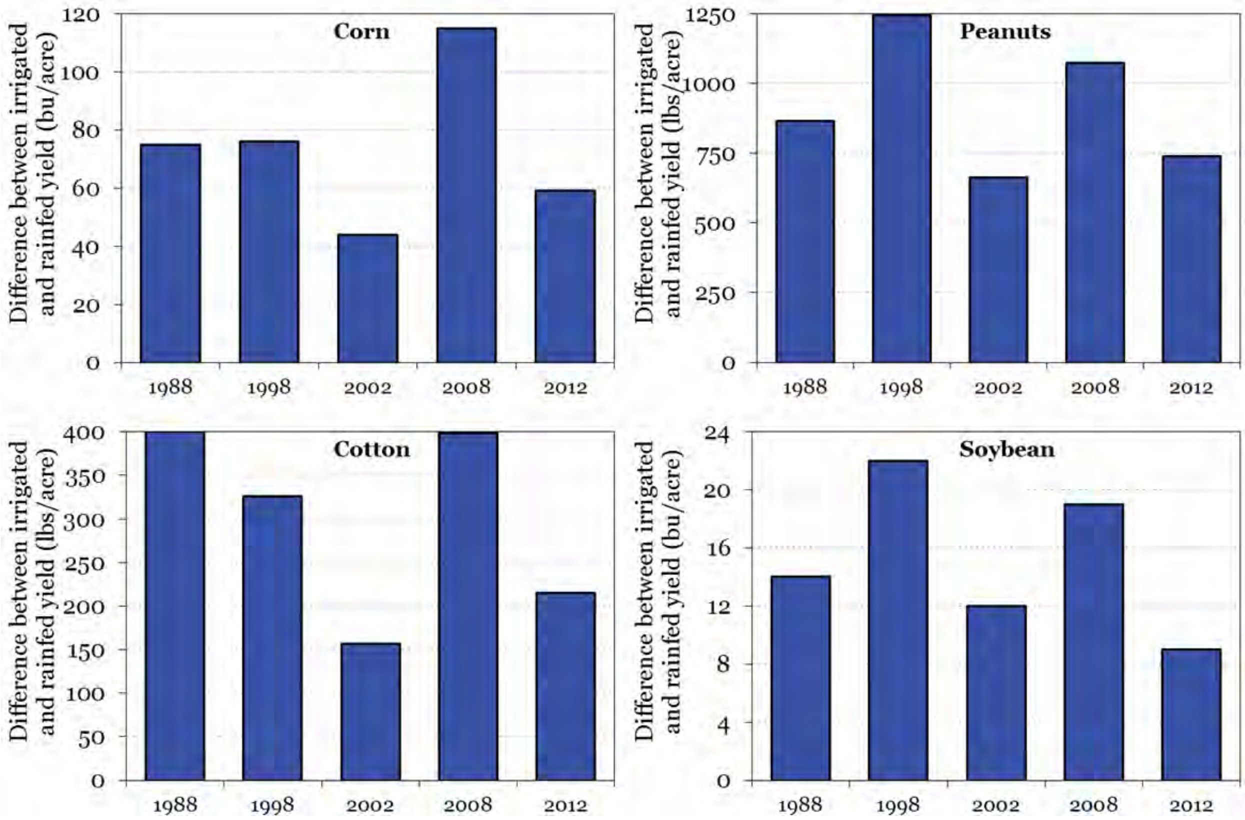

Figure 4. Statewide average difference between irrigated and rainfed yields for corn, peanuts, cotton and soybean in 1988, 1998, 2002, 2008 and 2012 in Georgia (Source: USDA-NASS, Figure 4_Average difference between irrigated and rainfed yields.xlsx).

E. Contrary to Dr. Sunding's Suggestion, "Deficit Irrigation" Cannot Be Reasonably or Profitably Adopted for Corn, Cotton, Peanuts, and Soybean in the ACF Basin

Dr. Sunding's report states that "Georgia can adopt deficit irrigation on corn, cotton, peanuts, and soybean" and (without pointing to any specific examples) refers to deficit irrigation as a "common conservation measure employed by states during times of drought." In fact, Dr Sunding's deficit irrigation proposal would be substantially detrimental to Georgia's agriculture industry and would severely reduce Georgia's ability to produce agricultural commodities. Dr. Sunding's proposal also indicates a lack of knowledge regarding some of the fundamentals and basic operational principles of deficit irrigation.

Deficit irrigation is a specialized practice that can only be applied in limited cases. Deficit irrigation management practices have generally only been applied in states with fine-textured soils that have very high water-holding capacities. Plants grown on fine-textured soils may have adequate time to adjust to low soil water status until the next irrigation and/or rainfall. In sandy soils, however, plants experience water stress very

of potential impacts	vary greatly depending on location, condition of the receiving aquifer and water quality considerations. • ASR is probably best suited to provide water supply storage; its capability to provide for in-stream flow augmentation has not been directly evaluated. • The Council recognizes the need for further evaluation of specific proposals for ASR in the region on a case-by-case basis. • The Council recommends that any ASR proposal be thoroughly evaluated for its environmental and other impacts.	Basin

The work of the RWPCs did not end upon adoption of the 2011 Plans. Funding provided by the State of Georgia allowed Georgia EPD to continue to support the Councils to develop reports on Plan implementation and prioritize items for discussion as part of the 5-year Review and Revision process now underway. Georgia EPD is now leading the effort to compile updated information on water use, including a revised assessment of current and forecast agricultural water demand, update the resource assessments based on surface and groundwater modeling and provide technical assistance to the RWPCs to revise their Plans as needed. This effort is scheduled to be complete in 2017.

D. Investments in Data and Information

Prior sections of this report have briefly mentioned occasions where the State acknowledged a need for additional data and information and responded with an appropriate commitment of funding and coordinated effort. The following section offers additional detail on two important data collection projects that have improved the State's ability to measure, and manage, its water resources.

1. Agricultural Metering

In 2003, the Georgia General Assembly passed legislation to establish the Agricultural Water Use Measurement Program (Agricultural Metering Program), an effort designed to measure use of permitted agricultural water withdrawals statewide. While metering of agricultural withdrawals exists in other states, I am not aware of any state making a commitment to capturing agricultural water use comparable to that of Georgia. Since

2004, the State has invested more than $22 million in deploying, maintaining and managing data collection on over 12,000 meters statewide.[30] Initial flowmeter installations during 2004–2007 were concentrated on agricultural irrigation in southwest Georgia. By the end of 2009, the Commission monitored agricultural withdrawals from a network of 6,985 meters.

Table 3. Water Meter Installations in the Middle and Lower Chattahoochee and Flint River Basins in Georgia (Source: USGS)

Source	**Meter Type**	
	Annually Reported	**Telemetry**
Middle and Lower Chattahoochee and Flint River Basins		
Groundwater	3,609	46
Surfacewater	748	35
Subtotal	4,357	81
Coastal Region		
Groundwater	679	20
Surfacewater	378	16
Subtotal	1,507	36
Central south Georgia		
Groundwater	912	15
Surfacewater	659	16
Subtotal	1,571	31
Grand total	6,985	148

Administered by the Georgia Soil and Water Conservation Commission (GSWCC), the Metering Program captures annual data on permitted withdrawals throughout the State. Meters are read each year between October 1 and December 31 which, when compared to the previous year's reading, provides a use generally corresponding to the growing season for most crops. At the time of reading, GSWCC personnel or their contracted support staff also record the crop grown during the previous year and perform a visual inspection of the meter. All meters receive a comprehensive inspection on a three-year rotating basis. Further, approximately 1% of meters are read on a monthly basis as a sample to provide additional information on timing and use patterns during the growing season.

2. Irrigated Acreage

Along with capturing data on agricultural withdrawals through the Metering Program, the State has invested heavily in compiling a database of irrigated acreage. These ongoing efforts, funded primarily through Georgia EPD and GSWCC, are completed under contract to the Georgia Water Planning and Policy Center (GWPPC) at Albany

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[30] Interview with David Eigenberg, GSWCC, Dawson, GA (September 22, 2015).

the 2006 Flint Plan expanded the acreage that could participate under the FRDPA to include groundwater within certain regions based on proximity to streams.

- ***Targeting of watersheds*** – Refinements to the FRDPA now allow Georgia EPD to target certain HUC 8 watersheds with FRDPA implementation rather than the entire Flint River Basin.

- ***Demonstration of use (meters)*** – In order to be eligible for the auction, a permittee must demonstrate that the land in question is actively irrigated and metered.

- ***Flexibility of auction*** – Clarification of the original FRDPA language provided GAEPD additional flexibility regarding auction implementation following a severe drought declaration.

- ***Protection of augmented flows*** – Language was included to protect flows that may be augmented by the State of Georgia (e.g. prohibits pumping water for irrigation use that comes from a state-sponsored stream augmentation project).

- ***Conservation mandates*** – Building on the framework established in the 2006 Flint Plan, a set of conservation efficiency mandates for *all* permitted withdrawals in the Flint Basin was adopted including:

    - A minimum 80% efficiency for center pivots (60% for mobile and solid set sprinklers) was required for permits issued after January 1, 2006 as of January 1, 2016;

    - For agricultural permits issued between 1991 and 2005, the efficiency requirements must be met by January 1, 2018;

    - For agricultural permits issued prior to 1991, the efficiency requirements must be met by January 1, 2020.

F. Conclusion

Based on my analysis of Georgia's policy and regulatory initiatives, I conclude that the State has been responsible, proactive, and progressive in its management of agricultural water resources and responsive to water resource challenges in the ACF Basin, especially the Lower Flint River Basin. These programs, policies, and initiatives by the State demonstrate good and responsible stewardship of agricultural water resources, and indicate that the State has taken a proactive and approach to agricultural water resource challenges.

II. SOIL AND WATER CONSERVATION PROGRAMS AND EFFORTS

There is substantial evidence of Georgia's investment in irrigation conservation technology, education, and outreach programs to help farmers and agricultural producers conserve water resources. Most of these outreach, education and training efforts have been planned, organized, and conducted by state agencies. Georgia EPD, in partnership and collaboration with the Georgia Soil and Water Conservation Commission (GSWCC), the Georgia Soil and Water Conservation Districts (GSWCDs), and other entities, has been a vital part of all these activities. The state has also invested greatly in various units of the university system of Georgia that have helped develop and implement new technologies for conserving agricultural water resources in the ACF Basin. These include the University of Georgia's Stripling Irrigation Research Park in Camilla, Georgia, and the Georgia Water Planning and Policy Center (GWPPC) at Albany State University.

A. Georgia Mobile Irrigation Laboratory

One of GSWCC's programs is the Mobile Irrigation Laboratory (MIL). The MIL is a service that GSWCC provides to farmers at no cost. The MIL increases irrigation efficiency by improving the uniformity of a farmer's irrigation system. Irrigation uniformity refers to the uniform distribution of water from a center pivot onto a field. For any given irrigation system to have a high irrigation efficiency, it must first have a high uniformity coefficient.

Upon request from an irrigator, a MIL technician visits the grower's field to collect data on the application uniformity of the farmer's irrigation system, including data about system pressure, flow rate, and sprinkler application rate. Once this data is collected and charted, the farmers have knowledge of the flow, application rate, and a scoring of the uniformity of their system. In conducting their analyses, the MIL technicians provide services and recommendations to improve the uniformity of the farmers' irrigation system (i.e., end-gun shut-offs and sprinkler uniformity), which can result in reducing water waste and increasing the efficiency of the system.

Over 450 center pivot systems have been serviced and/or retrofitted by the MIL, including many center pivot irrigation systems in the Lower Flint River Basin, to address and improve uniformity. Figure 23 shows the location of complete MIL projects in the State of Georgia, including a large number of projects in the LFRB.

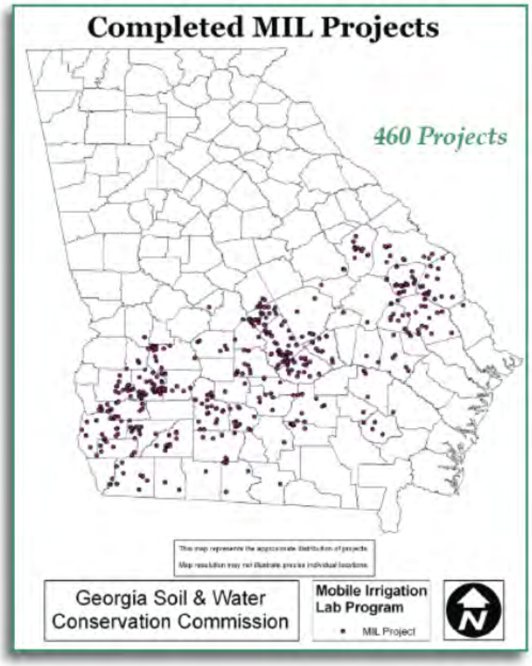

Figure 23. Map of the locations of completed Georgia Mobile Irrigation Lab projects.

In addition to improving the uniformity of nozels, the MIL tests and retrofits (when possible) end-gun shut-off devices on center pivot irrigation systems. Many center pivots have an end gun installed on the last tower of the pivot in order to increase the irrigated area within a field. An end gun shut-off device can considerably reduce the water requirements for a given field by turning off the end gun in locations within a production field where irrigation water does not need to be applied.

Before and after each retrofit of a center-pivot system, MIL personnel conduct uniformity and operational tests to quantify the improvements in uniformity and efficiency due to the retrofit performed by the MIL.

The uniformity values of individual center pivot irrigation systems before the improvements made by the MIL technical staff are presented in Figure 24a. These data were obtained from GSWCC in Dawson, Georgia (data were collected in 2012, 2013, and 2014). Before the MIL staff made improvements to the systems, the uniformity of center pivots ranged from as low as 23% to 89% with an overall average (of all center pivots tested) of 73.5%. After the retrofit/improvements, the uniformity of the center pivots improved substantially, ranging from 81% to 88% with an overall average of 85%. The improved uniformity values of the same center pivots are presented in Figure 24b.

The average improvement in the pivot uniformity is about 23%. The percent improvements made in the uniformity of individual center pivot irrigation systems after the retrofit by the MIL technical staff are presented in Figure 24c. The improvement in the uniformity of individual center pivots after retrofit ranged from zero percent to as high as 74.4%.

various counties in the Lower Flint River Basin in Georgia (Source: USDA NRCS EQIP[32]).

As shown in Figure 27, 106,519 acres of irrigated land area have been converted to low pressure center pivot systems through USDA-NRCS contracts. The irrigated land area ranged from 2,901 acres in Dougherty County to 20,640 acres in Baker County.

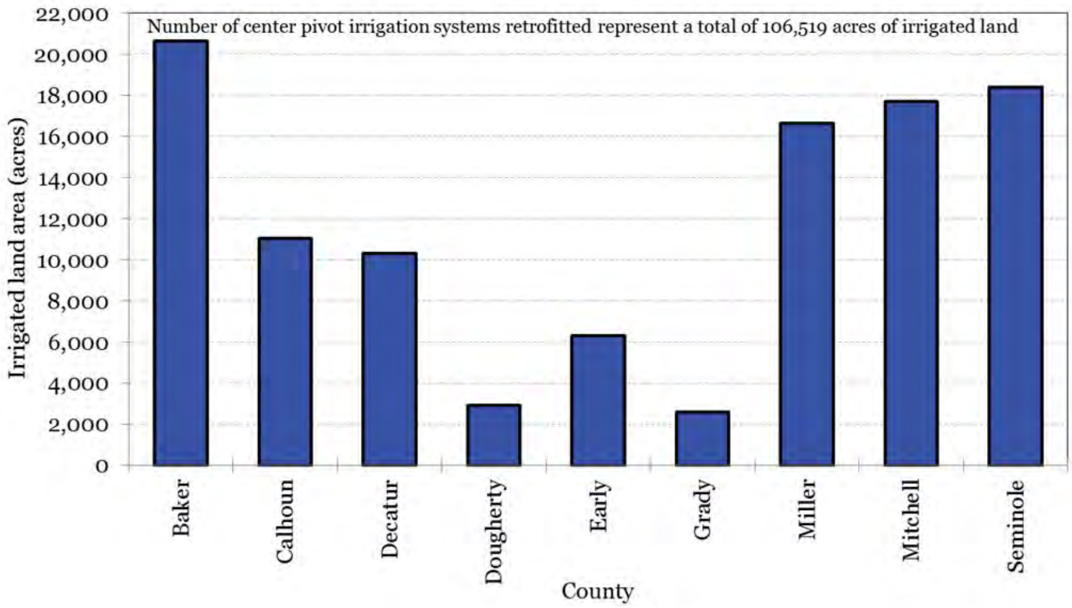

Figure 27. Total irrigated land areas represented by the retrofitted center pivot irrigation systems from 2005 to 2014 in various counties in the Lower Flint River Basin in Georgia (Source: USDA NRCS EQIP).

As mentioned earlier, the data in Figure 26 and Figure 27 only represents the number of center pivots that have been retrofitted with financial assistance from USDA-NRCS. It does not reflect farmers in the area that have retrofitted systems without any financial assistance, and therefore understates the number of pivots and total irrigated land area that have been converted to low pressure drop nozzles from 2005-2014.

2. GWPPC Data Demonstrate that the Majority of Center Pivots in the Lower Flint Basin Use Low Pressure Systems.

Data collected by the GWPPC demonstrates that Georgia's efforts to covert farmers to low pressures systems have been very successful. From 2013 through 2015, GWPPC conducted detailed field mapping in large portions of the Lower Flint River Basin, including field mapping covering 100% of the Capacity and Restricted HUC 12 watersheds. As shown in Table 4 below, this data demonstrates that approximately 90% of the center pivots in Capacity and Restricted Use watersheds employ low pressure

[32] Flint River Soil and Water Conservation District, USDA Natural Resources Conservation Service Environmental Quality Incentives Program (EQIP), 2005-2014.

sprinklers or low pressure drop nozzle technology. Table 4 also shows that low pressure systems irrigate approximately 93% of the acreage in those areas. To illustrate the efficiency improvements resulting from conversion to low pressure sprinklers, Table 4 includes my best estimate of the range of potential irrigation system application efficiency values for each type of center pivot system.

Table 4. Center Pivot Efficiency Data Collected Through Detailed Acreage Assessments (Source: GWPPC Field Mapping)

Type of Center Pivot	Percentage of Irrigation Systems	Percentage of Acreage	Efficiency Estimate[33]
Low Pressure/Sprinkers	30.6%	27.9%	75-85%
Lower Pressure/Drop Nozzles	58.9%	64.9%	80-85%
Total Low Pressure	**89.5%**	**92.8%**	-
High Pressure Impact Sprinklers	10.5%	7.2%	70-75%

Dr. Bottcher suggests that "irrigation efficiency can increase from 70% to 80% by upgrading to low pressure drop sprinkler systems at a cost of $115 to $150 per acre with a water savings of 45,000 gallons per year" and that "irrigation efficiency can increase from 80% to 90% by upgrading to even lower pressure drop nozzle in-canopy type systems for the additional cost of $17 to $70 per acre with an additional water savings of about 45,000 gallons per year."

Dr. Bottcher, however, does not cite to or rely on the above data regarding high-efficiency retrofits, and thus fails to account for the fact that a substantial percentage of irrigated acreage in the ACF Basin is already irrigated by the very irrigation systems he proposes. Again, in Capacity and Restricted Use Areas, nearly 90% of the center pivots employ low pressure sprinklers or low pressure drop nozzle technology, covering approximately 93% of the irrigated acreage in those areas.

Moreover, contrary to Dr. Bottcher's assumptions, some farmers cannot use low pressure or drip systems on their farms due to topographical conditions, water source issues, or other factors. Additionally, to the extent that there are any potential savings available from efficiency improving upgrades, farmers in Georgia are naturally incentivized to make those upgrades. Reducing waste in agricultural operations reduces costs and provides financial benefits for farmers. Finally, Georgia law already requires that all center pivots be 80% efficient as of January 1, 2016 for permits issued after 2005, as of January 1, 2018 for permits issued after 1991, and as of January 1, 2020 for

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33 These efficiency values represent a potential range of values; actual values are impacted by various factors, including how the irrigation system is managed by the irrigators, field characteristics, and weather conditions.

agents to establish a local work group to oversee these efforts and facilitate greater community involvement (Risse et al., 2009).

County-level staff has submitted over 3,300 reports of program activity related to the water conservation programs into the State reporting system. These activities resulted in more than 261,600 face to face contacts (Risse et al., 2009) with clientele by more than 340 distinct personnel in 151 counties. Approximately, 1,740 hours of training activities were included with approximately 65% of this training targeted to adult populations and 35% targeted to youth. These activities also resulted in 26,000 hours of volunteer time being contributed (Risse et al., 2009).

These activities cover a wide range of delivery products and audiences such as presentations to community groups and local officials, rain water harvesting workshops for homeowners and landscapers, neighborhood rain barrel construction by local 4-H clubs, or working with specific sectors such as agriculture and industry to develop site specific conservation plans (Risse et al., 2009). .

2. UGA Stripling Irrigation Park

The University of Georgia's Stripling Irrigation Research Park ("UGA Stripling") is a state-of-the-art irrigation research and education center located in the Lower Flint River Basin. The past and current research projects at UGA Stripling focus on soil and water conservation as well as water management using a variety of smart systems for irrigation.

Using UGA Stripling's land, equipment and other resources, scientists from UGA and other universities and state and federal agencies collaborate on research and education programs on a wide range of topics to address real-world issues related to irrigation management and soil and water conservation; crop water requirements; improving food, fiber and feed production under irrigated conditions.. One of the primary objectives of UGA Stripling is to research, develop and implement best management practices for agricultural irrigation. UGA Stripling's research and education/outreach programs include cotton, corn, peanut, wheat, watermelon, tomato, pepper, sweet corn, grain sorghum and soybean.

UGA Stripling is equipped with the following resources and facilities to research and develop practical solutions that can be implemented by area irrigators to enhance irrigation efficiency:

- 130 acres of land representing the major soil types (loamy sand and fine sand) found in the Flint River Basin,
- Three 8-inch diameter Floridan Aquifer wells with submersible pump,
- Four 2-span (tower) and one 4-span center pivot irrigation systems,
- Two 3-span center pivot,

VII. CONCLUSIONS REGARDING CROP WATER USE EFFICIENCY AND CROP WATER PRODUCTIVITY

Crop yields, which impact crop water productivity, have increased substantially in the last century for all major commodity crops in Georgia (Figure 43). For cotton, since 1928, the lint yield has increased at a rate of 10.4 lbs/acre per year with a total of 905 lbs per acre since 1928. For peanuts, since 1934, the yield has increased at a rate of 51 lbs/acre per year with a total of 4,131 pounds per acre since 1934. For corn, since 1954, the grain yield has increased at a rate of 3 bushels/acre every year with a total of about 182 bushels an acre from 1954 to 2014.

Crop ET and crop yield analyses have been conducted to evaluate the crop water use efficiency (CWUE) of the irrigation and crop water use practices in the Flint River Basin. CWUE is a powerful indication of how efficient crop production and irrigation systems are in terms of producing crop yield per unit of water used. While CWUE is a simple ratio of crop yield produced to crop ET during a crop growing season, accurate quantification of crop ET is a very difficult task. The NASS-reported grain yield data for Mitchell County are used as an example to quantify temporal CWUE of cotton, peanuts, and corn from 1990 to 2013, and are presented in Figure 44a, Figure 44b, and Figure 44c for cotton, peanuts, and corn, respectively.

These data show that there has been a clear and strong increase in CWUE for all three crops in the last 24 years with a strong slope. The CWUE had a slope of 0.857, 3.503, and 0.130 for cotton, peanuts and corn, respectively. The Mitchell County cotton growers have increased their cotton water use efficiency by 0.86 lbs/inch per year since 1990, and they increased water production efficiency by a total of 20.6 lbs/inch (Figure 44). In other words, they produced 17 lbs more cotton lint yield per inch of water they used in 2013 than they did in 1990. This is a significant increase in cotton water use efficiency and productivity.

Peanut water use efficiency has increased by 3.5 pounds per acre-inch per year, on average, since 1990 with an 84 pounds per acre-inch total improvement from 1990 to 2013 (Figure 44b). Thus, the LFRB producers were growing 135 pounds more peanuts (beyond the intercept) in 2013 per inch of water than they did 24 years ago in 1990. Similarly, corn water use efficiency (Figure 44c) has also increased substantially between 1990 and 2013 with a 0.13 bushel per acre-inch rate of increase per year. By 2013, Mitchell County corn growers were producing about 9 bushels of corn yield for every acre-inch of water they used (beyond the intercept) as compared to the 4.6 bushels of corn they were producing for every acre-inch of water they used in 1990. These are likewise significant improvements in crop water use efficiency values. Even one bushel per acre inch of improvement can substantially improve agricultural productivity while reducing water use.

Based in part on the extensive data available as a result of Georgia's investment in the Agricultural Metering Program, I can conclude that the overwhelming majority of the irrigators in the FRB, especially in the LFRB, practice efficient, responsible and reasonable irrigation management practices. Because these farmers apply less water to crops than necessary, they are demonstrating reasonable and beneficial use of surface and groundwater resources and responsible stewardship of the resource. These findings are contrary to claims by experts for Florida that Georgia farmers are "wasting water."

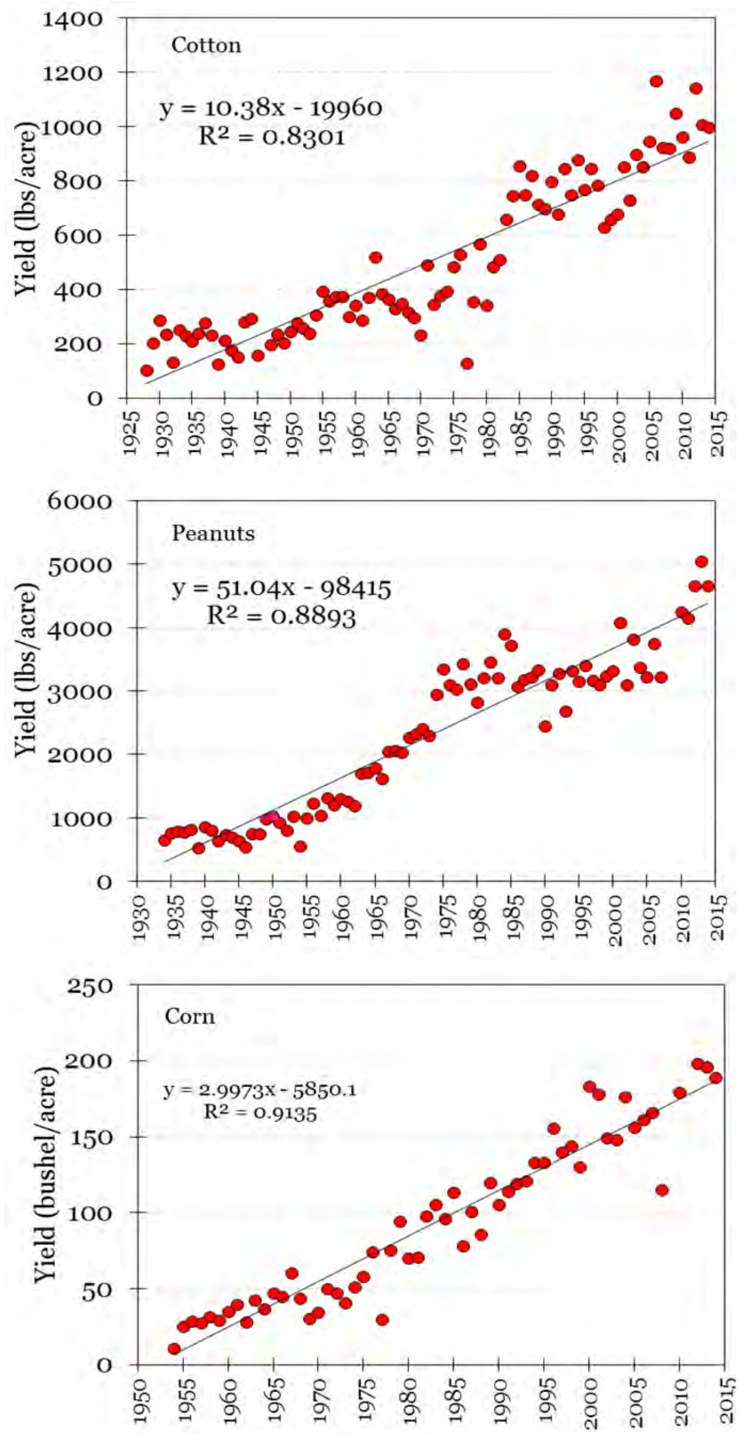


Figure 43. Temporal improvements in crop yields over time for cotton, peanuts and corn in Mitchell County, Georgia.

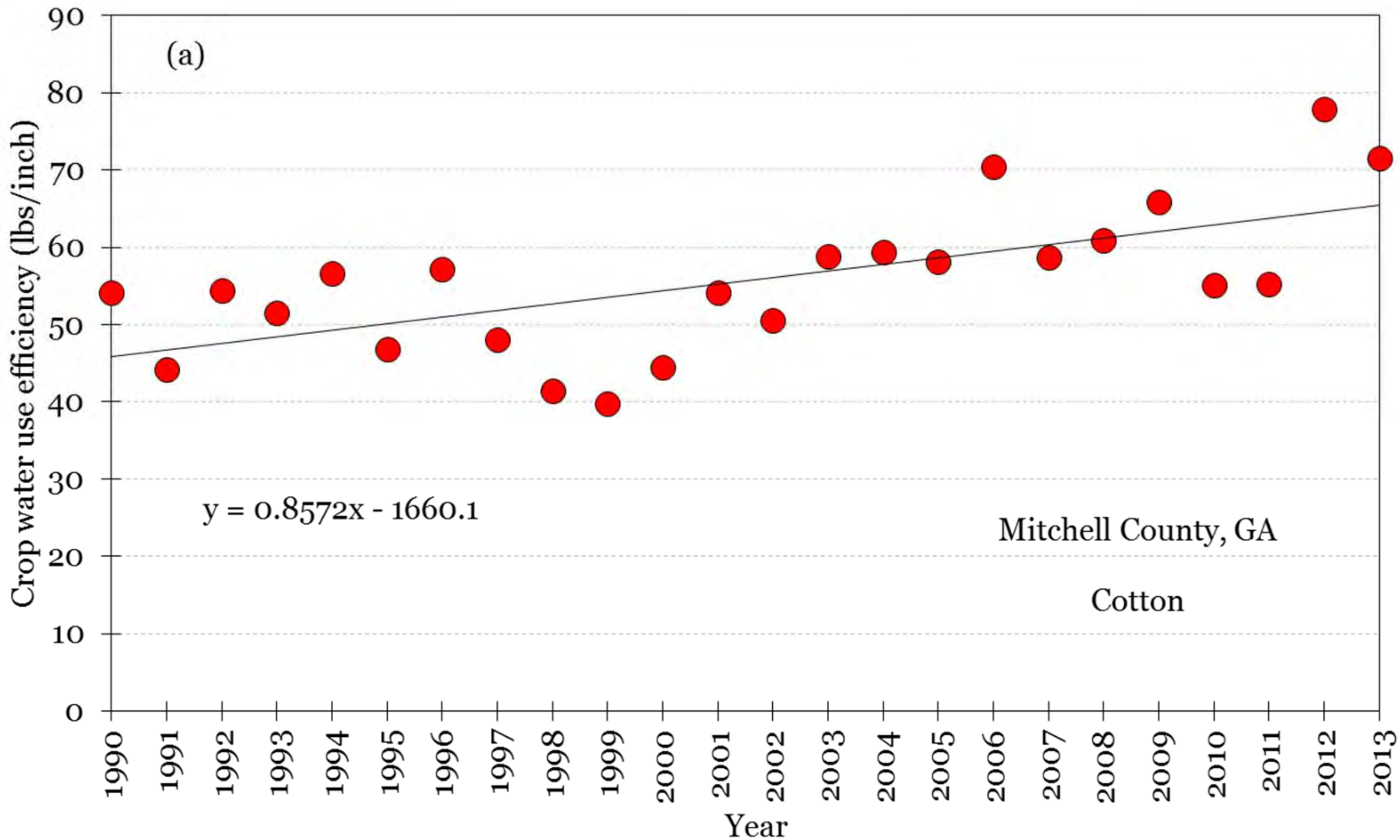


Figure 44a. Temporal trends in crop water productivity (crop water use efficiency) for cotton in Mitchell County, GA.

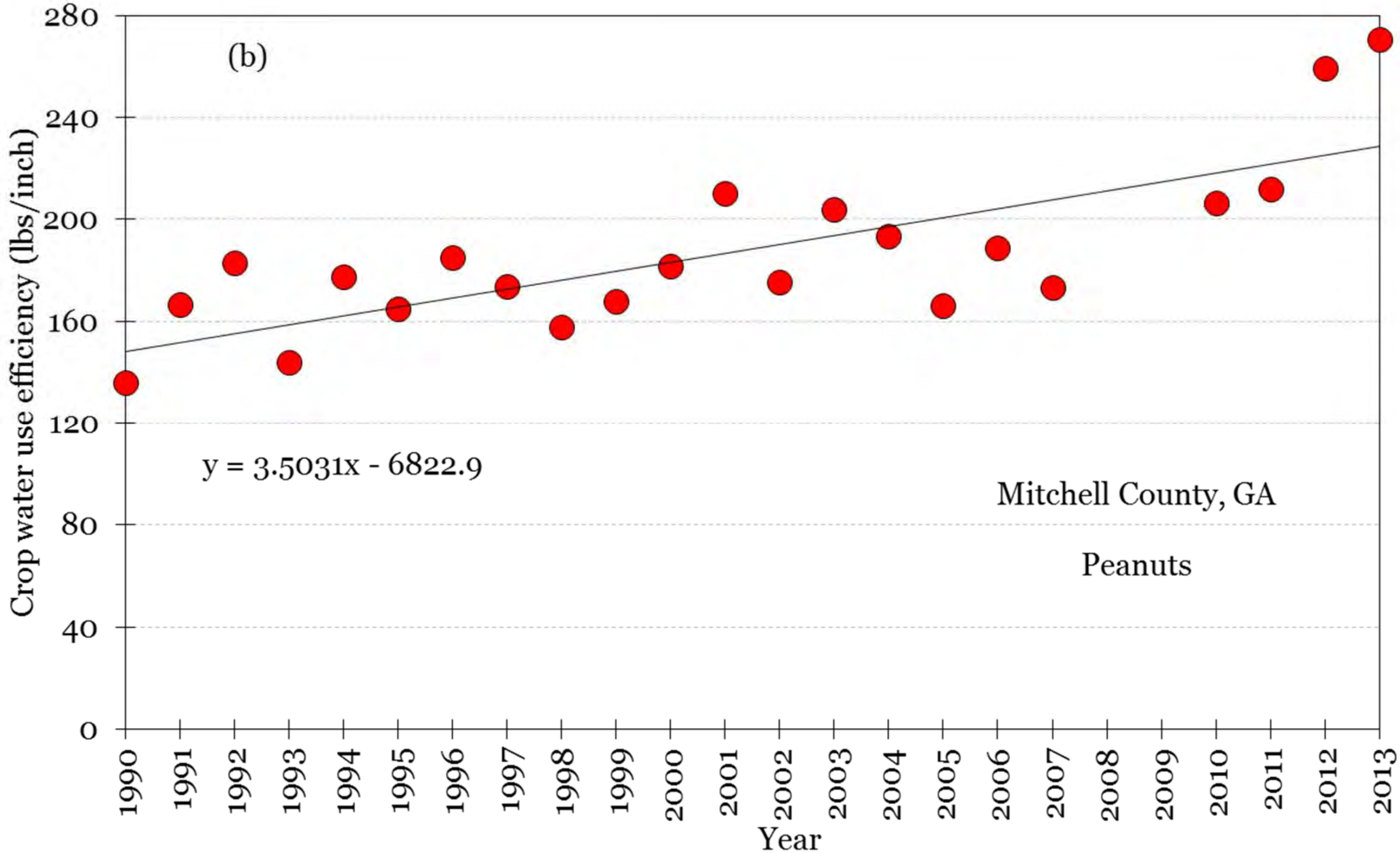


Figure 44b. Temporal trends in crop water productivity (crop water use efficiency) for peanuts in Mitchell County, GA.

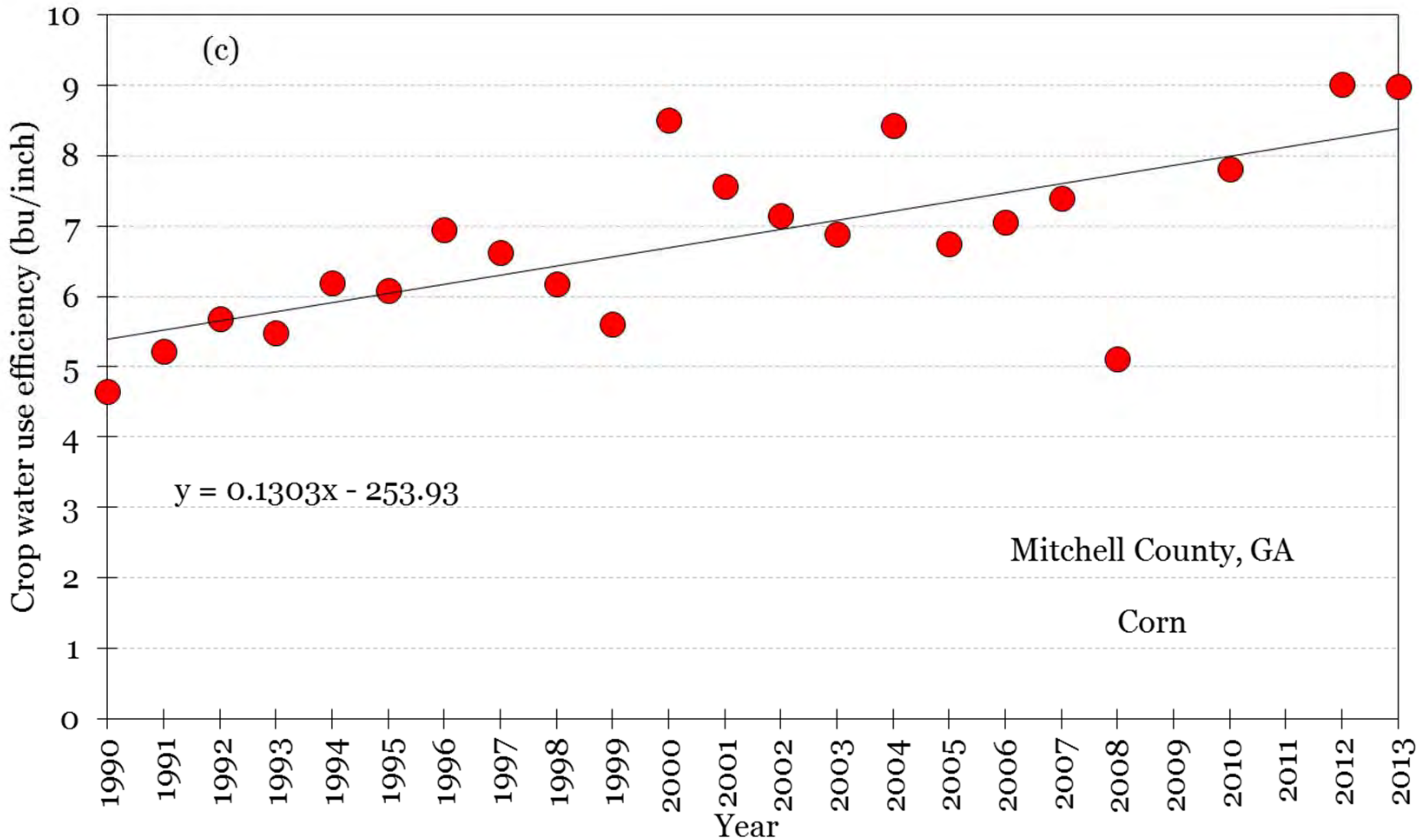


Figure 44c. Temporal trends in crop water productivity (crop water use efficiency) for corn in Mitchell County, GA.

Exhibit 47

ESTIMATING WATER USE FOR IRRIGATION USING A MODELING APPROACH

Dr. Gerrit Hoogenboom

Prepared for the State of Florida,
through Its Department of Environmental Protection,
and Its Counsel, Latham & Watkins LLP

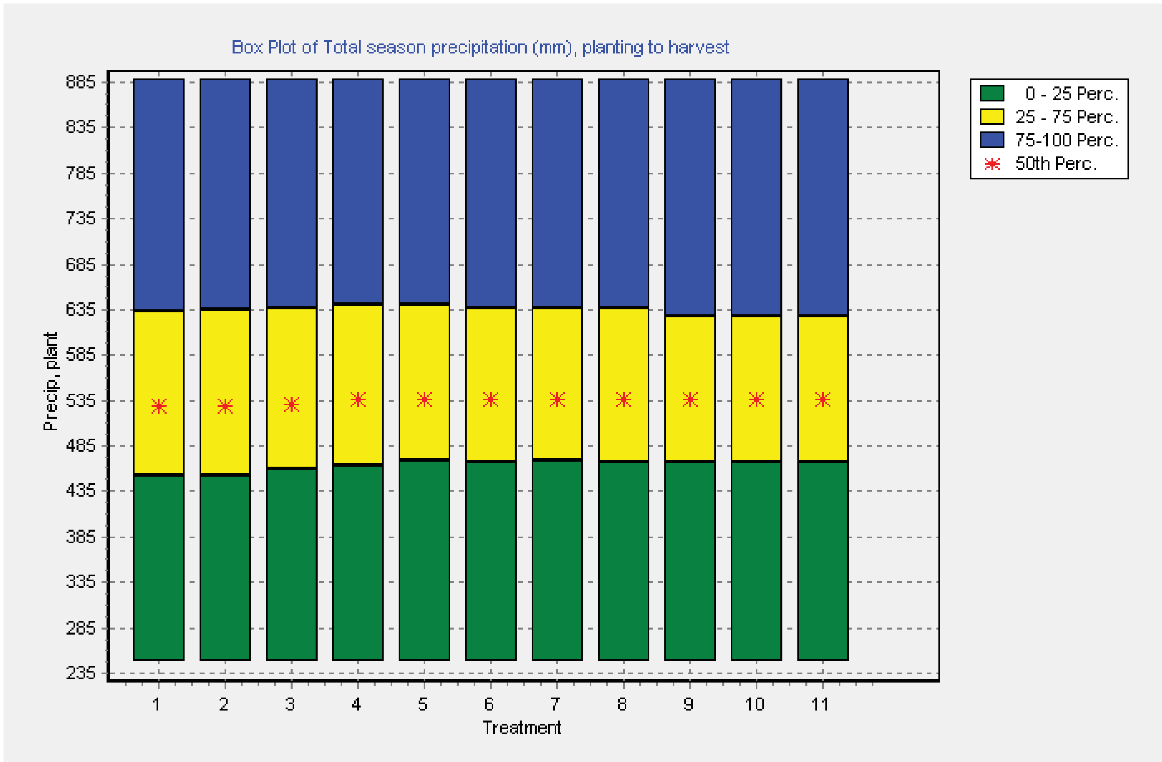
ii. Results

35. Peanuts are extremely sensitive to the precipitation received during the growing season (Figure 3) as well as the water holding capacity of the soil. For rainfed (no supplemental irrigation), yield for the Tifton Loamy Sand ranged from around 819 to 5,407 kg/ha; for the Orangeburg Sandy Loam, yield ranged from 888 to 6,231 kg/ha; for the Norfolk Loamy Sand, yield ranged 825 to 6,033 kg/ha; for the Greenville Sandy Clay Loam, yield ranged from 955 to 6,549 kg/ha; for the Faceville Loamy Sand, yield ranged from 455 to 4,102 kg/ha; for the Wagram Sand, yield ranged from 575 to 3,418 kg/ha; for the Lucy Sand, yield ranged from 638 to 4,889 kg/ha; and for the Troup Sand, yield ranged from 664 to 4,604 kg/ha (Figure 4). This yield variability under rainfed conditions illustrates that supplemental irrigation often increases yields. In some years, supplemental irrigation is not required to achieve high yields. But, there are other years when rainfall is insufficient to meet the demand of the peanut crop and thus causes a decrease in yield due to drought stress.

36. For fully irrigated crops, there is no difference in yield among soils, while for the rainfed yield the differences are significant (Figure 5). Depending on the soil type, some of the higher input scenarios do not show much difference in yield. For instance, for the first soil (Tifton Loamy Sand) the yield is very similar for the last four irrigation treatments. Similar responses can be found for the other soils, although the sandier soils (last three soils) still show a yield response at the higher irrigation threshold levels (Figure 4).

37. These yield responses also correspond to the supplemental irrigation amounts that are required to reach these high yield levels (Figure 6). Especially the Wagram Sandy soil shows extremely high water requirements under non-stress conditions. For all soils, the water requirements increase with the higher threshold value. However, it is important to understand that supplemental water requirements vary across years. The higher the threshold variable and potential yield goal, the larger the range between the minimum and maximum amount of water required for irrigation. In Figure 7, an example is shown for the Tifton Loamy Sand (top) and a Troup Sand (bottom), showing the differences among soils.

38. As expected, peanut pod yield is extremely responsive to supplemental irrigation. Summarized across years and scenarios the response is linear up to an amount of 300 mm (Figure 8). When all years and scenarios are considered the response is more scattered, but the variability is less with the increase in the amount of supplementary irrigation applied (Figure 9). The results are shown for the Tifton Loamy Sand only, but the other soils show a very similar response. These outcomes are important and can be used for further studies, such as by Dr. Sunding for his analysis and report. I have reviewed his use of the DSSAT outputs, and find that his use of outputs for only the drier weather years is sound.



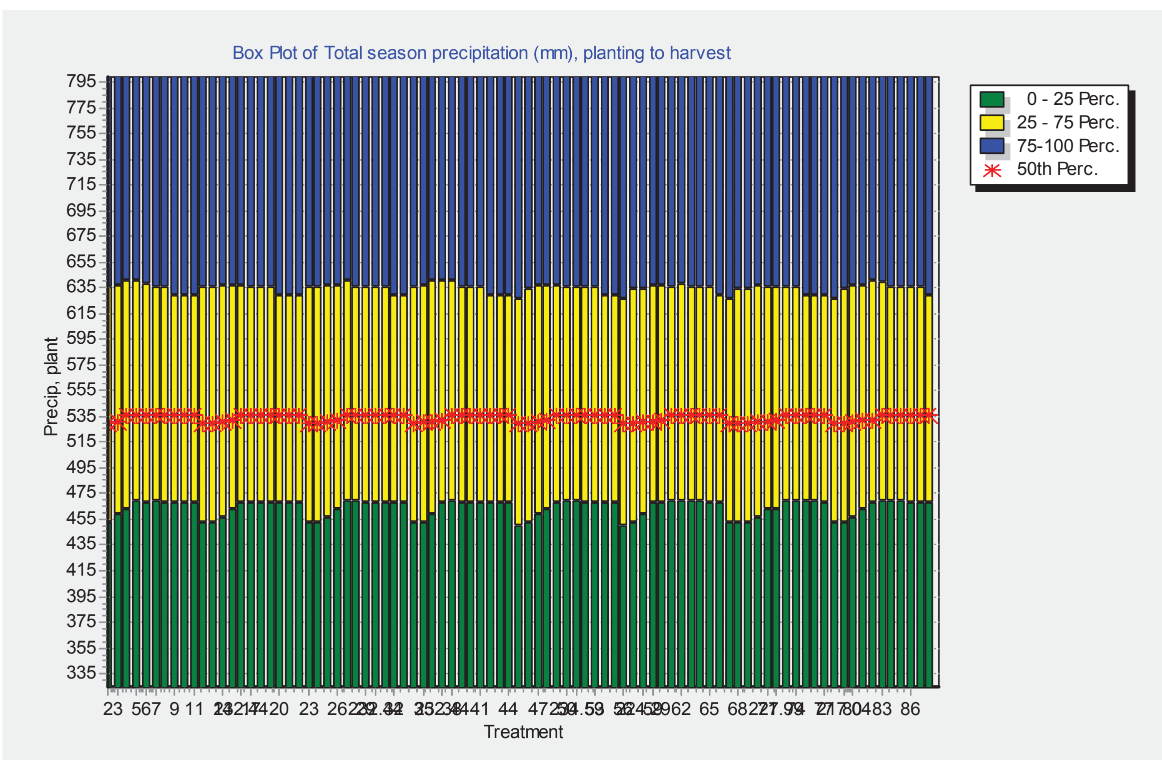


Figure 2 Seasonal total precipitation for the Tifton Loamy Sand (top) and all soils (bottom)

a. Cotton

i. Input Parameters

45. In my DSSAT model runs for cotton, I assumed that cotton was planted in early May at a plant density of 14 plants/m^2 and a row spacing of 90 cm (Collins et al., 2015). The variety was "Deltapine 555 BG/RR," a Deltapine variety that has been popular in the southeastern United States. The genetic coefficients for the variety Deltapine 555 BG/RR were obtained from the standard DSSAT model as found in the cotton cultivar file. For the analysis there were a total of 88 scenarios, referred to as "treatments" in the figures. To illustrate that I used the same weather data, the precipitation is summarized as a box plot (Figure 18) showing that rainfall ranged from 248 to 880 mm for an approximate growing season duration of 135 days, similar to the peanut growing season discussed in the prior section. The minimum amount of rainfall for cotton was significantly higher than the minimum amount of rain found for corn, partially due to the one month later planting and the longer growing season duration. Due to the large number of treatments/scenarios, the x-axis label is not very clear. Precipitation in Georgia is highly variable as demonstrated by the cumulative probability distribution function shown in Figure 19. Each point in this graph represents a different year, with the smallest amount of rainfall shown on the bottom left, i.e., 248 mm, and the highest amount of rainfall shown on the top right, i.e., 880 mm.

ii. Results

46. Cotton is harvested as seed cotton that includes the actual cotton seed and lint. After harvest, the lint is normally separated from the seed during the ginning process. Both cotton lint and cotton seed are sold for a range of applications. In the analysis shown here I used seed cotton, i.e. the seed and the lint combined. For economic analysis, the lint itself has a higher market value and we assumed that 38% of seed cotton was lint, based on literature values. In Figure 20 (bottom) and following figures treatments 1-11 represent the Tifton Loamy Sand; treatments 12-22 represent the Orangeburg Sandy Loam; treatments 23-33 represent the Norfolk Loamy Sand; treatments 34-44 represent the Greenville Sandy Clay Loam; treatments 45-55 represent the Faceville Loamy Sand; treatments 56-66 represent the Wagram Sand; treatments 67-77 represent the Lucy Sand; and treatments 78-88 represent the Troup Sand.

47. Cotton is also highly sensitive to the total amount of precipitation received during the growing season (Figure 19) as well as the water holding capacity of the soil, although it is considered an indeterminate crop that continues to grow. For rainfed (no supplemental irrigation), yield for the Tifton Loamy Sand ranged from around 571 to 3,603 kg/ha; for the Orangeburg Sandy Loam, yield ranged from 616 to 3,920 kg/ha; for the Norfolk Loamy Sand, yield ranged 558 to 3,731 kg/ha; for the Greenvile Sandy Clay Loam, yield ranged from 656 to 4,110 kg/ha; for the Faceville Loamy Sand, yield ranged from 129 to 3,222 kg/ha; for the Wagram Sand, yield ranged from 537 to 3,135 kg/ha; for the Lucy Sand, yield ranged from 499 to 3,358 kg/ha; and for the Troup Sand, yield ranged from 410 to 3,367 kg/ha (Figure 20). This yield variability under rainfed conditions illustrates that supplemental irrigation often increases yields, as the model simulated at least one year with a near crop failure due to limited rainfall.

Although there are some years for which supplemental irrigation is not required to increase yields, there are many others years for which rainfall is insufficient to meet the demand of the cotton crop and thus causing a decrease in yield due to drought stress. In addition, under rainfed conditions, yield will not reach the yield potential of non-stressed conditions.

48. For fully irrigated crops, there is no difference in yield among soils, while for the rainfed yield the differences are significant (Figure 21). Depending on the soil type, some of the higher input scenarios do not show much difference in yield. For instance, for the first soil (Tifton Loamy Sand) the yield is very similar for the last six irrigation treatments. Similar responses can be found for the other soils, although the sandier soils (last three soils) still show a yield response at the higher irrigation threshold levels. However, the response is somewhat less at the high irrigation levels compared to corn (Figure 20).

49. These yield responses also correspond to the supplemental irrigation amounts that are required to reach these high yield levels (Figure 22). Especially the Wagram Sandy soil shows extremely high water requirements under non-stress conditions, similar to what was found for peanut and corn. For all soils the water requirements increase with the higher threshold value. However, it is important to understand that supplemental water requirements vary across years. The higher the threshold variable and potential yield goal, the larger the range between the minimum and maximum amount of water required for irrigation. In Figure 23 an example is shown for the Tifton Loamy Sand (top) and the Troup Sand (bottom) to demonstrate this more explicitly.

50. As expected, cotton yield is very responsive to supplemental irrigation. Summarized across years and scenarios, the response is linear up to an amount of 225 mm of irrigation (Figure 24). When all years and scenarios are considered the response is extremely scattered, and the variability does not seem to change with the increase in the amount of supplementary irrigation applied although the variability is slightly less at higher irrigation amounts (Figure 25). The results are shown for the Tifton Loamy Sand only, but the other soils show a very similar response. As stated previously for peanuts and corn, these results are critical for further economic analyses, including for Dr. Sunding's report.

b. Soybeans

i. Input Parameters

51. In my DSSAT model runs for soybean, I assumed that soybean was planted on May 20 at a plant density of 29 plants/m^2 and a row spacing of 76 cm (Whitaker et al., 2014). The variety was Generic Maturity Group 5, representing the Maturity Group 5 cultivars that have a similar response to photoperiod. The genetic coefficients for the variety "Generic Maturity Group 5" were obtained from the standard DSSAT model as found in the soybean cultivar file. For the analysis there were a total of 88 scenarios, referred to as "treatments" in the figures. To illustrate that I used the same weather data, the precipitation is summarized as a box plot (Figure 26) showing that rainfall ranged from 244 to 772 mm for an approximate growing season duration of 127 days. The minimum amount of rainfall was significantly higher than the minimum amount of rain found for corn and somewhat similar to cotton, partially due to the one month later planting and the longer growing season duration for soybean compared to corn. Due to the large number of treatments/scenarios, the x-axis label is not very clear. Precipitation in Georgia is highly variable as demonstrated by the cumulative probability distribution function shown in Figure 27. Each point in this graph represents a different year, with the smallest amount of rainfall shown on the bottom left, i.e., 244 mm, and the highest amount of rainfall shown on the top right, i.e., 772 mm.

52. Soybean is harvested as grains or seeds that develop in a shell, referred to as a pod. During harvest, the seeds are automatically separated from the shell. In Figure 28 (bottom) and following figures, treatments 1-11 represent the Tifton Loamy Sand; treatments 12-22 represent the Orangeburg Sandy Loam; treatments 23-33 represent the Norfolk Loamy Sand; treatments 34-44 represent the Greenville Sandy Clay Loam; treatments 45-55 represent the Faceville Loamy Sand; treatments 56-66 represent the Wagram Sand; treatments 67-77 represent the Lucy Sand; and treatments 78-88 represent the Troup Sand.

ii. Results

53. Soybean is highly sensitive to the total amount of precipitation received during the growing season (Figure 27) as well as the water holding capacity of the soil. Soybean is a determinate crop and very sensitive to photoperiod or the length of the daily light period (daylength). Under long days, flowering is normally delayed. The actual sensitivity is also affected by the maturity group of the variety that is being planted. For rainfed (no supplemental irrigation), yield for the Tifton Loamy Sand ranged from around 321 to 3,093 kg/ha, for the Orangeburg Sandy Loam, yield ranged from 196 to 3,343 kg/ha; for the Norfolk Loamy Sand, yield ranged 181 to 3,225 kg/ha; for the Greenvile Sandy Clay Loam, yield ranged from 183 to 3,425 kg/ha; for the Faceville Loamy Sand, yield ranged from 111 to 2,520 kg/ha; for the Wagram Sand, yield ranged from 263 to 2,043 kg/ha; for the Lucy Sand, yield ranged from 267 to 2,690 kg/ha; and for the Troup Sand, yield ranged from 252 to 2,724 kg/ha (Figure 20). The yield levels for soybean are significantly lower than yields for the other crops, partially due to soybean's later planting in May. This yield variability under rainfed conditions illustrates that supplemental irrigation often increases yield, especially as the model simulated at least

one year with a near crop failure due to limited rainfall. Although there are some years for which supplemental irrigation is not required to increase yields, there are many other years for which rainfall is insufficient to meet the demand of the soybean crop and thus causing a decrease in yield due to drought stress. In addition, under rainfed conditions yield will never reach the yield potential of non-stressed conditions.

54. For fully irrigated crops, there is no difference in yield among soils, while for the rainfed yield the differences are significant (Figure 29). Depending on the soil type, some of the higher input scenarios show little difference in yield. For instance, for the first soil (Tifton Loamy Sand) the yield is very similar for the last four or five irrigation treatments. Similar responses can be found for the other soils, although the sandier soils (last three soils) still show a yield response at the higher irrigation threshold levels. However, the response is somewhat less at the high irrigation levels compared to soybean (Figure 28).

55. These yield responses also correspond to the supplemental irrigation amounts that are required to reach these high yield levels (Figure 30). Especially the Wagram Sandy soil shows extremely high water requirements under non-stress conditions, similar to what was found for peanut, corn, and cotton. For all soils the water requirements increase with the higher threshold value. However, it is important to understand that supplemental water requirements vary across years. The higher the threshold variable and potential yield goal, the larger the range between the minimum and maximum amount of water required for irrigation. In Figure 31 an example is shown for the Tifton Loamy Sand (top) and the Troup Sand (bottom) to demonstrate this more explicitly.

56. As expected, soybean yield is extremely responsive to supplemental irrigation. Summarized across years and scenarios, the response is linear up to an amount of 300 mm of irrigation (Figure 32). When all years and scenarios are considered the response is extremely scattered, with the variability slightly decreasing with an increase in the amount of supplementary irrigation applied (Figure 33). The results are shown for the Tifton Loamy Sand only, but the other soils show a very similar response. As stated earlier with regard to peanuts, corn and cotton, these results are critical for further economic analyses, including for Dr. Sunding's report.

Exhibit 48

MEASURING THE NONMARKET VALUE OF ENVIRONMENTAL SERVICES IN THE APALACHICOLA RIVER BASIN

Expert Opinion of

Daniel J. Phaneuf

University of Wisconsin

29 February 2016

publications have noted the unique flavor of Apalachicola oysters.[105] Oysters in the shallow and sheltered Apalachicola Bay are harvested by local fishermen using small boats and tongs, making the area one of the last of its types in the United States. The working waterfront in the City of Apalachicola houses oyster boats and fishing vessels that have been in service through multiple generations of artisanal fishermen. Thus the culinary excellence of the Bay oysters combines with the historical uniqueness of the coastal community, to create a cultural resource whose value is closely tied to the environmental health of the region.

Until recently, in a typical year, oyster harvest levels are between 2 and 3 million pounds, and generate revenues for local fishermen in the $5 to $8 million range. In 2013, the shrimp, crab, and finfish harvests provided an additional $4.5 million in revenues. For example, table 5 shows data on oyster harvests and revenues in Franklin County for the past decade, and table 6 summarizes harvest numbers and revenues from 2013 for five additional fisheries that are important in the region. These numbers significantly understate the true contribution of oystering and fishing to the local economy because they do not factor in indirect effects. Dr. Jenkins' expert report also identifies parts of Apalachicola Bay as an important nursery to other species that have significant commercial or recreational fisheries in the region, such as blue crabs, spot, hogchoker, Atlantic croaker, the silver perch, the Gulf flounder, the southern flounder, the sand seatrout, the spotted seatrout, and gar. According to NOAA,[106] in 2012, over 3.1 million recreational anglers took 23 million fishing trips in the Gulf of Mexico region (West Florida, Alabama, Louisiana, Mississippi, and Texas). The spotted seatrout was the most frequently caught fish. Other critical recreational species include the Atlantic croaker, sand seatrout, and southern flounder. As of 2012, recreational fishing activities in the region support over 75,000 full- and part-time jobs in West Florida, 17,000 jobs in Louisiana, and 14,000 jobs in Texas. In 2012, sales impacts from recreational fishing in this region were $5.3 billion in West Florida, $1.1 billion in Louisiana, $1 billion in Texas,

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[105] See, for example, http://www.oysterguide.com/new-discoveries/apalachicola-bay/ and http://www.nytimes.com/2002/06/15/us/from-apalachicola-bay-oysters-rated-the-best.html.
[106] https://www.st.nmfs.noaa.gov/economics/publications/feus/fisheries_economics_2012 (follow links to Complete Report).

Exhibit 49

Memorandum

EXHIBIT 47 SH Huseby.com 2-18-16

To: Judson Turner

From: Wei Zeng

Date: January 29, 2016

Re: Technical evaluation of Georgia's 2015 Updated Water Supply Request and comments on the Army Corps of Engineers Apalachicola-Chattahoochee-Flint (ACF) River Basin Water Control Manual Draft Environmental Impact Statement

I. Introduction

On October 2, 2015, the Army Corps of Engineers Mobile District (Corps) released a Draft Environmental Impact Statement (DEIS) on an updated ACF Basin Water Control Manual (WCM). The DEIS addresses two major categories of water resources management in the ACF Basin: (1) meeting Georgia's projected water supply needs through revised operations at Lake Lanier and the Chattahoochee River, and (2) revising the existing Revised Interim Operation Plan (RIOP) to better fulfill authorized purposes of the federal reservoirs in the basin.

The Corps' Proposed Action Alternative (PAA) incorporated a water supply storage assessment (WSSA) that meets part of Georgia's water supply needs from Lake Lanier and all of the needs from the Chattahoochee River. The PAA also incorporated many changes to the current water management in the basin. These changes cover a wide range of aspects, including reservoir rule curves, action zones, peaking power generation, instream flow targets, navigation, endangered species protection, and wildlife conservation.

The purpose of this memorandum is to (1) summarize the impact of Georgia's 2015 Updated Water Supply Request and (2) comment on a few key technical aspects of the Corps' proposed water management operations.

II. Georgia's 2015 Updated Water Supply Request

Updated Water Supply Needs

On December 4, 2015, Georgia sent the Corps an update to the January 2013 ACF Water Supply Request through a planning horizon of 2050. Georgia revised its water supply needs from 297 mgd from Lanier and 408 mgd from the Chattahoochee River down to 242 mgd from Lanier and between 355 and 379 mgd from the Chattahoochee River. The lowered numbers reflect the latest population projected by Georgia Office of Planning and Budget (May 2015) and the latest per capita water use observed in member counties of the Metropolitan North Georgia Water Planning District (Metro District). The latest per capita water use number is much lower than previously estimated, reflecting the beneficial effect of conservation measures put in place by the Metro District over the past 13 years and initial effects of implementing the 2010 Georgia Water Stewardship Act.

Table 1 contains the Metro District's latest projections of 2050 water supply needs upstream of Buford Dam and between Buford Dam and the Peachtree Creek confluence. Your letter to the Corps dated December 4, 2015 incorporated this information. Instead of seeking water supply in the amount of 297 mgd directly from Lake Lanier, the 2015 Updated Water Supply Request seeks an amount of 242 mgd, including 234 mgd projected for local governments within the Metro District (Appendix A) and 8 mgd projected for Dawson, Lumpkin, White, and Habersham Counties (Appendix B). The 2015 Updated Water Supply Request also contains a revision to the water supply need from the Chattahoochee River between Buford Dam and the Peachtree Creek confluence. The new projection puts this need between 355 and 379 mgd, rather than 408 mgd as sought by Georgia's 2013 Water Supply Request. The range reflects the uncertainty surrounding Cobb County-Marietta Water Authority's water supply operation in the ACF Basin and Alabama-Coosa-Tallapoosa (ACT) River Basin.[1] To model the largest possible impact of the 2015 Updated Water Supply Request, the analysis presented in this memo used 379 mgd as the gross withdrawal in the Chattahoochee River between Buford Dam and Peachtree Creek confluence.

Table 1: 2011 and Projected 2050 Water Withdrawals[2]

Reach	Upstream of Buford Dam		Between Buford Dam and Peachtree Creek
Sub-reach	Upstream of Lanier	Lake Lanier	Atlanta
2011	5.92	116.04	247.48
2050	5.92	242	355 ~ 379

On January 25, 2016, EPD received the Metro District's latest 2050 projection on treated wastewater returns to Lanier and the Chattahoochee River from jurisdictions within the Metro District. In addition, we project that an additional 5.6 mgd will be returned in 2050 by the four upstream counties. 5.6 mgd is calculated based upon a 70% return rate from the 8 mgd additional withdrawal from Lake Lanier by the four riparian counties upstream of Lanier. The 70% return rate is derived from the current return rate of 63% for these four upstream counties, plus additional increases in sewered flow that are anticipated as these jurisdictions develop over the planning period. This and the projected return amount of 98.96 mgd from the Metro District result in a combined return of 104.56 mgd to Lake Lanier. This information is shown in Table 2.

[1] Cobb County-Marietta Water Authority (CCMWA) has two water supply intakes, one of which is located along the Chattahoochee River upstream of the Peachtree Creek confluence. The other one is located in Lake Allatoona in the ACT River Basin. CCMWA's water supply operation depends on the Corps' operation and water supply reallocation in the ACT Basin, which has not been finally resolved. The range of Metro Atlanta withdrawal in the Chattahoochee River reflects this uncertainty.

[2] In the Corps PAA model, there is a newly separated reach upstream of Lake Lanier, breaking the original Lanier reach into two reaches. The 2015 Updated Water Supply Request follows the Corps' approach by identifying current and projected water use at these reaches.

Table 2: Current and Projected 2050 Returns[3]

Reach	Upstream of Buford Dam		Between Buford Dam and Whitesburg	
Sub-reach	Upstream of Lanier	Lake Lanier	Atlanta	Whitesburg
2011	3.72	34.61	38.77	187.38
2050	3.72	104.56	81.94	278.98[4]

Storage accounting of man-made return flows should incentivize municipalities to incur the costs associated with transport and discharge of highly treated wastewater to federal reservoirs. If the Corps incentivizes such returns, the potential for higher than projected return flows into Lake Lanier would be increased – something the State believes to be sound water policy. In that case, the impacts of water supply actions will be less than what are shown in this analysis.

In the DEIS, the Corps considered a number of water supply allocation alternatives, and deemed Alternative 7H as the proposed alternative. This alternative (identified as the PAA in the DEIS) provides 225 mgd of withdrawal from upstream of Buford Dam (40 mgd from the proposed Glades reservoir and 185 mgd from Lake Lanier) and 408 mgd from the Chattahoochee River between Buford Dam and Peachtree Creek confluence. Georgia's 2015 Water Supply Request is very similar to the PAA in terms of the total withdrawal amount sought, total return projected, total consumptive use, and even distribution of the withdrawal, return, and consumptive uses. A comparison of Georgia's 2015 Water Supply Request and the PAA is shown in Table 3.

Table 3. 2015 Georgia Water Supply Request in Comparison to PAA

River Reaches	Withdrawal Needs and Projected Returns	Georgia 2015 Water Supply Request (mgd)	Army Corps of Engineers October 2015 PAA (mgd)
Upstream of Buford Dam	Withdrawal	242	225
	Return	104.6	91
	Consumptive	137.4	134
Between Buford Dam and Peachtree Creek confluence	Withdrawal	379[5]	408
	Return	82	94
	Consumptive	297	314
Between Peachtree	Withdrawal		

[3] Projected return numbers are based on the best available information and are used to support accurate modeling, but are not intended to indicate a commitment to specific volumes of return flows in the future. Future return flows could be higher or lower depending on relevant circumstances. Differences between the current values listed in Table 2, which reflect 2011returns, and values provided in Georgia's January 2013 Water Supply Request reflect Georgia's continued progress in updating its water use data.

[4] There is a 3.93 mgd of return flow from discharging facilities that have not been included in the Metro District projections. This amount is added to the projected 284 mgd of return flow in the Whitesburg reach in modeling of future water supply conditions.

[5] Using the higher withdrawal number 379 mgd in the Chattahoochee River is more conservative in evaluating the impact of Georgia's 2015 Water Supply Request. The impact of using 355 mgd withdrawal from the Chattahoochee River would be lower than shown in the following section.

Creek confluence and Whitesburg	Return	279	290
	Consumptive	-279	-290
Total (Lanier/Upper Chattahoochee)	Withdrawal	621	633
	Return	465.6	475
	Consumptive	155.4	158

Formulation of Two Scenarios

To evaluate the impact of the projected water supply needs, the Hydrology Unit conducted HEC-ResSim modeling of the ACF Basin water resources management. The modeling platform used for this analysis is the Corps HEC-ResSim model version 3.2.1.22[6].

For both scenarios, the base model reflecting basin-wide water management is the PAA in the DEIS. This model contains 225 mgd from upstream of Buford Dam (40 mgd from a proposed Glades reservoir and 185 mgd from Lake Lanier) and 408 mgd from the Chattahoochee River between Buford Dam and Peachtree Creek confluence. For the first scenario comparison, we updated the PAA to reflect 2011 municipal, industrial, agricultural[7], and thermal electric water use conditions in river reaches outside the Metro Atlanta area (i.e., above Lake Lanier and below the USGS Whitesburg gage) (the "2011 Comparison"). We chose 2011 data because water use resulting from the 2011 hydrologic conditions has distinctive characteristics compared to water use in 2007, the data on which the Corps based its PAA (the "2007 Comparison"). Both 2007 and 2011 are notable drought years but the droughts affected different parts of the ACF Basin. For example, the epicenter of 2011's drought condition is in the lower basin, resulting in higher recorded agricultural water use. In comparison, the 2007 drought had greater effects in the northern part of the basin, resulting in higher M&I water use.

The first scenario we discuss incorporates 2011 water use conditions in Georgia and available 2007 Alabama water use in Columbus, Walter F. George, George Andrews, and Jim Woodruff reaches.[8] Using this 2011 and 2007 Alabama data, we created two runs: the PAA' (PAA Prime) and Scenario C.[9]

To isolate the effect of the 2015 Updated Water Supply Request, we did not change any other aspects of the PAA water management operations for the PAA'. This is true notwithstanding Georgia's comments

[6] HEC-ResSim modeling platform version 3.2.1.22 was released with the Final Environmental Impact Statement of ACT River Basin Water Control Manual. It is the latest version of the software that Georgia EPD received from the Corps.

[7] At the time of Georgia's January 2013 Water Supply Request, estimated 2011 agricultural water use was not available. Therefore, estimated 2007 agricultural water use was used instead because 2007 presented the most critical hydrologic conditions in the most recent half a century.

[8] At this time, Georgia EPD does not have 2011 Alabama water use data, and therefore uses Alabama 2007 water use to represent Alabama water use in a drought year such as 2011. Drought conditions in 2007 were the most severe in the ACF Basin and Alabama's consumptive use in 2007 was the highest in the preceding 10 years (the period for which Georgia has data).

[9] To avoid confusion with Georgia's 2013 Water Supply Request, which contained a Scenario A and a Scenario B, we chose to call this new run Scenario C.

on certain aspects of the Corps' water management operations in the following sections of this memorandum.

We formulated Scenario C to represent the 2015 Updated Water Supply Request. Scenario C has the same basin-wide water management operations as in the PAA', but incorporates 2050 water supply needs as projected by the Metro District for the counties within the district and by EPD for Dawson, Lumpkin, White, and Habersham Counties. The details of projected 2050 water supply needs can be found in Appendix A. EPD's projected additional water needs for Dawson, Lumpkin, White, and Habersham Counties can be found in Appendix B.

The HEC-ResSim model containing the PAA' and Scenario C is provided in Appendix C of this memorandum. A spreadsheet file containing reach-by-reach withdrawal and discharge quantities is provided in Appendix D of this memorandum (spreadsheet title: ACF_GA-Reqest_621mgd_Demand_cal_20151223_.xls).

The second scenario we model and discuss is the 2007 Comparison which analyzes the similarity between Georgia's 2015 Water Supply Request and the PAA. For the PAA, we used the Corps' PAA model. We compared that to Scenario D which starts from the Corps' PAA model but only changes the Metro Atlanta area demand settings to reflect Georgia's 2015 Water Supply Request. In other words, for the 2007 Comparison, we keep water use conditions in the rest of the basin the same as in the Corps' PAA model (adjusted 2007 water use).

Similarities Between PAA and 2015 Request

The amount of projected demand from Lanier and the Chattahoochee River in the 2015 Updated Water Supply Request is not materially different from what the Corps considered and proposed in its PAA. For example, Georgia's request of a gross withdrawal from Lake Lanier of 242 mgd is only 17 mgd greater than the 225 mgd (20 mgd[10] for relocation contracts plus 165 mgd reallocated from Lanier storage, plus 40 mgd placed on the potential Glades reservoir) specified by the Corps in the PAA. On the Chattahoochee River, Georgia seeks a sum lower than what the Corps considered in the DEIS. The overall gross withdrawal modeled by Georgia of 621 mgd is 12 mgd lower than the 633 mgd considered by the Corps in the DEIS. The overall metro area return rate in Scenario C used for this technical analysis is 75%, as calculated by (5.6+99+82+279) mgd of total return divided by (242+379) mgd of total withdrawal, virtually the same as the PAA metro return rate of 75%, as calculated by (91+384) mgd of total return divided by (225+408) mgd of total withdrawal.

For this reason, the impact from Scenario C is expected to be similar to that from the PAA' and the impact from Scenario D is expected to be similar to the PAA, notwithstanding the differences between the two in terms of placement of demands.

[10] The correct value of the relocation contracts is 23.3 mgd. The city of Buford's relocation contract is for 2 mgd. The City of Gainesville's relocation provides for up to "8,000,000 gallons of water per day from Buford Dam and Reservoir" which has been historically interrupted to mean to a net withdrawal of 8mgd. As provided for in a Supplement to the Relocation to the Contract, upon execution of new storage contract, this 8 mgd net withdrawal will be come 21.3 mgd.

Comparison Parameters

In the modeling results discussed below, Scenario C is compared to the PAA' and Scenario D is compared to the PAA. The potential impact of Georgia's Request (Scenario C and Scenario D) is described with regard to:

(1) Average elevations in the federal reservoirs of Lanier, West Point, and Walter F. George;
(2) Minimum elevations in these reservoirs;
(3) Elevation duration curves in these reservoirs;
(4) Daily average power generation in the federal reservoirs;
(5) Percentage of time when there is some level of recreational impact;
(6) Flow at Columbus;
(7) State line flow duration curve; and
(8) Navigation.

2011 Comparison

Reservoir Elevations

Using the Res-Sim Model, we determined the average and minimum daily elevations, and the elevation duration curves, of the federal reservoirs in the ACF Basin under the PAA' and Scenario C. The average and minimum daily elevations of a reservoir are obtained by looking at the daily elevation of the period of simulation, from January 1, 1975 to December 31, 2011, and calculating the average and minimum daily value for each of the 365 days in a year. The elevation duration curve shows the percentages of time over the entire 37-year period that the reservoirs will exceed certain elevations.

As shown in Figure 1, the average daily elevation of Lake Lanier under Scenario C will be 0.1 feet higher around May 1 as compared with the PAA'. May 1 is the date on which the top of conservation pool guide curve for Lake Lanier rises to 1071 feet for the first time in the year and is the beginning of the primary recreational season. Similarly, the average daily elevation of Lake Lanier around December 1 under Scenario C is less than 3 inches lower than under the PAA'.

The difference between Scenario C and the PAA' is slightly more pronounced in terms of the daily minimum elevation in Lake Lanier (see Figure 2). At the lowest point on the minimum daily elevation curve, which usually takes place in the month of December, the elevation under Scenario C is approximately 0.8 feet lower than in the PAA'.

The elevation duration curves for Lake Lanier are shown in Figure 3. For the upper 95% of the duration curve (representing all times but the lowest reservoir elevation), the elevation of Lake Lanier is essentially the same in Scenario C and the PAA'. The difference between Scenario C and the PAA' is only slightly greater, up to 0.8 feet, in the lower 5% of the duration curve.

The impact on Lakes West Point and Walter F. George is minor (see Figures 4 through 9). There is very little difference in average daily elevation at both West Point and Walter F. George between Scenario C and the PAA'. In terms of minimum daily elevation, the greatest impact of Scenario C in comparison to the PAA' is approximately 0.4 feet in West Point (in the month of November), and less than 0.2 feet at Walter F. George (in December). At the point in the year when West Point and Walter F. George typically reach their lowest elevation for the year (usually in November or December), there is little difference between Scenario C and the PAA'. Even less of a change is evident in the elevation duration curves for Lakes West Point and Walter F. George (Figures 6 and 9). In fact, during much of the summer, the modeling indicates a minor beneficial effect of the proposed water supply operation on West Point and Walter F. George daily minimum elevation (Figures 5 and 8).

Power Generation

The projected water withdrawals and Corps' proposed operations necessary to support them will not have a material impact on the production of hydropower at Buford Dam. Under Scenario C, the daily average energy generated at Lake Lanier is modeled to be 316 MWh (Figure 10), and the annual average energy generated at Lake Lanier is modeled to be 115,340 MWh. In comparison, the daily average energy generated under the PAA' is modeled to be 318 MWh and the annual average is 115,922 MWh. Thus, assuming updated 2050 water supply demands in the Lanier and upper Chattahoochee reaches, there would be a 0.5% reduction in power produced at Buford Dam compared to the PAA'.

As shown by Figure 10, Georgia's future water supply demands will have very little impact on the total amount of energy produced by all of the federal reservoirs in the ACF Basin. Under Scenario C, when Georgia has reached demands of 621 mgd, the daily average energy output from all ACF federal reservoirs is modeled to be 2,639 MWh (annual average 963,209 MWh). The daily average energy output under the PAA' is 2,642 MWh, and the annual average is 964,157 MWh. Thus, there will be only a reduction in daily average generation of 3 MWh (annual average reduction of 949 MWh) for all reservoirs combined. For the combined generation of all of the federal reservoirs in the ACF Basin, there is only a 0.1% reduction under Scenario C.

Recreational Impact

We evaluated the recreational impact by looking at the primary recreational season, defined by the DEIS as May through July for Lanier, May through September for West Point, and June through August for Walter F. George, and tallying the percentage of days when elevation of a reservoir is lower than the three levels of recreational impact, which are, in increasing degree of impact, the Initial Impact Line (IIL), Recreational Impact Line (RIL), and Water Access Limitation (WAL). According to the DEIS, the IIL at Lake Lanier is 1066 feet above mean sea level (msl), the RIL is 1063 feet above msl, and the WAL is 1060 feet above msl. For West Point Lake, the IIL is 632.5 feet above msl, RIL is 629 feet above msl, and WAL is 627 feet above msl. For Lake Walter F. George, the IIL is 187 feet above msl, the RIL is 185 feet above msl, and the WAL is 184 feet above msl.

The impact to recreation is shown in Figures 11 through 13. In Scenario C, as compared with the PAA', there is a slight improvement on the percentage of IIL (by roughly 1%) and very little difference on RIL and WAL (Figure 11).

The recreational impact on West Point is either non-existent or slightly beneficial. At West Point, the extent of recreational impact under the IIL is less in Scenario C when compared to the PAA' (by 1%), while the recreational impacts of RIL and WAL are virtually the same (Figure 12). At Walter F. George, there is no difference in the extent of recreational impact under all three impact levels. The elevation of Walter F. George does not fall to the RIL or WAL in either of the two scenarios (Figure 13).

Flow at Columbus

The impact on flow at Columbus, from either projected water supply needs or potential changes sought by Georgia to the Corps' operation of the federal reservoirs (elaborated in following sections of this memorandum), is very small. EPD staff made a comparison of flow exceedance at Columbus between the Scenario C and the PAA'. The two curves are almost identical for the portion below 2,000 cfs. For example, a flow equal to or lower than 1,350 cfs, which is tracked by Columbus stakeholders, occurs 4.4% of the time in both Scenario C and the PAA' (simulated 1975-2011).

From a water quality compliance perspective, the frequency of flows at Columbus below a daily average of 1150 cfs is an important measure for comparison among scenarios. Under both Scenario C and the PAA', this percentage is 2.5% (simulated 1975-2011).

Even though the PAA performs well in terms of this metric, Georgia has advocated in the past that further improvement can be realized in terms of both endangered species act performance measures and flow at Columbus if certain aspects of operating plans as suggested in the Georgia Contemplation are adopted.

State Line Flow

There is no noticeable difference between Scenario C and the PAA' in terms of the flow duration curve at the Georgia/Florida state line, which suggests that the updated water supply needs in the metro Atlanta area will not result in any significant change in state line flow when compared to the PAA'. (See Figure 14.) When we look more closely at the portion of the graph between the 80 and 95 percentiles exceedance, the curve resulting from Scenario C is barely below the curve resulting from the PAA' (see Figure 15). At the very bottom (the lowest 5%) of the duration curve, note that there is no difference between the two scenarios. Georgia's updated 2050 water supply needs, when compared to water supply settings in the PAA', do not have a material effect on the Corps' minimum flow operation and thus do not change the state line flow in this range. Overall, the change in state line flow is minor in comparison to the magnitude of state line flow under the Corps' proposed basin-wide operation.

Navigation

Without the benefit of the Corps' post-processing tools for navigation performance measures (PMs), EPD staff used the Corps' description to formulate navigation performance measures. Using these PMs, we found no difference between Scenario C and the PAA'. Thus Georgia's updated water supply needs will not have any material impact on navigation availability compared with the PAA'.

2007 Comparison

Reservoir Elevations

As shown in Figure 16, the average daily elevation of Lake Lanier under Scenario D will be slightly higher (by about 2 inches) around May 1 as compared with the PAA. The average daily elevation of Lake Lanier around December 1 under Scenario D is slightly lower (also by about 2 inches) than under the PAA.

The difference between Scenario D and the PAA is slightly more pronounced in terms of the daily minimum elevation in Lake Lanier (see Figure 17). At the lowest point on the minimum daily elevation curve, which usually takes place in the month of December, the elevation under Scenario D is less than 0.3 feet lower than in the PAA.

The elevation duration curves for Lake Lanier are shown in Figure 18. The elevation duration curves for Scenario D and the PAA are almost identical for the top 97% of the elevation spectrum. The difference between Scenario D and the PAA is only slightly greater, up to 4 inches, in the lower 3% of the duration curve.

The impact on Lakes West Point and Walter F. George is minor (see Figures 19 through 24). There is very little difference in average daily elevation at West Point between Scenario D and the PAA (Figure 19). The difference in average daily elevation at Walter F. George between Scenario D and the PAA is almost nonexistent (Figure 22). In terms of minimum daily elevation, the greatest impact of Scenario D in comparison to the PAA is less than 0.7 feet in West Point (in the month of October), and less than 0.4 feet at Walter F. George (in December). (See Figures 20 and 23.) At the time when West Point and Walter F. George typically reach their lowest elevation in a year (usually in November or December), there is little difference between Scenario D and the PAA. Even less change is evident in the elevation duration curves for Lakes West Point and Walter F. George (Figures 21 and 24).

Power Generation

The projected water withdrawals and Corps' proposed operations necessary to support them will not have a material impact on the production of hydropower at Buford Dam. Under Scenario D, with water supply needs of 621 mgd for the Metro Atlanta Area and Corps-adjusted 2007 demands elsewhere, the daily average energy generated at Lake Lanier is modeled to be 314 MWh (Figure 25), and the annual average energy generated at Lake Lanier is modeled to be 114,744 MWh. In comparison, the daily average energy generated under the PAA is modeled to be 315 MWh and the annual average is 114,962 MWh. Thus, assuming updated 2050 water supply demands in the Lanier and upper Chattahoochee reaches, there would be a 0.2% reduction in power produced at Buford Dam compared to the PAA.

As shown by Figure 25, Georgia's future water supply demands will have very little impact on the total amount of energy produced by all of the federal reservoirs in the ACF Basin. Under Scenario D, when Georgia has reached demands of 621 mgd, the daily average energy output from all ACF federal reservoirs is modeled to be 2,635 MWh (annual average 961,923 MWh). The daily average energy output under the PAA is 2,637 MWh, and the annual average is 962,511 MWh. Thus, there will only be a reduction in daily average generation of 2 MWh (annual average reduction of 588 MWh) for all reservoirs combined. For the combined generation of all of the federal reservoirs in the ACF Basin, there is only a 0.1% reduction under Scenario D.

Recreational Impact

The impact to recreation is shown in Figures 26 through 28. In Scenario D as compared with the PAA, there is a slight improvement on the percentage of IIL and RIL (both by roughly 1%) and very little difference on WAL (Figure 26).

The recreational impact on West Point is minor. At West Point, the extent of recreational impacts under the IIL and WAL are about one percent more in Scenario D when compared to the PAA, while the recreational impacts of RIL is the same (Figure 27). At Walter F. George, there is no difference in the extent of recreational impact under all three impact levels. The elevation of Walter F. George does not fall to the RIL or WAL in either of the two scenarios (Figure 28).

Flow at Columbus

Again, flows at Columbus between the two scenarios are very similar. For example, a flow equal to or lower than 1,350 cfs, which is tracked by Columbus stakeholders, occurs 5.2% of the time in the PAA, and 5.3% in Scenario D (simulated 1939-2011). From a water quality compliance perspective, the frequency of flows at Columbus below a daily average of 1150 cfs is an important measure for comparison among scenarios. Under both Scenario D and the PAA, this percentage is 3.2% (simulated 1939-2011).

State Line Flow

There is no noticeable difference between Scenario D and the PAA, in terms of the flow duration curve at the Georgia/Florida state line, which again suggests that the updated water supply needs in the metro Atlanta area will not result in any significant change in state line flow when compared to the PAA. (See Figure 29.) When we look more closely at the portion of the graph between the 80 and 95 percentiles exceedance, the curve resulting from Scenario D is barely below the curve resulting from the PAA (see Figure 30). At the very bottom (the lowest 5%) of the duration curve, note that there is no difference between the two scenarios. When Georgia's updated 2050 water supply needs are evaluated against the PAA with an alternative basin-wide water use (Corps-adjusted 2007 demand), these needs do not have a material effect on the Corps' minimum flow operation and thus do not change the state line flow in this range.

Navigation

Using staff-developed navigation performance measures, we found no difference between Scenario D and the PAA. Thus Georgia's updated water supply needs will not have any material impact on navigation availability compared with the PAA.

In conclusion, Scenario D performs essentially the same as the PAA in all of the performance measures we evaluated. This confirms our finding from the previous sub-section that Georgia's 2015 Water Supply Request is not materially different from what the Corps already considered and proposed in the DEIS.

III. Water Management Evaluation

Peachtree Creek Flow Target

The Corps operates Buford Dam to provide flow to support a flow target just upstream of the confluence of Peachtree Creek and the Chattahoochee River. This location is about two miles downstream from the USGS gaging station of Chattahoochee River at Atlanta, GA (02336000), and almost immediately downstream from the City of Atlanta's raw water intake. Treated wastewater is discharged into the Chattahoochee River just downstream from Peachtree Creek from the Cobb County R.L. Sutton Water Pollution Control Plant (WPCP) and the Atlanta RM Clayton WPCP. These discharges and corresponding water quality in the river are closely associated with the flow target at Peachtree Creek.

Through coordinated operations with the Atlanta Regional Commission and Georgia Power Company, the Corps, after receiving forecast tributary flows between Buford Dam and the Peachtree Creek confluence, ensures that releases from Buford Dam are enough to meet the needs of water withdrawal facilities along the Chattahoochee River and to meet the above-mentioned flow target after the withdrawals take place. The coordination has a mid-week correction mechanism to account for any errors in forecasting water supply needs and tributary flows.

In practice, this flow target is met by Georgia Power Company operating its Morgan Falls project to meet water supply needs downstream of Morgan Falls (Cobb County and the City of Atlanta) and the flow target at the Peachtree Creek confluence. The Corps schedules peaking hour generations at Buford Dam to make sure there is enough water stored at Morgan Falls to meet the combined needs. In water quantity modeling (HEC-ResSim presently and HEC-5 previously), Morgan Falls is treated as a run-of-river project, and the water supply needs and the flow targets are met directly with release from Buford Dam. The modeling is consistent with the practice in the sense that any potential deficit in meeting either water supply or the flow target at Peachtree Creek confluence is eliminated by additional release from storage at Lake Lanier.

Historically, the Corps has operated Buford Dam to provide a flow target of 750 cubic foot per second (cfs) throughout the year. In previous drought years, the State of Georgia has asked the Corps to lower the flow target temporarily during the colder wetter months. The State presented to the Corps the water resource benefits of preserving water during times of relative abundance in a drought year. The State also addressed water quality concerns, demonstrating compliance to water quality standards of both simulated and observed dissolved oxygen concentrations in the Chattahoochee River. After consideration and technical evaluation of the State's requests, the Corps implemented reduced flow support to 650 cfs during the years of 2008, 2009, 2011, and 2012, with no consequent violations of water quality standards.

The Corps' successful implementation of flow target reductions in the wetter periods of the drought years indicates that the operation of Buford Dam can be modified without negative effects on water quality and other aspects of the Chattahoochee River. These successful reductions suggest consideration of further reductions in the flow target at Peachtree Creek in the wetter periods of all years to achieve storage benefits at normal times and reduced probabilities of the system entering drought operations.

The models used to evaluate the benefits of a reduced flow target at the Peachtree Creek confluence on the lake levels are a set of ACF Basin HEC-ResSim models, which were released together with the DEIS in October 2015. We used two alternatives from this set of models. The first one is what the Corps refers to as the No Action Alternative (NAA) reflecting current water use and water management. In this alternative, the Peachtree Creek flow target is set at 750 cfs for the entire year. The second alternative is the PAA, as discussed above. In the PAA, the Corps revised the Peachtree Creek flow target to 650 cfs during the wetter and colder half of the year (November through April). In order to evaluate the effect of further reducing the flow target during the wetter and colder half of the year, we formulated a third alternative, which we refer to as the PAA Reduced or the PAA 550. The PAA Reduced has a November through April Peachtree Creek flow target of 550 cfs, but is otherwise the same as the PAA. In both the PAA and the PAA Reduced scenarios, the flow target remains at 750 from May through October.

Note that the water demand used in the NAA is not the same as that in the PAA. The Corps used Georgia's 2007 recorded water demand (128 mgd of withdrawal from Lake Lanier and 277 mgd from the upper Chattahoochee River) as the basis of the demand set in the NAA. The PAA, however, incorporated 225 mgd of Georgia's request of 297 mgd from Lanier and 408 mgd from the upper Chattahoochee River.[11] The newly formulated PAA Reduced (PAA 550) has the same demand as in the PAA. A comparison between the NAA and the PAA (or the PAA Reduced) therefore does not evaluate the effect of reduced Peachtree Creek flow targets. The beneficial effect of reducing the Peachtree Creek flow target in the wetter and colder time can best be seen in a direct comparison between the PAA and the PAA Reduced (PAA 550).

As can be seen in Figures 31 through 35, there is a persistent Lanier storage benefit through the most severe droughts recorded in history from the reduced winter/spring Peachtree Creek flow target in the PAA Reduced as compared to the PAA. The maximum benefit through the most severe drought, the 2007-2009 period, is 1.4 feet in elevation, or roughly 44,000 acre-feet in storage. The benefits from a reduced Peachtree Creek flow target in other droughts are less substantial, but still evident. For example, the storage benefit from the PAA Reduced (PAA 550) can be as much as 0.9 feet (or almost 30,000 acre-feet) in 1956, 0.9 feet (or more than 29,000 acre-feet) in 1989, 0.7 feet (or more than 22,000 acre-feet) in 1986, and 0.6 feet (or more than 21,000 acre-feet) in 1941.

Those higher Lake levels then provide system benefits to the entire Basin. In a drought year when basin inflow is lower than average and competing needs in the Basin stretch limited resources, maintaining storage in the Lake, the most upstream storage reservoir, preserves maximum operational flexibility to

[11] In the PAA, 40 mgd comes from the Glades Reservoir. In the PAA Reduced (PAA 550), that 40 mgd comes from Lake Lanier.

meet all authorized purposes and reduces the amount of time- by five months – that the Basin is in drought operations.

Looking at flows in the middle Chattahoochee reach, no impact is evident from the change in the Peachtree Creek flow target. A comparison of flow exceedance at Columbus was made among the NAA, the PAA, and the PAA Reduced (PAA 550) scenarios. The difference in flows below 2,000 cfs among the scenarios is almost non-existent.

For flows below a daily average of 1150 cfs in the middle Chattahoochee reach, a measure important from a water quality compliance perspective, there is also little difference between the scenarios. Under the NAA, the PAA, and the PAA Reduced (PAA 550) scenarios, the percentages are 3.1%, 3.2% and 3.2% (simulated 1939-2011).

Looking at water quality parameters specifically, water quality can be protected with a reduced Peachtree Creek flow target in the November-April time period. Based upon dissolved oxygen (DO), the parameter long tracked as a key indicator of conditions in the upper Chattahoochee River, lowering the Peachtree Creek flow target in the winter months does not present a water quality challenge downstream. Given past problems with DO in this reach, the significant improvements that have been made with respect to this parameter, and the significance of DO in determining wasteload allocations, Georgia believes that any changes in the Peachtree Creek flow target must be acceptable from a DO perspective.

The hydrodynamic water quality model GA RIV-1 was used to assess dissolved oxygen in the Chattahoochee River under NAA, the PAA, and the PAA Reduced (PAA 550). Specifically, model results at the DO sag near Dog River, the point of minimum DO concentration in the river below the wastewater discharges in the metro Atlanta area, were assessed for compliance with the instream dissolved oxygen water quality criteria (daily average of 5.0 milligrams per liter [mg/l] and not less than 4.0 mg/l). Specifics on the Metropolitan Chattahoochee River Model used for this evaluation are provided in Appendix E.

Results demonstrate that DO criteria are expected to be met throughout the year under all three alternatives. Table 4 provides the model results for the minimum daily average DO concentrations by year. Figure 36 shows the model results for daily average DO concentrations for each year for the NAA; Figure 37 shows the daily average DO concentrations for each year for the PAA; and Figure 38 shows the daily average DO concentrations for each year for the PAA Reduced (PAA 550). These results show that the DO criteria are met throughout the simulation period for each alternative.

Table 4: Minimum Predicted Dissolved Oxygen Concentrations by Year

Minimum Daily Average DO Concentration (mg/L)			
Year	NAA	PAA	PAA Reduced (PAA 550)
2000	4.97	4.95	4.96
2001	5.14	5.37	5.46
2002	5.19	5.08	5.18
2003	5.75	5.73	5.83
2004	5.38	5.32	5.45
2005	6.09	5.92	6.04
2006	5.29	5.08	5.14
2007	5.12	5.00	5.02
2008	5.21	5.12	5.20

For other parameters for which water quality standards have been defined, ecosystem response as well as assessment and management, are more complex than for dissolved oxygen. The best available data indicate that, under both the PAA and the PAA Reduced (PAA 550) alternatives, with implementation of the state's ongoing water quality management programs, waters that currently support designated uses would be expected to continue to do so and continued progress toward restoration would be expected for waters that are currently impaired.

West Point Potential Rule Curve Revision and Flood Risk Mitigation Operation

Water Resource Benefit of Rule Curve Revision

West Point Reservoir is the second largest federal storage project in the ACF Basin. It has 306,131 acre-feet of conservation storage at its summer (full) pool level when elevation is maintained at 635 feet MSL. In anticipation of seasonal precipitation and high inflow events, the Corps lowers the top of conservation pool from 635 feet MSL at the end of October to 628 feet MSL in mid-December. This is called a winter drawdown. The Corps keeps the project at 628 feet MSL from mid-December to mid-February, when a gradual rise of the rule curve starts toward a full pool level again in June. The drawdown from 635 feet MSL to 628 feet MSL corresponds to a storage difference of 162,500 acre-feet, or 53% of West Point conservation storage. In the drawdown period, this storage space is available for storing flood water from expected seasonal high precipitation events.

From the water resource management perspective, there are several potential issues with the winter drawdown, especially one as sharp as this one. First, the drawdown causes a large amount of stored water to be released from the federal reservoir system in the late fall, when the biological growing season for biota in the river is over and the need for release to the river is not as much as in the riverine growing season. Second, the Corps defines the period between December and February as the refill season for the federal reservoirs. The winter drawdown contradicts the concept of a refill season, when the amount that can be stored is greatly limited by the depressed winter storage capacity. Third, the rise of rule curve largely corresponds to what is called Sturgeon Spawning Season (March through May) under the Corps' basin-wide operation scheme. The Sturgeon Spawning Season happens to be the season with the largest minimum flow requirement in the Apalachicola River. The need to refill federal storage, including West Point Reservoir, to the full pool level is in direct competition with calls for higher releases for downstream purposes. Last but not least, the drawdown itself and the potential (as well as real experience) that West Point may not be refilled to its full pool level at the beginning of summer hurts Congressionally-authorized recreational purpose of the West Point project.

Stakeholders in the West Point area have long expressed the need to study the potential for eliminating or limiting the extent of the winter drawdown to improve conditions for the Congressionally-authorized recreation at the project. The Corps has countered that any reduction in winter drawdown, or increase in winter pool levels, would reduce the amount of seasonal flood retaining storage and thus be detrimental to flood risk mitigation operation. For this reason, the Corps did not consider raising the West Point winter rule curve in the Water Control Manual update process.

Georgia EPD has worked with stakeholders in the West Point Reservoir area and understands their positions. Prior work done by the Hydrology Unit and other consultants shows appreciable water resource benefits from raising the winter rule curve, not only at West Point, but also at Lanier and other locations in the basin. EPD's latest modeling based on the Corps' PAA model (with changes made only to increase West Point winter rule curve from 628 feet MSL to 632 feet MSL) again demonstrates such benefits. Figures 39 to 43 show storage benefits to West Point in the years of 1981, 1986, 2000, 2004, and 2006. The maximum elevation benefit to West Point is 4.8 feet in year 1954. Figures 44 to 47 show storage benefits to Lanier in the years of 1981, 2000, 2004, and 2006. The maximum benefit to Lanier is 1.84 feet in year 2004. There is also a slight improvement in recreational impact to both Lanier and West Point (Figures 48 and 49). Looking at flows in the middle Chattahoochee reach, modeling indicates that flows important for water quality compliance would not be affected by the rule curve change, with flows at Columbus equal to or great than 1150 cfs the same percentage of time under the higher rule curve as the current rule curve. Finally, an increase in the winter rule curve is likely to benefit water quality in West Point Lake. Higher water surface elevations generally contribute to lower levels chlorophyll a in reservoirs, and water quality modeling undertaken by Georgia supports that conclusion.

Revision to Flood Risk Mitigation Operation

Georgia EPD understands the reason behind the Corps' reluctance to consider a revised West Point winter rule curve. However, a review of the Corps' flood mitigation operation in the past and a revision to the existing procedure to reduce flood risk would allow the Corps to consider raising West Point's winter rule curve without having negative impacts on flood mitigation operations.

The Corps kindly provided Georgia information regarding its flood risk operations during May 2003, one of the most substantial flood events in recent history. EPD's review suggests that quicker response to high volumes of inflow to the West Point project might have avoided large volumes of water being stored in the reservoir and the project's elevation rising toward the top of the flood mitigation storage (640 feet MSL according to the ACF ResSim model). Figure 50 shows time series of West Point inflow, release, and pool elevation from May 3 to May 10, 2003. It can be seen that, as the 3-hour inflow to the project rose above West Point's power house capacity of around 16,500 cfs (approximately at 10:00 May 6, 2003) and continued to increase, the project release lagged behind inflow for 54 hours (until 16:00 May 8, 2003). At one point, release was less than inflow by as much as 92,400 cfs.

The Corps has since handled a fast rising flood pool and large volumes of inflow quite effectively in both 2009 and most recently in December 2015, accomplishing this in the face of limitations posed by real-time, incomplete information. To move beyond a focus on past flood events and post-hoc assessments using total knowledge of the incoming flow sequence, EPD worked with the Corps and the National Weather Service Southeast River Forecast Center (SERFC) to test the incorporation of probability-based forecast information in flood risk mitigation operations and seek revised flood mitigation procedures to reflect this incorporation. In this approach, the modeler/operator does not have full knowledge of the incoming flow sequence. Instead, he or she has project information and forecast information one time step at a time. In other words, the modeler/operator is in a virtual flood mitigation operation. The goal is to identify revised procedures with clear rules on when certain actions need to be taken given inflow seen at the project, runoff conditions in the contributing drainage area, and probability of certain levels of precipitation in the near future.

It is reasonable to think that in 2003 the project elevation would not have risen so fast toward the top of flood mitigation storage had the Corps made earlier and higher releases (not exceeding inflow on the rising limb of an event of course) with the beneficial information of "water on the ground" – defined as runoff that has already materialized in the reservoir's contributing drainage area but has not yet reached the storage (and thus remaining temporarily "unaccounted for" to the project inflow) – and "water in the air" or forecast of precipitation in the short term (a few days). Such a forecast of inflow would give the Corps early information on how much water is on its way to the project and with how much certainty. Armed with this information, the Corps can make early releases to "match inflow," even when the "inflow" is still on its way to the project and has not quite reached the reservoir yet, and thus avoid the delayed action that was observed in events such as the May 2003 one.

Georgia EPD contracted with Hydrologics to develop revisions to the West Point flood mitigation operation based on the Corps' flood control procedure as reflected by the Corps' 1989 Draft Water Control Manual[12], the Corps' recorded project operation data (elevation, inflow, and releases), recorded flow sequence by USGS, and flow and precipitation forecast made by SERFC between 2005 and 2015.

The study was designed to evaluate two questions: Is it possible to design a rule or a set of rules, given real-time gage readings from USGS and forecast information from SERFC, that would (1) allow for earlier releases from the West Point project to achieve lower peak release and no worse peak reservoir elevation, and (2) minimize false actions that lower reservoir elevation unnecessarily and have a negative effect on West Point and system storage?

The study demonstrated that both outcomes are achievable. As shown by the Hydrologics Report (Appendix F), the modeler/operator was faced with the same inflow conditions, same real-time gage readings from USGS, and the same SERFC forecast of stream flow and precipitation. After the single

[12] At the time EPD contracted this work, the DEIS was not available.

value SERFC forecast has been transformed into probability-based ensemble forecast, a set of rules designed to help the operators take certain actions, including what we call Inflow Following Rule (IFR), was incorporated into a flood operation model. This revised flood mitigation operation was then tested with real-time conditions between 2005 and 2015. The rules were revised in an iterative manner, and the results show that, during the September 2009 flooding event, substantially lowered peak release (by 15%) from West Point (by extension a lower risk flood operation) could have been achieved with the forecast information and the new rules (Figure 51). This was achieved not at the expense of reservoir storage either, since after-event reservoir elevation barely changed and the long-term reservoir elevation exceedance curve was almost identical to the operation without the new rules. Details of this study can be found in the Hydrologics Report attached to this memorandum in Appendix F.

This study demonstrated that a revised flood mitigation operation based on probability-based forecast information is not only possible but also effective in reducing flood risks and easy to implement. Furthermore, the current formulation of the rules and the parameters in the rules are just examples of what could be implemented. Other parameter values or other forms of rules aimed at reducing flood risks can also be tested. Georgia EPD encourages the Corps to continue to work with the State and SERFC in pursuit of reduced flood risks and increased water resource benefits from West Point Reservoir.

Navigation

The Corps has not implemented any meaningful navigation operation since 1999, mostly because the lack of navigation demand and Corps' inability to obtain necessary 401 water quality certification from the State of Florida for dredging and snagging operations to maintain navigation channels.

In the newly released DEIS, the Corps proposes to resume navigation operation on a regular basis for the wetter period of January through April (or May depending on hydrologic conditions) of each year. The Corps contemplated providing only a seven-foot channel for navigation though, requiring a flow of 16,200 cfs as measured at Apalachicola River at Blountstown, Florida.

Georgia EPD has serious concerns over the proposed navigation for a number of reasons and those concerns are discussed in more detail below.

First, the incorporation of navigation operation substantially increased the number of days when the ACF system is under drought operation. EPD staff took the Corps' PAA model and formulated a PAA No Navigation alternative by turning off the navigation operation. The PAA No Navigation alternative would result in a total drought operation of 3,622 days of the 1939-2011 period of simulation. In comparison, the Corps' PAA alternative with navigation operation would result in a total drought operation of 4,833 days. This is a 33% increase in drought operation. Furthermore, while the PAA No Navigation alternative would not result in any days of Extreme Drought operation, the PAA alternative with navigation operation would cause the system to be in Extreme Drought operation for 61 days.

The effect of PAA navigation operation, in comparison to the no navigation alternative, can be seen in Figures 52 through 60. Navigation triggers and drought triggers are expressed in a binary manner, with the value 1 representing "on" and 0 representing "off" conditions.

In previous analyses of the Corps' operation of the ACF system, EPD staff has seen in general drought operations taking place in the typical drought years of the 1950's (1951, 1954-1956), the 1980's (1981, 1986, and 1988-1989), the turn of the century (1999-2001), and the most recent ones (2006-2008). Upon review of the PAA alternative, however, staff noticed typical non-drought years with drought operation taking place. For example, drought operations closely follow navigation operations in 1940, (Figure 52), in 1985 (Figure 56), in 1992 (Figure 57), and in 2004 (Figure 58).

Even in the typical drought years when drought operations would usually occur, the PAA alternative with navigation operation would bring on drought operation earlier than the one without navigation. Also, the onset of drought operation in these times usually immediately follows the conclusion of a navigation operation, which strongly indicates causation. For example, under 1941 hydrology, a drought operation would occur in May under the PAA alternative without navigation. Under the PAA with navigation, however, the drought operation would take place in March, immediately after a navigation operation from January to February 1941 (Figure 52). Under hydrologic conditions of 1954 to 1956 and the PAA alternative without navigation, there would not be a drought operation until July 1955, and it would only last until May 1956. With the PAA navigation alternative, however, the drought operation would start in June 1954, more than a year earlier, and would linger on and off until early 1957 (Figure 54). Similar situations can be seen with the hydrology of 1981 (Figure 55), 2006-2008 (Figure 59), and 2011 (Figure 60).

Second, in the navigation season of drought or drier years, the system cycles multiple times between the two extremes of a navigation operation, when 16,200 cfs is needed, and a drought operation, when only a 5,000 cfs flow requirement is present. This reversal between two extremes is directly contradictory to the Corps' desire for steady operation and smooth transition.

The reversal can be seen under various hydrologic conditions. For example, under 1942 hydrology, the system would be operated for a month of navigation before it plunges into a drought operation in the next two months, which is then followed by another two months of navigation (Figure 52). Under 1951 conditions, the system would experience almost two months of navigation followed by a month of drought operation, which is then followed by another two months of navigation and another two months of drought operation (Figure 53). Similar bipolar behavior can be seen under 1957 (Figure 54), 2006-2007 (Figure 59), and 2011 (Figure 60) conditions.

Third, the mere prospect that navigation operation, which requires substantial flow support from storage, may take place in a drought year like 1954, 1981, 2006, 2007, and 2011 raises serious concerns. There appears to be no forecast hydrologic conditions used as a threshold for a navigation season to commence. Other than system Composite Storage being healthy at the beginning of a navigation season, there appears to be no hydrologic information that can be used to stop the implementation of storage-costing navigation operation until that storage plunges into Zone 3 for a reversal to drought operation.

Georgia EPD encourages the Corps to establish an inflow forecast mechanism, one that is not unlike the one discussed in the section titled West Point Potential Rule Curve Revision and Flood Risk Mitigation Operation. Such forecast can help the Corps implement navigation operation only when conditions warrant such and avoid costly navigation operations that aggravate storage burdens in drought years.

Fourth, there appears to be an error in the navigation performance measure for some of the alternatives including the PAA. Staff was not able to replicate the navigation availability of the PAA with an evaluation tool developed using only descriptions provided by the Corps. For example, the Corps stated that the PAA has a 42.5% seven-foot navigation channel availability, while we could only calculate an availability of 21.9%. Using the same understanding and performance measure, the PAA without navigation requirement would have a 19.2% availability of seven-foot channel. This means that there is an increase of only 2.9% or a mere two years of additional navigation availability under the PAA navigation operation in the entire 73-year period. The cost of this gain in navigation, however, can be high as evidenced by a four feet difference in minimum Lanier elevation (between the PAA and the PAA No Navigation alternatives) and by the points above related to impacts on system storage and the increased emergency drought operation of the system.

Fifth, EPD staff has been successful in formulating an alternative to achieve the same level of navigation availability without the impacts on storage seen with the PAA. With minor changes to the navigation parameters, 21.9% navigation availability has been achieved with Lanier elevation virtually unchanged from the PAA No Navigation alternative. We encourage the Corps to work with EPD to further explore implementing more apt and more efficient navigation operations.

Finally, navigation operation should be implemented only when there is demand for navigation, and should not serve as a secondary and implicit flow requirement. In the navigation season of January through May, the flow requirement of 16,200 cfs can be much higher than flow rates determined by the RIOP Jim Woodruff release requirements. The Corps should not treat the 16,200 cfs as a flow that has to take place in the navigation season. This flow should only take place following an established process. Georgia EPD suggests the following as essential elements of such a process: clear declarations of needs from potential users, favorable hydrologic conditions as forecast by established protocols, close coordination among multiple users so the same flow concentrated in a short period can support many users, and an evaluation and declaration of storage impact from the Corps. EPD is willing to work with the Corps in developing this procedure and its elements.

Methodology of Alternative Evaluation/Performance Measures

<u>Performance Measures for Endangered Species</u>

In previous communications with the Corps and the US Fish and Wildlife Service (Service), Georgia EPD advocated developing performance measures based on physical evidence, rather than arbitrary beliefs that are not supported by science. In January 2013, EPD presented in writing the concept of the Georgia

Contemplation, an operation set based on performance measures designed to meet all authorized purposes, including biological needs of endangered species in the Apalachicola River.

EPD staff and contractors developed a spawning season operation to enhance the availability of sturgeon spawning habitat. Using performance measures of spawning habitat availability developed by the Service, the Georgia Contemplation provides better habitat availability than the RIOP does. Using floodplain connectivity performance measures developed by the Service, the Georgia Contemplation provides better continuous floodplain connectivity than the RIOP.[13]

Georgia EPD also pointed out the lack of physical evidence supporting performance measures for flows between 5,000 cfs and 10,000 cfs. In the various Biological Opinions the Service has issued on operation of Jim Woodruff Lock and Dam, enumeration of flows between 5,000 cfs and 10,000 cfs, and percentages based on those counts, served as the performance measures. The 2012 Biological Opinion attributes adverse effects to listed species in the 5,000 to 10,000 cfs range. EPD was able to show that this is not correct.

Using characteristics (depth of inundation and slope) identified by the Service as appropriate habitat in its Biological Opinions and bathymetric data the Corps collected of the Apalachicola River, EPD was able to derive the aggregated amount of potential habitat, suitable for fat threeridge mussels, at more than forty sites along the Apalachicola River, as a function of stage and flow. Contrary to the 2012 Biological Opinion, EPD found that the maximum amount of aggregated mussel habitat occurs at flows much lower than 5,000 cfs. The result clearly indicates that the performance measure of flows between 5,000 and 10,000 cfs as formulated by the Service is inappropriate.

EPD staff has had personal communications with Service staff on field investigations of fat threeridge mussels and their habitat. It is EPD staff's understanding that large areas of habitat and large populations of the endangered mussels have been found when flow was roughly 5,000 cfs. The density of the mussels in the surveyed habitat indicated a newly estimated population to be between 5 and 6 million, several times the original estimate thus, the latest study identifying both large amounts of habitat and large populations of mussels does not support that there are any gains associated with flows above 5,000 cfs. Another prospect of this finding is that the abundance of the mussels makes it possible for the Service to start a delisting process.

Thus, Georgia suggests that the Corps should utilize this new information obtained by EPD and the Service and discontinue using invalid low flow performance measures in evaluating operation alternatives.

<u>Water Supply Performance Measures</u>

Some of the performance measures used in evaluating alternatives appear to be inappropriate. For example, in Table 4.3-12 Water Supply Performance for Water Management at Lake Lanier, Columns 3

[13] Beyond improved biological performance measures, we have also seen better performances in terms of other benefits across the basin, including better storage conditions in the federal reservoirs, better recreation outcomes, similar hydropower benefits, and improved flow conditions at Columbus.

through 5 were used to compare alternatives in terms of the frequency of the reservoir being in different action zones. The problem is that the different alternatives have different action zone definitions, or the conservation storage was divided differently. How can a comparison of storage being in different action zones be achieved in a fair manner when the zones are divided differently?

Hydropower Performance Measures

EPD staff review of the hydropower power performance measures indicates potential errors in the calculation of capacity benefits at West Point and Walter F. George. For example, in Table 4.3-3, the West Point, Lowest Annual Hydropower Capacity seems to have been calculated with long-term average of the annual capacities, rather than the stated "lowest" annual capacity. The same was observed for Walter F. George (Table 4.3-4).

Recreation Performance Measures

There appears to be a double use of the same performance measure in evaluating the alternatives at all three federal reservoirs. For example, in Table 4.3-8, the Column "Number of days below WAL (1,060')" provides the same information as in Column "Percent of time below WAL (1,060')." The latter one appears to contain values in the first one divided by the length of the recreational season. In other words, the same standard has been applied twice in evaluating the alternatives.

Navigation Performance Measures

Following the Corps' description of navigation performance measures, EPD staff tried to evaluate alternatives provided by the Corps as well as additional ones considered by EPD staff. It was found that EPD staff could not replicate performances of all of the alternatives provided by the Corps. The ranking would have been different if staff understanding of the performance measures is correct.

Georgia EPD encourages the Corps to share its performance measure tools with the stakeholders so the alternative evaluation process is transparent and well understood.

Alternative Ranking

To make the alternative evaluation and ranking process transparent and fair, Georgia EPD encourages the Corps to put forward all of the evaluating tools and ranking sheets so all the stakeholders can verify the alternative evaluation process.

Index of Appendices

Appendix A - Memorandum from Katherine Zitsch, Director, Metro District, to Judson Turner, Director, Georgia Environmental Protection Division, regarding Projected Future Treated Wastewater Returns for the Chattahoochee River and Lake Lanier System (Jan. 25, 2016) and Memorandum from Katherine Zitsch, Director, Metro District to Judson Turner, Director, Georgia Environmental Protection Division, Regarding projected future water supply demand for the Chattahoochee River and Lake Lanier System (Dec. 2, 2015)

Appendix B - Memorandum from Nap Caldwell, Water Supply Section, Georgia Environmental Protection Division to Judson Turner, Director, Georgia Environmental Protection Division, regarding 2050 Water Needs of Dawson, Habersham, Lumpkin and White Counties (Dec. 2, 2015)

Appendix C - HEC-ResSim models: PAA', Scenario C, and Scenario D

Appendix D - Georgia 2015 Updated Water Supply Request demand spreadsheet at ACF_GA -2015-Request_621mgd_Demand_20160127_HL.xls.

Appendix E - GA Riv-1 Metropolitan Chattahoochee River Model Overview

Appendix F - Development and Testing of Alternate Forecast-Based Flood Operations Rule for West Point Lake, Georgia, (Sheer, Schaake, Lebherz and Zeng)

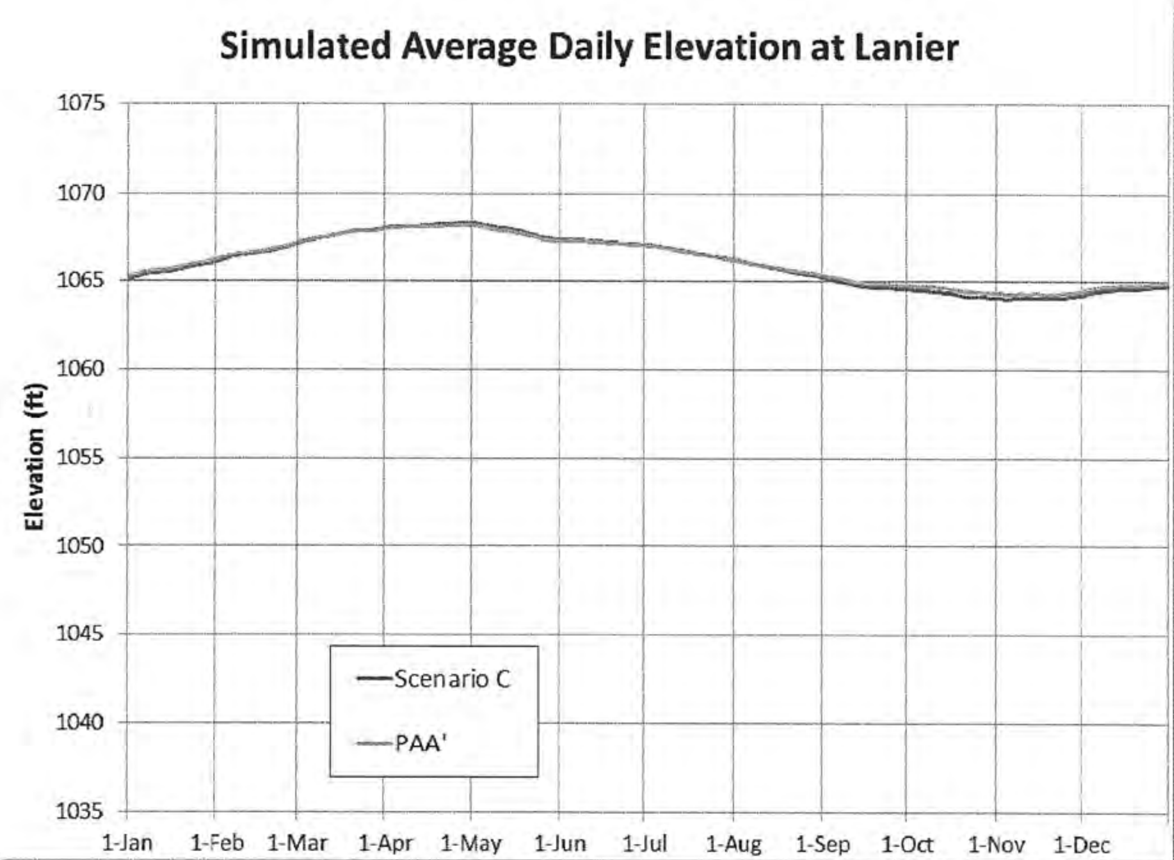

Figure 1. Simulated average daily elevation at Lake Lanier.

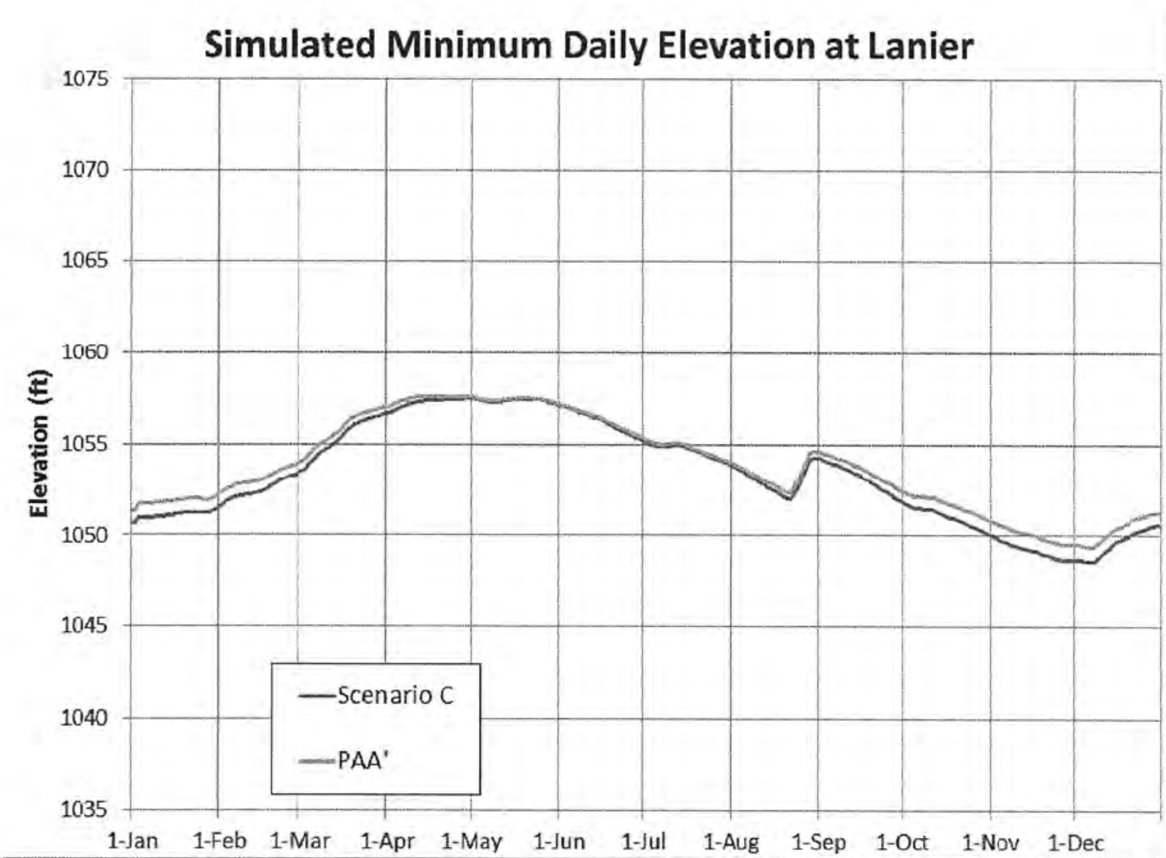

Figure 2. Simulated minimum daily elevation at Lake Lanier.

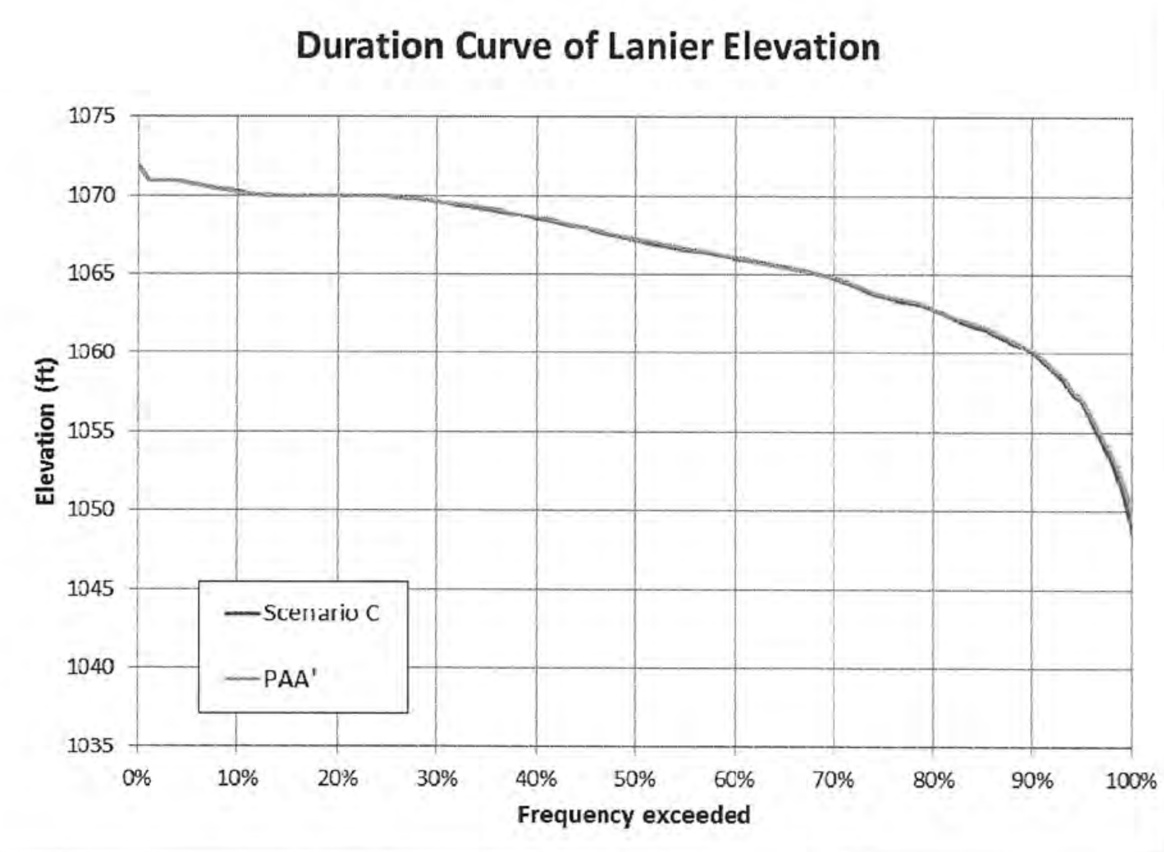

Figure 3. Duration curve of simulated Lanier elevation.

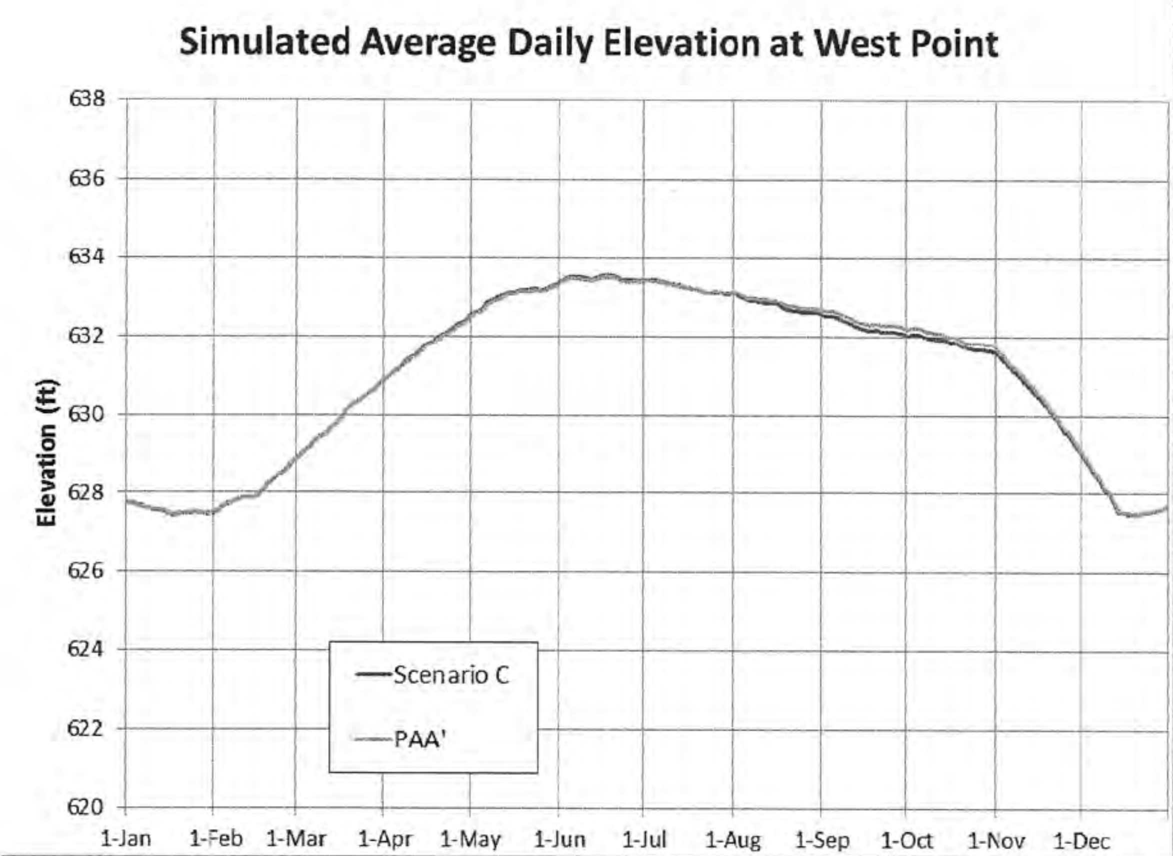

Figure 4. Simulated average daily elevation at West Point Lake.

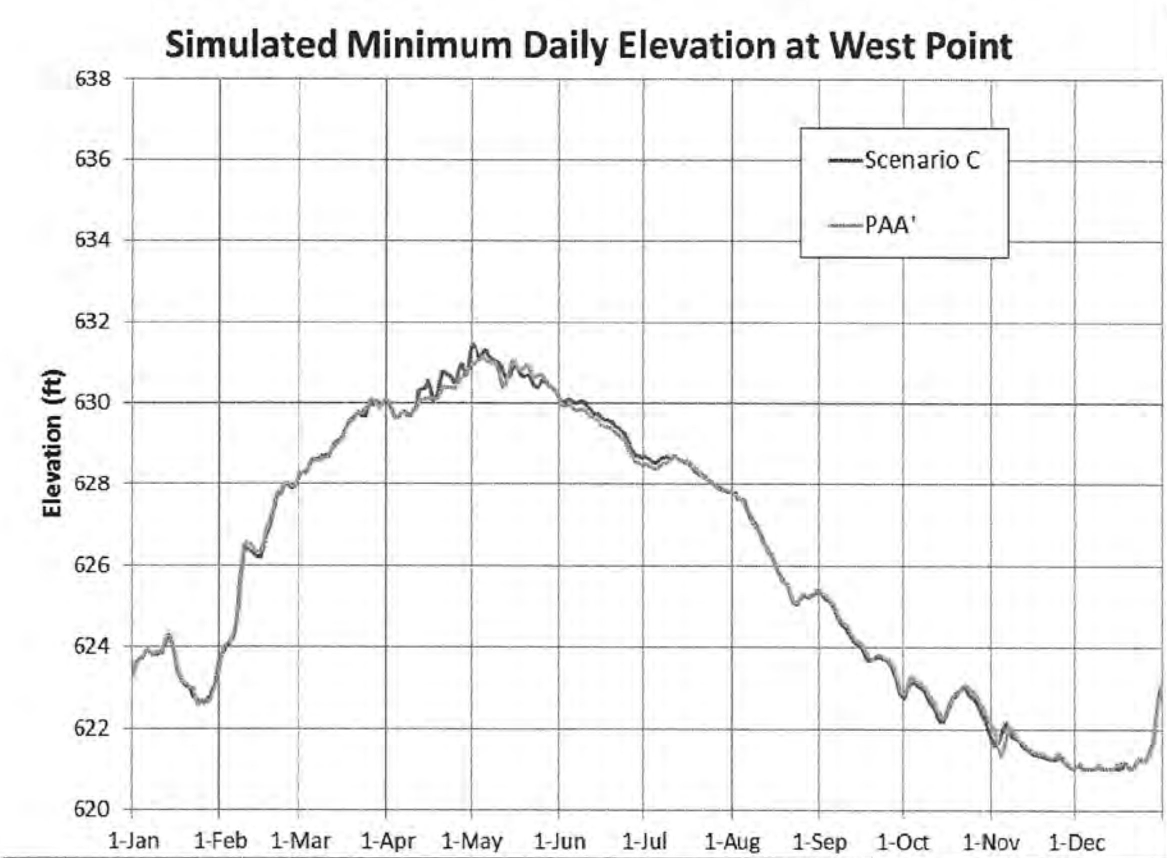

Figure 5. Simulated minimum daily elevation at West Point Lake.

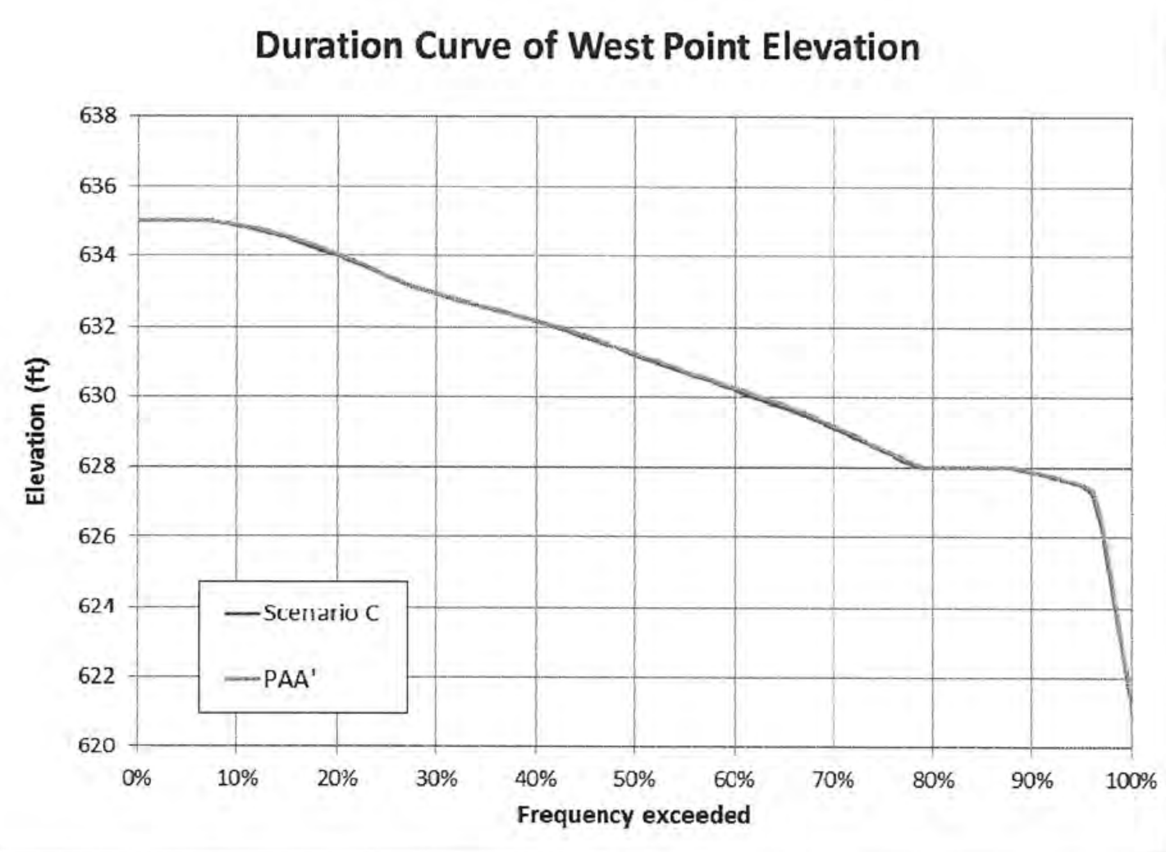

Figure 6. Duration curve of simulated West Point elevation.

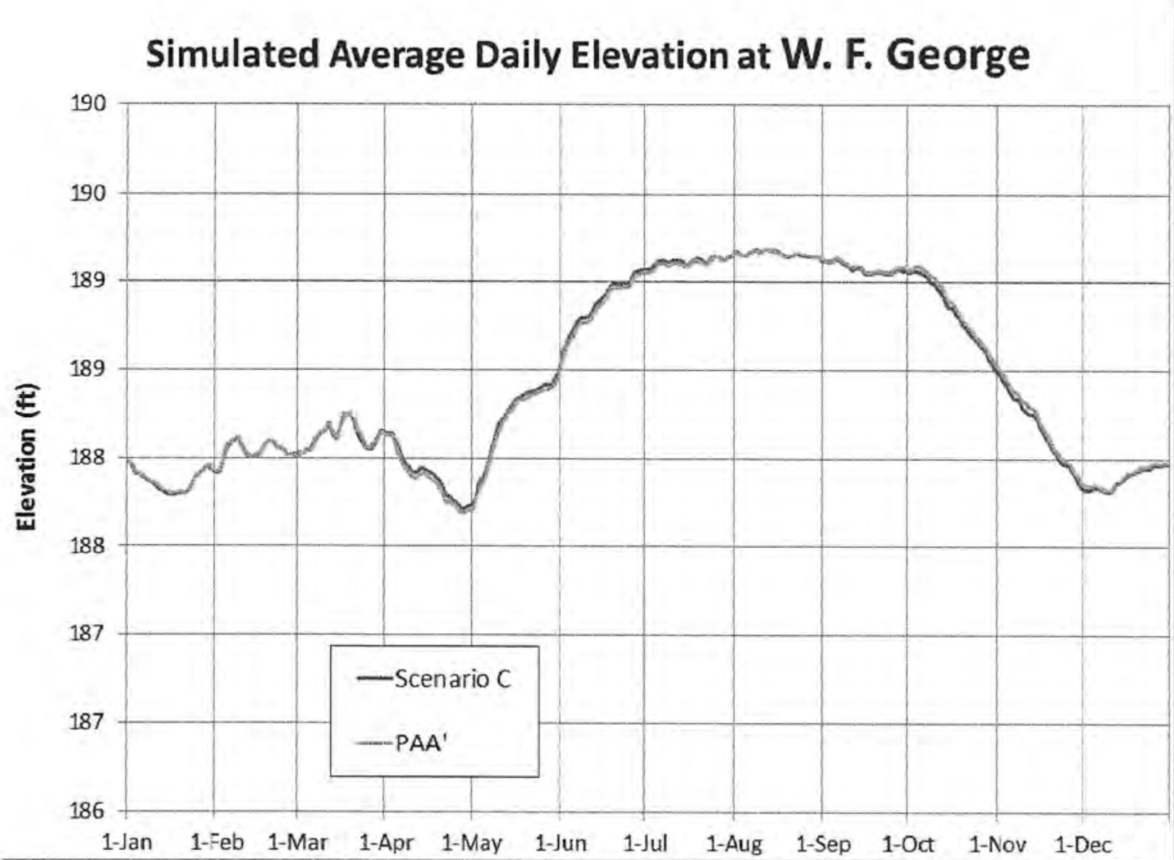

Figure 7. Simulated average daily elevation at Walter F. George Lake.

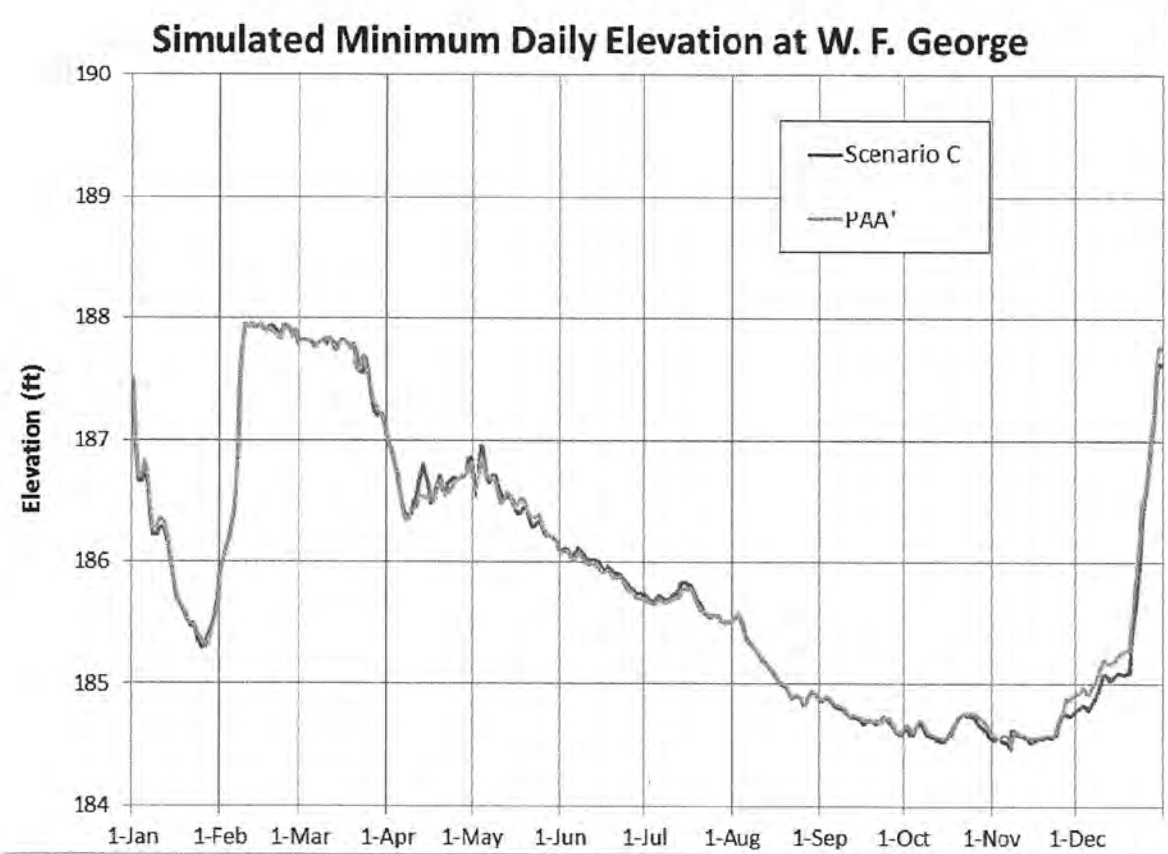

Figure 8. Simulated minimum daily elevation at Walter F. George Lake.

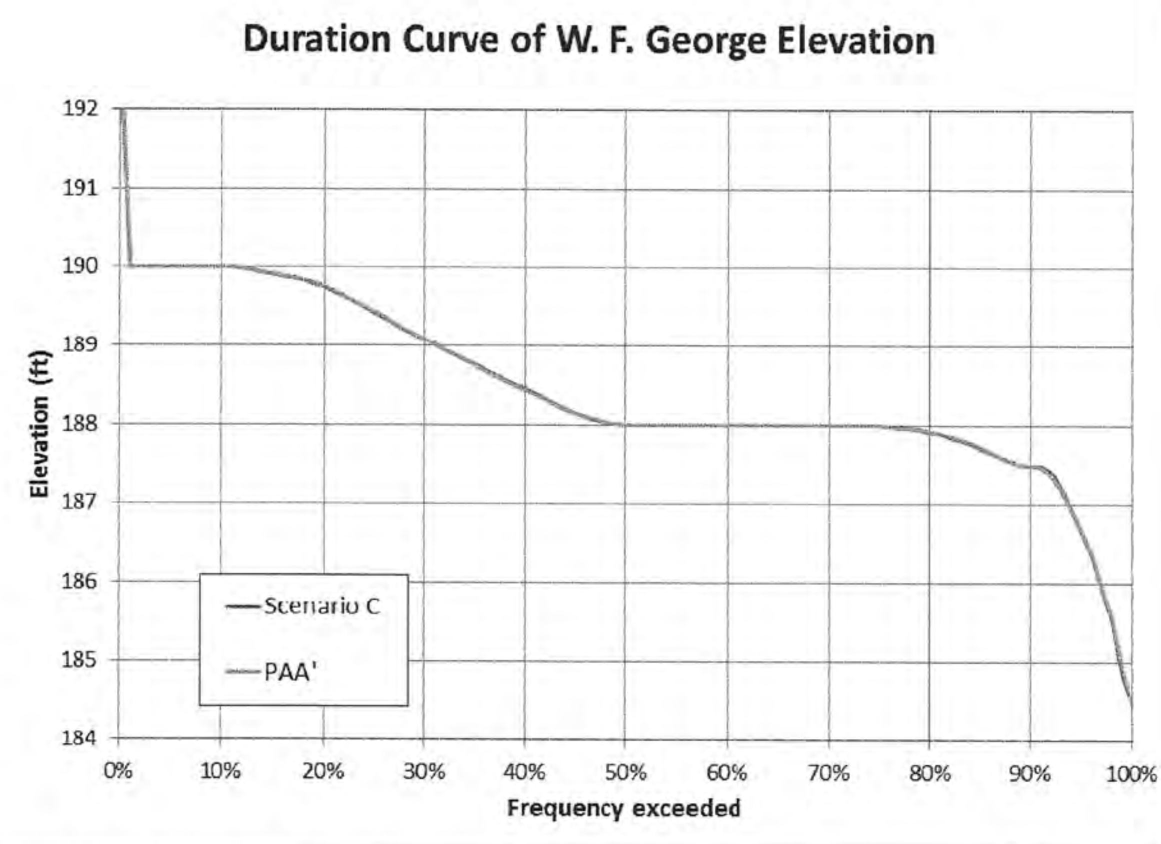

Figure 9. Duration curve of simulated W.F. George elevation.

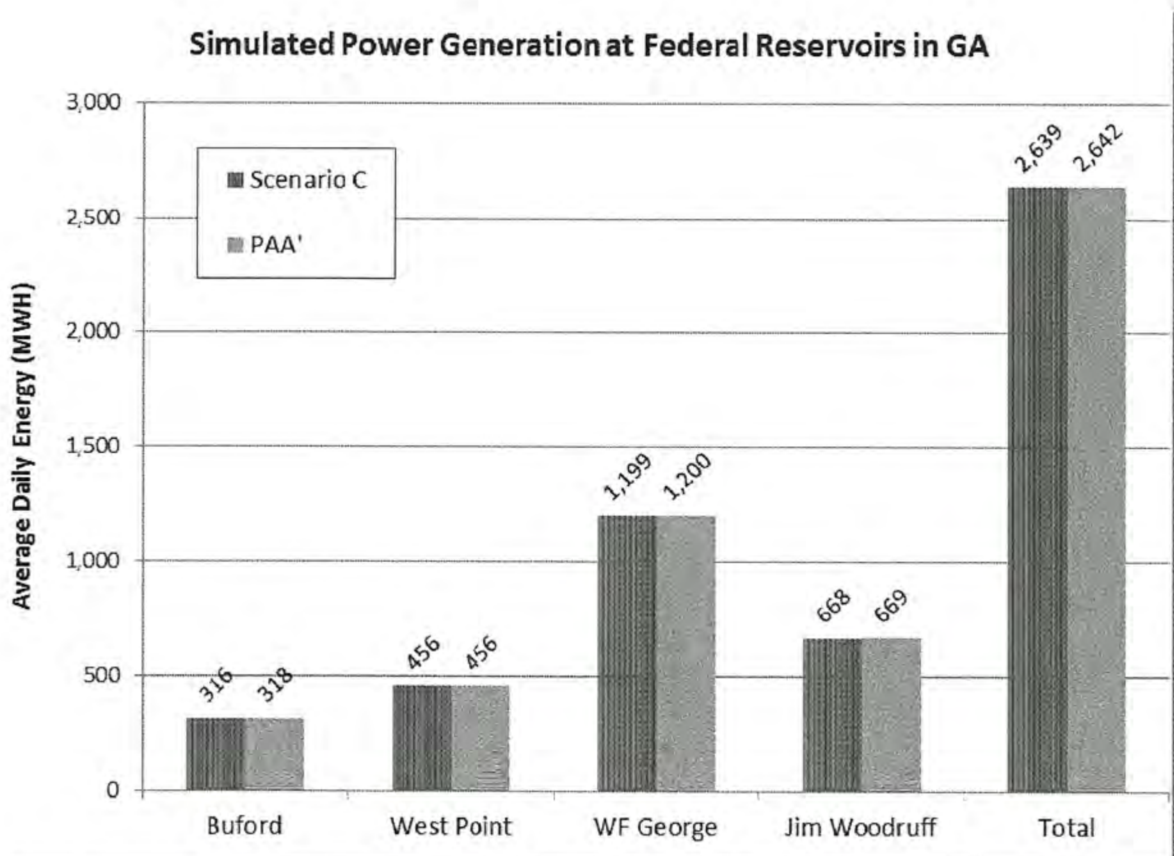

Figure 10. Simulated power generation at Federal reservoirs in Georgia.

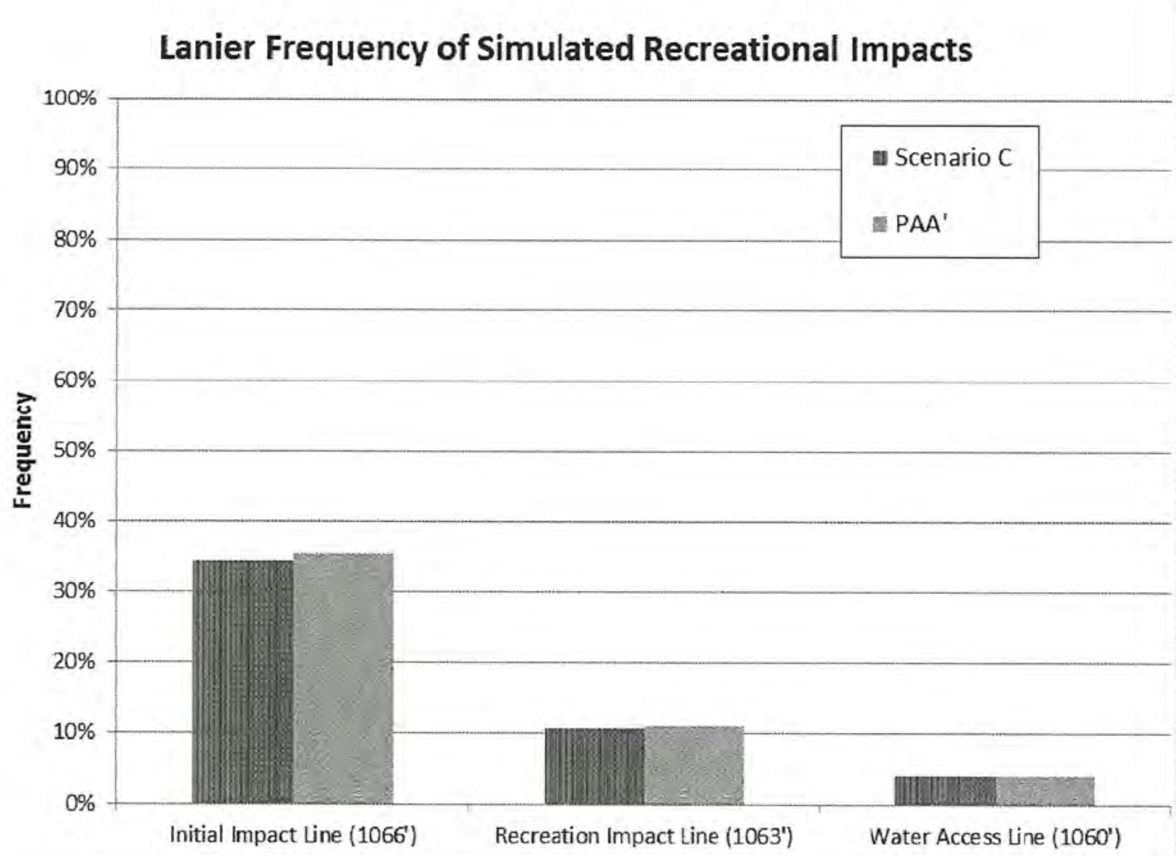

Figure 11. Frequency of simulated recreational impacts at Lanier.

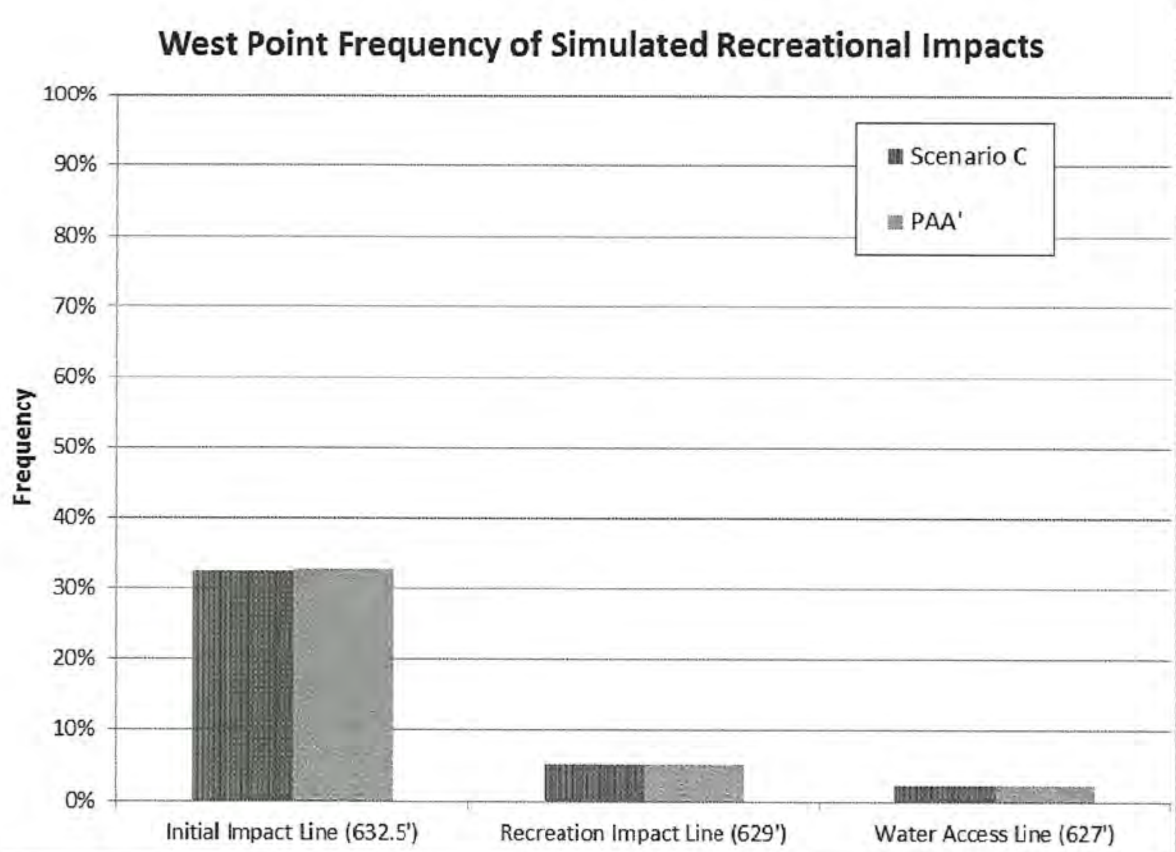

Figure 12. Frequency of simulated recreational impacts at West Point.

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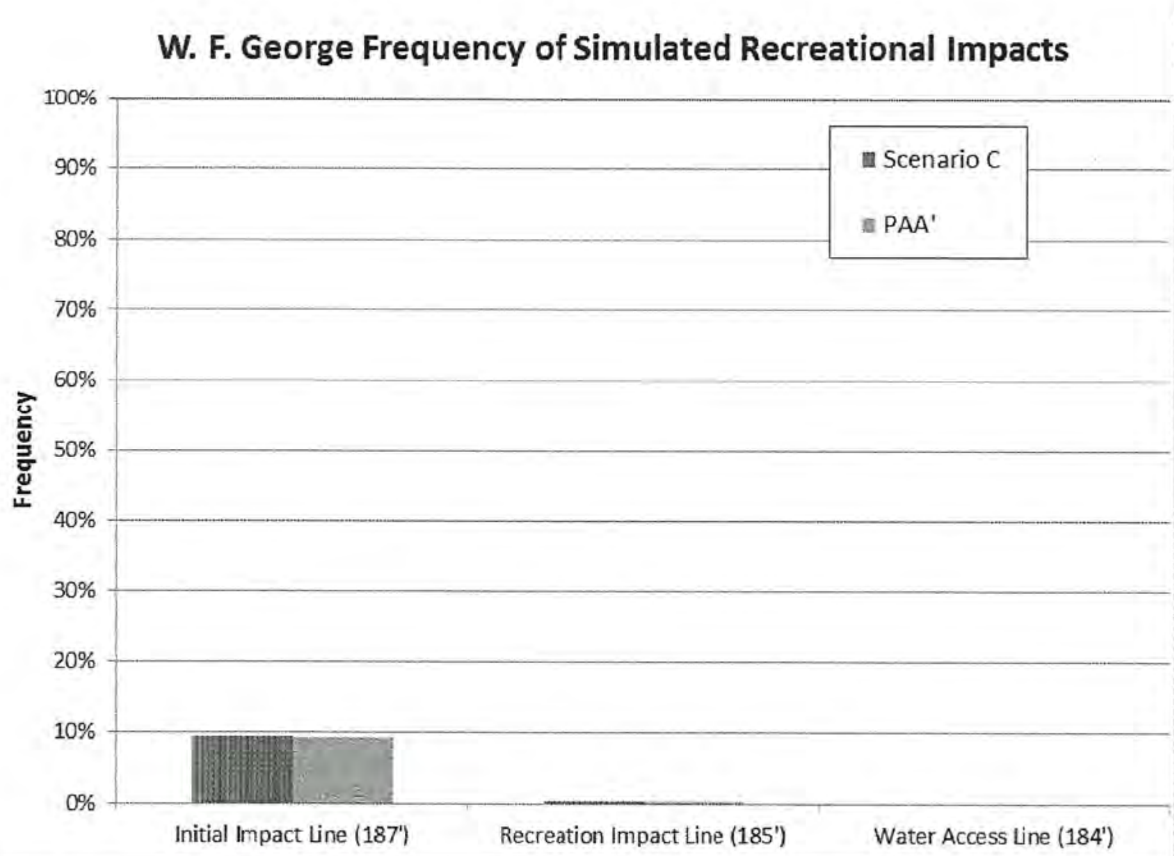

Figure 13. Frequency of simulated recreational impacts at W. F. George.

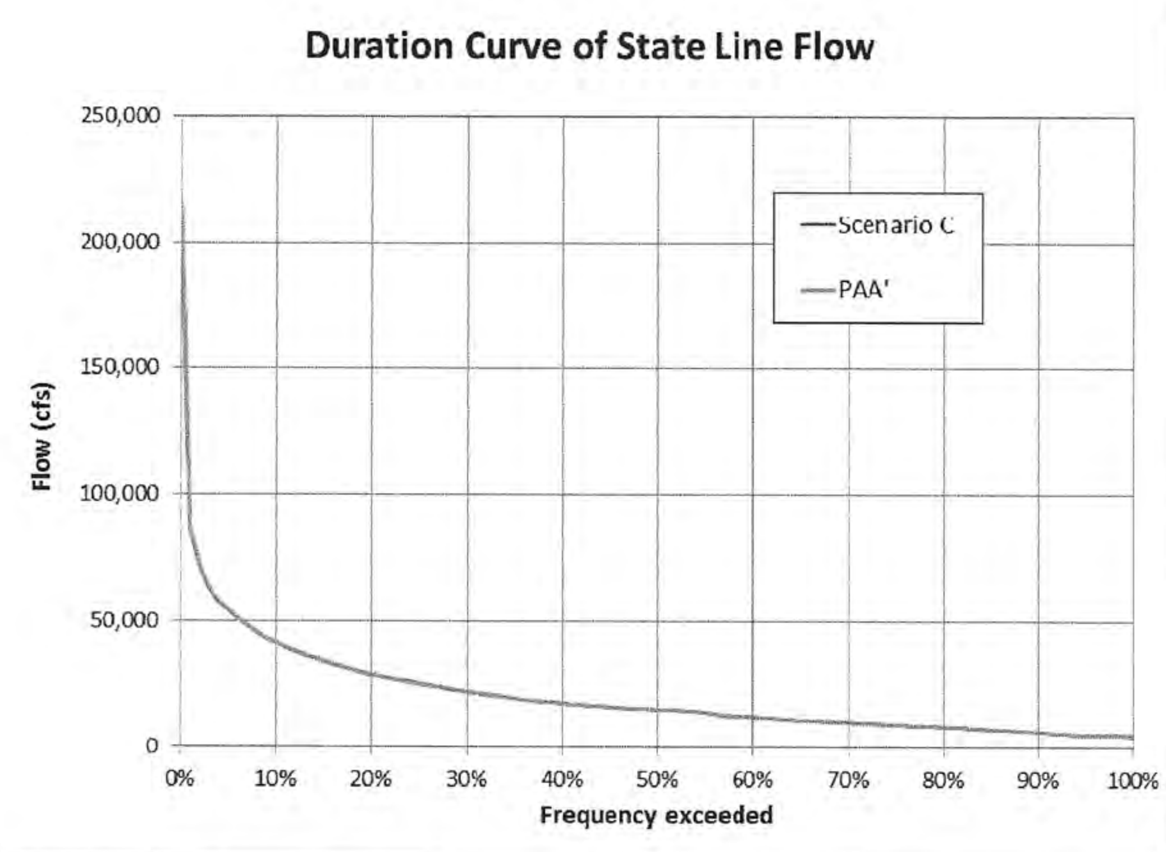

Figure 14. Duration of simulated state line flow.

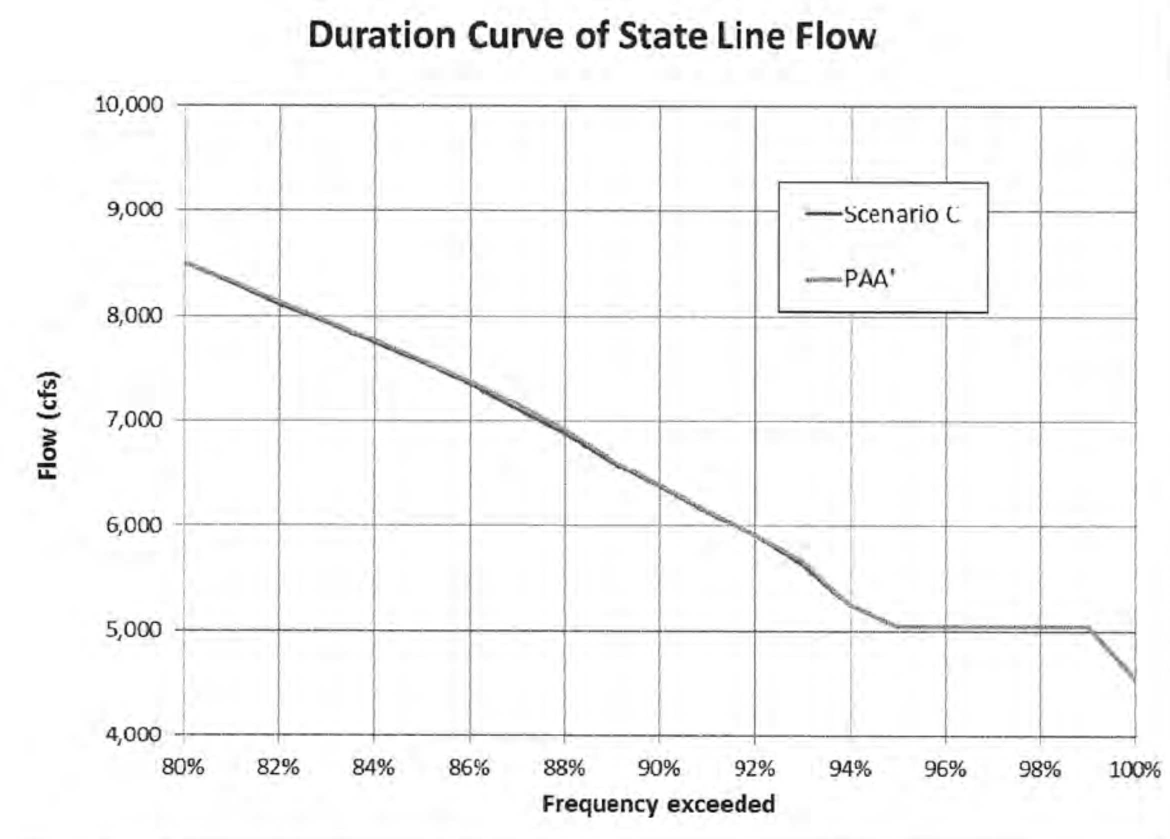

Figure 15. Duration of simulated state line flow (close-up).

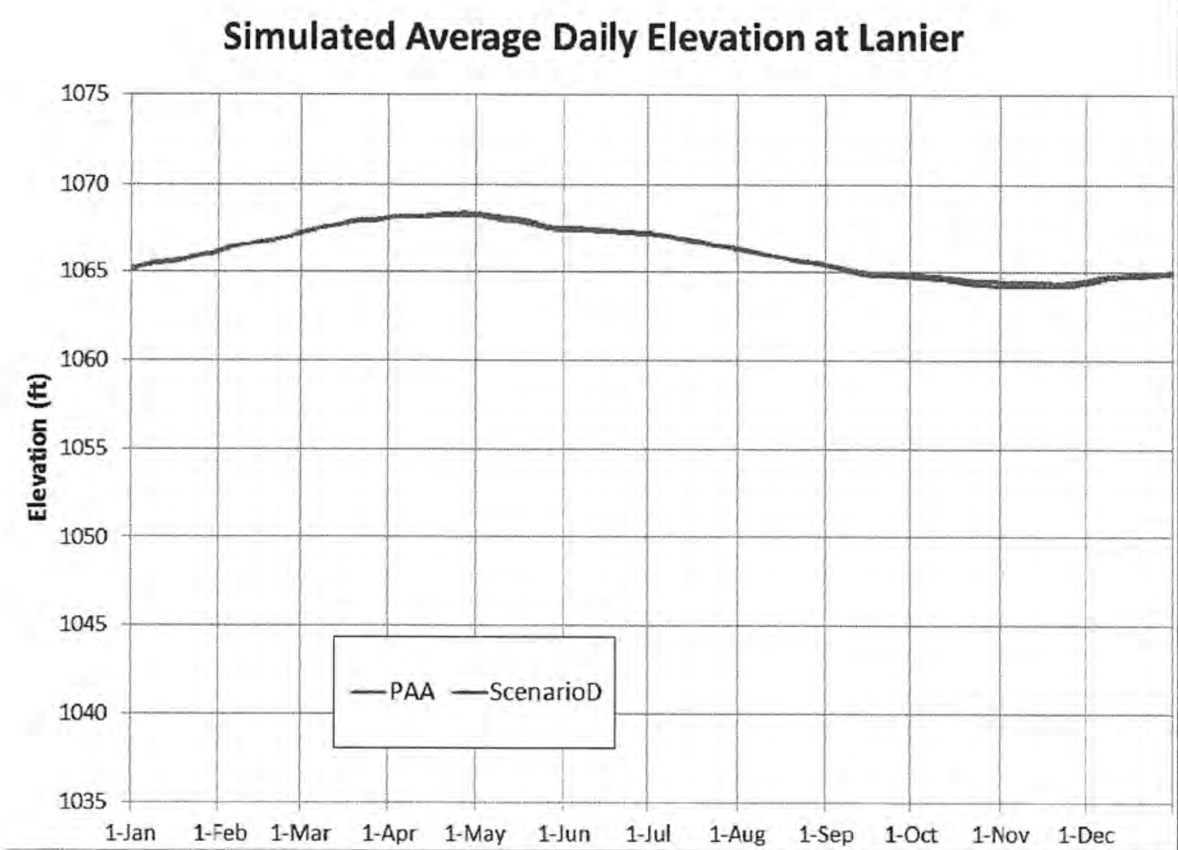

Figure 16. Simulated average daily elevation at Lanier

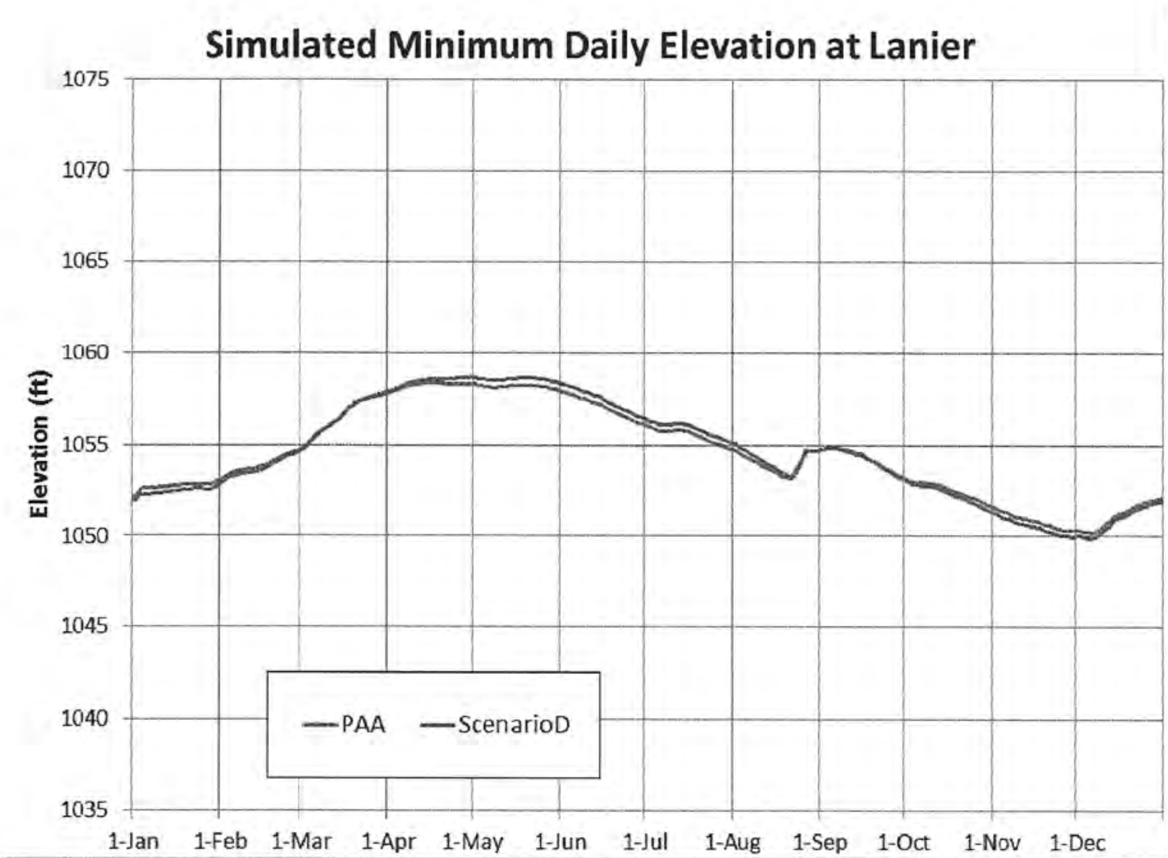

Figure 17. Simulated minimum daily elevation at Lanier

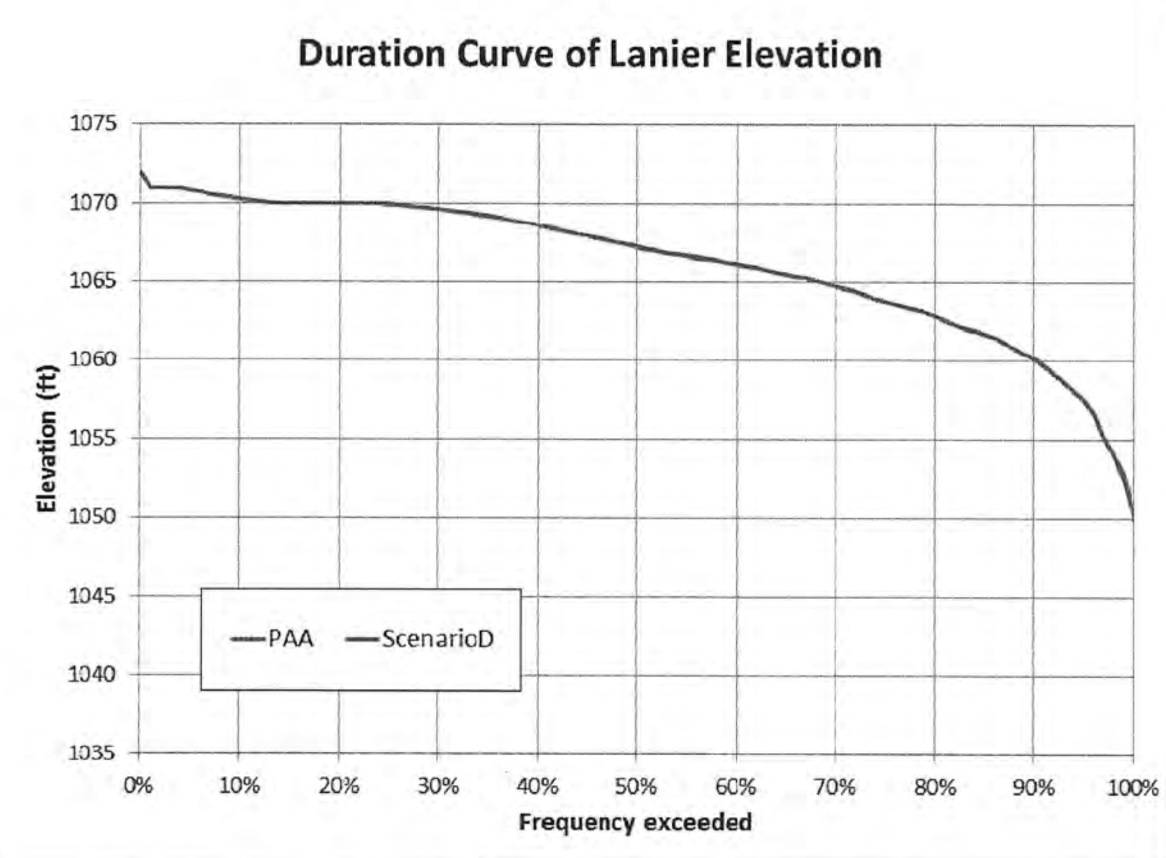

Figure 18. Duration curve of simulated Lanier elevation

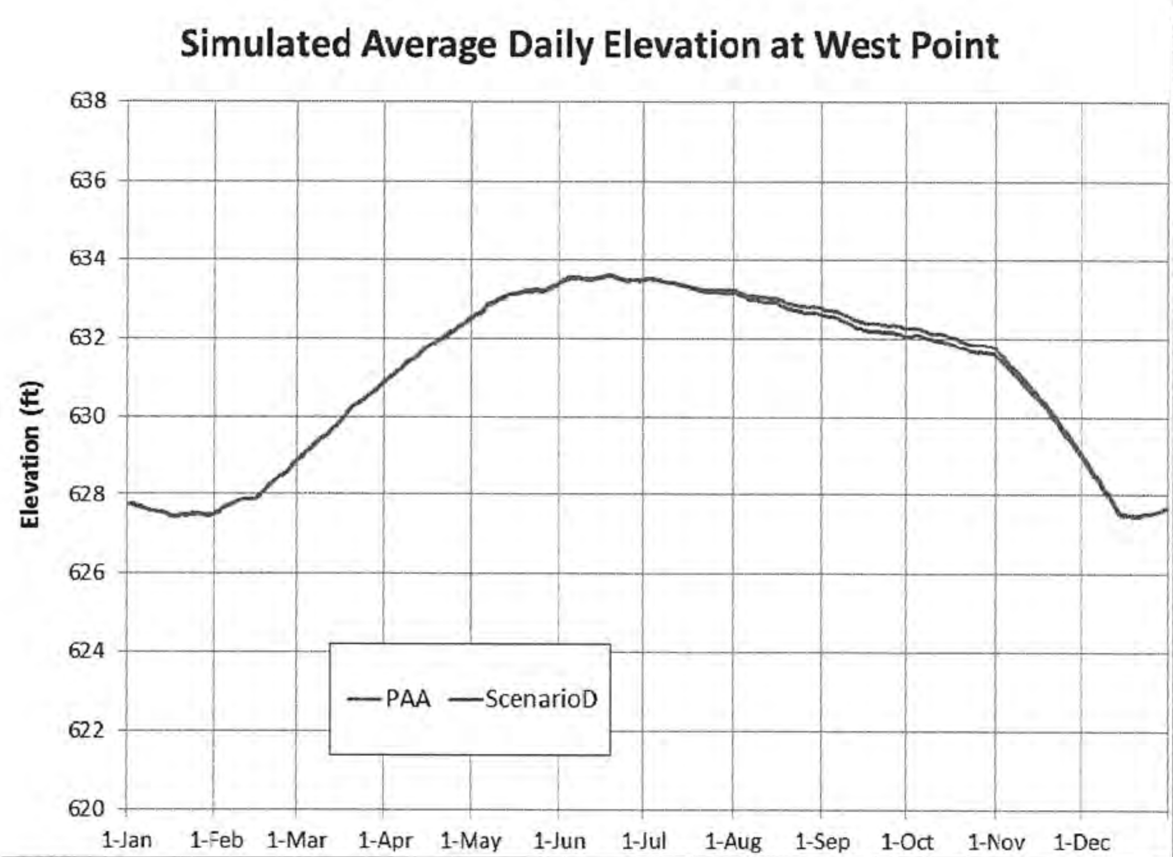

Figure 19. Simulated average daily elevation at West Point Lake

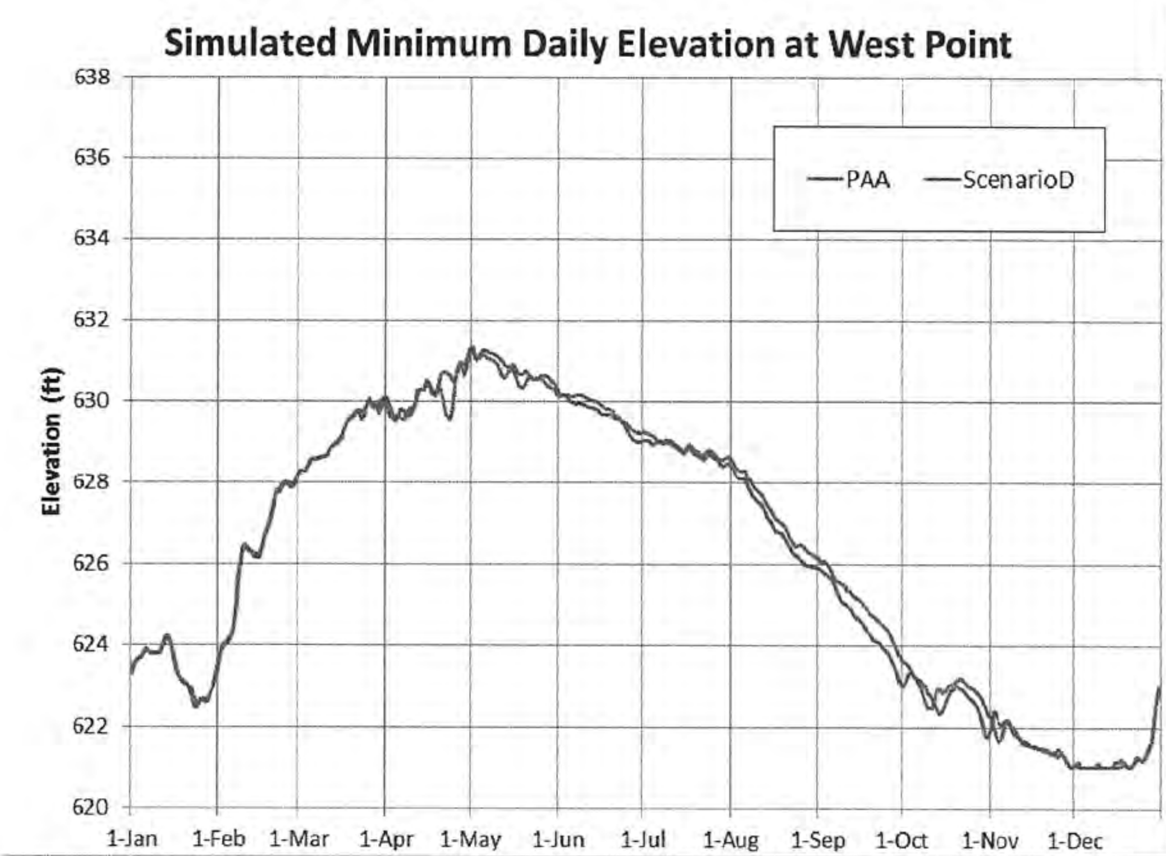

Figure 20. Simulated minimum daily elevation at West Point Lake

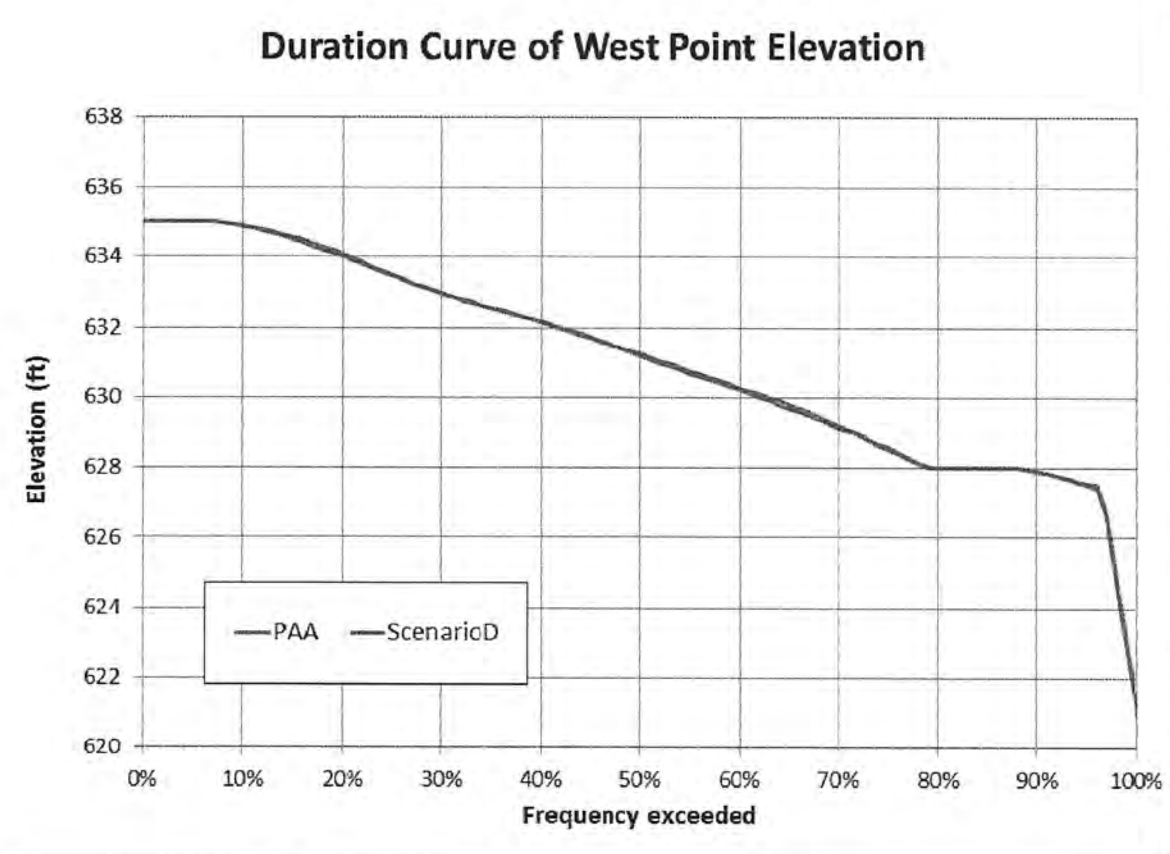

Figure 21. Duration curve of simulated West Point elevation

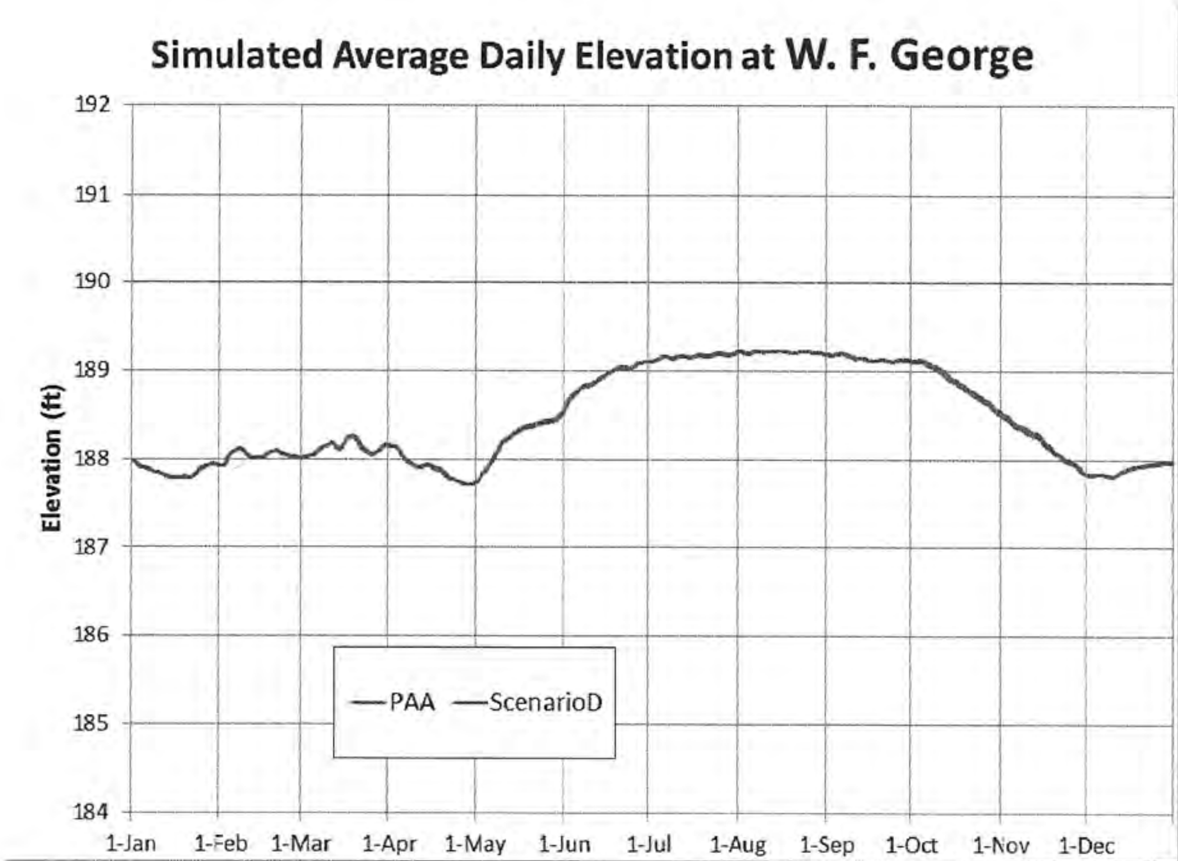

Figure 22. Simulated average daily elevation at Walter F. George Lake

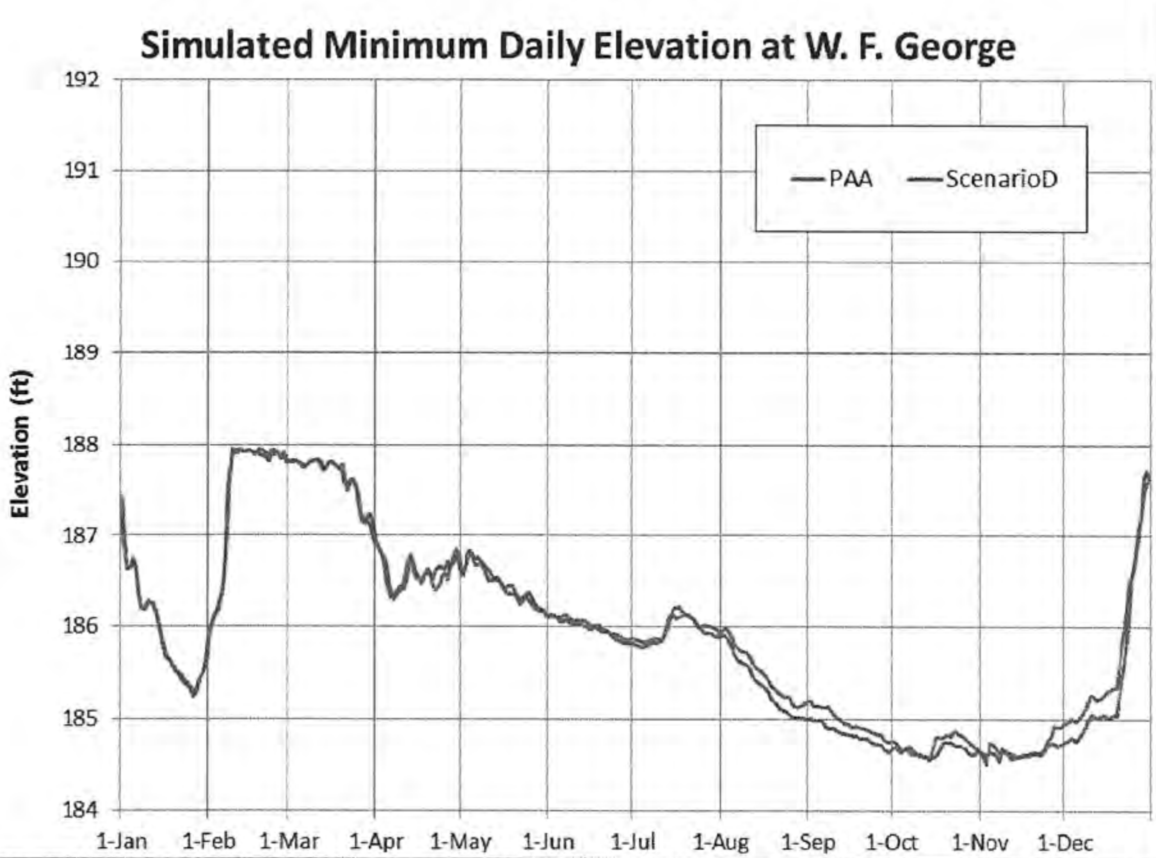

Figure 23. Simulated minimum daily elevation at Walter F. George Lake

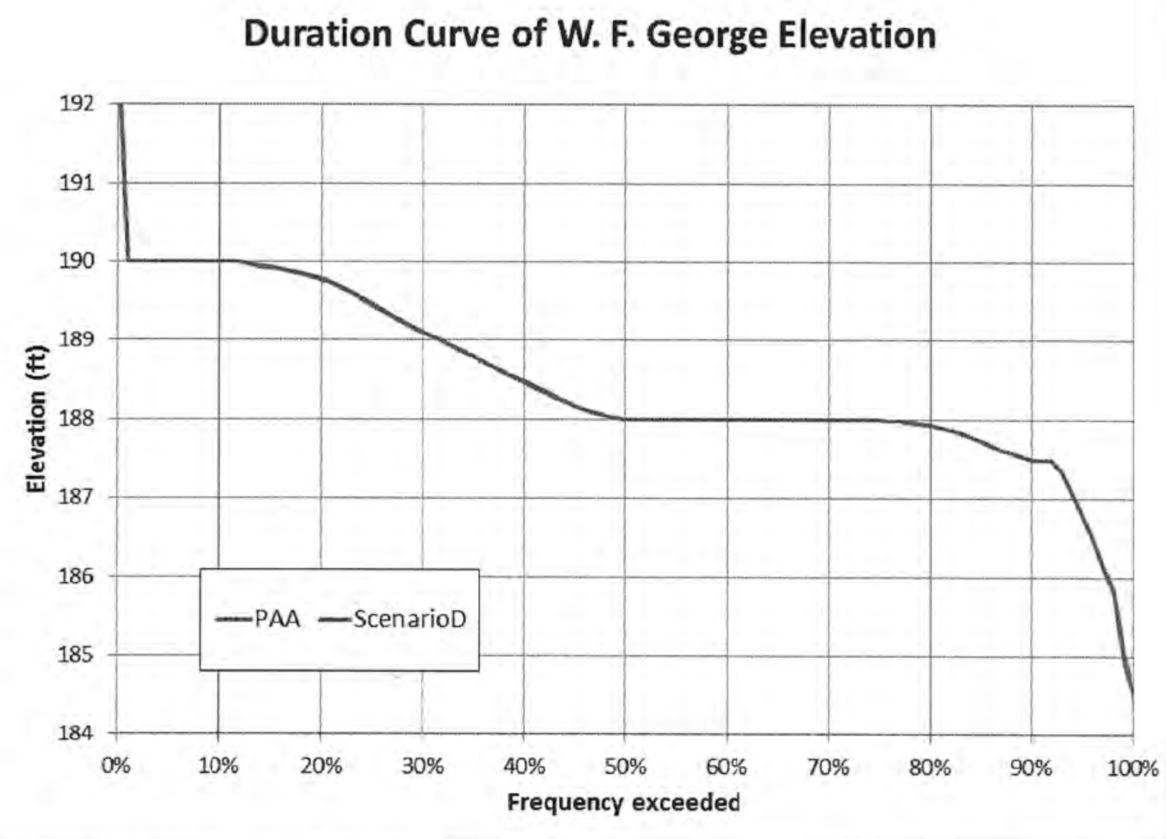

Figure 24. Duration curve of simulated W.F. George elevation

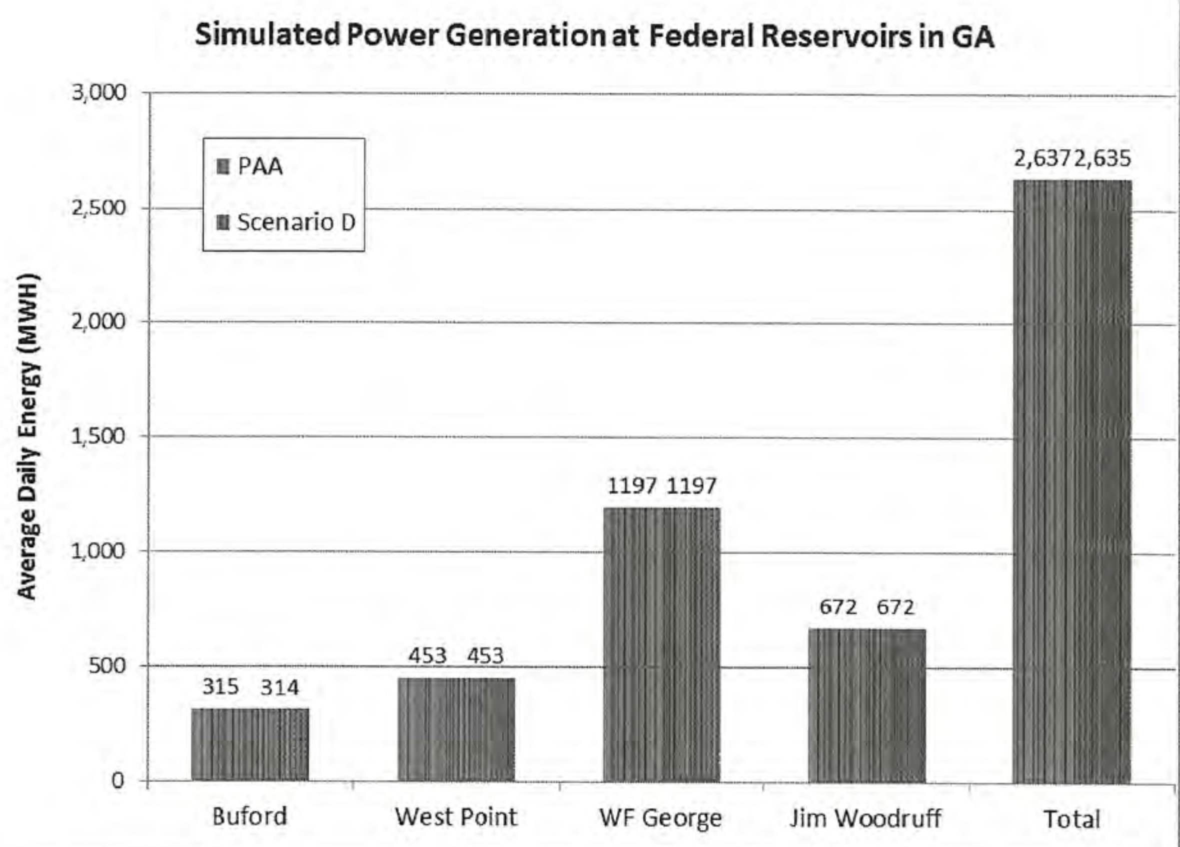

Figure 25. Simulated power generation at Federal reservoirs in Georgia

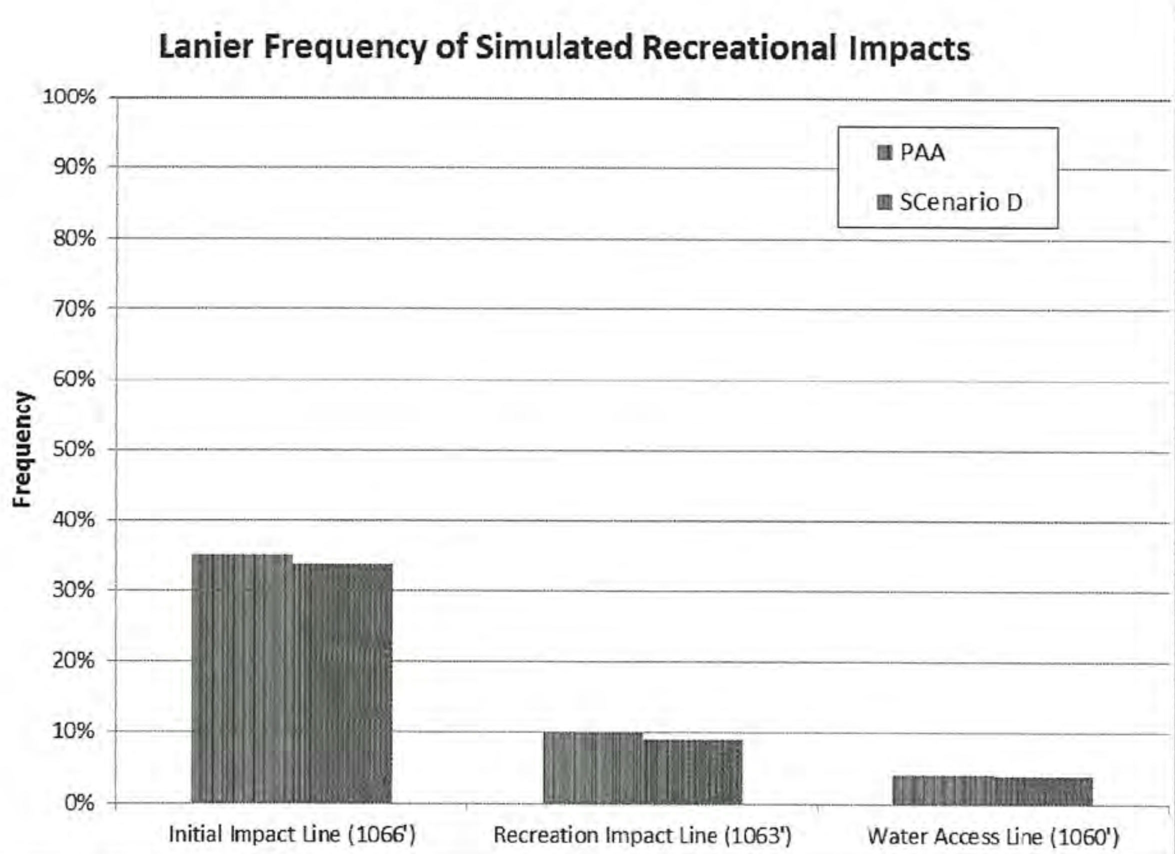

Figure 26, Frequency of simulated recreational impacts at Lanier

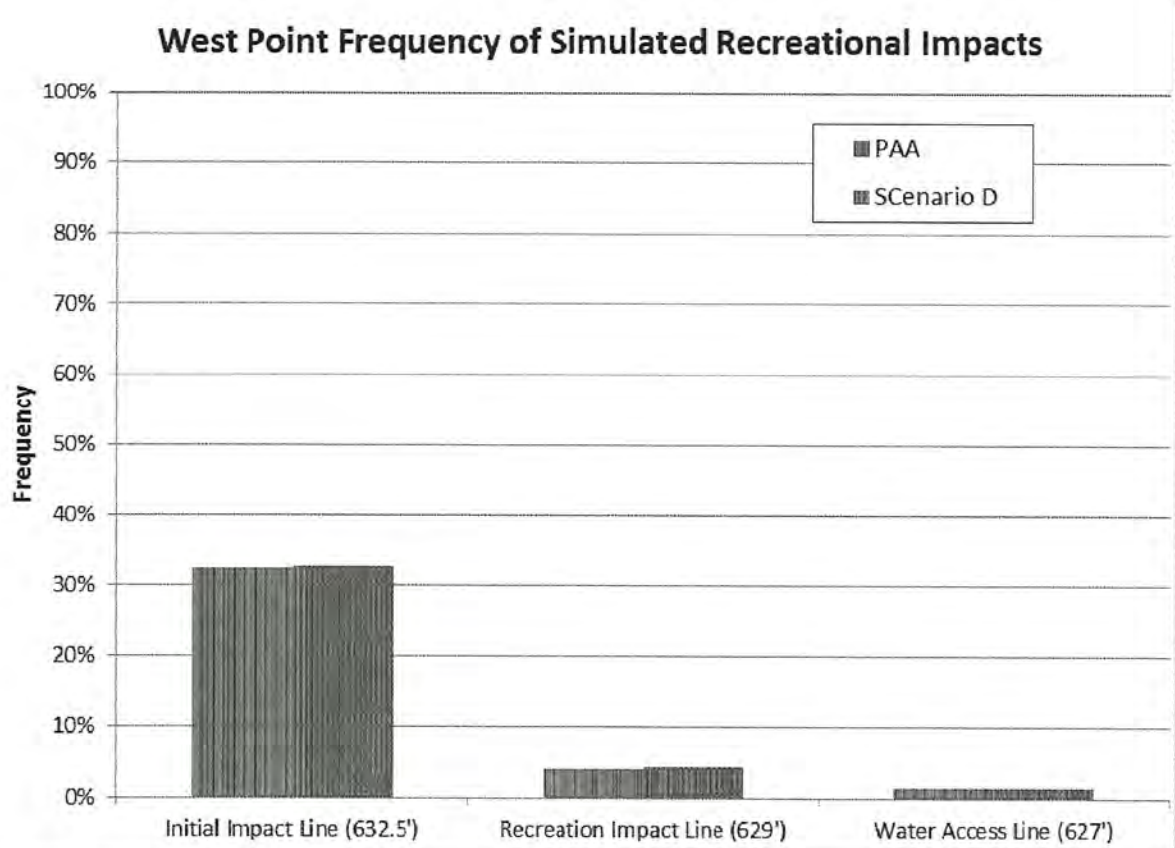

Figure 27. Frequency of simulated recreational impacts at West Point

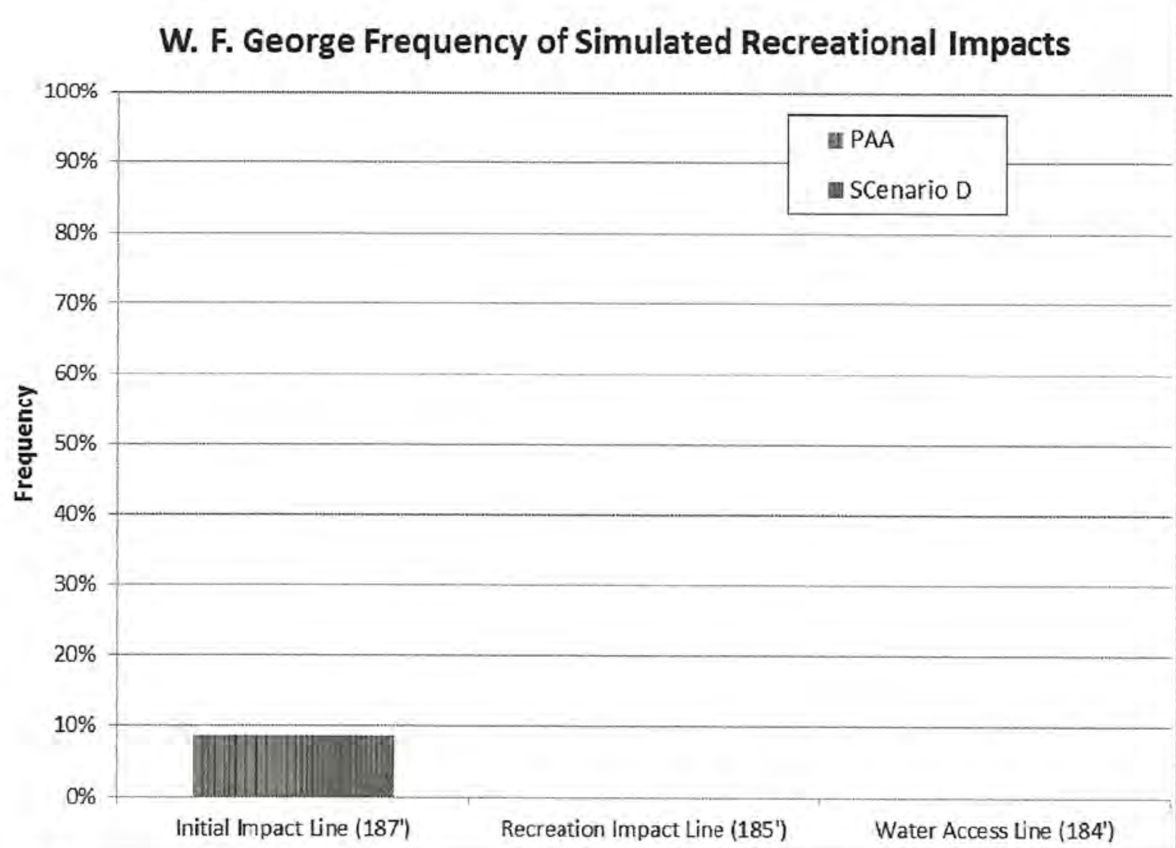

Figure 28. Frequency of simulated recreational impacts at W. F. George

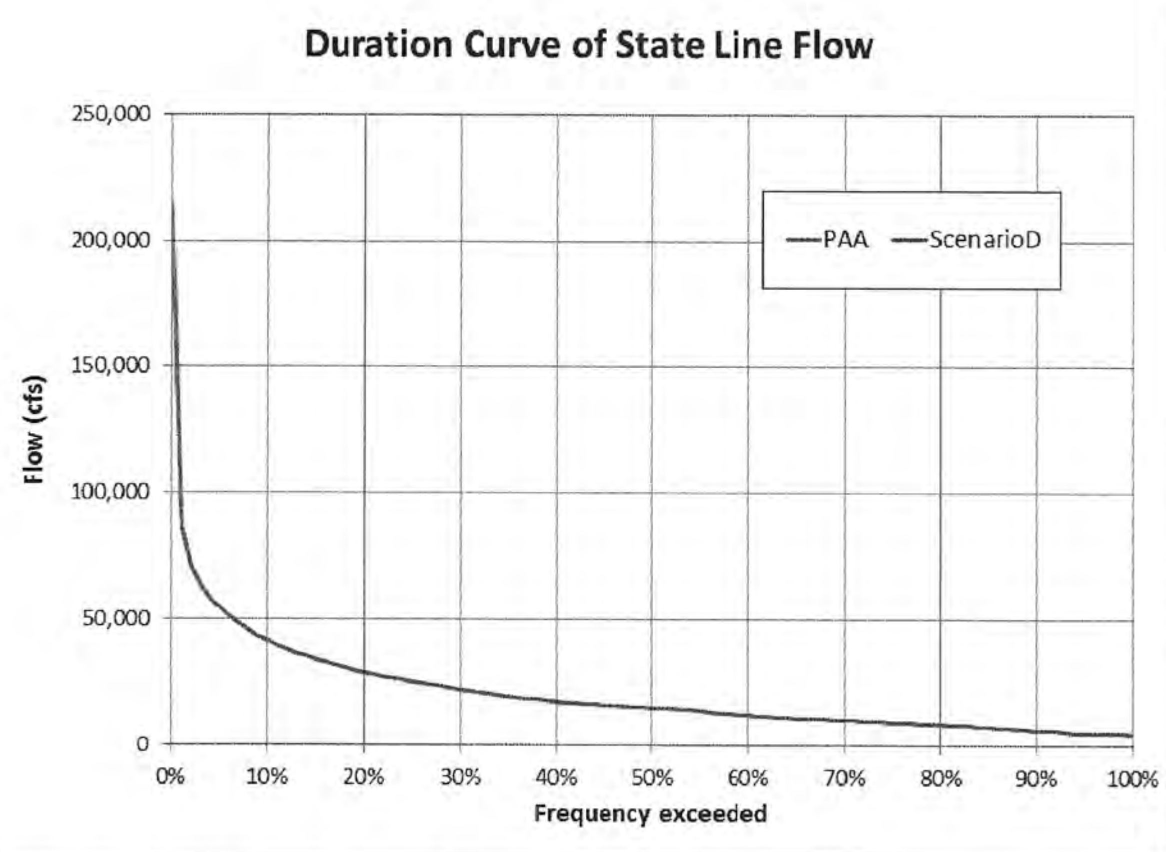

Figure 29. Duration of simulated state line flow

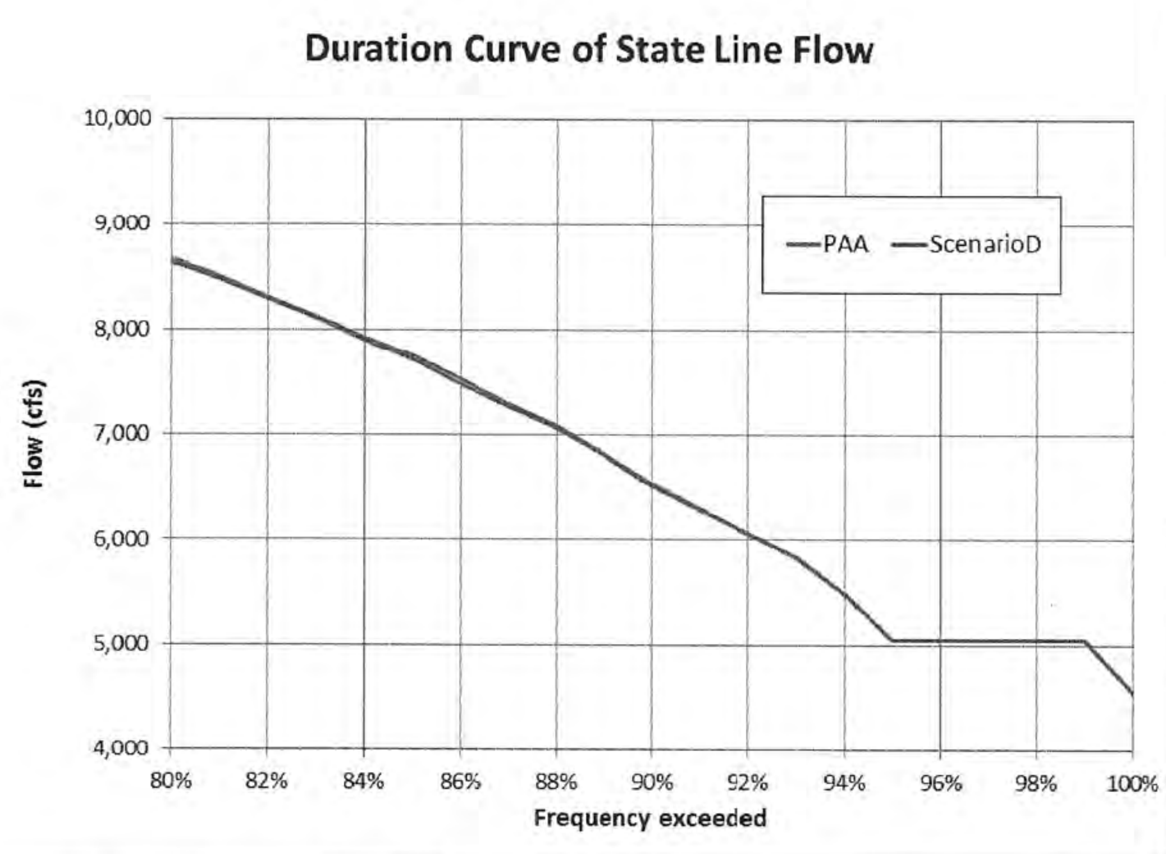

Figure 30. Duration of simulated state line flow (close-up)

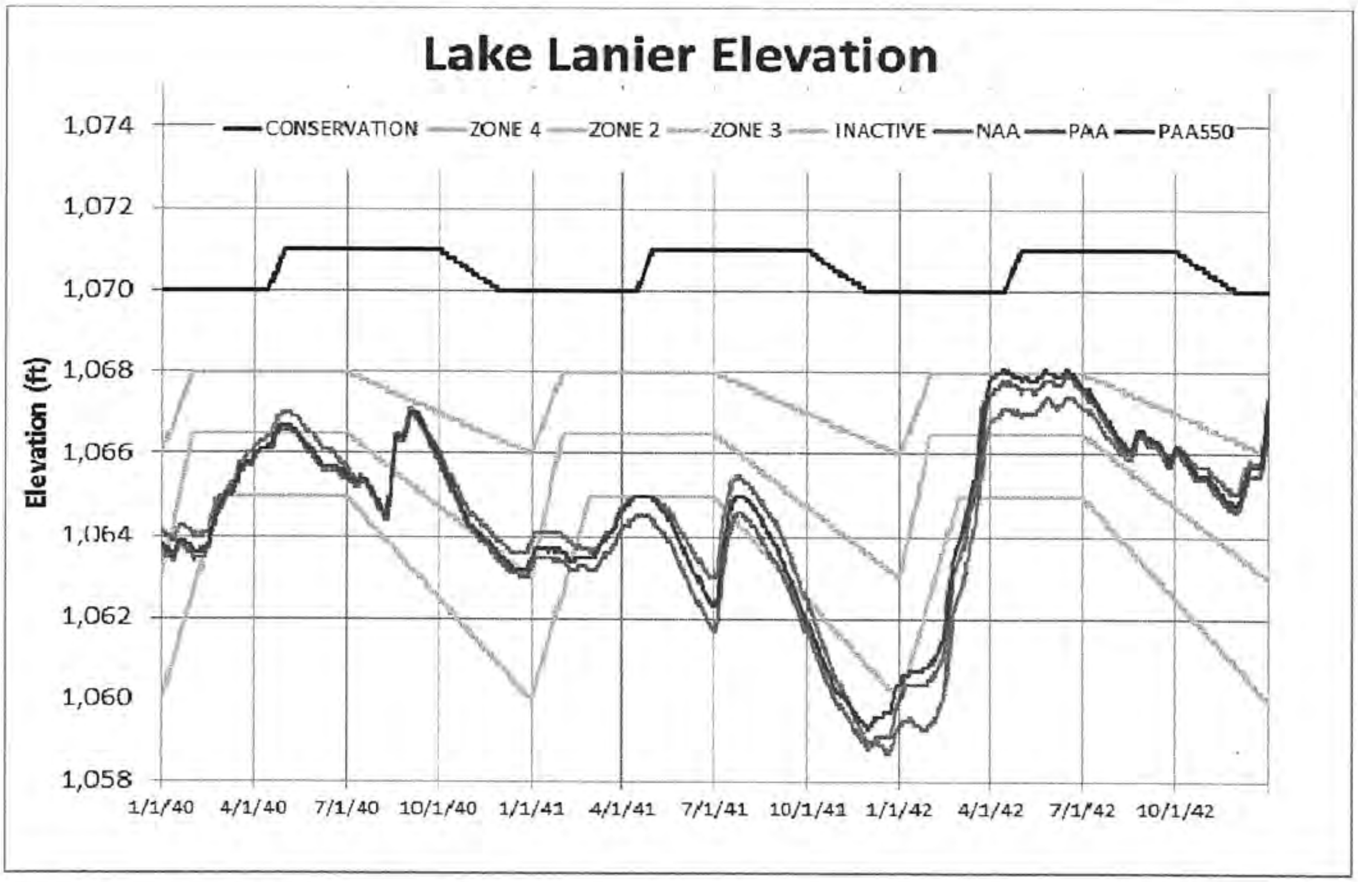

Figure 31. Simulated Lake Lanier Elevations in 1940-1942

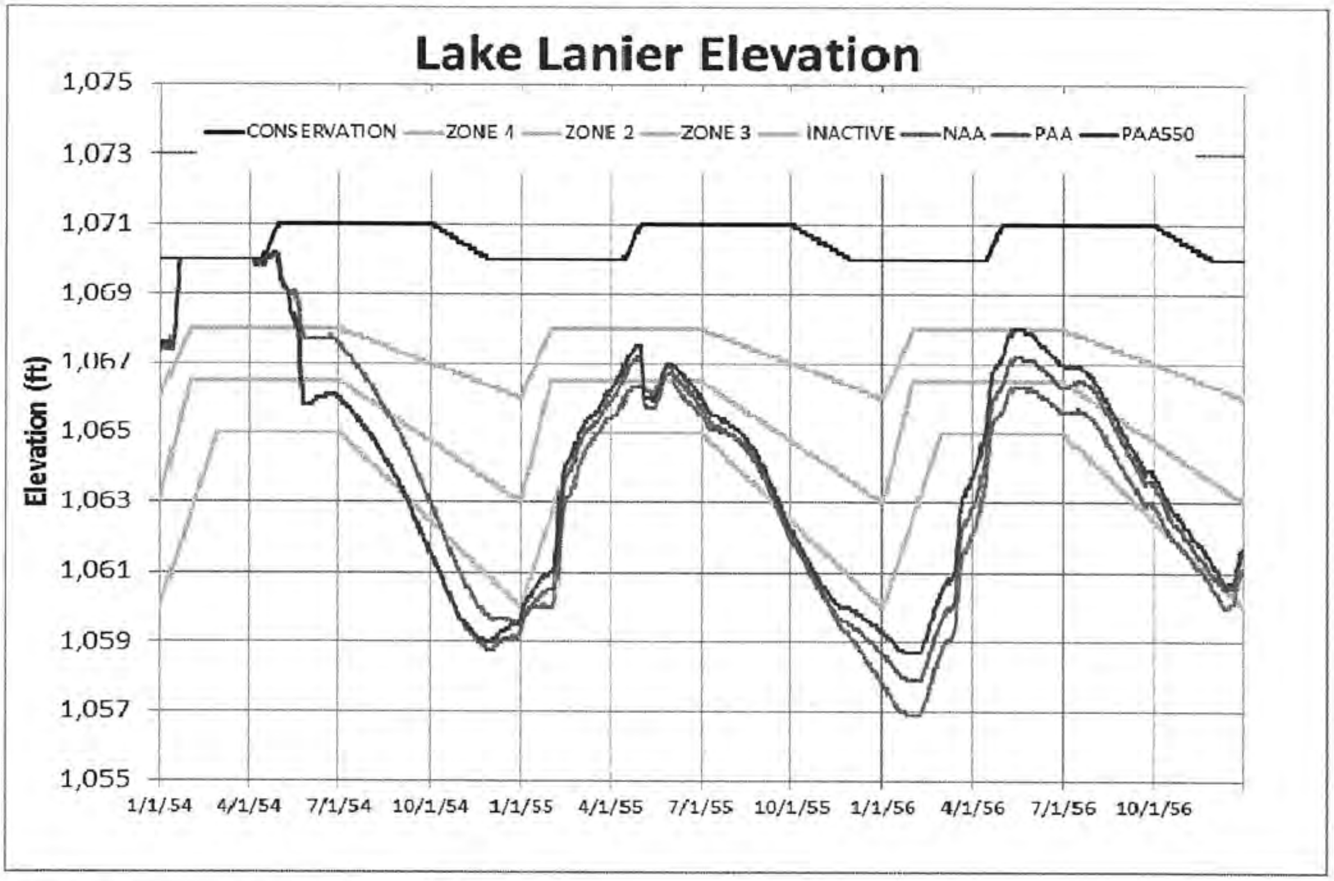

Figure 32. Simulated Lake Lanier Elevations in 1954-1956

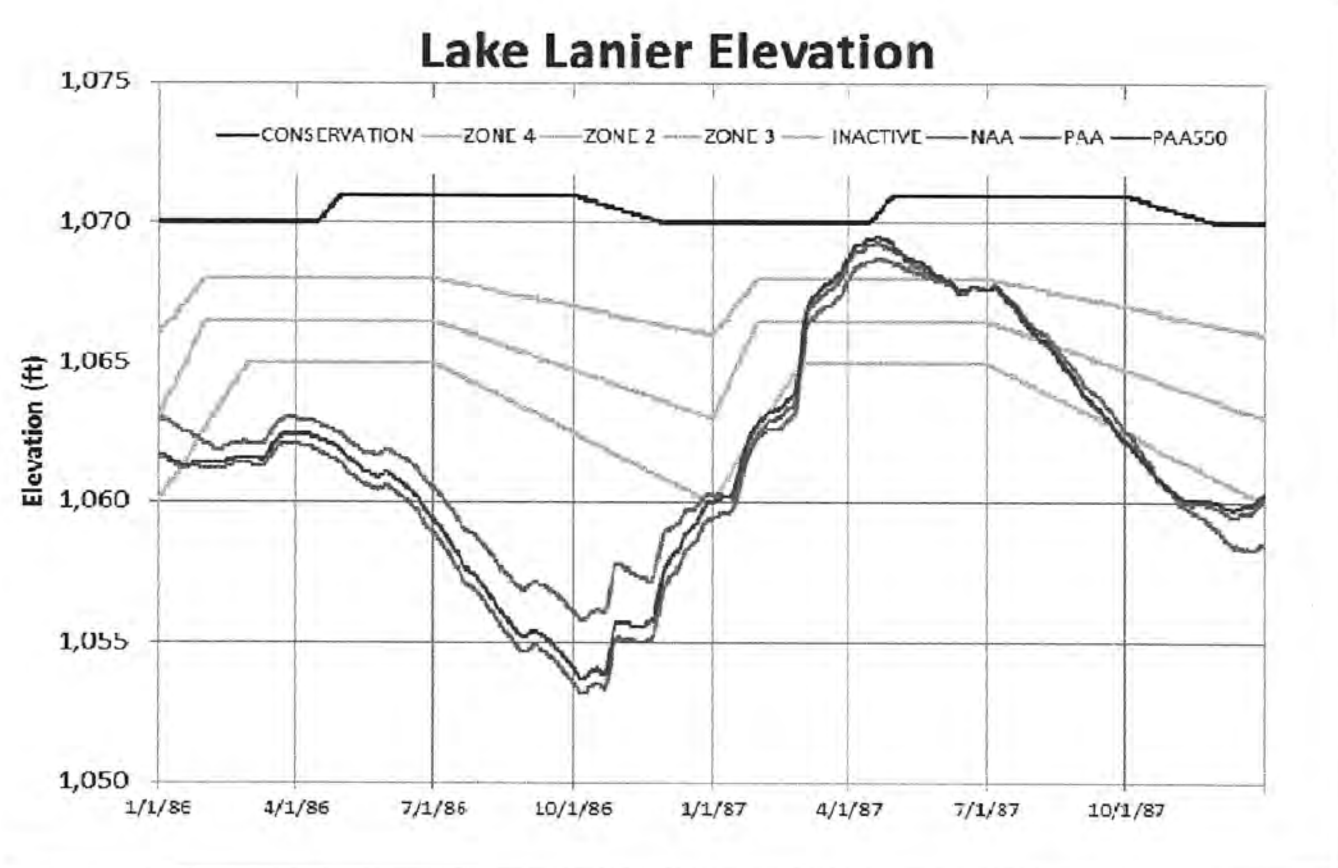

Figure 33. Simulated Lake Lanier Elevations in 1986-1987

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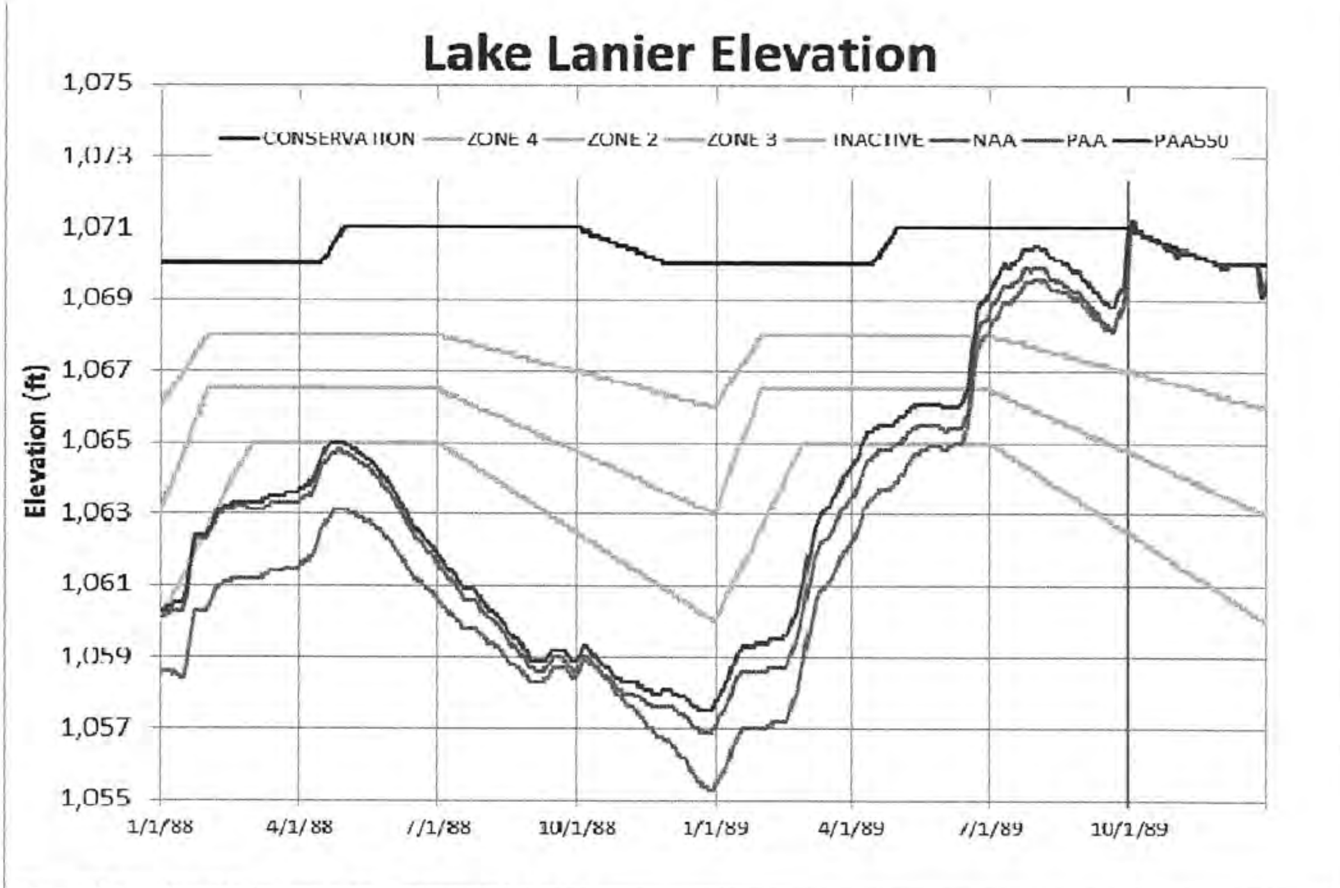

Figure 34. Simulated Lake Lanier Elevations in 1988-1989

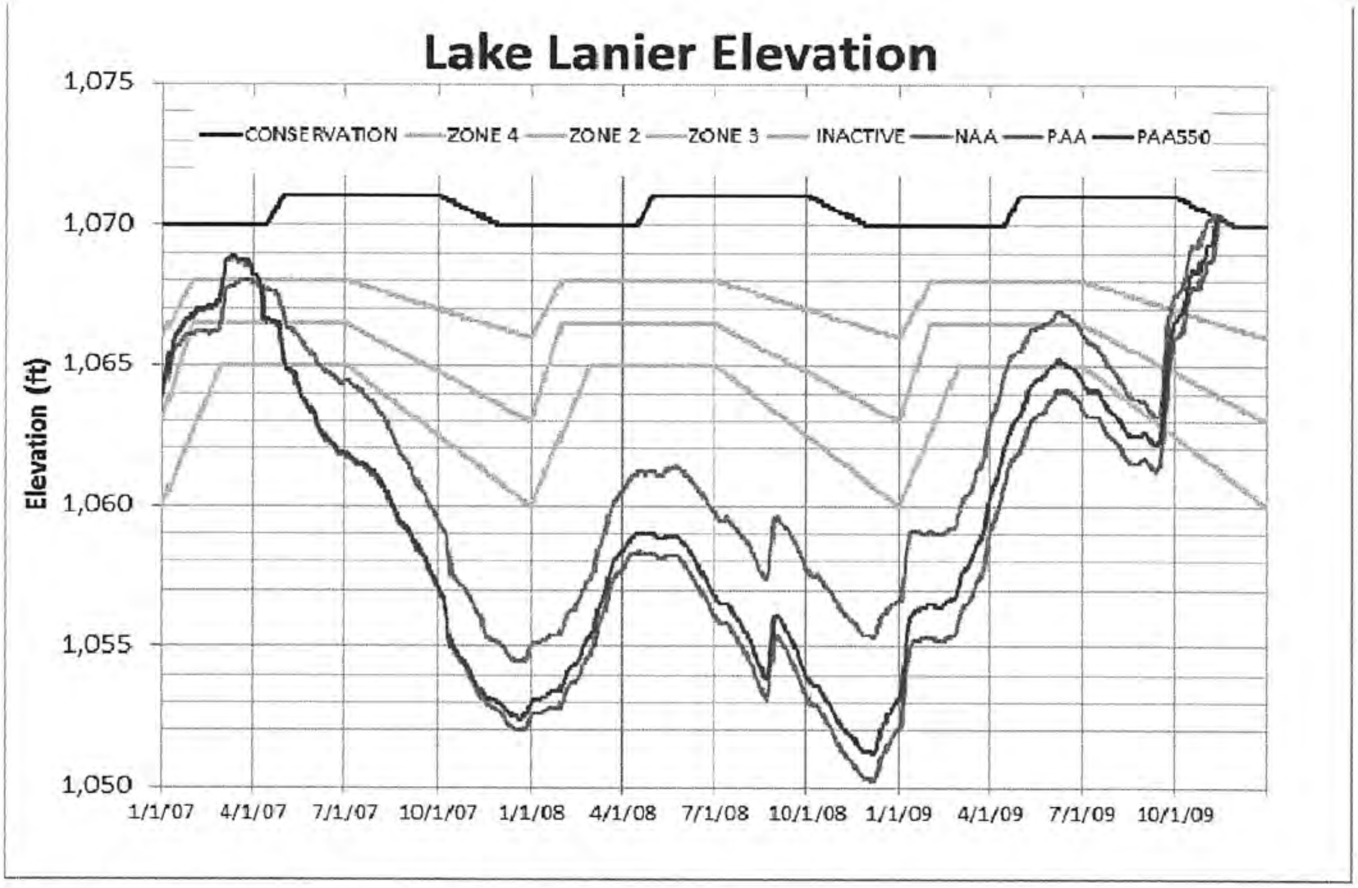

Figure 35. Simulated Lake Lanier Elevations in 2007-2009

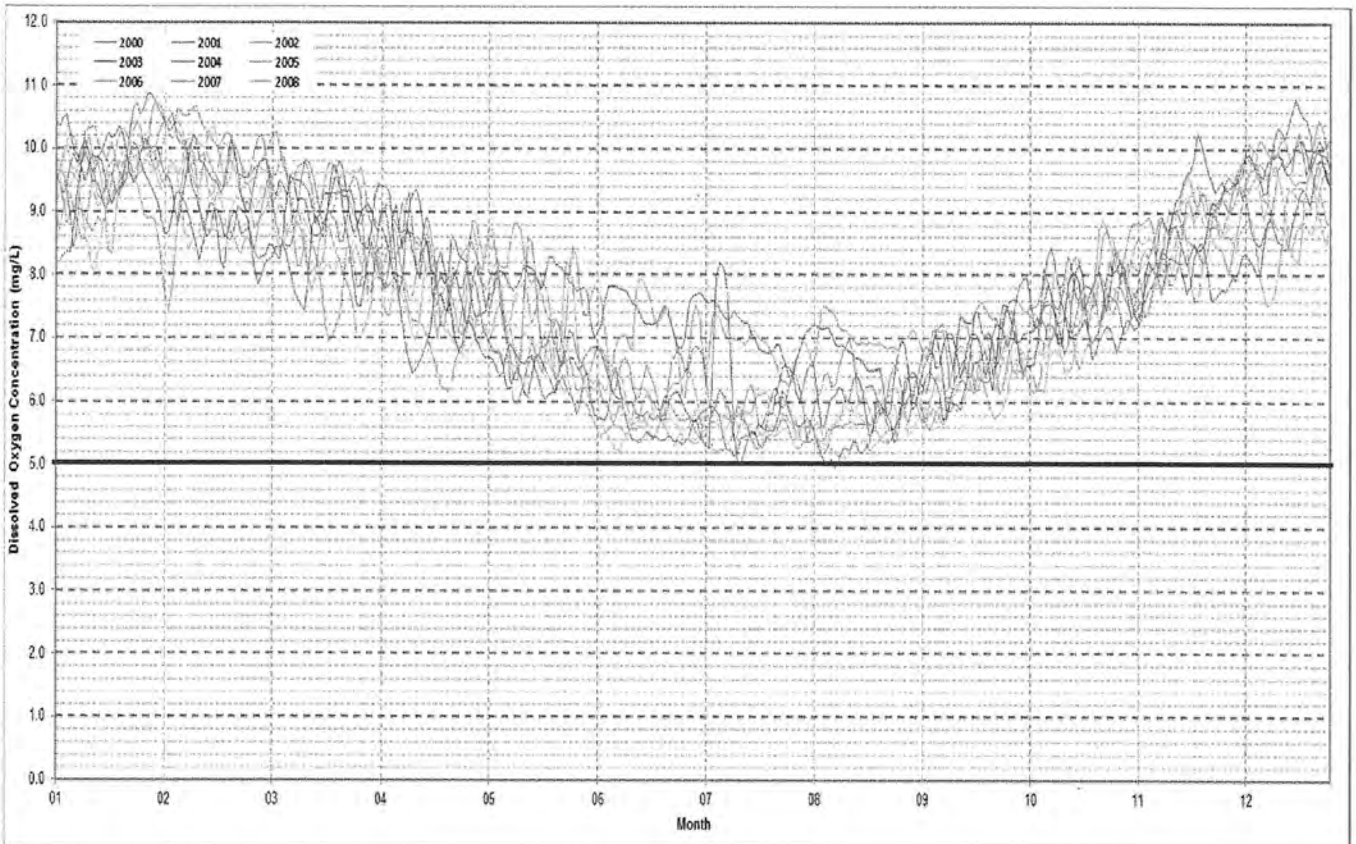

Figure 36: Chattahoochee River Predicted Daily Average Dissolved Oxygen Concentration near Dog River for the NAA

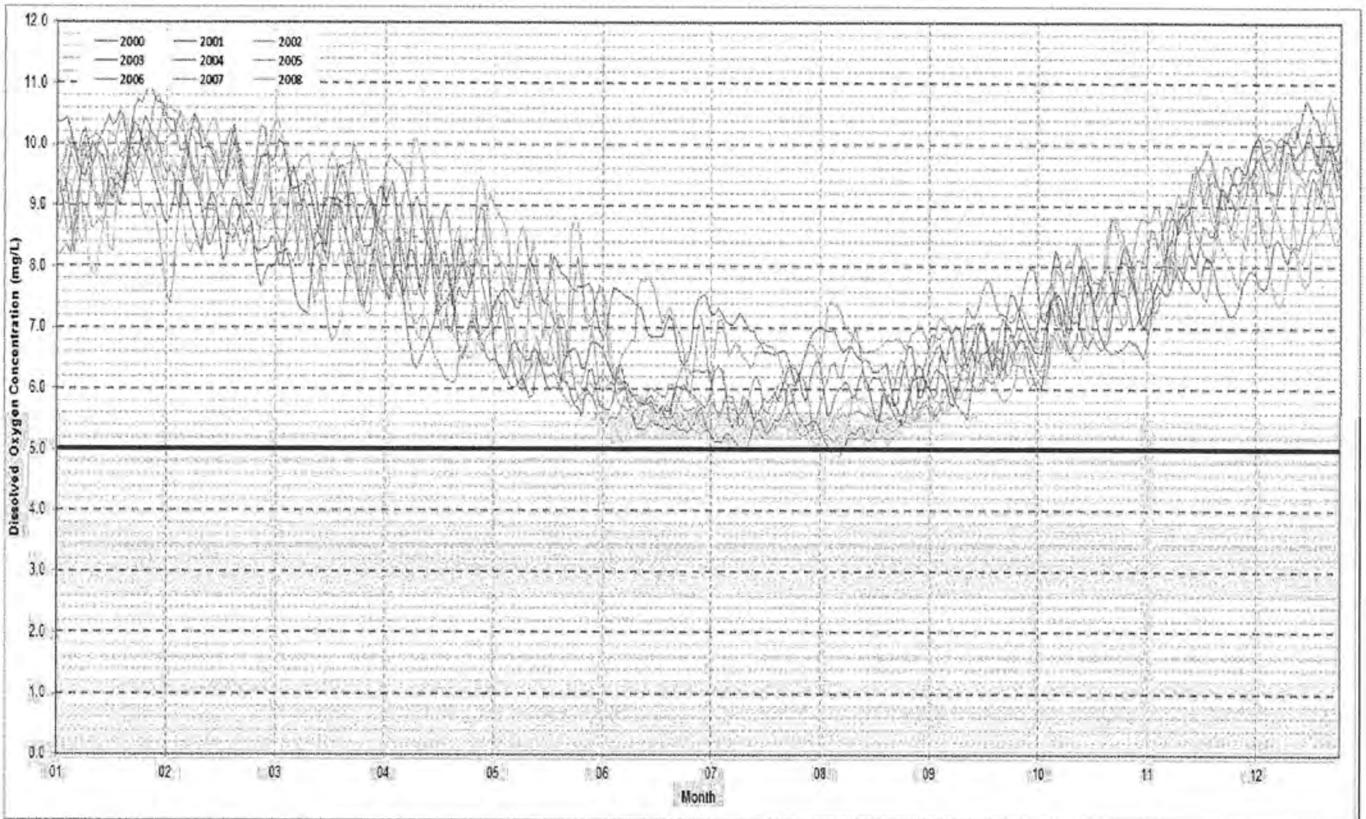

Figure 37: Chattahoochee River Predicted Daily Average Dissolved Oxygen Concentration near Dog River for the PAA

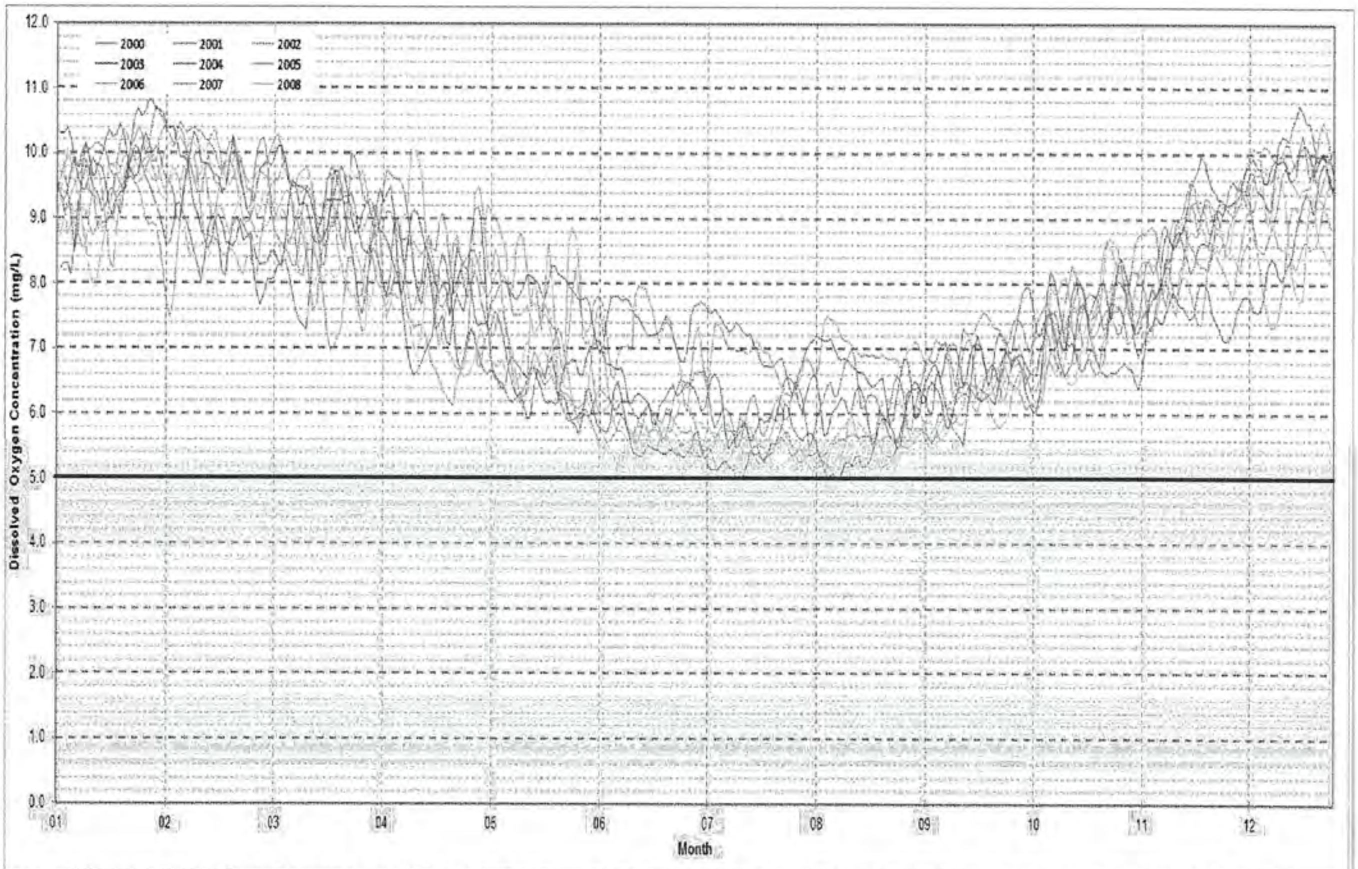

Figure 38: Chattahoochee River Predicted Daily Average Dissolved Oxygen Concentration near Dog River for the PAA (PAA 550)

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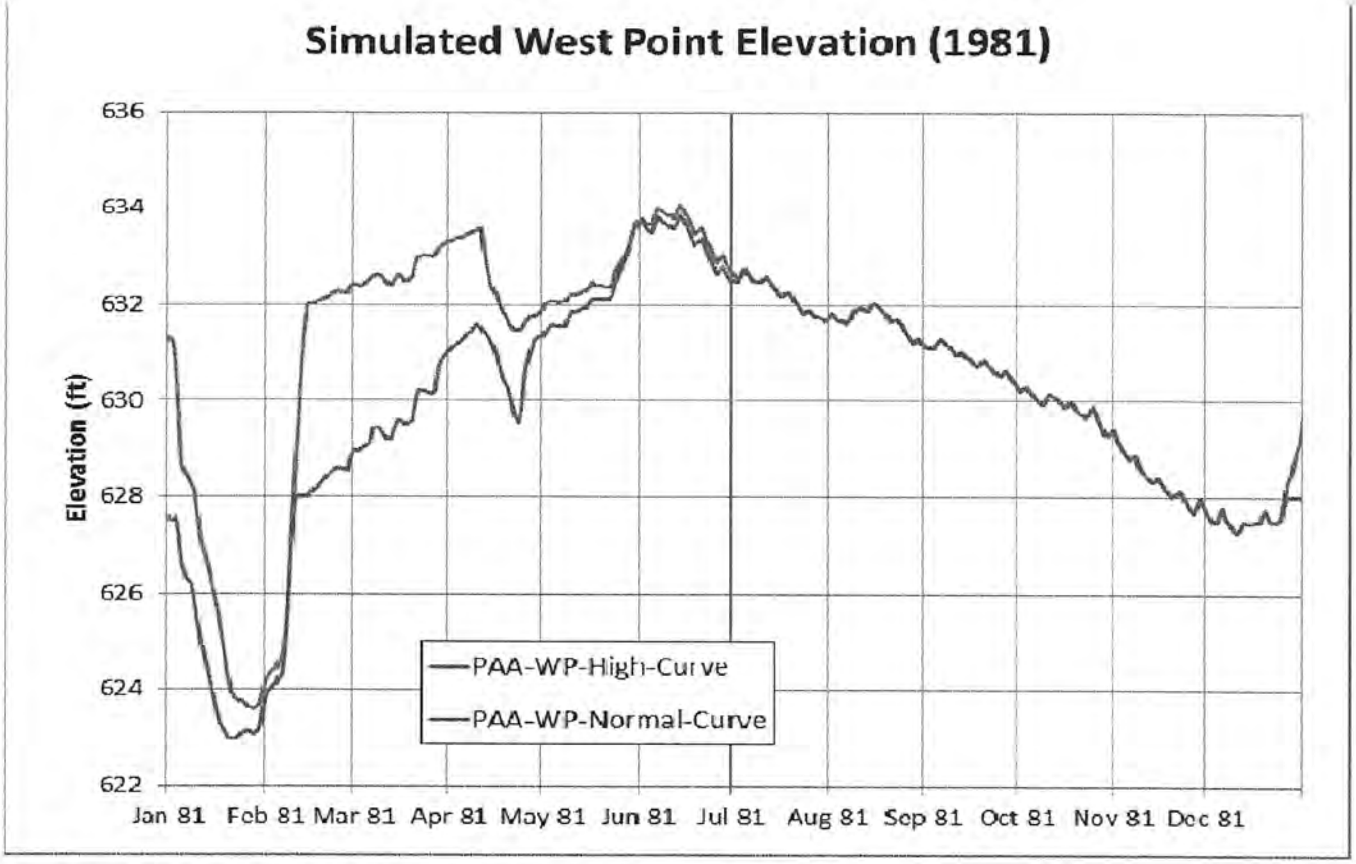


Figure 39. Simulated West Point Lake elevation in 1981.

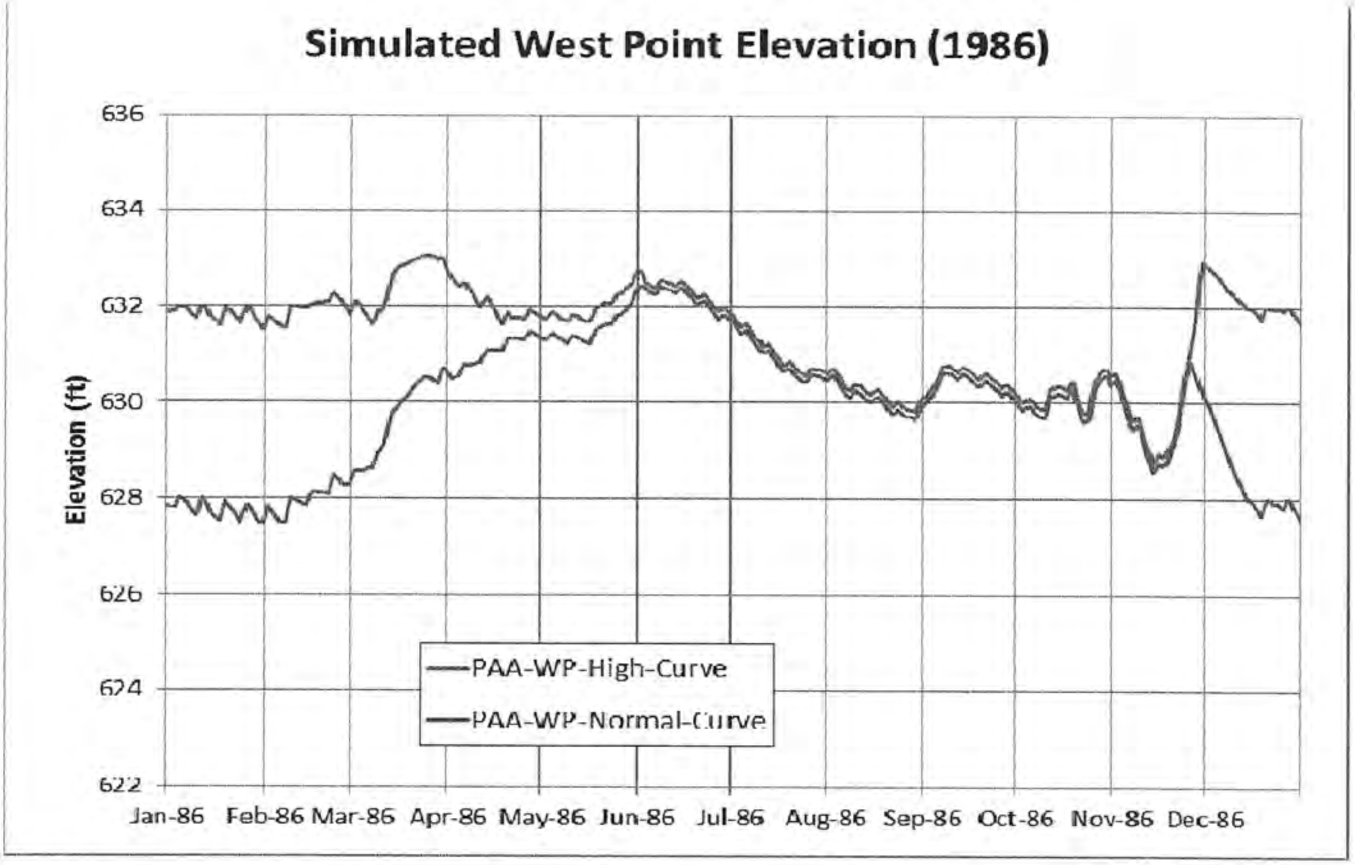


Figure 40. Simulated West Point Lake elevation in 1986.

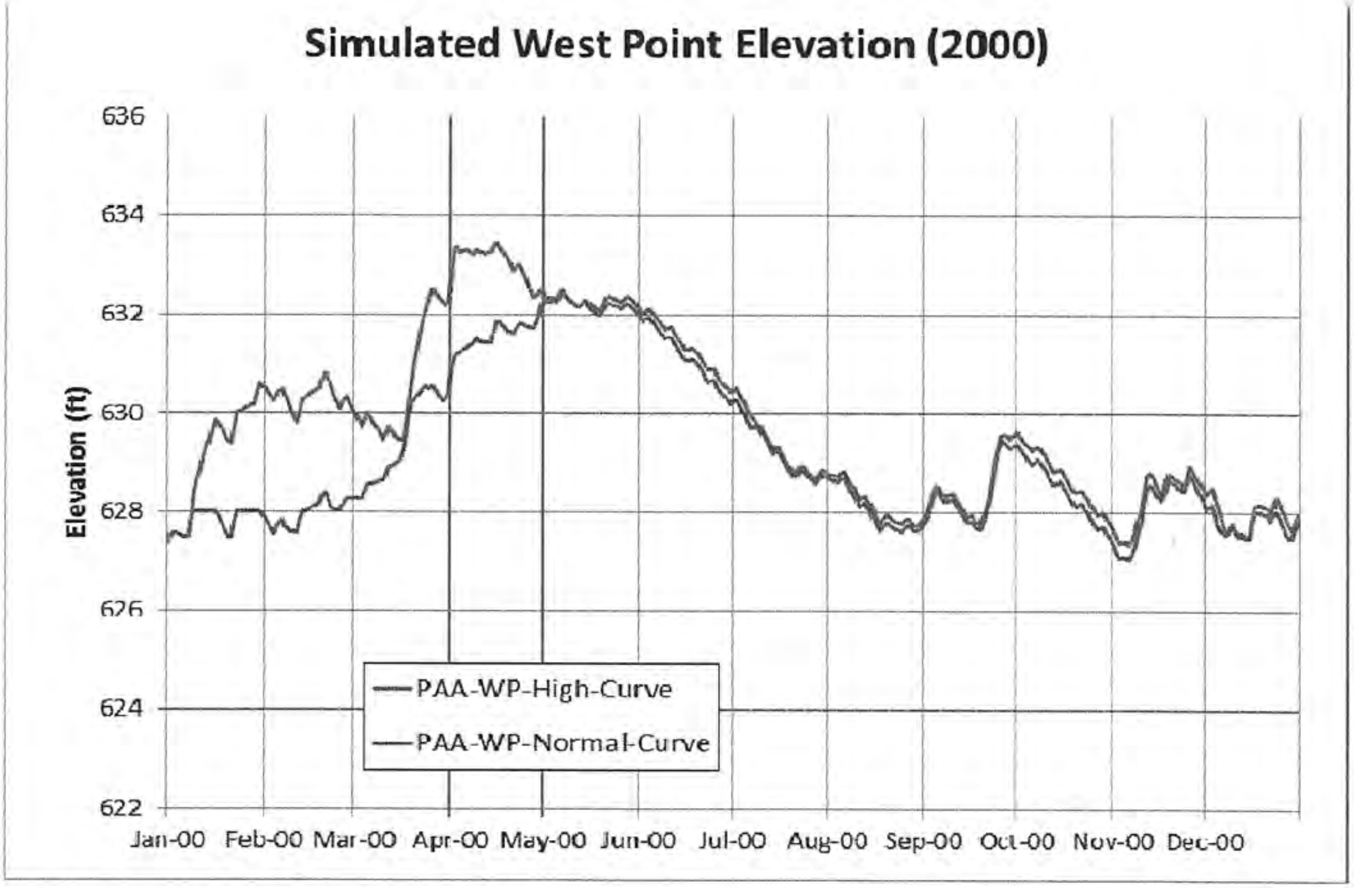


Figure 41. Simulated West Point Lake elevation in 2000.

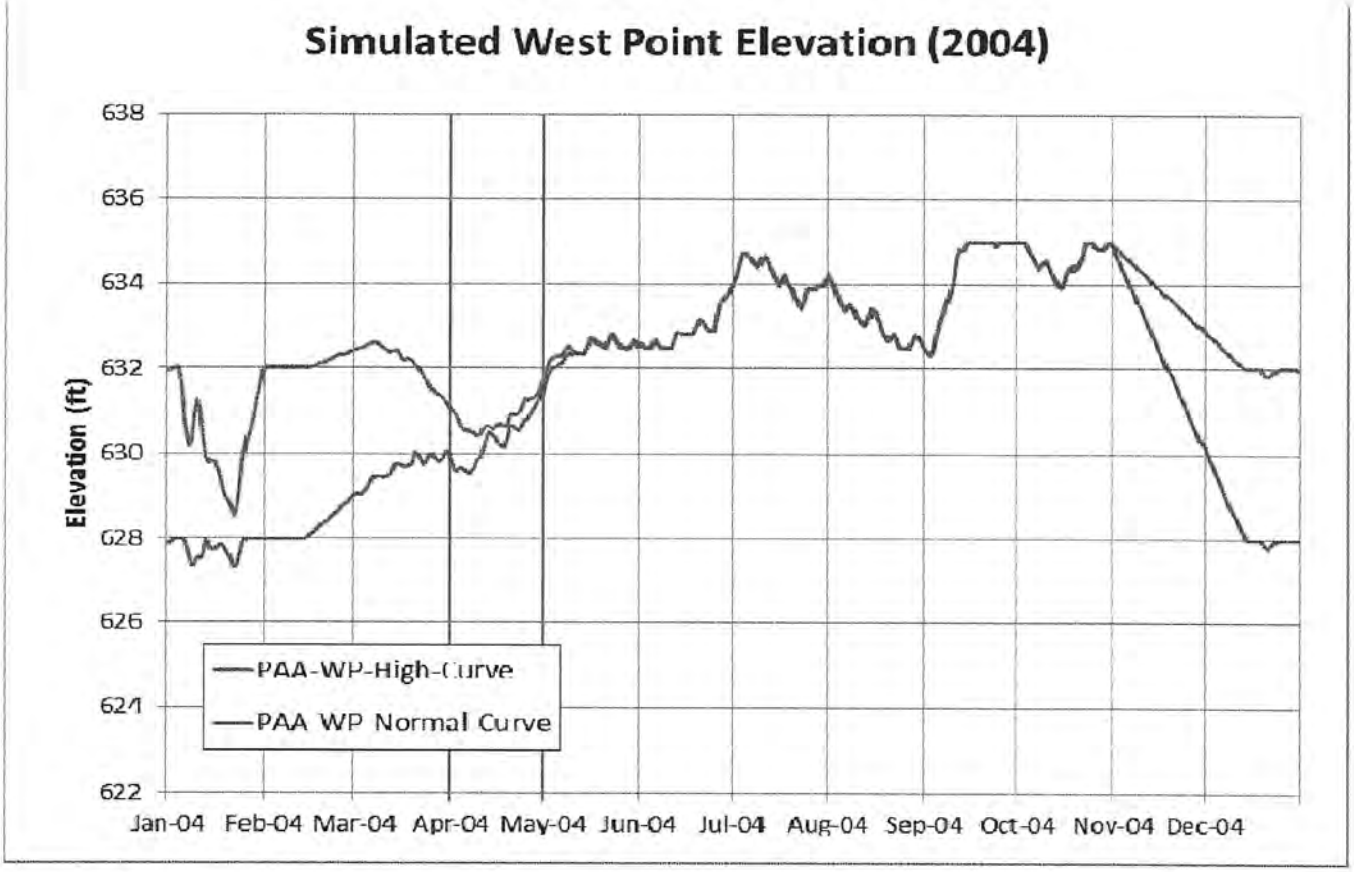


Figure 42. Simulated West Point Lake elevation in 2004.

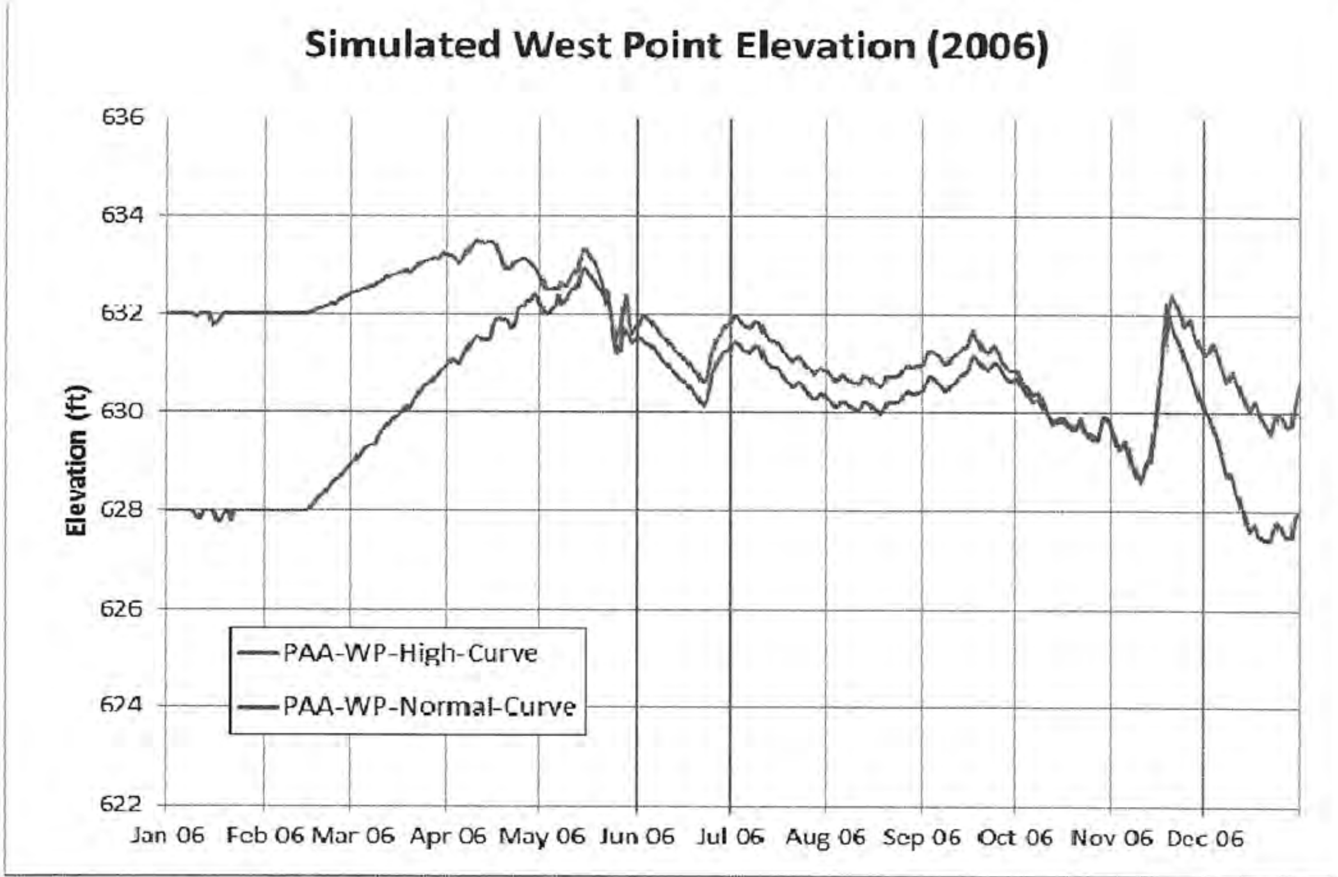


Figure 43. Simulated West Point Lake elevation in 2006.

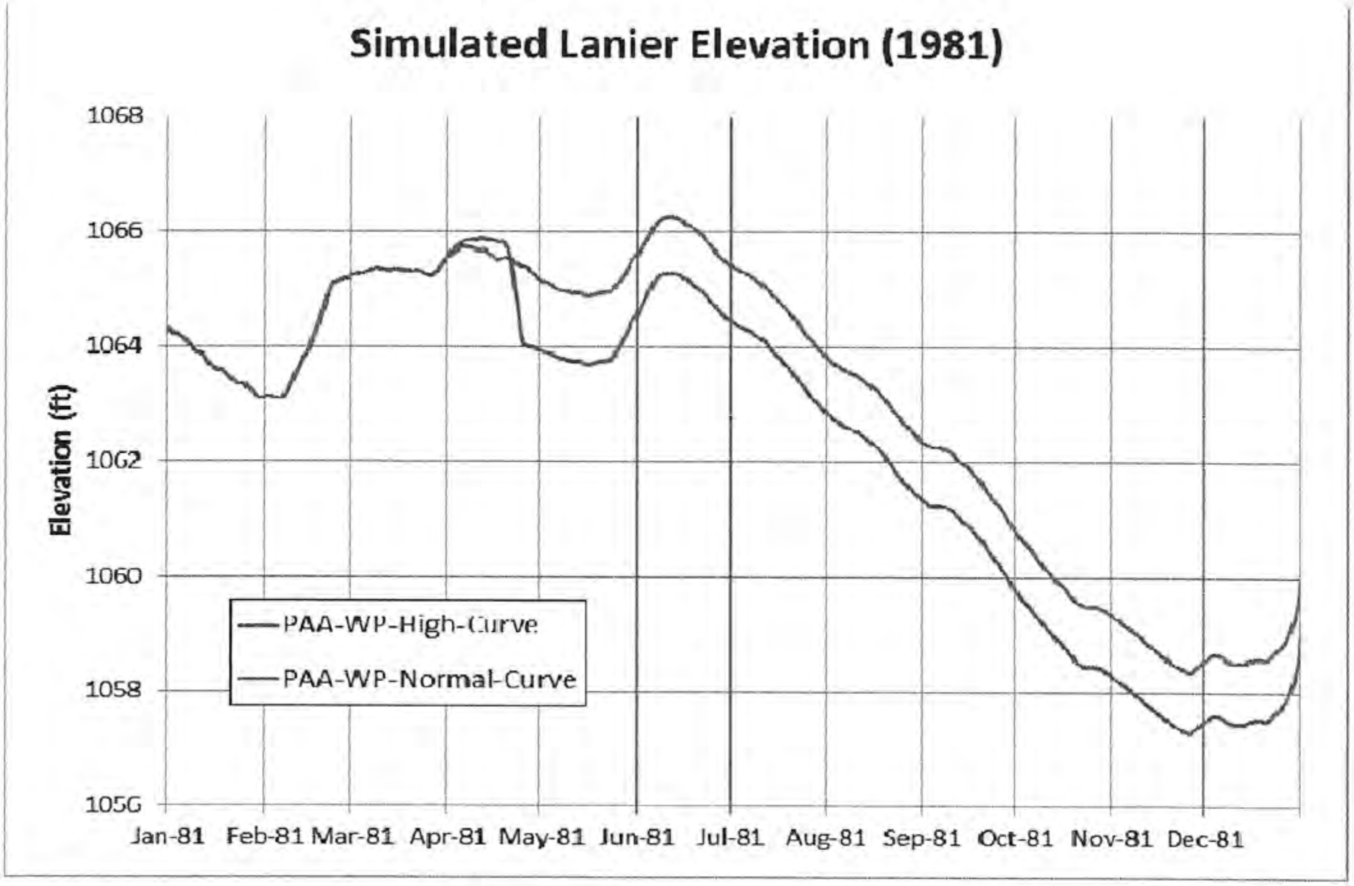


Figure 44. Simulated Lake Lanier elevation in 1981.

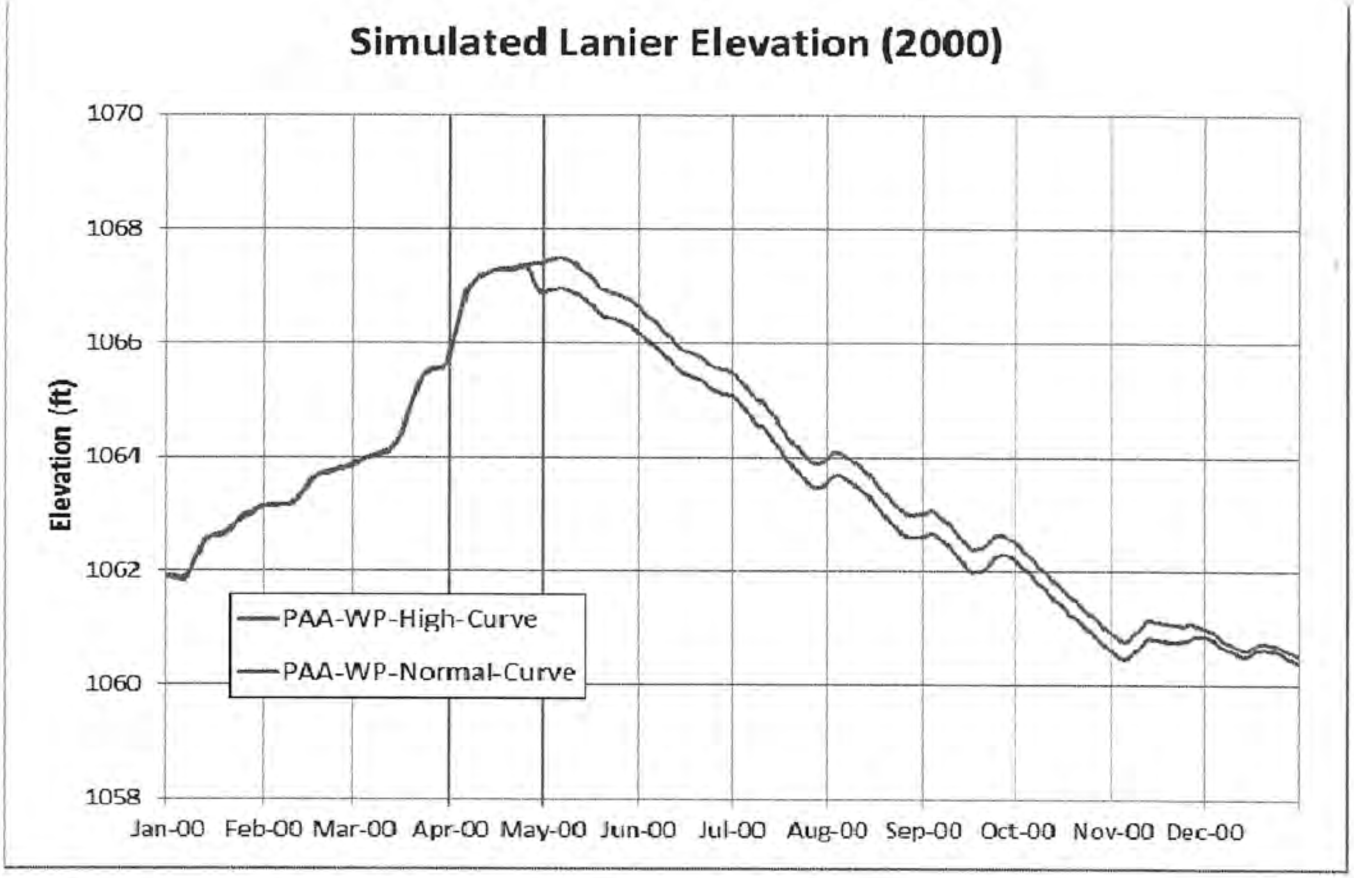


Figure 45. Simulated Lake Lanier elevation in 2000.

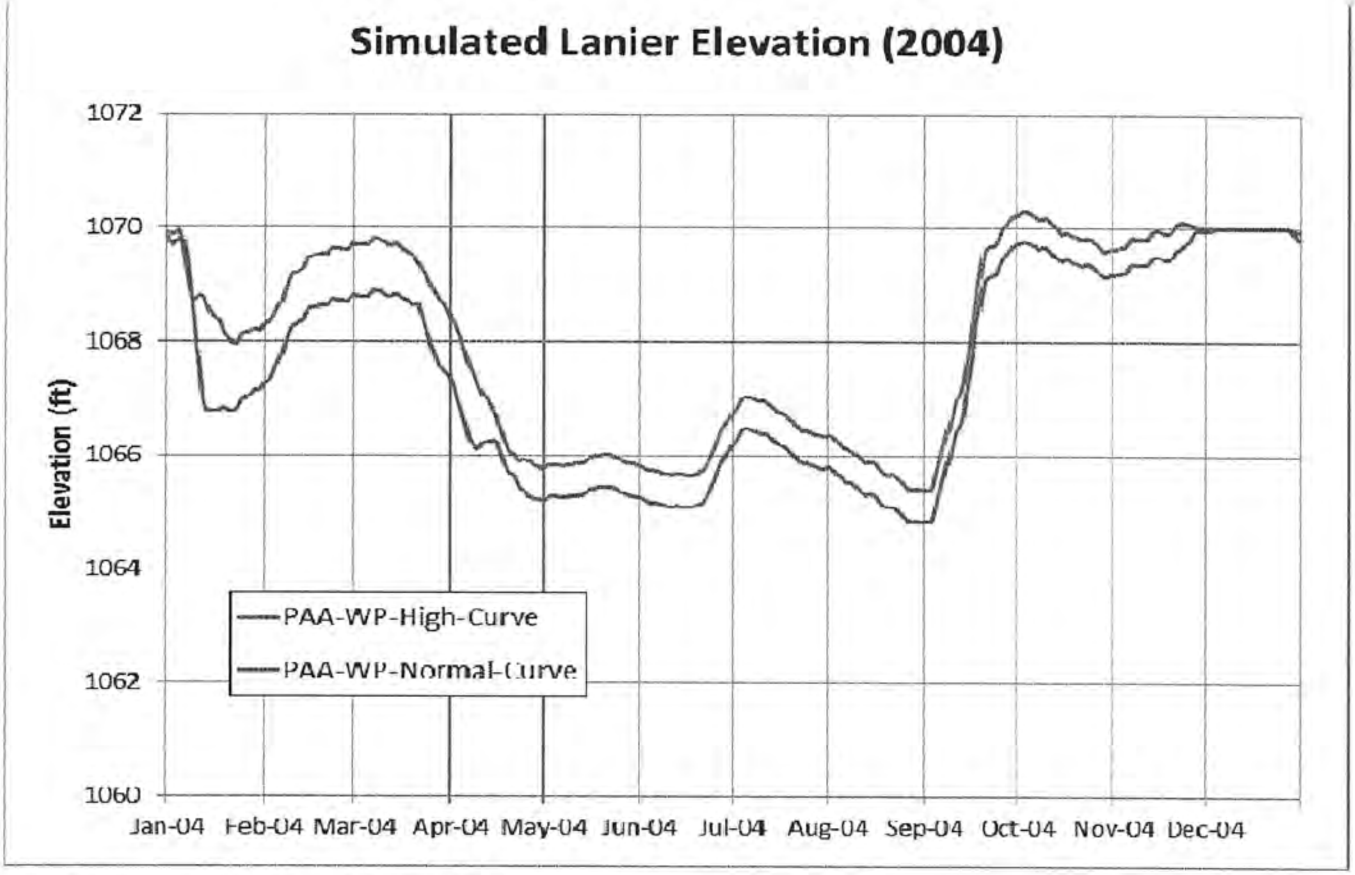


Figure 46. Simulated Lake Lanier elevation in 2004.

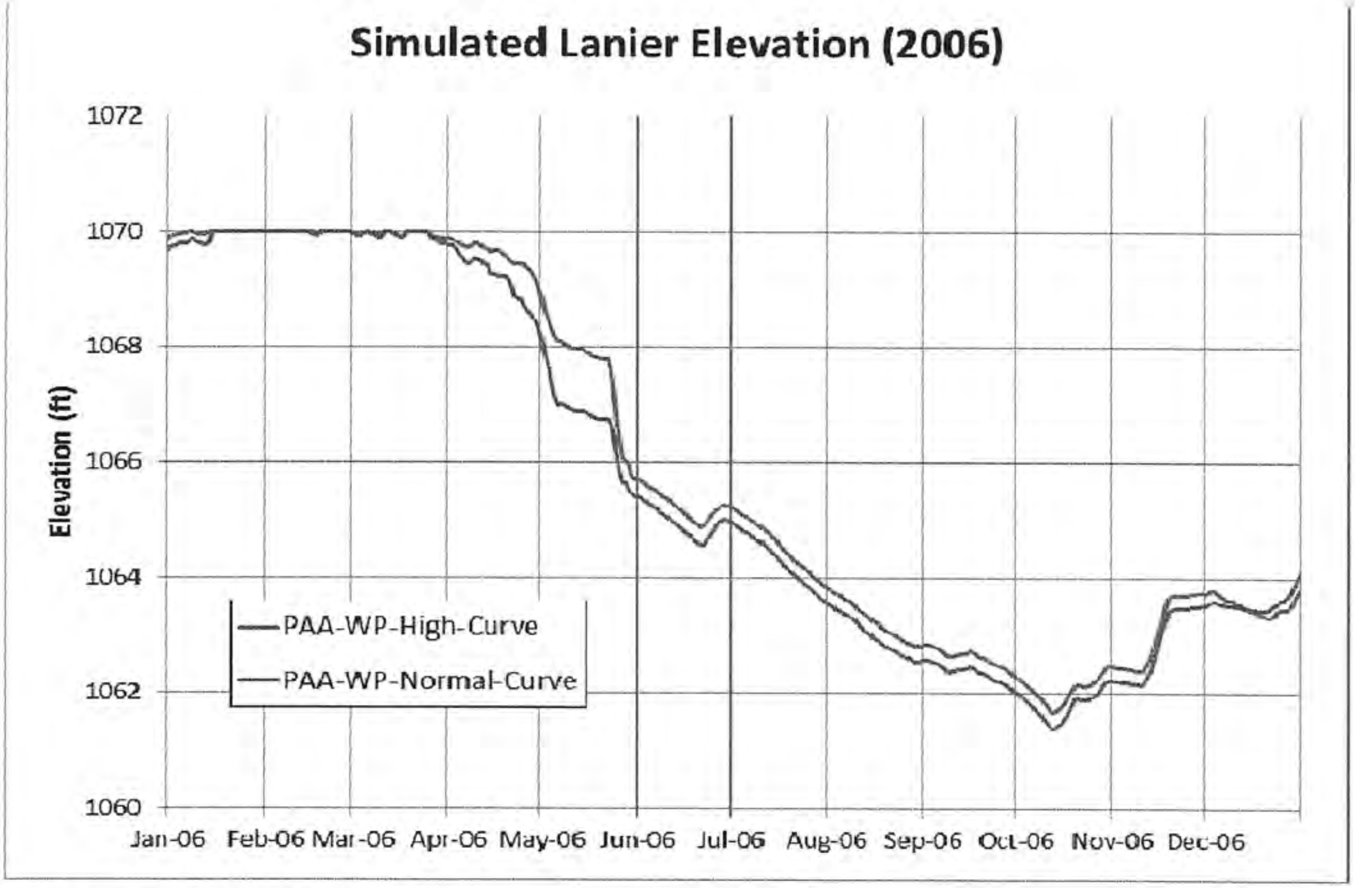


Figure 47. Simulated Lake Lanier elevation in 2006.

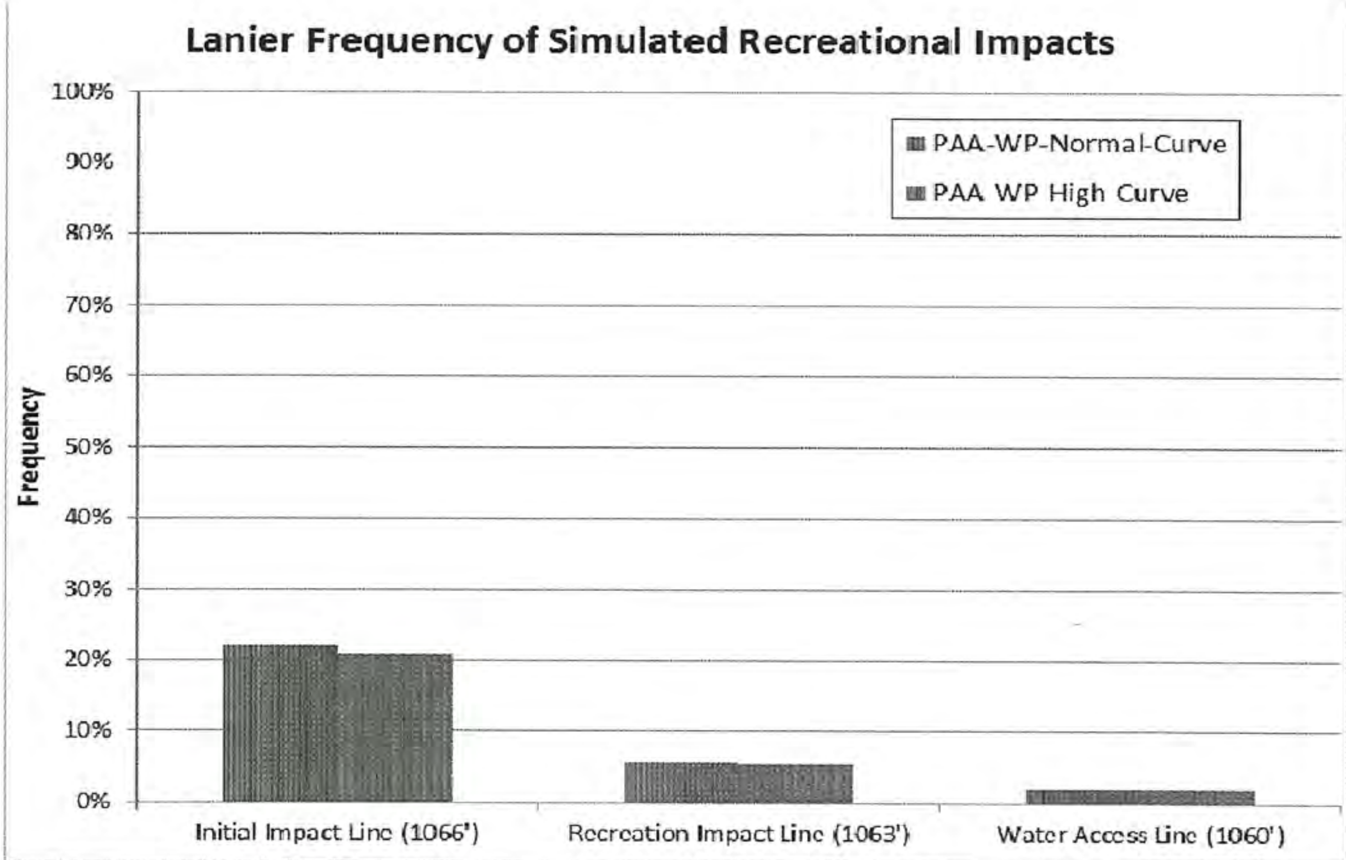


Figure 48. Frequency of simulated recreational impacts at Lanier.

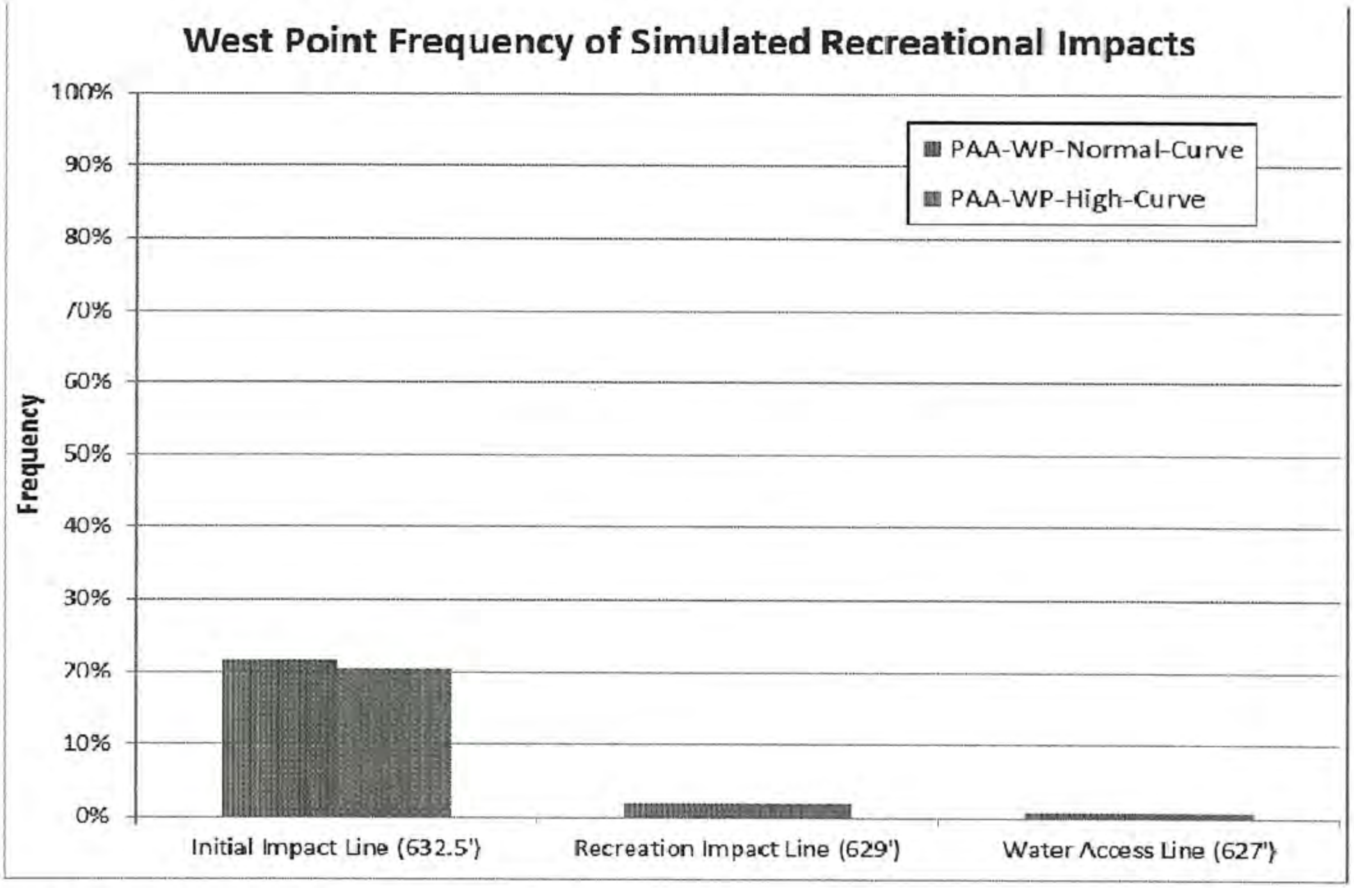


Figure 49. Frequency of simulated recreational impacts at West Point.

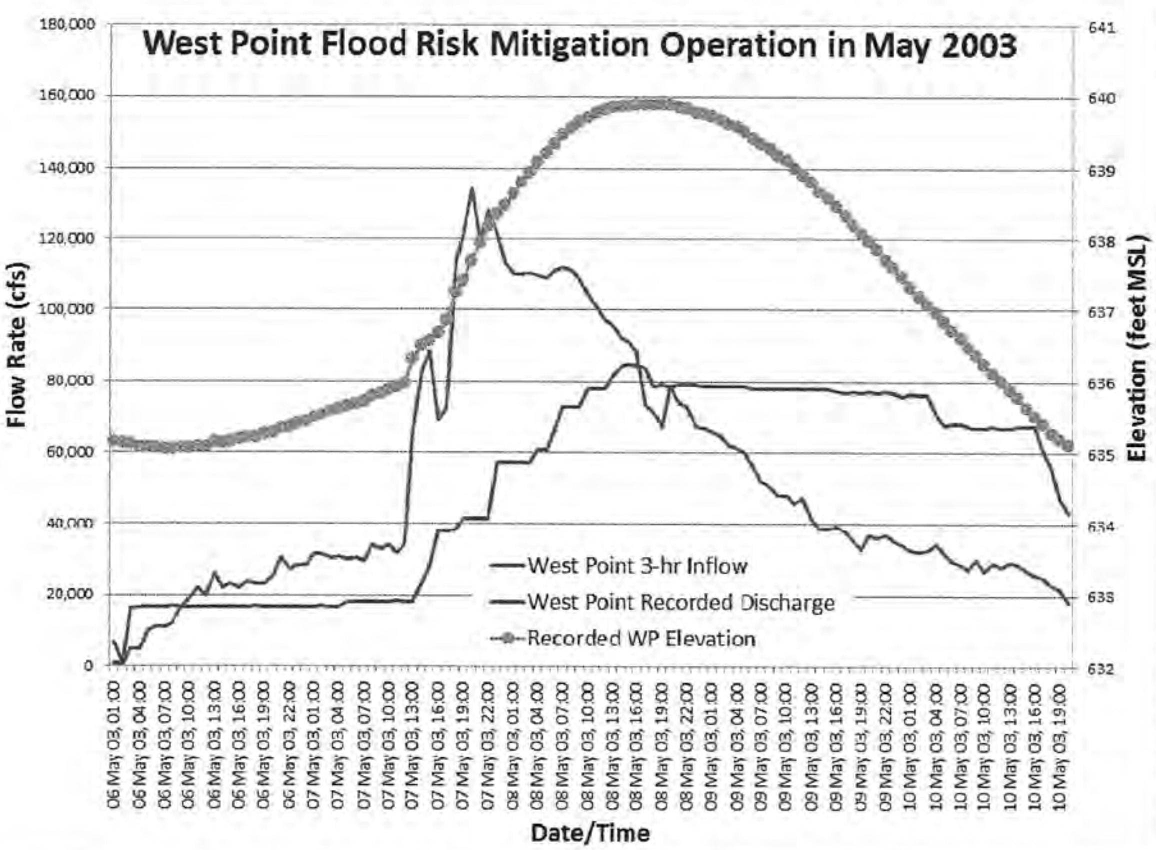


Figure 50. Recorded West Point flood risk mitigation operation in May 2003

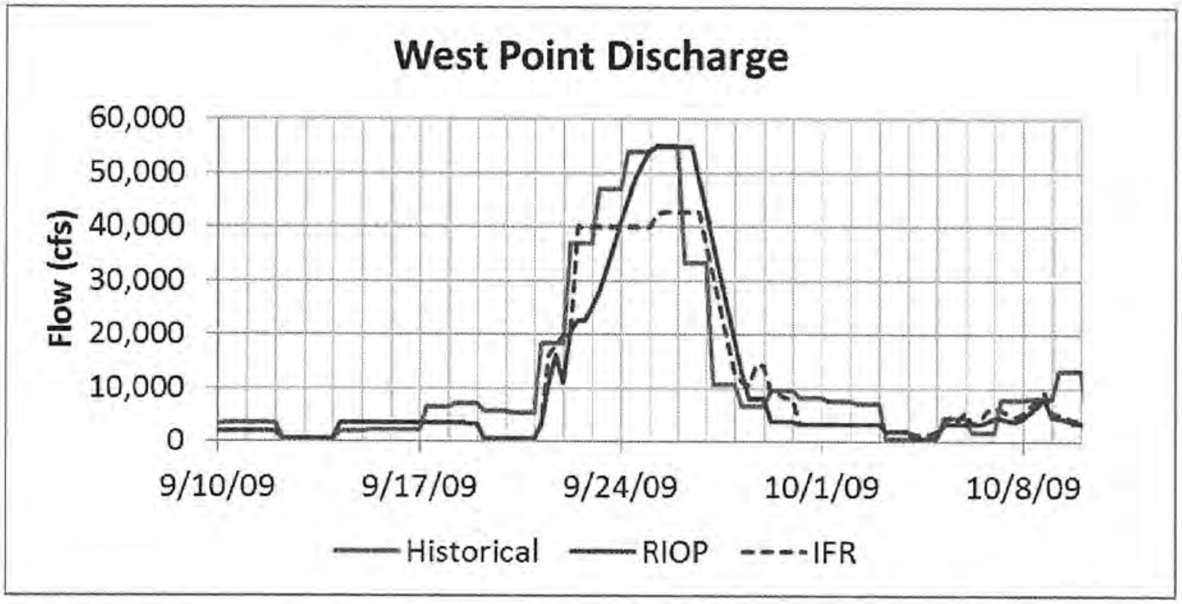


Figure 51. 6-hour West Point Discharge for the IFR and RIOP compared to historical daily discharge for the September 2009 flood event.

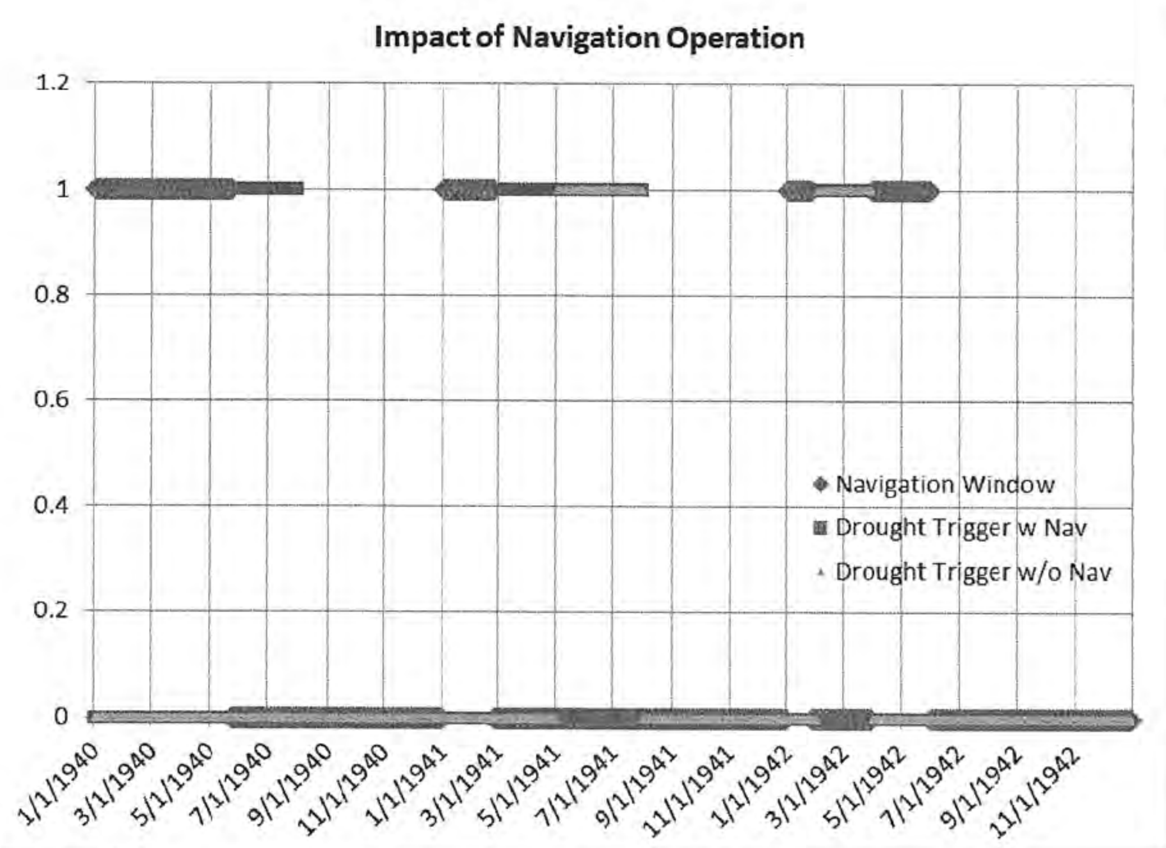


Figure 52. Additional system-wide drought operation resulting from navigation operations – 1940 – 1942

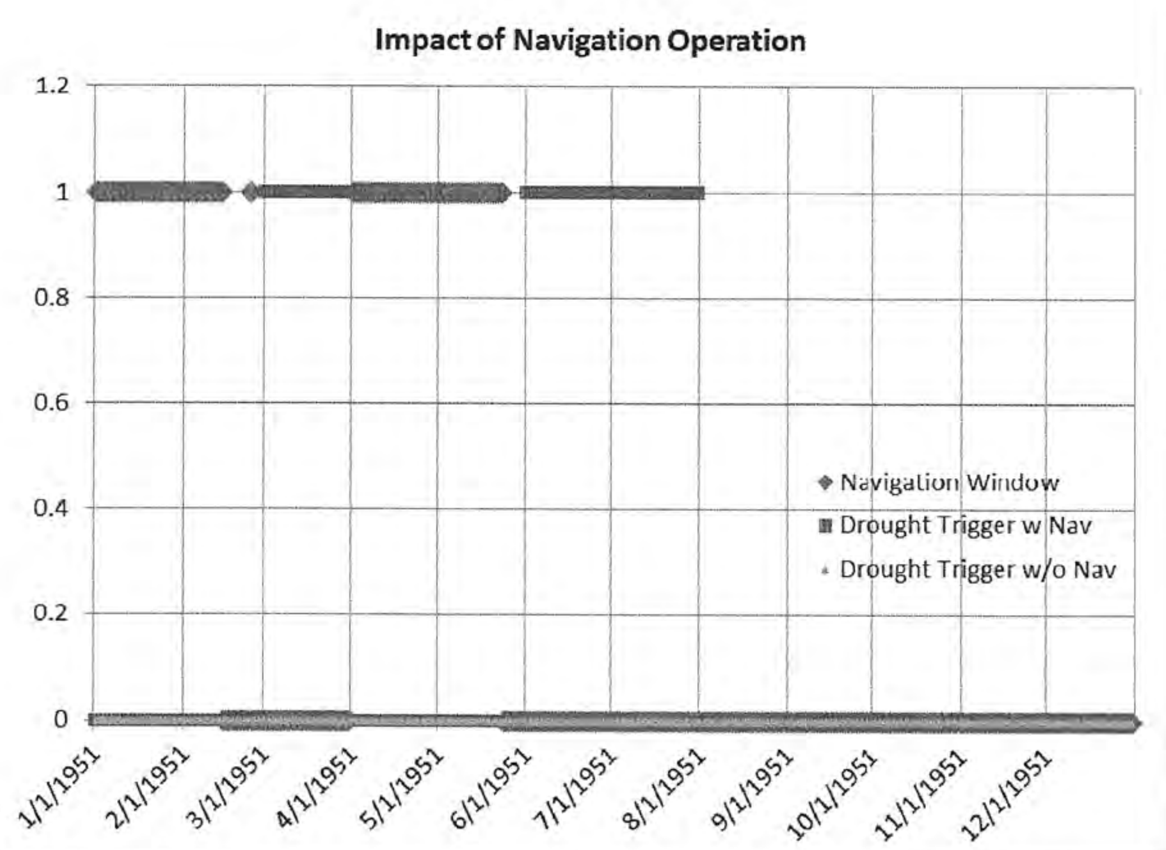


Figure 53. Additional system-wide drought operation resulting from navigation operations – 1951

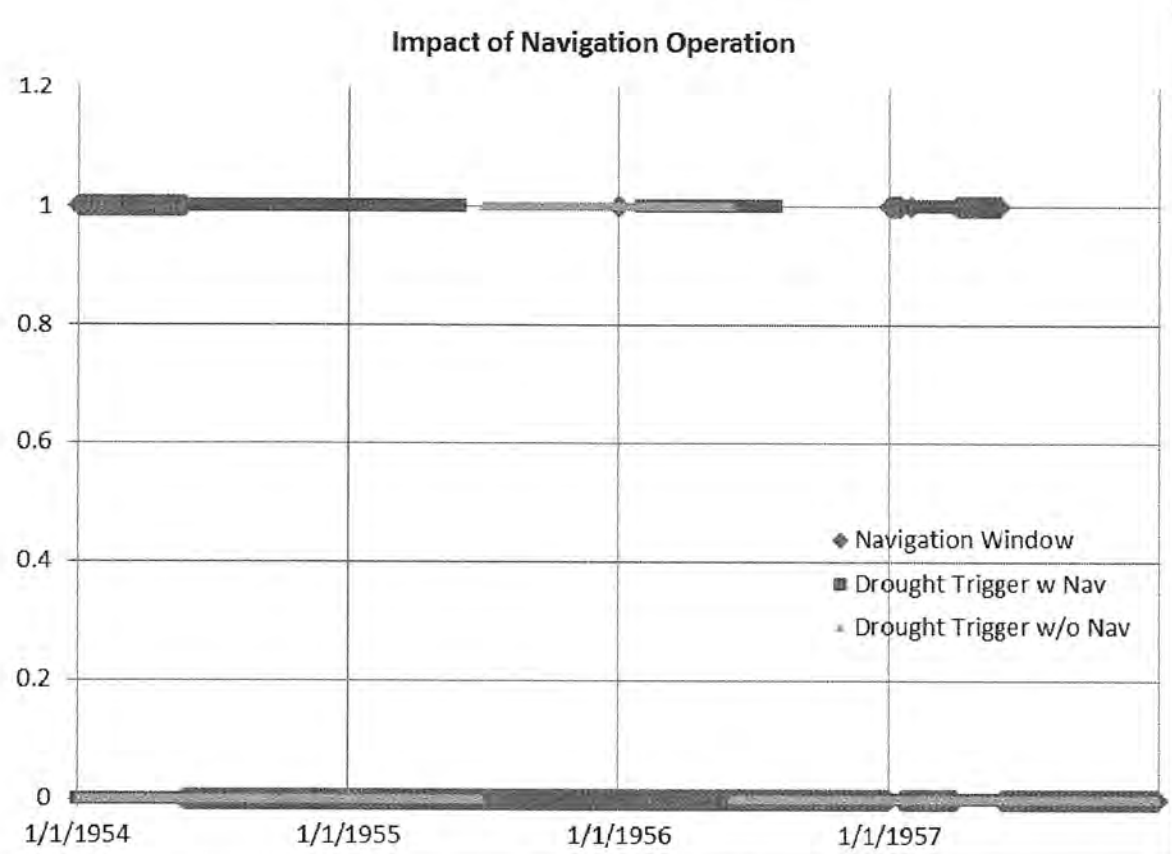


Figure 54. Additional system-wide drought operation resulting from navigation operations – 1954 – 1957

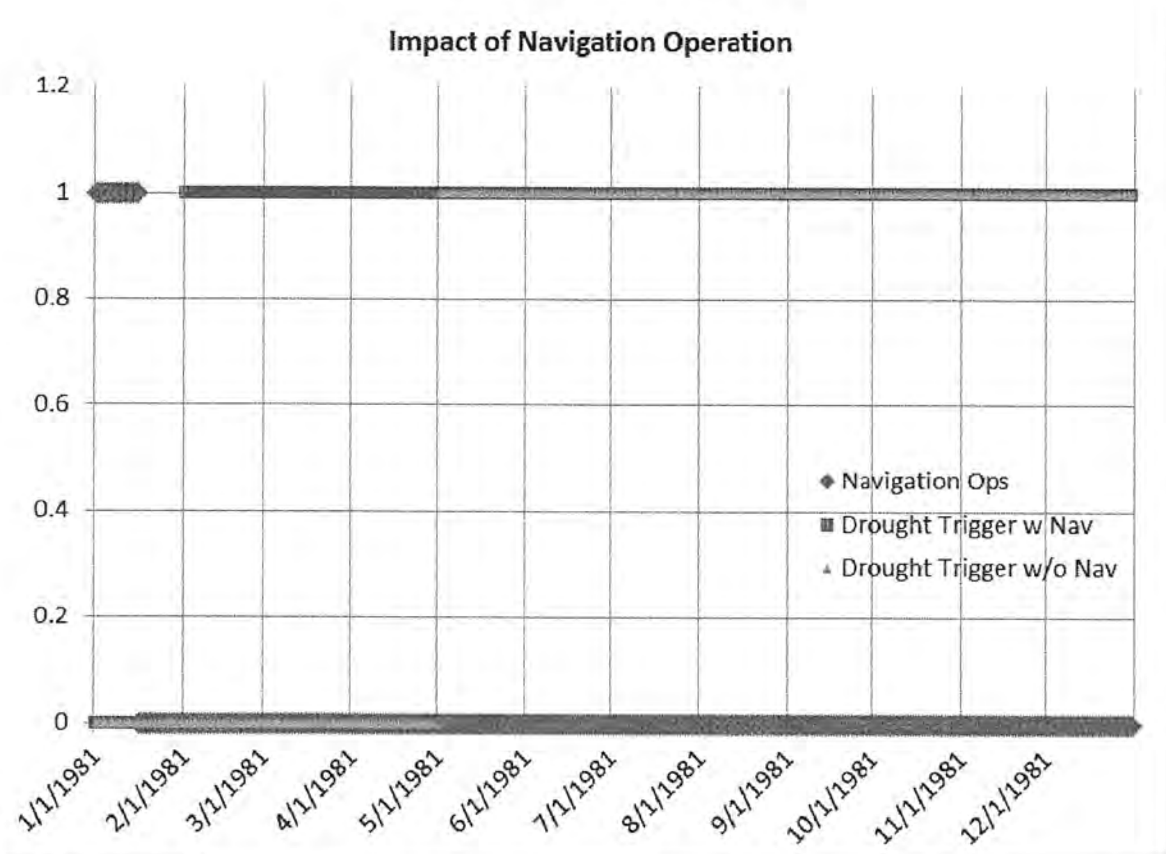


Figure 55. Additional system-wide drought operation resulting from navigation operations – 1981

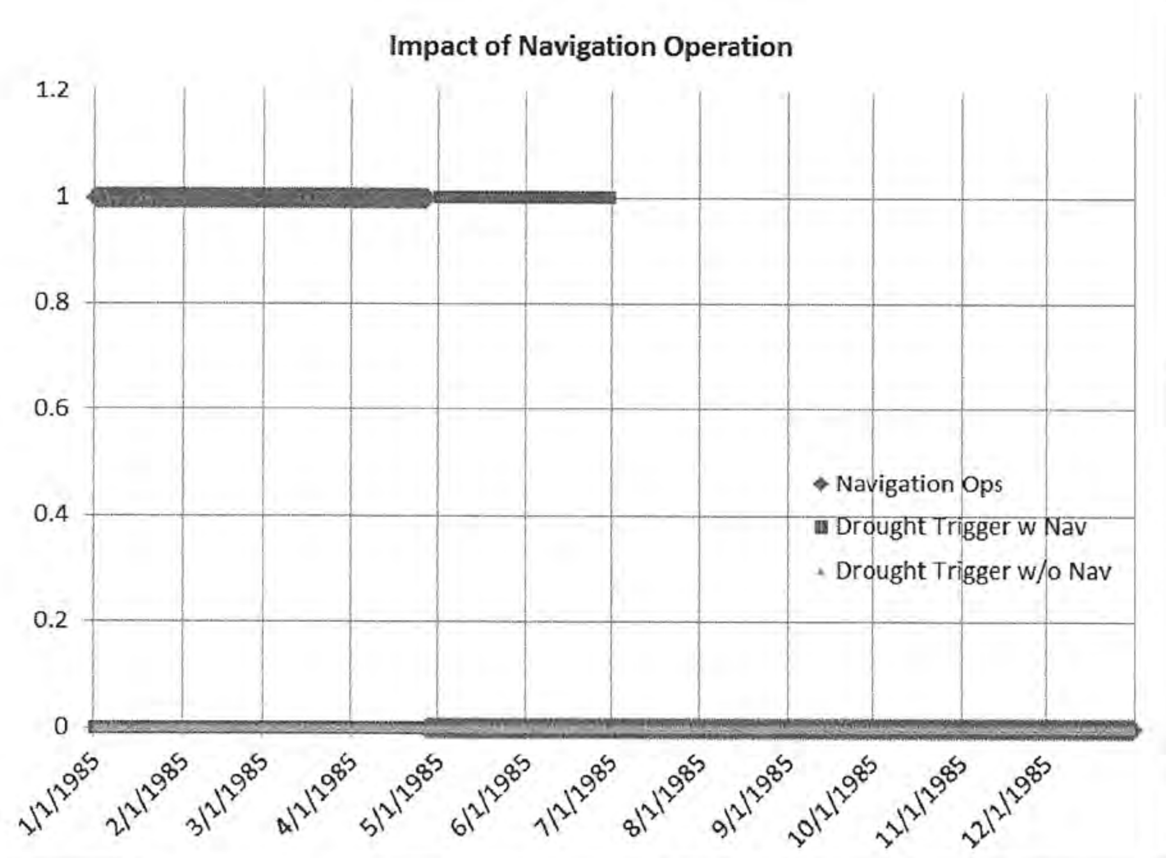


Figure 56. Additional system-wide drought operation resulting from navigation operations – 1985

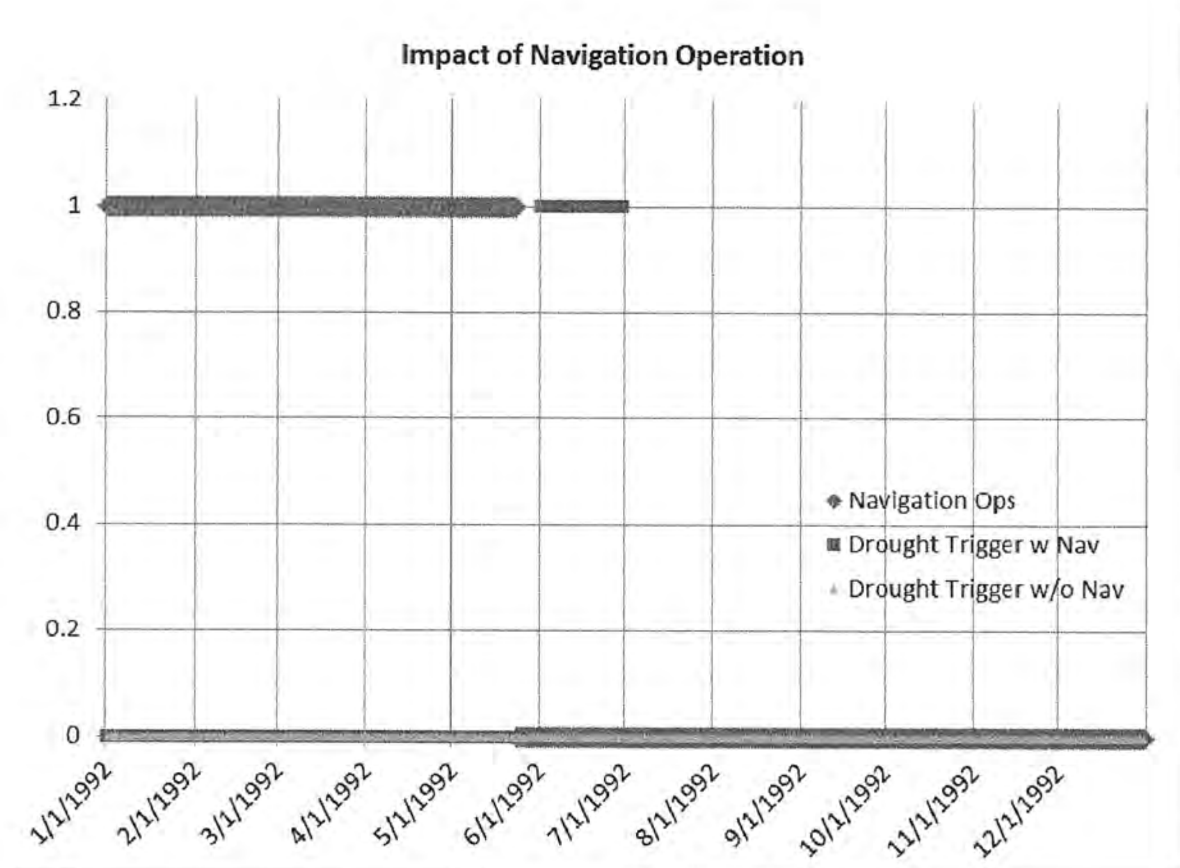


Figure 57. Additional system-wide drought operation resulting from navigation operations – 1992

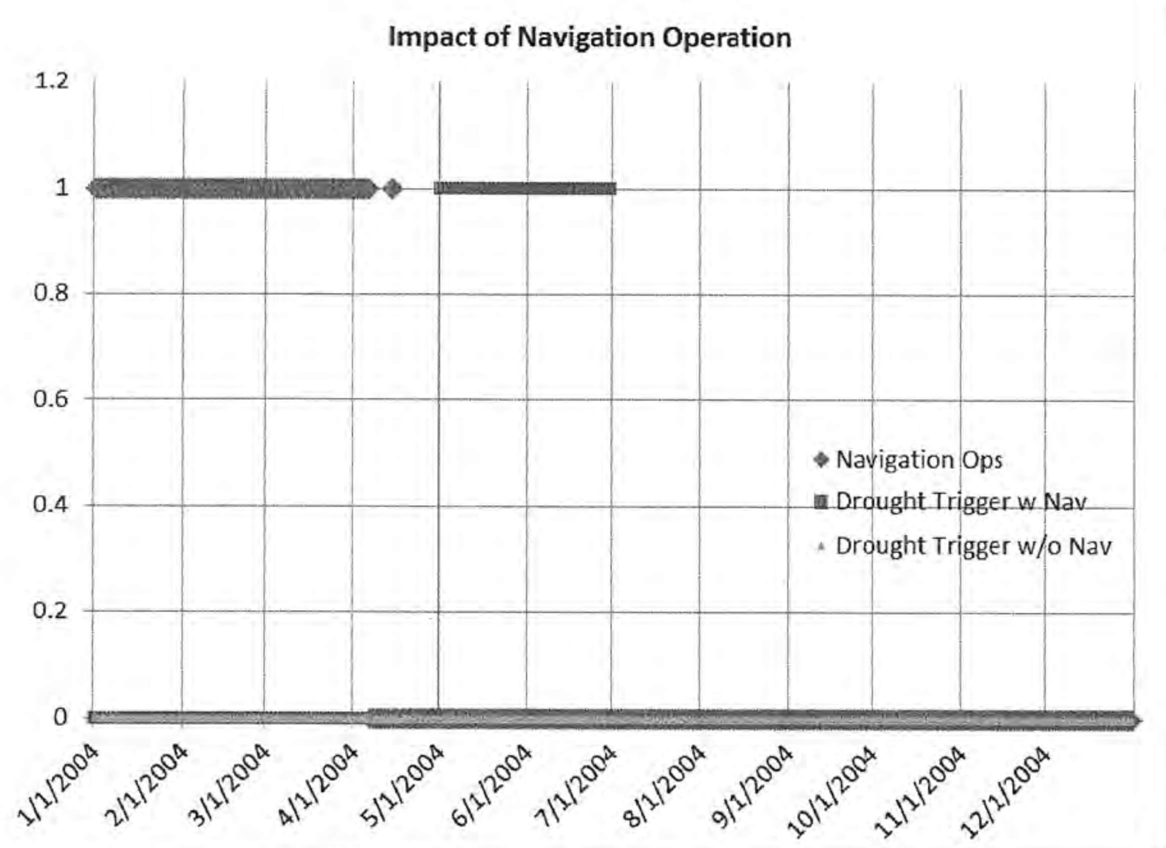


Figure 58. Additional system-wide drought operation resulting from navigation operations – 2004

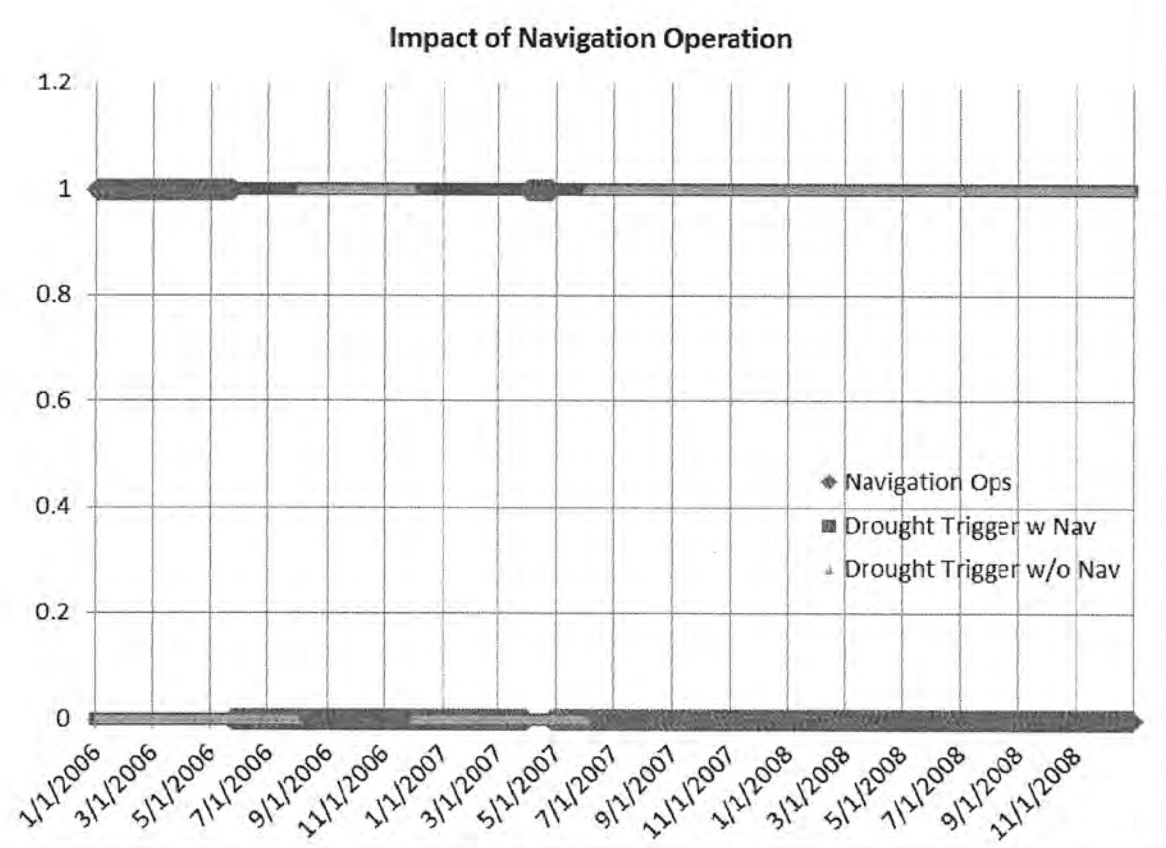


Figure 59. Additional system-wide drought operation resulting from navigation operations – 2006 – 2008

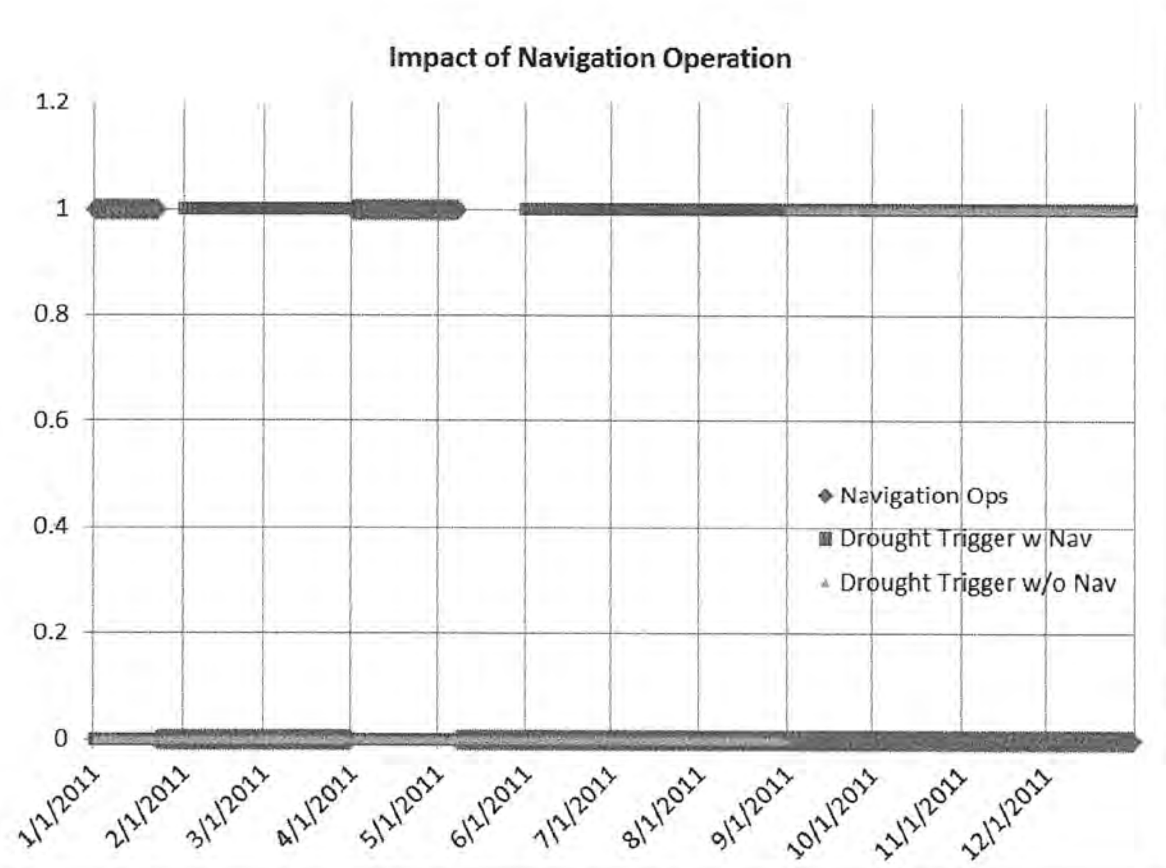


Figure 60. Additional system-wide drought operation resulting from navigation operations – 2011

Exhibit 50

STATE OF GEORGIA

OFFICE OF THE GOVERNOR

ATLANTA 30334-0900

Nathan Deal
GOVERNOR

January 11, 2013

The Honorable Jo-Ellen Darcy
Assistant Secretary of the Army for Civil Works
108 Army Pentagon
Washington, D.C. 20310-0108

Re: State of Georgia's Water Supply Request

Dear Secretary Darcy:

On May 16, 2000, Governor Roy Barnes submitted to the Assistant Secretary of the Army for Civil Works a request that the U.S. Army Corps of Engineers allow withdrawals and make releases from Lake Lanier to meet Georgia's projected water supply demands of 705 million gallons per day (mgd). In 2012, after years of litigation, the Corps determined that is has the legal authority to grant Georgia's request. The Corps is now preparing an Environmental Impact Statement and will decide whether and how it will satisfy Georgia's request.

More than 3.3 million Georgians in the Metropolitan Atlanta area now rely on withdrawals or releases from Lake Lanier for water supply. Approximately six million people will rely on Lake Lanier for water supply by the year 2040. Lake Lanier is the most economical and environmentally-protective source of water supply for these Georgians. Operating Lake Lanier as Georgia has requested represents the highest and best use of Lake Lanier. I am confident that the Corps' EIS will concur in this assessment.

To assist the Corps in making its review based on the best and most current information available, I enclose with this letter an Affidavit by Judson H. Turner, Director of the Georgia Environmental Protection Division. Mr. Turner's Affidavit contains updated demographic and water demand data that confirm the continued need for the action Georgia has requested of the Corps, as well as updated analysis of the impact of granting Georgia's request on other project purposes and waters downstream. At a later date, Georgia also will submit an updated analysis of the national economic development benefits of granting Georgia's request.

As reflected in Mr. Turner's affidavit, based on current demographic information and as a consequence of improved water conservation, Georgia now believes that 705 mgd will be sufficient to meet Georgia's water needs from Lake Lanier and the Chattahoochee River to approximately the year 2040. In addition, thanks to improved wastewater treatment, in most months Georgia requires less flow than previously requested in the Chattahoochee River at the confluence with Peachtree Creek to meet applicable water quality standards.

To provide long-term certainty for all of those involved, Georgia continues to request that the Corps enter into agreements that document the parties' understanding as to how the Corps will operate in support of Georgia's water supply needs. We anticipate that for lake withdrawals that require allocation of storage, certainty will be provided in the form of storage contracts. For river withdrawals, which do not require an allocation of storage, other forms of agreement would be appropriate.

I ask that you act on Georgia's outstanding request at the earliest possible date. If you desire further information from Georgia, please let me know.

Sincerely,

Nathan Deal

cc: Colonel Donald E. Jackson, Commander, South Atlantic Division, U.S. Army Corps of Engineers
Colonel Steven J. Roemhildt, Commander, Mobile District, U.S. Army Corps of Engineers

Affidavit of Judson H. Turner

1. My name is Judson H. Turner. I am Director of the Georgia Environmental Protection Division ("EPD") of the Georgia Department of Natural Resources.

2. In May 2000, the State of Georgia submitted to the Assistant Secretary of the Army for Civil Works a request for reallocation of storage in the Lake Lanier conservation pool to provide sufficient water supplies to meet future municipal and industrial water supply needs of 705 million gallons per day (mgd). In support of that request, Georgia provided an Affidavit from then-EPD Director Harold Reheis discussing Metropolitan Atlanta's then-current and projected water supply needs and why Georgia needed a reallocation of storage in Lake Lanier to meet those needs. Georgia's water supply request remains pending with the Corps. The purpose of this Affidavit is to provide updated data and information that are relevant to that request.

3. The State of Georgia is responsible for managing the quantity and quality of the waters of the State for public and private water supply, and for agricultural, industrial, and recreational uses, while protecting the environment and human health. Georgia law provides that "the government of the state shall assume responsibility for the quality and quantity of such water resources and the establishment and maintenance of a water quality and water quantity control program adequate for present needs and designed to care for the future needs of the state." O.C.G.A. § 12-5-21(a).

4. EPD is the state agency to which state law delegates the responsibility for regulating withdrawals of water from, and discharges of pollutants into, the surface waters of the State. To fulfill this responsibility, EPD maintains data on the population of counties and municipalities within the State, and projections of the State's future population growth and water needs. EPD's expertise in hydrologic and water quality modeling allows it to assess the impact of water withdrawals and wastewater returns. EPD prioritizes water needs and evaluates alternatives for meeting these needs from the State's finite water resources.

GEORGIA'S NEED FOR WATER SUPPLY FROM LAKE LANIER

Current Population and Projections for Future Growth

5. More than 3.3 million Georgians currently rely upon withdrawals of water directly from Lake Lanier or withdrawals of water that the Corps releases from Lake Lanier to the Chattahoochee River to meet their water supply needs. Attached as Appendix 1 is a table that identifies the counties within which municipal and industrial water use customers are dependent in whole or in part on withdrawals and releases from Lake Lanier for their water supply.

6. Also shown in Appendix 1 are projected populations of the counties that will depend on significant amounts of water from Lake Lanier in the future. EPD projects that the number of Georgians who depend upon Lake Lanier for water supply will rise to more than 6 million by around 2040. The numbers in Appendix 1 come from the last published projections of the Georgia Office of Planning and Budget ("OPB"). EPD also reviewed the last published

projections generated by the Metropolitan North Georgia Water Planning District (the "Metro Water District").

7. Municipal water systems in six counties within the Chattahoochee River watershed above the confluence with Peachtree Creek currently withdraw water from the Lake Lanier/Chattahoochee River system. EPD projects that water systems in four additional counties that are riparian or tributary to Lake Lanier will depend upon withdrawals from Lake Lanier in the future. In addition, the following other counties rely on Lake Lanier for water supply: Bartow, Cherokee, Clayton, Douglas, Fayette, Henry, Paulding, Rockdale, and Walton.

8. Counties that rely on Lake Lanier for water supply comprise the majority of the population for the Atlanta Metropolitan Statistical Area ("MSA"), which, according to the U.S. Census Bureau, is the ninth largest MSA by population in the United States. From 2000 to 2010, the Atlanta MSA grew by 24%, a growth rate exceeded by only two other MSA's in the United States. Two counties in the Atlanta MSA (Forsyth and Paulding) were among the 10 fastest growing counties in the United States during this period, both growing at rates greater than 74% for the decade. Gwinnett County added almost 217,000 persons to its population over the decade; for the same period, only 16 counties in the United States added more people.

Municipal and Industrial Water Supply Needs

9. Attached as Appendix 2 and Appendix 3 are the 2011 statistics for water withdrawals by the permit holders who rely upon the Lake Lanier/Chattahoochee River system. The average rate of water withdrawn directly from Lake Lanier in 2011 was 115.2 mgd. *See* Appendix 2. The annual average rate of water withdrawn from the Chattahoochee River between Buford Dam and Peachtree Creek was 245.7 mgd. *See* Appendix 3.

10. Appendix 4 shows projected withdrawals from Lake Lanier and the Chattahoochee River above the confluence with Peachtree Creek for the year 2040. EPD developed its forecasts for future water supply need projections in cooperation with the Metro Water District. These forecasts are based on a number of factors, including population, employment, and commercial and residential consumption rates.

11. EPD and the Metro Water District project that the nine local water systems that currently withdraw water from Lake Lanier or the Chattahoochee River above the confluence with Peachtree Creek will continue to do so. These systems are: City of Gainesville, City of Buford, Gwinnett County Water and Sewerage Authority, Forsyth County, City of Cumming, Atlanta-Fulton Water Resources Commission, DeKalb County Public Works (Water and Sewer), Cobb County Marietta Water Authority, and City of Atlanta.

12. Of these, five systems – City of Gainesville, City of Buford, Gwinnett County Water and Sewerage Authority, Forsyth County, and City of Cumming – withdraw from Lake Lanier. The other four facilities – Atlanta-Fulton Water Resources Commission, DeKalb County Public Works (Water and Sewer), Cobb County Marietta Water Authority, and City of Atlanta – withdraw from the Chattahoochee River upstream of the Peachtree Creek confluence. In

addition, EPD projects that Habersham, White, Lumpkin, and Dawson Counties in the future will need to withdraw approximately 41 mgd from Lake Lanier by 2040.

13. The Metro Water District's most recent Water Supply & Conservation Management Plan includes projections for municipal and industrial water supply needs for 2035 and 2050. Based on these projections, adding the 41 mgd of withdrawals by Habersham, White, Lumpkin, and Dawson Counties, and assuming that growth in water usage between 2035 and 2050 will be roughly linear, water supply needs that are dependent on withdrawals and special releases from Lake Lanier will meet or exceed 705 mgd on an annual average basis by 2040. This includes direct withdrawals from Lake Lanier of 297 mgd and withdrawals of 408 mgd from the Chattahoochee River below Buford Dam and above the confluence of the Chattahoochee River and Peachtree Creek.

14. Note that in calculating its water supply projections, the Metro Water District used a population growth rate for the region that is lower than the rate of growth that OPB has projected. Taking into account differing population projections and other variables affecting demand, EPD projects that municipal and industrial water supply demands that are dependent upon withdrawals and special releases from Lake Lanier will reach 705 mgd (including 297 mgd lake withdrawals and 408 mgd river withdrawals) sometime between 2035 and 2045. It is reasonable to plan using the assumption that Georgia's water supply needs will be at least 705 mgd by 2040.

15. In light of Georgia's projections that its water supply needs from Lake Lanier will equal or exceed 705 mgd by 2040, if not a few years sooner, Georgia's request of the Corps is unchanged from what was requested in 2000: that the Corps operate Lanier to accommodate withdrawals of up to 297 mgd annual average from Lake Lanier and 408 mgd annual average from the Chattahoochee River between Buford Dam and the confluence with Peachtree Creek.

16. Georgia plans to help meet demands from Lake Lanier with water that will be stored in the proposed Glades Reservoir upstream of Lake Lanier on Flat Creek, released to Flat Creek, and will flow into Lake Lanier to be withdrawn from one or several of the intakes in Lake Lanier. The Glades Reservoir currently is in the permitting process. Based on reasonable assumptions regarding operation of Glades Reservoir, EPD projects a 30-40 mgd yield from Glades Reservoir. EPD plans to work with the Corps and the reservoir sponsors to ensure that the Glades Reservoir serves as a net benefit to the system yield, provided that the Corps will be able to meet water supply needs of 705 mgd from Lake Lanier. Because the 30-40 mgd released from Glades Reservoir will be withdrawn from Lake Lanier at the same rate that it enters Lake Lanier, no storage should be required for the withdrawal of that water.

Water Conservation

17. The per capita water use rate in the Metropolitan Atlanta Region has fallen in recent years, and the projected demand the region assumes that per capita water use within the region will continue to fall. The use rate is currently 148 gallons per capita per day (gpcd), and is expected to decline to 135 gpcd by the 2035-2040 timeframe. The decline in per capita water use has and is expected to continue to result from implementation of aggressive state and local

water conservation policies, explained in greater detail below. Note that per capita water use and total population are among the factors, but are not the only factors, used to calculated total projected water use in the areas that are to be supplied by withdrawals and releases from Lake Lanier.

18. In 2001, the Georgia General Assembly created the Metro Water District and charged it with developing and maintaining comprehensive long-term plans for water supply and conservation, wastewater management, and watershed management for metro Atlanta. The Metro Water District is comprised of 15 counties, 92 cities, and 56 water supply systems. The plans are implemented by local water systems and local governments and are enforced by the State of Georgia through water permits and through eligibility for grants and loans. The Metro Water District completed development of its initial set of plans in September 2003. The governments within the Metro Water District spent the ensuing five years implementing the plans. In 2009, the Metro Water District adopted the first major update of its plans largely based upon lessons learned during the 2004-2009 implementation period.

19. Water conservation is an important element of the Metro Water District's Water Supply and Water Conservation Plan. The water conservation measures in the Plan are the most aggressive in Georgia and among the most aggressive in the United States. The 2003 Plan, as amended, included ten conservation measures applicable to all water systems and/or local governments. The 2009 update retained all and strengthened three of those measures. The Water Supply and Water Conservation Plan was again amended in December 2010 and added seven measures – two measures applicable throughout the District and five that apply to water systems that withdraw from Lake Lanier or the Chattahoochee River (denoted with asterisk). The water conservation measures in the Metro Water District Plan include: 1) conservation pricing; 2) replace older, inefficient plumbing fixtures; 3) pre-rinse spray valve retrofit education; 4) rain sensor shut-offs on new irrigation systems; 5) sub-unit meters in new multi-family buildings; 6) assess water losses with IWA/AWWA water audit methodology and develop programs to reduce systems water loss; 7) residential water audits; 8) low-flow retrofit kits for residential; 9) commercial water audits; 10) education and public awareness activities; 11) high-efficiency toilets and urinals in government buildings; 12) new car washes to recycle water; 13) expedited water loss reduction*; 14) multi-family HET rebates*; 15) meters with point of use leak detection*; 16) private fire lines to be metered*; 17) maintain a water conservation program*; 18) water waste policy or ordinance; and 19) HET plumbing fixtures in new construction consistent with state legislation.

20. The Metro Water District has made water conservation a priority, and local water systems have shown a strong record of implementation of water conservation measures. In annual progress surveys, the District has found: that tiered water conservation rates are in place throughout the metro area; that water systems serving 96% of the population offer toilet rebates, and over 76,872 older toilets have been replaced since 2008; that the larger systems have implemented programs to reduce system water losses, and, in 2010, over 10,000 leaks were repaired; and 98% of the population of the metro area is targeted with educational and outreach programs by local governments.

21. In 2010, the Georgia Water Stewardship Act was passed by the Georgia General Assembly and signed by Governor Sonny Perdue. For those water users relying on Lake Lanier and the Chattahoochee River above Peachtree Creek, the Water Stewardship Act amplified and supplemented the 19 water conservation policies and programs identified in the Metro Water District's water supply and conservation plan. Among the Act's provisions that supplement the Metro Water District's demand management initiatives are: 1) requiring state government agencies to examine their programs, practices, and rules to identify opportunities to provide for voluntary water conservation; 2) requiring local governments to include water conservation measures in local comprehensive plans; 3) incentives for public water systems to use full cost accounting; and 4) technical assistance to local governments and public water systems for water loss abatement activities.

22. In 2012, EPD conducted an evaluation of the 2000-2010 rates of growth in water demand compared to rates of population growth in the counties with the 15 largest municipal surface water systems in Georgia. Six of the 15 largest municipal surface water systems are located in five counties (i.e., Fulton, DeKalb, Cobb, Gwinnett, and Hall) that rely upon withdrawals or water supply releases from Lake Lanier. The evaluation showed that water use in each of the five counties demonstrated a consistent decreasing trend over the decade, while population in each of those counties increased over the decade. Trends such as these in the five counties and beyond clearly indicate that the water conservation initiatives being implemented in the Atlanta region by the Metro Water District are significantly reducing per capita water demand.

Crediting of Return Flows

23. EPD projects that returns of treated wastewater to Lake Lanier and tributaries immediately upstream of Lake Lanier will mitigate the effect of withdrawals from Lake Lanier. EPD projects that the average annual return of treated wastewater to Lake Lanier and its tributaries in 2040 (assuming withdrawals of 297 mgd) will be approximately 165 mgd. *See* Appendix 4. The net withdrawal from Lake Lanier is therefore expected to be 132 mgd (297 mgd minus 165 mgd).

24. The State of Georgia will allocate the treated wastewater returned to Lake Lanier and its tributaries to particular users of water supply storage in Lake Lanier. This should increase the yield of the storage account or accounts to which the wastewater return is credited rather than count the same as natural inflows, which increase the yield of a water supply storage account only according to the percentage of total conservation storage owned by that user.

25. I am aware of no legal or legitimate policy reason why the Corps should not credit metered return flows to Lake Lanier or its tributaries exclusively to individual water supply storage accounts to which the State of Georgia has allocated such returns.

26. In accordance with federal law, the Corps has long recognized that it is the State, not the Corps, that determines and allocates water rights, and that the Corps should defer to the State's allocation of water rights. Allocation of wastewater return flows to individual users also is a matter of water rights that is best determined by the State.

27. The return of highly-treated wastewater to an existing reservoir increases the yield of that reservoir by reducing the net withdrawals. As a result, return flows keep reservoir levels higher and mitigate the impact of water supply withdrawals. Return flows to a water supply reservoir are a form of water reuse that Georgia's statewide water plan favors.

28. EPD-permitted discharges from wastewater treatment plants are a function of water use and not rainfall and runoff, and therefore are more consistent and reliable than natural inflows. Because they are metered and reported to EPD, wastewater discharges also are easily monitored and accounted for, ensuring that a user would not obtain credit for any returns than do not actually occur.

29. It is more expensive for local wastewater utilities to discharge wastewater to Lake Lanier than to the Chattahoochee River or its tributaries, because they must treat the wastewater to a higher degree to meet applicable water quality standards. To make it worthwhile for these utilities to return wastewater to Lake Lanier, there must be policies in place that incentivize those returns. Therefore, EPD desires to credit to individual water users the exclusive right to withdraw or store the wastewater returns that are made. The Corps should do the same, or should defer to the State's allocation.

30. Thus, consistent with federal law and good policy, in determining the yield of the storage space that is held by or for a water supply user, the Corps should count exclusively to that user's storage space such returns as the State has allocated to that user.

Net Municipal and Industrial Water Consumption

31. A large portion of the metro Atlanta area's treated wastewater is returned to the Chattahoochee River downstream of Buford Dam and upstream of the United States Geological Survey ("USGS") gaging station at Whitesburg, Georgia. In 2011, an annual average of 34.4 mgd of treated wastewater was discharged to the Chattahoochee River between Buford Dam and the Peachtree Creek confluence, and an annual average of 184.2 mgd of treated wastewater was discharged to the Chattahoochee River between the Peachtree Creek confluence and the USGS Whitesburg gage. EPD projects that by 2040 (or as of the date when water withdrawals reach 705 mgd), the amount of treated wastewater discharged to the Chattahoochee River between Buford Dam and the Whitesburg gage will be 385 mgd on an annual basis, including 94 mgd discharged to the reach between Buford Dam and the Peachtree Creek confluence, and 291 mgd to the reach between the Peachtree Creek confluence and the USGS Whitesburg gage. When combined with return flow directly into Lake Lanier, the total return of wastewater associated with the withdrawal of 705 mgd is projected to be 550 mgd, or 78% of the total withdrawal.

32. Therefore, Georgia projects that as of 2040, the total consumptive use from municipal and industrial water supply from Lake Lanier and from the Chattahoochee River above the Whitesburg gage will be approximately 155 mgd, or 239 cfs, on an annual average basis. To put this amount into perspective, it is a mere 1.1% of the 21,587 cfs annual average daily flow of the Apalachicola River just downstream of the Georgia-Florida state line.

In-Stream Demands for Water Quality

33. Metropolitan Atlanta local governments that discharge treated wastewater to the Chattahoochee River also rely upon releases from Lake Lanier to provide consistent flows in the river to assimilate those discharges.

34. EPD has developed a mathematical model, known as the Chattahoochee River Model, to simulate temperature, dissolved oxygen, and the concentrations of individual pollutants (biochemical oxygen demand, organic nitrogen, ammonia, nitrate, organic phosphorus, and ortho phosphate) under different flow, intake, discharge, and meteorological conditions.

35. Based on conditions that existed at the time of Georgia's 2000 water supply request, EPD determined that certain seasonally-varying flows in the Chattahoochee River at the confluence with Peachtree Creek would be needed to meet water quality standards. Thanks to improvements in wastewater treatment since 2000, the Chattahoochee River Model now shows the flows needed to assimilate wastewater in the Chattahoochee River and maintain water quality standards may be reduced.

Why Assurance of Long-Term Supply is Needed Now

36. If Lake Lanier were not available to satisfy the needs included in Georgia's water supply request, additional reservoirs and water resource projects would be needed to replace it. Due to the complexity and uncertainty associated with the permitting processes, planning for the development of new water supply reservoirs must generally begin 15 to 25 years, or even more, before there is a demand for the water.

37. The three major stages of the planning processes are 1) alternatives analysis and source evaluation; 2) detailed engineering and environmental studies; and, 3) state and federal permitting. The first stage includes forecasting future service area population and water demands; evaluating demand management and supply alternatives for meeting the demands; evaluation of source water capacity, quality, and reliability; and development of environmental, historic/archeological, and socio-economic assessments of impacts. In the second stage, detailed engineering and environmental studies must be conducted on the preferred alternatives, and funding sources must be identified and secured. In the third stage, if a new or expanded water supply reservoir is the preferred alternative, the applicant must apply for and secure a Federal Clean Water Act Section 404 permit (issued by the Corps of Engineers), a Clean Water Act Section 401 Water Quality Certification (issued by the State of Georgia), a Safe Dams permit and a water withdrawal permit (both issued by the State of Georgia), and a Safe Drinking Water Act Permit (also issued by the State of Georgia). Before the Corps of Engineers can issue a Section 404 permit, it must comply with provisions of the National Environmental Policy Act (i.e., prepare an Environmental Assessment and possibly an Environmental Impact Statement) and federal regulations. Of all the stages, the Section 404 permitting process generally requires the greatest amount of time and often is followed by legal challenges to the issued permit. As shown in Appendix 6, the process of studying, designing, permitting, financing, and constructing water supply reservoirs in Georgia has required a range of 5 to 25 years to complete, based upon six cases selected for illustration.

38. Georgia desires assurance of storage for direct lake withdrawals through storage contracts. As for water supply releases, the Corps coordinates those with the Atlanta Regional Commission on a weekly basis. According to the 2011 ruling of the United States Court of Appeals for the Eleventh Circuit, the Corps is authorized to provide these releases without reallocating storage to those water supply users downstream. Nevertheless, to assure long-term certainty for all concerned, it is important that the Corps, Georgia, and local governments that Georgia may designate enter into a written agreement documenting their understandings regarding how and when releases for water supply will be coordinated.

Why Lake Lanier Continues to be the Best Alternative

39. As discussed in the Reheis Affidavit, numerous studies dating back to the 1960s have consistently concluded that Lake Lanier and the Chattahoochee River provide the most economical and environmentally-protective alternative for meeting the water supply needs of the region. *See* Reheis Affidavit at ¶¶ 21-28. As the Reheis Affidavit explains, a number of alternatives were investigated up through 1999, and none of them was determined to be a reasonable alternative. *See id.*

40. As part of the planning process for its 2003 plans and 2009 update, the Metro Water District considered potential water supply source alternatives for the communities in the study area through the planning period. The District's *Water Supply and Water Conservation Management Plan* determined that "after reviewing alternatives to the use of the federal reservoirs, the Metro Water District has concluded that there are no alternatives to the Chattahoochee River and the Etowah River as major water supply sources for north Georgia."

41. A water study task force, comprised of metro Atlanta area government and business leaders and assisted by Boston Consulting Group and technical experts, reached the same conclusion in 2009. The Governor of Georgia convened the task force, known as the Water Contingency Planning Task Force, in response to a decision of the United States District Court that threatened to eliminate virtually all water supply withdrawals and releases from Lake Lanier. The task force studied the costs associated with developing alternative sources of water resources to replace Lake Lanier if the Lake were to cease operating for water supply. The task force concluded that "Lake Lanier is by far the best water supply source for the metro region. If the recommended contingency options were required instead, these options would impose significant incremental costs and environmental impacts the region does not currently face." *See Water Contingency Planning Task Force Findings and Recommendations, 21 December 2009.*

IMPACT OF GEORGIA'S MUNICIPAL AND INDUSTRIAL WATER WITHDRAWAL ON LAKE LANIER AND WATERS DOWNSTREAM

42. EPD has performed computer modeling of the reservoir operations and water withdrawals contemplated in Georgia's water supply request to determine the effects of those operations and withdrawals on Lake Lanier and the Chattahoochee River. EPD's modeling is summarized below and discussed in greater depth in Exhibit A, the Memorandum of Dr. Wei Zeng, manager of EPD's Hydrological Analysis Unit. Although Dr. Zeng, for the purpose of his analysis, assumed that the Corps will continue to operate in accordance with the current version

of the Revised Interim Operation Plan ("RIOP"), the State of Georgia continues to believe that the ACF system can be operated more efficiently for the benefit of all Basin stakeholders and is proposing alternative to the RIOP in our comments on the ACF Water Control Manual EIS Scoping Comments.

Hydropower Production at Lake Lanier and within the ACF System

43. The projected water withdrawals and Corps operations necessary to support them will not have a material impact on the production of hydropower at Buford Dam or the federal reservoirs in the ACF Basin as a whole, and any impact will be gradual over the next several decades. EPD's modeling indicates that, if viewed in terms of hydropower generation for the federal reservoirs in the ACF Basin as a whole, when Georgia has reached demands of 705 mgd and year 2040 water supply needs are met throughout the rest of Georgia, average annual power generation will be 970,900 MWh, as compared with the 988,055 MWh of (simulated) annual average generation with 2011 water supply levels. Thus, EPD projects a mere 1.7% decrease in hydropower generation basin-wide. *See* Zeng Memorandum at Exhibit A.

44. When Georgia has reached demands of 705 mgd from Lanier and the Chattahoochee River above the Peachtree Creek confluence, and 2040 water supply demands exist throughout the remainder of the basin, the annual average energy generated at Lake Lanier is modeled to be 116,435 MWh, in comparison to the amount of 123,735 MWh under 2011 water use conditions. Thus, the amount of hydropower produced at Lake Lanier with 2040 demands will be only 6% less than the amount being produced with current water supply demands. The effect will be even less in the years before Georgia's water demand has reached 705 mgd. *See* Zeng Memorandum at Exhibit A.

45. Georgia's conclusions are consistent with those reached by the Corps in its assessment of the impact to hydropower from granting Georgia's water supply request as compared with a baseline that assumed virtually no water supply operations at all. Using that baseline of comparison, the Corps concluded that the water supply operations and lake withdrawals would result in less than a 1% reduction to ACF Basin dependable hydropower capacity, and that the lake withdrawals and water supply releases contemplated by Georgia's water supply request would result in reductions in basinwide hydropower value of 4.4% and less than 1%, respectively. *See* Zeng Memorandum at Exhibit A.

Recreation at Federal Reservoirs

46. The Corps has established three thresholds for assessing impact of reservoir elevation to recreation at Lake Lanier. The first threshold is called Initial Recreation Impact Level ("IIL"), which is the level at which falling reservoir elevation first has some adverse effect on recreation. The Corps has determined that the IIL at Lake Lanier is 1066 feet above mean sea level (msl). The second threshold, the Recreation Impact Level ("RIL"), is the level at which significant impacts to concessions and recreation occurs. The RIL at Lake Lanier is 1063 feet above msl. The third threshold is Water Access Limitation Level ("WAL"), which is the elevation at which more serious impacts to recreation are observed. The WAL at Lake Lanier is 1060 feet above msl.

47. As discussed at greater length in the attached Memorandum of Wei Zeng, under 2007 hydrologic conditions, with existing water supply demands, Lake Lanier is below RIL for 27 days during the primary recreational season in that year (May 1-September 8). EPD's modeling shows that this level of recreation impact will be increased by only 21 days under 2007 hydrologic conditions if Lanier is operated to meet the metro area's 2040 water needs of 705 mgd and Georgia's 2040 water supply needs in the remainder of the basin exist. EPD's modeling also shows that if Lanier is operated to meet Georgia's water supply request, metro area water supply needs from Lake Lanier reach 705 mgd, and 2040 water demands exist elsewhere in the basin, during the recreational season, the elevation of Lake Lanier would be below the ILL for only 5% more of the time, below the RIL for only 8% more of the time, and below the WAL 8% more of the time, than under the baseline condition. *See* Zeng Memorandum at Exhibit A.

48. At West Point Lake, the Corps has designated a ILL of 632 feet above msl, a RAL of 628 feet above msl, and a WAL of 627 feet above msl. If Lake Lanier is operated to meet water supply needs of 705 mgd, the number of days when West Point Lake falls below the RIL and ILL actually will be lessened, and there will be only a 1% increase in the number of days in which the elevation falls below the WAL.

49. For Lake Walter F. George, the ILL is 187 feet above msl, the RAL is 185 feet above msl, and the WAL is 184 feet above msl. With 2040 water supply demands imposed on the system, Lake Walter F. George will not experience elevations below RIL or WAL, and will see an increase of only 1% to 2% in the number of days below the ILL. *See* Zeng Memorandum at Exhibit A.

Navigation

50. As the ACF Basin reservoirs, for reasons unrelated to Georgia's water supply usage, are no longer used to support commercial navigation except under rare circumstances, Georgia's water supply request will not impact navigation.

Lake Lanier's Flood Control Function

51. The current request to reallocate the conservation storage to meet Georgia's projected future water supply needs does not involve changing the elevation of the top of conservation pool or the size of the flood control pool. Thus, reallocating part of the conservation storage to accommodate Georgia's increase water will have no impact on the flood control capability of Lake Lanier or the ACF system. Although changes to the size of the flood control pool are not necessary for the Corps to grant Georgia's request, Georgia may still recommend raising the conservation pool, at the appropriate time, if and when it determines that the benefits of doing so exceed any costs.

Impacts on Georgia/Florida State Line Flows

52. EPD's modeling indicates that the net water consumption associated with the municipal and industrial withdrawals contemplated in Georgia's water supply request is projected to have a

minor impact on the flow in the Apalachicola River at the state line. *See* Zeng Memorandum at Exhibit A.

CONCLUSION

53. The foregoing information affirms and updates Georgia's 2000 request that the Corps operate Lake Lanier to meet water supply needs of 705 mgd annual average gross withdrawal, including 297 mgd annual average gross withdrawal from Lake Lanier and 408 mgd annual average gross withdrawal from the Chattahoochee River between Buford Dam and the confluence of the Chattahoochee River and Peachtree Creek. Accordingly, the Governor of Georgia has asked that the Corps grant Georgia's request by taking the following actions:

(a) Accommodate water supply demands by providing for 297 mgd annual average gross withdrawal from Lake Lanier and by making releases to allow 408 mgd annual average gross withdrawal from the Chattahoochee River between Buford Dam and the confluence with Peachtree Creek.

(b) Provide certainty for those municipal and industrial water withdrawals from Lake Lanier that require an allocation of storage by entering into long-term contracts. No storage should be required for withdrawals covered by existing relocation contracts or withdrawals of water released to Lake Lanier from Glades Reservoir upstream. Returns to Lake Lanier or its tributaries of treated wastewater should be credited exclusively to the storage accounts of those whom Georgia EPD designates to receive such credit.

(c) Provide certainty for those municipal and industrial water withdrawals from the Chattahoochee River that rely upon special releases from Lake Lanier by entering into agreements that document the parties' understandings about assurance and coordination of releases.

(d) Release from Lake Lanier enough water to provide a flow in the Chattahoochee River at the confluence with Peachtree Creek as EPD may request to maintain applicable water quality standards.

FURTHER AFFIANT SAITH NOT.

This 10th day of January, 2013.

Judson H. Turner

Sworn to and subscribed before me this 10th day of January, 2013

YOLANDA P. FANNING NOTARY EXPIRES GEORGIA SEPT. 29, 2013 PUBLIC HENRY COUNTY

Yolanda P. Fanning
Notary Public
My commission expires: Sept. 29, 2013

GA02451943

APPENDIX 1

Historical and Forecasted Population of Counties Using Lake Lanier System for Water Supply

County	1990[1]	2000[1]	2010[1]	2020[2]	2030[2]	2040[3]
Cobb	447,745	607,751	688,078	800,469	909,747	1,033,943
Dawson[4]	9,429	15,999	22,330	27,029	32,022	37,937
DeKalb	545,837	665,865	691,893	761,537	817,276	877,096
Forsyth	44,083	98,407	175,511	256,307	383,258	573,089
Fulton	648,951	816,006	920,581	1,095,897	1,284,954	1,506,626
Gwinnett	352,910	588,448	805,321	1,019,098	1,270,020	1,582,724
Habersham[4]	27,621	35,902	44,553	48,705	54,623	61,260
Hall	95,428	139,277	179,684	226,172	282,164	352,018
Lumpkin[4]	14,573	21,016	29,966	38,075	47,960	60,411
White[4]	13,006	19,944	26,704	31,057	34,841	39,086
Totals[5]	2,199,583	3,008,615	3,584,621	4,273,267	5,116,865	6,127,000

[1]From US Census Bureau

[2]Georgia Office of Planning and Budget 2012 Projections

[3]Projection based upon assumption that 2030 – 2040 growth rate (in per cent) will be same as 2020 – 2030.

[4]Watershed counties not currently withdrawing from Lanier, but may withdraw in future.

[5]This total does not include the additional counties that purchase water from the water systems that withdraw water from Lake Lanier and the Chattahoochee River, such as Paulding County.

APPENDIX 2

Water Systems That Withdraw Directly from Lake Lanier

County	System Name	2011 Withdrawals (MGD)		
		Max. Month	Max. Day	Annual Average
Forsyth	City of Cumming	17.5	18.8	11.6
Forsyth	Forsyth County	11.8	12.8	8.6
Gwinnett	City of Buford	1.5	1.7	1.3
Gwinnett	Gwinnett County Water & Sewerage Authority	90.9	118.8	76.1
Hall	City of Gainesville	20.7	28.5	17.6
Total				115.2

APPENDIX 3

Water Systems That Rely on Water Supply Releases from Lake Lanier to the Chattahoochee River

County	System Name	2011 Withdrawals (MGD)		
		Max. Month	Max. Day	Average Annual
Cobb	Cobb County Marietta Water Authority	51.9	64.8	45.1
DeKalb	DeKalb County Public Works (Water and Sewer)	84.7	114.8	72.7
Fulton	Atlanta – Fulton Water Resources Commission	54.3	69.9	38.7
Fulton	City of Atlanta	101.8	123.4	89.2
Total				245.7

APPENDIX 4

Projected 2040 Water Withdrawals and Returns

(Annual Average)

Table 1 Current and Projected 2040 Water Withdrawals and Returns Above Buford Dam

Time Horizon	Withdrawal (mgd)	Return (mgd)	Net Consumptive Loss (mgd)
2011	120.6[1]	38.1	82.4
2040	297	165	132

Table 2 Current and Projected 2040 Chattahoochee River Water Withdrawals and Returns

Time Horizon	Withdrawal (mgd) (Buford Dam to Peachtree Creek)	Return (mgd)			Net Consumptive Loss (mgd)
		Atlanta Reach (Buford Dam to Peachtree Creek)	Whitesburg Reach (Peachtree Creek to Whitesburg gage)	Total	
2011	247.5[2]	34.5	185.3	219.8	27.7
2040	408	94	291	385	23

Notes:

[1] Including facilities upstream of Lake Lanier. These additional withdrawals are included to provide the sum of all consumptive loss above Buford Dam.

[2] Including facilities that withdrew from tributaries of the Chattahoochee River. These additional withdrawals are included to provide the sum of all consumptive loss below Buford Dam and above the Whitesburg gage.

APPENDIX 5

TIME REQUIRED TO PLAN, PERMIT, FINANCE, AND CONSTRUCT WATER SUPPLY RESERVOIRS IN GEORGIA [Note: Try to fit all on one page]

Project / Activity	Bear Creek Reservoir, Jackson Co.	Cedar Creek Reservoir, Hall Co.	Tussahaw Creek Reservoir, Butts Co.	Big Haynes Creek Reservoir, Rockdale Co.	Line Creek Reservoir (Lake McIntosh), Fayette Co.	Hickory Log Creek Reservoir, Cherokee Co.
Applicant's initial contact with EPD regarding a new reservoir.	2/2/1994	7/17/1996	9/22/2000	11/5/1987	10/27/1987	3/22/2000
Applicant initial contact with the Corps regarding 404 permit for reservoir.	2/2/1994	2/12/1997	9/22/2000	4/29/1991	1/6/1989	3/22/2000
Applicant submits water withdrawal permit application.	3/3/1997	4/2/2002	3/13/2001	6/21/1999	3/21/2001	10/4/2005
EPD comments on withdrawal application.	5/28/1997	4/22/2002	5/22/2001	12/7/1999	4/16/2001	11/22/2005
EPD provides confirmation of need (to the Corps).	4/20/1995	Information unavailable	11/3/2000	5/6/1991	11/20/2000	11/20/2000
Applicant submits 404 application to the Corps.	2/22/1995	8/26/1997	11/15/2000	5/28/1991	5/1/2002	4/27/2000
The Corps notifies public of the 404 application and requests comments.	5/26/1995	10/8/1997	12/27/2000	11/22/1991	10/3/2002	12/27/2000
The Corps responds to applicant's 404 application.	7/1/1995	11/13/1997	2/1/2001	12/28/1991	11/8/2002	2/28/2001
EPD **issues** 401 Water Quality Cert.	5/17/1996	8/21/1998	5/22/2001	8/31/1992	9/6/2006	8/2/2002
EPD issues withdrawal permit.	4/1/2002	8/1/2002	2/14/2003	3/22/2002	9/6/2006	9/12/2008
The Corps issues final 404 permit to applicant.	7/20/1996	11/16/1998	10/23/2002	10/2/1992	6/27/2007	5/24/2004
EPD issues Safe Dams permit.	10/1999	10/2001	8/25/2003	5/31/1994	12/9/2009	4/29/2008

Jurisdiction constructs dam.	04/2001	9/11/2003	June 2005	1/27/1997	April 2010	8/5/2005
Jurisdiction fills reservoir.	Spring 2002	8/11/2005	Sept. 2005	June 1998	Started November 1, 2012	6/30/2011

EXHIBIT A

Memorandum of Dr. Wei Zeng

Manager, Hydrologic Analysis Unit

Georgia Department of Natural Resources
Environmental Protection Division
Watershed Protection Branch
4220 International Pkwy., Suite 101, Atlanta, Georgia 30354
Linda MacGregor, P.E., Branch Chief
(404) 675-6232

Memorandum

To: Judson Turner, Director, Georgia EPD
From: Wei Zeng, Hydrology Unit, Georgia EPD
Date: January 10, 2013
Subject: Technical Analysis of Georgia's 2000 Water Supply Request

Introduction

You asked me to analyze the impact to the federal reservoirs in the Apalachicola-Chattahoochee-Flint (ACF) River Basin, to hydropower production and recreation at those reservoirs, and to river flows at the state line with Florida, of Georgia's 2000 Water Supply Request. Georgia submitted the water supply request to the U.S. Army Corps of Engineers in May 2000, asking for the Corps to operate Lake Lanier to accommodate future municipal and industrial direct withdrawals from Lake Lanier and river withdrawals downstream totaling 705 million gallons per day (mgd). As more than twelve years have passed since Georgia submitted its water supply request to the Corps, Georgia is providing the Corps updated demographic and water demand information in support of its request. Georgia forecasts that its municipal and industrial water supply demands from Lake Lanier will reach or exceed 705 mgd by approximately 2040.

The Hydrology Unit of EPD set up a mathematical model of the ACF Basin to analyze the potential impacts of Georgia's request. This memorandum documents the model settings and results.

Platform Model – HEC-ResSim

The mathematical model that we used for this analysis was developed by the U.S. Army Corps of Engineers Hydrologic Engineering Center (HEC) for analyzing reservoir operations and basin-wide water resource management. The Corps calls this platform model "HEC-ResSim." The Corps periodically upgrades HEC-ResSim's capability. The Corps released its current version of the model to the public in May 2011. This version of the model reflected the Corps' then-current ACF Basin reservoir operating plan, known as the Revised Interim Operation Plan (RIOP), as it existed as of May 2011.

Since May 2011, the Corps has made minor changes to the RIOP. The Hydrology Unit of EPD has added these changes to the Corps' May 2011 platform model. Thus, EPD's version of the HEC-ResSim model reflects operations under the current RIOP.

We modeled a 34-year period, assuming rainfall and inflow conditions that occurred from January 1, 1975 to December 31, 2008, and applied to each of these years the Corps' RIOP and, as discussed below, varying levels of water supply use. We chose the 1975-2008 period for several reasons. First, the Unimpaired Flow (UIF) data developed by the Corps only covers hydrologic conditions through December 31, 2008. In addition, this period excludes the period before all ACF federal reservoirs have been in operation. Finally, the U.S. Fish and Wildlife Service has used the same simulation period for its analyses of various ACF operations. It should be noted that the droughts that most affected the federal reservoirs in the ACF Basin occurred within in this period, with the possible exception of the current drought, the duration and severity of which cannot yet be determined.

Model Setting on Water Demand

To understand the impacts of Georgia's water supply request, we compiled current and proposed future water use conditions and ran three different scenarios: what we call Baseline Condition, Scenario A, and Scenario B. The Baseline Condition assumes current water use, as further defined below. Scenario A isolates the effect of the withdrawals associated with Georgia's water supply request by applying to the model annual average gross withdrawals of 705 mgd from Lake Lanier and the Chattahoochee River through Atlanta but keeps current demands throughout the remainder of the ACF Basin. Scenario B evaluates the effects of the water use contemplated in Georgia's water supply request in combination with forecasted demands throughout the basin by assuming annual average gross withdrawals of 705 mgd from Lake Lanier and the Chattahoochee River through Atlanta and year 2040 water use throughout the remainder of the ACF Basin in Georgia, plus increasing water use in ACF Basin in Alabama, as discussed further below.

Baseline Condition

To capture the effect of current water use within the ACF Basin, we included in the model the most recent available annual (2011) withdrawal and discharge data of all permitted municipal and industrial facilities in the Georgia portion of the ACF Basin. These include thermal electric power generating facilities that use water for cooling purposes and that incur consumptive water losses as a result of their cooling operations. We included the estimate of 2007 total ACF Basin agricultural water use that Georgia developed as part of its statewide water planning, which is the best information that we have on Georgia's current agricultural use.

We included Alabama's 2007 water consumption from the ACF Basin as estimated by the Alabama Office of Water Resources (OWR) in 2009. For water consumption in Florida, we used the numbers contained in the Corps' platform model.

In the Baseline Condition, and in Scenarios A and B, we assumed the current RIOP would remain in effect.

Scenario A – Impact of Water Supply Request

As Georgia's water supply request remains 297 mgd annual average gross lake withdrawal and 408 mgd annual average gross river withdrawal, for a total of 705 mgd, those are the amounts of withdrawal that we used in the impact analysis. We added back projected returns of treated wastewater to Lake Lanier and the Chattahoochee River. Using EPD projections, we assumed that 78% of the 705 mgd that is withdrawn will be discharged back to surface waters within the basin in the form of highly treated wastewater. This includes 165 mgd returned to Lanier and its upstream tributaries, 94 mgd returned to the Chattahoochee River between Buford Dam and Peachtree Creek, and 291 mgd returned to the Chattahoochee River downstream of Peachtree Creek.

As Scenario A is intended to isolate the impact of meeting the forecasted water supply needs that would be dependent on withdrawals and water supply releases from Lake Lanier, we held water use elsewhere in the basin at current levels (that is, levels according to most recent data available).

Scenario B – Impact of Water Supply Request in Combination with Other 2040 Georgia Demands in ACF Basin

In Scenario B, we added to the water supply uses contemplated by Georgia's water supply request the other projected 2040 water demands within the ACF Basin in Georgia. These include projected municipal, industrial, and agricultural water needs. EPD developed the forecasts for those demands as part of the planning associated with the State Water Plan and Regional Water Development Plans. We do not have projected water demands for portions of the basin that are in Alabama. To estimate the cumulative impact resulting from future Alabama demand, we assumed an increase of 15% to the current Alabama figure used in the baseline condition alternative. We held the level of water use in the Apalachicola River reach the same as in the Baseline Condition because we have no information upon which to base an estimate of future water use in the State of Florida.
I have enclosed a DVD containing these models.

Results and Analysis
In my discussion of the modeling results, Scenarios A and B are compared to the Baseline Condition. The potential impact of Georgia's Request is described with regard to:

(1) Average elevations in the federal reservoirs of Lanier, West Point, and Walter F. George;
(2) Minimum elevations in these reservoirs;
(3) Elevation duration curves in these reservoirs;
(4) Daily average power generation in the federal reservoirs;
(5) Percentage of time when there is some level of recreational impact; and
(6) State line flow duration curve.

Reservoir Elevations

Using the Res-Sim Model, we determined the average and minimum daily elevations, and the elevation duration curves, of the federal reservoirs in the ACF Basin under the Baseline Condition and Scenarios A and B. The average and minimum daily elevations of a reservoir are obtained by looking at the daily elevation of the period of simulation, from January 1, 1975 to December 31, 2008, and calculating the average and minimum daily value for each of the 365 days in a year. The elevation duration curve shows the percentages of time over the entire 34-year period that the reservoirs will exceed certain elevations.

As shown in Slides 9 and 25 of the attached Exhibit 1, the average daily elevation of Lake Lanier under both Scenarios A and B will be no more than 0.7 feet lower around May 1 as compared with the Baseline Condition. May 1 is the date on which the top of conservation pool guide curve for Lake Lanier rises to 1071 feet for the first time in the year and is the beginning of the primary recreational season. Similarly, the average daily elevation of Lake Lanier around December 1 under Scenarios A and B is no more than 1.5 feet lower than under the Baseline Condition.

The difference between the Baseline Condition and Scenarios A and B is more pronounced in terms of the daily minimum elevation in Lake Lanier. (See Slides 10 and 26.) At the lowest point on the minimum daily elevation curve, which usually takes place in the month of December, the elevation under Scenarios A and B is approximately 6 feet lower than in the Baseline Condition.

The elevation duration curves for Lake Lanier are shown on Slides 11 and 27. For the upper 30% of the duration curve (representing the times of higher reservoir elevation), the elevation of Lake Lanier is essentially the same in the Baseline Condition and Scenarios A and B. Moreover, for approximately 70% of the duration curve, the elevation under Scenarios A and B is only approximately one foot or less lower than in the Baseline Condition. The difference is greater, up to 6 feet, at the lowest point in the lower 30% of the duration curve.

The impact on Lakes West Point and Walter F. George is minor. (See Slides 12 through 17 and Slides 28 through 33.) There is very little, only inches, difference in average daily elevation at both West Point and Walter F. George between the Baseline Condition and Scenarios A and B. In terms of minimum daily elevation, the greatest difference between the Baseline Condition and Scenarios A and B is only 1.5 feet in West Point (in the months of September and October), and up to 1.2 feet at Walter F. George (in September and October). At the point in the year when West Point and Walter F. George typically reach their lowest elevation for the year (usually in November or December), there is little difference between the Baseline Condition and Scenarios A and B. Even less of a change is evident in the elevation duration curves for Lakes West Point and Walter F. George. (See Slides 14, 17, 30, and 33).

Power Generation

The projected water withdrawals and Corps operations necessary to support them will not have a material impact on the production of hydropower at Buford Dam. Under Scenario A, with water supply needs of 705 mgd for the Metro Atlanta Area and current demands elsewhere, the daily average energy generated at Lake Lanier is modeled to be 319 MWh, and the annual average energy generated at Lake Lanier is modeled to be 116,435 MWh. In comparison, the daily average energy generated under the Baseline Condition is modeled to be 339 MWh and the annual average is 123,735 MWh. When Georgia has reached demands of 705 mgd from Lake Lanier and the Chattahoochee River above the Peachtree Creek confluence, combined with 2040 water supply demands throughout the remainder of the basin, the annual average energy generated at Lake Lanier is modeled to be 116,435 MWh, in comparison to 123,735 MWh under the Baseline Condition. Thus, assuming 2040 water supply demands throughout the ACF Basin, there would be less than a 6% reduction in power produced at Lanier. The impact will be even less in the years before Georgia's water demand has reached 705 mgd.

As shown by Slides 18 and 34, Georgia's future water supply demands will have very little impact on the total amount of energy produced by all of the federal reservoirs in the ACF Basin. Under Scenario A, when Georgia has reached demands of 705 mgd, the daily average energy output from all ACF federal reservoirs is modeled to be 2,671 MWh (annual average 974,915 MWh). The daily average energy output under the Baseline Condition is 2,707 MWh, and the annual average is 988,055 MWh. Thus, there will be only a reduction in daily average generation of 36 MWh (annual average reduction of 13,140 MWh) for all reservoirs combined. Under Scenario B, the daily average energy output from all ACF federal reservoirs is modeled to be 2,660 MWh (annual average 970,900 MWh). The reduction in daily average generation will be only 47 MWh (annual average reduction of 17,155 MWh). For the combined generation of all of the federal reservoirs in the ACF Basin, there is only a 1.3% reduction under Scenario A and a 1.7% reduction under Scenario B.

Georgia's conclusions are consistent with those reached by the Corps in its assessment of the impact to hydropower from granting Georgia's water supply request as compared with a baseline that assumed virtually no water supply operations at all. Using that baseline of comparison, the Corps concluded that the water supply operations and lake withdrawals under Georgia's water supply request each would result in less than a 1% reduction to ACF Basin dependable hydropower capacity; that the lake withdrawals contemplated by the request would result in a reduction in basin-wide hydropower value of 4.4%; and, that the water supply releases contemplated by the request would result in a reduction in basin-wide hydropower value of less than 1%.

Recreational Impact

We evaluated the recreational impact by looking at the primary recreational season, defined by the Corps as May 1st through September 8th, and tallying the percentage of days when elevation of a reservoir is lower than the three levels of recreational impact, which are, in increasing degree of impact, the Initial Impact Line (IIL), Recreational Impact Line (RIL), and Water Access Limitation (WAL). According to the Corps, the IIL at Lake Lanier is 1066 feet above mean sea level (msl), the RIL is 1063 feet above msl, and the WAL is 1060 feet above msl. For West Point Lake, the ILL is 632 feet above msl, RAL is 628 feet above msl, and WAL is 627 feet above msl. For Lake Walter F. George, the ILL is 187 feet above msl, the RAL is 185 feet above msl, and the WAL is 184 feet above msl.

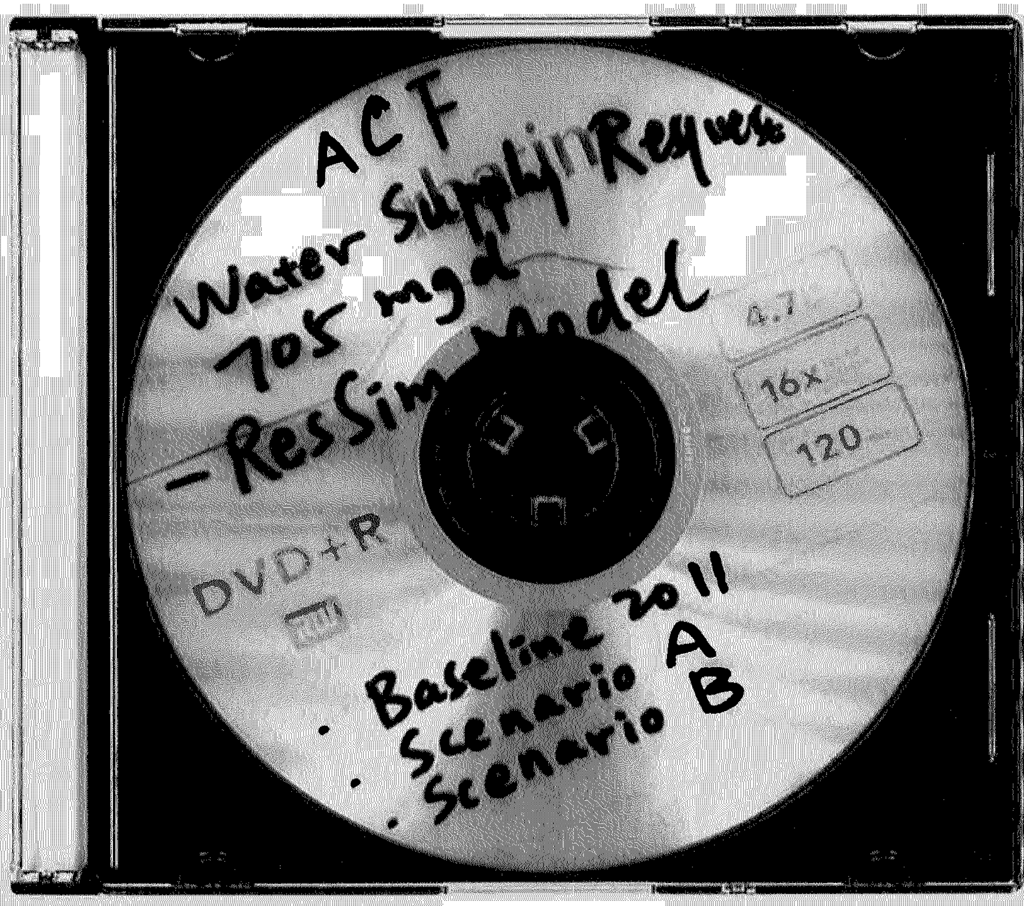
The impact to recreation is shown on Slides 19 through 21 and 35 through 37. In Scenarios A and B as compared with the Baseline Condition, the increase in percentage of days of IIL, RIL, and WAL at Lake Lanier will be 5%, 8%, and 8% respectively. Under hydrologic conditions of Year 2007, a drought year of exceptional dry conditions, the total number of days when the elevation of Lanier falls below the RIL under Scenario A is 47 days, under Scenario B is 48 days, and under the Baseline Condition is 27 days.

The recreational impact on West Point and Walter F. George is virtually non-existent. The only impact on West Point under Scenario A and Scenario B is a 1% increase in the frequency of WAL, while the recreational impact of IIL and RIL actually are lessened. At Walter F. George, there is a 1% and 2% increase in IIL in Scenario A and Scenario B, respectively. The elevation of Walter F. George does not fall to the RIL or WAL in any of the three scenarios.

State Line Flow

There is no noticeable difference between Scenario A and the Baseline Condition alternative in terms of state line flow duration curve, which suggests that the isolated increase in water supply in the metro Atlanta area itself will not result in any significant change in state line flow. (See Slides 22 and 23.) When we look at the portion of the graph between the 80 and 95 percentiles exceedence, the curve resulting from Scenario B is only around 200 cfs below the curve resulting from the Baseline Condition. (See Slides 38 and 39.) This 200 cfs is only 4% of the minimum flow requirement of 5,000 cfs, and less than 1% of the long term average simulated flow. At the very bottom of the duration curve, note that the RIOP's Drought Zone Operation will be triggered roughly 0.2% of the time under Scenario A and only 0.2% more often under Scenario B. Overall, the change in state line flow is minor in comparison to the magnitude of state line flow assuming the RIOP remains in place, and will likely remain so in any new operation plan that replaces the RIOP.

Enclosure


ACF
Water Supply Request
705 mgd
- ResSim Model
4.7
16x
120
DVD+R
. Baseline 2011
. Scenario A
. Scenario B

ACF Water Supply Request Evaluations

Georgia EPD

Hydrology Unit

January 2013

Model Scenarios

- Baseline
  - Recorded 2011 M&I and thermal water use
  - Estimated 2007 Agricultural water use
  - 2007 Alabama reach-wise (Columbus, WFG, and Jim Woodruff reaches) water use as provided in UIF data
  - May 2011 version ACF ResSim model
  - RIOP operation as revised and reflected in May 2012 Biological Opinion

Model Scenarios

- Scenario A
  - Projected 2040 Metro District (Atlanta area) water use as revised from 2009 Metro District Plan
  - Water use conditions held unchanged in the other reaches
  - May 2011 version ACF ResSim model
  - RIOP operation as revised and reflected in May 2012 Biological Opinion

Model Scenarios

- Scenario B
  - Projected 2040 Metro District (Atlanta area) water use as revised from 2009 Metro District Plan
  - Projected 2040 water use for the other reaches per State Water Plan
  - Alabama 2007 use water with a 15% increase
  - May 2011 version ResSim model
  - RIOP operation as revised and reflected in May 2012 Biological Opinion

Modeled 2040 Metro District Water Demand

- Withdrawal
  - 297 mgd in Lanier reach including 256 mgd from metro District entities and 41 mgd reserved for upstream entities
  - 408 mgd in the upper Chattahoochee River
- Return
  - 165 mgd to Lanier
  - 94 mgd to Chattahoochee River between Buford Dam and Peachtree Creek
  - 291 mgd to Chattahoochee River between Peachtree Creek and Whitesburg gage

Period of Simulation

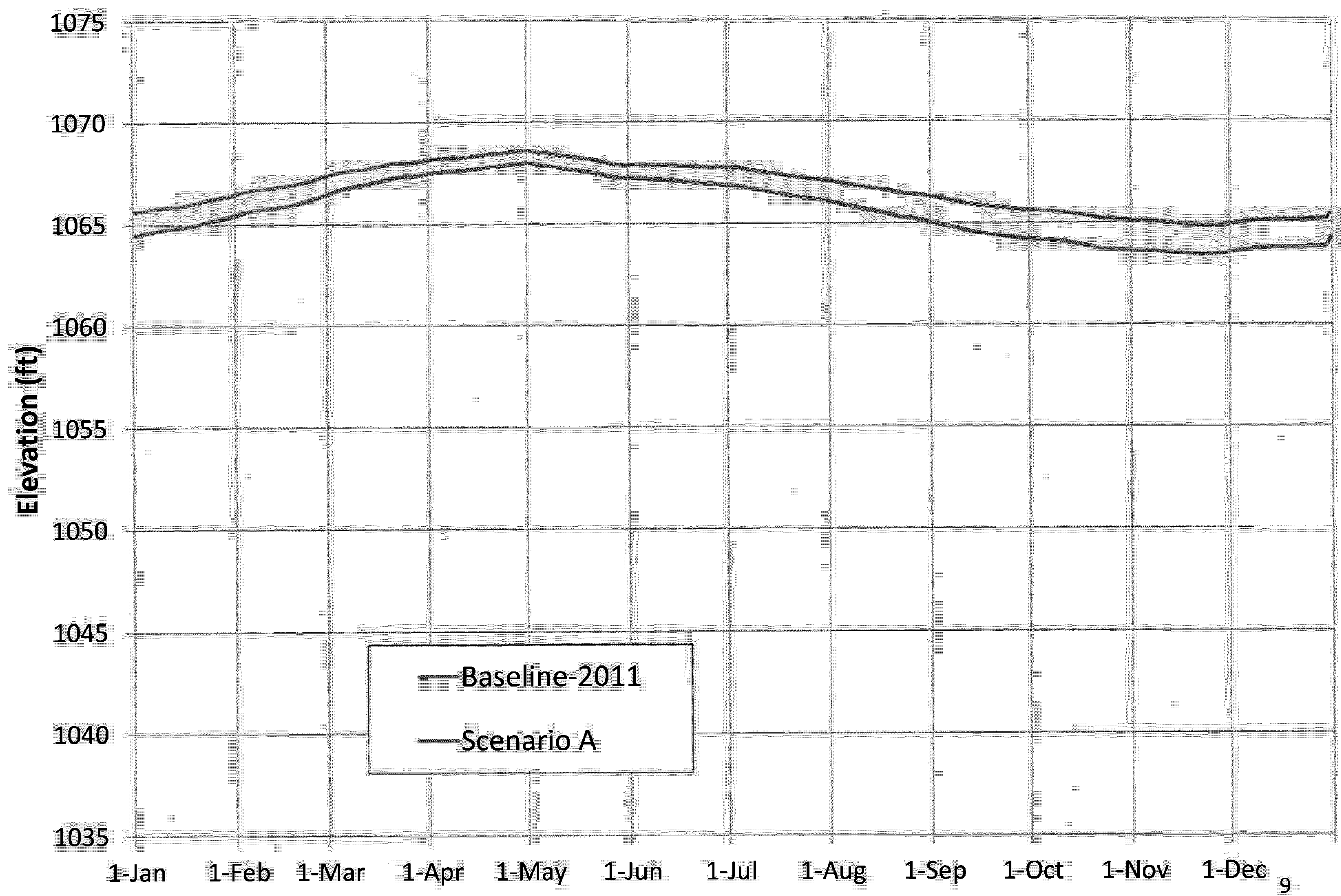
- January 1, 1975 through December 31, 2008
- Corresponding to period when all federal reservoirs are in place
- Period containing the most severe droughts in the past three decades
- Corresponding to the period used by USFWS for alternative evaluations

Modeling Results

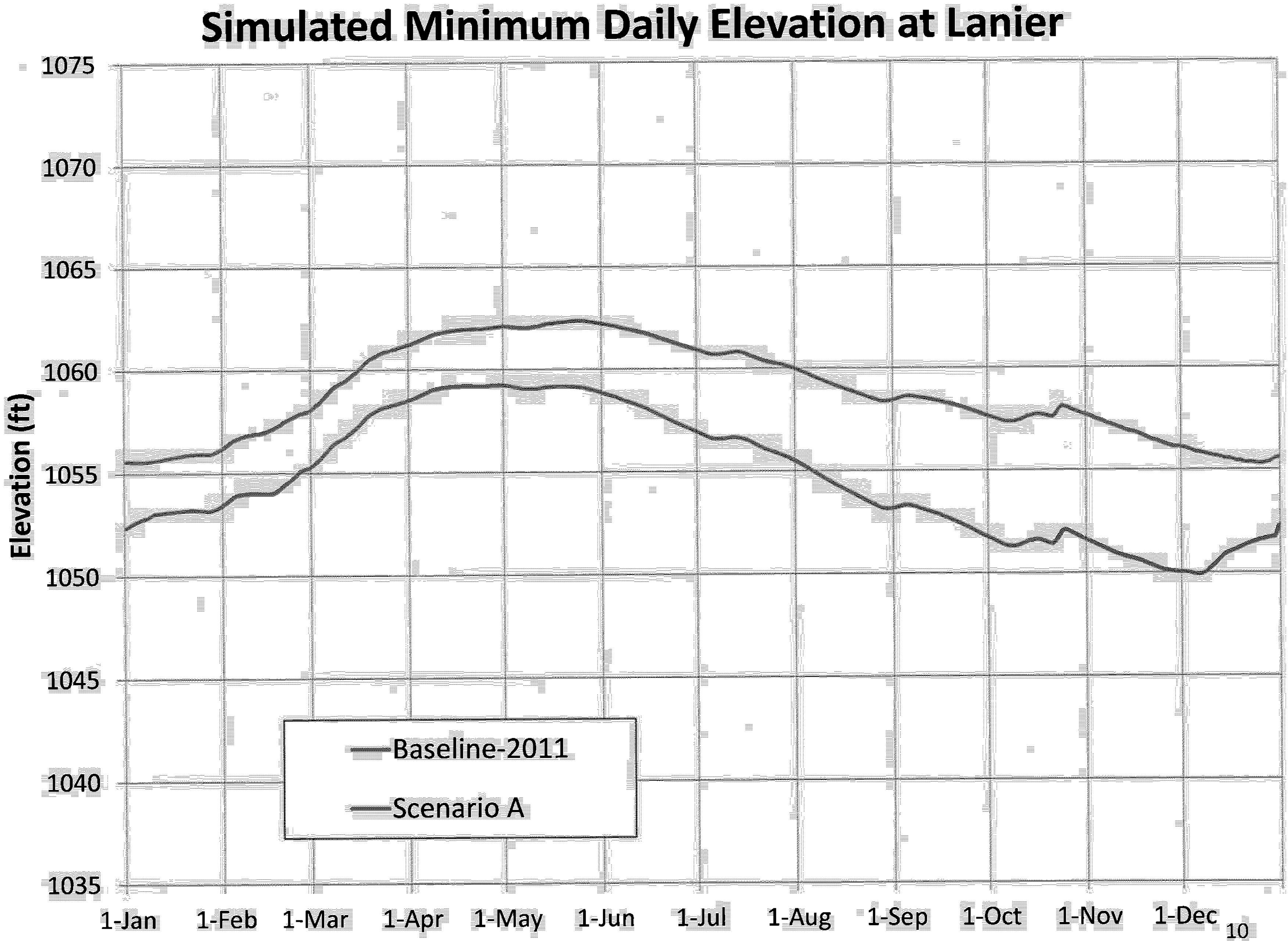
- Average lake elevations
- Minimum lake elevations
- Lake elevation exceedance
- Average power generation
- Recreation impacts
- State line flow

Scenario A vs. Baseline

Simulated Average Daily Elevation at Lanier

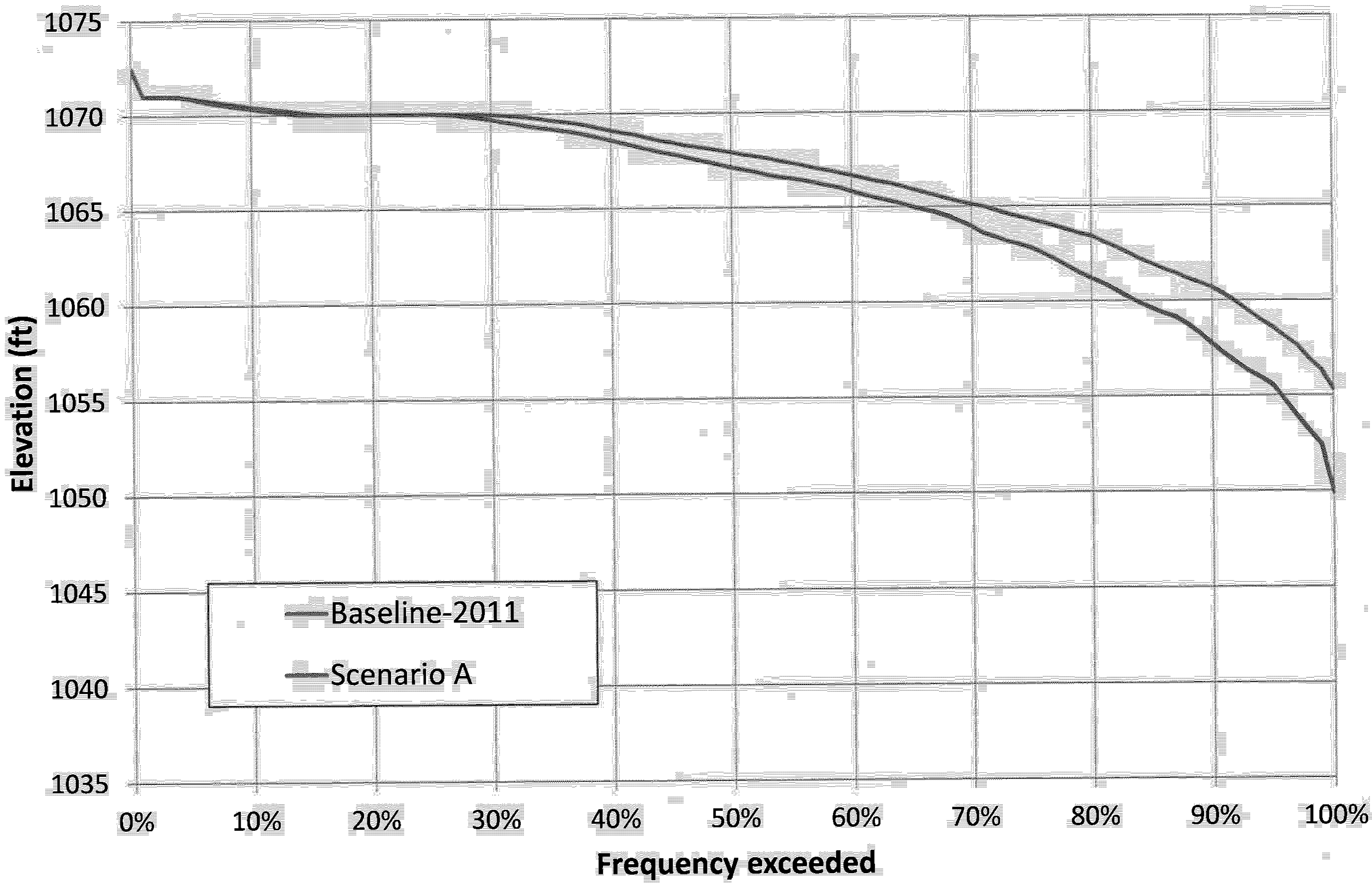


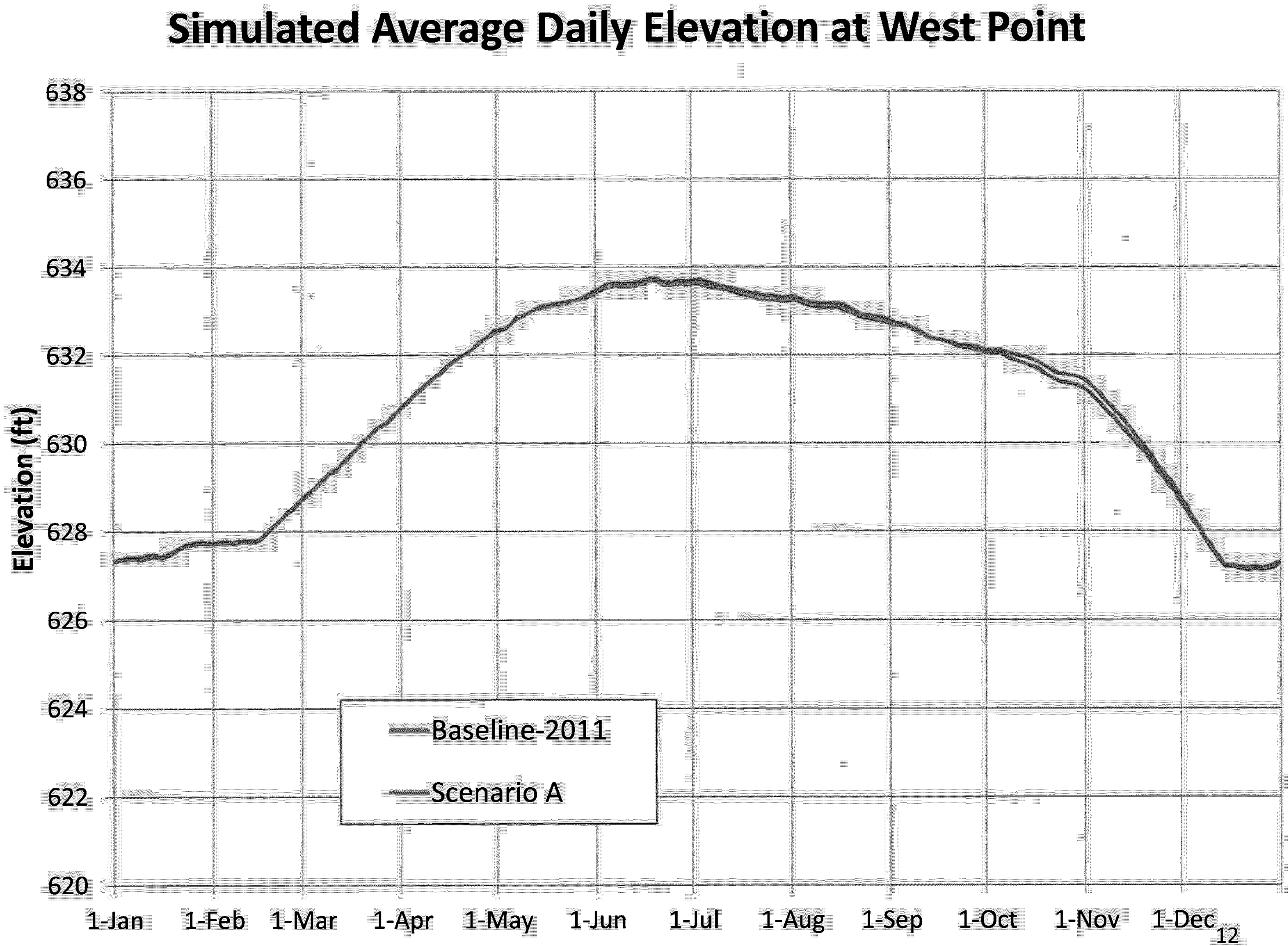
GA02451965

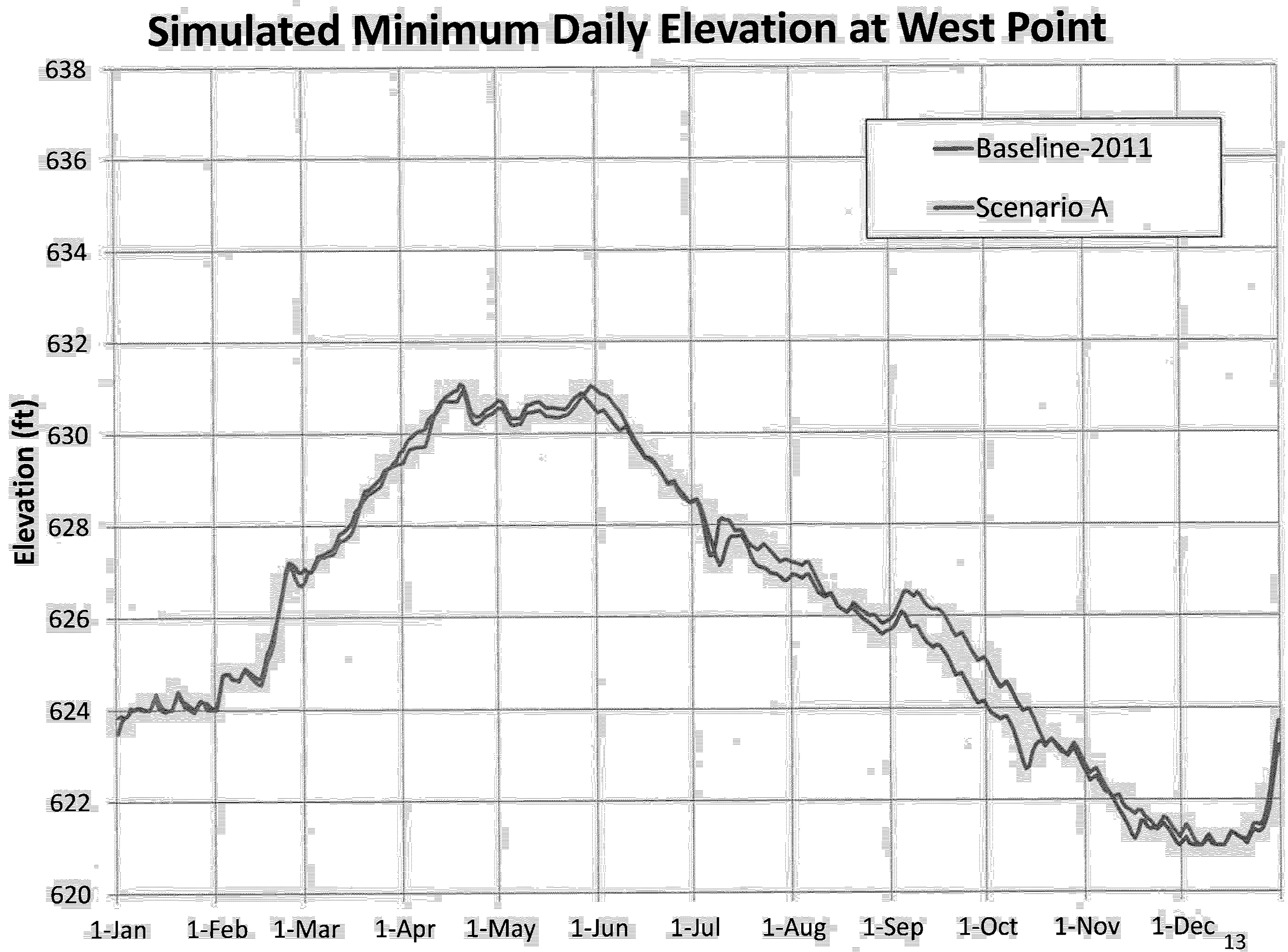

Simulated Minimum Daily Elevation at Lanier
Elevation (ft)
1075
1070
1065
1060
1055
1050
1045
1040
1035
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
Baseline-2011
Scenario A

GA02451966

Duration Curve of Lanier Elevation

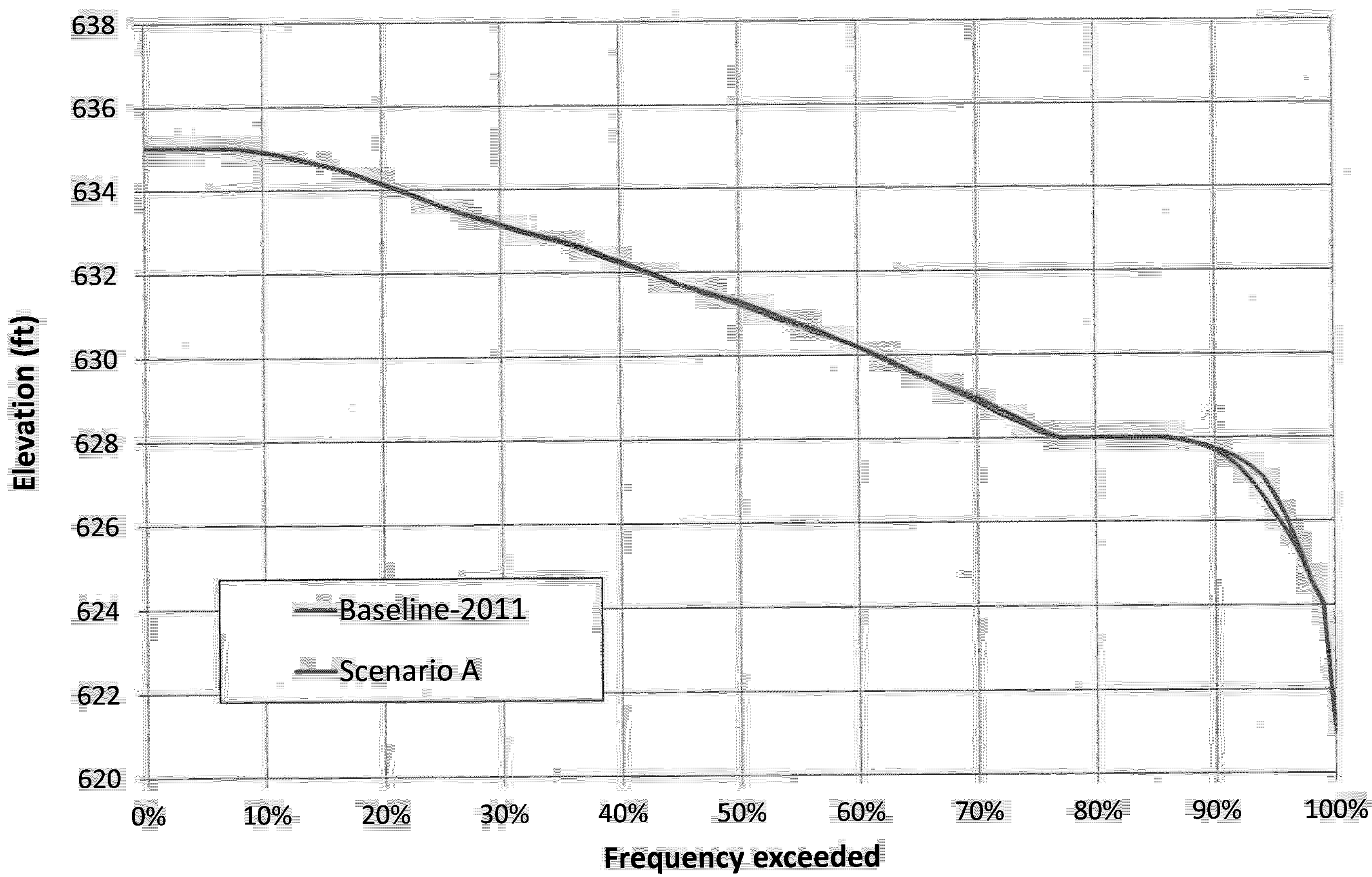



Simulated Average Daily Elevation at West Point
Elevation (ft)
638
636
634
632
630
628
626
624
622
620
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
12
Baseline-2011
Scenario A


Simulated Minimum Daily Elevation at West Point
Elevation (ft)
638
636
634
632
630
628
626
624
622
620
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
Baseline-2011
Scenario A

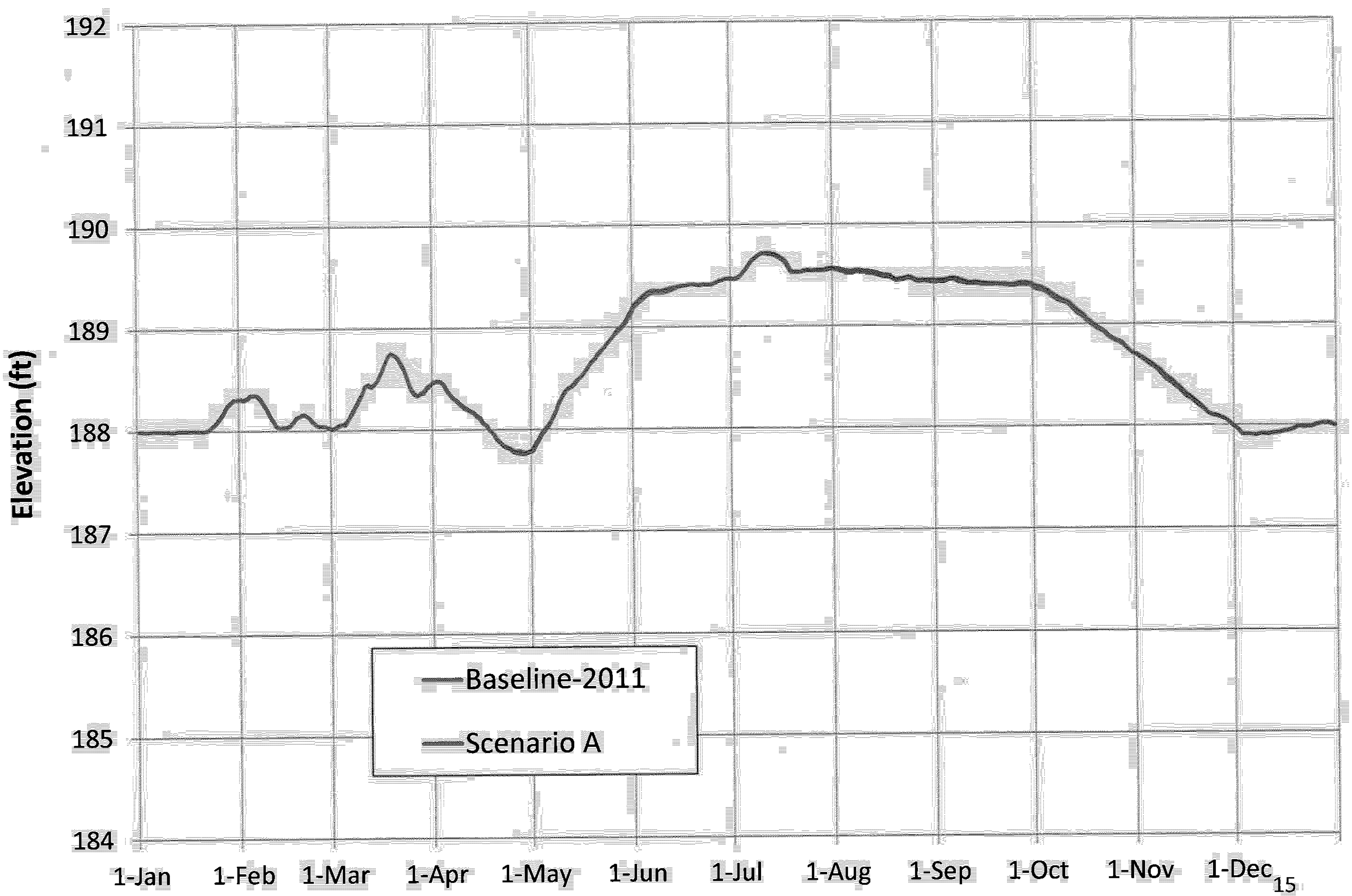
GA02451969

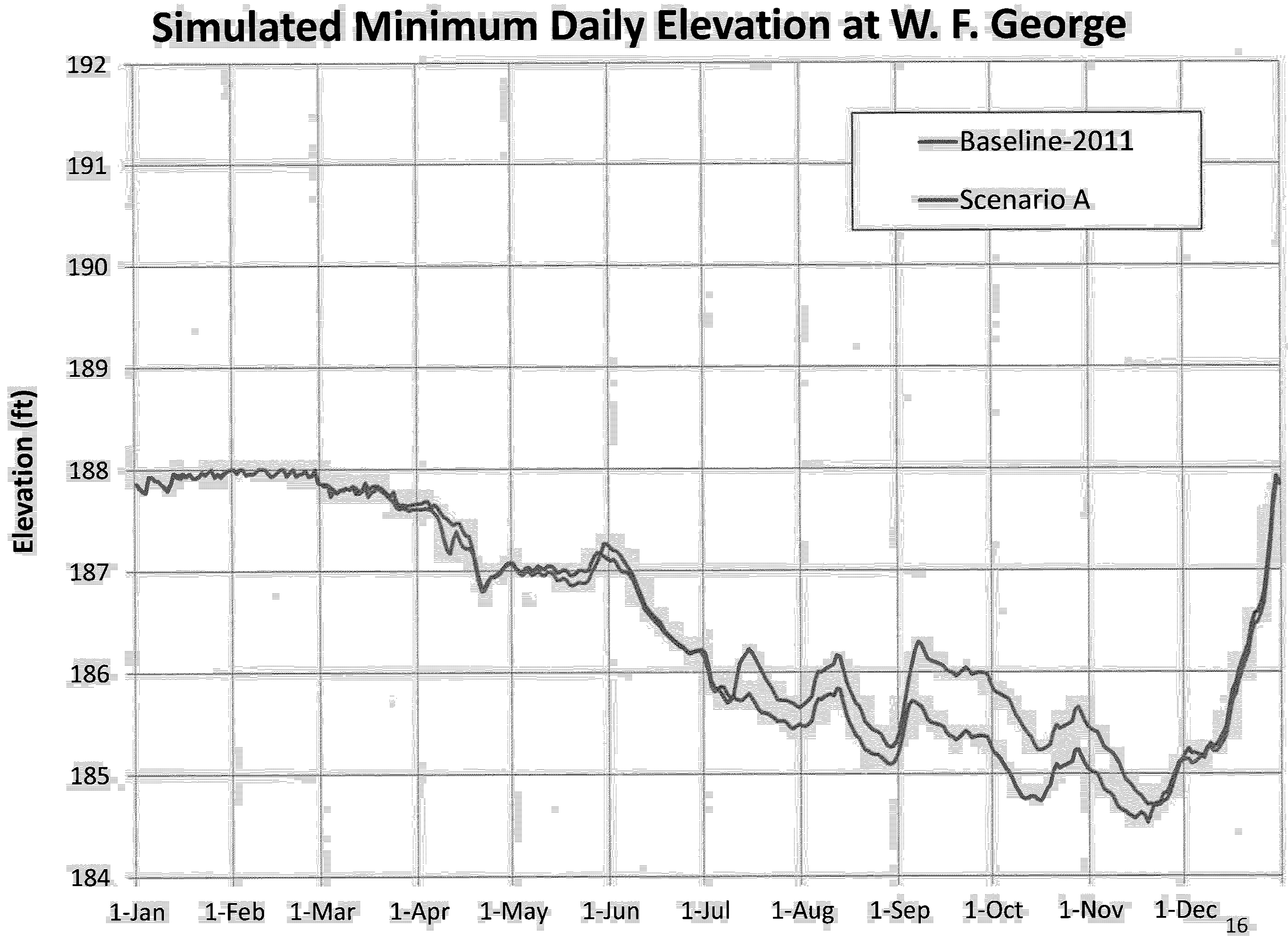
Duration Curve of West Point Elevation



GA02451970

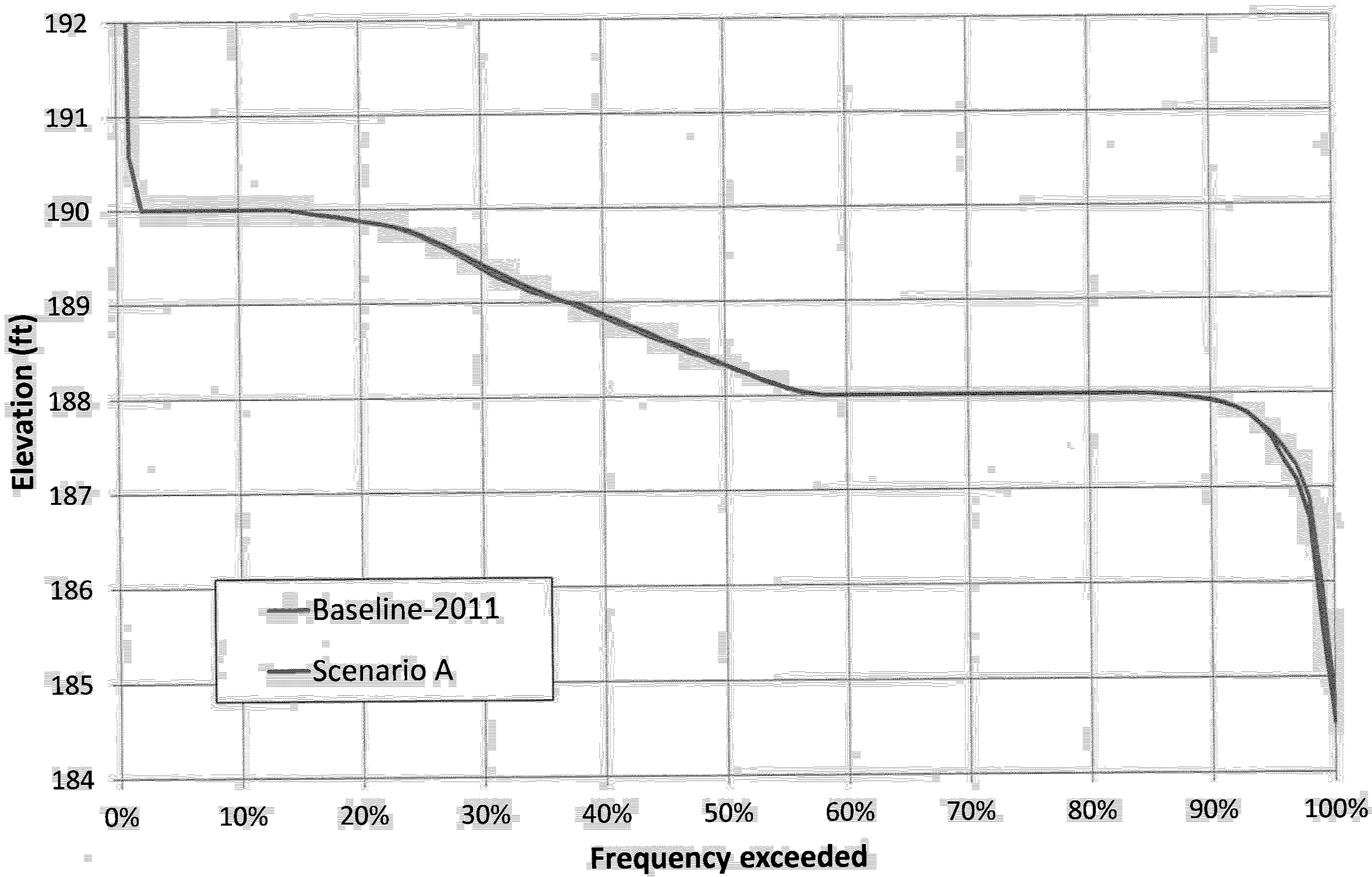
Simulated Average Daily Elevation at W. F. George



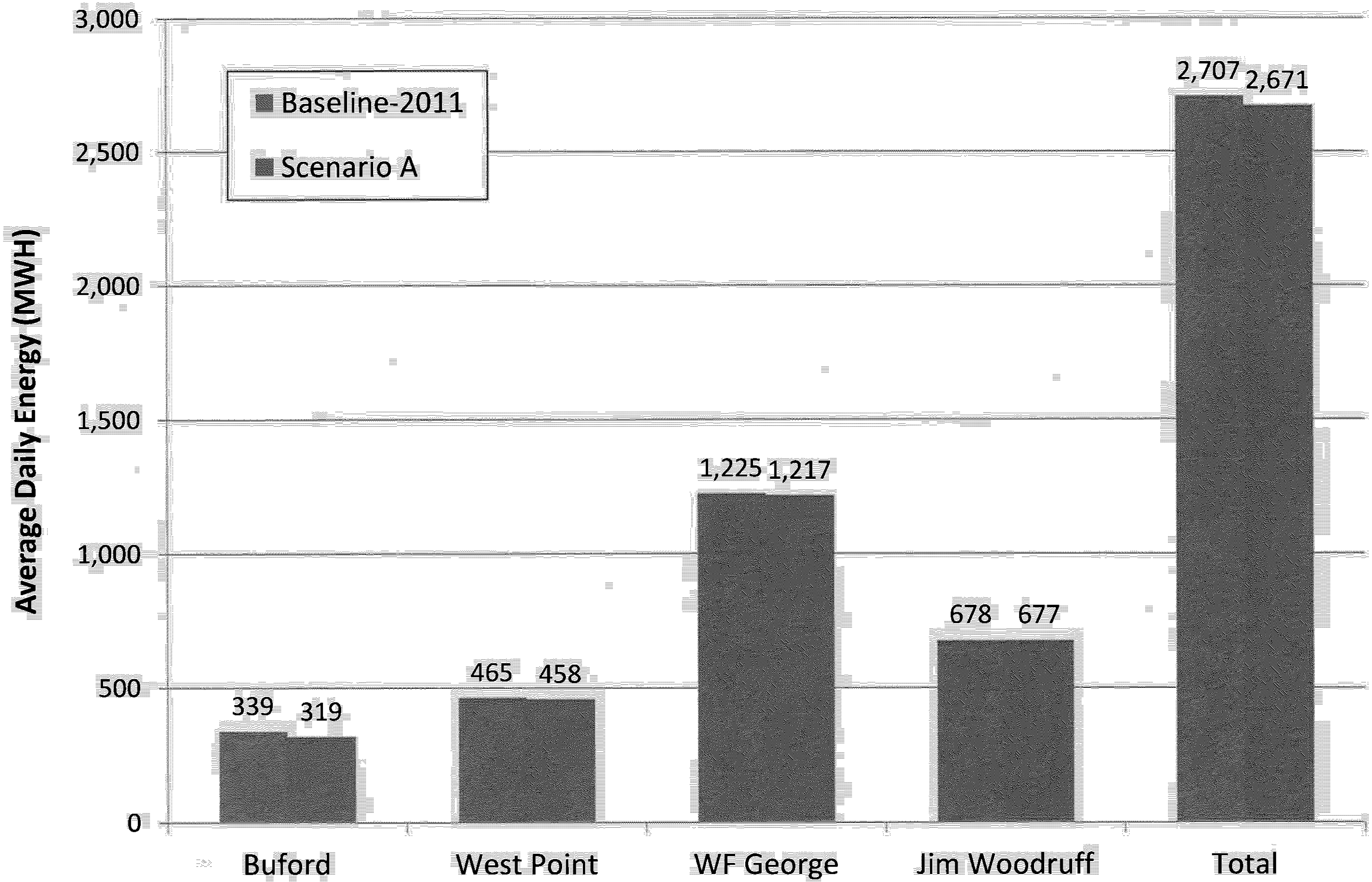

Simulated Minimum Daily Elevation at W. F. George
Elevation (ft)
192
191
190
189
188
187
186
185
184
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
Baseline-2011
Scenario A

GA02451972

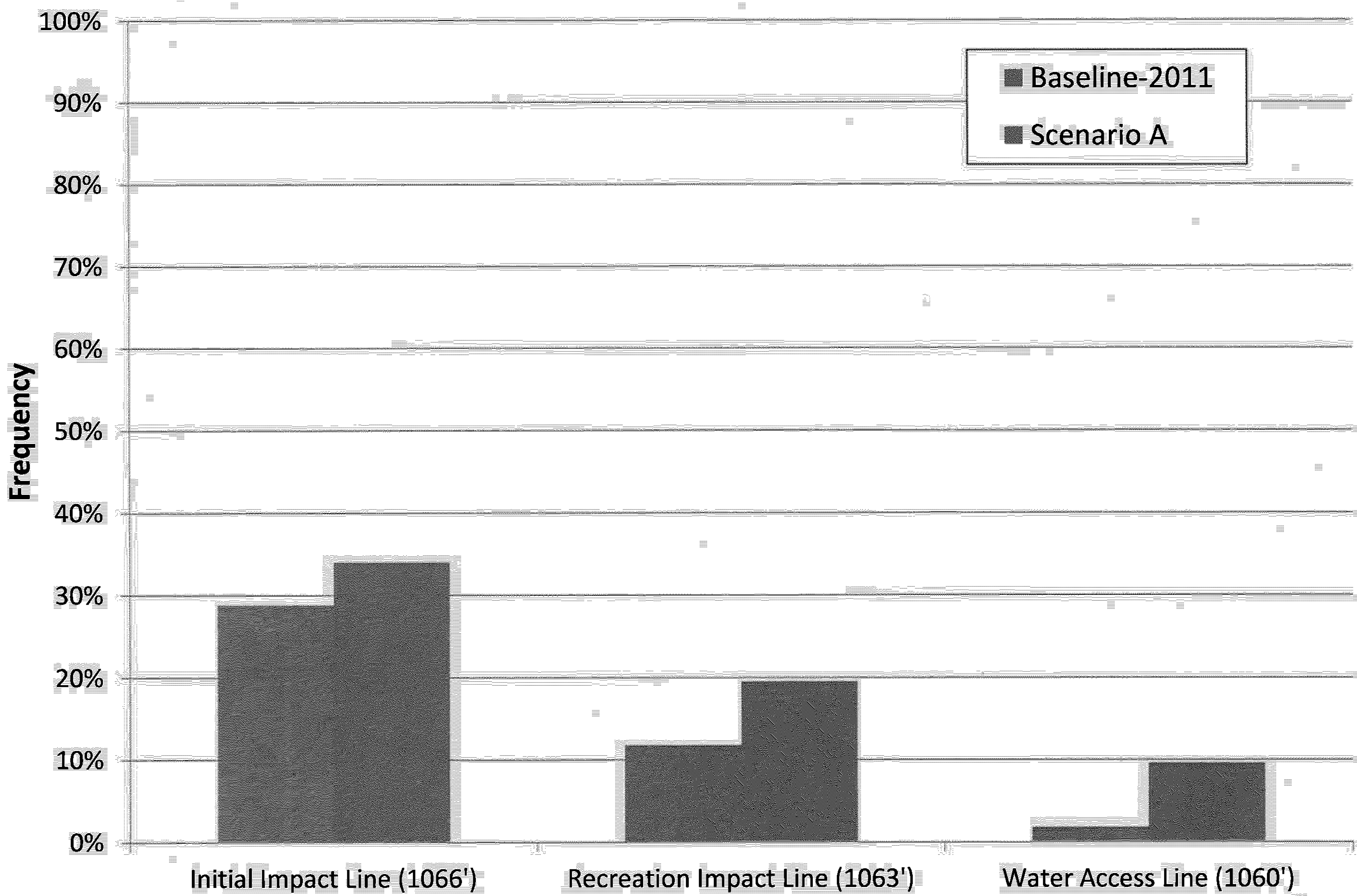
Duration Curve of W. F. George Elevation



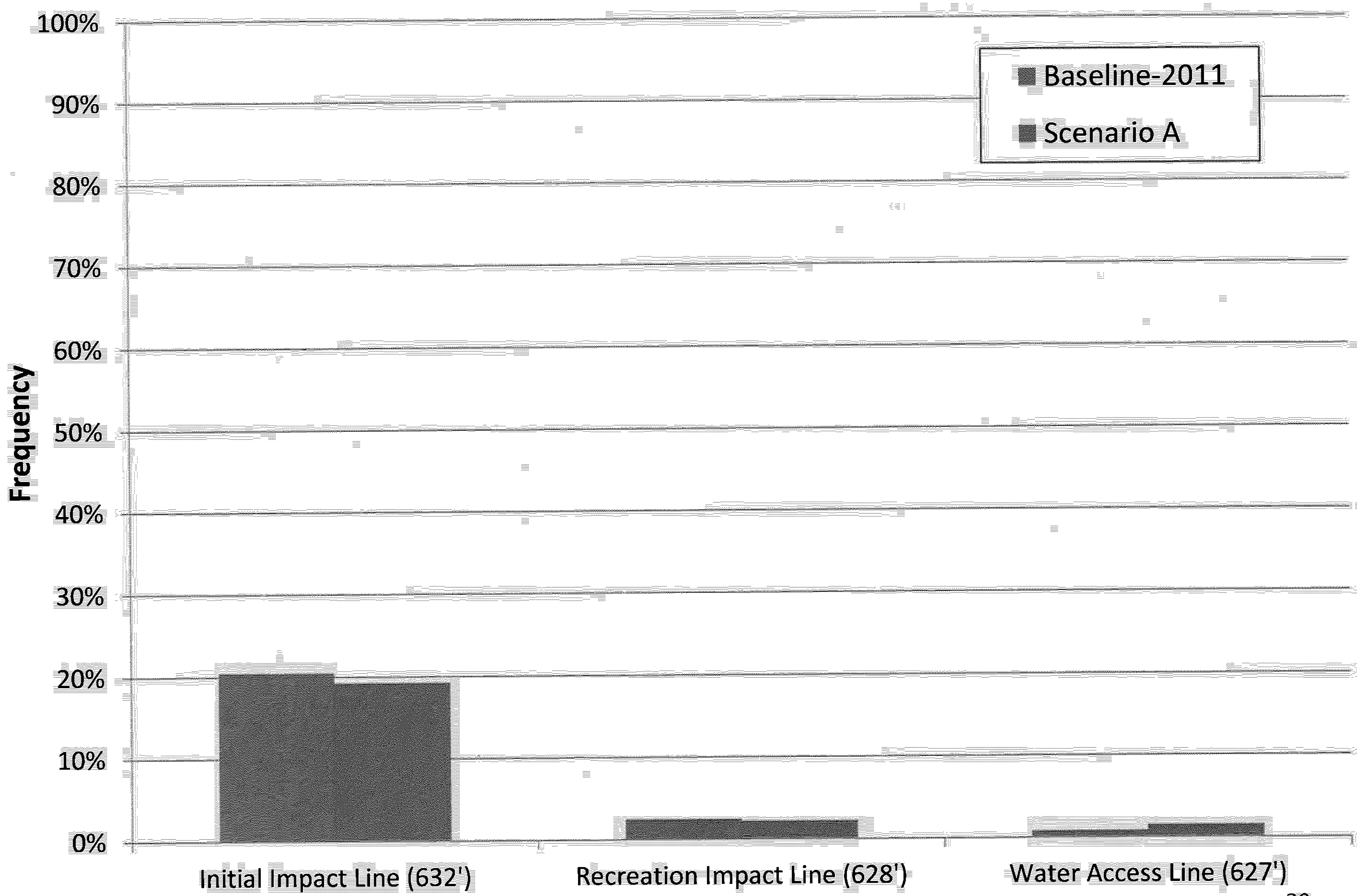
Simulated Power Generation at Federal Reservoirs in GA

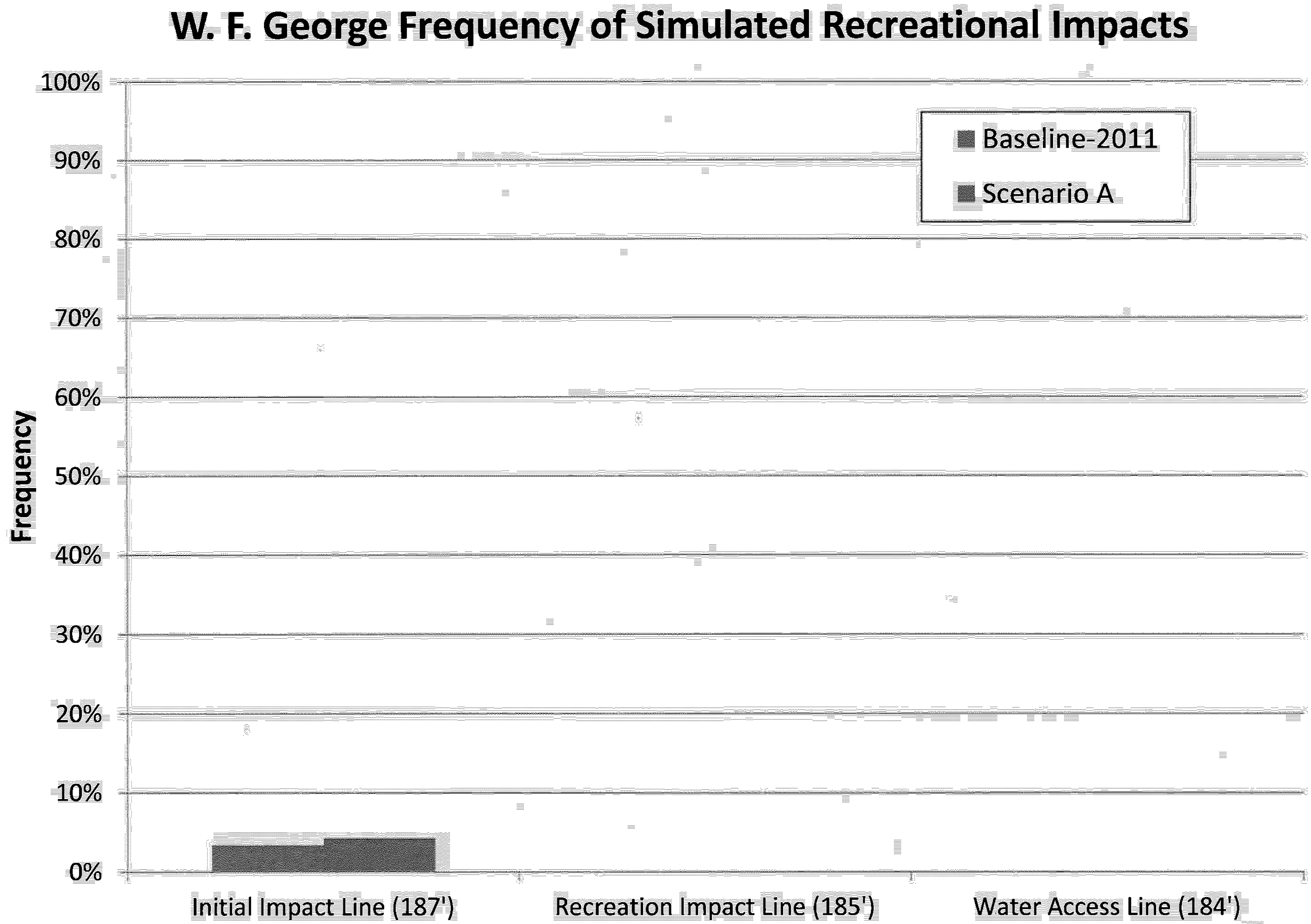


Lanier Frequency of Simulated Recreational Impacts

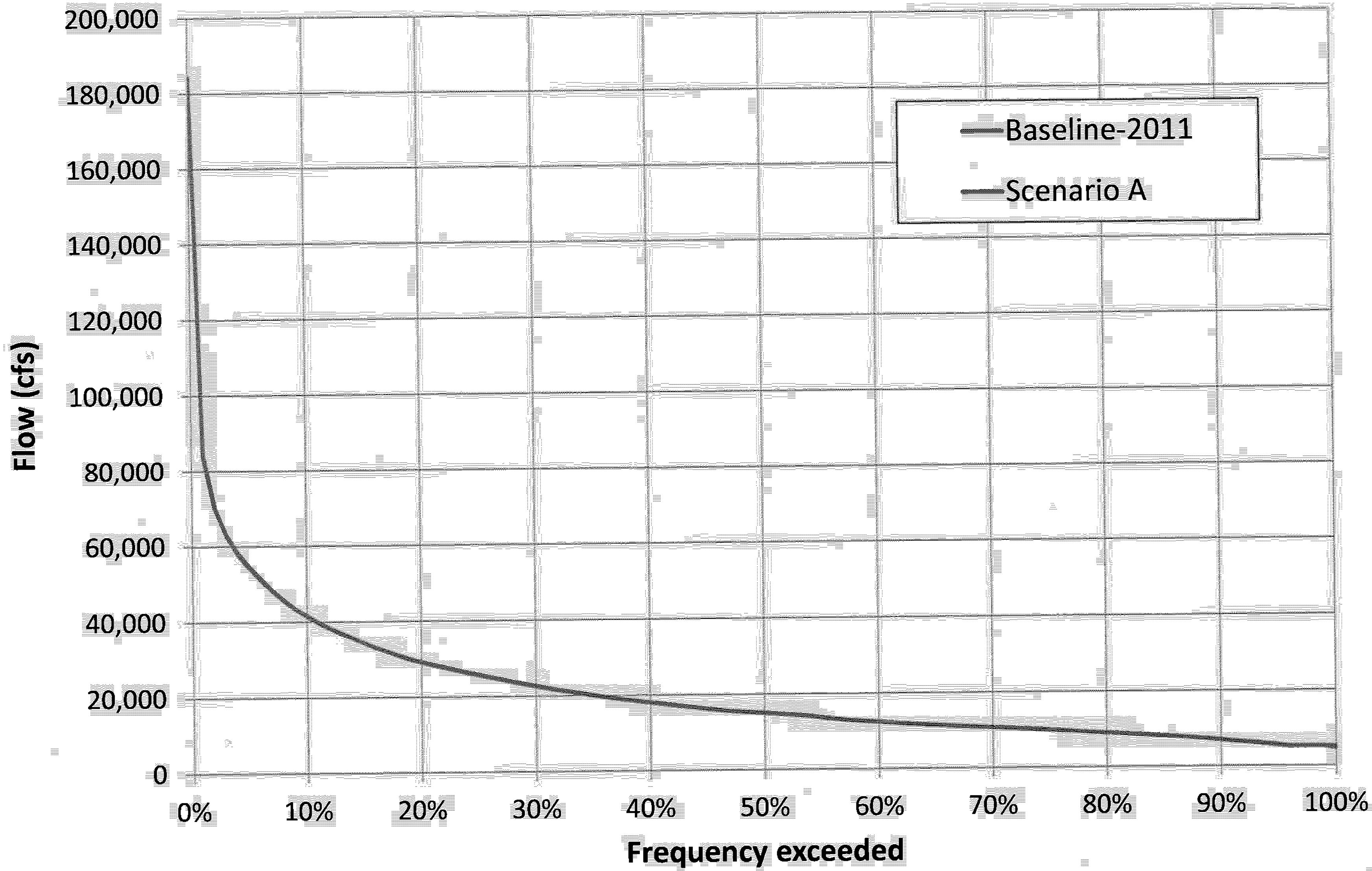


West Point Frequency of Simulated Recreational Impacts

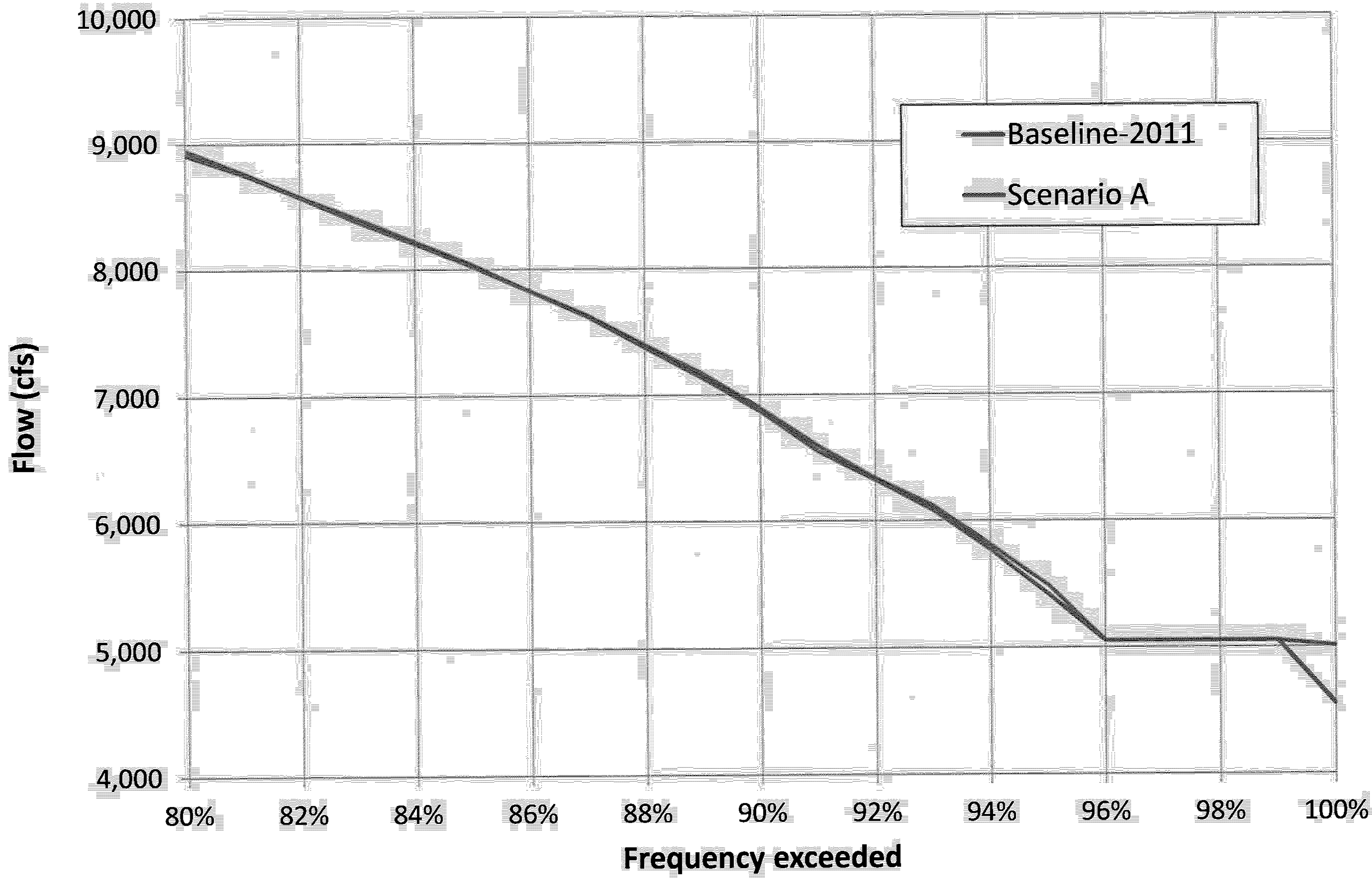



W. F. George Frequency of Simulated Recreational Impacts
Frequency
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Baseline-2011
Scenario A
Initial Impact Line (187')
Recreation Impact Line (185')
Water Access Line (184')

Duration Curve of State Line Flow



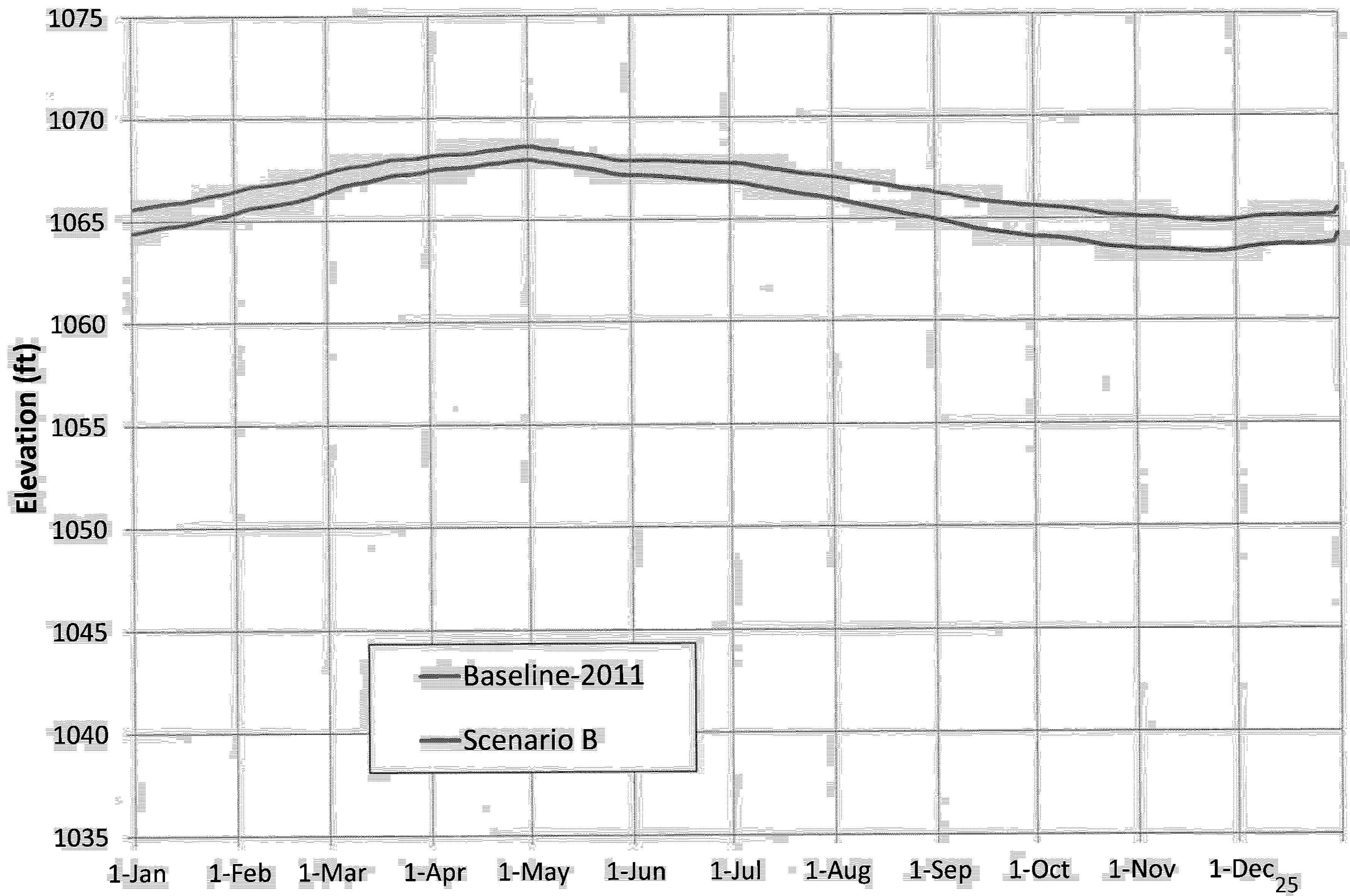
Duration Curve of State Line Flow



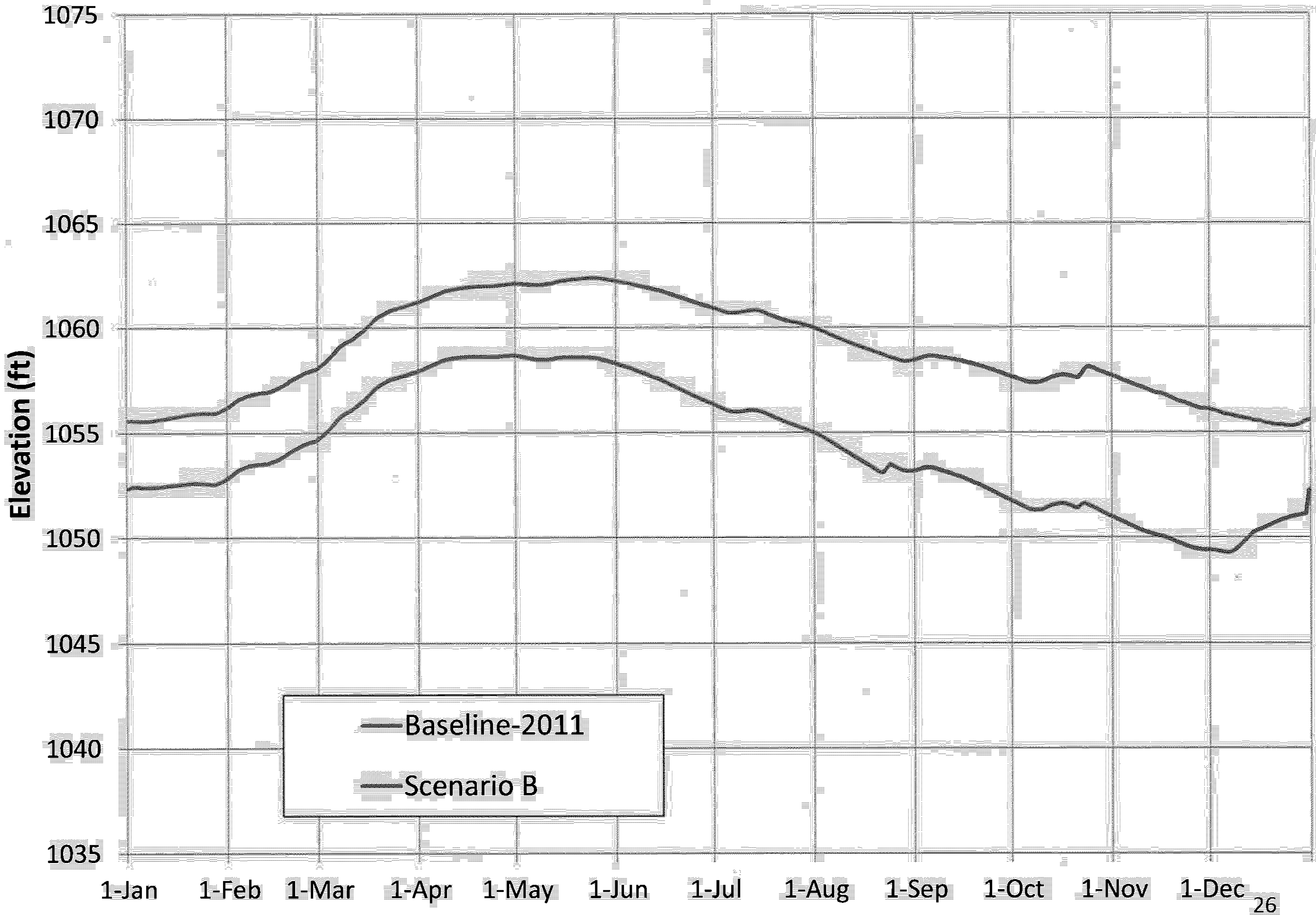
GA02451979

Scenario B vs. Baseline

Simulated Average Daily Elevation at Lanier

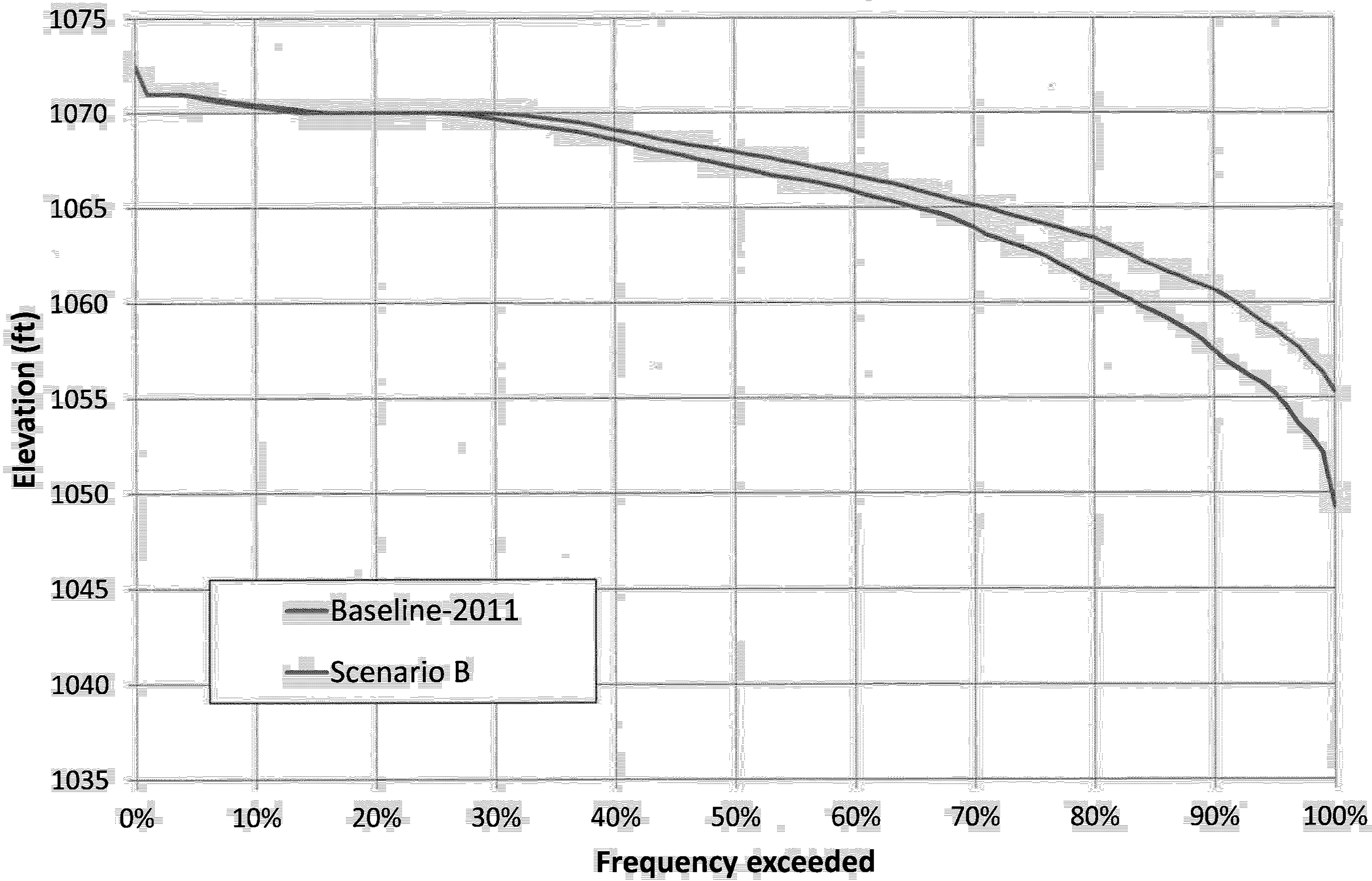


Simulated Minimum Daily Elevation at Lanier

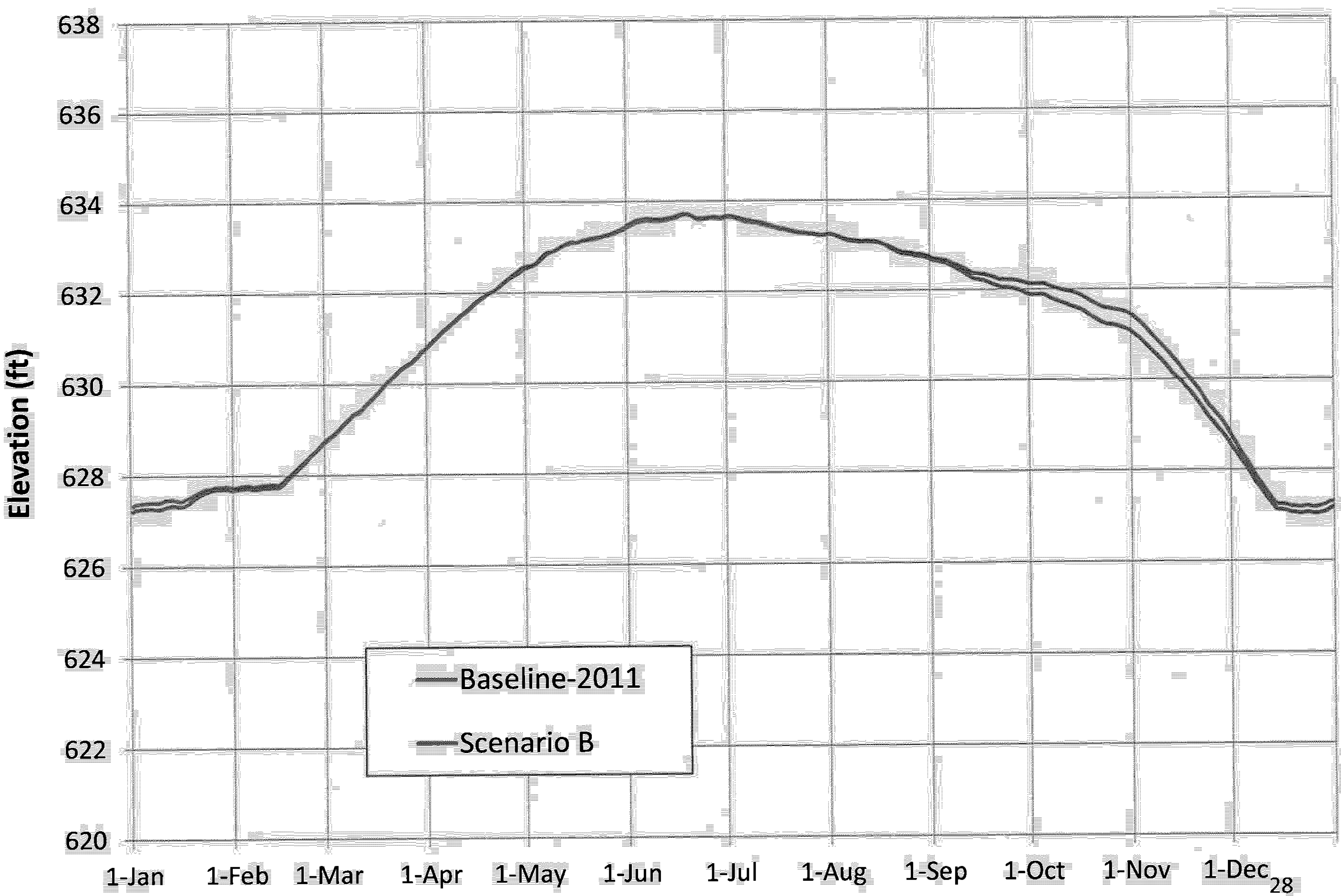


GA02451982

Duration Curve of Lanier Elevation

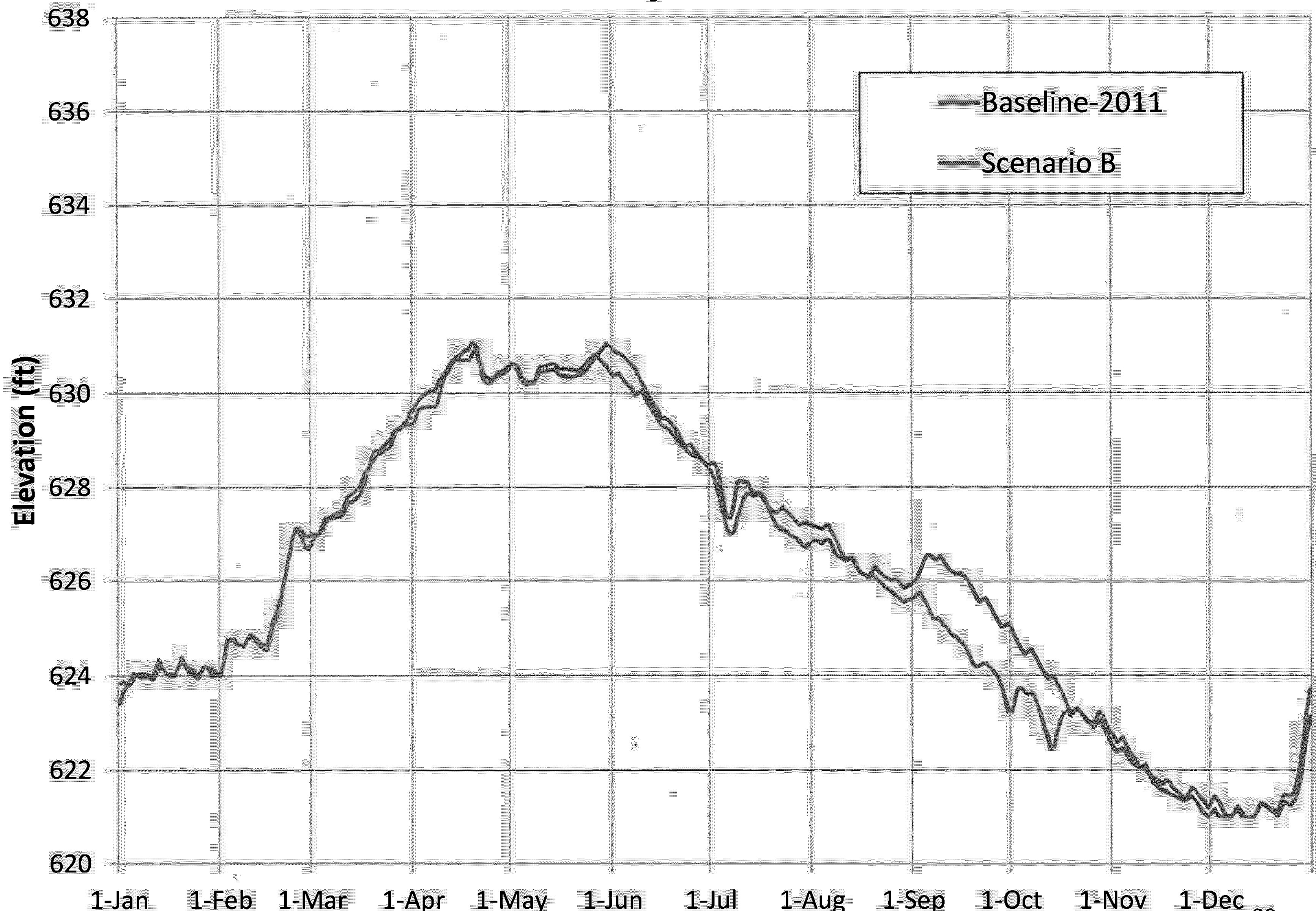


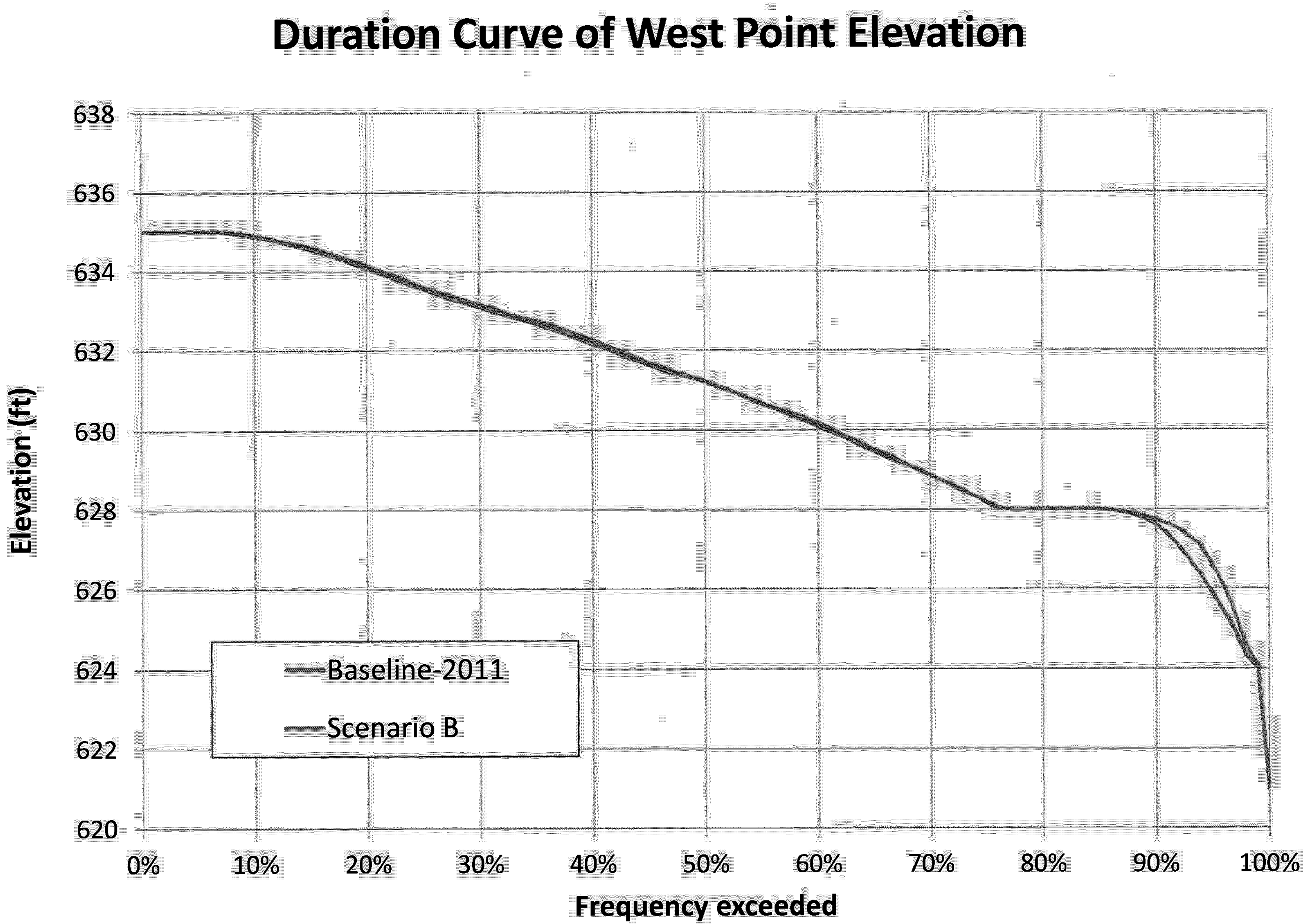
Simulated Average Daily Elevation at West Point



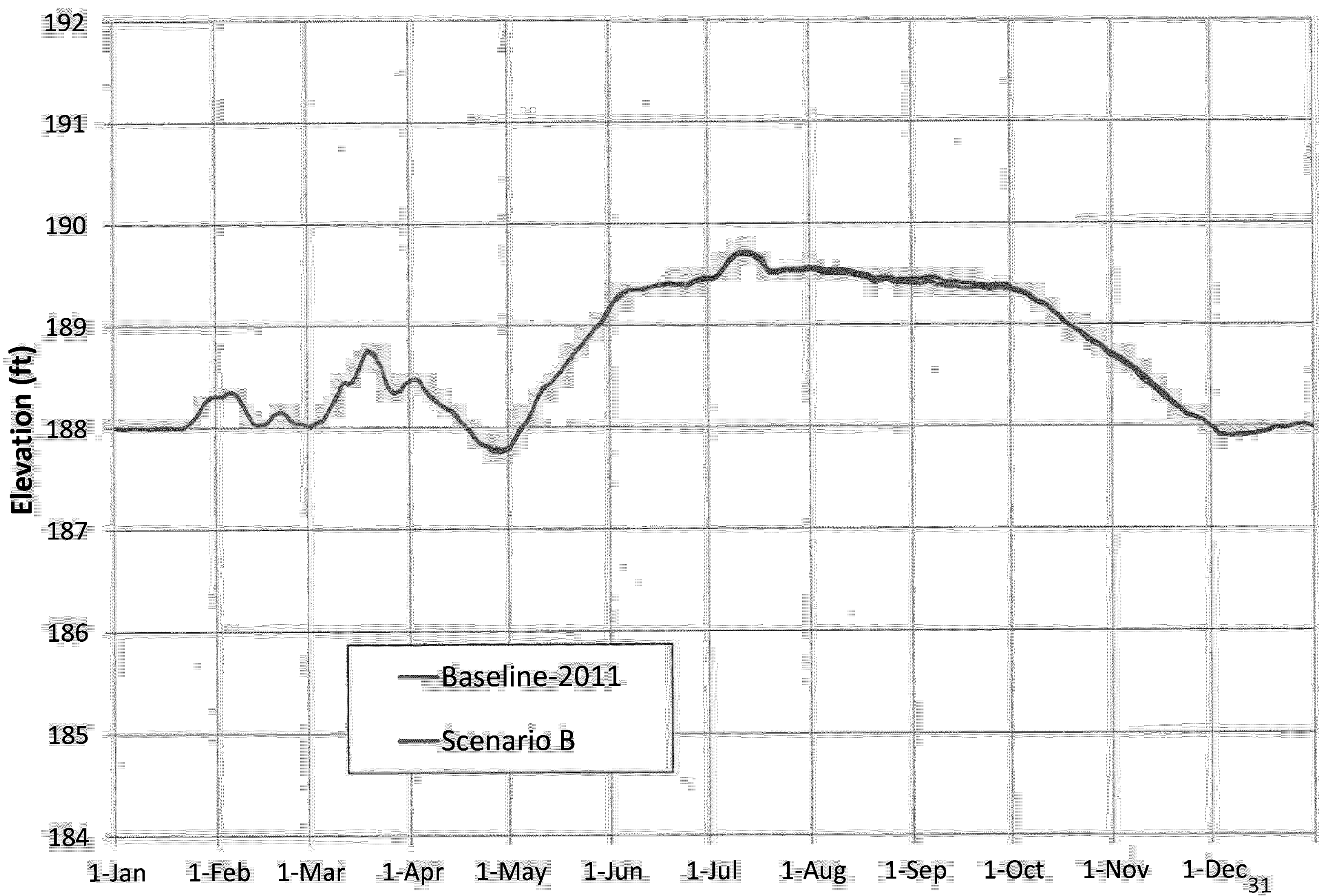
GA02451984

Simulated Minimum Daily Elevation at West Point

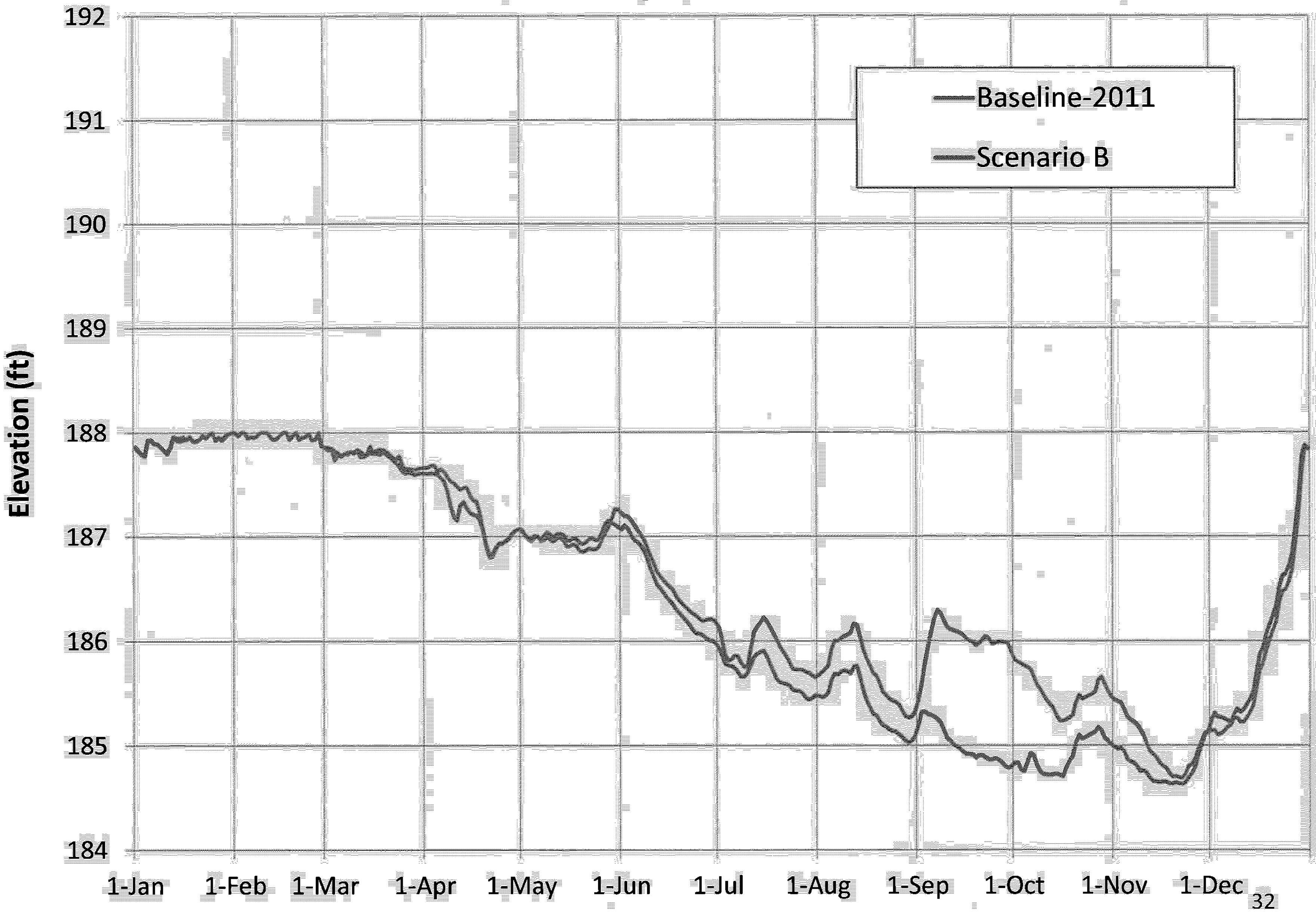



Duration Curve of West Point Elevation
Elevation (ft)
638
636
634
632
630
628
626
624
622
620
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Frequency exceeded
Baseline-2011
Scenario B

Simulated Average Daily Elevation at W. F. George

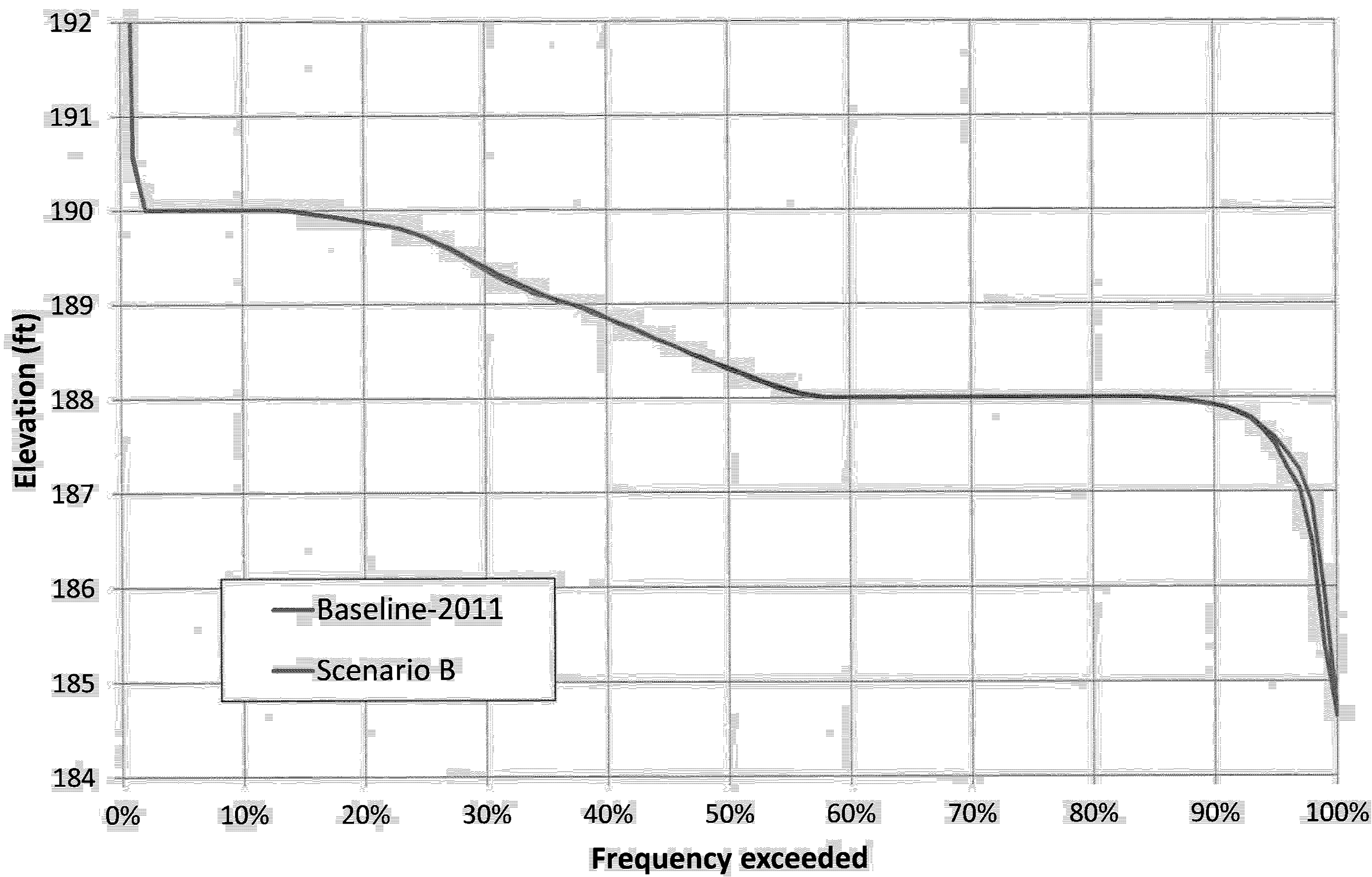


Simulated Minimum Daily Elevation at W. F. George

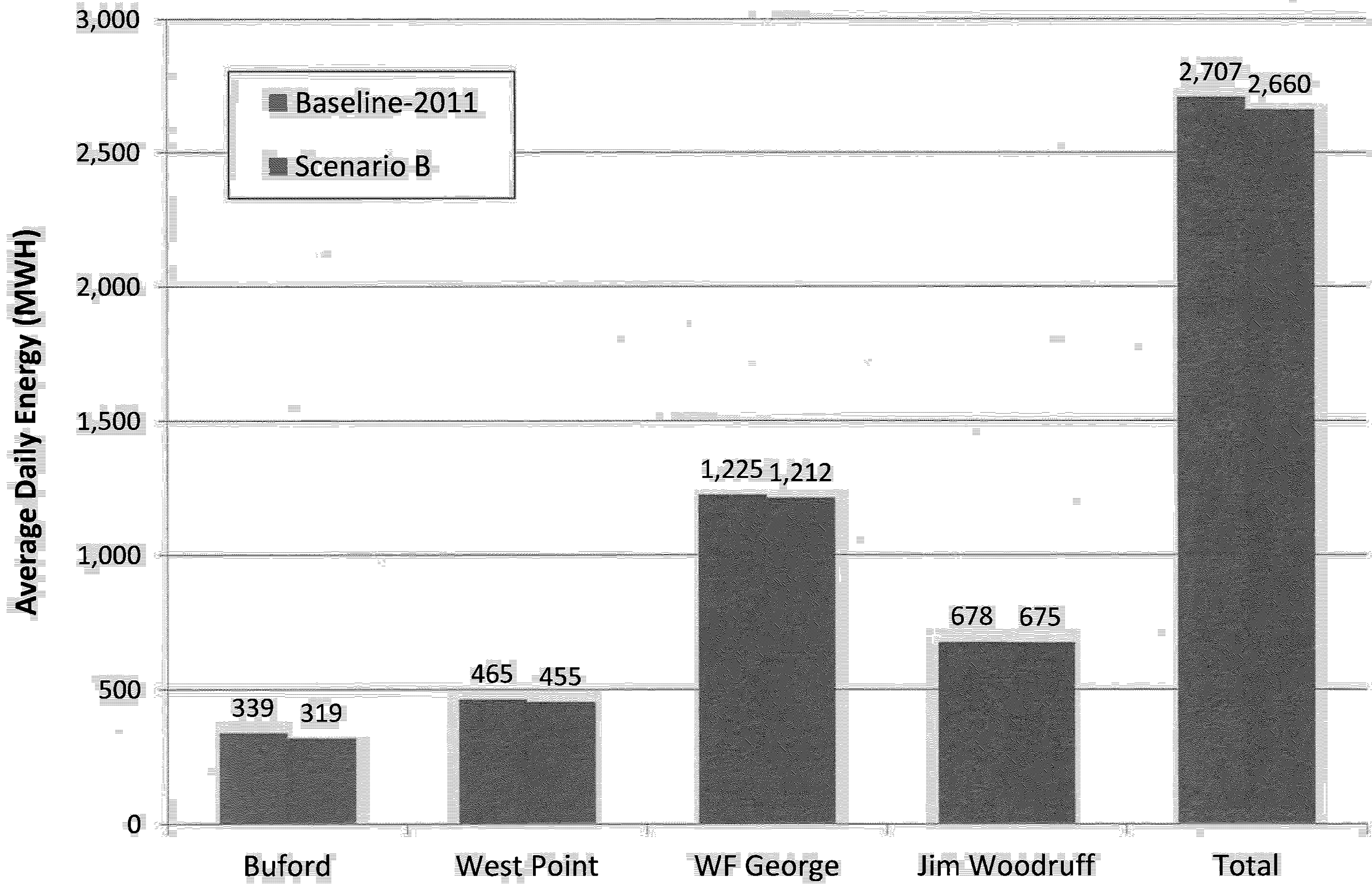


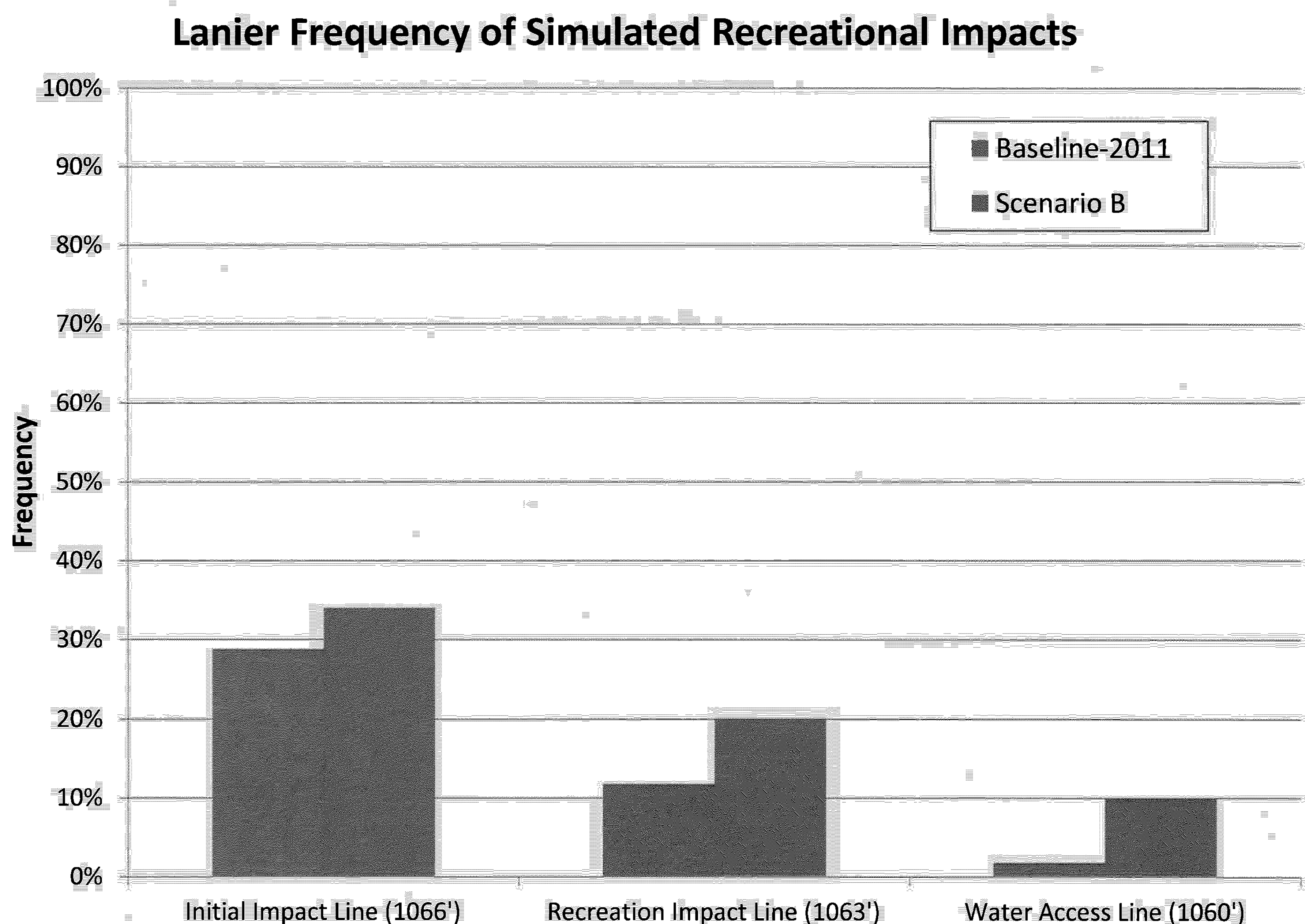
GA02451988

Duration Curve of W. F. George Elevation



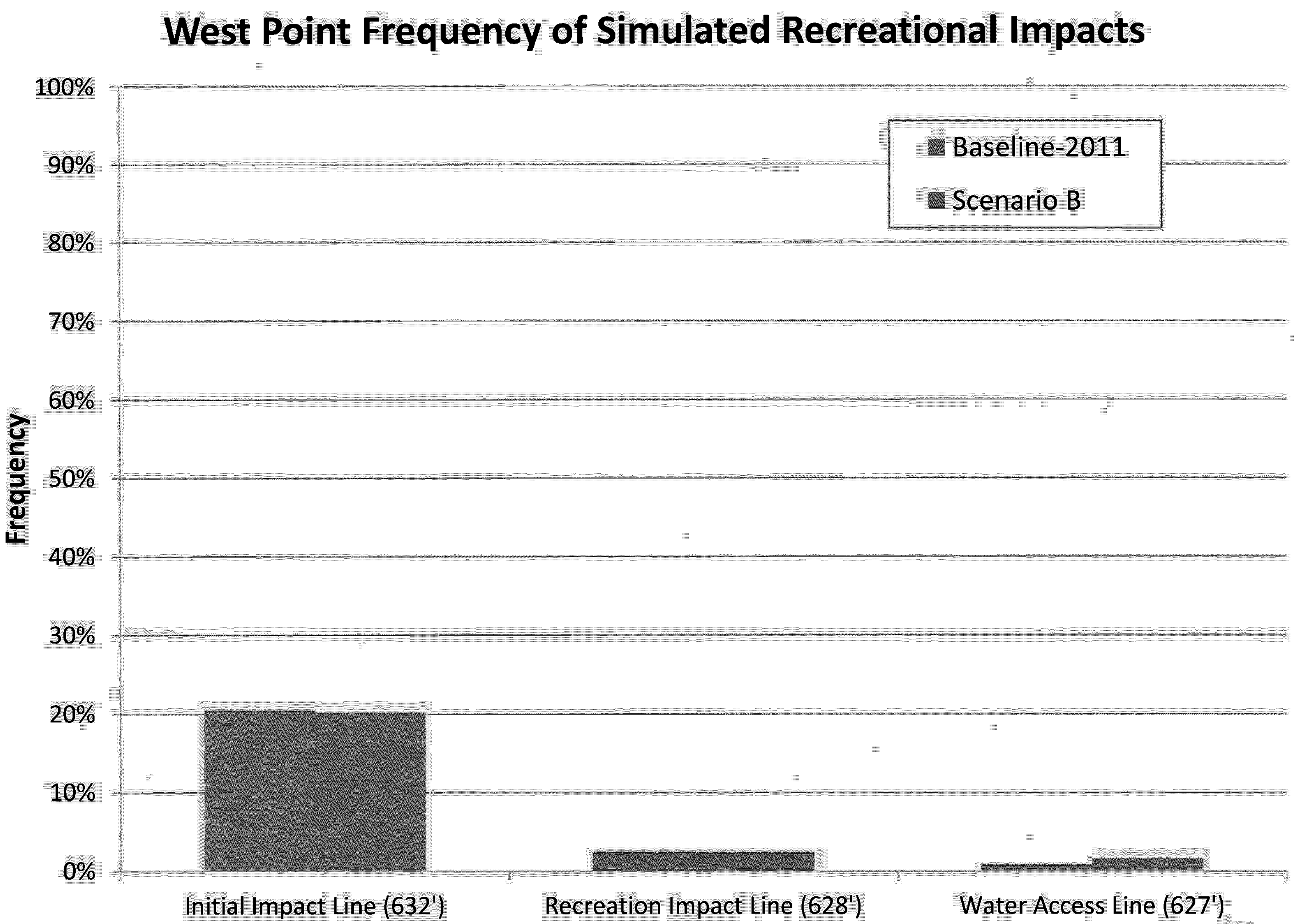
Simulated Power Generation at Federal Reservoirs in GA

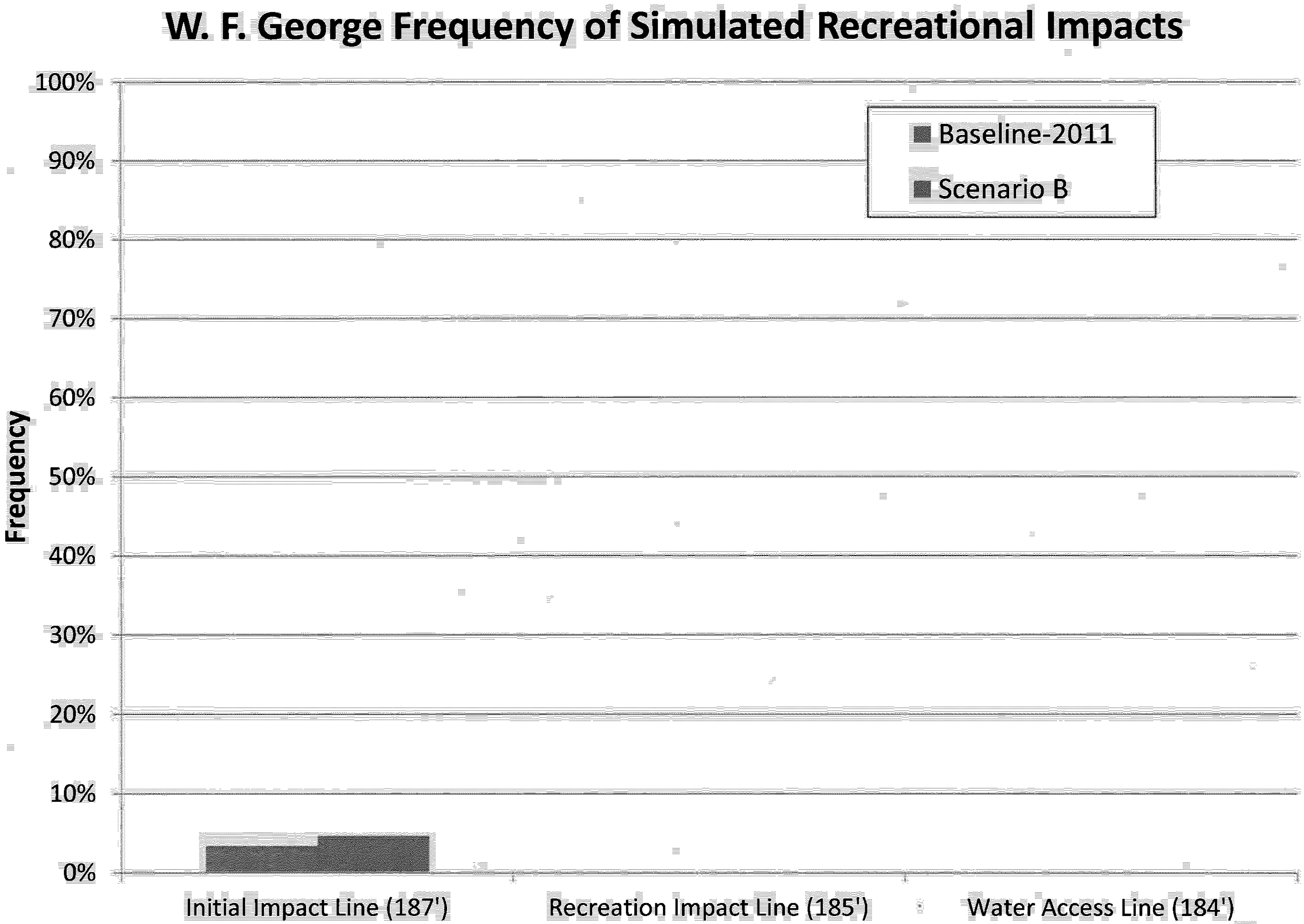




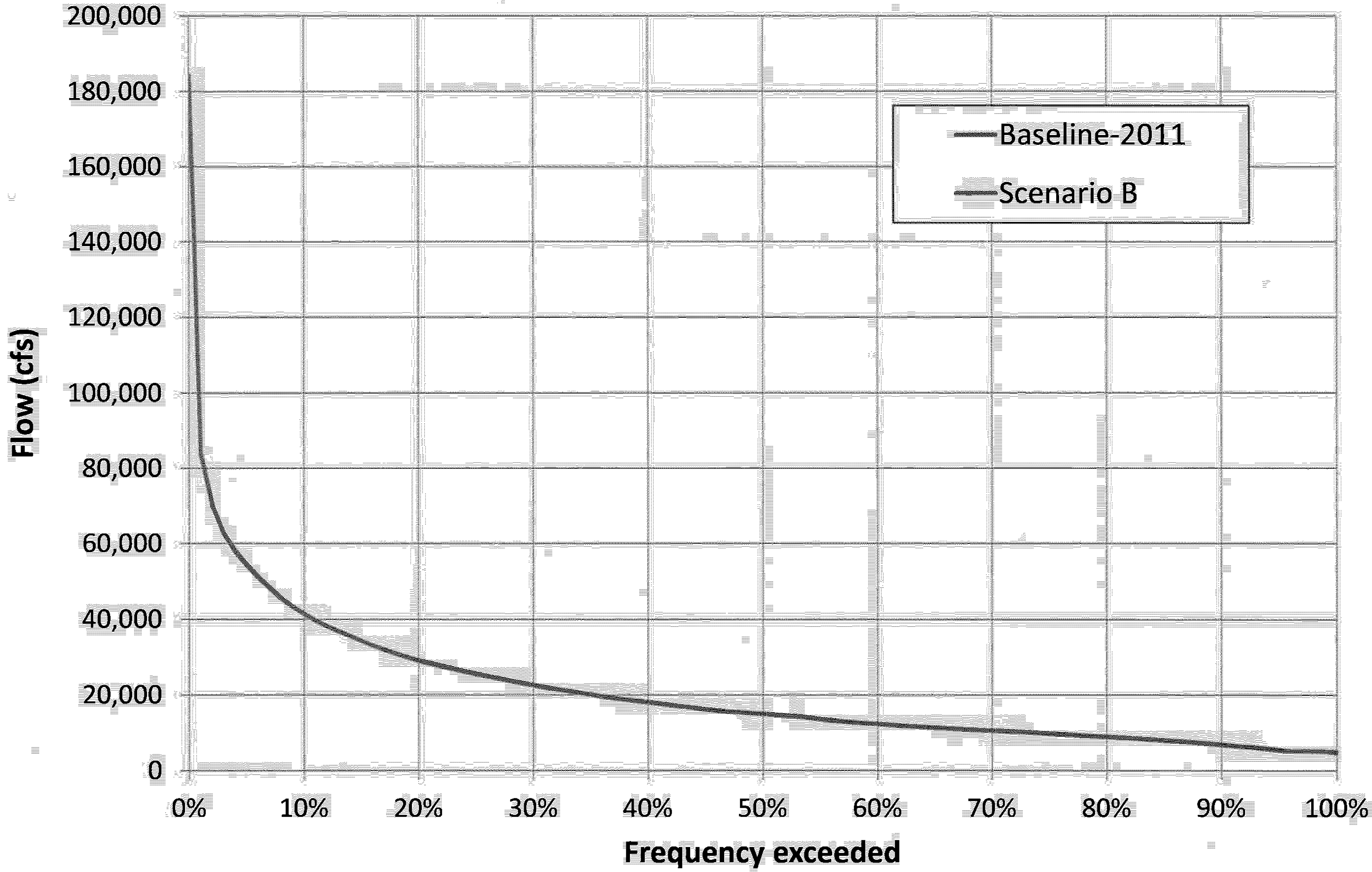
Lanier Frequency of Simulated Recreational Impacts
Frequency
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Baseline-2011
Scenario B
Initial Impact Line (1066')
Recreation Impact Line (1063')
Water Access Line (1060')

GA02451991


West Point Frequency of Simulated Recreational Impacts
Frequency
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Baseline-2011
Scenario B
Initial Impact Line (632')
Recreation Impact Line (628')
Water Access Line (627')


W. F. George Frequency of Simulated Recreational Impacts
Frequency
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Baseline-2011
Scenario B
Initial Impact Line (187')
Recreation Impact Line (185')
Water Access Line (184')

Duration Curve of State Line Flow



Duration Curve of State Line Flow

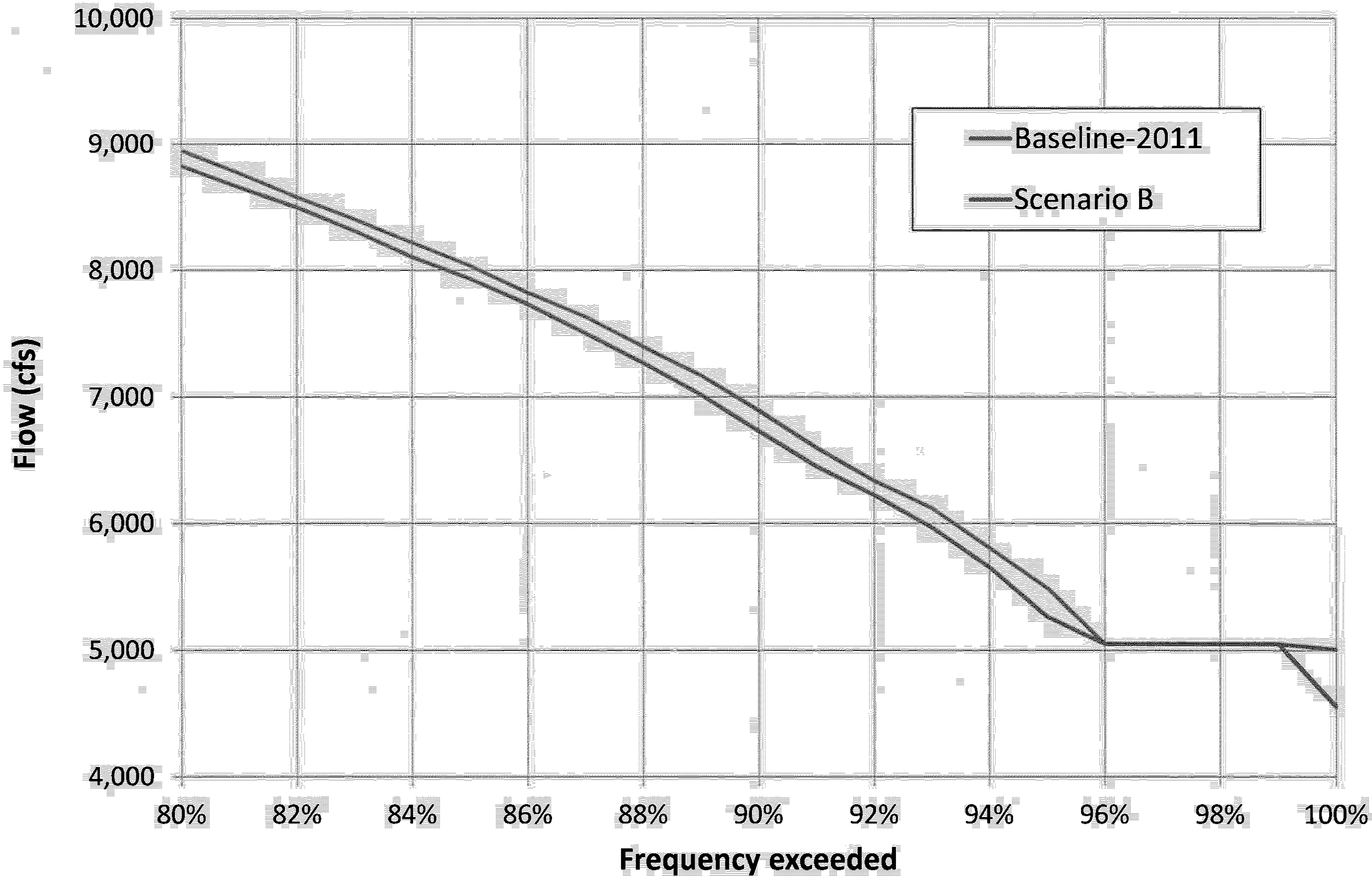


Exhibit 51

SUMMARY OF WATER CONSERVATION, WATER MANAGEMENT AND WATER EFFICIENCY PROJECTS WITH SPECIAL FOCUS ON THE LAKE LANIER/ CHATTAHOOCHEE RIVER USERS

Introduction

The first section is an overview of the implementation progress of the twelve water conservation measures in the Water Supply and Water Conservation Management Plan for all the water systems in the Metro Water District. The second section is information on the water management and efficiency efforts for water and wastewater by the water systems dependent on the Chattahoochee River and Lake Lanier.

Metro Water District Water Supply and Water Conservation Plan Efforts

Water conservation is an essential element of water resources management within the Metro Water District. With the adoption of the 2003 Water Supply and Water Conservation Management Plan, the Metro Water District and its member water providers immediately began implementing the water conservation measures in the Plan. In May 2009, the Plan was updated and the new Plan strengthened existing measures and added two additional measures. The following conservation measures are required to be implemented by all water systems in the Metro Water District. This requirement is enforced by the Georgia Environmental Protection Division.

Conservation Measure	2009 Implementation Survey Results
1. Conservation Pricing	Over 99% of the population in the Metro Water District is subject to increasing block or tiered rates.
2. Replace Older, Inefficient Plumbing Fixtures	There are 32 toilet rebate programs offered. In the first two years, over 28,000 toilets have been rebated and over $2 million spent.
3. Require Pre-rinse Spray Valve Retrofit Education Program	In the past three years, over 10,000 pre-rinse spray valve educational brochures have been provided to restaurants and food service establishments in the Metro Water District.
4. Require Sub-Meters in New Multi-Family Buildings	92% of the population in the Metro Water District is covered by a water system that requires new multi-family buildings to sub-meter either through a local ordinance or a water system policy.
5. Rain Sensor Shut-Off Switches On New Irrigations Systems	Per state law, all new in ground residential and commercial landscape irrigation systems in the Metro Water District are required to have rain sensor shut-off switches.
6. Assess And Reduce Water System Leakage	Currently, over 78 percent of the population is served by a water provider that has a leak detection program. In 2009, these programs have resulted in approximately 9,000 leaks repaired.

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7. Conduct Residential Water Audits	100,000 household water audit flyers or brochures have been distributed with many more customers accessing the audits via websites.
8. Distribute Low-Flow Retrofit Kits To Residential Users	147,000 retrofit kits have been distributed to residential users throughout the Metro Water District.
9. Conduct Commercial Water Audits	31 water systems offer water audits to commercial customers with an estimated 425 commercial customers having received audits.
10. Implement Education And Public Awareness Plan	Over 800 education and outreach activities and 325 public participation and involvement events were held from 2008 to 2009.
11. Install high efficiency toilets and urinals in government buildings (added in 2009). Installation must begin in 2014 and be completed by 2020.	Cobb County is ahead of schedule and has replaced their plumbing fixtures with high efficiency toilets and urinals in government buildings.
12. Require new car washes to recycle water (added in 2009). Ordinances or regulations must be in place by the end of 2010.	Many local governments have already begun developing draft ordinances and regulations for this measure.

Water Resources Management and Improvement Efforts of the Chattahoochee River/ Lake Lanier Water Systems

The information below summarizes many of the water efficiency efforts of the water providers who rely on the Chattahoochee River and Lake Lanier for water supply. Included in this summary are improvements to water supply like building new reservoirs, increasing reservoir capacity, constructing more efficient water treatment plants, and infrastructure improvements. Enhancements to the wastewater treatment process like constructing state of the art treatment plants, upgrading existing plants, and improving infrastructure can also help improve water efficiency and increase return flows back to the Chattahoochee River or Lake Lanier. Other efforts by the water providers listed below include awards and certifications achieved, educational efforts, and water reuse projects.

❖ WATER PROJECTS

- **<u>NEW RESERVOIRS</u>**
  - **Fulton County** added a 490 million gallon capacity reservoir at the Atlanta-Fulton County Water Treatment Plant that cost an estimated $47 million.
  - **City of Atlanta** purchased Bellwood Quarry property in northwest Atlanta from Vulcan Materials Company and Fulton County. This property is planned for transformation into a park and it will also be the site of the City's 1.9-billion-gallon Westside drinking water reservoir. The total estimated cost of this project is $216 million.
  - **DeKalb County** increased the capacity of its reservoir to 1 billion gallons in 2005 at an estimated cost of $48 million.
  - **Rockdale County** ceased buying Lake Lanier withdrawn water from Gwinnett County in 2003 as the Rockdale water system matured and the newly constructed Randy Poynter

reservoir came online. The new reservoir is anticipated to meet county water requirements through 2030, eliminating 6 MGD of withdrawals from Lake Lanier.

- **NEW TREATMENT PLANTS**
  - **Gwinnett County's** Shoal Creek Filter Plant is a 75 MGD facility which began operations in 2004 at a cost of nearly $120 million. This facility provides more modern and water efficient processes than the older facility. A second raw water pump station was constructed at the same time as the filter plant for a cost of approximately $50 million. This structure allows for full redundancy in feeding two filter plants and aids in peak demand management. It is estimated that this filter plant saves approximately 2% of water produced.
  - **DeKalb County** completed the Scott Candler Water Treatment Plant in 2007 at an estimated cost of $165 million. The plant has zero discharge of process water which saves an estimated 4.5 MGD.
  - **Forsyth County** constructed the Antioch Water Treatment Plant in 2000 at a cost of $16.5 million. It has the capability to treat 16 MGD using up-flow sludge blanket clarification, ozonation, and high rate filtration.
  - **City of Cumming** completed a 105 MGD Redundant Raw Water Intake Facility (RRWIF) on Lake Lanier in 2009 at a cost of approximately $16 million. This structure allows for full redundancy in feeding both the City of Cumming and Forsyth County Water Treatment Plants and enables the City to withdraw water from Lake Lanier at lake elevations as low as 1024 MSL. The new RRWIF is equipped with variable frequency driven pumps which reduce wasted raw water discharged to a local stream by 100%.
- **MAJOR UPGRADES TO WATER TREATMENT PLANTS**
  - **Gwinnett County's** Lanier Filter Plant was originally constructed in the 1970s. Over the years, the capacity of the plant has been expanded to 150 MGD. Several major improvements have been made at the facility to improve water efficiency. These projects include the addition of finished water storage capacity (which allows for multi-day averaging to reduce maximum day demand peaking factor from 1.67 to 1.5 extending the sufficiency of the filter plant capacity by two years); a residuals handling facility (which recovers water from residual solids prior to disposal saving approximately one MGD through recycle); a backwash equalization tank (which captures and returns filter backwash water in lieu of wasting it and saving approximately 3 MGD through recycle); and the replacement of the high service pumps with variable frequency drives (which allow more effective flow management to isolate and manage leaks). In total, these improvements represent an investment of over $37 million.
  - **Fulton County** provided $25 million in upgrades to the Atlanta-Fulton County Water Treatment Plant.
  - **Forsyth County** is currently bidding a project to expand the Antioch Water Treatment Plant (WTP) capacity to treat an additional 12 MGD using ZENON membrane based designs. The estimated cost for this project is $22 million. The County also spent $800,000 rehabilitating Settingdown Creek Watershed 10 Reservoir by removing 50,000 cubic yards of silt to increase the reservoir's capacity.
  - **City of Cumming's** 18 MGD Dahlonega Highway Potable Water Production Facility was expanded in 2009 to treat 24 MGD at a cost of $6 million.
- **INFRASTRUCTURE IMPROVEMENTS**
  - **Cobb County** sold $135 million in bonds at an AAA rating to rehab the county's water and sewer system in July 2009.

- **Gwinnett County** has invested in associated water projects and improvements including a new head chamber (which allows full redundancy in feeding two filter plants and aids in peak demand management); an upgrade at the original raw water pumping station (which provides variable frequency drives to allow more effective flow management to isolate and manage leaks); and site acquisition and design of a raw water storage facility (which will provide equalization during peak demand times). The cost of these associated projects brings the total investment in water production infrastructure in this decade to nearly $240 million. Gwinnett County has also completed the following infrastructure improvements:
  - Constructed or rehabilitated several distribution system storage tanks in the past decade with investments of nearly $20 million.
  - Since 2000, the County has expended nearly $25 million designing and constructing new large and replacement water transmission and distribution main projects.
- **City of Lawrenceville** was approved for a DWSRF loan (through ARRA) of $990,000 and a DWSRF subsidy of $660,000 for the extension and replacement of water mains. The total project cost is $1.65 million and GEFA is providing the entire amount.
- **Fulton County** has implemented various infrastructure improvements including adding elevated storage tanks, rehabilitating filters, replacing settlers, and water main improvements for an estimated $49.3 million. Fulton County also replaced water meters throughout the system for an estimated $24.5 million.
- **City of Atlanta** spent $35 million replacing older meters with Automated Meter Reading meters. $30 million has been spent on their valve and hydrant inspection and repair program. The City also has a water main replacement program that has replaced 48 miles of distribution systems mains for a cost of $45.7 million. The City has also completed the Hemphill Discharge Piping and Adamsville-Fulton Industrial transmission mains for a total cost of $24.1 million.
- **DeKalb County** completed a raw water pump station in 2009 at an estimated cost of $38 million and has begun the bidding process for adding a raw water transmission line that will cost an estimated $22 million. The County conducted a water audit that saved an estimated 20 million gallons for a cost of about $200,000. DeKalb County spends an estimated $5 -- $8 million annually on system improvements, $15 -- $25 million annually on system maintenance, and $5 -- $25 million on water infrastructure assumptions from new developments.
- **Forsyth County** has spent nearly $25 million on water related infrastructure improvements since 2005.
- **City of Cumming** was approved for a DWSRF loan (through ARRA) of $711,884 and a subsidy of $474,589 for modifications to the settling basins at the city's Potable Water Production Facility. The total project cost is $1.2 million and GEFA is providing the entire amount. The City recently completed construction in 2009 on its Hendrix Road 1 MG elevated water storage tank at a cost of $1.8 million. The tank will enable the City to provide water to the northern portion of its water and sewer service area. The Mary Alice Park Road Water Line Replacement Project was completed in 2009 at a cost of $300,000. The City of Cumming installed The Highway 369 Water Line in 2008 at a cost of $800,000. The Highway 20 East Water Line Relocation Project was completed in 2005 at a cost of $1 million.

ASSET MANAGEMENT PROGRAMS

- **Gwinnett County** has developed and fully implemented an Asset Management Program with the overall goal to instill an asset management mindset throughout the organization. Prioritization of both capital and operating investments is performed in a systematic way, carefully weighing risks and benefits using a triple bottom line approach, balancing economic, ecological and social aspects for every decision. The County has expended

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nearly $30 million since 2000 replacing small water mains and service lines with high failure rates as identified using asset management principles. This program has significantly reduced the number of annual main breaks and system leakage while improving customer service.

- **LEAK DETECTION PROGRAMS**
  - **Cobb County Water System** has a leak detection program that has surveyed over 650 miles of pipe through June 2009 for an estimated water savings of 23 million gallons.
  - **Gwinnett County** created a water accountability program in 2004 to minimize both real and apparent losses in the water system. To date, approximately $5 million has been spent under this program on various activities to help achieve that objective including a leak detection study of the entire water system, replacement of small water meters, and a large water meter testing effort currently underway. Additional dollars have been spent in meter and service line replacement over the past ten years under separate initiatives.
  - **The City of Atlanta** has implemented a leak detection program that includes 1) an ongoing meter calibration and replacement program, 2) working with intergovernmental departments to routinely inform the utility of standing water areas and potential leaks, 3) prioritizing leak repairs, 4) addressing leaks or inefficiencies in the water treatment plant, 5) maintaining an asset management program to track aging pipes and meters with a schedule for planned replacement, and 6) maintaining accurate billing system records. Beginning in June, 2010, the Bureau of Drinking Water (BDW) will undertake a 3 year leak detection project that will acoustically survey all of its 2,700 mile potable water distribution system. The survey work will be completed under a third party contract and it is anticipated that all leaks will be repaired by both BDW personnel and outside contractors. It is anticipated that the project cost will be $3.5 Million.
  - **Forsyth County** has implemented a leak detection program that includes 1) an ongoing meter calibration and replacement program, 2) tracking aging meters and improperly sized meters for planned replacement, 3) installing datalogger meters (e-coder) on all high usage customers, and 4) working with intergovernmental departments to maintain accurate billing records and ensure that all meter data is entered into the system correctly.
  - **DeKalb County** has a leak detection and valve exercising program in place to detect leaks by survey, assist emergency repairs by properly locating the leak, and exercising valves so that portions of the system can be isolated for repairs in a more efficient manner to minimize water loss.

WASTEWATER PROJECTS

- **NEW TREATMENT PLANTS**
  - **Gwinnett County's** F. Wayne Hill Plant is a 60 MGD state-of-the-art wastewater reclamation facility that is able to send 20 MGD back to the Chattahoochee River and 40 MGD into Lake Lanier, with a pending request to EPD to increase the capacity for more water reclamation. The County invested approximately $1.05 billion in the two phases of the plant construction with an additional $250 million investment in pumping stations and force mains to convey flows to the plant. Gwinnett County is constructing the Yellow River Water Reclamation Facility, a wastewater treatment facility with 22 MGD treatment capability designed to replace 6 older, smaller facilities, representing a $250 -- $275 million investment.

- **Fulton County** began construction on the new Johns Creek Environmental Campus in 2006 and the estimated project cost is just under $137 million. The new facility is permitted for 15 million gallons per day and uses Membrane Biological Reactor (MBR) technology to meet more stringent regulatory limits than the existing Johns Creek Water Reclamation Facility (WRF).
- **DeKalb County** is currently designing additional plants and tunnels for wastewater treatment; the estimated cost is $500 million.
- **Forsyth County's** Fowler Water Treatment Plant (WTP) was complete in 2003 at a cost of $27 million. It is permitted to treat 1.25 MGD, and expandable up to 2.5 MGD with the addition of further membranes.
- **City of Lula** was approved for a CWSRF loan (through ARRA) of $2.6 million and a subsidy of $6.0 million for the construction of a wastewater treatment plant. The total project cost is $8.6 million with GEFA providing the entire amount.

MAJOR UPGRADES TO TREATMENT PLANTS

- **Cobb County Water System** has upgraded the wastewater facilities of R. L. Sutton Water Reclamation Facility (WRF), Northwest WRF, Noonday WRF, and South Cobb WRF. Cobb County spent an estimated $212 million on upgrades to R. L. Sutton WRF; $75 million on upgrades to Noonday WRF; $10 million on upgrades to South Cobb WRF; $25.6 million on upgrades to Northwest WRF.
- **Fulton County** spent an estimated $14.5 million in expanding Big Creek WRF for UV disinfection and an estimated $91.7 million in expanding the Camp Creek WRF. The County also spent an estimated $300,000 on upgrades to the Little River WRF.
- **City of Atlanta** upgraded the R. M. Clayton Water Reclamation Facility (WRF) at a cost of $300 million that included the construction of new headworks, upgrading existing aeration basins and installing four new aeration basins with nutrient removal capability, 10 new secondary clarifiers and 22 deep-bed sand filters, an ultraviolet disinfection system, and installing odor control systems. Utoy Creek was also upgraded with new aeration basins, an ultraviolet disinfection system, cascade post aeration, odor control, and a new administration building with a laboratory; the estimated cost for these projects is $149 million. The South River Water Reclamation Center was upgraded at a cost of $70 million to improve existing headworks, upgrade existing aeration basins to remove nutrients, add new sand filters, an ultraviolet disinfection system, post aeration, and odor control. A 10 MG storage facility and a 34 MG Intrenchment Creek CSO Storage Tunnel were constructed to increase the total storage capacity to 44 MG in the Custer Avenue area for an estimated cost of $40 million.
- **DeKalb County** spent an estimated $250,000 on finishing its septage receiving station at the Snapfinger Advanced Wastewater Treatment Facility.
- **The City of Cumming** expanded its 3 MGD Bethelview Road Advanced Water Reclamation Facility to treat 8 MGD at a cost of $30 million in 2008. This facility is able to send 100% of the facility's flow back to the Chattahoochee River via Big Creek.

INFRASTRUCTURE IMPROVEMENTS

- **Cobb County Water System** is in the middle of a 5 year capital improvement plan costing $650 million that includes various sewer rehab and replacement projects and improvements to the Chattahoochee Tunnel and South Cobb Tunnel. Cobb County spent an estimated $133.6 million on improvements to the Chattahoochee Tunnel.
- **Gwinnett County's** Petition Sewer Program is designed to share costs between property owners and the County to provide sewer service to groups of residents who desire to connect to the public sewer system because they are experiencing septic tank failures.

The County has spent over $1 million since 2000 in this program to help improve water quality in local streams and reduce consumptive loss of water by conveying wastewater to be reclaimed and discharged back to waters of the State.

- **Fulton County** presently has over 100 flow meters installed at various points in the wastewater collection system that allow the County to monitor flow patterns and generally assess levels of inflow and infiltration (I & I). These assessments have been used as a basis for prioritizing rehabilitation projects aimed at reducing the levels of I & I. Presently, the County is undertaking rehabilitation work in the Big Creek and Morning Creek basins, with an $5.5 million spent in the Morning Creek Basin. Fulton County spent approximately $3.1 million in 2001 on the re-use distribution system from the Cauley Creek Plant for irrigation water at golf courses, large irrigation users and a few residential properties. The County has also spent an estimated $9.5 million on infrastructure improvements including sewer line relocation, rehabilitation and replacement since 2007.
- **City of Atlanta** spent $180 million on the 8.2-mile long Nancy Creek Tunnel that stores sanitary sewer overflows before they can be treated by R. M. Clayton WRF; its construction reduces sanitary sewer overflows by 70%. The West Area CSO Tunnel was approximately $250 million and designed to capture, store and convey CSO from the Clear Creek, Tanyard and North Avenue CSO Basins. The West Area CSO Storage Tunnel is 8.5 miles long and can store up to 177 MG of overflow from a rainstorm before being conveyed to a dedicated CSO treatment plant for pollutant removal and ultraviolet (UV) disinfection.
- **DeKalb County** spends an estimated $5 - $8 million annually on wastewater system improvements, an estimated $15 - $25 million annually in system maintenance, and an estimated $5 - $25 million on wastewater infrastructure assumptions from new developments.
- **Forsyth County** has spent $41 million over the last five years extending sewer infrastructure.
- **City of Cumming** completed the construction of several sewer infrastructure improvement projects in 2009. The Samples Road Pump Station, Force Main, and Gravity Sewer System were completed in 2009 at a cost of $1.6 million. The Cheatham Creek Gravity Sewer Line was installed in 2008 at a cost of $800,000. The Sawnee Creek Regional Wastewater Pumping Station, Force Main, and Cross-Town Gravity Sewer Relief Line were constructed in 2008 at a cost of $1.2 million. The Mary Alice Park Road Force Main and Gravity Sewer Projects were completed in 2009 at a cost of $300,000.

❖ ARRA FUNDED PROJECTS

- **Cobb County** was approved for a Clean Water State Revolving Fund (CWSRF) loan of $25 million. The loan will finance the third phase of construction of a 30,000 foot sewer tunnel, connecting tunnels, and a 130 million gallons-per-day lift station at the South Cobb Water Reclamation Facility.
- **Gwinnett County** was approved for a Clean Water State Revolving Fund (CWSRF) loan of $2 million and a CWSRF subsidy of $3 million for the installation of a power generator that will be fueled by gas drawn from anaerobic digesters. The electricity will be used to help power the wastewater treatment facility. The total project cost is $5.5 million with GEFA providing $5 million and Gwinnett County providing $500,000.
- **Gwinnett County** was approved for a Clean Water State Revolving Fund (CWSRF) loan of $6 million and a CWSRF subsidy of $4 million for the third phase of construction of a sewer tunnel to

store and convey wastewater to the site of the future No Business Creek Regional Pump Station. The total project cost is $55 million with GEFA providing the entire amount.

- **City of Lawrenceville** was approved for a Drinking Water State Revolving Fund (DWSRF) loan of $990,000 and a DWSRF subsidy of $660,000 for the extension and replacement of water mains. The total project cost is $1.65 million with GEFA providing the entire amount.

❖ GEFA FUNDED PROJECTS

- **COBB COUNTY: GEFA funded projects (non-ARRA)**
  - SOUTH COBB TUNNEL — $70 million
  - 369 ACRE RESERVOIR (Marietta Water Authority) — $59.6 million
  - POWDER SPRINGS (Rehab Sewer) — $654,000
- **FULTON COUNTY: GEFA funded projects (non-ARRA)**
  - EAST POINT (Leakage) — $11.5 million
  - ROSWELL (Line Construction) — $2.4 million
  - FULTON COUNTY (Water Treatment) — $2 million
  - VIRGINIA HIGHLANDS (Green Project) — $855,500
- **GWINNETT COUNTY: GEFA funded projects (non-ARRA)**
  - STORM WATER (NPS) SYSTEM — $5 million
  - REGIONAL WASTEWATER PUMPING STATION — $45 million
  - SUWANEE (Water Tank) — $499,000

❖ RE-USE PROJECTS

Jurisdiction	Reuse Projects
Fulton County	Fulton County has an active reuse program. The County provides up to 5 MGD of reuse quality water from its Cauley Creek Plant for irrigation water at golf courses, large irrigation users and a few residential properties. Additionally, Fulton County now has up to 15 MGD of reuse quality water available from the Johns Creek Environmental Campus; However, no distribution system yet exists from this facility.
Cobb County Water System	The Northwest Cobb WRF supplies reuse water to irrigate the Cobblestone Golf Course facility and the Acworth Sports Complex Baseball Field at the Cobb County Kenworth Park. The Northwest Cobb WRF is permitted to supply up to 2.0 MGD of reuse water to the supply pond for Cobblestone and the Baseball Field with separate delivery lines. Cobb County saves 75 million gallons per year in county government water reuse practices and 4 water treatment facilities save approximately 8 MGD through reuse water for processing and cleaning.

Forsyth County Department of Water and Sewer	In total, all Forsyth County plants provided approximately 40 million gallons of reuse water during July 2009. • The Fowler Water Reclamation Facility is permitted for 1.25 MGD and includes an 11-mile 20-inch reuse force main that supplies reuse irrigation water to a golf course, 5 County schools, a County school automated bus wash facility, one private school, 2 County parks, The Avenues commercial development, and 3 subdivision entrance features. The Fowler system also has 2 reuse hydrants that commercial contractors use to fill water trucks for construction water. • The Dick's Creek Water Reclamation Facility is permitted for 0.76 MGD and supplies reuse irrigation for a golf course, a rock quarry, a reuse hydrant for commercial contractors to fill water trucks for construction water, and landscaping for a residential development. • The Windermere Water Reclamation Facility is permitted for 0.55 MGD and provides reuse irrigation for a golf course and a County park. • The Manor Water Reclamation Facility is permitted for 0.5 MGD and provides reuse irrigation for a golf course and each residence within The Manor subdivision.
Gwinnett County	The reuse pipeline to Lake Lanier is currently under construction, and upon completion in 2010, the County will have the ability to discharge up to 40 MGD of highly treated reuse water directly into Lake Lanier, very close to the County's point of water withdrawal. At completion, the County's investment in that reuse line to the lake will exceed $70 million. This effort is now a national example of augmenting potable supplies with reclaimed water, and has gained the attention of the National Academy of Sciences and others. Currently the reuse line provides reclaimed water to a number of golf courses and parks, the Gwinnett Environmental and Heritage Center, F. Wayne Hill Water Resources Center, McGinnis Ferry Crossing mixed use Development, the Mall of Georgia and the new Gwinnett Braves Stadium. Gwinnett County distributed 180 MG of non-potable reuse water in 2008. Other projects that could be considered for reclaimed water service include golf courses, sports arenas/complexes, parks, commercial facilities, schools, LEED Buildings, and other projects that are non-consumptive (e.g. cooling towers). The location of the exiting reuse line does limit direct connection. One alternative a potential customer may consider is through the Reuse Trucking Program. This expansion of the reclaimed water program was developed in Spring 2008 for potential customers who complete an online training, meet vehicle requirements for transporting and operating within Gwinnett County to haul reuse water for irrigation. When Gwinnett expanded its program to allow truck distribution, the response from private industry was overwhelming despite their need to train employees and pay for annual truck inspections and permits.
DeKalb County Watershed	DeKalb has almost completed their reuse feasibility study and the estimated costs for the plan implementation are $30 million - $100 million.
Town of Braselton	The City currently provides reuse water to the Chateau Elan Golf Course and they have nearly completed the reuse distribution system for residential irrigation within the Chateau Elan community.
City of Flowery Branch	Reuse water is currently being sprayed at a land applied site until a consistent customer base can be established.

City of Gainesville	Both the Linwood Water Reclamation Facility (WRF) and the Flat Creek WRF return reuse standard wastewater to Lake Lanier. This is considered "In-direct" reuse.
Hall County	Hall County has a reuse program that supplies irrigation quality reuse to a local high school athletic complex, landscape irrigation to a regional library, and common areas on a large development in south Hall County. The County is awaiting more flows to be generated to be able to provide reuse to a golf course in the region. Hall County is also planning a reuse system with the Master Plan for North Hall that will provide reuse for 41,000 acres of potential development as well as water supply for two reservoirs Hall County operates or will operate.

❖ ADDITIONAL CONSERVATION EFFORTS

- **Cobb County**
  - The following WC programs have been implemented at a cost to the county of $688,000:
    - Cobb County has given away 10,000 home retrofit kits since 2005.
    - 5,000 1.5 gpm showerheads have been given away every October since 2005 as part of Cobb County's WaterSmart program's "take a shorter shower initiative".
    - Cobb County's single family toilet rebate program has replaced 2,689 1.28 gpf toilets at a $100 rebate and 5,137 1.6 gpf toilets at a $50 rebate since 2007 with an estimated water savings of 20.1 million gallons a year.
  - The Commercial Toilet Valve Rebate Program has spent $1,500 on rebating toilet valves for an estimated 33% reduction in water use for commercial customers who participated.
  - The County has further installed low flow fixtures in all County government buildings at a cost of $350,000.
  - Additional programs to promote conservation include participation in WaterSense initiatives like Fix a Leak Week, Efficient Irrigation Month, Reduce the Seasonal Peak, and the Energy and Water Efficient Sales Tax Holidays.
- **Gwinnett County**
  - Gwinnett County water usage per meter (all usage) has actually declined 35% from 1998 through 2008 from 400 MGD to 265 MGD. Residential demand has remained stable for the same 10 year period even with an annual growth of 25,000 citizens for the same 10 year period.
  - Gwinnett County has replaced 3,527 toilets (October 2009) through the toilet rebate program at a total cost of $300,000. The County saves an estimated 23 million gallons per year as a result of these toilet retrofits.
  - The County has distributed 11,001 leak detection tablets at an estimated cost of $4,510.
  - The County has distributed 1,785 low flow retrofit kits at an estimated cost of $13,405.
  - Single family household water use decreased by nearly 20% between 2006 and 2009.
  - The Department has invested over $15 million over the past decade in various technologies which help to optimize operations of the water system and assist in planning for the future. Some of the technologies included are an advanced GIS system, water and wastewater hydraulic models, SCADA systems, Derceto Pumping Optimization Software and asset management/work order systems.
  - Gwinnett County has provided pre-rinse spray valve educational material to all of its almost 1,800 restaurants and food service establishments.

- **<u>DeKalb County</u>**
  - DeKalb County has replaced at least 8,514 toilets (July 31, 2009) through the toilet rebate program at an estimated total rebate amount of $633,436. Because of this program, the County has conserved over 173 million gallons of water.
  - The County adopted the Inefficient Plumbing Fixtures Replacement Ordinance on February 26, 2008 that requires the owners of buildings/structures constructed before 1993 to replace all inefficient plumbing fixtures with low-flow water efficient plumbing fixtures upon reconnection for water service.
  - The County is reviewing and planning a revision and major upgrade for a water waste ordinance.
  - DeKalb County reached an agreement with the City of Dunwoody to utilize DeKalb County staff to enforce water ordinances in the City recorder court.
  - The County works closely with the Health Department to enforce septic tank issues by water shutoff until repairs are made.
  - DeKalb County has provided pre-rinse spray valve educational material to all of its 2,400 restaurants and food service establishments.
  - DeKalb County has provided over 1,800 low flow retrofit kits to residents.
  - DeKalb County has adopted a water waste ordinance.
- **<u>City of Atlanta</u>**
  - Clean Water Atlanta (CWA) Clean Water Atlanta is the City's comprehensive, long-term plan to ensure clean drinking water for Atlanta, clean streams and clean wastewater flows for Atlanta and its downstream neighbors. The objective of Clean Water Atlanta is to create the cleanest urban streams and rivers in the country within a decade. On October 16, 2002, Mayor Shirley Franklin announced the new Clean Water Atlanta initiative and unveiled a Five Point Plan for improving the city's wastewater system. The cost to implement Clean Water Atlanta is estimated at $3.8 billion for the four major program areas that include drinking water at an estimated $800 million, combined sewer overflow remediation at an estimated $1 billion, sanitary sewer system Improvements for an estimated $1 billion and water reclamation centers and other system improvements an estimated $1 billion. The Five-Point Plan includes the following areas:
    - Professional Management of Consent Decree Program through the Department of Watershed Management (DWM). The DWM is charged with planning, designing, constructing, operating and maintaining the City's entire system of water and wastewater treatment, pumping, collection and distribution, and proposed stormwater management facilities.
    - Reduce Flooding and Pollution Caused by Stormwater by implementing a stormwater utility to provide a steady and reliable source of revenue for reducing stormwater flooding and pollution and maximizing the use of natural pollution-reduction methods such as greenspace and ponds. A Stormwater Utility Master Plan is being developed that will outline the City's strategy for establishing the Stormwater Utility.
    - The Sanitary Sewer Overflow (SSO) Consent Decree Compliance addresses improvements in the City's sanitary sewer system and requires the elimination of sanitary sewer overflows (SSOs). The City is repairing, replacing or rehabilitating all 2,200 miles of sewer throughout the City and implementing long-term prevention and maintenance strategies under "Operation Clean Sewer." Operation Clean Sewer is an aggressive approach to inspecting, cleaning and relining the sewer

system, and includes a full-scale grease management program that was launched in January 2003.

- Water Quality Monitoring to Ensure Effectiveness of Clean Water Atlanta programs through a partnership with the U.S. Geological Survey and Southeast Waters to implement a comprehensive water quality monitoring plan.
- Under the Combined Sewer Overflow (CSO) Consent Decree Compliance the City will implemented the refined CSO Remediation Plan, which enabled the City to achieve the highest water quality at the lowest cost within the shortest time frame. The City's CSO Plan achieves 90% separation of the City's total sewer system and provides for the treatment of stormwater within the combined sewer area. CSOs will be reduced from more than 300 to an average of 16 per year. These remaining overflows will be screened, disinfected and dechlorinated before discharge to a receiving stream.

- The City of Atlanta has a three tier conservation rate structure for both residential and commercial customers.
- The City of Atlanta has replaced 2,191 toilets (October 2009) through the toilet rebate program at a total cost of $181,010. The City saves an estimated 4.4 million gallons per year as a result of these toilet retrofits.
- The City gives toilet valves to multi-family complexes.
- The City of Atlanta has provided pre-rinse spray valve educational material to all of its almost 2,000 restaurants and food service establishments.
- The City of Atlanta has provided over 113,000 low-flow retrofit kits to residents.
- The City has marketed their commercial audit program to their top 200 largest water using customers. To date, the City has conducted seven audits.
- The City of Atlanta SWAT (Save Water Atlanta Team) was created during the drought to enforce watering restrictions and conduct meter & irrigation system investigations.
- The City is a partner with the Green Plumbers Association, EPA WaterSense, and WaterSmart.
- The City of Atlanta has conducted water audits on elementary schools and is working with the schools to improve water efficiency.
- The City partnered with Trees Atlanta to have the non-profit collect water resulting from fire hydrant flushing and use it to maintain trees on public land throughout the City.
- The City of Atlanta will have all of their meters using automatic meter reading technology by 2010. This will improve the City's accuracy in reading meters and ultimately help to reduce the amount of non-revenue water and maximize rate payer dollars.

- **Fulton County**
  - Fulton County has replaced 1,440 toilets (October 2009) through the toilet rebate program at a total cost of $112,200. The County saves an estimated 3.6 million gallons per year as a result of these toilet retrofits.
  - Fulton County has provided pre-rinse spray valve educational material to almost 600 restaurants and food service establishments.
  - Fulton County has provided over 1,600 retrofit kits to residents.
  - Fulton County offers rain barrel workshops throughout the year and, to date, over 500 rain barrels have been given away.
  - Fulton County has reached over 20,000 people through a number of special community events such as Drinking Water Week, Water Conservation Day, Earth Day, Rivers Alive, Cool Waters, and Back to the Chattahoochee River Race and Festival.

- **Forsyth County**
  - Forsyth County has replaced 67 toilets (October 2009) through the toilet rebate program at a total cost of $5,470. The County saves an estimated 441,000 gallons per year as a result of these toilet retrofits.
  - Forsyth County has provided pre-rinse spray valve educational material to all of it almost 250 restaurants and food service establishments.
  - All Forsyth County school restrooms have been converted to waterless urinals and all new schools are built with waterless urinals.
  - The four Forsyth County high schools have artificial turf on their football fields to eliminate the need for irrigation.
  - Forsyth County has implemented a conservation rate structure as of February of 2006. This structure was modified in January 2009 to further increase water conservation.
  - The County is in the process of installing 5,000 e-coder meters for its highest water consuming customers at an anticipated cost of $935,000 with 1,200 already installed. The e-coder meters give the County the ability to monitor up to 96 days of 15-minute interval consumption data, which leads to accurate leak diagnostics and proactive leak notification. It also allows the county to easily enforce odd/even water restrictions when such restricts are in place.

❖ AWARDS WON

- **City of Atlanta**
  - 2008 Water Efficiency Leader Award to Rob Hunter (US Environmental Protection Agency)
  - 2007 Laboratory Analyst Award to Robert Williams (Water Environment Federation)
  - Department of Watershed Management
    - 2009 Platinum Award for Utility Excellence (Association of Metropolitan Water Agencies)
  - Chattahoochee Treatment Plant
    - 2007 Water Fluoridation Quality Award (Center of Disease Control)
  - 2001 Gold Award for Competiveness Achievement (Association of Metropolitan Water Agencies)
  - R. M. Clayton
    - 2001 Discharge Monitoring Report Quality Assurance Program Study 21 Letter Recognition (US EPA)
  - Utoy Creek Water Reclamation Center
    - 2003 Safety Award (Water Environment Federation)
    - L.E.E.D. certified Administration Building
    - National Environmental Laboratory Accreditation Program (US EPA)
  - Nancy Creek Tunnel
    - 2007 Public Works Project of the Year (American Public Works Association)
    - 2006 Outstanding Civil Engineering Achievement Award, Large Project category (American Society of Civil Engineers)
- **Fulton County**
  - The Atlanta-Fulton County Water Treatment Plant:
    - 2007 "Star Award" (U. S. Department of Occupational Safety and Health Administration's Voluntary Protection Program)

        - 2006 Distinguished Public-Private Partnership Service Award (National Council for Public-Private Partnership)
        - 2006 Partnership for Safe Drinking Water (American Water Works Association)
        - 2006 Georgia Wide Optimization Program Award (Georgia Environmental Protection Division)
        - 2006 Safety Award in the Surface Water Category (GA/AWWA and Georgia Association of Water Professionals)
        - 2006 Georgia Department of Labor Award of Excellence
    - 2009 Outstanding Operation of Wastewater Facility Greater than 10.0 MGD (Georgia Association of Water Professionals)
    - 2008 Plant of the Year for Big Creek WTP (Georgia Association of Water Professionals)
    - Water Environment Federation – Lab Analyst of the Year Award (Marie Bah), 2006
    - 2004 Environmental Award Wastewater from Air and Waste Management for the Cauley Creek WRF from the Georgia Chapter
    - 2003 Operator of the Year at the Little River WTP (Georgia Association of Water Professionals)
    - 2004 and 2008 Public Education Program of the Year (Georgia Association of Water Professionals)
    - The Presidents Volunteer Service Award 2008
- **<u>Gwinnett County</u>**
    - 2009 Reclaimed Water Program Innovative Drought Relief (National Association of Counties Achievement Award)
    - 2009 Reclaimed Water Program (ARC CREATE Award / Environmental Sustainability)
    - 2009 Reclaimed Water Program (ACCG County Excellence Award for Drought Relief and Reclaimed Water)
    - F. Wayne Hill Resources Center
        - 2005 and 2008 Plant of the Year (Georgia Association of Water Professionals)
        - 2007 Honor Award for Engineering Excellence (Georgia Engineering Alliance)
    - Shoal Creek Filer Plant
        - 2004 and 2007 Plant of the Year (Georgia Association of Water Professionals)
    - Jackson Creek Water Reclamation Facility
        - 2001 and 2002 Plant of the Year (Georgia Water & Pollution Control Association)
    - 2007 Cross Connection Control Program of the Year (Georgia Association of Water Professionals)
    - 2003 Public Education Award Program of the Year (Georgia Association of Water Professionals)
    - 2000 Water Resources Project of the Year (Georgia Water & Pollution Control Association)
    - 2000 Gwinnett County Department of Water Resources Outstanding Operations (Georgia Water & Pollution Control Association)

- **<u>Cobb County Water System</u>**
    - 2008 EPA WaterSense Large Promotional Partner of the Year
    - 2007 Fox McCarthy Water Wise Award For an Outstanding Water Efficiency Program (Georgia Association of Water Professionals)
    - 2002 and 2006 Public Education Program of the Year Award For an Exemplary Public Education Program that promotes understanding of the water and wastewater industry and the importance of protecting our water resources (Georgia Association of Water Professionals in 2006 and Georgia Water & Pollution Control Association in 2002)

- 2006 Achievement Award In recognition of an innovative program which contributes to and enhances county government in the United States – Cobb County Georgia Water Efficiency Program (National Association of Counties)
- 2000, 2002, 2004 and 2006 Award for Outstanding Operation of a Water Distribution System In the category of Large Systems (Georgia Water & Pollution Control Association)
- 2000, 2003. 2006 and 2008 Wastewater Collections Award For Outstanding Operation of a Wastewater Collection System In the category of Large Systems (Georgia Association of Water Professionals and Georgia Water & Pollution Control Association)
- The Chattahoochee Tunnel
  - 2006 State Award for Engineering Excellence (The American Council of Engineering Companies of Georgia and the Georgia Engineering Alliance)
  - 2005 Outstanding Civil Engineering Achievement of the Year (The American Society of Civil Engineers, Georgia Section)
- South Cobb Water Reclamation Facility
  - 2003 and 2005 Plant of the Year Facility Award For Outstanding Operation of a Wastewater Treatment Facility in the category of Advanced Treatment Greater than 10.1 MGD (Georgia Water & Pollution Control Association)
  - 2003 National Clean Water Act Recognition Award For a facility in Advanced Treatment Category greater than 10 MGD (Environmental Protection Agency)
- Northwest Water Reclamation Facility
  - 2002, 2003, 2005 Plant of the Year Facility Award For Outstanding Operation of a Wastewater Treatment Facility in the category of Advanced Treatment Less than 10 MGD (Georgia Water & Pollution Control Association)
- R.L. Sutton Water Reclamation Facility
  - 2002 and 2004 Plant of the Year Facility Award For Outstanding Operation of a Wastewater Treatment Facility in the category of Advanced Treatment Greater than 10.1 MGD (Georgia Water & Pollution Control Association)
- Noon Day Creek Water Reclamation Facility
  - 2001 Plant of the Year Facility Award For Outstanding Operation of a Wastewater Treatment Facility in the category of Advanced Treatment Greater than 10.0 MGD Noonday Creek WRF (Georgia Water & Pollution Control Association)
- Resolution in Appreciation of the Cobb County Water System, Cobb County-Marietta Water Authority, and the Marietta Board of Lights and Water (Cobb Chamber of Commerce, October 26, 2000)

➢ **<u>Forsyth County</u>**

- Antioch Water Treatment Plant
  - 2001 Plant of the Year Facility Award for "Outstanding Operation" (Georgia Association of Water Professionals)
- Community Watershed Assessment Project
  - 2001 Metro Atlanta Engineers Engineering Excellence Award
  - 2000 Region IV EPA Environmental Merit Award for the
- Forsyth County Water System
  - 2001 and 2009 "Best Tasting Water" in the District (Georgia Association of Water Professionals)
  - 2007 Water Fluoridation Quality Award (Center for Disease Control)
- Fowler Water Reclamation Facility
  - 2006 Plant of the Year Facility Award for "Outstanding Operation" (Georgia Association of Water Professionals)
  - 2004 "Engineering Excellence" (Award American Council of Engineering Companies)
- Manor Water Reclamation Facility

- 2008 National First Place Clean Water Act Recognition Award for Operations and Maintenance (United States Environmental Protection Agency)
- 2008 Excellence Award to Sawnee Mountain Preserve Visitors Center (Association County Commissions of Georgia and "Georgia Trend Magazine")

CERTIFICATIONS ACHIEVED

Cobb County Water System

- Water and Wastewater staff all have national and state required certifications
- 2005 WaterFirst Community Designation

Gwinnett County

- 2003 and 2008 Water First Community Designation – Department of Community Affairs
- Gwinnett County Environmental and Heritage Center – LEED Certified 2003
- AALA – Laboratory Accreditation (ongoing)
- 2008 EPA WaterSense Program Partner

Fulton County

- American Association for Laboratory Accreditation 1996 - 2009
- North Fulton Water Laboratory 1980 – 2009 Georgia State Certified Drinking Water Lab

City of Atlanta

- The Administration building at the Utoy Creek Water Reclamation Center (WRC) is LEED certified.
- The wastewater laboratory at the Utoy Creek WRC is certified through US EPA National Environmental Laboratory Accreditation Program.

EDUCATION AND OUTREACH ACTIVITIES

- **Cobb County** has numerous education and outreach efforts. The County spent an estimated $50,000 constructing two demonstration projects that include the rain garden at the Cobb County Water System office and the ET Controller Test Project. They have also created ten educational videos on different water conservation tips like efficient irrigation, rain barrel construction, detecting leaks, and many others. The County also publishes bill flyers quarterly, two newsletters throughout the year, and a number of other educational materials like brochures and posters. The Cobb County Water System staff gives approximately 125 presentations a year on various water resources topics. Cobb estimates these education and outreach efforts to cost $25,000 a year.

- **DeKalb County** publishes *Water Matters* in every billing cycle to provide customers information on water issues. DeKalb has also created numerous brochures on water conservation, Fats Oils and Grease (FOG), Xeriscape gardening, and other water facts. The County has also funded commercials, radio ads, newspaper ads, and movie ads in an effort to educate residents on water issues. County employees also give presentations to schools, homeowners associations, and special interest groups in an effort to educate their citizens.

- **Fulton County** estimates that their education and outreach activities cost $500,000. One of the largest education projects is the demonstration rain garden located at the Atlanta-Fulton County Water Resources Commission's water treatment plant that educates residents on responsible and water-efficient landscaping. The County has produced two educational videos on water conservation and fats, oils, and grease (FOG). In addition to providing residents with brochures created by the Metro Water District, the County has developed other brochures like drought guides, commercial water conservation tips, and how to conduct a commercial water audit. County employees also give at least 25 presentations a year on water issues.

- **Gwinnett County** has invested over $2 million in water conservation efforts in the past 9 years. Included in these costs are the development of three educational videos, 22 bill inserts, and 45 newsletters to inform residents about water related issues. The County has also given approximately 285 presentations over the past ten years. One unique hands-on education opportunity offered by the County is the Lanier Landscaping Project at the Lanier Filter Plant.
- **City of Atlanta** provides monthly bill stuffers and brochures at municipal facilities to inform customers of water topics. In addition to maintaining an informational website, the Watershed Department provides educational DVDs to the government cable station to air on City Channel 26. The Watershed staff also give 8 – 10 presentations a year to businesses, professional associations, and civic groups. The City has also worked to provide two unique programs, Care and Conserve (leak repairs & fixture retrofits for low-income Atlantans) and the Green Plumbers workshops. The City has recently created Club H20, an after-school program that follows the Project W. E. T. curriculum to promote awareness, appreciation, knowledge and stewardship of water resources among elementary school students. The City also works with the Upper Chattahoochee Riverkeeper & the Ellachee Nature Center to implement The Floating Classroom education program that teaches water ecology and hands-on activities to Atlanta Public School students. Already in 2009, The City of Atlanta has held over 210 education and outreach events. This City has offered over 20 workshops in 2009 covering many topics such as leak detection and repair, rain barrels, and outdoor water efficiency.
- **Forsyth County** provides several methods by which the public can stay informed as to water conservation. *The Current*, which is available online, is a newsletter which is designed to inform the community about important county topics, including water conservation and ways to become more involved within the local community. Keep Forsyth County Beautiful (KFCB) is an organization created to support the County's effort to cooperate with businesses, schools, civic organizations and citizens in order to improve beautification, reduce littering and promote recycling. Last year Forsyth County budgeted in excess of $200,000 for KFCB. TV Forsyth (on Comcast channel 23) broadcasts a variety of county meetings as well as original programming focused on informing citizens about the county. The channel also displays electronic bulletin board messages that provide information about government meetings, events, programs and more; including information on water conservation. EnviroScape® Classes teach about point source and non-point source water pollution in a typical community landscape. Build a Watershed activities teach how the location of building and roads can affect watershed runoff. The Volunteer Storm Drain Marker Program serves as a reminder about the connection between storm drains and local water resources. In 2008, the Rivers Alive Cleanup removed 6,450 pounds of debris from Lake Lanier and Chattahoochee shore lines.

PUBLIC PARTICIPATION & INVOLVEMENT ACTIVITIES

- **Cobb County** is very active in involving their residents in participation activities. They offer over 45 hands-on workshops a year covering topics from outdoor water use to how to create a rain barrel. Their water and wastewater facilities conduct more than 40 tours a year. The Water System staff is active in the school system and usually participates in over 50 school outreach activities a year. The County usually holds at least 5 training activities and 5 events a year. They have three contests which include the Allatoona Ally coloring book contest for elementary school students, The Rain Barrel of Fun Contest, and Mission Impossible Project for high schools in partnership with Cobb County Marietta Water Authority.

- **DeKalb County** has a number of activities to involve residents in water issues. They hold over 100 workshops a year to address topics like water wise landscaping, rain barrels, and fixing leaks. Many plant tours and the 2007 AWWA Annual Conference have occurred at the new Scott Candler treatment plant to inform residents and other interested parties about the plant. The County also held two symposiums on water issues in the past two years to educate DeKalb residents. The County staff give presentations and conduct activities at the elementary, middle, and high schools. Additionally, they work to provide Xeriscape gardens at the schools and they hold an annual art contest for elementary school students.

- **Fulton County** has an extensive public participation and activities program. They hold over 45 workshops a year that cover topics such as water wise landscaping, rain barrels, fixing leaks, rain gardens, and many more. They provide an estimated 75 tours at their water treatment facility. They have an active school outreach program that includes library programs, summer camps, workshops, career day programs, and participation in the schools' programs. Additionally, the County has held five training activities and 25 water related festivals and events. County staff have also attended over 35 community events to discuss water issues.

- **Gwinnett County** holds over 10 workshops each year addressing water wise landscaping, rain barrels, commercial water audits, and rain gardens. They have also held three festivals, nine water related events, and 30 training activities. They have an extensive school outreach program that costs an estimated $100,000 to provide school outreach activities and contests.

- **City of Atlanta** held 21 community workshops in 2009 for a variety of audiences, such as the top 100 large water users, senior citizens, and homeowners associations. The Watershed Department staff also attend community events and public participation activities to educate residents. The City is also working to create a Citizen Advisory Group. The Watershed Department also attends the Neighborhood Planning Unit meetings to address water issues that the citizens might have. The City created the "Water on Wheels" van as an interactive educational display about water. The City has held over 75 public participation events already in 2009. The City is working to adopt a water waste ordinance and develop a Xeriscape demonstration garden.

- **Forsyth County** held over 50 education and outreach activities and over 20 public participation and involvement activities in 2009. The County offered workshops and classes on rain barrels and held demonstrations on watersheds and stormwater run-off. The County also held classes and workshops on Adopt-a-Stream and organized waterway cleanups.

Exhibit 52

GEORGIA DROUGHT MANAGEMENT PLAN

1) DROUGHT DECLARATION PROCESS

2) AGENCIES and ORGANIZATIONS

3) PRE-DROUGHT STRATEGIES

4) DROUGHT RESPONSES

5) DROUGHT INDICATORS and TRIGGERS

6) CLIMATE DIVISIONS MAP

March 26, 2003

GEORGIA DROUGHT MANAGEMENT PLAN
Preamble

The Georgia Drought Management Plan as approved by the Department of Natural Resources Board on March 26, 2003 consists of pre-drought mitigation strategies and drought response strategies.

Pre-drought mitigation strategies are measures designed to minimize the potential effect of drought. They are water conservation measures predominantly.

Drought response strategies are measures or actions to be implemented during various stages of drought.

The Georgia General Assembly and the Board of Natural Resources have previously assigned the Environmental Protection Division director significant drought management responsibilities and mandates. The director also shall have those designated responsibilities and mandates contained herein.

Divisions of DNR are required to implement provisions of this plan as soon as practicable.

Non-DNR state, federal, and local agencies and other organizations identified herein are encouraged to implement those aspects of the plan identified as appropriate to the entity as soon as practicable.

The actions and responses contained in this document are the result of a collaboration of approximately 85 citizens with an interest and expertise in water related matters.

These citizens represent a geographical and political cross section of the state, as well as a cross section of business, industry, environmental, and water management.

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Section 1) DROUGHT DECLARATION PROCESS

The following is the process for declaring drought conditions and responses:

1A): The State Climatologist's office and EPD will routinely monitor and evaluate stream flows, lake levels, precipitation, groundwater levels, and other climatic indicators that are supplied by several cooperating entities, principally the U. S. Army Corps of Engineers, the US Geological Service, and the National Drought Mitigation Center. These indicators reflect the health of the hydrologic system. They are referred to as drought indicators in this document. The indicators for each of Georgia's nine-climate divisions are described in section six of this document.

Each of the nine-climate divisions has several indicators. If any one of the indicators in any one or more of the nine climate divisions reaches or passes a certain prescribed condition for two consecutive months, a preliminary evaluation by the state climatologist and the EPD director is triggered.

If the preliminary evaluation indicates the possible need for a drought response declaration for that climate division and all or part of the relative hydrologic regions in and adjacent to that climate division, the director will consult with members of the Drought Response Committee (see 1E) to determine the potential severity of the drought condition(s), and the expected impacts. The director, in consultation with the committee, will make a determination of the appropriate level of response, if any, to be made. Response guidance for each level of drought severity is provided by this plan, but particular drought conditions may require greater or lesser responses than those contained herein.

The director and, as appropriate, other members of the committee will notify the local RDC's, local governments and water supply providers as to the appropriate action to be taken. Press releases will be prepared explaining the situation and state response requirements.

The State Climatologist and EPD will continue to monitor the drought indicators for indication of changing conditions, and will act in response to those changing conditions. The director will consult with the Committee as necessary and will keep the Committee apprised of changes in climate conditions.

As further explained in the Drought Indicators section of this plan, as conditions improve a conservative approach is to be taken. All of the drought indicators for the climate division should be in a more favorable condition for at least four consecutive months before the director takes action to decrease the level of drought response requirements.

1B): Numerous agencies and organizations are tasked in this plan with some level of water resource or water related management responsibilities. EPD and those agencies and organizations shall coordinate closely and share information about their drought or water conservation concerns and solutions.

1C): The Drought Response Committee shall review this plan at least every five years, and after each drought event to evaluate the performance and suitability of the drought indicators, the effect of the pre-drought and drought responses, and to what extent the plan is being followed. Based on this evaluation, the Committee shall make appropriate changes.

1D): The pre-drought strategies contained in this plan are principally water conservation strategies. They should be implemented and followed at all times, not just during a drought situation. The DNR water conservation coordinator, as well as some agencies, RDC's, local governments, and water supply providers have (or will develop) water conservation plans. Those plans and this drought management plan should be as seamless and non-conflicting as possible. As water conservation plans are developed, they should, at a minimum, reflect the pre-drought strategies of this plan as appropriate to the responsibilities and audience of the planning entity. As those plans are developed, they shall be provided to EPD. If appropriate, this plan shall be modified to reflect the measure(s) contained in those plans.

1E): The director shall convene as necessary a Drought Response Committee. The committee membership shall include the EPD Director as convener and chair, as well as senior managers of DNR's WRD, P2AD, and CRD and the water conservation coordinator. Also, DCA, GDOA, GEMA, GFC, GSWCC, GW&PCA, OSC, ARC, GUAC, USACE, USGS, USF&WS, one RDC, one NGO, and one representative organization each of the business community and agriculture industry, shall be represented.

1F): This plan recommends incentives and actions that may require funding. Funding requests (grants and/or appropriations) shall be developed by the participating agencies and supported by the committee.

Section 2): Agencies and organizations:

Acronyms

ACCG	Association County Commissioners of Georgia
ARC	Atlanta Regional Commission
CE	Cooperating Entities
CES	Cooperative Extension Service
CRD	Coastal Resources Division, Georgia Department of Natural Resources
DCA	Department of Community Affairs
DNR	Department of Natural Resources
EPD	Environmental Protection Division, Georgia Department of Natural Resources
FB	Farm Bureau
GDHR	Georgia Department of Human Resources
GDOA	Georgia Department of Agriculture
GEFA	Georgia Environmental Facilities Authority
GEMA	Georgia Emergency Management Agency
GEP	Georgia Environmental Partnership
GFA	Georgia Forestry Association
GFC	Georgia Forestry Commission
GMA	Georgia Municipal Association
GRWA	Georgia Rural Water Association
GSWCC	Georgia Soil and Water Conservation Commission
GUAC	Georgia Urban Agriculture Coalition
ME	Marine Extension
NGO	Non-Government Organization
OSC	Office of the State Climatologist
P2AD	Pollution Prevention Assistance Division, Georgia Department of Natural Resources
RDC	Regional Development Center(s)
UGA	University of Georgia
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
USG	University System of Georgia
USGS	U.S. Geologic Survey
WRD	Wildlife Resources Division, Georgia Department of Natural Resources

GEORGIA DROUGHT MANAGEMENT PLAN

PRE-DROUGHT STRATEGIES AND DROUGHT RESPONSES
SECTION 3 - PRE-DROUGHT STRATEGIES

"Pre-drought strategies" are longer-term actions, implemented before a drought, for the purposes of preparedness, mitigation, monitoring, and conservation. "Drought responses" are shorter-term actions, implemented during a drought, according to the level of drought severity.

Section 3A: MUNICIPAL AND INDUSTRIAL– PRE-DROUGHT STRATEGIES

1. State actions

- Formalize the Drought Response Committee as a means of expediting communications among state, local, and federal agencies and non-governmental entities. [EPD, OSC, CE]
- Establish a drought communications system between the state and local governments and water systems. [EPD, OSC]
- Provide guidance to the local governments and water supply providers on long-term water supply, conservation and drought contingency planning. [DNR, EPD]
- Review the local governments and water supply providers' conservation and drought contingency plans. [EPD]
- Work with the golf course and turf industry to establish criteria for drought-tolerant golf courses. [EPD, P2AD]
- Encourage water re-use as opposed to additional withdrawals of raw water. [EPD, P2AD]
- Work with local water systems to provide water efficiency education for industry & business. [P2AD, CES]
- Through the Georgia Environmental Partnership, conduct voluntary water audits for businesses that use water for production of a product or service. [P2AD]
- Identify vulnerable water dependent industries (e.g. poultry, seafood, urban horticulture), and, as necessary and as funding is available, fund research to help determine impacts and improve predictive capabilities. As a long-term strategy, develop programs to assist communities impacted by drought effects on vulnerable industries. [P2AD, USG, CE, GDCA]

- Develop criteria for a voluntary certification program for landscape professionals (landscapers, golf course mangers, irrigation installers). [GUAC, EPD]

- The DNR water conservation coordinator is charged with developing and implementing a statewide water conservation program to encourage local and regional conservation measures. [EPD, DNR conservation coordinator, CE]

- Develop and implement an incentive program to encourage more efficient use of existing water supplies. [DNR, EPD, GDCA]

- At all times, including non-drought conditions, unless further restricted by the director or local authorities, outdoor watering shall follow the schedule specified in Section 4A. Exemptions to such schedule will be in accordance with Section 4A.

2. Local/regional actions

- Develop and implement a drought management and conservation plan, incorporating as many of the actions as are appropriate to the local or regional entity

- Assess and classify drought vulnerability of individual water systems (e.g., # of days/weeks supply remaining under certain drought conditions, water source, and soil moisture).

- Define pre-determined drought responses, with outdoor watering restrictions being at least as restrictive as the state minimum requirements listed below.

- Establish a drought communications system from local governments and water supply systems to the public.

SECTION 3B: AGRICULTURE – PRE-DROUGHT STRATEGIES

1. Farmer Irrigation Education

- Recommend that farmers attend classes in best management practices and conservation irrigation, prior to (i) receiving a permit, (ii) using a new irrigation system, or (iii) irrigating for a coming announced drought season. [EPD, OSC, CE]

- Provide for additional continuing education opportunities for farmers throughout the year. [CES]

- Distribute to existing permit holders and encourage the use of best management practices, conservation irrigation, efficient use of irrigation systems, and the Cooperative Extension Service's water conservation guidelines. [EPD, P2AD, CES]

- Collaborate with Cooperative Extension Service to develop web-based information directly linked to Stripling Irrigation Research Park and supporting faculty, the Hooks-Hanner Center, and other research facilities. [EPD]

- Develop electronic database for communicating with permit holders. [EPD, CE]

- Encourage the development and distribution of information on water efficient irrigation techniques. [EPD, P2AD, CES]

2. Field / Crop Type Management

- Encourage the use of more drought resistant crops, subject to market conditions. [CES, CE]

- Encourage the use of innovative cultivation techniques to reduce the amount of water needed or lost by a crop during summer. [CES, CE]

- The appropriate agencies should conduct crop irrigation efficiency studies. [CES, UGA]

- Provide farmers with normal year, real time irrigation, irrigation scheduling, and crop evaporation/transpiration information. [EPD, OSC, CES]

- Monitor soil moisture and provide real time data to farmers. [EPD, CES, OSC]

3. Irrigation Equipment Management

- For new systems, encourage the installation of water efficient irrigation technology. [EPD, CE, CES, GSWCC]

- For older systems, recommend retrofitting with newer and better irrigation technology (e.g., travelers or water cannons replaced by spray on drops or under plastic drip irrigation for vegetable crops). Set goal for complete overhaul in 5 to 7 years. Recommend updating any system over ten years old. [EPD, CE, CES, GSWCC]

- Provide information and encourage farmers to take advantage of available financial incentives (tax credits, BMP cost share programs, buy-back programs, etc.) for retrofitting and updating older or less efficient systems. Prepare and distribute a list of such incentives. [GSWCC, FB]

- Recommend irrigation system efficiency audits every five to seven years. [GSWCC, CES, EPD]

4. Government Programs

- Improve irrigation permit data to create a high degree of confidence in the information on ownership, location, system type, water source, pump capacity, and acres irrigated for every irrigation system in Georgia. Use this information to determine which watersheds and aquifers will be strongly affected by agricultural water use, especially in droughts. [EPD, CES]

- Improve on the agriculture irrigation water measurement and accounting statewide. [EPD, GSWCC]

- Improve communications and cooperation among farmers and relevant state and Federal agencies regarding available assistance during drought conditions. [EPD, GDOA, GSWCC, GEFA]

- Support legislation and efforts (research, loan opportunities, and infrastructure improvements) to enhance the ability of farmers to secure adequate water supplies during drought conditions. For instance, establish low interest loan program for construction of on-farm off-stream storage facilities (ponds for surface water irrigation). [EPD, DNR, GEFA, CES, CE, GSWCC]

SECTION 3C: WATER QUALITY, FLORA, AND FAUNA – PRE-DROUGHT STRATEGIES

1. State actions

- Encourage all responsible agencies to promote voluntary water conservation through activities such as:
  - Developing and distributing information (e.g., public service announcements) to all user groups about:
    Efficient irrigation methods and techniques,
    Efficient home water use,
    Available services (i.e., audits, literature, technical information including evaporation – transpiration rates, and other information).
  - Recommending and explore providing for incentives, or requiring installation and use of automatic rain shut-off devices for irrigation systems.
  - Providing for and conducting "Home and Farm Assist" water conservation audits.
  - Encourage and explore providing for incentives for irrigation users to have irrigation system audits performed.
  - Providing updated information and incentives for water efficient/low impact landscaping.
  - Establishing conservation pricing rate structures.
  - Encourage agriculture and industry to maximize water use efficiency at all levels of production and services. [EPD, P2AD]

- Monitor streamflow and precipitation at selected locations on critical streams [USGS, EPD,]
- Monitor water quality parameters, such as temperature and dissolved oxygen at selected critical streams [USGS, EPD]
- Provide the streamflow and water-quality data in real time for use by drought managers; and work with drought managers to optimize information delivery and use [USGS, EPD]
- Evaluate the impact of water withdrawals on flow patterns, and the impact of wastewater discharges on water quality during drought [USGS, EPD, USF&WS, WRD]

- Investigate indicators and develop tools to analyze drought impacts for waterways such as:
  - Coastal ecosystems (considering flows, flooding periods, salinity, and previous season's spawning or harvest success of sensitive species)
  - Thermal refuges such as the Flint River
  - Trout streams
    [CRD, WRD, ME, UGA]

- Improve the agencies capabilities and resources to monitor land-disturbing activities that might result in erosion and sedimentation violations. This capability is important because, during drought, dry soil surfaces can increase the rate of runoff while low stream-flows make streams more vulnerable to the effects of storm-water runoff. [EPD, GSWCC, CES]

- Identify funding mechanisms and develop rescue and reintroduction protocols for threatened and endangered species during extreme events. [USFWS, WRD]

- Develop and execute an effort to identify pollutant load reduction opportunities by wastewater discharge permit holders (i.e., below levels in wastewater discharge permits). These reductions will be implemented during drought flow periods as a voluntary commitment on the part of permit holders. [EPD]

- Develop and execute an effort to identify opportunities for industry to decrease water use during drought periods (i.e., use less water in producing products and services during drought, and thereby potentially reducing quantity of wastewater discharged). Incentives ought to be considered to encourage voluntary participation. [P2AD]

- Evaluate the impact of water withdrawals on flow regimes and the impact of wastewater discharges on water quality during drought. [EPD, USGS, CE]

- Develop and promote implementation of sustainable lawn care programs based on selected BMPs and/or integrated pest management practices. Educate landscape professionals and individual homeowners on proper application of pesticides and fertilizers and conservation of water in order to reduce effects on water quality. The target audiences among landscape professionals include lawn maintenance contractors, landscape installation contractors, golf course superintendents, commercial lawn care providers and retail garden centers; education could be provided as part of a voluntary certification program for landscape professionals (see pre-drought M&I strategies). [P2AD, GUAC, GDOA, UGA, CES, CE]

- Encourage protection and restoration of vegetated stream buffers, including incentives for property owners to maintain buffers wider than the minimum required by state law. [EPD, CE]

- Provide for protection of recharge areas through measures including land purchase or acquisition of easements. [EPD, CE]

- Encourage and explore wildland fire mitigation measures (such as pre-suppression firebreaks, fuel reduction burning, mowing, and outdoor fire safety measures for homesteads and farms). [GFC, GFA]

- Enhance programs to assist landowners and farmers with outdoor burning. [GFC, GFA]

PRE-DROUGHT STRATEGIES AND DROUGHT RESPONSES

SECTION 4: DROUGHT RESPONSES

"Pre-drought strategies" are longer-term actions, implemented before a drought, for the purposes of preparedness, mitigation, monitoring, and conservation. "Drought responses" are shorter-term actions, implemented during a drought, according to the level of drought severity.

Section 4A: MUNICIPAL AND INDUSTRIAL – DROUGHT RESPONSES

1. **Outdoor Watering Reduction Schedule:**

- Outdoor watering other than those exempted activities is to occur only on scheduled days
- Prior to onset of declared drought conditions, outdoor water use can occur during any hours on the scheduled days.
- During declared drought conditions, outdoor water use will only be allowed during scheduled hours on the scheduled days.

"Scheduled days are defined as follows":

- Odd-numbered addresses may water on Tuesdays, Thursdays, and Sundays.
- Even-numbered or unnumbered addresses may water on Mondays, Wednesdays, and Saturdays.

"Scheduled weekend day is defined as follows":

- Odd-numbered addresses may water on Sundays.
- Even-numbered or unnumbered addresses may water on Saturdays.

Schedule for Outdoor Water Use during Declared Drought Response Levels:

<u>Declared Drought Responses: Level One:</u>

Water on scheduled days - 12 midnight to 10 a.m - and - 4 p.m. to 12 midnight.

<u>Declared Drought Response: Level Two:</u>

Water on scheduled days - 12 midnight to 10 a.m.

<u>Declared Drought Response: Level Three:</u>

Water on scheduled weekend day - 12 midnight to 10 a.m.

<u>Declared Drought Response: Level Four:</u>

Complete outdoor water use ban

1a. Landscape Irrigation – Established Landscapes

Residential, commercial, industrial, governmental, and recreational landscapes:

° Established Landscapes using small capacity wells not requiring EPD water withdrawal permits for groundwater use are exempt from the above schedule.

° EPD will grant exemptions from the above schedule for use of recycled treated wastewater as determined on a case-by-case basis by EPD.

- Irrigation of personal food gardens is exempt from restrictions.
- Irrigation of landscapes (turf, ornamentals, annuals, and containerized plants) follows declared drought response levels schedule (above).

1b. Landscape Irrigation – Newly Installed Landscapes (in place less than 30 days)

Residential, commercial, industrial, governmental, and recreational landscapes

- Irrigation of landscapes (turf, ornamentals, annuals, and containerized plants) allowed any day of the week, during allowed hours for the level in effect, for a period of 30 days following installation. After this 30-day period, irrigation of newly installed landscapes follows schedule for established landscapes.
- For landscapes installed by licensed professionals, please see commercial exemptions below.

1c. Golf Courses

- Irrigation of fairways shall follow landscape irrigation schedules above, for unnumbered addresses.
    - o Golf course using small capacity wells not requiring EPD water withdrawal permits for groundwater use are exempt from the above schedule
    - o EPD will grant exemptions from the above schedule for use of recycled treated wastewater as determined on a case-by-case basis by EPD.
- Irrigation of greens and tees are exempt from restrictions.

1d. Other Restricted Outdoor Water Uses

Follow Basic schedule for Levels One and Two: Listed Activities are prohibited for Levels Three and Four.

- Filling installed swimming pools (except when necessary for health care or structural integrity)
- Washing vehicles, such as cars, boats, trailers, motorbikes, airplanes, golf carts
- Washing buildings or structures (except for immediate fire protection)
- Non-commercial fund-raisers, such as car washes
- Using water for ornamental purposes, such as fountains, reflecting pools, and waterfalls (Except when necessary to support aquatic life)

Basic schedule for Level One: Prohibited for Levels Two, Three, and Four.

- Washing hard surfaces, such as streets, gutters, sidewalks, driveways (Except when necessary for public health and safety)

Prohibited during all Levels

- Using hydrants for any purpose other than firefighting, public health, safety, or flushing.

2: Commercial Uses Exempt from State-Mandated Outdoor Water Use Restrictions

- Professional licensed landscapers, golf course contractors, and sports turf landscapers: during installation and 30 days following installation only. Professional landscapers must be licensed for commercial exemptions to apply.
- Irrigation contractors: during installation and as needed for proper maintenance and adjustments only
- Sod producers
- Ornamental growers
- Fruit and vegetable growers
- Retail garden centers
- Hydro-seeding
- Power-washing
- Construction sites (e.g., to re-implement vegetation after earth moving)
- Producers of food and fiber
- Car washes
- Other activities essential to daily business

Prudent water management will be expected of all commercial uses.
Note that some of these state allowed exemptions may be curtailed in drought response levels 3&4 by locally imposed restrictions

3: Local and Regional Options:

In the event of an emergency at the local water supply provider or government level, contact EPD and GEMA for assistance as appropriate.

In addition to the mandated requirements outlined above, local and regional authorities retain the option of going beyond the State's minimum provisions and specifying additional pre-drought strategies or drought responses within their jurisdiction. Action items to consider at the local/regional level include, but are not limited to, the following: developing system integration and interconnection to reduce drought vulnerability, placing additional water use restrictions on specific commercial uses, and placing additional restrictions on outdoor watering.

Water conservation and drought mitigation strategies should include conservation pricing. Local governments and water supply providers are strongly encouraged to evaluate a number of conservation pricing options and select the one that most readily satisfies their goals for water conservation. DNR's Water Conservation Manager, EPD and P2AD, as well as DCA, ARC and the RDC's can provide assistance in this effort.

- Non-conservation pricing: Defined, as decreasing or flat pricing as quantity used increases - should be eliminated.

- Conservation pricing: Defined as; 1) rates in which the unit price increases as the quantity used increases – or- 2) seasonal rates or excess-use surcharges to reduce peak demands during summer months - should replace non-conservation pricing.
- The conservation pricing base price should be sufficient to cover the costs of operating and maintaining the system. Income above this amount derived from increased charges to heavy users should be used to fund incentive programs to effect efficiency in water use.

Section 4B: Agriculture Drought Response:

- Implement the Flint River Drought Protection Act whenever severe drought conditions are predicted in the Flint River Basin. Measure and improve the effectiveness of the protective activities called for in the Act. [EPD]

Section 4C: WATER QUALITY, FLORA, AND FAUNA -- DROUGHT RESPONSES

1. Declared Drought Response Level One:

a. State actions

- Maintain minimal water quality parameters by:
  - Providing special releases from reservoirs and implementing innovative reservoir management to meet critical needs (e.g., alternative release patterns, controlling temperature of releases, changing storage purposes/authorized uses). (Implement only when not in violation or conflict with Federal Energy Regulatory Commission or Congressional authorizations.)
  - Reducing water withdrawals through implementation of the municipal and industrial section of this drought management plan.
  - Encouraging utilities and local governments to increase surveillance for sewer spills and leaks that may be more apparent as drought conditions worsen. [EPD, CE]
- Implement voluntary pollutant load reduction opportunities (i.e., below levels in wastewater discharge permits) when flows are less than the flow upon which discharge permit limits were established. [EPD]

- Implement industrial water reduction opportunities previously identified (i.e., use less water in producing products and services during drought, and thereby reducing quantity of water in waste stream). [P2AD, EPD]

b. Local /regional actions

- Require water conservation, building on on-going water conservation and education during non-drought periods and drawing on GUAC as a resource for urban irrigation. In addition to outdoor watering restrictions specified for M&I users, conservation-related drought responses at the regional or local level could include:
  - Running public service announcements about proper watering techniques, frequency.
  - Providing daily evaporation-transpiration rates for irrigation scheduling.
- Increase fire prevention measures during drought. [GFC, GFA, CES]

2. Declared Drought Response Levels Two through Four

- Continue Level one measures.
- Implement rescue and reintroduction of threatened and endangered species as previously identified thresholds are met. [USFWS, WRD]
- Evaluate pre-drought protocols and enhance if necessary to minimize any future drought impacts to threatened and endangered species. [USFWS, WRD]

SECTION 5 -- DROUGHT INDICATORS AND TRIGGERS

March 24, 2003

5A): Drought Indicators:

Drought indicators are variables that help to detect, characterize, and monitor changing climatic and drought conditions. This plan will use four primary indicators: precipitation, reservoir levels, groundwater levels, and streamflows. Indicators are selected for each of the nine climate divisions (CDs) in Georgia.

CD	Drought Indicators
1	SPI-3, SPI-6, SPI-12 Lake Allatoona Chattooga River at Summerville
2	SPI-3, SPI-6, SPI-12 Lake Lanier, Lake Allatoona Etowah River at Canton Chestatee River near Dahlonega
3	SPI-3, SPI-6, SPI-12 Lake Hartwell, Clark Hill Broad River near Bell Chattahoochee River near Cornelia
4	SPI-3, SPI-6, SPI-12 Flint River at Montezuma Groundwater Well (1)
5	SPI-3, SPI-6, SPI-12 Groundwater Well (1) Oconee River at Dublin Ocmulgee River at Macon
6	SPI-3, SPI-6, SPI-12 Lake Hartwell, Clark Hill Ogeechee River near Eden
7	SPI-3, SPI-6, SPI-12 Groundwater Wells (9) Spring Creek near Iron City Ichawaynochaway Creek at Milford
8	SPI-3, SPI-6, SPI-12 Alapaha River at Statenville
9	SPI-3, SPI-6, SPI-12 Satilla River at Atkinson

PRECIPITATION

Standardized Precipitation Index (SPI-3, 6, 12)
(Precipitation during the last 3, 6, and 12 months compared to the same months historically)

RESERVOIR LEVELS

Lake Allatoona
Lake Lanier
Lake Hartwell
Clark Hill

GROUNDWATER LEVELS

CD4 well:
11AA01
CD5 well:
21T001
CD7 wells:

13L180, 12M017, 11K003, 13J004,
12K014, 10G313, 08K001, 08G001,
09F520

STREAMFLOWS

Chattooga River at Summerville (02398000)
Etowah River at Canton (02392000)
Chestatee River near Dahlonega (02333500)
Broad River near Bell (02192000)
Chattahoochee River near Cornelia (02331600)
Flint River at Montezuma (02349500)
Oconee River at Dublin (02223500)
Ocmulgee River at Macon (02213000)
Ogeechee River near Eden (02202500)
Spring Creek near Iron City (02357000)
Ichawaynochaway Creek at Milford (02353500)
Alapaha River at Statenville (02317500)
Satilla River at Atkinson (02228000)

5B): DROUGHT TRIGGERS

- Drought triggers are specific values of indicators that help to determine when each level of drought response should begin or end. This plan contains four levels of increasing severity. A level is triggered when an indicator value reaches a certain percentile. By using percentiles, multiple indicators can be compared and combined within a consistent framework. Additional triggers are developed for reservoir levels based on zones, and streamflows based on average annual discharge (AAD) and monthly 7Q10 (M7Q10). (Analytic procedures are described in Section 5C.)
- Triggers are used for both going into a drought and coming out of a drought. Note that triggers do not automatically invoke a level and required response. Rather, the triggers prompt an evaluation (described in Section IA) about the possible need to declare a certain drought response level and take appropriate measures.
- Going into a drought: When <u>any one of the triggers</u> for any one of the CDs is at a more severe level for at least <u>two</u> consecutive months, then an evaluation is conducted about whether to increase the level of response.
- Getting out of a drought: When <u>all of the triggers</u> for that CD are at less severe level for at least <u>four</u> consecutive months, then an evaluation is conducted about whether to decrease the level of response.

Conditions	**Percentiles for All Triggers: Precipitation, Reservoir Levels, Groundwater Levels, Streamflows**
Level 1	**0.20 – 0.35**
Level 2	**0.10 – 0.20**
Level 3	**0.05 – 0.10**
Level 4	**0.00 – 0.05**

Conditions	Reservoirs Levels: Rule Curves
Level 1	< Zone 1
Level 2	< Zone 2
Level 3	< Zone 3
Level 4	< Zone 4

Conditions	Streamflows: AAD / M7Q10
Level 1	< 80/60/50 % AAD
Level 2	< M7Q10 + (2/3)
Level 3	< M7Q10 + (1/3)
Level 4	< M7Q10

5C: ANALYTIC PROCEDURES FOR INDICATORS AND TRIGGERS

The four levels of this plan were based on percentiles, relative to each month. This approach was designed to provide statistical comparability among indicators, temporal and spatial consistency, and ease of interpretation. For instance, percentiles can be related to probabilities of occurrence, and used to compare current conditions with historic conditions.

The indicators were selected through an analysis of several hundred combinations, using actual data, to generate the triggering sequences that would have occurred historically. These sequences were then compared to retrospective assessments of conditions in each of the climate divisions, and in each of the sectors of municipal and industrial, agriculture, and environmental, to determine the indicators and triggers that would have performed the best for the periods before, during, and after a drought.

To transform indicator data to percentiles, the following procedures were used:

- For precipitation, percentiles were calculated directly from the SPI value, which is a statistical Z-score, for each climate division. The SPI-3, -6, and -12 represents total precipitation during a 3, 6, and 12 month period, relative to those same months historically. Percentiles can also be determined by fitting a gamma distribution to the long-term record, and then determining 3, 6, and 12-month anomalies, relative to the historic record.
- For reservoir levels, percentiles were calculated using an empirical cumulative distribution function, which is a ranking procedure using the historic record of data, analyzed by each month. In addition, reservoir triggers were based on reservoir rule curves, and levels were associated with each of the zones.
- For groundwater, percentiles were calculated from U.S.G.S. duration analyses for probabilities of exceedance, using detrended data, and triggers were based on the most severe level for a majority of the selected wells.
- For streamflows, percentiles were calculated from empirical cumulative distribution functions, using long-term and equivalent records of average flow data, analyzed by each month. In addition to percentiles, an algorithm using average annual discharge (AAD) and monthly 7Q10 (M7Q10) was used for streamflow triggers. Here, delta (Δ) is the difference between 80/60/50% AAD and M7Q10, and 80/60/50% refers to 80%AAD for January through April, 60%AAD for May, June, and December, and 50%AAD for July through November.

Through evaluations of the drought plan and its performance (Section IC, it is likely that indicators, trigger levels, data sources, and calculation methods may change. This drought plan is designed to remain flexible, and to accommodate procedures that would provide the most useful guidance and ability to minimize the adverse impacts of drought.

SECTION 6: CLIMATE DIVISIONS OF GEORGIA

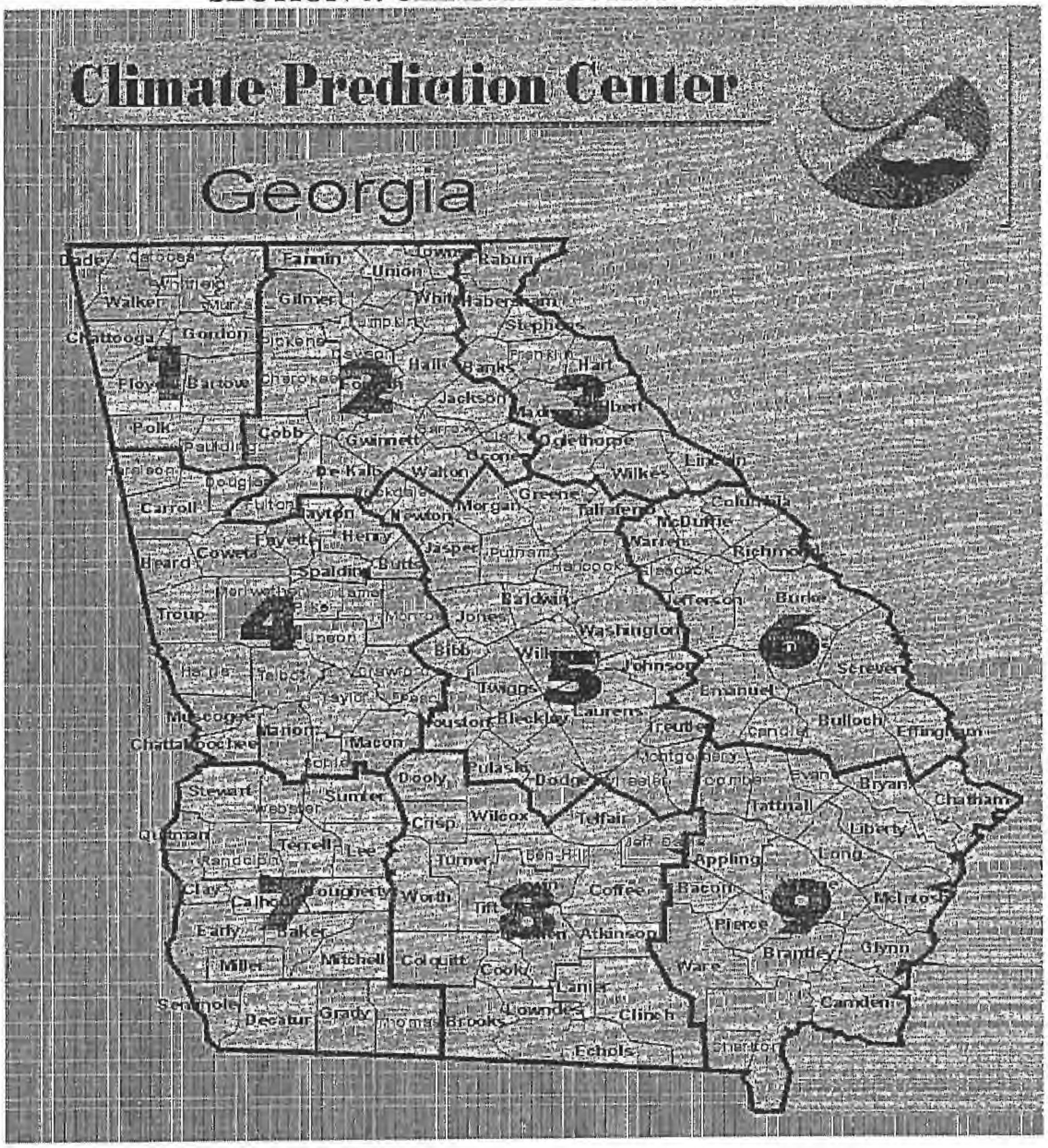

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Exhibit 53

RULES OF
GEORGIA DEPARTMENT OF NATURAL RESOURCES
ENVIRONMENTAL PROTECTION DIVISION

CHAPTER 391-3-30
OUTDOOR WATER USE

TABLE OF CONTENTS

391-3-30-.01 Definitions
When used in this Chapter:

(1) "Address" means the "house number" (a numeric or alphanumeric designation) that, together with the street name, describes a physical location of a specific property. "Even numbered address" means a house number ending with the number 0, 2, 4, 6, 8, or no house number. "Odd numbered address" means a house number ending with the number 1, 3, 5, 7, or 9.

(2) "Declared Drought Response Level" means one of four levels of drought that can be declared based on the severity of drought conditions, with one being the least severe and four being the most severe.

391-3-30-.02 Applicability of Rule

These rules apply to any entity, and its customers, permitted by the Georgia Environmental Protection Division (EPD) for water withdrawal or for operation of a drinking water system.

391-3-30-.03 Outdoor Water Use Schedule During Non-Drought Periods

(1) Outdoor water use other than exempted activities shall occur only as follows:

(a) Odd-numbered addresses: outdoor water use is allowed on Tuesdays, Thursdays and Sundays.

(b) Even-numbered addresses: outdoor water use is allowed on Mondays, Wednesdays and Saturdays.

391-3-30-.04 Outdoor Water Use Schedule During Declared Drought Response Levels

(1) The Director of the Environmental Protection Division is authorized to make drought declarations.

(2) During declared drought conditions, outdoor water use other than activities exempted in 391-3-30-.05, shall occur only during scheduled hours on the scheduled days.

(3) Declared Drought Response Level One – Outdoor water use may occur on scheduled days within the hours of 12:00 midnight to 10:00 a.m. and 4:00 p.m. to 12:00 midnight.

(a) Scheduled days for odd-numbered addresses are Tuesdays, Thursdays and Sundays.

(b) Scheduled days for even-numbered addresses are Mondays, Wednesdays and Saturdays.

(c) Use of hydrants for any purpose other than firefighting, public health, safety or flushing is prohibited.

(4) Declared Drought Response Level Two – Outdoor water use may occur on scheduled days within the hours of 12:00 midnight to 10:00 a.m.

(a) Scheduled days for odd-numbered addresses are Tuesdays, Thursdays and Sundays.

(b) Scheduled days for even-numbered addresses and golf course fairways are Mondays, Wednesdays and Saturdays.

(c) The following uses are prohibited:

1) Using hydrants for any purpose other than firefighting, public health, safety or flushing.

2) Washing hard surfaces, such as streets, gutters, sidewalks and driveways except when necessary for public health and safety.

(5) Declared Drought Response Level Three – Outdoor water use may occur on the scheduled day within the hours of 12:00 midnight to 10:00 a.m.

(a) The scheduled day for odd-numbered addresses is Sunday.

(b) The scheduled day for even-numbered addresses and golf course fairways is Saturday.

(c) The following uses are prohibited:

1) Using hydrants for any purpose other than firefighting, public health, safety or flushing.
2) Washing hard surfaces, such as streets, gutters, sidewalks, driveways, except when necessary for public health and safety
3) Filling installed swimming pools except when necessary for health care or structural integrity.

4) Washing vehicles, such as cars, boats, trailers, motorbikes, airplanes, golf carts.
5) Washing buildings or structures except for immediate fire protection.
6) Non-commercial fund-raisers, such as car washes.
7) Using water for ornamental purposes, such as fountains, reflecting pools, and waterfalls except when necessary to support aquatic life.

(6) Declared Drought Response Level Four – No outdoor water use is allowed, other than for activities exempted in 391-3-30-.05, or as the EPD Director may order.

391-3-30-.05 Exemptions

(1) This rule shall not apply to the following outdoor water uses:

(a) Capture and re-use of cooling system condensate or storm water in compliance with applicable local ordinances

(b) Re-use of gray water in compliance with applicable local ordinances

(2) The following established landscape water uses are exempt from the outdoor water use schedules of this rule.

(a) Use of reclaimed wastewater by a designated user from a system permitted by EPD to provide reclaimed wastewater.

(b) Irrigation of personal food gardens.

(3) Newly (in place less than thirty days) installed landscapes are subject to the following:

(a) Irrigation of newly installed landscapes is allowed any day of the week, but only during allowed hours for the drought response level in effect, for a period of 30 days following installation. No watering is allowed during Drought Response Level Four.

(b) For new landscapes installed by certified or licensed professionals, commercial exemptions apply.

(4) The following golf course outdoor water uses are exempt from the outdoor water use schedules of this rule.

(a) Use of reclaimed wastewater by a designated user from a system permitted by EPD to provide reclaimed wastewater.

(b) Irrigation of fairways during times of non-drought and Declared Drought Response Level One.

(c) Irrigation of tees during times of non-drought and Declared Drought Response Levels One, Two and Three.

(d) Irrigation of greens.

(5) The following commercial outdoor water uses are exempt from the outdoor water use schedules of this rule.

(a) Professionally certified or licensed landscapers, golf course contractors, and sports turf landscapers: during installation and 30 days following installation only. Professional landscapers must be certified or licensed for commercial exemptions to apply.
(b) Irrigation contractors: during installation and as needed for proper maintenance and adjustments only.
(c) Sod producers.
(d) Ornamental growers.
(e) Fruit and vegetable growers.
(f) Retail garden centers.
(g) Hydro-seeding.
(h) Power-washing.
(i) Construction sites.
(j) Producers of food and fiber.
(k) Car washes.
(l) Other activities essential to daily business.
(m) Watering-in of pesticides and herbicides on turf.

391-3-30-.06 Local and Regional Options

(1) Local and regional water providers are authorized to implement additional outdoor water use restrictions within their jurisdictions. Action items to consider at the local/regional level include, but are not limited to, the following: developing system integration and interconnection to reduce drought vulnerability, placing additional water use restrictions on specific commercial uses, putting water conservation based rates in place (increasing block/summer surcharge) and placing additional restrictions on outdoor water use.

(2) Local and regional water providers may request approval of alternative days for outdoor water use for purposes of enforcement, peak water usage, timing of recovery days, and other valid reasons. Approval shall be contingent upon:

(a) Written notification to, and approval by, EPD of the alternate watering schedule; and
(b) Enactment of a local ordinance allowing no more than 3 days a week outdoor watering during time(s) of day consistent with the level of drought as set forth in sections 391-3-30-.03 and -.04 of this rule.
(c) Regional consistency.

Exhibit 54

Georgia Department of Natural Resources
2 Martin Luther King Jr., Dr., Suite 1152 East Tower, Atlanta, Georgia 30334
Noel Holcomb, Commissioner
Carol A. Couch, Ph.D., Director
Environmental Protection Division
(404) 656-4713

For Immediate Release **September 28, 2007**

CITING HISTORIC DROUGHT, GEORGIA EPD BANS MOST OUTDOOR WATER USE IN NORTH GEORGIA

The director of the Georgia Environmental Protection Division (EPD) has declared a level four drought response across the northern third of Georgia, which prohibits most types of outdoor residential water use effective immediately.

"The drought of 2007 has reached historic proportions, so it's critical that we take immediate action to ensure that Georgians have a sufficient supply of safe drinking water," said EPD Director Carol A. Couch. "All of the counties included in the level four declaration are located in areas of either exceptional or extreme drought."

The drought declaration was made following a meeting today of the State Drought Response Committee. The Committee includes representatives from several state, federal and local agencies, as well as universities and non-government organizations. The EPD Director, working with State Climatologist David Stooksbury, consults with the Committee members and then determines the appropriate drought response.

"During a year of average rainfall, water levels in Georgia's large reservoirs such as Lanier and Allatoona tend to drop in late summer and then recover as the winter rains arrive," said State Climatologist Stooksbury. "But the forecast calls for a dry, mild winter and that could result in serious water supply problems by next spring."

The level four drought response was declared for all counties in north Georgia from Muscogee County on the Alabama line northeastward to Spalding County, and eastward to Lincoln County on the South Carolina line. The level four drought response includes all of metropolitan Atlanta, Rome, Athens and Columbus, but does not include the cities of Macon and Augusta. Click this link for a complete list of counties included in the level four drought response:

http://www.georgiaepd.com/Files_PDF/news/Level_4_Counties.pdf

Counties not on the list will remain subject to the current level two drought response. A level two drought response declaration limits outdoor watering to the following schedule:

- Odd-numbered addresses may water on Tuesdays, Thursdays and Sundays-12 midnight to 10 a.m.
- Even-numbered and unnumbered addresses may water on Mondays, Wednesdays and Saturdays-12 midnight to 10 a.m.

Georgia Department of Natural Resources

2 Martin Luther King Jr., Dr., Suite 1152 East Tower, Atlanta, Georgia 30334
Noel Holcomb, Commissioner
Carol A. Couch, Ph.D., Director
Environmental Protection Division
(404) 656-4713

A level four drought response prohibits most types of outdoor water use, although the state does offer some exemptions for commercial uses. However, local governments and water utilities may impose more stringent watering schedules, so citizens should contact their local water providers for more specific guidance.

EPD Director Couch said drought conditions will continue to be monitored and revised drought response declarations will be issued as necessary.

More information about the outdoor water use schedules can be found on the EPD web site at www.georgiaepd.com. To learn more about water conservation, please go to the EPD Water Conservation web site at www.conservewatergeorgia.net. Detailed information on the drought can be found at www.georgiadrought.org.

News Media Contact: Kevin Chambers
(404) 651-7970

Exhibit 55

Tuesday, October 23, 2007

Contact: Office of Communications 404-651-7774

Governor Perdue Orders Utilities, Permit Holders to Reduce Water Use by 10 Percent

EPD to direct permit holders to reduce withdrawals by 10 percent compared to last winter

ATLANTA- Governor Sonny Perdue today directed the Georgia Environmental Protection Division (EPD) to modify current surface water and groundwater withdrawal and drinking water permits to achieve a 10 percent reduction in withdrawals for permit holders in the 61 North Georgia counties covered under the Level 4 drought designation. Permit holders will be required to reduce water withdrawals by 10 percent compared to the permit holder's water usage of the last winter season (beginning of December 2006 through end of March 2007). The new restrictions are effective when the EPD director notifies all permit holders in writing. The permit modifications apply to all non-farm permit holders.

"In this unprecedented drought, we all have to pitch in and find ways to conserve our most precious resource," Governor Sonny Perdue said. "A 10 percent reduction in water use is a first step, and we will continue to evaluate our drought response and encourage additional conservation as needed."

The revised permit restrictions will be in place beginning November 1 and will continue as necessary. Georgia EPD will enforce permit restrictions and impose fines for noncompliance.

"Many communities already have successful conservation programs in place," said Governor Perdue. "I encourage all Georgians to make their dry lawns and dirty cars a badge of honor. By making individual conservation efforts, along with reasonable solutions from our federal government, we can collectively help to ensure that our water supply is sufficient."

The 61 counties included in the Level 4 drought declaration include: Banks, Barrow, Bartow, Butts, Carroll, Catoosa, Chattooga, Cherokee, Clarke, Clayton, Cobb, Coweta, Dade, Dawson, DeKalb, Douglas, Elbert, Fannin, Fayette, Floyd, Forsyth, Franklin, Fulton, Gilmer, Gordon, Greene, Gwinnett, Habersham, Hall, Haralson, Harris, Hart, Heard, Henry, Jackson, Jasper, Lincoln, Lumpkin, Madison, Meriwether, Morgan, Murray, Muscogee, Newton, Oconee, Oglethorpe, Paulding, Pickens, Polk, Rabun, Rockdale, Spalding, Stephens, Towns, Troup, Union, Walker, Walton, White, Whitfield and Wilkes.

This directive is the latest step taken to help Georgians through the worst drought in the state's history. The northern third of Georgia is under Level 4 drought restrictions, or a complete outdoor watering ban. Georgia's major federal reservoirs, such as West Point Lake and Lake Lanier, continue to dwindle as the U.S. Army Corps of Engineers sends billions of gallons of water downstream every day despite the impact their actions will have on Georgia's water supply and its citizens.

On Saturday, October 20, Governor Perdue signed an executive order declaring a state of emergency in 85 counties in Georgia due to the historic drought. Governor Perdue also sent a letter to President Bush outlining steps the state has taken to minimize the impact of the drought and emphasizing the increasingly severe threat to Georgia businesses, industry, economic stability and the health and safety of Georgia citizens. He requested President Bush to temporarily exempt the state of Georgia from the Endangered Species Act to reduce the flows from Georgia reservoirs and preserve Georgia's precious water resources.

On Friday, October 19, Governor Perdue filed a motion for preliminary injunction in the Middle District of Florida Federal Court requiring the Army Corps of Engineers to restrict water flows from Lake Lanier and Georgia's federal reservoirs.

Exhibit 56

Georgia Department of Natural Resources
Environmental Protection Division
2 Martin Luther King Jr. Drive, Suite 1456, Atlanta, Georgia 30334
Judson H. Turner, Director
(404) 656-4713

December 30, 2014

MEMORANDUM

TO: Board of Natural Resources

FROM: Judson H. Turner, Director
Environmental Protection Division

SUBJECT: Briefing on Amendments to Rules for Outdoor Water Use, Chapter 391-3-30; Rules for Groundwater Use, Chapter 391-3-2; and Rules for Water Quality Control, Chapter 391-3-6

The purpose of this briefing memo is to coordinate with the Environmental Protection Committee and seek input from all members of the Board on EPD's proposed Rules for Drought Management, Chapter 391-3-30. The proposed Rules for Drought Management would replace the current Rules for Outdoor Water Use (391-3-30) and the 2003 Drought Management Plan.

EPD proposes to amend Rules 391-3-30-.01 through .06 to replace the provisions relating to Outdoor Water Use with provisions relating to Drought Management, and to add new Rules 391-3-30-.07 through .08 relating to Drought Management. The new Rules for Drought Management are responsive to the requirement under O.C.G.A. § 12-5-8 for the DNR Board to adopt new rules relating to drought management, and are consistent with the provisions of O.C.G.A. § 12-5-7 and other Georgia Code sections charging EPD with the responsibility to ensure that water resources are responsibly conserved.

In addition, small amendments to the Rules for Groundwater Use, Chapter 391-3-2, and the Rules for Water Quality Control, 391-3-6, are proposed to address consistency between the drought contingency plan requirements of these rules and the requirements of the proposed Rules for Drought Management.

In preparing these proposed rules, EPD engaged various stakeholders through a series of three meetings on May 13, July 15, and October 22, 2014. EPD held the meetings to present concepts being considered for these proposed rules and to solicit input regarding those concepts or any specific recommendations from the stakeholders. Public comments were received after each stakeholder meeting, and informed the basis for these proposed rule amendments.

The Division will solicit public input and hold a public hearing, and expects to present the following amendments to the Board for action at the March 2015 meeting.

EPD proposes the following Rules for amendment:

RULES FOR DROUGHT MANAGEMENT, CHAPTER 391-3-30

391-3-30, title is being amended from "OUTDOOR WATER USE" to "**DROUGHT MANAGEMENT**."

391-3-30-.01, "Definitions." is being amended by removing these provisions of the Rules for Outdoor Water Use, and adding the **"Purpose"** of the Rules for Drought Management, which incorporates the purposes provided under O.C.G.A. § 12-5-8 for rules relating to drought management.

391-3-30-.02, "Applicability of Rule." is being amended by removing these provisions of the Rules for Outdoor Water Use, and adding the **"Definitions"** applicable to the Rules for Drought Management.

391-3-30-.03, "Outdoor Water Use Schedule During Non-Drought Periods." is being amended by removing these provisions of the Rules for Outdoor Water Use, and adding the **"Predrought Mitigation Strategies"** provisions of the Rules for Drought Management. The predrought mitigation strategies apply during non-drought periods and are designed to minimize the potential effects of drought in accordance with O.C.G.A. § 12-5-8.

391-3-30-.04, "Outdoor Water Use Schedule During Declared Drought Response Levels." is being amended by removing these provisions of the Rules for Outdoor Water Use, and adding the **"Drought Indicators and Triggers"** provisions of the Rules for Drought Management. These provisions: specify that the EPD Director monitor climatic indicators and water supply conditions to assess drought occurrence and severity; require the Director to periodically release public reports on climatic indicators and hold communications with permittees that may be affected by a drought response level declaration; require public water systems to notify EPD when their drought contingency plans are triggered; and provide that the Director may consult with other relevant agencies prior to making a drought response level declaration.

391-3-30-.05, "Exemptions." is being amended by removing these provisions of the Rules for Outdoor Water Use, and adding the **"Drought Declaration"** provisions of the Rules for Drought Management. Under this provision, the EPD Director may declare non-drought conditions and various drought response levels for specified affected drought area(s), and must provide notice of such declarations to all permittees within the affected drought area(s).

391-3-30-.06, "Local and Regional Options." is being amended by removing these provisions of the Rules for Outdoor Water Use, and adding the **"Drought Response Committee"** provision of the Rules for Drought Management. Under this provision, the EPD Director may convene and consult a drought response committee on the development and/or implementation of predrought mitigation strategies or drought response strategies.

391-3-30-.07, "Drought Response Strategies." is a new rule that addresses the drought response strategies, or "measures or actions to be implemented during various stages of

Drought," that are called for under O.C.G.A. § 12-5-8. The proposed rule specifies the drought response strategies to be implemented during declared drought response levels, which include public education, outdoor water use restrictions, rate structure requirements, numeric water usage reduction requirements, and a menu of other practices designed to achieve water use reductions during periods of drought. Professional exemptions are included for certain businesses that rely upon water for their operations and additional restrictions are not practicable.

391-3-30-.08, "Variance Requests." is a new rule that addresses the provisions of O.C.G.A. § 12-5-7 regarding the granting by the EPD Director of variances to local governments or authorities that would allow them to impose restrictions on outdoor water use that are more or less stringent that those specified in the drought response strategies.

RULES FOR GROUNDWATER USE, CHAPTER 391-3-2

391-3-2-.04, "Permit Application. Amended." is being amended in one specific provision (see page C-29) to ensure consistency between the drought contingency plan requirements of this rule and the requirements of O.C.G.A. § 12-5-7 and § 12-5-8. These code sections require local governments or authorities to get a variance from EPD in order to implement restrictions on outdoor water use that differ from those imposed by the state.

RULES FOR WATER QUALITY CONTROL, CHAPTER 391-3-6

391-3-6-.07, "Surface Water Withdrawals. Amended." is being amended in one specific provision (see page C-39) to provide consistency between the drought contingency plan requirements of this rule and the requirements of O.C.G.A. § 12-5-7 and § 12-5-8. These code sections require local governments or authorities to get a variance from EPD in order to implement restrictions on outdoor water use that differ from those imposed by the state.

The following documents are enclosed for your review:	Page No.
• Synopsis and Statement of Rationale for Proposed Rules for Drought Management and Proposed Amendments to the Rules for Groundwater Use and Water Quality Control	C-5
• Proposed Rules for Drought Protection showing deletions with ~~strikeouts~~ and additions with underlines	C-8
• Proposed Amendments to the Rules for Groundwater Use showing deletions with ~~strikeouts~~ and additions with underlines	C-23

- Proposed Amendments to the Rules for Water Quality Control showing deletions with ~~strikeouts~~ and additions with <u>underlines</u> C-32

Thank you for your attention to these proposed rule changes.

JHT:jac

SYNOPSIS
Proposed Rules for Drought Management, Chapter 391-3-30,
and
Proposed Amendments to the Rules for Groundwater Use, Chapter 391-3-2,
and the Rules for Water Quality Control, Chapter 391-3-6

The proposed Rules for Drought Management would amend **Rules 391-3-30-.01 through .06**, replacing the Rules for Outdoor Water Use, and add **Rules 391-3-30-.07 and .08**. Proposed amendments to the Rules for Groundwater Use and Water Quality Control, **Rules 391-3-2-.04** and **391-3-6-.07**, respectively, will address consistency between the drought contingency plan requirements of those rules and the requirements of the proposed Rules for Drought Management.

Purpose: To propose Rules for Drought Management that will replace the Rules for Outdoor Water Use, 391-3-30, to address the requirement under O.C.G.A. § 12-5-8 for the DNR Board to adopt new rules and regulations relating to drought management.

Main Features: As called for in O.C.G.A. § 12-5-8, the proposed Rules for Drought Management, 391-3-30, incorporate provisions for a drought response committee; drought indicators and triggers; a drought declaration process; predrought mitigation strategies designed to minimize the potential effects of drought; and drought response strategies to be implemented during various stages of drought. Narrow amendments are also proposed to the Rules for Groundwater Use, 391-3-2-.04, and the Rules for Water Quality Control, 391-3-6-.07, to ensure consistency between the drought contingency requirements of those rules and the provisions of the proposed Rules for Drought Management.

RULES FOR DROUGHT MANAGEMENT, CHAPTER 391-3-30

391-3-30, title is being amended from "OUTDOOR WATER USE" to "**DROUGHT MANAGEMENT**."

391-3-30-.01, "Definitions." is being amended by removing these provisions of the Rules for Outdoor Water Use, and adding the **"Purpose"** of the Rules for Drought Management, which incorporates the purposes provided under O.C.G.A. § 12-5-8 for rules relating to drought management.

391-3-30-.02, "Applicability of Rule." is being amended by removing these provisions of the Rules for Outdoor Water Use, and adding the **"Definitions"** applicable to the Rules for Drought Management.

391-3-30-.03, "Outdoor Water Use Schedule During Non-Drought Periods." is being amended by removing these provisions of the Rules for Outdoor Water Use, and adding the **"Predrought Mitigation Strategies"** provisions of the Rules for Drought Management. The predrought mitigation strategies apply during non-drought periods and are designed to minimize the potential effects of drought in accordance with O.C.G.A. § 12-5-8.

391-3-30-.04, "Outdoor Water Use Schedule During Declared Drought Response Levels." is being amended by removing these provisions of the Rules for Outdoor Water Use, and adding the **"Drought Indicators and Triggers"** provisions of the Rules for Drought Management. These provisions specify: that the EPD Director monitor climatic indicators and water supply conditions to assess drought occurrence and severity; require the Director to periodically release public reports on climatic indicators and hold communications with permittees that may be affected by a drought response level declaration; require public water systems to notify EPD when their drought contingency plans are triggered; and provide that the Director may consult with other relevant agencies prior to making a drought response level declaration.

391-3-30-.05, "Exemptions." is being amended by removing these provisions of the Rules for Outdoor Water Use, and adding the **"Drought Declaration"** provisions of the Rules for Drought Management. Under this provision, the EPD Director may declare non-drought conditions and various drought response levels for specified affected drought area(s), and must provide notice of such declarations to all permittees within the affected drought area(s).

391-3-30-.06, "Local and Regional Options." is being amended by removing these provisions of the Rules for Outdoor Water Use, and adding the **"Drought Response Committee"** provision of the Rules for Drought Management. Under this provision, the EPD Director may convene and consult a drought response committee on the development and/or implementation of predrought mitigation strategies or drought response strategies.

391-3-30-.07, "Drought Response Strategies." is a new rule that addresses the drought response strategies, or "measures or actions to be implemented during various stages of drought," that are called for under O.C.G.A. § 12-5-8. The proposed rule specifies the drought response strategies to be implemented during declared drought response levels, which include public education, outdoor water use restrictions, rate structure requirements, numeric water usage reduction requirements, and a menu of other practices designed to achieve water use reductions during periods of drought.

391-3-30-.08, "Variance Requests." is a new rule that addresses the provisions of O.C.G.A. § 12-5-7 regarding the granting by the EPD Director of variances to local governments or authorities that would allow them to impose restrictions on outdoor water use that are more or less stringent that those specified in the rule.

RULES FOR GROUNDWATER USE, CHAPTER 391-3-2

391-3-2-.04, "Permit Application. Amended." is being amended to provide consistency between the drought contingency plan requirements of this rule and the requirements of O.C.G.A. § 12-5-7 and § 12-5-8. These code sections require local governments or authorities to get a variance from the EPD Director in order to implement restrictions on outdoor water use that differ from those imposed in the Rules for Drought Management.

RULES FOR WATER QUALITY CONTROL, CHAPTER 391-3-6

391-3-6-.07, "Surface Water Withdrawals. Amended." is being amended to provide consistency between the drought contingency plan requirements of this rule and the requirements of O.C.G.A. § 12-5-7 and § 12-5-8. These code sections require local governments or authorities to get a variance from the EPD Director in order to implement restrictions on outdoor water use that differ from those imposed in the Rules for Drought Management.

STATEMENT OF RATIONALE
Proposed Rules for Drought Management, Chapter 391-3-30,
and
Proposed Amendments to the Rules for Groundwater Use, Chapter 391-3-2, and the Rules for Water Quality Control, Chapter 391-3-6

The Rules for Drought Management, Chapter 391-3-30, are proposed to replace the current Rules for Outdoor Water Use (391-3-30) and the 2003 Drought Management Plan. Amendments to the Rules for Groundwater Use, 391-3-2-.04, and the Rules for Water Quality Control, 391-3-6-.07, are proposed to address consistency between the drought contingency plan requirements of these rules and the requirements of the proposed Rules for Drought Management.

O.C.G.A § 12-5-7(a.1)(1) establishes that persons may irrigate outdoors daily for purposes of planting, growing, managing, or maintaining ground cover, trees, shrubs, or other plants only between the hours of 4:00 p.m. and 10:00 a.m. O.C.G.A § 12-5-7(a.1)(2) lists thirteen exemptions from the 4:00 p.m. and 10:00 a.m. schedule described in paragraph (1).

O.C.G.A. § 12-5-8 calls upon the DNR Board to adopt new rules relating to drought management, to include provisions for: a drought response committee; drought indicators and triggers; a drought declaration process; predrought mitigation strategies designed to minimize the potential effects of drought; and drought response strategies (measures or actions to be implemented during various stages of drought). The proposed Rules for Drought Management address all of these provisions and, as stated under O.C.G.A. § 12-5-8, will replace any previous drought management plan adopted by the Board.

O.C.G.A § 12-5-7(a)(1) and (a)(2) provide local governments or authorities a way to request a variance from the state requirements under O.C.G.A § 12-5-7(a.1) and the rules promulgated under O.C.G.A. § 12-5-8 to be either more stringent, or less stringent, than those requirements, provided that they are not less stringent than 4:00 p.m. and 10:00 a.m. schedule established in O.C.G.A § 12-5-7(a.1)(1).

Narrow amendments to the Rules for Groundwater Use, 391-3-2-.04, and the Rules for Water Quality Control, 391-3-6-.07, are proposed to ensure consistency between the drought contingency plan requirements of this rule and the requirements of O.C.G.A. § 12-5-7 and § 12-5-8. These code sections require local governments or authorities to get a variance from EPD in order to implement restrictions on outdoor water use that differ from those imposed by the state.

PROPOSED AMENDMENTS TO THE RULES
OF THE DEPARTMENT OF NATURAL RESOURCES
ENVIRONMENTAL PROTECTION DIVISION
RELATING TO OUTDOOR WATER USE, CHAPTER 391-3-30

The Rules of the Department of the Natural Resources, Chapter 391-3-30, Outdoor Water Use are hereby amended and revised for specific Rules, or such subdivisions thereof as may be indicated.

[Note: Underlined text is proposed to be added. ~~Lined-through~~ text is proposed to be deleted.]

CHAPTER 391-3-30 ~~OUTDOOR WATER USE~~DROUGHT MANAGEMENT

391-3-30-.01 ~~Definitions~~Purpose of Rule.

~~When used in this Chapter:~~
~~(1) "Address" means the "house number" (a numeric or alphanumeric designation) that, together with the street name, describes a physical location of a specific property. "Even numbered address" means a house number ending with the number 0, 2, 4, 6, 8, or no house number. "Odd numbered address" means a house number ending with the number 1, 3, 5, 7, or 9.~~
~~(2) "Declared Drought Response Level" means one of four levels of drought that can be declared based on the severity of drought conditions, with one being the least severe and four being the most severe.~~

To establish rules and regulations relating to drought management, including: provisions for a drought response committee; drought indicators and triggers; a drought declaration process; and state and local predrought mitigation strategies and drought response strategies. Predrought mitigation strategies are designed to minimize the potential effects of drought. Drought response strategies include measures or actions to be implemented during various stages of drought.

Authority: O.C.G.A. §§ ~~12-5-90 et seq., 12-5-170 et seq.~~ 12-5-8.

391-3-30-.02 ~~Applicability of Rule~~Definitions.

~~These rules apply to any entity, and its customers, permitted by the Georgia Environmental Protection Division (EPD) for water withdrawal or for operation of a drinking water system.~~

When used in this Chapter:

(1) "Affected drought area" means any area subject to a drought declaration made in accordance with Section 391-3-30-.05.

(2) "Director" means the director, or his/her designee, of the Environmental Protection Division of the Department of Natural Resources.

(3) "Division" means the Environmental Protection Division of the Department of Natural Resources.

(4) "Drip irrigation" means the use of an irrigation system manufactured and sold specifically for delivering water through small flexible pipes and emitters slowly and directly to the soil around the base of individual plants in a manner that minimizes evaporative losses, pooling, runoff and wetting of plant foliage. This type of system may be part of a larger automated irrigation system or may operate as a stand-alone system connected to a typical outdoor faucet.

(5) "Farm uses" means irrigation of any land used for general farming, forage, aquaculture, pasture, turf production, orchards, or tree and ornamental nurseries; or provisions of water supply for farm animals, poultry farming, or any other activity conducted in the course of a farming operation. Farm uses shall also include the processing of perishable agricultural products.

(6) "Permittee" is defined as:

(a) Any person that holds a water withdrawal permit issued by the Director pursuant to the Georgia Water Quality Control Act, O.C.G.A. §12-5-20 et seq.;

(b) Any person that holds a water withdrawal permit issued by the Director pursuant to the Groundwater Use Act, O.C.G.A. §12-5-90 et seq.; or

(c) Any person that holds a permit issued by the Director pursuant to the Georgia Safe Drinking Water Act, O.C.G.A. §12-5-170 et seq., that uses water obtained from any person meeting the criteria in paragraphs (a) or (b);

(d) Permittee does not include any person that holds a water withdrawal permit for farm uses.

(7) "Public water system" means a system for the provision to the public of piped water for human consumption.

(8) "Soaker hose" means a hose that is connected to a typical outdoor faucet and that is manufactured and sold specifically for delivering water slowly and directly to the soil around the base of individual plants by allowing water to seep from it in a manner that minimizes evaporative losses, pooling, runoff and wetting of plant foliage.

Authority: O.C.G.A. §§ 12-5-8, 12-5-20 et seq., 12-5-90 et seq., and 12-5-170 et seq.

391-3-30-.03 ~~Outdoor Water Use Schedule During Non-Drought Periods~~Predrought Mitigation Strategies.

~~(1) Outdoor water use other than exempted activities shall occur only as follows:~~
~~(a) Odd-numbered addresses: outdoor water use is allowed on Tuesdays, Thursdays and Sundays.~~
~~(b) Even-numbered addresses: outdoor water use is allowed on Mondays, Wednesdays and Saturdays.~~

(1) During non-drought periods, irrigation outdoors for purposes of planting, growing, managing, or maintaining ground cover, trees, shrubs, or other plants shall be in accordance with O.C.G.A. §12-5-7(a.1)(1) and (2).

(a) Persons may irrigate outdoors daily for purposes of planting, growing, managing, or maintaining ground cover, trees, shrubs, or other plants only between the hours of 4:00 p.m. and 10:00 a.m.

(b) Paragraph (a) shall not create any limitation upon the following outdoor water uses:

1. Commercial agricultural operations as defined in Code Section 1-3-3;

2. Capture and reuse of cooling system condensate or storm water in compliance with applicable local ordinances and state guidelines;

3. Reuse of gray water in compliance with Code Section 31-3-5.2 and applicable local board of health regulations adopted pursuant thereto;

4. Use of reclaimed waste water by a designated user from a system permitted by the Environmental Protection Division of the department to provide reclaimed waste water;

5. Irrigation of personal food gardens;

6. Irrigation of new and replanted plant, seed, or turf in landscapes, golf courses, or sports turf fields during installation and for a period of 30 days immediately following the date of installation;

7. Drip irrigation or irrigation using soaker hoses;

8. Handwatering with a hose with automatic cutoff or handheld container;

9. Use of water withdrawn from private water wells or surface water by an owner or operator of property if such well or surface water is on said property;

10. Irrigation of horticultural crops held for sale, resale, or installation;

11. Irrigation of athletic fields, golf courses, or public turf grass recreational areas;

12. Installation, maintenance, or calibration of irrigation systems; or

13. Hydroseeding.

(c) Paragraph (a) shall not create any limitation upon outdoor water uses for purposes other than planting, growing, managing, or maintaining ground cover, trees, shrubs, or other plants.

(2) The state has already made, and continues to make, extensive investments in water efficiency since conservation measures play such an important role in water stewardship. Therefore, with the exception of the outdoor irrigation requirements in O.C.G.A. §12-5-7(a.1)(1) and (2) and the Drought Contingency Plans and Water Conservation Plans required under Rules 391-3-2-.04(11), 391-3-6-.07(4)(b)8, and 391-3-6-.07(4)(b)9, this rule does not repeat or modify any existing predrought mitigation strategy or create any new predrought mitigation strategies.

Authority: O.C.G.A. §§ 12-5-90 et.seq., 12-5-170, et. Seq., 12-5-7, 12-5-8.

391-3-30-.04 Outdoor Water Use Schedule During Declared Drought Response LevelsDrought Indicators and Triggers.

(1) The Director of the Environmental Protection Division is authorized to make drought declarations.
(2) During declared drought conditions, outdoor water use other than activities exempted in 391-3-30-.05, shall occur only during scheduled hours on the scheduled days.
(3) Declared Drought Response Level One – Outdoor water use may occur on scheduled days within the hours of 12:00 midnight to 10:00 a.m. and 4:00 p.m. to 12:00 midnight.
(a) Scheduled days for odd-numbered addresses are Tuesdays, Thursdays and Sundays.
(b) Scheduled days for even-numbered addresses are Mondays, Wednesdays and Saturdays.
(c) Use of hydrants for any purpose other than firefighting, public health, safety or flushing is prohibited.
(4) Declared Drought Response Level Two – Outdoor water use may occur on scheduled days within the hours of 12:00 midnight to 10:00 a.m.
(a) Scheduled days for odd-numbered addresses are Tuesdays, Thursdays and Sundays.
(b) Scheduled days for even-numbered addresses and golf course fairways are Mondays, Wednesdays and Saturdays.
(c) The following uses are prohibited:
1) Using hydrants for any purpose other than firefighting, public health, safety or flushing.

~~2) Washing hard surfaces, such as streets, gutters, sidewalks and driveways except when necessary for public health and safety.~~
~~(5) Declared Drought Response Level Three -- Outdoor water use may occur on the scheduled day within the hours of 12:00 midnight to 10:00 a.m.~~
~~(a) The scheduled day for odd-numbered addresses is Sunday.~~
~~(b) The scheduled day for even-numbered addresses and golf course fairways is Saturday.~~
~~(c) The following uses are prohibited:~~
~~1) Using hydrants for any purpose other than firefighting, public health, safety or flushing.~~
~~2) Washing hard surfaces, such as streets, gutters, sidewalks, driveways, except when necessary for public health and safety~~
~~3) Filling installed swimming pools except when necessary for health care or structural integrity.~~
~~4) Washing vehicles, such as cars, boats, trailers, motorbikes, airplanes, golf carts~~
~~5) Washing buildings or structures except for immediate fire protection.~~
~~6) Non-commercial fund-raisers, such as car washes.~~
~~7) Using water for ornamental purposes, such as fountains, reflecting pools, and waterfalls except when necessary to support aquatic life.~~
~~(6) Declared Drought Response Level Four -- No outdoor water use is allowed, other than for activities exempted in 391-3-30-.05, or as the EPD Director may order.~~

(1) The Director shall monitor climatic indicators and water supply conditions as needed to assess drought occurrence and severity, and its impact upon the ability of permittees that are public water systems to provide adequate supplies of water and avoid or relieve local water shortages. Such indicators and conditions may include but may not be limited to the following:

(a) Precipitation;

(b) Streamflow;

(c) Groundwater;

(d) Reservoir Levels;

(e) Soil Moisture;

(f) Short Term Climate Predictions;

(g) U.S. Drought Monitor; and

(h) Water Supply Conditions.

(2) The Division shall periodically make available to the public reports of current climatic indicators. These reports shall be released at least semi-annually; however, when any

area of the state has, for at least two consecutive months, been under severe or higher intensity drought conditions, as indicated by the U.S. Drought Monitor, the reports shall be released at least monthly. These reports shall compare current climatic conditions to historical levels and/or reservoir rule curves, if appropriate, for each indicator. The Division shall employ an adaptive approach to these reports, as resources permit, to pursue improvements to the drought indicators and triggers to make the reports as effective as possible. These reports shall include, at a minimum, the following drought indicators:

(a) Precipitation: Precipitation during the prior 3, 6, and 12 months, compared to the same time periods historically.

(b) Streamflow from the following United States Geological Survey gage locations: Chattooga River at Summerville (02398000), Etowah River at Canton (02392000), Chestatee River near Dahlonega (02333500), Broad River near Bell (02192000), Chattahoochee River near Cornelia (02331600), Flint River at GA 26 near Montezuma (02349605), Oconee River at Dublin (02223500), Ocmulgee River at Macon (02213000), Ogeechee River near Eden (02202500), Spring Creek near Iron City (02357000), Ichawaynochaway Creek at Milford (02353500), Alapaha River at Statenville (02317500), Satilla River near Waycross (02226500).

(c) Groundwater: CD4 well: 11AA01, CD5 well: 21T001, CD7 wells: 13L180, 12M017, 11K003, 13J004, 12K014, 10G313, 08K001, 08G001, 09F520.

(d) Reservoir Levels: Allatoona Lake, Lake Hartwell, Clarks Hill Lake, Lake Lanier.

(3) Permittees that are public water systems shall notify the Division in writing within 7 days if a trigger level in the drought contingency plan required by Rules 391-3-2-.04(11)(d) or 391-3-6-.07(4)(b)9 is surpassed. The notification shall include the relevant drought condition(s) or event(s) such as streamflow levels, ground water levels, reservoir storage or levels, system demands, and/or other approved indicator(s) which required the notification.

(4) Prior to making a drought response level declaration pursuant to Section 391-3-30-.05, except for non-drought conditions, the Director shall convene a conference call, or similar communication medium, for all permittees for whom climatic indicators and water supply conditions are such that the Director is considering making a drought declaration. Within three business days of the Director's communication, potentially affected permittees may submit information to the Division regarding climatic indicators and/or their water supply conditions. For permittees whose principal source of water supply is surface water, they may submit a water supply and demand analysis as described in 391-3-30-.08(1)(b).

(5) During a declared drought pursuant to Section 391-3-30-.05, the Director shall convene a conference call, or similar communication medium, at least quarterly for all permittees subject to Drought Response Strategies in the affected drought area(s). The

purpose of this communication will be to review the latest climatic indicators and water supply conditions as they relate to the permittees.

(6) Prior to making a drought response level declaration pursuant to Section 391-3-30-.05, the Director may consult with state and federal entities charged with collecting, interpreting and disseminating data used as a basis for developing drought indices. Such agencies may include but not be limited to the following:

(a) State Climatologist;

(b) National Oceanic and Atmospheric Administration;

(c) United States Geological Survey; and

(d) United States Army Corps of Engineers.

Authority: O.C.G.A. Secs. ~~12-5-90 et.seq., 12-5-170 et. seq.,~~12-5-8.

391-3-30-.05 ~~Exemptions~~Drought Declaration.

~~(1) This rule shall not apply to the following outdoor water uses:~~
~~(a) Capture and re-use of cooling system condensate or storm water in compliance with applicable local ordinances.~~
~~(b) Re-use of gray water in compliance with applicable local ordinances.~~
~~(2) The following established landscape water uses are exempt from the outdoor water use schedules of this rule.~~
~~(a) Use of reclaimed wastewater by a designated user from a system permitted by EPD to provide reclaimed wastewater.~~
~~(b) Irrigation of personal food gardens.~~
~~(3) Newly (in place less than thirty days) installed landscapes are subject to the following:~~
~~(a) Irrigation of newly installed landscapes is allowed any day of the week, but only during allowed hours for the drought response level in effect, for a period of 30 days following installation. No watering is allowed during Drought Response Level Four.~~
~~(b) For new landscapes installed by certified or licensed professionals, commercial exemptions apply.~~
~~(4) The following golf course outdoor water uses are exempt from the outdoor water use schedules of this rule.~~
~~(a) Use of reclaimed wastewater by a designated user from a system permitted by EPD to provide reclaimed wastewater.~~
~~(b) Irrigation of fairways during times of non-drought and Declared Drought Response Level One.~~
~~(c) Irrigation of tees during times of non-drought and Declared Drought Response Levels One, Two and Three.~~
~~(d) Irrigation of greens.~~

~~(5) The following commercial outdoor water uses are exempt from the outdoor water use schedules of this rule.~~
~~(a) Professionally certified or licensed landscapers, golf course contractors, and sports turf landscapers: during installation and 30 days following installation only. Professional landscapers must be certified or licensed for commercial exemptions to apply.~~
~~(b) Irrigation contractors: during installation and as needed for proper maintenance and adjustments only.~~
~~(c) Sod producers.~~
~~(d) Ornamental growers.~~
~~(e) Fruit and vegetable growers.~~
~~(f) Retail garden centers.~~
~~(g) Hydro-seeding.~~
~~(h) Power-washing.~~
~~(i) Construction sites.~~
~~(j) Producers of food and fiber.~~
~~(k) Car washes.~~
~~(l) Other activities essential to daily business.~~
~~(m) Watering-in of pesticides and herbicides on turf.~~

(1) Based upon an evaluation in accordance with Section 391-3-30-.04, the Director may declare non-drought conditions and various drought response levels for the affected drought area(s). Such declaration shall be based upon the severity of drought conditions and their impact on the ability of permittees that are public water systems to provide adequate supplies of water within the affected drought area(s) and avoid or relieve local water shortages.

(2) The Director may declare non-drought conditions and drought response Level 1, 2 or 3, with Level 1 being the least severe and Level 3 being the most severe drought response level.

(3) The Director shall designate the geographical boundary of the affected drought area(s). The geographical delineation of a drought response level shall be based upon the severity of climatic indicators and condition of water supplies occurring within all or a portion of defined hydrologic units, counties or other areas. The drought response level shall apply to all permittees, except as described in subparagraph (4), within the affected drought area(s).

(4) The Director may differentiate between surface water drought and ground water drought in any affected drought area(s).

(5) Upon declaring a drought response level, including non-drought conditions, the Director shall provide notice of such declaration to all permittees and the general public within the affected drought area(s). At a minimum, the Director shall issue a press release and send each affected permittee a letter which shall include the drought response level and a summary of the requirements for that particular drought response level.

Authority: O.C.G.A. Secs. ~~12-5-90 et.seq., 12-5-170 et. seq.,~~ 12-5-8.

391-3-30-.06 ~~Local and Regional Options~~Drought Response Committee.

~~(1) Local and regional water providers are authorized to implement additional outdoor water use restrictions within their jurisdictions. Action items to consider at the local/regional level include, but are not limited to, the following: developing system integration and interconnection to reduce drought vulnerability, placing additional water use restrictions on specific commercial uses, putting water conservation based rates in place (increasing block/summer surcharge) and placing additional restrictions on outdoor water use.~~
~~(2) Local and regional water providers may request approval of alternative days for outdoor water use for purposes of enforcement, peak water usage, timing of recovery days, and other valid reasons. Approval shall be contingent upon:~~
~~(a) Written notification to, and approval by, EPD of the alternate watering schedule; and~~
~~(b) Enactment of a local ordinance allowing no more than 3 days a week outdoor watering during time(s) of day consistent with the level of drought as set forth in sections 391-3-30-.03 and -.04 of this rule.~~
~~(c) Regional consistency.~~

A Drought Response Committee may be convened by the Director at any time for purposes of consulting on the development and/or implementation of predrought mitigation strategies or drought response strategies and may consist of such members and for such period of time as the Director deems appropriate.

Authority: O.C.G.A. Secs. ~~12-5-90 et.seq., 12-5-170 et. seq.,~~12-5-8.

391-3-30-.07 Drought Response Strategies.

(1) Within 5 days of receipt of notice from the Division of a drought response level declared pursuant to 391-3-30-.05, each permittee within an area subject to a drought response level declaration shall implement the applicable drought response strategies listed below.

(2) Drought Response Level 1.

(a) Public water systems shall implement a public information campaign that shall include, at a minimum, public notice regarding drought conditions and drought specific public-service messages in one or more of the following ways: newspaper advertisements, bill inserts, website homepage, social media, and notices in public libraries.

(3) Drought Response Level 2. During Drought Response Level 2, permittees shall implement all Drought Response Level 1 measures plus the following additional Drought Response Level 2 measures:

(a) General Outdoor Watering. Outdoor irrigation for purposes of planting, growing, managing, or maintaining ground cover, trees, shrubs, or other plants, as described in 391-3-30-.03(1)(a), shall be limited to two days a week on an odd-even schedule. Even numbered addresses may irrigate on Wednesday and Saturday between the hours of 4:00 p.m. and 10:00 a.m. Odd numbered addresses may irrigate on Thursday and Sunday between the hours of 4:00 p.m. and 10:00 a.m. "Even numbered address" means an address number ending with the number 0, 2, 4, 6, 8, or the site does not have a numbered address. "Odd numbered address" means an address ending with the number 1, 3, 5, 7, or 9.

(b) The following outdoor water uses shall not be allowed, except as provided below:

1. Washing hard surfaces such as streets, gutters, sidewalks and driveways, except when necessary for public health and safety;

2. Using water for ornamental purposes, such as fountains, reflecting pools, and waterfalls;

3. Use of fire hydrants, except for the purposes of firefighting, public health, safety, or flushing;

4. Washing vehicles, such as cars, boats, trailers, motorbikes, airplanes, or golf carts;

5. Non-commercial washing, or pressure washing, of buildings or structures, except for immediate fire protection; and

6. Charity, or non-commercial fund-raiser, car washes.

(c) Permittees that are public water systems shall select and implement four, or more, additional practices from the Drought Response Strategies Menu in paragraph (5). Such permittees shall submit monthly reports to the Division by the 10th of each following month detailing the drought response strategies the system has selected, the extent of implementation, and enforcement strategy, if applicable.

(4) Drought Response Level 3. During Drought Response Level 3, permittees shall implement all Drought Response Level 1 and 2 measures plus the following additional Drought Response Level 3 measures:

(a) General Outdoor Watering. Outdoor irrigation for purposes of planting, growing, managing, or maintaining ground cover, trees, shrubs, or other plants, as described in 391-3-30-.03(1)(a), is not permitted.

(b) Specific Categories of Outdoor Water Use. The outdoor water uses listed in 391-3-30-.03(1)(b) shall be allowed, subject to the following additional requirements:

1. Irrigation of personal food gardens shall be conducted between the hours of 4:00 p.m. and 10:00 a.m., unless done using drip irrigation or soaker hoses. Irrigation of personal food gardens using drip irrigation or soaker hoses may be done at any time;

2. Irrigation of new and replanted plant, seed, or turf in landscapes, golf courses, or sports turf fields may be conducted at any time of day during installation and a maximum of 15 minutes every three hours for each zone for a period of 30 days immediately following the date of installation. The 15 minute duration may be extended and/or the three hour frequency may be shortened if a professional landscaper is onsite and determines that such adjustment is necessary to keep the plant, seed, or turf moist during the initial establishment period;

3. Handwatering with a hose with automatic cutoff or handheld container may be conducted between the hours of 4:00 p.m. and 10:00 a.m.;

4. Irrigation of athletic fields or public turf grass recreational areas may be conducted between the hours of 4:00 p.m. and 10:00 a.m., subject to the two days a week odd-even schedule described in Drought Response Level 2;

5. Irrigation of golf courses shall be conducted in accordance with the "Golf Irrigation Prediction and Estimation Worksheet" and only between the hours of 4:00 p.m. and 10:00 a.m., provided, however, irrigation of golf course greens may occur at any time of day;

6. Use of reclaimed waste water by a designated user from a system permitted by the Division to provide reclaimed waste water shall not be allowed for general outdoor watering as described in 391-3-30-.03(1)(a). It shall be allowed for any use described in 391-3-30-.03(1)(b) subject to the limitations in 391-3-30-.07(4)(b);

7. Installation, maintenance, or calibration of irrigation systems is allowed, provided that it is done by professional landscapers.

(c) Permittees that are public water systems shall implement all practices from the Drought Response Strategies Menu in paragraph (5).

(d) Rate Structures. Within 1 year of the effective date of this Rule, permittees that are public water systems shall develop a drought surcharge program as a temporary price incentive for customers to reduce water demand during a declared drought. Permittees with tiered conservation rates that comply with specific criteria for tiered conservation rates in the applicable Regional Water Plan are not required to develop a drought surcharge program. Permittees are not subject to requirements regarding Rate Structures if they do not serve retail customers.

1. The drought surcharge program shall meet the following criteria:

(i) Drought surcharge rate(s) shall be implemented within 60 days of receipt of drought response level declaration notice.

(ii) Drought surcharge rate(s) shall be distinct from established water rates;

(iii) Drought surcharge rate(s) shall apply only to the volumetric water rates; and

(iv) Drought surcharge rate(s) shall be approximately revenue neutral relative to non-drought periods. The Division will give deference to public water systems for their reasonable definition of revenue neutral.

(v) The drought surcharge program is not required to include industrial customers.

2. Permittees shall be exempted from the requirement to have drought surcharge rate(s) that are distinct from established water rates if they demonstrate to the Division that their billing system is unable to make such distinction. Such permittees shall notify all affected customers of the drought surcharge rate(s) through a billing insert whenever the drought surcharge program is initiated.

3. Permittees shall be exempted from the requirement to have drought surcharge rate(s) that apply only to the volumetric water rates if they demonstrate to the Division that their billing system is unable to apply a surcharge rate only to the volumetric use of water.

4. If the applicable Regional Water Plan does not have specific criteria for tiered conservation rates then permittees are exempted from the requirement to develop a drought surcharge program if their conservation rates are designed and implemented consistent with the Division's "Conservation-Oriented Rate Structures" guidance dated August 2007 or Conservation Action Item 5.1 in the Metropolitan North Georgia Water Planning District's 2009 Water Supply and Water Conservation Plan.

(e) Numeric Water Usage Reduction Requirements.

1. The Division may establish numeric reduction requirements for permittees that are public water systems and whose monthly average water use is greater than one million gallons per day. The numeric reduction requirements may vary based on time of year (i.e., warmer months and cooler months). The Division shall consider economic and climatic conditions during the baseline period when establishing the numeric reduction requirements. The Division shall also consider the public water system's peaking factor or their "Baseline Water Use and Efficiency Profile for Public Water Systems", if provided to the Division by the public water system, when establishing the numeric reduction requirements.

2. Permittees that are public water systems and whose industrial customers comprise more than 90 percent of water use shall be exempt from Numeric Water Usage Reduction Requirements.

(5) Drought Response Strategies Menu.

(a) Public information campaign that goes significantly beyond the minimum notice and public service messages associated with Drought Response Level 1;

(b) Glasses of water provided to restaurant customers only upon request;

(c) Distribute retrofit kits and water saving devices to customers. These kits and devices may include, but not be limited to, shower heads, leak dye tabs, toilet tank displacement devices, and hose shut off nozzles;

(d) Technical assistance outreach program to target high users to identify and/or recommend opportunities to reduce water usage;

(e) Reduce system pressure, unless such reduction would create unsafe water supply conditions;

(f) Pool cover requirements;

(g) Implement a drought surcharge program, or tiered conservation rates, that satisfy the criteria of this rule;

(h) Suspension of street cleaning program(s);

(i) Implement, or accelerate, leak detection and repair program(s);

(j) Impose monetary penalties or terminate water services to customers to reduce outdoor water waste due to excessive application, outdoor leaks, improper irrigation, or other similar reasons.

(6) Professional Exemptions. The following commercial outdoor water uses are exempt from the Outdoor Water Use restrictions of this rule:

(a) Pressure washing;

(b) Permanent car wash facility, provided that it is connected to a sanitary sewer system of a political subdivision or local government authority or recycles used wash water;

(c) Construction sites;

(d) Watering-in of pesticides and herbicides on turf; and

(e) Other activities essential to daily business.

Authority: O.C.G.A. §§ 12-5-7, 12-5-8, 12-5-170 et seq., 12-5-520 et seq., and 12-5-570 et seq.

391-3-30-.08 Variance Requests.

(1) Any application for a variance pursuant O.C.G.A. §12-5-7(a)(1) to impose restrictions on outdoor water use that are more stringent than those described in this Rule shall provide the following information demonstrating that the outdoor water use restrictions required by Chapter 391-3-30 will not avoid or relieve a local water shortage and the degree to which additional restrictions will avoid or relieve such water shortage:

(a) A statement of which Drought Response Level (Level 1, Level 2, Level 3, or Level 3 plus) the public water system seeks to apply, the duration of those restrictions, and a description of why such restrictions are necessary. For the purposes of this Rule, "Level 3 plus" means all Level 3 water usage restrictions plus additional restrictions proposed by the public water system in order to avoid or relieve a local water shortage.

(b) For permittees whose principal source of water is surface water, a water supply and demand analysis which includes a quantitative analysis of the effect that additional restrictions will have upon the permittee's source of water in terms of increased storage or streamflow available to the permittee for each month during which they will be implemented. The water supply and demand analysis shall, at a minimum, consist of a 24-month projection of the response of reservoir storage, or water withdrawals as a percent of streamflow, whichever is applicable, to demands represented by monthly water use for each month of the preceding calendar year, assuming calendar year 2007 – 2008 hydrologic conditions, and shall be conducted in accordance with the "Water Supply and Demand Analysis Worksheet."

(c) Quantity estimate of reduced water use on a monthly basis expected from implementing such restrictions for each month during which they will be implemented compared to a quantity estimate of reduced water use on a monthly basis expected from implementing the restrictions otherwise required by Chapter 391-3-30;

(d) Quantity estimate of the effect such restrictions will have upon the permittee's source of water in terms of increased storage or streamflow available to the permittee for each month during which they will be implemented.

(2) As provided for in O.C.G.A. §12-5-7(a)(2), a political subdivision of this state or local government authority shall not be prohibited from imposing more stringent restrictions on outdoor water use than those required by Chapter 391-3-30 in case of an emergency which immediately threatens the public health, safety, or welfare; provided, however, that such emergency restrictions shall be valid for a period not to exceed seven days unless a variance is granted by the Director.

(3) Any application for a variance pursuant O.C.G.A. §12-5-7(b) requesting restrictions on outdoor water use that are less stringent than those described in this Rule shall provide the following information demonstrating that the outdoor water use restrictions required by this Rule are not needed to avoid or relieve a local water shortage:

(a) A statement of which Drought Response Level (non-drought, Level 1, or Level 2) the public water system seeks to apply, the duration of the less stringent restrictions, and a description of why the restrictions described in the Rule are not necessary.

(b) For permittees whose principal source of water is surface water, a water supply and demand analysis which includes a quantitative analysis of the effect that the proposed less stringent restrictions will have upon the permittee's source of water in terms of storage or streamflow available to the permittee for each month during which they will be implemented. The water supply and demand analysis shall, at a minimum, consist of a 24-month projection of the response of reservoir storage, or water withdrawals as a percent of streamflow, whichever is applicable, to demands represented by monthly water use for each month of the preceding calendar year, assuming calendar year 2007 – 2008 hydrologic conditions, and shall be conducted in accordance with the "Water Supply and Demand Analysis Worksheet."

(c) Permittees whose water supply is obtained in whole or in part from storage in or releases from any project owned and operated by the United States Army Corps of Engineers may request a variance requesting restrictions on outdoor water use that are less stringent than those described in this Rule. However, for permittees that get more than 25 percent of their water supply from such projects, because these permittees have little control over the management of their water supply source, there shall be a rebuttable presumption that such variance requests should be denied by the Director.

(4) Upon consideration of the "good cause" showing required in Section 391-3-30-.08(1) or (3), as provided for in O.C.G.A. §12-5-7(c), the Director shall render a decision on an application for a variance within five business days after receipt thereof and grant a variance to the applicant of the restrictions required by this Rule if the applicant has provided sufficient evidence to support a reasonable conclusion that a variance is warranted.

(5) In order to provide for efficient implementation of the variance program and to facilitate effective communication to the media and the public regarding drought requirements, it is necessary and appropriate that variance requests be consistent with the framework of the Rule. Therefore, variance requests are limited to the Drought Response Levels (non-drought, Level 1, Level 2, Level 3, or Level 3 plus), and their corresponding Drought Response Strategies, as articulated in the rule.

Authority: O.C.G.A. §§ 12-5-7 and 12-5-8.

PROPOSED AMENDMENTS TO THE RULES
OF THE DEPARTMENT OF NATURAL RESOURCES
ENVIRONMENTAL PROTECTION DIVISION
RELATING TO GROUNDWATER USE, CHAPTER 391-3-2

The Rules of the Department of the Natural Resources, Chapter 391-3-2, Groundwater Use are hereby amended and revised for specific Rules, or such subdivisions thereof as may be indicated.

[Note: Underlined text is proposed to be added. ~~Lined-through~~ text is proposed to be deleted.]

CHAPTER 391-3-2 GROUNDWATER USE

391-3-2-.04 Permit Application. Amended.

(1) Any person who was withdrawing, obtaining or utilizing ground water prior to April 18, 1973 (or July 1, 1988 in the case of farm use), and who is required under Rule 391-3-2-.03 of this Chapter to obtain a permit shall submit an application for a permit to use ground water to the Division, on forms prepared and furnished, upon request, by the Division. The applicant shall furnish the Division with sufficient documented evidence as set forth in Paragraphs (5) or (6) of this Rule to evaluate the effects of the described water use upon the water resources of the area.

(2) Any person who started to withdraw, obtain, or utilize ground water after April 18, 1973 (or July 1, 1988 in the case of the farm use), and who is required under the Rule 391-3-2-.03 of this Chapter to obtain a permit, shall submit an application for a permit to use ground water to the Division, on forms prepared and furnished, upon request, by the Division. The applicant shall furnish the Division with sufficient documented evidence as set forth in Paragraphs (5) or (6) of this Rule to evaluate the proposed water use upon the water resources of the area. (Authority O.C.G.A. Sec. 12-5-105)

(3) Any person intending to withdraw, obtain, or utilize ground water and who is required under the Rule 391-3-2-.03 of this Chapter to obtain a permit, shall submit an application for a permit to use ground water to the Division, on forms prepared and furnished, upon request, by the Division. No ground water shall be withdrawn, obtained, or utilized until a permit has been granted. The applicant shall furnish the Division with sufficient documented evidence as set forth in Paragraphs (5) or (6) of the Rule to evaluate the impacts of the proposed water use upon the water resources of the area.

(4) During the early stages of planning for a proposed ground water withdrawal, and in any case prior to the start of well construction, the intended user should have a conference with representatives of the Division to determine the acceptability of the proposed well or wells, the aquifer or aquifers to be utilized, the well spacing and well depth, and the amount of intended ground water use. Such conference shall be granted within thirty (30) days after request therefor. The intended user should furnish the Division with such available documented evidence as set forth in Paragraphs (5), (6), or

(7) of this Rule for presentation at the conference or for later submittal, but prior to well construction. Based in part on the information furnished by the intended user and upon other considerations, a letter of concurrence may be issued by the Division setting forth such terms and conditions as the Division deems necessary. Upon completion of the construction of the well or wells and prior to any ground water use, the intended user shall submit an application for a ground water use permit to the Division pursuant to Rules 391-3-2-.05 and 391-3-2-.06 of this Chapter. The proposed water user proceeds at his own risk if he does not obtain a letter of concurrence from the Division prior to well construction.

(5) Sufficient documented evidence shall include, but not be limited to, the following (except for farm use permit applications):

(a) name and address of the applicant;

(b) the location of the existing or proposed well(s), identified by number, for which the permit is requested, marked on the best map available;

(c) the latitude and longitude, to the nearest ten (10) seconds, of the wells, obtained from the location map;

(d) the county in which the well(s) is located;

(e) the ground elevation of the well(s), if available;

(f) the amount of water withdrawn or proposed to be withdrawn or used, and a statement to indicate the extent to which such use or withdrawal is reasonably necessary to meet the needs of the applicant;

(g) any present or anticipated unreasonable adverse effects or potential unreasonable adverse effects on other water uses or users, including but not limited to, adverse effects on public or farm use;

(h) a statement specifying the beneficial use of the ground water withdrawn or to be withdrawn and whether the water use is a consumptive or nonconsumptive use, as herein defined;

(i) if the water use is, or proposes to be, a nonconsumptive use, the applicant shall state the following:

1. the treatment of the water and procedure used, or the proposed treatment of the water and the procedure to be used, to return the water to the aquifer or ground water system from which it is, or is proposed to be, withdrawn;

2. the location of the injection well or wells to be shown on the same map as the existing, or proposed, withdrawal wells;

3. the chemical, physical and bacteriological quality; and any other specified water quality analysis the Division may require, of the returned water, noting specifically any substantial impairment of the water quality from the water withdrawn;

4. the aquifer or ground water system from which the ground water is withdrawn, or intended to be withdrawn, and the amount of water to be returned to the aquifer or ground water system; and

5. any substantial decrease in quantity as originally withdrawn from the aquifer or ground water system.

(j) the aquifer or aquifers from which the ground water is withdrawn, or intended to be withdrawn;

(k) for existing wells, the well construction data for each well, on forms provided by the Division, including but not limited to, the following information:

1. name of driller;

2. date of drilling;

3. total well depth in feet;

4. diameter of drilled hole;

5. diameter and depth of casing, including casing material;

6. depth of grouting;

7. diameter and depth of the setting of the well screen or well screens, if used, and the material and type of screen;

8. type of permanent pump, size, horsepower, and yield;

9. static water level and pumping level; and

10. number of hours the well is pumped per day.

(6) For farm use, sufficient documented evidence shall include, but not be limited to, the following:

(a) applicant's full name;

(b) mailing address;

(c) county in which existing or proposed well is located;

(d) purposed of withdrawal;

(e) well construction data including, but not limited to the following:

1. well depth;

2. depth of pump intake below ground surface;

3. design pumping capacity of well; and

4. depth of well casing.

(f) month and year of well pump installation;

(g) number of acres irrigated from this well and average number of inches of water applied from this well per year;

(h) whether or not chemicals, fertilizers, fungicides, herbicides, insecticides, or nematicides are injected into the irrigation water; and

(i) county map supplied by the Division (or equivalent) showing the location of the water source. (Authority O.C.G.A. Sec. 12-5-105)

(7) Any person submitting an application for a ground water use permit who is at the time of application withdrawing, obtaining, or utilizing ground water, and who is unable to furnish accurate information concerning the amounts of ground water being withdrawn or used shall be required, as the Division deems necessary, to do the following:

(a) install one or more water meters; or

(b) some other more economical means acceptable to the Division, for measuring the ground water withdrawn or used.

(8) The Division, in determining the amount of ground water withdrawn or used by an applicant, may use one or more of the following:

(a) the rated capacity of the pump or pumps;

(b) the rated capacity of the cooling system;

(c) the standards or methods employed by the United States Geological Survey in determining such quantities; or

(d) any other acceptable method.

(9) Except for farm use, those applicants intending to withdraw, obtain or utilize ground water from wells constructed after April 18, 1973, shall submit, in addition to the information required in paragraph (5) of this Rule, well construction details and specifications, as the Division deems necessary, including, but not limited to, the following:

(a) total depth of well, in feet;

(b) size of drilled hole;

(c) size and depth of casing and type of casing material;

(d) size and depth of the placing of the well screen or screens and the type of material, if used;

(e) depth of grouting;

(f) deep well air line of steel, iron or heavy gage copper material, with screw cap, for water level measurements; and

(g) filling, plugging and sealing procedures for any well or wells that are to be abandoned.

(10) Due to the corrosive nature of the ground water in certain areas of the State, proposed well construction specifications and casing material may require modification as the Division deems necessary to avoid any potential unreasonable adverse effects on the aquifer or ground water system, or of other water uses.

(11) In the preparation of a permit application for a new permit or modification of an existing permit which includes an increase in the permitted water use (except for a farm use permit application) the applicant must submit to the Director for approval a water conservation plan prepared in accordance with the following guidelines. The plan must address the following items (or contain a statement why the item is not an appropriate part of the plan).

(a) System management;

1. Within the most recent 24 month period a minimum of twelve consecutive months of UAW data;

2. A description of current and planned programs to reduce UAW such as those listed below (include proposed schedules for planned activities);

(i) Leak detection and elimination;

(ii) Availability of accurate maps of the water system;

(iii) Meter maintenance, testing, replacement, calibration, etc.;

(iv) Prevention of tank overflows;

(v) Flushing programs without degradation of water quality;

(vi) Prevention of unauthorized water use--fire hydrants, fire lines etc.;

(vii) A list of unmetered service connections including publicly owned facilities, churches, etc.,

(viii) Other;

3. A list of inter-connections with other water systems and a description of any contractual agreements, type (emergency back-up, wholesale sale or purchase) and purchase amounts;

4. Any additional current or planned activities pertaining to system management that will contribute to water conservation.

(b) Treatment plant management;

1. The condition, calibration frequency, type, etc. of raw and finished water metering;

2. An analysis of in-plant water use for filter backwashing, overflows, laboratory use, etc. as a percentage of total plant production. Also, the plan must outline any ongoing or planned plant improvements (including schedules for planned improvements) and/or revised operational procedures to reduce in-plant use;

3. A description of any recycling or reuse of filter backwash water.

(c) Rate making policies;

1. A list of non-billed service connections. Also, if available, a breakdown by number of meters or % of total production for each class of customer, e.g., residential, commercial, industrial, wholesale;

2. A copy of the water rate structure currently in use including any surcharges, demand charges, etc., which may apply to certain customers and a description of the effects of this rate structure on water conservation;

3. A description of any system policies concerning second meters for landscape irrigation and any use of sewer meters for billing;

4. A statement in response to the following questions:

(i) Is the water system self-supporting?

(ii) Are water system expenditures subsidized by non-water/sewer system revenues?

(d) A drought contingency plan ~~approved~~submitted for approval by the Director and prepared in accordance with the following guidelines. The plan should include alternative system and resource management strategies to be implemented under drought conditions that may severely reduce the availability of the resource. The plan shall be consistent with Rule 391-3-30 with respect to restrictions on outdoor water use. If there are conflicts between this plan and Rule 391-3-30 with respect to restrictions on outdoor water use, Rule 391-3-30 shall prevail. The applicant must provide the following items in the plan (or a statement as to why the item is not an appropriate part of the plan):

1. Drought conditions or events that put the drought contingency plan into effect;

(i) The applicant must develop a system for determining drought severity based on some approved indicator, e.g.:

(I) System demands;

(II) Ground water levels;

(III) Other;

2. Potable water use priorities program;

(i) The following order of potable water use priorities is generally recommended but may be modified as needed based on local conditions:

(I) Emergency facilities for essential life support measures;

(II) Domestic and personal uses, including drinking, cooking, washing, sanitary and health related;

(III) Farm uses;

(IV) Industrial uses (including those industries on public water systems);

(V) Other uses such as lawn sprinkling, non-commercial car washing, garden watering, etc.;

(VI) Outdoor recreational uses;

3. Restrictions on lower priority uses (including enforcement procedures);

4. Rationing and/or other emergency procedures.

(e) Plumbing ordinances and/or codes;

1. Description of compliance with State Water Conservation Law which requires the use of ultra-low flow plumbing fixtures. The applicant may include copies of adopted ordinances if applicable;

2. Ordinances/codes or other special requirements pertaining to outside water use such as landscape irrigation systems, commercial car washes, etc.;

(f) Recycling--reuse;
A description or accounting of any recycling or reuse of treated wastewater;

(g) A description of current and planned education programs for the promotion of water conservation.

(h) Progress report;
Five years after issuance of a new or modified Ground Water Use Permit, the permittee must submit to the Director a progress report that outlines actions and/or improvements made to conserve water and reduce water loss, e.g., leak detection/repair, meter installation, calibration, or replacement, summer and peak use surcharges, enforcement of ultra-low flow plumbing fixture requirements, etc. Permittees with a total permitted withdrawal less than one million gallons per day may use a simplified reporting format supplied by the Division.

(i) Water use data;
Permittees must submit to the Director an annual water use data report that includes information on unaccounted for water for the past 12 months. The report must be submitted annually starting 12 months after new or modified permit issuance.

(j) Long range planning;
All permittees must incorporate water conservation into long term water demand and supply planning. Permittees must develop water demand projections covering a 20 year time period using a method or methods approved by the Director. The demand projects must reflect the effects (demand reduction) inherent in the implementation of new or enhanced water conservation programs.

(k) A description of any additional water conservation activities.

(12) Permitted capacities of applicant's water treatment and wastewater treatment plants, existing or planned, that will treat water and wastewater to be generated by new or increased use.

(13) Any other information deemed necessary; provided, however, any information already provided to the Director in connection with prior dealings, with the Division may

be incorporated into the application by specific and detailed reference and a statement that the information is still valid and correct.

Authority Ga. Laws 1972, pp. 976, 982, 985, et seq., as amended by Ga. Laws 1973, pp. 1273, 1277. Effective June 3, 1974. O.C.G.A. Secs. 12-5-7, 12-5-8, 12 -5-90, 12-5-91.

PROPOSED AMENDMENTS TO THE RULES OF THE DEPARTMENT OF NATURAL RESOURCES ENVIRONMENTAL PROTECTION DIVISION RELATING TO WATER QUALITY CONTROL, CHAPTER 391-3-6

The Rules of the Department of the Natural Resources, Chapter 391-3-6, Water Quality Control are hereby amended and revised for specific Rules, or such subdivisions thereof as may be indicated.

[Note: Underlined text is proposed to be added. ~~Lined-through~~ text is proposed to be deleted.]

CHAPTER 391-3-6 WATER QUALITY CONTROL

391-3-6-.07 Surface Water Withdrawals. Amended

(1) Purpose. This chapter establishes procedures to be followed in obtaining a permit to withdraw, divert or impound surface waters of the State. It sets forth the types of information to be supplied on a permit application. It also outlines the procedures for granting, denying, revoking and modifying such permits.

(2) Definitions. Whenever a term appears in this Chapter which has been defined in the Georgia Water Quality control Act (O.C.G.A. § 12-5-31, et seq.) such definition shall apply. Whenever a term appears in this Chapter that is defined below, such definition shall apply, so long as such definitions is not inconsistent with any definition in the Georgia Water Control Act.

(a) "Withdrawal" shall mean the taking away of surface water from its natural course.

(b) "Diversion" shall mean a turning aside or altering of the natural course of surface water.

(c) "Impoundment" shall mean the storing or retaining of surface water by whatever method or means.

(d) "Watershed" means that area of landing draining into any given point of a basin.

(e) "Surface water(s) of the State" or "surface water(s)" shall mean any and all rivers, streams, creeks, branches, lakes, reservoirs, ponds, drainage systems, springs producing in excess of 100,000 gallons per day, and all other bodies of surface water, natural or artificial, lying within or forming a part of the boundaries of the State which are not entirely confined and retained completely upon the property of a single individual, partnership or corporation.

(f) "Director" shall mean the Director of the Environmental Protection Division of the Department of Natural Resources, State of Georgia, or his designee.

(g) "Farm uses" shall mean irrigation of any land used for general farming, forage, aquaculture, pasture, turf production, orchards, or tree and ornamental nurseries; provisions of water supply for farm animals, poultry farming, or any other activity conducted in the source of farming operation. Farm uses shall also include the processing or perishable agricultural products and the irrigation of recreational turf, except in the Chattahoochee River watershed upstream from the Peachtree Creek confluence, where irrigation of recreational turf shall not be considered a farm use.

(h) "Domestic and personal uses" shall mean uses for drinking, cooking, washing, sanitary purposes, and all health related activities.

(i) "Instream flow" shall mean that minimum continuous flow reserved to the Surface Waters of the State at or immediately downstream of the point of withdrawal, diversion, or impoundment.

(j) "7Q10 Flow" shall mean that lowest average stream flow expected to occur for seven consecutive days with an average frequency of once in ten years.

(k) "Non-Depletable Flow" shall mean that instream flow consisting of the 7Q10 flow plus an additional flow needed to ensure the availability of water to downstream users. Non-depletable flow is normally calculated by adding the 7Q10 flow to the pro rata share of the downstream withdrawal, using the drainage area ratio method.

(l) "Basin" shall mean that the area within one of the fourteen river drainages listed below comprising the sum of the watershed within that basin.

1. Altamaha

2. Chattahoochee

3. Coosa

4. Flint

5. Ochlockonee

6. Ocmulgee

7. Oconee

8. Ogeechee

9. St. Marys

10. Satilla

11. Savannah

12. Suwannee

13. Tallapoosa

14. Tennessee

(m) "Interbasin Transfer" shall mean a withdrawal or diversion of water from one river basin, followed by use and/or return of some or all of that water to a second river basin. The river basin from which the withdrawal or diversion occurs is termed the 'donor' basin, and the river basin to which all or a portion of the water is diverted and returned is termed the 'receiving' basin.

(n) "Unaccounted for Water" (UAW) means the difference between the total amount of water pumped into the water system from the source(s) and the amount of metered water use by the customers of the water system expressed as a percentage of the total water pumped into the system. UAW generally includes system leakage and unmetered uses such as fire fighting, flushing, broken water mains, etc.

(o) “Made inflow to a reservoir” shall mean water that flows into a reservoir (1) after having been released from a storage project upstream of the reservoir as part of a plan approved by the Director; or (2) after having been discharged from a wastewater reclamation plant as part of a plan approved by the Director to increase flows into the reservoir.

(3) Permit Required.

(a) Any person who, on a monthly average, withdrawals more than 100,000 gallons of surface water per day; diverts surface water so as to reduce the flow by more than 100,000 gallons per day at the point where the watercourse, prior to diversion, leaves the property on which the diversion occurs; or constructs an impoundment which reduces the flow of surface water by more than 100,000 gallons per day downstream of the impoundment, must obtain a permit from the Director prior to any withdrawal, diversion or impoundment subject to the following exceptions:

1. Exceptions - No permit shall be required for the following:

(i) Any diversion accomplished as part of construction for transportation purposes which does not reduce the flow of surface waters in the diverted watercourse by more than 150,000 gallons per day on a monthly average.

(ii) Any reduction of flow of surface waters during the period of construction of an impoundment, including the initial filling of the impoundment;

(iii) Any farm pond or farm impoundment constructed and managed for the sole purpose of fish, wildlife, recreation or other farm uses.

(b) In evaluating a permit application for a new interbasin transfer, the Director should consider the factors specified in DNR Rule 391-3-6-.07(14) as well as the following:

1. Donor Basin Considerations.

(i) The quantity of the proposed withdrawal and the stream flow of the donor basin, with special consideration for dry years and low flow conditions;

(ii) The current and reasonably foreseeable future water needs of the donor basin, with special consideration for dry years and low flow conditions;

(iii) Protection of water quality in the donor basin, with special consideration for dry years and low flow conditions;

(iv) Any offsetting increases in flow in the donor basin that may be arranged through permit conditions;

(v) The number of downstream river miles from which water will be diverted as a result of the transfer.

(vi) The connection between surface water and groundwater in the donor basin, and the effect of the proposed transfer on either or both.

2. Receiving Basin Considerations.

(i) Determination of whether or not the applicant's proposed use is reasonable, including consideration of whether the applicant has implemented water conservation practices and achieved reasonable water conservation goals;

(ii) Assessment of the wastewater treatment capacity of the receiving basin;

(iii) The supply of water presently available to the receiving basin, as well as the estimates of overall current water demand and the reasonable foreseeable future water needs of the receiving basin;

(iv) The beneficial impact of any proposed transfer, and the demonstrated capability of the applicant to effectively implement its responsibilities under the requested permit;

(v) The impact of the proposed transfer on water conservation;

(vi) The applicant's efforts to explore all reasonable options for use of reclaimed water and recycling of available sources to meet the needs of the receiving basin;

(vii) Assessment of the adequacy of treatment capacity and current water quality conditions.

3. Considerations Affecting Both Basins.

(i) The economic feasibility, cost effectiveness, and environmental impacts of the proposed transfer in relation to alternative sources of water supply;

(ii) The cumulative impacts of the current and proposed interbasin transfers in the basin;

(iii) The requirements of the state and federal agencies with authority related to water resources;

(iv) The availability of water for responding to emergencies, including drought, in the donor basin and the receiving basin;

(v) The impact, whether beneficial or detrimental, on offstream and instream uses;

(vi) The quantity, quality, location, and timing of water returned to the donor basin, receiving basin, and basins downstream;

(vii) Impact on interstate water use;

(viii) The cumulative effect on the donor basin and the receiving basin of any water transfer or consumptive use that is authorized or forecasted;

(ix) Such other factors as are reasonably necessary to carry out the purposes of Georgia law.

4. Interbasin transfers of water as might occur in connection with mining, conveying, processing, sale, or shipment of minerals (e.g., as in the kaolin industry), or other products transported for further processing or sale shall be exempt from the requirements of 391-3-6-.07(3)(b).

(4) Permit Application: Non-Farm Uses.

(a) All applications shall be on forms furnished by the Division.

(b) The applications shall include:

1. Name and address of applicant;

2. Date of filing.

3. Source of water supply.

4. Quality applied for, both maximum day and monthly average. Maximum day withdrawal, diversion or impoundment shall be computed as the highest annual use by a water source or system in a 24-hour period, expressed in gallons per day. Monthly average withdrawal diversion or impoundment shall be computed as the highest total amount of water used by a water source or water system in any one month divided by the number of days in that month, expressed in gallons per day.

5. Use to be made, and documentation of need for water within five (5) years after date of filing.

6. Place of use.

7. Location withdrawal, diversion or impoundment plotted on a U.S. Geological Survey, 7½ minute quadrangle map or latest county highway map; and the latitude and longitude of the withdrawal expressed in degrees, minutes and seconds.

8. In the preparation of a permit application for a new permit or modification of an existing permit which includes an increase in the permitted water use (except for a farm use permit application), the applicant must submit to the Director for approval a water conservation plan prepared in accordance with the following guidelines. The plan must address the following items (or contain a statement why the item is not an appropriate part of the plan):

(i) System management;

(I) Within the most recent 24 month period, a minimum of twelve consecutive months of UAW data;

(II) A description of any current or planned programs to reduce UAW such as those listed below (include proposed schedules for planned activities);

I. Leak detection and elimination;

II. Availability of accurate maps of the water systems;

III. Meter maintenance, testing, replacement, calibration, etc.;

IV. Prevention of tank overflows;

V. Flushing programs without degradation of water quality;

VI. Prevention of unauthorized water use - fire hydrants, fire lines, etc.;

VII. A list of unmetered service connections including publicly owned facilities, churches, etc.;

VIII. Other;

(III) A list of inter-connections with other water systems and a description of any contractual agreements, type (emergency back-up wholesale sale or purchase) and purchase amounts;

(IV) Any additional current or planned activities pertaining to system management that will contribute to water conservation.

(ii) Treatment plant management:

(I) The condition, calibration frequency, type, etc. of raw and finished water metering;

(II) An analysis of in-plant water use for filter backwashing, over-flows, laboratory use, etc. as a percentage of total plant production. Also, the plan must outline any ongoing or planned plant improvements (including schedules for planned improvements) and/or revised operational procedures to reduce in-plant use;

(III) A description of any recycling or reuse of filter backwash water.

(iii) Rate making policies;

(I) A list of non-billed service connections. Also, if available, a breakdown by number of meters or % of total production for each class of customer, e.g., residential, commercial, industrial, wholesale;

(II) A copy of the water rate structure currently in use including any surcharges, demand charges, etc., which may apply to certain customers and a description of the effects of this rate structure on water conservation:

(III) A description of any system policies concerning second meters for landscape irrigation and may use of sewer meters for billing;

(IV) A statement in response to the following questions:

I. Is the water system financially self-supporting?

II. Are water system expenditures subsidized by non-water/sewer system revenues?

(iv) Plumbing ordinances and/or codes;

(I) A description of compliance with State Water Conservation Law which requires the use of ultra-low plumbing fixtures. The applicant may include copies of adopted ordinances if applicable;

(II) Ordinances/codes or other special requirements pertaining to outside water use such as landscape irrigation systems, commercial car washes etc.;

(v) Recycle - reuse; A description or accounting of any recycling or reuse of treated wastewater.

(vi) A description of current and planned education programs for the promotion of water conservation.

(vii) Progress report; Five years after issuance of a new or modified Surface Water Withdrawal Permit, the permittee must submit to the Director a progress report that outlines actions and/or improvements made to conserve water and reduce water loss, e.g. leak detection/repair, meter installation, calibration, or replacement, summer and/or peak use surcharges, enforcement of ultra-low flow plumbing fixture requirements, etc. Permittees with a total permitted withdrawal less than one million gallons per day on a monthly average may use a simplified reporting format supplied by the Division.

(viii) Water use data:

(I) Permittees must submit to the Director an annual water use data report that includes information on unaccounted for water for the past 12 months. This report will be submitted in conjunction with the annual water use report that is required pursuant to subsection 391-3-6-.07(15).

(ix) Long range planning.
All permittees must incorporate water conservation into long term water demand and supply planning. Permittees must develop water demand projections covering a 20 year time period using a method or methods approved by the Director. The demand projections must reflect the effects (demand reductions) inherent in the implementations of new or enhanced water conservation programs.

(x) A description of any additional water conservation activities.

9. A drought contingency plan ~~approved~~submitted for approval by the Director and prepared in accordance with the following guidelines. The plan should include alternative system and resource management strategies to~~p~~ be implemented under drought conditions that may severely reduce the availability of the resource. The plan shall be consistent with Rule 391-3-30 with respect to restrictions on outdoor water use. If there are conflicts between this plan and Rule 391-3-30 with respect to restrictions on outdoor water use, Rule 391-3-30 shall prevail. The applicant or permittee must provide the following items in the plan (or a statement as to why the item is not an appropriate part of the plan):

(i) Drought condition indicators;

(I) The applicant or permittee must develop a system for determining drought severity based on some approved indicator, e.g.:

I. Streamflow levels;

II. Ground water levels;

III. Reservoir storage or levels;

IV. Other.

(ii) Potable water use priorities program;

(I) The following order of potable water use priorities is generally recommended but may be modified as needed based on local conditions:

I. Emergency facilities for essential life support measures;

II. Domestic and personal uses, including drinking, cooking, washing, sanitary and health related;

III. Farm uses;

IV. Industrial uses (including those industries on public water systems);

V. Other uses such as lawn sprinkling, non-commercial car washing, garden watering, etc.;

VI. Outdoor recreational uses.

(II) Conditions or events that put priority use system into effect;

(III) Adopted priority use system for service during periods of water shortages;

(IV) Restrictions on lower priority uses (including enforcement procedures);

(V) Rationing and/or other emergency procedures.

(iii) Low flow protection;

(I) For applications for new or modified permits to withdraw, impound or divert surface water: No permit will be issued by the Director which authorizes the depletion of the instream flow established for the withdrawal, diversion or impoundment of surface water, except for periods of Emergency Water Shortage as described in Subsection 391-3-6-.07(12);

(II) For applications for new or modified permits, the applicant will be required to pass instream flow at or immediately downstream of the point of withdrawal, diversion or impoundment so long as it is available from upstream. When upstream flows drop below the required instream flow at the point of withdrawal, diversion or impoundment, the applicant will be required to pass that upstream flow. The Instream Flow required for new or modified permits in this subsection shall be:

I. The 7Q10 flow, if no unreasonable adverse effects to the stream or other water users will occur from the withdrawal, diversion or impoundment; or

II. The Non-Depletable Flow, as established by the Director, if probable impacts of the withdrawal, diversion or impoundment would occur to other water users; or

III. Other appropriate instream flow limit, as established by the Director;

(III) Low-flow monitoring plan that outlines applicant's procedure to monitor and protect instream flow below the point of withdrawal. Where applicable, the applicant must develop a plan for monitoring stream flow so that the instream flow limit can be protected. The monitoring plan must determine stream flow based on one of the following:

I. U.S.G.S. staff gage or continuous recording station;

II. Other staff gage as approved by the Director;

III. Weir;

IV. Other.

(iv) Water storage available to ensure availability of raw water to applicant through a critical drought period. Examples of suitable critical drought periods include but are not limited to: 50-year recurrence interval; 1954-1956 drought; 1984-1988 drought. The definition of available storage should include:

(I) Yield vs. drought return period;

(II) Storage type, e.g., main stream or off-stream supplemental;

(III) Any available alternate sources of finished and raw water such as ground water, interconnections, contractual agreements.

10. Consumptive loss of water withdrawn, diverted or impounded.

11. Permitted capacities of applicant's water treatment and wastewater treatment plants, existing or planned, that will treat water and wastewater to be generated by new or increased use.

12. Any other information deemed necessary; provided, however, any information already provided to the Director in connection with prior dealings with Division may be incorporated into the application by specific and detailed reference and a statement that the information is still valid and correct.

(5) Permit Applications: Farm Uses.

(a) Prior Uses. A permit for the withdrawal or diversion of surface waters for farm uses shall be issued by the Director to any person when the applicant submits an application which provides reasonable proof that the applicant's farm use of surface waters occurred prior to July 1, 1991. If submitted prior to July 1, 1991, an application for a permit to be issued based upon farm uses of surface waters occurred prior to July 1, 1988, shall be granted for the withdrawal or diversion or surface waters at a rate of withdrawal or diversion equal to the greater of the operating capacity in place for withdrawal or diversion on July 1, 1988, or, when measured in gallons per day on a monthly average for a calendar year, the greatest withdrawal or diversion capacity during the five-year period immediately preceding July 1, 1988.

(b) New Uses. If submitted after July 1, 1991, or regardless of when submitted, if it is based upon a withdrawal or diversion of surface waters for farm use occurring or proposed to occur on or after July 1, 1988, an application shall be subject to evaluation and classification pursuant to subsection 391-3-6-.07(4), -.07(6) and -.07(7) of these Rules; but a permit based upon such evaluation and classification shall be issued to ensure the applicant's right to a reasonable use of such surface waters.

(c) Permittees shall submit application for withdrawal or diversion of water for farm use to the Division on forms to be supplied by the Division. One application will be required for each water source. Applications will include the following information:

1. Applicant's full name;

2. Mailing address;

3. County in which water source is located;

4. Purpose of withdrawal;

5. Source pond, lake, reservoir, stream, river or sinkhole, with name;

6. Number of pumps withdrawing/diverting surface water from above source;

7. Design pumping capacity (total) of pumps withdrawing water from this source for this farm (gallons per minute);

8. Month and year this capacity was installed;

9. Number of acres irrigated from this water source, and average number of inches of water applied per year;

10. Whether or not chemicals, fertilizers, fungicides, herbicides, insecticides or nematicides are injected into the irrigation water; and

11. County map supplied by the Division (or equivalent) showing the location of the water source.

(6) Combination Uses.

A combination of farm and non-farm surface use shall be considered a non-farm surface use, unless the director determines that the predominant use to which the water is put is farm use.

(7) System of Classification for Competing Permit Applications.

(a) In situations involving competing uses, existing or proposed, for a supply of available surface water, the Division shall consider:

1. The number of persons using the particular water source and the object, extent and necessity of their respective withdrawals or uses;

2. Nature and size of water source;

3. Low flows during droughts of record;

4. Any water quality of the water source which would adversely affect its availability or fitness for use;

5. The probable severity and duration of low flows, poor water quality or other impairments of the water source which would adversely affect its availability or fitness for use;

6. The injury to public health, safety or welfare which would result if such impairment were not prevented or abated;

7. The kinds of businesses or activities to which the various uses are related and the economic consequences;

8. The importance and necessity of the uses, including farm uses, claimed by permit applicants and the extent of any injury or detriment caused or expected to be caused to other water uses;

9. Diversion from or reduction of flows in other watercourses;

10. The prior investments of any person in lands, and plans for the farm usage of water in connection with such lands, which plans have been submitted to the Director within a reasonable time after July 1, 1988; provided that the granting of such a permit shall not have unreasonably adverse effects upon other water uses in the area, including potential as well as present use;

11. The varying circumstances of each use.

(8) Priorities for Competing Applications.

(a) When there are competing applications for water from the same source, and the source is insufficient to supply all applicants, the following order of priorities shall prevail:

1. Emergency facilities for essential life support measures.

2. Domestic and personal uses, including drinking, cooking, washing, sanitary purposes and all health related activities.

3. Farm uses as defined herein.

4. Industrial uses (including those industries on public water systems).

5. Other uses such as lawn sprinkling, noncommercial car washing, garden watering, etc.

6. Outdoor recreational uses.

(b) Competing applicants or users within the above categories shall be assigned a priority rating based upon a consideration of the facts set forth in subsection 391-3-6-.07(6) of these Rules. In the event two or more competing applicants or users qualify equally under the priority rating, the Director will grant permits to such competing applicants, or modify the existing permits of the users, for use of specified quantities of surface water on a prorated or other reasonable basis in those situations where such action is feasible, provided, however, that the Director will give preference to an existing use over an initial application.

(c) The Division shall take into consideration the extent to which such withdrawals, diversions or impoundments are reasonably necessary in the judgment of the Director to meet the applicant's reasonable needs; including the needs of any third party to whom the permit applicant was furnishing water for the processing of perishable agricultural products which require minimum quantities of water to comply with State or federal laws or regulations, and shall grant a permit which shall meet those reasonable needs; provided, however, that the granting of such permit shall not have unreasonable adverse affect upon other water uses in the area including but not limited to public use, farm use, and potential as well as present use, and provide, further, however, notwithstanding the above, that the Director shall grant a permit to any permit applicant who on the effective date of this Act has outstanding indebtedness in the form of revenue certificates or general obligation bonds which are being amortized through the sale of surface water, the permitted quantity of such shall be at least in a amount consistent with the quantity for which the revenue certificates or general obligation bonds were issued.

(9) Duration of Permits.

(a) Any permit granted for the withdrawal, diversion or impoundment of surface waters shall be for a period of time not less than ten (10) years (unless the applicant requests a shorter period of time) nor more than twenty (20) years, except that farm use permits shall have no term and may be transferred or assigned to subsequent owners of the land which are the subject of such permit. Provided, however, that the Division shall be notified in writing by the permittee of such transfer or assignment. The Director may authorize a permit of duration of up to fifty (50) years in the case of a municipality or other governmental body where such period is required to provide for the retirement of bonds for the construction of water works or waste disposal facilities;

(b) If requested by the applicant, the Director may issue a temporary permit for less than ten (10) years, or letter of concurrence for transient uses lasting less than 180 days. Applicant's concurrence with a draft permit whose duration is less than ten (10) years shall serve as a request for a temporary permit.

(10) Renewal of Permits.

All permittees desiring to renew a permit shall submit an application for renewal to the Director within six (6) months prior to its expiration. All renewals will be treated in the same manner as the initial permit.

(11) Revocation, Suspension or Modification of Permits.

(a) Any permit granted for the withdrawal, division or impoundment of surface waters may be revoked, in whole or in part, permanently or temporarily, for the following reasons:

1. Any material false statement in an application for a permit or in any report required to be made;

2. Any willful violation of a condition of a permit;

3. Nonuse of the water supply (or a significant portion thereof) allowed by a permit for a period of two (2) consecutive years or more, unless the permittee can reasonably demonstrate that his nonuse was due to extreme hardship caused by factors beyond his

control; except that this paragraph will not apply to farm use permits issued after initial use has commended;

4. With the written consent of the permittee.

(b) Any such permit may be revoked, in whole or in part, for a period not to exceed one (1) year for violation of any provision of Section 12-5-31, et seq. of the Georgia Water Quality Control Act;

(c) Any such permit may be suspended or modified if the Director should determine that the quantity of water allowed under the permit is greater than that needed by the permittee for the particular use upon which the application for permit was based, or would prevent other applications from reasonable use of surface waters, including farm use;

(d) The director may suspend or modify a farm use permit if he should determine through inspection, investigation, or otherwise that the quantity of water allowed under the permit would prevent other applicants from reasonable use of surface waters for farm use;(e) Consistent with the consideration set forth in Chapter 391-3-6-.07(7), any such permit may be revoked, suspended or modified for any other good cause consistent with the health and safety of the citizens of this State and within the provisions of this Act;

(f) In the event of modification, suspension or revocation of permit, the Director shall serve written notice of such action on the permit holder and give the reason for such action.

(12) Emergency Water Shortage.

(a) Any permit may be suspended, restricted or otherwise modified by emergency order of the Director when an emergency period of water shortage exists. Prior to any such action, it must clearly appear to the Director from specific facts shown by affidavits of residents of the affected area of this State that an emergency period of water shortage exists within such area, so as to place in jeopardy the health or safety of the citizens of such area or to threaten serious harm to the water resources of the area. Any permittee has five (5) days from the date of mailing of the notice of the proposed change in the permit to appear in opposition to the proposed action. Except as to farm uses, any change, suspension or restriction in the permit is effective immediately upon receipt of such order by the permittee, his agent for service of process, or any agent of employee of the permittee who receives the notification at the permittee's principal place of business in the State. Any permittee, other than a farm use permittee, to whom such order is directed shall comply therewith immediately;

(b) Upon application, the permittee, including a farm use permittee, shall be afforded a hearing before a hearing officer appointed by the Department of Natural Resources within twenty (20) days of receipt of said application by the hearing officer. Farm use permittees may continue to make use of water to their permitted capacity during the appeal process, but failure to timely request a hearing in accordance with Subsection (c) of Code Section 12-2-2 shall waive such right;

(c) In the event of dire emergency, only water for domestic and personal uses, for drinking, cooking, washing, sanitary purposes and all health related activities will be permitted. Farm uses will be given second priority; however, all other usages will be established by the Director based on the priorities established in subsection 391-3-6-.07(7). The importance and necessity of water for industrial purposes are in no way modified or diminished by this subsection;

(d) Upon expiration of the emergency period of water shortage, the permittee will be notified in writing of such expiration and the said permittee may then operate under the permit as issued prior to the emergency.

(13) Request for Modification of Unexpired Permit.

A permittee may seek modification of any of terms of an issued permit. The Director may modify such permit providing the permittee establishes at least one of the following:

(a) a change in conditions has resulted in a need by the permittee of more water than is allowed under the existing permit;

(b) The proposed modification would result in a more efficient use of water than is allowed under the existing permit; or

(c) A proposed change in conditions would result in a need by the permittee of more than is allowed under the existing permit. Any such modification shall be consistent with the health and safety of the citizens of this State and with provisions of this Act.

(14) New Interbasin Transfers.

(a) In the consideration of applications for permits which if granted would authorize a new interbasin transfer as defined in paragraph 391-3-6-.07(2)(m), the Director shall be bound by the following requirements:

1. The Director shall give due consideration to competing existing uses and applications for permits which would not involve interbasin transfer of surface water and, subject to subsection 391-3-6-.07(7), shall endeavor to allocate a reasonable supply of surface waters to such users and applicants.

(b) Public Notification.

1. A notice of the draft permit which would authorize a new interbasin transfer of surface water shall be circulated by at least one of the following means: publication in one or more newspapers of general circulation in the area which would be affected by such

issuance; posting on website(s); or distribution to interested parties by email or other mechanisms.

2. The Director shall provide a public comment period of 30 days following the date of the notice of the draft permit.

3. If the Director determines sufficient public interest exists, he shall hold a hearing somewhere within the area affected prior to the issuance of the permit. The Director shall provide reasonable notice of such meeting.

(15) Records.

Except for farm use permits issued pursuant to subsection 391-3-6-.07(5), whenever required to carry out the objectives of Section 12-5-31 et seq. of the Georgia Water Quality Control Act, the Director may by order, permit or otherwise, in writing, require any person holding a permit or any other person who the Director reasonably believes in unlawfully withdrawing, diverting or impounding surface waters to:

(a) Establish and maintain records;

(b) Make reports;

(c) Install, use and maintain monitoring equipment or methods;

(d) Submit other information as required; provided any information already furnished to the Director in connection with prior dealing with the Division may be incorporated into the records or reports by specific and detailed reference and a statement that the information is still valid and correct;

(e) Except for farm uses, permittees shall submit annually to the Division a report of water use for the previous calendar year, to include monthly average and maximum day use for each month. Such reports shall be on forms provided by the Division and shall be submitted to the Division by January 31 of the current year for water use in the previous calendar year.

(16) Storage Rights

(a) When a user has contracted for the right to utilize storage space within a reservoir that is owned or operated by an agency of the federal government, the Director shall retain authority to allocate any State water rights subject to regulation under O.C.G.A § 12-5-31, including the right to withdraw State waters from the project as well as the right to impound made inflow to the reservoir. When the Director allocates to a specific user made inflows to a reservoir, pursuant to the permitting authority and procedure provided by O.C.G.A. § 12-5-31, that user will have the right to impound such flows in the storage space for which it has contracted, to the extent storage space is available.

(b) The intent of subparagraph (a) is to retain and exercise to the fullest extent the State's sovereign authority to control the use and storage of surface waters within its boundaries. In the event a court of competent jurisdiction determines that the Director's exercise of authority pursuant to this subsection is preempted by federal law, the Director's allocation shall be given effect to the maximum extent permissible.

(c) The following factors shall be considered by the Director when allocating made inflows to a reservoir pursuant to paragraph (a):

1. The criteria set forth in 391-3-6-.07(7).

2. Whether the water to be stored will be utilized in a manner consistent with the Georgia Comprehensive State-wide Water Management Plan and any plans prepared by the applicable Regional Water Planning Council or the Metropolitan North Georgia Water Planning District.

3. Such other physical and equitable factors as the Director may deem appropriate.

(17) Enforcement.

The administration and enforcement of these Rules shall be in accordance with the Georgia Water Quality Control Act and the Georgia Administrative Procedure Act.

(18) Effective Date.

This Rule shall become effective twenty days after filing with the Secretary of State's office.

Authority Ga. L. 1964, p. 416, et seq., as amended (O.C.G.A. Sec. 12-5-20 et seq.), Ga. L. 1972, p. 1015, et seq., as amended (Ga. Code Ann. 40-3501 et seq.), Ga. L. 1977, p. 368-380 (Ga. Code Ann. Sec. 17-510.1); O.C.G.A. Sec. 12-6-31 et seq.

Exhibit 57

Senate Bill 370

By: Senators Tolleson of the 20th, Bulloch of the 11th, Cowsert of the 46th, Hooks of the 14th, Weber of the 40th and others

AS PASSED

A BILL TO BE ENTITLED

AN ACT

To enact and revise provisions of law relating to water supply and water conservation; to state legislative findings; to amend Chapter 5 of Title 12 of the Official Code of Georgia Annotated, relating to water resources, so as to require the Georgia Department of Natural Resources, including its Environmental Protection Division, the Georgia Environmental Facilities Authority, the Georgia Department of Community Affairs, the Georgia Forestry Commission, the Georgia Department of Community Health, including its Division of Public Health, the Georgia Department of Agriculture, and the Georgia Soil and Water Conservation Commission to examine their practices, programs, policies, rules, and regulations in order to develop programs and incentives for voluntary water conservation and to make regular reports of measurable progress to the Governor, Lieutenant Governor, Speaker of the House, and General Assembly; to require the establishment of best management practices by public water systems; to change provisions relating to state and local watering restrictions; to provide for the classification and continuation or discontinuation of certain farm use water withdrawal permits; to provide for measuring and separate charging of water to units in certain new construction; to amend Article 1 of Chapter 2 of Title 8 of the Official Code of Georgia Annotated, relating to buildings in general, so as to require high-efficiency toilets, shower heads, and faucets; to require high-efficiency cooling towers; to create the Joint Committee on Water Supply; to provide for related matters; to provide for an effective date; to repeal conflicting laws; and for other purposes.

BE IT ENACTED BY THE GENERAL ASSEMBLY OF GEORGIA:

SECTION 1.

The General Assembly recognizes the imminent need to create a culture of water conservation in the State of Georgia. The General Assembly also recognizes the imminent need to plan for water supply enhancement during future extreme drought conditions and other water emergencies. In order to achieve these goals, the General Assembly directs the Georgia Department of Natural Resources to coordinate with its Environmental Protection

Division, the Georgia Environmental Facilities Authority, the Georgia Department of Community Affairs, the Georgia Forestry Commission, the Georgia Department of Community Health, including its Division of Public Health, the Georgia Department of Agriculture, and the Georgia Soil and Water Conservation Commission to work together as appropriate to develop programs for water conservation and water supply.

SECTION 2.

Chapter 5 of Title 12 of the Official Code of Georgia Annotated, relating to water resources, is amended by inserting in lieu of reserved Code Section 12-5-4 a new Code Section 12-5-4 to read as follows:

"12-5-4.

(a) As used in this Code section, the term 'agency' or 'agencies' means the Georgia Department of Natural Resources, including its Environmental Protection Division, the Georgia Environmental Facilities Authority, the Georgia Department of Community Affairs, the Georgia Forestry Commission, the Georgia Department of Community Health, including its Division of Public Health, the Georgia Department of Agriculture, and the Georgia Soil and Water Conservation Commission individually or collectively as the text requires.

(b) On or before August 1, 2010, the agencies shall examine their practices, programs, policies, rules, and regulations to identify opportunities to provide enhanced programming and incentives for voluntary water conservation. The agencies shall, without limitation, identify and provide for rules, regulations, incentives, or opportunities to:

(1) Include water conservation measures in the comprehensive plans submitted to the Department of Community Affairs by local governments;

(2) Provide technical assistance to local governments and public water systems for water loss abatement activities;

(3) Support state-wide water campaigns and public outreach programs, such as Conserve Georgia and WaterFirst programs;

(4) Encourage residential and commercial retrofits for water efficient fixtures and equipment;

(5) Encourage residential and commercial retrofits for water efficient landscaping irrigation systems;

(6) Encourage the installation of landscapes in commercial and residential settings utilizing landscape best management practices that include soil preparation, plant selection, and water use efficiency;

(7) Encourage the use of rain water and gray water, where appropriate, in lieu of potable water;

(8) Encourage the installation of submeters on existing nonsubmetered multifamily complexes and multiunit commercial and industrial complexes;

(9) Encourage public water systems to develop and improve water loss abatement programs;

(10) Encourage public water systems to implement the industry's best management practices for controlling water loss and achieve the recommended standards;

(11) Provide incentives for residential and commercial water conservation pricing by public water systems;

(12) Provide incentives for public water systems to use full cost accounting;

(13) Encourage voluntary inclusion of water conservation guidelines in applications for new ground-water withdrawal permits and surface-water withdrawal permits; and

(14) Examine the effect that water conservation has on water rates and consider policies to mitigate the financial impact that rate increases or reductions in water use have on water utilities and water users.

(c) On or before August 1, 2010, the agencies shall examine their practices, programs, policies, rules, and regulations to identify opportunities to enhance the state's water supply. The agencies shall, without limitation, identify opportunities to:

(1) Obtain funding; and

(2) Conduct feasibility studies on reservoir dredging and water management measures that could enhance water supply when funding is available.

(d) Each agency shall coordinate with the Department of Natural Resources to:

(1) Establish administrative programs and procedures to encourage water conservation and to enhance the state's water supply consistent with the results of the reviews required under subsections (b) and (c) of this Code section;

(2) Submit an interim report of the reviews required under subsections (b) and (c) of this Code section to the Governor, Lieutenant Governor, and Speaker of the House on or before July 1, 2010, which shall include, at a minimum, the programmatic changes and proposed changes being implemented to encourage water conservation and to enhance the state's water supply;

(3) Submit a final report of the review required under subsections (b) and (c) of this Code section to the General Assembly by August 1, 2010, which report shall include at a minimum an outline and narrative summary of the rules, regulations, and policies that have been adopted to encourage water conservation and to enhance the state's water supply; and

(4) Submit a report to the General Assembly on or before January 1 of 2011, 2012, 2013, 2014, and 2015 including an outline and narrative summary of the the programmatic changes encouraging water conservation and to enhance the state's water supply that were

implemented during the immediately preceding calendar year, outlining the agency's goals for the next calendar year, and identifying the rules, regulations, and policies that were adopted to support those programmatic changes."

SECTION 3.

Said chapter is further amended by adding a new Code Section 12-5-4.1, to read as follows:

"12-5-4.1.

(a) As used in this Code section, the term:

(1) 'Division' means the Environmental Protection Division of the Department of Natural Resources.

(2) 'Public water system' means a system for the provision to the public of piped water for human consumption, if such system regularly serves at least 3,300 individuals. Such term includes but is not limited to any collection, treatment, storage, and distribution facilities under the control of the operator of such system and used primarily in connection with such system and any collection or pretreatment storage facilities not under such control which are used primarily in connection with such system.

(b) The Board of Natural Resources shall by January 1, 2011, adopt rules for the minimum standards and best practices for monitoring and improving the efficiency and effectiveness of water use by public water systems to improve water conservation. The best practices program shall include without limitation:

(1) The establishment of an infrastructure leakage index;

(2) The establishment of categories of public water systems based on geographical size and service population;

(3) A phased-in approach requiring public water systems to conduct standardized annual water loss audits according to the International Water Association water audit method/standard and to submit those audits to the division;

(4) A phased-in approach requiring public water systems to implement water loss detection programs; and

(5) The development of a technical assistance program to provide guidance to public water systems for water loss detection programs, to include without limitation metering techniques, utilization of portable and permanent water loss detection devices, and funding when available.

By January 1, 2012, public water systems serving at least 10,000 individuals shall have conducted a water loss audit pursuant to the minimum standards and best practices adopted by the Board of Natural Resources. By January 1, 2013, all other public water systems shall have conducted a water loss audit pursuant to the minimum standards and best practices adopted by the Board of Natural Resources. Audit results shall be submitted to the division within 60 days of completion and shall be posted on the division's website in a timely manner after receipt by the division."

SECTION 4.

Said chapter is further amended by revising Code Section 12-5-7, relating to local variances from state restrictions on outdoor watering, as follows:

"12-5-7.

(a)(1) Any political subdivision of this state or local government authority may, upon application to and approval by the director of the Environmental Protection Division of the department for good cause shown, impose more stringent restrictions on outdoor water use during nondrought periods or state declared periods of drought than those applicable restrictions, if any, imposed by the state during such periods. For purposes of this subsection, 'good cause' means evidence sufficient to support a reasonable conclusion, considering available relevant information, that such additional restrictions are necessary and appropriate to avoid or relieve a local water shortage. A variance granted pursuant to this subsection shall be valid for such period as determined by the director.

(2) Paragraph (1) of this subsection shall not prohibit a political subdivision or local government authority from imposing more stringent restrictions on outdoor water use in case of an emergency which immediately threatens the public health, safety, or welfare; provided, however, that such emergency restrictions shall be valid for a period not exceeding seven days unless a variance is granted by the director pursuant to paragraph (1) of this subsection. If the director determines that a political subdivision or local government authority is exercising emergency powers granted by this paragraph in a manner to circumvent the necessity of obtaining such a variance, he or she may suspend the emergency powers granted by this paragraph to such political subdivision or local government authority.

(3) In the event that a political subdivision of this state or local government authority is unable to satisfy reduced water consumption or other permit requirements under its water withdrawal or operating permit due to its inability under this subsection to impose more stringent restrictions on outdoor water use during periods of drought than those applicable restrictions, if any, imposed by the state, such political subdivision or local government authority shall be exempt from fines, sanctions, or other penalties applicable for such failure upon the approval of the director of the Environmental Protection Division of the department. The director shall consider all measures implemented by such political subdivision or local government authority prior to issuing fines, sanctions, or other penalties applicable, if any, for such failure. The political subdivision or local

government authority shall notify the director of the Environmental Protection Division of the department within ten business days following the discovery of such failure. The director may request additional information at any time to substantiate such a claim.

(4) The director of the Environmental Protection Division may revoke, suspend, or modify, upon not less than three days' written notice, a political subdivision's or local government authority's water withdrawal or waste treatment permit issued pursuant to this chapter consistent with the health, safety, and welfare of the citizens of this state for violation of paragraph (1) or (2) of this subsection or any variance granted pursuant thereto.

(a.1)(1) Persons may irrigate outdoors daily for purposes of planting, growing, managing, or maintaining ground cover, trees, shrubs, or other plants only between the hours of 4 P.M. and 10:00 A.M.

(2) Paragraph (1) of this subsection shall not create any limitation upon the following outdoor water uses:

(A) Commercial agricultural operations as defined in Code Section 1-3-3;

(B) Capture and reuse of cooling system condensate or storm water in compliance with applicable local ordinances and state guidelines;

(C) Reuse of gray water in compliance with Code Section 31-3-5.2 and applicable local board of health regulations adopted pursuant thereto;

(D) Use of reclaimed waste water by a designated user from a system permitted by the Environmental Protection Division of the department to provide reclaimed waste water;

(E) Irrigation of personal food gardens;

(F) Irrigation of new and replanted plant, seed, or turf in landscapes, golf courses, or sports turf fields during installation and for a period of 30 days immediately following the date of installation;

(G) Drip irrigation or irrigation using soaker hoses;

(H) Handwatering with a hose with automatic cutoff or handheld container;

(I) Use of water withdrawn from private water wells or surface water by an owner or operator of property if such well or surface water is on said property;

(J) Irrigation of horticultural crops held for sale, resale, or installation;

(K) Irrigation of athletic fields, golf courses, or public turf grass recreational areas;

(L) Installation, maintenance, or calibration of irrigation systems; or

(M) Hydroseeding.

(3) Governing authorities of counties and municipalities shall adopt the provisions of paragraphs (1) and (2) of this subsection by ordinance, to become effective not later than January 1, 2011, and violations of such adopted provisions shall be punished as ordinance violations.

(b) Any political subdivision of this state or local government authority may apply for and, upon approval by the director of the Environmental Protection Division of the department for good cause shown, shall be granted an exemption from nonstatutory outdoor watering restrictions or water use reductions imposed by the state. For purposes of this subsection, 'good cause' means evidence sufficient to support a reasonable conclusion, considering available relevant information, that such restrictions, reductions, or both are not necessary and appropriate to avoid or relieve a local water shortage. A variance granted pursuant to this subsection shall be valid for such period as determined by the director.

(c) The director shall render a decision on an application made by a political subdivision or local government authority under subsection (a) or (b) of this Code section within five business days after receipt thereof.

(d) This Code section shall stand repealed and reserved on July 1, 2010.

(d)(1) Any permittee who is aggrieved or adversely affected by any order or action of the director of the Environmental Protection Division pursuant to this Code section shall have a right to a hearing pursuant to the provisions of Code Section 12-2-2.

(2) Notwithstanding the stay provisions of subparagraph (c)(2)(B) of Code Section 12-2-2, the filing of a petition for a hearing before an administrative law judge from an action taken pursuant to this Code section stays the order of the director of the Environmental Protection Division for not more than five days and such stay shall automatically be lifted without further action by the director if the petition has not been ruled upon by the end of the fifth day following filing of the petition; provided, however, that the petitioner's right to a hearing remains in full force and effect."

SECTION 5.

Said chapter is further amended in Code Section 12-5-31, relating to permits for withdrawal, diversion, or impoundment of surface waters, by adding a new subsection to read as follows:

"(p) In addition to the other provisions of this Code section, there shall be established three categories of farm use surface water withdrawal permits: active, inactive, and unused. The rules and regulations implementing this subsection shall provide without limitation for the following:

(1) An active farm use surface water withdrawal permit means one that has been acted upon and used for allowable purposes;

(2) An inactive farm use surface water withdrawal permit means one where the permit holder has requested inactive status in order to retain ownership of the permit for possible future use or reuse. Inactive permits shall be retained by the permit holder without modification;

(3) An unused farm use surface water withdrawal permit means one that has never been used for allowable purposes. Unused permits expire after two years unless changed to active or inactive status by notification to the director. Unused permits shall not be transferred or assigned to subsequent owners of the lands as provided in paragraph (3) of subsection (a) of this Code section;

(4) An inactive farm use surface water withdrawal permit shall be reclassified to an active permit when the permit holder has given the director 60 days' written notice and paid any applicable fees in accordance with paragraph (3) of subsection (a) of this Code section; and

(5) The director shall, via certified mail, return receipt requested, contact, or cause to be contacted, any person who holds a permit that the director has determined is unused. The notification shall include the permit identification and information regarding the classifications and procedures for changing classifications. The permit holder shall have 120 days to respond after which the director shall issue a second notice via certified mail, return receipt requested. Two years after the date on which the director first notified the permit holder via certified mail, return receipt requested, of the unused status determination of the permit, the director shall revoke the permit if the permit holder has not requested that the unused permit be reclassified as inactive or active."

SECTION 6.

Said chapter is further amended in Code Section 12-5-105, relating to permits for use of ground waters, by adding a new subsection to read as follows:

"(d) In addition to the other provisions of this Code section, there shall be established three categories of farm use ground-water withdrawal permits: active, inactive, and unused. The rules and regulations implementing this subsection shall provide without limitation for the following:

(1) An active farm use ground-water withdrawal permit means one that has been acted upon and used for allowable purposes;

(2) An inactive farm use ground-water withdrawal permit means one where the permit holder has requested inactive status in order to retain ownership of the permit for possible future use or reuse. Inactive permits shall be retained by the permit holder without modification;

(3) An unused farm use ground-water withdrawal permit means one that has never been used for allowable purposes. Unused permits expire after two years unless changed to active or inactive status by notification to the director. Unused permits shall not be transferred or assigned to subsequent owners of the lands as provided in paragraph (1) of subsection (b) of this Code section;

(4) An inactive farm use ground-water withdrawal permit shall be reclassified to active when the permit holder has given the director 60 days' written notice and paid any applicable fees in accordance with subsection (a) of this Code section;

(5) The director shall, via certified mail, return receipt requested, contact, or cause to be contacted, any person who holds a permit that the director has determined is unused. The notification shall include the permit identification and information regarding the classifications and procedures for changing classifications. The permit holder shall have 120 days to respond after which the director shall issue a second notice via certified mail, return receipt requested. Two years after the date on which the director first notified the permit holder via certified mail, return receipt requested, of the unused status determination of the permit, the director shall revoke the permit if the permit holder has not requested that the unused permit be reclassified as inactive or active."

SECTION 7.

Said chapter is further amended by revising Code Section 12-5-180.1, relating to allocating water and waste-water usage among tenants and charging tenants for usage, as follows:

"12-5-180.1.

(a) Except as otherwise provided in subsections (c) and (d) of this Code section, the ~~The~~ owner or operator of a building containing residential units may install equipment or use an economic allocation methodology to determine the quantity of water that is provided to the tenants and used in the common areas of such a building; and the owner of such a building may charge tenants separately for water and waste-water service based on usage as determined through the use of such equipment or allocation methodology.

(b) Except as otherwise provided in subsections (c) and (d) of this Code section, the ~~The~~ owner or operator of a building containing residential units may charge tenants separately for water and waste-water service, provided that the total amount of the charges to the tenants of such a building shall not exceed the total charges paid by the owner or operator for water and waste-water service for such building plus a reasonable fee for establishing, servicing, and billing for water and waste-water service and provided, further, that the terms of the charges are disclosed to the tenants prior to any contractual agreement.

(c) All new multiunit residential buildings permitted on or after July 1, 2012, shall be constructed in a manner which will permit the measurement by a county, municipal, or other public water system or by the owner or operator of water use by each unit. This subsection shall not apply to any building constructed or permitted prior to July 1, 2012, which is thereafter: (1) renovated; or (2) following a casualty or condemnation, renovated or rebuilt.

(d) All new multiunit retail and light industrial buildings permitted or with a pending permit application on or after July 1, 2012, shall be constructed in a manner which will permit the measurement by the owner or operator of water use by each unit. This subsection shall not apply to any building constructed or permitted prior to July 1, 2012, which is thereafter: (1) renovated; or (2) following a casualty or condemnation, renovated or rebuilt. This subsection is not intended to apply to newly constructed multiunit office buildings or office components of mixed use developments. Multiunit office buildings and the office component of mixed use developments may seek reimbursement from office tenants for water and waste-water use through an economic allocation which approximates the water use of each tenant based on square footage. The retail component of a mixed use development shall be constructed in a manner which will permit the measurement by the owner or operator of water use by each retail unit.

(e)(1) A county, municipal, or other public water system, if applicable, or the owner or operator of a building which is subject to subsection (c) or (d) of this Code section shall seek reimbursement for water and waste-water usage by the units through an economic allocation methodology which is based on the measured quantity of water used by each unit.

(2) The owner or operator of such a building which includes common areas for the benefit of the units may also seek reimbursement for common area water and waste-water use through an economic allocation which approximates the portion of the common area water and waste-water services allocable to each unit.

(3) The total amount of charges to the units under paragraphs (1) and (2) of this subsection shall not exceed the total charges paid by the owner or operator for water and waste-water service for the building, plus a reasonable fee for establishing, servicing, and billing water and waste-water consumption.

(4) The director shall be empowered to issue a temporary waiver of this subsection upon a showing by an owner or operator of a building subject to this subsection that compliance with this subsection has temporarily become impracticable due to circumstances beyond the control of the owner or operator. Such waiver shall be limited in duration to the period during which such circumstances remain in effect and beyond the control of the owner or operator to change.

(5) The owner or operator who seeks reimbursement for water and waste-water usage as required by this chapter shall be relieved of liability for actions or inactions that occur as a result of billing or meter-reading errors by an unaffiliated third-party billing or meter-reading company.

(f) A county, municipal, or other public water system shall be prohibited from charging any fee or levy for the installation or use of privately owned meters or other devices which measure or assist in the measurement of water use under subsection (c) of this Code section; provided, however, a county, municipal or other public water system shall be permitted to charge a fee or levy for the installation or use of publicly owned meters or other devices which measure or assist in the measurement of water use.

(g) Subsections (c), (d), and (e) of this Code section shall not apply to any construction of a building the permit for which was granted prior to July 1, 2012."

SECTION 8.

Article 1 of Chapter 2 of Title 8 of the Official Code of Georgia Annotated, relating to buildings in general, is amended by revising Code Section 8-2-3, relating to requirements for toilets, shower heads, and faucets, as follows:

"8-2-3.

(a) On or before July 1, 2012, the department, with the approval of the board, shall amend applicable state minimum standard codes to require the installation of high-efficiency plumbing fixtures in all new construction permitted on or after July 1, 2012.

(b) As used in this Code section, the term:

(1) ~~'Commercial' means any type of building other than residential.~~

~~(2)~~ 'Construction' means the erection of a new building or the alteration of an existing building in connection with its repair or renovation or in connection with making an addition to an existing building and shall include the replacement of a malfunctioning, unserviceable, or obsolete faucet, showerhead, toilet, or urinal in an existing building.

(2) 'Department' means the Department of Community Affairs.

(3) ~~'Residential' means any building or unit of a building intended for occupancy as a dwelling but shall not include a hotel or motel.~~ 'Lavatory faucet' means a faucet that discharges into a lavatory basin in a domestic or commercial installation.

(4) 'Plumbing fixture' means a device that receives water, waste, or both and discharges the water, waste, or both into a drainage system. The term includes a kitchen sink, utility sink, lavatory, bidet, bathtub, shower, urinal, toilet, water closet, or drinking water fountain.

(5) 'Plumbing fixture fitting' means a device that controls and directs the flow of water. The term includes a sink faucet, lavatory faucet, showerhead, or bath filler.

(6) 'Pressurized flushing device' means a device that contains a valve that:

(A) Is attached to a pressurized water supply pipe that is of sufficient size to deliver water at the necessary rate of flow to ensure flushing when the valve is open; and

(B) Opens on actuation to allow water to flow into the fixture at a rate and in a quantity necessary for the operation of the fixture and gradually closes to avoid water hammer.

(7) 'Toilet' means a water closet.

(8) 'Water closet' means a fixture with a water-containing receptor that receives liquid and solid body waste and on actuation conveys the waste through an exposed integral trap into a drainage system and which is also referred to as a toilet.

(9) 'WaterSense™' means a voluntary program of the United States Environmental Protection Agency designed to identify and promote water efficient products and practices.

~~(b) After April 1, 1992, there shall not be initiated within this state the construction of any residential building of any type which:~~

(c) The standards related to high-efficiency plumbing fixtures shall include without limitation, the following:

(1) ~~Employs a gravity tank-type, flushometer-valve, or flushometer-tank toilet that uses more than an average of 1.6 gallons of water per flush; provided, however, this paragraph shall not be applicable to one-piece toilets until July 1, 1992;~~ A water closet or toilet that:

(A) Is a dual flush water closet that meets the following standards:

(i) The average flush volume of two reduced flushes and one full flush may not exceed 1.28 gallons;

(ii) The toilet meets the performance, testing, and labeling requirements prescribed by the following standards, as applicable:

(I) American Society of Mechanical Engineers Standard A112.19.2-2008; and

(II) American Society of Mechanical Engineers Standard A112.19.14-2006 'Six-Liter Water Closets Equipped with a Dual Flushing Device'; and

(iii) Is listed to the WaterSense™ Tank-Type High Efficiency Toilet Specification; or

(B) Is a single flush water closet, including gravity, pressure assisted, and electro-hydraulic tank types, that meets the following standards:

(i) The average flush volume may not exceed 1.28 gallons;

(ii) The toilet must meet the performance, testing, and labeling requirements prescribed by the American Society of Mechanical Engineers Standard A112.192/CSA B45.1 or A112.19.14; and

(iii) The toilet must be listed to the WaterSense™ Tank-Type High Efficiency Toilet Specification;

(2) ~~Employs a~~ A shower head that allows a flow of no more than an average of 2.5 gallons of water per minute at 60 pounds per square inch of pressure;

(3) ~~Employs a~~ A urinal ~~that uses more than an average of 1.0 gallon of water per flush;~~ and associated flush valve that:

(A) Uses no more than 0.5 gallons of water per flush;

(B) Meets the performance, testing, and labeling requirements prescribed by the American Society of Mechanical Engineers Standard A112.19.2/CSA B45.1;

(C) For flushing urinals, meets all WaterSense™ specifications for flushing urinals; and

(D) Where nonwater urinals are employed, complies with American Society of Mechanical Engineers Standard A112.19.3/CSA B45.4 or American Society of Mechanical Engineers Standard A112.19.19/CSA B45.4. Nonwater urinals shall be cleaned and maintained in accordance with the manufacturer's instructions after installation. Where nonwater urinals are installed they shall have a water distribution line roughed-in to the urinal location at a minimum height of 56 inches (1,422 mm) to allow for the installation of an approved backflow prevention device in the event of a retrofit. Such water distribution lines shall be installed with shut-off valves located as close as possible to the distributing main to prevent the creation of dead ends. Where nonwater urinals are installed, a minimum of one water supplied fixture rated at a minimum of one water supply fixture unit shall be installed upstream on the same drain line to facilitate drain line flow and rinsing;

(4) ~~Employs a~~ A lavatory faucet or lavatory replacement aerator that allows a flow of no more than ~~2.0~~ 1.5 gallons of water per minute at a pressure of 60 pounds per square inch in accordance with American Society of Mechanical Engineers Standard A112.18.1/CSA B.125.1 and listed to the WaterSense™ High-Efficiency Lavatory Faucet Specification; ~~or~~ and

(5) ~~Employs a~~ A kitchen faucet or kitchen replacement aerator that allows a flow of no more than ~~2.5~~ 2.0 gallons of water per minute.

~~(c) On and after July 1, 1992, there shall not be initiated within this state the construction of any commercial building of any type which does not meet the requirements of paragraphs (1) through (5) of subsection (b) of this Code section.~~

~~(d) The requirements of subsection (b) of this Code section shall apply to any residential construction initiated after April 1, 1992, and to any commercial construction initiated after July 1, 1992, which involves the repair or renovation of or addition to any existing building when such repair or renovation of or addition to such existing building includes the replacement of toilets or showers or both.~~ To the extent that the standards set forth in this Code section exceed the National Energy Conservation Policy Act, as amended, and 10 C.F.R. 430.32, the department is directed to petition the Department of Energy for a waiver of federal preemption pursuant to 42 U.S.C. Section 6297(d).

(e) The department is directed to amend the applicable state minimum codes so as to permit counties ~~Counties~~ and municipalities ~~are authorized and directed~~ to provide by ordinance for an exemption to the requirements of ~~subsections (b), (c), and (d)~~ subsection

(c) of this Code section, relative to new construction and to the repair or renovation of an existing building, under the following conditions:

(1) When the repair or renovation of the existing building does not include the replacement of the plumbing or sewage system servicing toilets, faucets, or shower heads within such existing building;

(2) When such plumbing or sewage system within such existing building, because of its capacity, design, or installation, would not function properly if the toilets, faucets, or shower heads required by this part were installed;

(3) When such system is a well or gravity flow from a spring and is owned privately by an individual for use in such individual's personal residence; or

(4) When units to be installed are:

(A) Specifically designed for use by persons with disabilities;

(B) Specifically designed to withstand unusual abuse or installation in a penal institution; or

(C) Toilets for juveniles.

(f) The ordinances adopted by counties and municipalities pursuant to subsection (e) of this Code section shall provide procedures and requirements to apply for the exemption authorized by said subsection.

(g) ~~This Code section shall not apply to any construction of a residential building the contract for which was entered into prior to April 1, 1992, and shall not apply to any construction of a commercial building the contract for which was entered into prior to July 1, 1992.~~

~~(h)~~ Any person who installs any toilet, faucet, urinal, or shower head in violation of this Code section shall be guilty of a misdemeanor.

~~(i)~~(h) Before ~~April 1, 1992~~ July 1, 2012, a city, county, or authority shall adopt and enforce the provisions of this Code section in order to be eligible to receive any of the following grants, loans, or permits:

(1) A water or waste-water facilities grant administered by the Department of Natural Resources or the Department of Community Affairs; or

(2) A water or waste-water facilities loan administered by the Georgia Environmental Facilities Authority.

~~(j)~~(i) ~~For purposes of this part, after April 1, 1992,~~ After July 1, 2012, the sale of a gravity tank-type, flushometer-valve, or flushometer-tank toilet that uses more than an average of ~~1.6~~ 1.28 gallons of water per flush ~~shall be~~ is prohibited in this state.

~~(k)~~(j) The provisions of this Code section shall not be construed to prohibit counties or municipalities from adopting and enforcing local ordinances which provide requirements which are more stringent than the requirements of this Code section."

SECTION 9.

Said article is further amended in Code Section 8-2-23, relating to amendment and revision of state minimum code standards, by adding a new subsection to read as follows:

"(c)(1) On or before July 1, 2012, the department, with the approval of the board, shall amend applicable state minimum standard codes to require the installation of high-efficiency cooling towers in new construction permitted on or after July 1, 2012.

(2) As used in this subsection, the term 'cooling tower' means a building heat removal device used to transfer process waste heat to the atmosphere.

(3) The standards related to high-efficiency cooling towers shall include without limitation the minimum standards prescribed by the American Society of Heating, Refrigerating, and Air-Conditioning Engineers Standard 90.1 as adopted and amended by the department."

SECTION 10.

There is created the Joint Committee on Water Supply to be composed of ten members as follows: five members of the House of Representatives shall be appointed by the Speaker of the House with one being the chairperson of the House Natural Resources and Environment Committee and five members of the Senate shall be appointed by the President of the Senate with one being the chairperson of the Senate Natural Resources and the Environment Committee. The House and Senate Natural Resources and Environment Committee chairpersons shall serve as co-chairpersons. The committee shall meet on the call of either co-chairperson. The committee shall undertake a study and analysis of the current status of the state's reservoir system and shall conduct a comprehensive analysis of the state's strategic needs for additional water supply, including without limitation the identification of creative financing options for water reservoirs and other opportunities for water supply enhancement. The committee may conduct its meetings at such places and at such times as it may deem necessary or convenient to enable it to exercise fully and effectively its powers, perform its duties, and accomplish its objectives and purposes. The members of the committee shall receive the allowances authorized for legislative members of interim legislative committees but shall receive the same for not more than five days unless additional days are authorized. The funds necessary to carry out the provisions of this section shall come from the funds appropriated to the House of Representatives and Senate. The committee is directed to make a report of its findings and recommendations not later than December 31, 2010. The committee shall stand abolished on December 31, 2010.

SECTION 11.

This Act shall become effective upon its approval by the Governor or upon its becoming law without such approval.

SECTION 12.

All laws and parts of laws in conflict with this Act are repealed.

Exhibit 58

The Water Efficiency and Conservation State Scorecard:

An Assessment of Laws and Policies

September 2012

Project Partners

Alliance for Water Efficiency

The Alliance for Water Efficiency (AWE) is dedicated to the efficient and sustainable use of water in the United States and Canada. Headquartered in Chicago, AWE advocates for water efficient products and programs and provides information and assistance on water conservation efforts. AWE works with over 350 member organizations, providing benefit to water utilities, business and industry, government agencies, environmental and energy advocates, universities, and consumers.

33 N. LaSalle Street, Suite 2275 | Chicago, IL 60602 | 773-360-5100 | **www.a4we.org**

Environmental Law Institute

The Environmental Law Institute (ELI) is a non-profit, non-partisan research and education organization. ELI's mission is to foster innovative, just, and practical law and policy solutions to enable leaders across borders and sectors to make environmental, economic, and social progress. Since 1969, ELI has been a preeminent source of information on federal, state, and local approaches to solving environmental problems. Through its research, practical analysis, and forward-looking publications, ELI informs and empowers opinion makers, including government officials, environmental and business leaders, academics, members of the environmental bar, and journalists.

2000 L Street, NW, Suite 620 | Washington, D.C. 20036 | 202-939-3800 | **www.eli.org**

Project Team

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Megan Herzog	*Environmental Law Institute*
Kenneth Mirvis	*Alliance for Water Efficiency*
Alexa Loftus	*Alliance for Water Efficiency*

Project Advisory Committee

The project team was privileged to have input and guidance from an esteemed advisory committee comprised of professionals working on water efficiency and conservation at the state level. We extend our gratitude to:

Alice Miller Keyes	*Georgia Environmental Protection Division*
Jeffrey Ripp	*Public Service Commission of Wisconsin*
Frances Spivy-Weber	*California State Water Resources Control Board*
John T. Sutton	*Texas Water Development Board*
Thomas Swihart	*Florida Department of Environmental Protection (Retired)*
Cheri Vogel	*New Mexico Office of the State Engineer*

State Water Agency Employees

This project would not be possible without the assistance of numerous state water agency personnel. The project team is thankful for their contributions to the data gathering effort.

Funding

The Turner Foundation provided partial funding for this project. Completing the project required additional resources from the Alliance for Water Efficiency in the form of staff resources as well as monetary contributions from its general operating budget.

The Water Efficiency and Conservation State Scorecard:

September 2012

An Assessment of Laws and Policies

Online State Information Housed on the AWE Website

The completed surveys are housed online in the Alliance for Water Efficiency's Resource Library and are open to the public for viewing and comment at www.a4we.org/2012-state-information.aspx. While the scoring and report are final for this effort, the online resource will be continually updated as we become aware of policy changes.

Please let us know of any new developments by sending an email to info@a4we.org. Online information will also be available for the Canadian Provinces.

Contents

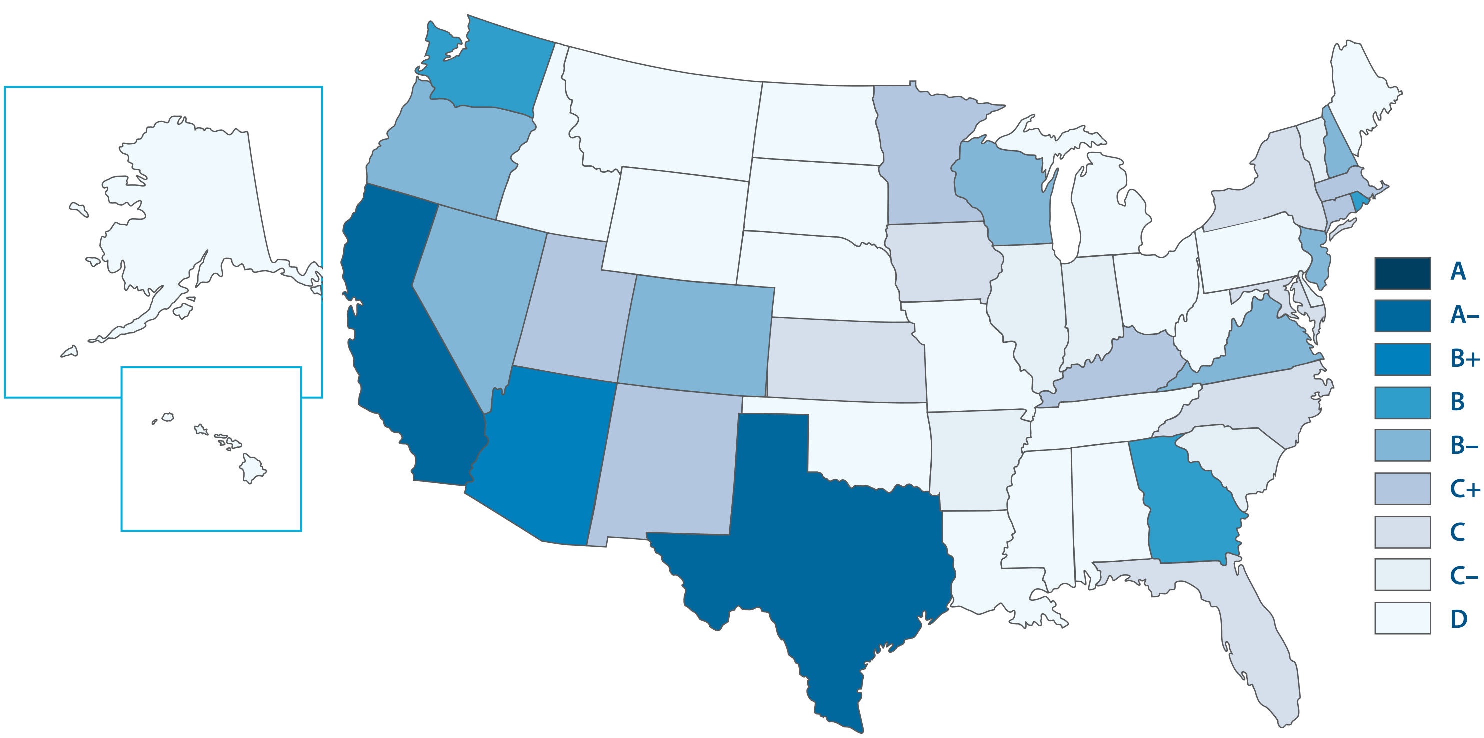
Executive Summary

The sustainable management of our fresh water resources is a crucial component of supporting future population and economic growth. State laws and policies can be a powerful mechanism to promote the efficient use of water. This report describes research efforts taken to identify and assess state-level laws and policies related to water efficiency and conservation.

The analysis was based on a 20-question survey developed by the project team under the guidance of a project advisory committee. Each state was surveyed, and the responses for every question were scored. The results are framed in a style similar to a school report card. Presenting this information collectively provides a resource that policy makers, and other professionals active in the water efficiency and conservation movement, can utilize.

The intention behind adding the report and assigning grades is to create concise and useful information, and to bring attention to exemplary policies that may be used as models for other states to emulate. Additionally, the outcomes will likely create a catalyst for dialogue about current and future water efficiency and conservation laws and policies, and generate friendly and healthy competition among states in regard to water efficiency and conservation efforts.

After the 20-question survey was developed and approved by the advisory committee in April, 2011 the data collection effort began. Data collection proved to be a large undertaking and ran through the end of the calendar year. When the finished surveys were gathered, the project team began reviewing the answers for completeness and accuracy. Citations were required for a "yes" answer to be counted. Following preliminary efforts to verify responses and seek feedback from the states regarding any unverified answers, AWE forwarded augmented survey responses to a team of attorneys at the Environmental Law Institute (ELI) for a more comprehensive legal review.



ELI mapped the spectrum of existing policy alternatives and, in cooperation with AWE, created a tiered scoring method that was applied to each response. A total of 40 possible points could be earned from the survey questions. Additionally, each state was eligible for three additional points in the form of extra credit.

Following scoring, ELI and AWE identified laws and regulations they believe to represent the strongest examples of water efficiency and conservation law under each question. Strong statutory and regulatory language is the foundation of an effective statewide water efficiency program. The report includes a chapter that showcases examples from across the country of outstanding state statutory and regulatory provisions to promote potable water efficiency and conservation. The highlighted examples may serve as useful models for states wishing to create new water efficiency and conservation policies, or strengthen existing ones.

Collectively, the 50 states earned a total of 492.5 points which averages out to a "C" grade. The summary table and map presented herein display the distribution of grades among states. Two states earned an "A" grade, and there were 11 "B's," 18 "C's," and 19 "D's." The results demonstrate that state level water efficiency and conservation laws and policies throughout the United States vary greatly. Many states have virtually no relevant policies and regulations, while others have a compendium of well-planned and strongly implemented practices.

The fully completed surveys are not included with the report, but are posted to the Alliance for Water Efficiency's online Resource Library at **www.a4we.org/2012-state-information.aspx**.

STATE	POINTS	GRADE
Alabama	2	D
Alaska	3	D
Arizona	23	B+
Arkansas	7	C-
California	29	A-
Colorado	16.5	B-
Connecticut	14	C+
Delaware	7	C-
Florida	11	C
Georgia	18.5	B
Hawaii	4	D
Idaho	3	D
Illinois	5	C-
Indiana	6	C-
Iowa	10.5	C
Kansas	10	C
Kentucky	13	C+
Louisiana	2	D
Maine	3	D
Maryland	7.5	C
Massachusetts	13	C+
Michigan	3	D
Minnesota	14.5	C+
Mississippi	2	D
Missouri	2	D
Montana	3	D
Nebraska	3	D
Nevada	17.5	B-
New Hampshire	17	B-
New Jersey	16.5	B-
New Mexico	14	C+
New York	11	C
North Carolina	11	C
North Dakota	2	D
Ohio	3.5	D
Oklahoma	3	D
Oregon	15.5	B-
Pennsylvania	3	D
Rhode Island	20	B
South Carolina	6.5	C-
South Dakota	4	D
Tennessee	4	D
Texas	29	A-
Utah	14	C+
Vermont	6	C-
Virginia	16.5	B-
Washington	21.5	B
West Virginia	4	D
Wisconsin	15.5	B-
Wyoming	2	D

Introduction

State level laws and policies represent a powerful means to reduce water consumption in the United States. The implementation of water efficiency and conservation strategies is more important than ever. As of this writing, large portions of Arizona, New Mexico, Texas, and much of the Southeastern United States are in the midst of long-term severe drought conditions. The bulk of the Midwest is currently under exceptional drought conditions, the highest intensity listed by the U.S. Drought Monitor. A 2003 U.S. General Accounting Office survey revealed that 36 states are expecting water shortages by 2013. The number would likely have been higher if California, Nevada, New Mexico, Mississippi, and Michigan had provided input to the survey. Even without the aforementioned water shortages, water efficiency and conservation are necessary to support future population and economic growth.

During 2011, the Alliance for Water Efficiency (AWE) surveyed the 50 states to identify and assess state-level water efficiency and conservation laws and policies. This effort built upon existing state and provincial information that was produced and posted to the AWE resource library in 2009. Since the Alliance receives a great deal of positive feedback about the value of the state and provincial information, an update was both needed and warranted. The effort in 2009 did not include a written report or a qualitative evaluation of each state. The 2011 update included a reworking of the previous survey, a new data collection effort, the addition of a grading scheme to assign each state a score and grade, updating the online resource library, and a written report.

The intention behind adding the report and assigning grades is to create concise and useful information, and to bring attention to exemplary policies that may be used as models for other states to emulate. Additionally, the outcomes will likely be a catalyst for dialogue about current and future water efficiency and conservation laws and policies, and will create friendly and healthy competition among states in regard to water efficiency and conservation efforts.

This report begins with a discussion of the project background and survey questions. Next, the data collection process and scoring methodology used to assign grades to each state are described. This is followed by a summary of the results, and a section that provides detail on the most rigorous and robust water efficiency and conservation laws and policies. The Great Lakes States are discussed in a separate section to explain some of the issues surrounding the Great Lakes Compact. Project challenges are addressed prior to the concluding remarks.

The results demonstrate that state level water efficiency and conservation laws and policies throughout the United States vary greatly. There are states with virtually no relevant policies and regulations, while others have an abundance of well-planned and strongly implemented practices. It is also important to note that this effort does not attempt to analyze the actual program implementation within each state as a result of these laws and policies. Such an effort would have required extensive research far beyond the financial resources that were available. It is hoped that any future updates will include an analysis of implementation.

This report does not contain the completed surveys. Those may be found in the Alliance for Water Efficiency's online Resource Library.[1]

[1] Alliance for Water Efficiency Resource Library: **http://www.allianceforwaterefficiency.org/resource-library/default.aspx**

Background & Methodology

This section provides a brief historical background of AWE's data collection efforts regarding state level laws and policies for water efficiency and conservation, and presents the data collection and scoring methodology. The aforementioned 2009 effort is described briefly because it set the foundation for the 2011 research.

2009 Survey

In 2009, AWE surveyed states to identify water efficiency and conservation laws and policies. The survey consisted of 11 questions, the results of which were posted to the online AWE Resource Library. The questions are presented below. The Alliance for Water Efficiency received a great deal of feedback regarding the information generated by the survey, and the state information pages represent a highly trafficked section of the AWE website. President and CEO Mary Ann Dickinson presented the 2009 survey results at the 2010 WaterSmart Innovations Conference and summarized the results based on a simple analysis of "yes" versus "no" answers. This generated a lot of interest in scoring states and created a demand for additional analytical information in respect to state level water efficiency and conservation laws and policies.

Figure 1: AWE 2009 State Survey Questions

1.	What state agency or agencies are in charge of drinking water conservation/efficiency?
2.	Does the state require preparation of drought emergency plans by water utilities or cities on any prescribed schedule?
3.	Does the state have a mandatory planning requirement for drinking water conservation separate from drought emergency plans?
4.	Does the state require implementation of conservation measures as well as preparation of plans?
5.	Does the state have the authority to approve or reject the conservation plans?
6.	Does the state have minimum water efficiency standards more stringent than federal or national requirements?
7.	Does the state regulate drinking water supplies and require conservation as part of its permitting process or water right permit?
8.	Does the state allow funding for conservation programs under a State Revolving Fund?
9.	Does the state offer other financial assistance? Bonds? Appropriations?
10.	Does the state offer direct or indirect technical assistance?
11.	Does the state provide statewide ET microclimate information?

2011 Survey

In 2011, AWE formed a project advisory committee to develop a new set of questions to update the 2009 effort. The end result contained four new questions, and several questions that were similar to their 2009 survey counterparts, but reworded or expanded to be more specific. The project advisory committee, representing water agencies from six states, met via conference call on January 26 and April 5, 2011 to develop and vet the survey instrument. The survey was finalized on April 22, 2011. This task was a challenging endeavor and required the committee to review changes and provide feedback between and after meetings. The committee could have easily created a survey containing 30 or more questions. However, a large survey would have overwhelmed survey respondents, and required more financial and staff resources than were available to complete this project. The final questionnaire is listed below in its entirety, followed by a discussion of each question. The data collection and scoring methodology are described in the next section.

Figure 2: AWE 2011 State Survey Questions

1.	What state agency or agencies are in charge of drinking water conservation/ efficiency?
2.	Does the state have a water consumption regulation for toilets that is more stringent than the federal standard?
3.	Does the state have a water consumption regulation for showerheads that is more stringent than the federal standard?
4.	Does the state have a water consumption regulation for urinals that is more stringent than the federal standard?
5.	Does the state have a water consumption regulation for clothes washers that is more stringent than the federal standard?
6.	Does the state have a water consumption regulation for pre-rinse spray valves that is more stringent than the federal standard?
7.	Does the state have mandatory building or plumbing codes requiring water efficient products that exceed the federal standard?
8.	Does the state have any regulations or policies for water utilities regarding water loss in the utility distribution system?
9.	Does the state require conservation activities as part of its water permitting process or water right permit?
10.	Does the state require preparation of drought emergency plans by water utilities or cities on any prescribed schedule?
11.	Does the state have a mandatory planning requirement for potable water conservation/efficiency separate from drought emergency plans?
12.	Does the state have the authority to approve or reject the conservation plans?
13.	How often does the state require the water utilities to submit a potable water conservation plan (not part of a drought emergency plan)?
14.	If the state has a mandatory planning requirement for potable water conservation separate from drought emergency plans, is there a framework or prescribed methodology?
15.	Does the state require water utilities to implement conservation measures, beyond just the preparation and submittal of plans?
16.	Does the state offer financial assistance to utilities, cities, or counties for urban water conservation programs such as a revolving loan fund? Grants? Bonds? Appropriations?
17.	Does the state offer technical assistance for urban water conservation programs?
18.	Does the state require volumetric billing?
19.	What percentage or number of publicly supplied water connections (residential and nonresidential) are metered in your state?
20.	Does the state provide statewide ET microclimate information for urban landscapes?

Survey Questions

1. What state agency or agencies are in charge of drinking water conservation/efficiency?

This question remained unchanged from the previous survey both in terms of its position and the wording. This question simply aims to identify state agencies that are responsible for drinking water efficiency and conservation. These responsibilities are often divided among multiple agencies in a single state, but only one agency per state is listed in the report cards found in the appendix due to available space. The full survey responses posted in the AWE Resource Library contain complete listings.

2. Does the state have a water consumption regulation for toilets that is more stringent than the federal standard?

Questions 2-7 of the current survey were disaggregated from Question 6 of the 2009 survey which asked, "Does the state have minimum water efficiency standards more stringent than federal or national requirements?" The wording of the original Question 6 was too vague and generated answers that were not in line with what was being sought, which was information on standards for plumbing fixtures that are more stringent than what is required federally. Standards for water-using fixtures and appliances are extremely effective in reducing water use through the process of natural replacement. If a federal standard exists for a particular fixture, and there are an abundance of high-efficiency models of that fixture in the marketplace (preferably third-party tested and approved by an entity such as WaterSense), then there may be states with a more stringent standard.

The Energy Policy Act of 1992 set a federal standard for toilets at a maximum flush volume of 1.6 gallons per flush (gpf). This standard took effect in 1994 for residential toilets and in 1997 for commercial toilets. Question 2 seeks to identify any states that have a standard for toilets that is less than 1.6 gallons per flush. Toilet technology has advanced a great deal since the Energy Policy Act of 1992 and high-efficiency toilets are becoming more commonplace. The U.S. EPA WaterSense program has labeled over 1,000 high-efficiency toilet models that flush at a volume of 1.28 gpf, and perform well. Fixtures with the WaterSense label are 20 percent more water efficient than their average counterparts, and have undergone rigorous third party testing to ensure equal or better performance.[2] This is important because it reflects a marketplace that contains a sufficient stock of well performing high-efficiency toilets. If the marketplace cannot support a new efficiency standard the results will be disastrous.

3. Does the state have a water consumption regulation for showerheads that is more stringent than the federal standard?

Question 3 also stemmed from question number 6 of the 2009 survey, and specifically asks if the state has a requirement for showerheads that is more stringent than the federal standard. WaterSense created a specification for showerheads in 2010 and has labeled many models at a flow rate of 2.0 gallons per minute (gpm). This is 0.5 gpm more efficient than the federal standard of 2.5 gpm set forth in the Energy Policy Act of 1992. The WaterSense labeling of showerheads indicates that there are a variety of well performing showerheads in the marketplace that are more efficient than the national standard. The project advisory committee wanted to identify any states with a standard for showerheads that is more stringent than the one imposed federally.

Any standard-making process for showerheads should consider the potential for thermal shock with a flow rate less than 2.5 gpm. There is detailed information about this issue in the AWE Resource Library on the Residential Shower and Bath Introduction page.

4. Does the state have a water consumption regulation for urinals that is more stringent than the federal standard?

When Question 6 from the 2009 survey was reworked into multiple questions the advisory committee chose urinals as a specific fixture to be included. The standard for urinals in the United States is 1.0 gpf as per the Energy Policy Act of 1992. WaterSense began labeling high-efficiency urinals in 2009, with a maximum flush volume of 0.5 gpf.[3] At present there are 140 urinal models labeled by WaterSense.[4] If states choose to go beyond the federal standard for urinals there are many options that meet water efficiency and performance criteria. Examples of such standards will provide valuable information for the water efficiency community.

[2] The WaterSense Label: **http://www.epa.gov/WaterSense/about_us/watersense_label.html**

[3] WaterSense Specification for Flushing Urinals: **http://www.epa.gov/WaterSense/docs/urinal_finalspec508.pdf**

[4] WaterSense Labeled Urinal List: **http://www.epa.gov/WaterSense/product_search.html?Category=3**

5. Does the state have a water consumption regulation for clothes washers that is more stringent than the federal standard?

Clothes washers were included when Question 6 from the 2009 survey was divided into specific components. Currently the federal standard for residential and commercial family-sized clothes washers requires a water factor (WF) of 9.5 or less based on the Energy Independence and Security Act of 2007 and the Energy Policy Act of 2005. The water factor is a value used to determine the water efficiency of a clothes washer, and represents the number of gallons used to wash 1 cubic foot of laundry.[5] The lower the water factor, the higher the efficiency. On May 31, 2012 the U.S. Department of Energy issued new standards for residential clothes washers that will take effect in 2015 and change again in 2018. The new standards use an integrated water consumption factor (IWF) and are presented in Table 1 below.

Table 1: New U.S. Department of Energy Clothes Washer Standards

AMENDED RESIDENTIAL CLOTHES WASHER STANDARDS			
		INTEGRATED WATER FACTOR (IWF)*	
Product Type	Effective:	3/7/2015	1/1/2018
Top-loading, Compact (less than 1.6 ft^3 capacity)		14.4	12.0
Top-loading, Standard		8.4	6.5
Front-loading, Compact (less than 1.6 ft^3 capacity)		8.3	N/A
Front-loading, Standard		4.7	N/A

*IWF (integrated water consumption factor) is calculated as the sum, expressed in gallons per cycle, of the total weighted per-cycle water consumption.[6]

ENERGY STAR® labeled clothes washers must currently have a water factor of 6.0 or less to qualify, which is 37 percent lower than the WF required by the existing national standard.[7] As of this writing, ENERGY STAR has labeled 367 residential clothes washers and 71 family sized commercial clothes washers.[8] Consumers would have a large variety of clothes washers to choose from if a state created a standard more efficient than what is found in the Energy Independence and Security Act of 2007.

It is important to note that in order for a state to establish a water consumption requirement for clothes washers more stringent than the national standard, it would have to obtain a waiver for federal preemption. Preemption, in this case, means that the federal standard preempts any state or local standard for clothes washers. Federal preemption was waived for faucets, showerheads, toilets, and urinals in 2010.[9]

Code of Federal Regulations

Title 10: Energy

§ 431.408 Preemption of State regulations for covered equipment other than electric motors and commercial heating, ventilating, air-conditioning and water heating products.

This section concerns State regulations providing for any energy conservation standard, **or water conservation standard (in the case of commercial prerinse spray valves or commercial clothes washers)**, or other requirement with respect to the energy efficiency, energy use, or water use (in the case of commercial prerinse spray valves or commercial clothes washers), for any covered equipment other than an electric motor or commercial HVAC and WH product. **Any such regulation that contains a standard or requirement that is not identical to a Federal standard in effect under this subpart is preempted by that standard**, except as provided for in sections 327(b) and (c) and 345(e), (f) and (g) of the Act.[10]

[5] Alliance for Water Efficiency Residential Clothes Washer Introduction: http://www.allianceforwaterefficiency.org/Residential_Clothes_Washer_Introduction.aspx?terms=water+factor

[6] 2012-05-31 Energy Conservation Program: Energy Conservation Standards for Residential Clothes Washers; Direct final rule: http://www.regulations.gov/#!documentDetail;D=EERE-2008-BT-STD-0019-0041

[7] ENERGY STAR Clothes Washer Criteria: http://www.energystar.gov/index.cfm?c=clotheswash.pr_crit_clothes_washers

8 Residential and Commercial Clothes Washers Qualified Product Lists: http://downloads.energystar.gov/bi/qplist/res_clothes_washers.pdf?53a8-df0d and http://downloads.energystar.gov/bi/qplist/comm_clothes_washers.pdf?182e-6c2b

[9] Federal Register/Vol. 75, No. 245/Wednesday, December 22, 2010/Rules and Regulations: http://www.allianceforwaterefficiency.org/uploadedFiles/Federal-Register75.pdf

[10] Electronic Code of Federal Regulations–Title 10: §431.408: http://www.ecfr.gov/cgi-bin/text-idx?c=ecfr&SID=fe07ab8cd91125ac440c160ac8182365&rgn=div5&view=text&node=10:3.0.1.4.19&idno=10#10:3.0.1.4.19.22.83.8

6. Does the state have a water consumption regulation for pre-rinse spray valves that is more stringent than the federal standard?

Pre-rinse spray valves are commonly used in restaurants and other commercial food operations to rinse particles from plates and other items with a high pressured spray of water before loading them into a dishwasher. The current federal standard is 1.6 gpm according to the Energy Policy Act of 2005. A specification is currently being developed by WaterSense for pre-rinse spray valves which will likely require a flow rate of 1.25 gpm to be labeled.[11] If a specification is developed it will help ensure that there are a variety of models in the marketplace that meet both efficiency and performance requirements set forth by WaterSense. The federal standard for pre-rinse spray valves is relatively new and the project advisory committee wanted to recognize any states with a standard more stringent than the one imposed nationally. As is the case with clothes washers, a state requirement for pre-rinse spray valves that is more efficient than the federal standard would require a waiver of preemption. This question was derived from Question 2 from the 2009 survey.

7. Does the state have mandatory building or plumbing codes requiring water efficient products that exceed the federal standard?

In addition to asking about standards for specific water-using fixtures and appliances, the advisory committee concluded it was important to ask about building and plumbing codes. Building and plumbing codes can require the installation of water-efficient products in buildings. These codes may include efficiency standards for the aforementioned fixtures in Questions 2-6, additional fixtures and fittings, or may contain requirements for plumbing system design.

8. Does the state have any regulations or policies for water utilities regarding water loss in the utility distribution system?

According to the AWE Resource Library,

> *Losses in water utility operations occur in two distinctly different manners. Apparent losses occur due to customer meter inaccuracies, billing system data errors and unauthorized consumption. These losses cost utilities revenue and distort data on customer consumption patterns. Losses also occur as real losses or water that escapes the water distribution system, including leakage and storage overflows. These losses inflate the water utility's production costs and stress water resources since they represent water that is extracted and treated, yet never reaches beneficial use.*[12]

Losses from the distribution system may very well represent the most inefficient consumption of treated water. This is a new question. The 2009 survey did not directly ask about water loss, and the project advisory committee decided that this important topic should be included.

9. Does the state require conservation activities as part of its water permitting process or water right permit?

This question was asked in the 2009 survey (Question 7) and was included again in the 2011 survey. Water withdrawal permits may contain conditions to ensure that water is not being wasted or used inefficiently. Requiring conservation activities in the permit approval process represents a means to promote the efficient use of water. Procedures vary among states, and this question was asked to identify what conditions are set forth in regard to conservation in the water permitting process.

10. Does the state require preparation of drought emergency plans by water utilities or cities on any prescribed schedule?

Times of drought require immediate action to reduce the demand for water. It is important to have this action well planned in advance. Drought plans often include strategies to reduce demand for a varying degree of shortage situations. This is the same as Question 2 in the 2009 survey and is intended to find out if states are requiring water suppliers to prepare such plans.

11. Does the state have a mandatory planning requirement for potable water conservation/ efficiency separate from drought emergency plans?

The 2009 survey (Question 3) and the 2011 survey both asked if conservation plans are required separately from drought emergency plans. This distinction between drought plans and conservation plans clearly identifies states that are focused on water efficiency and conservation during non-drought conditions. Measures taken during a drought may only have short-term savings impacts, whereas programs implemented via a conservation plan are intended to have long-term effects on water demand.

12. Does the state have the authority to approve or reject the conservation plans?

This question was utilized in the 2009 survey (Question 5) and sought to identify authority held by the state to approve or reject required conservation plans. This question builds upon Question 11. Without authority to approve or reject plans, it will be difficult, if not impossible, for the state to hold utilities to any specific planning requirements. The state's authority to approve or reject plans gives strength to the overall planning process.

[11] WaterSense Notification of Intent (NOI) to Develop Draft Performance Specifications for High-Efficiency Pre-Rinse Spray Valves: **http://www.energystar.gov/ia/partners/prod_development/new_specs/downloads/pre_rinse_spray_valves/PRSV_Notice_of_Intent.pdf**

[12] Water Loss Control—What Can Be Done? **http://www.allianceforwaterefficiency.org/Water_Loss_Control_-_What_Can_Be_Done.aspx**

13. How often does the state require the water utilities to submit a potable water conservation plan (not part of a drought emergency plan)?

This question asks how often utilities must submit water conservation plans, and is intended to add detail to any "yes" answers for Question 11. This new question was not included in the 2009 survey.

14. If the state has a mandatory planning requirement for potable water conservation separate from drought emergency plans, is there a framework or prescribed methodology?

This was a new question and not asked in the 2009 survey. Must conservation plans adhere to a methodology or include mandatory components? Answers to this question provide insight into the strength of the planning requirements set forth by states. A prescribed methodology helps water providers prepare plans and creates a standardized approach.

15. Does the state require water utilities to implement conservation measures, beyond just the preparation and submittal of plans?

This question was asked in the 2009 survey (Question 4) as well. Water conservation plans alone will not reduce water use; the plans have to be put into action. Legal language regarding implementation can vary from suggestions to enforceable penalties for failure to implement. This question was formulated to recognize the importance of actual implementation, and to identify the different requirements among states.

16. Does the state offer financial assistance to utilities, cities, or counties for urban water conservation programs such as a revolving loan fund? Grants? Bonds? Appropriations?

The 2009 survey contained multiple questions regarding funding for water conservation programs. The 2011 survey condensed these questions into one. Technically all states can capitalize water conservation programs via the Clean Water State Revolving Fund (CWSRF) and Drinking Water State Revolving Fund (DWSRF) programs. A September 2000 EPA memorandum titled, "Policy on Using the CWSRF on Water Efficiency/Conservation Measures," details eligible projects, which include conservation programs. A similar EPA memo regarding the DWSRF programs indicates the fund can be used for water conservation programs.[13] In addition to these memorandums, the EPA factsheet, "Funding Water Efficiency through the State Revolving Fund Programs," confirms that both the CWSRF and DWSRF can be used for, "financial assistance to help states and systems initiate a variety of efficiency measures and programs."

This question asked about additional resources such as grant programs, bonds, and appropriations. Without financial assistance many water efficiency and conservation programs would not be possible.

17. Does the state offer technical assistance for urban water conservation programs?

Question 10 of the 2009 survey essentially asked the same question, "Does the state offer direct or indirect technical assistance?" The 2009 question lacked specificity in regard to urban water conservation programs, and the "yes" answers were not always relevant or could be slightly misleading. The question was reworded for the 2011 survey, and only technical assistance that is designed for urban water use was included.

18. Does the state require volumetric billing?

This question was not part of the 2009 survey, but its subject is of great importance to water efficiency and conservation. If customers are billed for the amount of water consumed they are less likely to waste water.[14] Volumetric billing also makes it possible to implement water rate structures that encourage conservation.

19. What percentage or number of publicly supplied water connections (residential and nonresidential) are metered in your state?

Water meters allow consumption to be measured. Without them suppliers cannot identify the amount of water being used and charge accordingly. The advisory committee designed this question to identify the percentage of metered connections in each state. If the state could not provide the percentage, but rather a number of connections, the project team would estimate a percentage from data on the total number of connections.

20. Does the state provide statewide ET microclimate information for urban landscapes?

Question 11 of the 2009 survey asked, "Does the state provide Statewide ET microclimate information?" For the 2011 survey, the question was altered to ask specifically about evapotranspiration (ET) information for urban landscapes. A significant portion of existing weather and irrigation data concerns agricultural water use. Because the focus of this effort is urban water use, the question was changed to eliminate those responses. Microclimate information can be used to increase the efficiency of outdoor water use through improved irrigation scheduling.

[13] EPA DWSRF Memorandum (July 25, 2003) Use of Drinking Water State Revolving Fund (DWSRF) Program Funds for Water Efficiency Measures

[14] Alliance for Water Efficiency Metering Introduction: **http://www.allianceforwaterefficiency.org/metering.aspx**

Data Collection and Scoring Methodology

Once the survey was fully vetted, the project team began collecting data. The data collection effort, which included a thorough review of the results, ran through the end of calendar year 2011. Question 1 of the 2009 survey asked, "What state agency or agencies are in charge of drinking water conservation/ efficiency?" The information produced from this question was used to find appropriate contacts in each state to assist with completing the survey. Contact was initiated via phone calls and emails. Due to the length of the survey and the need to include citations, the completed surveys were sent from the respondents to the project team via email instead of being conducted over the phone.

There were a small number of instances when the project team repeatedly attempted to connect with state personnel and received little or no assistance. In these cases the team conducted extensive research to find information for any unanswered survey questions.

After the finished surveys were gathered the project team began reviewing the responses for completeness and accuracy. The questions generated complex answers and there was a great deal of variance among states. Even with the help of state employees, the survey results required extensive research and cite checking to verify answers. Many responses were edited in the course of the verification process and additional information often was added to support answers.

Ultimately, all "yes" answers required a supporting citation to be counted. Not all "yes" answers are equal, and there are often nuanced details behind a "yes" designation. To account for this, a substantial amount of supporting information is posted along with the completed surveys in the AWE Resource Library. The variation and complexity of answers also created a need to expand point ranges for scoring questions, which is discussed in greater detail below.

Following AWE's preliminary efforts to verify responses and seek feedback from the states regarding any unverified answers, AWE forwarded augmented survey responses to a team of attorneys at the Environmental Law Institute (ELI) for a more comprehensive legal review. The Institute restricted its analysis to the survey questions that involved legal matters: Questions 2-6, 7-15, and 18. Through legal research databases, ELI obtained current versions of each statute or regulation cited by the survey respondents. In the course of exploring state codes, ELI located relevant but un-cited authorities and also included those sources in its evaluation.

Using the referenced laws, ELI verified whether the provisions cited by the respondents were sufficient to support the respondents' answers. ELI relied only on the language of the laws to cite check and evaluate the accuracy of responses; ELI disregarded as immaterial to its analysis any citations to non-binding guidance documents, evidence of future or historical policies, statements regarding administrative practice, or other non-legal data. When necessary and appropriate, the ELI attorneys exercised their professional judgment to interpret and evaluate the statutory or regulatory language.

In the course of its analysis, ELI changed answers where, in the professional judgment of its staff, respondents' answers were incorrect or the cited authority failed to support the proffered answer. Where the information provided by the state was insufficient for ELI to evaluate the answer as either correct or incorrect, ELI flagged the answer for AWE as requiring further attention; in some instances, AWE was able to obtain the necessary additional information from the state and re-forward the answer to ELI for analysis. To support its conclusions, ELI cataloged direct quotations of all on-point statutory and regulatory provisions. Additionally, ELI identified for AWE publicly-available copies of each relevant law it examined.

Comparing the relative strength of water efficiency and conservation laws between the 50 states allowed ELI to stratify the states into tiers. These tiers are directly reflected in the scoring rubric developed by ELI and AWE. Accordingly, the inclusion of numerous scoring intervals for a particular question reflects the fact that the project team observed a broad diversity in the quality of answers to that question.

Based on ELI's legal analysis, and in consultation with ELI, AWE scored each answer according to the scoring rubric presented in Table 2 (on next page). Scoring challenges encountered by the project team are discussed in the Project Challenges section below. Following scoring, ELI and AWE identified laws and regulations they believe to represent the strongest examples of water efficiency and conservation law under each question. Model examples are presented in the Policy Highlights section below. In identifying model examples, the project team sought to showcase the diversity of effective policy alternatives and innovative policymaking efforts.

A total of forty possible points could be earned from the survey questions. Additionally, the states were eligible for three additional points in the form of extra credit. Table 2 presents the guidelines used for the scoring of each question. It is followed by the overall grading scale. The Policy Highlights section includes some additional discussion of the nuances of scoring the questions that underwent legal review.

Table 2: Scoring Guidelines

SCORING GUIDELINES FOR INDIVIDUAL QUESTIONS	
1. State agency in charge of drinking water conservation?	All states received **1** point for answering
2. Water consumption regulation for toilets?	**0** = No **1** = Yes, but limited applicability (e.g., only applies to new construction) **2** = Yes
3. Water consumption regulation for showerheads?	**0** = No **1** = Yes, but limited applicability (e.g., only applies to new construction) **2** = Yes
4. Water consumption regulation for urinals?	**0** = No **1** = Yes, but limited applicability (e.g., only applies to new construction) **2** = Yes
5. Water consumption regulation for clothes washers?	**0** = No **1** = Yes, but limited applicability (e.g., only applies to new construction) **2** = Yes
6. Water consumption regulation for pre-rinse spray valves?	**0** = No **1** = Yes, but limited applicability (e.g., only applies to new construction) **2** = Yes
7. Mandatory building or plumbing codes?	**0** = No **1** = Codes are only applied to a specific subset set of buildings, or conditions (e.g., Texas has code that applies only to state buildings) **2** = Codes applied to most or all buildings
8. Water loss regulation or policy?	**0** = No **1** = Some kind of policy in writing, but without a specific target or requirements, or target is weak **2** = Specific target or requirement, but only for new permits, or strong initiative demonstrated by state **3** = Robust target and requirements, and required by all suppliers, or if only for new permits with very strong law
9. Conservation activities as part of water permitting process?	**0** = No **1** = Little more than a plan is required, or a strong law with limited geographic applicability **2** = Water rights expressly can be conditioned (or rejected) based on water conservation efforts **3** = Robust application or approval requirements (compliance with conservation plans, mandatory conservation conditions, etc.)
10. Drought emergency plans required?	**0** = No **1** = Yes, but plan only connected to permitting; OR no updating of plan required once it has been submitted **1.5** = Yes, plan is required, but the framework for developing the plan is not robust **2** = Yes, plan is required and must adhere to a detailed framework
11. Conservation planning required separate from drought plans?	**0** = No, or already given credit under Question 9 **1** = Plan is required only for a very limited set of users, or broadly applicable but conservation is only a component of a larger plan **2** = Plan requirement is broadly applicable, and it is a standalone conservation plan
12. Authority to approve or reject conservation plans?	**0** = No or N/A **0.5** = The plan must be submitted as part of a complete permit application, but its substance is not really part of the application review process **1** = Yes, the plan is reviewed as part of reviewing a permit application **2** = Yes, the plan is approved via an independent review process

13.	How often are plans required?	**0** = No or N/A **0.5** = 25+ years **1** = 11-24 years; or split between two planning processes (i.e., CT) **1.5** = 7-10 years **2** = 1-6 years
14.	Planning framework or methodology?	**0** = No; N/A; only unenforceable policy guidelines **0.5** = No, but the law requires the agency to draft unenforceable guidelines; OR there is a framework for what plans may include **1** = Yes, but the framework is not robust **2** = Yes, and the framework is robust
15.	Implementation of conservation measures required?	**0** = No or N/A **1** = There is some language facilitating implementation, but it lacks an enforceable hook **2** = The plan is enforceable as a permit condition **3** = Robust provisions to facilitate and enforce implementation (e.g., penalties, permit revocation, submitting schedules and reports, drafting an implementation plan, identifying legal and financial sources for implementation)
16.	State funding for urban water conservation programs?	**1** = DWSRF and CWSRF Programs (all states received 1 point) **2** = Funding resources beyond State Revolving Funds
17.	Technical assistance for urban water conservation programs?	**0** = No **1** = Online or other resources **2** = Direct technical assistance offered by state
18.	Does the state require volumetric billing?	**0** = No **1** = Yes **2** = Yes, and conservation rates are required
19.	Percent of publicly supplied connections that are metered?	Due to a lack of citable references, no states were scored on this question
20.	ET microclimate information for urban landscapes?	**0** = No **1** = Online state resource including turfgrass ET data available **2** = Online resource specifically targeted for urban landscape irrigation

After each question was scored, the total was summed and states were assigned a grade based on the scale presented in Table 3. If a state was one half point away from the next grade on the scale, the score was rounded up (e.g., 15.5 points would equal a "B-" instead of a "C+" grade). The water efficiency scorecards are notably different from a school report card. There are no "F" grades, for example, and the grading scale is much more forgiving than the typical percentage-based scoring utilized by educational institutions. The grades are intended to serve as a guide, and the project team made every effort to create a grading scale that demonstrated the level of effort states are making toward water efficiency via state-level laws and policies.

A draft report was release on April 26, 2012 and a public comment period was open until June 15, 2012. The main purpose of the public comment period was to give states and other interested parties an opportunity to identify any policies that were missed during the data collection phase, make clarifications, or disagree with the project team's findings. General comments were welcome as well. In all, 13 sets of comments were received. The comments resulted in scoring adjustments for the states of Arizona, Georgia, Massachusetts, Nevada, New Mexico, Washington, and Wisconsin. The public comments are available for viewing in a separate document that serves as an appendix to the main report.

Table 3: Grading Scale

GRADING SCALE	
34 - 40	A+
30 -33	A
27 - 29	A-
23 - 26	B+
19 - 22	B
16 - 18	B-
12 - 15	C+
8 - 11	C
5 - 7	C-
1 - 4	D
*.5's round up	

Discussion

This chapter is comprised of four sections. First, summary results are provided that present the grades among the 50 states. This is followed by the Policy Highlights se ction, which provides examples of exceptional laws and policies. The Great Lakes States are discussed in light of the Great Lakes Compact, and the last section identifies project challenges.

Summary of Results

This section presents a complete score and grade for each of the 50 states. The individual state water efficiency scorecards appear in alphabetical order in the appendix. Two summary tables and a map present the results. Table 4 shows the number of states that were assigned each grade. Table 5 contains a point total and letter grade for each of the 50 states. Figure 3 displays the spatial distribution of the results in a choropleth map. Only two states earned an "A" grade and both were "A-"; additionally, there were 11 "B's," 18 "C's," and 19 "D's." Table 6 contains a point total and average grade for the United States as a whole. The 50 states earned a total of 492.5 points. When divided by 50 the result is 9.85, which is the middle of the range for a "C" grade.

Much can be learned from existing policies, regulations, and initiatives. While many robust water efficiency and conservation policies are in place, the results also indicate that there is great opportunity for improvement. Not only can policies be put in place where they are currently lacking, but existing policies and laws can be strengthened to increase their overall effectiveness.

Table 4: Grade Totals

GRADE	TOTALS
A+	0
A	0
A-	2
B+	1
B	3
B-	7
C+	6
C	6
C-	6
D	19
Total	50

Table 5: Point Totals and Grade by State

STATE	POINTS	GRADE
Alabama	2	D
Alaska	3	D
Arizona	23	B+
Arkansas	7	C-
California	29	A-
Colorado	16.5	B-
Connecticut	14	C+
Delaware	7	C-
Florida	11	C
Georgia	18.5	B
Hawaii	4	D
Idaho	3	D
Illinois	5	C-
Indiana	6	C-
Iowa	10.5	C
Kansas	10	C
Kentucky	13	C+
Louisiana	2	D
Maine	3	D
Maryland	7.5	C
Massachusetts	13	C+
Michigan	3	D
Minnesota	14.5	C+
Mississippi	2	D
Missouri	2	D
Montana	3	D
Nebraska	3	D
Nevada	17.5	B-
New Hampshire	17	B-
New Jersey	16.5	B-
New Mexico	14	C+
New York	11	C
North Carolina	11	C
North Dakota	2	D
Ohio	3.5	D
Oklahoma	3	D
Oregon	15.5	B-
Pennsylvania	3	D
Rhode Island	20	B
South Carolina	6.5	C-
South Dakota	4	D
Tennessee	4	D
Texas	29	A-
Utah	14	C+
Vermont	6	C-
Virginia	16.5	B-
Washington	21.5	B
West Virginia	4	D
Wisconsin	15.5	B-
Wyoming	2	D

Table 6: Water Efficiency Scorecard All 50 States

WATER EFFICIENCY SCORECARD ALL 50 STATES		GRADE: C
QUESTION	TOTAL "YES" ANSWERS	TOTAL POINTS
1. State agency in charge of drinking water conservation?	50	50
2. Water consumption regulation for toilets?	3	6
3. Water consumption regulation for showerheads?	0	0
4. Water consumption regulation for urinals?	3	3
5. Water consumption regulation for clothes washers?	0	0
6. Water consumption regulation for pre-rinse spray valves?	0	0
7. Mandatory building or plumbing codes?	2	3
8. Water loss regulation or policy?	24	38
9. Conservation activities as part of water permitting process?	24	35
10. Drought emergency plans required?	15	22.50
11. Conservation planning required separate from drought plans?	28	33
12. Authority to approve or reject conservation plans?	25	34.50
13. How often are plans required?	N/A	35
14. Planning framework or methodology?	23	31
15. Implementation of conservation measures required?	19	37
16. State funding for urban water conservation programs?	50	72
17. Technical assistance for urban water conservation programs?	24	39
18. Does the state require volumetric billing?	6	8
19. Percent of publicly supplied connections that are metered?	N/A	0
20. ET microclimate information for urban landscapes?	8	13
Extra Credit		32.50
Total		492.50
Average		9.85

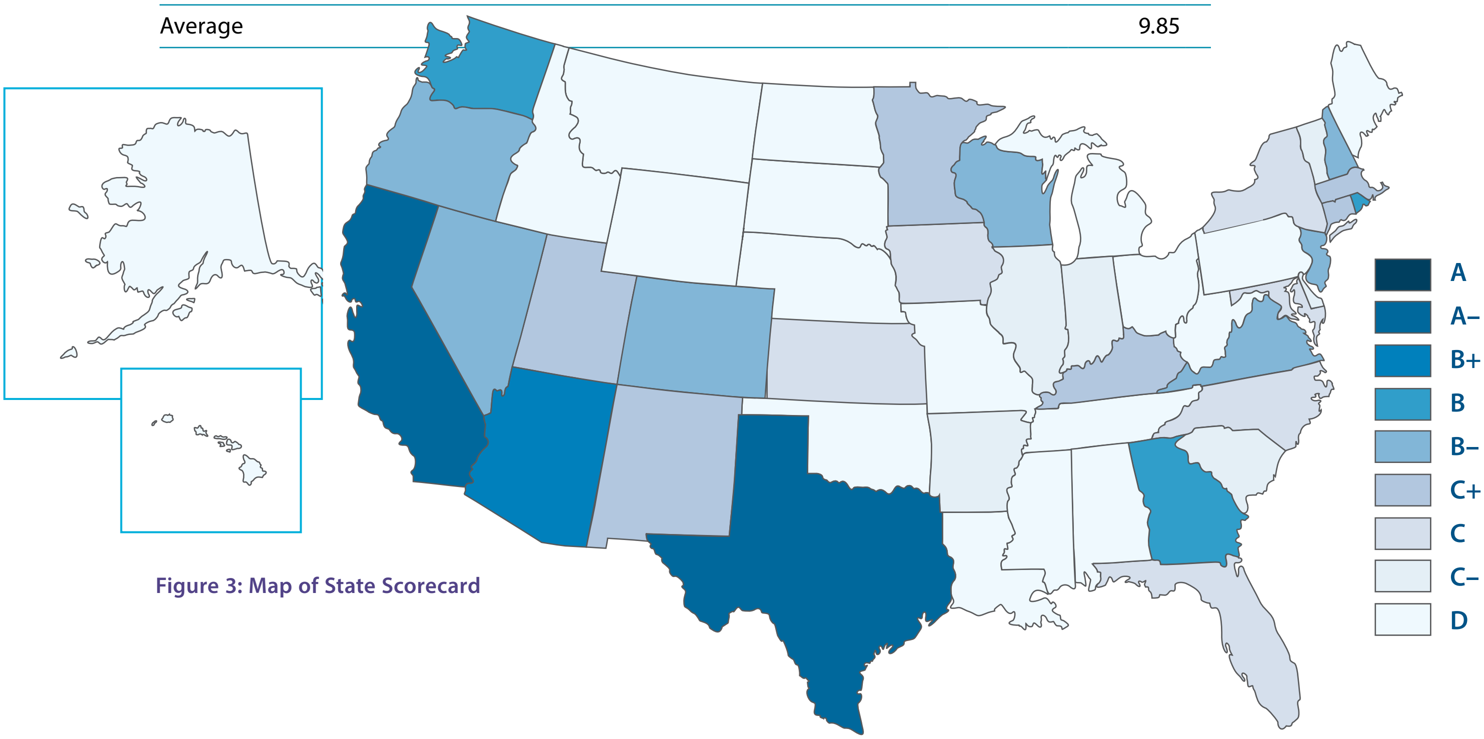


Figure 3: Map of State Scorecard

Policy Highlights

Strong statutory and regulatory language is the foundation of an effective statewide water efficiency program. This chapter showcases examples from across the country of outstanding state statutory and regulatory provisions to promote potable water efficiency, conservation, and planning. In some cases, diverse examples were selected in order to demonstrate a variety of effective methods for facilitating water efficiency through legal requirements. This chapter further summarizes the range of answers received for each topic and details why the top-performing states within each question received maximum credits. The highlighted examples may serve as useful policy models for states wishing to strengthen their water conservation requirements and improving their future water efficiency score. Answers for Questions 1, 16, 17, 19, and 20 were not put through a legal review process, but represent important initiatives and are included in this section.

Question 1

State Agencies

Each state was awarded one point for answering this question and no additional points were available. There is no particular highlight, or state that has an example for others to follow. States with a high overall score have active agencies, but the structures differ. Some states have several agencies in charge of water efficiency and conservation. This can have advantages, such as putting specialized agencies in charge of specific components of water efficiency and conservation. However, when multiple agencies are involved there can be a lack of cohesion. It is important for agencies to be aware of each other's responsibilities and work together as much as possible.

Questions 2-6

Water Consumption Regulations

Questions 2-6 are similar: does the state have a water consumption regulation more stringent than the federal standard for toilets, showerheads, urinals, clothes washers, and pre-rinse spray valves? Each state answering yes to any of these questions cited the same state law for each "yes" answer. Additionally, the standards were the same for all states with "yes" answers. For toilets, the average flush volume for single flush toilets may not exceed 1.28 gallons, and the average flush volume of two reduced flushes and one full flush for dual flush toilets may not exceed 1.28 gallons. For urinals, the maximum flow may not exceed an average of 0.5 gallons of water per flush, with minimal exceptions. No state identified laws more stringent than the federal standards for showerheads, clothes washers, or pre-rinse spray valves.

While the more stringent standards were uniform among those states with them, the three states differed in the scope of application of those standards. **California** and **Texas**' standards apply to all sales, as does Georgia's standard for toilets but Georgia's standard for urinals applies only to new construction (see the Question 7 policy highlight for more details). California and Texas have slightly different language regarding application and exemptions.

California

(b)

(1) All water closets sold or installed in this state shall use no more than an average of 1.6 gallons per flush. On and after January 1, 2014, all water closets, other than institutional water closets, sold or installed in this state shall be high-efficiency water closets.

(2) All urinals sold or installed in this state shall use no more than an average of one gallon per flush. On and after January 1, 2014, all urinals, other than blow-out urinals, sold or installed in this state shall be high-efficiency urinals.

. . . .

(g) As used in this section, the following terms have the following meanings:

(1) "Blow-out urinal" means a urinal designed for heavy-duty commercial applications that work on a powerful nonsiphonic principle.

(2) "High-efficiency water closet" means a water closet that is either of the following:

(A) A dual flush water closet with an effective flush volume that does not exceed 1.28 gallons, where effective flush volume is defined as the composite, average flush volume of two reduced flushes and one full flush . . . .

(B) A single flush water closet where the effective flush volume shall not exceed 1.28 gallons . . . .

(3) "High-efficiency urinal" means a urinal that uses no more than 0.5 gallons per flush.

(4) "Institutional water closet" means any water closet fixture with a design not typically found in residential or commercial applications or that is designed for a specialized application, including, but not limited to, wall-mounted floor-outlet water closets, water closets used in jails or prisons, water closets used in bariatrics applications, and child water closets used in day care facilities.[15]

[15] CAL. HEALTH & SAFETY CODE § 17921.3.

Texas

(a) A person may not sell, offer for sale, distribute, or import into this state a plumbing fixture for use in this state unless: (1) the plumbing fixture meets the water saving performance standards provided by Subsection (b) . . . .

(b) The water saving performance standards for a plumbing fixture are the following standards. . . . (4) except as provided by Subsection (g), for a urinal and the associated flush valve, if any, sold, offered for sale, or distributed in this state on or after January 1, 2014:

(A) maximum flow may not exceed an average of 0.5 gallons of water per flush

. . . .

(6) except as provided by Subsection (h), for a toilet sold, offered for sale, or distributed in this state on or after January 1, 2014:

(A) the toilet must be a dual flush water closet that meets the following standards:
(i) the average flush volume of two reduced flushes and one full flush may not exceed 1.28 gallons . . . . or

(B) the toilet must be a single flush water closet that meets the following standards:
(i) the average flush volume may not exceed 1.28 gallons . . . .

. . . .

(g) The water saving performance standards for a urinal and the associated flush valve, if any, sold, offered for sale, or distributed in this state on or after January 1, 2014, are [maximum flow may not exceed an average of one gallon of water per flush] if the urinal was designed for heavy-duty commercial applications.

(h) The water saving performance standards for a toilet sold, offered for sale, or distributed in this state on or after January 1, 2014, are [maximum flow may not exceed an average of 1.6 gallons of water per flush] if the toilet is a water closet that has a design not typically found in a residential application or that is designed for a specialized application, including a water closet that:

(1) is mounted on the wall and discharges to the drainage system through the floor;

(2) is located in a correctional facility, as defined by Section 1.07, Penal Code;

(3) is used in a bariatric application;

(4) is used by children at a day-care facility; or

(5) consists of a non-tank type commercial bowl connected to the plumbing system through a pressurized flushing device.[16]

Question 7

Building and Plumbing Codes

Question 7 asks whether the state has mandatory building or plumbing codes that require water efficient products exceeding the federal standard. Ideally, the building or plumbing codes will apply to all construction and the required efficiency of all products will exceed the federal standard; however, few states answered yes. As with Questions 2-6, the scope of application as well as the standard established separated the "yes" answers. Partial credit was given to states with laws applicable to a specific subset of buildings or conditions.

Georgia requires the installation of high-efficiency plumbing fixtures in all new construction, including new buildings, the alteration of existing buildings, and even replacement of malfunctioning, unserviceable, or obsolete fixtures, regardless of the owner or location. In addition to the provisions concerning toilets and urinals, the statute sets a standard for lavatory faucets and lavatory replacement aerators at no more than 1.5 gallons of water per minute, and kitchen faucets with a flow rate at no more than 2.0 gallon per minute. Current federal standards for both fixtures are 2.2 gpm. The standards for other fixtures match the federal standards. Georgia also requires new multiunit residential buildings and new multiunit retail and light industrial buildings to be constructed so as to allow the measurement of water use by each unit.

Georgia

(a) On or before July 1, 2012, the department, with the approval of the board, shall amend applicable state minimum standard codes to require the installation of high-efficiency plumbing fixtures in all new construction permitted on or after July 1, 2012.

(b) As used in this Code section, the term:

(1) "Construction" means the erection of a new building or the alteration of an existing building in connection with its repair or renovation or in connection with making an addition to an existing building and shall include the replacement of a malfunctioning, unserviceable, or obsolete faucet, showerhead, toilet, or urinal in an existing building.

. . . .

[16] TEX. HEALTH & SAFETY CODE ANN. § 372.002.

(c) The standards related to high-efficiency plumbing fixtures shall include without limitation, the following

. . . .

(4) A lavatory faucet or lavatory replacement aerator that allows a flow of no more than 1.5 gallons of water per minute at a pressure of 60 pounds per square inch . . . .[17]

. . . .

(c) All new multiunit residential buildings permitted on or after July 1, 2012, shall be constructed in a manner which will permit the measurement by a county, municipal, or other public water system or by the owner or operator of water use by each unit. This subsection shall not apply to any building constructed or permitted prior to July 1, 2012, which is thereafter: (1) renovated; or (2) following a casualty or condemnation, renovated or rebuilt.

(d) All new multiunit retail and light industrial buildings permitted or with a pending permit application on or after July 1, 2012, shall be constructed in a manner which will permit the measurement by the owner or operator of water use by each unit. This subsection shall not apply to any building constructed or permitted prior to July 1, 2012, which is thereafter: (1) renovated; or (2) following a casualty or condemnation, renovated or rebuilt. This subsection is not intended to apply to newly constructed multiunit office buildings or office components of mixed use developments. Multiunit office buildings and the office component of mixed use developments may seek reimbursement from office tenants for water and waste-water use through an economic allocation which approximates the water use of each tenant based on square footage. The retail component of a mixed use development shall be constructed in a manner which will permit the measurement by the owner or operator of water use by each retail unit.[18]

Question 8

Utility Distribution Water Loss

Question 8 asks whether the state has regulations or policies regarding water loss from water utility distribution systems. The answer for most states is yes, but information-gathering, reporting, and response requirements, as well as which utilities are covered, varies widely. Ideally, state law will require industry best practices for calculating water loss and mandate corrective action, and will apply to all municipal purveyors. Limited credit was given in this scorecard to states that have a policy in writing, but with a weak or vague target or requirement. Partial credit was also given to states with a specific target or requirement but only for new permits, or with industry best practices for calculating water loss but no mandate for corrective action.

Finding outstanding examples for Question 8 posed a unique challenge because the states with the strongest laws do not appear to utilize the most up-to-date water loss accounting methodology as outlined in the American Water Works Association's most current M36 Manual. Likewise, states with the most current water loss accounting methodology do not have a strong legal foundation for their requirements. The project team was not presented with an outstanding example that encompasses both characteristics. That is, no state presented laws that require both corrective action and industry best practices for calculating water loss.

This is clearly the direction in which states must evolve: strong statutory authority, a requirement for corrective action as well as audit reporting, and use of the correct methodology for calculating non-revenue water. A state that has strong legal authority but is still using percentages is a state that is no longer correctly addressing the problem even though they have the legal muscle to do so.

Thus this section discusses examples from both perspectives, since none exist that do it all. The examples for New Hampshire, New Jersey, and Washington shown below are offered to demonstrate strong law. That is, the specific requirements and corrective action are expressly written in statute, and they do require the correction of water losses exceeding identified levels. However, these states use the wrong accounting methodology and still refer to percentages. Texas, Tennessee, and Georgia are also summarized in this section, because these states utilize the more refined and precise methodology for calculating water loss, but they lack a strong statutory foundation, as well as requirements for action to correct losses.

Strong Legal Authority

New Hampshire, **New Jersey**, and **Washington** have very different but strong laws regarding water loss, but none employs the latest methodology. New Jersey and Washington's municipal water loss laws apply to all municipal purveyors. New Hampshire and New Jersey require purveyors to implement leak detection. New Hampshire requires water purveyors to repair all leaks within 60 days of being discovered. New Jersey requires purveyors to "proceed expeditiously to correct leakage." New Hampshire requires purveyors to develop and implement a response plan if lost water exceeds 15 percent of total water. Washington requires something similar of purveyors with 500 or more connections when water loss is greater than 10 percent for the prior three-year average, greater than 20 percent for purveyors with fewer than 500 connections. New Jersey requires the purveyors with the highest proportion of lost water for each purveyor size class to reduce losses to the median percentage for that class within one year, or else be subject to a specified compliance schedule.

[17] GA. CODE ANN. § 8-2-3.

[18] GA. CODE ANN. § 12-5-180.1.

New Hampshire

(g) [New community water systems and large existing ones obtaining a new source of water] shall implement a water audit and leak detection program in accordance with "Manual of Water Supply Practices, Water Audits and Leak Detection". . . .

(h) The water system shall repair all leaks identified by the activities required by (g), above, within 60 days of discovery unless a waiver is obtained . . . .

(i) The water system shall estimate the volume and percentage of unaccounted-for water once every year using protocols and procedures described in "Manual of Water Supply Practices, Water Audits and Leak Detection" . . . .

(j) The water system shall prepare and submit a response plan to the department within 60 days if the percentage of unaccounted for water in the water system . . . exceeds 15% of the total water introduced to the water system.

(k) The response plan prepared pursuant to (j), above, shall identify how the water system intends to reduce the percentage of unaccounted-for water to below 15% within 2 years, except for leaks that have been identified which must be repaired in accordance with (h), above.

. . . .

(m) The water system shall implement the response plan in accordance with the approved schedule upon receiving approval from the department.[19]

New Jersey

(b) For each purveyor size class, the Department shall determine the percentage of purveyors having the highest proportion of unaccounted-for water, and these purveyors will be determined by the Department to be provisionally delinquent. This determination may not include more than 35 percent of the total number of purveyors each year. . . .

(c) Purveyors found provisionally delinquent will be allowed one year in which to take appropriate corrective action . . . an annual review of each provisionally delinquent purveyor will be conducted by the Department.

1. If the review establishes that the percentage of unaccounted-for water has been reduced to the median percentage for purveyors of that class, the provisionally delinquent status of the purveyor will be terminated.
2. If the provisionally delinquent status is reaffirmed and unless the purveyor submits a schedule for corrective action which is approved by the Department, an order will be issued by the Department, requiring the elimination of all undue losses in the system in accordance with a specified compliance schedule.[20]

. . . .

[A]ll public community water systems shall:

1. Proceed expeditiously to correct leakage in the total distribution system, as detected through a systematic program to monitor leakage.[21]

Washington

(1)

. . . .

(b) Municipal water suppliers will be considered in compliance with this section if any of the following conditions are satisfied:

(i) Distribution system leakage calculated in accordance with subsection (2) of this section is ten percent or less for the last three-year average;

(ii) Distribution system leakage calculated under subsection (3) of this section meets the numerical standards for the approved alternative methodology for the last three-year average;

(iii) For systems serving less than five hundred total connections, distribution system leakage calculated in accordance with subsection (2) of this section is twenty percent or less for the last three-year average and the steps outlined in subsection (5) of this section are completed; or

(iv) A water loss control action plan has been developed and implemented under subsection (4) of this section and the system is meeting the implementation schedule.

. . . .

(4) If the average distribution system leakage for the last three years does not meet the standard calculated under subsection (1)(b)(i), (ii), or (iii) of this section, the municipal water supplier shall develop and implement a water loss control action plan . . . . [22]

[19] N.H. CODE ADMIN. R. ANN. Env-Wq 2101.04 - .05.

[20] N.J. ADMIN. CODE tit. 7, § 19-6.4.

[21] N.J. ADMIN. CODE tit. 7, § 19-6.5(a).

[22] WASH. ADMIN. CODE § 246-290-820.

Good Non-Revenue Water Accounting Practices

Texas, **Tennessee**, and **Georgia** are very different from the previous examples and do not have the strong legal foundation. For all three, authority is given in statute to a state board to develop a water loss reporting methodology; the state boards then adopt requirements that all employ the current water audit methods. In the case of Tennessee, evidence of a poor reporting score means referral to a review board with the potential for a fine or mandate to correct high leakage rates, but even those potential corrective action options are not actually specified. The common weakness among these three states is that the methodologies are not written in statute and can be changed without an official rule making process. Statutes, of course, can be changed, but this entails an official and much more intensive process than changing policy created through the administrative action of a board.

Texas law requires water utilities to conduct a water loss audit using the methodology developed by the Texas Water Development Board. Tennessee has statutory language that gives the Utility Management Review Board authority to create a methodology for estimating average unaccounted for water. On June 6, 2012 new rules were adopted by the Utility Management Review Board that require water utilities to use the AWWA water audit software. Interestingly, the statute still contains the language "unaccounted for water" while the new rules adopted by the board use "non-revenue water." The latter represents preferred nomenclature, but the former lingers in statute. Georgia gives authority to the Board of Natural Resources to develop water loss methodology, which uses the AWWA water audit software.

Texas utilities are not eligible for financial assistance for water supply projects if they fail to complete an audit. Tennessee utilities that don't submit a water loss audit will be, "referred to the utility management review board." There is no statutory hook for Georgia utilities that fail to submit an audit. Texas requires the audit every five years, and Tennessee every year, while Georgia does not indicate any reoccurring reporting requirements beyond the initial filing deadline of January 2012 (January 2013 for utilities serving less than 10,000 individuals).

An ideal water loss policy would incorporate both strong statutory requirements and industry best practices for calculating water loss. It is hoped that this report will highlight the need for formally adopting these newest accounting methods for auditing and quantifying non-revenue water, as referenced in the AWWA M36 Manual, in state statutes and regulations.

Question 9

Conservation and Water Permitting

Question 9 asks whether the state requires conservation activities as part of its water permitting process. The answer for most states is yes, but linkage to existing plans, the amount and quality of information required, the consideration that must be given by the permitting agency, the authority of the permitting agency to condition a permit, and the types of conditions possible vary. Ideally, a state will require all municipal water permittees to plan for and adopt specific water conservation measures, and condition the permit on implementation of those measures and others that may be necessary in the future. Limited credit was given to states that required nothing more regarding water conservation in the course of the permitting process than the development of a conservation plan. At least partial credit was given to states that have established a process for review of plan implementation, expressly allow water rights to be conditioned or rejected based on water conservation, or require conservation provisions on all water permits or licenses.

California, **Georgia**, and **Massachusetts** received top points for their robust permitting requirements regarding water conservation. Massachusetts requires water withdrawal applications to include a description of existing and planned water conservation measures and a water conservation program and implementation timetable. Massachusetts also requires the reviewing agency to consider the conservation practices and measures in its decision-making. Georgia requires water withdrawal permitting decisions to be made in accordance with the statewide and regional water management plans. Massachusetts requires all permits to be conditioned on implementation of water conservation measures. California also requires all permits to contain a water conservation condition, but that condition is more extensive, establishing the continuing authority of the permitting agency to impose additional requirements at a later date to eliminate waste of water and avoid unreasonable draft on the source. Massachusetts requires each permit holder to file an annual statement of new conservation measures implemented within the past year and of the savings due to conservation measures.

California

In addition to the applicable standard terms which are included in each permit, the following terms shall be included in every water right permit issued by the board, and shall be included in every existing permit as a condition for granting an extension of time to commence or to complete construction work or to apply the water to full beneficial use:

(a) Continuing Authority… The continuing authority of the board may be exercised by imposing specific requirements over and above those contained in this permit with a view to eliminating waste of water and to meeting the reasonable water requirements of permittee without unreasonable draft on the source. Permittee may be required to implement a water conservation plan, features of which may include but not necessarily be limited to:

(1) reusing or reclaiming the water allocated;
(2) using water reclaimed by another entity instead of all or part of the water allocated;

. . . .

(4) suppressing evaporation losses from water surfaces;

. . . . and

(6) to installing, maintaining, and operating efficient water measuring devices to assure compliance with the quantity limitations of this permit and to determine accurately water use as against reasonable water requirements for the authorized project.[23]

Georgia

The division shall make all water withdrawal permitting decisions in accordance with this chapter, the comprehensive state-wide water management plan that has been approved or enacted by the General Assembly as provided by this article, and any applicable regional water development and conservation plan, including, but not limited to, restrictions, if any, on diversion from or reduction of flows in other watercourses. Any political subdivision or local water authority that is not in compliance with the plan shall be ineligible for state grants or loans for water projects, except for those projects designed to bring such political subdivision or local water authority into compliance with the plan.[24]

Massachusetts

Every registration statement must contain, at a minimum . . . (f) Conservation measures instituted, or to be instituted, by the registrant . . . .[25]

. . . .

Each permit application filing shall include, at a minimum . . . (f) a description of water conservation measures instituted or to be instituted by the applicant, including a schedule for implementation of those measures.[26]

. . . .

Each permit applicant must submit, in accordance with guidelines developed by the Department, a detailed water conservation program and implementation timetable with the permit application.[27]

. . . .

In reviewing a permit application, the Department shall consider at least the following . . . (h) reasonable conservation practices and measures . . . .[28]

. . . .

All permits shall be conditioned on at least the following . . . (e) implementation of water conservation measures. . .[29]

. . . .

Each permit holder shall file an annual statement of withdrawal which includes at least the following . . .
(b) conservation measures instituted in the past 12 months; (c) savings due to conservation measures implemented . . . .[30]

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23 CAL. CODE REGS. tit. 23, § 780.
24 GA. CODE ANN. § 12-5-522(e).
25 MASS. REGS. CODE tit. 310, § 36.06(2).
26 MASS. REGS. CODE tit. 310, § 36.20(1).
27 MASS. REGS. CODE tit. 310, § 36.25(1)
28 MASS. REGS. CODE tit. 310, § 36.26(1).
29 MASS. REGS. CODE tit. 310, § 36.28(1).
30 MASS. REGS. CODE tit. 310, § 36.33(1)..

Question 10

Drought Plans

Question 10 asks whether water utilities or municipalities are required to plan for drought, and if so, how frequently they need to reexamine their drought plans. Ideally, state law will require water utilities and/or municipalities to prepare drought plans at least every five years, and the law will include a robust, detailed framework outlining the required elements of an acceptable drought plan. An independent drought planning process is superior to a requirement that drought plans be submitted with water rights permit applications mainly for two reasons:

1. In reviewing a permit application, the state must consider a variety of diverse factors and interests, and therefore may not rigorously evaluate the contents of the drought plan, and
2. A drought plan connected to the permitting process is likewise connected to the state's permit renewal schedule and enforceability regime.

A number of states require municipalities to prepare "emergency" plans, but do not mention drought specifically in their plan preparation instructions. Because emergency plans are geared towards terrorism, mechanical failures, and storm events, these states received no credit; droughts are distinct from typical public infrastructure emergencies and require the implementation of unique water conservation policies and measures. Another portion of states received limited credit for requirements that water rights permit applicants prepare drought plans, or that drought plans to be prepared but not regularly updated. The states highlighted following: **Arizona** and **Texas**, both received top points for their robust drought plan requirements.

Both Arizona and Texas require water suppliers to develop drought plans, submit the plans to the state for review, and update the plans every five years. Arizona's detailed plan requirements are concise but sufficient; the state asks water systems to identify and describe water reduction measures, public education initiatives, alternative water supplies, and demand management strategies. Texas' drought plan requirements are slightly more detailed than Arizona's, but essentially target the same planning elements. Texas additionally requires drought plans to include enforcement procedures, such as fines and service discontinuation, to ensure mandatory water use restrictions are followed. Furthermore, Texas requires drought plans to be consistent with broader regional water plans, thus ensuring a cohesive multi-level water planning process across the state.

Arizona

[E]ach community water system shall prepare and submit to the director a system water plan that includes . . . [a] drought preparedness plan.[31]

. . . .

The drought preparedness plan shall be designed to meet the specific needs of the water system for which it applies and shall include:

1. The name, address and telephone number of the community water system and the names of the officers or other persons responsible for directing operations during a water shortage emergency.
2. Drought or emergency response stages providing for the implementation of measures in response to reduction in available water supply due to drought . . . .
3. A plan of action that the community water system will take to respond to drought or water shortage conditions, including:
   (a) Provisions to actively inform the public of the water supply shortage and a program for continued education and information regarding implementation of the drought preparedness plan.
   (b) Development of emergency supplies, which may include identification of emergency or redundant facilities to withdraw, divert or transport substitute supplies of the same or other types of water.
   (c) Specific water supply or water demand management measures for each stage of drought or water shortage conditions, subject to approval by the corporation commission if the community water system is a public service corporation. This requirement may be met by providing a curtailment tariff on file with the corporation commission.[32]

. . . .

[A] large community water system . . . shall submit an updated plan within six months prior to January 1 of every fifth calendar year . . . .[33]

[31] ARIZ. REV. STAT. § 45-342(A)(2).

[32] ARIZ. REV. STAT. § 45-342(I).

[33] ARIZ. REV. STAT. § 45-342(B)

(5) Drought contingency plans for retail public water suppliers. Retail public water suppliers shall submit a drought contingency plan meeting [applicable] requirements . . . to the executive director after adoption by its governing body. The retail public water system shall provide a copy of the plan to the regional water planning group for each region within which the water system operates.[34]

. . . .

(1) Minimum requirements. Drought contingency plans shall include the following minimum elements.

(A) Preparation of the plan shall include provisions to actively inform the public and affirmatively provide opportunity for public input. Such acts may include, but are not limited to, having a public meeting at a time and location convenient to the public and providing written notice to the public concerning the proposed plan and meeting.

(B) Provisions shall be made for a program of continuing public education and information regarding the drought contingency plan.

(C) The drought contingency plan must document coordination with the Regional Water Planning Groups for the service area of the retail public water supplier to insure consistency with the appropriate approved regional water plans.

(D) The drought contingency plan shall include a description of the information to be monitored by the water supplier, and specific criteria for the initiation and termination of drought response stages, accompanied by an explanation of the rationale or basis for such triggering criteria.

(E) The drought contingency plan must include drought or emergency response stages providing for the implementation of measures in response to at least the following situations:

(i) reduction in available water supply up to a repeat of the drought of record;

. . . .

(F) The drought contingency plan must include the specific water supply or water demand management measures to be implemented during each stage of the plan including, but not limited to, the following:

(i) curtailment of non-essential water uses; and

(ii) utilization of alternative water sources and/or alternative delivery mechanisms with the prior approval of the executive director as appropriate (e.g., interconnection with another water system, temporary use of a non-municipal water supply, use of reclaimed water for non-potable purposes, etc.).

(G) The drought contingency plan must include the procedures to be followed for the initiation or termination of each drought response stage, including procedures for notification of the public.

(H) The drought contingency plan must include procedures for granting variances to the plan.

(I) The drought contingency plan must include procedures for the enforcement of any mandatory water use restrictions, including specification of penalties (e.g., fines, water rate surcharges, discontinuation of service) for violations of such restrictions.

(2) Privately-owned water utilities. Privately-owned water utilities shall prepare a drought contingency plan in accordance with this section and shall incorporate such plan inwto their tariff.

(3) Wholesale water customers. Any water supplier that receives all or a portion of its water supply from another water supplier shall consult with that supplier and shall include in the drought contingency plan appropriate provisions for responding to reductions in that water supply.

(c) The retail public water supplier shall review and update, as appropriate, the drought contingency plan, at least every five years, based on new or updated information, such as the adoption or revision of the regional water plan.[35]

[34] 30 TEX. ADMIN. CODE § 288.30.
[35] 30 TEX. ADMIN. CODE § 288.20.

Question 11

Water Conservation Plans

Question 11 asks whether the state requires water utilities and/or municipalities to prepare water conservation plans. Unlike drought emergency plans, which only apply during drought emergency events, water conservation plans outline measures that are broadly applicable at all times of operation to promote efficient water use.

States received full credit for requirements that cover a large set of water suppliers outside of the permitting process. Many states have no law regarding water conservation planning. A portion of states only require water conservation planning with permit applications, or for new appropriators. Because conservation planning associated with water rights permitting is examined in Question 9, those states received no credit here. Ideally, states should require all suppliers to undertake an independent water conservation planning process separate from permitting. As with drought planning, an independent water conservation planning process is superior.

California, **Colorado**, **Rhode Island**, **Utah**, **Washington**, and **Wisconsin** received top points for their broadly applicable water conservation planning requirements. These states represent a range of ways to describe and require water conservation planning processes. For instance, California requires conservation planning within its mandated urban water management plans. Along with water conservation planning requirements, California urban water management plans also require an identification of water use reduction targets based on the 20x2020 requirements added in 2009 legislation.[36] Colorado is representative of how broadly the law can define the scope of entities required to undertake water conservation planning.

Rhode Island uniquely employs a “Water Use Efficiency Rule” to establish targets for per capita per day water use, leakage, efficient use, and accurate metering, then lists required and optional methods for reaching those targets, which users must include in their plans. Utah’s law includes a hearty definition of “water conservation plan.” Washington’s definition of a water conservation plan is notable in its specificity; a water plan must include both a resource analysis component and a financial evaluation component, both stretching at least 20 years into the future. Finally, Wisconsin represents how water conservation planning can vary by source; Wisconsin has one generally applicable planning process for public water suppliers, and another planning process only applicable to large withdrawers from the Great Lakes Basin.

California

(a) Every urban water supplier shall prepare and adopt an urban water management plan . . . .

(b) Every person that becomes an urban water supplier shall adopt an urban water management plan within one year after it has become an urban water supplier. . . .[37]

(a) The state shall achieve a 20-percent reduction in urban per capita water use in California on or before December 31, 2020.[38]

. . . .

(e) An urban retail water supplier shall include in its urban water management plan due in 2010 pursuant to Part 2.6 (commencing with Section 10610) the baseline daily per capita water use, urban water use target, interim urban water use target, and compliance daily per capita water use, along with the bases for determining those estimates, including references to supporting data... (g) An urban retail water supplier may update its 2020 urban water use target in its 2015 urban water management plan required pursuant to Part 2.6 (commencing with Section 10610).[39]

Colorado

‘Covered entity’ means each municipality, agency, utility, including any privately owned utility, or other publicly owned entity with a legal obligation to supply, distribute, or otherwise provide water at retail to domestic, commercial, industrial, or public facility customers, and that has a total demand for such customers of two thousand acre-feet or more. [40]

Each covered entity shall . . . develop, adopt, make publicly available, and implement a plan pursuant to which such covered entity shall encourage its domestic, commercial, industrial, and public facility customers to use water more efficiently.[41]

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[36] SB X7-7, 2009 - http://www.water.ca.gov/wateruseefficiency/sb7/[37] CAL. WAT. CODE § 10620(1)(b).

[38] CAL. WAT. CODE § 10608.16(a)

[39] CAL. WAT. CODE § 10608.20

[40] CAL. WAT. CODE § 10620(2)(a).

[41] COLO. REV. STAT. § 37-60-126.

Rhode Island

Rhode Island's "Water Use Efficiency Rule" establishes targets for per capita per day water use, leakage, efficient use, and accurate metering.[42]

Suppliers shall prepare a Water Efficiency and Demand Management Strategy (DMS) to achieve targets identified in section 3.0 through the application of required methods in section 4.1 and through the application of selected optional methods listed in section 4.2 and or any other methods as appropriate.[43]

All water suppliers and institutional water suppliers which obtain, transport, purchase, or sell more than 50,000,000 gallons of water per year shall be required to prepare, maintain, and carry out a Water Supply Systems Management Plan (WSSMP) as described by these procedures.

Utah

"Water conservation plan" means a written document that contains existing and proposed water conservation measures describing what will be done by retail water providers, water conservancy districts, and the end user of culinary water to help conserve water and limit or reduce its use in the state in terms of per capita consumption so that adequate supplies of water are available for future needs. . . . [45]

[E]ach water conservancy district and each retail water provider shall: prepare and adopt a water conservation plan if one has not already been adopted . . . .[46]

Washington

(2) Purveyors . . . shall submit a water system plan for review and approval by the department:

. . . .

(4) In order to demonstrate system capacity, the water system plan shall address the following elements, as a minimum, for a period of at least twenty years into the future:

. . . .

(f) Water resource analysis, including:

(i) A water use efficiency program

. . . .

(vii) For systems serving one thousand or more total connections, an evaluation of opportunities for the use of reclaimed water, where they exist

. . . .

(j) Financial program, including demonstration of financial viability by providing:

. . . .

(iv) An evaluation that has considered:

. . . .

(B) The feasibility of adopting and implementing a rate structure that encourages water demand efficiency.[47]

Wisconsin

1. The department shall establish, by rule, and administer a continuing water supply planning process for the preparation of water supply plans for persons operating public water supply systems. . . .
2. A person operating a public water supply system that serves a population of 10,000 or more and that withdraws water from the waters of the state shall have an approved plan . . . . [48]

The department shall issue one or more general permits to cover withdrawals from the Great Lakes basin that average 100,000 gallons per day or more in any 30-day period but that do not equal at least 1,000,000 gallons per day for any 30 consecutive days.[49]

All persons identified [as withdrawers from the Great Lakes Basin] . . . shall submit with the application for a new or increased withdrawal, diversion, or water loss approval . . . (1) A water conservation plan . . . .[50]

[42] 96-110-008 R.I. CODE R. § 3.0.
[43] 96-110-008 R.I. CODE R. § 5.2.
[44] 96-110-008 R.I. CODE R. § 7.00.
[45] UTAH CODE ANN. § 73-10-32(1)(f)(f).
[46] UTAH CODE ANN. § 73-10-32(3)(a)(i)(A).
[47] WASH. ADMIN. CODE § 246-290-100.
[48] WIS. STAT. § 281.348(3)(a).
[49] WIS. STAT. § 281.346(4s)(a).
[50] WIS. ADMIN. CODE NR § 852.04.

Question 12

State Approval of Water Conservation Plans

Question 12 seeks information about the amount of control the state exercises over local water conservation planning processes. Ideally, a state agency will have the authority to review, and approve or reject water conservation plans independent of a water rights permitting process and against specified criteria. State approval authority helps to ensure that water conservation planning is cohesive across the state, and makes certain that plans meet all legal requirements. An independent approval process outside of permitting is ideal; however, states received additional credit where reviewing the sufficiency of the water conservation plan was a distinct and substantive element of permit application review. Although the question did not seek information on the extent to which entities must involve stakeholders in the planning process, bonus points were awarded for notice and comment procedures, mandatory public hearings, and other measures to promote broad involvement of stakeholders in the plan adoption process. Additionally, extra credit was awarded where the law sets forth specific criteria against which the state must evaluate conservation plans.

The states highlighted here are: **Connecticut**, **Colorado**, **Kentucky**, and **Virginia**. Both Connecticut and Virginia are notable in that they allow interested state agencies and other entities to provide comments on the proposed plans before the state decides whether to approve or reject the plan. Additionally, both states list criteria against which plans will be judged. Virginia, in particular, has a detailed checklist for plan approval. Kentucky's regulations focus on whether the plan complies with all applicable laws and regulations, and further, whether the plan is consistent with broader state resource plans. Although Colorado's criteria are not set forth by statute, the law does specifically require the reviewing state entity to draft guidelines and methods for the review of water conservation plans. Finally, Virginia law contains robust notice and comment requirements allowing all interested persons to comment on approval of proposed plans.

Connecticut

(1) The Department of Environmental Protection and the Department of Public Utility Control, in the case of any plan which may impact any water company regulated by the Department of Public Utility Control, shall have ninety (90) days upon notice that a plan is deemed complete to comment on the plan. In the event that either the Department of Environmental Protection or the Department of Public Utility Control, in the case of any plan which may impact any water company regulated by the Department of Public Utility Control, fails to provide written comments within ninety (90) days, the Department of Public Health shall notify, in writing, both departments of such failure, and in sixty (60) days from issuance of such notice, the Department of Public Health shall make a determination on approval, modification, or rejection of the plan using all available information. If within sixty (60) days following the issuance of such notice, the Department of Public Utility Control or the Department of Environmental Protection provides written comments on such plan, the Department of Public Health shall approve or reject such plan as appropriate based on such comments. If within sixty (60) days of the issuance of the above notice, the Department of Public Utility Control or the Department of Environmental Protection fails to provide written comments on such plan, such department shall upon expiration of such sixty (60) day period issue a letter concurring with such plan and the Department of Public Health shall approve or reject such plan as the Department of Public Health deems appropriate. Notwithstanding the above, the Department of Public Health may reject any plan deemed acceptable to the Department of Public Utility Control and the Department of Environmental Protection.

(2) The department in making a decision to approve, modify or reject a plan shall consider the following:

  (A) the ability of the company to provide a pure, adequate and reliable water supply for present and projected future customers;

  (B) adequate provision for the protection of the quality of future and existing sources;

  (C) comments from state agencies; and

  (D) consistency with state regulations and statutes.

(3) Within sixty days after the Department of Environmental Protection and the Department of Public Utility Control, in the case of a water company regulated by that agency, have commented to the department regarding whether a plan should be approved, or in no case more than one hundred and fifty days after written notice that the plan has been deemed complete, the commissioner shall advise the water company whether the plan is rejected, approved or approved with conditions.

(4) If the commissioner fails to approve or reject the plan within the timeframes required . . . the plan shall be deemed approved as submitted.

(5) If the commissioner rejects the plan, he shall advise the water company in writing that the plan is being rejected and the reason the plan cannot be approved as submitted.[51]

[51] CONN. AGENCIES REGS. § 25-32d-5(c).

Colorado

The board shall adopt guidelines for the office to review water conservation plans submitted by covered entities and other state or local governmental entities. The guidelines shall define . . . the methods for office review and approval of the plans . . . .[52]

Kentucky

The planning council shall submit one (1) copy of the plan formulation document and three (3) copies of the final plan document to the [Energy & Environment] cabinet.

(a) No plan shall be approved by the cabinet unless it meets all the provisions of this administrative regulation and is consistent with state laws and administrative regulations.

(b) The cabinet shall examine the plan for consistency with other water supply plans that have been approved by the cabinet pursuant to this administrative regulation. . . . If any portion of any county in a planning unit is located within the watershed of the Kentucky River, the cabinet shall examine the plan for consistency with administrative regulations promulgated by the Kentucky River Authority and with the Kentucky River Authority's water resource plan and notify the planning council and the Kentucky River Authority of inconsistencies.[53]

Virginia

A. The [State Water Control] board shall review all programs to determine compliance with this regulation and consistency with the State Water Resources Plan. The board will review adopted elements of a local program according to review policies adopted by the board. Copies of the adopted local program documents and subsequent changes thereto shall be provided to the board.

B. To assist in the review of the program, the board shall provide the Department of Health and other agencies listed in 9 VAC 25-780-150 B along with any other agency the board deems appropriate, 90 days to evaluate the program. . . .

C. The board will assess the compliance of submitted programs with these regulations. The board shall prepare a tentative statement of findings on whether the program has demonstrated compliance with the following:

1. All elements of a local program identified in 9 VAC 25-780-50 have been submitted;
2. The program was developed through a planning process consistent with this chapter;
3. The results of any evaluation conducted pursuant to subsection G of this section have been appropriately accommodated;
4. The existing sources information complies with 9 VAC 25-780-70;
5. The existing water use information complies with 9 VAC 25-780-80;
6. The existing resources information complies with 9 VAC 25-780-90;
7. The projected water demand is based on an accepted methodology and complies with 9 VAC 25-780-100;
8. The water demand management information complies with 9 VAC 25-780-110;
9. The drought response and contingency plan complies with 9 VAC 25-780-120;
10. The statement of need complies with 9 VAC 25-780-130 A;
11. When required, the alternatives comply with 9 VAC 25-780-130;
12. The local program is consistent with 9 VAC 25-390-20, § 62.1-11 of the Code of Virginia and Chapter 3.2 (§ 62.1-44.36 et seq.) of Title 62.1 of the Code of Virginia.

D. If the board's tentative decision is to find the local program in compliance with subsection C of this section, the board shall provide public notice of its findings pursuant to 9 VAC 25-780-150.

E. If the tentative decision of the board is to find the local program in noncompliance with subsection C of this section, the board shall identify (i) the reason for the finding of noncompliance, (ii) what is required for compliance, and (iii) the right to an informational proceeding under Article 3 (§ 2.2-4018 et seq.) of Chapter 40 of the Virginia Administrative Process Act.

F. The board shall make a final decision on whether the local program is in compliance with this chapter after completing review of the submitted program, any agency comments received, and any public comment received from a public meeting held pursuant to 9 VAC 25-780-160.

G. In conjunction with the compliance determination made by the board, the state will develop additional information and conduct additional evaluation of local or regional alternatives in order to facilitate continuous planning. This additional information shall be included in the State Water Resources Plan and used by localities in their program planning. This information shall include:

1. A cumulative demand analysis, based upon information contained in the State Water Resources Plan and other sources;
2. The evaluation of alternatives prepared pursuant to 9 VAC 25-780-130 B and C;
3. The evaluation of potential use conflicts among projected water demand and estimates of requirements for in-stream flow; and

[52] COLO. REV. STAT. § 37-60-126(7)(a).
[53] 401 KY. ADMIN. REGS. 4:220 § 7(4).

4. An evaluation of the relationship between the local plan and the State Water Resources Plan.

H. The board may facilitate information sharing and discussion among localities when potential conflicts arise with regard to demands upon a source.

I. A local program's information shall be included in the State Water Resource Plan when determined to be in compliance by the board. [54]

. . . .

A. The board shall give public notice on the department website for every tentative and final decision to determine local program compliance.

B. The board shall give public notice to the Department of Health, the Department of Conservation and Recreation, the Marine Resources Commission, the Department of Historic Resources, and the Department of Game and Inland Fisheries for every tentative and final decision on program compliance. The agencies shall have 90 days to submit written comment. At the request of the applicant, the board will convene a technical evaluation committee meeting to facilitate receipt of these comments.

C. The board shall provide a comment period of at least 30 days following the date of the public notice for interested persons to submit written comments on the tentative or final decision. All written comments submitted during the comment period shall be retained by the board and considered during its final decision.

D. Commenters may request a public meeting when submitting comments. In order for the board to grant a public meeting, there must be a substantial public interest and a factual basis upon which the commenter believes that the proposed program might be contrary to the purposes stated in 9 VAC 25-780-20. . . .[55]

Question 13

Updating Water Conservation Plans

A water conservation plan is most useful if it is relevant and updated. Accordingly, Question 13 asks how often water conservation plans must be updated or resubmitted to the state. States received limited credit where updates are required on an 11- to 24-year schedule, middling credit for a 7- to 10-year schedule, and top credit for a 1- to 6-year schedule.

Although almost a dozen states received top credit, the update requirements of **Massachusetts**, **South Carolina**, and **Texas** are notable. Although conservation plan approval is connected to permit application approval in Massachusetts, Massachusetts' regulations require permits with terms greater than five years to be reviewed every five years for compliance. Additionally, regulations explicitly authorize the reviewing state agency to modify permit conditions and terms based on the updated information submitted by the applicant. In South Carolina, conservation plans are also linked to the permitting process. Interestingly, South Carolina allows the state permitting agency to issue permits for a period even less than five years, should the agency find a shorter period necessary to conserve water resources. Finally, in Texas, water conservation plan updates are required every five years to coincide with regional water planning efforts. Importantly, implementation reports must accompany any revised water conservation plans that are submitted to the State of Texas for review.

Massachusetts

Each holder of a permit which has a term greater than five years shall file every five years for a review of the permit on a form provided by the Department at least 60 days prior to the fifth anniversary of the original permit application date. The permit holder shall submit at the time of service any additional information requested by the Department. . . . The Department will review for adequacy and compliance all permit conditions and provisions, additional information submitted by the applicant, and any available safe yield information. The Department may modify permit conditions or provisions accordingly.[56]

South Carolina

No permit shall be issued for a period longer than the following:

a. Five (5) years; [or]

b. The period found by the Department necessary to conserve and protect the resource, prevent waste, and to provide and maintain conditions which are conducive to the development and use of water resources . . .[57]

[54] 9 VA. ADMIN. CODE § 25-780-140.

[55] 9 VA. ADMIN. CODE § 25-780-150.

[56] 310 MASS. CODE REGS. 36.33(4).

[57] S.C. CODE ANN. REGS. 61-113(H)(1).

Texas

[T]he next revision of the water conservation plan for municipal, industrial, and other non-irrigation uses must be submitted . . . every five years . . . to coincide with the regional water planning group. Any revised plans must be submitted to the executive director within 90 days of adoption. The revised plans must include implementation reports.[58]

Question 14

Required Elements of Water Conservation Plans

Question 14 seeks information regarding the required elements of a water conservation plan. Although process is important to the effectiveness of plans in promoting water efficiency, the substance of the plan itself is really the heart of a water conservation planning process. Robust frameworks listing required plan elements drive comprehensive, detailed, and thoughtful conservation planning processes. Although agency guidelines are helpful tools for conservation planners, states that only use unenforceable or optional guidelines to steer conservation planning processes received no or limited credit. Middling credit was awarded for mandatory frameworks even if the frameworks lacked detail. Top credit went to states with especially detailed frameworks of requirements.

States receiving top credit under Question 14 include: **California** and **Texas**. Both states have laws outlining in detail the elements that must be incorporated into water conservation plans. For example, in California, conservation plans must include: specified water demand management measures, estimated water savings, the feasibility of using recycled water, and the effects of water quality on water availability. Additionally, California plans must include cost-benefit analyses, public health and social impact analyses, implementation schedules, and identification of available implementation funds. Texas has an equally robust framework of what must be included in water conservation plans, including: water conservation goal-setting, metering programs, rate restructuring, and leak detection programs. Additionally, Texas has a supplemental list of plan elements that may be required at the discretion of the reviewing entity, including: water reuse, adoption of plumbing ordinances, landscape water management, and monitoring programs.

California

A plan shall be adopted in accordance with this chapter that shall do all of the following:
. . . .

(f) Provide a description of the supplier's water demand management measures. This description shall include all of the following:

- (1) A description of each water demand management measure that is currently being implemented, or scheduled or implementation, including the steps necessary to implement any proposed measure, including, but not limited to, all of the following:
  - (A) Water survey programs for single-family residential and multifamily residential customers.
  - (B) Residential plumbing retrofit.
  - (C) System water audits, leak detection, and repair.
  - (D) Metering with commodity rates for all new connections and retrofit of existing connections.
  - (E) Large landscape conservation programs and incentives.
  - (F) High-efficiency washing machine rebate programs.
  - (G) Public information programs.
  - (H) School education programs.
  - (I) Conservation programs for commercial, industrial, and institutional accounts.
  - (J) Wholesale agency programs.
  - (K) Conservation pricing.
  - (L) Water conservation coordinator.
  - (M) Water waste prohibition.
  - (N) Residential ultra-low-flush toilet replacement programs.[59]
- (2) A schedule of implementation for all water demand management measures proposed or described in the plan.
- (3) A description of the methods, if any, that the supplier will use to evaluate the effectiveness of water demand management measures implemented or described under the plan.
- (4) An estimate, if available, of existing conservation savings on water use within the supplier's service area, and the effect of the savings on the supplier's ability to further reduce demand.

[58] 30 TEX. ADMIN. CODE § 288.30.
[59] CAL. WAT. CODE § 10631.

(g) An evaluation of each water demand management measure listed in paragraph (1) of subdivision (f) that is not currently being implemented or scheduled for implementation. In the course of the evaluation, first consideration shall be given to water demand management measures, or combination of measures, that offer lower incremental costs than expanded or additional water supplies. This evaluation shall do all of the following:

(1) Take into account economic and noneconomic factors, including environmental, social, health, customer impact, and technological factors.

(2) Include a cost-benefit analysis, identifying total benefits and total costs.

(3) Include a description of funding available to implement any planned water supply project that would provide water at a higher unit cost.

(4) Include a description of the water supplier's legal authority to implement the measure and efforts to work with other relevant agencies to ensure the implementation of the measure and to share the cost of implementation.

(h) Include a description of all water supply projects and water supply programs that may be undertaken by the urban water supplier to meet the total projected water use . . . . The description shall identify specific projects and include a description of the increase in water supply that is expected to be available from each project. The description shall include an estimate with regard to the implementation timeline for each project or program.

(i) Describe the opportunities for development of desalinated water . . . .

. . . .

The plan shall provide, to the extent available, information on recycled water and its potential for use as a water source . . . [60]

. . . .

The plan shall include information, to the extent practicable, relating to the quality of existing sources of water available to the supplier . . . and the manner in which water quality affects water management strategies and supply reliability.[61]

Texas

(1) Minimum requirements. All water conservation plans for municipal uses by public drinking water suppliers shall include the following elements:

(A) a utility profile including, but not limited to, information regarding population and customer data, water use data, water supply system data, and wastewater system data;

(B) specification of conservation goals including, but not limited to, municipal per capita water use goals, the basis for the development of such goals, and a time frame for achieving the specified goals;

(C) metering device(s), within an accuracy of plus or minus 5.0% in order to measure and account for the amount of water diverted from the source of supply;

(D) a program for universal metering of both customer and public uses of water, for meter testing and repair, and for periodic meter replacement;

(E) measures to determine and control unaccounted-for uses of water (for example, periodic visual inspections along distribution lines; annual or monthly audit of the water system to determine illegal connections, abandoned services, etc.);

(F) a program of continuing public education and information regarding water conservation;

(G) a water rate structure which is not "promotional," i.e., a rate structure which is cost-based and which does not encourage the excessive use of water;

(H) a reservoir systems operations plan, if applicable, providing for the coordinated operation of reservoirs owned by the applicant within a common watershed or river basin in order to optimize available water supplies; and

(I) a means of implementation and enforcement . . . .

(J) documentation of coordination with the Regional Water Planning Groups for the service area of the public water supplier in order to insure consistency with the appropriate approved regional water plans.

(2) Additional content requirements. Water conservation plans for municipal uses by public drinking water suppliers serving a current population of 5,000 or more and/or a projected population of 5,000 or more within the next ten years subsequent to the effective date of the plan shall include the following elements:

(A) a program of leak detection, repair, and water loss accounting for the water transmission, delivery, and distribution system in order to control unaccounted-for uses of water;

(B) a record management system to record water pumped, water deliveries, water sales, and water losses which allows for the desegregation of water sales and uses into the following user classes:

(i) residential;
(ii) commercial;
(iii) public and institutional; and
(iv) industrial; and

[60] CAL. WAT. CODE § 10633.

[61] CAL. WAT. CODE § 10634.

(C) a requirement in every wholesale water supply contract entered into or renewed after official adoption of the plan (by either ordinance, resolution, or tariff), and including any contract extension, that each successive wholesale customer develop and implement a water conservation plan or water conservation measures using the applicable elements in this chapter; if the customer intends to resell the water, then the contract between the initial supplier and customer must provide that the contract for the resale of the water must have water conservation requirements so that each successive customer in the resale of the water will be required to implement water conservation measures in accordance with applicable provisions of this chapter.

(3) Additional conservation strategies. Any combination of the following strategies shall be selected by the water supplier, in addition to the minimum requirements in paragraphs (1) and (2) of this subsection, if they are necessary to achieve the stated water conservation goals of the plan. The commission may require that any of the following strategies be implemented by the water supplier if the commission determines that the strategy is necessary to achieve the goals of the water conservation plan:

(A) conservation-oriented water rates and water rate structures such as uniform or increasing block rate schedules, and/or seasonal rates, but not flat rate or decreasing block rates;

(B) adoption of ordinances, plumbing codes, and/or rules requiring water-conserving plumbing fixtures to be installed in new structures and existing structures undergoing substantial modification or addition;

(C) a program for the replacement or retrofit of water-conserving plumbing fixtures in existing structures;

(D) reuse and/or recycling of wastewater and/or greywater;

(E) a program for pressure control and/or reduction in the distribution system and/or for customer connections;

(F) a program and/or ordinance(s) for landscape water management;

(G) a method for monitoring the effectiveness and efficiency of the water conservation plan; and

(H) any other water conservation practice, method, or technique which the water supplier shows to be appropriate for achieving the stated goal or goals of the water conservation plan.[62]

Question 15

Implementation of Water Conservation Plans

A water conservation planning process is essentially worthless if the utility or municipality is not legally required to implement the plan once the plan has been developed. Question 15 evaluates the extent to which state law facilitates plan implementation and also the extent to which plan implementation is enforceable by the state. For example, legal enforcement incentives to implement the plan can include monetary penalties or water rights permit revocation if the plan is not implemented. Provisions facilitating implementation, for example, can include requirements to submit reports and implementation schedules, or requirements to identify the legal and financial mechanisms necessary for plan implementation.

States received minimal credit if the law included some language facilitating implementation, such as language that the planning entity "shall implement the plan." States received middling credit where implementation of the conservation plan is incorporated as a condition to a water rights allocation permit. States received top credit where the law contained a combination of enforcement provisions and requirements to facilitate implementation.

States with stand-out implementation measures include: **California**, **New Hampshire**, **Oregon**, and **Texas**. California requires conservation plans to include a schedule for implementation and requires that plans be implemented according to that schedule. State water management grants and loans are conditioned upon implementation of the water demand management measures identified in the plan. Additionally, the state requires water providers to meet a 15 percent reduction in per capita water use by December 31, 2015 and a 20 percent reduction by December 31, 2020.

In New Hampshire, compliance with implementation requirements is determined through a field inspection and submission of a report evidencing implementation. If the user is not implementing the required water conservation measures, the state can revoke the associated water rights allocation permit. In Oregon, where a water conservation plan is required, the planning entity must submit periodic progress reports discussing progress towards achieving five-year water conservation benchmarks. Progress reports are then submitted for public notice and comment. If the State of Oregon determines a supplier is not implementing a required plan, the state may initiate its own water regulation, rescind approval of the conservation plan, and, in some cases, revoke a water rights permit or assess a civil penalty. Texas requires conservation plans to include a copy of the legal authorities (e.g., ordinance, resolution, tariff, etc.) under which the water supplier will implement and enforce its conservation plan. If a water supplier is not following the minimum plan requirements or submitting annual reports, the reviewing state entity is authorized to take enforcement actions against the supplier.

[62] 30 TEX. ADMIN. CODE § 288.2(a).

California

The plan must include "A schedule of implementation for all water demand management measure proposed or described in the plan."[63]

An urban water supplier shall implement its plan adopted pursuant to this chapter in accordance with the schedule set forth in its plan.[64]

. . .

(1) Beginning January 1, 2009, the terms of, and eligibility for, a water management grant or loan made to an urban water supplier and awarded or administered by the department, state board, or California Bay-Delta Authority or its successor agency shall be conditioned on the implementation of the water demand management measures . . . .

(2) For the purposes of this section, water management grants and loans include funding for programs and projects for surface water or groundwater storage, recycling, desalination, water conservation, water supply reliability, and water supply augmentation.

. . . .

(a) Each urban retail water supplier shall meet its interim urban water use target by December 31, 2015.

(b) Each urban retail water supplier shall meet its urban water use target by December 31, 2020.[65]

New Hampshire

A water user shall submit a report that demonstrates [implementation].[66]

. . . .

(a) The department shall issue or deny approval to operate a new source of water . . . within 45 days of receipt of the report

. . . .

(b) The department shall conduct a site visit within 30 days of receipt of the report prepared in accordance with Env-Wq 2101.10 in order to:

(1) Review the report with the water user; and

(2) Assess the accuracy of the processes described in the report.

(c) The department shall issue approval to operate a new source when:

(1) The information in the report produced in accordance with Env-Wq 2101.10 is complete and correct;

(2) The information in the report produced in accordance with Env-Wq 2101.10 demonstrates that the water conservation measures . . . are being or will be implemented in accordance with the timeframes specified therein; . . . .

(d) The department shall deny approval if:

(1) The report submitted pursuant to Env-Wq 2101.10 does not show compliance with the requirements . . . .[67]

. . . .

If, after the issuance of an approval, the department receives information that indicates that the information upon which the approval was based was not true and complete or was misleading or that the water user is not complying with applicable requirements of Env-Wq 2101, the department shall notify the water user of the date, time and place of a hearing at which the water user shall be given an opportunity to show cause why the approval should not be revoked . . . .[68]

Oregon

(1) Each municipal water supplier required to submit a water management and conservation plan shall exercise diligence in implementing the approved plan and shall update and resubmit a plan consistent with the requirements of these rules as prescribed during plan approval.

. . . .

(3) Progress reports submitted by municipal water suppliers will be used in determining whether five-year benchmarks are being met, whether the Department will authorize additional diversion of water under extended permits, and/or if schedule changes proposed in updated plans are reasonable and appropriate.

(4) Progress reports submitted by municipal water suppliers shall include:

(a) A list of the benchmarks established under OAR 690-086-0150 and a description of the progress of the municipal water supplier in implementing the associated conservation or other measure;

. . . .

[63] CAL. WAT. CODE § 10631(f)(2).
[64] CAL. WAT. CODE § 10643.
[65] CAL. WAT. CODE § 10608.24
[66] N.H. CODE R. ENV-WQ 2101.10.
[67] N.H. CODE R. ENV-WQ 2101.12.
[68] N.H. CODE R. ENV-WQ 2101.14(b).

(c) A description of the results of the annual water audit required under OAR 690-086-0150(4)(a); and
(d) A comparison of quantities of water used in each sector as identified and described in OAR 690-086-0140(6) with the quantities of water used in each sector for the previous five years.

(5) Upon receipt of a progress report the Department shall give public notice in the weekly notice published by the Department and provide an opportunity for written public comment.[69]

. . . .

If the Director determines that a water supplier . . . has failed to satisfactorily implement an approved water management and conservation plan, the Director may proceed with one or more of the following actions:

(1) Provide an additional, specified amount of time for remedy;

(2) Initiate an evaluation of the supplier's water management practices and facilities to determine if the use of water is wasteful;

(3) Initiate regulation of water use under OAR 690-250-0050 to eliminate waste;

(4) Rescind a previous approval of a water management and conservation plan; and

(5) If the submittal of the water management and conservation plan is required under a condition of a permit or an extension approved under OAR chapter 690, division 315 or 320, assess a civil penalty under OAR 690-260-0005 to 690-260-0110 or cancel the permit.[70]

Texas

All water conservation plans for municipal uses by public drinking water suppliers shall include the following elements:

. . . .

(I) a means of implementation and enforcement which shall be evidenced by:

(i) a copy of the ordinance, resolution, or tariff, indicating official adoption of the water conservation plan by the water supplier; and

(ii) a description of the authority by which the water supplier will implement and enforce the conservation plan.[71]

. . . .

The Texas Water Development Board shall notify the commission if the Texas Water Development Board determines that an entity has not complied with the Texas Water Development Board rules relating to the minimum requirements for water conservation plans or submission of plans or annual reports. The commission shall take appropriate enforcement action upon receipt of notice from the Texas Water Development Board.[72]

Question 16

Funding

Each state received one point for this question for the capability to fund water efficiency and conservation programs through the CWSRF and DWSRF programs. An additional point was awarded if the state demonstrated funding opportunities beyond the drinking water and clean water state revolving fund programs. Maximum credit was given to 22 states for Question 16. Strong examples include Colorado's Water Efficiency Grant Program and Oregon's Water Conservation, Re-use and Storage Grant Program.[73, 74] **North Carolina** has a unique approach that is highlighted below. Local governments and large community water systems must meet water efficiency and conservation requirements to be eligible for state funding to expand delivery or treatment capacity.

[69] OR. ADMIN. R. 690-086-0120.
[70] OR. ADMIN. R. 690-086-0920.
[71] 30 TEX. ADMIN. CODE § 288.2(1).
[72] 30 TEX. ADMIN. CODE § 288.30(10)(D).
[73] Colorado Water Efficiency Grant Program: **cwcb.state.co.us/LoansGrants/water-efficiency-grants/Pages/main.aspx**
[74] Oregon Water Conservation, Re-use and Storage Grant Program: **http://www.oregon.gov/owrd/Pages/LAW/conservation_reuse_storage_grant.aspx**

North Carolina

(b) To be eligible for State water infrastructure funds from the Drinking Water State Revolving Fund or the Drinking Water Reserve or any other grant or loan of funds allocated by the General Assembly whether the allocation of funds is to a State agency or to a nonprofit organization for the purpose of extending waterlines or expanding water treatment capacity, a local government or large community water system must demonstrate that the system:

(1) Has established a water rate structure that is adequate to pay the cost of maintaining, repairing, and operating the system, including reserves for payment of principal and interest on indebtedness incurred for maintenance or improvement of the water system during periods of normal use and periods of reduced water use due to implementation of water conservation measures. The funding agency shall apply guidelines developed by the State Water Infrastructure Commission in determining the adequacy of the water rate structure to support operation and maintenance of the system.

(2) Has implemented a leak detection and repair program.

(3) Has an approved water supply plan pursuant to G.S. 143355.

(4) Meters all water use except for water use that is impractical to meter, including, but not limited to, use of water for firefighting and to flush waterlines.

(5) Does not use a rate structure that gives residential water customers a lower per unit water rate as water use increases.

(6) Has evaluated the extent to which the future water needs of the water system can be met by reclaimed water.

(7) Has implemented a consumer education program that emphasizes the importance of water conservation and that includes information on measures that residential customers may implement to reduce water consumption. (2008143, s. 9; 2010142, s. 13; 2010180, s. 16; 2011374, s. 3.2.)[75]

Question 17

Technical Assistance

States could earn two points for this question depending on the extent of technical assistance available. States with initiatives such as online resources were awarded one point, and states that offer direct technical assistance via staff resources were awarded two points. Arizona, California, Colorado, Florida, Minnesota, New Mexico, North Carolina, South Dakota, Texas, Utah, Virginia, Washington, and Wisconsin all earned maximum credit for Question 17.

Question 18

Volumetric Billing

Question 18 asks whether the state requires volumetric billing. Few states do. While good policy, metering requirements alone did not receive credit for this question because they do not take that final step of defining billing policy. Likewise, nonbinding encouragement in law for volumetric billing did not receive credit. Ideally, state law requires not only volumetric billing but a rate structure explicitly designed to encourage water conservation, as **Minnesota** and **New Jersey** law do.

Minnesota requires all public water suppliers serving more than 1,000 people to implement demand reduction measures, which must include a conservation rate structure, or a uniform rate structure with a conservation program. New Jersey requires all public community water systems to establish water rate structures with water conservation incentives, unless the system has fewer than 500 connections and demonstrates that metering is not practical but annual average daily water use does not exceed 75 gallons per person per day.

[75] NC General Statute §143-355.4. Water system efficiency.

Minnesota

(a) For the purposes of this section, "demand reduction measures" means measures that reduce water demand, water losses, peak water demands, and nonessential water uses. Demand reduction measures must include a conservation rate structure, or a uniform rate structure with a conservation program that achieves demand reduction. A "conservation rate structure" means a rate structure that encourages conservation and may include increasing block rates, seasonal rates, time of use rates, individualized goal rates, or excess use rates. If a conservation rate is applied to multifamily dwellings, the rate structure must consider each residential unit as an individual user.

(b) To encourage conservation, a public water supplier serving more than 1,000 people must implement demand reduction measures by January 1, 2015.[76]

New Jersey

Unless more stringent water conservation measures are required by the Department, all public community water systems shall… 4. File water rate structures which provide incentives for water conservation with the Department and the Board of Public Utilities, as appropriate; and 5. Require installation of water meters for all service connections. This shall not apply to fire emergency uses. Water systems with fewer than 500 service connections or systems where it is demonstrated to the satisfaction of the Department that metering is not practical may be exempted from metering if it is shown that the annual average daily water use by the system does not exceed 75 gallons per person per day.[77]

Question 19

Metered Connections

Many states provided an answer for Question 19 that exceeded 90 percent. However, not one state was able to support its estimate with a citable reference. Because of this lack of adequate documentation, the project team decided to discard this question and not report any of the responses. Therefore, no states were scored on this item. While this question failed to yield useable results, it highlighted the lack of documentation and reporting among states in regard to the number or percentage of metered connections.

States could create valuable information by requiring uniform metering *and* consistent reporting of the number of metered connections. Currently there are no examples to share.

Question 20

Microclimate Information

States could earn two points for Question 20. Some states have climatic data that can be utilized to reduce urban landscape water use, but that information is not directly intended for, or targeted to, urban water customers. States with online ET data specifically for turfgrass earned one point. If a state demonstrated a resource designed specifically to improve the efficiency of urban irrigation, two points were awarded. Only eight states answered "yes" to Question 20, and four were awarded maximum credit.

New Mexico's Landscape Irrigation "Smart" Calculator is a great example of an initiative that targets and empowers urban water customers to increase landscape water use efficiency.[78]

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[76] MINN. STAT. § 103G.291(4).

[77] N.J. ADMIN. CODE tit. 7, § 19-6.5(a).

[78] New Mexico Landscape Irrigation "Smart" Calculator: **http://wuc.ose.state.nm.us/irrcalc/**

Great Lakes States

When evaluating state level water efficiency and conservation laws and policies, the Great Lakes States fall into a class of their own. The Great Lakes-St. Lawrence River Water Resources Compact was signed into federal law on October 3, 2008 and took effect December 8, 2008. The Compact contains water efficiency and conservation provisions applicable to the states of Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Pennsylvania, and Wisconsin. Section 4.2 of the Compact, "Water Conservation and Efficiency Programs," sets forth planning, implementation, and reporting requirements related to water conservation.

Great Lakes-St. Lawrence River Basin Water Resources Compact

1. The Council commits to identify, in cooperation with the Provinces, Basin-wide Water conservation and efficiency objectives to assist the Parties in developing their Water conservation and efficiency program. These objectives are based on the goals of:
    a. Ensuring improvement of the Waters and Water Dependent Natural Resources;
    b. Protecting and restoring the hydrologic and ecosystem integrity of the Basin;
    c. Retaining the quantity of surface water and groundwater in the Basin;
    d. Ensuring sustainable use of Waters of the Basin; and,
    e. Promoting the efficiency of use and reducing losses and waste of Water.
2. Within two years of the effective date of this Compact, each Party shall develop its own Water conservation and efficiency goals and objectives consistent with the Basin-wide goals and objectives, and shall develop and implement a Water conservation and efficiency program, either voluntary or mandatory, within its jurisdiction based on the Party's goals and objectives. Each Party shall annually assess its programs in meeting the Party's goals and objectives, report to the Council and the Regional Body and make this annual assessment available to the public.
3. Beginning five years after the effective date of this Compact, and every five years thereafter, the council, in cooperation with the Provinces, shall review and modify as appropriate the Basinwide objectives, and the Parties shall have regard for any such modifications in implementing their programs. This assessment will be based on examining new technologies, new patterns of Water use, new resource demands and threats, and Cumulative Impact assessment under Section 4.15.
4. Within two years of the effective date of this Compact, the Parties commit to promote Environmentally Sound and Economically Feasible Water Conservation Measures such as:
    a. Measures that promote efficient use of Water;
    b. Identification and sharing of best management practices and state of the art conservation and efficiency technologies;
    c. Application of sound planning principles;
    d. Demand-side and supply-side Measures or incentives; and,
    e. Development, transfer and application of science and research.
5. Each Party shall implement in accordance with paragraph 2 above a voluntary or mandatory Water conservation program for all, including existing, Basin Water users. Conservation programs need to adjust to new demands and the potential impacts of cumulative effects and climate.[79]

Scoring the eight Great Lakes States was not as straightforward as scoring the other 42 states. Some policies in these states only apply to withdrawals from a Great Lakes body of water. Illinois is a prime example, as its water loss policy only applies to the portion of the state in the Great Lakes Basin. Therefore, Illinois was only given partial credit for this otherwise strong water loss requirement. Summary results of the Great Lakes States are included in the following table. The Provinces of Ontario and Québec are included as well, but the reader should note that the Canadian Provinces were not scored or assigned a grade. Complete Canadian provincial survey responses will be uploaded to the AWE Resource Library.

Table 7 shows a range of grades from "D" to "B-" and a point total range of 3 to 15.5 based on the survey results. All of these states have committed to water efficiency and conservation per the Great Lakes-St. Lawrence River Water Resources Compact. While the analysis presented in this report assesses state level water efficiency and conservation activity, it does not directly measure state compliance within the provisions of the Great Lakes Compact. The Great Lakes-St. Lawrence River Basin Water Resources Council (Compact Council) website houses a variety of resources, including program reports by state.[80]

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[79] Pub. L. No. 110-342, 122 Stat. 3749 § 4.2 (2008).

[80] The Great Lakes-St. Lawrence River Basin Water Resources Council Website: **http://www.glslcompactcouncil.org/Resolutions.aspx#ProgramReports**

Table 7: Summary of Great Lake States and Provinces Survey Responses

		IL	IN	MI	MN	NY	OH	PA	WI	ON	QC
2.	Water consumption regulation for toilets?	No	No	No	No	No	No	No	No	N/A	N/A
3.	Water consumption regulation for showerheads?	No	No	No	No	No	No	No	No	N/A	N/A
4.	Water consumption regulation for urinals?	No	No	No	No	No	No	No	No	N/A	N/A
5.	Water consumption regulation for clothes washers?	No	No	No	No	No	No	No	No	No	No
6.	Water consumption regulation for pre-rinse spray valves?	No	No	No	No	No	No	No	No	No	No
7.	Mandatory building or plumbing codes?	No	No	No	No	No	No	No	No	No	Pending
8.	Water loss regulation or policy?	Yes	Yes	No	Yes	Yes	No	No	Yes	No	Yes
9.	Conservation activities as part of water permitting process?	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	No	No
10.	Drought emergency plans required?	No	Yes	No	No	No	No	No	No	No	No
11.	Conservation planning required separate from drought plans?	No	Yes	No	Yes	Yes	No	No	Yes	Pending	Yes
12.	Authority to approve or reject conservation plans?	No	Yes	No	Yes	Yes	No	No	Yes	Yes	Yes
13.	How often are plans required?	N/A	50 yrs	N/A	10 yrs	10 yrs	N/A	N/A	20 yrs	Undetermined	Annually
14.	Planning framework or methodology?	No	No	No	No	Yes	No	No	Yes	N/A	Yes
15.	Implementation of conservation measures required?	No	No	No	Yes	Yes	No	No	Yes	Pending	Yes
16.	State funding for urban water conservation programs?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
17.	Technical assistance for urban water conservation programs?	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
18.	Does the state require volumetric billing?	No	No	No	Yes	No	No	No	Yes	No	No
19.	Percent of publicly supplied connections that are metered?	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
20.	ET microclimate information for urban landscapes?	No	No	No	No	No	No	No	No	No	No
	Points Scored	5	6	3	14.5	11	3.5	3	15.5	N/A	N/A
	Grade	**C-**	**C-**	**D**	**C+**	**C**	**D**	**D**	**B-**	**N/A**	**N/A**

Question #1 was intentionally omitted from this table. Each state earned one point for answering.

Project Challenges

The project team encountered a myriad of challenges throughout the course of this research. Those challenges were related to the survey instrument, data collection, survey review, and scoring. The information produced from this project will become outdated in a short time and regular updates will be required. Minnesota's April 2, 2012 amendment of its law that required water conservation rate structures is a great example of how quickly things can change.[81] This occurred just before the draft report was released. Also, on June 12, 2012, after the draft report was released, Tennessee updated its water loss policy. Project challenges are discussed so future efforts may be conducted more efficiently and effectively.

Designing the survey instrument itself was a complex task requiring stakeholder involvement and approval. It is difficult to include all topic areas surrounding water efficiency and conservation in a survey that is sized appropriately. A small survey will not capture enough data and a large survey will likely have a very low response rate. Further, some of the questions created complications, which was not revealed until several surveys had been completed and reviewed. This is detailed below.

Question 7 invites potential overlap for the scoring in Questions 2-6. Georgia's requirement for toilets and urinals provides an example. Georgia answered "yes" to Question 4 and the answer pertained to a requirement for urinals that are more efficient than the national standard, but only for new construction. Georgia's "yes" response in Question 2 includes point-of-sale as well as new construction. In Question 7, a very large part of Georgia's "yes" answer includes the requirements for toilets and urinals in new construction. There are additional requirements for bathroom and kitchen faucets in new construction, and an additional code that requires sub-metering in newly constructed multifamily housing after July 1, 2012. Because of the requirements beyond toilets and urinals, and the multi-family submetering code, Georgia was awarded two points for Question 7.

Question 9 asks if any conservation activities are required in connection with water rights permitting processes. The most commonly reported requirement was a conservation plan. Question 11 asks directly about the requirement of conservation plans. Because the same plan requirement was often reported by states as an answer to both Questions 9 and 11, there is potential for confusion when reviewing the survey answers and scorecards. Further adding to the complexity is the heterogeneity of conservation plan requirements among states. Some states require conservation plans only in association with the permitting process (e.g., Massachusetts), while others require conservation plans outside of the permitting process (e.g., Colorado), and still other states have requirements both within permitting and outside of permitting (e.g., California).

Questions 12-15 relate to conservation plans, but the answers to these questions can be based on a "yes" answer for Questions 9 or 11. Question 15, in particular, can be a source of double-counting if a state was awarded multiple points in Question 9. Future project updates should include adjustments to the survey instrument for these questions and improve overall specificity. The current order and wording of the questions can produce challenges for the individuals filling out the survey and add complexity to interpreting the results.

A project like this is inherently challenging due to the large amount of information that must be gathered from 50 different states. The 20-question survey applied to 50 states created 1,000 text-based data points. The project relied on assistance from state personnel and connecting with the appropriate people was often difficult. Making contact with the appropriate people did not guarantee they had the time or inclination to provide assistance. Moreover, the survey responses had to be thoroughly reviewed and typically expanded upon for the purposes of this study. The review required the project team to retrieve and analyze legal citations, which was a very time-consuming process.

As previously mentioned, this project relied on legal documentation to determine if a state has water efficiency and conservation policies in place. This can be viewed as a drawback of the methodology, but it also gives strength to the results. It allowed the project team to draw a distinct line in terms of what evidence was to be considered and credited. It is possible that there are states with strong laws that are not being properly implemented. It is also possible that there are states successfully carrying out water efficiency and conservation policies that are

[81] Representative O'Driscoll and Senator Pederson Announce Passage of Bill to Modify Mandatory Tiered Water Pricing for Cities **http://www.senate.mn/members/member_pr_display.php?ls=&id=4420**

not legally binding. But law is the strongest evidence of existing policy, and it contains actual authority. Policies created by an administrative body with no legal basis can be changed much easier than a law, and lack enforceability.

Because the project based its analysis on legal language, the actual implementation of water efficiency and conservation policies and programs was not addressed. To do so would require a much larger amount of funding, as it would require much more in the way of staff resources, and would add a layer of complexity to the project.

Scoring the survey responses was a new concept for the 2011 project effort. The responses were not numerical and thus hard to quantify. At their root, the answers were "yes" and "no," which can be thought of as 1 and 0 respectively. But complications arose due to immense variation in the details of the "yes" answers. Not all "yes" answers were simply a "1." Scoring tiers were employed to manage this variability in the scoring process. The drawback of scoring tiers based on variability is that it may add a large number of points, and thus weight, to a policy that may lack importance in terms of water savings. However, estimating the savings impact of various laws and policies would be a large research undertaking in its own right. The project team made every effort to create a fair and consistent scoring methodology.

Funding was also a challenge. The Turner Foundation provided partial funding for this project, for which AWE is grateful. Unfortunately, AWE was unable to secure any additional financial support. When finished, the project will have required a substantial amount of money beyond what was procured.

Recommendations for Future Updates

- Involve a project advisory committee comprised of state representatives for guidance. They were very helpful and provided a tremendously important perspective.
- Update the survey instrument to be more specific and directive. Address issues mentioned above and ask specifically for legal citations (or appropriate references when it is not a legal question). Respondents were asked to include citations in correspondence, but this was sometimes forgotten because it was not explicitly stated in the survey. The team received multiple surveys with "yes" and "no" answers that were not accompanied by any explanation or supported by a citation.
- Involve a team of legal experts such as the Environmental Law Institute, whose large contribution to this project cannot be overstated.
- Create and follow a systematic scoring methodology and improve upon the guidelines presented in this report when possible. This project team was exploring new territory when it came to scoring the questions. While the scoring methodology in this report created meaningful results, future updates should amend the survey instrument and scoring methodology synergistically. Consideration should be given to the value of laws and policies in terms of the level of effectiveness they have in reducing water consumption (if feasible) as well as their legal strength.
- Properly estimate time and budget. It is easy to underestimate the amount of work required to collect and review the data for a project of this magnitude. Proper estimations will help avoid potential compromise.
- If financially feasible, include an analysis of water efficiency and conservation policy and program implementation.
- If financially feasible, future updates could overlay the results with other state information such as state water consumption values (total and per capita), and water supply conditions.

Conclusion

Water efficiency and conservation efforts can be initiated by the federal government, regional entities, state governments, water providers, and even by customers. Strong initiatives taken by individual states are a critical component of the sustainable management of our nation's fresh water resources. This research effort identified state level water efficiency and conservation policies and laws throughout the 50 states via a 20 question survey. Water efficiency and conservation laws and policies encompassed in the survey included plumbing fixture standards, water conservation requirements related to water rights, water loss control rules, conservation planning and program implementation, volumetric billing for water, funding sources for water efficiency and conservation programs, and technical assistance and other informational resources.

The project began with the creation of the survey with the assistance of a project advisory committee, followed by the data collection effort. After the data were gathered the surveys were thoroughly reviewed and amended based on further research findings. Following the review, the responses were put through a systematic legal analysis. Each question was then scored, and states were assigned a report card style grade based on a point total.

This report evaluates the states individually and presents the information collectively. It demonstrates areas of deficiency and provides valuable examples that can serve as models for future policy. Perhaps of greatest value are the highlights of robust laws and policies that can be used as examples by others to support new efforts.

These highlights not only demonstrate that a state has a particular robust policy, but also shows how the policy is worded, and where it exists in state statute. It is hoped that this report will provide great value to planners, policy makers, and professionals active in the water efficiency movement.

Only two states scored an "A", 11 states scored a "B" grade, 18 states scored a "C", and 19 states were assigned a "D." So what does this say? States with "A" grades are certainly leaders, and are employing many laws and policies to promote water efficiency and conservation. "B" states are also making great effort and likely have valuable examples of strong policy. "C" states may also have a small number of robust laws and policies, but they may be lacking a comprehensive approach. A grade of a "C" certainly does not indicate a complete absence of initiative. "D" states have a lot of opportunity for growth. All states, regardless of grade, can improve their policies, and there are plenty of strong examples documented by this research to serve as models.

State Water Efficiency & Conservation Scorecards

Alabama

Water Efficiency Scorecard Grade: **D**

QUESTION		ANSWER	NOTABLE DETAILS	POINTS
1.	State agency in charge of drinking water conservation?	Alabama Office of Water Resources		1
2.	Water consumption regulation for toilets?	No		0
3.	Water consumption regulation for showerheads?	No		0
4.	Water consumption regulation for urinals?	No		0
5.	Water consumption regulation for clothes washers?	No		0
6.	Water consumption regulation for pre-rinse spray valves?	No		0
7.	Mandatory building or plumbing codes?	No		0
8.	Water loss regulation or policy?	No		0
9.	Conservation activities as part of water permitting process?	No		0
10.	Drought emergency plans required?	No		0
11.	Conservation planning required separate from drought plans?	No		0
12.	Authority to approve or reject conservation plans?	N/A		0
13.	How often are plans required?	N/A		0
14.	Planning framework or methodology?	N/A		0
15.	Implementation of conservation measures required?	N/A		0
16.	State funding for urban water conservation programs?	Yes		1
17.	Technical assistance for urban water conservation programs?	No		0
18.	Does the state require volumetric billing?	No		0
19.	Percent of publicly supplied connections that are metered?	N/A		0
20.	ET microclimate information for urban landscapes?	No		0
EXTRA CREDIT				0
		TOTAL		**2**

Alaska

Water Efficiency Scorecard Grade: **D**

QUESTION		ANSWER	NOTABLE DETAILS	POINTS
1.	State agency in charge of drinking water conservation?	Alaska Department of Environmental Conservation		1
2.	Water consumption regulation for toilets?	No		0
3.	Water consumption regulation for showerheads?	No		0
4.	Water consumption regulation for urinals?	No		0
5.	Water consumption regulation for clothes washers?	No		0
6.	Water consumption regulation for pre-rinse spray valves?	No		0
7.	Mandatory building or plumbing codes?	No		0
8.	Water loss regulation or policy?	No		0
9.	Conservation activities as part of water permitting process?	No		0
10.	Drought emergency plans required?	No		0
11.	Conservation planning required separate from drought plans?	No		0
12.	Authority to approve or reject conservation plans?	N/A		0
13.	How often are plans required?	N/A		0
14.	Planning framework or methodology?	N/A		0
15.	Implementation of conservation measures required?	N/A		0
16.	State funding for urban water conservation programs?	Yes		1
17.	Technical assistance for urban water conservation programs?	No		0
18.	Does the state require volumetric billing?	No		0
19.	Percent of publicly supplied connections that are metered?	N/A		0
20.	ET microclimate information for urban landscapes?	No		0
EXTRA CREDIT		Statute 46.15.035 Water Conservation Fee; Reservation of Water for Fish		1
		TOTAL		**3**

Arizona

Water Efficiency Scorecard Grade: **B+**

QUESTION		ANSWER	NOTABLE DETAILS	POINTS
1.	State agency in charge of drinking water conservation?	Arizona Department of Water Resources		1
2.	Water consumption regulation for toilets?	No		0
3.	Water consumption regulation for showerheads?	No		0
4.	Water consumption regulation for urinals?	No		0
5.	Water consumption regulation for clothes washers?	No		0
6.	Water consumption regulation for pre-rinse spray valves?	No		0
7.	Mandatory building or plumbing codes?	No		0
8.	Water loss regulation or policy?	Yes		1
9.	Conservation activities as part of water permitting process?	Yes		1
10.	Drought emergency plans required?	Yes	Every five years	2
11.	Conservation planning required separate from drought plans?	Yes		2
12.	Authority to approve or reject conservation plans?	Yes		2
13.	How often are plans required?	5 Years		2
14.	Planning framework or methodology?	Yes		2
15.	Implementation of conservation measures required?	Yes		3
16.	State funding for urban water conservation programs?	Yes		2
17.	Technical assistance for urban water conservation programs?	Yes		2
18.	Does the state require volumetric billing?	No		0
19.	Percent of publicly supplied connections that are metered?	N/A		0
20.	ET microclimate information for urban landscapes?	Yes		1
EXTRA CREDIT	1 point for evaporative cooling systems and decorative fountains being required to have water recycling or reuse systems. 1 point for Arizona's Rinse Smart, pre-rinse spray valve program.			2
			TOTAL	**23**

Arkansas

Water Efficiency Scorecard Grade: **C–**

QUESTION		ANSWER	NOTABLE DETAILS	POINTS
1.	State agency in charge of drinking water conservation?	Arkansas Natural Resources Commission		1
2.	Water consumption regulation for toilets?	No		0
3.	Water consumption regulation for showerheads?	No		0
4.	Water consumption regulation for urinals?	No		0
5.	Water consumption regulation for clothes washers?	No		0
6.	Water consumption regulation for pre-rinse spray valves?	No		0
7.	Mandatory building or plumbing codes?	No		0
8.	Water loss regulation or policy?	No		0
9.	Conservation activities as part of water permitting process?	Yes		1
10.	Drought emergency plans required?	No		0
11.	Conservation planning required separate from drought plans?	Yes	For permitting, already credited in Question 9	0
12.	Authority to approve or reject conservation plans?	Yes		1
13.	How often are plans required?		Only at time of permit application	0
14.	Planning framework or methodology?	No		0
15.	Implementation of conservation measures required?	Yes	Only in regard to permit applications	1
16.	State funding for urban water conservation programs?	Yes	Has programs beyond DWSRF and CWSRF	2
17.	Technical assistance for urban water conservation programs?	Yes		1
18.	Does the state require volumetric billing?	No		0
19.	Percent of publicly supplied connections that are metered?	N/A		0
20.	ET microclimate information for urban landscapes?	No		0
EXTRA CREDIT				0
			TOTAL	**7**

California

Water Efficiency Scorecard Grade: **A–**

QUESTION		ANSWER	NOTABLE DETAILS	POINTS
1.	State agency in charge of drinking water conservation?	There are 5 agencies with water conservation responsibilities.		1
2.	Water consumption regulation for toilets?	Yes		2
3.	Water consumption regulation for showerheads?	No		0
4.	Water consumption regulation for urinals?	Yes		1
5.	Water consumption regulation for clothes washers?	No		0
6.	Water consumption regulation for pre-rinse spray valves?	No		0
7.	Mandatory building or plumbing codes?	No		0
8.	Water loss regulation or policy?	Yes		1
9.	Conservation activities as part of water permitting process?	Yes		3
10.	Drought emergency plans required?	Yes	Every 5 years	2
11.	Conservation planning required separate from drought plans?	Yes		2
12.	Authority to approve or reject conservation plans?	No		0
13.	How often are plans required?	5 Years		2
14.	Planning framework or methodology?	Yes		2
15.	Implementation of conservation measures required?	Yes		3
16.	State funding for urban water conservation programs?	Yes		2
17.	Technical assistance for urban water conservation programs?	Yes		2
18.	Does the state require volumetric billing?	Yes		1
19.	Percent of publicly supplied connections that are metered?	N/A		0
20.	ET microclimate information for urban landscapes?	Yes		2
EXTRA CREDIT	Max extra credit for robust answers to Questions 10, 11, 14, & 15. Also, California MOU and Landscape Ordinance (AB 1881).			3
		TOTAL		**29**

Colorado

Water Efficiency Scorecard Grade: **B–**

QUESTION		ANSWER	NOTABLE DETAILS	POINTS
1.	State agency in charge of drinking water conservation?	Colorado Water Conservation Board (CWCB)		1
2.	Water consumption regulation for toilets?	No		0
3.	Water consumption regulation for showerheads?	No		0
4.	Water consumption regulation for urinals?	No		0
5.	Water consumption regulation for clothes washers?	No		0
6.	Water consumption regulation for pre-rinse spray valves?	No		0
7.	Mandatory building or plumbing codes?	No		0
8.	Water loss regulation or policy?	No		0
9.	Conservation activities as part of water permitting process?	No		0
10.	Drought emergency plans required?	No		0
11.	Conservation planning required separate from drought plans?	Yes		2
12.	Authority to approve or reject conservation plans?	Yes		2
13.	How often are plans required?	7 Years		1.5
14.	Planning framework or methodology?	Yes		2
15.	Implementation of conservation measures required?	Yes		1
16.	State funding for urban water conservation programs?	Yes	CWCB has a Water Efficiency Grant Fund	2
17.	Technical assistance for urban water conservation programs?	Yes		2
18.	Does the state require volumetric billing?	No		0
19.	Percent of publicly supplied connections that are metered?	N/A		0
20.	ET microclimate information for urban landscapes?	No		0
EXTRA CREDIT	Extra credit for extremely transparent water conservation reporting process, Question 11, and requirement of builders to offer homebuyers efficient fixtures			3
		TOTAL		**16.5**

Connecticut

Water Efficiency Scorecard Grade: **C+**

QUESTION		ANSWER	NOTABLE DETAILS	POINTS
1.	State agency in charge of drinking water conservation?	Connecticut Department of Energy and Environmental Protection		1
2.	Water consumption regulation for toilets?	No		0
3.	Water consumption regulation for showerheads?	No		0
4.	Water consumption regulation for urinals?	No		0
5.	Water consumption regulation for clothes washers?	No		0
6.	Water consumption regulation for pre-rinse spray valves?	No		0
7.	Mandatory building or plumbing codes?	No		0
8.	Water loss regulation or policy?	Yes		1
9.	Conservation activities as part of water permitting process?	Yes		1
10.	Drought emergency plans required?	Yes	Drought is part of the required Water Supply Plans	1
11.	Conservation planning required separate from drought plans?	Yes		2
12.	Authority to approve or reject conservation plans?	Yes		2
13.	How often are plans required?	Variable		1
14.	Planning framework or methodology?	Yes		1
15.	Implementation of conservation measures required?	No		0
16.	State funding for urban water conservation programs?	Yes		2
17.	Technical assistance for urban water conservation programs?	No		0
18.	Does the state require volumetric billing?	No		0
19.	Percent of publicly supplied connections that are metered?	N/A		0
20.	ET microclimate information for urban landscapes?	No		0
EXTRA CREDIT	Extra credit for Question 12 and for the requirement of rain sensors on automatic irrigation systems.			2
			TOTAL	**14**

Delaware

Water Efficiency Scorecard Grade: **C–**

QUESTION		ANSWER	NOTABLE DETAILS	POINTS
1.	State agency in charge of drinking water conservation?	Department of Natural Resources and Enviornmental Control		1
2.	Water consumption regulation for toilets?	No		0
3.	Water consumption regulation for showerheads?	No		0
4.	Water consumption regulation for urinals?	No		0
5.	Water consumption regulation for clothes washers?	No		0
6.	Water consumption regulation for pre-rinse spray valves?	No		0
7.	Mandatory building or plumbing codes?	No		0
8.	Water loss regulation or policy?	Yes		1
9.	Conservation activities as part of water permitting process?	Yes		2
10.	Drought emergency plans required?	No		0
11.	Conservation planning required separate from drought plans?	Yes	For permitting, already credited in Question 9	0
12.	Authority to approve or reject conservation plans?	Yes		0.5
13.	How often are plans required?	30 Years	Only when applying for new allocation permit	0.5
14.	Planning framework or methodology?	Yes	Requirements are listed in the regulations	1
15.	Implementation of conservation measures required?	No		0
16.	State funding for urban water conservation programs?	Yes		1
17.	Technical assistance for urban water conservation programs?	No		0
18.	Does the state require volumetric billing?	No		0
19.	Percent of publicly supplied connections that are metered?	N/A		0
20.	ET microclimate information for urban landscapes?	No		0
EXTRA CREDIT				0
			TOTAL	**7**

Florida

Water Efficiency Scorecard Grade: **C**

QUESTION		ANSWER	NOTABLE DETAILS	POINTS
1.	State agency in charge of drinking water conservation?	Florida Department of Environmental Protection		1
2.	Water consumption regulation for toilets?	No		0
3.	Water consumption regulation for showerheads?	No		0
4.	Water consumption regulation for urinals?	No		0
5.	Water consumption regulation for clothes washers?	No		0
6.	Water consumption regulation for pre-rinse spray valves?	No		0
7.	Mandatory building or plumbing codes?	No		0
8.	Water loss regulation or policy?	No		0
9.	Conservation activities as part of water permitting process?	No		0
10.	Drought emergency plans required?	Yes	Water Management Districts are required to have a plan	1
11.	Conservation planning required separate from drought plans?	No		0
12.	Authority to approve or reject conservation plans?	N/A		0
13.	How often are plans required?	N/A		0
14.	Planning framework or methodology?	N/A		0
15.	Implementation of conservation measures required?	N/A		0
16.	State funding for urban water conservation programs?	Yes	Water Savings Incentive Program	2
17.	Technical assistance for urban water conservation programs?	Yes		2
18.	Does the state require volumetric billing?	No		0
19.	Percent of publicly supplied connections that are metered?	N/A		0
20.	ET microclimate information for urban landscapes?	Yes		2
EXTRA CREDIT	Extra credit for F.S. 373.227 and FLA. ADMIN. CODE ANN. r. 62-40.412, for soil moisture sensor requirement for irrigation systems, and for the Florida Water Star program.			3
		TOTAL		**11**

Georgia

Water Efficiency Scorecard Grade: **B**

QUESTION		ANSWER	NOTABLE DETAILS	POINTS
1.	State agency in charge of drinking water conservation?	Georgia Department of Natural Resources		1
2.	Water consumption regulation for toilets?	Yes		2
3.	Water consumption regulation for showerheads?	No		0
4.	Water consumption regulation for urinals?	Yes		1
5.	Water consumption regulation for clothes washers?	No		0
6.	Water consumption regulation for pre-rinse spray valves?	No		0
7.	Mandatory building or plumbing codes?	Yes		2
8.	Water loss regulation or policy?	Yes		1
9.	Conservation activities as part of water permitting process?	Yes		3
10.	Drought emergency plans required?	Yes		1
11.	Conservation planning required separate from drought plans?	Yes	For permitting, already credited in Question 9	0
12.	Authority to approve or reject conservation plans?	Yes		1
13.	How often are plans required?	10 Years	Permits are 10 years for groundwater, 10-20 years for surface water	1.5
14.	Planning framework or methodology?	Yes	Requirements are listed in the rules	2
15.	Implementation of conservation measures required?	No		0
16.	State funding for urban water conservation programs?	Yes	Georgia Environmental Finance Authority	2
17.	Technical assistance for urban water conservation programs?	Yes		1
18.	Does the state require volumetric billing?	No		0
19.	Percent of publicly supplied connections that are metered?	N/A		0
20.	ET microclimate information for urban landscapes?	No		0
EXTRA CREDIT				0
		TOTAL		**18.5**

Hawaii

Water Efficiency Scorecard Grade: **D**

QUESTION		ANSWER	NOTABLE DETAILS	POINTS
1.	State agency in charge of drinking water conservation?	The Commission on Water Resource Management		1
2.	Water consumption regulation for toilets?	No		0
3.	Water consumption regulation for showerheads?	No		0
4.	Water consumption regulation for urinals?	No		0
5.	Water consumption regulation for clothes washers?	No		0
6.	Water consumption regulation for pre-rinse spray valves?	No		0
7.	Mandatory building or plumbing codes?	No		0
8.	Water loss regulation or policy?	No		0
9.	Conservation activities as part of water permitting process?	No		0
10.	Drought emergency plans required?	No		0
11.	Conservation planning required separate from drought plans?	No		0
12.	Authority to approve or reject conservation plans?	N/A		0
13.	How often are plans required?	N/A		0
14.	Planning framework or methodology?	N/A		0
15.	Implementation of conservation measures required?	N/A		0
16.	State funding for urban water conservation programs?	Yes	Water Resource Management Fund	2
17.	Technical assistance for urban water conservation programs?	Yes		1
18.	Does the state require volumetric billing?	No		0
19.	Percent of publicly supplied connections that are metered?	N/A		0
20.	ET microclimate information for urban landscapes?	No		0
EXTRA CREDIT				0
		TOTAL		**4**

Idaho

Water Efficiency Scorecard Grade: **D**

QUESTION		ANSWER	NOTABLE DETAILS	POINTS
1.	State agency in charge of drinking water conservation?	Department of Water Resources		1
2.	Water consumption regulation for toilets?	No		0
3.	Water consumption regulation for showerheads?	No		0
4.	Water consumption regulation for urinals?	No		0
5.	Water consumption regulation for clothes washers?	No		0
6.	Water consumption regulation for pre-rinse spray valves?	No		0
7.	Mandatory building or plumbing codes?	No		0
8.	Water loss regulation or policy?	No		0
9.	Conservation activities as part of water permitting process?	No		0
10.	Drought emergency plans required?	No		0
11.	Conservation planning required separate from drought plans?	No		0
12.	Authority to approve or reject conservation plans?	N/A		0
13.	How often are plans required?	N/A		0
14.	Planning framework or methodology?	N/A		0
15.	Implementation of conservation measures required?	N/A		0
16.	State funding for urban water conservation programs?	Yes		2
17.	Technical assistance for urban water conservation programs?	No		0
18.	Does the state require volumetric billing?	No		0
19.	Percent of publicly supplied connections that are metered?	N/A		0
20.	ET microclimate information for urban landscapes?	No		0
EXTRA CREDIT				0
		TOTAL		**3**

Illinois

Water Efficiency Scorecard Grade: **C–**

QUESTION		ANSWER	NOTABLE DETAILS	POINTS
1.	State agency in charge of drinking water conservation?	Department of Natural Resources		1
2.	Water consumption regulation for toilets?	No		0
3.	Water consumption regulation for showerheads?	No		0
4.	Water consumption regulation for urinals?	No		0
5.	Water consumption regulation for clothes washers?	No		0
6.	Water consumption regulation for pre-rinse spray valves?	No		0
7.	Mandatory building or plumbing codes?	No		0
8.	Water loss regulation or policy?	Yes		1
9.	Conservation activities as part of water permitting process?	Yes	Only for Lake Michigan allocations	1
10.	Drought emergency plans required?	No		0
11.	Conservation planning required separate from drought plans?	No		0
12.	Authority to approve or reject conservation plans?	N/A		0
13.	How often are plans required?	N/A		0
14.	Planning framework or methodology?	N/A		0
15.	Implementation of conservation measures required?	N/A		0
16.	State funding for urban water conservation programs?	Yes		1
17.	Technical assistance for urban water conservation programs?	No		0
18.	Does the state require volumetric billing?	No		0
19.	Percent of publicly supplied connections that are metered?	N/A		0
20.	ET microclimate information for urban landscapes?	No		0
EXTRA CREDIT	Soil moisture sensors are required for irrigation systems			1
		TOTAL		**5**

Indiana

Water Efficiency Scorecard Grade: **C–**

QUESTION		ANSWER	NOTABLE DETAILS	POINTS
1.	State agency in charge of drinking water conservation?	Department of Natural Resources, Division of Water		1
2.	Water consumption regulation for toilets?	No		0
3.	Water consumption regulation for showerheads?	No		0
4.	Water consumption regulation for urinals?	No		0
5.	Water consumption regulation for clothes washers?	No		0
6.	Water consumption regulation for pre-rinse spray valves?	No		0
7.	Mandatory building or plumbing codes?	No		0
8.	Water loss regulation or policy?	Yes		1
9.	Conservation activities as part of water permitting process?	Yes	Only in relation to the Great Lakes Compact	0.5
10.	Drought emergency plans required?	Yes		0.5
11.	Conservation planning required separate from drought plans?	Yes		1
12.	Authority to approve or reject conservation plans?	Yes		0.5
13.	How often are plans required?	50 Years	Only when appling for permit	0.5
14.	Planning framework or methodology?	No		0
15.	Implementation of conservation measures required?	No		0
16.	State funding for urban water conservation programs?	Yes		1
17.	Technical assistance for urban water conservation programs?	No		0
18.	Does the state require volumetric billing?	No		0
19.	Percent of publicly supplied connections that are metered?	N/A		0
20.	ET microclimate information for urban landscapes?	No		0
EXTRA CREDIT				0
		TOTAL		**6**

Iowa

Water Efficiency Scorecard Grade: **C**

QUESTION		ANSWER	NOTABLE DETAILS	POINTS
1.	State agency in charge of drinking water conservation?	Iowa Department of Natural Resources		1
2.	Water consumption regulation for toilets?	No		0
3.	Water consumption regulation for showerheads?	No		0
4.	Water consumption regulation for urinals?	No		0
5.	Water consumption regulation for clothes washers?	No		0
6.	Water consumption regulation for pre-rinse spray valves?	No		0
7.	Mandatory building or plumbing codes?	No		0
8.	Water loss regulation or policy?	No		0
9.	Conservation activities as part of water permitting process?	Yes		2
10.	Drought emergency plans required?	No		0
11.	Conservation planning required separate from drought plans?	Yes		1
12.	Authority to approve or reject conservation plans?	Yes		1
13.	How often are plans required?	10 Years		1.5
14.	Planning framework or methodology?	Yes		2
15.	Implementation of conservation measures required?	Yes		1
16.	State funding for urban water conservation programs?	Yes		1
17.	Technical assistance for urban water conservation programs?	No		0
18.	Does the state require volumetric billing?	No		0
19.	Percent of publicly supplied connections that are metered?	N/A		0
20.	ET microclimate information for urban landscapes?	No		0
EXTRA CREDIT				0
		TOTAL		**10.5**

Kansas

Water Efficiency Scorecard Grade: **C**

QUESTION		ANSWER	NOTABLE DETAILS	POINTS
1.	State agency in charge of drinking water conservation?	Kansas Water Office		1
2.	Water consumption regulation for toilets?	No		0
3.	Water consumption regulation for showerheads?	No		0
4.	Water consumption regulation for urinals?	No		0
5.	Water consumption regulation for clothes washers?	No		0
6.	Water consumption regulation for pre-rinse spray valves?	No		0
7.	Mandatory building or plumbing codes?	No		0
8.	Water loss regulation or policy?	No	Assistance for systems with over 30% unaccounted for water use	0
9.	Conservation activities as part of water permitting process?	Yes		1
10.	Drought emergency plans required?	No		0
11.	Conservation planning required separate from drought plans?	Yes		1
12.	Authority to approve or reject conservation plans?	Yes		1
13.	How often are plans required?	N/A		0
14.	Planning framework or methodology?	Yes		1
15.	Implementation of conservation measures required?	Yes		2
16.	State funding for urban water conservation programs?	Yes		1
17.	Technical assistance for urban water conservation programs?	Yes	For utilities developing a conservation plan	1
18.	Does the state require volumetric billing?	No		0
19.	Percent of publicly supplied connections that are metered?	N/A		0
20.	ET microclimate information for urban landscapes?	No		0
EXTRA CREDIT	Extra credit given for the water loss assistance mentioned in Question 8			1
		TOTAL		**10**

Kentucky — Water Efficiency Scorecard — Grade: C+

QUESTION		ANSWER	NOTABLE DETAILS	POINTS
1.	State agency in charge of drinking water conservation?	Kentucky Division of Water		1
2.	Water consumption regulation for toilets?	No		0
3.	Water consumption regulation for showerheads?	No		0
4.	Water consumption regulation for urinals?	No		0
5.	Water consumption regulation for clothes washers?	No		0
6.	Water consumption regulation for pre-rinse spray valves?	No		0
7.	Mandatory building or plumbing codes?	No		0
8.	Water loss regulation or policy?	Yes		1
9.	Conservation activities as part of water permitting process?	No		0
10.	Drought emergency plans required?	Yes	5 Years	2
11.	Conservation planning required separate from drought plans?	Yes		2
12.	Authority to approve or reject conservation plans?	Yes		2
13.	How often are plans required?	5 Years		2
14.	Planning framework or methodology?	Yes		1
15.	Implementation of conservation measures required?	Yes		1
16.	State funding for urban water conservation programs?	Yes		1
17.	Technical assistance for urban water conservation programs?	No		0
18.	Does the state require volumetric billing?	No		0
19.	Percent of publicly supplied connections that are metered?	N/A		0
20.	ET microclimate information for urban landscapes?	No		0
EXTRA CREDIT				0
		TOTAL		**13**

Louisiana — Water Efficiency Scorecard — Grade: D

QUESTION		ANSWER	NOTABLE DETAILS	POINTS
1.	State agency in charge of drinking water conservation?	Department of Natural Resources		1
2.	Water consumption regulation for toilets?	No		0
3.	Water consumption regulation for showerheads?	No		0
4.	Water consumption regulation for urinals?	No		0
5.	Water consumption regulation for clothes washers?	No		0
6.	Water consumption regulation for pre-rinse spray valves?	No		0
7.	Mandatory building or plumbing codes?	No		0
8.	Water loss regulation or policy?	No		0
9.	Conservation activities as part of water permitting process?	No		0
10.	Drought emergency plans required?	No		0
11.	Conservation planning required separate from drought plans?	No		0
12.	Authority to approve or reject conservation plans?	N/A		0
13.	How often are plans required?	N/A		0
14.	Planning framework or methodology?	N/A		0
15.	Implementation of conservation measures required?	N/A		0
16.	State funding for urban water conservation programs?	Yes	Water conservation can be used to assign priority for state funding	1
17.	Technical assistance for urban water conservation programs?	No		0
18.	Does the state require volumetric billing?	No		0
19.	Percent of publicly supplied connections that are metered?	N/A		0
20.	ET microclimate information for urban landscapes?	No		0
EXTRA CREDIT				0
		TOTAL		**2**

Maine

Water Efficiency Scorecard Grade: **D**

QUESTION		ANSWER	NOTABLE DETAILS	POINTS
1.	State agency in charge of drinking water conservation?	Department of Health and Human Services		1
2.	Water consumption regulation for toilets?	No		0
3.	Water consumption regulation for showerheads?	No		0
4.	Water consumption regulation for urinals?	No		0
5.	Water consumption regulation for clothes washers?	No		0
6.	Water consumption regulation for pre-rinse spray valves?	No		0
7.	Mandatory building or plumbing codes?	No		0
8.	Water loss regulation or policy?	Yes		1
9.	Conservation activities as part of water permitting process?	No		0
10.	Drought emergency plans required?	No	Emergency and security plans required but no mention of drought	0
11.	Conservation planning required separate from drought plans?	No		0
12.	Authority to approve or reject conservation plans?	N/A		0
13.	How often are plans required?	N/A		0
14.	Planning framework or methodology?	N/A		0
15.	Implementation of conservation measures required?	N/A		0
16.	State funding for urban water conservation programs?	Yes		1
17.	Technical assistance for urban water conservation programs?	No		0
18.	Does the state require volumetric billing?	No		0
19.	Percent of publicly supplied connections that are metered?	N/A		0
20.	ET microclimate information for urban landscapes?	No		0
EXTRA CREDIT				0
		TOTAL		**3**

Maryland

Water Efficiency Scorecard Grade: **C**

QUESTION		ANSWER	NOTABLE DETAILS	POINTS
1.	State agency in charge of drinking water conservation?	Department of Environment		1
2.	Water consumption regulation for toilets?	No		0
3.	Water consumption regulation for showerheads?	No		0
4.	Water consumption regulation for urinals?	No		0
5.	Water consumption regulation for clothes washers?	No		0
6.	Water consumption regulation for pre-rinse spray valves?	No		0
7.	Mandatory building or plumbing codes?	No		0
8.	Water loss regulation or policy?	Yes		1
9.	Conservation activities as part of water permitting process?	Yes		1
10.	Drought emergency plans required?	No		0
11.	Conservation planning required separate from drought plans?	Yes		2
12.	Authority to approve or reject conservation plans?	Yes		1
13.	How often are plans required?		Only when applying for permit	0
14.	Planning framework or methodology?	Yes	Guidance but not a required framework	0.5
15.	Implementation of conservation measures required?	No		0
16.	State funding for urban water conservation programs?	Yes		1
17.	Technical assistance for urban water conservation programs?	No		0
18.	Does the state require volumetric billing?	No		0
19.	Percent of publicly supplied connections that are metered?	N/A		0
20.	ET microclimate information for urban landscapes?	No		0
EXTRA CREDIT				0
		TOTAL		**7.5**

Massachusetts — Water Efficiency Scorecard — Grade: C+

QUESTION		ANSWER	NOTABLE DETAILS	POINTS
1.	State agency in charge of drinking water conservation?	Water Resources Commission		1
2.	Water consumption regulation for toilets?	No		0
3.	Water consumption regulation for showerheads?	No		0
4.	Water consumption regulation for urinals?	No		0
5.	Water consumption regulation for clothes washers?	No		0
6.	Water consumption regulation for pre-rinse spray valves?	No		0
7.	Mandatory building or plumbing codes?	No		0
8.	Water loss regulation or policy?	Yes		2
9.	Conservation activities as part of water permitting process?	Yes		3
10.	Drought emergency plans required?	No		0
11.	Conservation planning required separate from drought plans?	Yes	For permitting, already credited in Question 9	0
12.	Authority to approve or reject conservation plans?	Yes		1
13.	How often are plans required?	5 Years	Permits issued every 20 years, conservation plans reviewed every 5 years	2
14.	Planning framework or methodology?	No		0
15.	Implementation of conservation measures required?	Yes		2
16.	State funding for urban water conservation programs?	Yes		1
17.	Technical assistance for urban water conservation programs?	Yes		1
18.	Does the state require volumetric billing?	No		0
19.	Percent of publicly supplied connections that are metered?	N/A		0
20.	ET microclimate information for urban landscapes?	No		0
EXTRA CREDIT				0
		TOTAL		**13**

Michigan — Water Efficiency Scorecard — Grade: D

QUESTION		ANSWER	NOTABLE DETAILS	POINTS
1.	State agency in charge of drinking water conservation?	Department of Environmental Quality		1
2.	Water consumption regulation for toilets?	No		0
3.	Water consumption regulation for showerheads?	No		0
4.	Water consumption regulation for urinals?	No		0
5.	Water consumption regulation for clothes washers?	No		0
6.	Water consumption regulation for pre-rinse spray valves?	No		0
7.	Mandatory building or plumbing codes?	No		0
8.	Water loss regulation or policy?	No		0
9.	Conservation activities as part of water permitting process?	Yes		1
10.	Drought emergency plans required?	No	Emergency plans required but no mention of drought	0
11.	Conservation planning required separate from drought plans?	No		0
12.	Authority to approve or reject conservation plans?	N/A		0
13.	How often are plans required?	N/A		0
14.	Planning framework or methodology?	N/A		0
15.	Implementation of conservation measures required?	N/A		0
16.	State funding for urban water conservation programs?	Yes		1
17.	Technical assistance for urban water conservation programs?	No		0
18.	Does the state require volumetric billing?	No		0
19.	Percent of publicly supplied connections that are metered?	N/A		0
20.	ET microclimate information for urban landscapes?	No		0
EXTRA CREDIT				0
		TOTAL		**3**

Minnesota

Water Efficiency Scorecard

Grade: **C+**

QUESTION		ANSWER	NOTABLE DETAILS	POINTS
1.	State agency in charge of drinking water conservation?	Department of Natural Resources		1
2.	Water consumption regulation for toilets?	No		0
3.	Water consumption regulation for showerheads?	No		0
4.	Water consumption regulation for urinals?	No		0
5.	Water consumption regulation for clothes washers?	No		0
6.	Water consumption regulation for pre-rinse spray valves?	No		0
7.	Mandatory building or plumbing codes?	No		0
8.	Water loss regulation or policy?	Yes		2
9.	Conservation activities as part of water permitting process?	Yes		1
10.	Drought emergency plans required?	No	Emergency plans are required but the word "drought" is not used	0
11.	Conservation planning required separate from drought plans?	Yes	As part of Water Supply Plans, already credited in Question 9	0
12.	Authority to approve or reject conservation plans?	Yes		2
13.	How often are plans required?	10 Years		1.5
14.	Planning framework or methodology?	No		0
15.	Implementation of conservation measures required?	Yes		1
16.	State funding for urban water conservation programs?	Yes		1
17.	Technical assistance for urban water conservation programs?	Yes		2
18.	Does the state require volumetric billing?	Yes		2
19.	Percent of publicly supplied connections that are metered?	N/A		0
20.	ET microclimate information for urban landscapes?	No		0
EXTRA CREDIT		Minnesota requires landscape irrigation systems to have a rain sensor		1
		TOTAL		**14.5**

Mississippi

Water Efficiency Scorecard

Grade: **D**

QUESTION		ANSWER	NOTABLE DETAILS	POINTS
1.	State agency in charge of drinking water conservation?	Department of Environmental Quality		1
2.	Water consumption regulation for toilets?	No		0
3.	Water consumption regulation for showerheads?	No		0
4.	Water consumption regulation for urinals?	No		0
5.	Water consumption regulation for clothes washers?	No		0
6.	Water consumption regulation for pre-rinse spray valves?	No		0
7.	Mandatory building or plumbing codes?	No		0
8.	Water loss regulation or policy?	No		0
9.	Conservation activities as part of water permitting process?	No		0
10.	Drought emergency plans required?	No		0
11.	Conservation planning required separate from drought plans?	No		0
12.	Authority to approve or reject conservation plans?	N/A		0
13.	How often are plans required?	N/A		0
14.	Planning framework or methodology?	N/A		0
15.	Implementation of conservation measures required?	N/A		0
16.	State funding for urban water conservation programs?	Yes		1
17.	Technical assistance for urban water conservation programs?	No		0
18.	Does the state require volumetric billing?	No		0
19.	Percent of publicly supplied connections that are metered?	N/A		0
20.	ET microclimate information for urban landscapes?	No		0
EXTRA CREDIT				0
		TOTAL		**2**

Missouri — Water Efficiency Scorecard — Grade: D

QUESTION		ANSWER	NOTABLE DETAILS	POINTS
1.	State agency in charge of drinking water conservation?	Department of Natural Resources		1
2.	Water consumption regulation for toilets?	No		0
3.	Water consumption regulation for showerheads?	No		0
4.	Water consumption regulation for urinals?	No		0
5.	Water consumption regulation for clothes washers?	No		0
6.	Water consumption regulation for pre-rinse spray valves?	No		0
7.	Mandatory building or plumbing codes?	No		0
8.	Water loss regulation or policy?	No		0
9.	Conservation activities as part of water permitting process?	No		0
10.	Drought emergency plans required?	No		0
11.	Conservation planning required separate from drought plans?	No		0
12.	Authority to approve or reject conservation plans?	N/A		0
13.	How often are plans required?	N/A		0
14.	Planning framework or methodology?	N/A		0
15.	Implementation of conservation measures required?	N/A		0
16.	State funding for urban water conservation programs?	Yes		1
17.	Technical assistance for urban water conservation programs?	No		0
18.	Does the state require volumetric billing?	No		0
19.	Percent of publicly supplied connections that are metered?	N/A		0
20.	ET microclimate information for urban landscapes?	No		0
EXTRA CREDIT				0
		TOTAL		**2**

Montana — Water Efficiency Scorecard — Grade: D

QUESTION		ANSWER	NOTABLE DETAILS	POINTS
1.	State agency in charge of drinking water conservation?	Department of Natrual Resources and Conservation		1
2.	Water consumption regulation for toilets?	No		0
3.	Water consumption regulation for showerheads?	No		0
4.	Water consumption regulation for urinals?	No		0
5.	Water consumption regulation for clothes washers?	No		0
6.	Water consumption regulation for pre-rinse spray valves?	No		0
7.	Mandatory building or plumbing codes?	No		0
8.	Water loss regulation or policy?	No		0
9.	Conservation activities as part of water permitting process?	No		0
10.	Drought emergency plans required?	No		0
11.	Conservation planning required separate from drought plans?	No		0
12.	Authority to approve or reject conservation plans?	N/A		0
13.	How often are plans required?	N/A		0
14.	Planning framework or methodology?	N/A		0
15.	Implementation of conservation measures required?	N/A		0
16.	State funding for urban water conservation programs?	Yes		2
17.	Technical assistance for urban water conservation programs?	No		0
18.	Does the state require volumetric billing?	No		0
19.	Percent of publicly supplied connections that are metered?	N/A		0
20.	ET microclimate information for urban landscapes?	No		0
EXTRA CREDIT				0
		TOTAL		**3**

Nebraska

Water Efficiency Scorecard Grade: **D**

QUESTION		ANSWER	NOTABLE DETAILS	POINTS
1.	State agency in charge of drinking water conservation?	Nebraska Department of Natrual Resources		1
2.	Water consumption regulation for toilets?	No		0
3.	Water consumption regulation for showerheads?	No		0
4.	Water consumption regulation for urinals?	No		0
5.	Water consumption regulation for clothes washers?	No		0
6.	Water consumption regulation for pre-rinse spray valves?	No		0
7.	Mandatory building or plumbing codes?	No		0
8.	Water loss regulation or policy?	No		0
9.	Conservation activities as part of water permitting process?	No		0
10.	Drought emergency plans required?	No		0
11.	Conservation planning required separate from drought plans?	No		0
12.	Authority to approve or reject conservation plans?	N/A		0
13.	How often are plans required?	N/A		0
14.	Planning framework or methodology?	N/A		0
15.	Implementation of conservation measures required?	N/A		0
16.	State funding for urban water conservation programs?	Yes		2
17.	Technical assistance for urban water conservation programs?	No		0
18.	Does the state require volumetric billing?	No		0
19.	Percent of publicly supplied connections that are metered?	N/A		0
20.	ET microclimate information for urban landscapes?	No		0
EXTRA CREDIT				0
		TOTAL		**3**

Nevada

Water Efficiency Scorecard Grade: **B–**

QUESTION		ANSWER	NOTABLE DETAILS	POINTS
1.	State agency in charge of drinking water conservation?	State of Nevada Division of Water Resources		1
2.	Water consumption regulation for toilets?	No		0
3.	Water consumption regulation for showerheads?	No		0
4.	Water consumption regulation for urinals?	No		0
5.	Water consumption regulation for clothes washers?	No		0
6.	Water consumption regulation for pre-rinse spray valves?	No		0
7.	Mandatory building or plumbing codes?	No		0
8.	Water loss regulation or policy?	Yes		1
9.	Conservation activities as part of water permitting process?	No	State Engineer has discretionary authority for interbasin transfers	0.5
10.	Drought emergency plans required?	Yes	Every 5 years as part of the Plan for Conservation	1.5
11.	Conservation planning required separate from drought plans?	Yes		2
12.	Authority to approve or reject conservation plans?	Yes		2
13.	How often are plans required?	5 Years		2
14.	Planning framework or methodology?	Yes		1
15.	Implementation of conservation measures required?	Yes		1
16.	State funding for urban water conservation programs?	Yes	Office of Financial Assistance–Water Grants Program	2
17.	Technical assistance for urban water conservation programs?	No		2
18.	Does the state require volumetric billing?	No		0
19.	Percent of publicly supplied connections that are metered?	N/A		0
20.	ET microclimate information for urban landscapes?	Yes		1
EXTRA CREDIT			NRS § 116.330	0.5
		TOTAL		**17.5**

New Hampshire — Water Efficiency Scorecard — Grade: B–

QUESTION		ANSWER	NOTABLE DETAILS	POINTS
1.	State agency in charge of drinking water conservation?	Department of Environmental Services		1
2.	Water consumption regulation for toilets?	No		0
3.	Water consumption regulation for showerheads?	No		0
4.	Water consumption regulation for urinals?	No		0
5.	Water consumption regulation for clothes washers?	No		0
6.	Water consumption regulation for pre-rinse spray valves?	No		0
7.	Mandatory building or plumbing codes?	No		0
8.	Water loss regulation or policy?	Yes		3
9.	Conservation activities as part of water permitting process?	Yes		3
10.	Drought emergency plans required?	No		0
11.	Conservation planning required separate from drought plans?	Yes	Already credited in Question 9	0
12.	Authority to approve or reject conservation plans?	Yes	Only applies to permits and applications for new water withdrawal	1
13.	How often are plans required?	N/A		0
14.	Planning framework or methodology?	Yes		2
15.	Implementation of conservation measures required?	Yes		3
16.	State funding for urban water conservation programs?	Yes		2
17.	Technical assistance for urban water conservation programs?	Yes		1
18.	Does the state require volumetric billing?	No		0
19.	Percent of publicly supplied connections that are metered?	N/A		0
20.	ET microclimate information for urban landscapes?	No		0
EXTRA CREDIT			Extra credit awarded for Question 14	1
		TOTAL		**17**

New Jersey — Water Efficiency Scorecard — Grade: B–

QUESTION		ANSWER	NOTABLE DETAILS	POINTS
1.	State agency in charge of drinking water conservation?	Department of Environmental Protection		1
2.	Water consumption regulation for toilets?	No		0
3.	Water consumption regulation for showerheads?	No		0
4.	Water consumption regulation for urinals?	No		0
5.	Water consumption regulation for clothes washers?	No		0
6.	Water consumption regulation for pre-rinse spray valves?	No		0
7.	Mandatory building or plumbing codes?	No		0
8.	Water loss regulation or policy?	Yes		3
9.	Conservation activities as part of water permitting process?	Yes		1
10.	Drought emergency plans required?	Yes		1
11.	Conservation planning required separate from drought plans?	Yes	For permitting, already credited in Question 9	0
12.	Authority to approve or reject conservation plans?	Yes	Permits shall not exceed 10 years	1
13.	How often are plans required?	10 years		1.5
14.	Planning framework or methodology?	Yes		1
15.	Implementation of conservation measures required?	Yes		2
16.	State funding for urban water conservation programs?	Yes		2
17.	Technical assistance for urban water conservation programs?	No		0
18.	Does the state require volumetric billing?	Yes		2
19.	Percent of publicly supplied connections that are metered?	N/A		0
20.	ET microclimate information for urban landscapes?	No		0
EXTRA CREDIT		New Jersey requires landscape irrigation systems to have a rain sensor		1
		TOTAL		**16.5**

New Mexico — Water Efficiency Scorecard — Grade: C+

QUESTION		ANSWER	NOTABLE DETAILS	POINTS
1.	State agency in charge of drinking water conservation?	Office of the State Engineer		1
2.	Water consumption regulation for toilets?	No		0
3.	Water consumption regulation for showerheads?	No		0
4.	Water consumption regulation for urinals?	No		0
5.	Water consumption regulation for clothes washers?	No		0
6.	Water consumption regulation for pre-rinse spray valves?	No		0
7.	Mandatory building or plumbing codes?	No		0
8.	Water loss regulation or policy?	No		0
9.	Conservation activities as part of water permitting process?	No	State Engineer can refuse permit if "contrary to the conservation of water"	2
10.	Drought emergency plans required?	No		0
11.	Conservation planning required separate from drought plans?	Yes	For funding application to the NM Finance Authority/Water Trust Board	2
12.	Authority to approve or reject conservation plans?	No		0
13.	How often are plans required?	N/A		0
14.	Planning framework or methodology?	Yes		1
15.	Implementation of conservation measures required?	No		0
16.	State funding for urban water conservation programs?	Yes		2
17.	Technical assistance for urban water conservation programs?	Yes		2
18.	Does the state require volumetric billing?	No		0
19.	Percent of publicly supplied connections that are metered?	N/A		0
20.	ET microclimate information for urban landscapes?	Yes		2
EXTRA CREDIT	1 point for the NMOSE gallons per capita per day (GPCD)methodology and calculator. 1 point for § 47 6 9(4) NMSA 1978.			2
		TOTAL		14

New York — Water Efficiency Scorecard — Grade: C

QUESTION		ANSWER	NOTABLE DETAILS	POINTS
1.	State agency in charge of drinking water conservation?	Division of Water		1
2.	Water consumption regulation for toilets?	No		0
3.	Water consumption regulation for showerheads?	No		0
4.	Water consumption regulation for urinals?	No		0
5.	Water consumption regulation for clothes washers?	No		0
6.	Water consumption regulation for pre-rinse spray valves?	No		0
7.	Mandatory building or plumbing codes?	No		0
8.	Water loss regulation or policy?	Yes		1
9.	Conservation activities as part of water permitting process?	Yes		1
10.	Drought emergency plans required?	No		0
11.	Conservation planning required separate from drought plans?	Yes	For permitting, already credited in Question 9	0
12.	Authority to approve or reject conservation plans?	Yes		0.5
13.	How often are plans required?	10 Years	When applying for a permit	1.5
14.	Planning framework or methodology?	Yes	Guidance is provided, but only applies for new permit applications	1
15.	Implementation of conservation measures required?	Yes		2
16.	State funding for urban water conservation programs?	Yes		2
17.	Technical assistance for urban water conservation programs?	Yes		1
18.	Does the state require volumetric billing?	No		0
19.	Percent of publicly supplied connections that are metered?	N/A		0
20.	ET microclimate information for urban landscapes?	No		0
EXTRA CREDIT				0
		TOTAL		11

North Carolina

Water Efficiency Scorecard Grade: **C**

QUESTION		ANSWER	NOTABLE DETAILS	POINTS
1.	State agency in charge of drinking water conservation?	Department of Environmental and Natural Resources		1
2.	Water consumption regulation for toilets?	No		0
3.	Water consumption regulation for showerheads?	No		0
4.	Water consumption regulation for urinals?	No		0
5.	Water consumption regulation for clothes washers?	No		0
6.	Water consumption regulation for pre-rinse spray valves?	No		0
7.	Mandatory building or plumbing codes?	No		0
8.	Water loss regulation or policy?	No		0
9.	Conservation activities as part of water permitting process?	Yes		1
10.	Drought emergency plans required?	Yes	Every 5 years	2
11.	Conservation planning required separate from drought plans?	No		0
12.	Authority to approve or reject conservation plans?	N/A		0
13.	How often are plans required?	N/A		0
14.	Planning framework or methodology?	N/A		0
15.	Implementation of conservation measures required?	N/A		0
16.	State funding for urban water conservation programs?	Yes		2
17.	Technical assistance for urban water conservation programs?	Yes		2
18.	Does the state require volumetric billing?	No		0
19.	Percent of publicly supplied connections that are metered?	N/A		0
20.	ET microclimate information for urban landscapes?	Yes		2
EXTRA CREDIT	North Carolina's conservation requirements for drought planning and the conservation requirements to be eligible for state funding earned an extra point. See answers to Questions 10 and 16.			1
		TOTAL		**11**

North Dakota

Water Efficiency Scorecard Grade: **D**

QUESTION		ANSWER	NOTABLE DETAILS	POINTS
1.	State agency in charge of drinking water conservation?	North Dakota State Water Commission		1
2.	Water consumption regulation for toilets?	No		0
3.	Water consumption regulation for showerheads?	No		0
4.	Water consumption regulation for urinals?	No		0
5.	Water consumption regulation for clothes washers?	No		0
6.	Water consumption regulation for pre-rinse spray valves?	No		0
7.	Mandatory building or plumbing codes?	No		0
8.	Water loss regulation or policy?	No		0
9.	Conservation activities as part of water permitting process?	No		0
10.	Drought emergency plans required?	No		0
11.	Conservation planning required separate from drought plans?	No		0
12.	Authority to approve or reject conservation plans?	N/A		0
13.	How often are plans required?	N/A		0
14.	Planning framework or methodology?	N/A		0
15.	Implementation of conservation measures required?	N/A		0
16.	State funding for urban water conservation programs?	Yes		1
17.	Technical assistance for urban water conservation programs?	No		0
18.	Does the state require volumetric billing?	No		0
19.	Percent of publicly supplied connections that are metered?	N/A		0
20.	ET microclimate information for urban landscapes?	No		0
EXTRA CREDIT				0
		TOTAL		**2**

Ohio

Water Efficiency Scorecard Grade: **D**

QUESTION		ANSWER	NOTABLE DETAILS	POINTS
1.	State agency in charge of drinking water conservation?	Department of Natural Resources		1
2.	Water consumption regulation for toilets?	No		0
3.	Water consumption regulation for showerheads?	No		0
4.	Water consumption regulation for urinals?	No		0
5.	Water consumption regulation for clothes washers?	No		0
6.	Water consumption regulation for pre-rinse spray valves?	No		0
7.	Mandatory building or plumbing codes?	No		0
8.	Water loss regulation or policy?	No		0
9.	Conservation activities as part of water permitting process?	Yes		0.5
10.	Drought emergency plans required?	No	Contigency plans required, but no mention of drought	0
11.	Conservation planning required separate from drought plans?	No		0
12.	Authority to approve or reject conservation plans?	N/A		0
13.	How often are plans required?	N/A		0
14.	Planning framework or methodology?	N/A		0
15.	Implementation of conservation measures required?	N/A		0
16.	State funding for urban water conservation programs?	Yes		1
17.	Technical assistance for urban water conservation programs?	Yes		1
18.	Does the state require volumetric billing?	No		0
19.	Percent of publicly supplied connections that are metered?	N/A		0
20.	ET microclimate information for urban landscapes?	No		0
EXTRA CREDIT				0
		TOTAL		**3.5**

Oklahoma

Water Efficiency Scorecard Grade: **D**

QUESTION		ANSWER	NOTABLE DETAILS	POINTS
1.	State agency in charge of drinking water conservation?	Oklahoma Water Resources Board		1
2.	Water consumption regulation for toilets?	No		0
3.	Water consumption regulation for showerheads?	No		0
4.	Water consumption regulation for urinals?	No		0
5.	Water consumption regulation for clothes washers?	No		0
6.	Water consumption regulation for pre-rinse spray valves?	No		0
7.	Mandatory building or plumbing codes?	No		0
8.	Water loss regulation or policy?	No		0
9.	Conservation activities as part of water permitting process?	No		0
10.	Drought emergency plans required?	No		0
11.	Conservation planning required separate from drought plans?	No		0
12.	Authority to approve or reject conservation plans?	N/A		0
13.	How often are plans required?	N/A		0
14.	Planning framework or methodology?	N/A		0
15.	Implementation of conservation measures required?	N/A		0
16.	State funding for urban water conservation programs?	Yes		2
17.	Technical assistance for urban water conservation programs?	No		0
18.	Does the state require volumetric billing?	No		0
19.	Percent of publicly supplied connections that are metered?	N/A		0
20.	ET microclimate information for urban landscapes?	No		0
EXTRA CREDIT				0
		TOTAL		**3**

Oregon — Water Efficiency Scorecard — Grade: B–

QUESTION		ANSWER	NOTABLE DETAILS	POINTS
1.	State agency in charge of drinking water conservation?	Water Resources Department		1
2.	Water consumption regulation for toilets?	No		0
3.	Water consumption regulation for showerheads?	No		0
4.	Water consumption regulation for urinals?	No		0
5.	Water consumption regulation for clothes washers?	No		0
6.	Water consumption regulation for pre-rinse spray valves?	No		0
7.	Mandatory building or plumbing codes?	No		0
8.	Water loss regulation or policy?	Yes	Only for suppliers seeking municipal water use permit extensions	1
9.	Conservation activities as part of water permitting process?	No		0
10.	Drought emergency plans required?	Yes	Only for suppliers submitting Water Management Conservaiton Plan	1
11.	Conservation planning required separate from drought plans?	Yes	Not all suppliers are required to submit plans	1
12.	Authority to approve or reject conservation plans?	Yes		2
13.	How often are plans required?	10 years		1.5
14.	Planning framework or methodology?	Yes		1
15.	Implementation of conservation measures required?	Yes		3
16.	State funding for urban water conservation programs?	Yes		2
17.	Technical assistance for urban water conservation programs?	Yes		1
18.	Does the state require volumetric billing?	No		0
19.	Percent of publicly supplied connections that are metered?	N/A		0
20.	ET microclimate information for urban landscapes?	No		0
EXTRA CREDIT			Extra credit awarded for Question 15	1
		TOTAL		**15.5**

Pennsylvania — Water Efficiency Scorecard — Grade: D

QUESTION		ANSWER	NOTABLE DETAILS	POINTS
1.	State agency in charge of drinking water conservation?	Bureau of Watershed Management		1
2.	Water consumption regulation for toilets?	No		0
3.	Water consumption regulation for showerheads?	No		0
4.	Water consumption regulation for urinals?	No		0
5.	Water consumption regulation for clothes washers?	No		0
6.	Water consumption regulation for pre-rinse spray valves?	No		0
7.	Mandatory building or plumbing codes?	No		0
8.	Water loss regulation or policy?	No		0
9.	Conservation activities as part of water permitting process?	No		0
10.	Drought emergency plans required?	No		0
11.	Conservation planning required separate from drought plans?	No		0
12.	Authority to approve or reject conservation plans?	N/A		0
13.	How often are plans required?	N/A		0
14.	Planning framework or methodology?	N/A		0
15.	Implementation of conservation measures required?	N/A		0
16.	State funding for urban water conservation programs?	Yes		1
17.	Technical assistance for urban water conservation programs?	Yes		1
18.	Does the state require volumetric billing?	No		0
19.	Percent of publicly supplied connections that are metered?	N/A		0
20.	ET microclimate information for urban landscapes?	No		0
EXTRA CREDIT				0
		TOTAL		**3**

Rhode Island

Water Efficiency Scorecard Grade: **B**

QUESTION		ANSWER	NOTABLE DETAILS	POINTS
1.	State agency in charge of drinking water conservation?	Water Resources Board		1
2.	Water consumption regulation for toilets?	No		0
3.	Water consumption regulation for showerheads?	No		0
4.	Water consumption regulation for urinals?	No		0
5.	Water consumption regulation for clothes washers?	No		0
6.	Water consumption regulation for pre-rinse spray valves?	No		0
7.	Mandatory building or plumbing codes?	No		0
8.	Water loss regulation or policy?	Yes		3
9.	Conservation activities as part of water permitting process?	No		0
10.	Drought emergency plans required?	Yes	Part of Water Supply System Management Plan, "reviewed" every 5 years	2
11.	Conservation planning required separate from drought plans?	Yes		2
12.	Authority to approve or reject conservation plans?	Yes		2
13.	How often are plans required?	5 Years		2
14.	Planning framework or methodology?	Yes		1
15.	Implementation of conservation measures required?	Yes		3
16.	State funding for urban water conservation programs?	Yes		1
17.	Technical assistance for urban water conservation programs?	Yes		1
18.	Does the state require volumetric billing?	Yes		1
19.	Percent of publicly supplied connections that are metered?	N/A		0
20.	ET microclimate information for urban landscapes?	No		0
EXTRA CREDIT			Extra credit for Question 11	1
		TOTAL		**20**

South Carolina

Water Efficiency Scorecard Grade: **C–**

QUESTION		ANSWER	NOTABLE DETAILS	POINTS
1.	State agency in charge of drinking water conservation?	Bureau of Water		1
2.	Water consumption regulation for toilets?	No		0
3.	Water consumption regulation for showerheads?	No		0
4.	Water consumption regulation for urinals?	No		0
5.	Water consumption regulation for clothes washers?	No		0
6.	Water consumption regulation for pre-rinse spray valves?	No		0
7.	Mandatory building or plumbing codes?	No		0
8.	Water loss regulation or policy?	No		0
9.	Conservation activities as part of water permitting process?	Yes		0.5
10.	Drought emergency plans required?	No		0
11.	Conservation planning required separate from drought plans?	Yes		1
12.	Authority to approve or reject conservation plans?	Yes		1
13.	How often are plans required?	5 Years		2
14.	Planning framework or methodology?	No		0
15.	Implementation of conservation measures required?	No		0
16.	State funding for urban water conservation programs?	Yes		1
17.	Technical assistance for urban water conservation programs?	No		0
18.	Does the state require volumetric billing?	No		0
19.	Percent of publicly supplied connections that are metered?	N/A		0
20.	ET microclimate information for urban landscapes?	No		0
EXTRA CREDIT				0
		TOTAL		**6.5**

South Dakota

Water Efficiency Scorecard Grade: **D**

QUESTION		ANSWER	NOTABLE DETAILS	POINTS
1.	State agency in charge of drinking water conservation?	Department of Environment and Natural Resources		1
2.	Water consumption regulation for toilets?	No		0
3.	Water consumption regulation for showerheads?	No		0
4.	Water consumption regulation for urinals?	No		0
5.	Water consumption regulation for clothes washers?	No		0
6.	Water consumption regulation for pre-rinse spray valves?	No		0
7.	Mandatory building or plumbing codes?	No		0
8.	Water loss regulation or policy?	No		0
9.	Conservation activities as part of water permitting process?	No		0
10.	Drought emergency plans required?	No		0
11.	Conservation planning required separate from drought plans?	No		0
12.	Authority to approve or reject conservation plans?	N/A		0
13.	How often are plans required?	N/A		0
14.	Planning framework or methodology?	N/A		0
15.	Implementation of conservation measures required?	N/A		0
16.	State funding for urban water conservation programs?	Yes		1
17.	Technical assistance for urban water conservation programs?	Yes		2
18.	Does the state require volumetric billing?	No		0
19.	Percent of publicly supplied connections that are metered?	N/A		0
20.	ET microclimate information for urban landscapes?	No		0
EXTRA CREDIT				0
		TOTAL		**4**

Tennessee

Water Efficiency Scorecard Grade: **D**

QUESTION		ANSWER	NOTABLE DETAILS	POINTS
1.	State agency in charge of drinking water conservation?	Department of Environment and Conservation		1
2.	Water consumption regulation for toilets?	No		0
3.	Water consumption regulation for showerheads?	No		0
4.	Water consumption regulation for urinals?	No		0
5.	Water consumption regulation for clothes washers?	No		0
6.	Water consumption regulation for pre-rinse spray valves?	No		0
7.	Mandatory building or plumbing codes?	No		0
8.	Water loss regulation or policy?	Yes		2
9.	Conservation activities as part of water permitting process?	No		0
10.	Drought emergency plans required?	No		0
11.	Conservation planning required separate from drought plans?	No		0
12.	Authority to approve or reject conservation plans?	N/A		0
13.	How often are plans required?	N/A		0
14.	Planning framework or methodology?	N/A		0
15.	Implementation of conservation measures required?	N/A		0
16.	State funding for urban water conservation programs?	Yes		1
17.	Technical assistance for urban water conservation programs?	No		0
18.	Does the state require volumetric billing?	No		0
19.	Percent of publicly supplied connections that are metered?	N/A		0
20.	ET microclimate information for urban landscapes?	No		0
EXTRA CREDIT				0
		TOTAL		**4**

Texas — Water Efficiency Scorecard — Grade: A–

QUESTION		ANSWER	NOTABLE DETAILS	POINTS
1.	State agency in charge of drinking water conservation?	Texas Water Development Board		1
2.	Water consumption regulation for toilets?	Yes		2
3.	Water consumption regulation for showerheads?	No		0
4.	Water consumption regulation for urinals?	Yes		1
5.	Water consumption regulation for clothes washers?	No		0
6.	Water consumption regulation for pre-rinse spray valves?	No		0
7.	Mandatory building or plumbing codes?	Yes		1
8.	Water loss regulation or policy?	Yes		2
9.	Conservation activities as part of water permitting process?	Yes		1
10.	Drought emergency plans required?	Yes	Reviewed every 5 years	2
11.	Conservation planning required separate from drought plans?	Yes		2
12.	Authority to approve or reject conservation plans?	Yes		1
13.	How often are plans required?	5 Years		2
14.	Planning framework or methodology?	Yes		2
15.	Implementation of conservation measures required?	Yes		3
16.	State funding for urban water conservation programs?	Yes		2
17.	Technical assistance for urban water conservation programs?	Yes		2
18.	Does the state require volumetric billing?	Yes		1
19.	Percent of publicly supplied connections that are metered?	N/A		0
20.	ET microclimate information for urban landscapes?	No		1
EXTRA CREDIT		Maximum extra cerdit awarded for Questions 10, 11, 14 and 15		3
		TOTAL		**29**

Utah — Water Efficiency Scorecard — Grade: C+

QUESTION		ANSWER	NOTABLE DETAILS	POINTS
1.	State agency in charge of drinking water conservation?	Division of Water Resources		1
2.	Water consumption regulation for toilets?	No		0
3.	Water consumption regulation for showerheads?	No		0
4.	Water consumption regulation for urinals?	No		0
5.	Water consumption regulation for clothes washers?	No		0
6.	Water consumption regulation for pre-rinse spray valves?	No		0
7.	Mandatory building or plumbing codes?	No		0
8.	Water loss regulation or policy?	No		0
9.	Conservation activities as part of water permitting process?	No		0
10.	Drought emergency plans required?	No		0
11.	Conservation planning required separate from drought plans?	Yes		2
12.	Authority to approve or reject conservation plans?	No		0
13.	How often are plans required?	5 Years		2
14.	Planning framework or methodology?	Yes		2
15.	Implementation of conservation measures required?	No		0
16.	State funding for urban water conservation programs?	Yes		2
17.	Technical assistance for urban water conservation programs?	Yes		2
18.	Does the state require volumetric billing?	No		0
19.	Percent of publicly supplied connections that are metered?	N/A		0
20.	ET microclimate information for urban landscapes?	Yes		2
EXTRA CREDIT			Extra credit for Question 11	1
		TOTAL		**14**

Vermont

Water Efficiency Scorecard Grade: **C–**

QUESTION		ANSWER	NOTABLE DETAILS	POINTS
1.	State agency in charge of drinking water conservation?	Drinking Water and Ground Water Protection Division		1
2.	Water consumption regulation for toilets?	No		0
3.	Water consumption regulation for showerheads?	No		0
4.	Water consumption regulation for urinals?	No		0
5.	Water consumption regulation for clothes washers?	No		0
6.	Water consumption regulation for pre-rinse spray valves?	No		0
7.	Mandatory building or plumbing codes?	No		0
8.	Water loss regulation or policy?	No		0
9.	Conservation activities as part of water permitting process?	Yes		1
10.	Drought emergency plans required?	No		0
11.	Conservation planning required separate from drought plans?	Yes	For permitting, already credited in Question 9	0
12.	Authority to approve or reject conservation plans?	Yes		1
13.	How often are plans required?		At time of permit application	0
14.	Planning framework or methodology?	Yes		1
15.	Implementation of conservation measures required?	No		0
16.	State funding for urban water conservation programs?	Yes		2
17.	Technical assistance for urban water conservation programs?	No		0
18.	Does the state require volumetric billing?	No		0
19.	Percent of publicly supplied connections that are metered?	N/A		0
20.	ET microclimate information for urban landscapes?	No		0
EXTRA CREDIT				0
		TOTAL		**6**

Virginia

Water Efficiency Scorecard Grade: **B–**

QUESTION		ANSWER	NOTABLE DETAILS	POINTS
1.	State agency in charge of drinking water conservation?	Department of Environmental Quality		1
2.	Water consumption regulation for toilets?	No		0
3.	Water consumption regulation for showerheads?	No		0
4.	Water consumption regulation for urinals?	No		0
5.	Water consumption regulation for clothes washers?	No		0
6.	Water consumption regulation for pre-rinse spray valves?	No		0
7.	Mandatory building or plumbing codes?	No		0
8.	Water loss regulation or policy?	Yes		1
9.	Conservation activities as part of water permitting process?	Yes		1
10.	Drought emergency plans required?	Yes		2
11.	Conservation planning required separate from drought plans?	Yes		2
12.	Authority to approve or reject conservation plans?	Yes		2
13.	How often are plans required?	5 or 10 Years		1.5
14.	Planning framework or methodology?	Yes		1
15.	Implementation of conservation measures required?	Yes		1
16.	State funding for urban water conservation programs?	Yes		1
17.	Technical assistance for urban water conservation programs?	Yes		2
18.	Does the state require volumetric billing?	No		0
19.	Percent of publicly supplied connections that are metered?	N/A		0
20.	ET microclimate information for urban landscapes?	No		0
EXTRA CREDIT			Extra credit awarded for Question 12	1
		TOTAL		**16.5**

Washington

Water Efficiency Scorecard Grade: **B**

	QUESTION	ANSWER / NOTABLE DETAILS	POINTS
1.	State agency in charge of drinking water conservation?	Department of Health's Office of Drinking Water	1
2.	Water consumption regulation for toilets?	No	0
3.	Water consumption regulation for showerheads?	No	0
4.	Water consumption regulation for urinals?	No	0
5.	Water consumption regulation for clothes washers?	No	0
6.	Water consumption regulation for pre-rinse spray valves?	No	0
7.	Mandatory building or plumbing codes?	No	0
8.	Water loss regulation or policy?	Yes	3
9.	Conservation activities as part of water permitting process?	No	0
10.	Drought emergency plans required?	Yes	1.5
11.	Conservation planning required separate from drought plans?	Yes	2
12.	Authority to approve or reject conservation plans?	Yes	2
13.	How often are plans required?	6 Years	2
14.	Planning framework or methodology?	Yes	2
15.	Implementation of conservation measures required?	Yes	3
16.	State funding for urban water conservation programs?	Yes	1
17.	Technical assistance for urban water conservation programs?	Yes	2
18.	Does the state require volumetric billing?	No	0
19.	Percent of publicly supplied connections that are metered?	N/A	0
20.	ET microclimate information for urban landscapes?	No	0
EXTRA CREDIT		Extra credit awarded for Questions 11 and 14	2
		TOTAL	**21.5**

West Virginia

Water Efficiency Scorecard Grade: **D**

	QUESTION	ANSWER / NOTABLE DETAILS	POINTS
1.	State agency in charge of drinking water conservation?	Department of Environmental Protection	1
2.	Water consumption regulation for toilets?	No	0
3.	Water consumption regulation for showerheads?	No	0
4.	Water consumption regulation for urinals?	No	0
5.	Water consumption regulation for clothes washers?	No	0
6.	Water consumption regulation for pre-rinse spray valves?	No	0
7.	Mandatory building or plumbing codes?	No	0
8.	Water loss regulation or policy?	Yes	2
9.	Conservation activities as part of water permitting process?	No	0
10.	Drought emergency plans required?	No	0
11.	Conservation planning required separate from drought plans?	No	0
12.	Authority to approve or reject conservation plans?	N/A	0
13.	How often are plans required?	N/A	0
14.	Planning framework or methodology?	N/A	0
15.	Implementation of conservation measures required?	N/A	0
16.	State funding for urban water conservation programs?	Yes	1
17.	Technical assistance for urban water conservation programs?	No	0
18.	Does the state require volumetric billing?	No	0
19.	Percent of publicly supplied connections that are metered?	N/A	0
20.	ET microclimate information for urban landscapes?	No	0
EXTRA CREDIT			0
		TOTAL	**4**

Wisconsin

Water Efficiency Scorecard Grade: **B–**

QUESTION		ANSWER / NOTABLE DETAILS	POINTS
1.	State agency in charge of drinking water conservation?	Department of Natural Resource	1
2.	Water consumption regulation for toilets?	No	0
3.	Water consumption regulation for showerheads?	No	0
4.	Water consumption regulation for urinals?	No	0
5.	Water consumption regulation for clothes washers?	No	0
6.	Water consumption regulation for pre-rinse spray valves?	No	0
7.	Mandatory building or plumbing codes?	No	0
8.	Water loss regulation or policy?	Yes	2
9.	Conservation activities as part of water permitting process?	Yes	1
10.	Drought emergency plans required?	No	0
11.	Conservation planning required separate from drought plans?	Yes	2
12.	Authority to approve or reject conservation plans?	Yes	2
13.	How often are plans required?	20 Years	1
14.	Planning framework or methodology?	Yes	0.5
15.	Implementation of conservation measures required?	Yes	1
16.	State funding for urban water conservation programs?	Yes	1
17.	Technical assistance for urban water conservation programs?	Yes	2
18.	Does the state require volumetric billing?	Yes	1
19.	Percent of publicly supplied connections that are metered?	N/A	0
20.	ET microclimate information for urban landscapes?	No	0
EXTRA CREDIT		1 point for PSC allowing municipally owned utilities to recover the costs of water conservation and efficiency efforts through rates	1
		TOTAL	**15.5**

Wyoming

Water Efficiency Scorecard Grade: **D**

QUESTION		ANSWER / NOTABLE DETAILS	POINTS
1.	State agency in charge of drinking water conservation?	Wyoming Water Development Commission	1
2.	Water consumption regulation for toilets?	No	0
3.	Water consumption regulation for showerheads?	No	0
4.	Water consumption regulation for urinals?	No	0
5.	Water consumption regulation for clothes washers?	No	0
6.	Water consumption regulation for pre-rinse spray valves?	No	0
7.	Mandatory building or plumbing codes?	No	0
8.	Water loss regulation or policy?	No	0
9.	Conservation activities as part of water permitting process?	No	0
10.	Drought emergency plans required?	No	0
11.	Conservation planning required separate from drought plans?	No	0
12.	Authority to approve or reject conservation plans?	N/A	0
13.	How often are plans required?	N/A	0
14.	Planning framework or methodology?	N/A	0
15.	Implementation of conservation measures required?	N/A	0
16.	State funding for urban water conservation programs?	Yes	1
17.	Technical assistance for urban water conservation programs?	No	0
18.	Does the state require volumetric billing?	No	0
19.	Percent of publicly supplied connections that are metered?	N/A	0
20.	ET microclimate information for urban landscapes?	No	0
EXTRA CREDIT			0
		TOTAL	**2**

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Exhibit 59

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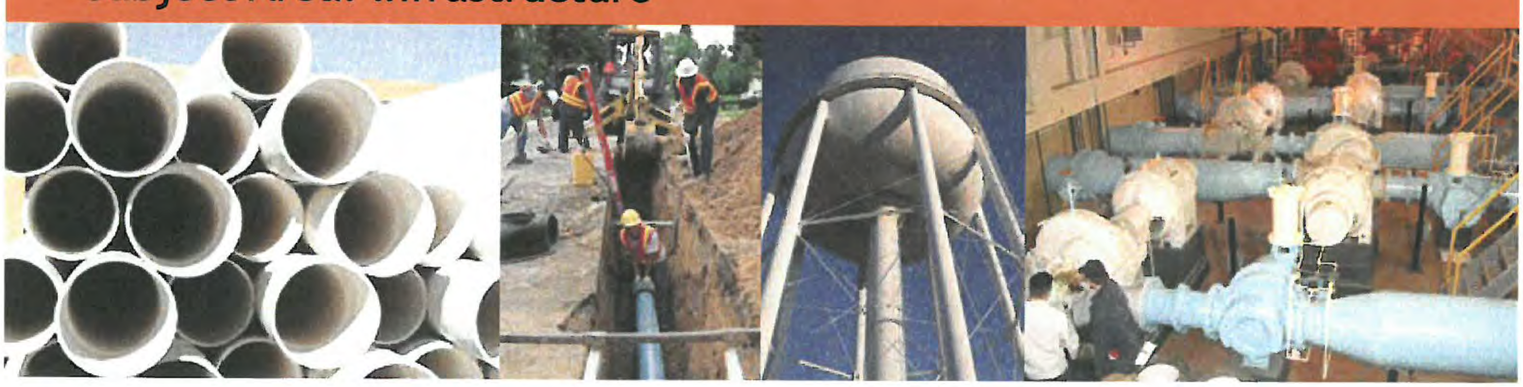
Water Audits in the United States: A Review of Water Losses and Data Validity

PDF Report #4372b

Subject Area: Infrastructure



Water Audits in the United States: A Review of Water Losses and Data Validity

About the Water Research Foundation

The Water Research Foundation (WRF) is a member-supported, international, 501(c)3 nonprofit organization that sponsors research that enables water utilities, public health agencies, and other professionals to provide safe and affordable drinking water to consumers.

WRF's mission is to advance the science of water to improve the quality of life. To achieve this mission, WRF sponsors studies on all aspects of drinking water, including resources, treatment, and distribution. Nearly 1,000 water utilities, consulting firms, and manufacturers in North America and abroad contribute subscription payments to support WRF's work. Additional funding comes from collaborative partnerships with other national and international organizations and the U.S. federal government, allowing for resources to be leveraged, expertise to be shared, and broad-based knowledge to be developed and disseminated.

From its headquarters in Denver, Colorado, WRF's staff directs and supports the efforts of more than 800 volunteers who serve on the board of trustees and various committees. These volunteers represent many facets of the water industry, and contribute their expertise to select and monitor research studies that benefit the entire drinking water community.

Research results are disseminated through a number of channels, including reports, the Website, Webcasts, workshops, and periodicals.

WRF serves as a cooperative program providing subscribers the opportunity to pool their resources and build upon each other's expertise. By applying WRF research findings, subscribers can save substantial costs and stay on the leading edge of drinking water science and technology. Since its inception, WRF has supplied the water community with more than $460 million in applied research value.

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Water Audits in the United States: A Review of Water Losses and Data Validity

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FOREWORD

The Water Research Foundation (Foundation) is a nonprofit corporation dedicated to the development and implementation of scientifically sound research designed to help drinking water utilities respond to regulatory requirements and address high-priority concerns. The Foundation's research agenda is developed through a process of consultation with Foundation subscribers and other drinking water professionals. The Foundation's Board of Trustees and other professional volunteers help prioritize and select research projects for funding based upon current and future industry needs, applicability, and past work. The Foundation sponsors research projects through the Focus Area, Emerging Opportunities, and Tailored Collaboration programs, as well as various joint research efforts with organizations such as the U.S. Environmental Protection Agency and the U.S. Bureau of Reclamation.

This publication is a result of a research project fully funded or funded in part by Foundation subscribers. The Foundation's subscription program provides a cost-effective and collaborative method for funding research in the public interest. The research investment that underpins this report will intrinsically increase in value as the findings are applied in communities throughout the world. Foundation research projects are managed closely from their inception to the final report by the staff and a large cadre of volunteers who willingly contribute their time and expertise. The Foundation provides planning, management, and technical oversight and awards contracts to other institutions such as water utilities, universities, and engineering firms to conduct the research.

A broad spectrum of water supply issues is addressed by the Foundation's research agenda, including resources, treatment and operations, distribution and storage, water quality and analysis, toxicology, economics, and management. The ultimate purpose of the coordinated effort is to assist water suppliers to provide a reliable supply of safe and affordable drinking water to consumers. The true benefits of the Foundation's research are realized when the results are implemented at the utility level. The Foundation's staff and Board of Trustees are pleased to offer this publication as a contribution toward that end.

Denise Kruger
Chair, Board of Trustees
Water Research Foundation

Robert C. Renner, P.E.
Executive Director
Water Research Foundation

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EXECUTIVE SUMMARY

OBJECTIVES

This Water Research Foundation project aimed to assess the adoption of American Water Works Association (AWWA) water audit methodology and evaluate the levels of distribution-system water loss occurring in five regions. To this end, the research team investigated the reporting frameworks of regions that track water loss and collected AWWA-methodology water audits from the California Urban Water Conservation Council (CUWCC), the Delaware River Basin Commission (DRBC), the Georgia Department of Natural Resources (GA DNR), the Tennessee Comptroller of the Treasury (TN COT), and the Texas Water Development Board (TWDB) to assemble a composite water audit data set. Audits submitted to these entities were completed by water utilities and capture distribution system performance.

Using both the results of the research into regional water loss reporting requirements and the composite data set, this report addresses the following questions:

- What are the reporting frameworks of states that track water loss?
- Is the data submitted in water audits reasonable?
- Has audit data quality changed with repeated auditing?
- Have reported water loss volumes and relevant metrics changed with repeated auditing?
- What trends in both water loss and cost figures can be observed in the composite data set?
- How is the quality of audit data affected by reporting requirements and validation?

The findings of this project are relevant to water utilities, regulatory and reporting entities, legislators considering reporting and validation programs, water efficiency and conservation groups, and water loss control industry professionals.

BACKGROUND

As of the publication of this report, five regional entities in the United States require water loss reporting concordant with AWWA methodology. The CUWCC, DRBC, GA DNR, and TN COT collect water audits periodically using AWWA Free Water Audit Software. The TWDB also collects audits but uses a unique submission form that adheres to AWWA methodology. AWWA methodology is employed in order to avoid the term "unaccounted-for" water and instead promote the division of water losses into distinct volumes, as prescribed by AWWA manual *M36: Water Audits and Loss Control Programs*. The entities report that they collect water loss data to track improvements in efficiency, evaluate utility performance, and promote water loss control. Also, all five entities provide water utilities with training in audit methodology, to varying degrees. An additional three entities (the New Mexico Office of the State Engineer, the Washington Department of Health, and the Wisconsin Public Services Commission) collect some water loss information but do not fully employ AWWA methodology and/or administer comprehensive auditing programs.[1]

Most audits collected by the entities studied in this project are self-reported and have not been through a formal validation process. However, all Georgia audits were reviewed by a third party as part of the state reporting program. In this program, the data sources informing the water audit were examined to identify potential sources of inaccuracy and to grade data quality accordingly (see Chapter 3 for more information on levels of data validation). More rigorous audit validation is occasionally pursued by individual utilities in order to produce accurate audit results, but no entity currently has a higher-level validation program in place due to the financial and human resources necessary for such an effort.

Because most of the audits collected for this research have not been validated, the calculated regional and composite water loss statistics must necessarily be qualified as indicative of potential patterns but not exact values. Additionally, even validated audits have margins of error. Nonetheless, the regional and composite data sets still present an opportunity to examine the relationships between water auditing requirements, data validity, and water loss performance.

RESEARCH METHODOLOGY

To evaluate the validity of water audit data and calculate water loss performance indicators, the research team collected a total of 4,575 AWWA-methodology water audits from five reporting entities, spanning a five-year period from 2010 to 2014 (see Table ES.1).

Table ES.1 Counts of audits collected by regional entities

ENTITY	AUDITS COLLECTED	YEARS	TOOL
CUWCC	300	2010-2012	AWWA Software
DRBC	517	2012-2013	AWWA Software
GA DNR	452	2012-2013	AWWA Software
TN COT	630	2010-2014	AWWA Software
TWDB	2,646	2010, 2013	own form (AWWA methodology)
TOTAL	**4,575**	**AWWA-methodology audits**	

Then, to accurately calculate the water loss statistics specific to each region and for the composite data set as a whole, the research team identified and removed unrealistic audits using the series of filters listed in Table ES.2. This "filtering" process reviewed the self-reported audit data validity on a high level; the rigor and individualized attention of level 1 audit validation was not applied. Audits passing the filtering process contributed to the calculation of median performance indicators.

[1] The Colorado Water Conservation Board (CWCB) began collecting water loss date in 2014 from retail water providers who sell 2,000 acre feet or more of water annually, as mandated by Colorado General Assembly HB10-1051 (Colorado Water Conservation Board 2014). Through a unique online data entry portal, the CWCB collects information about distribution system characteristics, water demand, conservation efforts, and water losses. However, the data are not necessarily pursuant to AWWA methodology. Because the program began in 2014 and is therefore outside the scope of this report, the CWCB reporting program will not be discussed further.

Table ES.2 Filters used to exclude audits

	METRIC	CRITERIA FOR EXCLUSION
volumetric	Infrastructure Leakage Index	< 1.0
		> 20.0
	Real Losses	< 0 (negative)
	cost of Non-Revenue Water	> 100% of system operating costs
	incomplete audit	key fields not filled out
financial	Customer Retail Cost	more than 2 orders of magnitude off of the data set's median
	Variable Production Cost	more than 2 orders of magnitude off of the data set's median

Upon calculation, median performance indicators were examined for trends through time and between regions.

RESULTS

Performance indicators calculated for the composite data set (the most recent audits from each of the five regions) are provided below in Table ES.3. In order to generate the median and average performance indicators, the composite data set was filtered for plausibility using the filters presented previously in Table ES.2. The number of audits passing the various filters and contributing to median and average performance indicators is given in Table ES.3.

Of note is the median Infrastructure Leakage Index (ILI) of 2.48, indicating that 50% of audits report water losses that exceed the technical minimum volume by a factor of at least 2.48. Additionally, the filtering process excluded 21.1% of the audits in the composite data set from the calculation of performance indicator statistics, indicating that more than 1 out of every 5 audits presents an implausible water loss scenario. This suggests that the data used to populate the excluded water audits may not be accurate.

Table ES.3 Composite water audit data set median performance indicators

	PERFORMANCE INDICATOR	MEDIAN	AVERAGE	UNIT	*n*	FILTERS
financial	**customer retail unit cost**	**$4.67**	$8.33	$ / 1,000 gallons	*1,545*	passes customer retail unit cost check
financial	**variable production cost**	**$950.00**	$2,085.28	$ / million gallons	*1,489*	passes variable production cost check
financial	**NRW as % of operating cost**	**7.8%**	10.2%	% of operating cost	*630*	passes both cost checks passes volumetric validity checks does not come from Texas (operating cost not reported)
operational	**Apparent Losses**	**5.73**	14.88	gallons / serv conn / day	*1,290*	passes volumetric validity checks
operational	**Real Losses (serv conn)**	**39.88**	51.81	gallons / serv conn / day	*812*	passes volumetric validity check service connection density ≥ 32 conn / mile of main
operational	**Real Losses (mains)**	**785.54**	1,132.42	gallons / mile of main / day	*478*	passes volumetric validity checks service connection density < 32 conn / mile of main
operational	**Real Losses (pressure)**	**0.59**	0.79	gallons / serv conn / day / PSI	*812*	passes volumetric validity checks service connection density ≥ 32 conn / mile of main
operational	**ILI**	**2.48**	3.12	*(dimensionless)*	*644*	passes basic volumetric validity checks UARL calculation applies – $(32 \times Lm) + Nc \geq 3{,}000$
	data validity score	**73.1**	71.7	points out of 100	*679*	passes basic volumetric validity checks does not come from Texas

Other notable findings are presented below.

- In all of the regional data sets reviewed, audits were excluded from further analysis due to implausible data. Table ES.4 presents the total number and percentage of audits excluded from each region's data set. Georgia and Tennessee — the regions with the highest levels of training to support reporting requirements — have the fewest excluded audits.

Table ES.4 Excluded audits by region for all audits to date

ENTITY	CA	DRBC	GA	TN	TX
Total Audits Submitted	300	517	452	629	5,646
# of Audits Excluded	100	130	74	122	1065
% Of Excluded Audits	*33%*	*25%*	*16%*	*19%*	*40%*

- Utilities whose audit results were not plausible tended to grade their data validity notably higher than utilities that submitted audits with realistic data. Audits excluded from the calculation of summary statistics for reporting unreasonable results had a median self-reported data validity score of 77.1, whereas audits included in the calculation of summary statistics had a median self-reported data validity score of 73.1. Additionally, the lowest data validity scores are seen in Georgia, where the most rigorous data validation is pursued. These findings indicate that utility self-scoring of data validity does not actually capture true data validity. As a result, third-party validation of audit data tends to produce lower (but more accurate) data validity scores.
- All regional data sets show an increasing Real Losses per service connection per day over time. Given the changing level of accuracy and consistency with which these audits are completed, the research team cannot confirm that this trend in the data absolutely reflects an increasing volume of Real Losses. It is possible it also reflects more accurate reporting over time.
- Examining correlations in the composite data set revealed a number of valuable findings:
    - Systems with the highest variable production cost tend to have the lowest levels of normalized Real Losses.
    - Real Losses increase as average operating pressure increases.
    - No significant relationships were found in comparing Real Losses with customer retail cost or Real Losses with system size.

CONCLUSION AND RECOMMENDATIONS

An impressive number of utilities are assessing and reporting their water losses in partnership with regional entities. As the first step in developing a water loss control strategy, the growing adoption of the AWWA Free Water Audit Software signals increased attention being paid to supply-side efficiency in water management. Additionally, the use of AWWA methodology to quantify distinct water loss volumes instead of the obsolete "unaccounted-for" water volume is essential for devising targeted and effective water loss reduction programs. However, in order for water audits to inform water loss control programs, they must accurately represent the types and magnitudes of water loss occurring in a system. This research project suggests that many audits do not reflect the actual water losses of reporting utilities, evidenced by the high number of audits (21%) that do not pass basic checks of plausibility.

In reviewing the largest compilation of AWWA Software and AWWA-methodology audits to date, it is clear that more training and education is needed to improve confidence in regional water loss reporting. Additionally, more rigorous audit validation will be required to produce audits that truly capture reality. Currently, the only region to require audit validation is Georgia, where all audits are subject to level 1 validation (see "Levels of Data Validation" in Chapter 3 for definitions of level 1, level 2, and level 3 validation efforts). The Georgia data set produced the fewest unrealistic audits, thereby providing evidence that third-party audit validation improves audit quality. More rigorous validation at levels 2 and 3 could further improve audit quality and perhaps even eliminate all unreasonable audits.

Until the number of implausible audits decreases, it will be difficult to discuss typical levels of water loss without qualification of the accuracy of the data set. In the meantime, this study highlights general but noteworthy trends, such as the connections between Real Losses and pressure and the relationship between Real Losses and production cost. The research team is optimistic that as the reliability of regional data sets improves, more insight into appropriate and effective water loss control programs will surface.

CHAPTER 1: INTRODUCTION

For Water Research Foundation Project #4372 Part A: *Real Loss Component Analysis – A Tool for Economic Water Loss Control*, the research team developed a software tool ("the Model") to advance utilities' understanding of the types of leakage in their systems. To inform the development of the Model, the research team studied AWWA Free Water Audit Software ("AWWA Software"), the most widely-adopted software tool used to assess water losses. This report, Water Research Foundation Project #4372 Part B, is an extension of that study.

Here, the research team examines the adoption of AWWA Software and methodology in select regions. Recent water audit data sets were collected from regional entities that track the water losses of their member water utilities. Audits submitted to the entities were completed by water utilities and capture distribution system performance. The data sets were individually considered by regional entity, and a "composite data set" of the most recent water audits was compiled. The composite data set is the largest group of AWWA Software and AWWA-methodology water loss audits reviewed and analyzed to date.

The entities whose audit data sets are studied in this report employ a range of educational and outreach programs and structured validation in supporting their water loss reporting requirements. Only the State of Georgia requires comprehensive data validation, considered level 1 validation. The AWWA Water Audit Data Initiative (WADI) validates a small set of utility audits every year but was not included in this study due to the fact that WADI audits are not submitted to a state or regional entity.

The research team tackled two main areas of investigation: the quality of the AWWA-methodology water audits and the levels of water loss reported. Of course, these two areas of interest are linked, as the quality of audit data directly influences the calculation of water losses. The AWWA-methodology water audits examined here are largely self-reported and feature some level of inaccuracy. Therefore, it is important to stress that all discussion of water loss levels in this report must be qualified by uncertainty.

Acknowledging the imperfect nature of the AWWA-methodology water audits collected, the research team posits that the composite data set still presents interesting patterns and findings. This report aims to address the following questions:

- What are the reporting frameworks of states that track water loss?
- Is the data submitted in water audits reasonable?
- Has audit data quality changed with repeated auditing?
- Have reported water loss volumes and relevant metrics changed with repeated auditing?
- What trends in both water loss and cost figures can be observed in the composite data set?
- How is the quality of audit data affected by reporting requirements and validation?

In Chapter 2, the AWWA Software is introduced and the regulatory requirements for each regional entity are examined. Chapter 3 presents the methodology used to filter and analyze data sets. Chapter 4 presents each region's data set separately, and Chapter 5 presents the composite data set. The research team presents the water loss data collected to highlight both the successful adoption of the AWWA Software and auditing methodology and the remaining challenges in attaining reliable, insightful water loss reporting.

CHAPTER 2: WATER LOSS REPORTING GUIDELINES

INTRODUCTION

Throughout the country, some state and regional water utility regulatory bodies require water loss reports from member utilities. These reporting programs aim to evaluate regional water loss, encourage utilities to proactively pursue water loss control, and defensibly allocate financial and educational resources. Water loss reporting requirements vary from stand-alone reported water loss totals to annual submission of complete American Water Works Association (AWWA) audits. This chapter describes the primary tool available to utilities to comply with reporting requirements and the reporting frameworks of eight entities that collect water loss reports.

WATER LOSS REPORTING TOOL

Most entities included in this report require audit submissions using the free Water Audit Software published by AWWA. As the most prevalent reporting tool, the AWWA Software is described in detail below. However, a handful of entities have their own water balance reporting forms. Entity-specific forms often use AWWA terminology and definitions in their reporting framework, although this is not always the case.

AWWA Free Water Audit Software

The AWWA Free Water Audit Software was developed by the AWWA Water Loss Control Committee (WLCC) and features ten worksheets in a Microsoft Excel spreadsheet file. The most recent iteration of AWWA Software is version 5.0. However, most audits included in this data set were submitted using version 4.2, the version that was current at the time that the water audits were prepared and submitted to the state entity.

The AWWA Software prompts the user to enter water balance volumes (e.g. Volume Supplied from Own Sources, Billed Metered Authorized Consumption, Customer Metering Inaccuracies, etc.) and choose a unit of volume from a short list of options. Recognizing that some utilities do not tabulate all of the data necessary to complete a water balance, the software permits the user to supply either measured or estimated volumes. For certain volumes (for example, Unauthorized Consumption) estimates can be calculated using software-supplied default percentages, if desired. Additionally, the quality of each data input must be graded for validity on a scale of 1 to 10, and guidelines are provided for assigning validity scores.

Once all data entry fields are populated, the software calculates a series of performance indicators, identifies three volumes for priority attention to improve audit accuracy, and produces an IWA/AWWA water balance. AWWA's current standard water balance is provided below in Figure 2.1. Please note that while the water balance lists sources of Real Loss – leakage on mains, leakage and overflows at storage tanks, and leakage on service connections (italicized in Figure 2.1) – AWWA Software does not calculate these Real Loss component volumes.

For Real Losses to be broken down further, a utility must complete a component analysis of Real Losses, also known as a "bottom-up" approach to Real Loss quantification. The research team developed a tool to pursue a component analysis of Real Losses in WRF #4372 Part A, which is fully detailed in the report titled *Real Loss Component Analysis: A Tool for Economic Water Loss Control*.

<table>
<tr><td rowspan="8">Volume from Own Sources (corrected for known errors)</td><td rowspan="11">System Input Volume</td><td>Water Exported (corrected for known errors)</td><td colspan="3">Billed Water Exported</td><td rowspan="3">Revenue Water</td></tr>
<tr><td rowspan="10">Water Supplied</td><td rowspan="4">Authorized Consumption</td><td rowspan="2">Billed Authorized Consumption</td><td>Billed Metered Consumption</td></tr>
<tr><td>Billed Unmetered Consumption</td></tr>
<tr><td rowspan="2">Unbilled Authorized Consumption</td><td>Unbilled Metered Consumption</td><td rowspan="8">Non-Revenue Water (NRW)</td></tr>
<tr><td>Unbilled Unmetered Consumption</td></tr>
<tr><td rowspan="6">Water Losses</td><td rowspan="3">Apparent Losses</td><td>Unauthorized Consumption</td></tr>
<tr><td>Customer Metering Inaccuracies</td></tr>
<tr><td>Systematic Data Handling Errors</td></tr>
<tr><td rowspan="3">Water Imported (corrected for known errors)</td><td rowspan="3">Real Losses</td><td>Leakage on Transmission and Distribution Mains</td></tr>
<tr><td>Leakage and Overflows at Utility's Storage Tanks</td></tr>
<tr><td>Leakage on Service Connections up to the point of Customer Metering</td></tr>
</table>

Source: AWWA 2016.

Figure 2.1 Standard AWWA water balance

AWWA Software is available for free online, uses standardized IWA/AWWA terminology, can be quickly compiled using Microsoft Excel-based software for the creation of an audit database, and comes with many tutorials and online resources to promote accessibility and utility.

REGIONAL WATER LOSS REPORTING REQUIREMENTS

The research team identified eight entities that require some level of water loss reporting.[2] The California Urban Water Conservation Council, the Delaware River Basin Commission, the Georgia Department of Natural Resources, the New Mexico Office of the State Engineer; and the Tennessee Comptroller of the Treasury require submission using AWWA Software. The Texas Water Development Board uses AWWA terminology and water balance methodology but has its own specific form. The Washington State Department of Health and the Wisconsin Public Services Commission each have unique reporting forms derived from AWWA methodology but are less rigorous in the amount of data they require and the data validity information they collect. The entities responsible for collecting audits and basic audit program information are supplied in Table 2.1. The following sections describe each of the entities' mandates, reporting framework, and training programs in more detail.

[2] The Colorado Water Conservation Board (CWCB) began collecting water loss data in 2014 from retail water providers who sell 2,000 acre feet or more of water annually, as mandated by Colorado General Assembly HB10-1051 (Colorado Water Conservation Board 2014). Through a unique online data entry portal, CWCB collects information about distribution system characteristics, water demand, conservation efforts, and water losses. However, the data are not necessarily pursuant to AWWA methodology. Because the program began in 2014 and is therefore outside the scope of this report, the CWCB reporting program will not be discussed further.

Table 2.1 Summary of regional water loss reporting requirements and frequency

ENTITY	TOOL	PARTICIPATION	FREQUENCY	START	LEVEL OF VALIDATION
California Urban Water Conservation Council	AWWA Software	all signatories	two years of data submitted every two years	2010	self-reported
Delaware River Basin Commission	AWWA Software	all utilities	annual	2012	self-reported
Georgia Department of Natural Resources	AWWA Software	utilities serving a population greater than 3,300	annual	2012	level 1
New Mexico Office of the State Engineer	AWWA Software	permit applicants	variable	2005	self-reported
Tennessee Office of the Comptroller	AWWA Software	all utilities	annual	2013	self-reported
Texas Water Development Board	own form	all utilities	annual to every five years	2005	self-reported
Washington State Department of Health	own form	all utilities	annual	2007	self-reported
Wisconsin Public Services Commission	own form	all utilities	annual	1997	self-reported

California Urban Water Conservation Council

The California Urban Water Conservation Council (CUWCC) is a membership organization that brings together urban water utilities, public interest organizations, governmental bodies, and private entities to promote urban water efficiency in California. The CUWCC is committed to integrating technology, effective public policy, research, and education to improve the management of California's water resources. To this end, the CUWCC has outlined water efficiency goals in a Memorandum of Understanding (MOU). Currently the CUWCC has more than 400 members, of which 250 are utility signatories of the MOU (California Urban Water Conservation Council 2015).

The MOU, first adopted in 1991, contains 14 Best Management Practices (BMPs) organized into 5 categories. MOU signatories commit to implementing the BMPs voluntarily. As a result, the CUWCC does not penalize noncompliant utilities. BMPs categorized as "Utility Operations" or "Education" are considered "foundational" and are therefore expected to be implemented on an ongoing basis (California Urban Water Conservation Council 2008). Among these foundational BMPs is BMP 1.2: Water Loss Control. BMP 1.2, as revised in September of 2009, outlines the requirements of a water loss control program and provides a 10-year implementation schedule. The first half of the 10-year program focuses on data validation and water loss accounting. The second phase of the program establishes water loss benchmarks and assists utilities in achieving water loss reduction goals (California Urban Water Conservation Council 2009).

Annual submission of a water audit using AWWA Software is mandatory under BMP 1.2. This requirement and other tenets of BMP 1.2 are described in Table 2.2 below.

Table 2.2 CUWCC implementation framework for BMP 1.2

PROGRAM COMPONENT	DESCRIPTION	FREQUENCY/ TIMING
standard water audit & water balance	Complete AWWA Software to quantify the volumes and costs of Real and Apparent Losses.	Annually
validation	Follow AWWA methods to improve the validity of the data used for water balance to achieve an AWWA data validity score of 66 and later satisfy data validity Level IV (data validity score of 71). By the 2nd year of implementation, test all source import and production meters annually.	4 years allotted for attainment of a data validity score of 66; by 5th year, Level IV
economic values	Determine the economic value of Real Loss recovery, using the guidelines outlined in the Council's Avoided Cost Model.	Annually
component analysis	Conduct a component analysis to break Real Losses down into volumes categorized by cause.	At least once every 4 years
interventions	Reduce Real Losses to the extent cost-effective, repairing all reported and unreported leaks as dictated by economic analysis. By the second year of implementation, maintain a record-keeping system for repair of reported leaks.	Continuous
customer leaks	Alert and advise customers when leaks appear on customer's side of the meter.	Continuous

Source: Adapted from California Urban Water Conservation Council 2008

Utilities signing the MOU prior to December 31, 2008 were required to submit their first BMP 1.2 report by December 1, 2010 for years 2008-2009 and 2009-2010. Utilities signing the MOU after December 31, 2008 are required to implement BMP 1.2 by July 1st of the year following signing and report on the first report period after implementation (California Urban Water Conservation Council 2008).

As BMP 1.2 was implemented and new utilities became signatories of the MOU, the CUWCC provided eleven two-day workshops for member utilities between July of 2009 and April of 2011. Additionally, a three-hour webinar workshop was offered in November of 2012. The workshops were designed to train signatories on AWWA methodology and Water Audit Software, data validation, and CUWCC reporting requirements. Additionally, the CUWCC has a three-hour workshop recording available to stream to help utilities meet BMP 1.2 requirements.

Delaware River Basin Commission

The Delaware River Basin Commission (DRBC), established in 1961, manages the Delaware River Basin, which covers parts of New York, Pennsylvania, New Jersey, and Delaware. The Commission is tasked with equitably allocating water supply, protecting water quality, managing droughts and floods, and protecting environmental interests Delaware River Basin Commission 2015).

Prior to 2009, the DRBC required reporting on annual volumes of "unaccounted-for water." However, these volumes were not informative or reliable enough to serve as effective planning or regulatory tools. To improve the quality of information available to both utilities and regulators, the DRBC revised its Comprehensive Plan and Water Code in 2009. The revision required the "owners of water supply systems serving the public with sources or service areas located in the Delaware River Basin [to] implement an annual calendar year water audit program," starting in 2012 (Delaware River Basin Commission 2013). From 2009 to 2011, submission of water audits was voluntary but encouraged. The audit requirement applies to suppliers who have been approved to withdraw greater than an average of 100,000 gallons per day of water in any 30-day period (Alliance for Water Efficiency 2014). All audits are to comply with AWWA Water Audit Methodology as a best management practice in water loss control.

The first round of audits were submitted in March of 2013. In preparation for the first round of submissions, the DRBC conducted several outreach efforts. The commission offered a full-day training and workshop to prepare utilities for the water auditing process and familiarize users with AWWA terminology and methodology (Sayers 2012). Additionally, the DRBC published guides to its requirements and AWWA audit procedure on its website, including proceedings of the training workshops and a list of frequently-asked questions.

Georgia Department of Natural Resources

In 2010, the Georgia Senate enacted the Georgia Water Stewardship Act (GWSA) to encourage a culture of water conservation throughout the state (Kiepper and Evans 2011). One key component of the GWSA was to require public water providers to complete annual AWWA water audits. The state emphasized the need for minimum standards and best practices in monitoring and improving the efficiency of public water systems and the effectiveness of water conservation. The state highlighted water audits and incremental implementation of water loss abatement programs.

The Environmental Protection Division (EPD) of the Department of Natural Resources (DNR) was tasked with collecting audits, employing a categorization system for utilities by size and service population, and developing a technical assistance program to provide guidance (Georgia Senate 2010). In order to stagger initial audit submissions, the GWSA required the first round of submissions from systems serving more than 10,000 individuals in March, 2012. In March of 2013, systems serving between 3,300 and 10,000 individuals submitted their first audits.

To aid utilities in fulfilling audit requirements, the EPD partnered with the Georgia Environmental Finance Authority (GEFA) and the Georgia Association of Water Professionals (GAWP) to develop a technical assistance manual. In addition, the GAWP sponsored five full-day training sessions in 2011 for large water systems (before the first round of submissions) to provide training in audit methodology and AWWA Software. The following year, the Georgia Rural Water Association (GRWA) provided a similar training for smaller water systems prior to their first audit. This training was offered six times for a full day each time.

In order to ensure that audits submitted to the EPD were not only complete but also reasonable and insightful, Georgia chose to conduct third-party independent audit validation. Consultants versed in AWWA water audit methodology interviewed utility auditors to assess the accuracy of data validity grading assignments. Any audits identified as incorrectly-graded were returned to their respective utilities for revision and resubmission (Alliance for Water Efficiency 2014). As a result of this third-party review process, the research team describes Georgia audits as level 1 validated, according the definitions of data validity review provided in the section titled "Levels of Data Validation" (Chapter 3).

Survey feedback provided to the EPD suggests that the implementation schedule and AWWA Software posed challenges for some Georgia water utilities. To maximize participant success, submission deadline extensions and technical support were provided whenever necessary. Additionally, training workshops and continued technical assistance were provided in anticipation of 2014 submissions (Georgia Association of Water Professionals 2014).

New Mexico Office of the State Engineer

The New Mexico Office of the State Engineer (NMOSE) has not established a state-wide program for water loss accounting but has implemented AWWA methodology to assess Real Losses, revenue losses, and conservation potential. While the NMOSE does not have a legal mandate requiring submissions, the NMOSE affirms that water loss accounting is a growing state focus. In its *water Conservation Planning Guide for Public Water Suppliers – Technical Report 53* (TR 53), the NMOSE encourages water suppliers to evaluate the efficiency of their systems using AWWA Software (Office of the State Engineer 2013).

Furthermore, the NMOSE considers water loss performance when evaluating a utility's new water appropriation application, change-of-place application, or purpose-of-use application. Application approval is generally conditional on submission of an AWWA audit within one year (Vogel 2012). Additionally, in order to qualify for 2015 Water Trust Board (WTB) funding, applicants diverting more than 500 AF per year were required to submit a conservation plan prepared in accordance with TR 53 and therefore complete an AWWA audit.

As a result of these application procedures and WTB requirements the NMOSE has received twenty-one AWWA audits and is currently working with other utilities on water conservation and AWWA Software use. However, the NMOSE has not yet provided training services on AWWA methodology to utilities.

Tennessee Comptroller of the Treasury

In 2007, the General Assembly of the State of Tennessee passed House Bill No. 743 containing Public Chapter No. 243 to assure "the provision and preservation of adequate water" (General Assembly of the State of Tennessee 2007). The legislation required that public water systems submit an annual unaccounted-for water loss percentage and the calculation steps leading to the volume. Unaccounted-for water percentages were then subject to review by the Comptroller of the Treasury (COT), and any utilities exceeding a threshold deemed "excessive" were referred to the Utility Management Review Board (UMRB) or the Water and Wastewater Financing Board (WWFB). The initial threshold for excessive water loss was 35%, calculated according to the manner prescribed by the COT. Utilities with excessive unaccounted-for water percentages could be subject to legal action requiring water loss reduction or the removal of commissioners from office.

That same year, the Tennessee Association of Utility Districts (TAUD) recommended the standardized use of AWWA water audit methodology. Shortly thereafter, the UMRB and the WWFB chose to adopt the AWWA audit method for financial reports. The UMRB and the WWFB also assumed responsibility for defining the threshold for "excessive" water loss and the appropriate methodology for quantifying water loss (Leauber 2011). When AWWA methodology requirements went into effect in 2013, the evaluated performance indicator became Non-Revenue Water (NRW) as a percent of operating cost (Alliance for Water Efficiency 2014).

In 2012, the WWFB and the UMRB approved an order requiring utilities to achieve both a certain minimum data validity score and NRW as a percent of operating cost below an identified threshold. The specific scores and thresholds become more stringent as utilities learn audit procedure, as outlined in Table 2.3 below. Any utility that does not meet the standards is required to submit a plan for improvement, while utilities who do not comply with submission requirements will be referred to the appropriate board (Comptroller of the Treasury 2015). Additionally, the term "unaccounted-for" water was removed from relevant legislation and replaced instead with more precise definitions of water loss.

Table 2.3 Tennessee reporting thresholds requiring improvement plan submission

DATE EFFECTIVE	DATA VALIDITY SCORE	NRW AS % OF OPERATING COST
1/1/2013	65 or lower	30% or greater
1/1/2015	70 or lower	25% or greater
1/1/2017	75 or lower	20% or greater
1/1/2019	80 or lower	20% or greater

TAUD has provided a series of trainings on how to perform an AWWA audit and comply with COT requirements (Alliance for Water Efficiency 2014). Additional trainings are planned during 2015.

Texas Water Development Board

In 2003, the Texas Legislature enacted House Bill 3338 in order to conserve the state's water resources by quantifying and reducing utility water losses. Bill 3338 requires that retail public utilities file standardized water audits with the Texas Water Development Board (TWDB). Although the TWDB is not a regulatory agency, failure to comply with submission requirements results in barred access to TWDB funding. Initial submissions were scheduled to occur once every five years. In 2011, House Bill 3090 was passed to require utilities with an outstanding loan from the TWDB to submit audits annually. In 2013, House Bill 857 was passed to require utilities with more than 3,300 connections to submit audits annually.

In response to audit requirements, the TWDB developed an audit form soliciting data typically required for an internal, top-down water audit. Most of the data can be compiled from water consumption and water loss reports commonly completed by water utilities (Mathis et al. 2008). The first round of audits were collected in 2005 and found to contain suspect data. To improve the utility of the audits and acknowledge the possible range of data quality, the second iteration of the audit form required users to grade the validity of data inputs. The updated *Water Loss Audit Manual for Texas Utilities* (2008) provides guidance for assigning data validity scores ranging from 1 (low) to 5 (high). This rating scheme is similar to but not directly comparable to the data validity assignments in AWWA Software. The *Water Loss Audit Manual* also encourages all utilities to submit audits annually.

In addition to the *Water Loss Audit Manual*, the TWDB has developed online resources to instruct utilities on best management practices and AWWA methodology. The TWDB also offers staff consultation and an outreach program for water utilities.

Washington State Department of Health

The Washington Administrative Code (WAC) 246-290-820 requires that all state water municipalities determine their distribution system leakage volume annually by submitting a System Input Volume and an Authorized Consumption Volume and then calculating the difference. In agreement with AWWA definitions, System Input Volume is defined as the sum of all metered water from both utility-owned sources and purchased water. Authorized Consumption is considered all metered customer use plus authorized unmetered uses. Additionally, the WAC requires that utilities achieve a distribution leakage percentage of less than 10%, calculated as a three-year running average (Washington State Legislature 2008).

The Department of Health (DOH) sponsors water loss reporting through an online submission form. Once every six years, water loss figures are calculated as part of comprehensive water system plans. If a utility fails to meet the 10% water loss standard, they must create and implement a water loss control strategy and reporting annual progress (Dexel 2012). While this reporting process and focus on utility accountability encourage water loss control, DOH methodology does not meet best practices as established by the IWA and AWWA, especially in the evaluation of data validity. However, the DOH permits the use of AWWA tools and procedures in complying with state requirements, as long as the distribution system leakage volume can be calculated in line with WAC instructions (Washington State Department of Health 2011).

To assist utilities in fulfilling reporting requirements, the DOH has conducted or contracted out training since 2007. Over 50 training events have been held, focusing on clear explanation of legal requirements and the importance of water loss accounting in utility operations. The DOH has also published a manual to its Water Use Efficiency regulations and uploaded supplemental literature to its website.

Wisconsin Public Services Commission

The Wisconsin Public Service Commission (PSC) regulates 582 water utilities, including both municipal and investor-owned systems (Public Services Commission 2013). In 1997, the PSC updated its operating requirements to establish water loss standards and incorporated them into annual financial reporting requirements that every utility must meet. Systems losses, calculated as the difference between metered system input and metered authorized consumption, must be less than 25% of system losses for small systems (fewer than 14,000 customers) and less than 15% for mid-size and large systems (more than 14,000 customers). Additionally, all utilities are required to submit an annual water audit listing the following volumes (Public Services Commission 1997).

- Water purchased or pumped from all sources
- Water used in treatment or production processes
- Water entering the distribution system
- Water sold, including both metered and unmetered sales
- Water not sold but used for utility-authorized purposes, including flushing mains, fire protection, freeze prevention, and other authorized system uses
- Water loss
- Unknown or unaccounted-for water

While the PSC still tabulates "unaccounted-for" water volumes and therefore does not comply with AWWA best practices, much of the language in the Wisconsin State Administrative Code was updated in 2012 to reflect AWWA terminology. Utilities are now expected to calculate their percentages of NRW and water losses and implement a water loss control plan if NRW is greater than 30% of system input or if water losses exceed the aforementioned thresholds (Public Services Commission 1997). Nonetheless, utilities are not currently required to reflect on the validity of the data contributing to their reports and water loss figures. However, proposed Administrative Code changes, in the comment and review phase at the time of publication of this report, include a requirement that utilities submit a water audit using AWWA Software. For the 2015 reporting year, audit data submission through AWWA Software is optional.

The PSC has published a guide to water loss terminology and control on its website in addition to guidance filling out the state reporting form. Furthermore, PSC employees are available to answer any questions that may arise during the auditing and reporting process. While formal training sessions are not frequently offered, a pilot training program is scheduled for fall of 2015, with plans to expand the training in 2016 and subsequent years (Schmidt 2015).

SUMMARY AND SYNTHESIS

The research team examined the auditing requirements of eight proactive entities that mandate some level of utility water loss reporting. Five of the eight entities employ AWWA Software; the other three entities have their own forms based to varying degrees on AWWA methodology. Six of the eight entities require annual audit submissions. The New Mexico Office of the State Engineer requires audit submissions as part of new project applications. The Texas

Water Development Board mandates submissions every five years. However, Texas systems with more than 3,300 service connections and systems with active financial engagements with the Board must submit audits every year. The entities studied herein report that they collect water loss data to track improvements in efficiency, evaluate utility performance, and promote water loss control.

For water audits to be useful in devising water loss control strategies, they must accurately represent the types and magnitudes of water loss occurring in a system. Because audits involve a process of repeated subtraction to reach final water loss volumes, the accuracy of each data input affects the ultimate calculation of water losses. As a result, the best practices promoted by the AWWA include a standardized data validity grading system to acknowledge sources of potential inaccuracy. Therefore, entities employing AWWA Software automatically collect data validity grades. However, the degree to which data validity is emphasized varies among the entities studied in this report. The Washington State Department of Health and the Wisconsin Public Services Commission do not allow for the quality of data inputs to be graded. In contrast, the Georgia Department of Natural Resources contracts with third-party consultants to externally verify the validity scores of audits through a phone-call interview process. Most entities discussed in this report provide some level of audit training to regulated utilities.

As they focused on water auditing requirements, most entities transitioned from collecting data about "unaccounted-for" water to a more precise approach that quantifies distinct water loss volumes. The five entities that employ AWWA Software collect Apparent Loss and Real Loss volumes. The Texas Water Development Board also requires the calculation of both Real Losses and Apparent Losses in its unique reporting form. The Washington State Department of Health, on the other hand, calculates a "distribution system leakage" volume that is composed of both Apparent Losses and Real Losses, and the Wisconsin Public Services Commission collects unaccounted-for water figures. While requiring utilities to track their water loss volumes annually can reveal general trends in water loss and prompt intervention, a detailed breakdown of Water Losses into component volumes is necessary for targeted and effective water loss reduction.

In evaluating utility performance with collected audit data, most entities use a version of water losses as a percent of input volume. This usually takes the form of Non-Revenue Water as a percent of System Input Volume or Non-Revenue Water as a percent of Operating Costs. Percent of Water that is "Unaccounted-for" is no longer considered a valid performance indicator by AWWA. While Non-Revenue Water as a Percent of System Input Volume is a standard performance indicator calculated by AWWA Software, there are other performance indicators that may serve as more reliable metrics of efficiency. Non-Revenue Water as a Percent of System Input Volume is unduly influenced by System Input Volume; if water losses are consistent year-to-year but System Input Volume changes, this performance indicator will also change. Therefore, the research team recommends that regional entities consider more resilient metrics like the Infrastructure Leakage Index and Real Losses per Service Connection per Day as better measures of system performance, particularly when designing strategies for leakage loss reduction and financing efficiency improvements.

A water audit describes the unique water loss profile of a utility. As a result, water audits can serve utilities and regulators alike by equipping each with the data necessary to inform water loss control efforts at the utility and state levels. Only by appreciating the types and magnitudes of water losses can utilities and their regulatory partners cost-effectively target the distinct forms of water loss. Each of the eight entities described above has recognized the value of water loss assessment by requiring audit completion and submission on a regular basis. Auditing programs can be improved by following AWWA standardized methodology, focusing on data validation as an essential audit component, increasing outreach and education efforts to improve the quality of water audits, and tracking data from year-to-year to identify trends and prioritize intervention.

CHAPTER 3: RESEARCH METHODOLOGY

INTRODUCTION

In order to discuss the accuracy of audit data sets and determine typical water loss performance, the research team defined levels of data validity, filtered data sets for implausible audits, and chose to describe the center of data sets with median values rather than averages. Each of these data handling considerations is described in detail below.

LEVELS OF DATA VALIDATION

Audits are most useful when the water loss volumes they report capture reality. To this end, audit data is graded for validity. Each validity grading describes the accuracy of the estimation or data source. Beyond the basic data scoring required by AWWA Software, a more in-depth review of data validity is possible, ranging from a brief assessment of the technical plausibility of audit volumes to a thorough third-party review and testing of all contributing data sources. This report will employ the terms "self-reported," "filtered," "level 1 validated," "level 2 validated," and "level 3 validated" according to the definitions below.

- Self-reported audits have not been subject to in-depth review. The utility auditor has assigned a data validity grade to each data input based on his or her understanding of the reliability of the contributing data sources and the data validity assignment guidelines presented in AWWA Software.
- Filtered audits have been checked for technical plausibility by the research team based on simple, broad criteria below in the section titled "Data Filtering Steps." Beyond a check on whether or not the audit presents a realistic scenario, the accuracy of contributing data sources has not been investigated. Filtered audits will be either included in or excluded from calculations based on their technical plausibility.

Third-party data validation improves data validity beyond self-reporting and simple filtering. Third-party validation can be performed at one of three levels depending on available time and resources, as described below. Definitions have been adapted from a working document prepared by the AWWA Water Loss Control Committee – Software Subcommittee (Water Loss Control Committee – Software Subcommittee 2015).

- Level 1 validated audits have been subject to third-party "desktop review" of data that is immediately available, like supply reports, consumption reports, and testing reports. Third-party validators have interviewed utility staff, usually in an hour-long phone call, in addition to spending time preparing for the interview and documenting results. Interview questions were focused on outlining organizational practices to make sure that data validity scores have been assigned correctly and consistently. Anomalies were discussed and either confirmed, corrected, or noted as needing further investigation.
- Level 2 validated audits have been third-party reviewed with a deeper "desktop" analysis. To inform the validation, utility data sources have been thoroughly recruited for analysis of non-revenue water components, and available data (including the production database and reports from the SCADA system) have been dissected to identify gaps or overlaps in

the data chain. The billing system has been investigated to confirm and clean consumption data, thereby removing redundancies, duplicates, and lag-time effects. In addition, third-party reviewers have verified the exclusion of non-potable volumes from the audit, and any available meter test results have been applied to volume calculations. Finally, 95% confidence limits have been calculated for all water balance volumes. However, no field testing has been performed to confirm instrument accuracy, and no new data has been gathered to inform analysis.

- Level 3 validated audits have been third-party reviewed using both "desktop analysis" (as described in level 2 validation) and field investigations. Supply meters have been tested for accuracy, and in-field verification of SCADA data chain transfer from instrument to transmitter to database system has been performed. Customer meters have been tested through representative and random sampling, pressure data has been collected and studied, and night-time flows have been recorded and analyzed for leakage.

DATA FILTERING STEPS

In order to accurately calculate the water loss statistics specific to each region and for the composite data set as a whole, the research team identified and removed unrealistic audits using the series of filters listed in Table 3.1 and detailed below. This "filtering" process reviewed audit data validity beyond self-reporting but without the rigor of true audit validation. For definitions of the levels of audit data validation, please refer to the section titled "Levels of Data Validation" (Chapter 3).

Table 3.1 Filters used to exclude audits

	METRIC	CRITERIA FOR EXCLUSION
volumetric	Infrastructure Leakage Index	< 1.0
		> 20.0
	Real Losses	< 0 (negative)
	cost of Non-Revenue Water	> 100% of system operating costs
	incomplete audit	key fields not filled out
financial	Customer Retail Cost	more than 2 orders of magnitude off of the data set's median
	Variable Production Cost	more than 2 orders of magnitude off of the data set's median

Infrastructure Leakage Index (ILI)

The Infrastructure Leakage Index (ILI) is a dimensionless number used to compare leakage occurring in systems regardless of differences in size, infrastructure, or input volume. The ILI is calculated by dividing the Current Annual Real Loss (CARL) volume by the Unavoidable Annual Real Loss (UARL) volume to get a ratio. The UARL is the technical minimum level of leakage losses achievable for a system using all applicable water loss control best practices. The UARL is determined using an internationally-standardized formula that incorporates a variety of system-specific characteristics affecting Real Losses, including operating pressure, length of mains, and number of service connections. It is important to note that the UARL is only calculated when the number of service connections plus 32 times the length of main in the system is equal to or greater than 3,000 (AWWA 2009). Written mathematically, this requirement is:

$$(32 \times Lm) + Nc \geq 3{,}000$$

where

Lm	is the length of mains in miles
Nc	is the count of service connections

If a utility does not meet this threshold, the UARL and ILI are not calculated. If this is the case, these fields are completed with "N/A" in audit forms. Audits with incalculable ILIs are not automatically excluded from the composite data set.

An ILI of 1.0 indicates that the current losses are equal to the technical minimum. As such, an ILI less than 1.0 indicates that losses are below the technical minimum, which is implausible. Audits with an ILI of less than 1.0 most likely contain suspicious data inputs and as a result were not incorporated in data set summary statistics. However, some water utilities with excellent leakage management practices have questioned the derivation of the UARL formula and believe that with the UARL formulated as it currently is, an ILI value below 1.0 is achievable. Nonetheless, water utilities in North America with such highly sophisticated leakage management in place are extremely rare, and it has been found that the vast majority of water utilities reporting an ILI below 1.0 are found to have questionable data.

Additionally, audits with an ILI greater than 20.0 were eliminated because few, if any, systems in the United States lose more than 20 times their technical minimum.

Negative Real Losses

It is possible that the ILI is not calculated for a utility (given the limitations of the ILI formula discussed above) but that utility's audit still reports negative Real Losses. Negative Real Losses are technically impossible.[3] Therefore, the research team excluded audits reporting negative Real Losses in the absence of ILI values.

Non-Revenue Water

In AWWA water balance methodology, Non-Revenue Water (NRW) is the sum of Unbilled Authorized Consumption, Apparent Losses, and Real Losses (see Figure 3.1). NRW is all water supplied to a system that does not generate revenue. To calculate the volume of NRW, Billed Authorized Consumption is subtracted from Water Supplied.

[3] The AWWA Software includes a number of built-in checks, and one of these checks flags negative Real Losses and alerts the auditor by displaying a message asking the auditor to reassess their input data. It is curious that some auditors nonetheless submit an AWWA Software water audits with a negative Real Loss value, despite being alerted to this implausibility by the software.

<table>
<tr><td rowspan="8">Volume from Own Sources (corrected for known errors)</td><td rowspan="11">System Input Volume</td><td>Water Exported (corrected for known errors)</td><td colspan="3">Billed Water Exported</td><td rowspan="3">Revenue Water</td></tr>
<tr><td rowspan="10">Water Supplied</td><td rowspan="4">Authorized Consumption</td><td rowspan="2">Billed Authorized Consumption</td><td>Billed Metered Consumption</td></tr>
<tr><td>Billed Unmetered Consumption</td></tr>
<tr><td rowspan="2">Unbilled Authorized Consumption</td><td>Unbilled Metered Consumption</td><td rowspan="8">Non-Revenue Water (NRW)</td></tr>
<tr><td>Unbilled Unmetered Consumption</td></tr>
<tr><td rowspan="6">Water Losses</td><td rowspan="3">Apparent Losses</td><td>Unauthorized Consumption</td></tr>
<tr><td>Customer Metering Inaccuracies</td></tr>
<tr><td>Systematic Data Handling Errors</td></tr>
<tr><td rowspan="3">Water Imported (corrected for known errors)</td><td rowspan="3">Real Losses</td><td>Leakage on Transmission and Distribution Mains</td></tr>
<tr><td>Leakage and Overflows at Utility's Storage Tanks</td></tr>
<tr><td>Leakage on Service Connections up to the point of Customer Metering</td></tr>
</table>

Source: AWWA 2016.

Figure 3.1 Standard AWWA water balance, non-revenue water highlighted

To determine the monetary value of NRW, component volumes are valued at either customer retail cost (in the case of Apparent Losses and Unbilled Authorized Consumption) or variable production cost (in the case of Real Losses). The values of these component volumes are then summed to calculate the value of NRW. Therefore, the accuracy of NRW valuation depends on reliable volume calculations in tandem with accurate entry of variable production cost and customer retail cost.

Comparing the value of NRW to system operating costs can serve as a measure of system efficiency. NRW Water as a Percent of System Operating Costs is a standard performance indicator calculated by AWWA Software. NRW as a Percent of System Operating Costs can vary from only a couple of percentage points to more than half of a system's operating costs. However, NRW valued in excess of total operating costs (i.e. greater than 100%) indicates an invalid audit. Such a utility could not maintain financial solvency. As a result, audits reporting NRW as a Percent of System Operating Costs greater than 100% are excluded from the calculation of data set statistics.

Incomplete Audits

Audits missing key fields – those fields used to calculate performance indicators – were excluded from data set summary statistics and the composite data set as a whole.[4]

[4] As is the case for negative Real Losses, AWWA Software includes a built-in check alerting the auditor when certain key data is not complete. The submittal of an incomplete water audit from an auditor using AWWA Software is therefore unusual.

Cost Figures

In order to calculate financial performance indicators like NRW as a Percent of System Operating Costs, a utility must report a variable production cost and a customer retail unit cost. Incorrect calculation of either cost can skew financial performance indicators but will not affect volumetric performance indicators. Therefore, the audits of utilities reporting suspicious cost figures were excluded from calculation of average financial performance indicators but included in calculating average volumetric performance indicators. To identify errant cost figures, the research team first calculated the median variable production cost and median customer retail cost for each regional data set. The research team then identified audits whose reported cost figures were two orders of magnitude (i.e. 100 times) greater than or less than the median.

Errors in reported costs are often attributable to auditors incorrectly converting units. Most data in AWWA Software is inputted in units of million gallons (MG) or acre-feet (AF). However, customer retail cost must be reported either in units of dollars per thousand gallons ($/1000 gal) or dollars per one hundred cubic feet ($/CCF). In contrast, variable production cost is inputted in units of MG or AF. This change in units often prompts order-of-magnitude and conversion errors in cost reporting. The Texas Water Development Board has avoided this potential source of inaccuracy by requiring that *all* volumes and costs are reported only in units of gallons.

PERFORMANCE INDICATORS

The International Water Association (IWA) and AWWA have developed a series of standardized performance indicators to evaluate utility water loss performance and identify areas for improvement. Performance indicators can be categorized as either financial or operational. Performance indicators can also be sorted by the amount of data required to calculate the indicator (the "level" of the indicator in Table 3.2). Key performance indicators and descriptions are presented in Table 3.2 on the following page. Data set medians of each of the performance indicators listed in Table 3.2 will be calculated for each region, where possible.

The research team has chosen to exclude Fi36 (NRW as a percent of Water Supplied), even though it is calculated by the current version of AWWA Software, because the AWWA WLCC has decided that this performance indicator is obsolete. Because NRW as a percent of Water Supplied is primarily influenced by the volume of Water Supplied, rather than the volume of NRW, comparisons between utilities and years using this performance indicator are not informative. The WLCC reports that in future versions of AWWA Software, this performance indicator will not be calculated.

Table 3.2 IWA/AWWA performance indicators

INDICATOR	CODE	LEVEL	CALCULATION AND UNITS	DESCRIPTION
Operational				
Apparent Losses (normalized)	Op23	1 – basic	gallons / service connection / day	Basic but meaningful performance indicator for Apparent Losses. Easy to calculate once Apparent Losses are quantified.
Real Losses (normalized)	Op24	1 – basic	gallons / service connection / day (service connection density ≥ 32/mile of main) *or* gallons / mile of main / day (service connection density < 32/mile of main)	Useful for target setting. Limited use for comparisons between systems.
Real Losses (normalized, including pressure)	Op24	2 - intermediate	gallons / service connection / day / pressure unit *or* gallons / mile of main / day / pressure unit	Useful for comparisons between systems operating at different average pressures.
Unavoidable Annual Real Losses	UARL	3 – detailed	UARL (gallons) = (5.41Lm + 0.15 Nc + 7.5Lc) x P *where* Lm = length of mains (miles) Nc = number of service connections Lc = total length of customer service connection piping (miles) P = average operating pressure (PSI)	A theoretical reference value representing the technical low limit of leakage that could be achieved if all of today's best technology were to be successfully applied. UARL is a key variable in calculating the ILI. The calculation for UARL is not valid for systems whose service connection count added to 32 times the length of main is less than 3000.
Infrastructure Leakage Index (ILI)	Op25	3 – detailed	dimensionless	Ratio of Real Losses volume to UARL. Best indicator for comparisons between systems.
Financial[5]				
Non-Revenue Water (cost)	Fi37	3 – detailed	value of NRW as percent of system operating cost	Incorporates different unit costs for non-revenue components. Good financial indicator. In calculating the cost of NRW, Apparent Losses and Billed Unmetered volumes are usually valued at customer retail cost, while Real Losses are valued at variable production cost.
Other				
Data validity	-	-	sum of all data validity scores, normalized to 100 ranges from 1 to 100	Individual data entries are graded on a scale from 1 to 10 for validity, based on a scoring guide. Broadly indicates the reliability of the data entries.

Source: adapted from AWWA 2015.

[5] The research team has chosen to exclude performance indicator Fi36 (NRW as a percent of Water Supplied) from this study because the AWWA WLCC has deemed this performance indicator uninformative and therefore obsolete.

STATISTICAL INTERPRETATION

The majority of audits collected by the research team are self-reported. AWWA Software requires that data inputs are graded for validity using a standardized scale, but the data validity scores are also self-reported and subject to error. Additionally, scoring data validity does not actually correct errors. Instead, the process only acknowledges the potential for inaccuracy.

Since the accuracy of audits assessed in this study is unverifiable, the research team cannot comment on the performance of any single utility. However, compiled data sets can be analyzed for relative patterns, as the error from a single audit is diluted by the size of the data set. Of course, it must still be acknowledged that the data set is imperfect, and summary statistics are not conclusive or absolute. Instead, the values presented in this report, particularly those describing the center of each data set, are intended to demonstrate relationships between water loss metrics and the potential magnitude of water loss.

The research team employed a filtering process in order to eliminate clearly erroneous audits. The filtering process excludes audits based on implausible or technically impossible reported results. While this step improves the reliability of summary statistics, it also makes the comparison of multiple years in each state data set an imperfect process. Filtering can eliminate a specific water audit, but not necessarily all audits from that utility. Therefore, the utilities contributing to annual state data sets are different from year to year. However, the number of audits included year to year is approximately constant. Therefore, this report discusses the center of each data set (using statistics like medians and averages), rather than individual utilities, under the assumption that excluded audits fall equally above and below the center of the data set and so do not affect center values. While this assumption is not ideal, it permits the research team to qualify the results presented in this report and navigate the uncertainty of self-reported audits.

In order the measure the center of each data set, the research team used median values rather than averages. The median is defined as the midpoint of a frequency distribution where 50% of values fall below and 50% fall above. A median value therefore minimizes the skew that outlying data points might introduce to the average.

NOTE ON COST FIGURES

In order to value Water Losses, AWWA Software requires submission of two unit cost figures:

- customer retail unit cost ($/1,000 gal or $/CCF): the charge that customers pay for water service, often calculated by dividing total potable water revenue by the number of units sold or by determining a weighted average cost using the customer rate structure. Customer retail unit cost should include additional charges for sewer, stormwater, and biosolids processing, but only if these charges are linked to the volume of potable water consumed.
- variable production cost ($/MG or $/AF): the cost to produce and distribute the next unit of water. This is usually composed of bulk water purchasing rates and the cost of water treatment and pumping. Variable production cost can also include other appropriate miscellaneous costs included in providing the next unit of water.

The calculation of cost figures is specific to each utility, as the customer rates and water production costs of each utility are unique. Currently, AWWA Software does not collect information on the expenses included in determining customer retail unit cost and variable production cost. Therefore, the research team cannot confirm that customer retail unit costs and variable production costs are directly comparable between utilities. However, the state of Georgia encourages utilities to exclude sewer, stormwater, and biosolids charges when calculating customer retail unit cost so that this cost can be compared from utility to utility and represents only the rates applied to potable water consumption.

While side-by-side consideration of cost figures may not be an "apples-to-apples" comparison, when cost figures are viewed as a valuation of Water Losses, comparison becomes more practical. Viewed this way, cost figures represent the financial boundaries and economic potential of water loss recovery, making comparison between audits and data sets a fruitful practice.

CHAPTER 4: REGIONAL WATER AUDIT DATA SETS

INTRODUCTION

To assemble regional water audit data sets and create a larger composite data set, the research team collected audits submitted over the past five years to the state entities that use the AWWA methodology. Audits from the California Urban Water Conservation Council, the Delaware River Basin Commission, the Georgia Department of Natural Resources, the Tennessee Comptroller of the Treasury, and the Texas Water Development Board were examined.

Counts of audits collected and years represented are presented below in Table 4.1. This data set will inform an assessment of water loss performance in each of these states or regions, with an understanding that the data set is primarily composed of self-reported and unscrutinized audits. Audits adhering to AWWA methodology will contribute to a calculation of national water loss statistics.

Table 4.1 Count of audits collected by regional entities

ENTITY	AUDITS COLLECTED	YEARS	TOOL
CUWCC	300	2010-2012	AWWA Software
DRBC	517	2012-2013	AWWA Software
GA DNR	452	2012-2013	AWWA Software
TN COT	630	2010-2014	AWWA Software
TWDB	2,646	2010, 2013	own form (AWWA methodology)
TOTAL	**4,575**	**AWWA-methodology audits**	

WATER LOSS STATISTICS BY REGION

The following sections present the water loss statistics for each region by summarizing the count of audits submitted, the count of audits that passed the aforementioned data filtering tests, and the average water loss statistics of the filtered data set.

California Urban Water Conservation Council

The research team received 300 audits from the CUWCC. The audits covered reporting periods from 2009 to 2013, with the majority of the audits reflecting 2010, 2011, and 2012 data. Counts of audits collected and filtered are presented below in Table 4.2.

Table 4.2 Number of California (CUWCC) audits by year

YEAR	2009	2010	2011	2012	2013	ALL YEARS
INCLUDED AUDITS	4	59	67	68	2	200
EXCLUDED AUDITS	2	21	36	41	0	100
% EXCLUDED	*33%*	*26%*	*35%*	*38%*	*0%*	*33%*
TOTAL AUDITS	**6**	**80**	**103**	**109**	**2**	**300**

Due to the low number of audits from 2009 and 2013, the research team focused exclusively on 2010, 2011, and 2012 in presenting water loss statistics for California. A summary of performance indicators for these years is provided in Table 4.3.

Table 4.3 California (CUWCC) water loss statistics

	STATISTIC	2010 (*n* = 59) median	2011 (*n* = 67) median	2012 (*n* = 68) median	UNIT
financial	customer retail unit cost	$3.38	$3.52	$3.70	$ / 1,000 gallons
	variable production cost	$1,562.52	$1,313.48	$1,448.40	$ / million gallons
	NRW as % of operating cost	3.4%	3.6%	4.1%	% of operating cost
operational	Apparent Losses	5.24	6.09	6.95	gallons / serv conn / day
	Real Losses (service connections)	35.40	35.68	36.57	gallons / serv conn / day
	Real Losses (mains)	11,532.72	4,538.43	3,979.32	gallons / mile of main / day
	Real Losses (pressure)	0.49	0.52	0.51	gallons / serv conn / day / PSI
	ILI	2.08	2.10	2.12	*(dimensionless)*
	data validity score	73.5	73.8	74.3	points out of 100

Observations

- The number of audits excluded from the data set by the filtering process increases from 2010 to 2012. In 2010, only 26% of audits were excluded, whereas in 2012, 38% of audits were excluded.
- Data validity score increases from 2010 to 2012. Utilities reported higher confidence in their data, as demonstrated by the increase in the data validity score.
- Water loss increases from 2010 to 2012. Normalized Apparent Losses increase from 5.24 gallons per service connection per day in 2010 to 6.95 gallons per service connection per day in 2012. The Real Loss metrics – ILI, normalized Real Losses, and NRW as percent of input and operating cost – all increase as well.
- Customer retail cost increases from 2010 to 2012. Median customer retail unit cost grows by nearly 10% from 2010 to 2012, though variable production cost does not display the same trend.

Delaware River Basin Commission

The research team received 517 audits from the DRBC. The audits capture data from 2012 and 2013. Counts of audits collected and filtered are presented below in Table 4.4.

Table 4.4 Number of DRBC audits by year

YEAR	2012	2013	ALL YEARS
INCLUDED AUDITS	194	193	387
EXCLUDED AUDITS	64	66	130
% EXCLUDED	*25%*	*25%*	*25%*
TOTAL AUDITS	**258**	**259**	**517**

A summary of performance indicators for the DRBC is provided in Table 4.5.

Table 4.5 DRBC water loss statistics

	STATISTIC	2012 (*n = 194*) median	2013 (*n = 193*) median	UNIT
financial	customer retail unit cost	$5.33	$5.69	$ / 1,000 gallons
	variable production cost	$532.16	$520.00	$ / million gallons
	NRW as % of operating cost	6.7%	7.2%	% of operating cost
operational	Apparent Losses	3.54	3.40	gallons / serv conn / day
	Real Losses (service connections)	31.41	35.71	gallons / serv conn / day
	Real Losses (mains)	503.23	746.74	gallons / mile of main / day
	Real Losses (pressure)	0.48	0.55	gallons / serv conn / day / PSI
	ILI	2.39	2.52	*(dimensionless)*
	data validity score	75.1	75.4	points out of 100

Observations

- The percentage of audits excluded by the filtering process is 25% in both 2012 and 2013. The count of excluded audits increases from 64 to 66, but because the total number of audits also increases, the rounded percentage of excluded audits does not change.
- Water Losses increase from 2012 to 2013. Apparent Losses decrease nominally, while all Real Losses and Non-Revenue Water performance indicators increase.
- The median data validity score increases marginally from 2012 to 2013, from 75.1 to 75.4.
- Customer retail unit cost increases from 2012 to 2013, but variable production cost decreases.

Georgia Department of Natural Resources

The research team received 452 audits from the GA DNR. The audits capture 2012 and 2013 data. Counts of audits collected and filtered are presented below in Table 4.6.

Table 4.6 Number of Georgia (DNR) audits by year

YEAR	2012	2013	ALL YEARS
INCLUDED AUDITS	190	188	378
EXCLUDED AUDITS	36	38	74
% EXCLUDED	*16%*	*17%*	*16%*
TOTAL AUDITS	**226**	**226**	**452**

A summary of performance indicators for Georgia is provided in Table 4.7.

Table 4.7 Georgia (DNR) water loss statistics

	STATISTIC	2012 (*n* = *190*) median	2013 (*n* = *188*) median	UNIT
financial	customer retail unit cost	$4.13	$4.27	$ / 1,000 gallons
	variable production cost	$415.47	$426.65	$ / million gallons
	NRW as % of operating cost	6.7%	6.6%	% of operating cost
operational	Apparent Losses	6.56	5.96	gallons / serv conn / day
	Real Losses (service connections)	42.98	51.57	gallons / serv conn / day
	Real Losses (mains)	1,678.00	1,729.82	gallons / mile of main / day
	Real Losses (pressure)	0.66	0.75	gallons / serv conn / day / PSI
	ILI	2.34	2.50	*(dimensionless)*
	data validity score	57.3	59.4	points out of 100

Observations

- The percentage of audits excluded increases from 16% in 2012 to 17% in 2013. All Georgia audits were reviewed by a third party for data validity grading accuracy and are therefore level 1 validated. This validation process and the rigorous training provided prior to audit submittal may have caused fewer Georgia audits being excluded than in other regions. However, it is important to note that level 1 validation does not correct inaccurate inputs; instead, level 1 validation acknowledges and qualifies the inaccuracy.
- Customer retail unit cost and variable production cost increase in tandem from 2012 to 2013.
- The median data validity score increases from 2012 to 2013. All Georgia audits were subject to third party review of data validity scores and appropriate use of the audit software, so the increase in self-reported data validity may indeed reflect more valid data. Notably, this review cannot correct for the poor meter performance, lack of data resolution, and insufficient tracking. These factors may still result in the submission of an audit that would be excluded from the research team's analysis. See Table 4.6 for a count of excluded audits.
- All metrics of Real Losses increase from 2012 to 2013, while normalized Apparent Losses decrease.

Tennessee Comptroller of the Treasury

The research team received 629 audits from the TN COT. The audits capture data from 2011 through 2014. Counts of audits collected and filtered are presented below in Table 4.8. Audits representing financial years instead of calendar years were assigned to whichever year the majority of the financial year covered. In cases where the financial year ran from July to June (therefore covering six months of each year), the second year was designated the primary year for categorization. As a result, the 2014 audit data set is incomplete; audits covering FY13-14 were received and filed as 2014 audits, but calendar-year 2014 audits had not been filed at the time of this report's writing.

Table 4.8 Count of Tennessee (COT) audits by year

YEAR	2011	2012	2013	2014	ALL YEARS
INCLUDED AUDITS	7	126	226	148	507
EXCLUDED AUDITS	2	37	58	25	122
% EXCLUDED	*22%*	*23%*	*20%*	*14%*	*19%*
TOTAL AUDITS	**9**	**163**	**284**	**173**	**629**

A summary of performance indicators for Tennessee is provided in Table 4.9.

Table 4.9 Tennessee (COT) water loss statistics

	STATISTIC	2012 (*n = 126*) *median*	2013 (*n = 226*) *median*	2014 (*n = 148*) *median*	UNIT
financial	customer retail unit cost	$7.52	$7.25	$6.97	$ / 1,000 gallons
financial	variable production cost	$1,081.41	$1,163.57	$966.92	$ / million gallons
financial	NRW as % of operating cost	11.2%	11.7%	12.0%	% of operating cost
operational	Apparent Losses	7.27	6.22	5.57	gallons / serv conn / day
operational	Real Losses (service connections)	58.49	61.25	65.76	gallons / serv conn / day
operational	Real Losses (mains)	1,062.04	1,091.84	1,162.88	gallons / mile of main / day
operational	Real Losses (pressure)	0.84	0.81	0.78	gallons / serv conn / day / PSI
operational	ILI	1.93	2.19	2.17	*(dimensionless)*
	data validity score	76.6	79.7	80.7	points out of 100

Observations

- The percentage of audits excluded through filtering decreases from 2012 to 2014. It is possible that the combination of auditor training and practice with reporting enhanced audit quality.
- Median customer retail unit cost decreases with time, while variable production cost does not display a trend.
- Real Losses normalized to service connections increase from 2012 to 2014, but Real Losses normalized to service connections and pressure decreases during the same time period. This indicates that the increase in reported system pressure perhaps contributes to the increase in Real Losses, but the increase in pressure is proportionally greater than the increase in Real Losses.
- Apparent Losses decrease from 2012 to 2014, a trend observed in most of the regional data sets.
- The quality of data submitted in audits improves from 2012 to 2014. Data validity scores consistently improve, and the percentage of audits excluded via the research team's filtering decreases.

Texas Water Development Board

The research team received 2,646 audits from the TWDB. The water audits were submitted using a unique form which adheres to AWWA methodology. The audits capture data from 2010 and 2013. Counts of audits collected and filtered are presented below in Table 4.10. 2010 was a standard reporting year, so all Texas utilities were required to submit an audit. 2013 was an off year, so only larger systems and systems with an active financial engagement with the TWDB were required to submit an audit. As a result, less than one-third the number of audits submitted in 2010 were submitted in 2013.

Table 4.10 Number of Texas (TWDB) audits by year

YEAR	2010	2013	ALL YEARS
INCLUDED AUDITS	966	615	1,581
EXCLUDED AUDITS	930	135	1,065
% EXCLUDED	*49%*	*18%*	*40%*
TOTAL AUDITS	**1,896**	**750**	**2,646**

A summary of performance indicators for Texas is provided in Table 4.11. Texas does not require that utilities report an annual operating cost, so NRW as a percent of operating cost does not apply as a performance indicator. Additionally, the Texas reporting form utilizes a different data validity scoring scale than the AWWA Software, so data validity score is also not considered an applicable performance indicator in comparing Texas performance to the composite data set.

Table 4.11 Texas (TWDB) water loss statistics

		2010 (*n* = 966)	2013 (*n* = 615)	
	STATISTIC	*median*	*median*	UNIT
financial	customer retail unit cost	$3.10	$3.83	$ / 1,000 gallons
	variable production cost	$1,750.00	$1,400.00	$ / million gallons
	NRW as % of operating cost	N/A	N/A	% of operating cost
operational	apparent losses	6.86	5.78	gallons / serv conn / day
	real losses (service connections)	38.10	32.80	gallons / serv conn / day
	real losses (mains)	943.93	484.68	gallons / mile of main / day
	real losses (pressure)	0.64	0.54	gallons / serv conn / day / PSI
	ILI	2.51	2.83	*(dimensionless)*
	data validity score	N/A	N/A	points out of 100

Observations

The Texas data set must be interpreted with caution because the 2010 and 2013 data sets are comprised of different samples pools and sample sizes.

- The percentage of audits excluded by the filtration process decreases from 49% in 2010 to 18% in 2013. The 2013 audits primarily represent large utilities, while the 2010 audits represent a range of system sizes. The TWDB requires annual audit submission from large utilities, which suggests that frequent audit submission improves data validity and/or that larger utilities submit audits of higher validity.
- Median customer retail unit cost increases from 2010 to 2013, but variable production cost decreases.
- Normalized Real Losses decrease from 2010 to 2013.

- Median ILI increases. This must be interpreted with caution, as utilities reporting in 2013 are on average larger. Therefore, the ILI applies as a performance indicator to proportionally more utilities in the 2013 data set than the 2010 data set.

COMPARISON BETWEEN REGIONS

Regional data sets must be compared to each other with caution. Performance indicators are useful for benchmarking the water loss levels of systems and regions but do not acknowledge the regulatory, historic, meteorological, and financial contexts in which utilities operate. With this caveat in mind, the following sections juxtapose and discuss state and regional median performance indicators. The most recent audit year's filtered data serves as the snapshot of each state or region's performance, as highlighted below in Table 4.12. Additionally, only those states or regions employing AWWA methodology and requiring a significant number of utilities to submit audits are included in these comparisons.

Table 4.12 Count of audits from most recent complete year

STATE or REGION	California (CUWCC)	DRBC	Georgia (DNR)	Tennessee (COT)	Texas (TWDB)	TOTAL
most recent year	2012	2013	2013	2013	2013	
count of audits	68	193	188	226	615	**1,290**

Customer Retail Unit Cost and Variable Production Cost

Figure 4.1 below displays the customer retail unit costs ($/MG) and variable production costs ($/MG) for each region. Cost figures for each region are also tabulated in Table 4.13. Regions with higher variable production costs tend to report lower customer retail unit costs. Conversely, regions with lower variable production costs tend to report higher customer retail unit costs. For example, California has both the highest median variable production cost and the lowest customer retail unit cost. In contrast, the Delaware River Basin has the second lowest variable production cost and the second highest customer retail unit cost. However, please note that the exact expenses contributing to utilities' calculations of the cost figures are not known. Additionally, Georgia's customer retail unit costs likely do not contain sewer, stormwater, and biosolids charges. For more information on the calculation and comparison of cost figures, please refer back to the "Note on Cost Figures" in Chapter 3.

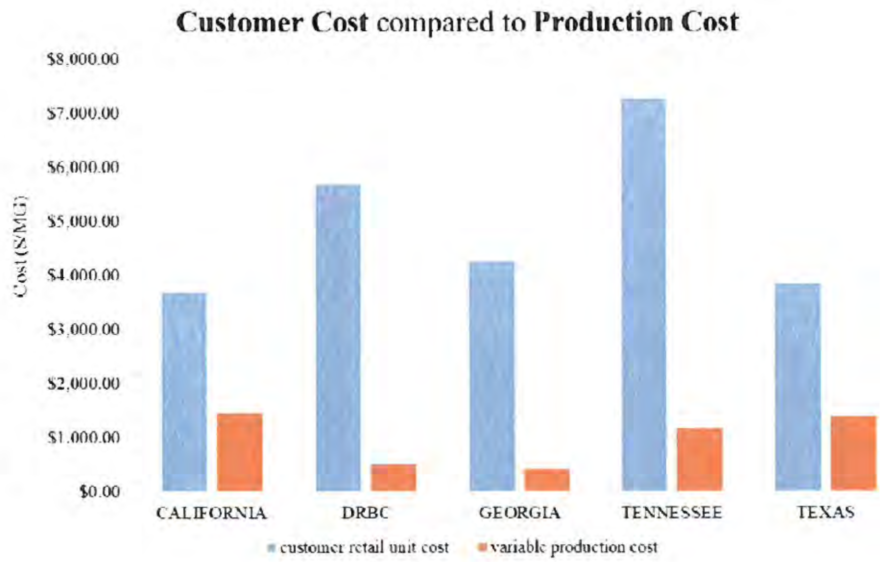

Figure 4.1 Customer retail unit cost compared to variable production cost

Table 4.13 Customer retail unit cost compared to variable production cost

STATE or REGION	California (CUWCC)	DRBC	Georgia (DNR)	Tennessee (COT)	Texas (TWDB)
median customer retail unit cost ($ / 1,000 gal)	$3.70	$5.69	$4.27	$7.25	$3.83
median variable production cost ($ / MG)	$1,448.40	$520.00	$426.65	$1,163.57	$1,400.00
median customer retail unit cost ($ / MG)	$3,696.27	$5,685.00	$4,270.00	$7,250.00	$3,830.00
customer retail unit cost as a multiple of variable production cost	*2.6*	*10.9*	*10.0*	*6.2*	*2.7*

Customer Retail Unit Cost and Normalized Real Losses

Figure 4.2 below displays the customer retail unit costs ($/1,000 gallons) and normalized Real Losses (gallons/service connection/day) for each region. Please note that two distinct vertical axes provide different scales, one for cost and the other for Real Losses volume. Table 4.14 displays this information in tabular form. Higher customer costs tend to correlate with greater Real Losses. The inverse is also true – lower customer costs tend to correlate with lower levels of Real Losses. Tennessee has both the highest customer cost and the highest level of normalized Real Losses. Conversely, Texas and California have the lowest customer retail unit costs and two of the lowest levels of Real Losses. Further research into the revenue generation tools and justification of rate structures could investigate the relationship between inefficiency and customer rates. Additionally, clarification of the costs included in customer retail cost (e.g. sewer costs) would need to be clarified. For more information on the calculation and comparison of cost figures, please refer back to the "Note on Cost Figures" in Chapter 3.

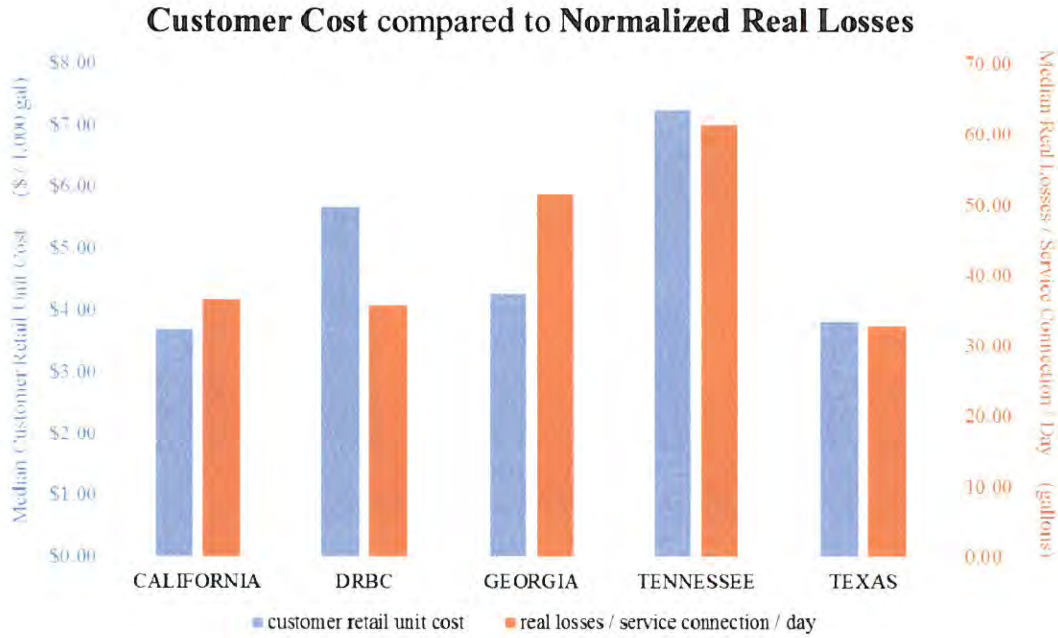

Figure 4.2 Customer retail unit cost compared to normalized real losses

Table 4.14 Customer retail unit cost compared to normalized real losses

STATE or REGION	California (CUWCC)	DRBC	Georgia (DNR)	Tennessee (COT)	Texas (TWDB)
median customer retail unit cost ($ / 1,000 gal)	$3.70	$5.69	$4.27	$7.25	$3.83
median normalized Real Losses (gallons / service conn / day)	36.57	35.71	51.57	61.25	32.80

Variable Production Cost and Normalized Real Losses

Figure 4.3 below displays the variable production costs ($/MG) and normalized Real Losses (gallons/service connection/day) for each region. Please note that two distinct vertical axes provide different scales, one for cost and the other for Real Losses volume. These values for each region are also tabulated in Table 4.15. Variable production cost does not display a clear relationship with normalized Real Losses. California and Texas have the highest variable production costs and two of the lowest Real Losses levels. Similarly, Georgia has the lowest variable production cost but the second-highest Real Losses value. However, the DRBC has the lowest variable production cost and one of the lowest levels of Real Losses. Additionally, Tennessee has the highest normalized volume of Real Losses and a relatively high variable production cost. In comparing median regional variable production costs and normalized real losses, it appears that higher costs of production do not correspond with lower levels of Real

Losses, as would be expected were higher production costs to effectively incentivize Real Losses recovery.

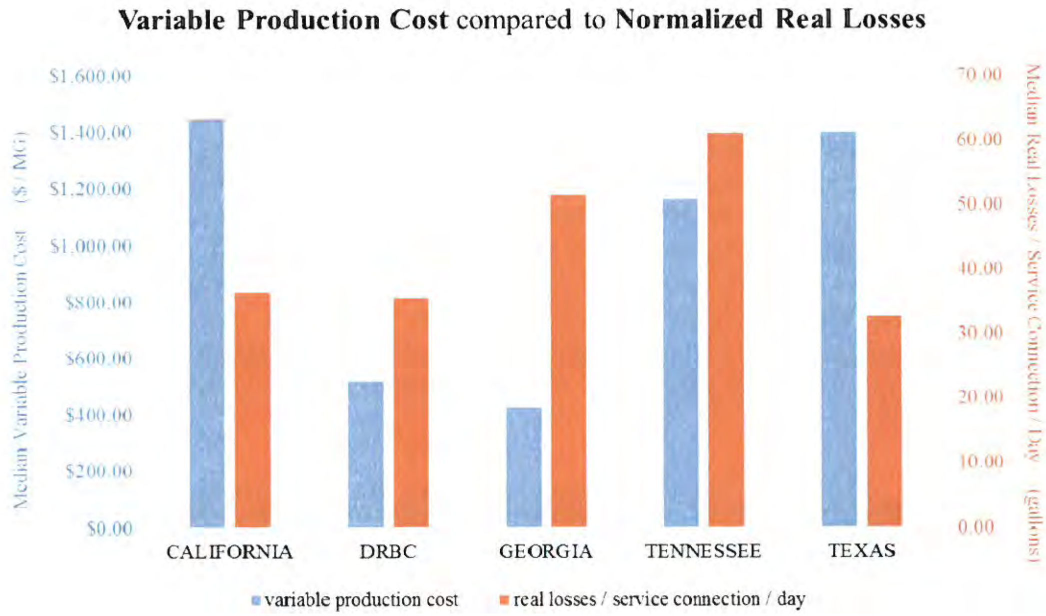

Figure 4.3 Variable production cost compared to normalized real losses

Table 4.15 Variable production cost compared to normalized real losses

STATE or REGION	California (CUWCC)	DRBC	Georgia (DNR)	Tennessee (COT)	Texas (TWDB)
median variable production cost ($ / MG)	$1,448.40	$520.00	$426.65	$1,163.57	$1,400.00
median normalized Real Losses (gallons / service conn / day)	36.57	35.71	51.57	61.25	32.80

CHAPTER 5: COMPOSITE WATER AUDIT DATA SET

INTRODUCTION

State and regional water audit data sets capture valuable snapshots of water loss and regulatory practices in parts of the United States. When combined to form a single composite data set, the audits can provide an insight into the relationships between infrastructure, pressure, and water losses. To create a composite water audit data set, the research team selected the most recent audit period with complete data from each state or region. All audits – regardless of the filters for reasonable results as discussed earlier - were included in the data set to allow for discussion of data validity. However, only the audits that passed the filtering tests described in the previous section titled "Data Filtering Steps" contributed to the calculation of median performance indicators. Counts of audits in the composite data set and the year they describe are given by region in Table 5.1. The full data set consisted of 1,636 audits, capturing 2012 for California and 2013 for all other regions.

Table 5.1 Composite water audit data set composition

STATE or REGION	California (CUWCC)	DRBC	Georgia (DNR)	Tennessee (COT)	Texas (TWDB)	TOTAL
most recent year	2012	2013	2013	2013	2013	
count of audits	109	259	226	292	750	**1,636**

It is important to again note that the data set is composed primarily of self-reported audits. Only audits from Georgia have been subjected to level 1 validation. Therefore, interpretations of data and trends should be viewed with caution, as descriptive of potential patterns but not absolute values.

DATA FILTERING

The research team examined the basic plausibility of the composite audit data set by filtering audits through the same data filtering checks used to examine the regional data sets. Please reference the previous section titled "Data Filtering Steps" for details on this process. The basic data filtering checks are reproduced below in Table 5.2. It is important to note that data failing the cost checks (Customer Retail Unit Cost and Variable Production Costs) were excluded from the calculation of median financial performance indicators but not median volumetric performance indicators. Audits failing a volumetric check or composed of incomplete data were excluded from the calculation of all median volumetric performance indicators.

Table 5.2 Criteria used to exclude audits

	METRIC	CRITERIA FOR EXCLUSION
volumetric	**Infrastructure Leakage Index**	< 1.0
		> 20.0
	Real Losses	< 0 (negative) – *if ILI does not apply*
	cost of Non-Revenue Water	> 100% of system operating costs
	incomplete audit	key fields not filled out
financial	**Customer Retail Unit Cost**	more than 2 orders of magnitude off of the regional median
	Variable Production Cost	more than 2 orders of magnitude off of the regional median

Excluded Audits and Self-Reported Data Validity Scores

The median self-reported data validity score of all included audits (those passing the aforementioned volumetric filtering checks) is 73.1 out of 100. In contrast, the median self-reported data validity score of all excluded audits (those failing the aforementioned volumetric filtering checks) is 77.1. Audits excluded for reporting technically-impossible situations tended to have higher self-reported validity scores than audits reporting plausible water balances. A breakdown of the number of excluded audits by reason for exclusion and the median self-reported data validity score of each group is given in Table 5.3. Texas audits are included in the counts presented in Table 5.3. However, the TWDB submission form uses a unique data validity grading scheme that makes comparison with AWWA Software data grading impractical. Therefore, Texas data does not contribute to the validity scores listed in the right-most column of Table 5.3.

Table 5.3 Counts of excluded audits by reason for exclusion

REASON FOR EXCLUSION	COUNT	% OF COMPOSITE DATA SET	MEDIAN VALIDITY SCORE
ILI < 1	284	17.4%	77.0
ILI > 20	10	0.6%	81.7
Negative Real Losses	35	2.1%	84.0
NRW > 100% operating cost	8	0.5%	62.1
Incomplete	9	0.6%	84.5
TOTAL	**346**	**21.1%**	**77.1**

Figure 5.1 below displays box plots that describe the range and density of self-reported audit validity scores. The plots display the minimum and maximum scores reported (shown as the end points of the lines to the left and right of the boxes). The middle 50% of the data set is contained within the boxes (the bounds of the boxes show the first and third quartiles). The medians are marked by the lines in the center of the boxes. Again, please note that this figure excludes audits from Texas, as Texas uses a unique data validity grading system.

Self-Reported Data Validity Scores of Included and Excluded Audits

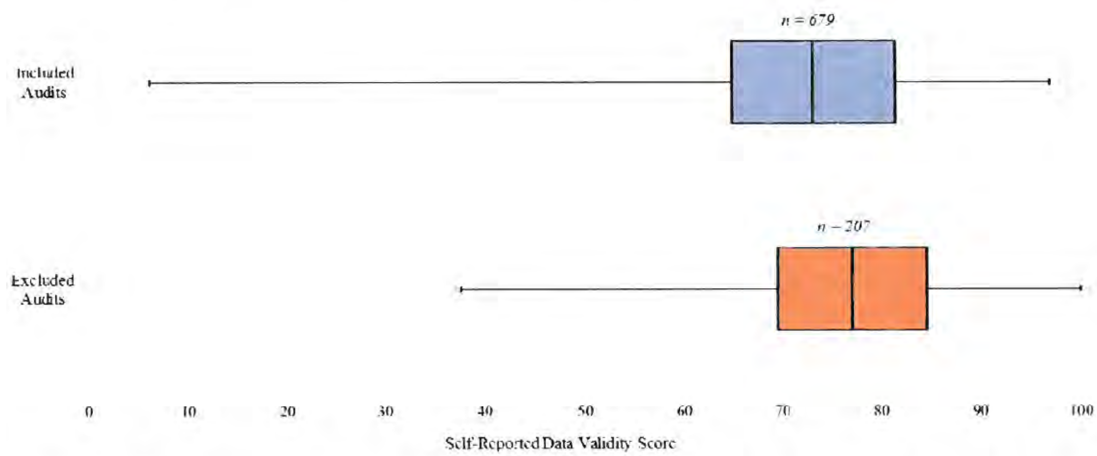

Figure 5.1 Comparison of self-reported validity scores of included and excluded audits

Presentation of data in this format shows that the validity scores reported in included audits (those kept in the composite data set) are lower in all five descriptive statistics – minimum, maximum, and the three quartiles – than the scores reported in excluded audits. Utilities whose audit results were not plausible tended to grade their data validity notably higher that utilities that submitted audits with realistic data. This indicates any of the following possible conclusions.

A significant portion of auditors:

- require further training and assistance with the water balance methodology
- require further training and assistance on how to accurately use the Water Audit Software
- require further training and assistance on how to accurately assign data validity scores
- did not verify the feasibility of their results upon completing a water balance
- require further training and assistance in how to interpret performance indicators

The gap between self-assessment of validity and the research team's filtering for reasonable water balances suggests that merely collecting audits is insufficient in promoting utility accountability and proactive water loss control. Fortunately, utility reporting of data accuracy can be improved to better reflect operational reality, promote transparent evaluation, and anchor effective water loss intervention strategies. Audit workshops, educational outreach, and provision of guides and auditing materials can aid auditors in becoming familiar with AWWA methodology and accurately completing water audits and data validity assessment. This is evidenced by the high percentage of reasonable audits from Georgia and Tennessee, where the most training is offered. Additionally, third-party review of audits and technical assistance programs, as has been performed in Georgia, can improve the quality of audits. The percentage of audits excluded by the filtering process is lowest in Georgia, likely due to third-party validation, trainings, and technical assistance.

PERFORMANCE INDICATOR STATISTICS

Table 5.4 on the following page lists the composite data set performance indicators, the count of data points contributing to each indicator, and the filters applied to the calculation of each indicator. A total of 1,636 audits compose the data set. Of those audits,

- 1,290 audits (78.9%) pass all volumetric validity checks
- 1,463 audits (89.4%) pass all financial validity checks

Both median performance indicator values and average performance indicator values are provided. The median is considered a more robust measure of central tendency when a data set is skewed or populated by asymmetric extreme values. Therefore, the research team will present composite water loss performance in terms of median values. Average values are provided to give a sense of the direction and magnitude of skew.

Observations

- The median ILI is 2.48. Therefore, half of systems report losing between the technical minimum volume of Real Losses (UARL) and 2.48 times the UARL. The other half of systems report losing more than 2.48 times the UARL.
- Average indicators of Water Loss are higher than median values. This indicates that Water Losses are positively skewed (skewed toward higher values). A minority of unusually-high reported Water Loss volumes pull the average above the median.

Table 5.4 Composite water audit data set median performance indicators

	PERFORMANCE INDICATOR	MEDIAN	AVERAGE	UNIT	*n*	FILTERS
financial	**customer retail unit cost**	**$4.67**	$8.33	$ / 1,000 gallons	*1,545*	passes customer retail unit cost check
	variable production cost	**$950.00**	$2,085.28	$ / million gallons	*1,489*	passes variable production cost check
	NRW as % of operating cost	**7.8%**	10.2%	% of operating cost	*630*	passes both cost checks passes volumetric validity checks does not come from Texas (operating cost not reported)
operational	**Apparent Losses**	**5.73**	14.88	gallons / serv conn / day	*1,290*	passes volumetric validity checks
	Real Losses (serv conn)	**39.88**	51.81	gallons / serv conn / day	*812*	passes volumetric validity check service connection density $\geq$ 32 conn / mile of main
	Real Losses (mains)	**785.54**	1,132.42	gallons / mile of main / day	*478*	passes volumetric validity checks service connection density < 32 conn / mile of main
	Real Losses (pressure)	**0.59**	0.79	gallons / serv conn / day / PSI	*812*	passes volumetric validity checks service connection density $\geq$ 32 conn / mile of main
	ILI	**2.48**	3.12	*(dimensionless)*	*644*	passes basic volumetric validity checks UARL calculation applies – $(32 \times Lm) + Nc \geq 3{,}000$
	data validity score	**73.1**	71.7	points out of 100	*679*	passes basic volumetric validity checks does not come from Texas

COMPOSITE DATA SET CORRELATIONS

To discuss correlations between Real Losses and other performance indicators and operational variables, the research team isolated the 812 audits in the composite data set for which Real Losses normalized to service connections were calculated (see Table 5.4). The count of audits contributed by each region is provided in Table 5.5. Please note that values presented in these correlations are medians.

Table 5.5 Composition of composite data set

STATE or REGION	California (CUWCC)	DRBC	Georgia (DNR)	Tennessee (COT)	Texas (TWDB)	TOTAL
most recent year	2012	2013	2013	2013	2013	
count of audits	66	179	133	82	352	**812**

System Size and Real Losses

The research team sorted systems into size categories based on the number of service connections. Small systems have between 0 and 3,000 service connections; medium-sized systems have between 3,001 and 30,000 service connections; and large systems have more than 30,000 service connections. The number of utilities captured by each size range is provided in Figure 5.2.

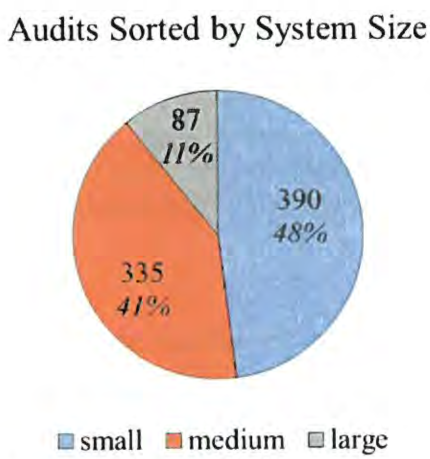

Figure 5.2 Audits included in the composite data set by system size

The median Real Losses volume per service connection per day was then calculated for each size range. The results are displayed below in Figure 5.3.

Figure 5.3 Correlation between system size and normalized real losses

In this analysis, Real Losses do not correlate with system size as measured by the number of service connections. Of course, the boundaries selected to define size ranges are arbitrary. As a result, choosing alternate boundaries might reveal a different pattern. Previous studies have determined that larger systems tend to lose more water (Chastain-Howley et al. 2013), but this analysis shows that for the composite audit data set, large systems have higher Real Losses than small systems but lower Real Losses than mid-sized systems.

Operating Pressure and Real Losses

To consider the relationship between average operating pressure and Real Losses, the research team divided audits into categories of low, medium and high pressure. Low-pressure systems operate at an average pressure of 50 PSI or less, medium-pressure systems between 50 PSI and 80 PSI, and high-pressure systems greater than 80 PSI. A correlation between pressure and Real Losses is presented below in Figure 5.4.

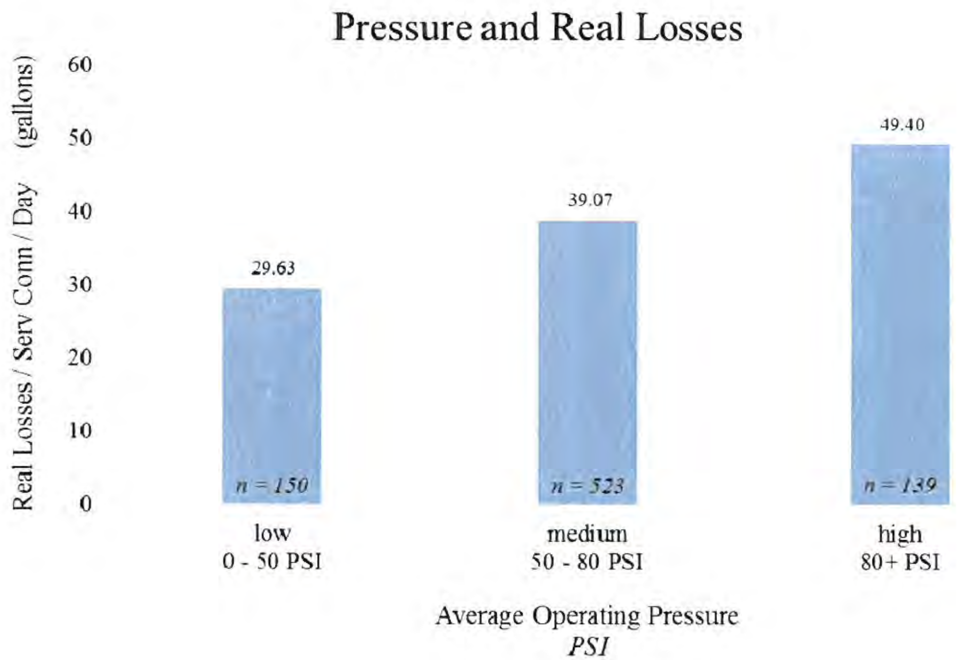

Figure 5.4 Correlation between average operating pressure and normalized real losses

As expected, Real Losses increase as average operating pressure increases. Previous studies have demonstrated that higher pressures result in greater leakage. This pressure-leakage relationship is incorporated in the UARL formula to acknowledge that systems operating at higher pressures have higher thresholds for the technical minimum level of Real Losses (see the discussion of UARL and ILI in Chapter 3 for the specific calculation).

Also of note is the fact that the majority of systems (64%) in the composite audit data set operate at mid-range pressures between 50 PSI and 80 PSI.

Import Volume and Real Losses

The research team next examined the composite data set by looking at the relationships between percent of water imported, normalized Real Losses, and variable production cost. To this end, audits were divided into categories of "little" water imported (0% to 25% of System Input Volume), "some" water imported (25% to 75% of System Input Volume), and "most" water imported (75% to 100% of System Input Volume). System Input Volume is the volume of potable water inputted into the distribution system and is composed of imported water and water produced from utility-owned sources. The specific language of the AWWA definition for System Input Volume can be found in the AWWA Software. The results of these comparisons are presented below in Figure 5.5.

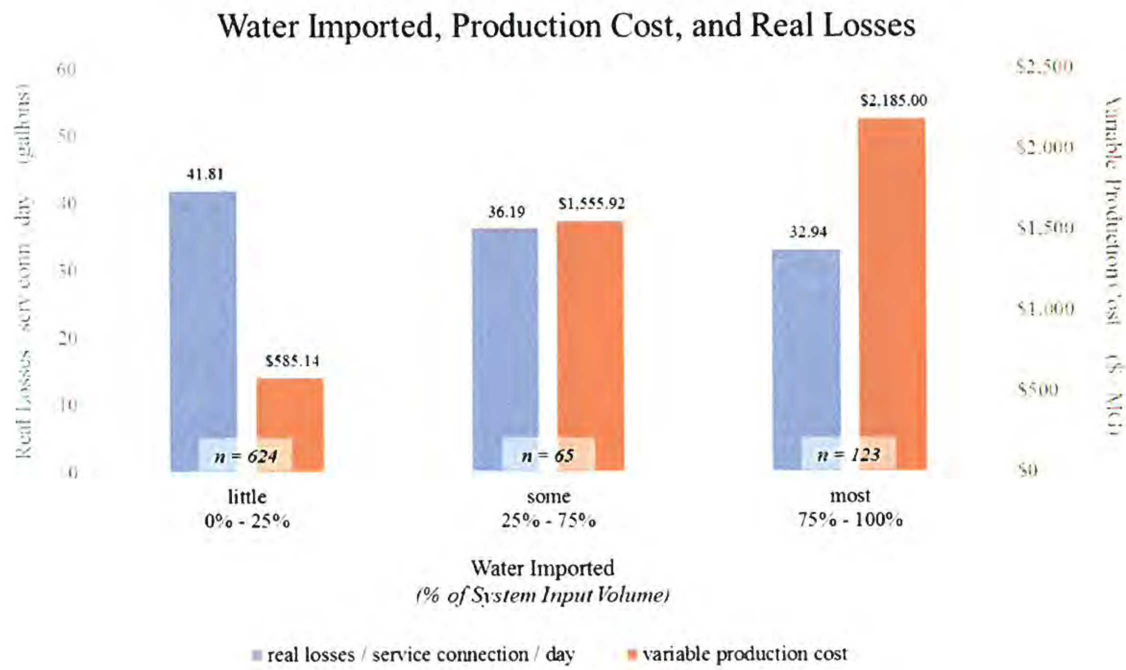

Figure 5.5 Correlations among water imported, normalized real losses, and variable production cost

As the percent of SIV composed of imported water increases, variable production cost increases and Real Losses decrease. It appears that greater percentages of imported water lead to higher variable production costs, thereby incentivizing efficiency in the form of lower levels of Real Losses. Additionally, most systems (77%) import less than 25% of total supply.

Retail Cost and Real Losses

To further investigate the relationship between cost of water and Real Losses, the research team compared customer retail unit cost to normalized Real Losses. Customer retail unit cost was divided into terciles so that each tercile contained approximately one-third of the audits in the entire audit data set (with invalid customer retail cost figures removed). The first tercile – "low" customer retail unit cost – ranged from $0.00 per 1,000 gallons to $3.30 per 1,000 gallons. "Medium" customer retail unit cost ranged from $3.31 per 1,000 gallons to $5.55 per 1,000 gallons. "High" customer retail unit cost was considered above $5.56 per 1,000 gallons. These terciles and associated median customer retail unit costs are presented in Figure 5.6.

Figure 5.6 Correlation between customer retail unit cost and normalized real losses

This basic analysis indicates that there is no correlation between customer retail cost and Real Losses. However, the highest customer retail cost (greater than $5.56 per 1,000 gallons) corresponds to the greatest volume of normalized Real Losses. A similar phenomenon was observed when comparing customer cost and Real Losses on a regional basis (see Table 4.14). While customer retail unit cost reflects both the regulatory pricing parameters and the operational expenses unique to each system, this analysis suggests that for those utilities with the highest volumes of Real Losses normalized to service connections, the cost of real losses may manifest in customer pricing. However, please note that the exact expenses (e.g. sewer cost) included in utilities' reported customer retail costs are not known. For more information on the calculation and comparison of cost figures, please refer back to the "Note on Cost Figures" in Chapter 3.

Variable Production Cost and Real Losses

To examine the relationship between variable production cost and normalized Real Losses without incorporating import percent, the research team sorted audits into variable production cost terciles. The lowest tercile ranged from $0.00 per MG to $500.00 per MG, and the middle tercile ranged from $500.01 per MG to $1,600.00 per MG. The highest tercile was composed of any audits reporting a variable production cost higher than $1,600.01 per MG.

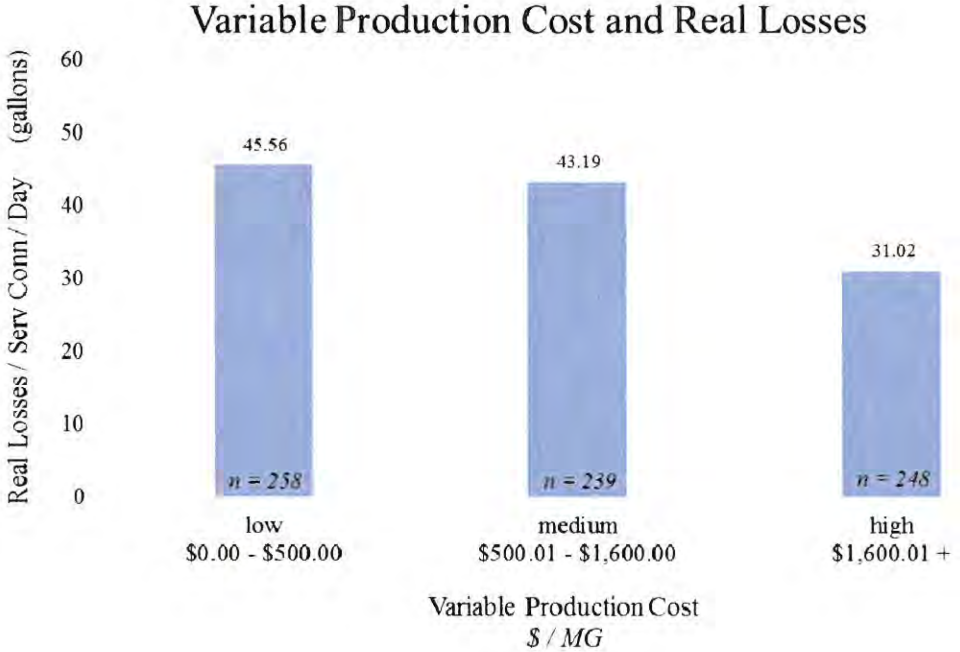

Figure 5.7 Correlation between variable production cost and normalized real losses

As observed in the previous comparisons between import percent, variable production cost, and Real Losses, systems with the highest variable production cost tend to have the lowest levels of normalized Real Losses. This relationship is displayed above in Figure 5.7. When divided into terciles based on production cost, systems with the lowest variable production cost lose 50% more water per service connection than systems with the highest variable production cost.

TOTAL WATER AND FINANCIAL LOSSES

The composite audit data set provides a unique opportunity to quantify water losses and financial losses at a multi-state level. The 1,290 valid audits capturing the most recent audit period in California, the Delaware River Basin, Georgia, Tennessee, and Texas record 355,906 MG of Water Losses (both Real Losses and Apparent Losses), conservatively valued at $556,752,484. This equates to an average of 275.9 MG of audit-period Water Losses per utility, conservatively valued at $431,591.

To determine the volume of Water Losses reflected in the audits, the research team summed the Apparent Loss volume and Real Losses volume reported in each audit. To then quantify the financial losses associated with these Water Losses, the median retail unit cost of the full data set was applied to Apparent Losses, and the median variable production cost was applied to Real Losses. Using median values allowed the research team to incorporate the financial losses of systems that reported invalid cost figures but valid volumetric data. Additionally, the research team also calculated financial losses using average cost figures. A minority of unusually high reported costs pulled average values significantly above median values. Therefore, employment of median cost figures produces more conservative estimates of financial losses. Total data set Water Losses and financial losses are presented below in Table 5.6.

Table 5.6 Calculation of total water losses and financial losses

	VOLUME OF LOSSES (MG)	MEDIAN COST	COST OF LOSSES (median)	AVERAGE COST	COST OF LOSSES (average)
Apparent Losses	58,774.78	$4.67 / 1,000 gal	$274,478,228	$8.33 / 1,000 gal	$489,483,725
Real Losses	297,130.80	$950.00 / MG	$282,274,256	$2,085.28 / MG	$619,602,300
TOTAL WATER LOSSES	**355,905.58**	–	**$556,752,484**	–	**$1,109,086,025**

While these audits are primarily self-reported, this analysis nonetheless suggests that the median utility in the data set lost a volume of water valued at nearly half a million dollars during a single audit period. These losses occurred as both Apparent Losses and Real Losses, with each audit presenting a unique loss profile.

The data set suggest that much of the Real Losses volume (and therefore the expenses associated with Real Losses) is technically recoverable, as the median ILI value in the data set is 2.48 – approximately two and a half times the technical minimum level of leakage. The amount of water that is economically recoverable depends on the distinct financial and operational profile of each utility. The volumes of Apparent Losses that might be technically recoverable and economically recoverable depend on the distinct forms of Apparent Loss and each utility's revenue generation framework.

CHAPTER 6: CONCLUSIONS

An impressive number of utilities are assessing and reporting their water losses. As the first step in developing a water loss control strategy, the growing adoption of the AWWA Water Audit Software and audit methodology signals increased attention being paid to supply-side efficiency in water management. The research team examined both the quality of the AWWA-methodology audits from state entities across the country and the levels of water loss reported. The following findings summarize the trends observed in the data sets and suggest areas for focus and improvement.

- In all of the regional data sets reviewed, audits were excluded from further analysis due to implausible data. Table 6.1 presents the total number and percentage of audits excluded from each region's data set based on a series of filters (see "Data Filtering Steps" in Chapter 3).

Table 6.1 Excluded audits by region for all audits to date

ENTITY	CA	DRBC	GA	TN	TX
Total Audits Submitted	300	517	452	629	5,646
# of Audits Excluded	100	130	74	122	1065
% Of Excluded Audits	*33%*	*25%*	*16%*	*19%*	*40%*

  It is notable that the regions with the fewest audit exclusions – Georgia and Tennessee, with 16% and 19% of audits excluded, respectively – have the highest levels of training to support their reporting requirements.
- Utilities whose audit results were not plausible tended to grade their data notably higher than the utilities that submitted audits with realistic data. Audits excluded from the calculation of summary statistics for reporting unreasonable results had a median self-reported data validity score of 77.1, whereas audits included in the calculation of summary statistics had a median self-reported data validity score of 73.1. This indicates that utility self-scoring of data validity does not actually capture true data validity. The gap between self-assessment of validity and the research team's filtering for reasonable water balances suggests that merely collecting audits is insufficient in promoting utility accountability. Fortunately, inaccuracy in data validity assessment can be corrected by audit validation, as defined in the section titled "Levels of Data Validation" in Chapter 3. Validation tends to result in lower data validity scores that better reflect true data validity, as seen in Georgia.
- The trend in number of audits excluded over time differs between regions. For Georgia and the DRBC, the number of audits that were excluded from the reasonable data sets remained consistent from year to year. In Tennessee's data set, fewer audits were excluded from year to year, whereas in California, more audits were excluded from year to year. Texas data is primarily composed of a single year, so temporal trends were not examined.
- The research team observed that all regional programs collect audits that require improvement in order to be informative. As a result, data validity is a worthwhile subject for trainings and other education and outreach programs. Given the number of excluded water audits, this kind of training is a critical first step before more reliable insight into national water loss statistics is possible.

- After exclusions of implausible audits, the composite data set – composed of the most recent audits from each regional data set – has a median ILI of 2.48. Therefore, half of systems report losing between the technical minimum volume of Real Losses (UARL) and 2.48 times the UARL. The other half of systems report losing more than 2.48 times the UARL.
- Looking a bit more closely at the data reveals that the average indicators of Water Loss are higher than median values. This indicates that normalized Water Losses are positively skewed (skewed toward higher values). A minority of unusually high reported Water Loss volumes pull the average above the median. See Chapter 4 for further analysis of the composite data set. Further investigation is required to determine whether these outliers reflect a reality of high losses or are the result of data integrity or data entry issues.
- All regional data sets show an increasing median value of Real Losses per service connection per day over time. Given the changing levels of accuracy and consistency with which these audits are completed, the research team cannot confirm that this trend in the data actually reflects an increasing volume of Real Losses. It is possible it also reflects more accurate reporting over time.
- Examining correlations in the composite data set revealed a number of valuable findings:
    - Systems with the highest variable production cost tend to have the lowest levels of normalized Real Losses.
    - Real Losses increase as average operating pressure increases.
    - No significant relationships were found in comparing Real Losses with customer retail cost or Real Losses with system size.

In reviewing the largest compilation of AWWA-methodology audits to date, it is clear that more training and education would be worthwhile to improve confidence in regional water loss reporting. Additionally, more rigorous audit validation will be required to produce audits that truly reflect reality. Currently, the only region to require audit validation is Georgia, where all audits are subject to level 1 validation (see Chapter 3 for definitions of audit validation levels). The Georgia data set produced the fewest unrealistic audits, thereby providing evidence that third-party audit validation improves audit quality. More rigorous validation at levels 2 and 3 could further improve audit quality and perhaps even eliminate all unreasonable audits.

Until the number of implausible audits decreases, it will be difficult to discuss typical levels of water loss without qualification of the accuracy of the data set. In the meantime, this study highlights general but noteworthy trends, such as the connections between Real Losses and pressure and the relationship between Real Losses and production cost. The research team is optimistic that as the reliability of regional data sets improves, more insight into appropriate and effective water loss control programs will surface.

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LIST OF ACRONYMS AND ABBREVIATIONS

AF	acre-feet
AWWA	American Water Works Association
BMP	Best Management Practices
CARL	Current Annual Real Losses
CCF	hundred cubic feet
COT	Comptroller of the Treasury
CUWCC	California Urban Water Conservation Council
CWCB	Colorado Water Conservation Board
DNR	Department of Natural Resources
DOH	Department of Health
DRBC	Delaware River Basin Commission
EPD	Environmental Protection Division
gal	gallons
GAWP	Georgia Association of Water Professionals
GEFA	Georgia Environmental Finance Authority
GWSA	Georgia Water Stewardship Act
ILI	Infrastructure Leakage Index
IWA	International Water Association
MG	million gallons
MOU	Memorandum of Understanding
NMOSE	New Mexico Office of the State Engineer
NRW	Non-Revenue Water
PI	performance indicator
PSC	Public Services Commission
serv conn	service connection
SIV	System Input Volume
TAUD	Tennessee Association of Utility Districts
UARL	Unavoidable Annual Real Losses
UMRB	Utility Management Review Board
VPC	variable production cost

WAC	Washington Administrative Code
WADI	Water Audit Data Initiative
WLCC	Water Loss Control Committee
WRF	Water Research Foundation
WTB	Water Trust Board
WUE	Water Use Efficiency
WWFB	Water and Wastewater Financing Board

Exhibit 60

WaterSense Awards

You will need Adobe Acrobat Reader to view some of the files on this page. See EPA's PDF page to learn more about PDF, and for a link to the free Acrobat Reader.

2015 WaterSense Partners of the Year

EPA WaterSense 2015 PARTNER OF THE YEAR

On October 8, 2015, the 2015 WaterSense Sustained Excellence Award winner, Partners of the Year, and Excellence Award winners were announced at the WaterSense and Alliance for Water Efficiency Awards Luncheon. The luncheon was held at the WaterSmart Innovations Conference and Exposition EXIT Disclaimer.

Since the program began in 2006, WaterSense labeled products have helped Americans save 1.1 trillion gallons of water and $21.7 billion in water and energy bills. In 2014 alone, WaterSense labeled products saved 346 billion gallons of water. By working together, WaterSense partners across the country continue to make a difference every day.

WaterSense recognizes four Sustained Excellence Award winners, seven WaterSense Partners of the Year, and six Excellence Award winners for helping to advance and promote WaterSense and water efficiency throughout 2014.

The winners are:

2015 WaterSense Sustained Excellence Award Winners:

- Kohler Co.
- Delta Faucet Company
- KB Home
- The Home Depot

2015 WaterSense Partners of the Year:

- The City of Charlottesville (Virginia)
- Cobb County Water System (Georgia)
- Murray City Corporation (Utah)
- Texas A&M Agrilife Research and Extension Center at Dallas
- The Toro Company
- Energy Inspectors Corporation
- The Sonoma-Marin Saving Water Partnership (California)

2015 WaterSense Excellence Award Winners:

- Metropolitan North Georgia Water Planning District
- New Hampshire Department of Environmental Services
- Colorado Springs Utilities (Colorado)
- Denver Water (Colorado)

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- Municipal Water District of Orange County (California)
- Puget Sound Energy (Washington)

Learn about the Sustained Excellence, Partners of the Year and Excellence Award winners' accomplishments (PDF) (8 pg, 2.9MB) and read the EPA press release EXIT Disclaimer.

2015 Sustained Excellence Award Winners

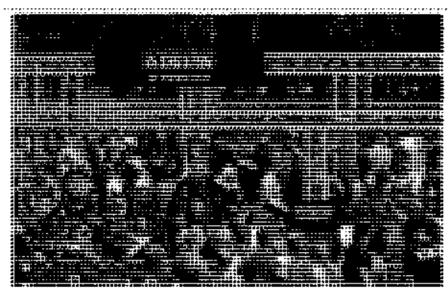
Kohler Co.

Kohler Co. EXIT Disclaimer, now a three-time WaterSense Sustained Excellence winner, made it a priority in 2014 to address the country's drought concerns. The company worked with The Home Depot to provide special promotions on WaterSense labeled toilets and showerheads in areas hardest hit by California's drought. In addition, Kohler employees collaborated with the City of Brownwood, Texas, to offer significant discounts on WaterSense labeled toilets, faucets, and showerheads and helped retrofit Brownwood City Hall with water-efficient products. Looking beyond products, Kohler supported the Charting New Waters initiative, led by the Johnson Foundation, which gathered stakeholders to identify solutions to protect water resources across the country.

Kohler continued to educate consumers and professionals through its "Trust the Flush" EXIT Disclaimer mobile marketing campaign. The 2014 cross-country bus tour showcased WaterSense labeled toilets at more than 195 events, including multiple stops at WaterSense distributor partners. For the second consecutive year, Kohler provided WaterSense labeled products for the Green Builder Media's VISION House® in INNOVENTIONS at Walt Disney World's Epcot® in Orlando, Florida, which was visited by more than 200,000 people.

Delta Faucet Company

Delta Faucet Company EXIT Disclaimer, a three-time Manufacturer Partner of the Year, earned its first WaterSense Sustained Excellence Award for its collaborative efforts to promote water efficiency and WaterSense labeled products in 2014. Delta met quarterly with major retail chains to create and execute strategic plans to promote WaterSense labeled products. To help hotels understand water efficiency improvements and the possible need for installing WaterSense labeled showerheads, Delta worked with global hotel chains to conduct studies on guests' water usage and shower experiences.



Delta's HappiMess campaign continued into 2015 at Warrior Dash races nationwide, where runners cleaned up with the help of WaterSense labeled showerheads. (Photo: Steven Mitchell/AP Images for Delta Faucet Company)

Further expanding its WaterSense labeled product line, Delta introduced the WaterSense labeled FlushIQ® toilet in 2014, which offers leak detection and overflow protection to promote water efficiency and includes a touch-free flush. Delta's WaterSense labeled Dryden™ and Ara™ faucets were recognized by an international trade publication for design excellence.

In 2014, Delta launched the HappiMess EXIT Disclaimer campaign to help consumers embrace mess with confidence knowing that WaterSense labeled and other water-efficient products will be there to help clean up even the dirtiest of messes. The campaign utilized both traditional and social media outreach, including a feature in more than 90 blog posts, more than 2,700 tweets leveraging the hashtag #HappiMess, and an article in *The New York Times,* resulting in more than 83 million media impressions.

KB Home

Four-time WaterSense Builder Partner of the Year, KB Home EXIT Disclaimer, received its first Sustained Excellence Award for demonstrating its commitment to water efficiency by constructing 96 WaterSense labeled homes in 2014, an increase of 60 percent from 2013. The company introduced five new communities in which all homes will be designed to earn the WaterSense label.

To further showcase its water efficiency innovation, KB Home built its first Double ZeroHouse 2.0 model home in Lancaster, California, and its first Double ZeroHouse 3.0 model home in El Dorado Hills, California—both were designed to achieve net-zero energy and the highest levels of resource efficiency. These homes are WaterSense labeled and also feature water- and energy-efficient dishwashers and graywater recycling systems. The Double ZeroHouse 3.0 model uses recycled drain water in all of the home's WaterSense labeled toilets to achieve zero freshwater flushing.

KB Home's accomplishments in support of WaterSense were featured in two high-profile news stories: Builder

Magazine's "WaterSense Is Good Business Sense" in October 2014 and local television station KTLA's news series "Be Waterwise Wednesdays" in August 2014. During 2014, KB Home continued to educate and train its sales staff on water efficiency, including the benefits and features of the WaterSense label, and required employees to pass a certification test regarding the proper use of the WaterSense label. They also held trainings for landscape and plumbing contractors on WaterSense's indoor and outdoor homes criteria.

The Home Depot

The Home Depot EXIT Disclaimer, a three-time WaterSense Retailer Partner of Year, earned its first Sustained Excellence Award for its dedication to WaterSense education and outreach efforts. In 2014, 518 billion WaterSense media impressions were generated. In addition to regularly featuring WaterSense on The Home Depot's website and in-store promotions, the company launched an online advertising campaign, featuring WaterSense labeled products, through Google and high-traffic websites such as The Weather Channel.

The company also hosted more than 80,000 Web-based video courses to train sales associates on WaterSense and WaterSense labeled products. In order to help consumers purchase WaterSense labeled products, The Home Depot discounted WaterSense labeled products in stores and online, helping customers achieve more than $39 million in product markdowns.

"When we were approached by the California governor's office to help with easing the effects of the drought in the West, we knew this was an opportunity to not only provide immediate relief but also to educate about the water conservation commitments of WaterSense."

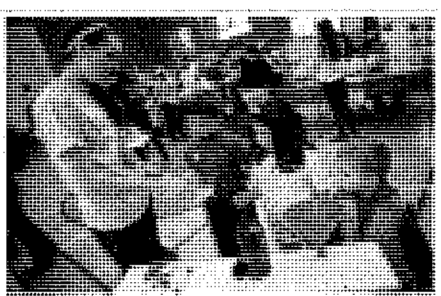
Ron Jarvis
Vice President of
Environmental Innovations
The Home Depot

In conjunction with Fix a Leak Week 2014, The Home Depot ran a five-week water efficiency national press campaign in the spring. During the campaign, stores hosted events, including a special event at the retailer's Raleigh, North Carolina, store in collaboration with WaterSense promotional partner, the City of Raleigh Public Utilities Department. The store invited the community to learn more about fixing leaks in their homes and installing water-efficient products. Attendees were given water conservation kits featuring WaterSense labeled products. The Home Depot also partnered with AmeriCorps and the State of California to distribute more than 30,000 water conservation kits to households in disadvantaged communities affected by drought.

2015 Utility Partners of the Year

City of Charlottesville

The City of Charlottesville EXIT Disclaimer, Virginia, received the WaterSense Promotional Partner of the Year award for its various events and outreach promoting WaterSense in 2014. One of the city's most celebrated events was the Fix a Leak Week Family 5K where 75 participants chased a "running toilet" to the finish line. Each participant received t-shirts with the WaterSense program logo and information on the city's WaterSense labeled toilet rebate program. In addition, the city participated in a number of events focused on children, including Kid*Vention, an annual science event sponsored by the Virginia Discovery Museum with more than 1,200 attendees. At the event, the City of Charlottesville distributed numerous activity books that included stickers and pens with tips on "The Top 5 Ways to Save Water."



The City of Charlottesville, Virginia, promoted water efficiency at Kid*Vention, an annual science event with more than 1,200 attendees.

The city also partnered with Charlottesville's Local Energy Alliance Program (LEAP), which offered local home energy check-ups and identified areas for water-efficient improvements. To encourage residents to implement the identified changes, the city provided all LEAP home energy coaches with water conservation kits containing WaterSense labeled showerheads and leak-detection dye tablets that were distributed to LEAP participants.

The City of Charlottesville developed a "Blue Team" comprised of a small group of high school students who conducted door-to-door outreach to more than 200 homes and provided residents with water conservation kits, including WaterSense labeled showerheads and additional product rebate information. Through radio advertisements, local events, online outreach, and social media, the city was able to distribute nearly 500 toilet rebates to both residential and multi-family homes.

Cobb County Water System

Cobb County Water System EXIT Disclaimer in Georgia, now a four-time WaterSense Promotional Partner of the Year, made an effort to participate in all of WaterSense's outreach campaigns in 2014. For the H_2Otel Challenge, Cobb County offered free water audits at hotel facilities and distributed marketing materials with WaterSense messaging. The utility successfully recruited five hotels to participate in the Challenge and featured one of the hotels in its *Water $aver* quarterly e-newsletter. To promote Sprinkler Spruce-Up, Cobb County produced a segment for the local county cable station, instructing consumers about water-efficient irrigation systems and successful watering practices. The utility also had a hands-on WaterSense labeled irrigation controller demonstration in its lobby during Sprinkler Spruce-Up where consumers could practice scheduling the weather-based irrigation controller and ask questions of county staff. As part of Fix a Leak Week 2014 and the Green City program EXIT Disclaimer, Cobb County collaborated with Niagara Conservation and Green Plumbers USA to replace toilets and showerheads with WaterSense labeled models. For the Shower Better campaign, Cobb County provided 3,600 WaterSense labeled showerheads to Kennesaw State University students to retrofit their dorms.

Cobb County...Expect the Best!

"Our most successful initiatives always begin and end with great partnerships, and WaterSense is one of those partners, as well as the bridge we often use to build other partnerships."

Kathy Nguyen
Senior Project Manager
Cobb County Water System

In addition to supporting WaterSense campaigns, Cobb County once again participated in the Metropolitan North Georgia Water Planning District's Water Drop Dash 5K. During the event, Cobb County distributed 100 outdoor water efficiency kits to attendees who visited four exhibitors during the water festival. Cobb County also held events at local Home Depot stores during a Georgia sales tax holiday weekend and gave away 6,000 WaterSense labeled showerheads to consumers throughout the year.

The utility supported a couple key research initiatives and concluded a three-year grant project on the outdoor component of WaterSense labeled homes. The results included three articles that described how the financial barriers for achieving WaterSense labeled homes outdoor criteria were not significant.

Murray City Corporation

WaterSense Promotional Partner of the Year, Murray City Corporation EXIT Disclaimer, in Utah, used its limited resources to make a big water efficiency splash in its small community. The city launched its "Tap Into Murray Quality" campaign to promote WaterSense and water conservation as its key message to customers. The campaign incorporated WaterSense promotional materials, including bill stuffers, blog posts, the WaterSense promotional label, and social media posts to promote awareness. To educate the community about WaterSense, Murray City hosted a traveling booth at local farmers' markets, youth sporting events, and other local happenings to introduce residents to WaterSense and learn how to be more water-efficient.

Murray City partnered with local plumbers and plumbing suppliers during Fix a Leak Week 2014 to educate consumers about water efficiency, fixing leaks, and the city's rebate program. Plumbers and plumbing companies promoted the event by offering a special Fix a Leak Week discount to their customers. When Murray City hosted a Fix a Leak Week booth at a local Lowe's Home Improvement store, it resulted in the Lowe's store selling out of its WaterSense labeled showerheads. The city surveyed both plumbers and rebate participants on their experiences with WaterSense labeled products in an effort to gain more research on product satisfaction. Nearly 80 percent of participants surveyed indicated they would purchase WaterSense labeled products again. Staff also partnered with the National Energy Foundation and administered a survey to obtain results from its Water Wise Kids program and water-efficient practices. The city found that the education program was effective, as the kids surveyed were knowledgeable about ways to be water-efficient. For example, 80 percent of the kids said they take five-minute showers, and nearly 40 percent have helped their parents install water-efficient aerators in their homes.

2015 Promotional Partner of the Year

Texas A&M AgriLife Research and Extension Center at Dallas

Texas A&M AgriLife Research and Extension Center EXIT Disclaimer at Dallas received a WaterSense Promotional Partner of the Year award for its efforts to promote WaterSense to consumers across the state of Texas. In 2014, Texas AgriLife continued touring with its Mobile WaterSense Home, an 8-by-14-foot mobile home with a bathroom showcasing a WaterSense labeled dual-flush toilet, bathroom sink fixture, and showerhead. Texas AgriLife also created giant irrigation heads and flags promoting the "Find It, Flag It, Fix It" campaign, which was launched in conjunction with Fix a Leak Week 2014. The "Find It, Flag It, Fix It" campaign encouraged homeowners to inspect their in-ground irrigation systems for leaks and flag any necessary points of repair. About 6,000 irrigation flags with the "Find It, Flag It, Fix It" slogan, Texas AgriLife's website, and the WaterSense partner logo were distributed to consumers. In addition to promoting to consumers, Texas AgriLife's WaterSense labeled home was showcased during a traveling demonstration to professional audiences.

At 24 regional outreach events, Texas AgriLife proudly displayed the WaterSense partner logo and promoted WaterSense labeled products, either with the use of the Mobile WaterSense Home, the dual-flush toilet demonstration, or the wall of irrigation controller demonstrations. Texas AgriLife also exhibited information on WaterSense labeled weather-based irrigation controllers and rainwater harvesting at the State Fair of Texas. In total, Texas AgriLife was able to reach nearly 500,000 participants at these events.

In 2014, Texas AgriLife had 46 appearances on a Sunday morning news program reaching 560,000 viewers each week. In addition to the news program, Urban Water Team members conducted 19 television interviews related to the WaterSense labeled homes, irrigation-related water efficiency, and plant selection, reaching a viewership of nearly 2 million. The organization also started work with a local developer on the design of a new residential community featuring WaterSense labeled homes. When fully constructed in 2015, the development will have 900 homes, 120 townhomes, and an elementary school.

2015 Manufacturer Partner of the Year

The Toro Company

The Toro Company EXIT Disclaimer earned the WaterSense Manufacturer Partner of the Year award for its demonstrated commitment to expanding awareness of WaterSense labeled products in 2014. Its regional sales managers partnered with water agencies throughout their territories to educate end users on the installation and programming of weather-based irrigation controllers and municipal rebates. The company also partnered with the Irrigation Association's regional chapters and other organizations to train and educate contractors and distributors, including John Deere Landscapes, on water efficiency best practices, the availability of WaterSense labeled products, and tips on how to install and use weather-based irrigation controllers to obtain maximum water efficiency.

To further promote water efficiency, The Toro Company featured its WaterSense labeled weather-based irrigation controllers at 30 national and regional trade shows, expositions, and sales events with exposure to more than 70,000 consumers, contractors, landscape architects, and irrigation professionals. In addition to its outreach, the Toro Company supported WaterSense as it conducted research about soil-moisture based control technologies by developing test criteria for these products.

2015 Licensed Certification Provider Partner of the Year

Energy Inspectors Corporation

Three-time WaterSense Licensed Certification Provider Partner of the Year, Energy Inspectors Corporation EXIT Disclaimer, exemplified its continued leadership in the WaterSense New Homes program and maintained its strong collaboration with WaterSense builder partners in 2014. Working closely with KB Home, the company certified more than 95 properties that met WaterSense homes criteria—double the number of homes it certified in 2013. With Energy Inspectors' support and promotion in 2014, KB Home committed to building 10 communities of WaterSense labeled homes, which represents around 600 homes.

The company's inspectors continue to follow its hands-on training approach to the WaterSense Labeled New Home Inspection Checklist on model homes. To date, Energy Inspectors Corporation has trained 11 inspectors to perform WaterSense specification inspections. In 2014, the company developed an online training video for both new and existing inspectors to maintain their knowledge on performing WaterSense labeled home inspections.

2015 Professional Certifying Organization Partner of the Year

Sonoma-Marin Saving Water Partnership

Two-time WaterSense Professional Certifying Organization Partner of the, Year Sonoma-Marin Saving Water Partnership (SMSWP) EXIT Disclaimer in California, continued to promote the WaterSense labeled Qualified Water Efficient Landscaper (QWEL) certification program. In 2014, SMSWP accepted four professional certifying organizations that adopted the QWEL certification program and certified 200 professionals. It also continued to educate irrigation professionals and its customers on the benefits of sound landscape design, management, and irrigation practices, including WaterSense labeled weather-based irrigation controllers. Outreach to existing QWEL certified professionals increased in 2014 with the launch of the monthly *QWEL North Bay Newsletter*, which provided information related to WaterSense training and continuing education opportunities.

SMSWP continued collaborating with the International Association of Plumbing and Mechanical Officials in 2014 to jointly promote the Green Plumbers Training program and QWEL through its newly developed website at www.gpqwel.org EXIT Disclaimer. In early 2014, SMSWP refined the QWEL graywater specialty training module with instructions covering graywater codes in California, system design and sizing, laundry-to-landscape, branched drain systems, and plant selection. Using the module, they sponsored a successful initial class in Sonoma County, California, in April 2014 with 23 participants. SMSWP also began working with a San Francisco-based nonprofit organization, WaterNow, to increase the reach of the QWEL graywater module and train additional irrigation professionals and plumbers to install graywater systems.

2015 Excellence in Strategic Collaboration

Colorado Springs Utilities

In 2014, Colorado Springs Utilities (CSU) EXIT Disclaimer in Colorado developed successful partnerships with a variety of organizations to promote the WaterSense mission. For example, CSU helped the University of Colorado at Colorado Springs by supporting a student-led dormitory retrofit of early 1990s-era toilets with WaterSense labeled models. Students researched and tested multiple models and ultimately replaced 233 units, recycled the old models as aggregate, and completed rebate applications.

Colorado Springs Utilities

It's how we're all connected

CSU introduced its "Guerilla Green" campaign, a proactive water efficiency education and outreach approach to work with WaterSense partners and promote WaterSense in their communities. Staff developed relationships with multiple WaterSense partners within their communities to elevate the value of water in business operations and to establish WaterSense as the solution for implementing conservation initiatives. In turn, these partners demonstrated their support for water efficiency by informing their customers about WaterSense and how to participate in available CSU incentive programs.

2015 Excellence in Promoting WaterSense Labeled Products

Denver Water

Denver Water EXIT Disclaimer in Colorado promoted the adoption of WaterSense labeled products through retailer education, rebate programs, and targeted outreach. Staff visited approximately 60 retail outlets in 2014 and held conversations with sales and customer service representatives, provided point-of-sale displays for applicable products, and received feedback on customer service. The Denver Water conservation team members worked with retailers to promote the utility's toilet rebate program, explain WaterSense performance testing, and encourage retailers to carry more WaterSense labeled products. The utility also offered rebates for WaterSense labeled toilets and promote the use of every WaterSense labeled product category.

DENVER WATER

In addition, Denver Water created a new WaterSense Challenge in 2014 to identify large, multi-family buildings with exceptionally high indoor water use per unit. A dedicated team member worked closely with participants to conduct a home makeover using WaterSense labeled fixtures. In 2014, Denver Water encouraged eight large condominium and apartment complexes (approximately 3,700 units) to retrofit bathrooms with WaterSense labeled fixtures.

2015 Excellence in Education and Outreach

Metropolitan North Georgia Water Planning District

In 2014, the Metropolitan North Georgia Water Planning District EXIT Disclaimer educated consumers about water efficiency and WaterSense labeled products across Metro Atlanta. In conjunction with WaterSense's Fix a Leak Week, the Metro Water District hosted its annual Water Drop Dash 5K and Water Festival to promote simple ways to find and fix leaks in homes. Prior to the event, the Metro Water District partnered with Cox Media Group to air 15-second radio spots and a 30-minute interview about Fix a Leak Week and the event. More than 700 runners participated in the 2014 race, and each runner received indoor and outdoor water conservations kits. At the Water Festival, the Metro Water District and 11 participating water utilities provided hands-on, water-related activities and giveaways, such as toilet dye tablets, shower timers, and rain gauges.

Metropolitan North Georgia · Water Planning District

In addition, the Metro Water District educated consumers about WaterSense labeled products by promoting its rebate program via its website, press releases, program fliers, and Georgia Sales Tax Holiday materials. They also updated two irrigation brochures that educate consumers about WaterSense labeled weather-based irrigation controllers and reminds consumers to hire certified irrigation professionals.

New Hampshire Department of Environmental Services

The New Hampshire Department of Environmental Services (NHDES) EXIT Disclaimer utilized information in WaterSense materials to develop the New Hampshire We're for Water campaign tailored specifically for state residents. NHDES also promoted the WaterSense label statewide and encouraged water behavioral changes through a social marketing campaign. NHDES held a New Hampshire "Cute Kid Photo Contest" within the department to compile photos for marketing the WaterSense program. The winner was featured on the cover of a "Saving Water Is in Your Future" brochure featuring WaterSense's simple steps to save water.

In addition to its outreach to residents, NHDES educated utilities, municipalities, and other stakeholders about WaterSense and encouraged them to become partners. NHDES collaborated with the NHSaves program, a partnership program between several electric and gas utilities in New Hampshire, to update its catalog in 2014 with WaterSense labeled products and a Shower Better infographic.

2015 Excellence in Sprinkler Spruce-Up Activities

Municipal Water District of Orange County

In spring and fall of 2014, the Municipal Water District of Orange County (MWDOC) EXIT Disclaimer in California used the Orange County Garden Friendly (OCGF) Program as a platform to promote WaterSense's Sprinkler Spruce-Up campaign with water-efficient plant choices. MWDOC teamed up with the Orange County Stormwater Program and University of California Cooperative Extension to host six events throughout Orange County—three at Home Depot stores and three at other local garden centers. At these events, more than 700 retail customers learned about WaterSense labeled weather-based irrigation controllers and the importance of "sprucing up" irrigation systems.

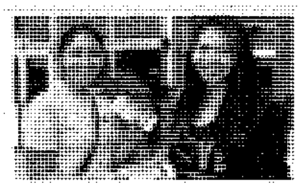
WaterSense labeled weather-based irrigation controller sales increased during the events by more than 225 percent at three Home Depot stores as compared to the average daily sales. Through the OCGF platform, MWDOC distributed approximately 25,000 fliers to Home Depot stores across Orange County to promote WaterSense labeled products eligible for rebates.

2015 Excellence in Promoting the Water/Energy Nexus

Puget Sound Energy

Puget Sound Energy (PSE) EXIT Disclaimer in Bellevue, Washington continued to demonstrate its leading role in promoting the water/energy nexus in 2014 by launching a sports-themed "Energy Upgrade" campaign targeting 14 high-profile events. The campaign's cornerstone event was held in September 2014. PSE targeted ferry, bus, light-rail, and train commuters as they made their way to an NFL football game between the Seattle Seahawks and the Denver Broncos. Commuters received a "Golden Upgrade Ticket" to redeem for a free WaterSense labeled showerhead or energy-efficient appliance. In total, 10,037 golden tickets were distributed and 29 percent were redeemed.

Another key component of the campaign's success was its retailer and manufacturer partnerships. Partners such as Kohler Co. donated prizes, and PSE increased its rebates on the partners' WaterSense labeled products during the campaign.


A PSE employee (left) gives a Golden Upgrade Ticket to a Seattle Seahawks fan.

About the Awards Program

Each year, WaterSense Partners of the Year contribute to the program's success by enhancing the market for water-efficient products, practices, and services. Learn what previous WaterSense Partners of the Year have done to increase water efficiency and promote the WaterSense label within their respective partner categories.

- 2015
- 2014
- 2013
- 2012
- 2011
- 2010
- 2009
- 2008

Share

LOOKING FOR SOMETHING A BIT MORE TECHNICAL?

Click here if you are part of the media, an educator, manufacturer, professional or promotional partner.

Helpline: (866) WTR-SENS (987-7367) | Contact Us | Office of Water
WaterSense, U.S. Environmental Protection Agency, Office of Wastewater Management (4204M), 1200 Pennsylvania Avenue, N.W.Washington, D.C. 20460

Last updated on 2/23/2016

Exhibit 61

Water Availability and Competing Demands

Southwest Georgia Sound Science Initiative

Lynn J. Torak, Hydrologist

U.S. Department of the Interior
U.S. Geological Survey

Ongoing Investigations

- Effects of impoundment of Lake Seminole on water resources in the lower Apalachicola-Chattahoochee-Flint River Basin, in parts of Alabama, Florida, and Georgia
- Effects of hydrologic variation and seasonal ground-water withdrawal on stream-aquifer relations in the lower Apalachicola-Chattahoochee-Flint River Basin

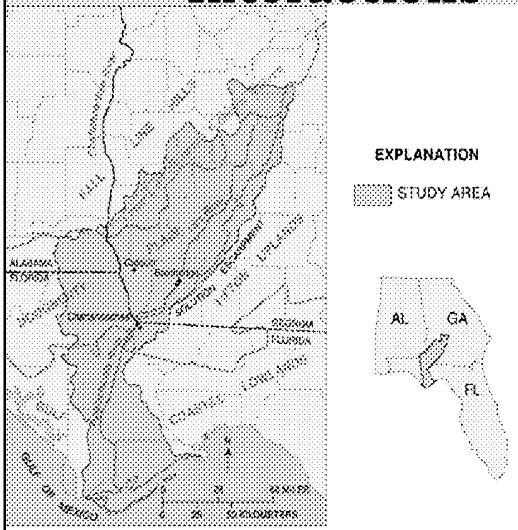
USGS

Cooperative Water Program Participants

- U.S. Army Corps of Engineers
- U.S. Fish and Wildlife Service
- Alabama Department of Economic and Community Affairs, Office of Water Resources
- Northwest Florida Water Management District
- Georgia Department of Natural Resources, Environmental Protection Division
- City of Albany, Water, Gas, and Light Commission

USGS

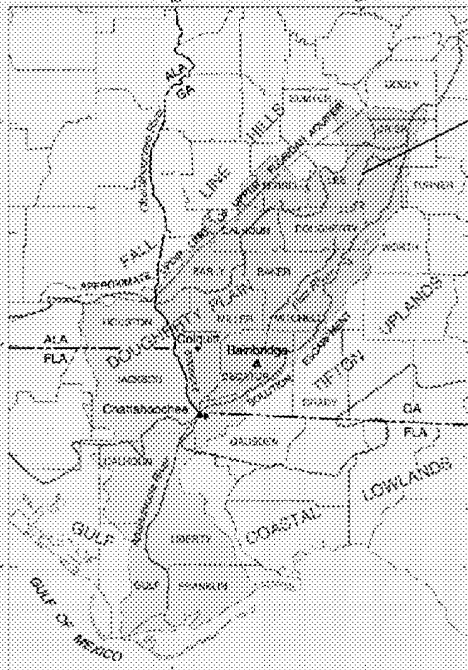
Ground-Water/Surface-Water Interactions—SW Ga.-SSI



- Lower Apalachicola-Chattahoochee-Flint River Basin
- 6,800 square miles
- Drains karst limestone of Upper Floridan aquifer
- Over 3 Bgal/d withdrawn from the basin
- Hosts 7 Federally listed threatened and endangered freshwater mussel species
- Apalachicola River and Bay ecosystem issues
- Tri-State "Water War" fought since 1991

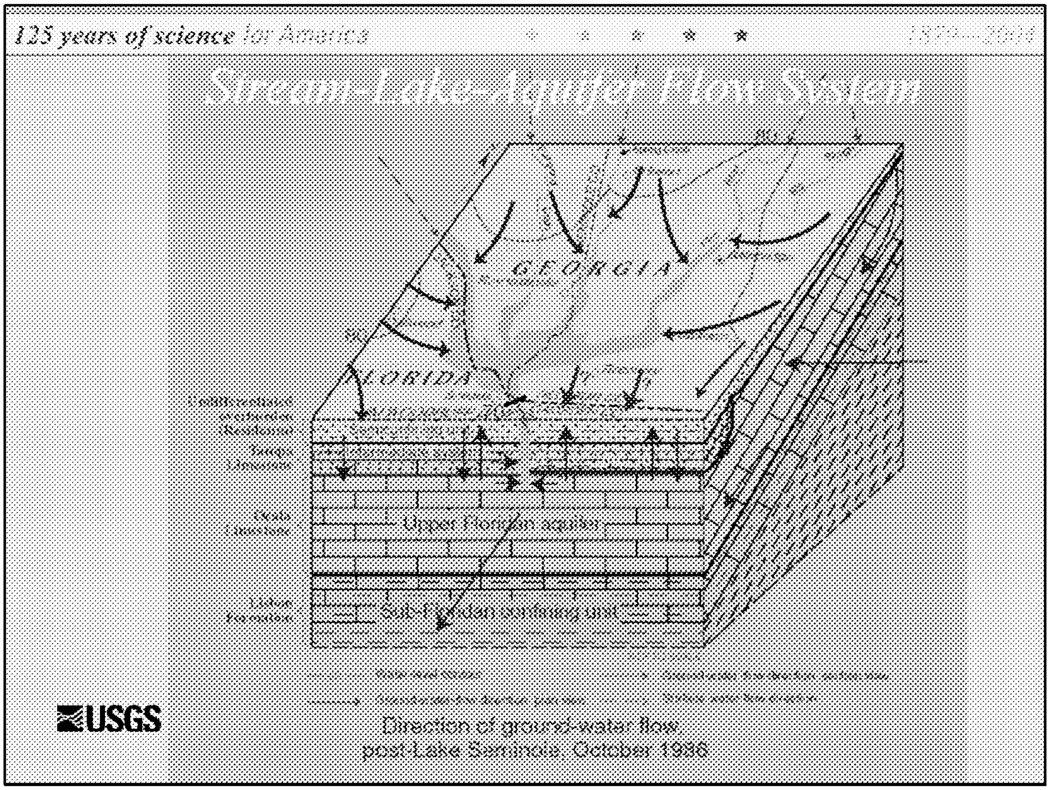
USGS

125 years of science for America 1879—2004

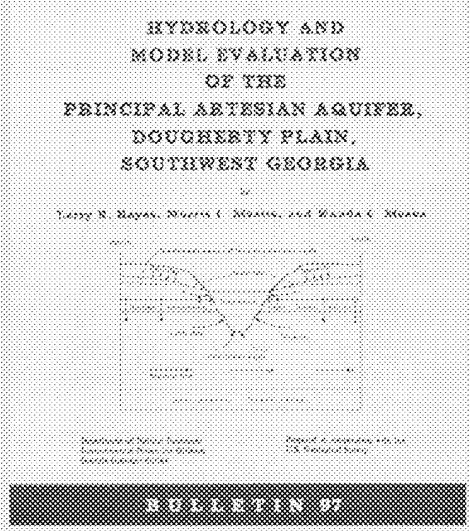


Lower ACF River Basin in Georgia: Study area evaluated for Flint River Basin Water Plan

USGS


125 years of science for America
1879—2004
Stream-Lake-Aquifer Flow System
GEORGIA
FLORIDA
Upper Floridan aquifer
Sub-Floridan confining unit
USGS
Direction of ground-water flow,
post-Lake Seminole, October 1986

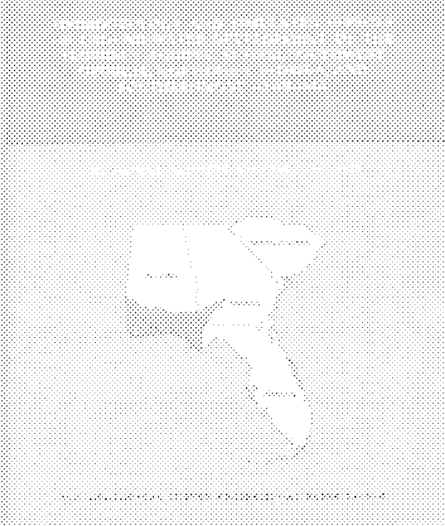
Science Past: Humble Beginnings



- Basinwide "Firsts," ca.1983
  - Hydrogeologic conceptual-ization containing gw/sw interaction
  - 2-D MODFLOW application: simulated effects of hypothetical drought and irrigation-pumpage increases on gw levels and streamflow
- Collaboration with USDA, Soil Conservation Service and Georgia Geologic Survey

USGS

USGS Professional Paper 1403-H, Morris L. Maslia and Larry R. Hayes, 1988



- SW Georgia included in Regional Aquifer Systems Analysis (RASA) study
- MODFLOW simulations in Dougherty Plain
  - November 1979 flow conditions
  - May—November seasonal flow-system conditions
  - Flow-system sensitivity to changes in rainfall and pumping

USGS

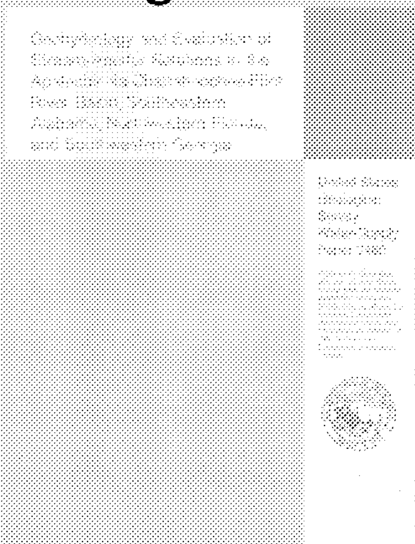
USGS-0020242

Southwest Georgia MODFE Application
Torak, Davis, Strain, and Herndon, 1993

- First published District usage of model, MODFE
- Simulation of flow in limestone caverns and fractures
- Detailed water budget of stream-aquifer interaction
- Well-field location based on model results

USGS

Collaboration: U.S. Army Corps of Engineers and State Agencies, 1996

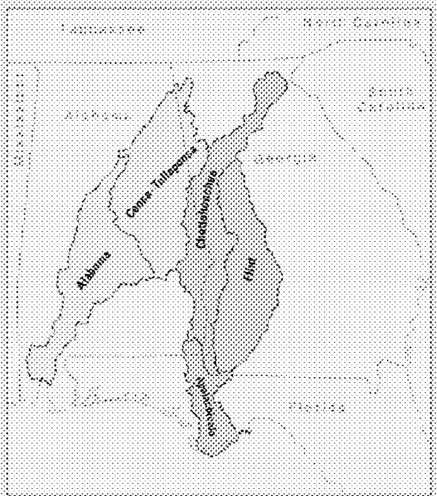


Torak, Davis, Strain, and Herndon, 1996

- First regional, multi-state application of MODFE
- Pilot study for Corps' management of regulated streams
- Simulation of historic, 1986 drought conditions

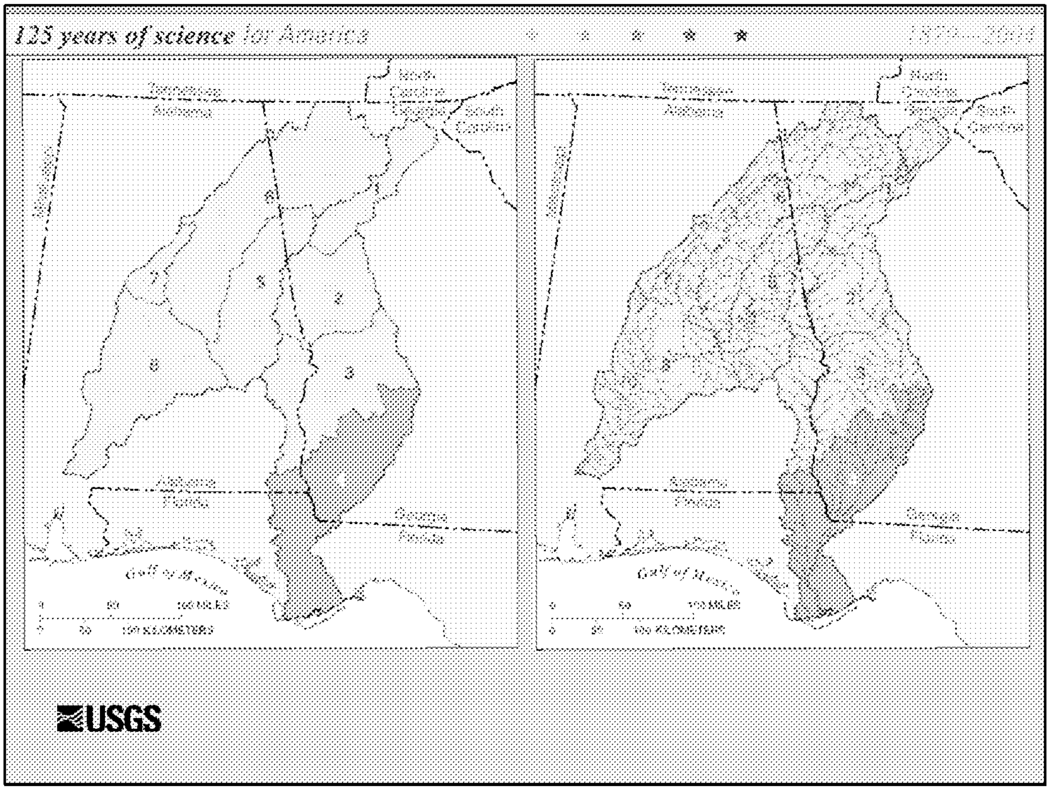
USGS

Water War!! USGS Involvement in Tri-State Water Conflict

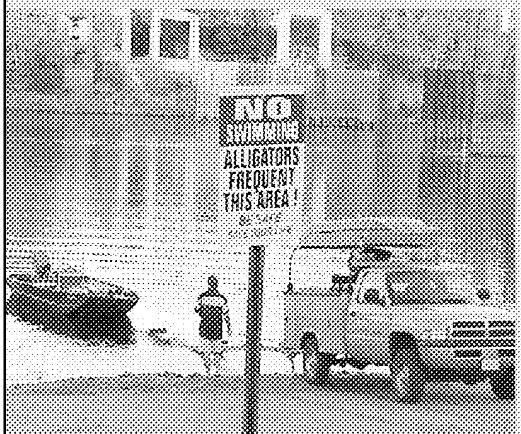


- 1990: Alabama sued Corps of over planned increased surface-water allocation for Atlanta
- 1991: Lawsuit stayed in lieu of a **Comprehensive Study** of water resources in the ACT-ACF River Basins, 49,000 square-mile area
- 1993: **USGS (Torak)** created 8 "Subareas" and drafted work plan for Ground-Water-Supply Element of Comprehensive Study
- 1996: Interstate Water Compacts signed ***without*** water-allocation formula

USGS


125 years of science for America
1879—2004
Tennessee
Alabama
North Carolina
Georgia
South Carolina
Alabama
Florida
Georgia
Florida
Gulf of Mexico
USGS

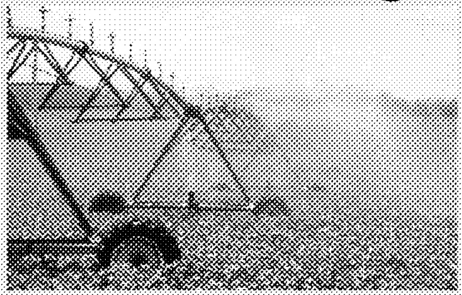
Comprehensive Study Multi-Agency Connections

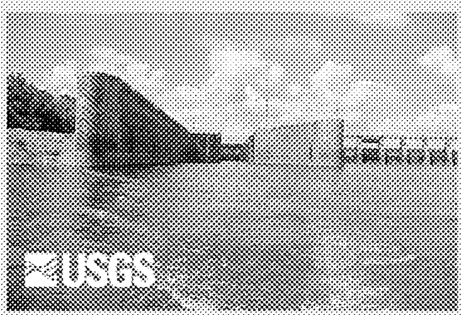


- U.S. Army Corps of Engineers
- U.S. Fish and Wildlife Service
- National Park Service
- U.S. Geological Survey
- U.S. Environmental Protection Agency
- U.S. Department of Agriculture Forest Service
- Natural Resources Conservation Service
- National Marine Fisheries Service
- National Oceanographic and Atmospheric Administration
- Southeastern Power Administration
- Department of Justice

USGS

USGS Role in Comprehensive Study– Federal Interagency Management Plan





- Ground-Water-Supply Element for 8 Subareas
- Evaluate proposed water-allocation formula for ACT and ACF River Basins
- Assist other federal agencies in understanding hydrologic impacts of allocation formula
- Prepare long-term ground-water-monitoring plan

Diversity and Complexity of Tasks– Subarea 4 Study, Torak and McDowell, OFR 95-321, 1996


GROUND-WATER RESOURCES OF THE LOWER APALACHICOLA-CHATTAHOOCHEE-FLINT RIVER BASIN IN PARTS OF ALABAMA, FLORIDA, AND GEORGIA--SUBAREA 4 OF THE APALACHICOLA-CHATTAHOOCHEE-FLINT AND ALABAMA-COOSA-TALLAPOOSA RIVER BASINS

USGS

MODFE simulations

- Stream-aquifer interaction in Upper Floridan aquifer (limestone)
- Flow-system response to increased pumpage with streamflow variation
- Detailed water budgets for streams
- Identified pumpage effects on flow to Apalachicola River and Bay ecosystem
- October 1986 conditions
- Predicted that the Flint River would go dry!!!

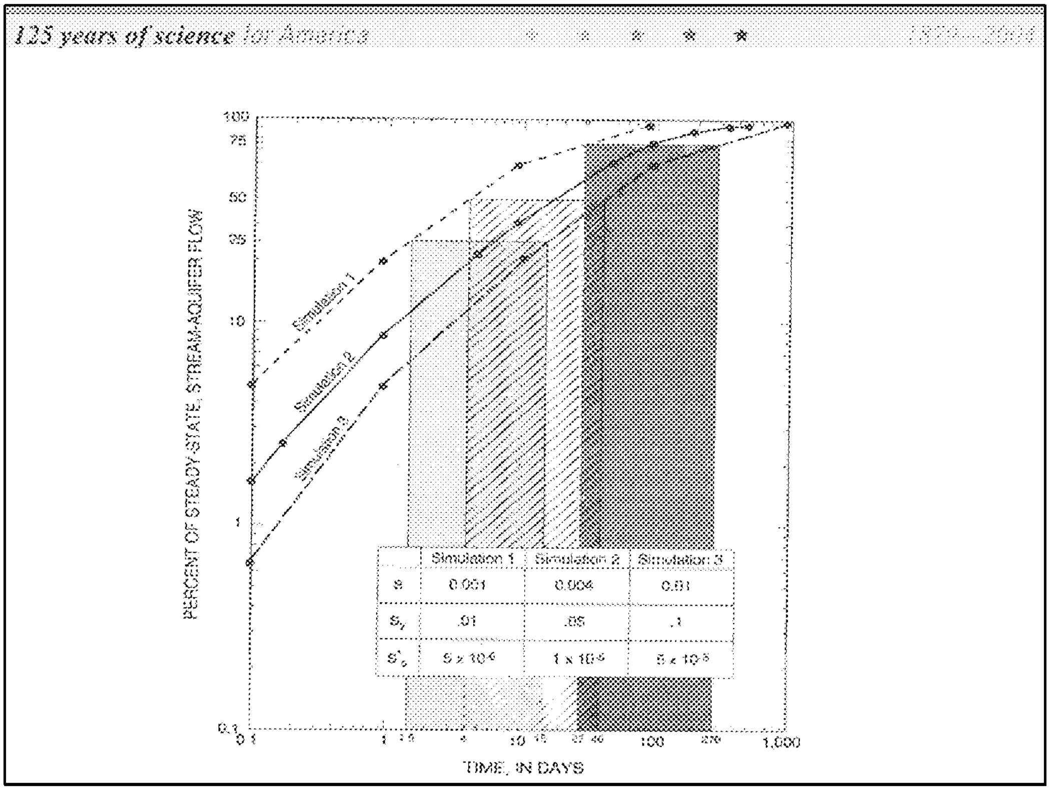

125 years of science for America
1879—2004
PERCENT OF STEADY-STATE, STREAM-AQUIFER FLOW
TIME, IN DAYS
Simulation 1
Simulation 2
Simulation 3
S
0.001
0.004
0.01
Sy
.01
.05
.1
S's
5 x 10-6
1 x 10-5
5 x 10-5
100
75
50
25
10
1
0.1
1
10
15
27
40
100
270
1,000

Table 35. Temporal recovery of stream-aquifer-flow decline by stream reach following simulated reduction in October 1986 pumpage to zero---results from Simulation 2 of Upper Floridan model

[Storage coefficient and specific yield of Upper Floridan aquifer equal 0.004 and 0.05, respectively; specific, storage of overlying semiconfining unit equals 1×10^{-5} feet^{-1}; negative values indicate losing stream]

Reach		Elapsed simulation time since pumpage decrease (days)			
(pl. 4)	Stream	0	1	10	100
		Computed net stream-aquifer flow (cubic feet per second)			
1	Gum Creek	3.6	3.6	3.9	4.7
2	Cedar Creek	1.3	1.3	1.3	1.4
3	Swift Creek	3.8	3.8	3.8	4
4	Jones Creek	2.3	2.3	2.3	2.4
5	Abrams Creek	2.6	2.6	2.7	2.9
6	Mill Creek	6.9	6.9	7	7.4
7	Coolewahee Creek	.5	0.5	.8	1
8	Chickasawhatchee Creek	4.1	4.1	4.1	4.1
9	Chickasawhatchee Creek	.3	.3	.3	.4
10	Chickasawhatchee Creek	2.8	2.8	3.1	3.4
11	Dry Creek (Ga.)	2.8	2.8	2.9	3.3
12	Spring Creek	3.5	3.5	3.7	4.1
13	Spring Creek	19.5	19.9	22.5	28.4
14	Spring Creek	1.1	1.2	2	6.7
15	Sawhatchee Creek	9.6	9.6	9.6	9.8
16	Cowarts Creek	19.9	19.9	19.9	20
17	Marshall Creek	31.6	31.6	31.6	31.7
18	Spring Creek	42.2	42.4	45.6	60.1
19	Dry Creek (Fla.)	42.1	42.1	42.1	42.2
20	Ichawaynochaway Creek	52.6	52.7	53.2	54.3
21	Ichawaynochaway Creek	23.7	23.7	24.1	24.8
22	Muckalee Creek	17.8	17.8	17.9	19.6
23	Muckalee Creek	3.9	3.9	3.9	4.1
24	Muckalee Creek	14.2	14.2	14.3	14.7
25	Kinchafoonee Creek	−2.3	−2.3	−2.3	−2.3
26	Kinchafoonee Creek	5.9	5.9	6	6.3
27	Chipola River	114.7	114.7	114.8	115.2
28	Chipola River	339.6	339.6	339.6	339.9
29	Chipola River	359.2	359.2	359.3	359.3
30	Flint River	6.3	6.3	6.4	6.5
31	Flint River	605	622.2	637.5	651.7
32	Flint River	537.3	545	569	589.5
33	Flint River	363.5	365.1	376.3	414.1
34	Flint River	352.2	353.8	371.2	416

Table 36. Reduction in flow of Apalachicola River at Chattahoochee, Fla., and near Sumatra, Fla., caused by simulated pumpage in Upper Floridan aquifer

[Mgal/d, million gallons per day. Accuracy of streamflow records is "good," except for those at Sumatra, Fla., below 9,695 Mgal/d (15,000 cubic feet per second), which are tide affected and rated "fair." Good means that about 95 percent of the daily discharges are within 10 percent; and fair, within 15 percent]

Pumpage		Streamflow reduction by condition, Q_{xxx}					
n × Oct 1986 rates	Rate (Mgal/d)	Q_{OCT86} [1] (Mgal/d)	Percent	Q_{90} [2] (Mgal/d)	Percent	Q_{50} [3] (Mgal/d)	Percent
Apalachicola River at Chattahoochee, Fla.							
0.5	237	142.6	3.7	142.3	2.5	140.4	1.3
1	475	286.9	7.4	286	5	281.8	2.7
2	949	584.2	15.1	581.7	10.1	570.8	5.5
5	2,375	1,263	32.7	1,255	21.8	1,365	13
Apalachicola River near Sumatra, Fla.							
0.5	237	144	3	144	2.2	142	1.1
1	475	290	6.1	289	4.5	284	2.2
2	949	590	12.5	588	9.2	576	4.5
5	2,375	1,276	27	1,268	19.8	1,378	10.8

[1] From pumpage scenarios R1P*n* (table 14); Q_{OCT86} is October 1986 streamflow, equal to 3,864 Mgal/d at Chattahoochee, Fla., and 4,735 Mgal/d near Sumatra, Fla.

[2] From pumpage scenarios R3P*n* (table 16); Q_{90} is streamflow exceeded 90 percent of the time, equal to 5,772 Mgal/d at Chattahoochee, Fla., and 6,392 Mgal/d near Sumatra, Fla.

[3] From pumpage scenarios R6P*n* (table 19); Q_{50} is streamflow exceeded 50 percent of the time, equal to 10,471 Mgal/d at Chattahoochee, Fla., and 12,798 Mgal/d near Sumatra, Fla.

Table 14. Net changes in water-budget components for simulations of increased pumpage with dry conditions of boundary and semiconfining-unit head and stream stage at October 1986 levels, corresponding to scenarios R1P*n* (*n*=0.5, 1, 2, 5) of simulation matrix (table 1)

[Net changes computed from rates given by appropriate zero-pumpage simulation listed in table 10]

	Pumpage (*n* × October 1986 rates)			
	0.5	1	2	5
Budget component	Volumetric rates (million gallons per day)			
Well discharge	237	475	949	2,375
Reduced discharge to:				
Streams and in-channel springs[1]	144	289.8	590.1	1,276
Off-channel springs[2]	0	0	0	0
Regional flow	13.8	27.1	53.4	117.5
Undifferentiated overburden	7.9	15.5	28	43.7
Induced recharge from:				
Undifferentiated overburden	57.8	113.7	213.3	491.6
Regional flow	9.1	18.9	40.2	122.4
Upper Floridan aquifer outcrop	4.3	8.8	17.8	45
Streams	0.2	0.7	6.4	237.6
Budget component	Well discharge (percent)			
Well discharge	100	100	100	100
Reduced discharge to:				
Streams and in-channel springs[1]	60.7	61.1	62.3	54.7
Off-channel springs[2]	0	0	0	0
Regional flow	5.8	5.7	5.5	5
Undifferentiated overburden	3.4	3.3	3	1.9
Induced recharge from:				
Undifferentiated overburden	24.4	24	22.5	21.1
Regional flow	3.9	4	4.2	5.3
Upper Floridan aquifer outcrop	1.8	1.9	1.9	1.9
Streams	0.1	0.1	0.7	10.2

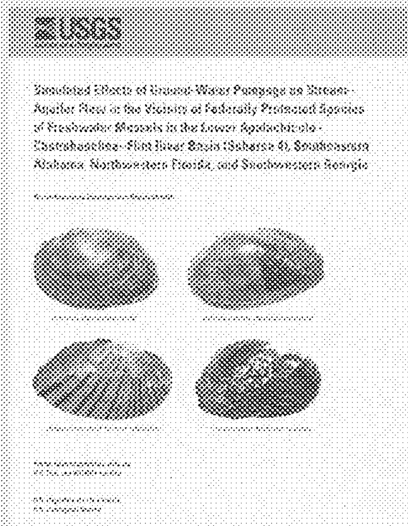
[1] In-channel springs discharge in or near streams and contribute to streamflow.
[2] Off-channel springs are located away from streams and do not contribute to streamflow.

Table 20. Computed net stream-aquifer flow from pumpage scenarios R1Pn (n=0.5, 1, 2, 5) simulating dry conditions of boundary and semiconfining-unit head and stream stage at October 1986 levels (table 1)

[Negative values indicate recharge to aquifer by streamflow]

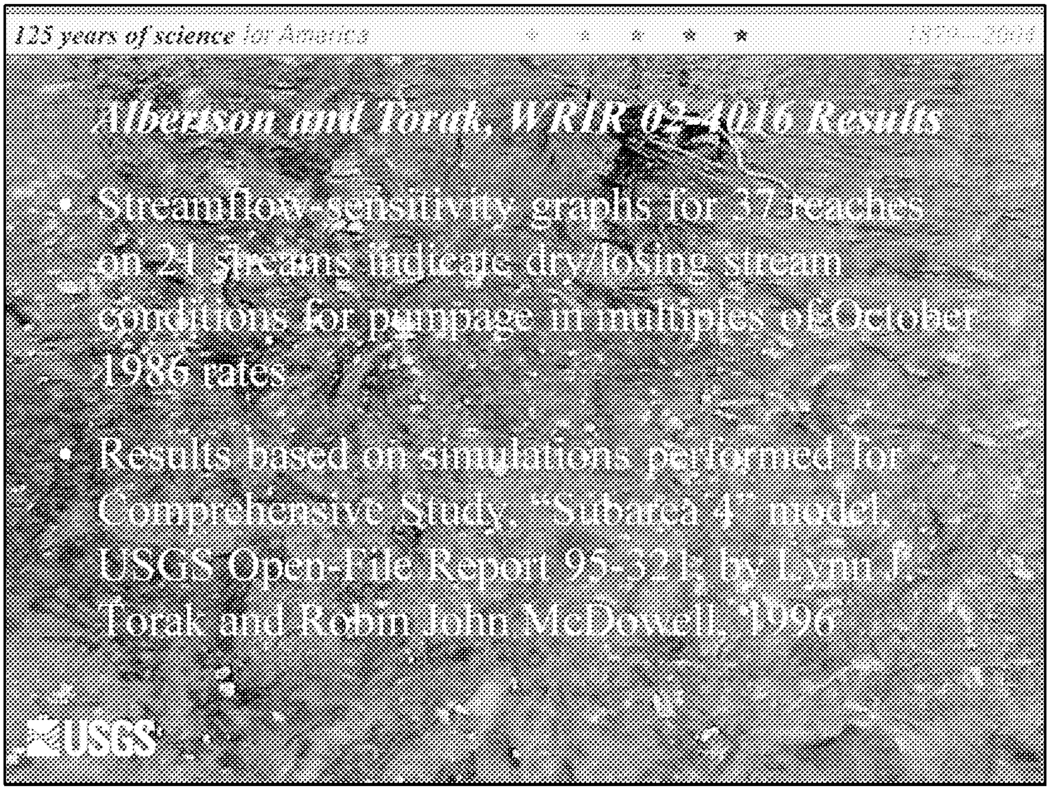
Reach (pl. 9)	Stream	Pumpage (n ×October 1986 rates) 0.5	1	2	5
		Computed net stream-aquifer flow (million gallons per day)			
1	Gum Creek	2.9	2.3	1.1	0
2	Cedar Creek	0.9	0.8	0.6	0.1
3	Swift Creek	2.6	2.5	2.2	1.4
4	Jones Creek	1.7	1.5	1	0
5	Abrams Creek	1.9	1.7	1.2	.1
6	Mill Creek	4.7	4.5	3.8	2
7	Cooleewahee Creek	.5	.3	.1	0
8	Chickasawhatchee Creek	2.6	2.6	2.6	2.5
9	Chickasawhatchee Creek	.3	.2	.2	.2
10	Chickasawhatchee Creek	2	1.8	1.5	.5
11	Dry Creek (Ga.)	2	1.8	1.4	.3
12	Spring Creek	2.5	2.3	1.7	.3
13	Spring Creek	16.1	12.6	5.9	.5
14	Spring Creek	2.6	.7	0	0
15	Sawhatchee Creek	6.3	6.2	5.9	5.1
16	Cowarts Creek	12.9	12.9	12.7	12.2
17	Marshall Creek	20.5	20.4	20.3	20
18	Spring Creek	34.2	27.3	9.9	0
19	Dry Creek (Fla.)	27.3	27.2	27.1	26.7
20	Ichawaynochaway Creek	34.7	34	32.5	27.6
21	Ichawaynochaway Creek	15.8	15.3	14.3	10.7
22	Muckalee Creek	15	11.5	4.5	−11.3
23	Muckalee Creek	3.7	2.5	.1	−5.2
24	Muckalee Creek	9.7	9.2	8.1	5.6
25	Kinchafoonee Creek	−1.5	−1.5	−1.5	−1.5
26	Kinchafoonee Creek	4.3	3.8	2.8	.6
27	Chipola River	74.4	74.1	73.4	71.2
28	Chipola River	219.6	219.4	218.9	217.4
29	Chipola River	232.1	232	231.9	231.6
30	Flint River	4.7	4.1	2.8	1
31	Flint River	407	390.8	358.4	260.4
32	Flint River	364.8	347.1	311.6	203.5
33	Flint River	256.2	234.8	190.6	48.2
34	Flint River	254.8	227.5	167.6	−49.2

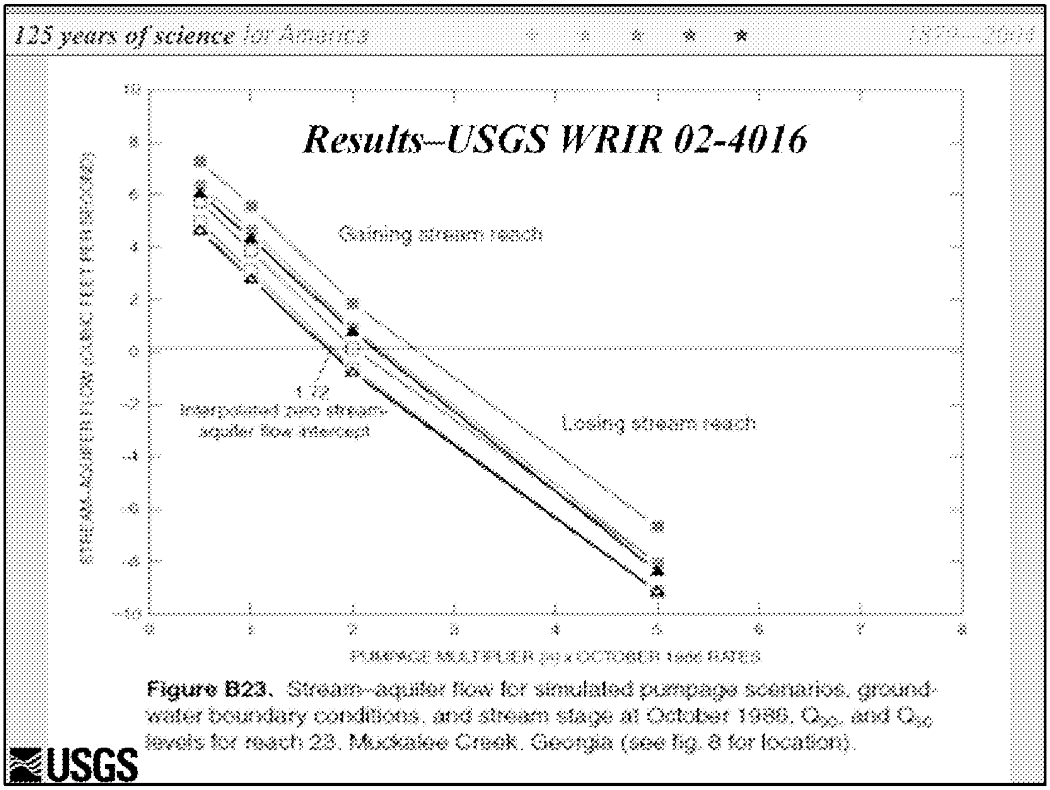
Coordination with US Fish and Wildlife



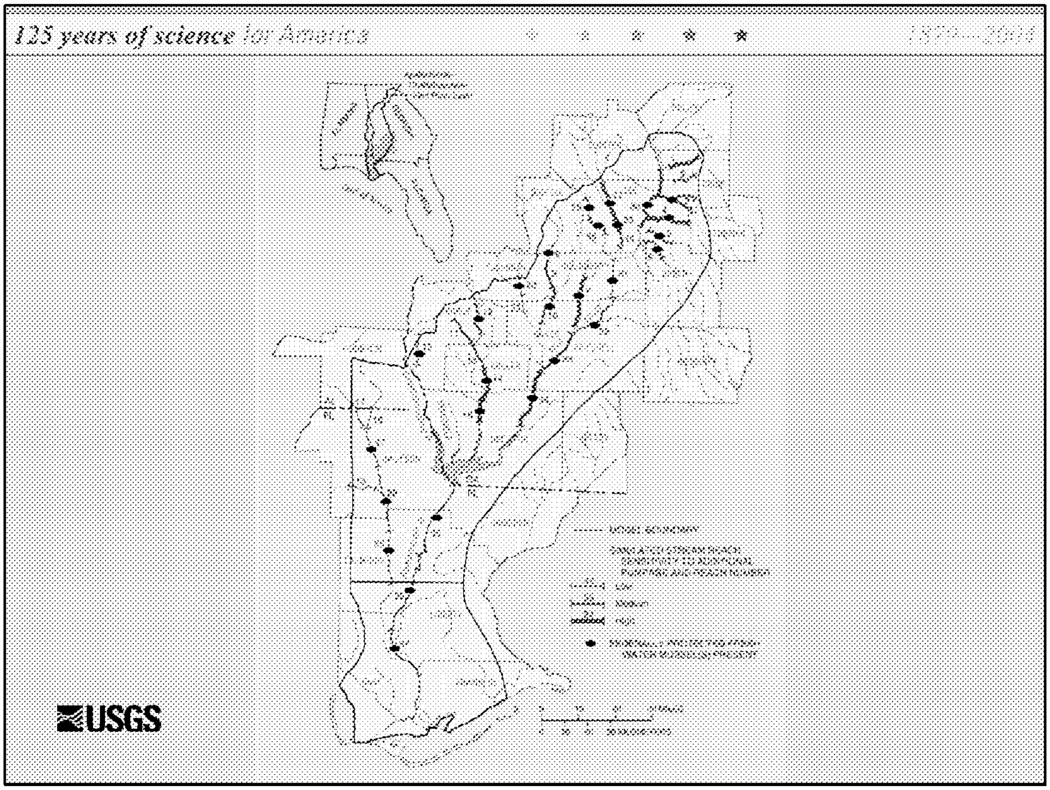
- **Albertson and Torak, WRIR 02-4016, 2002**
- **Simulated effects of pumpage on mussel habitat**
- **Subarea 4 model results recast**
  - Detailed stream-reach sensitivity to increased pumpage
  - Identified pumpage thresholds for zero-aquifer contribution to stream reaches

USGS


125 years of science for America
1879—2004
Albertson and Torak, WRIR 02-4016 Results
• Streamflow-sensitivity graphs for 37 reaches on 24 streams indicate dry/losing stream conditions for pumpage in multiples of October 1986 rates
• Results based on simulations performed for Comprehensive Study, "Subarea 4" model, USGS Open-File Report 95-321, by Lynn J. Torak and Robin John McDowell, 1996
USGS



USGS-0020257


125 years of science for America
1879—2004
USGS

Impact of Subarea 4 Study on Outcome of the "Water War"

- Federal Commissioner decision to accept allocation
- Simulates streamflow reduction and pumpage
- Identified "unknowns" about the flow system (aquifer properties, Lake Seminole, Ga.-Fla. ground-water flow, agricultural pumping rates)

USGS

Improving Understanding of Ground-Water and Surface-Water Relations

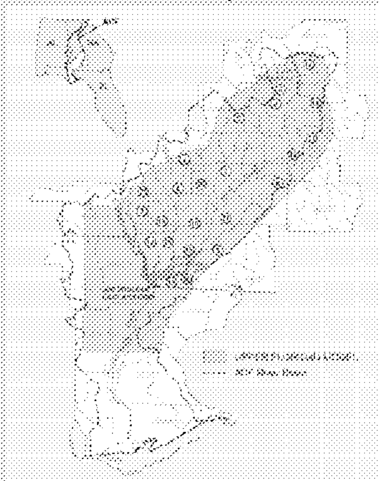
USGS

Stream-Aquifer Relations and the Potentiometric Surface of the Upper Floridan Aquifer in the Lower Apalachicola–Chattahoochee–Flint River Basin in parts of Georgia, Florida, and Alabama, 1999–2000

- **Mosner, USGS WRIR 02-4244, 2002**
- **Comprehensive data collection, October 1999, April and August 2000; drought conditions**
  - Ground-water levels–324 wells
  - Streamflow–74 gaging stations
  - Springflow–12 springs
  - Rainfall–4 weather stations
- **Identified gaining/losing reaches; estimated gw seepage to streams; mapped water-level surface of Upper Floridan aquifer**

USGS

Effects of Hydrologic Variability and Seasonal Ground-Water Withdrawal on Stream-Aquifer Relations, 1999-2005

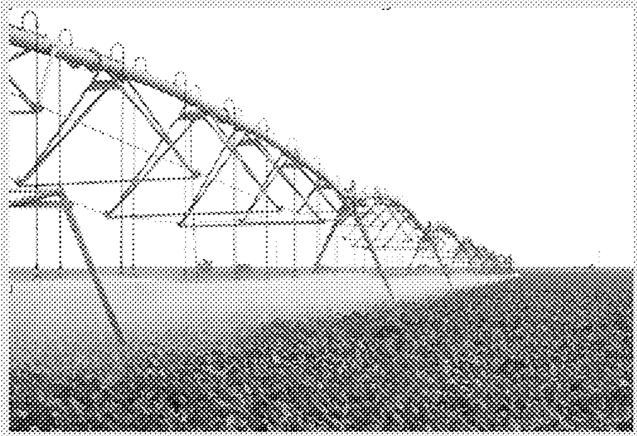


Field Data Collection—Well drilling and aquifer testing: 23 Sites

- Improve understanding of aquifer properties
- Fill data gaps prior to new model development
- Provide input to new MODFE model of growing season conditions

USGS

"...Lower ACF River Basin Study"

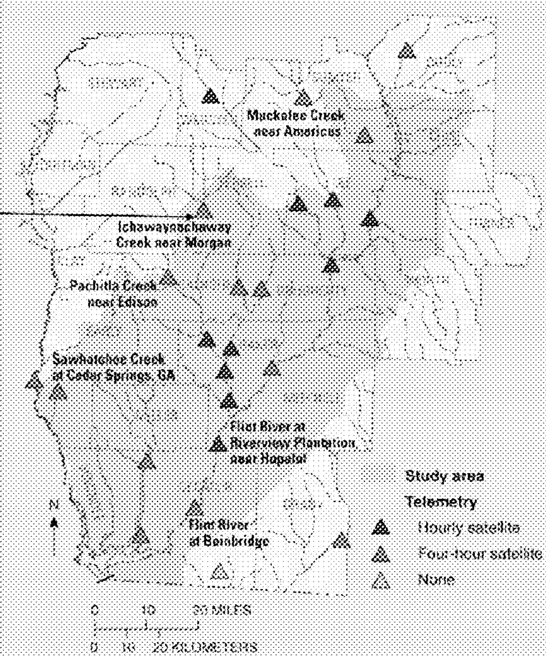


- Ag Water PUMPING II Study
- Real-Time Center-Pivot and Irrigation-System Monitoring
- Develop inputs to MODFE growing-season model
- Collaboration with the University of Georgia, College of Agriculture and Environmental Sciences, National Environmentally Sound Production Agriculture Laborabory, Tifton, Ga.

USGS

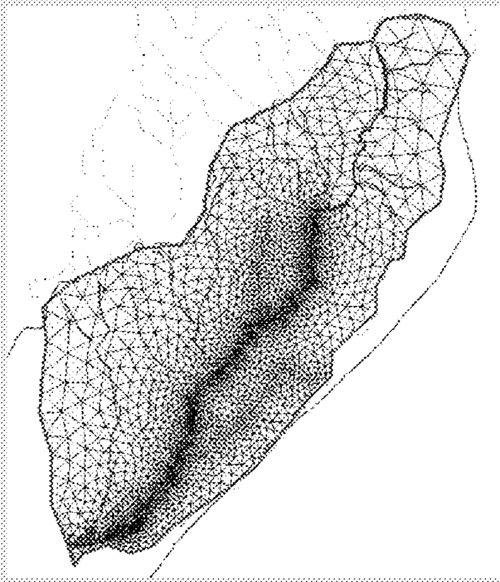
"...Lower ACF River Basin Study"

- Improve streamflow monitoring



USGS

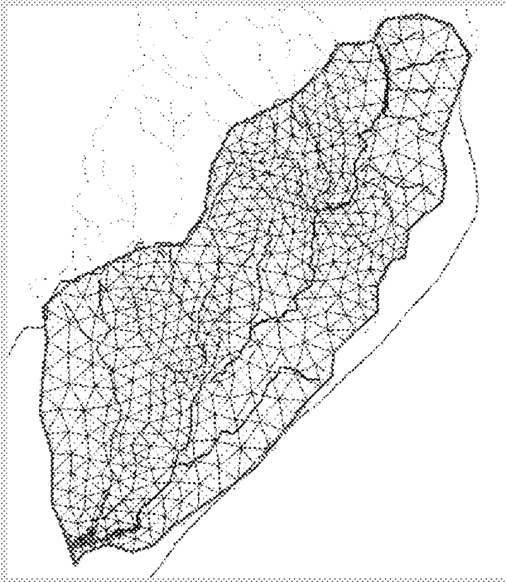
"...Lower ACF River Basin Study"



- Develop automated mesh-generation and model-input techniques
- Evaluate effects of irrigation pumpage on streams and aquifer

USGS

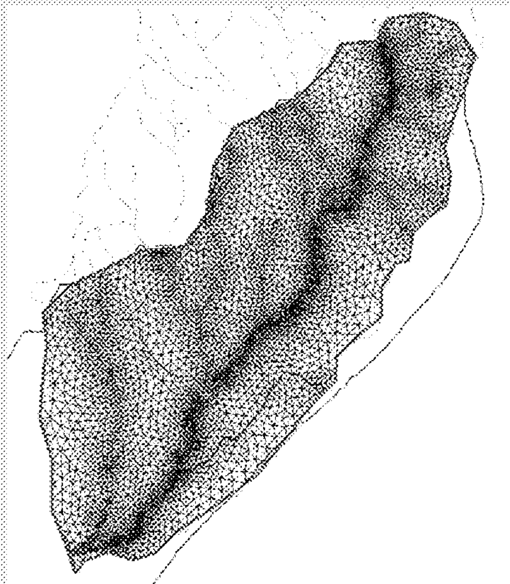
"...Lower ACF River Basin Study"



- Simulation of transient, growing-season pumpage and stream-aquifer interaction using USGS model MODFE
- Lower ACF River Basin in Georgia and parts of Florida and Alabama

USGS

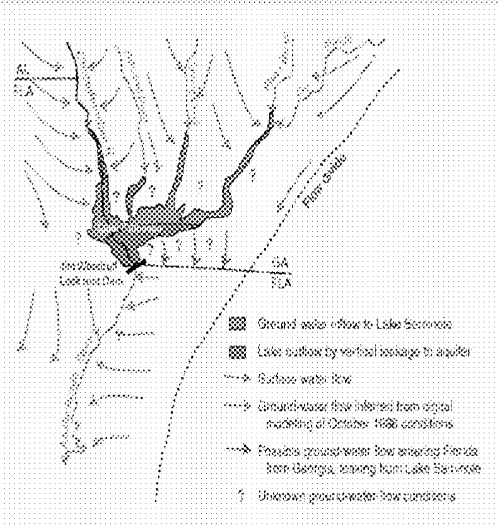
"...Lower ACF River Basin Study"



- MODFE results used to assist basinwide water management
  - Flint River Basin Water Development and Conservation Plan, State of Georgia
  - Permitted ground-water withdrawals
  - Irrigate/no-irrigate decision each Spring (Flint River Drought Protection Act)

USGS

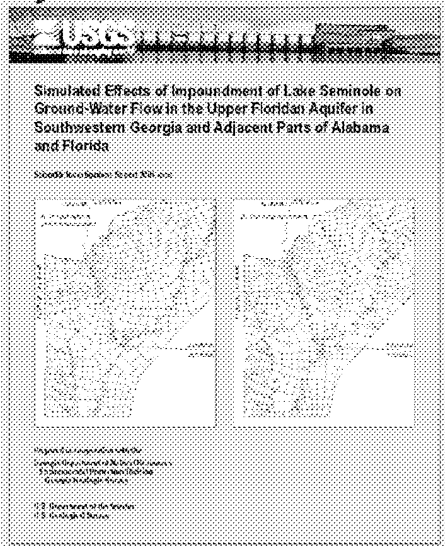
Lake Seminole Study, 1999-2004, Georgia EPD cooperative investigation



- Estimate ground-water flow from Ga. to Fla.
- Pre- and Post-impoundment conditions
- Assess likelihood of sinkhole collapse and lake drainage
- Evaluate effect of lake's existence on regional water resources

USGS

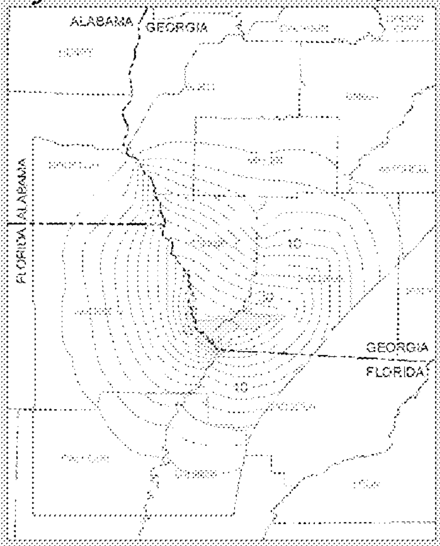
Lake Seminole Study Products–
Jones and Torak, SIR 2004-5077



- MODFE simulations
  - Pre- and post-impoundment conditions
  - State-Line flow, Ga.-Fla.-Ala
- Identified ground-water inflow to lake and lake leakage to Upper Floridan aquifer

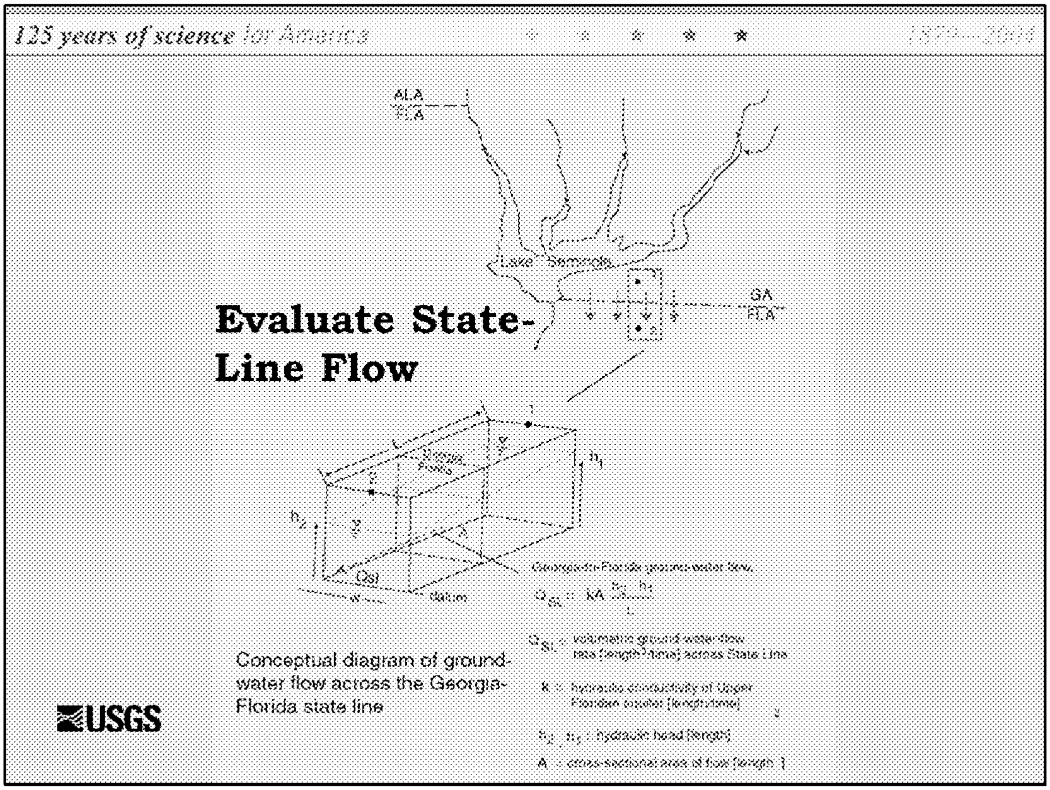
USGS

Lake Seminole Study Products– Jones and Torak, SIR 2004-5077–*continued*

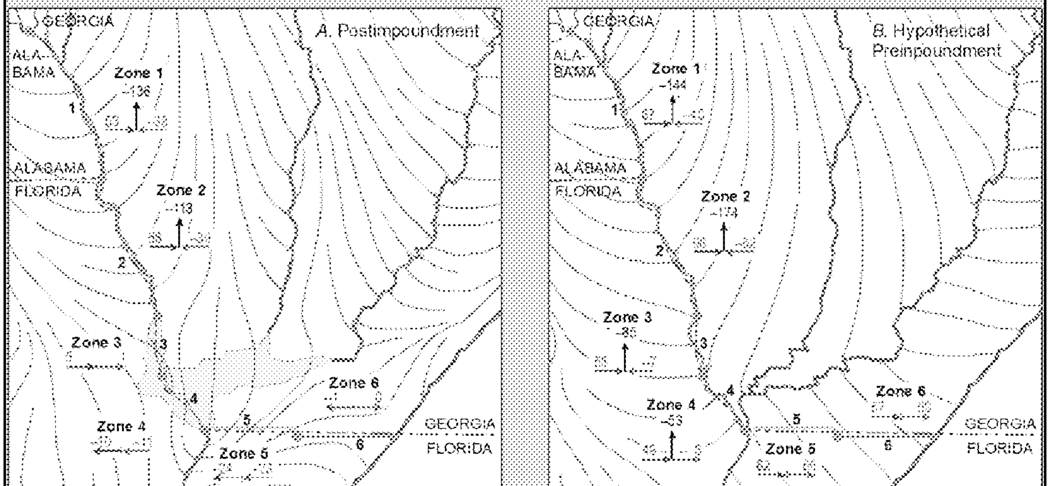


- Simulated ground-water-level increase resulting from impoundment of Lake Seminole
- Evaluated changes to ground-water and surface-water resources caused by the lake

USGS


125 years of science
ALA
FLA
Lake Seminole
GA
FLA
Evaluate State-
Line Flow
h_1
h_2
Qsl
Georgia-to-Florida ground-water flow,
$Q_{SL} = KA \frac{h_2 - h_1}{L}$
Conceptual diagram of ground-
water flow across the Georgia-
Florida state line
USGS

Model Results: State-Line Flow



All models are wrong.
Some models are useful.

George Box, economist, 1978

Exhibit 62

Flint River Basin Regional Water Development and Conservation Plan

March 20, 2006

Georgia Dept. of Natural Resources
Environmental Protection Division

Carol A. Couch
Director

Robin John McDowell
Plan Coordinator

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Flint River Basin Regional Water Development and Conservation Plan

Introduction

The Flint River Basin Water Development and Conservation Plan ("the Plan") was initiated in October 1999 in response to a prolonged drought, increased agricultural irrigation in southwest Georgia since the late 1970's, and scientific studies that predicted severe impacts on streamflow in the Flint River Basin (FRB) due to withdrawals from area streams and the Floridan aquifer. As defined in Georgia statutes, regional water development and conservation plans "shall promote the conservation and reuse of water within the state, guard against a shortage of water within the state, promote the efficient use of the water resource, and be consistent with the public welfare of the state." (O.C.G.A. 12-5-31(h)). Similar language is found in the Groundwater Use Act, which also requires plans to address "sustainable use".

Because agricultural irrigation uses the largest volume of water in the FRB, this report and its recommendations will focus on irrigation and farm-use withdrawal permits. The report summarizes the most recent and comprehensive scientific studies available on water use and hydrogeology in the FRB, evaluates impacts of water use on the stream-aquifer system and stream ecology of the lower FRB, and establishes EPD permitting actions based on stakeholder-developed recommendations. The Plan covers agricultural water use in the entire FRB, but the focus is on the lower Flint River Basin where agricultural water use is greatest.

The FRB extends from Hartsfield-Jackson International Airport in Atlanta to the southwestern corner of Georgia (Fig. 0.1). It's southern half lies within the Coastal Plain physiographic province. South of Dooly County, the Flint River and some of its tributaries are in hydraulic connection with the Floridan aquifer, and either receive water from the aquifer or lose water to it depending on the head difference between the streams and the aquifer. This area where the streams are connected to the Floridan aquifer is known as "Subarea 4 of the Apalachicola-Chattahoochee-Flint (ACF) Basin", and it includes part of the lower Chattahoochee watershed as well as a narrow strip on the eastern edges of the Ochlockonee and Suwannee River Basins. For simplicity, these areas adjacent to Subarea 4 will be included in all subsequent discussions of the FRB.

Water use in the FRB below the fall line is dominated by agricultural irrigation, which comprises as much as 90% of the water used during the April-September growing season. Overall, a total of approximately 160,000 acres are irrigated from surface-water throughout the FRB and approximately 403,000 acres from Floridan aquifer wells in Subarea 4 (Fig. 0.1). Approximately 250 mgd are used basin wide by agricultural surface-water users in July (the peak month) of a typical irrigation season during a drought year, and approximately 950 mgd are withdrawn from Floridan aquifer irrigation wells at the peak of the irrigation season during a drought year. These withdrawals reduce streamflow, and can degrade aquatic habitat in the lower FRB. Surface-water withdrawals have a more direct effect than do ground-water withdrawals.

Permitted municipal and industrial (M&I) water withdrawals throughout the FRB total approximately 120 mgd on a monthly average from surface-water sources (mostly north of the fall line), 88 mgd from aquifers other than the Floridan aquifer, and 30 mgd from the Floridan aquifer in Subarea 4. Actual surface water use in 2004 was approximately 50 mgd (Table 5.3). M&I withdrawals from the Floridan are equivalent to 3% of the agricultural ground-water use, and thus will not be discussed in any further detail in this report. The permitted withdrawals of consumptive M&I surface-water usage is offset by water returned as treated wastewater, which in the Flint River Basin is approximately 126 mgd. Actual discharges are much smaller. Thus, the amount of M&I water removed and not returned from the Flint River and its tributaries is only a fraction of the total consumptively used surface-water withdrawals. Because agriculture irrigation uses the largest volume of water in the FRB, this report and its recommendations will focus on irrigation and farm-use withdrawal permits.

Surface-water and ground-water withdrawals in the FRB can have a negative impact on stream ecology and the viability of sensitive aquatic species. Specifically, the FRB is home to species of federally protected freshwater mussels, whose populations have been declining precipitously since the early 1900's. During the drought of 1999-2002, mussel populations in many locations in the lower FRB were substantially reduced, especially in parts of Ichawaynochaway Creek and Spring Creek sub-basins (Fig. 0.1). Significant declines in surveyed mussel populations also occurred in other watersheds, mostly inside Subarea 4. The lower FRB also contains a significant population of gulf striped bass. In summer, the bass take thermal refuge in the cooler water of the blue-hole springs that are dependent on adequate ground-water discharge. Ground-water withdrawals from the Floridan aquifer may lower aquifer head, reduce spring flow, and deprive the bass of thermal refuge.

Two hydrologic modeling systems were used to evaluate the effects of ground-water and surface-water (irrigation) withdrawals on streamflow in the lower FRB. The ground-water model was developed by the U.S. Geological Survey (USGS) and modified by EPD, and simulates flow between the Floridan aquifer and streams that are hydraulically connected to the Floridan aquifer. The streamflow modeling system, Hydrologic Simulation Program Fortran (HSPF), was used by EPD to simulate the extent to which streamflow is affected by surface-water irrigation withdrawal and reduced base flow as calculated by the USGS ground-water model. HSPF modeling included a series of "future scenario" analyses that imposed irrigation stresses on likely rainfall patterns for the next 50 years.

Simulated streamflow was modeled under a range of scenarios and compared with in-streamflow criteria. It is thought that sustaining flows that meet the criteria will prevent further harm being done to the freshwater mussels. The criteria against which flows were compared were developed by the U.S. Fish and Wildlife Service (USFWS) for regulated and un-regulated streams in the ACF basins (U.S. Fish and Wildlife Service, 1999). EPD used the specific criteria for unregulated streams since the Flint River downstream from Lake Cheehaw is free flowing, and the major tributaries have no significant impoundments. The criteria for unregulated streams evaluate the one-day minima that occur in a stream, the frequency with which those minima occur, and the duration of low flows. According to these criteria, the lowest daily flows, the lowest quartile of all daily flows, and the median of all daily low flows are not to be exceeded a certain number of times, and they are not to be exceeded for prescribed lengths of time.

Food and fiber production is a major aspect of the FRB economy, and the majority of agricultural production is for human consumption. Combined with processing facilities, direct manufacturing, and the agriculture-related trade sector, the total impact of agriculture in the lower FRB is approximately $5.8 billion, or 34% of the regional economy. Irrigation greatly increases crop yields, crop quality, crop diversity, gross and net return, land values, etc., and thus plays a major role in the regional economy. Economic models were used to estimate the economic impact of reducing irrigation in parts of the FRB.

The Flint River Basin Regional Water Development and Conservation Plan incorporates recommendations developed by a Stakeholder Advisory Committee (SAC) during a year-long series of public meetings, and technical findings of several sound-science studies conducted in the Basin. The Plan is presented in three parts following an executive summary. Part I contains a summary of technical findings and the permitting actions EPD will take to manage agricultural water use in the Flint River Basin. Part II consists of a description of the Stakeholder process and the recommendations adopted by the SAC for permitting strategies and regulatory reform. Part III consists of detailed discussions of the sound-science studies and the technical foundations of the Plan. Appendices containing detailed hydrologic and geologic data follow Part III.

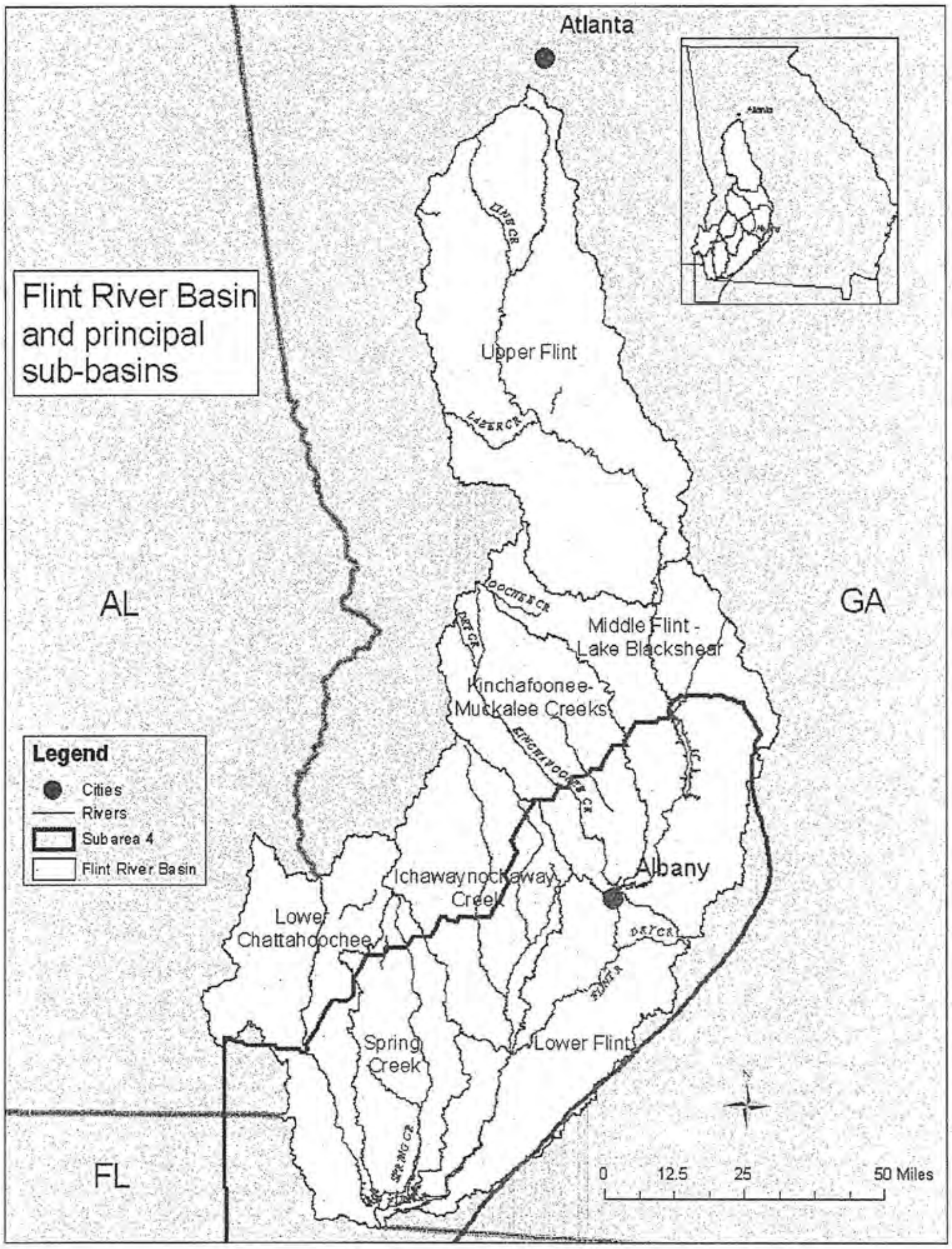


Figure 0.1: The Flint River Basin and sub-basins

Acknowledgements

The Flint River Regional Water Development and Conservation was developed through the close cooperation of many different people and organizations. Specifically, the members of the Stakeholder Advisory Committee (SAC) and their associates in southwest Georgia have been instrumental in developing and maintaining an excellent working relationship among themselves and with the Georgia EPD. The hard work and dedication of the SAC were essential to completion of this Plan. The Stakeholder Advisory Committee consisted of the following southwest Georgia residents:

Mr. James Lee Adams, Mitchell County
Mr. Lucius Adkins, Farmer, Baker County
Mr. Dan Bollinger, Director, Southwest Georgia RDC
Mr. John Bridges, Farmer, Decatur County
Mr. Charles (Chop) Evans, Farmer, Macon County
Mr. Thomas C. Chatmon, Jr., CEO Albany Tomorrow, Inc.
Mr. Vince Falcione, Proctor and Gamble, Albany
Mr. Tommy Gregors, Georgia Wildlife Federation, Albany
Mr. Hal Haddock, Chairman, Flint River Water Council and Farmer, Early County
Mr. Chris Hobby, City Manager, Bainbridge
Mr. Bubba Johnson, Farmer, Mitchell County
Mr. John Leach III, Developer, Lee County
Ms. Janet Sheldon, Southwest Georgia Water Task Force, and Georgia Conservancy
Mr. Mike Newberry, Farmer, Early County
Mr. Kim Rentz, Farmer, Decatur County
Mr. Steve Singletary, GSWCC Commissioner and Farmer, Early County
Mr. Marcus Waters, Crisp County Power, Cordele
Mr. Jimmy Webb, Farmer, Calhoun County
Mr. Joe Williams, Farm owner, Crisp County

Technical Advisory Committee (TAC) meetings were held mostly at the J.W. Jones Ecological Research Center at Ichauway as a result of the generosity of Dr. Lindsay Boring and the Robert W. Woodruff Foundation. The TAC provided the scientific foundation of the Plan through extreme diligence and hard work. The TAC consisted of the following scientists and technical experts:

Dr. Steve Golladay. J.W. Jones Ecological Research Center, Baker County
Mr. Mike Harris, DNR Wildlife Resources Division, Non-Game Section, Social Circle
Mr. Kerry Harrison, Cooperative Extension Service, Tifton
Mr. Woody Hicks, J.W. Jones Ecological Research Center, Baker County
Dr. James Hook,, University of Georgia/NESPAL, Tifton
Dr. Mark Masters, Director, Flint River Water Policy and Planning Center
Mr. Rob Weller, DNR Wildlife Resources Division, Fisheries Section, Albany
Mr. Joe Williams, Farm owner, Crisp County
Mr. Rad Yeager, Superintendent, Stripling Irrigation Research Park, Camilla

SAC meetings were very ably facilitated by staff from the Fanning Institute of the University of Georgia under contract with EPD. The facilitators kept the meetings, and thus the entire process, on track for more than a year. The facilitators were:

Mr. Dennis Epps, University of Georgia Fanning Institute
Ms. Courtney Tobin, University of Georgia Fanning Institute
Ms. Louise Hill, University of Georgia Fanning Institute

This document was written by a variety of people; specifically, Sections 5.3 and 5.4 on municipal and industrial permitting in Georgia were written by Bill Frechette and Kevin Farrell of the Georgia EPD; Sections 6.2 and 6.3 on surface water models and scenario impact evaluation, and Appendix I were written by David Hawkins of the Georgia EPD; Section 8 (Economic Status of the Flint River Basin) was written by Dr. Mark Masters, Director of the Flint River Planning and Policy center; Section 9 (Water Conservation in the Flint River Basin) was written by Alice Miller-Keyes of the Georgia EPD); the remainder of the document was written and assembled by Rob McDowell of the Georgia EPD.

Flint River Basin Regional Water Development and Conservation Plan

PART I: SUMMARY OF TECHNICAL FINDINGS AND EPD PERMITTING ACTIONS

The authority of the Georgia Environmental Protection Division (EPD) to develop and implement water development and conservation plans is provided in the Water Quality Act (O.C.G.A. 12-5-31(h)) and the Groundwater Use Act (O.C.G.A. 12-5-96(e)). This Plan sets forth how EPD will conduct management of agricultural water use and permitting in the Flint River Basin. The goals of the Plan, as defined by statute, are to promote conservation and reuse of water, guard against a shortage of water, promote the efficient use of the water resource, manage the water resources of the Flint River Basin such that they are used sustainably, and to be consistent with the public welfare. All farm-use permits issued after adoption of this Plan by the Director of EPD must, under Georgia law, be consistent with the Plan.

A. Summary of technical findings

The technical findings summarized below are accompanied by page and section references from Part III of the Flint River Basin Regional Water Development and Conservation Plan. Detailed information, analyses, and discussion may be found at those referenced sections.

1. Timing and volume of agricultural irrigation are extremely variable, and vary based on local rainfall distribution and other weather phenomena, crop type and planting date, soil conditions, and growers experience and preferences. However, for the Flint River Basin as a whole, large-scale crop irrigation typically starts in April and lasts through September. During that time, irrigation usage typically reaches a maximum in June, July, or August (Section 5.2).

2. Agricultural withdrawals from the Floridan aquifer decrease base flow to streams that are in hydrologic connection with the Floridan aquifer. However, depending on the nature of the connection between streams and the aquifer, groundwater withdrawals in some parts of the Basin reduce stream flow more than in other parts. There are 6 major sub-basins in the Flint River Basin, and these sub-basins can be divided into smaller watersheds. In some watersheds, computer models of stream-aquifer relations indicate that groundwater withdrawals from the Floridan aquifer have almost no effect on stream flow. Elsewhere, groundwater withdrawals have a more direct effect and decrease baseflow by a significant percentage of the total baseflow reduction in a sub-basin. In other words, groundwater withdrawals in some small watersheds account for most of the total baseflow reductions for the whole sub-basin. Withdrawals from surface water affect stream flow more directly than do groundwater withdrawals (Section 6.1; Appendix II).

3. Since extensive development of irrigation in the lower Flint River Basin, drought-year low flows are reached sooner and are lower than before irrigation became widespread. Furthermore, low-flow criteria established by the U.S. Fish and Wildlife Service designed to protect aquatic habitats are not met more frequently and for longer periods of time since development of irrigation. These data provide the clearest evidence that agricultural irrigation compounds the effect of climatic drought on stream flow in the Basin. This effect is magnified during droughts, and is minimal during normal to wet years (Section 6.3; Section 7; Appendix I).

4. Of the six sub-basins in the Flint River basin, Spring Creek sub-basin has the greatest density of irrigation. It also exhibits a very close connection between the Floridan aquifer and surface water. Statistical studies of stream discharge and biological studies of endangered fresh-water mussels indicate that Spring Creek

sub-basin has exceeded its safe yield in terms of farm-use withdrawals (Section 5.2; Section 6.1; Section 7.2).

5. A review of historical stream flow data indicate that 7Q10 flow used by EPD to set current permit discharge limits in the Flint River basin was based on pre-1970 data. Since then, extensive development of irrigation, combined with severe droughts, has caused post-1970 7Q10 flows to be lower. This implies that water quality standards may be violated more frequently if point and non-point-source loadings are not reduced, or if permitted water withdrawals reduce stream flows below quantities necessary to maintain water quality standards (Section 6.3.3; Appendix I).

6. If, under the Rules for Flint River Drought Protection (Chapter 391-3-28) irrigation withdrawals are reduced by 20% in those sub-basins with the greatest risk of experiencing irrigation-induced low flows, stream discharges that will prevent stream drying and harm to endangered fresh-water mussels will likely be sustained (Section 6.3).

B. EPD permitting and water resource management actions

1. Moratorium lifted.

The permit moratorium on new farm-use permits from the Floridan aquifer in Subarea 4 is hereby lifted according to permitting actions listed below. For purposes of implementing these actions and restrictions, three categories of smaller (HUC-12) watersheds are identified. These categories are: Capacity Use Areas, Restricted Use Areas and Conservation Use Areas (Figs. 0.2-0.5). Existing limits and restrictions on new withdrawal permits from the Floridan aquifer and surface waters will continue in Capacity Use areas after issuance of all Letters of Concurrence for applications in the 'backlog'. However, Floridan aquifer withdrawal permits will be issued if an individual farm straddles the divide between a Capacity Use Area and Restricted or Conservation Use Area.

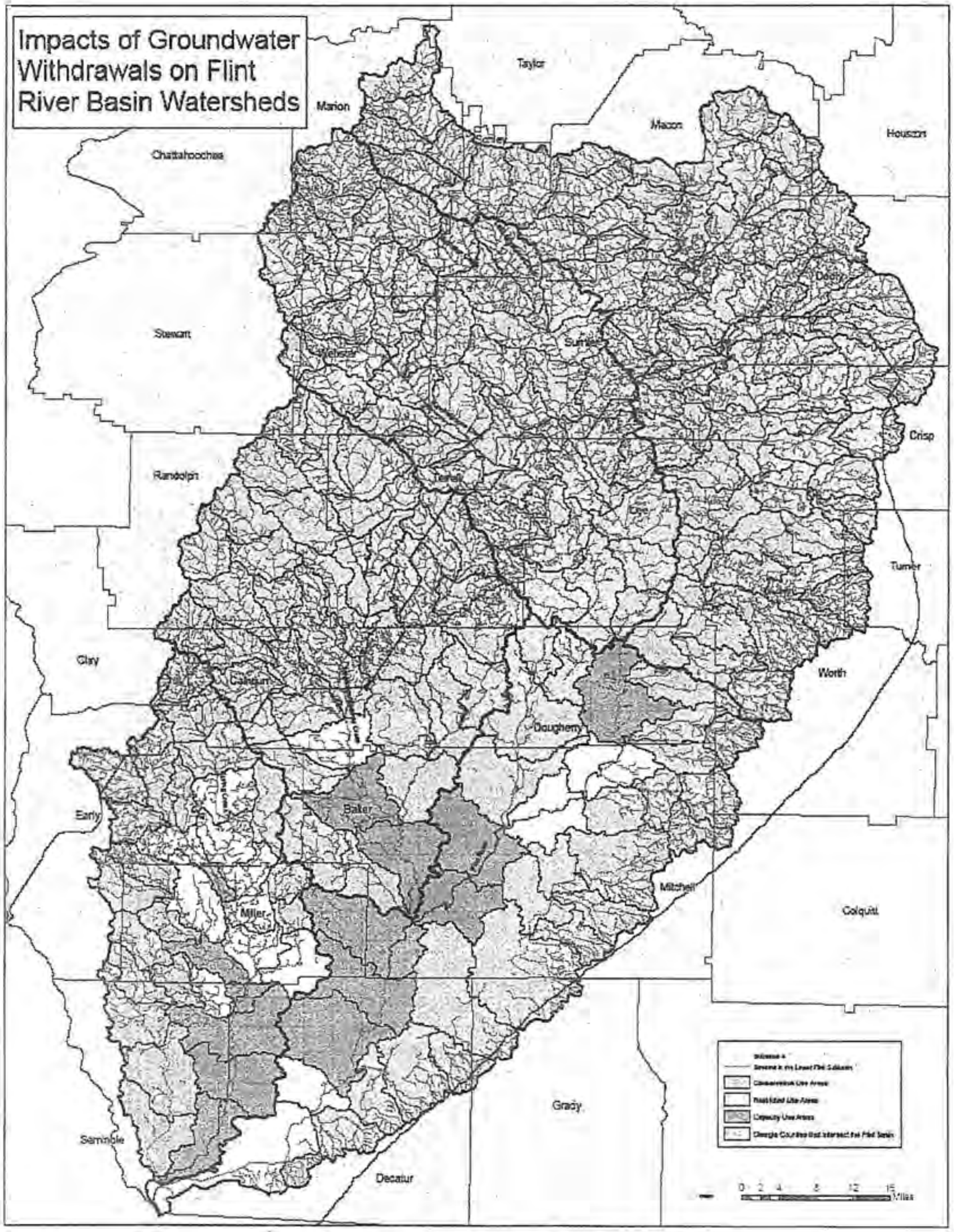


Figure 0.2. Classification of HUC-12 watersheds in the lower Flint River Basin.

(a) **Capacity Use Areas**: Those watersheds in Spring Creek sub-basin (Fig. 0.4) in which hydrologic models indicate decreased baseflow of more than 5 cfs in any month of a drought year, and more than 10 cfs in Ichawaynochaway Creek sub-basin (0.3), are hereby termed Capacity Use Areas, in which irrigation use from the Floridan aquifer is at the maximum permittable capacity. In the Lower Flint River sub-basin (Fig. 0.5), Capacity Use Areas are defined as those watersheds in which baseflow is reduced by more than 30 cfs in any month of a drought year (Section 6.1, Appendix II). Capacity Use Areas are shown in red on the accompanying map.

(b) **Restricted Use Areas:** Those watersheds in Spring Creek sub-basin (Fig. 0.4) in which hydrologic models indicate decreased baseflow of 1-5 cfs in any month of a drought year, and 1-10 cfs in Ichawaynochaway Creek (Fig. 0.3), are hereby termed Restricted Use Areas, in which additional irrigation must be restricted in order to prevent the watershed from becoming a Capacity Use Area. In the Lower Flint River sub-basin (Fig. 0.5), Restricted Use Areas are defined as those watersheds in which baseflow is reduced by 3-30 cfs (Section 6.1, Appendix II). Restricted Use Areas are shown in yellow on the accompanying map.

(c) **Conservation Use Areas**: Those watersheds in the Spring Creek and Ichawaynochaway Creek sub-basins (Figs. 0.3-0.4) in which hydrologic models indicate decreased baseflow of less than 1 cfs in any month of a drought year, and less than 3 cfs in the Lower Flint River sub-basin (Fig. 0.5; Section 6.1, Appendix II), are hereby termed Conservation Use Areas. Conservation Use Areas are shown in green on the accompanying map.

The designation of Capacity Use, Restricted Use, and Conservation Use areas is based on current understanding of hydrogeology and current irrigation practices in the lower Flint River Basin. These designations may change as irrigation patterns and amounts change, or as computer modeling of the stream-aquifer relationship improves.

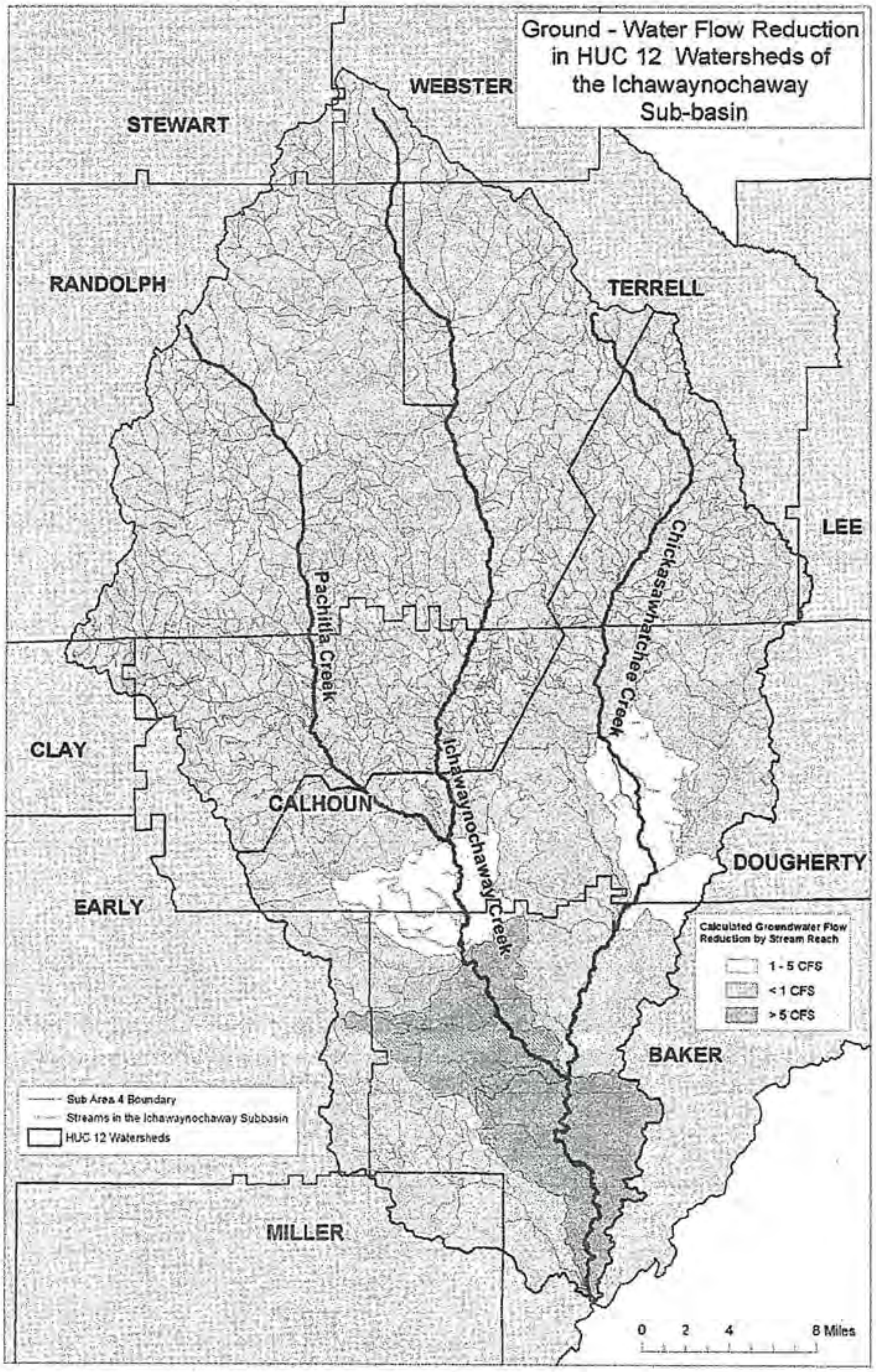


Figure 0.3. Classification of HUC-12 watersheds in the Ichawaynochaway Creek sub-basin.

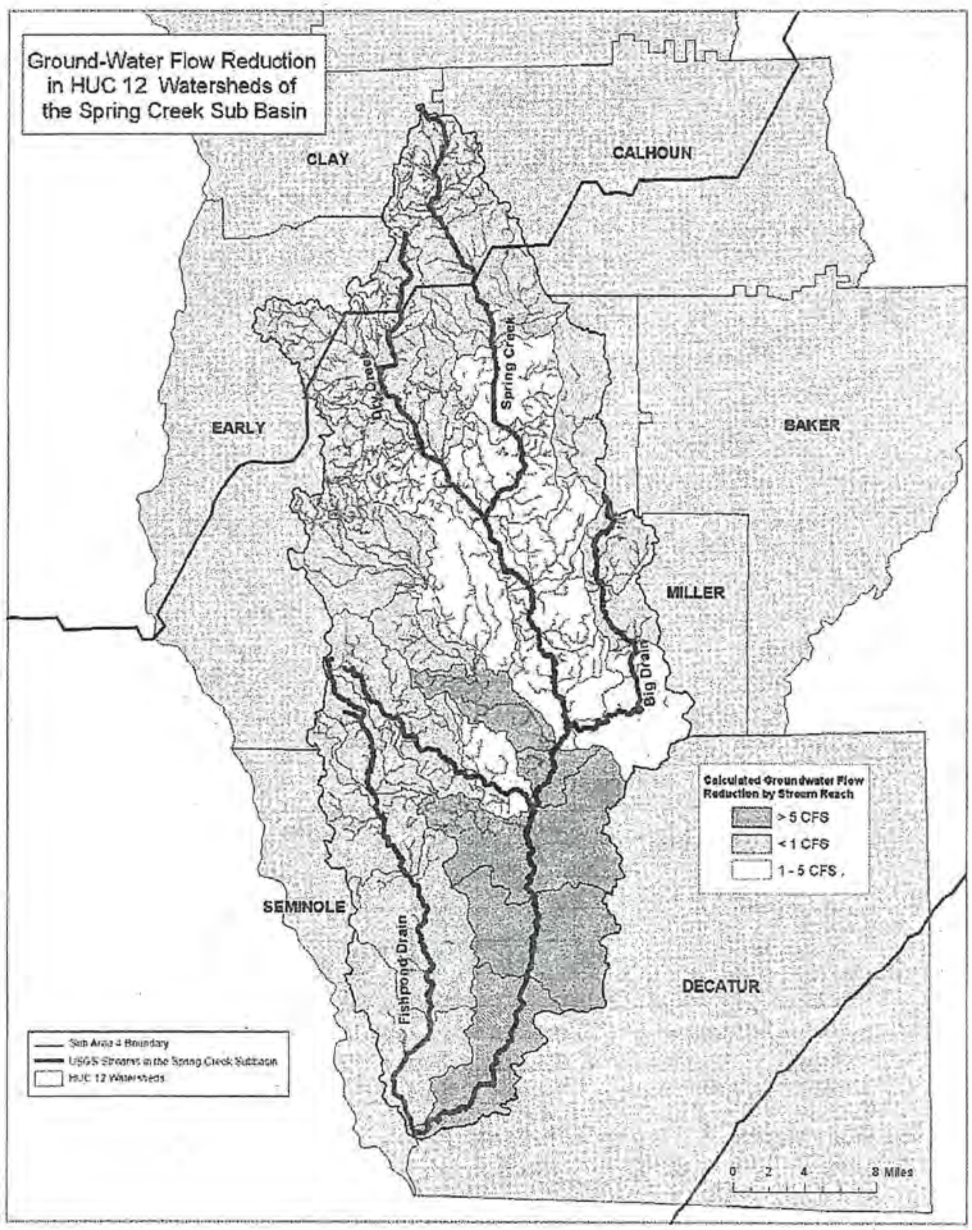


Figure 0.4. Classification of HUC-12 watersheds in the Spring Creek sub-basin.

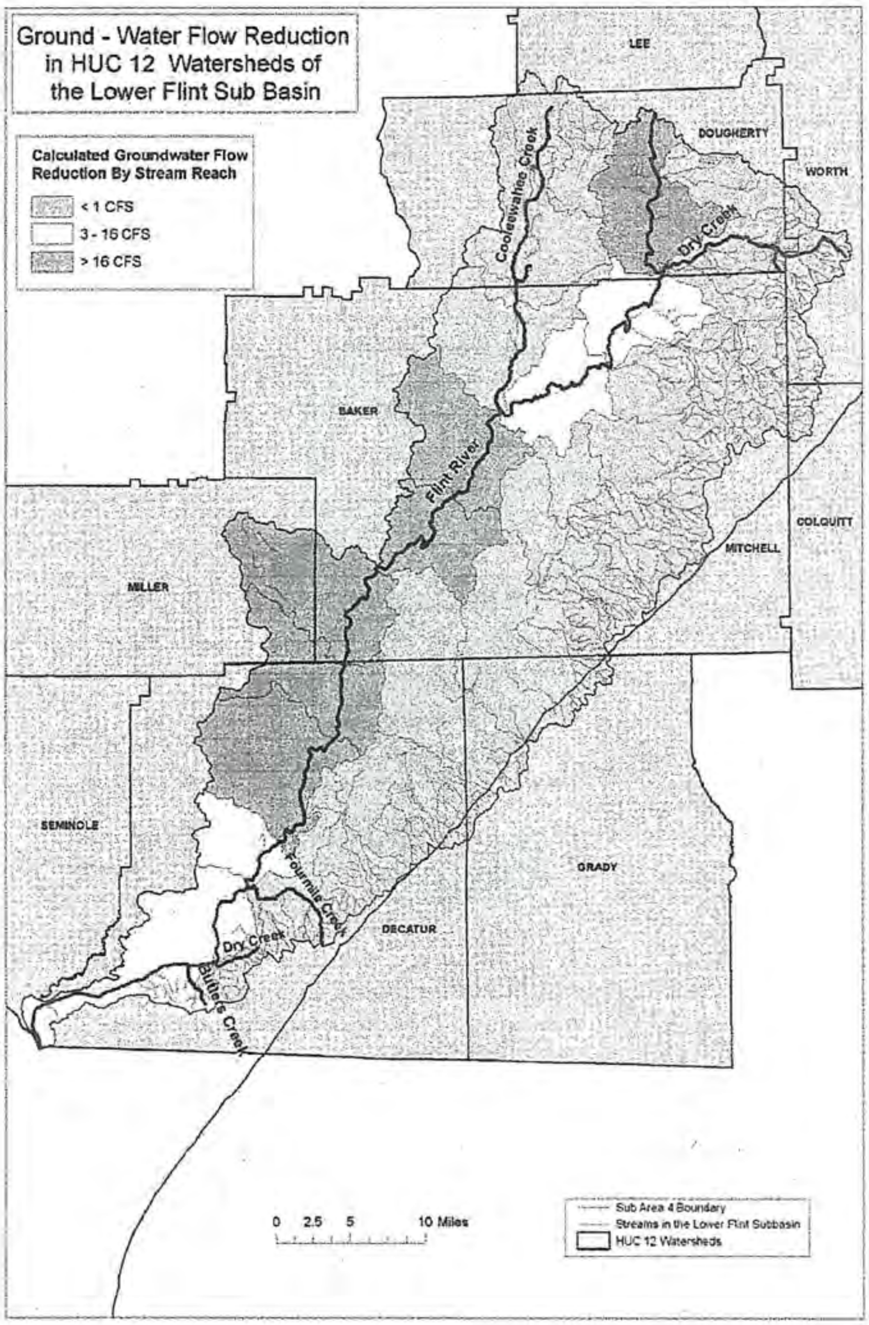


Figure 0.5. Classification of HUC-12 watersheds in the Lower Flint River sub-basin.

2. Sub-basin management.

The largest scale on which water management and permitting decisions will be based will be a sub-basin level corresponding to the USGS HUC-8 designation. Where necessary, and/or where data are available, permitting and management decisions will take into account site-specific conditions and local stream impacts down to a HUC-12 watershed scale. The HUC-8 sub-basins in the Flint River Basin are:

A. Upper Flint

B. Middle Flint

C. Kinchafoonee-Muckalee Creeks

D. Lower Flint

E. Ichawaynochaway Creek

F. Spring Creek

A map of the Flint River Basin showing these sub-basins and smaller (HUC-12) watersheds accompanies this document. Permitting decisions in these sub-basins will be based on the proposed volume of water to be pumped, surface-water and ground-water connections as determined by USGS and EPD groundwater modeling studies, the calculated impact of existing withdrawals on stream flows, the calculated impact of each proposed withdrawal on stream flow, and the presence of endangered or threatened species in each sub-basin.

3. Processing the pending (backlog) permits

The goals of the Plan, combined with the need to protect drought-year flows, will require a much more careful evaluation of farm-use permit applications than before the plan was initiated. Because of the large number of permit applications (1134) held in abeyance since December 1999 (i.e., the 'backlog'), EPD cannot process and issue all letters of concurrence or a withdrawal permit before the 2006 April-October growing season. After the 'backlog' applications have all been evaluated according to this Plan, applicants in the Flint River Basin should expect a much shorter response time of approximately 30 days.

(a) For all groundwater permit applications held in abeyance during the permit moratorium which began on December 1, 1999, EPD will evaluate them in the following order:

(1) Groundwater applications for wells in Conservation Use Areas, starting with the earliest ones received before October 23, 1999, the date of the announcement of the permit moratorium.

(2) Groundwater applications for wells in Restricted and Capacity Use Areas, starting with the earliest ones received before October 23, 1999, the date of the announcement of the permit moratorium.

(3) All other groundwater applications received <u>after</u> October 23, 1999, the date of the announcement of the permit moratorium.

(b) For surface water permit applications held in abeyance during the permit moratorium which began on December 1, 1999, EPD will evaluate them in the following order:

(1) Surface water applications for wells in Conservation Use Areas, starting with the earliest ones received before October 23, 1999, the date of the announcement of the permit moratorium.

(2) Surface water applications for wells in Restricted and Capacity Use Areas, starting with the earliest ones received before October 23, 1999, the date of the announcement of the permit moratorium.

(3) All other surface water applications received <u>after</u> October 23, 1999, the date of the announcement of the permit moratorium.

4. Requirements for pending & new farm permit applications

EPD received more than 1500 permit applications after the Plan was announced on October 23, 1999. This was approximately 5 times the normal rate of application submission, suggesting that many post-October 23 applications were duplicates of existing applications or permits, or speculative applications. Subsequent inquiries by EPD have shown this to be true for many applications.

(a) For all permit applications, EPD will require proof of ownership or a lease before a letter of concurrence is issued to the applicant. EPD will also require accurate latitude/longitude coordinates of a proposed well or surface-water pump location to be included on the permit application. This data will be used to determine whether the proposed well will impact adjacent users, nearby springs, or streams.

(b) All farm-use permit applicants who have not yet received a permit must demonstrate a need for a farm-use permit as defined by the Water Quality Act (O.C.G.A. 12-5-31 (b)(3)) and the Groundwater Use Act (O.C.G.A. 12-5-92 (5.1)).

5. Application Evaluation Procedures

In considering new and existing applications for both ground-water and surface-water withdrawals, EPD will evaluate the effect of the proposed water use on existing users and stream flow, and issue the new permit in such a way that the new permit will not adversely impact stream flow or the water available to existing users. Maps of the watersheds and sub-basins described below accompany this document. Specific permitting strategies are:

(a) All Floridan aquifer irrigation well permits will be evaluated to determine the calculated radius of influence of a proposed well and its relationship to the radii of influence of nearby Floridan aquifer wells on adjacent property. This evaluation may result in EPD issuing a permit for less than the applicant requested; requiring the applicant to use a different aquifer than requested; requiring the applicant to drill in a different location to avoid overlapping radii of influence or unacceptable impacts on an adjacent stream or surface-water withdrawal point.

(1) EPD will no longer issue permits for proposed Floridan aquifer irrigation wells that are within 0.25 miles of another user's well, unless hydrogeologic evaluation indicates that the proposed well would not cause or contribute to excessive drawdown in the other user's well. Excessive drawdown can be defined as that which would lower the static, non-pumping water level in an existing well by more than 5% of the intake depth recorded in EPD's permit database. For example, if the pump intake for an existing irrigation well is at a depth of 100 feet below ground surface, calculated drawdown from a new well could not the lower water level by more than 5 ft in the existing well. If hydrogeologic evaluation indicates excessive drawdown, the location of the proposed well may need to be changed, an alternative aquifer may need to be used, or the permitted pump capacity decreased, for the well to be permitted.

(b) Regardless of their location, all proposed Floridan aquifer wells will be evaluated for their impact on nearby streams and springs. Proposed irrigation wells that would draw from the Floridan aquifer within 0.5 miles of an in-channel spring or stream which exhibits a demonstrable connection with the Floridan aquifer will not be permitted if hydrogeologic evaluation indicates that, for the stream reach closest to the proposed well, the well would lower the Floridan aquifer water level to below the average stream stage or decrease the discharge of the spring. Streams to which this action applies are identified in Part III of the Plan.

6. Conservation provisions for farm permits

Irrigation water conservation measures are encouraged for all existing farm permittees. For new or modified permits issued after January 1, 2006 conservation measures will be a condition of the permits.

(a) In those watersheds termed Capacity Use Areas, all permits issued or modified after March 1, 2006 for irrigation systems supplied by wells withdrawing from the Floridan aquifer or any surface water will be required to: 1) have end-gun shut off switches installed to prevent irrigation of non-cropped areas by center pivot systems, 2) be maintained to prevent and repair leaks, 3) have pump-safety shutdown systems installed on center-pivot systems that will stop water delivery in the event of an irrigation system malfunction; 4) have rain-gage shut-off switches for traveler, solid set, or drip irrigation systems.

(b) In those watersheds termed Restricted Use Areas, all permits issued or modified after March 1, 2006 for irrigation systems supplied by wells withdrawing from the Floridan aquifer or any surface water will be required to: 1) have end-gun shut off switches installed to prevent irrigation of non-cropped areas by center pivot systems, 2) be maintained to prevent and repair leaks; 3) have pump-safety shutdown systems installed on center-pivot systems that will stop water delivery in the event of an irrigation system malfunction; 4) have rain-gage shut-off switches for traveler, solid set, or drip irrigation systems.

(c) In those watersheds termed Conservation Use Areas, all irrigation systems supplied by newly permitted wells drawing from the Floridan aquifer or any surface water will require end-gun shut off switches to prevent irrigation of non-cropped areas, and maintenance to prevent and repair leaks.

(d) Those sub-basins for which no detailed hydrologic modeling has yet been completed; specifically, Middle Flint and Kinchafoonee-Muckalee Creek Sub-basins, are termed Conservation Use Areas. All newly permitted wells drawing from the Floridan aquifer or any surface water will require, as a condition of the permit, end-gun shut off switches such that non-cropped areas are not watered, and maintenance to prevent and repair leaks. All proposed Floridan wells will be evaluated for their impact on existing nearby wells, streams, and springs.

(e) EPD will conduct random site inspections to ensure that all new permittees are following their required conservation plans. In the event that a required conservation plan is not being followed, the permittee will be issued a notice of violation requiring correction of the problem and compliance with the conservation plan in such a way that irrigation during a growing season is not interrupted. However, the violator will have his or her permit suspended if the problem is not corrected before the next growing season.

7. Drought season provisions for farm permits

Although low-flow protection plans will be used to protect flow in Spring Creek and Ichawaynochaway sub-basins, all permittees are encouraged to adopt conservation measures to assure that flow, and hence irrigation, continue as long as possible into drought seasons. Innovative new technologies or appropriate existing technologies adopted from other regions, particularly arid or drought-prone regions, will also be considered when they show potential to reduce seasonal water withdrawal amounts.

(a) For all newly issued surface water withdrawal permits in Spring Creek and Ichawaynochaway sub-basins, low-flow protection plans will be a standard permit condition. These plans will require a complete cessation of irrigation from the newly permitted source when discharge at the withdrawal location falls below 25% of the average annual discharge as calculated at that point based on the period of record for the nearest downstream continuous flow gauge, plus a prorated portion of the permitted amount of downstream users. Permittees subject to this requirement will be notified by EPD via e-mail and phone call when irrigation from the newly permitted source must stop; however, permittees are required to abide all permit conditions regardless of whether or not they have been contacted by EPD. During times of drought, EPD will be conducting regular inspections to ensure compliance with all low-flow protection plans.

8. Public Notice

Because all new withdrawals may potentially affect other water users in the basin, and because it is in the public's interest that EPD act expeditiously on farm-use permit applications, EPD will publicize via the Internet the name of current and new farm-use permit applicants, the location of their proposed withdrawal (county, latitude/longitude, stream name), proposed pump capacity, date of application, and the date a letter of concurrence was issued. No other information will be provided, such as address, phone number, or acreage to be irrigated. Posted information will be available on EPD's web page at http://www.gaepd.org/Documents/index_water_wrb.html. Upon issuance of a farm-use permit, the applicant's name and all information associated with the application will be removed from publication.

9. Revocation of duplicate or unactivated permits

All existing permits known to be duplicate permits will be revoked by EPD. All existing permits for which initial use of water has not commenced will be considered null and void, and revoked. Upon revocation of a permit, the permittee will have 30 days to appeal the revocation, and will be required to provide proof that the permit was being used for farm use prior to the date of issuance of the notice of revocation. If the permit was in use at the time of the notice of revocation, the permittee may continue to irrigate during the appeal process.

10. Conservation and Development Plan revisions

The Flint River Regional Water Development and Conservation Plan will be re-evaluated every 3 years based on new scientific information such as groundwater models or model results, observed impacts on endangered species in the lower Flint River Basin, observed impacts on other threatened species in the lower Flint River basin to ensure that no more species become endangered, regional economic impact of the current version of the Plan, and other criteria as determined by scientists and stakeholders in the Flint River Basin.

PART II: STAKEHOLDER PROCESS AND RECOMMENDATIONS FOR REGULATION OF AGRICULTURAL WATER WITHDRAWALS

SECTION 1: BACKGROUND AND FRAMEWORK

1.1 Explanation and justification for the Flint Basin Plan

The Flint River Basin (Fig. 0.1) is one of 14 major river basins in Georgia. Water use in the Flint River Basin (FRB) is dominated by agricultural irrigation, although municipalities and industry use more than 10% of the water withdrawn. Because agricultural irrigation uses the largest volume of water in the FRB, this report and its recommendations will focus on irrigation and farm-use withdrawal permits. The report summarizes the most recent and comprehensive scientific studies available on water use and hydrogeology in the FRB, evaluates the impacts of water use on the stream-aquifer system and stream ecology of the lower FRB, and makes stakeholder-developed recommendations for water resource management and farm-use irrigation permitting. The two-part recommendations are for management under existing statute, and recommendations for management that require statutory and regulatory reform. These recommendations are submitted for the consideration of the Director to be incorporated into the FRB Water Development and Conservation Plan.

The FRB Water Development and Conservation Plan, hereafter referred to as "the Plan", was announced on October 23, 1999, by the Director of the Georgia EPD. The Plan was initiated in response to several factors: 1) a drought that began in summer of 1998; 2) an increasing number of farm-use permit applications from southwest Georgia; and 3) hydrogeologic studies performed by the U.S. Geological Survey (USGS) that predicted a severe impact on the Flint River and some of its tributaries under conditions of drought and increased irrigation withdrawals from the Floridan aquifer (Torak and McDowell, 1996). These studies, when combined with surface-water flow models used by EPD, suggested that parts of the Flint River could cease flowing for brief periods of time during severe droughts. In order to prevent this, the Director announced the Plan under the authority of the statutes that regulate water withdrawal permitting in Georgia: the Water Quality Act and the Ground-water Use Act. Specifically, the Water Quality Act states:

> "In evaluating any application for a permit for the use of water for a period of 25 years or more, the director shall evaluate the condition [i.e. quantity] of the water supply to assure that the supply is adequate to meet the multiple needs of the citizens of the state as can reasonably be projected for the term of the permit **and ensure that the issuance of such permit is based upon a water development and conservation plan** for the applicant or for the region. Such **water development and conservation plan** for the applicant or for the region shall promote the conservation and reuse of water within the state, guard against a shortage of water within the state, promote the efficient use of the water resource, and be consistent with the public welfare of the state." (Official Code of Georgia Annotated 12-5-31(h)).

Similar language is found in the Ground-water Use Act:

> (e) The division or a party designated by the division may develop a **regional water development and conservation plan** for the state's major aquifers or any portion thereof. Such plan shall include water development, conservation, and sustainable use and shall be based on detailed scientific analysis of the aquifer, the projected future condition of the aquifer, and current demand and estimated future demands on the aquifer. Upon adoption of a regional plan, all permits issued by the division shall be consistent with such plan. The term of any permit and all provisions of any permit for which an application for renewal is made prior to the completion of any regional plan shall be extended at least until the completion of such plan. (OCGA 12-5-96(e)).

These statutes state that any permit issued for more than 25 years, such as farm-use permits, must be in accordance with a regional development and conservation plan, which EPD is authorized to initiate. Initiation of such a plan allows EPD to suspend issuance of permits until plan completion, after which all permits must be consistent with the plan. Thus, as part of the FRB Flint, and because agricultural water use is by far the largest use category in the FRB, the Director announced that EPD would not process farm-use permit applications for Floridan aquifer withdrawals in Subarea 4 and for surface-water withdrawals in the entire FRB after November 31, 1999. This moratorium would remain in place until the FRB Plan is adopted by EPD.

1.2 Agricultural permit and permit application trends

With the exception of the period 1988-91, the number less than 200 applications for farm use permits have been received annually by EPD for all regions of the State. During 1988-91, the early years of the permitting process ,more than 15,000 permit applications were received by EPD (Fig. 1.1). The vast majority of these permits were issued by 1992. The rate of application submittal rapidly declined until 1999 when the pending permit moratorium was announced (Fig. 1.2).

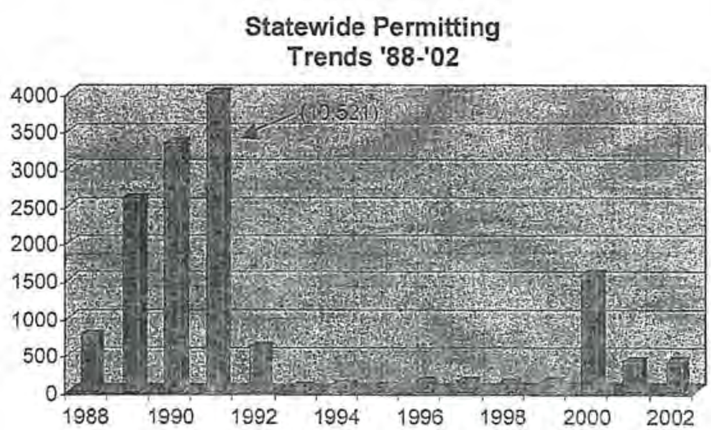


Figure 1.1: Statewide Permitting Trends 1988-2002 (REF)

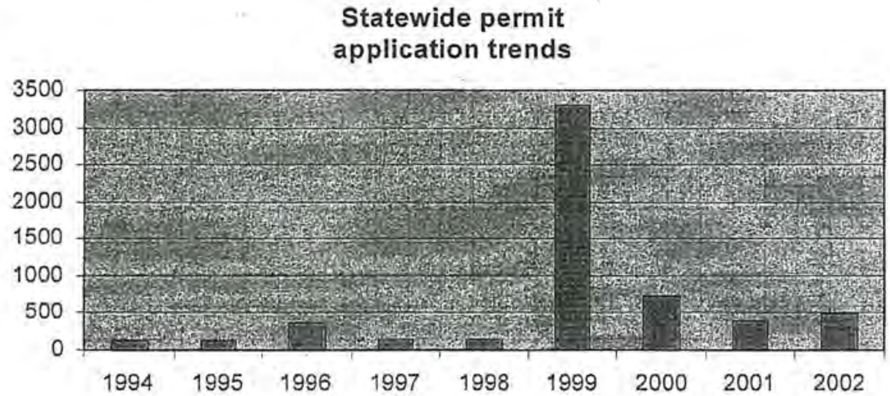


Figure 1.2: Statewide permit application trends

In early 1999, increased public concern over irrigation use in southwest Georgia, combined with the worsening drought, caused a gradual increase in the rate at which permit applications were submitted. In October 1999, it was announced that applications received after November 31, 1999, would not be reviewed until after the moratorium was lifted. This caused a drastic jump in the number of applications submitted, such that more than 1,500 were submitted during November 1999 (Fig. 1.3).

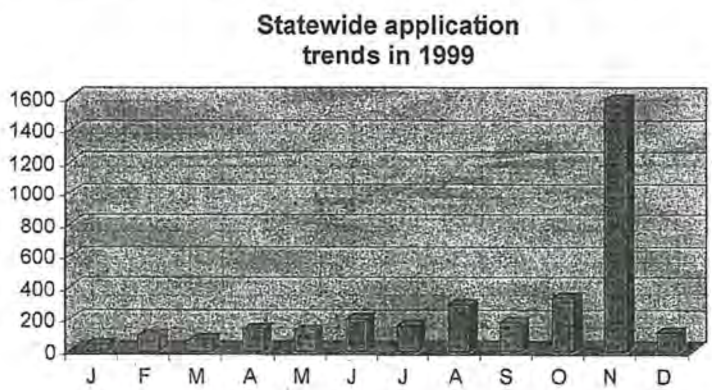


Figure 1.3: Statewide Application Trends in 1999 (REF)

Beginning in February 2000, DNR staff attempted to locate all un-permitted irrigation wells for which permit applications had been submitted. This work was mostly completed by November 1, 2000, by which time more than 800 irrigation wells and 100 surface-water pumps had been located and permitted. Applications for the remaining ("backlogged") proposed wells and surface-water pumps (Table 1.1) are filed with the EPD Agricultural Permitting Unit, and will not be processed until adoption of the Plan.

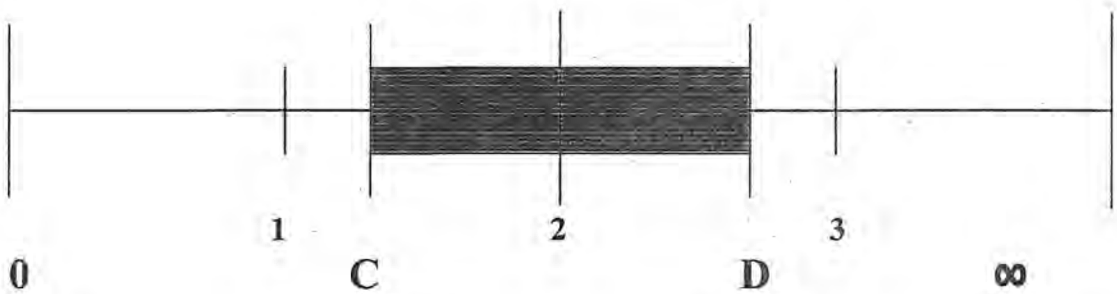
Acreage associated with permit application backlog				
Sub-basin	gw acres using Upper Floridan	surface-water irr_acres	well to pond acres	well to pond acres using Upper Floridan
Lower Flint	18506	1308		
Ichawaynochaway Ck.	6477	10040		
Spring Creek	14197	2708	350	200
Kinchafoonee-Muckalee creeks	5138	7732		
Middle Flint	19949	8701	785	128
Total Flint	64267	30489	1135	328

Table 1.1: Backlog acreage

1.3 Conservation, development, and ecologic sustainability

An important aspect of this Plan is to consider the economic impact of any actions that would affect agricultural irrigation. Agriculture in Georgia is a $9.9 billion industry, and $1.9 billion of that is derived from agriculture in southwest Georgia (McKissick, 2004a). However, although the success of Georgia farmers is dependent on a sustainable supply of water for irrigation, unlimited use of our water resources could result in a decline of farming in southwest Georgia due to degradation of the resource. Conversely, the FRB is ecologically significant due to its unique geology, long stretches of unimpeded flow, and threatened or federally protected and endangered aquatic species. Water use in southwest Georgia cannot occur at a level that would destroy or irreparably harm the ecological health and diversity of the FRB.

A balance must thus be struck between acceptable water use that allows for robust economic activity and strong communities, and acceptable conservation that maintains the aquatic health of the water resources. This balance can be expressed as a range of conditions that would exist between total conservation and total exploitation:



KEY:

0 = Pre-development; no artificial withdrawals from stream-aquifer system.
C = Maximum allowable conservation: Economic use of resource is entering optimal phase, perhaps because of farm and business synergies, but ecological impacts may begin to be noticed. Risks of low flows or competition among water users are beginning, probably noticeable in drought years or in selected locations in the basin.
D = Maximum allowable development: Ecological impacts become intolerable (illegal). No further gains in economics from water development are possible because declines in regional revenues would occur from low flows in streams or low water tables; i.e., businesses and other economic interests would avoid the region; competition among users becomes intolerable (illegal because some users are denied the right of reasonable use); or flows could not meet federally imposed state-line or other limits.
∞ = Complete development, no water or land available; ecological impacts severe and irreversible.

Shaded area represents acceptable working range of conditions in which conservation and development are reasonably balanced. Economically and ecologically, permitting cannot create a situation outside of this area.

1 = Potential existing situation where more permitting can occur; practical level of conservation not yet reached
2 = Potential existing [optimal] situation where conservation and development are balanced
3 = Potential existing situation where permitting has exceeded resource limits

Figure 1.3: "Decision line" displaying the range of management options in the FRB

1.3.1 Factors affecting maximum possible development

Maximizing withdrawals for economic purposes may have a number of legal restraints that could impose an upper limit on resource development. These factors include:

1. The Federal Endangered Species Act (ESA): The FRB is home to five species of endangered freshwater mussels. Certain provisions of the ESA could result in legal penalties against Georgia should permitted withdrawals cause extirpation or extinction of those mussel species. In addition, lawsuits from environmental groups could precipitate court action against Georgia and permitted water users.
2. The Federal Clean Water Act: Waters of the State in Georgia must be "fishable" and "swimable", implying that a certain level of chemical and ecological health is required by law. This not only applies to wastewater discharges and non-point source pollution in the FRB, but to ensuring that there is sufficient stream flow to assimilate wastewater discharges and to maintain minimum water quality standards.
3. Georgia is a "regulated **riparian***" state, which provides property owners with "reasonable use" of the waters flowing on, past, or under their property. However, Georgia laws also demand that all potential users be guaranteed that use, meaning that a resource cannot be so over-allocated that legitimate, potential users (such as new farmers) do not have sufficient water for their needs.
4. The State must consider "injury to public health, safety, or welfare which would result if...[aquifer] impairment were not prevented or abated', and the extent of any injury or detriment caused or expected to be caused to other water users, including public use" (O.C.G.A. 12-5-96). Thus, a maximum level of water withdrawals that caused injury or detriment would expose Georgia and existing users to legal action from the affected parties. This could include homeowners,

farmers, municipalities, recreational outfitters, or anyone adversely affected by excessively lowered ground-water or surface-water levels.

1.3.2 Factors limiting maximum conservation

Similar to scenarios of maximum development, there are limiting factors that would prevent, or at least argue against, complete conservation with little to no use of the water resources. These include:

1. The economic vitality of southwest Georgia communities is closely tied to the availability of water for irrigation. Those counties with the highest farm gate values and land prices are those where irrigation water is inexpensive and abundant. Those counties of the FRB with the lowest farm gate values are typically those that do not have abundant and inexpensive ground-water resources. Denying or severely limiting access to water for farm use would have a devastating economic impact on the entire region.
2. Georgia is a major agricultural producer in the nation and world. Most Georgia agriculture is in the Coastal Plain, south of the fall line, where water is abundant. Georgia's ability to compete in agricultural markets of all scales would be [1]severely affected if access to water were limited. This applies to in-state production as well, as producers in parts of south Georgia with no restrictions on water use would quickly out-produce FRB producers.
3. Crop patterns are driven by markets and subsidy structures. In southwest Georgia, the principal crops are cotton, corn, and peanuts. However, changing market trends are favoring an increase in vegetable and green industry production that require more water per acre than the more common crops.
4. The availability of water for irrigation is a financial consideration in determining property values, loan rates, profit margins, and other measures of economic security for farmers and their communities.
5. Georgia's legal structure provides for the reasonable use of the State's water resources through an EPD-managed riparian system. Denying, severely limiting,

* Terms that are defined in the Glossary appear in bold face the first time they are used

or reducing water use in southwest Georgia would require substantial legislative changes to Georgia's legal codes. This includes 'grandfathered' farm use permits, whose access to reasonable use have few restrictions on the amount of water that can be legally used. Denying the reasonable use of water to any eligible user would be a violation of State law, and be grounds for legal action against the State (or more likely, EPD).

1.4 The Flint River Drought Protection Act

In response to the drought conditions of 1999-2000, the Georgia General Assembly created and passed into law the Flint River Drought Protection Act (O.C.G.A. 12-5-540). This Act created a program providing financial incentives to ensure that certain irrigated agricultural lands in the lower FRB are temporarily not irrigated during times of declared severe drought, thus protecting stream flow and aquatic species in the **basin** (391-3-28-.01).

The Flint River Drought Protection Act, and the Rules for the Flint River Drought Protection (391-2-28), developed a voluntary auction process by which permitted surface-water irrigators would be paid on a per-acre basis to not irrigate land covered by a specific surface-water permit during the entire calendar year after the "drought protection auction". Funds for this auction were provided by the Georgia Environmental Facilities Authority and were taken from the "One Georgia" fund.

Eligible auction participants were those with permitted farm-use surface-water withdrawals on perennial streams anywhere in the FRB. Because of the uncertainties surrounding the effects of ground-water withdrawals on stream flow, ground-water permittees were not eligible for participation.

A drought protection auction would be initiated only if the Director of EPD issued a severe drought declaration. On or before March 1 of each year, the Director must issue a prediction as to whether severe drought conditions are expected during that calendar year.

If ground-water and surface-water levels are below a critical threshold and climate predictions indicate an impending drought, then the Director makes a severe drought declaration. An auction must be completed before March 22 of that year.

To participate in the drought protection auction, eligible permittees must have an auction certificate that verifies the permit number and the acres irrigated by that permitted withdrawal. EPD must verify both the permit and its associated acreage. EPD must also determine the amount of irrigated acreage to be removed from irrigation, based on an acceptable flow to be maintained in the Flint River or targeted stream basin during the drought year. The Director of EPD shall determine the auction process by which irrigators offer to voluntarily retire their irrigated acreage in return for payment. (391-2-28).

To date, there have been two drought protection auctions: in 2001 and 2002. The first auction in 2001 proceeded by an iterative and interactive process by which participants submitted blind bids for a per acre price that they wanted in order to suspend irrigation. A linked computer network installed at auction stations throughout the lower FRB accomplished this. Auction participants submitted sealed bids, which were entered into the computer network and tabulated on a central computer in Atlanta. The Director of EPD was able to monitor the incoming bids, and either accepted or rejected bids based on the total cost of all bids presented. Participants whose bids were rejected could re-submit bids during subsequent rounds until the Director had accepted enough bids to remove the targeted amount of acreage from irrigation.

This auction process was very inefficient. Bids submitted over five auction rounds ranged from \$75/-800/acre, but the highest bids were rejected. The average accepted bid was \$135/acre. More than 33,000 acres were taken out of irrigation for a total cost of approximately \$4.5 million.

In 2002, a second auction was held due to continuation of the drought. To maximize efficiency and still remove enough acres from irrigation, the Director announced that

EPD would not accept bids above $150/acre, but that all bids below that would be accepted up to the point where sufficient acreage was taken out of irrigation. In the sole auction round, bids ranged from $74-145/acre. The average bid was $128/acre. In this auction, more than 41,000 acres were removed from irrigation at a cost of $5.3 million.

Both auctions had problems and inconsistencies. Eligibility requirements for the first auction stipulated only that a participant have a surface-water permit with no requirement of recent use. Consequently, a significant number of participants were paid for very marginal or long-fallow land, or for land that is not typically irrigated (e.g. trees). This loophole was closed for the second auction such that only those permit holders who had irrigated in the previous three years could participate. However, both auctions failed to remove the highest water use cropland from irrigation. This probably reflects the low cost per acre of accepted bids, and their inability to compensate for loss of a high-value crop. Regardless of the auctions shortcomings, other states such as Washington, Kansas, and Nebraska are either considering or enacting drought auctions similar to Georgia's.

SECTION 2: RECOMMENDED WATER RESOURCE MANAGEMENT AND PERMITTING STRATEGIES FOR THE FLINT RIVER BASIN

2.1 General Plan goals

As defined in Georgia statutes, water development and conservation plans shall:

- promote the development, conservation, reuse, and sustainable use of water within the state;
- guard against a shortage of water within the state;
- promote the efficient use of the water resource;
- be consistent with the public welfare of the state;
- be based on detailed scientific analysis of the aquifer, the projected future condition of the aquifer, and current demand and estimated future demands on the aquifer.

Upon adoption of a regional plan, all permits issued by the division shall be consistent with such plan.

2.2 Stakeholder Advisory Committee

The Flint River Basin Regional Water Development and Conservation Plan was developed in two parts: the legal and technical background upon which policy recommendations could be made, and a set of policy recommendations consensually developed by a stakeholder advisory committee (SAC). The Flint River SAC was developed by EPD in the fall of 2004 with the goal of having qualified representatives of the following major groups:

- Farmers and agribusiness representatives
- Southwest Georgia Water Task Force
- Flint River Regional Water Council
- Local elected officials
- Utilities, municipal authorities
- Sportsmen, anglers, boaters
- Georgia Conservancy, League of Conservation Voters, etc.

To this end, EPD was successful in developing a broadly based Committee representing most of these major constituencies. The FRB Stakeholder Advisory Committee SAC held their first meeting in Albany, GA on September 12, 2004. The Committee is comprised of the following southwest Georgia stakeholders:

Mr. James Lee Adams, farmer and developer, Mitchell County
Mr. Lucius Adkins, farmer, Baker County
Mr. Dan Bollinger, Director, Southwest Georgia RDC
Mr. John Bridges, farmer, Decatur County
Mr. Charles (Chop) Evans, farmer, Macon County
Mr. Thomas C. Chatmon, Jr., CEO Albany Tomorrow, Inc.
Mr. Vince Falcione, Proctor and Gamble, Albany
Mr. Tommy Gregors, Georgia Wildlife Federation, Albany
Mr. Hal Haddock, Farmer, Miller County
Mr. Chris Hobby, City Manager, Bainbridge
Mr. Bubba Johnson, Farmer, Mitchell County
Mr. John Leach III, Developer, Lee County
Ms. Janet Sheldon, Georgia Conservancy
Mr. Mike Newberry, Farmer, Calhoun County

Mr. Kim Rentz, Farmer, Decatur County
Mr. Steve Singletary, Farmer and GSWCC Commissioner
Mr. Marcus Waters, Crisp County Power, Cordele
Mr. Jimmy Webb, Sunbelt Expo 2005 Farmer of the Year
Mr. Joe Williams, Farm owner, Crisp County

The roles of the SAC were to: 1) help craft a Plan for water withdrawal in the FRB that takes conservation and economic development into consideration; 2) deliver concrete recommendations, reached by consensus, that would best manage the water resources of the FRB under *existing* statutes and regulations; 3) deliver recommendations, also reached by consensus, for regulatory and statutory reforms that would fulfill the broader goals of a regional development and conservation plan.

A central aspect of the Plan is the current moratorium on farm-use permits in the FRB. The immediate goal of the Plan is to develop water management strategies that would allow the Director of EPD to lift the moratorium while protecting the resource during droughts. However, the FRB Plan will necessarily be a significant part of the developing Statewide Water Plan, and in many ways will be a model for it. Specifically, the FRB Plan illustrates the importance of long-term stakeholder development, the need for a transparent stakeholder involvement process, and the importance of comprehensive scientific studies upon which to base water management strategies.

Agricultural production is the biggest category of water use in the FRB. Agriculture is the economic engine of southwest Georgia, and water is the basis of successful agriculture. For this reason approximately half of the SAC members are farmers. Because the most immediate aspect of the Plan was the permit moratorium, and because agriculture will continue to be the biggest water user for the foreseeable future, most of the SAC's focus was on agricultural water use, management, and regulation.

2.3 Technical Advisory Committee

To assist the SAC in understanding the complex scientific issues involved in development of the Plan, a Technical Advisory Committee (TAC) was created by EPD in mid-2004. Experts were selected who were specialists in their field and who were familiar with the geological, bio-ecological, agricultural, and economic issues specific to southwest Georgia. The TAC consisted of the following individuals:

Dr. Steve Golladay, J.W. Jones Ecological Research Center, Baker County
Mr. Mike Harris, DNR Wildlife Resources Division, Non-Game Section, Social Circle
Mr. Kerry Harrison, Cooperative Extension Service, Tifton
Mr. Woody Hicks, J.W. Jones Ecological Research Center, Baker County
Dr. James Hook, University of Georgia/NESPAL, Tifton
Dr. Mark Masters, Director, Flint River Planning and Policy Center,, Albany
Mr. Rob Weller, DNR Wildlife Resources Division, Fisheries Section, Albany
Mr. Joe Williams, Farm owner, Crisp County
Mr. Rad Yeager, Superintendent, Stripling Irrigation Research Park, Camilla

Throughout the development of the Plan, the TAC provided scientific and analytical perspectives in review of the Plan and of EPD's models and conclusions. When called upon they provided independent data and analysis to EPD. They also prepared and presented information on the stream hydrology, hydrogeology, ecology, water use patterns and economy of the region to EPD and the SAC. However, their participation in the planning process should not be construed as an endorsement of the FRBP by the individual TAC members or by the institutions they represent. The TAC met approximately every month between SAC meetings, in order to address questions raised by the SAC at previous meetings and to discuss the on-going studies that were incorporated into this report.

2.4 Guiding principles of the Stakeholder Advisory Committee

The SAC consistently expressed a number of consensus opinions, which guided their deliberations and discussions of permitting and water management strategies. These opinions are listed and described below. Some relate to managing the water resources of the FRB under existing regulations, while others were expressions of how the Basin should be managed.

1. The lifting of the permit moratorium may mean that future water users may adversely impact existing users. Therefore, future permitting should be done such that existing users are protected.

2. Secure access to irrigation water is critical to the viability of a farm. Banks are reluctant to provide affordable financing if the availability of irrigation is unpredictable. Permitting strategies should not allow a reliable, predictable, and permitted water source to be interrupted.

3. Farmers in Georgia are currently practicing some of the most effective water conservation measures available. The steadily rising price of operating an irrigation system makes wasting water economically impractical. Further conservation, mandatory or otherwise, should be economically feasible to the farmer, and should convey positive conservation messages about Georgia farmers.

4. A number of other States, such as Florida, Texas, Kansas, and Nebraska manage water through regional water management districts. The structure of these varies, as does the level of regulatory authority, but the general concept of decentralized and local water management should be a future consideration for Georgia.

2.5 Conclusions about "safe yield"

As described in Sections 5 and 6 of this report, the combination of the USGS ground-water model, HSPF stream models, historical stream flow, and simulated future stream flow scenarios compared to Federal in-stream flow guidelines demonstrated that the amount of water *currently* withdrawn for agricultural irrigation in drought years increases both the magnitude and duration of low flows in streams of the FRB, thus further harming endangered species and potentially limiting the amount of water available for all users. This is especially true in Spring Creek and Ichawaynochaway Creek sub-basins. Expanded drought-year irrigation will worsen this situation; reduced irrigation will improve it. *In normal to wet years, the impact of irrigation on stream flow and aquifer* *levels is insufficient to jeopardize the availability of water for all users, or to jeopardize stream ecology.* Therefore, some parts of the lower FRB have already reached their drought-year "safe yield". If more withdrawal permits are issued for the lower FRB, more aggressive drought-year management strategies will have to be employed, mostly (if not exclusively) in those parts of the Basin closest to their safe yield.

2.6 EPD regulatory limits

As the permitting agency for farm water use in Georgia, EPD must meet the following current statutory requirements, described in more detail in Section 1 of this report:

1. All legitimate requests for **farm use** permits must be granted in the FRB once the Plan is adopted.
2. The permit moratorium must be lifted upon completion of the Plan.
3. EPD may issue permits for less than the amount requested by the permit applicant.
4. In issuing new permits, EPD may decrease the permitted withdrawal amounts of all other permitted users including "grandfathered" permits.
5. EPD may initiate provisions of the Flint River Drought Protection Act during severe drought years in an effort to maintain critical stream flow.
6. EPD cannot revoke permits for non-use once initial use has commenced.

In this context, and after having been exposed over a period of months to the ground- and surface-water models and their conclusions, the SAC evaluated the existing permitting procedures, for both ground and surface-water permits, with the goal of making consensus recommendations as to how farm-use permitting could resume while protecting existing users and the resource. The results of the SAC discussions, begun at the August 12, 2005, meeting and concluded at the November14, 2005, meeting, are presented here.

2.8 Consensus recommendations for permitting strategies

1. The largest scale on which water management and permitting decisions should be based should be a sub-basin level corresponding to the USGS HUC-8 designation. In the FRB these are:

G. Upper Flint
H. Middle Flint
I. Kinchafoonee-Muckalee Creeks
J. Lower Flint
K. Ichawaynochaway Creek
L. Spring Creek

Permitting decisions in these sub-basins will take into account the water use characteristics, hydrology, geology, surface-water and ground-water interactions, and the ecology unique to each sub-basin. Where necessary, and where data are available, permitting and management decisions should also take into account site-specific conditions and local stream impacts down to a HUC-12 scale.

2. In considering new and existing applications both ground-water and surface-water, the goal of EPD will be to evaluate the effect of the proposed water use on existing users, and issue the new permit in such a way that the new permit will not adversely impact the water available to existing users. This evaluation may result in EPD issuing a permit for less than the applicant requested; requiring the applicant to use a different aquifer than requested; requiring the applicant to drill in a different location to avoid causing drawdown in an existing permitted well or unacceptable impacts on an adjacent stream or surface-water withdrawal point; and imposing more stringent low-flow protection requirements on surface-water users than are currently recommended (such as protecting a flow higher than 7Q10 or other appropriate tabulations of low flow characteristics.)

Because of the variable characteristics of the Floridan aquifer, there may be parts of the FRB in which ground-water withdrawals have no significant impact on nearby users or on stream flow. In these areas, permits should be issued as requested by the applicant as long as all other requirements are met (such as proof of ownership, conservation measures, etc.).

3. Newly issued permits in the FRB (i.e. those issued after January 1, 2006 regardless of when an application was submitted) will require an economically feasible, state-of-the-art conservation plan that reduces the volume of water withdrawn, used, or applied as a condition of the permit. Such plans may include end-gun shut off switches, rain-gauge shut-off systems, and leak repair. Applicants and EPD shall refer to conservation measures recommended by the University of Georgia Cooperative Extension Service or the Georgia Soil and Water Conservation Commission.

In the event that a required conservation plan is not being followed, the permittee will be issued a notice of violation requiring correction of the problem and compliance with the conservation plan in such a way that irrigation during a growing season is not interrupted. However, the violator will have his or her permit suspended if the problem is not corrected before the next growing season.

4. If irrigation is decreased during a drought year by 20% of current use in Ichawaynochaway Creek and lower Flint River sub-basins, critical low-flow criteria will be met. If irrigation is decreased during a drought year in the Spring Creek sub-basin by 20%, it is assumed this will have a beneficial affect on water levels and stream ecology even though critical low-flow criteria may not be met. This will require application of the Flint River Drought Protection Act in such a way that enough irrigated acreage is temporarily converted to dry-land acreage, which can be done either through the voluntary auction process or non-voluntary irrigation suspension with compensation as defined by State law.

5. For new permit applications, EPD will require proof of ownership or a lease before a letter of concurrence is issued to the applicant. EPD will also require accurate

latitudinal/longitudinal, coordinates of a proposed well or surface-water pump location to be included on the permit application.

6. All existing permits known to be duplicate permits will be revoked by EPD. All existing permits for which initial use of water has not commenced will be considered null and void, and revoked.

<u>2.9 Stakeholder recommendations for regulatory and statutory reform</u>

In addition to recommendations for permitting strategies that could be enacted under current statutes and rules, the SAC recognized the need for changes to those statutes and Rules that would result in better management of water resources. Specifically:

1. In order to minimize or eliminate speculative farm-use permit applications, EPD should charge a permit application fee of $250. This money should be dedicated to assisting management of agricultural water use or as an incentive for conservation, and should not be put into the State general fund.

2. For existing permits, those that are 'grandfathered' as defined by the Water Quality Act and Groundwater Use Act should be exempt from being modified in any way in order to provide new users with sufficient water.

3. For declared drought years, the Flint River Drought Protection Act should be modified to allow focus on individual sub-basins, including areas with critical habitats that are host to endangered species:

   a. Upper Flint
   b. Middle Flint
   c. Kinchafoonee-Muckalee Creeks
   d. Lower Flint
   e. Ichawaynochaway Creek

f. Spring Creek

4. Funding for the Flint River Drought Protection Act should be expanded and assured beyond its current limits such funding is available to pay higher per-acre prices for suspension of irrigation. This would allow the State to suspend irrigation on high-water use lands as opposed to marginal farmland; increase the likelihood of taking more land out of irrigation; allow the EPD Director to require non-voluntary suspension of irrigation with fewer challenges; and offset the direct and indirect costs of reducing irrigation.

5. Ground-water users should be included in the FRDPA, at the same payment rates as surface-water users, where the best available science indicates that they would directly impact stream flow.

6. Future permitting decisions, policing, review, etc. should be made at a local level, such as by a regional water management district or authority similar to those operating in other states.

7. The state should consider subsidies for conversion of permits from surface-water to ground-water, as this may be a cost effective way to maintain adequate streamflow in some areas.

8. The state should consider using existing wells or installing and operating wells during extreme droughts to supplement the flow in Spring Creek and other tributaries to maintain streamflow and protect endangered species.

9. The statutory requirement that EPD "shall" issue all new permits should be re-evaluated in order to protect existing users and the resource.

10. Alternatives to issuing permits based on rated pump capacity should be explored.

PART III: TECHNICAL AND STATUTORY BACKGROUND OF PLAN RECOMMENDATIONS

SECTION 3: STATE OF THE BASIN'S NATURAL RESOURCES

3.1 Basin hydrography

The FRB covers approximately 8,460 square miles, and extends 212 miles from Hartsfield-Jackson International Airport to the southwestern corner of Georgia, where it joins with the Chattahoochee River to form the Apalachicola River (Fig. 0.1). The Flint River flows through the Piedmont Province of North America, and at the fall line crosses into the Coastal Plain Province.

The FRB is divided into smaller sub-basins, or watersheds, by the U.S. Geological Survey (USGS). Watersheds of varying sizes are designated as Hydrologic Unit Codes, or **HUC**'s, which is the number of integers in the code. Smaller HUC's have more numbers in their code. For example, the FRB has a HUC-6 designation of 031300. In the FRB, there are six HUC-8 watersheds. These are: Upper Flint, Middle Flint, lower Flint, Kinchafoonee-Muckalee Creeks, Ichawaynochaway Creek, and Spring Creek (Fig. 0.1). Each HUC-8 has definable hydrologic characteristics, and will be treated individually in subsequent discussions of water use, effects of water use, and permitting strategies.

Each HUC-8 can be divided into HUC-10 and HUC-12 watersheds. The latter is the smallest scale designated by USGS. In some cases, depending on HUC-8 hydrology, discussions of water use and permitting strategies will be at the HUC-10 scale. HUC-12 watersheds are very small and their boundaries typically cut through individual farms, and even individual fields. This would make permitting and resource management decisions impractical.

3.2 Rainfall patterns: normal, drought, and long-term trends

Average annual rainfall in the FRB ranges from 48-54 in/yr (Fig. 3.1). Most of this falls between early November and mid-April, although frontal rainfall, convective storms in late spring through fall, and tropical storms can add significantly to annual rainfall totals.

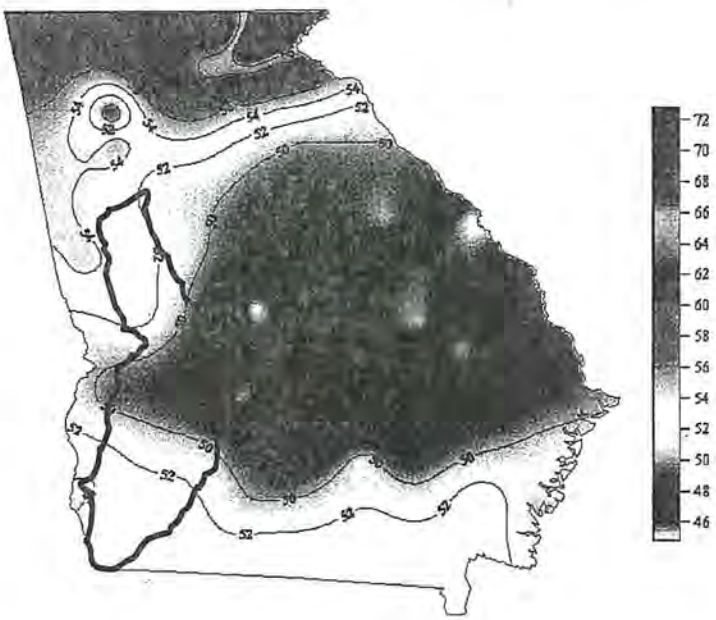


Figure 3.1: Average annual rainfall in Georgia. FRB outlined in black.
(Georgia Automated Environmental Monitoring Network)

During the drought of 1998-2002, rainfall patterns were significantly altered. The spring of 1998 was very wet, but normal seasonal rainfall trends ceased in summer of 1998. Subsequent winter rains did not occur until late winter or early spring of 1999, and were insufficient to make up for previous periods of low rainfall. A cumulative rainfall deficit developed in Georgia that, in some places, exceeded the annual average rainfall for that area (Georgia Automated Environmental Monitoring Network). During the 1998-2002 drought, many streams and aquifer levels reached record lows. Normal rainfall patterns resumed in September 2002, causing the Floridan aquifer in Subarea 4 to recharge fully.

Droughts are normal aspects of Georgia's climate. Since the 1950's there have been several periods of below-average rainfall in southwest Georgia: 1950-57; 1980-82; 1985-89; and 1992-2002 (Barber and Stamey, 2000). A one-year drought in 1968 ranked as the second driest year on record in terms of annual precipitation. (A ranking of years by precipitation can be found in Appendix I). From 1952 to the late 1980's, southwest Georgia had an accumulating rainfall deficit of as much as 60 inches (GAEMN, 2005). In other words, annual rainfall was, over a period of decades, cumulatively less than the average rainfall amount of 52 in. Individual years may have exceeded the annual average, but those years could not overcome the below-average rainfall of prior years. Thus, from 1952 until the late 1970's, southwest Georgia was in a comparatively dry period. In the 1970's, annual rainfall amounts increased, and created a cumulative rainfall surplus that persisted until 1998. From 1998-2003, the cumulative rainfall surplus decreased to near zero (Fig. 3.2). The period from the late 1980's until 1998 corresponds to the rapid and extensive growth of irrigation in the Dougherty Plain.

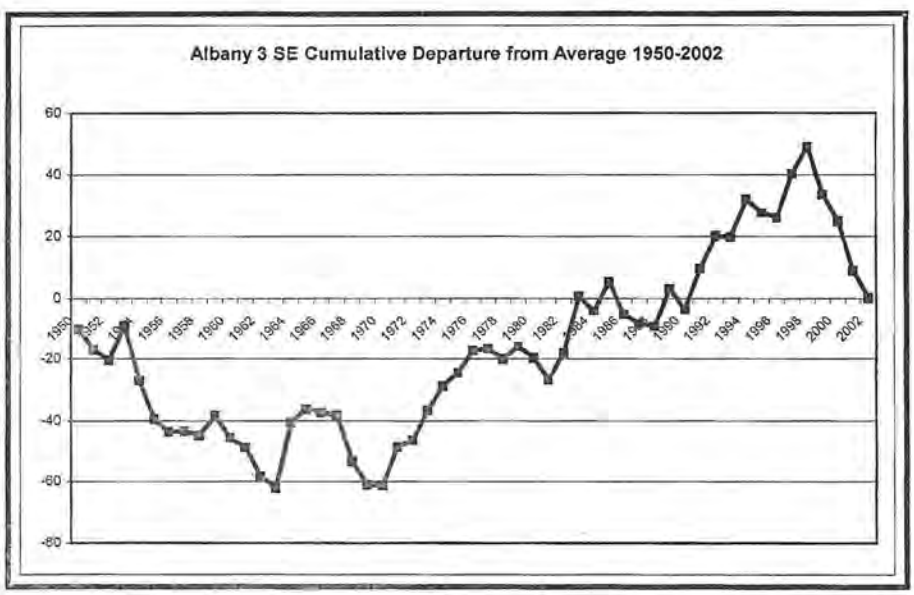
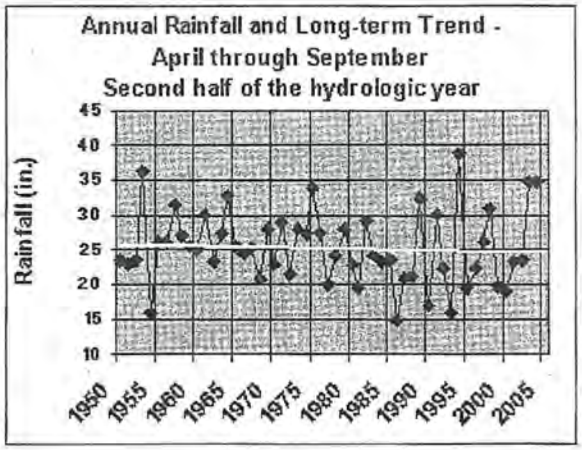


Figure 3.2: Long-term trends in average rainfall at Albany, showing the cumulative departure from average precipitation between 1950 and 2002
(W. Hicks, written communication).

An analysis of monthly rainfall patterns over the same time period indicates that rainfall patterns have been changing slightly. From April to September, which corresponds to the main agricultural growing season, monthly rainfall totals have declined slightly. Conversely, from October through March, rainfall totals have increased slightly. In other words, in addition to the multi-year cumulative deficits and surpluses, summers have been slightly drier and winters have been getting slightly wetter (Hook, 1998).



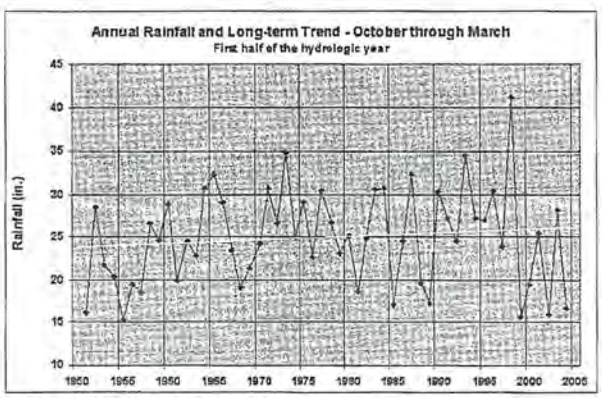


Figure 3.3: Comparison of rainfall for winter and summer seasons

(Hook, 1998)

3.4 Surficial geology

From its source in metro Atlanta to where Ga. Highway 128 crosses from Crawford to Taylor County, the Flint River flows over deformed **igneous** and **metamorphic** rocks of the Piedmont (Georgia Geologic Survey, 1976). These **crystalline** rock types are extremely non-porous and impermeable, and they do not weather as easily as the limestone rocks typical of Georgia's Coastal Plain. Flow of the Flint River in the Piedmont is mostly sustained by rainfall; however, streamflow is augmented by variable amounts of ground-water inflow (Hicks, 2000). Ground-water **base flow** to the Flint River in the Piedmont province is discharged through weathered fractures in the hard, crystalline bedrock (Kellam et al, 1993). Rainfall enters these fractures from outcrops, and from water stored in the soils and **saprolite**. Together, the soil and saprolite act as a sponge and store infiltrated rainwater. However, the low permeability of the saprolite and crystalline rocks limit the rate and volume of infiltration (Hicks, 2000). In the Piedmont, very large bedrock fractures, or collections of fractures, preferentially direct the streamflow and eventually become stream valleys; therefore, much of the Flint River channel north of the fall line may be locally controlled by the existence of bedrock fractures that supply a portion of the streamflow (Kellam et al, 1993).

Between Ga. Highway 36 and Ga. Highway 137 near Thomaston, the Flint River drops out of the Piedmont through a series of rocky shoals. It descends more than 300 feet in a distance of less than 15 miles. This rocky zone is called the fall line, and it marks the boundary between the Piedmont and the Coastal Plain Province of North America. The Coastal Plain is underlain by relatively soft, weakly consolidated rocks and unconsolidated sediments deposited by the sea or streams when the shoreline was at or near the fall line between 80 and 100 million years ago. These deposits thicken to the south and southeast, and they are very gently tilted (**dip**) in the same direction.

The upper section of the Coastal Plain, north of Dooly County, Americus, and Dawson, is called the fall line Hills district (Wharton, 1978). This area is underlain by sandy sediments of the Tertiary Clayton Formation (Tuscahoma Sand member) and sandy sediments of the Claiborne Formation (Georgia Geologic Survey, 1976; McFadden and Periello, 1983). These **formations** comprise aquifers at depth, and are only **recharged** in the fall line Hills area where they are near the land surface (Davis et al, 1989).

The Clayton aquifer consists of Clayton Formation limestone exposed in stream valleys of the upper Ichawaynochaway and Muckalee sub-basins, but its exposed recharge area is very small (McFadden and Periello, 1983; Davis et al, 1989). This, combined with an increase in irrigation pumping which began in the late 1970's, caused dramatic declines in water levels of the Clayton aquifer. For this reason, no additional permits are being issued in the Clayton aquifer and water-levels have stabilized.

The Claiborne aquifer consists mostly of saturated sands of the Tallahatta Formation. In those areas where the Claiborne is relatively shallow, it is a viable alternative aquifer to the Floridan, although well yields rarely if ever match those of Floridan aquifer wells (McFadden and Periello, 1983). The Claiborne has a much larger recharge area than the Clayton, and has not experienced long-term potentiometric declines like the Clayton aquifer.

The southern half of the basin is underlain by the Ocala Limestone, a fossil-rich limestone that is the main water-bearing unit of the Floridan aquifer. The up-dip extent of the Ocala Limestone coincides with the approximate northwestern limit of the Dougherty Plain and Subarea 4. Thickness of the Ocala ranges from 0 ft at its up-dip boundary, to more than 300 ft along the southeastern side of Subarea 4 (Miller, 1986; Torak and others, 1993). Intensive weathering of the Ocala Limestone and the formations that once overlaid it has generated an extremely uneven upper surface of the remaining limestone, and a highly variable thickness of the weathered material that mantels the limestone (Hayes et al, 1983; Hicks and others, 1987). This **residuum** typically has a clay layer directly overlying the limestone, which locally acts as the upper semi-**confining unit** to the Floridan, although under most of Subarea 4 the Floridan functions as an unconfined or semi-**confined aquifer** (Miller, 1986: Torak and McDowell, 1996). Where present, the upper clay layer ranges from less than 5 ft thick to more than 50 ft thick in the down-dip parts of the FRB. Above the clay layer is sandy-clay residuum of higher **permeability** that transmits precipitation to the underlying Floridan aquifer. In most of the FRB, the Floridan aquifer is confined below by low-permeability sediments of the Lisbon Formation (Wagner and Allen, 1984; Torak and McDowell, 1996).

The Floridan aquifer receives annual recharge directly from seepage through the overlying residuum, and through the numerous and extensive sinkholes in Subarea 4 (Torak and McDowell, 1996). Like streams in the area, aquifer heads are highest in late winter and early spring due to direct and rapid recharge, low usage, and low **evapotranspiration.** The lowest seasonal levels of the Floridan aquifer occur in middle to late autumn (Fig. 3.4). If normal rainfall follows the periods of lowest stream and aquifer levels, the aquifer recharges to levels comparable to those of the previous year (Groundwater Conditions in Georgia, USGS annual report). This suggests that, in some parts of Subarea 4, the Floridan aquifer is semi-confined. It also reflects the extremely permeable nature of the sandy residuum above the Ocala Limestone.

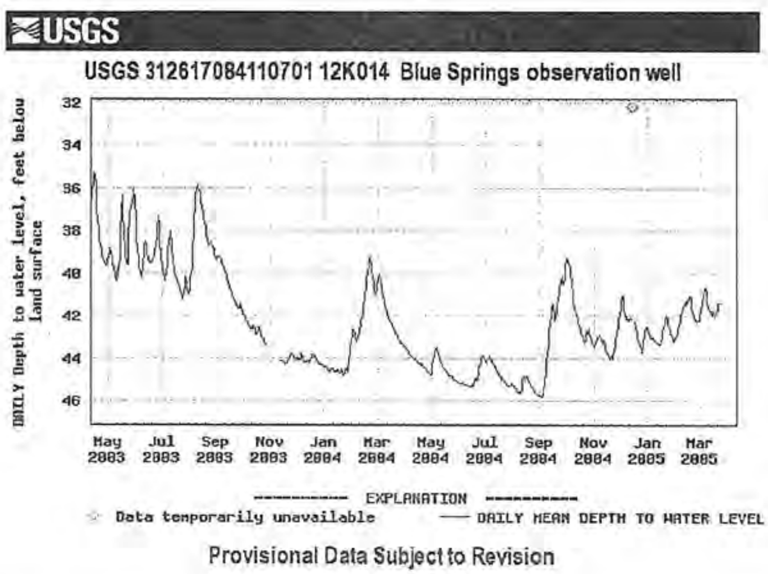


Figure 3.4: Hydrograph of well in Floridan aquifer in Subarea 4, showing typical seasonal variations in water level.

In most areas, the Floridan aquifer is a very prolific source of water because it has abundant cavities and fractures, widened by naturally acidic ground-water. For this reason, **transmissivity** values of the Floridan aquifer range from 2,000 to 1,300,000 ft^2/day (Torak and McDowell, 1996). Transmissivity values decrease towards the northern Subarea 4 boundary and the northwestern extent of the Floridan aquifer (Torak and McDowell, 1996) where aquifer yields will not support irrigation pumping. Yields are highest in the south and in areas adjacent to streams (Maslia and Hayes, 1988).

Because the Floridan aquifer is so highly transmissive and fractured, large ground-water withdrawals do not form deep cones of depression as in sandy, less transmissive aquifers. Instead, cones of depression in the Floridan aquifer are broad and shallow, and may be distorted by fracture zones into irregular or elongated shapes. Furthermore, withdrawals from the numerous irrigation wells in the Dougherty Plain region rarely create individual cones of depression (Torak, 1993). Because of the close spacing of the wells, their cones of depression overlap to create a regional lowering of the **potentiometric surface** rather than local declines adjacent to pumping wells (Torak and McDowell, 1996).

The high transmissivity and storage of the Floridan aquifer also causes rapid recovery of aquifer levels in many places. In other words, when pumping is initiated, there may be a rapid drawdown around the pumping well, but when the pumping ceases there is an equally rapid recovery as water flows quickly back into the area around the well with only a slight change in aquifer storage that is observed as a slight decline in static ground-water level (Fig. 3.5).

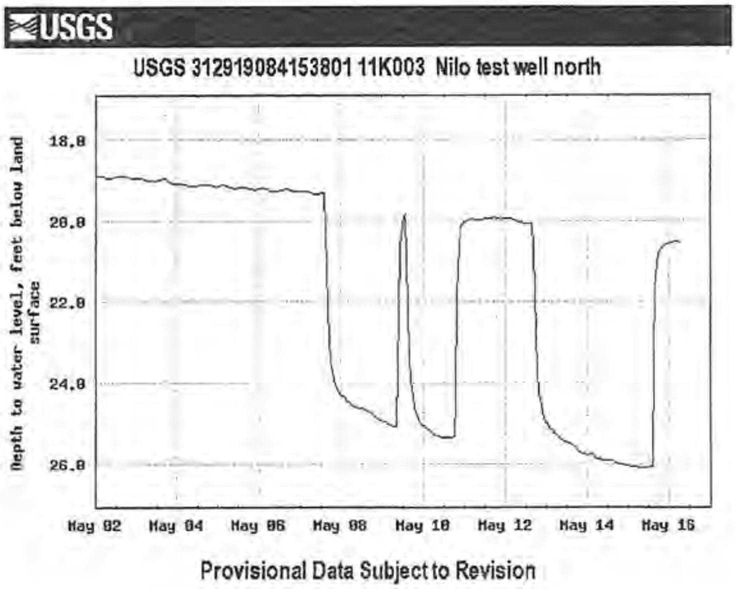


Figure 3.5: Hydrograph of Floridan aquifer well showing rapid recovery after cessation of pumping

3.5 Stream-aquifer interaction

From Vienna, Ga. in Dooly County, southward the Flint River is in hydraulic connection with the Floridan aquifer. In other words, the river has cut downward into the limestone, and exchanges water with the aquifer. For the remainder if its length, the Flint River remains in hydraulic connection with the Floridan aquifer to varying degrees. Similarly, many of the Flint's tributary streams are also in direct contact with the limestone and exchange ground-water discharge with it (Torak and McDowell, 1996).

This connection between streams and the aquifer is evident in potentiometric maps of the lower FRB, in which potentiometric contours bend strongly upstream where they cross the Flint River or some of its tributaries (e.g. Peck et al, 1999). The more pronounced the bend, the greater the hydraulic connection between stream and aquifer, and the greater the discharge from the aquifer to the stream. The flow of water back and forth from stream to aquifer is referred to as "stream-aquifer flux". When it is positive; that is, from aquifer to stream, the stream is said to be an "effluent" or "gaining" stream. When it is negative; that is, from stream back into aquifer, the stream is said to be an "influent" or "losing stream". Under conditions of normal rainfall patterns, most stream reaches in the lower FRB are effluent, or gaining, streams.

Ground-water discharges to streams directly through the streambed or stream banks, but it may also be added in large quantities from in-channel springs (Torak and McDowell, 1996). In the FRB, these are called "blue-hole" springs from the striking blue appearance of the streambed around the springs (Fig. 3.6). This blue color is caused by precipitation of carbonate minerals around the opening of the spring.

Figure 3.6: "The Shaft", a blue-hole spring on the Flint River between Albany and Newton, GA. (photo by S. Opsahl, J.W. Jones Ecological Research Center).

Some blue-hole springs have substantial discharges on the order of tens of millions of gallons per day. For example, the flow of Radium Springs in Albany, Ga has been measured at 49,000 gallons per minute (70.6 mgd). However, as a result of drought and increased withdrawals Radium Springs went dry in 1981 for the first time in recorded history, and has been going dry more frequently since then (W. Hicks, personal communication, 2005).

Blue-hole springs are more numerous and productive in the lower FRB. They are found on the major tributaries of the Flint, such as Ichawaynochaway Creek, Spring Creek, and others. Spring Creek takes its name from the numerous and prolific blue-hole springs along its length. A very high proportion of the streamflow of Spring Creek is derived from these springs: more so perhaps than in other tributaries of the Flint. The Flint River may receive as much as 500 mgd of ground-water discharge between Albany and Bainbridge (Torak and McDowell, 1996).

SECTION 4: FISH AND WILDLIFE RESOURCES OF THE LOWER FLINT RIVER BASIN

4.1 Mussels

Twenty-nine freshwater mussel species were historically known from the lower FRB with 22 species currently believed to still occur in the basin (Brimbox and Williams 2000). In 1998, the U.S. Fish and Wildlife Service listed three of these species as endangered and one as threatened under the U.S. Endangered Species Act (USFWS 2003). An additional species, the Fat Threeridge (*Amblema neislerii*) was also listed as endangered, but is presumed extirpated from Georgia.

North American mussels have experienced drastic declines in the past century as a result of dam construction, siltation, water pollution, and harvesting for pearl buttons (Brim Box and Williams, 2000). Today, formerly large populations of freshwater mussels have dwindled to small remnant populations that, in some cases, are functionally extinct; i.e., the populations are not capable of replacing themselves through reproduction (DNR, 1999; Golliday et al., 2002).

Freshwater mussels belong to the family *Unionidae* and are commonly referred to as "Unionids". Unionids generally live partially burrowed in the streambed, leaving only a small part of their shell exposed. They are able to move slowly by extending and retracting their muscular foot. This burrowing behavior as well as their slow movement leaves them unable to evade siltation and low levels of dissolved oxygen (DO).

The reproductive cycle of Unionids includes a short phase in which larval mussels ~~is a~~ must parasitize specific fishes (Parmalee and Bogan 1998). Many mussel species release larvae throughout the spring and early summer when they must locate proper fish hosts quickly. After a few weeks upon the fish, larvae drop off the host fish and begin their life on the stream bottom as a mussel.

Because Unionids burrow into the streambed, filter feed, and depend on adequate fish populations to complete their life cycle, they are susceptible to the types of environmental stressors that commonly occur in the lower FRB. Specifically, soil erosion from human development, pollution, river impoundments, and natural or human-caused low flows have led to large declines in mussel populations (Brim Box and Mossa 1999).

The ability to survive desiccation varies among mussel species however, few species found in the lower FRB can tolerate prolonged drought. While some mussel populations are thought to naturally decline during droughts, they are believed to recover after conditions return to normal. However, droughts combined with other stresses on mussel populations threaten the long-term survival of many mussel species in southwestern Georgia.

Researchers were able to examine the impacts of the 2000 drought conditions on mussel populations (Fig. 4.1). In 2001, 21 stream reaches that contained recently surveyed populations of Unionids were resurveyed to determine the impact of the drought on the mussels. Some sites were non-flowing; i.e. the streambed was dry or had isolated pools of slack water during the drought; other sites maintained flow. The most severely impacted populations (those with the greatest population declines) were those at non-flowing sites, and most of the non-flowing sites were in the Dougherty Plain. Non-flowing sites with high amounts of woody debris had lower mortality rates than non-flowing sites without woody debris (Golladay et al, 2004).

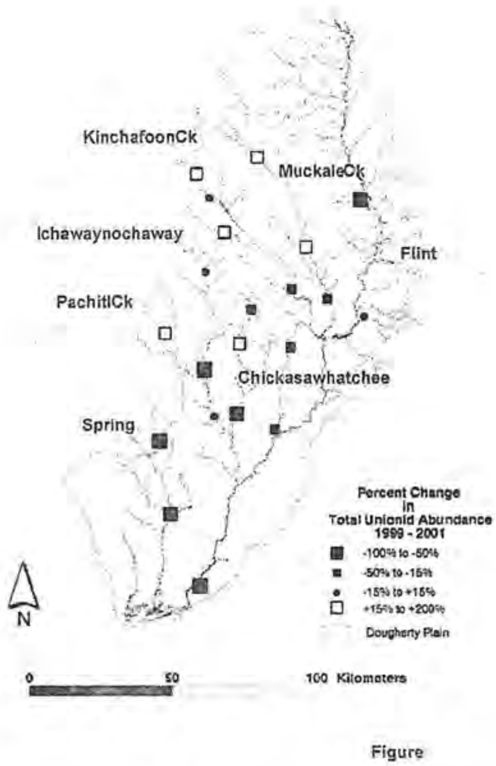


Figure 4.1: Percent change in total unionid abundance in the lower FRB, 1999 and 2001 *(from Golladay et al, 2004)*

The most extreme mussel mortality (of all surveyed sites) occurred in Ichawaynochaway sub-basin on Chickasawhatchee Creek near Elmodel. Although Chickasawhatchee Creek is normally a gaining stream above this location, it ceased flowing during 2000 (Golladay et al, 2004). This site is downstream of numerous large surface-water withdrawal points in Dougherty County, especially on Spring Creek north of Ga. Route 62. Although Chickasawhatchee Creek is not in good hydraulic connection with the Floridan aquifer upstream in Terrell County, it does become better connected in Calhoun County (Albertson and Torak, 2002).

On the main stem of Ichawaynochaway Creek where it flows into Subarea 4, mussel populations experienced large declines (a drop of between 50% and 100%, depending on species; Golladay et al, 2004). There is probably little ground-water contribution to the stream at this location, but under normal circumstances there is substantial tributary flow above this point, as well as significant of surface-water withdrawals. Even under drought conditions, flows at this point would have been substantially higher, almost certainly precluding a large mussel die-off.

One of the sites of greatest increases in surveyed mussel populations was also on Chickasawhatchee Creek near the Terrell-Dougherty County line (Golladay et al, 2004). Although this site is near and downstream of relatively dense distribution of ground-water irrigation, it is also in an area where the Floridan aquifer is very thin. Many wells in that area are not tapping the Floridan aquifer and thus have no impact on surface-water flow. The USGS has designated this stream segment as having a low susceptibility to ground-water withdrawals, but as the creek bends towards the south, deeper into Subarea 4, its susceptibility increases as its base flow contribution from the Floridan aquifer increases (Albertson and Torak, 2002).

Clearly, the 2000 drought conditions greatly impacted Unionids in the Dougherty Plain. Although the drought severely affected the whole southwest Georgia region, ground-water withdrawals in the Dougherty Plain area may have compounded drought stresses, and thus played a major role in mussel mortality. During the 2000 drought, researchers noted that many streams showed declining flows from their headwaters downstream across the Dougherty Plain (Johnston et al, 2001). This provided additional evidence irrigation in the Dougherty Plain decreases aquifer discharge, and thus exacerbates drought-related low streamflow.

In addition, patterns of mussel mortality may reflect competing effects of ground-water base flow and surface-water withdrawals. In those areas where there is little or no ground-water base flow, large surface-water withdrawals upstream may cause stream drying and possibly mussel die-offs. A possible example is the Morgan location where mussels died in large numbers downstream of numerous surface-water withdrawals from perennial streams. The locations upstream where mussels increased in population were in upland tributaries where surface-water withdrawals were not sufficient to cause dry streams or catastrophically low stream-flow. South of Morgan on Ichawaynochaway Creek, ground-water baseflow was sustained by the Floridan aquifer and offset surface-water withdrawals, allowing mussels to survive. The two locations in Terrell County where streamflow ceased were on upland tributaries with relatively small amounts of irrigation and no connection with the Floridan aquifer; therefore, mussel mortality there can be attributed mostly to drought conditions.

4.2 Gulf striped bass

The lower Flint River and its major tributaries contain a significant population of Gulf striped bass (*Morone saxatilis*) (Fig. 4.2). Striped bass are diadromous species, meaning that they can live in either fresh-water or salt-water, although in the lower ACF striped bass are a riverine species that rarely migrate into salt water (Dudley et al. 1977). Before construction of Jim Woodruff Lock and Dam (JWLD) in the 1950's, striped bass would typically spawn in the Chattahoochee and Flint Rivers then return to the Gulf. Spawning still occurs above JWLD, but stocking is required to maintain sufficient populations (Gulf States Marine Fisheries Commission, 2005; Alabama Department of Conservation and Natural Resources et al, 2004).

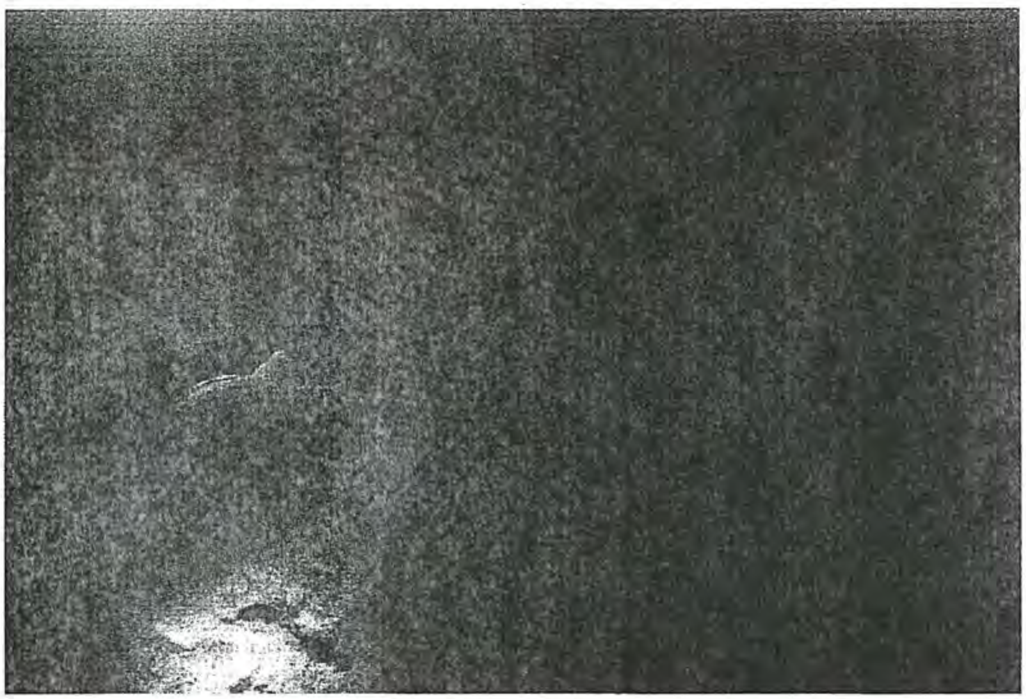


Figure 4.2: Gulf striped bass in the blue-hole spring exhibit at the Flint RiverQuarium
(photo by Flint RiverQuarium).

In the Flint River, Gulf striped bass are dependent on "thermal refuges." When river temperature exceeds 23° C (usually by early May) striped bass seek out cool water (blue hole springs) to spend the summer months. At temperatures above 27° C, mature bass (>15 lbs) stop feeding and die (Zale et al, 1990). The fish remain in or near these refuges throughout the summer, and by mid-October begin to vacate them (Alabama Department of Conservation and Natural Resources et al, 2004). Dissolved oxygen concentrations are critical for survival in summer thermal refuges (Coutant, 1985). However, crowding in the refuges due to temperature preferences or avoidance of low oxygen can lead to stress-induced pathology and over fishing, both of which can contribute to population declines Coutant (1985). To reduce the exploitation of Gulf striped bass in thermal refuges by anglers, the Flint River is closed to striped bass fishing from May 1st through October 31st (Georgia 2004-2005 Sport Fishing Regulation, Department of Natural Resources, Wildlife Resources Division).

Availability of the thermal refuges plays an important role in the survival of these fish, and limited summer thermal refuge habitat is probably the major factor for high adult striped bass mortality in Gulf Coast rivers (Lukens, 1988). In the lower FRB, blue-hole springs are the preferred thermal refuges for striped bass (Weeks and Van Den Avyle, 1996). Water discharging from the Floridan aquifer into blue-hole springs provides a further benefit to the bass' survivability in the Flint River, as alkalinity is beneficial to striped bass (Kerby 1993).

Striped bass are not a major species supporting saltwater recreational or commercial fishing in the Gulf of Mexico; however, the Flint River is one of the largest recreational striped bass fisheries in the Gulf region. There is a substantial directed recreational fishery for Gulf striped bass during the winter and spring months on the Flint River at the Georgia Power Dam in Albany and at the USACOE Andrews lock and dam on the Chattahoochee River (GA DNR unpublished data). Throughout the rest of their range, the majority of striped bass are caught incidentally by anglers targeting other fish such as catfish, bass, and sea trout (Gulf States Marine Fisheries Commission, 2005).

Conditions necessary for striped bass survival normally exist in the lower FRB, although low flows can impose stresses on the bass in addition to the unavailability of thermal refuges. Gulf striped bass population data collected by the Georgia Wildlife Resources Division (Department of Natural Resources) includes spring electrofishing surveys and counts of adults using thermal refuges during summer. These surveys have not indicated a substantial reduction in Gulf striped bass numbers in the Flint River. However, these methods of assessing the population may not adequately measure the impact drought has on this species. Decreased flow and increased temperatures that occur during drought conditions should be negatively correlated to the survival of Gulf striped bass. In addition, the Wildlife Resources Division has noted a decrease in the number of springs that are being utilized as thermal refuge habitat. These changes may be directly related to drought and low-flow conditions.

SECTION 5: WATER USE IN THE FLINT RIVER BASIN

5.1 Agricultural water withdrawal permitting

Ground-water withdrawals are regulated by EPD under the authority of the Groundwater Use Act (OCGA 12-5-90 et seq.) and Rules for Groundwater Use (391-3-2), and surface-water withdrawals are regulated by (EPD) under the authority of the Water Quality Act (OCGA 12-5-20 et seq.) and Rules for Water Quality Control (391-3-6). Permits for withdrawal of water for industrial, municipal, or agricultural use are required in Georgia for withdrawals that have the capacity to exceed 100,000 gallons per day (gpd) on a monthly average (O.C.G.A. 12-5-105).

Georgia law defines agricultural water use:

> "Farm-use permits are for the irrigation of any land used for general farming, forage, aquaculture, pasture, turf production, orchards, or tree and ornamental nurseries; provisions of water supply for farm animals, poultry farming, or any other activity conducted in the course of a farming operation. Farm uses shall also include the processing of perishable agricultural products and the irrigation of recreational turf, except in Chatham, Effingham, Bryan, and Glynn counties, where irrigation of recreational turf shall not be considered a farm use." (O.C.G.A. 12-5-92).

5.1.1 Application for a permit

When an applicant wishes to obtain a farm-use permit, they submit a permit application to EPD on forms supplied by EPD. Applicants provide information that must include, but not be limited to: Applicant's full name; mailing address; county in which existing or proposed water withdrawal is located and the purpose of the proposed withdrawal. If a withdrawal is for the purpose of irrigation, applicants are asked for the number of acres irrigated from this source and average number of inches of water applied from this source per year, as well as whether or not chemicals, fertilizers, fungicides, herbicides, insecticides, or nematicides are injected into the irrigation water. Applicants mark the withdrawal location of the water source on a county map supplied by the Division (or equivalent). If the application is for ground-water withdrawal, well construction data including (but not limited to) well depth; depth of pump intake below ground surface; design pumping capacity of well; depth of well casing; and month and year of well pump installation. Similarly if it is for a surface-water withdrawal, applicants are asked for the name of the withdrawal source (stream, lake, pond, etc. name); design pumping capacity of the pump or pumps at this location; number of pumps involved, if more than one; and month and year of pump installation. (O.C.G.A. Sec. 12-5-105).

5.1.2 Application evaluation – ground-water withdrawal permits

If the permit is for ground-water use, a geologic appraisal is performed to determine what aquifer the well will be using. This is a relatively simple procedure that compares surface elevation of the proposed well, the proposed well depth, and the known depths of aquifer tops and bottoms as shown in Georgia Geologic Survey Hydrologic Atlas 10 "Hydrologic evaluation for underground injection control in the Coastal Plain of Georgia" (Arora, 1984) and other published reports that describe the aquifers of Georgia. In the Coastal Plain, the heavily used Clayton aquifer has experienced extreme head declines, which causes adverse effects on other water users in those areas where the Clayton is currently being used. Under these circumstances, EPD can require future water users to withdraw "from other fresh-water aquifers than presently utilized" (391-3-2-.11). If the proposed well is using an aquifer in which EPD is still issuing permits, the applicant will be sent a "Letter of Concurrence to Drill an Irrigation Well" (391-3-2-.04). The applicant is required to drill the new well within one year to the approximate specifications described in the Letter of Concurrence. The proposed water user proceeds at their own risk if they do not obtain a letter of concurrence from EPD before constructing the well. (391-3-2-.04). After completion of the well, the applicant must return the Letter of Concurrence along with well completion data forms (also provided by EPD) describing well depth, casing depths, pump capacity, and other well construction details. If the well is drilled into an aquifer for which EPD is not issuing withdrawal permits, the applicant will be denied a permit and may be required to plug and abandon the well. If the well is constructed in accordance with the Letter of Concurrence, then a permit is issued to the applicant for the well.

5.1.3 Application evaluation – surface-water withdrawal permits

If a farm-use permit is for a surface-water withdrawal, then the applicant must specify their intended withdrawal capacity. The same criteria for issuance of a "grandfathered" ground-water permit apply to surface-water permits; however, in the case of surface-water permits for which an application was submitted before July 1, 1991, no low-flow protection plan is required and a permit is issued for the original pump capacity. All surface-water permits for which an application was submitted after July 1, 1991, must be evaluated to determine the need for a low-flow protection plan in order to protect the 7Q10 or the natural streamflow, whichever is less. The 7Q10 is defined as the minimum average flow for 7 consecutive days that occurs on average once every 10 years. If prior permitted withdrawals exist downstream, the new permit applicant must develop a drought contingency plan to protect the "non-depletable flow" (NDF) or the natural streamflow, whichever is less (391-2-3-.04). NDF is equal to the 7Q10 plus the calculated amount required to protect prior users. For withdrawals south of the fall line, where streams channels are not well defined, EPD has determined that it is necessary to protect only non-depletable flows of 1.0 cfs or greater. If evaluation of streamflow indicates that NDF would be less than 1.0 cfs, a low-flow plan is not required.

The process of evaluating an agricultural surface-water permit application involves establishing the presence and needs of downstream users, using EPD's **GIS** database of agricultural permits. The current methodology for processing surface-water withdrawal applications involves determining a local 7Q10 flow for each withdrawal point. This value is then used to determine if an applicant must submit a low-flow protection plan. Data from USGS gauging stations used to determine 7Q10 flows is available from "Low-Flow Frequency of Georgia Streams", or http://ga2.er.usgs.gov/lowflow. These gauging stations are located throughout the state, but are located in much fewer places in the

Coastal Plain. To obtain the most accurate information, 7Q10 flows are determined using continuous records obtained from USGS gauging stations. When a nearby gauging station can't be located, partial-record gauging stations are used. These, however, aren't always close to the applicant's withdrawal point. In these cases, "Effect of a Severe Drought (1954) on Stream flow in Georgia" (Thompson and Carter (REF)) is used to locate a gauging station with partial-record data. A 7Q10 flow can almost always then be calculated for the withdrawal point. Very rarely will a withdrawal point be located in close proximity to a gauging station, so the 7Q10 flow will almost always be interpolated from nearby gauges. In southern Georgia, however, some counties have very few (if any) gauging stations. Also, if a station is near a withdrawal point, they may not necessarily be in the same drainagebasin.

If 7Q10 data are not available for the proposed withdrawal location, it must be estimated from a known 7Q10 flow in the vicinity of the withdrawal using the drainage area (DA) ratio method (proposed withdrawal 7Q10 = known 7Q10 x proposed withdrawal DA/ known 7Q10 DA). Drainage areas above the proposed withdrawal can be obtained using a map and planimeter, or they can be calculated using advanced GIS software. Once 7Q10 is calculated for the proposed withdrawal point, the existing nearby downstream withdrawals must be totaled. If a major tributary enters the stream, then withdrawals below the **confluence** should not be considered. NDF is obtained by summing the 7Q10 flow and a prorated portion of nearby downstream withdrawals (determined by the DA ratio method).

5.1.4 "Grandfathered" farm-use permits

Agricultural withdrawal permitting began in Georgia in 1988 when the Ground-water Use Act of 1972 was amended. If a permit applicant could prove to EPD's satisfaction that a well or surface-water pump with a specified pumping capacity was installed before July 1, 1988, EPD granted a permit for such capacity from this well or pump. The application for such capacity had to have been received by the EPD on or before July 1, 1991. If submitted on of before that date, EPD granted a permit for the withdrawal of water at a rate of withdrawal equal to the greater of the operating capacity in place for withdrawal on July 1, 1988, or, when measured in gallons per day on a monthly average for a calendar year, the greatest withdrawal capacity during the 5-year period immediately preceding July 1, 1988. If the permit application was submitted after July 1, 1991, or, regardless of when submitted, if it is based upon a withdrawal of ground-water for farm uses occurring or proposed to occur on or after July 1, 1988, the application was subject to evaluation and classification as described in the Code Sections 12-5-96 and 12-5-97.

In other words, if a farmer had a well or pump that he or she could prove was in existence before July 1, 1988, and if they submitted a permit application before July 1, 1991, they would be issued a "grandfathered" permit for the *existing pump capacity*. Applications received after July 1, 1991, are not "grandfathered", and have been subject to evaluation according to the procedures described in the Rules for Groundwater Use and the Groundwater Use Act. To date, almost all permit applications received have been approved for the requested pump capacity.

5.1.5 Expiration, revocation, modification and transfer of agricultural permits

Farm-use permits have no expiration, and cannot be revoked for non-use in whole or in part after initial use has commenced (O.C.G.A. 12-5-105 (b)(2). However, the Director may suspend or modify a permit, grandfathered or not (see below) for farm use if he or she should determine through inspection, investigations, or otherwise that the quantity of water allowed would prevent other applicants from reasonable use of ground-water beneath their property for farm use (O.C.G.A. 12-5-105 (b)(3)), or if permitted withdrawals cause unreasonable adverse effects on other water users, including adverse effects on public and farm use (391-3-2-.11). A farm-use permit may be revoked if the proposed well was never drilled or if it was constructed in a manner significantly different from that indicated in supporting documentation. A farm-use permit is tied to a location, not a person, and may be transferred to subsequent owners of the land associated with the well, provided that EPD receives written notice of any transfer.

Under current State law, they cannot be transferred to different locations or between persons who are not owners of the land. Any modifications in the use or capacity conditions contained in the permit or lands which are the subject of the permit shall require the permittee to submit an application for review and approval by the Director (O.C.G.A. 12-5-105 (b)(1)).

5.2 Historical agricultural water use in southwest Georgia

Irrigation represents the largest category of agricultural water use in the FRB. For the 42 counties in which the Flint Basin lies, fewer than 25 % of agricultural permits have been requested solely for livestock, aquaculture, or other farm uses. However, it is understood that many small wells pumping less than 100,000 gpd (and would thus not require a permit), are also used for these purposes. Because of the importance of irrigation to the state and region, irrigation use has been surveyed and studied for many years.

5.2.1 Extension irrigation surveys

Since the onset of center-pivot irrigation in the 1970's, the Georgia Cooperative Extension Service (CES) has conducted periodic surveys of its agents to enumerate ongoing irrigation practices, acreage, and amounts (Harrison, 2005; Harrison and Hook, 2005). The statewide results of the most recent CES survey in 2004 can be found on-line at http://www.nespal.org/agwateruse/facts/survey/. The survey shows cotton, peanut, corn, vegetables, and pecans to be the most extensively irrigated crops, with 42, 22, 12, 8, and 5%, respectively, of the 1,550,000 acres irrigated statewide. In the 42 counties in which the Flint Basin lies, the same crops predominate with 48, 24, 12, 7, and 7%, respectively, according to the extension survey. The average amount applied to crops statewide is shown below (Fig. 5.1) for crops of importance.

The CES survey also asked agents to estimate the average amount of water applied to each crop in the agent's county during the year of the survey. For the most recent survey, the statewide irrigation application depths varied from about 4 to 20 inches. The amount applied to crops on average statewide is shown below for crops of importance to the Flint Basin. In the 2004 survey, as in most other years of the survey, cotton, peanuts, and corn received 6 to 8 inches of water; vegetables and pecans, 8 to 10 inches; and athletic areas, sod, and nursery plants, greater than 15 inches.

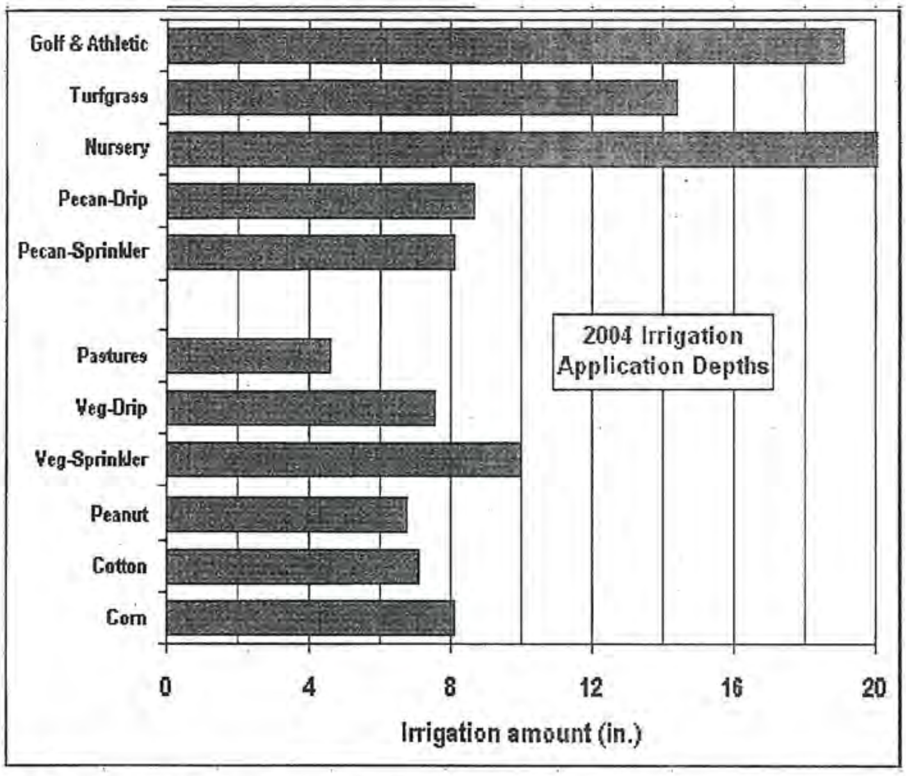


Figure 5.1: Statewide irrigation application depth in the 2004 survey of Cooperative Extension agents

excerpted from the on-line data
http://www.nespal.org/agwateruse/facts/survey/amtbycrop.asp 28 Sep 2005)

5.2.2 Subarea 4 and Flint Basin Sound Science Studies – Irrigated acreage

While CES irrigation surveys provided practical estimates of irrigation areas, application amounts, and crops produced, they provided too little detail on specific watershed areas, and the estimates were based on surveys of agents only.

To provide a working knowledge of specific withdrawal locations, area under current irrigation systems, and identification of permits used with those irrigation water withdrawals, EPD commissioned two Sound Science studies under the auspices of the ACF Compact negotiation and the FRB Plan to map irrigated area in Subarea 4 and beyond. In the first effort, Litts et al. (2001) measured center-pivot irrigation systems visible in aerial photographs and estimated non-pivot acres. They reported approximately 475,800 irrigated acres could be found in the Subarea 4 portions of the lower FRB and adjacent parts of the Chattahoochee Basin.

Subsequently, EPD, UGA-NESPAL and the J.W. Jones Ecological Research Center worked with farmers and other permit holders to identify specific sources and irrigated areas associated in an effort to map each permitted withdrawal. In Subarea 4, they identified 570,000 acres that were under irrigation. Of these, approximately 79,000 acres were irrigated by surface-water and 466,000 acres by ground-water, while the remainder were supplied by multiple sources of ground-water and surface-water (Danna Betts, UGA-NESPAL, personal communication, summary of areas mapped Jan. 5, 2005). The permit mapping initiated under this Sound Science study was extended northward to include the entire FRB. Since specific irrigation sources and irrigation systems were mapped in a Geographic Information System (GIS), these data were used in subsequent Flint Basin analyses and models that form the basis of this Plan.

An evaluation of irrigated acres by sub-basins within the FRB (Fig. 5.5) indicates that the highest concentration of irrigation is in the lower Flint River and Spring Creek sub-basins. Irrigation in these areas is almost exclusively supplied by ground-water. The Ichawaynochaway sub-basin is equally divided between ground-water and surface-water. This is particularly evident in the southern half of the sub-basin in Subarea 4, in contrast to the northern half, which is supplied by a combination of surface-water and ground-water. The Middle Flint and Kinchafoone-Muckalee Creek sub-basins, have lesser amounts of land under irrigation. Irrigation is dominated by surface-water withdrawals. The Upper Flint sub-basin has a comparatively small irrigated area and was not examined closely for impacts in this Flint Basin Plan.

Thus, irrigation from ground-water is most heavily concentrated in the Dougherty Plain section of the Coastal Plain where the Floridan aquifer is relatively shallow and generally prolific. Outside of Subarea 4, especially north of it, surface-water use exceeds ground-water use (Figs. 5.2, 5.3).

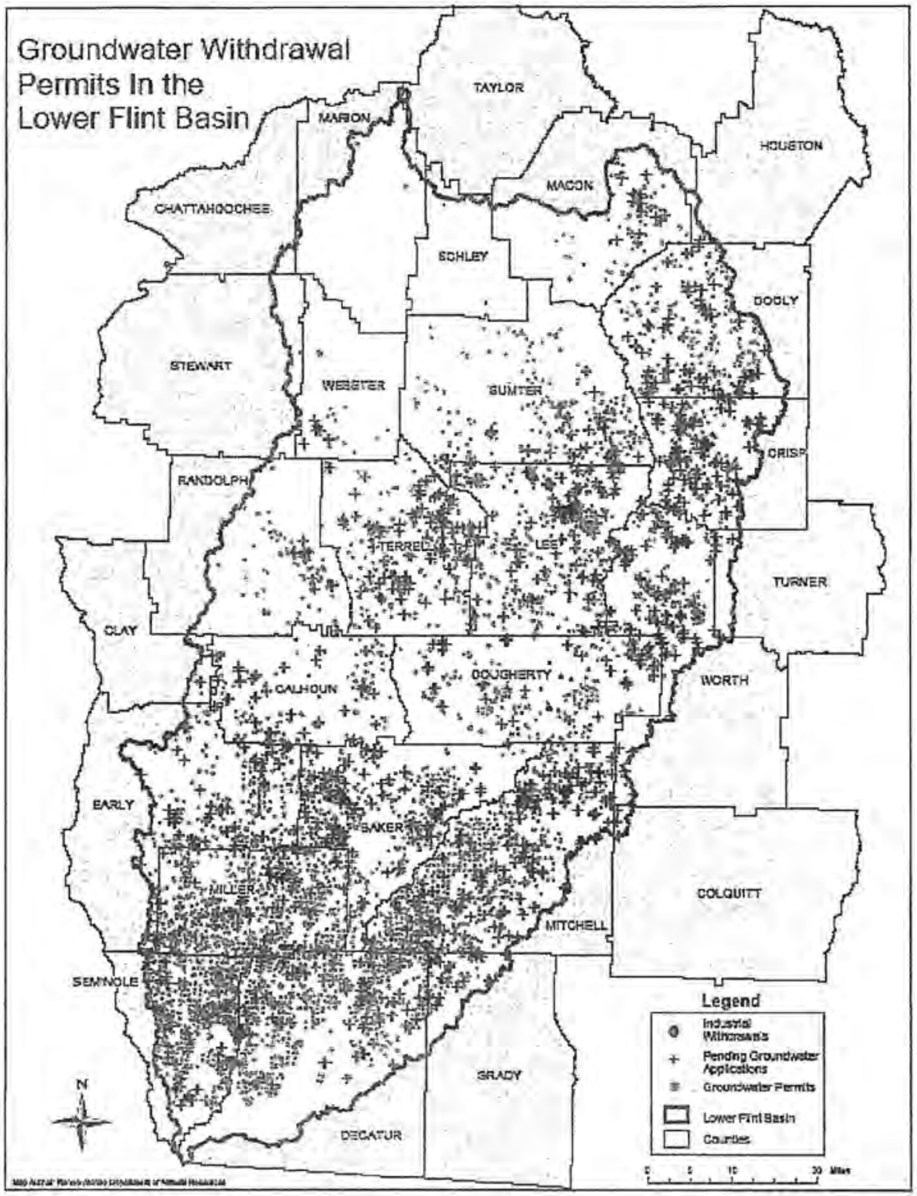


Figure 5.2: Pending and permitted ground-water locations

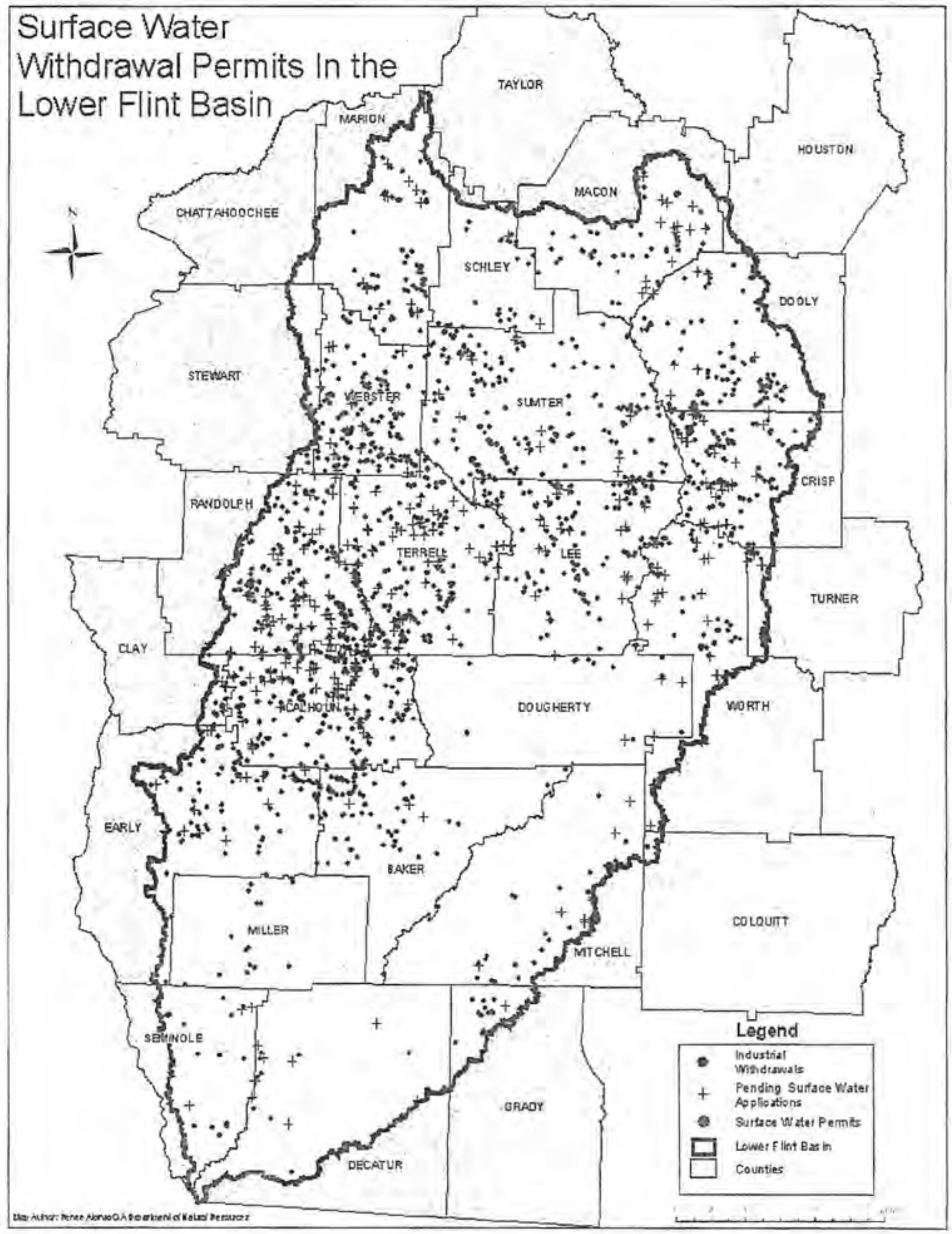


Figure 5.3. Pending and permitted surface-water withdrawal locations

5.2.3 Subarea 4 and Flint Basin Sound Science Studies – Irrigation amounts

With funding from EPD, agricultural water use in Georgia was extensively studied by The University of Georgia Agricultural Experiment Station and CES. From 1999 through 2004, a random 2% sample of irrigation systems was metered across Georgia (Hook et al, 2005), and a random 5% sample of ground-water-supplied systems in Subarea 4 was metered. Together this resulted in multi-year, monthly measurement of irrigation application amounts on 41,500 acres (7.3% of Flint Basin acres) for 305 permitted withdrawals (7% of Flint Basin permits). Flow rates on sampled irrigation systems were measured with "strap-on" digital flow meters, and usage hours were recorded monthly for each system. Additionally, crop type, wetted area, power source, and water source were determined during each observation. The final report of this statewide irrigation monitoring research, "Ag Water Pumping" (or AWP), as well as summaries from the research, was placed on-line (http://www.nespal.org/awp/2005.02.AWP-Final.pdf). The combination of irrigation amounts obtained from AWP (Fig. 5.4), combined with irrigation surveys and permit mapping provided most of the agricultural water-use data used for the hydrologic models discussed below.

Most irrigation systems in the Dougherty Plain, whether supplied by surface-water or ground-water, are center-pivot systems (Table 5.1). These are the most efficient systems in the very low topography of the Dougherty Plain. In the Fall Line Hills where topography is more rolling, traveler irrigation systems are more common.

System Type	Acres
Portable Pipe	2190
Cable Tow	43666
Hose Reel	26327
Center Pivot	557632
Lateral Move	428
Solid Set Sprinkler	19197
Drip/Trickle	28813
Athletic Field/Golf	3733
SDI	73

Table 5.1: Irrigated acres by system type in southwest Georgia (NESPAL, 2005)

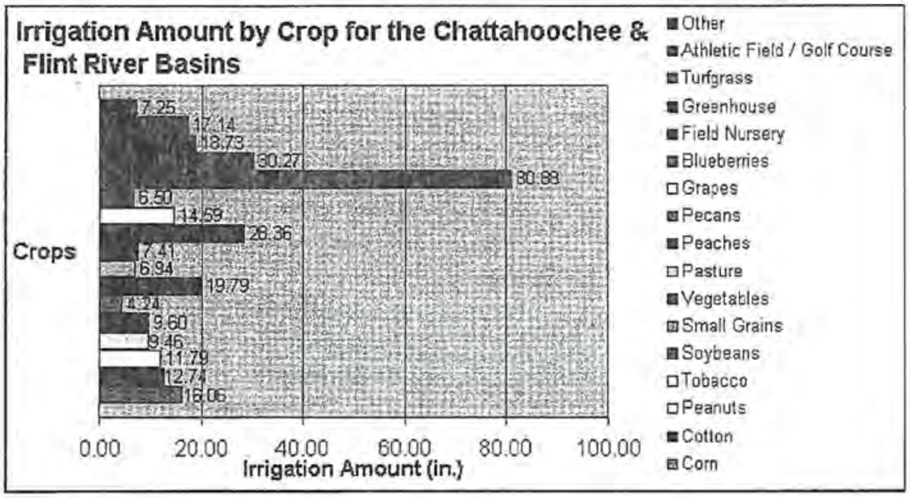


Figure 5.4. Irrigation amounts by crop in southwest Georgia

As part of the AWP study, permitted irrigation wells and surface-water pumps and the acreage wetted by them were mapped by NESPAL and EPD using advanced GIS software. This provided invaluable data relevant to water-use patterns and geographic trends in irrigation. More than 95% of the permitted wells and surface-water pumps and associated irrigated fields have been mapped. Results of the permit mapping reveal the distribution of irrigation by sub-basin in southwest Georgia (Figure 5.5). The lower Flint sub-basin has the largest area under irrigation, but it is also the largest HUC-8 sub-basin in the study area. Significantly, Spring Creek is one of the smaller sub-basins in the FRB, but it has the highest percentage of land under irrigation (REF).

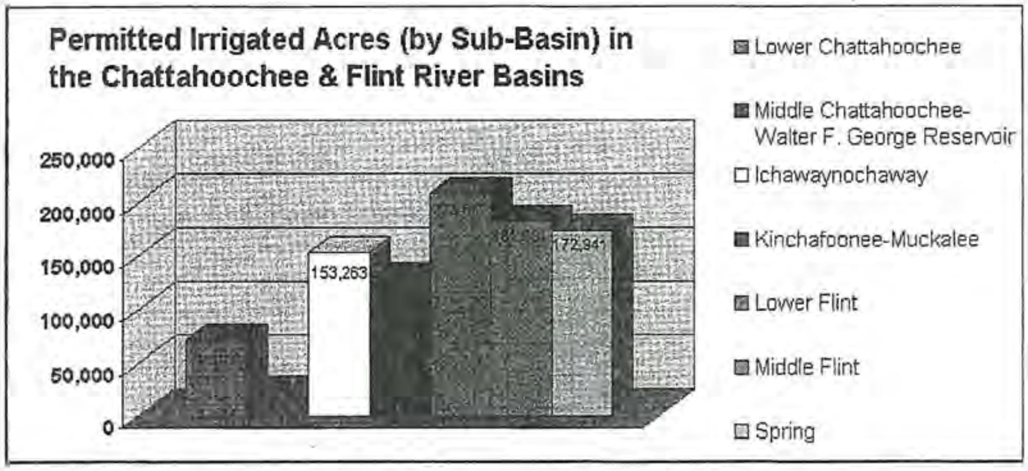


Figure 5.5: Distribution of irrigated acreages by sub-basin in southwest Georgia (NESPAL, 2005)

The AWP study also revealed details about the distribution of irrigation throughout the year (Fig. 5.6). Irrigation does not occur uniformly throughout any given growing year; rather, it mostly occurs during the main growing season from April through September. Variations in irrigated depths and amounts within the growing season depend on rainfall patterns, crop needs, and crop distribution. Typically, however, irrigation volume peaks in June, July, or August, and drops rapidly after September. Not coincidentally, this corresponds with the hottest and/or driest parts of the year when evapotranspiration is highest, and streams and ground-water levels are approaching their seasonally lowest levels. Very little water is applied outside of the May-September growing season (Hook et al, 2005).

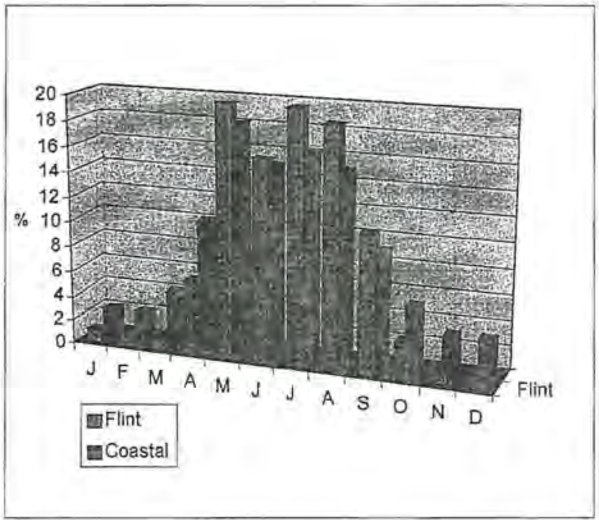


Figure 5.6. Temporal distribution of irrigation during 2000-2001 (NESPAL, 2005).

Irrigation depths and volumes measured and calculated during the AWP study for southwest Georgia are shown in Table 5.2. The period 2000-2002 represents moderate to severe drought conditions; 2003 was a relatively wet year. Year 2004 is categorized as an "average" to dry year in terms of precipitation (AEMN, 2004).

Mean annual area-weighted irrigation depths and calculated withdrawals, southwest Georgia							
Year	GW	SW	W2P	GW	SW	W2P	All
	in./yr			Mgal/yr			
2000	12.0	7.5	9.4	178,000	34,000	18,000	230,000
2001	9.1	5.3	7.5	140,000	24,000	15,200	180,000
2002	10.0	7.5	7.4	157,000	34,000	14,600	206,000
2003	5.3	2.5	4.5	80,000	13,100	9,000	102,000
2004	8.5	6.8	5.9	130,000	31,000	11,400	172,000

Table 5.2: Mean annual area-weighted irrigation depths and calculated withdrawals, southwest Georgia (Hook et al, 2005).

Application depths varied substantially depending on crop type, soil type, local rainfall patterns, location, and individual farmer preference, and were computed from individual application depths that varied from 0 to over 300 in./yr (Hook et al, 2005). Average regional values were combined with wetted acreages to calculate irrigation amounts in million gallons per day.

It is notable that ground-water-supplied irrigation systems consistently applied more water than surface-water systems. This may have been a result of greater reliability of ground-water supply in a drought in which many streams and ponds dried; the ability to produce higher value crops with ground-water; or the relative availability of ground-water in many areas (Hook et al, 2005). The FRB also has the highest volume of ground-water withdrawn for irrigation in the State (123 billion gal/yr in 2002) and the highest volume of surface-water withdrawn for irrigation (27 billion gal/yr in 2002). The FRB has the second highest basin-wide mean irrigation application depth (1.02 in/yr) after the Ochlockonee River Basin, and the highest percentage of area under irrigation. It is important to note that the irrigation volumes applied are quite small when compared to the amount of annual precipitation (Hook et al, 2005).

5.3 Municipal and industrial ground-water withdrawal permitting

5.3.1 Municipal and industrial ground-water permitting

The Georgia Groundwater Use Act of 1972 requires all non-agricultural ground-water users (i.e. municipal and industrial users statewide and in addition, recreational turf irrigation (golf courses) in the four coastal counties of Bryan, Chatham, Effingham and Glynn) or projected users of more than 100,000 gpd for any purpose to obtain a Ground-water Use Permit from EPD.

For a complete ground-water withdrawal application, at a minimum the following forms and information are required (O.C.G.A. 12-5-96 et seq.):

- **Part A Form:** General system and contact information, along with maximum monthly and annual average requested from an aquifer, for a specific defined use. Sufficient justification of the requested water amount is essential. Justification, including current needs and future water demand projections, population growth, business growth, annexation or any additional factors related to increased (or an explanation for decreased) water usage, must be provided to determine if the water can be allocated.

• **Part B Form:** Drillers log of each system well indicating depth and lithologies to allow a determination of the source aquifer used. Also specific well construction/completion information such as casing size, depths, and screened interval, is required. Location maps of the wells must be provided.

• **Ground-water Use Report:** Provide the previous, historic water use for a system or operation along with required reporting of monthly production values, sent to EPD every six months. This is to justify the amount of water needed and to assure permit compliance with production limits once a permit is issued.

• **Water Conservation Plan:** A permittee must incorporate water conservation into long-term water demand and supply planning following an approved outline for developing an effective water conservation plan based upon specific needs and conditions of the water system. This provides EPD with adequate information showing the applicant is a good steward of the ground-water resource, and making efficient use of the water. This material defines current and proposed 20-year plans for discouraging waste and encouraging conservation.

• **Water Conservation 5 year report:** A requirement of the law is that five years after permit issuance, the permit holder must provide to EPD a synopsis of their water usage over the previous five years. This must include an accounting of previous and current water conservation efforts and their impact, along with a description of future plans to increase efficiency. An applicant must also explain where their wastewater goes once the ground-water is used. This is to assure that the treatment option is large enough to be able to handle the amount of water withdrawn.

• **Service Delivery Strategy:** Municipal users must provide documentation that their water withdrawal, in some defined service delivery area, is consistent with the County planning and the planning of neighboring municipalities, to avoid duplication of services in any area. EPD cannot issue a withdrawal permit if such a service delivery agreement is not provided.

Other information may be required depending on the particular situation or the amount of water requested. This may include detailed hydrologic testing to assure that the aquifer can deliver adequate water without detrimental impacts to other users.

Once a complete ground-water withdrawal application is received, EPD will then place the list of applicants out for at least 30 days of public comment. If there is limited public interest in an application, this will then be followed by at least 30 days of public notice on the draft permit. Only after these comment periods are complete does the Director of EPD recommend any municipal and industrial ground-water permit for approval. If at any stage of the permitting process sufficient internal or external comments or questions are received, the applicant must provide adequate information to address those concerns. In select cases an official public hearing on the application might be scheduled by EPD.

In any case, after an analysis of all the above materials, taking into account hydrologic impacts and the operation's need for the water, any application for a ground-water withdrawal permit might either be approved and a permit issued, or a permit denied. There is no requirement that a municipal or industrial ground-water withdrawal permit be issued to every applicant.

If approved, an EPD issued Ground-water Use Permit identifies the allowable monthly average and annual average withdrawal maximum, sets a permit expiration date (generally ten years out), defines a specific withdrawal purpose, accounts for the number of wells allowed, and enumerates standard and any additional special conditions for ground-water resource use. Standard conditions define statutory provisions, permit transfer restrictions and reporting requirements (e.g. semi-annual ground-water use reports), while special conditions identify such things as the source aquifer and conditions of well replacement, or any unique requirements specific to this permit.

Failure to follow any of the required permit conditions can result in compliance actions being taken against the permit holder, up to and including permit revocation.

Once a ground-water withdrawal permit is issued to any party, any changes in permit operator, permitted water withdrawal amount, number of wells allowable, the defined permitted use of the water, standard or special conditions, etcetera, can only occur with written EPD approval and the issuance of a modified withdrawal permit.

5.4 Municipal and industrial surface-water withdrawal permitting

The Georgia Water Quality Control Act requires that an EPD-issued Surface-water Withdrawal Permit be sought and obtained by all those users of surface-waters who intend to withdraw, divert, or impound water at a rate of at least 100,000 gallons per day (on monthly average basis). The Permit identifies the allowable monthly average and 24-hour maximum withdrawal rates, permit expiration date, designated withdrawal purpose, source of water, and standard and any special conditions for resource use.

To obtain a withdrawal permit, the Rules for Water Quality Control (391-3-6) require submitting a permit application to EPD. This application requires information about proposed withdrawal location, historic water use, water demand projections, water conservation, drought contingency planning, and other pertinent information on the water's source. Municipal and Industrial surface-water users must report their monthly water use to EPD. EPD requires, among other things, the following of a permit applicant before a draft permit can be developed and made available for public review prior to the issuance of a Surface-water Withdrawal Permit:

1. EPD requires every applicant to develop a Water Conservation Plan that addresses items such as system management, plant management, ratemaking policies, plumbing ordinances, recycle and reuse, public education, long range planning forecasts, etc. The applicant is required to track statistics such as per capita use, and un-accounted for water and report trends in the service areas via Water Conservation Progress Reports.

2. EPD requires every applicant to develop a Drought Contingency Plan aimed at reducing water use during critical low flow periods. Additionally the applicant must defer to the Georgia Drought Management Plan (which restricts all outdoor water use to 3 days per week even during non-drought periods) when it is more stringent.
3. EPD requires every applicant to maintain a base stream-flow (non-depletable flow) below the intake to provide for the aquatic habitats and downstream needs.
4. EPD requires every applicant within one of the 16 counties of the Metropolitan North Georgia Water Planning District to operate in accord with District's Water Supply and Water Conservation Management Plan.

EPD is empowered to modify or revoke any permit if the withdrawal is not in compliance with the terms of the permit or if there is an unreasonable adverse effect upon other water uses or users in the area. EPD may deny a permit application if the application is found to be contrary to the public interest or general welfare.

Enforcement authority

Under the Rules and Statutes referenced above, EPD has the legal authority to enforce violations of permit conditions. EPD also has the right to conduct investigations into permit violations and to enter any property, public or private, to conduct such investigations with or without the consent of the permit holder. When the Director of EPD has reason to believe that a permit violation has occurred, he or she shall attempt to remedy the violation by conference, conciliation, or persuasion. If this approach fails, the Director may issue an order requiring compliance by the violator, and file this order in the superior court of the county where the violation is taking place. The permittee may appeal the order and obtain a hearing. On the basis of this hearing, EPD shall continue the order, revoke it, or modify it. If a person or entity fails to comply with the final order, they are liable for a civil penalty not to exceed $1,000.00 per day for each violation, and an additional civil penalty not to exceed $500.00 for each day during which the violation continues.

5.5 Permitted municipal and industrial withdrawals

In the FRB, permitted municipal and industrial water use is substantially less than agricultural water use. Most of the surface-water usage is in the northern part of the basin; i.e. in the Piedmont region north of the fall line (Table 5.3).

Permitted municipal and industrial surface-water withdrawals in the Flint River Basin

County	Facility	Permit number		Source	Monthly avge. (MGD)	Monthly average use (2004
Clayton	Clayton County Water Auth - Shoal	031-1101-01	M	J.W. Smith Res./Shoal Cr.	17	4.4
Coweta	Senoia, City Of	038-1102-05	M	Hutchins Lake	0.3	.223
Fayette	Board Of Commissioners Of Fayette Co.	056-1102-09	M	Line Cr (McIntosh Site)	2	0.000
Fayette	Board Of Commissioners Of Fayette Co.	056-1102-10	M	Whitewater Creek	2	.734
Fayette	Fayette County Water System	056-1102-03	M	Lake Peachtree	0.5	1.70
Fayette	Fayette County Water System	056-1102-12	M	Horton Creek Reservoir	14	6.9
Fayette	Fayetteville, City Of	056-1102-14	M	Whitewater Creek	3	1.142
Macon	Weyerhaeuser Company	094-1191-01	I	Flint River	12	10.189
Meriwether	Roosevelt Warm Springs Rehab	099-1106-04	M	Cascade Creek	0.14	.144
Meriwether	Woodbury, City Of	099-1106-02	M	Cain Cr Res On Pond Cr	0.5	.167
Pike	Griffin, City of	114-1104-03	M	Still Branch Reservoir	42	0
Pike	Zebulon, City Of	114-1104-01	M	Elkins Creek	0.3	0
Spalding	Griffin, City Of	126-1190-01	M	Flint River	12	8.479
Talbot	Manchester, City of	130-1106-05	M	Rush Creek Reservoir	1.44	1.015
Taylor	Unimin Georgia Company, L.P.	133-1109-01	I	Remote Pond on Black Creek	1.73	1.344
Taylor	Unimin Georgia Company, L.P.	133-1109-02	I	Black Creek (Remote Jr.)	0.38	.353
Upson	Southern Mills, Inc.	145-1104-02	I	Thundering Springs Lake	0.5	.205
Upson	Thomaston, City Of	145-1105-01	M	Potato Creek	3.4	0
Upson	Thomaston, City Of	145-1105-02	M	Potato Creek	0.4	.015
Upson	Thomaston, City Of	145-1105-03	M	Raw Water Cr Res	4.3	2.789
TOTAL					**117.39**	**50.545**
	Hydropower and cooling-water use					
Dougherty	Georgia Power Co - Plant Mitchell	047-1192-01	I	Flint River	232	232
Worth	Crisp County Power Comm - Hydro	159-1112-02	I	Lake Blackshear	4,847.30	4,847.30
Worth	Crisp County Power Comm - Steam	159-1112-01	I	Lake Blackshear	15	15
TOTAL					**5502.7**	**5094.3**

Table 5.3: Permitted municipal and industrial surface-water withdrawals in the FRB

Surface-water withdrawals for hydropower usage are considered to be non-consumptive, as almost all of the water is returned to the river. Furthermore, in the case of the Crisp County Power's permitted withdrawals, that water is not retained or pumped out of the river; instead, it is locally diverted into hydropower turbines and returned immediately to the Flint River. Thus, its withdrawal amount is totally non-consumptive.

Municipal and Industrial ground-water users south of the fall line withdraw water from the Floridan, Claiborne, Clayton, and Cretaceous aquifers.(Table 5.4). Withdrawals from aquifers other than the Floridan do not significantly impact streamflow. Floridan aquifer withdrawals are more substantial, but the total M&I withdrawals represent less than 3 % of agricultural irrigation withdrawals. Thus, their cumulative impact on stream-aquifer flux and the regional ground-water **budget** is negligible.

GEORGIA COUNTY	GW W/D PERMIT NUMBER	GROUND-WATER PERMIT HOLDER	PERMITTED MONTHLY AVG W/D (MGD)	PERMITTED YEARLY AVG W/D (MGD)	Aquifer
Baker	004-0001	Newton, City of	0.250	0.250	Claiborne
Calhoun	019-0001	Leary, City of	0.300	0.300	Claiborne, Tallahatta
Calhoun	019-0002	Edison, City of	0.300	0.200	Clayton
Calhoun	019-0003	Arlington, City of	0.350	0.300	Floridan
Calhoun	019-0004	Morgan, City of	0.350	0.300	Clayton
Clayton	031-0002	Clayton County Water Authority	0.729	0.729	Crystalline Rock
Crawford	039-0001	Roberta, City of	0.240	0.180	Cretaceous Sand
Crawford	039-0002	Crawford County Board of Commissioners	0.300	0.250	Cretaceous Sand
Crisp	040-0001	Cordele, City of	4.100	3.000	Floridan, Claiborne, Wilcox
Crisp	040-0002	Norbord Georgia Inc - Cordele OSB Mill	0.225	0.210	Floridan
Crisp	040-0004	Crisp County - Waterworks	1.000	0.800	Claiborne
Decatur	043-0001	Florida Rock Industries - Bainbridge Sand Plant	0.285	0.235	Floridan
Decatur	043-0002	Propex Fabrics, Inc - Bainbridge Mills	0.900	0.750	Floridan
Decatur	043-0003	Bainbridge, City of	5.000	4.400	Floridan
Decatur	043-0004	Decatur County Industrial Airpark	0.650	0.550	Floridan
Decatur	043-0005	Z.A. Adams Construction Company	0.400	0.400	Floridan

Dooly	046-0002	Vienna, City of	2.609	2.153	Cretaceous Sand, Claiborne
Dougherty	047-0001	Cooper Tire & Rubber Company	0.720	0.720	Floridan
Dougherty	047-0002	Albany, City of - Water, Gas & Light Com	36.000	24.000	Clayton, Claiborne, Floridan, Providence
Dougherty	047-0003	Merck & Company, Inc	10.440	8.550	Floridan
Dougherty	047-0004	Florida Rock Industries - Albany Sand Plant	0.250	0.160	Floridan
Dougherty	047-0005	Procter & Gamble Paper Products Company	10.500	10.500	Floridan
Dougherty	047-0007	Miller Breweries East, Inc	3.000	3.000	Clayton, Tallahatta
Dougherty	047-0008	Marine Corps Logistics Base	2.000	1.500	Floridan, Claiborne, Tallahatta, Wilcox, Clayton
Dougherty	047-0010	Young Pecan Company - Nut Tree Division	0.180	0.100	Floridan
Dougherty	047-0011	Doublegate Country Club	0.720	0.720	Floridan
Dougherty	047-0012	Georgia Power Company - Plant Mitchell	0.250	0.250	Floridan
Dougherty	047-0013	Barton Brands / Viking Distillery, Inc	0.200	0.200	Clayton, Floridan
Fayette	056-0001	Fayette County Water System	0.875	0.825	Crystalline Rock
Fayette	056-0002	Fayetteville, City of	0.937	0.937	Crystalline Rock
Fulton	060-0005	Ford Motor Co - Atlanta Assembly Plant	0.291	0.291	Crystalline Rock
Lee	088-0001	Leesburg, City of	0.320	0.300	Tallahatta, Wilcox, Paleocene
Lee	088-0002	Lee County Utilities Authority	2.500	2.000	Claiborne, Clayton, Providence
Macon	094-0001	Montezuma, City of	1.250	0.810	Cretaceous Sand
Macon	094-0002	Flint River Foods	2.000	1.000	Cretaceous Sand
Macon	094-0003	Marshallville,City of	0.155	0.120	Cretaceous Sand
Macon	094-0004	C-E Minerals - Plant #5 Mulcoa	0.100	0.100	Midway, Providence
Macon	094-0005	Weyerhaeuser Company - Flint River Operations	1.836	1.836	Cretaceous Sand
Macon	094-0006	Oglethorpe, City of	0.370	0.330	Cretaceous Sand
Marion	096-0001	Buena Vista, City of	2.000	1.750	Cretaceous Sand
Marion	096-0002	Marion County Water System	0.637	0.482	Cretaceous Sand
Meriwether	099-0003	Georgia-Pacific - Warm Springs Plywood	0.200	0.200	Crystalline Rock
Miller	100-0001	Colquitt, City of	1.000	0.800	Floridan
Mitchell	101-0002	Camilla, City of	5.500	5.000	Floridan
Mitchell	101-0003	Mitchell County - State	0.300	0.300	Floridan,

		Prison			Oligocene
Mitchell	**101-0004**	Gum Pond, LLC - Power Plant	**1.100**	**1.100**	Floridan
Randolph	**120-0001**	Cuthbert, City of	**1.000**	**0.800**	Clayton, Providence (K)
Randolph	**120-0002**	Shellman, City of	**0.180**	**0.150**	Clayton
Randolph	**120-0003**	Georgia Feed Products, Inc	**0.200**	**0.200**	Clayton
Schley	**123-0001**	Ellaville, City of	**0.350**	**0.275**	Cretaceous Sand
Schley	**123-0002**	Schley County Board of Commissioners	**0.133**	**0.100**	Cretaceous Sand
Seminole	**125-0001**	Donalsonville, City of	**1.000**	**0.800**	Floridan
Spalding	**126-0001**	Griffin, City of	**1.461**	**1.461**	Crystalline Rock
Stewart	**128-0001**	Richland, City of	**0.100**	**0.100**	Cretaceous Sand
Sumter	**129-0001**	Americus, City of	**4.200**	**3.750**	Cretaceous Sand
Sumter	**129-0002**	Plains, City of	**0.220**	**0.195**	Claiborne (Tallahatta)
Sumter	**129-0003**	C. E. Minerals - Plant #1	**0.360**	**0.360**	Cretaceous Sand
Sumter	**129-0004**	C. E. Minerals - Plant #2	**0.684**	**0.684**	Cretaceous Sand
Talbot	**130-0001**	Talbotton, City of	**0.200**	**0.200**	Crystalline Rock
Taylor	**133-0002**	Reynolds, City of	**0.450**	**0.255**	Cretaceous Sand
Taylor	**133-0003**	Butler, City of	**0.750**	**0.550**	Cretaceous Sand
Taylor	**133-0004**	Natural Water, LLC	**0.500**	**0.500**	Cretaceous Sand
Terrell	**135-0001**	Dawson, City of	**3.000**	**2.000**	Clayton
Upson	**145-0001**	Sunset Village Water System (Upson County)	**0.106**	**0.106**	Crystalline Rock

	Active Monthly Permitted	Active Annual Permitted
Active GW permits.......PERMITTED TOTALS	**118.513 mgd**	**95.374 mgd**

Table 5.4: Permitted municipal and industrial ground-water withdrawals in the FRB

SECTION 6: HYDROLOGIC MODELS IN THE LOWER FLINT RIVER BASIN

6.1 Ground-water models

6.1.1 Model area and boundaries

The flow of water between the Floridan aquifer and streams in the lower FRB was mathematically simulated using the USGS' Modular Finite Element Model (**MODFE**) (Cooley, 1992; Torak, 1993). The part of southwestern Georgia and adjacent parts of Florida and Alabama where the Floridan aquifer is in hydraulic connection with surface-water is referred to as "Subarea 4", one of eight divisions delineated for the ACT-ACF Comprehensive Study. Although Subarea 4 extends outside of Georgia, subsequent discussion of it and the ground-water models will only relate to the part inside Georgia (Fig. 6.0).

Model boundaries are discontinuities in aquifer extent and hydrologic properties that influence the flow of water in an aquifer area (Torak, 1992). Water can enter or leave a model area across the boundaries. Model boundaries may be external, such as the physical extent of an aquifer, or internal to the model area, such as a stream. The northern boundary of Subarea 4 is defined by the approximate up-dip limit of the Ocala Limestone. The southeastern boundary was originally defined by the existence of a no-**flow boundary**, a ground-water "divide" that separates easterly ground-water flow into the FRB from westerly flow out of the basin and Subarea 4 (Torak and McDowell, 1996). Subsequent modeling indicated that this divide is not entirely a no-flow boundary. Ground-water can and does flow across it into and out of Subarea 4, although more than half it does indeed act as a no-flow boundary (Jones and Torak, in review).

Preliminary Analysis—Subject to Review and Revision by the Director of U.S. Geological Survey

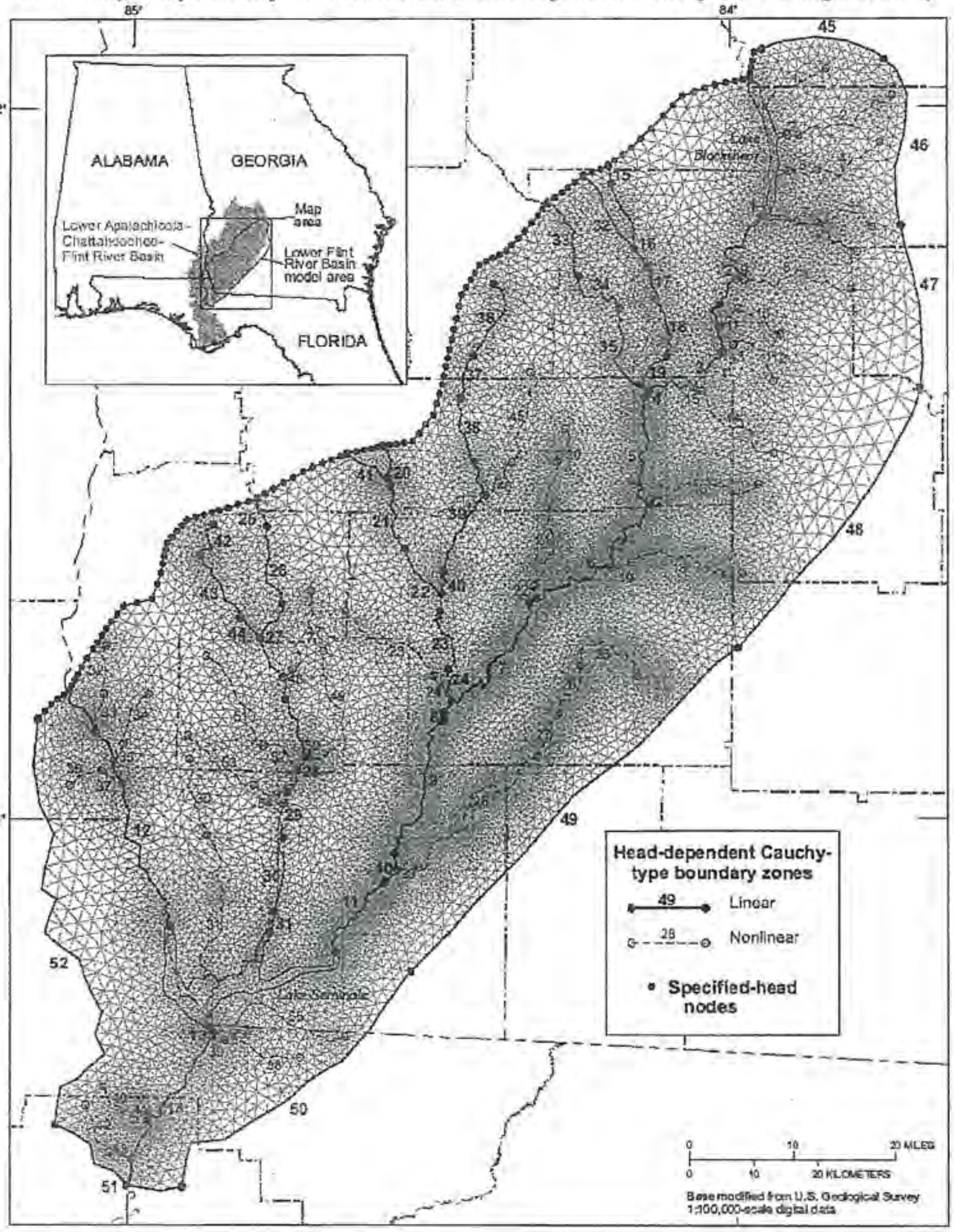


Figure 3. Finite-element mesh, linear and nonlinear head-dependent (Cauchy-type) boundary zones of element sides, and specified-head nodes in the lower Flint River Basin model.

Figure 6.1: MODFE model area, showing finite-element mesh, model boundaries, and simulated stream segments
(Jones and Torak, in review).

Internal boundaries in the model area consist of: 1) streams that can receive water from the Floridan aquifer, supply water to the aquifer, or both; 2) the outcrop of the Ocala Limestone; and 3) the sediments and soils overlying the Floridan aquifer (**overburden**). Whether water leaves or enters the Floridan aquifer, or the model area, depends on the head difference between the aquifer and the overburden; the aquifer and outcrop area; the aquifer and surface streams; or the model area and the area outside of it. The direction of water flow across a boundary may change through time as water levels change due, for example, to seasonal fluctuations in aquifer head or to pumping-induced changes in head.

6.1.2 Model application and results

MODFE is based on the complex mathematical relationships that govern fluid flow in aquifers. To simulate the stream-aquifer system in two or three dimensions, the model employs a detailed grid, or mesh, consisting of triangular "elements" that graphically represent the complex drainage network and extent of the Floridan aquifer in Subarea 4, and the potentiometric surface of the Floridan aquifer (Fig. 6.1). For each triangular element, a **hydraulic head** is assigned to the corners (nodes) such that the slope of the potentiometric surface can be calculated for that element. Pumping wells are also located at element nodes (Torak, 1992). Using 1) water levels in the Floridan aquifer as measured in observation wells; 2) hydraulic properties of the aquifer as determined by aquifer tests performed throughout Subarea 4; 3) water levels in the overburden as measured in observation wells; 4) stream levels; and 5) pumping rates at model mesh nodes, MODFE can simulate the movement of water across the model boundaries, especially between streams and the Floridan aquifer (Torak 1993, Torak and McDowell, 1996). This can be done for steady state conditions, when the flow of water between the stream and aquifer is occurring at a constant rate, or for **transient** conditions, when stream-aquifer flow and pumping rate are changing through time. For the FRB Plan, transient conditions were simulated to see how the stream-aquifer flow changed as irrigation amounts and aquifer head changed during a drought year.

Calculated volumes of water flowing across all external and internal model boundaries are expressed as individual components of a total water budget. The budgets are broken into main categories: recharge and discharge. Recharge budget components consist of downward **leakage** of water from the overburden, direct **infiltration** of water into the aquifer, regional ground-water flow entering the model area from outside Subarea 4, water that enters the aquifer from its outcrop exposures, and water that seeps into the aquifer from losing streams. Discharge budget components consist of water flowing from the aquifer into the streams, water pumped from wells, water leaving the model area to regional ground-water flow, water leaking upwards into the overburden, water leaking out of the outcrop area, and water discharging to springs (Torak and McDowell, 1996).

6.1.3 Water budget analysis

A principal goal of the stream-aquifer modeling was to determine, in the water budget of the model area, what portion of the ground-water used for irrigation is intercepted base flow. In other words, how much of the water pumped from the Floridan aquifer would otherwise have seeped into the Flint River and its tributaries? Water pumped from the Floridan aquifer is derived from **storage** within the aquifer, infiltration from the Floridan aquifer outcrop, downward leakage from the overburden, regional ground-water flow, and intercepted base flow to streams. Using precipitation records, well levels, and metered irrigation usage derived from the AWP Study, the transient model simulated monthly changes to the ground-water budget for the drought period extending from March 2001 to February 2002. Results were calculated as percentages of total change in the water budget components for all of Subarea 4 and the percentage of ground-water withdrawals comprised of those components (Fig. 6.2).

Because of differing pumping rates throughout the year and changing hydrologic conditions, the proportion of water coming from different budget components likewise varied. For example, in July 2001, when ground-water withdrawals were the highest for that year, 28% of the water pumped came from intercepted base flow (Fig. 6.2).

Preliminary Analysis—Subject to Review and Revision by the Director of U.S. Geological Survey

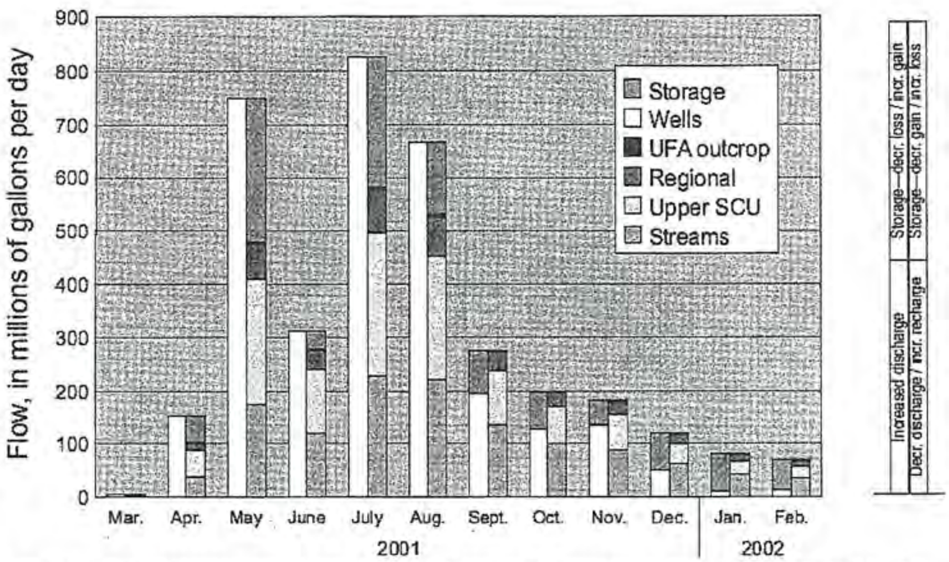


Figure 30. Simulated change in ground-water-budget components and storage gain or loss in the Upper Floridan aquifer due to irrigation pumpage for the March 2001February 2002 transient lower Flint River Basin model.

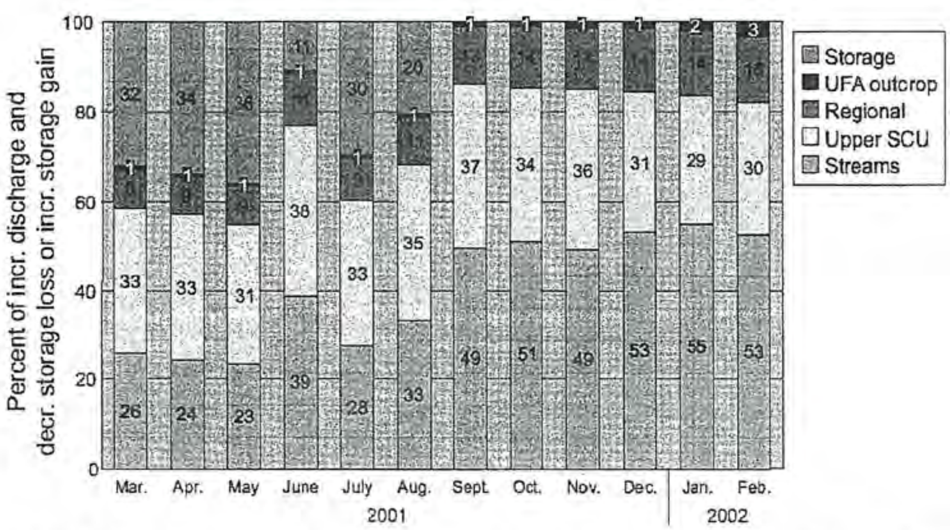


Figure 6.2. Simulated changes in ground-water budget components in the Floridan aquifer caused by pumpage from March 2001-February 2002 (L.E. Jones,in review).

Approximately 33% was derived from the overburden (i.e. local rainfall and recharge); 9% came from intercepted regional flow, 30% was derived from aquifer storage, and only 1% was derived from outcrops of the aquifer (Jones and Torak, in review). In other words, for every million gallons per day of water pumped from the Floridan aquifer in July 2001, streamflow in the entire Subarea 4 portion of the FRB was reduced by 280,000 gallons per day. The percentage of ground-water withdrawals derived from intercepted base flow varies from month to month, but during the 6-month growing season of 2001 the ratio of pumpage to intercepted base flow never exceeded 49%. Other monthly water budget analyses can be seen in Figure 6.2. It is important to realize that these percentages can and do change every year as hydrologic conditions change; therefore, it is difficult to apply one particular percentage of base flow reduction when calculating the effect of ground-water withdrawals on the Flint River and its tributaries. However, it may be reasonably assumed that the percentages shown in the figure below represent the approximate range of base flow decreases in a severe drought year.

Previous studies simulating steady-state conditions (e.g. Torak and McDowell, 1996) indicated a base flow reduction ratio of 0.61, such that for every one million gallons of ground-water pumped per day streamflow was reduced by 610,000 gpd. However, accurate measurements of irrigation volumes and new information on aquifer properties were not available to those studies. Irrigation pumping rates and depths used for the steady-state model were almost certainly too high, and it is unlikely that steady-state conditions are ever reached at the simulated pumping rates. Thus, the ratio of base flow reduction was overestimated.

6.1.4 Base flow reduction by HUC-12 and HUC-8 sub-basin

The USGS Subarea 4 model was adapted by EPD to analyze water budgets for three sub-basins of the FRB: Ichawaynochaway Creek, Spring Creek, and the lower Flint River (Fig 6.3). Water budget components were calculated for individual stream reaches in Subarea 4, using normal and drought year conditions and irrigation depths. The latter were compiled using the highest monthly values of irrigation measured during the 1998-

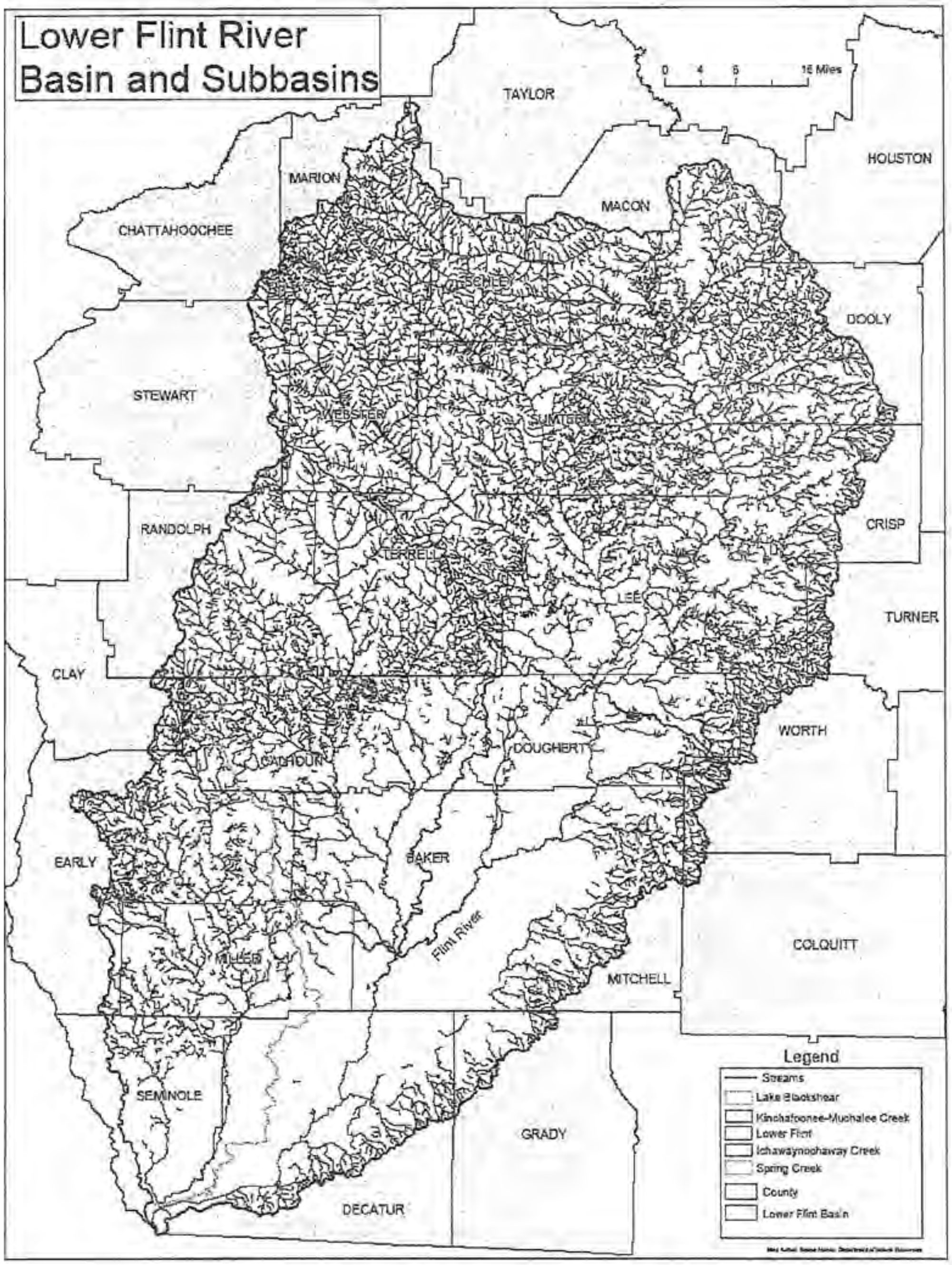


Figure 6.3. HUC-8 sub-basins of the lower FRB

2002 drought. "Normal year" irrigation depths were compiled using measured irrigation depths from 2003-2004. Results were expressed in terms of streamflow reduction in cubic feet per second for individual HUC-12 watersheds, for the entire sub-basin, and for each major stream gauge. Modeled stream reaches are shown in Figure 6.1, and the HUC-12 watersheds associated with these reaches are shown in Figures I2.1 (Ichawaynochaway Creek sub-basin), I.2-11 (Spring Creek sub-basin), and. I.2-20 (Lower Flint River sub-basin). Tables 6.1 (a)-(c) shows calculated reductions in streamflow caused by reduced ground-water discharge to HUC-12 watersheds. Color coding of the table columns matches the color coding of HUC-12's shown in Figures 0.2-0.5.

BASEFLOW REDUCTION IN HUC-12 WATERSHEDS OF ICHAWAYNOCHAWAY SUB-BASIN (CFS)

Current irrigated acres (drought year)

	HUC-12																		
	15	16	17	18	19	22	23	23	24	25	26	35	37	39	40	41	42	43	SUM
Mar	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.1	0.5	0.8	0.0	0.0	2.0
Apr	0.0	0.0	0.0	0.0	0.2	0.0	0.2	0.1	0.2	0.0	0.0	0.0	0.0	0.4	1.5	1.5	0.1	0.0	4.3
May	0.0	0.0	0.0	0.0	0.6	0.0	0.7	0.0	0.6	0.0	0.0	0.0	0.0	1.6	4.6	5.9	0.2	0.1	14.4
Jun	0.0	0.0	0.0	0.1	1.1	0.0	0.9	0.2	0.7	0.0	0.0	0.0	0.1	2.7	7.6	7.8	0.3	0.2	21.7
Jul	0.0	0.0	0.0	0.1	1.2	0.0	1.0	0.0	0.9	0.0	0.0	0.0	0.1	4.0	10.6	9.8	0.4	0.2	28.4
Aug	0.1	0.1	0.0	0.1	1.4	0.0	1.1	0.0	1.0	0.0	0.0	0.0	0.0	5.4	13.5	11.8	0.5	0.3	35.3
Sep	0.1	0.1	0.0	0.1	1.1	0.0	0.8	0.0	0.6	0.0	0.0	0.0	0.0	6.2	13.0	5.0	0.2	0.3	27.5
Oct	0.0	0.0	0.0	0.1	0.6	0.0	0.4	0.0	0.2	0.0	0.0	0.0	0.0	6.0	11.4	1.6	0.1	0.3	20.7
Nov	0.0	0.0	0.0	0.1	0.7	0.0	0.3	0.0	0.2	0.0	0.0	0.0	0.0	5.7	10.1	1.2	0.1	0.3	18.8
Dec	0.1	0.0	0.0	0.1	0.5	0.0	0.2	0.0	0.1	0.0	0.0	0.0	0.0	5.3	8.7	0.7	0.0	0.3	16.0

Current irrigated acres + 'backlog' (drought year)

	HUC-12																		
	15	16	17	18	19	22	23	23	24	25	26	35	37	39	40	41	42	43	SUM
Mar	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.1	0.0	0.0	0.0	0.1	0.2	0.6	0.9	0.0	0.03	2.36
Apr	0.0	0.0	0.0	0.0	0.2	0.0	0.2	0.1	0.2	0.0	0.0	0.0	0.0	0.5	1.7	2.0	0.1	0.05	5.05
May	0.1	0.1	0.0	0.0	0.8	0.0	0.8	0.0	0.7	0.0	0.0	0.0	0.1	1.7	5.4	8.2	0.3	0.13	18.3
Jun	0.2	0.1	0.0	0.1	1.4	0.0	1.1	0.2	0.9	0.0	0.0	0.0	0.1	2.9	8.6	10.4	0.4	0.29	26.8
Jul	0.2	0.1	0.0	0.1	1.5	0.0	1.2	0.0	1.0	0.0	0.0	0.0	0.1	4.2	11.6	11.9	0.5	0.32	32.7
Aug	0.2	0.1	0.0	0.1	1.7	0.0	1.2	0.0	1.1	0.0	0.0	0.0	0.1	5.6	14.5	13.5	0.6	0.35	39
Sep	0.2	0.1	0.0	0.1	1.4	0.0	0.9	0.0	0.7	0.0	0.0	0.0	0.0	6.4	13.8	5.9	0.3	0.41	30.2
Oct	0.2	0.1	0.0	0.1	0.8	0.0	0.4	0.0	0.2	0.0	0.0	0.0	0.0	6.3	12.0	1.9	0.1	0.35	22.4
Nov	0.2	0.1	0.0	0.1	0.9	0.0	0.4	0.0	0.2	0.0	0.0	0.0	0.0	6.0	10.6	1.4	0.1	0.4	20.3
Dec	0.2	0.1	0.0	0.1	0.7	0.0	0.3	0.0	0.1	0.0	0.0	0.0	0.0	5.5	9.2	0.9	0.1	0.36	17.5

Table 6.1 (a): Calculated streamflow reduction due to irrigation pumping from the Floridan aquifer, simulated for HUC-12 watersheds in Ichawaynochaway Creek sub-basin for drought years (cubic feet/sec.)

BASEFLOW REDUCTION IN HUC-12 WATERSHEDS OF SPRING CREEK SUB-BASIN (CFS)

Current irrigated acres (drought year) — **HUC-12**

	2	4	5	6	7	8	9	10	11	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	33	34	35	SUM
mar	0.0	0.0	0.1	0.0	0.0	0.3	0.2	0.2	0.0	0.2	0.1	0.0	0.0	0.2	0.3	0.2	0.7	0.0	0.2	0.0	0.2	0.7	0.0	1.9	0.8	1.7	0.2	0.0	0.1	0.8	9.1
apr	0.0	0.1	0.3	0.1	0.0	0.6	0.6	0.5	0.0	0.4	0.3	0.0	0.0	0.4	0.4	0.5	1.6	0.0	0.1	0.0	0.5	1.7	0.0	4.4	1.9	3.9	0.5	0.0	0.2	2.0	21.1
may	0.0	0.4	1.8	0.3	0.0	1.0	3.1	2.1	0.0	1.2	1.1	0.0	0.0	1.6	0.8	1.9	5.1	0.0	0.0	0.0	2.0	7.7	0.0	21.1	9.3	18.8	2.7	0.2	0.5	9.4	92.1
jun	0.1	0.5	2.1	0.3	0.0	1.4	3.6	2.6	0.0	1.4	1.4	0.0	0.0	2.2	1.2	2.6	6.7	0.0	0.0	0.0	2.4	9.2	0.0	24.6	10.7	21.3	3.1	0.2	0.9	10.4	108.8
jul	0.1	0.4	1.7	0.3	0.0	1.0	2.9	2.1	0.0	1.2	1.2	0.0	0.0	1.9	0.9	2.2	5.4	0.0	0.0	0.0	2.0	7.6	0.0	20.2	8.7	17.4	2.5	0.2	0.6	8.6	89.0
aug	0.1	0.3	1.4	0.3	0.0	0.9	2.4	1.8	0.0	1.1	1.1	0.0	0.0	1.7	0.8	2.0	4.8	0.0	0.0	0.0	1.7	6.5	0.0	17.1	7.3	14.7	2.0	0.1	0.5	7.3	75.8
sep	0.1	0.2	0.8	0.2	0.0	0.7	1.6	1.3	0.0	0.8	0.6	0.0	0.0	1.5	0.8	1.8	4.0	0.0	0.0	0.0	1.2	4.5	0.0	11.1	4.6	9.4	1.1	0.1	0.3	4.7	51.2
oct	0.1	0.1	0.3	0.1	0.0	0.3	0.6	0.6	0.0	0.3	0.2	0.0	0.0	0.9	0.4	1.0	1.9	0.0	0.0	0.0	0.5	1.9	0.0	4.3	1.7	3.1	0.4	0.0	0.1	1.4	20.4
nov	0.1	0.1	0.2	0.1	0.0	0.3	0.4	0.5	0.0	0.2	0.2	0.0	0.0	0.6	0.4	0.8	1.4	0.0	0.0	0.0	0.4	1.4	0.0	3.1	1.2	2.2	0.3	0.0	0.1	1.0	14.9
dec	0.1	0.1	0.2	0.1	0.0	0.1	0.3	0.3	0.0	0.2	0.1	0.0	0.0	0.3	0.2	0.3	0.8	0.0	0.0	0.0	0.3	0.9	0.0	2.2	0.9	1.8	0.2	0.0	0.1	0.8	10.2

Current irrigated acres + 'backlog' (drought year) — **HUC-12**

	2	4	5	6	7	8	9	10	11	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	33	34	35	SUM
mar	0.0	0.0	0.2	0.0	0.0	0.3	0.3	0.2	0.0	0.2	0.1	0.0	0.0	0.2	0.4	0.2	0.7	0.0	0.2	0.0	0.3	0.8	0.0	2.1	1.0	2.0	0.2	0.0	0.1	1.0	10.4
apr	0.0	0.1	0.4	0.1	0.0	0.6	0.6	0.5	0.0	0.4	0.3	0.0	0.0	0.5	0.5	0.6	1.7	0.0	0.1	0.0	0.6	1.9	0.0	5.0	2.2	4.6	0.5	0.0	0.2	2.3	23.9
may	0.0	0.5	2.0	0.3	0.0	1.1	3.3	2.3	0.0	1.2	1.1	0.0	0.0	1.7	0.8	2.0	5.3	0.0	0.0	0.0	2.1	8.3	0.0	23.1	10.4	21.2	2.9	0.2	0.6	10.6	100.9
jun	0.1	0.6	2.4	0.4	0.0	1.4	3.8	2.7	0.0	1.4	1.4	0.0	0.0	2.3	1.2	2.7	6.9	0.0	0.0	0.0	2.6	9.8	0.0	26.6	11.8	23.7	3.3	0.3	1.0	11.7	118.2
jul	0.1	0.5	1.9	0.4	0.0	1.1	3.1	2.3	0.0	1.2	1.2	0.0	0.0	2.0	0.9	2.4	5.6	0.0	0.0	0.0	2.1	8.3	0.0	22.4	9.9	19.9	2.6	0.2	0.7	9.8	98.5
aug	0.1	0.4	1.5	0.3	0.0	0.9	2.6	2.0	0.0	1.1	1.1	0.0	0.0	1.9	0.8	2.2	5.1	0.0	0.0	0.0	1.8	7.2	0.0	19.1	8.4	16.9	2.1	0.2	0.5	8.4	84.6
sep	0.1	0.3	0.9	0.2	0.0	0.7	1.6	1.4	0.0	0.8	0.7	0.0	0.0	1.6	0.8	2.0	4.4	0.0	0.0	0.0	1.4	5.1	0.0	12.8	5.5	11.3	1.2	0.1	0.4	5.8	59.0
oct	0.1	0.2	0.3	0.2	0.0	0.3	0.7	0.7	0.0	0.3	0.3	0.0	0.0	1.0	0.5	1.2	2.2	0.0	0.0	0.0	0.6	2.2	0.0	4.9	1.9	3.6	0.4	0.0	0.1	1.7	23.4
nov	0.1	0.2	0.2	0.2	0.0	0.3	0.5	0.6	0.0	0.2	0.2	0.0	0.0	0.8	0.5	0.9	1.7	0.0	0.0	0.0	0.4	1.6	0.0	3.6	1.4	2.6	0.3	0.0	0.1	1.2	17.5
dec	0.1	0.2	0.2	0.1	0.0	0.2	0.3	0.3	0.0	0.2	0.1	0.0	0.0	0.3	0.2	0.4	0.9	0.0	0.0	0.0	0.3	1.0	0.0	2.5	1.0	2.0	0.3	0.0	0.1	0.9	11.4

Table 6.1 (b): Calculated streamflow reduction due to irrigation pumping from the Floridan aquifer, simulated for HUC-12 watersheds in Spring Creek sub-basin for drought years (cubic feet/sec.)

BASEFLOW REDUCTION IN HUC-12 WATERSHEDS OF LOWER FLINT SUB-BASIN (CFS)

Current irrigated acres (drought year) — HUC-12

	1	3	5	6	8	9	10	11	12	13	15	16	17	20	21	22	23	24	25	26	28	29	31	33	SUM
Jan	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.1	0.0	1.0	0.0	0.0	0.2	0.6	3.1
Feb	0.0	0.0	0.4	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.1	0.0	1.0	0.0	0.0	0.2	0.7	3.5
Mar	0.1	0.4	7.4	0.0	0.6	3.2	0.0	0.0	0.0	0.0	0.0	3.4	0.0	0.0	0.0	0.0	2.1	2.7	6.0	2.5	0.0	0.0	2.1	6.4	36.9
Apr	0.0	0.3	8.8	0.0	1.0	5.2	0.0	0.0	0.0	0.0	0.0	5.4	0.0	0.0	0.0	0.0	6.5	7.1	12.6	4.1	0.0	0.0	4.3	12.9	68.3
May	0.0	0.0	26.4	0.0	1.5	15.1	0.0	0.0	0.0	0.0	0.0	15.3	0.0	0.0	0.0	0.0	20.0	22.8	46.3	13.6	0.0	0.0	16.9	36.3	214.2
Jun	0.0	0.4	34.6	0.0	2.9	18.0	0.0	0.1	0.0	0.0	0.0	18.2	0.0	0.0	0.0	0.0	29.6	31.0	48.3	13.7	0.0	0.0	17.1	52.0	265.8
Jul	0.0	0.0	35.4	0.0	1.7	18.2	0.0	0.0	0.0	0.0	0.0	17.4	0.0	0.0	0.0	0.0	35.9	34.7	45.8	12.5	0.0	0.0	15.3	60.5	277.4
Aug	0.0	0.0	37.0	0.0	1.2	18.4	0.0	0.0	0.0	0.0	0.0	17.1	0.0	0.0	0.0	0.0	39.3	36.3	44.8	11.9	0.0	0.0	14.3	65.5	285.9
Sep	0.0	0.0	38.7	0.0	1.4	18.8	0.0	0.0	0.0	0.0	0.0	17.9	0.0	0.0	0.0	0.0	41.4	36.6	41.3	10.4	0.0	0.0	12.1	68.7	287.3
Oct	0.0	0.0	24.4	0.0	0.6	11.1	0.0	0.0	0.0	0.0	0.0	9.9	0.0	0.0	0.0	0.0	34.8	25.1	13.8	3.4	0.0	0.0	3.0	55.0	181.0
Nov	0.0	0.0	19.1	0.0	0.3	8.3	0.0	0.0	0.0	0.0	0.0	7.2	0.0	0.0	0.0	0.0	27.2	17.5	10.1	2.8	0.0	0.0	2.3	42.6	137.4
Dec	0.0	0.0	15.9	0.0	0.3	6.2	0.0	0.0	0.0	0.0	0.0	5.1	0.0	0.0	0.0	0.0	20.8	11.8	6.0	2.0	0.0	0.0	1.4	32.2	101.7

Current irrigated acres + 'backlog' (drought year) — HUC-12

	1	3	5	6	8	9	10	11	12	13	15	16	17	20	21	22	23	24	25	26	28	29	31	33	SUM
Jan	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.1	0.0	1.0	0.0	0.0	0.2	0.6	3.1
Feb	0.0	0.0	0.4	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.1	0.0	1.0	0.0	0.0	0.2	0.7	3.5
Mar	0.1	0.5	7.7	0.0	0.6	3.5	0.0	0.0	0.0	0.0	0.0	3.6	0.0	0.0	0.0	0.0	2.2	3.0	6.4	2.6	0.0	0.0	2.2	6.8	39.2
Apr	0.0	0.3	9.4	0.0	1.1	5.8	0.0	0.0	0.0	0.0	0.0	5.9	0.0	0.0	0.0	0.0	7.0	8.0	13.6	4.4	0.0	0.0	4.6	13.8	73.7
May	0.0	0.0	28.2	0.0	1.6	16.7	0.0	0.0	0.0	0.0	0.0	16.6	0.0	0.0	0.0	0.0	21.5	26.4	50.7	14.7	0.0	0.0	18.1	39.2	233.7
Jun	0.0	0.4	37.1	0.0	3.2	20.2	0.0	0.1	0.0	0.0	0.0	20.0	0.0	0.0	0.0	0.0	32.0	36.3	53.5	15.0	0.0	0.0	18.4	56.7	292.8
Jul	0.0	0.0	38.3	0.0	1.8	20.6	0.0	0.0	0.0	0.0	0.0	19.1	0.0	0.0	0.0	0.0	38.8	40.0	50.5	13.6	0.0	0.0	16.5	65.9	305.3
Aug	0.0	0.0	40.0	0.0	1.3	20.7	0.0	0.0	0.0	0.0	0.0	18.8	0.0	0.0	0.0	0.0	42.5	41.3	48.7	12.8	0.0	0.0	15.3	71.1	312.6
Sep	0.0	0.0	41.8	0.0	1.4	21.0	0.0	0.0	0.0	0.0	0.0	19.4	0.0	0.0	0.0	0.0	44.5	40.5	44.0	11.0	0.0	0.0	12.8	73.9	310.3
Oct	0.0	0.0	26.9	0.0	0.6	12.7	0.0	0.0	0.0	0.0	0.0	11.0	0.0	0.0	0.0	0.0	37.4	27.7	15.1	3.6	0.0	0.0	3.2	59.4	197.7
Nov	0.0	0.0	21.3	0.0	0.4	9.7	0.0	0.0	0.0	0.0	0.0	8.0	0.0	0.0	0.0	0.0	29.5	19.3	11.0	2.9	0.0	0.0	2.4	46.1	150.6
Dec	0.0	0.0	17.8	0.0	0.3	7.1	0.0	0.0	0.0	0.0	0.0	5.7	0.0	0.0	0.0	0.0	22.6	13.1	6.6	2.1	0.0	0.0	1.6	35.1	112.1

Table 6.1 (c): Calculated streamflow reduction due to irrigation pumping from the Floridan aquifer, simulated for HUC-12 watersheds in Lower Flint River sub-basin for drought years (cubic feet/sec.)

Table 6.2 (a)-(f) shows calculated reductions in streamflow caused by reduced ground-water discharge to HUC-8 sub-basins. The table columns show, from left to right, the total calculated streamflow reduction for the entire sub-basin; the reduction for the part of the sub-basin upstream from the referenced gauge; the calculated reduction that would result if the permit backlog were issued; the calculated reduction that would result if the backlog were issued and irrigation volume were increased by 25%; and the observed average monthly streamflow at the referenced gauge.

Table 6.2 (a): Streamflow reduction due to irrigation pumping from the Floridan aquifer, simulated at Milford gauge on Ichawaynochaway Creek for drought years (cubic feet/sec.)

		current acres	backlog	1.25 x backlog	
Month	sub-basin (current acres)	Simulated flow reduction at Milford (cfs)			Observed (2000)
March	2	0.2	0.2	0.3	495
Apr	4	0.3	0.4	0.5	379
May	15	0.9	1.3	1.6	124
Jun	23	1.6	2.1	2.7	42
Jul	31	1.9	2.3	2.9	103
Aug	38	2.2	2.6	3.2	87
Sep	30	1.7	2.1	2.6	182
Oct	23	1.0	1.2	1.6	138
Nov	20	1.1	1.4	1.7	296
Dec	17	0.9	1.1	1.4	388

Table 6.2 (b): Streamflow reduction due to irrigation pumping from the Floridan aquifer, simulated at the Milford gauge on Ichawaynochaway Creek for normal years (cubic feet/sec.)

		current acres	backlog	1.25 x backlog	
Month	Whole sub-basin (current acres)	Simulated flow reduction at Milford (cfs)			Observed (1958)
March	1	0.1	0.1	0.1	1897
Apr	3	0.2	0.2	0.3	1698
May	9	0.6	0.8	1.0	658
Jun	14	1.0	1.2	1.5	516
Jul	19	1.2	1.5	1.9	575
Aug	21	1.2	1.5	1.9	430
Sep	21	0.9	1.2	1.5	299
Oct	13	0.6	0.8	0.9	298
Nov	11	0.6	0.8	1.0	327
Dec	9	0.5	0.6	0.8	472

Table 6.2 (c): Streamflow reduction due to irrigation pumping from the Floridan aquifer, simulated at the Iron City gauge on Spring Creek for drought years (cubic feet/sec.)

		current acres	backlog	1.25 x backlog	
Month	Whole sub-basin (current acres)	Simulated flow reduction at Iron City (cfs)			Observed (2000)
March	9	3.5	3.8	4.8	262
Apr	20	8.1	8.8	11.0	164
May	93	30.9	32.9	41.1	25
Jun	109	38.5	40.9	51.1	2
Jul	88	31.4	33.7	42.1	1
Aug	76	27.3	29.5	36.9	.13
Sep	48	19.9	21.9	27.4	.08
Oct	17	9.3	10.5	13.2	1
Nov	11	7.0	8.3	10.3	10
Dec	11	4.2	4.7	5.9	61

Table 6.2 (d): Streamflow reduction due to irrigation pumping from the Floridan aquifer, simulated at the Iron City gauge on Spring Creek for normal years (cubic feet/sec.)

		current acres	backlog	1.25 x backlog	
Month	Whole sub-basin (current acres)	Simulated flow reduction at Iron City (cfs)			Observed (1958)
March	4	1.7	1.8	2.3	1625
Apr	15	6.1	6.5	8.1	1505
May	53	19.7	20.8	26.0	599
Jun	58	23.1	24.6	30.7	458
Jul	56	20.8	22.6	28.3	486
Aug	47	17.8	19.6	24.5	396
Sep	47	11.0	12.3	15.4	166
Oct	10	3.9	4.4	5.5	114
Nov	5	2.3	2.4	3.0	85
Dec	5	2.1	2.2	2.7	96

Table 6.2 (e): Streamflow reduction due to irrigation pumping from the Floridan aquifer, simulated at the Bainbridge gauge of the lower Flint River for drought years (cubic feet/sec.)

		current acres	backlog	1.25 x backlog	
Month	Whole sub-basin (current acres)	Simulated flow reduction at Bainbridge (cfs)			Observed (1954)*
March	59	39	42	52	8714
Apr	90	73	79	98	7903
May	236	229	252	315	5293
Jun	288	287	320	399	3739
Jul	299	306	338	422	3337
Aug	308	321	352	440	3052
Sep	309	315	341	426	2409
Oct	203	202	220	275	2213
Nov	159	156	171	214	2424
Dec	124	118	130	162	3627

* 1954 was used as a drought year because Bainbridge gauge data is unavailable for 1999-2000.

Table 6.2 (f): Streamflow reduction due to irrigation pumping from the Floridan aquifer, simulated at the Bainbridge gauge of the lower Flint River for normal years (cubic feet/sec.)

Month	Whole sub-basin (current acres)	current acres	backlog	1.25 x backlog	Observed (1958)
		Simulated flow reduction at Bainbridge (cfs)			
March	37	16	17	22	21970
Apr	51	32	35	44	19440
May	112	98	110	137	10090
Jun	150	140	156	195	7650
Jul	191	186	207	258	9262
Aug	201	199	220	275	6871
Sep	160	153	169	212	3873
Oct	115	105	116	145	3920
Nov	80	69	76	95	4094
Dec	64	51	56	70	5003

Several observations can be made: 1) in all three sub-basins, the simulated streamflow reduction increased with added acreage (i.e. the application backlog) and increased irrigation volume; 2) the proportionately greatest increases in streamflow reduction, compared to observed flows, occurred in Spring Creek, where the simulated streamflow reduction caused by aquifer withdrawals represents the highest proportion of observed flow. Indeed, in drought years the simulated reduction is actually greater than the observed flows during a drought year. This happened only in Spring Creek; 3) simulated reductions for the entire Ichawaynochaway sub-basin are substantially higher than those calculated for the Milford gauge. This is because much of the sub-basin above the Milford gauge is outside of Subarea 4, and Floridan aquifer withdrawals would have the greatest effect on streamflow downstream of the Milford gauge. A similar relationship is true for Spring Creek below the Iron City gauge, although not to the same degree as in Ichawaynochaway sub-basin. It is important to note that these figures do not include surface-water withdrawals, which for Ichawaynochaway sub-basin would have a *significant* impact on the total reduction to streamflow caused by all withdrawals.

Figures 0.2-0.5 indicate that, within the larger sub-basins, HUC-12 watersheds with closer hydrologic connections to the Floridan aquifer and larger volumes of groundwater withdrawals experience greater decreases in baseflow to streams. Some stream reaches are not in hydrologic connection with the Floridan aquifer, and thus experience little or no baseflow reduction from nearby irrigation withdrawals. Comparing Figures 0.2-0.5 with Tables 6.1 (a) –(c) and 6.2 (a) -(f), it is evident that only a few HUC-12 watersheds can account for much or most of the decreased streamflow in a HUC-8 sub-basin. For example, more than 71% of the total baseflow reduction in Ichawaynochaway Creek during August of a drought year, irrigating existing acreage, is caused by groundwater withdrawals in only two HUC-12 watersheds (40 and 41).

In all three sub-basins, HUC-12 watersheds could be grouped into three categories based on the amount of decreased baseflow caused by Floridan aquifer withdrawals in each. The watersheds are color coded based on these categories in Figures 0.2-0.5 and Tables 6.1 (a) - (c). Green-colored watersheds, referred to as "Conservation Use Areas: are those in which baseflow reduction is less than 1 cfs during drought years. These streams either have a week hydrologic connection with the Floridan aquifer, have a low amount of irrigation withdrawals from the Floridan, or both. Watersheds with intermediate levels of reduced baseflow are colored yellow, and referred to as "Restricted Use Areas". These watersheds may have large volumes of withdrawals from the Floridan aquifer, but the degree of hydrologic connection with the aquifer is greater than in the Conservation Use Areas. Those watersheds with the highest amount of reduced baseflow are colored pink, and referred to as "Capacity Use Areas". These watersheds experience the largest volume of baseflow reduction due to a close connection between streams and the Floridan aquifer, and the largest volume of irrigation withdrawals. In most cases, these categories reflect a natural grouping in the calculated volumes of decreased baseflow. There is typically very little gradation between categories. Most Capacity Use Areas individually account for more than 10% of total baseflow reduction in a sub-basin, and together they may account for more than 50% of total baseflow reduction in a HUC-8 sub-basin.

6.1.5 Ground-water flow directions

Under pre-development or wet-season conditions, ground-water flow is generally towards the Flint River and its major tributaries (Clarke, 1987; Mosner, 2002). This may change locally as heads in the aquifer decline during the year. Figure 6.4 shows the modeled potentiometric surface of the Floridan aquifer and Figure 6.5 shows flow directions for the Ichawaynochaway Creek sub-basin, which are generally perpendicular to the potentiometric contours, superimposed on the potentiometric map. (Flow direction maps for other sub-basins of the lower FRB are found in Appendix II). Widely spaced potentiometric contours on Figure 6.4 indicate high aquifer transmissivity, whereas contours that are more closely spaced indicate lower transmissivity. Where contours are deflected upstream, such as along the Flint River and in the lower reaches of Ichawaynochaway, Pachitla, Kinchafoonee, and Spring Creeks, ground-water discharges to that stream. Where contours are not deflected by streams, such as in the upper reaches of Spring Creek, those streams are not in direct hydraulic connection with the Floridan aquifer.

Figure 6.4 indicates that, from the northern model boundary, ground-water flow is to the south and southeast towards the Flint River and its tributaries. East of the Flint River, ground-water flow is almost parallel to the Flint River except close to it, where it diverges abruptly towards the river. The color of the modeled stream segment indicates the ground-water flow rate, such that pink and red hues indicate high flow rates, and blue indicates lower rates. As can be seen along the Flint River, ground-water discharges along its length from Lake Chehaw to Lake Seminole. Significant volumes of ground-water are discharged into Spring Creek south of Iron City, as well as to sections of Ichawaynochaway Creek, Pachitla Creek, Kinchafoonee Creek, and Muckalee Creek. The volume of ground-water received by these stream segments changes throughout the year. In the summer when stream and aquifer levels are dropping and irrigation pumpage is typically high, ground-water discharges may decrease such that some stream segments become losing reaches (Jones and Torak, in review) and streamflow may be lost to the aquifer.

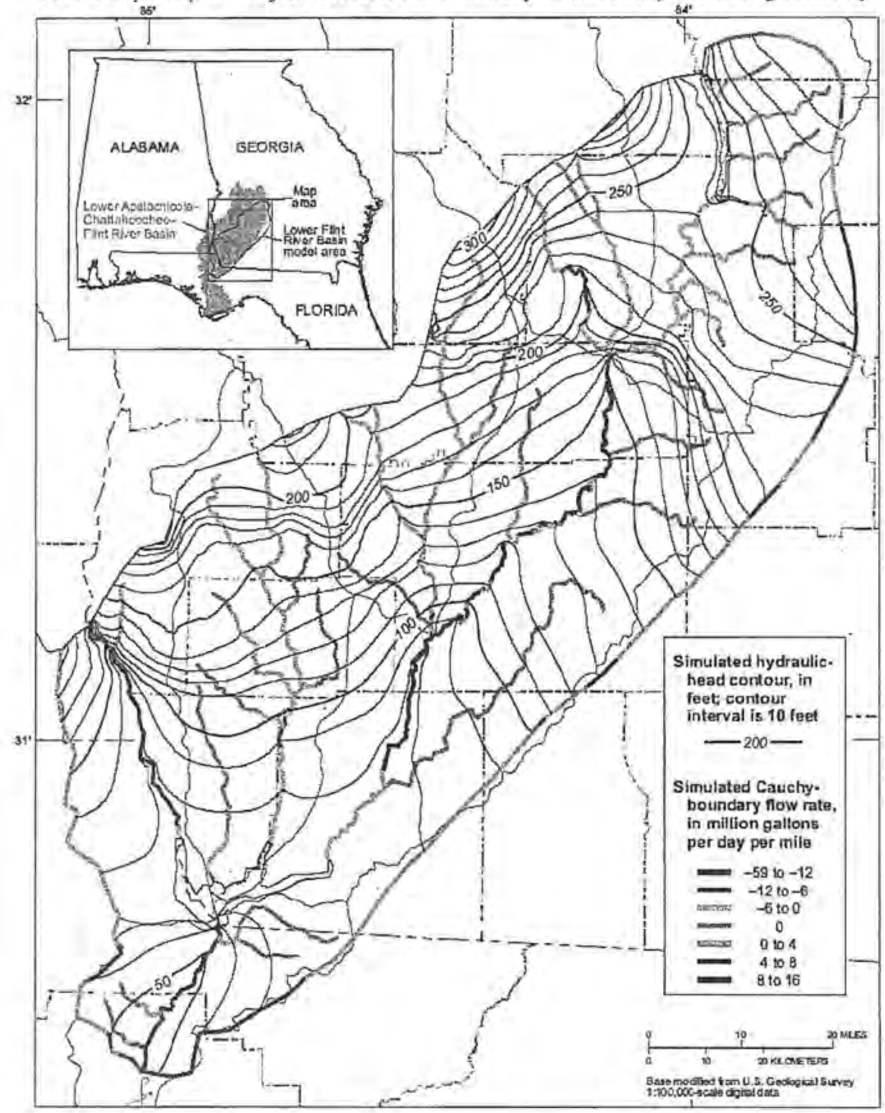


Figure 6.4: Simulated potentiometric contours, USGS Subarea 4 model (Jones and Torak, in review)

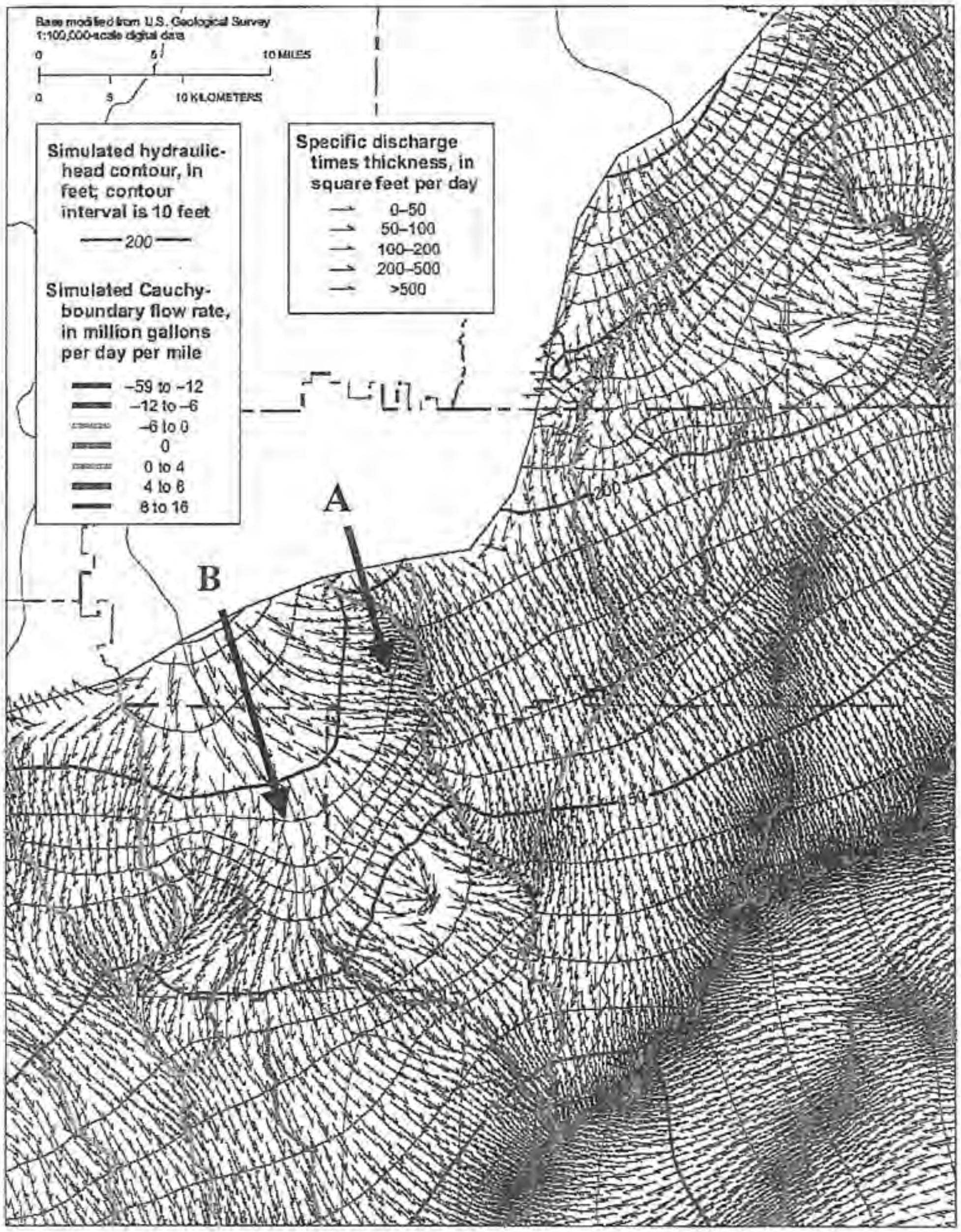


Figure 6.5: Ground-water flow directions in the Ichawaynochaway sub-basin (Jones and Torak, in review).

Although ground-water generally flows towards the Flint and its tributaries, the ground-water flow lines shown in Figure 6.5 reveal local complexities to the direction of ground-water flow caused by local changes in pumping, aquifer properties, topography, and the presence of streams. Also, the ground-water flow lines indicate that the impact of a well may not occur along the stream reach nearest the well; rather, the impact (as reduced flow) may occur miles downstream from the well. In areas where ground-water flows into streams at a high angle to the stream channel, the impact of a ground-water well near that stream segment may have a more direct impact due to decreased base flow. An example of this would be a pumping well within several miles of Ichawaynochaway Creek ('A', Fig. 6.5). Thus, the impact of pumping wells on base flow is not the same throughout Subarea 4. Wells close to streams segments that have a high degree of connectedness to the aquifer will have a volumetrically greater and more rapid impact on base flow than wells that are farther away from streams (e.g. 'B', Fig. 6.5), especially those streams with a poor connection to the Floridan aquifer.

6.2 Surface-water models

6.2.1 Description of Model Scenarios

The challenge faced in developing a management plan for water use in the lower FRB requires that likely future scenarios of agricultural water use be tested for their effects on streamflow. The tool to be used to test these scenarios is a combination of the USGS MODFE ground-water model, and the calibrated HSPF surface-water models.

Estimated current acreages irrigated from surface-water and ground-water sources in the Flint sub-basins are shown in Table 6.3. Among the three sub-basins being modeled, the lower Flint has the most irrigated land (about 170,000 acres), 98% of which are irrigated from the Upper Floridan aquifer. Spring Creek has about 139,000 irrigated acres, 92% from ground-water, and Ichawaynochaway Creek has 100,000 acres, with 66% irrigated from surface-water sources. Current application rates in inches per month are given for typical rainfall and drought years, by sub-basin, and for ground-water, surface-water, and well-to-pond sources in Table I.3-2 (Hook et al, 2005).

sub-basin	gw acres using Upper Floridan	surface-water acres	well to pond irr_acres	well to pond acres using Upper Floridan
Lower Flint	166187	3941	198	182
Ichawaynochaway Ck.	33474	65938	1344	402
Spring Creek	128011	10213	1531	1126
Kinchafoonee-Muckalee	12714	44223	951	355
Middle Flint	25533	36147	2756	1331
Total Flint	365919	160461	6781	3396

(a)

basin	gw acres using Upper Floridan	surface-water irr_acres	well to pond acres	well to pond acres using Upper Floridan
Lower Flint	18506	1308		
Ichawaynochaway Ck.	6477	10040		
Spring Creek	14197	2708	350	200
Kinchafoonee-Muckalee	5138	7732		
Middle Flint	19949	8701	785	128
Total Flint	64267	30489	1135	328

(b)

Table 6.3 (a): Estimated current irrigated acres in FRB, obtained from NESPAL/EPD permit mapping; (b) Proposed new irrigated acres associated with permit application "backlog"

Tables 6.3(a) and (b) are the basis for the Current Irrigation Scenario. Other scenarios modeled include the Backlog Scenario, which accounts for the option of approving all of the permit applications received by EPD during the permit moratorium (i.e. the "backlog"). This is equivalent to an increase of about 18% in irrigated acreage. A further increase in water use is represented by increasing the application rates shown in Table 3-2 for the Backlog Scenario by 25%, for example as a result of an extensive Crop Mix Scenario change. Finally, in case the evaluations of model results show that the Current Scenario over-allocates the water supply under drought conditions, Cutback Scenarios of 80%, 70%, and 60% of current water use rates are also modeled.

6.2.2 Model Results

The USGS MODFE model was used to compute the estimated monthly reduction in streamflow rates in each of the modeled sub-basins for each scenario in both drought and normal rainfall years. Tables 6.2 (a-f) provide comparison of the streamflow reductions at key gauges: Milford on Ichawaynochaway Creek, Iron City on Spring Creek, and Bainbridge in the lower Flint, for the Current, Backlog, and 1.25xBacklog scenarios in the growing season months of a drought year. The computed daily flow reductions obtained from MODFE are subtracted from the corresponding daily flow rates in the HSPF models to yield the estimated streamflow rates for each scenario at each model node.

Figure 6.5 (and Figure I.3-1) compares the computed flow exceedance curves for the Current, Backlog, and 1.25 X Backlog scenarios at Milford on Ichawaynochaway Creek. The flow rate exceeded 95% of the time can be seen to decrease from about 120 cfs for the Current Scenario to 110 cfs for the Backlog Scenario and 95 cfs for the 1.25 X Backlog Scenario. At Spring Creek near Iron City, the flow rate exceeded 95% of the time can be seen to decrease from about 25 cfs for the Current Scenario to about 20 cfs for the Backlog Scenario and to about 10 cfs for the 1.25 × Backlog Scenario (Fig. 6.6). At Flint River at Bainbridge, the flow rate exceeded 95% of the time is about 2280 cfs for the Current Scenario; it is reduced to about 2250 cfs for the Backlog Scenario, and further reduced to about 2200 cfs for the 1.25 × Backlog Scenario (Fig. 6.6). These effects include the computed ground-water reductions described in Section 3.2.1 from the MODFE model.

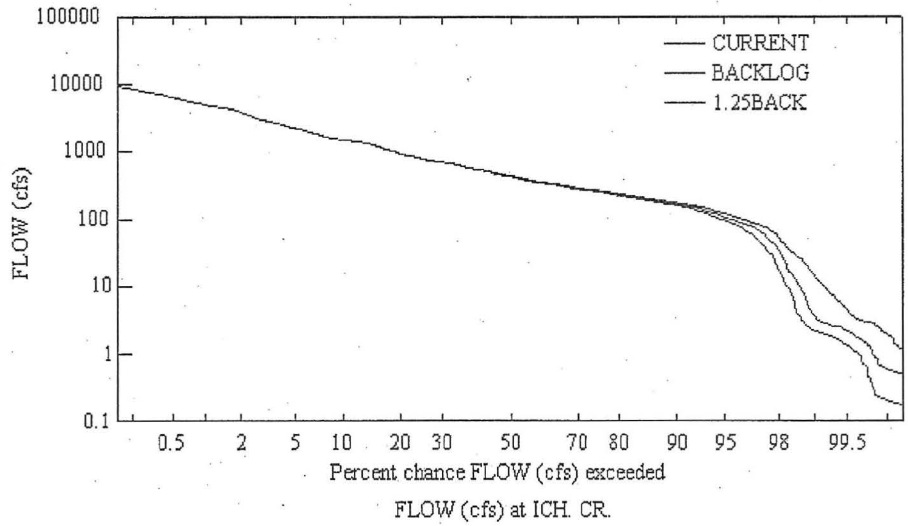


Figure 6.6: Flow exceedance (duration) curve of scenarios Current, Backlog, and 1.25X backlog at Ichawaynochaway Creek at Milford

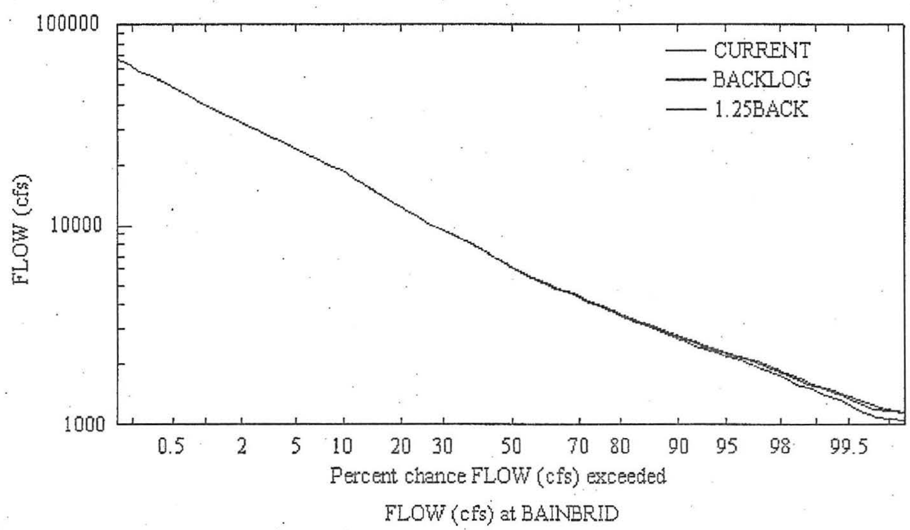


Figure 6.7: Flow exceedance (duration) curves of scenarios Current, Backlog, and 1.25Xbacklog at Flint River at Bainbridge

Another view of the modeled effect on streamflow can be illustrated by looking at daily flow computed for specific years at the same model nodes. Using the same years chosen to illustrate the model calibration results in section I.2.1.1 (drought, wet, and normal year), Figures I.3-4 thru I.3-12 present these comparisons for the same three selected scenarios. It can be seen that the most significant difference in simulated streamflow occurs in drought years. For example, the lowest flow rate at Ichawaynochaway Creek near Milford, given the 1955 meteorology (Fig. 6.7 and Fig. I.3-4), is about 60 cfs under the Current Irrigation Scenario. The flow rate is reduced to less than 40 cfs under the Backlog Irrigation Scenario, and to less than 20 cfs under the 1.25 × Backlog Scenario."

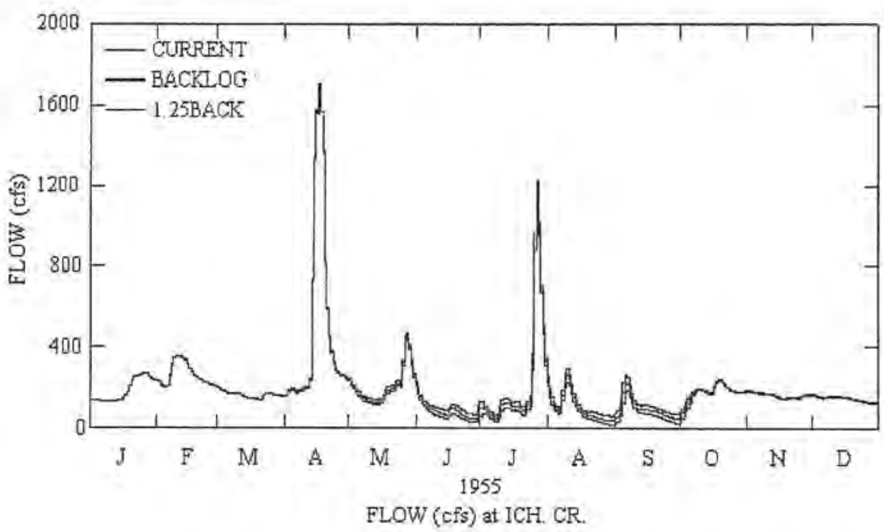


Figure 6.8: Sample hydrograph of simulated flow rates for current, backlog, and 1.25 X backlog scenarios

6.3 Scenario Impact Evaluation

6.3.1 Discussion of In stream Flow Impact Criteria

Having computed streamflow resulting from several possible future irrigation scenarios, results were compared to two sets of criteria: 1) low flow criteria that would be protective of endangered aquatic species; and 2) the effect on streamflow protective of water quality standards.

6.3.2 Aquatic Habitat Protection Streamflow Criteria

As part of the federal agency preparation for review of negotiated ACT and ACF basins Water Allocation Formulas, the USFWS and U. S. Environmental Protection Agency (USEPA) developed a set of draft guidelines for protection of the basins' riverine ecosystems. The guidelines were intended for evaluation under the USFWS's Endangered Species Act authority and EPA's Clean Water Act authority. The guidelines were not intended to be exclusive, but it was stated that an allocation formula that did not comply with the guidelines would require a more detailed review by both agencies. It was felt that the guidelines would protect both the present structure and function of the riverine ecosystems as well as endangered species (USFWS and USEPA, October 25, 1999).

The selected guidelines were developed for unregulated streams and consisted of the Monthly 1-day Flow Minima (U1) and the Annual Low-Flow Duration (U2) (USFWS and USEPA, October 25, 1999). Specifically, these were defined as:

Monthly 1-day minima ("U1")

These criteria are derived from the complete daily **discharge** record for the stream. From this record, the <u>lowest</u> 1-day minimum flow for each month of the year in all years is identified. From the complete record of all 1-day minimum flows for a particular month, the lowest 25th percentile and median of these values are calculated. For each future month, the 1-day minimum flow guideline is to:

a. Exceed the lowest 1-day minimum in all years.
b. Exceed the 25th percentile in 3 out of 4 years.
c. Exceed the median in half of the years.

Annual low-flow duration ("U2")

These criteria are also derived from the complete daily **discharge** record for the stream. From this, the average annual **discharge** (AAD) for each calendar year is calculated, and then these yearly averages are themselves averaged. The number of days per year for all calendar years during which daily **discharge** is less than 25 percent of the AAD is then calculated. The maximum number of days per year for all calendar years in which discharge is less than 25% AAD, the 75th percentile of the number of days per year in which discharge is less than 25% AAD, and median of the number of days are computed. For each year the guideline is:

a. Do not exceed the maximum number of days in all years.
b. Do not exceed the 75th percentile in 3 out of 4 years.
c. Do not exceed the median in half the years.

6.3.3 Water Quality Guidelines

Potential impacts to water quality are also important to the evaluation of scenario model results in the Flint Basin. Georgia EPD develops waste load allocations and associated National Pollutant Discharge Elimination System (NPDES) permit limits for municipal and industrial surface-water discharges that protect the State in-stream dissolved oxygen concentration water quality standards and other in-stream criteria. NPDES permits are developed to protect water quality standards using a minimum streamflow equal to the 7Q10. The 7Q10 is the minimum 7-day average streamflow having a 10% chance of occurrence in any year, or a theoretical recurrence interval of 10 years. Changes to surface-water hydrology that cause streamflow to be less than the 7Q10 streamflow used to determine the NPDES limits could adversely affect a stream's ability to meet the dissolved oxygen water quality standard and other criteria during critical low streamflow conditions. Reduced 7Q10 streamflow may require that the waste allocation loading, which determines the NPDES permit limits, may need to be decreased to prevent the standards from being violated.

A review of historic streamflow data and NPDES permit conditions, as well as computation of the 7Q10 flow rates for various time periods, indicates that the 7Q10 used by EPD to set current permit discharge limits in southwest Georgia was based on pre-1970 historic flow data. The computed 7Q10 for this period is 2500 cfs for the Flint River at Bainbridge, 140 cfs for Ichawaynochaway Creek near Milford, and 15 cfs for Spring Creek near Iron City.

6.3.4 Computation of Criteria

For the purposes of this Plan, streamflow criteria are calculated at three representative gauge locations, Ichawaynochaway Creek at Milford, Spring Creek near Iron City, and the Flint River at Bainbridge. The first two of these (Figures I2.-1 and I2.-11) are locations with long-term USGS gauging stations spanning the periods before and after significant irrigation. The Bainbridge gauge is located in the headwaters of Lake Seminole and has very little gauge data since 1970; therefore, the historical data does not represent pre-irrigation conditions. The Newton and Albany gauges are the only other stations with long periods of record; these gauges are located further upstream in the HSPF-modeled lower Flint sub-basin and therefore do not fully include all the rainfall-driven modeled conditions in the sub-basin as completely as the Bainbridge gauge.

6.3.5 Evaluation of In-Stream Flow Criteria

Table I.4-1 presents the in-stream flow criteria guidelines computed for each of the gauge locations based on the entire period of record.

The effects on U1 and U2 streamflow guidelines can be computed for the future irrigation scenarios described in Section 3.0. In these model runs, assumed irrigation distribution patterns and application rates for each scenario are modeled for the 54-year hydrologic pattern observed for the period from 1950-2003. The irrigation acreage is not changed from year to year (see Table 6.3) and the application rates change only according to whether a particular year was a drought or not (Table I3-2).

Ichawaynochaway Creek at Milford.

Table 6.4 (and Tables I4.2 and I4.3) shows how the modeled scenario streamflow perform with respect to the USFWS in-stream flow guidelines. The monthly 1-day minimum flow rates computed for the future scenarios should never be less than the monthly minimum U1 criteria. Observed gauge flow rates meet this criterion, (all "0's"), but modeled flows do not meet the criterion as many as five times (Table VV) for the scenarios with the highest level of irrigation use; that is, the Backlog and 1.25xBacklog Scenarios, and in late summer months. Reducing irrigation by 20% from the Current Scenario would reduce the number of times the criteria are not met to two in September. In other words, modeled future scenarios of increased irrigation would cause the 1-day flow minimum to be exceeded more often. Reducing irrigation by at least 20% would not eliminate the exceedance, but would reduce the number of times more than if irrigation were increased above current levels.

For the U1B guideline (Table 6.4), the criterion should not be exceeded more than 1 in every 4 years, or 25% of the time. This does occur with the observed data for the period from 1953-2003, but only by a very small margin. However, as with the 1-day minimum criterion, it happens more often for the Backlog Scenarios and in August and September. The U1C guideline should not be exceeded more than 50% of the time (1 in 2 years), but this does occur in late summer for those scenarios of increased irrigation and for existing irrigation over the next 50 years.

The differences between scenario U1 variances can be seen for selected years (1980's) in Figure I.4-1, which shows the modeled minimum 1-day flow rates during the month of August vs. the minimum (U1A), 25% (U1B), and 50% (U1C) criteria. U1A is not met in 1986 with the Current and Backlog Scenarios, but is met in all other years and scenarios. Variances occur for the U1B guideline in 1981 and 1986 (all scenarios) and in 1985 and 1988 for some scenarios, but a 25% variance rate is acceptable for U1B. Only 1980, 1982, 1984, and 1989 have no U1C variances, though a 50% variance rate is acceptable.

Lowest monthly 1-day minimum flow (U1-A)						
(Number. of years that flow was below the monthly criteria - should not exceed zero)						
	Apr	May	Jun	Jul	Aug	Sep
Criteria (cfs)	175	43	12	21	6	10
Observed 1939-1975	0	0	0	0	0	0
Observed 1953-2003	0	0	0	0	0	0
No irr 1953-2003	**1**	0	0	0	0	0
Calibrated 1953-2003	**1**	0	0	0	**1**	**2**
0.6 x Current irrigation	**1**	0	0	0	0	0
0.7 x Current irrigation	**1**	0	0	0	0	**1**
0.8 x Current irrigation	**1**	0	0	0	**1**	**2**
Current irr. over 50 yrs	**1**	0	0	**2**	**3**	**4**
Backlog	**1**	0	**1**	**2**	**3**	**5**
1.25 x Backlog	**1**	0	**1**	**3**	**4**	**5**

25 percentile of monthly 1-day minimum flows (U1-B)						
(Percent of years with that flow was below monthly criteria - should not exceed 25%)						
	Apr	May	Jun	Jul	Aug	Sep
Criteria (cfs)	342	228	162	153	139	148
Observed 1939-1975	23.1%	15.4%	15.4%	7.7%	3.8%	15.4%
Observed 1953-2003	21.6%	23.5%	**25.5%**	23.5%	**25.5%**	24.0%
No irr 1953-2003	19.6%	11.8%	7.8%	9.8%	7.8%	12.0%
Calibrated 1953-2003	19.6%	15.7%	13.7%	11.8%	11.8%	16.0%
0.6 x Current irrigation	19.6%	15.7%	19.6%	13.7%	15.7%	22.0%
0.7 x Current irrigation	19.6%	15.7%	19.6%	13.7%	17.6%	22.0%
0.8 x Current irrigation	19.6%	15.7%	19.6%	15.7%	17.6%	**26.0%**
Current irr. over 50 yrs	19.6%	19.6%	19.6%	15.7%	**27.5%**	**28.0%**
Backlog	21.6%	21.6%	19.6%	23.5%	**27.5%**	**32.0%**
1.25 x Backlog	21.6%	23.5%	**25.5%**	**29.4%**	**35.3%**	**32.0%**

Median of monthly 1-day minimum flows (U1-C)						
(Percent of years that flow was below the monthly criteria - should not exceed 50%)						
	Apr	May	Jun	Jul	Aug	Sep
Criteria (cfs)	473	308	228	227	223	197
Observed 1939-1975	46.2%	38.5%	34.6%	38.5%	34.6%	38.5%
Observed 1953-2003	39.2%	**51.0%**	43.1%	49.0%	**52.9%**	50.0%
No irr 1953-2003	37.3%	27.5%	23.5%	23.5%	29.4%	22.0%
Calibrated 1953-2003	39.2%	33.3%	29.4%	31.4%	37.3%	38.0%
0.6 x Current irrigation	39.2%	33.3%	31.4%	31.4%	43.1%	36.0%
0.7 x Current irrigation	39.2%	37.3%	33.3%	31.4%	45.1%	42.0%
0.8 x Current irrigation	39.2%	41.2%	33.3%	35.3%	45.1%	50.0%
Current irr. over 50 yrs	45.1%	45.1%	37.3%	43.1%	**52.9%**	**56.0%**
Backlog	45.1%	49.0%	43.1%	49.0%	**60.8%**	**58.0%**
1.25 x Backlog	45.1%	**51.0%**	43.1%	**51.0%**	**64.7%**	**60.0%**

Table 6.4: U1 guideline effects for Ichawaynochaway Creek near Milford: Monthly 1-day Minima Criteria – Variances Criteria are from full period of record

Table 6.4 shows the results of comparisons of the duration of U2 computed scenario flows below 25% of the annual average for Ichawaynochaway Creek. The allowable number of years in which the maximum duration is exceeded is zero; however, this is exceeded in all model runs. The U2B criterion is not to be exceeded more than 25% of the time, or 1 in 4 years, but this is exceeded in several scenarios simulating current irrigation and expanded irrigation. The U2C criterion, based on the median number of years in which flow is less than 25% annual average discharge is not exceeded in the modeled scenarios. Recalling that these scenarios project identical climatic patterns from the past 54 years into the future, Ichawaynochaway Creek would not meet the U2 criteria only in the worst drought years of the past 54 years. Specifically, in future years with conditions like those of 1954, 1955, 1968, 1986, 1999, and 1990, Ichawaynochaway Creek would likely not meet the U2 criteria. The likelihood of this increases if the backlogged permits are issued, and if the volume of irrigation increases over current levels.

Annual Low Flow Duration (U2) Statistics			
25% Annual Average Discharge	171 cfs		
	Maximum	1 in 4 yrs	1 in 2 yrs
Criteria: Annual Low Flow Duration (days)	168	28	0
Allowable years of variance	0	<25%	<50%
Observed 1939-1975	0	8.0%	18.0%
Observed 1953-2002	0	**28.0%**	48.0%
No irr 1953-2002	**1**	14.0%	28.0%
Calibrated 1953-2003	**2**	22.0%	34.0%
0.6 x Current irrigation	**5**	22.0%	34.0%
0.7 x Current irrigation	**5**	24.0%	34.0%
0.8 x Current irrigation	**6**	**28.0%**	34.0%
Current irr. over 50 yrs	**6**	**28.0%**	42.0%
Backlog	**6**	**32.0%**	48.0%
1.25 x Backlog	**6**	**36.0%**	50.0%

Table 6.5: guideline effects for Ichawaynochaway Creek near Milford: Annual Low Flow Duration Variances Criteria are from full period of record

In summary, simulations of future irrigation scenarios indicate that Ichawaynochaway Creek will not meet the U1 and U2 USFWS in-stream flow criteria in late summer of drought years. Furthermore, if more permits are issued, or if irrigation volumes increase over current levels, the violation of the criteria will become more frequent. A 20% reduction in irrigation below current levels during drought years would cause the creek to meet the in-stream criteria virtually all the time (Table 5-4). If irrigation is increased over existing levels, a greater reduction in irrigation will be required in drought years to meet the U1 flow criteria.

Spring Creek

Tables 6.6 and I.4-4 summarize USFWS in-stream flow guideline results for Spring Creek. Spring Creek model results indicate that the criteria fail at very high rates, except in August and September (U1A), but including scenarios in April and May with no irrigation and scenarios with drastic cutbacks in irrigation. This contrasts with the U2A low-flow duration criteria in which there are no violations of the criteria. These highly unlikely results suggest that the USFWS in-stream flow guidelines cannot be applied to Spring Creek. This may be the result of Spring Creek's tendency to reach low flows early in the year; the karstic nature of the sub-basin, such that surface-water flows do not operate independently of ground-water; or the extreme low flows that occurred after 1976 skewing the streamflow statistics towards an unworkable standard. If the USFWS criteria cannot be used to develop a management strategy for Spring Creek, then other criteria must be used or it must be assumed that a management strategy that would protect in-stream flows and riverine habitat for other sub-basins of the FRB would have a beneficial effect on Spring Creek.

Lowest monthly 1-day Minimum flow (U1-A) (Number of years that flow was below the monthly criteria - should not exceed zero)	Apr	May	Jun	Jul	Aug	Sep
Criteria (cfs)	51.30	3.51	0.81	0.16	0.00	0.00
Observed 1937-1971	0	0	0	0	0	0
Observed 1953-2003	0	0	0	0	0	0
No irr 1953-2002	**2**	0	0	0	0	0
Calibrated 1953-2003	**3**	**3**	**4**	**5**	0	0
0.6 x Current irrigation	**4**	**3**	**8**	**7**	0	0
0.7 x Current irrigation	**6**	**4**	**9**	**7**	0	0
0.8 x Current irrigation	**6**	**4**	**11**	**8**	0	0
Current irr. over 50 yrs	**7**	**5**	**14**	**11**	0	0
Current irr. over 50 yrs(updated)	**7**	**4**	**14**	**8**	0	0
Backlog	**7**	**7**	**16**	**11**	0	0
1.25 x Backlog	**7**	**11**	**17**	**12**	0	0

25 percentile of monthly 1-day minimum flows (U1-B) (Percent of years that flow was below monthly criteria - should not exceed 25%)	Apr	May	Jun	Jul	Aug	Sep
Criteria (cfs)	197.1	87.8	48.2	45.9	36.7	32.4
Observed 1937-1971	11.8%	6.1%	2.9%	5.9%	11.8%	11.8%
Observed 1953-2003	**26.2%**	**26.8%**	**29.3%**	**31.0%**	**33.3%**	**29.3%**
No irr 1953-2002	**33.3%**	**45.1%**	**29.4%**	**25.5%**	13.7%	16.0%
Calibrated 1953-2003	**33.3%**	**51.0%**	**33.3%**	**35.3%**	**27.5%**	18.0%
0.6 x Current irrigation	**33.3%**	**56.9%**	**47.1%**	**41.2%**	**31.4%**	22.0%
0.7 x Current irrigation	**33.3%**	**56.9%**	**49.0%**	**43.1%**	**31.4%**	22.0%
0.8 x Current irrigation	**33.3%**	**58.8%**	**51.0%**	**43.1%**	**33.3%**	**30.0%**
Current irr. over 50 yrs	**33.3%**	**60.8%**	**52.9%**	**47.1%**	**39.2%**	**38.0%**
Current irr. over 50 yrs(updated)	**33.3%**	**58.8%**	**52.9%**	**45.1%**	**37.3%**	**36.0%**
Backlog	**33.3%**	**60.8%**	**56.9%**	**49.0%**	**41.2%**	**38.0%**
1.25 x Backlog	**33.3%**	**60.8%**	**58.8%**	**54.9%**	**47.1%**	**44.0%**

Median of monthly 1-day minimum flows (U1-C) (Percent of years that flow was below the monthly criteria - should not exceed 50%)						
	Apr	May	Jun	Jul	Aug	Sep
Criteria (cfs)	299.7	122.4	90	92.7	79.2	58.95
Observed 1937-1971	26.5%	15.2%	20.6%	23.5%	20.6%	23.5%
Observed 1953-2003	50.0%	**56.1%**	**53.7%**	**57.1%**	**52.4%**	**56.1%**
No irr 1953-2002	**52.9%**	**58.8%**	**56.9%**	**52.9%**	45.1%	38.0%
Calibrated 1953-2003	**52.9%**	**64.7%**	**60.8%**	**58.8%**	**51.0%**	50.0%
0.6 x Current irrigation	**52.9%**	**62.7%**	**70.6%**	**58.8%**	**54.9%**	**58.0%**
0.7 x Current irrigation	**52.9%**	**62.7%**	**70.6%**	**58.8%**	**54.9%**	**58.0%**
0.8 x Current irrigation	**52.9%**	**64.7%**	**72.5%**	**60.8%**	**56.9%**	**58.0%**
Current irr. over 50 yrs	**52.9%**	**66.7%**	**74.5%**	**64.7%**	**58.8%**	**62.0%**
Current irr. over 50 yrs(updated)	**52.9%**	**64.7%**	**72.5%**	**62.7%**	**58.8%**	**62.0%**
Backlog	**52.9%**	**68.6%**	**74.5%**	**64.7%**	**60.8%**	**62.0%**
1.25 x Backlog	**54.9%**	**74.5%**	**74.5%**	**70.6%**	**62.7%**	**70.0%**

Table 6.6: U1 guideline effects for Spring Creek near Iron City: Monthly 1-day Minima Criteria – Variances Criteria are from entire period of record

Lower Flint River

The lower Flint River model results show very few examples of the criteria not being met (and Tables 6.7 and I.4-6). Even projecting climatic patterns of the past 50 years into the future, the criteria are met except for scenarios of increased irrigation in July. However, as with Ichawaynochaway Creek, the flow criteria results indicate that if more irrigation occurs in the lower Flint River sub-basin, irrigation will have to be reduced in drought years for the flow criteria to be met.

Lowest monthly 1-day minimum flow (U1-A) (Number. of years that flow was below the monthly criteria - should not exceed zero)						
	Apr	May	Jun	Jul	Aug	Sep
Criteria (cfs)	3077	1463	1151	1165	988	1003
No irr 1953-2003	0	0	0	0	0	0
Calibrated 1953-2003	0	0	0	0	0	0
0.6 x Current irrigation	0	0	0	0	0	0
0.7 x Current irrigation	0	0	0	0	0	0
0.8 x Current irrigation	0	0	0	0	0	0
Current irr. over 50 yrs	0	0	**1**	**1**	0	0
Backlog	0	0	**1**	**2**	0	**1**
1.25 x Backlog	0	0	**1**	**2**	**1**	**1**

25 percentile of monthly 1-day minimum flows (U1-B)						
(Percent of years with that flow was below monthly criteria - should not exceed 25%)						
	Apr	May	Jun	Jul	Aug	Sep
Criteria (cfs)	4448	3107	2377	2516	2398	2062
No irr 1953-2003	17.6%	17.6%	9.8%	17.6%	13.7%	10.0%
Calibrated 1953-2003	17.6%	17.6%	13.7%	19.6%	17.6%	18.0%
0.6 x Current irrigation	17.6%	17.6%	19.6%	21.6%	21.6%	20.0%
0.7 x Current irrigation	17.6%	17.6%	19.6%	21.6%	21.6%	22.0%
0.8 x Current irrigation	17.6%	17.6%	21.6%	21.6%	21.6%	22.0%
Current irr. over 50 yrs	17.6%	17.6%	23.5%	23.5%	25.5%	22.0%
Backlog	17.6%	17.6%	23.5%	23.5%	25.5%	24.0%
1.25 x Backlog	17.6%	23.5%	**25.5%**	**29.4%**	**29.4%**	**30.0%**

Median of monthly 1-day minimum flows (U1-C)						
(Percent of years that flow was below the monthly criteria - should not exceed 50%)						
	Apr	May	Jun	Jul	Aug	Sep
Criteria (cfs)	6165	4248	3363	3400	3022	2549
No irr 1953-2003	45.1%	45.1%	37.3%	33.3%	33.3%	30.0%
Calibrated 1953-2003	45.1%	47.1%	39.2%	35.3%	43.1%	36.0%
0.6 x Current irrigation	45.1%	47.1%	39.2%	35.3%	45.1%	38.0%
0.7 x Current irrigation	45.1%	47.1%	39.2%	35.3%	45.1%	40.0%
0.8 x Current irrigation	45.1%	47.1%	39.2%	35.3%	45.1%	40.0%
Current irr. over 50 yrs	45.1%	47.1%	39.2%	39.2%	47.1%	44.0%
Backlog	45.1%	47.1%	39.2%	41.2%	47.1%	44.0%
1.25 x Backlog	45.1%	47.1%	41.2%	41.2%	49.0%	48.0%

Table 6.7: U1 guideline effects for lower Flint River at Bainbridge: Monthly 1-day Minima Criteria – Variances Criteria are from full period of HSPF calibrated model (1953-2003)

6.3.6 Water Quality Guidelines

Table 6.8 (and Table I.4-8) compares the computed 7Q10 for Ichawaynochaway Creek at Milford, for Spring Creek at Iron City, and for the lower Flint River at Bainbridge for pre-1970's gauge data (the current basis for NPDES Permit discharges in southwest Georgia), and the model results from four future irrigation scenarios. The differences between each of the future scenario low-flow computations and the pre-irrigation computation are significant in each case. This implies that either water quality standards will be violated more frequently in the future or pollutant loadings will have to be significantly reduced.

7Q10 Stream flow Rates (cfs)			
Modeling Scenario	Ichawaynochaway Ck. near Milford	Flint River at Bainbridge	Spring Ck. near Iron City
Pre-1970's Data	140	2500	15
60% Current Model	65	1650	0
Current Model	20	1500	0
Backlog Model	10	1460	0
125% Backlog Model	3.5	1380	0

Table 6.8: Calculated 7Q10 Streamflow for FRB Modeling Scenarios

Location	7Q10	Historic	0.6 x Current	Current	Backlog	1.25xBacklog
Milford	140 cfs	2.9%	4.6%	6.5%	7.2%	8.1%
Iron City	15 cfs	3.5%	3.9%	5.8%	6.3%	7.8%
Bainbridge	2500 cfs	5.4%	5.9%	6.9%	7.2%	8.0%

Table 6.9: Frequency of Flow Less than 7Q10

The computed frequency of flows less than the 7Q10 is shown for the three modeled scenarios at the three modeled locations in Table 6.9 (and Table I.4-9). For Milford, the frequency of occurrence of the pre-1970 7Q10 flow rate is 2.9%. This increases to 6.5% for the Current Scenario and 7.2% for the Backlog Scenario. For Iron City the pre-1970 frequency of 3.5% increases to 6.3% for the Backlog Scenario and for Bainbridge the increase is from 6.4% to 7.2%. This implies that the frequency of flow conditions under which water quality standards may be violated could more than double at Milford and could increase by 70% at Iron City and by 40% at Bainbridge in the future, if pollution loadings are not decreased or steps taken to reduce irrigation withdrawals under severe drought conditions.

6.4 Interpretation of Scenario Impact Model Results

There is a wide range of results for the various conditions represented by the MODFE ground-water and HSPF surface-water model simulations, as well as the observed data. The most extreme differences are between the low criteria failure rate for the lower Flint River and the almost complete failure of Spring Creek. But there are also differences in how the guidelines are missed in Ichawaynochaway and Spring Creeks and the fact that observed data at those locations do not indicate any variances (since the guidelines were developed from those data).

These widely divergent failure rates may result from at least three possible aspects of the evaluation process: 1) the calibration of the models; 2) the uncertainties in the measurement and modeling process, especially for very low flows; or 3) the appropriateness of applying the criteria to Spring Creek.

The process of model calibration has uncertainties: rainfall and gauge flow observations; surface-water and ground-water characteristics that affect water movement, water withdrawal and return rates; exchange rates (and direction) between ground-water and surface-water under different seasonal conditions; and others. HSPF models are rainfall driven and the capability of detecting the rainfall events that drive the streamflow, especially during summer, is limited and uneven in effectiveness. The comparisons of calibration results with gauge observed streamflow (shown in Section I2.0 for Spring Creek and Ichawaynochaway Creek) reveal many instances of significant deviation, even though the calibration coefficients are quite good.

With the primary concern being low flows, then uncertainties are magnified. The errors in observed gauge flows alone probably exceed the 7Q10 of Spring Creek at Iron City, for example. This may not be true at Milford, but the uncertainties are still a significant fraction of the 7Q10. On the lower Flint the flow rates are much greater, even under drought conditions, but there is another reason for both the much better calibration match at Bainbridge and the lack of guideline variance; the lower Flint HSPF model is much less dependent on rainfall input as the driver and more dependent on the more reliable flow measurements from the gauge at Albany, where upstream inflow is incorporated into the model. The other two sub-basins do not have gauged flows that control a large percentage of the surface-water flow at then modeled locations.

Because of these uncertainties and limitations, the model results should be interpreted with consideration for the differences between scenario results rather than strictly in terms of a direct comparison with the guidelines. In general, models are most accurate when used to determine differences between scenarios. The differences between computed scenarios relative to the allowable criteria may be more meaningful than whether the scenarios fail to meet the allowable criteria, as the differences may indicate the changes to the flow regime that may occur. For example, in Spring Creek there is only about a 2% increase in the failure rate of U1C for the backlog scenario versus the current scenario compared to a 50% variance allowance. Similarly, the U2 criteria are not met for the observed period, but the same variance rates appear for the current irrigation. Therefore, in some situations it may be more appropriate to compare failure rates and reduced irrigation scenarios against existing performance rather than against the actual criteria.

SECTION 7: HYDROLOGIC EVALUATION OF SPRING CREEK, ICHAWAYNOCHAWAY, AND LOWER FLINT SUB-BASINS

7.1 Ichawaynochaway Creek sub-basin

Approximately 22% of the total land area in Ichawaynochaway Creek sub-basin is irrigated (Fig. 7.1). Irrigation in the Subarea 4 part of Ichawaynochaway sub-basin has increased by approximately 34% since 1993 (Litts et al, 2001), and by more than 90% since 1970 (Pierce et al, 1984). The distribution of permitted and proposed irrigation withdrawal points is shown on Figures 4.2 and 4.3. Several trends are immediately clear.First is the greater density of permitted ground-water withdrawals in the Subarea 4 part of the sub-basin, especially in Baker County west of Ichawaynochaway Creek.The same pattern exists for proposed new well locations. Secondly, with only a few exceptions, most notably the heavy concentration of surface-water withdrawals in the northwestern corner of Baker County, permitted and proposed surface-water withdrawals in the southern half of Ichawaynochaway sub-basin comprise only a fraction of the ground-water withdrawals. Almost all the proposed new surface-water withdrawal locations are north of the Subarea 4 boundary.

The higher density of permitted surface-water withdrawals in the northern half of the basin reflects the absence of the Floridan aquifer there. Exceptions to this trend are two "bands" of ground-water wells in eastern Randolph County and western Terrell County. Wells in these areas are tapping the Claiborne and Clayton aquifers, and thus have very little impact on local streamflow.

In summary, Ichawaynochaway Creek sub-basin is almost evenly divided by the Subarea 4 model boundary, such that irrigation in the northern half of the sub-basin is mostly from surface-water, and mostly from the Floridan aquifer in the southern half of the basin.

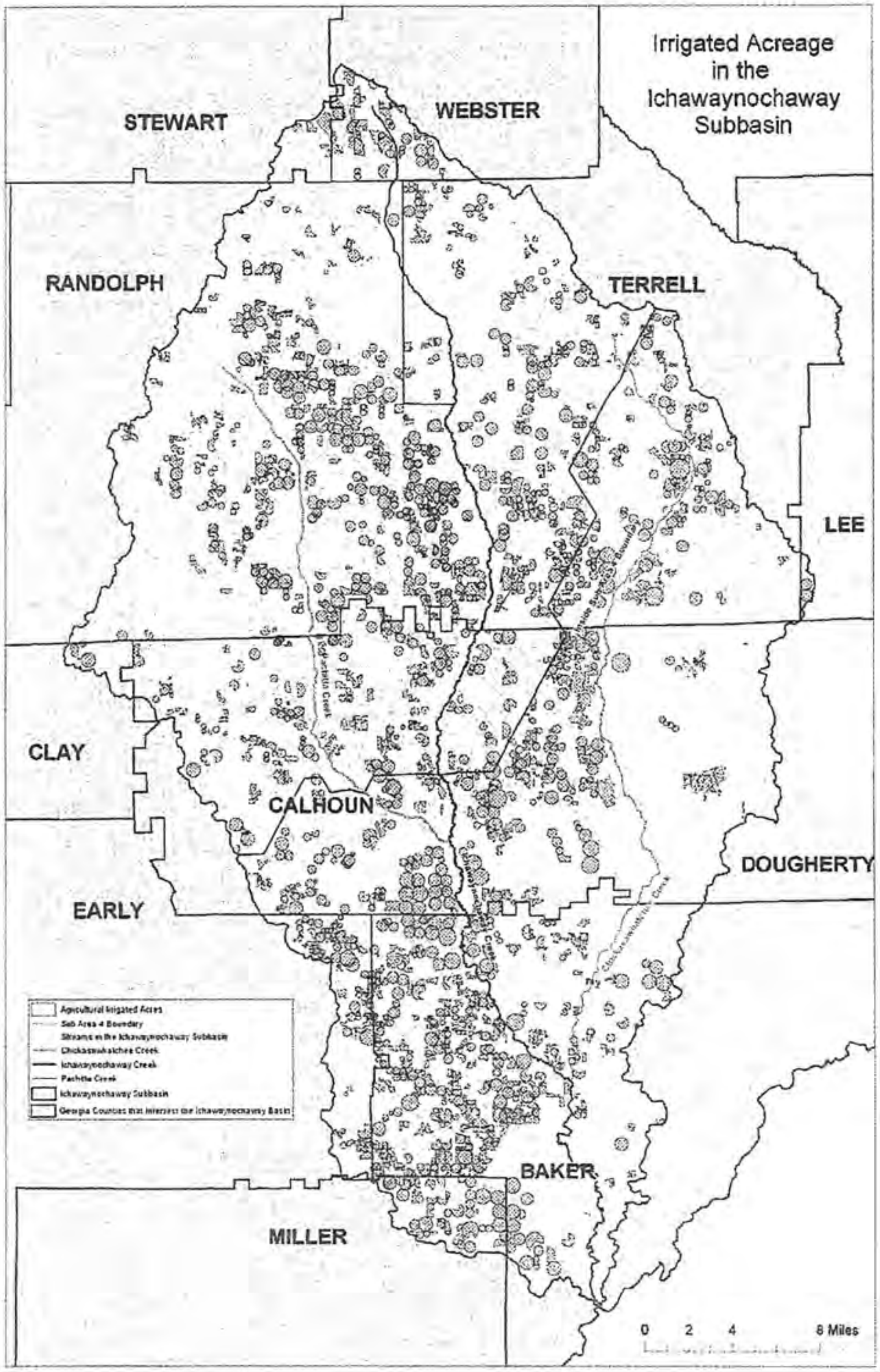


Figure 7.1. Irrigated acreage in Ichawaynochaway sub-basin

Like other streams in southwest Georgia, Ichawaynochaway Creek has experienced record or near-record low flows during the drought periods described above. One of the worst droughts on record occurred in 1954. A hydrograph of Ichawaynochaway Creek at Milford is shown in Figure 7.2. The lowest discharge (120 cfs) occurred in September 1954. From the beginning of the year to that point the hydrograph displays a typical decrease in discharge, with rainfall-driven increases superimposed.

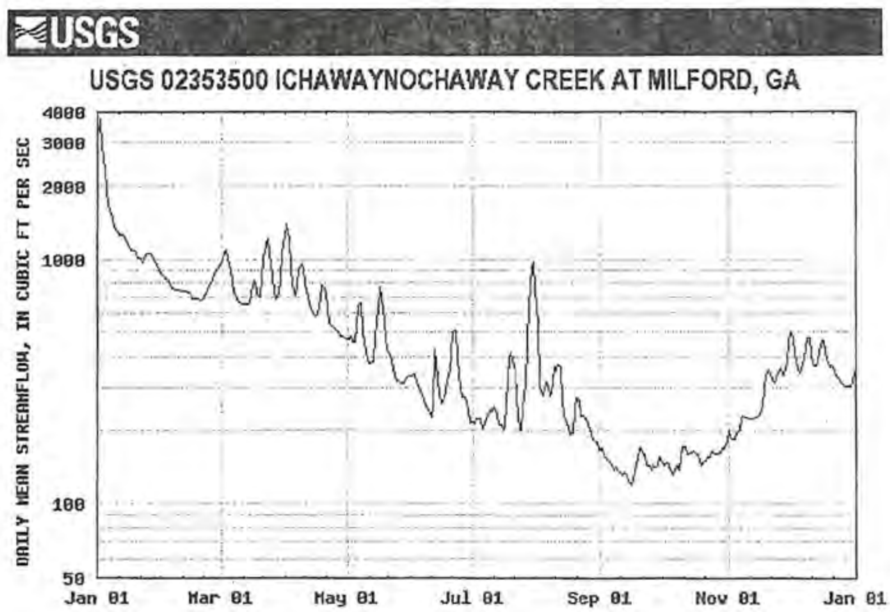


Figure 7.2. Streamflow of Ichawaynochaway Creek near Milford for 1954

Another major drought occurred in 1986, after agricultural irrigation had become widespread. The hydrograph of Ichawaynochaway Creek at Milford (Figure 7.3) shows the decline in discharge that occurred in 1986. The decline is much steeper than that which occurred in 1954, and reached a lower discharge (48 cfs) in spite of significant rainfall events that occurred early in the year. The discharge peaks associated with those events display a typically logarithmic, or concave-upward, decline typical of gradually waning flow after a major precipitation pulse. That gradual decline in discharge does not occur after the sharp rise in discharge that occurred in August 1986; rather, discharge drops off almost linearly. This suggests that the streamflow of Ichawaynochaway Creek in 1986 was affected by irrigation withdrawals.

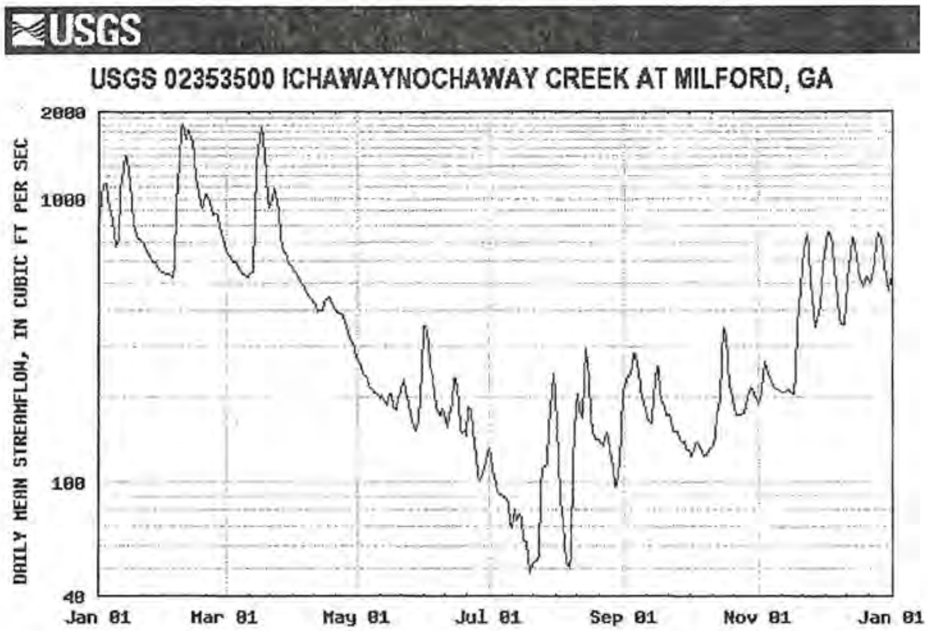


Figure 7.3. Streamflow of Ichawaynochaway Creek near Milford for 1986

A third hydrograph is shown that records the severe drought conditions of 2000, during which Ichawaynochaway Creek reached its lowest recorded flows (Fig. 7.4). It is important to note that early-year streamflow was significantly lower than in either 1954 or 1986. This may have resulted in more rapid streamflow decline than in 1986. However, beginning in June and continuing through September 2000, the hydrograph shows a very unusual pattern of very steep increases and decreases in discharge that could not be easily attributed to natural streamflow fluctuations. This is especially evident during August 20-22, when discharge declined from 102 cfs to a record low of 6.6 cfs in the 3-day period. The extreme discharge fluctuations are almost certainly due to alternating patterns of rainfall and irrigation pumping from Ichawaynochaway Creek and its tributaries at the typical peak of the irrigation season. Since the Milford gauge is near the boundary of Subarea 4, irrigation withdrawals causing the fluctuations in streamflow would have been mostly surface-water as opposed to Floridan aquifer withdrawals.

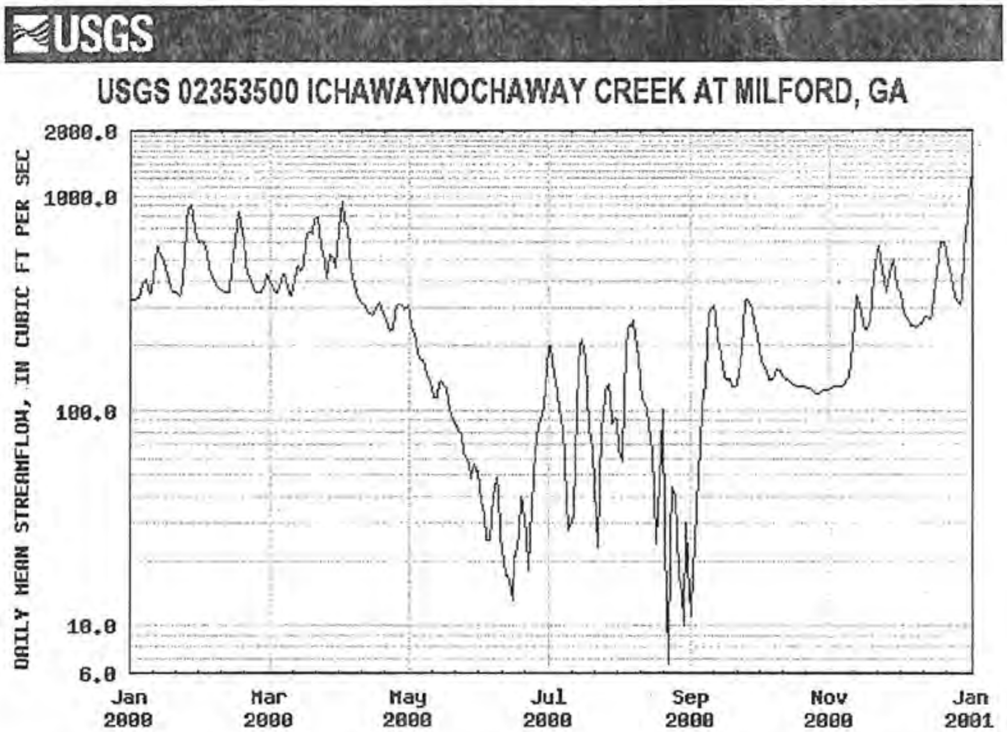


Figure 7.4. Streamflow of Ichawaynochaway Creek near Milford for 2000

As described above, ground-water withdrawals in the Ichawaynochaway Creek sub-basin do not decrease baseflow by more than a few percent (Table 7.1(a)). The greatest baseflow decline result from ground-water withdrawals in the sub-basin downstream of the Milford gauge where Floridan aquifer withdrawals are greatest. Therefore, other than drought, any artificial impacts on the flow of Ichawaynochaway Creek at, and upstream of, Milford can be attributed to surface-water withdrawals.

7.2 Spring Creek sub-basin

Approximately 30% of the land area in the Spring Creek sub-basin (Fig. 7.5) is irrigated. As its name implies, Spring Creek is strongly influenced by ground-water input from the Floridan aquifer. The creek flows almost entirely within Subarea 4, and is thus in hydraulic connection with the Floridan aquifer for most of its length.

Because of the shallow depth and prolific nature of the Floridan aquifer, ground-water pumpage for agricultural irrigation is extremely heavy in Spring Creek sub-basin. Specifically, ground-water usage comprises more than 89% of permitted agricultural withdrawals in the watershed. As with Ichawaynochaway Creek sub-basin, most of this is center-pivot irrigation, which has increased by approximately 34% since 1993 (Litts et al, 2001). The distribution of permitted and proposed irrigation wells and surface-water pumps is shown in Figures 4.2, 4.3, and 7.6.

7.2.1 Basin hydrography

A USGS stream gauge provides real-time data on Spring Creek near Iron City in Seminole County. This gauge has a long period of record, and like the gauge at Milford on Ichawaynochaway Creek has recorded streamflow during the severe droughts that have occurred since 1950. Figure 7.7 is the stream hydrograph from 1954, generally considered to be the worst, or one of the worst, droughts in southwest Georgia history. Streamflow reached its lowest rate gradually, achieving a low flow of 9.1cfs in early November. A local farmer reports that Spring Creek actually ceased flowing just upstream from the Iron City gauge although stream guage records do not confirm this observation (J. Bridges, personal communication 2005). Irrigation was extremely rare in 1954; thus, streamflow was not affected by irrigation withdrawals that would have reduced baseflow significantly.

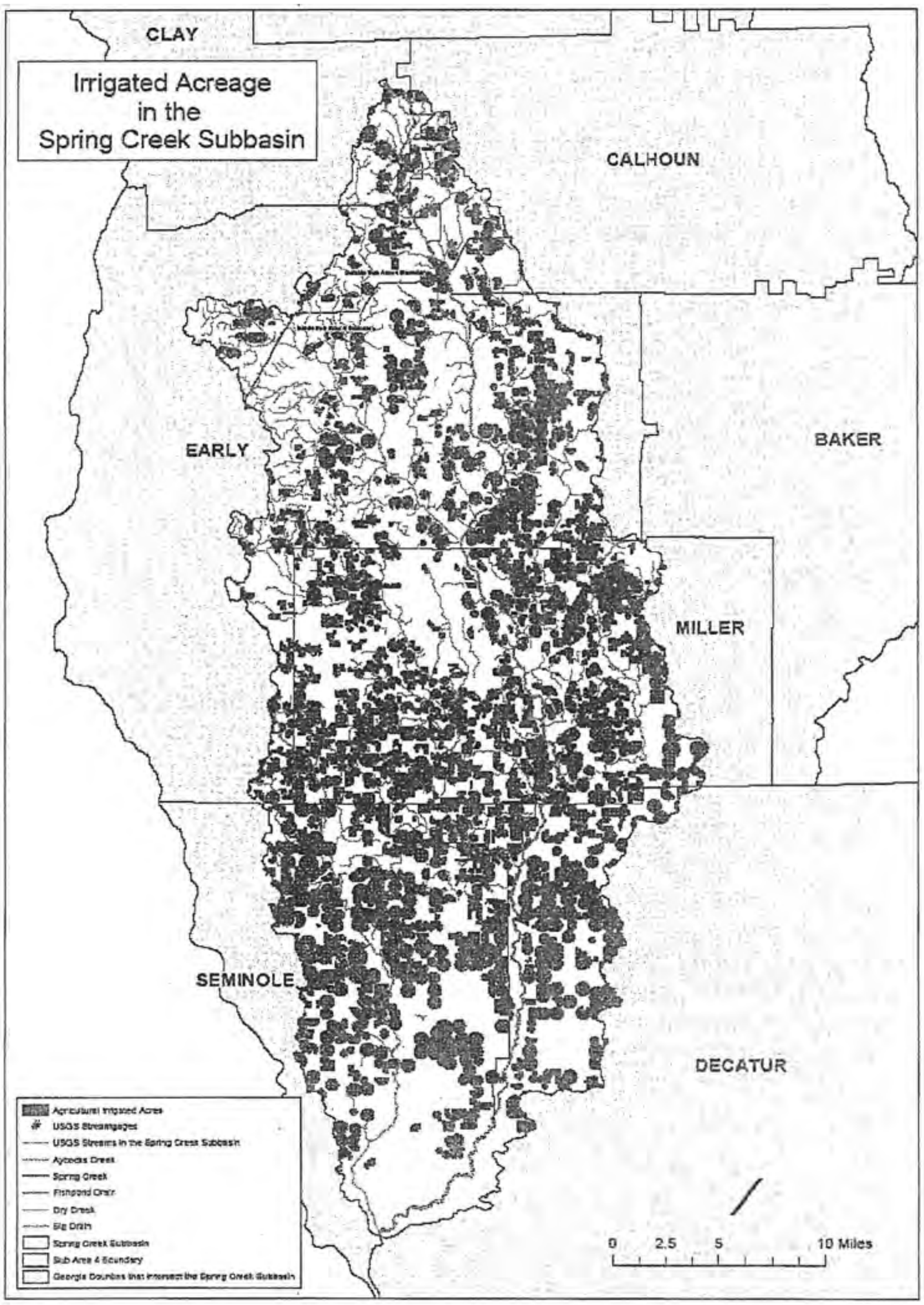


Figure 7.5. Irrigated acreage in Spring Creek sub-basin

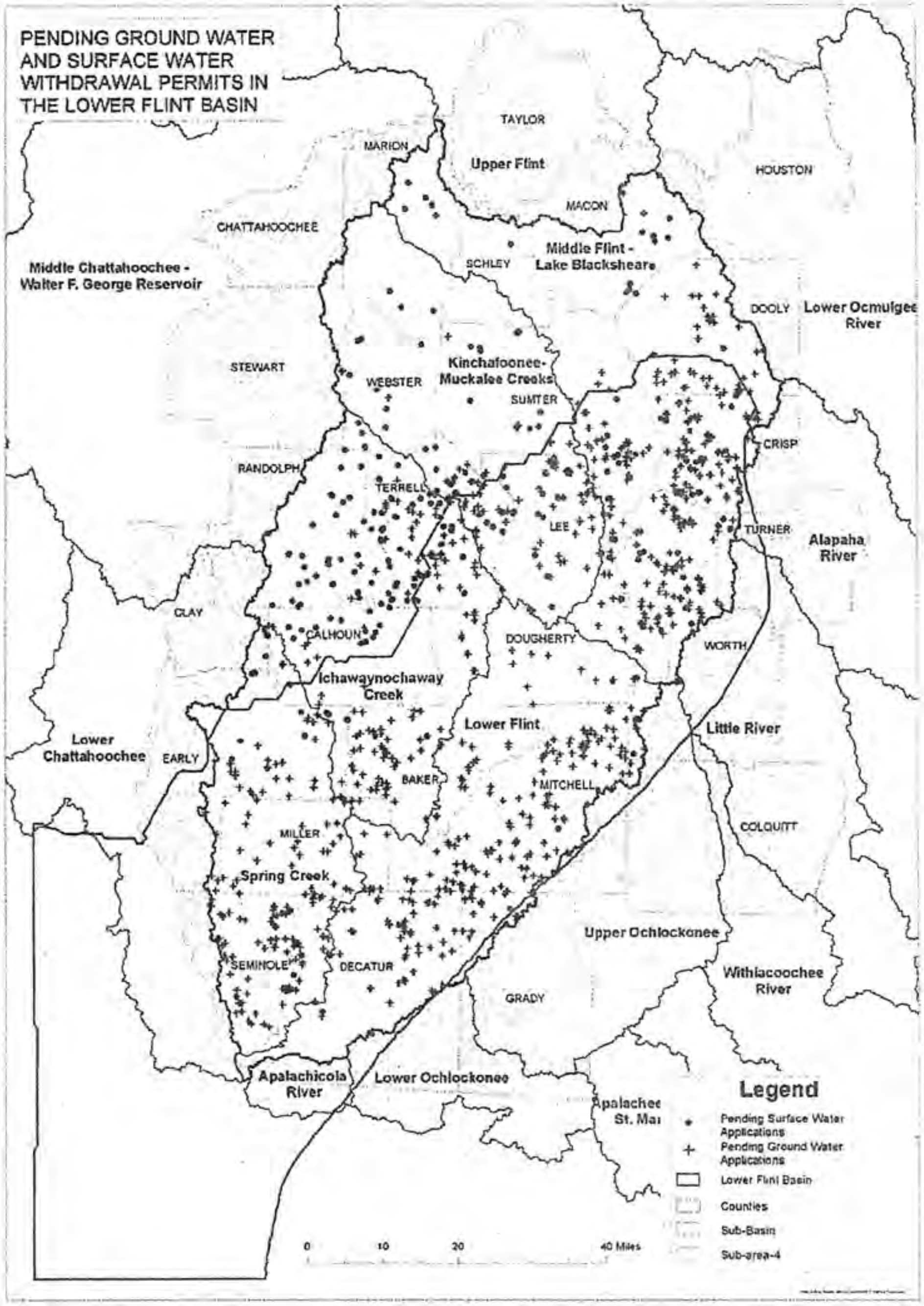


Figure 7.6. Proposed ground-water and surface-water withdrawals in the lower FRB.

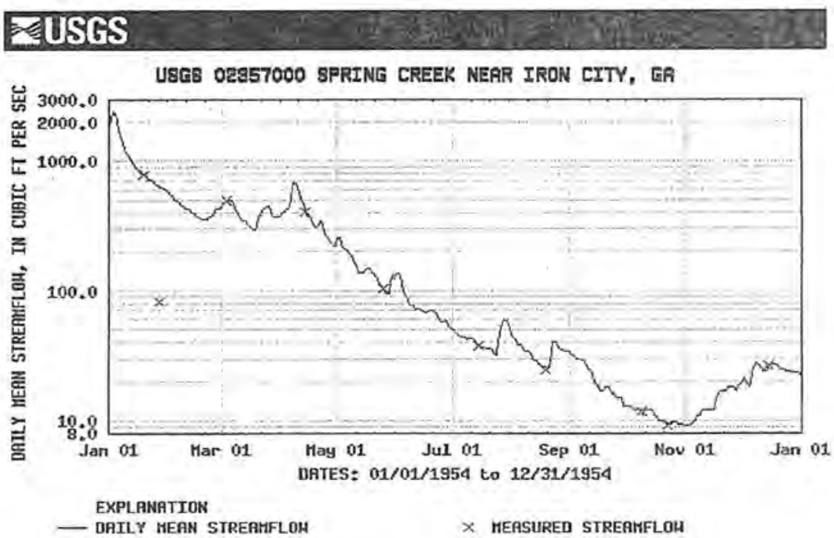


Figure 7.7: Streamflow of Spring Creek near Iron City for 1954

The effect of the drought of 1986 on the flow of Spring Creek is shown in Figure 7.8. Discharge declined steadily with no significant runoff events recorded. The annual low (5.1 cfs) was reached in August, almost three months sooner than the 1954 annual low was reached even though the seasonal decline began in both years at approximately the same stream level. A similarly accelerated decline was recorded in Ichawaynochaway Creek during this same time period.

The most severe drought conditions observed in the Spring Creek sub-basin was arguably the drought of 2000. A critical factor that affected the heavily ground-water-fed stream was that winter rains were insufficient to recharge the Floridan aquifer in that area, such that baseflow was already far lower than normal going into 2000. Figure 7.9 shows the stream hydrograph for 2000. Maximum discharge during the spring was less than one-third what it was in 1954 and 1986, and Spring Creek reached extreme low flow conditions

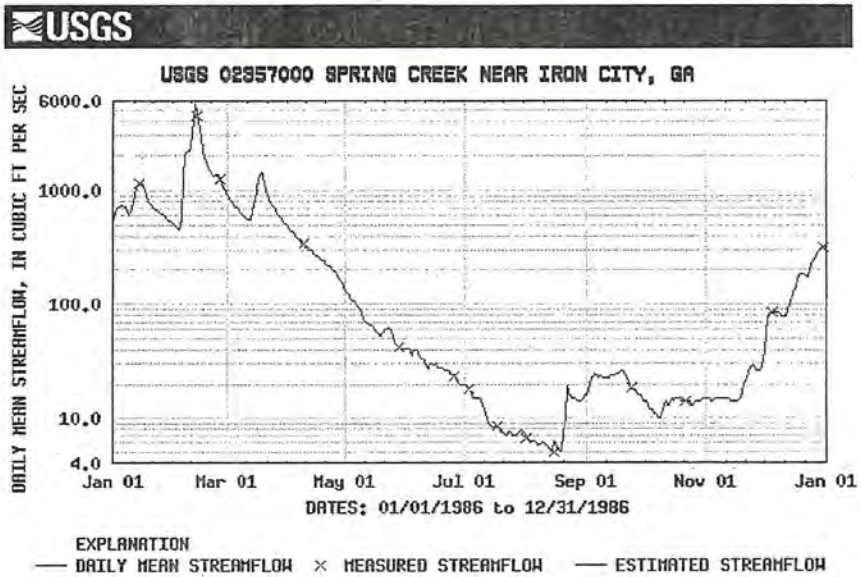


Figure 7.8: Streamflow of Spring Creek near Iron City for 1986

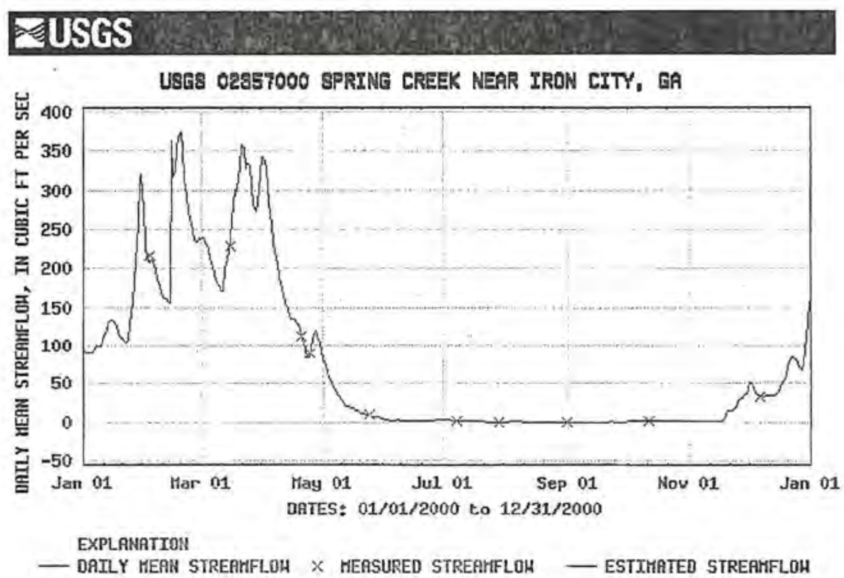


Figure 7.9: Streamflow of Spring Creek near Iron City for 2000

early in the year (May). On July 7, 2000, discharge fell below 1.0 cfs, and the creek ceased to flow from August 25 to September 10. Discharges remained below 1.0 cfs for another month.

Comparing the three worst droughts that affected Spring Creek since 1950, it can be seen that annual low flows were lower and were reached sooner with each successive drought. The lack of abrupt declines in discharge as seen on Ichawaynochaway Creek reflects the relative lack of surface-water withdrawals upstream of Iron City. However, the MODFE stream-aquifer models indicate that Floridan aquifer withdrawals can significantly reduce baseflow to Spring Creek. If this is the case, then it can be logically assumed that ground-water withdrawals significantly affected the discharge in Spring Creek during the drought years described above. This may have been especially true in 2000, when irrigation was necessarily intense because of the drought, but the aquifer had not recharged from the previous year.

An interesting contrast to the Iron City hydrograph for 2000 is the hydrograph for Spring Creek at Reynoldsville (Fig. 7.10), approximately 9 miles downstream from the Iron City gauge. During the drought of 2000, this gauge did not record the extreme low flows observed at Iron City. The gauge did record sharp, but brief, declines in flow in late August and September that could only have been the result of direct surface-water withdrawals upstream of the gauge. More importantly, in the southern parts of Spring Creek sub-basin, the Floridan aquifer is more than 300 feet thick, is extremely karstic, and has very high transmissivity. In that area, filling of Lake Seminole has raised and stabilized ground-water levels in much of lower Seminole and Decatur Counties. In northern Seminole County near Donalsonville, aquifer heads were raised approximately 10 feet when the lake filled. The potentiometric levels progressively increased southward Lake Seminole, such that near Reynoldsville heads were raised as much as 25 feet (Jones and Torak, 2003). Thus, the Reynoldsville gauge is strongly affected by higher and more stable heads in the Floridan aquifer as well as backwater conditions created by the impoundment.

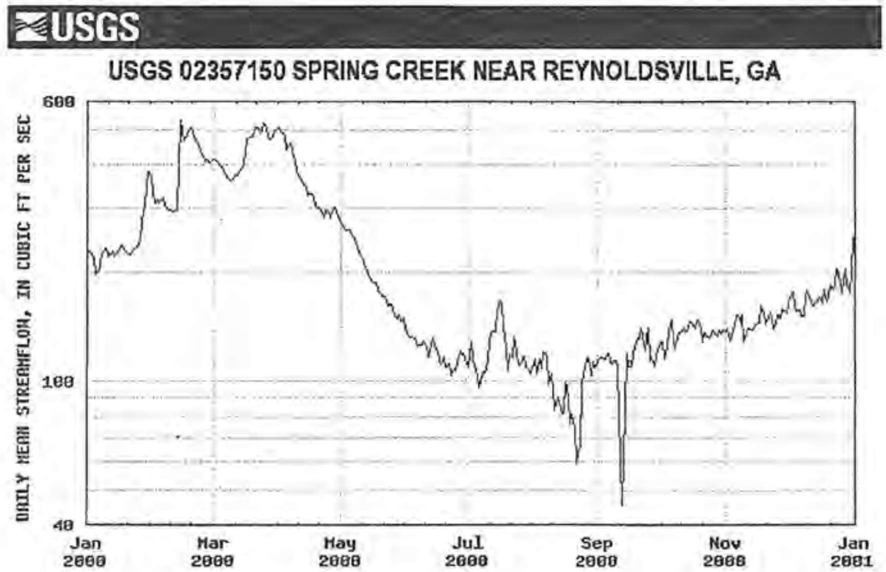


Figure 7.10: Streamflow of Spring Creek near Reynoldsville for 2000

7.3 Lower Flint River sub-basin

The Lower Flint River sub-basin (Figure 5.3) is substantially larger in area than either Ichawaynochaway Creek or Spring Creek sub-basins. Also, it is heavily irrigated with wells drawing almost exclusively from the Floridan aquifer. Surface-water withdrawals are concentrated along the western side of the Pelham Escarpment, which forms the eastern topographical boundary of the sub-basin. The streams associated with these withdrawals commonly sink into, and recharge, the Floridan aquifer in that area and never reach the Flint River; therefore, the majority of surface-water withdrawals in the lower Flint River sub-basin do not directly affect flows of the Flint River as do direct withdrawals from the river or its tributaries. These are volumetrically very small compared to ground-water withdrawals.

As described above, the USGS gauge at Bainbridge was affected by construction of Lake Seminole in 1957. The gauge is at the upstream end of the lake, and is thus affected by lake levels. Lake Seminole is maintained at a nearly constant elevation of 76-77 ft above MSL;

therefore, from 1957 until the gauge was modeified in 2003, the gauge does not accurately reflect flow of the Flint River.

The 1954 hydrograph of the Flint River at Bainbridge (Fig. 7.11) does record the effects of that year's drought. As with Spring Creek, discharge declined steadily through the year until an annual low flow (1,930 cfs) was reached in late October. Irrigation was rare at this time, so this hydrograph would not be significantly affected by irrigation from the Floridan aquifer, the Flint River, or its tributaries.

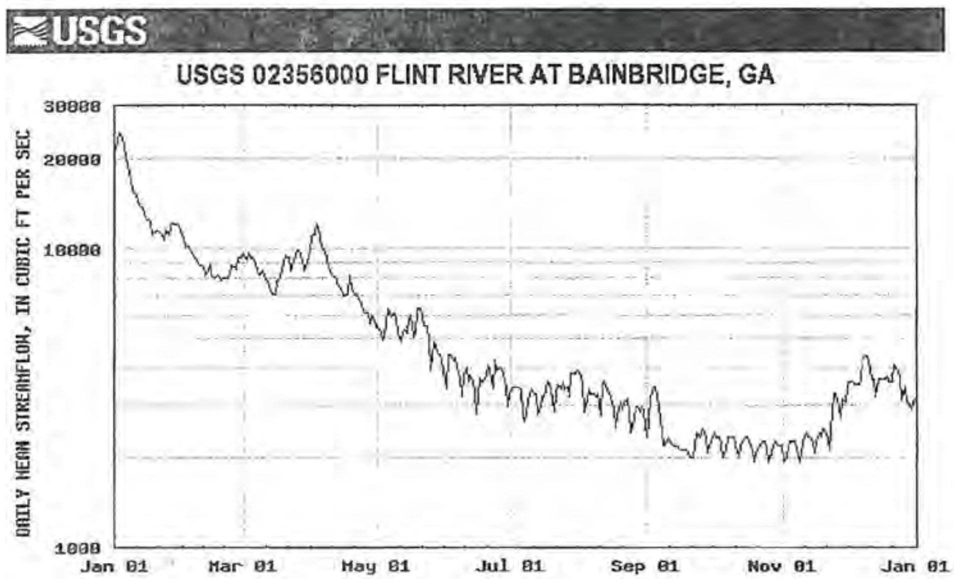


Figure 7.11: Streamflow of the Flint River Creek at Bainbridge for 1954

Because the post-1957 gauge readings at Bainbridge are affected by Lake Seminole and the USGS ceased continuous operation of the station after 1971, a comparison of subsequent droughts with 1954 is of limited value if another gauge is used such as the Flint River gauge at Newton. The Newton gauge is upstream of both the confluences of Spring Creek and Ichawaynochaway Creek, and is affected by surface-water and ground-water withdrawals and flows originating outside of the sub-basin. Thus, the impact of irrigation and drought on streamflow in the lower Flint River sub-basin must be based on other criteria, such as the stream-aquifer MODFE model. As discussed, this model indicates that drought year Floridan aquifer withdrawals do not have as great an impact on flow of the Flint River as they do in Spring Creek or Ichawaynochaway Creek.

SECTION 8: ECONOMIC STATUS OF THE LOWER FLINT RIVER BASIN

8.1 Agriculture

Agriculture is one of the largest economic sectors in the lower FRB. The 18 counties of the lower FRB generate approximately 18% of Georgia's total agricultural value (Doherty and McKissick, 2000), and agriculture in the FRB generates $1.92 billion in farm gate value. This represents 12% of the total FRB economy. The top ten agricultural commodities produced in the FRB are cotton, broilers, peanuts, tomatoes, sweet corn, beef, timber, field corn, container nurseries, watermelons, and "other". This last category includes vegetables, fruits and nuts, aquaculture, poultry and eggs, ornamental horticulture, and agritourism (McKissick, 2004a).

Much of the agricultural production in the FRB is dependent on irrigation. In fact, in the FRB, almost 40% of the harvested cropland is irrigated (McKissick, 2004a). For some commodities, such as vegetables, container nurseries, and ornamental horticulture, irrigation is a prerequisite. For other crops, irrigation significantly increases crop yields, which increases the farm gate value and the total economic impact of agriculture.

Farm income in Georgia, and the FRB, increased fairly steadily from 1969-1996 (McKissick, 2004b). The causes for this increase have been the growth in irrigation, improved production technologies, and a growing consumer demand. Since 1996, farm income has been generally declining as a result of global competition and increased production costs, even though government payments have been steadily increasing over the same time frame. The number of farms has declined since 1945 while the size of farms has increased; yet, the total amount of acreage in harvested cropland has remained relatively steady since the early 1980's (McKissick, 2004b). Employment projections from 2002 to 2012 suggest that agriculture-based employment will decline in southwest Georgia by as much as 14% (Ga. Dept. of Labor). These statistics suggest that row-crop agriculture in Georgia may not expand as rapidly as some other sectors of the economy. Whether or not this affects irrigation water use in the FRB will depend in part on changes in crop mix, as traditional row crops such as cotton, corn, and peanuts are replaced by increased vegetable production or specialty nichemarket crops. However, if the current distribution of crops and rainfall patterns in the FRB does not change substantially, irrigation amounts will not increase much above current levels.

8.2 Manufacturing and other sectors

Manufacturing is the largest economic sector in southwest Georgia, accounting for more than 50% of the FRB economic output and approximately 14% of the employment (Ga. Dept. of Labor; McKissick, 2004a). The biggest industries in the manufacturing sector are food, paper, textile mills, apparel manufacturing, wood products manufacturing, plastics and rubber products, and fabricated metal manufacturing. Of these only beverage and tobacco, and plastics and rubber manufacturing are projected to experience growth from 2002-2012 (Ga. Dept. of Labor).

Other major economic sectors in southwest Georgia are, in decreasing order of employment, health care and social assistance; retail trade, educational services; administrative and support/waste remediation services; wholesale trade; construction; transportation and warehousing; and finance and insurance (Table VV, Ga. Dept. of Labor). The largest projected growth sector of these is administrative and support/waste remediation services (+55%); the sector projected to shrink by the largest margin is finance and insurance (-25%).

8.3 Modeled economic impacts of reducing irrigation

As part of the FRB Water Development and Conservation Plan, a preliminary economic analysis was performed to examine the potential impact of irrigated acreage reductions in the lower FRB. The model scenarios used in the economic analysis were patterned after similar scenarios used in the EPD HSPF surface-water models. Specifically, the impacts of a 20%, 30%, and 40% reduction in irrigated acreage in both the Ichawaynochaway (HUC 03130008) and Spring Creek (HUC 031300010) watersheds were evaluated. Also examined was the potential economic benefit to each region by issuing all the backlogged permits currently being held by EPD. A general discussion of the modeling procedure, specific assumptions made in this analysis, and a presentation of results and limitations is given below.

Given the time constraints and the desire to have a quick "first-glance" at some potential impacts of water management strategies discussed in previous Stakeholder Advisory Committee meetings, the IMPLAN (IMpact analysis for PLANning) model was chosen to provide the requested information. Other models exist such as REMI (Regional Economic Modeling, Inc.) that are more robust and can be configured for any region within a multi-area framework such as HUC 8 sub-basins within the larger area of southwest Georgia. While IMPLAN can aggregate combinations of areas into a single region (i.e. a group of counties into a region), the results cannot be reported at the area (county) level. Unfortunately, the use of REMI for this analysis was both time and cost prohibitive. IMPLAN is an input-output model in which purchases for final use (final demand) drive the model. Industries produce goods and services for final demand and purchase goods and services from other producers. These other producers in turn purchase goods and services. The buying of goods and services (indirect purchases) continues until leakages from the region stops the cycle. These indirect effects can be mathematically derived and the resulting set of multipliers describe the change of output for each and every regional industry that is caused by a one-dollar change in final demand for any given industry (Lindall and Olson, 1999). IMPLAN was used to estimate the reduction in total regional output caused by a reduction in final demand to the farming industry. This reduction in final demand is simply the revenue lost to the farming industry resulting from inability to irrigate. In order to look at the impact of reducing irrigated acreage by watershed within the IMPLAN county framework, the Ichawaynochaway Region was designated as Terrell, Randolph, Calhoun, and Baker Counties. The Spring Creek Region was designated as Early, Miller, Seminole, and Decatur Counties.

The reduction in final demand, in this case the output lost from a lack of irrigation, that drives the IMPLAN model was calculated based on acreage data, assumptions of crop mix, and yield/price information, each of which are discussed below. First, the base number of acres from which the above percentage reductions were computed was provided by EPD. These "eligible" acres were determined by summing (a) all areas in Ichawaynochaway Creek and Spring Creek sub-basins that are irrigated using surface-water and (b) those areas in Ichawaynochaway Creek and Spring Creek sub-basins that are irrigated using ground-water from the Upper Floridan. Total acreage meeting the above criteria includes 100,890 in Ichawaynochaway and 140,130 acres in Spring Creek. This amounts to roughly 66% and 81% of the total permitted acres in Ichawaynochaway Creek and Spring Creek sub-basins, respectively (Hook et al., 2003).

The second integral part of the calculation involved several key assumptions regarding basin-wide crop mix and cropping strategies: (a) it was assumed that any reduction/increase in irrigated acreage would only impact the production of corn, cotton, and peanuts. While we recognize the significant impact of vegetable production in this region, especially in the Spring Creek sub-basin, our basis for exclusion of these commodities is two-fold: First, the number of acres in vegetable production is relatively small when compared to that of the "big-three"; and second, irrigation is considered necessary rather than supplementary for meaningful vegetable production (Doherty and McKissick, 2000). We deem it highly unlikely that vegetable production would be considered without irrigation. (b) reduction in crop acreage is assumed to follow a distribution similar to current trends in irrigated acreage. That is, 15% corn, 50% cotton, and 35% peanut for the southwest Georgia area (USDA Farm Service Agency, 2005). Therefore, if irrigated acreage will be reduced in Ichawaynochaway by 100 acres, we assume that 15 acres of corn production will be lost, 50 acres of cotton, and 35 acres would come out of irrigated peanut production; and (c) production will still occur on the retired acres on a dry-land basis. The acres per crop used for all can be found in Table 1.

Finally, assumptions on yield and price were incorporated. Utilizing data collected in 2004 from the USDA National Peanut Research Laboratory's Multi-Crop Irrigation Research Farm located in Randolph County (Upper Ichawaynochaway), an average irrigated and average dry-land yield was determined for corn, cotton, and peanut. In the absence of reliable county-level yield information, these average crop yields were assumed to be consistent throughout both Ichawaynochaway Creek and Spring Creek sub-basins. Price information was obtained from "2004 Estimated Georgia Prices" as compiled by the University of Georgia College of Agricultural and Environmental Sciences. A summary of irrigated and dry-land crop yields as well as price information can be found below in Table 2.

The reduction or increase in final basin demand was calculated by multiplying the per-acre change in revenue between irrigated and dry land by the acreages associated with the various scenarios. For example, a 20% reduction in irrigated acreage in Ichawaynochaway amounts to 20,178 acres (3,027 corn, 10,089 cotton, and 7,062 peanuts). From Table 2, we can calculate the per acre change from dry land to irrigated production to be $197.20, $620.16, and $521.36 for corn, cotton, and peanuts respectively. By multiplying though by each respective crop and then summing, we arrive at the total reduction in final revenue of $10,535,562.96. This loss in final demand, which serves as the main input to the IMPLAN model, may be explained more clearly as the money that is no longer available to purchase goods and services from other sectors.

The IMPLAN model was run independently for both the Ichawaynochaway and Spring Creek Regions. Results showed up to a $24.9 million loss in total output and a loss of 341 jobs with a 40% reduction in irrigated acreage. Conversely, issuing the backlog created 140 jobs and an additional $12 million in output. Sectors most impacted by the reduction in demand were Farm, Ag Services, Retail and Wholesale Trade and Financial, Insurance, and Real Estate (FIRE). Similar results were found in Spring Creek but with a higher magnitude. Reducing irrigated acreage by 40% caused a reduction in total output of $44.6 million and nearly 600 jobs. Issuing the backlog in the Spring Creek region would increase output by $13.5 million and create an additional 197 jobs. A detailed breakdown of the IMPLAN model results can be found in Tables 3-7. Table 3 provides a summary of the direct and total change in output and jobs for both regions. Tables 4-7 provide detailed sector analysis for both regions at 20%, 30%, and 40% reductions and backlog issuance respectively. It should be noted again that the results provided from this preliminary study do not reflect the total impact of agriculture on the lower FRB economy. Rather, we have demonstrated the effect, through final demand spending of farmers, of a loss of revenue attributed to a reduction of irrigated acreage in these two sub-basins. While we can trace the impact of this reduction in spending through various other sectors (multipliers), there are further impacts that are beyond the scope and measurement capabilities of this IMPLAN study. For example, the value of output and jobs lost or gained by processing such as cotton gins or peanut shellers is not captured in the results discussed above. Further, the reader should be mindful of the assumptions leading to the results discussed and be prudent when making comparisons to other economic analyses.

	Baseline	20%	30%	40%	Bklg.
Ichawaynochaway	*100,890*	*-20,178*	*-30,267*	*-40,356*	*+16,517*
Peanut		-7,062	-10,593	-14,124	+5,781
Cotton		-10,089	-15,133	-20,178	+8,258
Corn		-3,027	-4,541	-6,054	+2,478
Spring	*140,130*	*-28,026*	*-42,039*	*-56,052*	*+17,255*
Peanut		-9,809	-14,714	-19,618	+6,039
Cotton		-14,013	-21,019	-28,026	+8,627
Corn		-4,204	-6,306	-8,408	+2,589

Table 8.1: Acreage Totals per Crop/Basin Under Each Scenario

Crop	Irrigated Yield	Non-Irrig Yield	Irrig (ac/in)	$/unit
Peanut	5256 lb/ac	2512 lb/ac	10.5	$.19
Cotton	1402 lb/ac	433 lb/ac	11.15	$.64
Corn	185 bu/ac	117 bu/ac	14.95	$2.90

Table 8.2: Yield and Price Data per Crop

Ichawaynochaway Region				
	Output (1.395)		**Employment (1.686)**	
	Direct	Total	Direct	Total
Ich – 20%	-$10,535,660	-$14,699,214	-101	-170
Ich – 30%	-$15,803,660	-$22,048,819	-151	-254
Ich – 40%	-$21,071,320	-$29,398,430	-202	-341
Ich – Bklg.	+$8,624,120	+$12,032,259	83	+140
Spring Creek Region				
	Output (1.525)		**Employment (1.946)**	
	Direct	Total	Direct	Total
Spr – 20%	-$14,633,383	-$22,331,058	-152	-296
Spr – 30%	-$21,950,075	-$33,496,590	-228	-445
Spr – 40%	-$29,266,767	-$44,612,051	-310	-596
Spr – Bklg.	+$9,009,457	+$13,460,439	+102	+197

Table 8.3: Summary IMPLAN Output by Region, All Scenarios

	Ichawaynochaway Region		**Spring Creek Region**	
	Output	Employment	Output	Employment
Manufacturing				
Non-Durables	-$74,086	-0.7	-$364,286	-1.8
Durables	-$108,026	-0.6	-$167,930	-0.8
Non-Manufact.				
Ag Services	-$738,282	-29.8	-$1,668,524	-71.5
Mining	$0	0	-$4,740	0
Construction	-$53,054	-1	-$145,239	-2.1
Trans/Utilities	-$374,669	-2.7	-$519,583	-3.6
Ret/Whl Trade	-$1,046,811	-7.7	-$1,578,065	-30.2
Fin/Ins/Real Est	-$796,157	-3.1	-$1,562,687	-8.3
Services	-$414,627	-7.3	-$1,029,382	-17.8
Government	-$184,349	-1.9	-$206,966	-2.5
Farm	-$10,909,152	-105.5	-$15,083,655	-157.7
TOTAL	***-$14,699,214***	***-170***	***-$22,331,058***	***-296.5***

Table 8.4: Detailed IMPLAN Output by Region, 20% Reduction

	Ichawaynochaway Region		Spring Creek Region	
	Output	Employment	Output	Employment
Manufacturing				
Non-Durables	-$111,130	-1.1	-$546,430	-2.7
Durables	-$162,040	-0.8	-$251,895	-1.3
Non-Manufact.				
Ag Services	-$1,107,423	-44.5	-$2,502,786	-107.3
Mining	$0	0	-$7,111	0
Construction	-$79,581	-1.4	-$217,859	-3.2
Trans/Utilities	-$562,003	-4.2	-$779,375	-5.3
Ret/Whl Trade	-$1,570,217	-26.5	-$2,367,098	-45.4
Fin/Ins/Real Est	-$1,194,235	-4.7	-$2,344,031	-12.5
Services	-$621,941	-10.9	-$1,544,073	-26.7
Government	-$276,523	-2.8	-$310,450	-3.8
Farm	-$16,363,727	-157.6	-$22,625,485	-236.6
TOTAL	***-$22,048,819***	***-254***	***-$33,496,590***	***-444.7***

Table 8.5: Detailed IMPLAN Output by Region, 30% Reduction

	Ichawaynochaway Region		Spring Creek Region	
	Output	Employment	Output	Employment
Manufacturing				
Non-Durables	-$148,174	-1.3	-$724,498	-3.6
Durables	-$216,052	-1.2	-$336,546	-1.7
Non-Manufact.				
Ag Services	-$1,476,564	-59.5	-$3,294,180	-141.1
Mining	$0	0	-$9,459	-0.1
Construction	-$106,108	-1.8	-$289,287	-4.4
Trans/Utilities	-$749,338	-5.6	-$1,034,991	-7
Ret/Whl Trade	-$2,093,621	-35.4	-$3,148,931	-60.4
Fin/Ins/Real Est	-$1,592,313	-6.3	-$3,126,011	-16.6
Services	-$829,255	-14.5	-$2,061,299	-35.6
Government	-$368,697	-3.8	-$413,899	-5.1
Farm	-$21,818,306	-211	-$30,172,949	-320.8
TOTAL	***-$29,398,430***	***-341***	***-$44,612,051***	***-596.4***

Table 8.6: Detailed IMPLAN Output by Region, 40% Reduction

	Ichawaynochaway Region		Spring Creek Region	
	Output	Employment	Output	Employment
Manufacturing				
Non-Durables	+$51,056	+0.6	+$212,800	+1.2
Durables	+$74,446	+0.5	+$99,355	+0.6
Non-Manufact.				
Ag Services	+$604,332	+24.5	+$959,078	+46.6
Mining	$0	0	+$2,851	0
Construction	+$43,428	+0.7	+$83,649	+1.5
Trans/Utilities	+$306,690	+2.3	+$302,677	+2.3
Ret/Whl Trade	+$856,883	+14.6	+$946,823	+19.9
Fin/Ins/Real Est	+$651,706	+2.6	+$879,247	+5.4
Services	+$339,400	+6	+$570,261	+11.7
Government	+$150,901	+1.6	+$115,282	+1.7
Farm	+$8,929,848	+86.6	+$9,288,415	105.8
TOTAL	***+$12,032,259***	***+139.8***	***+$13,460,439***	***+196.6***

Table 8.7: Detailed IMPLAN Output by Region, Issuance of Backlog

SECTION 9 : WATER CONSERVATION IN THE FLINT RIVER BASIN

8.1 Definition

Irrigation is a critical aspect of agricultural life in Georgia. Many farmers in the state have been practicing water conservation for decades. The potential water savings increase every year, thanks to improved technology and innovative on-farm management practices (Vickers 2001). Water conservation is not only good stewardship of the resource, but it also saves money and in many cases, increases productivity.

EPD defines water conservation as the beneficial reduction in water use, waste, and loss. This definition includes issues related to the efficient use of water and resource management. Such a broad definition applies to all water users, and does not single out any one user group. For example, when faced with the challenges presented by limited water resources, all those who use that resource must ask about the rate at which water is withdrawn (efficiency), how much water can be withdrawn without depleting the resource, and if there other alternatives to that source (resource management). By defining water conservation in this way, all water users can contribute to discussions about the management and conservation of our water resources.

EPD is currently drafting the first comprehensive statewide water management plan that will be completed by January 2008. Because water conservation is one of the cornerstone elements of the statewide plan, water conservation practices and measures included in the Flint Plan should inform the statewide planning efforts. To ensure these two plans are compatible, the definitions used in each must be consistent, particularly related to water conservation. The statewide plan will encourage all water use groups to implement water-conserving practices in order to meet the statewide management objective of minimizing water withdrawals. Water-conservation practices for farms are well documented and generally include source management, the use of reclaimed water, and irrigation efficiency. Efforts to minimize water withdrawals are particularly important in sub-areas of the FRB where water resources are already strained.

9.2 Proposed strategies

For the purpose of this plan, water-conserving efforts related to source management, reuse, and efficiency will be collectively referred to as water conservation. The water conservation strategy described below was compiled to capture four critical elements of successful water conservation planning: education and outreach, technical assistance, funding, information management and data analysis, and permitting.

Conservation education and outreach

- Enhance partnerships between EPD and other State agencies (such as DNR Wildlife Resources Division, Soil and Water Conservation Commission, the Cooperative Extension Service) and other entities in the area to develop messages about the importance of implementing efficient irrigation practices and *reducing* water withdrawals. Target educational efforts in those sensitive sub-basins and extend efforts to the rest of the basin.

Technical assistance

- EPD will partner with and assist these agencies and non-profit entities in the region to provide technical consultation, training, and recommendations for agricultural efficiency improvements and technical assistance for activities that can effectively reduce water withdrawals. Target technical assistance in the sensitive sub-basins.
- Information about *statewide* water use and regional water issues will be available to the farming community on the EPD website.
- EPD will work with other agencies to develop guidance documents to promote voluntary best management practices (BMPs) for minimizing water withdrawals while maintaining and enhancing economic, social, and environmental sustainability of soil and crop production. Such guidance documents will be provided to all applicants seeking a water withdrawal permit.

Funding for water conservation practices

- EPD will work with Georgia Soil and Water Conservation Commission to secure more federal funding for water-conservation programs, especially programs targeted to help communities in the FRB reduce withdrawals in sensitive sub-basins. The programs currently include water efficiency efforts such as end-gun shut off, leak detection and repair, and retrofitting of irrigation systems. Programs also include those related to site management, including conservation tillage, shifting from high-water using crops, etc.
- EPD will work with NRCS and the Georgia Environmental Facilities Authority (GEFA) to give preference, in the consideration of funding, to applicants who implement water-conserving practices.

Information management and data analysis

- As scheduled in the amended Water Quality Act and Groundwater Use Act, EPD will use information collected and compiled by the GSWCC through the irrigation metering program. This information will help EPD and other state and federal agencies to identify target areas where enhanced water conservation practices are needed. This type of monitoring can help target education and outreach and financial assistance programs (as described above) most appropriately.
- EPD will work with other state and federal agencies to develop a process for determining success of water conservation practices. This process should be built around the data colletion currently being conducted by the GSWCC and used to identify those areas that need additional resources for more conservation implementation and/or education efforts.

Permit conditions

In ecologically and hydrologically sensitive sub-basins, all new, modified or transferred water withdrawal permits (for farm and non-farm activities) can be conditioned in the following way:

- By statute, all permitees are required to install flow meters and report annual water use, developed in conjunction with the SWCC metering program;

- To eliminate water loss and water waste, all new farm permits will be required to submit a conservation plan as a condition of the permit. Such plans could involve use of cost-effective, water-efficient conservation technology. These technologies could include, but not be limited to, end gun shutoffs, rain gauge shut offs, and pivot-nozzle retrofitting. Also, applicants for new, modified, or transferred water withdrawal permit applicants could be required to implement water conservation measures. Practices and technology that qualify as water efficient will be identified by EPD and other agencies, and periodically reviewed to ensure information is current.

Water loss control

- EPD will partner with SWCC and other agencies to develop a program to help irrigators identify and repair leaks and eliminate off-target application. Program development should include the irrigation manufacturers and providers in southwest Georgia. Initially the program should target the largest irrigation water users in the basin and then expand to the other irrigation users.
- EPD and its partners will encourage development of individual field irrigation scheduling to ensure optimal water, land, and crop input efficiency

Water withdrawal control during drought

- As much as possible, EPD will work with surface-water withdrawal permit holders to coordinate and/or schedule water use among multiple users of surface-water sources that are home to sensitive aquatic species.

GLOSSARY

Aquifer: a saturated geologic formation capable of storing and transmitting economic quantities of water

Base flow: the portion of s stream's discharge derived from ground-water seepage

Basin: An area drained by a river or stream network. Drainage divides separate adjacent basins.

Boundary condition: Used for simulating ground-water or surface-water flow, the mathematical representation of springs, irrigation drains, wells, streams, faults, lakes, precipitation, evapotranspiration, drainage divides, and region beyond the model area.

Calibration: The process by which a computer model's validity is checked against known, measured conditions.

Cone of depression: The 3-dimensional area of drawdown around a pumping well

Confined aquifer: an aquifer sealed above and below by impermeable layers, such that water in a tightly cased well completed in the aquifer would rise above the top of the aquifer

Confining Unit: an impermeable layer of very low hydraulic conductivity that prevents water from leaking out of an aquifer

Correlation coefficient: a measure of how well two variables are related to each other. A perfect correlation has a correlation coefficient of 1.0; that is, changes to one variable cause a direct change in the other variable. The closer a correlation coefficient is to 1.0, the better the relationship between the two variables being analyzed. Correlation coefficients close to –1.0 indicate a strong opposite correlation between two variables.

Confluence: the point where two streams meet

Crystalline: rocks composed of interlocking crystals as opposed to fragments or particles

Dip: The "tilt", or inclination, of a rock layer, fault, fracture, or any other planar geologic feature.

Discharge: the amount of water flowing through or past a point or model boundary

Duration curve: a graph showing the percentage of time a flow is equaled or exceeded

Ecology: the scientific study of the processes influencing the distribution and abundance or organisms, the interactions among organisms, and the interactions between organisms and the transformation and flux of energy and matter

Effluent stream: A stream that gains water from the ground or an aquifer. Also called a gaining stream.

Equilibrium: a state of balance, in which flow conditions and model parameters are no longer changing. Roughly equivalent to "steady state".

Evapotranspiration (ET): The loss of ground-water to the atmosphere by direct evaporation from the soil and transpiration from plants (which take ground-water and release it as vapor into the air).

Farm use: irrigation of any land used for general farming, forage, aquaculture, pasture, turf production, orchards, or tree and ornamental nurseries; provisions of water supply for farm animals, poultry farming, or any other activity conducted in the course of a farming operation. Farm uses shall also include the processing of perishable agricultural products and the irrigation of recreational turf, except in Chatham, Effingham, Bryan, and Glynn counties, where irrigation of recreational turf shall not be considered a farm use. (O.C.G.A. 12-5-92)

Flow boundary: the point, line, or area across which water flows in a basin. They are approximated in a model by flow boundaries.

Flux: same as flow. "Stream-aquifer flux" refers specifically to the exchange of water between streams and the aquifer

Formation: an aerially extensive geologic layer of unique physical characteristics that can be traced laterally, either underground or at the ground surface, for one mile or more.

HSPF: a computer surface-water model that simulates streamflow, taking into account precipitation, runoff, infiltration, etc. Stands for "Hydrologic Simulation Program - Fortran".

Hydrologic Unit Code (HUC): a USGS watershed designation based on the size of the watershed. The smaller a watershed is, the larger its HUC designation (e.g. a HUC-10 is smaller than a HUC-8). The HUC number refers to the number of digits in the HUC code (e.g. 031300090104 is a HUC-12).

Hydraulic Conductivity: a physical property of a geologic formation that determines the relative ability of water to flow through that formation; expressed as a velocity, such as feet per day. It relates aquifer permeability, hydraulic head, cross sectional area, and discharge. Sometimes called "coefficient of permeability", and represented by the letter 'K'. Formations with high values of K are good aquifers, such as the

Floridan aquifer (K = 2000); those with low values of K are poor aquifers, like the Lisbon Formation that underlies the Floridan (K < 1).

Hydraulic head: the potential for water to flow in an aquifer, commonly known as water level, but comprised of pressure, elevation, and velocity components.

Hydrograph: a graph showing ground-water levels, stream discharge, or stream stage (height above a reference level)

GIS: Geographic Information System. A complex set of computer mapping software and techniques in which many different types of information can be retained and displayed in map form.

GPS: Global Positioning System. A network of satellites that constantly transmit accurate locational data to any hand held or fixed receivers on the ground.

Igneous: a type of rock formed from the cooling and crystallization from a melt

Influent stream: A stream that loses water to the ground or aquifer. Also called a losing stream.

Infiltration: The process by which precipitation or surface-water soaks into the ground

Interflow: shallow lateral ground-water flow that occurs between the surface and the water table

Leakage: flow or seepage of water across a model boundary, either laterally (such as to streams, irrigation wells, or springs) or vertically

Metamorphic: a rock type that has enjoyed increased conditions of temperature and pressure below the melting point

MODFE: A ground-water flow model developed by USGS, which uses a grid composed of thousands of small triangles to simulate ground-water flow between triangles. Stands for Modular Finite Element model.

Overburden: sediment overlying an aquifer

Overland flow: water flowing directly across the land surface, outside of stream channels

Parameter: a factor or variable used to describe a physical process such as ground-water flow, values of which are input to a model, such as transmissivity, infiltration rate, head, etc

Percolation: downward seepage of water from the ground surface

Recession: decline in ground-water or stream levels on a hydrograph

Residual water level: in MODFE, a calibration criterion calculated as the difference between simulated water level and a measured water level. The greater the difference, the higher the residual water level. Ideally, residuals in a calibrated model should be small, randomly distributed over a model area, and have an average value near zero.

Riparian: the zone along either side of a stream or wetland

Routing: a modeling process that calculates the amount of time it takes a "slug" of water to move through a basin

Runoff: the process by which precipitation or surface-water flows across the land surface towards streams, lakes, or ponds

Porosity: the percentage of a geologic formation that is empty space. Primary porosity consists of open spaces between individual grains or particles; secondary porosity consists of fractures and bedding planes that cut through the formation.

Permeability: the ease with which water flows through a formation. A formation may be very porous but not very permeable.

Potentiometric surface: A surface that represents the level to which water would rise in tightly cased wells (Fetter)

Recharge: the addition of water to an aquifer by vertical leakage. Typically, leakage is downward from the surface or an aquifer outcrop area, but it may be upwards out of a confined aquifer into a layer of lower pressure.

Residuum: the "residual" material left on top of an aquifer, derived from the weathering of the aquifer itself

Saprolite: heavily weathered crystalline bedrock, which retains the original fabric of the rock, but in which the more easily dissolved minerals have been weathered to clay.

Saturated zone: The part of a soil profile or aquifer that is completed saturated with water.

Sedimentary: a rock type formed from the settling or precipitation of rock, mineral, plant, or animal fragments, or mineral crystals from a solution.

Sensitivity: a measure of how much a parameter affects a model outcome. A model may be very sensitive to a parameter, meaning that small changes in that parameter cause large changes in the model results.

Steady state: the point where a model has achieved equilibrium

Storage: the process of storing or releasing water stored in an aquifer when the hydraulic head changes. This may come from water in pore spaces (such as in an unconfined aquifer), or the actual decompression of water and the aquifer when pumping occurs and head is lowered in a confined aquifer.

Transient: time-varying hydrologeologic conditions. A transient model analyzes flow under time-varying conditions of withdrawals, stream stage, changing head, etc.

Transmissivity: the rate at which water moves through a width of a fully saturated aquifer or confining bed under a hydraulic gradient of 1. It is a function of the nature of the aquifer and its thickness; specifically, it is the product of hydraulic conductivity and aquifer thickness. Aquifers with high values of transmisssivity, such as the Floridan aquifer ($T > 1{,}000{,}000 ft^2/day$) are very productive aquifers.

Unconfined aquifer: an aquifer sealed below by an impermeable layer, but open to atmospheric pressure above. Also called "water table aquifers". The water level in an unconfined aquifer is at or below the top of the aquifer, and defines the water table.

Unimpaired flow: a model simulation of streamflow that removes the effects of dams, withdrawals, etc. It seeks to re-create pre-development streamflow.

Unlithified: not yet turned to rock

Water budget: a tally of where, and how much, water is entering or leaving a model area

Water table: the surface or narrow zone below which all open spaces are filled with water. Also referred to as the top of the saturated zone.

Watershed: An area drained by a stream network. Multiple watersheds comprise a river basin.

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APPENDIX I: SURFACE-WATER MODEL AND APPLICATION

I.1.1 Surface Water Model Development

EPD identified the following key objectives for the FRB surface-water modeling component of the study. The surface water modeling should:

- Simulate and predict stream flow conditions (historic, current and future scenarios) in any place of interest in the modeled sub-basins;
- Evaluate and assess the impact of various management alternatives on stream flow conditions as a management tool;
- Be able to predict changes in water quantity response to a variety of future management scenarios; and
- Be flexible so the tool can be refined to include results of future studies.

Although USGS stream flow gauge data provides valuable hydrologic information for this study, the number of gauge stations with sufficient period of record is limited. Methods are needed to provide calculations of stream flow data in ungauged places of interest such as known habitats of federal protected mussels to develop a detailed water resources management model. Based on these objectives, the BASINS modeling platform (Duda et al, 2001) was selected for the watershed modeling. The HSPF modeling component within BASINS was used to develop the hydrological model and water resources management model for the FRB management.

I.1.2 Introduction

The Hydrological Simulation Program-FORTRAN, also known as HSPF, is a comprehensive, continuous watershed model and computer software package developed under EPA sponsorship for use on digital computers to simulate hydrology and associated water quality processes on pervious and impervious land surfaces and in natural and man-made water systems such as streams, well-mixed lakes, reservoirs, and impoundments

(Duda et al, 2001). HSPF is an analytical computational tool, which can be used in the planning, management, design, and operation of water resources systems. The model uses historical time-series information of rainfall, evaporation, temperature, and parameters related to land use and coverage patterns, soil properties, river channel characteristics, and agricultural practices and other water uses to simulate a comprehensive range of water quantity and quality processes that occur in a watershed or river basin. (At present, the HSPF models developed for the Flint River sub-basins do not incorporate water quality, although the models have this capability.) The output of an HSPF simulation is a time series of the quantity and quality of water transported over the land surface to the streams/rivers, and also through various soil zones down to the groundwater aquifers. Runoff flow rate, sediment loads, nutrients, pesticides, toxic chemicals, and other quality constituent concentrations can be calculated. The model then uses these results and stream channel information to simulate instream processes.

I.1.3 Applications

HSPF is considered the most comprehensive and flexible watershed model available for hydrology and water quality simulation. It is currently one of the very few available models that can simulate a continuous, dynamic event, or steady-state behavior of both hydrologic / hydraulic and water quality processes in a watershed. HSPF uses existing meteorologic and hydrologic data; soils and topographic information; and land use, drainage, and system (physical and man-made) characteristics to simulate water quantity and quality response occurring in a watershed with reasonable accuracy. The potential applications and uses of the model include: (Aqua Terra Consulting website)

- Flood control planning and operations
- Hydropower studies
- River basin and watershed planning
- Storm drainage analyses
- Water quality planning and management
- Point and nonpoint source pollution analyses
- Soil erosion and sediment transport studies
- Evaluation of urban and agricultural best management practices
- Fate, transport, exposure assessment, and control of pesticides, nutrients, and toxic substances

I.1.4 Model Structure and Functionality

HSPF contains three application modules and five utility modules. The three application modules simulate the hydrologic/hydraulic and water quality components of the watershed. The utility modules are used to manipulate and analyze time-series data. Brief descriptions of the modules follow: (Bicknell et al. 2001)

Application Modules:

The three application modules are:

- PERLND - Simulates runoff and water quality constituents from pervious land areas in the watershed. It is the most frequently used part of HSPF. To simulate these processes, PERLND models the movement of water along three paths: overland flow, interflow, and groundwater flow. Each of these three paths experiences differences in time delay and differences in interactions between water and its various dissolved constituents. A variety of storage zones are used to represent the processes that occur on the land surface and in the soil horizons. Some of the capabilities available in the PERLND module include the simulation of: water budget, snow accumulation and melt, sediment production and removal, nitrogen and phosphorous behavior, pesticide behavior, movement of a tracer chemical.
- IMPLND - Simulates impervious land area runoff and water quality. IMPLND is used in urban areas where little or no infiltration occurs. IMPLND includes all of the pollutant wash off capabilities of the commonly used urban runoff models, such as the STORM, SWMM, and NPS models.
- RCHRES - Simulates the movement of runoff water and its associated water quality constituents in stream channels and mixed reservoirs. RCHRES is used to route runoff and water quality constituents simulated by PERLND and IMPLND through stream channel networks and reservoirs. The processes that can be modeled include: Hydraulic behavior, Water temperature; Inorganic sediment deposition, scour, and transport by particle size; Chemical partitioning, hydrolysis, volatilization, oxidation, biodegradation, and radionuclide decay; DO and BOD balances; Inorganic nitrogen and

phosphorous balances; Plankton populations, pH, carbon dioxide, total inorganic carbon, and alkalinity.

Utility Modules

The five utility modules are used to access, manipulate, and analyze time series information stored by the user in HSPF's TSS (Time Series Store) and WDM (Watershed Data Management) files. These time series, such as hourly precipitation, daily evaporation, daily stream flow, are used by the application modules. The five utility modules are:

- COPY - copy data in the TSS to another file
- PLTGEN - generates a plot file for data display on a plotter
- DISPLY - creates data display tables
- DURANL - performs frequency, duration, and excursion analyses; computes statistics; and performs toxicity/lethality analysis
- GENER - permits the transformation of a time series to produce a second, different time series

I.1.5 Basic Concept and Principle in HSPF Model

HSPF has its origin in the Stanford Watershed Model developed by Crawford and Linsley (1966). The model is classed as a general-purpose model; "general purpose" is defined as a comprehensive representation of the hydrologic cycle, which can be used to represent a broad variety of catchments regimes. This model has been widely recognized as one of the best watershed models available and has been applied to many catchments throughout the world.

The model is a conceptual representation of the complete land phase of the hydrological cycle and is based on the following principles: (Computer Simulation In Hydrology)

- The model should represent the hydrological regimes of a wide variety of streams and rivers with a high order of accuracy.
- It should be easily applied to different watersheds with existing hydrological data.
- The model should be physically relevant so that estimates of other useful data in addition to stream flow, such as overland flow or actual evapotranspiration, can be obtained.

Fig. I-1 is a flowchart depicting the structure of the SWM IV. (Crawford and Linsley, 1966)

In SWM, the various hydrologic processes are represented mathematically as flows and storages. Each flow is an outflow from a storage, usually expressed as a function of the current storage amount and the physical characteristics of the subsystem. Thus, the overall model is physically based, although many of the flows and storages are represented in a simplified or conceptual manner. For simulation with the model, the basin has to be represented in terms of land segments and reaches/reservoirs. A land segment is a subdivision of the simulated watershed. A segment of land that has the capacity to allow enough infiltration to influence the water budget is considered pervious. Otherwise it is considered impervious. The two groups of land segments are simulated independently. (Hydrocomp, Inc. Website)

SWM divides land and ground into three different zones: upper zone, lower zone and groundwater storage, plus a zone above the ground. The model simulates the water movement along three paths: overland flow, interflow and groundwater flow. Water goes from clouds to ground surface, then to upper zone, lower zone and finally to groundwater. In each zone, the hydrologic processes include flow, interception or storage, and evapotranspiration. All these processes are part of the hydrologic cycle and follow the water balance equation.

When rain or snow falls to land surface, part of the precipitation is retained on the plants, called interception. From there, it is evaporated without adding to moisture storage of the soil. The portion of precipitation intercepted by plants is measured by the parameter CEPSC. The rest of precipitation goes to the upper zone, in which, water first fills upper zone storage measured by parameter UZSN, then some of the water goes through the upper zone directly to the lower zone, some becomes the interflow measured by parameter INTFW in the upper zone, and finally, overland flow is formed when infiltration capability is exceeded. Infiltration capability is measured by parameter, INFILT. The overland flow and interflow go directly to the stream, while the water in upper zone storage eventually goes to lower zone or groundwater storage through depletion in addition to evapotranspiration. The water that goes to the lower zone first fills lower zone storage (capacity measured by parameter LZSN), then the rest of the water goes to groundwater storage, in which, some of the groundwater will go to the deep or inactive groundwater storage (amount measured by parameter DEEPER), while some will recharge into stream flow (amount is measured by parameter AGWRC). Notice that waters in any storage zone are all subject to evapotranspiration.

The hydraulic processes that occur in the river channel network arc simulated by reaches. The outflow from a reach or a completely mixed lake may be distributed across several targets to represent normal outflow, diversions and multiple gates on a lake or reservoir. Evaporation, precipitation and other fluxes that take place in the surface are also represented. Routing is done using a modified version of the kinematic wave equation.

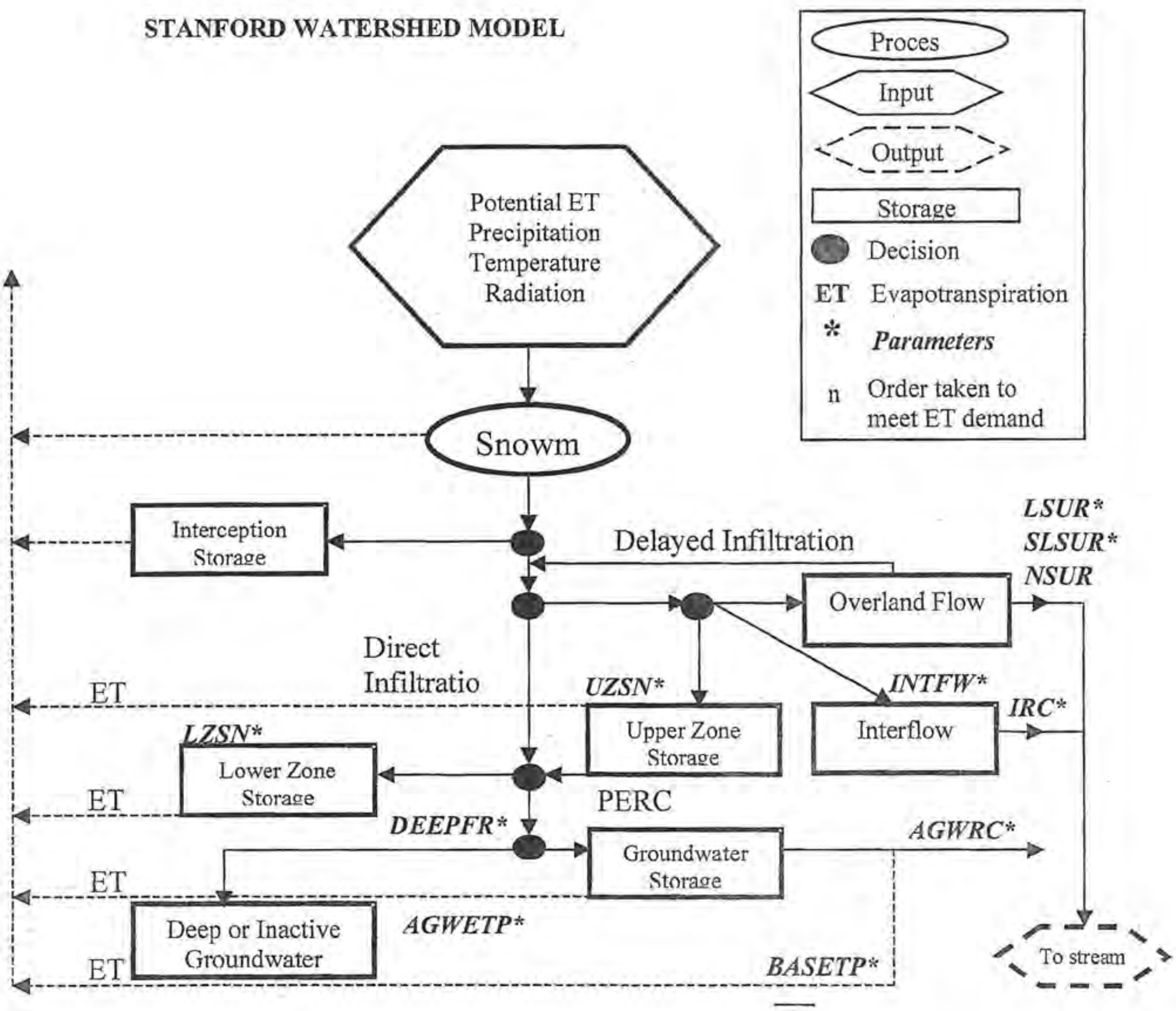

Figure I.1: Flow Chart of Concept Model of SWM

I.1.6 Data Needed for HSPF

- Meteorological Data

Precipitation and Other Meteorological data: hourly time series data including evaporation, air temperature, cloud cover, dew point temperature, wind speed, and solar radiation. For hydrological modeling purposes, such as the FRB study, only evaporation and air temperature are needed.

- Land Cover Data
    - Stream Channel Characterization: the hydraulic characteristics of each stream reachincluding the flow rate, surface area, and volume as a function of the water depth, channel slope and roughness coefficient etc.
- Hydrologic and Water Quality Data: these include observed flow and water quality data.

Water Withdrawals: these include surface water and groundwater withdrawals due to agriculture irrigation, municipal and industrial water use etc., and surface water reduction due groundwater pumping.

I.1.7 Model Development Process

The processes of a hydrological model development by using HSPF include following steps:

- Data preparation

To develop the model using WinHSPF, the study area needs to be delineated into a number of sub-basins and the data described above needs to be collected as model input. The delineation and data collection are conducted in the BASIN 3.1 platform based ARCVIEW GIS. The data is then input into WINHSPF to construct the watershed model.

- Model Assembling

Based on the data collected in the previous step, an initial hydrologic model is constructed and assembled in WINHSPF.

- Model Calibration

The initial model is tuned so that the simulated flow resembles the observed flow as closely as possible (Aqua Terra et al, 2004). This is completed by adjusting various input parameters within the WinHSPF model. Several indices, including Correlation Coefficient, Coefficient of Determination and Nash-Sutcliffe Coefficient, were used to measure "the goodness of fit" between the simulated flow and observed flow at the calibration station.

- Model Validation

After model calibration, the calibrated model needs to be verified and validated by comparing simulated flow and observed flow for different time periods. A reasonable match between the two flows should be achieved; otherwise, the model needs to be recalibrated.

- Model Applications

The validated model then can be used for application and analysis for various future scenarios.

<u>I.2 Model Calibration and Validation</u>

HSPF models must first be calibrated to available, long-term flow data before they can be used to estimate effects of future water use. The purpose of calibration is to match simulated stream flow with observed stream flow for the period before irrigation was widely used. Simulated streamflow is based on historic water use, rainfall, land use, soil properties, and river channel hydraulic characteristics during periods of limited irrigation. Model parameters are then adjusted within acceptable bounds to obtain a satisfactory correlation with observed flow in the sub-basins. The calibration period selected is prior to 1976, when there was relatively little irrigation in southwest Georgia. Using the calibrated model and parameter values obtained from calibration, estimates of post-1975 irrigation usage, rainfall, and other data were input to the model and computed flow rates from were compared to observed post-

1975 data in a process called model validation. Data sources and results of this process are presented in the following subsections for the Ichawaynochaway Creek, Spring Creek, and Lower Flint sub-basins. Very similar methods were used to calibrate and validate the HSPF models for each sub-basin; however, it was necessary to consider and incorporate differences in data such as periods of record and rainfall data.

I.2.1. Model Calibration

I.2.1.1. Ichawaynochaway Creek Sub-Basin

The USGS gauge at Milford (#02353500) on Ichawaynochaway Creek (Figure I.2.-1) is the only stream gauge in the sub-basin with an extensive period of record pre- and post-irrigation and therefore the only location suitable for model calibration. Hourly or daily meteorological records were available at several stations (Figure I.2-1) in or near the sub-basin (Cuthbert, Dawson, Morgan, Albany, Edison, Colquitt, and Camilla) from which rainfall data could be obtained for 1950 through 1975 and 1976 through 1995, periods of time considered sufficient for calibration and validation. Gaps in the precipitation data, found at every meteorological station, have been filled using available data from the nearest stations

Flow and meteorological data from 1950 through 1975 were input to the HSPF surface-water model, and a series of simulations was run for comparison with observed flow at Milford under conditions of no agricultural irrigation. Calibration indices, including Correlation Coefficient, Coefficient of Determination, and Nash-Sutcliffe Coefficient, were computed as a measure of "goodness of fit". Parameters were varied to best match dry-season flows, as these are most important to analyzing how permit management policies may affect critical (low) flow conditions during droughts. Generally, the fit to historical data was reasonably good. Selection of the "best" model parameters was influenced by the need to keep these parameters within acceptable ranges; consistency with the characteristics of the other sub-basins; and the hydrologic and geologic characteristics of the modeled sub-basins. The

Ichawaynochaway Creek model calibration parameters are listed in Table I.2-1 and the calibration indices are listed in Table I.2-2.

Comparisons of model simulation and historical flows at the Milford gauge for years 1955 (a drought year), 1958 (a normal year), and 1973 (a wet year) are shown in Figures I.2-2 thru I.2-4. Despite the statistically "good" fit, as measured by the calibration indices, the simulations do not precisely match measured flow rates. The HSPF model uses rainfall as the driving mechanism for simulated stream flow. When meteorological stations do not record a rainfall event responsible for the Milford stream flow at any given time period, flow peaks will be missed during simulation, or if a localized storm occurs at a meteorological station but does not affect streamflow, peaks will be simulated which did not actually occur. Other mismatches in calibration can be caused by errors in gauge measurements, and in water withdrawal or return rates (most evident during post 1975 irrigation periods, see Section I.2.1.2). Extremely low flows cannot be accurately simulated with consistency by the model due to the cumulative uncertainty in the process (i.e. measurement errors, modeling uncertainties, etc.). However, the model is considered to be sufficiently accurate to indicate conditions that should be avoided, or corrected in some way, to prevent extended low-flow conditions.

Another method of displaying the comparison between the calibrated model and measured flow data for the period 1950 through 1975 is the flow duration, or flow exceedance, curve in Figure I.2-5. As an example, this curve shows that 10% of the time (horizontal axis) simulated and measured flow at Milford (vertical axis), over the whole period of record from 1950 through 1975, exceeds about 2000 cfs. The calibration simulation exceeds the observed flow rate over the upper 8% of the flow range and is slightly below observed flows over the lowest 80% of the flows.

I.2.1.2. Model validation

The process of model calibration was performed for the period prior to extensive agricultural irrigation. Consequently, no irrigation withdrawals were used in calibration simulations. Before the model can be used for estimation of future irrigation water use scenarios, however, it should first be validated for a different period of time. For the HSPF models, the validation period was chosen to be one in which significant irrigation withdrawals were taken from the sub-basin. Based on estimates shown in Figure I.2-6, widespread irrigation started around 1976 (Hook, 2005).

Model validation started with the calibrated model developed as described in Section I.2.1.1, but with the addition of estimated agricultural withdrawal rates believed to correspond to historically varying rates for the period 1976 thru 2003. Estimated irrigation rates and distributions (Hook et al, 2005) from which sub-basin specific estimates were derived for 2001-2002 were used in the validation model (Table I.2-3). These rates were then adjusted for each year of the validation period by applying the regression curve formula shown in Figure I.2-6.

Also required for the validation simulation is the effect of assumed historical groundwater withdrawal on surface water flow. The USGS calibrated the transient MODFE model for the period from March 2001 to February 2002, which includes all of the growing season months of 2001. Based on the USGS calibration, EPD divided the USGS modeling area into additional sub-basins and computed flow reductions by stream reaches for each sub-basin based on the calibrated pumping rates by comparing to the rates with no pumping. Table I.2-4 provides the estimated cumulative flow reductions derived from the MODFE model at Milford on the Ichawaynochaway, Iron City on Spring Creek, and Bainbridge on the Lower Flint for estimated pumping rates in 2001.

With the estimated surface and groundwater irrigation rates and the calculated reduction in surface water flow due to groundwater withdrawal, the validation model was run for the period 1976 through 1995. Surface and groundwater pumping rates for this period were estimated from current irrigation acreage, modified by the historic rate of growth of irrigation over this period, and the drought and normal year application rates as discussed above.

As was done for model calibration in Subsection I.2.1.1, comparisons of model validation and historic flows at the Milford gauge for years 2000 (a drought year), 1983 (a normal year), and 1998 (a wet year) are shown in Figures I.2-7 thru I.2-9. Again, the simulations do not perfectly match. In these validation simulations, there are additional uncertainties of irrigation water use rate and distribution and the effect of groundwater withdrawal on stream flow. However, the overall model validation indices listed in Table I.2-5 are still acceptable.

The validation period exceedance curve comparison is shown in Figure I.2-10. This graph shows that deviations above and below the historical exceedances are focused at the upper and lower ends of the flow range, respectively.

I.2.2. Spring Creek Sub-Basin

I.2.2.1 Model Calibration

The USGS gauge on Spring Creek (#02357000) near Iron City (Figure I.2-11) is the only flow gauge in the sub-basin with an extensive period of record both pre- and post-irrigation and therefore is the only location suitable for model calibration. Hourly or daily meteorological records were available at several stations (Figure I.2-11) within or near the sub-basin (Edison, Blakely, and Colquitt) from which rainfall data could be obtained for periods from 1950 thru 1975 and from 1976 thru 2003, periods of time considered sufficient for the purposes of calibration and validation.

The Spring Creek model calibration parameters are listed in Table I.2-1 and the calibration indices are listed in Table I2-2. Comparisons of model simulation and historical flows at the Iron City gauge for years 1956(a drought year), 1958 (a "normal" year) and 1965(a wet year) are shown in Figures I.2-12 thru I.2-14. Despite the statistically "good" fit, as measured by the calibration indices, the simulations do not precisely match measured flow rates. As with the calibration for Ichawaynochaway Creek, extremely low flows cannot be accurately simulated with consistency by the model.

A flow exceedance curve for the Spring Creek model calibration is shown in Figure I.2-15. This curve shows that 80% of the time (horizontal axis) the simulated and measured flow at Iron City (vertical axis), over the whole period of record from 1950 thru 1971 (gauge flow data is absent from 1971-1975), exceeds about 100 cfs. The calibration simulation slightly exceeds the measured flow rate over the upper 7% of the flow range and is below the measured flows over the lowest 1% of the flows.

I.2.2.2. Model Validation

The Spring Creek validation model was run for the period from 1982 thru 2001 (gauge flow data is missing from 1976 to 1982). Comparisons of model simulation and historical flows at the Iron City gauge for years 1988(a drought year), 1983(a normal year), and 1989(a wet year) are shown in Figures I.2-16 thru I.2-18. Again, the simulations are not a perfect match; in this case there are the additional uncertainties of the irrigation water use rate and distribution and the groundwater withdrawal effect on streamflow. However, the overall model validation indices listed in Table I.2-5 are acceptable.

The validation period exceedance curve comparison is shown in Figure I.2-19. This graph shows that simulated flow is slightly higher than observed flow statistically, but in general, both match satisfactorily.

I.2.3 Lower Flint River Sub-Basin

I.2.3.1 Model Calibration

Inside the Lower Flint River Sub-Basin, two USGS gauging stations have long-term observations enabling calibration. These two stations are Flint River near Newton (#02353000) and Flint River near Bainbridge (#02356000). The record at the Newton station contains data of in-stream flow rates for the period from 1956 to present; and the record at the Bainbridge station contains the same type of data for the period from 1928 to 1971. Date at both stations can be used in the calibration process. Because the Bainbridge gauge covers significantly more drainage area in the basin, that data was chosen for HSPF model calibration. Daily meteorological data at five different rain gauges, both inside and outside (but close to) the Lower Flint Sub-Basin, are available. These rain gauges are located at Albany, Bainbridge, Cairo, Camilla, and Colquitt. Most of these gauges have recorded historic precipitation data from 1950 to August of 2003

A map showing the delineation of the Lower Flint River Sub-Basin, locations of the USGS gauges, and locations of the meteorological stations is shown in Figure I.2 – 20. It is worth noting that this sub-basin has two points of inflow from upstream: the Flint River at Albany and Ichawaynochaway Creek. Recorded historic flow at Flint River near Albany (#02352500) was used as inflow to the most upstream sub-watershed (No. 5). Simulated flow at the outlet of the Ichawaynochaway Creek (see Section I.2.1 for details) was used as inflow to sub-watershed 23. The locations of these inflows are shown in the map with blue downward arrows.

The Lower Flint River Sub-Basin model parameters obtained from the calibration process are listed in Table I.2 – 1 and the calibration indices in Table I.2 – 2.

Comparison of simulated and observed historic flows at Flint River at Bainbridge for years 1955 (a drought year), 1958 (a normal year), and 1965 (a wet year) are shown in Figures I.2 – 21 through I.2 – 23. As shown by both these figures and the calibration indices, the match between simulated flow and observed flow is quite good. This is in part due to the dominant effect of the inflow from upstream. Tributary flow originating within this sub-basin is relatively small compared to the magnitude of the inflow. Nonetheless, tributary flow simulated from rainfall-driven runoff by the HSPF model contributed to satisfactory matching between simulated and observed flow at Bainbridge, which provides confidence in using the model to assist management decisions in this sub-basin.

Exceedance curves of simulated and observed flow at Bainbridge are shown in Figure I.2 – 5. The close match at all levels of the exceedance curves strongly indicates satisfactory calibration of the Lower FRB surface water model.

I.2.3.2. Model Validation

Ideally, the validation of the Lower Flint River Sub-Basin should be conducted using an independent flow data set on the Flint River at Bainbridge, the same location used for calibration. However, USGS ceased operating the Bainbridge gauge after September 30, 1971; the gauge did not resume operation until October 1, 2001. Given the absence of an independent data set at Bainbridge, we chose to validate the model using flow rates observed on the Flint River at Newton (#02353000) in the period from 1976 to 2003, even though the Newton gauge only includes about 40% of the drainage area above the Bainbridge gauge within this Sub-Basin.

As was done for the calibration in Subsection I.2.3.1, comparisons of model simulation and historical flows at the Newton gauge for years 2000 (a dry year), 1983 (a normal year), and 1998 (a wet year) are shown in Figures 2.3 – 25through 2.3 – 27. Slight deviations from the observed flow can be seen; however, the simulation followed observed flows closely. In fact, the model's indices, shown in Table I.2 – 5, indicate a satisfactory validation.

The validation period exceedance curve comparison is shown in Figure I.2 – 9. It can be seen that the simulated data closely matches the observed data, providing additional confidence in the application of the surface water model.

I.3. Model Simulations

I.3.1. Description of Model Scenarios

The challenge faced in developing a permit management plan for agricultural water use in the FRB requires that representative future scenarios of agricultural water use be tested for their likely effects on surface-water. The tool to be used to test these scenarios is a combination of the USGS MODFE groundwater model and the calibrated HSPF surface-water models. The computer models have been described in Sections I.1. and I.2. Scenarios for future water usage are described in this subsection.

Estimated current and backlog (i.e., irrigation permit applications which have been submitted to EPD during the moratorium but not yet acted upon) acreages irrigated from surface water and groundwater sources in the Flint sub-basins are shown in Table I.3-1. Among the three sub-basins being modeled, the Lower Flint has the most irrigated land (about 170,000 acres), 98% of which are irrigated from Upper Floridan aquifer groundwater. Spring Creek has about 139,000 irrigated acres, 92% from groundwater, and Ichawaynochaway Creek has 100,000 acres, with 66% irrigated from surface water sources. Current application rates in inches per month are given for typical rainfall and drought years, by sub-basin, and for groundwater and surface water sources in Table I.3-2. .

Tables I.3-1 and I.3-2 are the basis for the Current Irrigation Scenario. Other scenarios modeled include the Backlog Scenario, which accounts for the option of approving all permit applications received by EPD during the permit moratorium, which began in 1999. This is equivalent to an increase in irrigation acreage of about 18% above currently mapped acreage irrigated by ground and surface water permits for the entire Flint Basin. A further increase in irrigation water use is represented by increasing the application rates for the Backlog Scenario by 25%, for example as a result of an extensive Crop Mix Scenario change. Finally, in case the evaluations of model results show that the Current Scenario over-allocates the water supply under drought conditions, Cutback Scenarios of 80%, 70%, and 60% of current irrigation use rates are also modeled.

I.3.2. Model Results

I.3.2.1. Groundwater Model Results

The USGS MODFE model was used to compute the estimated reduction in surface water flow rates in each of the modeled sub-basins for each scenario in both dry and normal rainfall years. The computations are made monthly for each stream reach in the model area and can therefore be accumulated for each node in the model. Table I.3-3 provides an example comparison of the calculated stream flow reductions (compared to simulated scenarios of no pumping) at selected nodes (the Milford gage on Ichawaynochaway Creek, the Iron City gauge on Spring Creek, and the Bainbridge gauge on the Lower Flint) for the Current, Backlog, and 1.25xBacklog scenarios in the growing season months of a drought and normal year. Streamflow reductions are much greater at the Bainbridge gauge in the Lower Flint sub-basin and at Iron City in the Spring Creek sub-basin than at the Milford gauge in the Ichawaynochaway Creek sub-basin due to the larger number of irrigation wells in the former two basins. The computed daily flow reductions obtained from MODFE for these locations are subtracted from the corresponding daily flow rates in the HSPF models to yield the estimated surface flow rates for each scenario at each model node (See Section I.3.2.2).

I.3.2.2. Surface Water Model Results

In order to evaluate the effect of a range of future agricultural irrigation pumping rates, the calibrated HSPF sub-basin models were applied to the hydrologic period extending from1950 thru 2003 with the pumping scenarios described in Section I.3.1. Using the criterion that unimpaired flow rates at the Newton gauge (US Army Corps of Engineers, 1997) be among the lowest 25% in the historical record for the growing season, years that met the criterion were considered drought years and thus chosen for higher irrigation rates in the model runs were 1951, 1954, 1955, 1956, 1968, 1977, 1981, 1985, 1986, 1988, 1990, 1995, 1999, 2000, and 2002. This 54-year sequence of climatic conditions represents one possible view of the future. Due to the complexity of changing data input for both models in their current formats, multiple sequences of statistically comparable, yet randomly varying, hydrologic conditions can not be set up and computed in an efficient manner. This is a goal for future analysis.

To illustrate the range of modeled flow effects, Figures I.3-1, I.3-2, and I.3-3 compare the computed flow exceedance curves for the Current, Backlog, and 1.25 × Backlog (the latter representing future, significantly higher irrigation rates, such as may be due to a crop mix requiring much greater irrigation rates) scenarios in the Ichawaynochaway Creek, Spring Creek, and Lower Flint River sub-basins. For example, on Ichawaynochaway Creek near Milford, the flow rate exceeded 95% of the time can be seen to decrease from about 120 cfs for the Current Scenario to about 110 cfs for the Backlog Scenario and to about 95 cfs for the 1.25 × Backlog Scenario. On Spring Creek near Iron City, the flow rate exceeded 95% of the time can be seen to decrease from about 25 cfs for the Current Scenario to about 20 cfs for the Backlog Scenario and to about 10 cfs for the 1.25 × Backlog Scenario. On the Flint River at Bainbridge, the flow rate exceeded 95% of the time is about 2280 cfs for the Current Scenario; it is reduced to about 2250 cfs for the Backlog Scenario, and further reduced to about 2200 cfs for the 1.25 × Backlog Scenario. These effects include the computed groundwater reductions described in Section I.3.2.1 from the MODFE model.

Another view of the modeled effects on flow rates can be illustrated by looking at daily flow rates computed for specific years at the same model nodes. Using the years chosen to illustrate the model calibration results in Section I.2.1.1 (a drought, wet, and normal year), Figures I.3-4 thru I.3-12 present comparisons of the simulated flow rates for the Current, Backlog, and 1.25xBacklog Scenarios. Specifically, Figures I.3-4 through I.3-6 show simulated stream flow on Ichawaynochaway Creek near Milford under the three scenarios in 1955 (drought year), 1958 (normal year), and 1973 (wet year). Figures I.3-7 through I.3-9 show simulated stream flow on Spring Creek near Iron City under the three scenarios in 1988 (drought year), 1958 (normal year), and 1965 (wet year), and Figures I.3-10 through I.3-12 show simulated stream flow on the Flint River at Bainbridge under the three scenarios in 1955 (drought year), 1958 (normal year), and 1973 (wet year). It can be seen that the most significant differences in simulated stream flow rates occur in drought years. For example, the lowest flow rate at Ichawaynochaway Creek near Milford, given the 1955 meteorology

(Figure I.3-4), is about 60 cfs under the Current Irrigation Scenario. The flow rate is reduced to less than 40 cfs under the Backlog Irrigation Scenario, and to less than 20 cfs under the 1.25 × Backlog Scenario.

I.4 Scenario Impact Evaluation

I.4.1. Discussion of Instream Flow Impact Criteria

Having computed stream flows resulting from several possible future irrigation scenarios, the next step is to evaluate the impact of these reduced flow rates ontwo sets of criteria: 1) low flow criteria that would be protective of endangered aquatic species and 2) the effect on streamflows protective of water quality standards.

I.4.1.1. Aquatic Habitat Protection Stream Flow Criteria

As part of the federal agency preparation for review of negotiated ACT and ACF basins Water Allocation Formulas between Georgia, Alabama, and Florida, the U.S. Fish & Wildlife Service and U. S. Environmental Protection Agency (USEPA) developed a set of draft guidelines for protection of the basins' riverine ecosystems. The guidelines were intendedfor evaluation under the FWS's Endangered Species Act authority and EPA's Clean Water Act authority. The guidelines were not intended to be exclusive, but stated that an allocation formula that did not comply with the guidelines would require a more detailed review by both agencies. It was felt that the guidelines would protect both the present structure and function of the riverine ecosystems as well as endangered species (USFWS and USEPA, October 25, 1999).

The Flint River Technical Advisory Committee agreed that the Monthly 1-day Flow Minima (U1) and the Annual Low-Flow Duration (U2) guidelines would be an appropriate measure of the impact on streamflows resulting from the range of irrigation scenarios described above. Specifically, these guidelines (USFWS and USEPA, October 25, 1999) are defined as:

U1: Monthly 1-day minima

Computational definition: using the complete daily discharge record for the reach, compute the 1-day minimum flow for each month of the year in all years. Compute the minimum, 25th percentile, and median of these minimum flow values. For each future month, the 1-day minimum flow guideline is to:

d. Exceed the minimum in every year.
e. Exceed the 25th percentile in 3 out of 4 years.
f. Exceed the median in half of the years.

U2: Annual low-flow duration

Computational definition: using the computed daily discharge record for the reach, compute the average annual discharge (AAD) for each calendar year, and then the average of these annual values. Compute the number of days per year for each calendar year during which daily discharge is less than 25 percent of the AAD. Compute the maximum, 75th percentile, and median of these values. For each future year the guideline is:

d. Do not exceed the maximum duration in any years.
e. Do not exceed the 75th percentile in 3 out of 4 years.
f. Do not exceed the median in half the years.

Maintenance of the U1 and U2 guidelines in the Flint Basin would be an attempt to prevent irrigation in the Flint Basin from lowering the monthly historical 1-day low flow minima and also from increasing the duration of annual low flow conditions.

I.4.1.2. Water Quality Guidelines

Potential impacts to water quality may also be important to the evaluation of scenario model results in the FRB. Georgia EPD develops waste-load allocations and associated National Pollutant Discharge Elimination System (NPDES) permit limits for municipal and industrial surface water discharges that protect in-stream dissolved oxygen standards and other in-stream water quality criteria. NPDES permits are developed to protect water-quality standards using a minimum stream flow equal to the annual 7Q10; i.e. the minimum 7-day average stream flow having a 10 percent chance of occurrence in any year, or a theoretical recurrence interval of 10 years. Changes to surface water hydrology that cause stream flows to more frequently be less than the 7Q10 used to determine NPDES limits could adversely affect a stream's ability to meet the dissolved oxygen standard and other criteria during critical low flow conditions. If decreased stream flows persist for a long period, such that annual 7Q10 must be re-calculated downward, allowable waste-load allocations may need to be decreased to prevent the new, more rigorous standards from being violated. This could impose an additional water treatment burden on those municipalities or industries with NPDES permits.

To address this, ririgation scenario model results were evaluated for their potential effect on the frequency of 7Q10 flows at selected locations in the sub-basins.

I.4.2. Computation of In-stream flow criteria

For the purposes of this Plan, in-stream flow criteria are calculated at three representative gauge locations: Ichawaynochaway Creek at Milford, Spring Creek near Iron City, and the Flint River at Bainbridge.

I.4.2.1 Aquatic Habitat Protection Stream Flow Criteria

Table I4-1 presents comparisons of the aquatic habitat guidelines computed for each of the gauge locations based on the full period of record at each gauge location.

I.4.2.2 Water Quality Guidelines

A review of historic streamflow data and NPDES permit conditions, as well as computation of 7Q10 flow rates for various time periods, indicates that the 7Q10 used by EPD to set current permit discharge limits in Southwest Georgia was based on pre-1970 historic flow data. The computed 7Q10 for this period is 2500 cfs for Bainbridge, 140 cfs at Milford, and 15 cfs for Iron City.

I.4.3 Model Scenario Effects

I.4.3.1. Aquatic Habitat Protection Stream Flow Guidelines

The effects on U1 and U2 stream flow guidelines can be computed for the future irrigation scenarios described in Section I.3. In these model runs, assumed irrigation distribution patterns and application rates for each scenario are modeled for the 54-year hydrologic pattern observed for the period from 1950-2003. The irrigation acreage does not change from year to year in these scenarios (see Table I.3-1) and the application rates change only according to whether a particular year was a drought or not (Table I.3-2). The 54-year series of computed flow rates can be viewed as being representative of the likelihood that particular surface water flow rates will be observed if the climatological conditions and irrigation patterns do not significantly change from those modeled.

. Thus, to meet the U1 guidelines described and computed in Sections I.4.1 and I.4.2, and shown in Table I.4-1, none of the monthly 1-day minimum flow rates computed for the future scenarios as shown in Table I.4-2 for Ichawaynochaway Creek at Milford should be less than the criteria. Observed gauge flow rates show no variances (all "0's"), but model results show as many as 5 variances in the month of September, generally being greatest for the more intensive irrigation scenarios (i.e., Backlog and 1.25x Backlog Scenarios) and in the August-September months of the growing season. For the U1-B guideline, variances should not exceed 1 in 4 years (25%), but this does occur, again mostly for the Backlog Scenarios in August and September. The U1-C guideline should not show variances greater than 50% (1 in 2 years), but this occurs in late summer.

The differences between scenario U1 variance computations at the three gauge locations can be seen for selected years (1980's) in Figure I.4-1 which shows the modeled minimum 1-day flow rates during the month of August vs. the minimum (U1-A), 25% (U1-B), and mean (50%) (U1-C) criteria. U1-A is not met in 1986 with the Current and Backlog Scenarios, but is met in all other years and scenarios. Variances occur for the U1-B guideline in 1981 and 1986 (all scenarios) and in 1985 and 1988 for some scenarios, but a 25% variance rate is acceptable for U1-B. Only 1982, 1984, and 1989 have no U1-C variances, though a 50% variance rate is acceptable.

Table I.4-3 displays the results of comparisons of the duration of U2 computed scenario flows below 25% of the annual average for Ichawaynochaway Creek. The maximum allowable duration is exceeded in each of the model runs. The 1 in 4 year allowance is exceeded in several scenarios. The median allowable duration is equaled only in the 1.25xBacklog Scenario.

Tables I.4-4 and I.4-5 and Figure I.4-2 summarize guideline results for Spring Creek and Tables I.4-6 and I.4-7 and Figure I.4-3 for the Lower Flint. Spring Creek model results indicate very high rates of variance for U1 and for U1C and low rates for U2A compared to Ichawaynochaway Creek. Flint River model results show virtually no variances for any of the criteria. Section I.4.4 presents discussions of reasons for some of the variability in sub-basin guideline variance computations and comments on the interpretation of these model results.

I.4.3.2. Water Quality Guidelines

Table I.4-8 compares the 7Q10 streamflows at Milford on Ichawaynochaway Creek, on Spring Creek near Iron City, and at Bainbridge on the Lower Flint, computed from pre-1970's gauge data and using model simulation results from four future irrigation scenarios. The differences between the future scenario low-flow computations and the pre-irrigation computation are significant in each case. This implies that water quality standards would be violated more frequently in the future if permitted constituent loadings are not reduced.

One way to estimate the increased frequency of potential water quality standard violations implied by this analysis, if loadings are not reduced, is to compute the change in frequency of occurrence of the pre-1970 7Q10 flow rate for the scenarios in Table I.4-8. These are shown for the three modeled locations in Table I.4-9. For the Milford gauge, the frequency of flows less than the pre-1970 7Q10 flow rate is 2.9%. This increases to 6.5% for the Current

Scenario and 7.2% for the Backlog Scenario. For the Iron City gauge, the frequency of flows less than pre-1970 7Q10 increases from 3.5% for the Current Scenario to 6.3% for the Backlog Scenario; for the Bainbridge gauge, the increase is from 5.4% to 7.2%.

I.4.4. Interpretation of Scenario Impact Model Results

Tables I.4-2 thru I.4-9 show a wide range of results for the various conditions represented by the MODFE groundwater and HSPF surface water model simulations, as well as the observed data. The most extreme differences may be the small number of variances from the U1 and U2 guidelines for the Flint River at Bainbridge compared to Ichawaynochaway and Spring Creeks. However, there are also differences in how the guidelines are missed in the latter two locations and the fact that the observed data at those locations do not indicate any variances (since the guidelines were developed from those data).

The reason for these apparent discrepancies is primarily due to: 1) the calibration of the models, and 2) the uncertainties in the measurement and modeling process, which are especially evident at low flows.

Uncertainties inherent in model calibration have been discussed previously. , These uncertainties are magnified at low flows. For example, measurement errors in gauged flow probably exceed the 7Q10 of Spring Creek at Iron City. This may not be true at Milford on the Ichawaynochaway, but the uncertainties are still a significant fraction of the 7Q10. On the Lower Flint the flow rates are much higher, even under drought conditions, but the much better calibration match at Bainbridge and the lack of guideline variance are becausethe Lower Flint HSPF model is much less dependent on rainfall input as the driver and much more dependent on the more reliable flow gauge at Albany, where upstream inflow is incorporated into the model. The other two basins do not have gauged inflows that control a large percentage of the surface water flow at the modeled locations. In other words, the large inflow to the Lower Flint sub-basin numerically "overwhelms" measurement and modeling uncertainties, whereas in Spring Creek and Ichawaynochaway sub-basins those uncertainties make up a larger portion of the simulated stream flow.

Because of the uncertainties and limitations described above, the model results should be interpreted with consideration for the differences between scenarios relative to the guidelines rather than strictly in terms of a direct comparison with the guidelines. In general, models are most accurate when used to determine differences between scenarios. The differences between computed scenario criteria relative to the magnitude of the allowable criteria may be more meaningful than whether the scenario criteria exceed the allowable criteria. For example, for Spring Creek (Table I.4-4) there is only about a 2% increase in U1-C for the Backlog Scenario vs. the Current Scenario compared to a 50% variance allowance. Even the calibrated results are 8 to 10% above the variance limit in most summer months. Another example can be taken from comparisons of flows against 7Q10 (Tables I4-8 and I4-9). The difference between modeled scenario results may be more meaningful than the difference from the historical data.

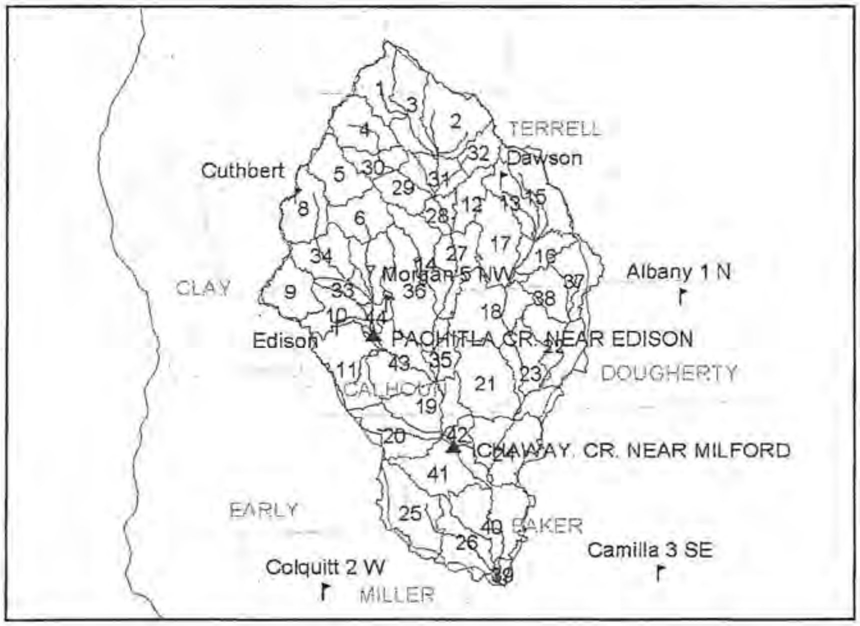

Figure I.2 – 1: Ichawaynochaway Creek Sub-Basin with Gauging Stations, Met Stations, and sub-basin delineations

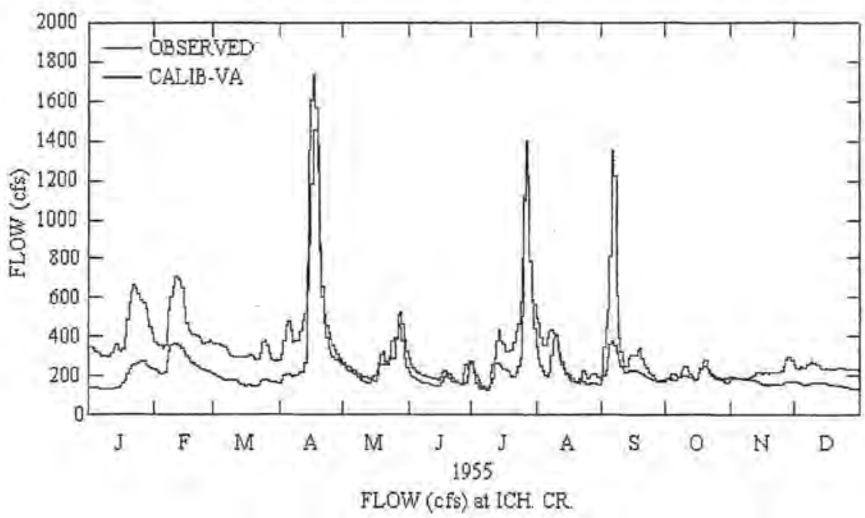

Figure I.2 – 2: Observed vs. calibrated streamflow of Ichawaynochaway Creek near Milford for 1955 (dry year)

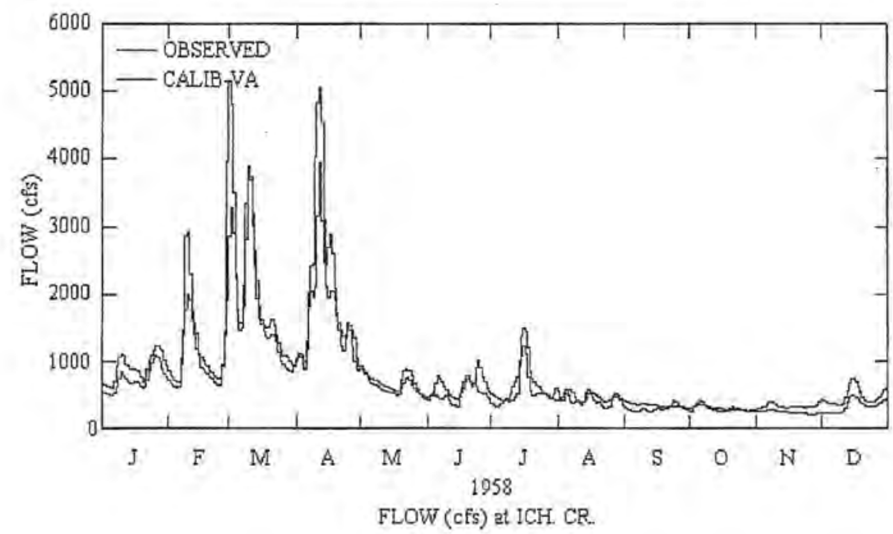

Figure I.2 – 3: Observed vs. calibrated streamflow of Ichawaynochaway Creek near Milford for 1958 (Normal Year)

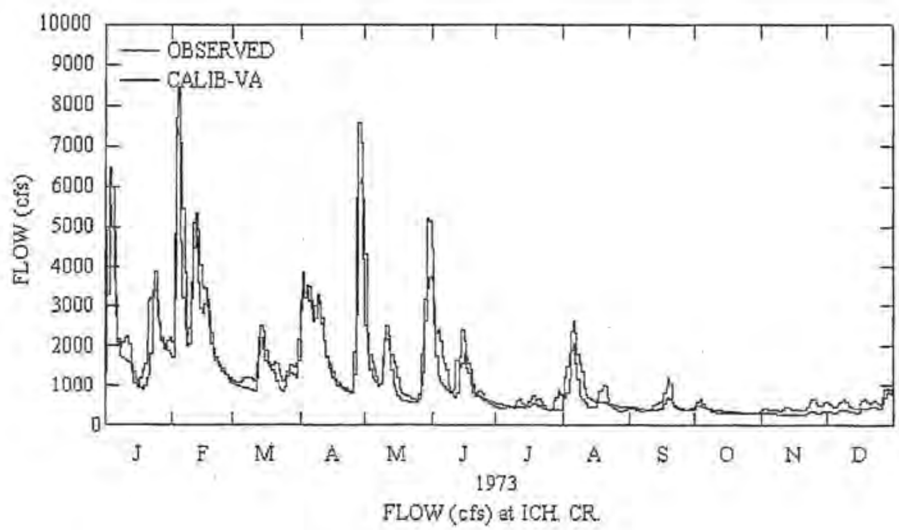

Figure I.2 – 4: Observed vs. calibrated streamflow of Ichawaynochaway Creek near Milford for 1973 (Wet Year)

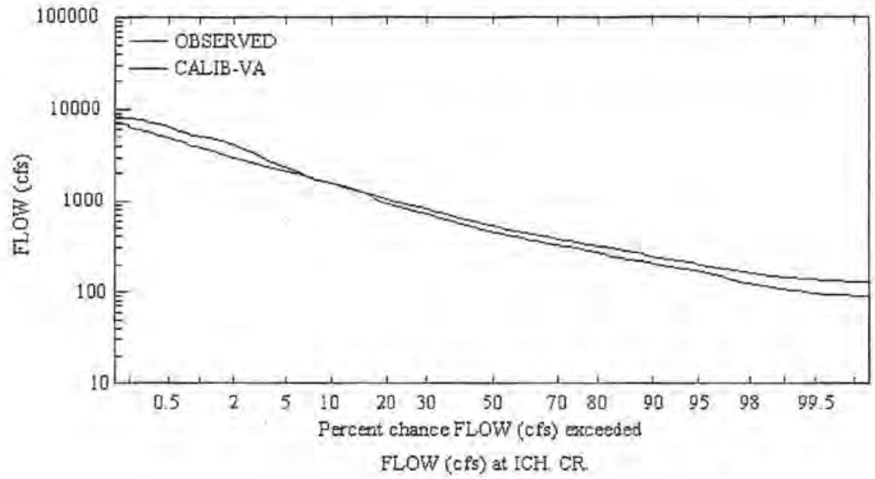

Figure I.2 – 5: Duration Curve for Calibrated vs. Observed Flow of Ichawaynochaway Creek at Milford

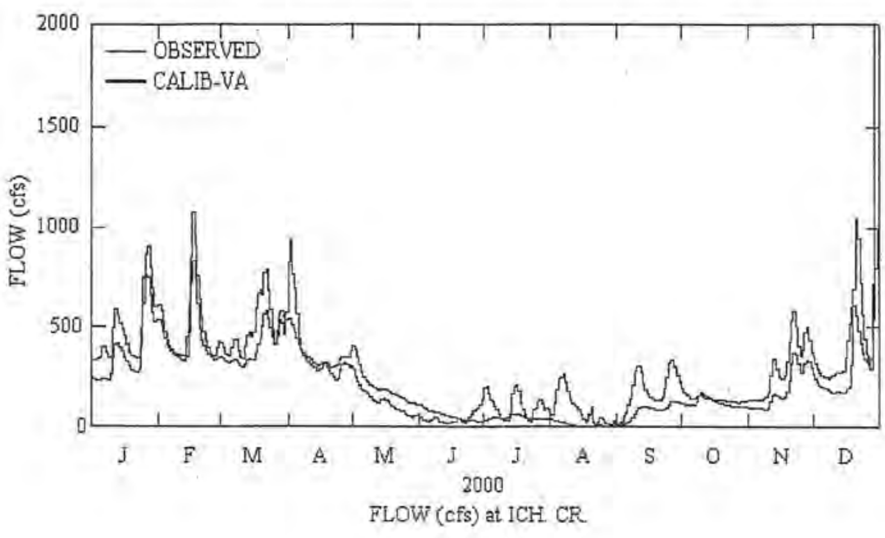

Figure I.2.1 – 7: Observed vs. calibrated streamflow of Ichawaynochaway Creek near Milford for 2000 (Dry Year)

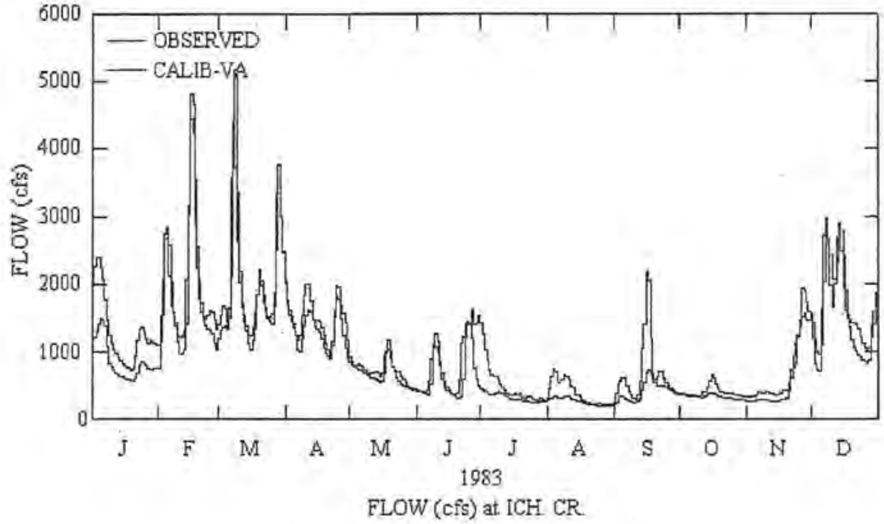

Figure I.2 – 8: Observed vs. calibrated streamflow of Ichawaynochaway Creek near Milford for 1983 (Normal Year)

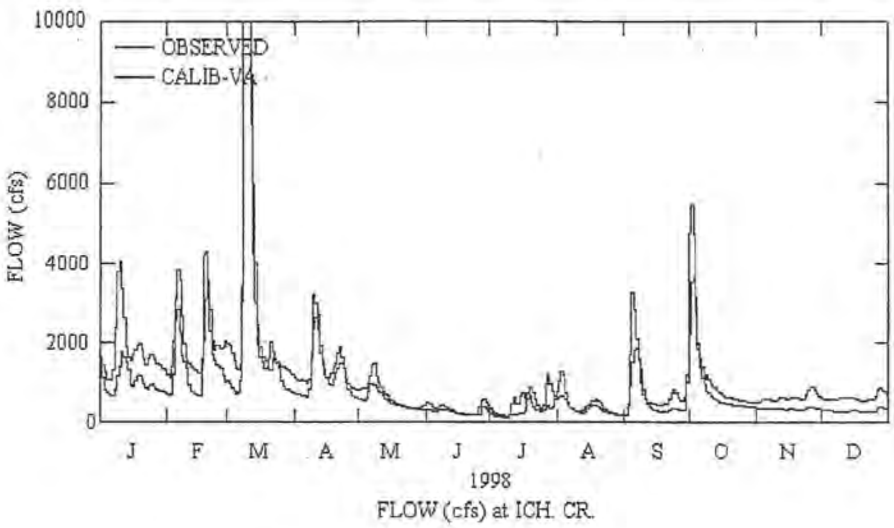

Figure I.2 – 9: Observed vs. calibrated streamflow of Ichawaynochaway Creek near Milford for 1988 (Wet Year)

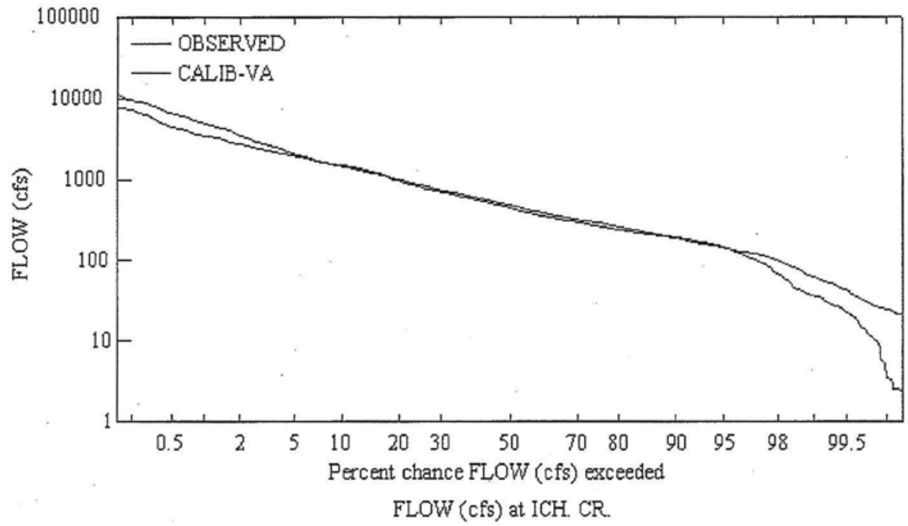

Figure I.2 – 10: Duration Curve of Validated vs. Observed Flow of Ichawaynochaway Creek near Milford

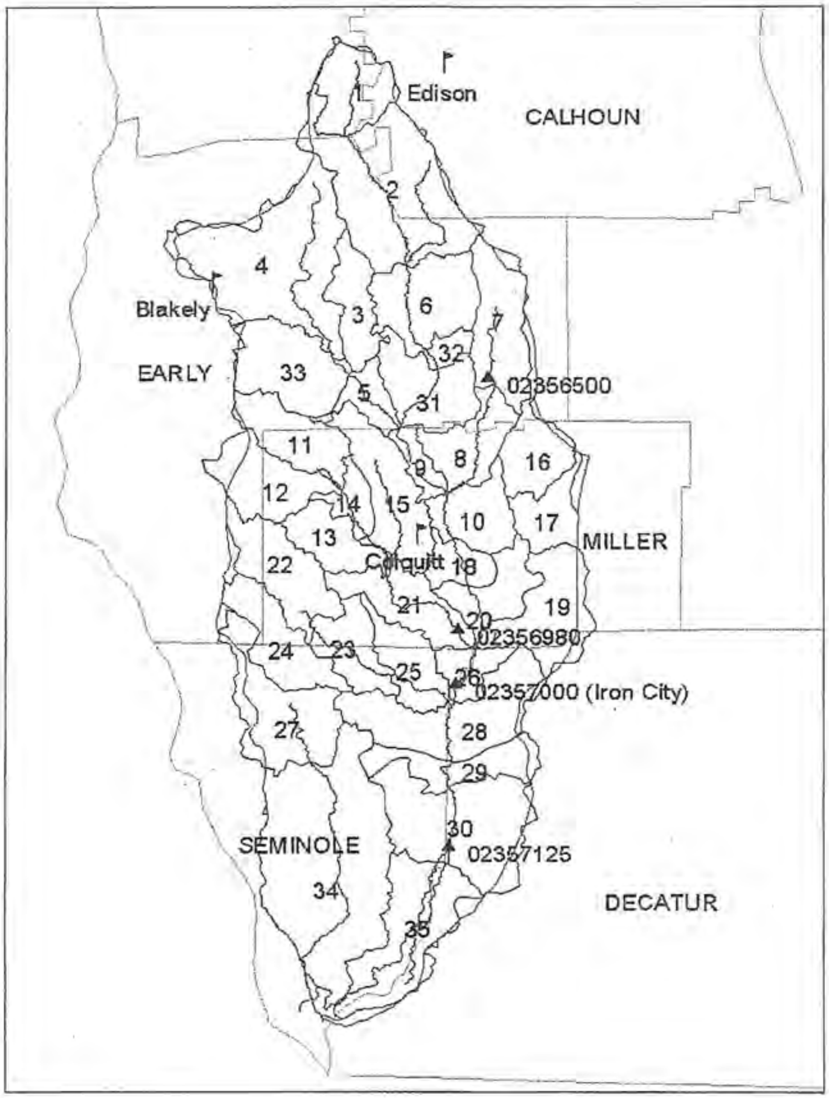

Figure I.2 – 11: Map of Spring Creek sub-basin showing gauge stations, meteorologic stations and sub-basin delineation.

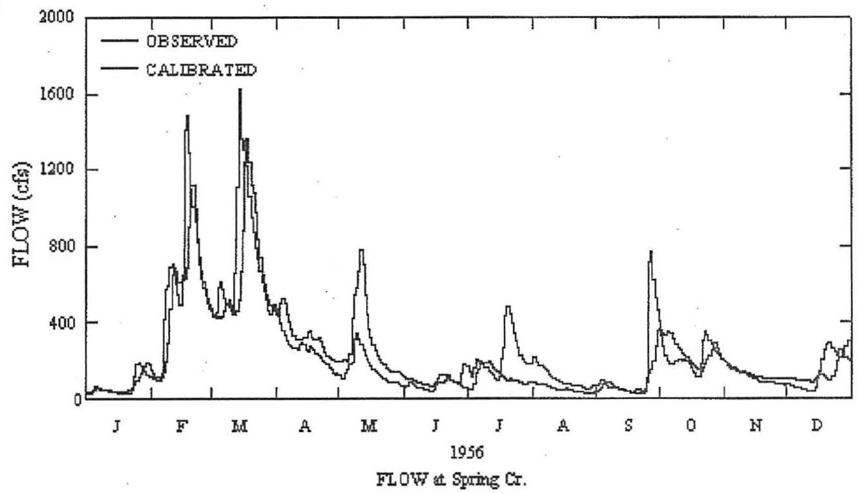

Figure I.2 – 12: Observed vs. calibrated streamflow of Spring Creek near Iron City for 1956 (Dry Year)

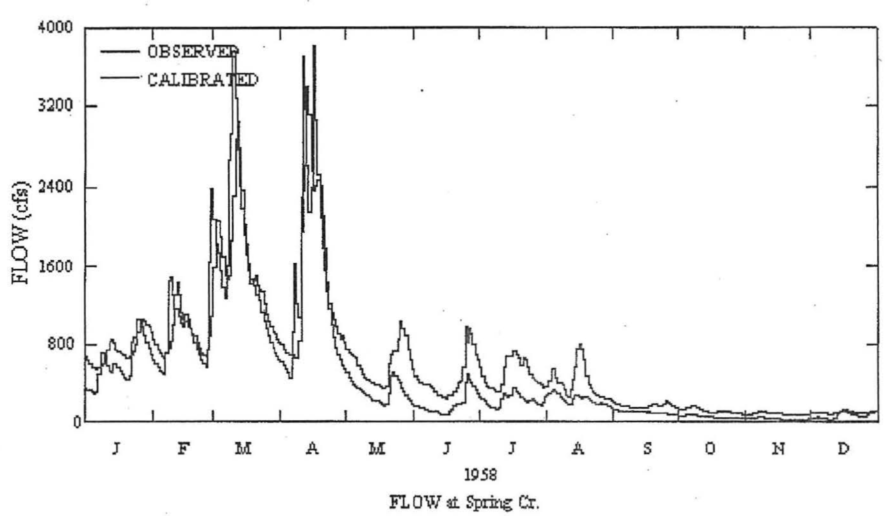

Figure I.2 – 13: Observed vs. calibrated streamflow of Spring Creek near Iron City for 1958 (Normal Year)

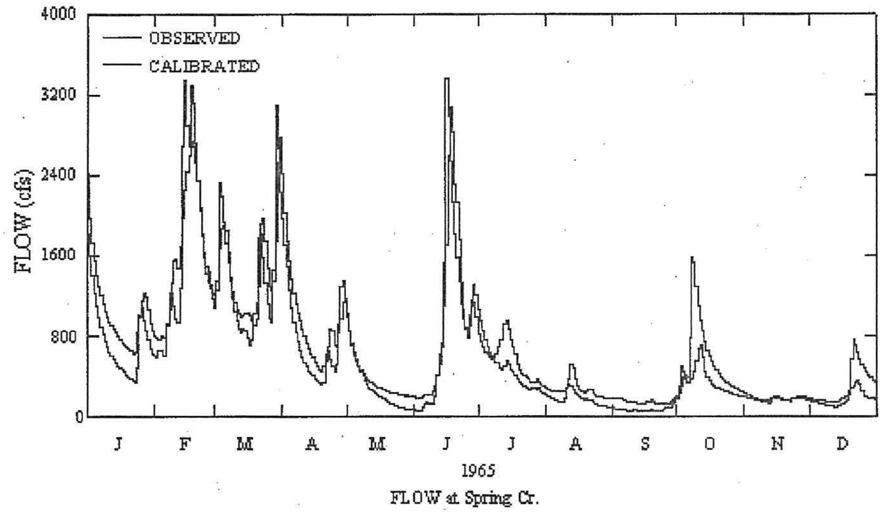

Figure I.2 – 14: Observed vs. calibrated streamflow of Spring Creek near Iron City for 1965 (Wet Year)

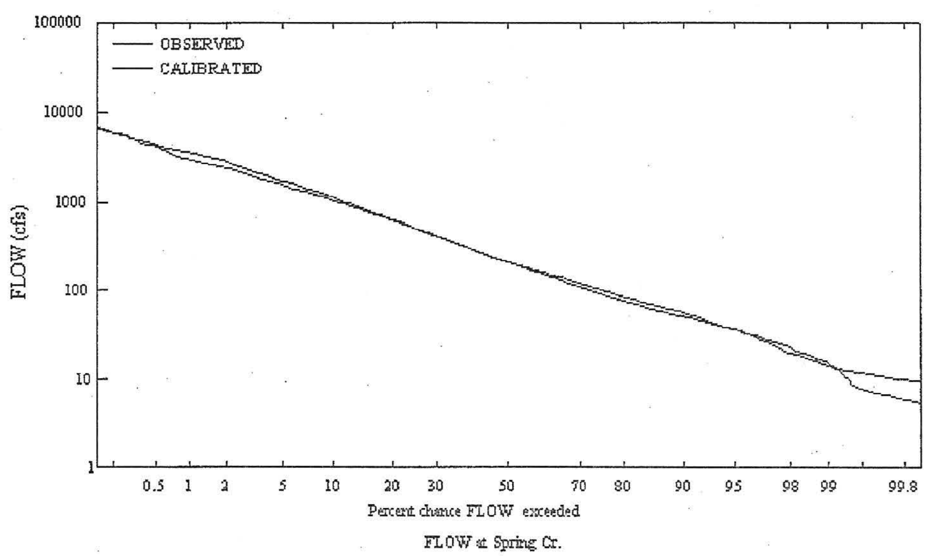

Figure I.2 – 15: Duration curve for calibrated vs. observed flow for Spring Creek near Iron City

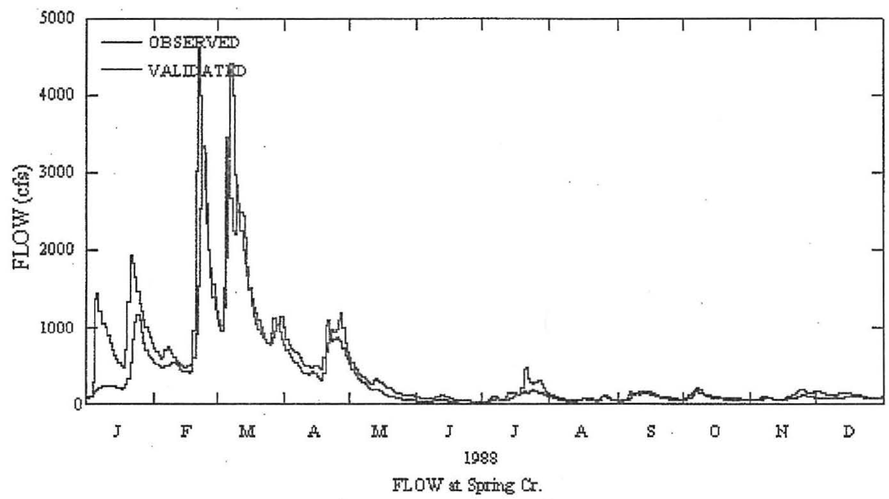

Figure I.2 – 16: Observed vs. calibrated streamflow of Spring Creek near Iron City for 1988 (Dry Year)

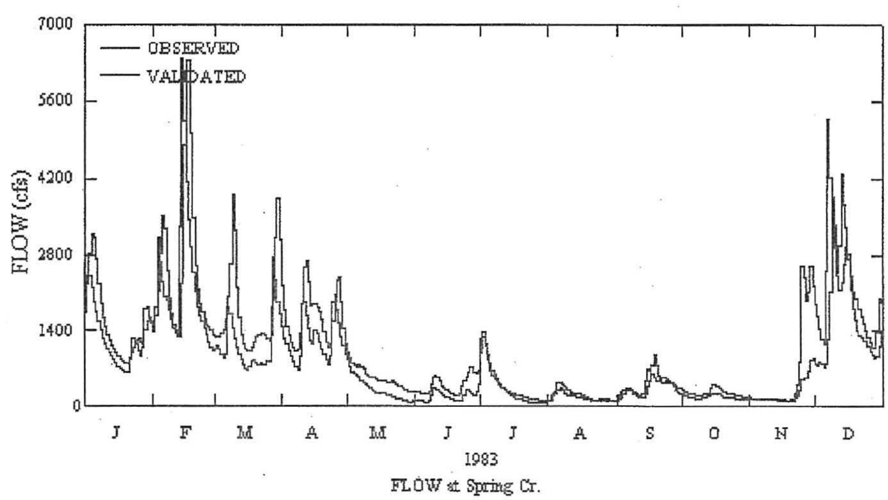

Figure I.2 – 17: Observed vs. calibrated streamflow of Spring Creek near Iron City for 1983 (Normal Year)

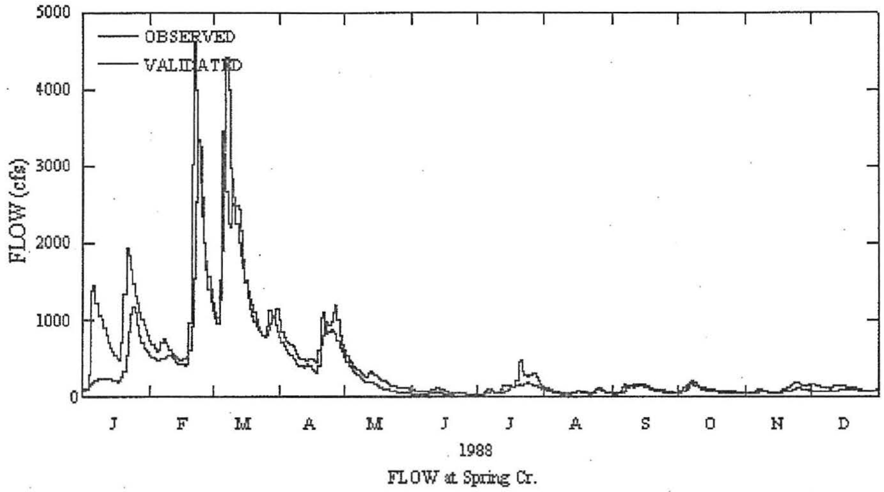

Figure I.2 – 18: Observed vs. calibrated streamflow of Spring Creek near Iron City for 1989 (Wet Year)

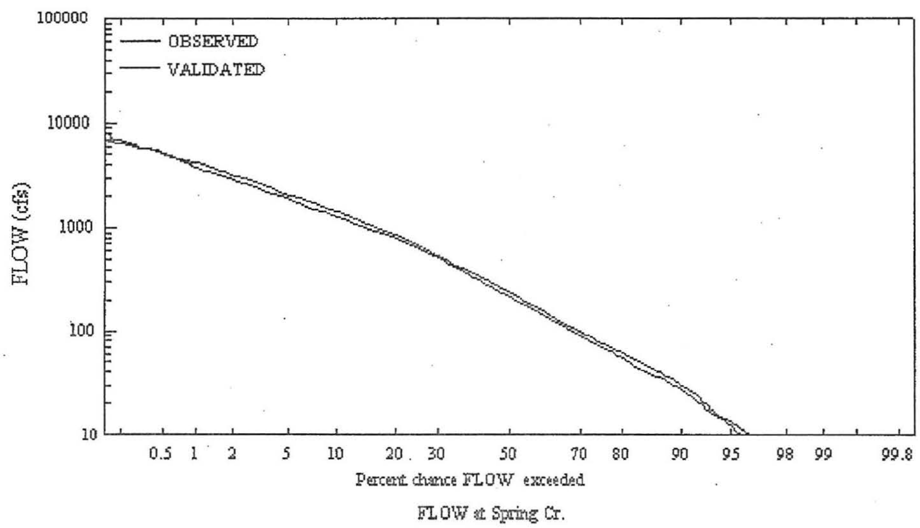

Figure I.2 – 19: Duration Curve of Validated vs. Observed flow at Spring Creek near Iron City

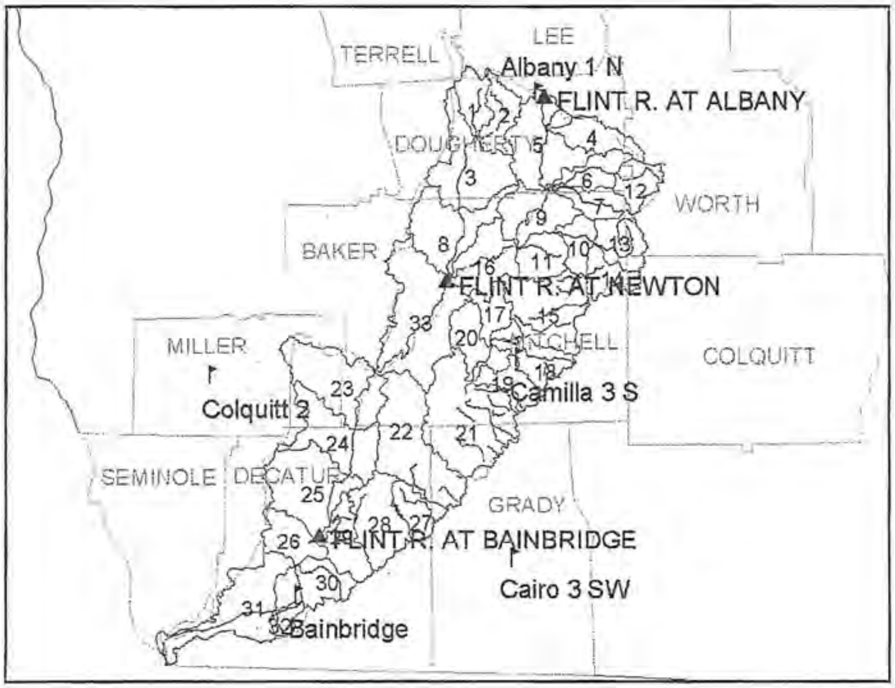

Figure I.2 – 20: Lower Flint River Sub-Basin with Gauging Stations, Met Stations, and sub-basin delineations

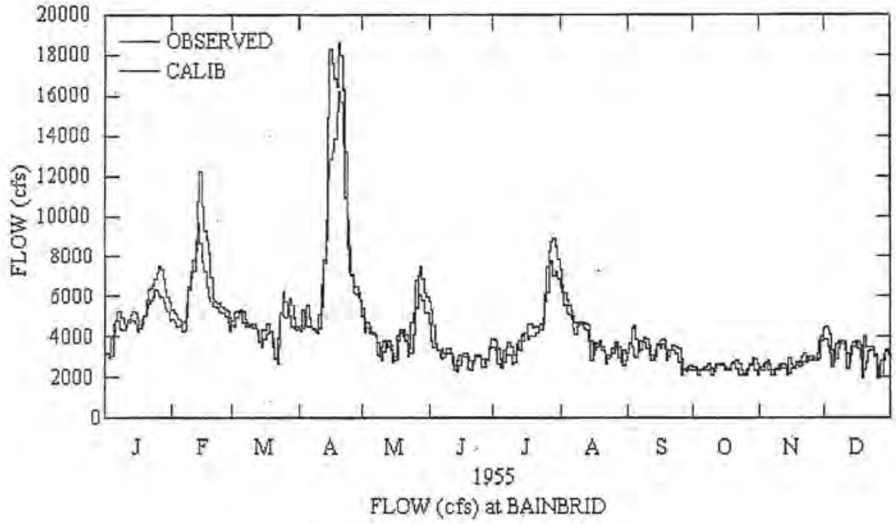

Figure I.2 – 21: Observed vs. calibrated streamflow of the Flint River at Bainbridge for 1955 (Dry Year)

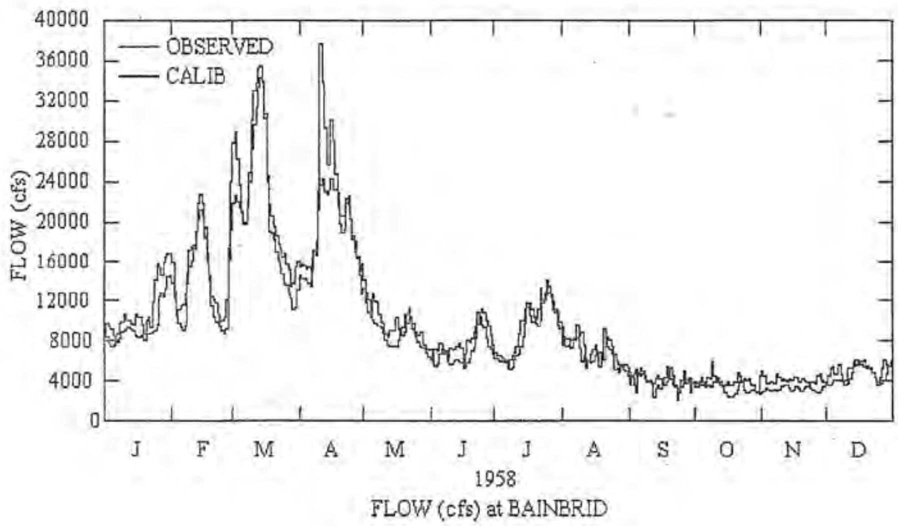

Figure I.2 – 22: Observed vs. calibrated streamflow of the Flint River at Bainbridge for 1958 (Normal Year)

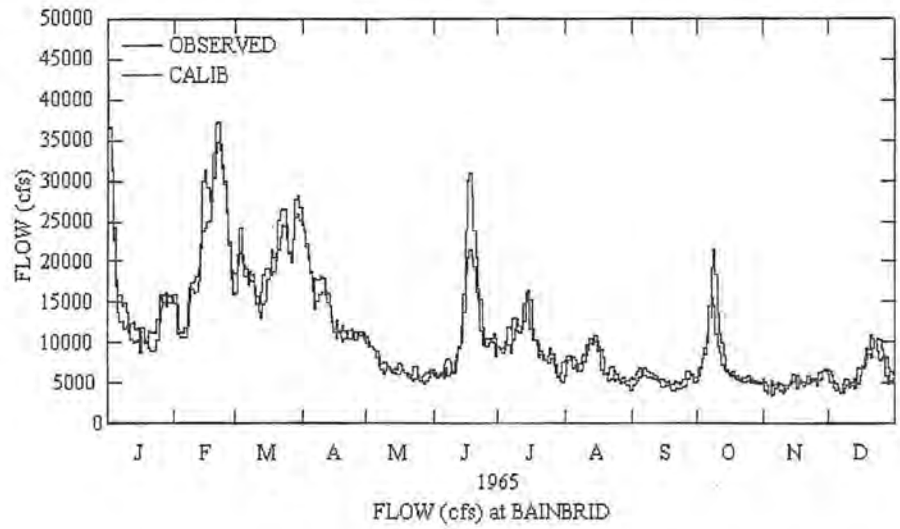

Figure I.2 – 23: Observed vs. calibrated streamflow of the Flint River at Bainbridge for 1965 (Wet Year)

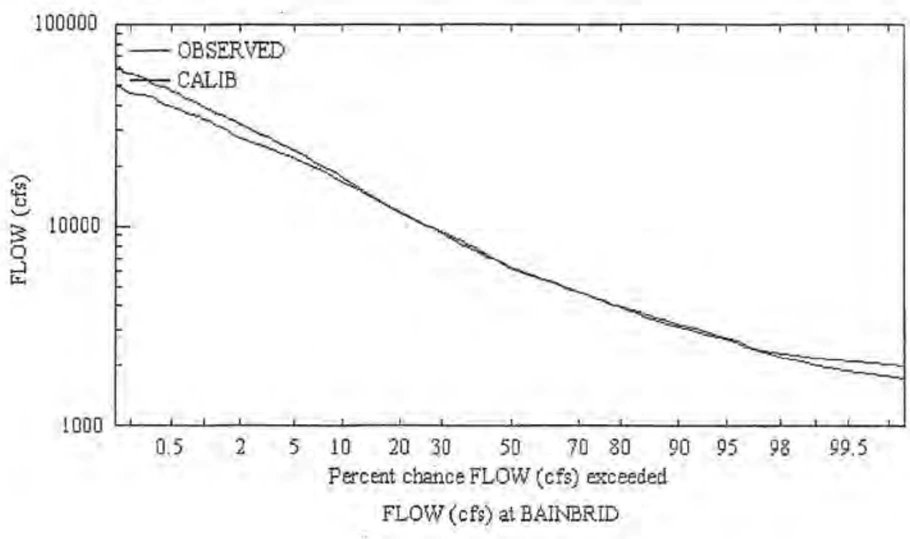

Figure I.2 –24: Duration Curve of Calibrated vs. Observed Flow of Flint River at Bainbridge (for period 1953 to 1971)

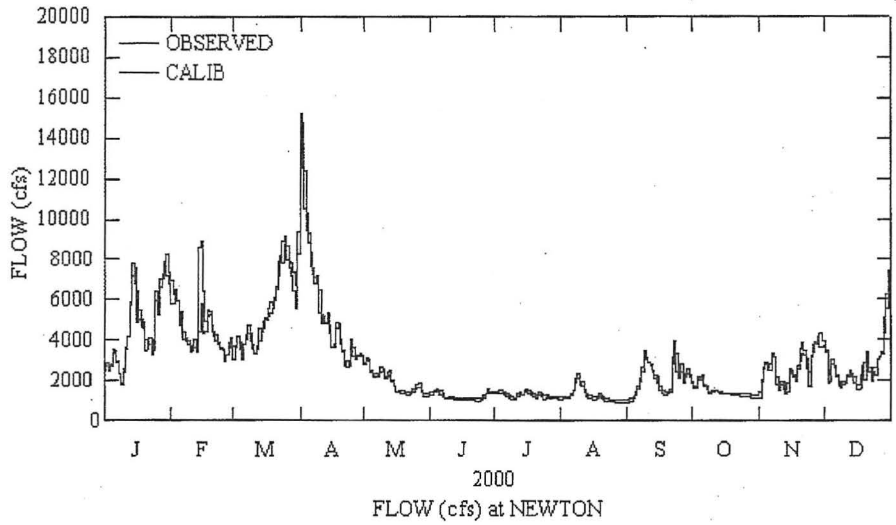

Figure I.2 – 25: Observed vs. calibrated streamflow of the Flint River at Newton for 2000 (Dry Year)

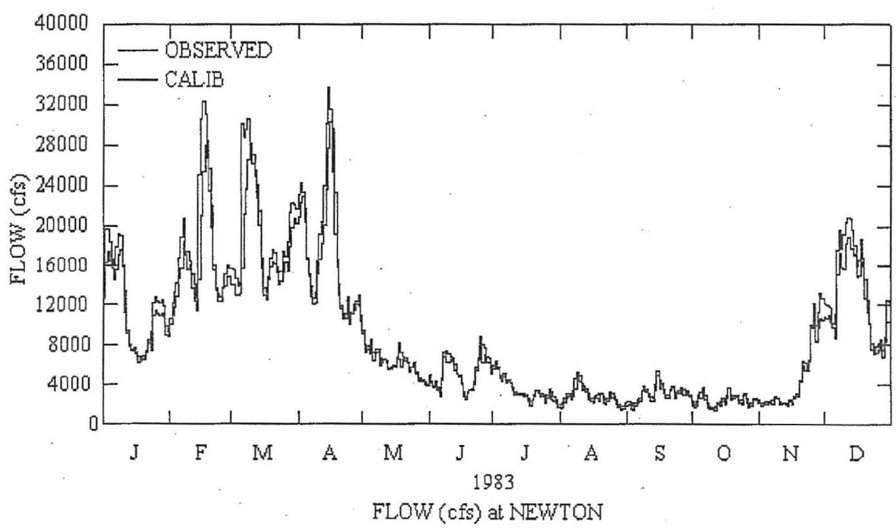

Figure I.2 – 26: Observed vs. calibrated streamflow of the Flint River at Newton for 1983 (Normal Year)

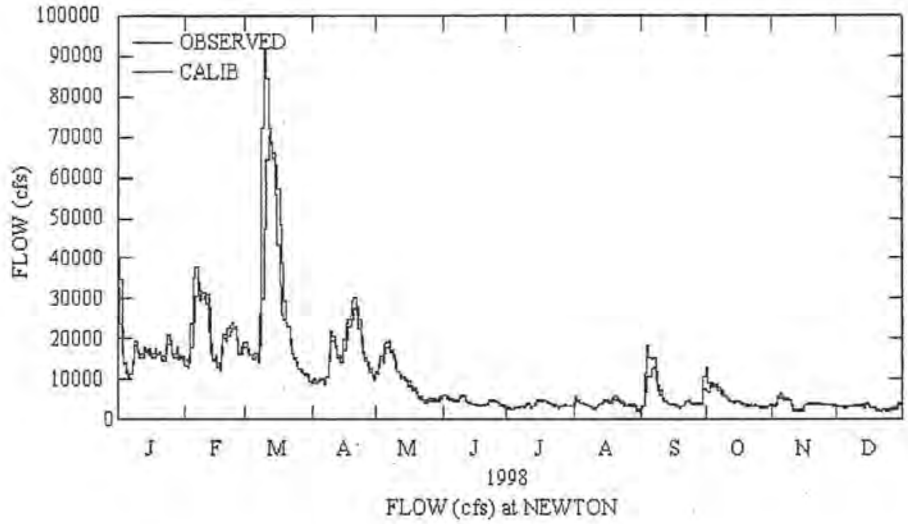

Figure I.2 – 27: Observed vs. calibrated streamflow of the Flint River at Newton for 1998 (Wet Year)

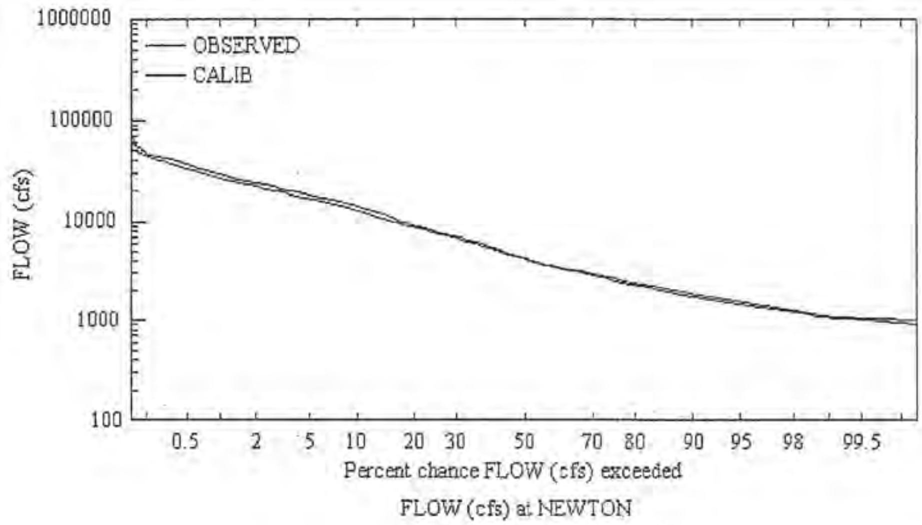

Figure I.2 – 28: Duration Curve for Calibrated vs. Observed Flow of Flint River at Newton (period 1976 to 2003)

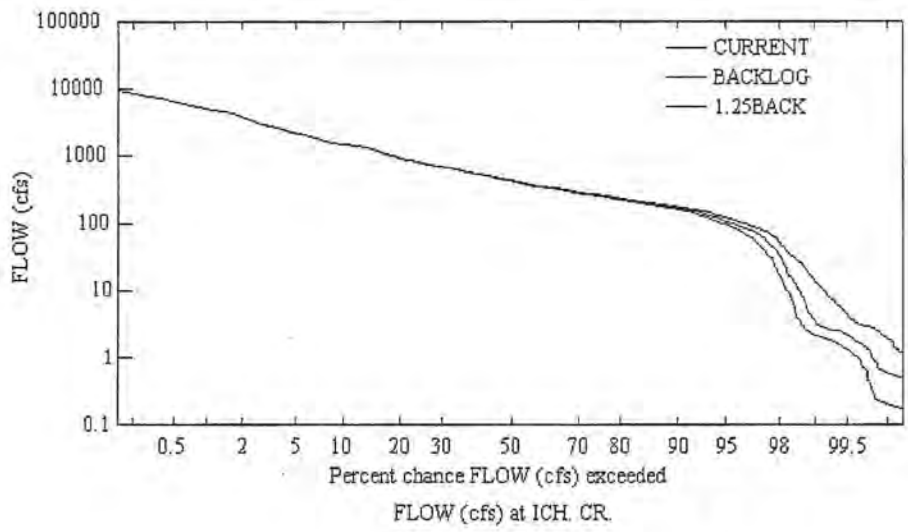

Figure I.3 – 1: Duration Curves of Scenarios Current, Backlog, and 1.25Xbacklog of Ichawaynochaway Creek near Milford

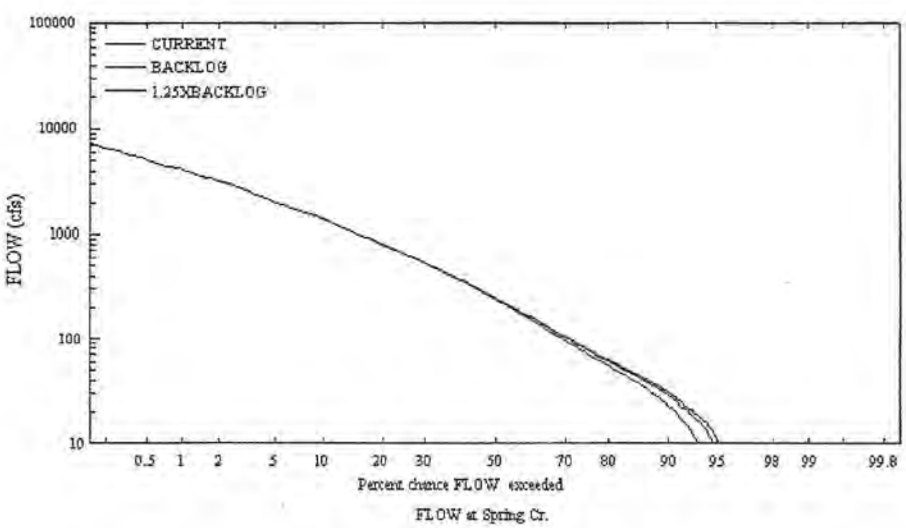

Figure I.3 – 2: Duration curves of Scenarios Current, Backlog, and 1.25Xbacklog at Spring Creek near Iron City

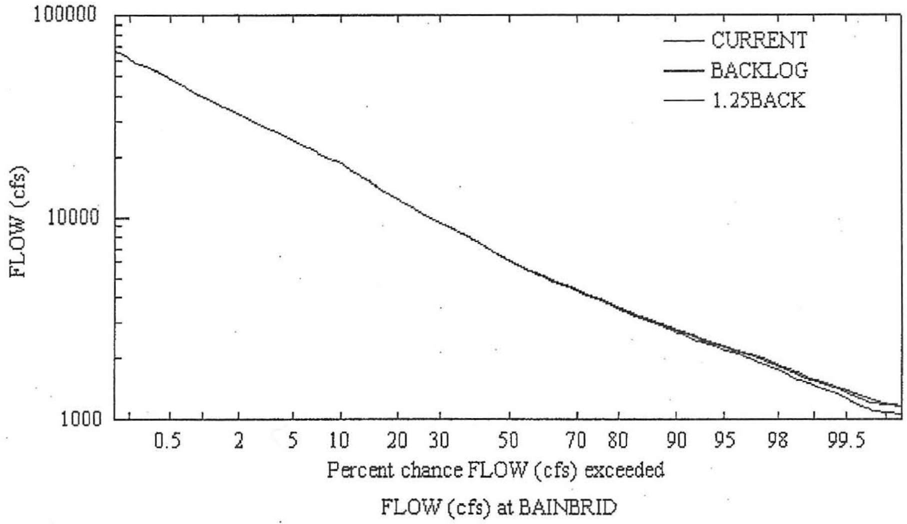

Figure I.3 – 3: Duration Curves of Scenarios Current, Backlog, and 1.25Xbacklog of Flint River at Bainbridge

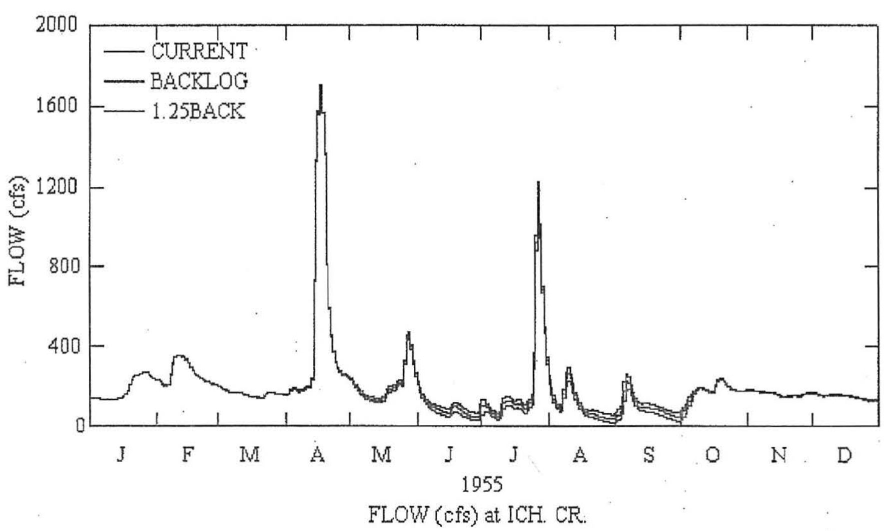

Figure I.3 – 4: Simulated streamflow of Ichawaynochaway Creek near Milford for 1955 (Dry Year)

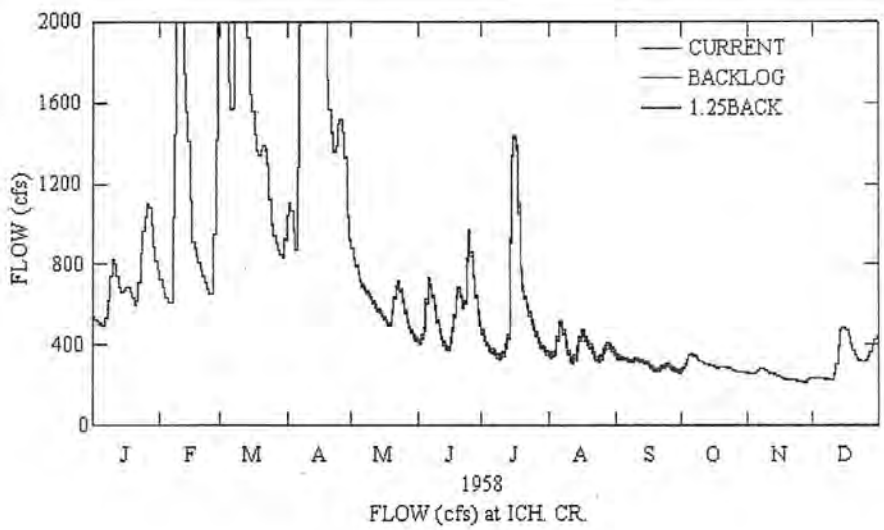

Figure I.3 – 5: Simulated streamflow of the Flint River at Bainbridge for 1958 (Normal Year)

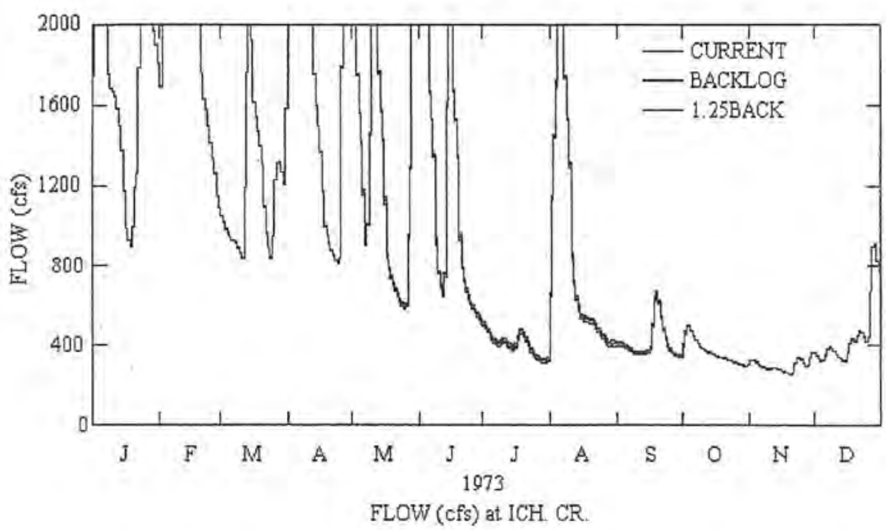

Figure I.3 – 6: Simulated streamflow of Ichawaynochaway Creek near Milford for 1973 (Wet Year)

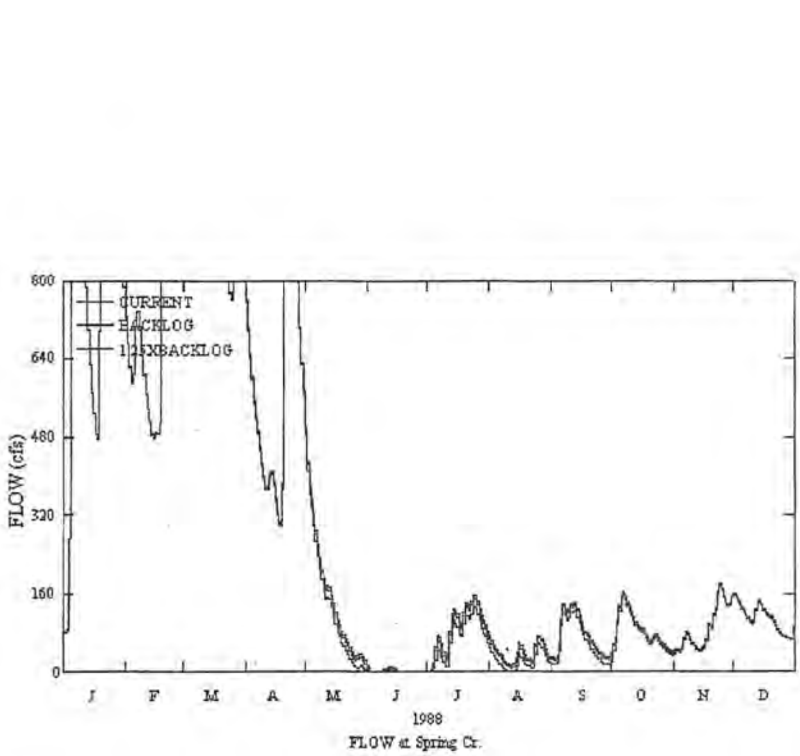

Figure I.3 – 7: Simulated streamflow of Spring Creek near Iron City for 1988 (Dry Year)

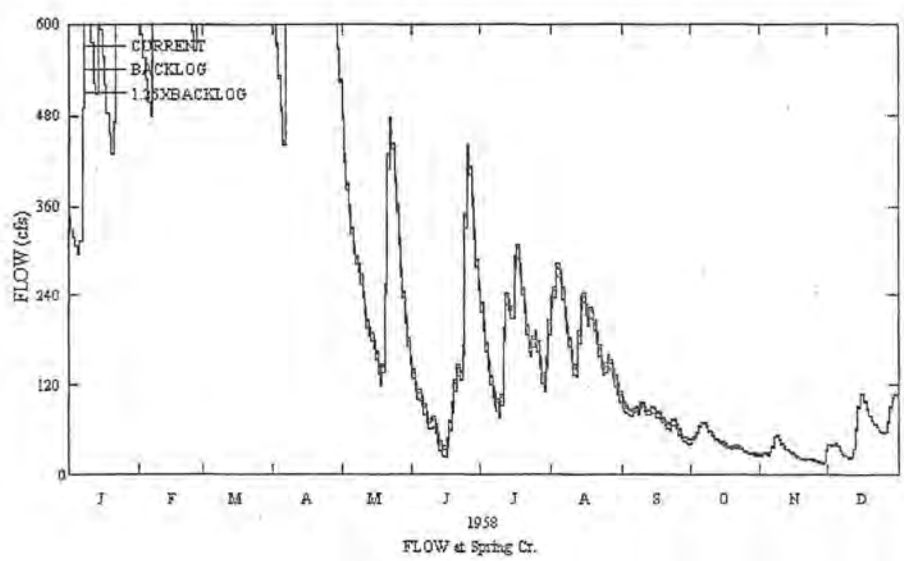

Figure I.3–8: Simulated streamflow of Spring Creek near Iron City for 1958 (Dry Year)

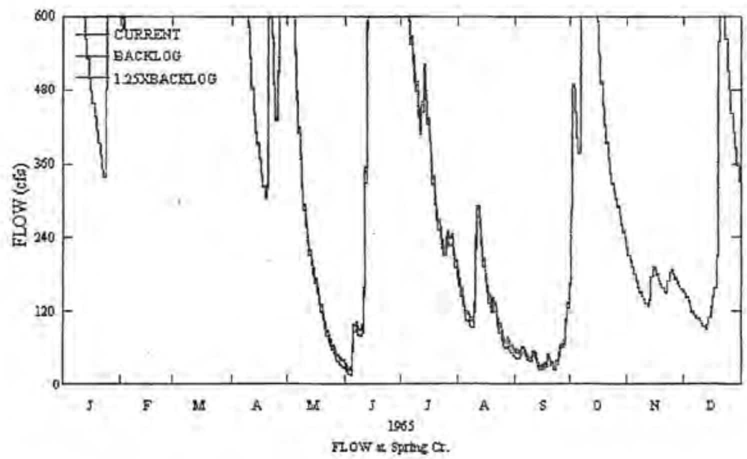

Figure I.3 – 9: Simulated streamflow of Spring Creek near Iron City for 1965 (Wet Year)

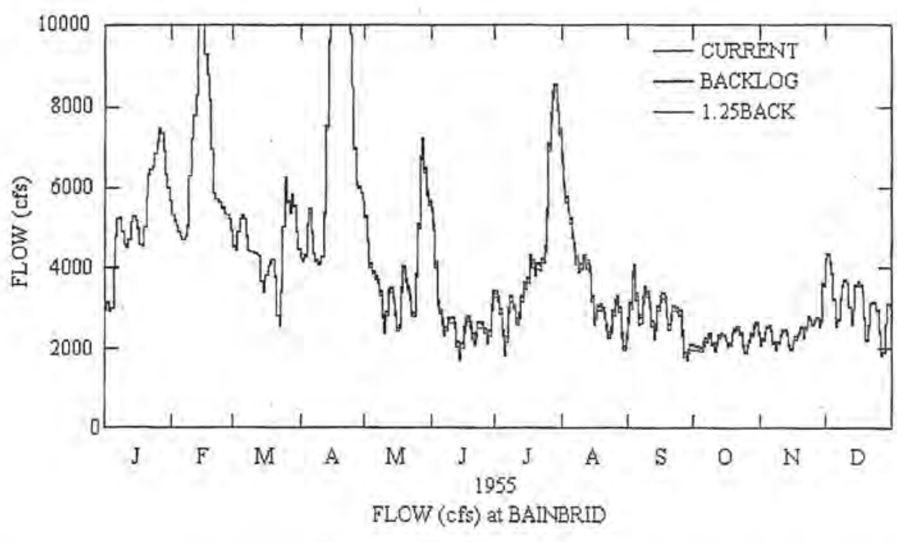

Figure I.3 – 10: Simulated streamflow of the Flint River at Bainbridge for 1955 (Dry Year)

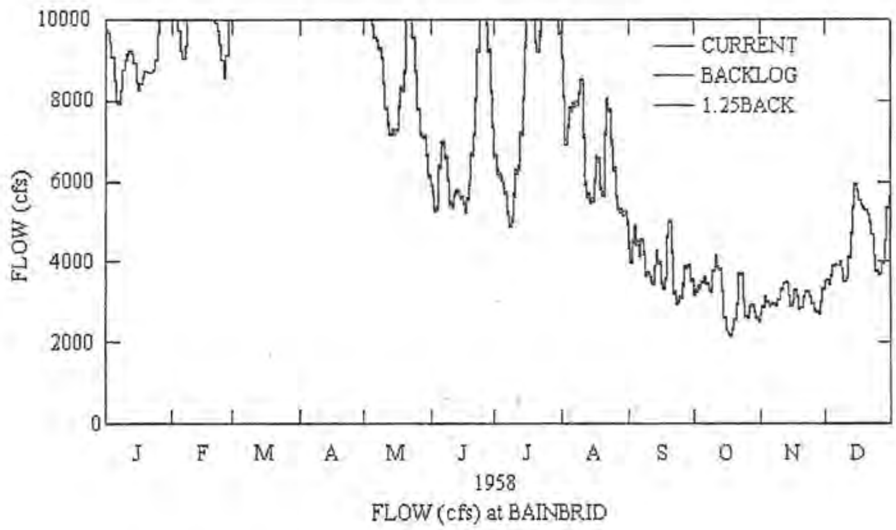

Figure I.3 – 11: Simulated streamflow of the Flint River at Bainbridge for 1958 (Normal Year)

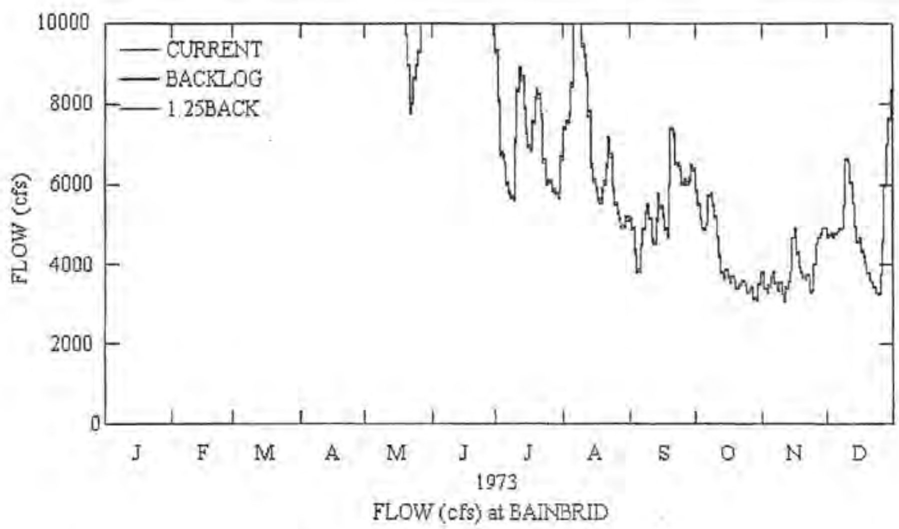

Figure I.3 – 12: Simulated streamflow of the Flint River at Bainbridge for 1973 (Wet Year)

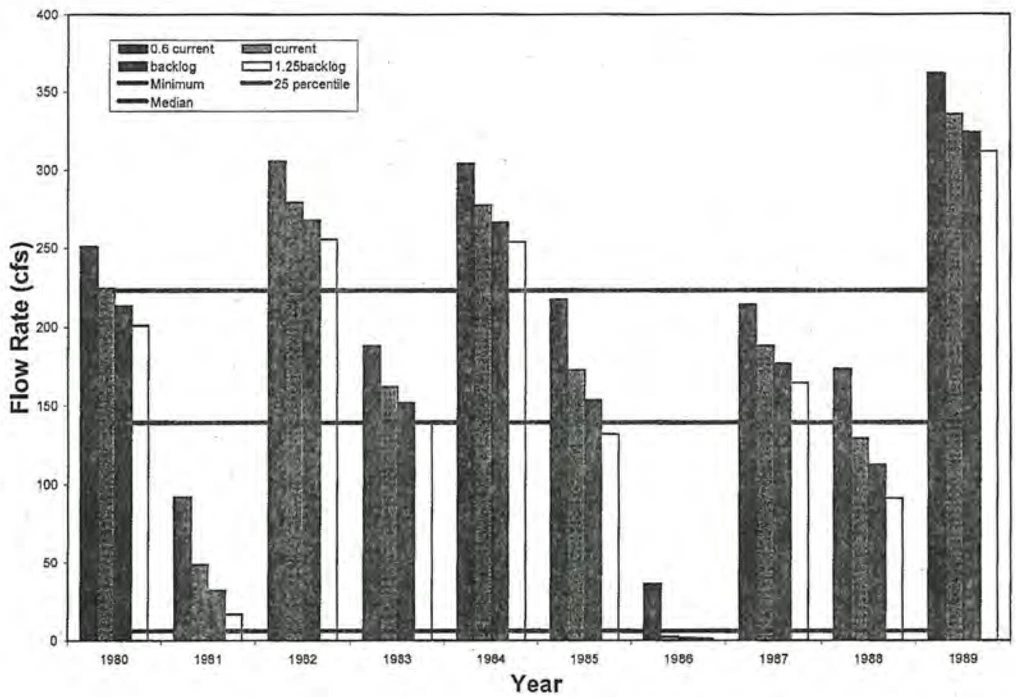

Figure I.4 – 1: Evaluation of Scenarios Using U1 Criteria Ichawaynochaway Creek near Milford (month of August)

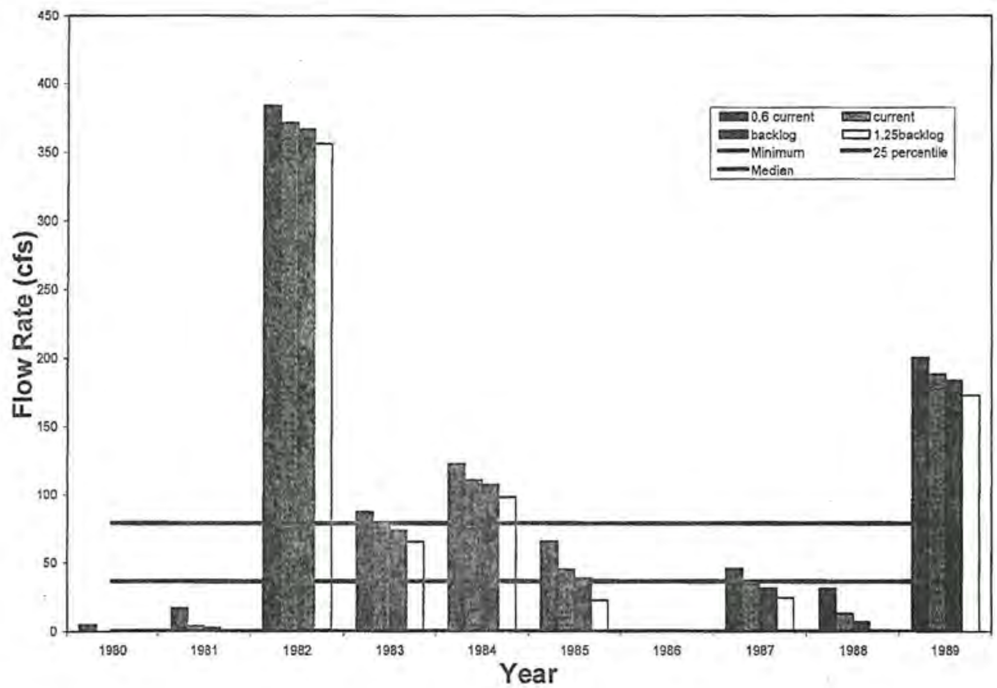

Figure I.4 – 2: Evaluation of Scenarios Using U1 Criteria Spring Creek at Iron City (month of August)

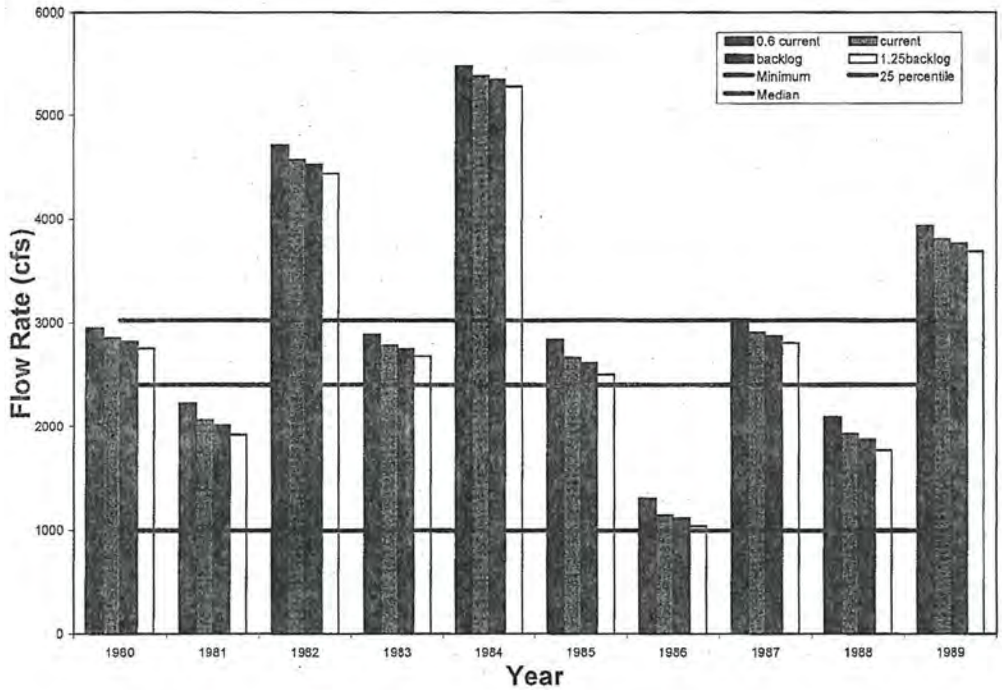

Figure I.4 – 3: Evaluation of Scenarios Using U1 Criteria Flint River at Bainbridge (month of August)

Table I.4 – 1: Computed guideline for U1 and U2 for full period of record
(a) Guideline for U1 and U2 for Ichawaynochaway Ck. at Milford for full period of record

Ichawaynochaway Creek at Milford U1-Daily minimum flows derived from full period of record 10/1939-9/2003 plus part of 1905, all 1906 and 1907			
Month	lowest daily minimum	25 percentile of daily minima	median of daily minima
Jan	193	381	482
Feb	224	451	576
Mar	220	478	603
Apr	175	342	473
May	43	228	308
Jun	12	162	228
Jul	21	153	227
Aug	6	139	223
Sep	10	148	197
Oct	98	179	235
Nov	115	222	274
Dec	200	289	365

Annual Low Flow Duration (U2) Statistics			
25% Annual Average Discharge	171cfs		
	Maximum	1 in 4 yrs	1 in 2 yrs
Criteria: Annual Low Flow Duration (days)	168	28	0

(b) Guideline for U1 and U2 for Spring Ck. near Iron City for full period of record

Spring Creek at Iron City U1-Criteria derived from full period of record 7/1937-9/2003			
	U1-A	U1-B	U1-C
monrhly Statistics	minimum	25percentile	median
Jan	12.6	108.0	226.8
Feb	31.5	204.3	387.9
Mar	47.7	256.5	459.0
Apr	51.3	197.1	299.7
May	3.5	87.8	122.4
Jun	0.8	48.2	90.0
Jul	0.2	45.9	92.7
Aug	0.0	36.7	79.2
Sep	0.0	32.4	59.0
Oct	0.3	28.8	63.9
Nov	0.6	34.2	65.7
Dec	10.8	49.5	97.2

Annual Low flow Duration (U2) Statistics			
25% Average Annual Discharge	110 cfs		
	Maximum	1 in 4 yrs	1 in 2 yrs
Criteria: Annual Low Flow Duration (Days)	272	174.25	111

(c) Guideline for U1 and U2 for lower Flint River at Bainbridge for full period of record

Lower Flint at Bainbridge U1-Daily minimum flows derived from whole period of HSPF calibrated model,1953-2003			
Month	lowest daily minimum	25 percentile of daily minima	median of daily minima
Jan	1888	3757	5430
Feb	2368	4672	7164
Mar	2349	5848	7449
Apr	3077	4448	6165
May	1463	3107	4248
Jun	1151	2377	3363
Jul	1165	2516	3400
Aug	988	2398	3022
Sep	1003	2062	2549
Oct	1358	2035	2542
Nov	1442	2055	2832
Dec	1784	2585	3374

Annual Low Flow Duration (U2) Statistics			
25% Annual Average Discharge	1998 cfs		
	Maximum	1 in 4 yrs	1 in 2 yrs
Criteria: Annual Low Flow Duration (days)	140	8	0

Table I.4 – 2: U1 guideline effects for Ichawaynochaway Creek at Milford: Monthly 1-day Minima Criteria – Variances Criteria are from full period of record

Lowest monthly 1-day minimum flow (U1-A)						
(Number. of years that flow was below the monthly criteria - should not exceed zero)						
	Apr	May	Jun	Jul	Aug	Sep
Criteria (cfs)	175	43	12	21	6	10
Observed 1939-1975	0	0	0	0	0	0
Observed 1953-2003	0	0	0	0	0	0
No irr 1953-2003	**1**	0	0	0	0	0
Calibrated 1953-2003	**1**	0	0	0	**1**	**2**
0.6 x Current irrigation	**1**	0	0	0	0	0
0.7 x Current irrigation	**1**	0	0	0	0	**1**
0.8 x Current irrigation	**1**	0	0	0	**1**	**2**
Current irr. over 50 yrs	**1**	0	0	**2**	**3**	**4**
Backlog	**1**	0	**1**	**2**	**3**	**5**
1.25 x Backlog	**1**	0	**1**	**3**	**4**	**5**

25 percentile of monthly 1-day minimum flows (U1-B)						
(Percent of years with that flow was below monthly criteria - should not exceed 25%)						
	Apr	May	Jun	Jul	Aug	Sep
Criteria (cfs)	342	228	162	153	139	148
Observed 1939-1975	23.1%	15.4%	15.4%	7.7%	3.8%	15.4%
Observed 1953-2003	21.6%	23.5%	**25.5%**	23.5%	**25.5%**	24.0%
No irr 1953-2003	19.6%	11.8%	7.8%	9.8%	7.8%	12.0%
Calibrated 1953-2003	19.6%	15.7%	13.7%	11.8%	11.8%	16.0%
0.6 x Current irrigation	19.6%	15.7%	19.6%	13.7%	15.7%	22.0%
0.7 x Current irrigation	19.6%	15.7%	19.6%	13.7%	17.6%	22.0%
0.8 x Current irrigation	19.6%	15.7%	19.6%	15.7%	17.6%	**26.0%**
Current irr. over 50 yrs	19.6%	19.6%	19.6%	15.7%	**27.5%**	**28.0%**
Backlog	21.6%	21.6%	19.6%	23.5%	**27.5%**	**32.0%**
1.25 x Backlog	21.6%	23.5%	**25.5%**	**29.4%**	**35.3%**	**32.0%**

Median of monthly 1-day minimum flows (U1-C)						
(Percent of years that flow was below the monthly criteria - should not exceed 50%)						
	Apr	May	Jun	Jul	Aug	Sep
Criteria (cfs)	473	308	228	227	223	197
Observed 1939-1975	46.2%	38.5%	34.6%	38.5%	34.6%	38.5%
Observed 1953-2003	39.2%	**51.0%**	43.1%	49.0%	**52.9%**	50.0%
No irr 1953-2003	37.3%	27.5%	23.5%	23.5%	29.4%	22.0%
Calibrated 1953-2003	39.2%	33.3%	29.4%	31.4%	37.3%	38.0%
0.6 x Current irrigation	39.2%	33.3%	31.4%	31.4%	43.1%	36.0%
0.7 x Current irrigation	39.2%	37.3%	33.3%	31.4%	45.1%	42.0%
0.8 x Current irrigation	39.2%	41.2%	33.3%	35.3%	45.1%	50.0%
Current irr. over 50 yrs	45.1%	45.1%	37.3%	43.1%	**52.9%**	**56.0%**
Backlog	45.1%	49.0%	43.1%	49.0%	**60.8%**	**58.0%**
1.25 x Backlog	45.1%	**51.0%**	43.1%	**51.0%**	**64.7%**	**60.0%**

Table I.4 – 3: U2 guideline effects for Ichawaynochaway Creek at Milford: Annual Low Flow Duration Variances Criteria are from full period of record

Annual Low Flow Duration (U2) Statistics			
25% Annual Average Discharge	171 cfs		
	Maximum	1 in 4 yrs	1 in 2 yrs
Criteria: Annual Low Flow Duration (days)	168	28	0
Allowable years of variance	0	<25%	<50%
Observed 1939-1975	0	8.0%	18.0%
Observed 1953-2002	0	**28.0%**	48.0%
No irr 1953-2002	**1**	14.0%	28.0%
Calibrated 1953-2003	**2**	22.0%	34.0%
0.6 x Current irrigation	**5**	22.0%	34.0%
0.7 x Current irrigation	**5**	24.0%	34.0%
0.8 x Current irrigation	**6**	**28.0%**	34.0%
Current irr. over 50 yrs	**6**	**28.0%**	42.0%
Backlog	**6**	**32.0%**	48.0%
1.25 x Backlog	**6**	**36.0%**	50.0%

Table I.4 – 4: U1 guideline effects for Spring Creek near Iron City: Monthly 1-day Minima Criteria – Variances Criteria are from full period of record

Lowest monthly 1-day Minimum flow (U1-A) (Number of years that flow was below the monthly criteria - should not exceed zero)	Apr	May	Jun	Jul	Aug	Sep
Criteria (cfs)	51.30	3.51	0.81	0.16	0.00	0.00
Observed 1937-1971	0	0	0	0	0	0
Observed 1953-2003	0	0	0	0	0	0
No irr 1953-2002	**2**	0	0	0	0	0
Calibrated 1953-2003	**3**	**3**	**4**	**5**	0	0
0.6 x Current irrigation	**4**	**3**	**8**	**7**	0	0
0.7 x Current irrigation	**6**	**4**	**9**	**7**	0	0
0.8 x Current irrigation	**6**	**4**	**11**	**8**	0	0
Current irr. over 50 yrs	**7**	**5**	**14**	**11**	0	0
Current irr. over 50 yrs(updated)	**7**	**4**	**14**	**8**	0	0
Backlog	**7**	**7**	**16**	**11**	0	0
1.25 x Backlog	**7**	**11**	**17**	**12**	0	0

25 percentile of monthly 1-day minimum flows (U1-B) (Percent of years that flow was below monthly criteria - should not exceed 25%)	Apr	May	Jun	Jul	Aug	Sep
Criteria (cfs)	197.1	87.8	48.2	45.9	36.7	32.4
Observed 1937-1971	11.8%	6.1%	2.9%	5.9%	11.8%	11.8%
Observed 1953-2003	**26.2%**	**26.8%**	**29.3%**	**31.0%**	**33.3%**	**29.3%**
No irr 1953-2002	**33.3%**	**45.1%**	**29.4%**	**25.5%**	13.7%	16.0%
Calibrated 1953-2003	**33.3%**	**51.0%**	**33.3%**	**35.3%**	**27.5%**	18.0%
0.6 x Current irrigation	**33.3%**	**56.9%**	**47.1%**	**41.2%**	**31.4%**	22.0%
0.7 x Current irrigation	**33.3%**	**56.9%**	**49.0%**	**43.1%**	**31.4%**	22.0%
0.8 x Current irrigation	**33.3%**	**58.8%**	**51.0%**	**43.1%**	**33.3%**	**30.0%**
Current irr. over 50 yrs	**33.3%**	**60.8%**	**52.9%**	**47.1%**	**39.2%**	**38.0%**
Current irr. over 50 yrs(updated)	**33.3%**	**58.8%**	**52.9%**	**45.1%**	**37.3%**	**36.0%**
Backlog	**33.3%**	**60.8%**	**56.9%**	**49.0%**	**41.2%**	**38.0%**
1.25 x Backlog	**33.3%**	**60.8%**	**58.8%**	**54.9%**	**47.1%**	**44.0%**

Median of monthly 1-day minimum flows (U1-C) (Percent of years that flow was below the monthly criteria - should not exceed 50%)						
	Apr	May	Jun	Jul	Aug	Sep
Criteria (cfs)	299.7	122.4	90	92.7	79.2	58.95
Observed 1937-1971	26.5%	15.2%	20.6%	23.5%	20.6%	23.5%
Observed 1953-2003	50.0%	**56.1%**	**53.7%**	**57.1%**	**52.4%**	**56.1%**
No irr 1953-2002	**52.9%**	**58.8%**	**56.9%**	**52.9%**	45.1%	38.0%
Calibrated 1953-2003	**52.9%**	**64.7%**	**60.8%**	**58.8%**	**51.0%**	50.0%
0.6 x Current irrigation	**52.9%**	**62.7%**	**70.6%**	**58.8%**	**54.9%**	**58.0%**
0.7 x Current irrigation	**52.9%**	**62.7%**	**70.6%**	**58.8%**	**54.9%**	**58.0%**
0.8 x Current irrigation	**52.9%**	**64.7%**	**72.5%**	**60.8%**	**56.9%**	**58.0%**
Current irr. over 50 yrs	**52.9%**	**66.7%**	**74.5%**	**64.7%**	**58.8%**	**62.0%**
Current irr. over 50 yrs(updated)	**52.9%**	**64.7%**	**72.5%**	**62.7%**	**58.8%**	**62.0%**
Backlog	**52.9%**	**68.6%**	**74.5%**	**64.7%**	**60.8%**	**62.0%**
1.25 x Backlog	**54.9%**	**74.5%**	**74.5%**	**70.6%**	**62.7%**	**70.0%**

Table I.4 – 5: U2 guideline effects for Spring Creek near Iron City: Annual Low Flow Duration Variances Criteria are from full period of record

Annual Low flow Duration (U2) Statistics 25% Average Annual Discharge 110cfs			
	Maximum	1 in 4 yrs	1 in 2 yrs
Criteria: Annual Low Flow Duration (Days)	272	174.25	111
Allowable years of Variance	0	<25%	<50%
Observed 1937-1970	0	12.1%	27.3%
Observed 1953-2002	0	**30.0%**	**52.5%**
No irr 1953-2002	0	12.0%	46.0%
Calibrated 1953-2002	0	16.0%	**52.0%**
0.6 x Current irrigation	0	18.0%	**52.0%**
0.7 x Current irrigation	0	20.0%	**54.0%**
0.8 x Current irrigation	0	22.0%	**54.0%**
Current irr over 50 yrs	0	**26.0%**	**56.0%**
Current irr over 50 yrs (updated)	0	**26.0%**	**56.0%**
Backlog	0	**28.0%**	**56.0%**
1.25 x Backlog	0	**30.0%**	**56.0%**

Table I.4 – 6: U1 guideline effects for Flint River at Bainbridge: Monthly 1-day Minima Criteria – Variances Criteria are from full period of HSPF calibrated model (1953-2003)

Lowest monthly 1-day minimum flow (U1-A)						
(Number. of years that flow was below the monthly criteria - should not exceed zero)						
	Apr	May	Jun	Jul	Aug	Sep
Criteria (cfs)	3077	1463	1151	1165	988	1003
No irr 1953-2003	0	0	0	0	0	0
Calibrated 1953-2003	0	0	0	0	0	0
0.6 x Current irrigation	0	0	0	0	0	0
0.7 x Current irrigation	0	0	0	0	0	0
0.8 x Current irrigation	0	0	0	0	0	0
Current irr. over 50 yrs	0	0	**1**	**1**	0	0
Backlog	0	0	**1**	**2**	0	**1**
1.25 x Backlog	0	0	**1**	**2**	**1**	**1**

25 percentile of monthly 1-day minimum flows (U1-B)						
(Percent of years with that flow was below monthly criteria - should not exceed 25%)						
	Apr	May	Jun	Jul	Aug	Sep
Criteria (cfs)	4448	3107	2377	2516	2398	2062
No irr 1953-2003	17.6%	17.6%	9.8%	17.6%	13.7%	10.0%
Calibrated 1953-2003	17.6%	17.6%	13.7%	19.6%	17.6%	18.0%
0.6 x Current irrigation	17.6%	17.6%	19.6%	21.6%	21.6%	20.0%
0.7 x Current irrigation	17.6%	17.6%	19.6%	21.6%	21.6%	22.0%
0.8 x Current irrigation	17.6%	17.6%	21.6%	21.6%	21.6%	22.0%
Current irr. over 50 yrs	17.6%	17.6%	23.5%	23.5%	25.5%	22.0%
Backlog	17.6%	17.6%	23.5%	23.5%	25.5%	24.0%
1.25 x Backlog	17.6%	23.5%	**25.5%**	**29.4%**	**29.4%**	**30.0%**

Median of monthly 1-day minimum flows (U1-C)						
(Percent of years that flow was below the monthly criteria - should not exceed 50%)						
	Apr	May	Jun	Jul	Aug	Sep
Criteria (cfs)	6165	4248	3363	3400	3022	2549
No irr 1953-2003	45.1%	45.1%	37.3%	33.3%	33.3%	30.0%
Calibrated 1953-2003	45.1%	47.1%	39.2%	35.3%	43.1%	36.0%
0.6 x Current irrigation	45.1%	47.1%	39.2%	35.3%	45.1%	38.0%
0.7 x Current irrigation	45.1%	47.1%	39.2%	35.3%	45.1%	40.0%
0.8 x Current irrigation	45.1%	47.1%	39.2%	35.3%	45.1%	40.0%
Current irr. over 50 yrs	45.1%	47.1%	39.2%	39.2%	47.1%	44.0%
Backlog	45.1%	47.1%	39.2%	41.2%	47.1%	44.0%
1.25 x Backlog	45.1%	47.1%	41.2%	41.2%	49.0%	48.0%

Table I.4 – 7: U2 guideline effects for Flint River at Bainbridge: Annual Low Flow Duration Variances Criteria are from full period of HSPF calibrated model (1953-2002)

Annual Low Flow Duration (U2) Statistics			
25% Annual Average Discharge	1998cfs		
	Maximum	1 in 4 yrs	1 in 2 yrs
Criteria: Annual Low Flow Duration (days)	140	8	0
Allowable years of variance	0	<25%	<50%
No irr 1953-2003	0	8.0%	22.0%
Calibrated 1953-2003	0	10.0%	22.0%
0.6 x Current irrigation	0	12.0%	24.0%
0.7 x Current irrigation	0	12.0%	26.0%
0.8 x Current irrigation	0	14.0%	28.0%
Current irr. over 50 yrs	0	14.0%	30.0%
Backlog	0	16.0%	32.0%
1.25 x Backlog	0	20.0%	34.0%

Table I.4 – 8: Calculated 7Q10 Streamflow Rates for FRB Modeling Scenarios

7Q10 Streamflow Rates (cfs)			
Modeling Scenario	Ichawaynochaway Ck. near Milford	Flint River at Bainbridge	Spring Ck. near Iron City
Pre-1970's Data	140	2500	15
60% Current Model	65	1650	0
Current Model	20	1500	0
Backlog Model	10	1460	0
125% Backlog Model	3.5	1380	0

Table I.4 – 9: Frequency of Flow Less than 7Q10

Location	7Q10	Historic	0.6 x Current	Current	Backlog	1.25xBacklog
Milford	140 cfs	2.9%	4.6%	6.5%	7.2%	8.1%
Iron City	15 cfs	3.5%	3.9%	5.8%	6.3%	7.8%
Bainbridge	2500 cfs	5.4%	5.9%	6.9%	7.2%	8.0%

APPENDIX II:
GROUND-WATER MODEL AND APPLICATION

Table I.3 –1: Current Irrigation Acres in the FRBFRB

sub-basin	gw acres using Upper Floridan	surface-water acres	well to pond irr_acres	well to pond acres using Upper Floridan
Lower Flint	166187	3941	198	182
Ichawaynochaway Ck.	33474	65938	1344	402
Spring Creek	128011	10213	1531	1126
Kinchafoonee-Muckalee	12714	44223	951	355
Middle Flint	25533	36147	2756	1331
Total Flint	365919	160461	6781	3396

(a) Additional Backlog Acres in the FRB

basin	gw acres using Upper Floridan	surface-water irr_acres	well to pond acres	well to pond acres using Upper Floridan
Lower Flint	18506	1308		
Ichawaynochaway Ck.	6477	10040		
Spring Creek	14197	2708	350	200
Kinchafoonee-Muckalee	5138	7732		
Middle Flint	19949	8701	785	128
Total Flint	64267	30489	1135	328

Table I.3 – 2: Irrigation Application Depth (inches) by Month for Ground-water and Surface-water, Drought and Normal Year

2004.

Source	Scenario	Sub-basin	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
			in.											
G	Typical	Ichaway-Nochaway	0.0	0.0	0.1	0.3	1.1	1.3	1.7	1.7	0.6	0.2	0.1	0.1
		Kinchafoonee-Muckalee	0.1	0.1	0.2	0.4	1.4	1.4	1.7	1.4	0.8	0.2	0.1	0.1
		Lower Flint	0.1	0.1	0.2	0.7	1.8	1.8	1.7	1.7	1.0	0.3	0.1	0.1
		Middle Flint	0.0	0.0	0.1	0.3	1.1	1.3	1.8	1.7	0.8	0.3	0.0	0.0
		Spring	0.0	0.0	0.1	0.4	1.5	1.6	1.5	1.2	0.6	0.2	0.1	0.1
	Drought	Ichaway-Nochaway	0.1	0.1	0.2	0.4	1.6	2.1	2.7	3.3	1.2	0.3	0.2	0.1
		Kinchafoonee-Muckalee	0.1	0.1	0.4	0.7	2.1	2.3	2.9	2.0	1.3	0.5	0.2	0.1
		Lower Flint	0.1	0.1	0.4	0.8	2.9	2.7	2.6	2.6	2.5	0.5	0.4	0.2
		Middle Flint	0.1	0.1	0.4	0.7	1.7	2.4	3.0	2.3	1.0	0.5	0.1	0.1
		Spring	0.0	0.0	0.2	0.5	2.7	3.1	2.4	1.9	1.0	0.3	0.2	0.2
S	Typical	Ichaway-Nochaway	0.0	0.0	0.1	0.1	0.7	0.8	1.0	1.1	0.6	0.0	0.0	0.0
		Kinchafoonee-Muckalee	0.0	0.0	0.1	0.3	0.7	0.9	1.5	1.4	0.6	0.0	0.0	0.1
		Lower Flint	0.1	0.0	0.1	0.4	1.2	0.9	0.5	0.4	0.4	0.2	0.3	0.1
		Middle Flint	0.0	0.0	0.0	0.2	0.9	0.9	2.2	2.0	0.3	0.0	0.0	0.0
		Spring	0.0	0.0	0.0	0.2	0.6	0.8	1.1	1.4	0.5	0.1	0.0	0.0
	Drought	Ichaway-Nochaway	0.0	0.1	0.1	0.3	1.0	1.8	1.8	1.9	2.0	0.1	0.0	0.0
		Kinchafoonee-Muckalee	0.0	0.1	0.5	1.0	1.0	1.5	2.1	2.3	1.0	0.1	0.2	0.4
		Lower Flint	0.3	0.0	0.3	0.6	1.6	1.5	0.8	0.7	1.0	0.4	1.2	0.3
		Middle Flint	0.0	0.1	0.1	0.4	1.5	1.6	2.9	3.7	0.9	0.0	0.0	0.1
		Spring	0.0	0.1	0.2	0.4	1.5	1.5	1.9	2.3	1.7	0.7	0.1	0.0
W	Typical	Ichaway-Nochaway	0.0	0.0	0.0	0.1	0.7	1.2	1.5	1.5	0.7	0.1	0.0	0.0
		Kinchafoonee-Muckalee	0.0	0.1	0.3	0.8	1.6	1.9	1.7	1.4	0.7	0.2	0.1	0.1
		Lower Flint												
		Middle Flint	0.0	0.0	0.0	0.1	0.3	0.4	0.5	0.6	0.3	0.0	0.0	0.0
		Spring	0.0	0.0	0.2	0.3	1.4	1.1	1.8	1.2	0.3	0.0	0.0	0.0
	Drought	Ichaway-Nochaway	0.0	0.0	0.1	0.3	1.6	2.0	1.9	2.5	1.9	0.3	0.0	0.0
		Kinchafoonee-Muckalee	0.0	0.4	0.7	1.1	2.7	3.5	2.6	2.2	1.3	0.6	0.5	0.5
		Lower Flint												
		Middle Flint	0.0	0.0	0.0	0.3	0.9	1.3	0.9	0.8	0.9	0.1	0.0	0.0
		Spring	0.0	0.2	0.5	0.7	1.8	2.0	3.3	1.9	0.6	0.1	0.0	0.0

Source: Jim Hook of University of Georgia, 2005
*G: ground-water application
*S: surface-water application
*W: well to pond, it is a combination of using surface/ground-water

Table I.3-3 (a): Streamflow Reduction due to the Irrigation Pumping from the Upper Floridan at Milford in Ichawaynochaway Creek for Drought Years (cubic feet/sec.)

Month	current acres	backlog	1.25 x backlog
March	0.2	0.2	0.3
Apr	0.3	0.4	0.5
May	0.9	1.3	1.6
Jun	1.6	2.1	2.7
Jul	1.9	2.3	2.9
Aug	2.2	2.6	3.2
Sep	1.7	2.1	2.6
Oct	1.0	1.2	1.6
Nov	1.1	1.4	1.7
Dec	0.9	1.1	1.4

Streamflow Reduction due to the Irrigation Pumping from the Upper Florida at Milford of Ichawaynochaway Creek for Normal Years (cubic feet/sec.)

Month	current acres	backlog	1.25 x backlog
March	0.1	0.1	0.1
Apr	0.2	0.2	0.3
May	0.6	0.8	1.0
Jun	1.0	1.2	1.5
Jul	1.2	1.5	1.9
Aug	1.2	1.5	1.9
Sep	0.9	1.2	1.5
Oct	0.6	0.8	0.9
Nov	0.6	0.8	1.0
Dec	0.5	0.6	0.8

Note: the reduction is the accumulated effect of ground-water pumping up to Milford Gauge instead of the effect of the whole Ichawaynochaway Creek sub-basin.

Table I.3 - 3 (b): Streamflow Reduction due to the Irrigation Pumping from the Upper Floridan at Iron City of Spring Creek for Drought Years (cubic feet/sec.)

Month	current acres	backlog	1.25 x backlog
March	3.5	3.8	4.8
Apr	8.1	8.8	11.0
May	30.9	32.9	41.1
Jun	38.5	40.9	51.1
Jul	31.4	33.7	42.1
Aug	27.3	29.5	36.9
Sep	19.9	21.9	27.4
Oct	9.3	10.5	13.2
Nov	7.0	8.3	10.3
Dec	4.2	4.7	5.9

Streamflow Reduction due to the Irrigation Pumping from the Upper Floridan at Iron City of Spring Creek for Normal Years (cubic feet/sec.)

Month	current acres	backlog	1.25 x backlog
March	1.7	1.8	2.3
Apr	6.1	6.5	8.1
May	19.7	20.8	26.0
Jun	23.1	24.6	30.7
Jul	20.8	22.6	28.3
Aug	17.8	19.6	24.5
Sep	11.0	12.3	15.4
Oct	3.9	4.4	5.5
Nov	2.3	2.4	3.0
Dec	2.1	2.2	2.7

Note: the reduction is the accumulative effect up to Iron City instead of the effect of the whole Spring Creek sub-basin.

Table I.3 - 3 (c): Streamflow Reduction due to the Irrigation Pumping from the Upper Floridan at Bainbridge of lower Flint River for Drought Years (cubic feet/sec.)

Month	current acres	backlog	1.25 x backlog
March	39	42	52
Apr	73	79	98
May	229	252	315
Jun	287	320	399
Jul	306	338	422
Aug	321	352	440
Sep	315	341	426
Oct	202	220	275
Nov	156	171	214
Dec	118	130	162

Streamflow Reduction due to the Irrigation Pumping from the Upper Floridan at Bainbridge of lower Flint River for Normal Years (cubic feet/sec.)

Month	current acres	backlog	1.25 x backlog
March	16	17	22
Apr	32	35	44
May	98	110	137
Jun	140	156	195
Jul	186	207	258
Aug	199	220	275
Sep	153	169	212
Oct	105	116	145
Nov	69	76	95
Dec	51	56	70

Note: the reduction is the effect up to Bainbridge gauge. It is the combination of the whole Ichawaynochaway Creek and most of the lower Flint River Sub-basins.

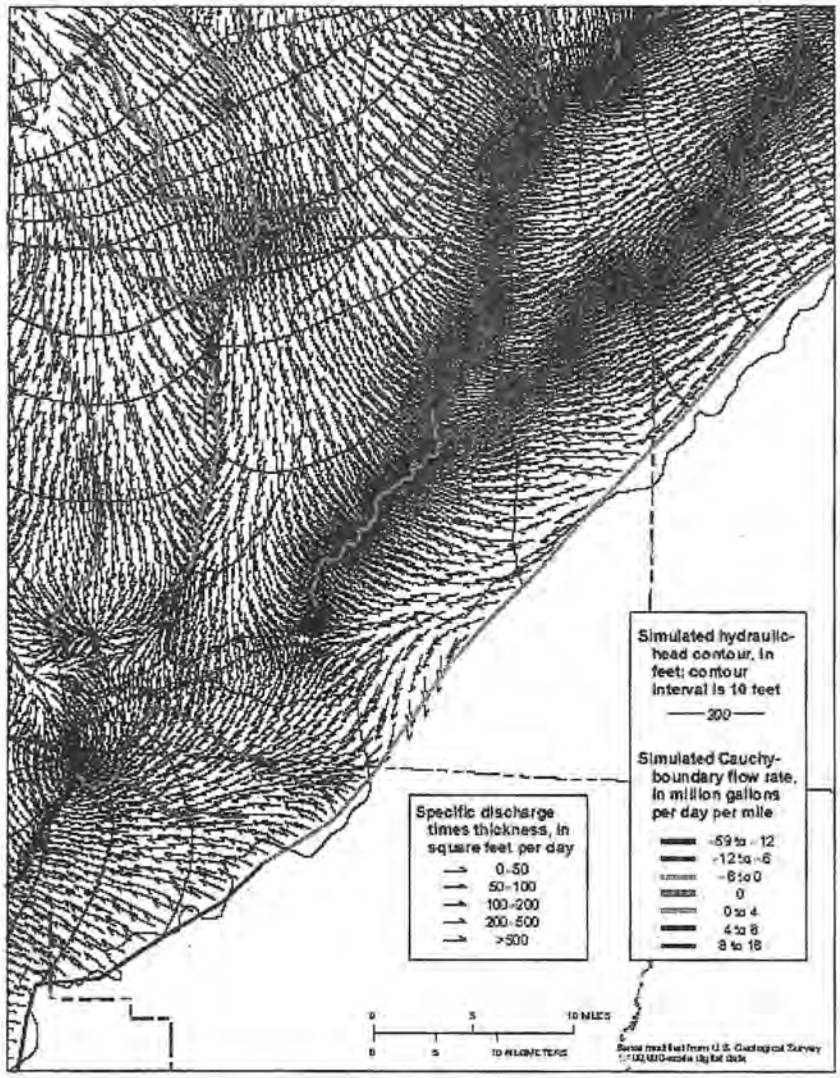

Figure II.1: Simulated hydraulic head contours, ground-water flow direction by element, and Cauchy-boundary flow by element side in the southern part of the lower Flint River sub-basin for the October 1999 calibrated lower FRB model (Jones and Torak, in review).

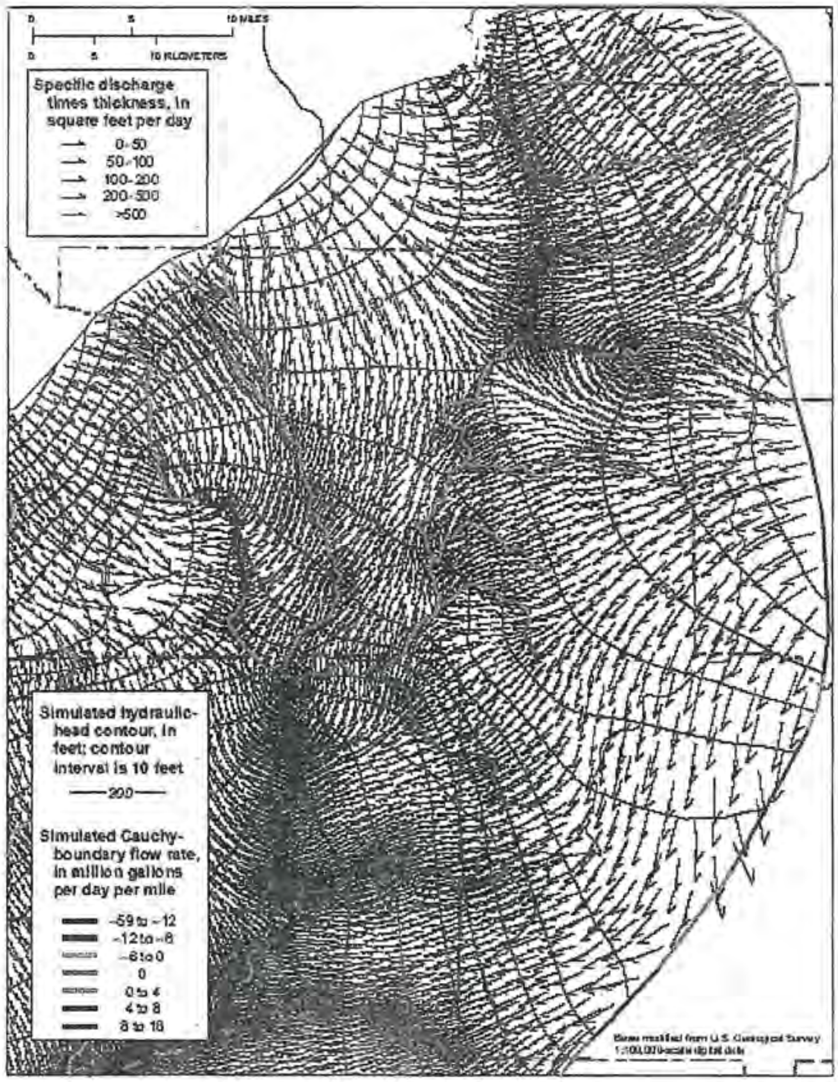

Figure II.2: Simulated hydraulic head contours, ground-water flow direction by element, and Cauchy-boundary flow by element side in the northern part of the lower Flint River sub-basin for the October 1999 calibrated lower FRB model (Jones and Torak, in review).

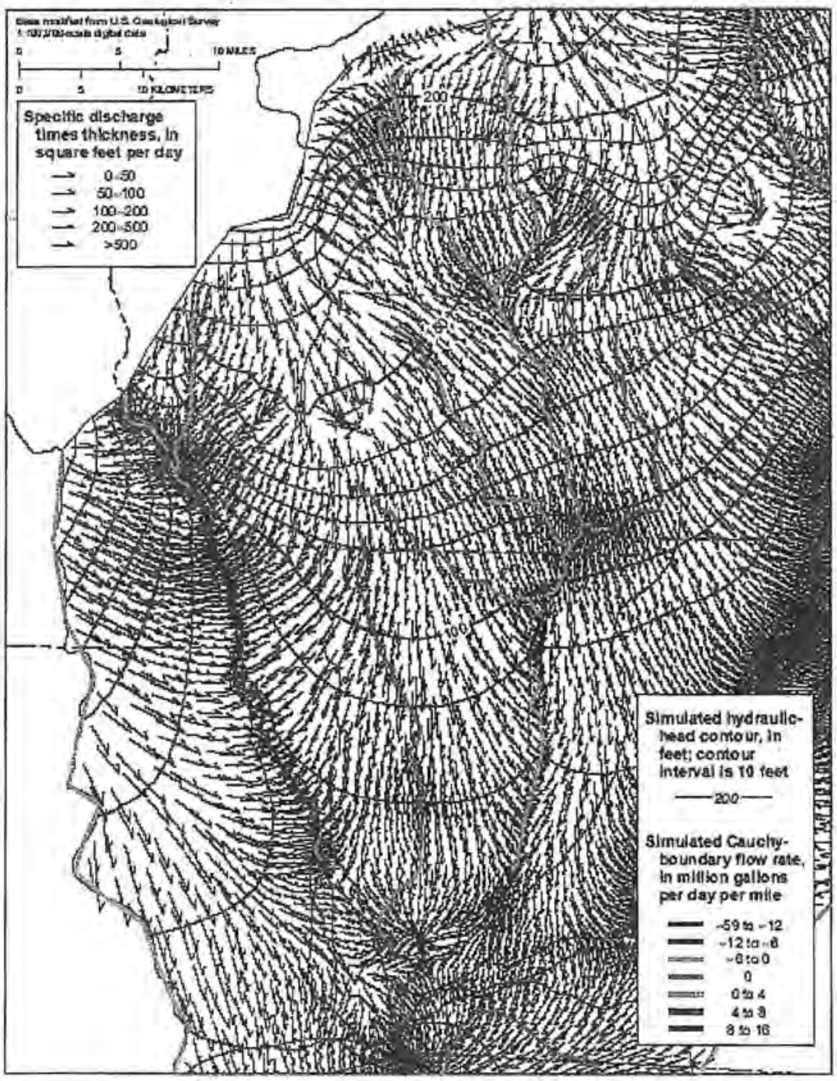

Figure II.3: Simulated hydraulic head contours, ground-water flow direction by element, and Cauchy-boundary flow by element side in Spring Creek sub-basin for the October 1999 calibrated lower FRB model. (Jones and Torak, in review).

Habitat Conservation Plan (HCP) Land Acquisition Grants

PURPOSE

The HCP Land Acquisition Grants program provides funding to States and Territories (and non-governmental organizations through their States and Territories) for land acquisitions that are associated with approved HCPs.

The HCP Land Acquisition program has three primary purposes: 1) to fund land acquisitions that complement, but do not replace, private mitigation responsibilities contained in HCPs, 2) to fund land acquisitions that have important benefits for listed, proposed, and candidate species, and 3) to fund land acquisitions that have important benefits for ecosystems that support listed, proposed and candidate species.

For fiscal year 2003, competition for the Habitat Conservation Plan Land Acquisition Grants will be held at the National level.

ELIGIBILITY

To be eligible for funding under the HCP Land Acquisition program, **a land acquisition proposal must meet all of the mandatory conditions listed below**. If a land acquisition does not meet these conditions, do not submit a proposal for consideration.

1. A proposal must include 25 percent non-Federal cost share (decreases to 10 percent if 2 or more States or Territories are contributors to the proposal and its activities) as per section 6 of the ESA. Insular Areas including the Virgin Islands, Guam, American Samoa, the Trust Territory of the Pacific Islands, and the Government of the Northern Mariana Islands are exempt from any matching requirements under all Fish and Wildlife Service Grant Programs (based on an August 23, 1993, Director's Memorandum)

2. A proposal cannot include FWS FTE costs.

3. We do not intend to grant funding for projects that serve to satisfy regulatory requirements of the Act including complying with a biological opinion under section 7 of the Act or fulfilling commitments of a Habitat Conservation Plan under section 10 of the Act, or for projects that serve to satisfy other local, State, or Federal regulatory requirements (e.g., mitigation for local, State, or Federal permits).

4. The land acquisition complements, but does not replace, private mitigation responsibilities contained in the HCP.

5. The specific parcel(s) to be acquired with the grant money is identified. NOTE: Evidence demonstrating that the landowners are willing sellers (i.e., a letter or other form of written acknowledgment) will be required prior to transfer of funds.

6. Habitat must be set aside in perpetuity for the purposes of conservation (this can include easements deeded in perpetuity or other similar instruments).

7. The proposal must state a commitment to funding for, and implementation of, management of the habitat in perpetuity, consistent with the conservation needs of the species.

ADDITIONAL GUIDANCE

Only one proposal per HCP may be submitted. However, a proposal may include more than one parcel for funding consideration. For regional HCPs with subarea plans, please submit multiple acquisition proposals under the one regional plan title. The proposal must specifically identify the parcel to be acquired. Proposals that do not identify specific parcels will not be considered. We encourage you to include more than one parcel in the proposal in the event the transaction for the highest priority acquisition cannot be completed; subject to the outcome of fund reassignment procedures, funding of the next highest priority parcel acquisition identified in the proposal may be approved. In addition, acquisition of more than one parcel per HCP may be funded. If you submit more than one parcel for consideration in your proposal, include the relative acquisition priorities for each parcel, the price of each parcel, and the amount of the request (purchase price minus the non-Federal match) for each parcel.

As in previous years, the ranking factors give priority to land acquisitions associated with larger, multiple species HCPs. The ranking factors assign points according to the number of species covered by the HCP (i.e., included in the section 10 permit). In prior years, proposals associated with HCPs that covered one or few species were unable to compete successfully for grants under this program. Again this year, we are setting aside a portion of the funding specifically for grants to single-species proposals to ensure some funds will be available to support acquisitions associated with single-species HCPs.

Smaller HCPs or HCPs with fewer covered species may also receive special consideration, especially if the acquisition is relatively low in cost and provides high conservation value, therefore, we encourage such proposals. However, the proposal or Regional priority justification must describe the circumstances that warrant special consideration.

States, Territories, or other non-Federal partners will be responsible for ensuring that appraisal and title work are completed. The cost of conducting an appraisal(s) and completing title work, in accordance with Federal requirements, must either be assumed by the State or a non-Federal subgrantee, or included in the total cost of the proposal.

State administrative costs must also either be assumed by the State or included in the proposal in accordance with Federal requirements.

U.S. Department of the Interior

NEWS

U.S. Department of the Interior

Office of the Secretary
FOR IMMEDIATE RELEASE
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Secretary Kempthorne Announces $57.9 Million in Grants to Support Land Acquisition and Conservation Planning for Endangered Species

WASHINGTON, D.C. – Secretary of the Interior Dirk Kempthorne today announced more than $57.9 million in grants to 23 states and one territory to support conservation planning and acquisition of vital habitat for threatened and endangered fish, wildlife and plants. (a list of states receiving grants is included below) The grants, awarded through the Cooperative Endangered Species Conservation Fund, will benefit numerous species ranging from the red-cockaded woodpecker to the Lake Erie watersnake.

"These grants build long-term partnerships with landowners who help to conserve our nation's imperiled species," said Secretary Kempthorne. "They are important tools that empower landowners and communities to safeguard habitat and foster conservation stewardship efforts for future generations."

Authorized by Section 6 of the Endangered Species Act, the grants enable States to work with private landowners, conservation groups and other agencies to initiate conservation planning efforts and acquire and protect habitat to support the conservation of threatened and endangered species.

This year, the cooperative endangered species fund provides $8.6 million through the Habitat Conservation Planning Assistance Grants Program, $35.3 million through the Habitat Conservation Plan Land Acquisition Grants Program and $14 million through the Recovery Land Acquisition Grants Program, which includes approximately $1.5 million of funds carried over from previous years or recovered from previous projects. The three programs were established to help avoid potential conflicts between the conservation of threatened and endangered species and land development and use.

Habitat Conservation Plans (HCPs) are agreements between a landowner and the Service, allowing a landowner to undertake otherwise lawful activities on their property that may result in the death, injury or harassment of a listed species, when that landowner agrees to conservation measures designed to minimize and mitigate the impact of those actions. HCPs may also be developed by a county or state to cover certain activities of all landowners within their own jurisdiction and may address multiple species. There are more than 675 HCPs currently in effect covering nearly 600 species on approximately 42 million acres.

Under the HCP Land Acquisition Program, the Service provides grants to states or territories for land acquisition associated with approved HCPs. The grants are targeted to help landowners who volunteer to conserve imperiled species on their lands. Among recipients of today's HCP Land Acquisition grants is the state of Georgia, which is receiving a $2,000,000 grant to acquire 8,430 acres of mature pine habitat in Decatur County to benefit the red-cockaded woodpecker. The land will be protected in perpetuity as a State Heritage Preserve and will be managed as a State Wildlife Management Area. This project ensures permanent conservation for lands that provide connecting habitat for red-cockaded woodpeckers in this area. This grant also benefits the wood stork, Eastern indigo snake, Flatwoods salamander and state protected species including the gopher tortoise and southern hognose snake.

The HCP Planning Assistance Program provides grants to states and territories to support the development of HCPs through funding of baseline surveys and inventories, document preparation, outreach and similar planning activities. For example, the states of Indiana, Kentucky, Louisiana, New Hampshire, New Jersey, Ohio, Tennessee, and Virginia will receive $3,007,270 to assist in the development of a landscape level, multi-species HCP covering a 15,500-mile planning area. The HCP will cover 6.4 million acres of land that has the potential to affect 74 federally listed species habitat in a total of 17 states. The NiSource HCP will be designed to avoid and minimize impacts to endangered and threatened species associated with construction, operation and maintenance of its natural gas transmission lines and ancillary facilities running from Louisiana to Indiana, and Ohio and throughout the northeast to Maine. NiSource will work in collaboration with The Conservation Fund, who will lead a strategic conservation planning process that focuses on integrating species needs with potential habitat mitigation across the landscape, providing multiple species benefits and addressing needs in a cumulative and comprehensive fashion. Species expected to benefit from the NiSource HCP include the Indiana bat, copperbelly watersnake and numerous species of federally listed freshwater mussels.

The Recovery Land Acquisition Grants Program provides funds to states and territories to acquire habitat for endangered and threatened species with approved recovery plans. Habitat acquisition to secure long term protection is often an essential element of a comprehensive recovery effort for a listed species. One of this year's grants will provide $1,471,500 to acquire a conservation easement over 654 acres of high-priority private forestland in the Kootenai Valley of northern Idaho. The property provides a critical link between the higher elevation public lands of the Selkirk Mountains and more than 2,000 acres of low-elevation protected areas owned by the Idaho Department of Fish and Game, Vital Ground Foundation and the Owens Foundation for Wildlife Conservation. The protection of this property will contribute to the recovery of grizzly bear, mountain caribou, bull trout, Canada lynx, and gray wolf.

Below is a list of the states that received funding and the amount awarded for species conservation.

	Individual States
Arkansas	$ 225,500
California	17,945,231
Florida	1,134,605
Georgia	2,717,772
Hawaii	2,101,196
Idaho	1,471,500
Michigan	689,305
Montana	6,515,319
Nebraska	385,911
Ohio	1,835,000
Oklahoma	186,000
Oregon	306,000
Puerto Rico	1,500,000
Tennessee	1,763,450
Texas	6,324,500
Utah	458,080
Virginia	704,000
Washington	8,435,081
Wisconsin	88,355
	Multi-state grants
Tennessee and Kentucky	$129,150
Indiana, Kentucky, Louisiana, New Hampshire, New Jersey, Ohio, Tennessee, and Virginia	$3,007,270

For a complete list of the 2008 grant awards for these programs (Catalog of Federal Domestic Assistance Number

15.615), see the Service's Endangered Species Grants home page at http://endangered.fws.gov/grants/section6/index.html.

— DOI —

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Last Updated on 03/21/08

Exhibit 63

FLINT RIVER IRRIGATION REDUCTION AUCTION

Previous auctions

The Flint River Drought Protection Act, signed into law in 2000, provides financial incentives for farmers in the Flint River Basin to temporarily suspend irrigation during severe droughts. The Act and Rules establish an "irrigation reduction auction" by which farmers are paid on a per acre basis not to irrigate land associated with a permitted irrigation withdrawal. The first Flint River irrigation reduction auction was held in 2001. A second auction was held in 2002.

In an irrigation reduction auction, eligible farm-use permittees are paid to voluntarily stop irrigating all acres associated with a particular irrigation system pulling from a well or surface water pump. If not enough acres are obtained voluntarily, the Director has the authority to require irrigation suspension, but the permittee will still be compensated at the average per acre price paid to those who participated voluntarily. Therefore, both auctions required that EPD carefully establish the eligibility of all farm-use surface water permittees. Establishing auction eligibility required detailed mapping of irrigation systems and associated acreage, and tying those to one unique irrigation permit. This was accomplished with extensive interaction between EPD personnel and permittees, creation of new GIS databases, extensive permit database reconfiguration and analysis, and field mapping. (For the 2001 auction, all permitted surface water users in the entire Flint River Basin were eligible to participate. For the second auction, EPD limited eligibility to those surface water permittees who had irrigated within the past three years.)

The Rules for Lower Flint River Basin Drought Protection allow for different auction methods to be used. The first auction was conducted as a day-long multiple bid process. In this auction, the Director of EPD decided confidentially on how many acres EPD intended to suspend irrigation. Five auction sites were established throughout the lower Flint River Basin, at which computer stations were operated by students and staff of Georgia State University. Farmers submitted blind bids based on what they expected to receive per acre from EPD to not irrigate. Bids initially ranged from $800 per acre to $75 per acre. Bids were entered into a computer database linked to all five auction sites. The Director, stationed at a central computer in Atlanta, could evaluate all bids submitted during an auction round, and thus decided which bids to accept and which to reject based on the total amount of acreage removed from irrigation compared with available money in the auction fund. Accepted bids were posted at each auction site, such that farmers could see which bids were accepted but not for how much. As a result, bid prices declined with each round until the amount of acreage targeted by the Director had been achieved, and he called a halt to the auction. All bids that had been accepted were issued receipts. Successful bidders were then paid from the drought protection fund, administered by GEFA. In the first auction, 33,006 acres were removed from irrigation at an average price of $136 per acre. Bids ranged from $75 to $800 per acre. A total of $4.49 million was expended on the auction. No involuntary irrigation suspension was ordered by the Director.

This auction method was very inefficient. Farmers had no prior information as to what a reasonable bid would be, and presented "wish lists", such as the $800 per acre bid. This auction also resulted in thousands of acres of marginal and fallow farmland that might not have been irrigated normally being 'removed' from irrigation. Otherwise, regular compliance inspections by EPD did not find any violations; that is, no one was found irrigating land they were paid to not irrigate.

The second auction in 2002 was conducted much differently. In this auction, the Director announced beforehand that no bid above $150 per acre would be accepted, and that EPD would entertain all bids at or below that price up to the point at which the targeted acreage was removed from irrigation. As before, the Director did not reveal what the targeted acreage would be. Bids were submitted by mail, and their evaluation occurred all at once on the "auction day". In this auction, 40, 861 acres were removed from irrigation at an average price of $128 per acre. Bids ranged from $74 to $145 per acre. A total of $5.25 million was expended on the auction. No involuntary irrigation suspension was ordered by the Director.

This auction method was more efficient and resulted in more acreage being removed from irrigation at a lower average price per acre than in the previous auction. Also, more land that is normally irrigated was removed from irrigation as opposed to fallow or marginal land. Compliance inspections by EPD did not find any violations.

Exhibit 64

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GSWCC
Georgia Soil and Water Conservation Commission

Prepared in cooperation with the State of Georgia Soil and Water Conservation Commission

Summary of the Georgia Agricultural Water Conservation and Metering Program and Evaluation of Methods Used to Collect and Analyze Irrigation Data for the Middle and Lower Chattahoochee and Flint River Basins, 2004–2010

Scientific Investigations Report 2011–5126

U.S. Department of the Interior
U.S. Geological Survey

Cover. Water meter installed on irrigation system in southern Georgia (photograph by Lynn J. Torak, USGS).

Summary of the Georgia Agricultural Water Conservation and Metering Program and Evaluation of Methods Used to Collect and Analyze Irrigation Data for the Middle and Lower Chattahoochee and Flint River Basins, 2004–2010

By Lynn J. Torak and Jaime A. Painter

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U.S. Department of the Interior
U.S. Geological Survey

U.S. Department of the Interior
KEN SALAZAR, Secretary

U.S. Geological Survey
Marcia K. McNutt, Director

U.S. Geological Survey, Reston, Virginia: 2011

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Contents

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Conversion Factors and Datums

Multiply	By	To obtain
	Length	
inch	2.54	centimeter (cm)
inch	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
acre	4,047	square meter (m^2)
acre	0.4047	hectare (ha)
acre	0.4047	square hectometer (hm^2)
acre	0.004047	square kilometer (km^2)
	Volume	
gallon (gal)	3.785	liter (L)
gallon (gal)	0.003785	cubic meter (m^3)
gallon (gal)	3.785	cubic decimeter (dm^3)
cubic foot (ft^3)	28.32	cubic decimeter (dm^3)
cubic foot (ft^3)	0.02832	cubic meter (m^3)
acre-foot (acre-ft)	1,233	cubic meter (m^3)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

$$°F = (1.8 \times °C) + 32$$

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows:

$$°C = (°F - 32) / 1.8$$

Vertical coordinate information is referenced to the North American Vertical Datum of 1988 (NAVD 88).

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

Summary of the Georgia Agricultural Water Conservation and Metering Program and Evaluation of Methods Used to Collect and Analyze Irrigation Data for the Middle and Lower Chattahoochee and Flint River Basins, 2004–2010

By Lynn J. Torak and Jaime A. Painter

Abstract

Since receiving jurisdiction from the State Legislature in June 2003 to implement the Georgia Agricultural Water Conservation and Metering Program, the Georgia Soil and Water Conservation Commission (Commission) by year-end 2010 installed more than 10,000 annually read water meters and nearly 200 daily reporting, satellite-transmitted, telemetry sites on irrigation systems located primarily in southern Georgia. More than 3,000 annually reported meters and 50 telemetry sites were installed during 2010 alone. The Commission monitored rates and volumes of agricultural irrigation supplied by groundwater, surface-water, and well-to-pond sources to inform water managers on the patterns and amounts of such water use and to determine effective and efficient resource utilization.

Summary analyses of 4 complete years of irrigation data collected from annually read water meters in the middle and lower Chattahoochee and Flint River basins during 2007–2010 indicated that groundwater-supplied fields received slightly more irrigation depth per acre than surface-water-supplied fields. Year 2007 yielded the largest disparity between irrigation depth supplied by groundwater and surface-water sources as farmers responded to severe-to-exceptional drought conditions with increased irrigation. Groundwater sources (wells and well-to-pond systems) outnumbered surface-water sources by a factor of five; each groundwater source applied a third more irrigation volume than surface water; and, total irrigation volume from groundwater exceeded that of surface water by a factor of 6.7. Metered irrigation volume indicated a pattern of low-to-high water use from northwest to southeast that could point to relations between agricultural water use, water-resource potential and availability, soil type, and crop patterns.

Normalizing metered irrigation-volume data by factoring out irrigated acres allowed irrigation water use to be expressed as an irrigation depth and nearly eliminated the disparity between volumes of applied irrigation derived from groundwater and surface water. Analysis of per-acre irrigation depths provided a commonality for comparing irrigation practices across the entire range of field sizes in southern Georgia and indicated underreporting of irrigated acres for some systems. Well-to-pond systems supplied irrigation at depths similar to groundwater and can be combined with groundwater irrigation data for subsequent analyses. Average irrigation depths during 2010 indicated an increase from average irrigation depths during 2008 and 2009, most likely the result of relatively dry conditions during 2010 compared to conditions in 2008 and 2009.

Geostatistical models facilitated estimation of irrigation water use for unmetered systems and demonstrated usefulness in redesigning the telemetry network. Geospatial analysis evaluated the ability of the telemetry network to represent annually reported water-meter data and presented an objective, unbiased method for revising the network.

Introduction

The Georgia General Assembly enacted House Bill 579 on June 4, 2003, granting jurisdiction to the Georgia Soil and Water Conservation Commission (hereafter referred to as the Commission) to

> "...[implement] a program of measuring farm uses of water in order to obtain clear and accurate information on the patterns and amounts of such use, which information is essential to proper management of water resources by the state and useful to farms for improving the efficiency and effectiveness of their use of water ... and [for] improving water conservation" (Georgia General Assembly, 2003).

During late 2003, the Commission began installing water meters for the annually reported and daily telemetry networks to provide estimates of applied irrigation volumes and per-acre irrigation depths derived from groundwater, surface-water, and well-to-pond sources.

Since November 2008, the U.S. Geological Survey (USGS), in cooperation with the Commission, has investigated methods for estimating agricultural water use and growing-season pumping rates through the analysis of water-meter data. Initial investigations assured the quality of irrigation water-meter data collected since the establishment of the metering program in 2003. Geospatial analyses of these data yielded promising results for identifying patterns of seasonal agricultural water use.

Study Objectives

The following objectives describe the USGS investigation of irrigation data collected by the Commission in accordance with and support of the metering program:

- Develop a quality-assurance program to ensure completeness and internal consistency of water-meter data;
- Calculate descriptive statistics of aggregated water-use data;
- Evaluate the potential to relate daily water-use telemetry (telemetered data) to annually reported water-use data through a descriptive statistical model; and
- Identify spatial and temporal distributions of agricultural-irrigation pumpage.

Purpose and Scope

This report summarizes agricultural water-meter irrigation data collected by the Georgia Soil and Water Conservation Commission during 2004–2010 in support of the Georgia Agricultural Water Conservation and Metering Program that has been implemented in Georgia. The report contains maps showing the status of the metering program at years-end 2009 and 2010 for visual comparison of the level of completeness of meter installations at these time horizons.

The report describes an evaluation of methods used to assess the accuracy of the annually reported and telemetry water-meter networks to represent the entire population of irrigation systems in Georgia. Results of this assessment involved irrigation data from the middle and lower Chattahoochee and Flint River basins for the 2007 growing season and are presented as an example.

Described in this report are summary analyses of 4 years of complete irrigation water-meter data collected in the middle and lower Chattahoochee and Flint River basins during the 2007–2010 growing seasons and a detailed geospatial analysis of metered agricultural-irrigation data for the 2007 growing season. The 2007 growing-season data proved to be the most interesting of the 4 years of complete irrigation data, yielding the largest disparity between irrigation supplied by groundwater and surface-water sources as farmers responded to severe-to-exceptional drought conditions with increased irrigation. The geospatial analysis demonstrated the usefulness of this technology for evaluating the ability of the telemetry network to represent annually reported water-meter data and presented an objective, unbiased method for revising the network and estimating irrigation water use at unmetered irrigation sites.

Data and mathematical relations expressed in this report are used solely in a manner consistent with the intent of Georgia General Assembly House Bill 579 (Georgia General Assembly, 2003) and the Privacy Act of 1974 (U.S. Department of Justice, 2010) and the intent of both of these documents to protect the right to privacy of each farmer. Therefore, this report, contains aggregated data and analyses without reference to specific water use by individual farmers.

The cooperative research of agricultural water-use data by USGS and the Commission aligns directly with the USGS mission to provide reliable, impartial, and timely information that is needed to understand the Nation's water resources. The unique water-use dataset generated by the agricultural irrigation water-metering program in Georgia could be integrated with corresponding national water-use and availability datasets under the WaterSMART Availability and Use Assessment Program, which has identified the metered area of the middle and lower Chattahoochee and Flint River basins as part of a focus area study (U.S. Geological Survey, 2010). The analyses of metered irrigation data presented herein demonstrate a possible technique for water-use assessment that could be scaled up to the national level for developing future Water Census products (Eric Evenson, U.S. Geological Survey, Coordinator, WaterSMART Initiative, written commun., May 2011). Researchers for the WaterSMART initiative have expressed interest in comparing these methods of data analysis with that currently used in the national Water Census program (Phillip J. Zarriello, Hydrologist, U.S. Geological Survey, Northborough, Massachusetts; Molly A. Maupin, Hydrologist, U.S. Geological Survey, Boise, Idaho, written commun., June 2011). USGS impartiality in developing results of this cooperative investigation with the Commission enables objective analyses of agricultural water-meter data and provides a scientific foundation for making water-management decisions involving the use of limited groundwater and surface-water resources by agriculture in Georgia.

Summary of the Georgia Agricultural Water Conservation and Metering Program, 2004–2010

Initial meter installations during 2004–2007 coincided geographically with the concentration of agricultural irrigation in south Georgia, focusing mainly in the middle and lower parts of the Chattahoochee and Flint River basins (fig. 1). A few water meters were installed in the southern part of the upper Flint River basin. By year-end 2009, the Commission monitored agricultural withdrawal from a network of 6,985 annually read flow meters and 148 daily reporting, satellite telemetry sites operating at water-withdrawal-permit locations in southern Georgia (table 1).

Installation of water meters continued in other areas of Georgia through 2010, increasing to a total of more than 10,000 annually reported and about 200 telemetry sites (David A. Eigenberg, Georgia Soil and Water Conservation Commission, written commun., May 2011; fig. 2). Compared with the map showing the 2009 status of the metering program (fig. 1*A*), the 2010 map illustrates the effectiveness of the State Agricultural Water Conservation and Metering Program (hereafter referred to as simply the metering program) for installing water meters on nearly every permitted agricultural water-withdrawal system in Georgia.

Installation of annually reported and daily telemetry water-meter networks progressed to completion in the Chattahoochee and Flint River basins in time to monitor water use during the 2007 growing season. Three statistical regions were identified for analysis of agricultural water-meter irrigation data based on completion of water-meter installations by 2007 (fig. 1). Statistical region 1, the middle and lower Chattahoochee and Flint River basins, contained completed networks of annually reported and daily telemetry water-meter data by the beginning of the 2007 growing season. Installation of water-meter networks for statistical region 2, the coastal region, and statistical region 3, central-south Georgia, continued during 2007–2010.

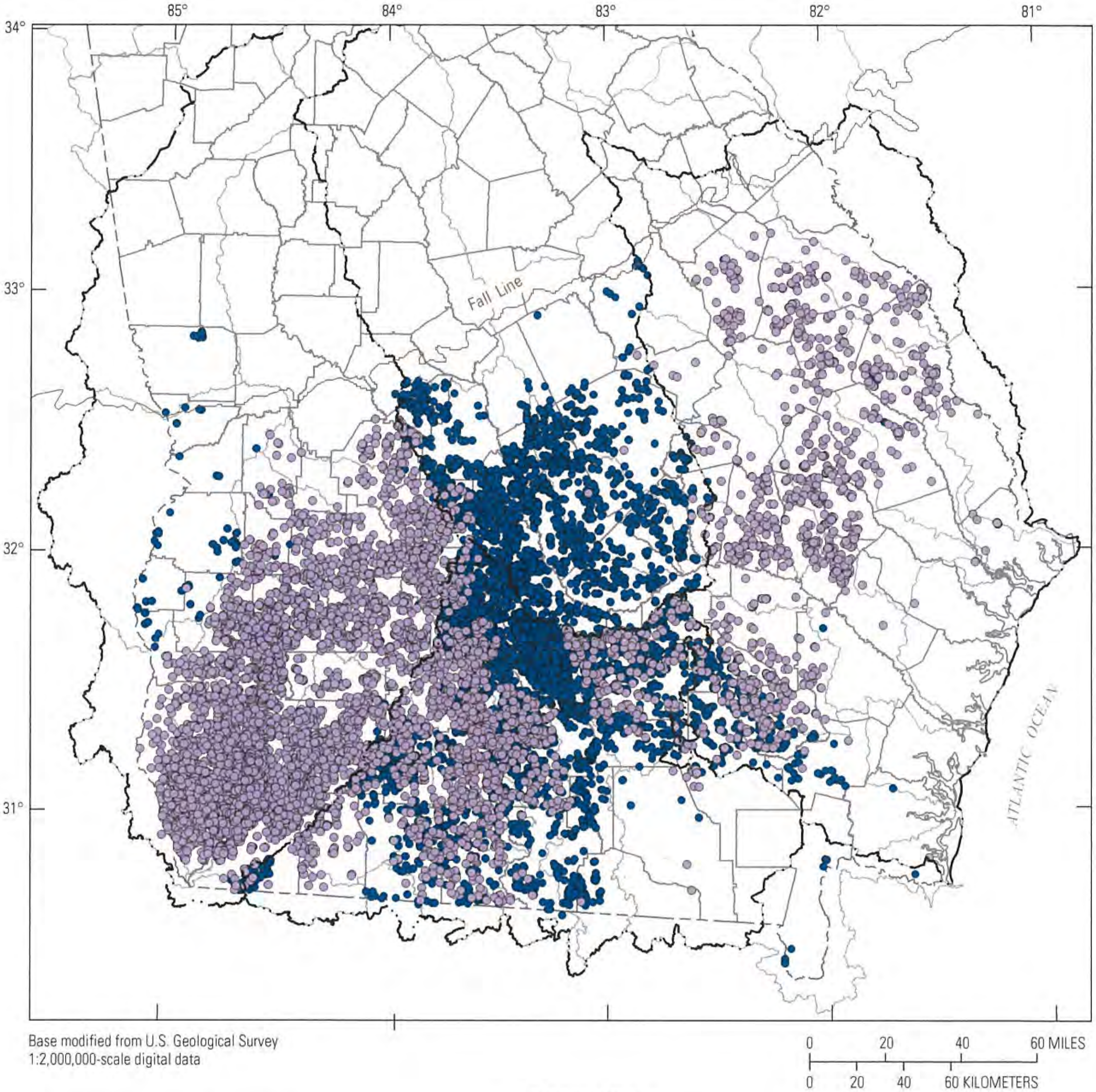
By the end of 2009, in the middle and lower Chattahoochee and Flint River basins, groundwater meters outnumbered surface-water meters by a factor of five (3,609 groundwater meters compared to 748 surface-water meters; fig. 1, table 1). The disparity between these numbers likely is a result of the relative ease of obtaining groundwater from high-yielding wells, installed virtually at the point of irrigation in the field, compared to piping surface water from a limited network of streams, each of which contains limited water availability and the potential to dry up during the height of the growing season.

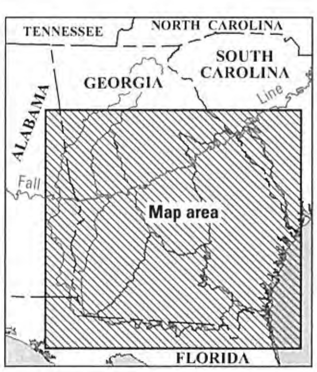
Table 1. Summary of water-meter installations in southern Georgia, 2009.

[See figure 1 for location]

Source	Meter type	
	Annually reported	Telemetry
Middle and lower Chattahoochee and Flint River basins		
Groundwater	3,609	46
Surface water	748	35
Subtotal	4,357	81
Coastal region		
Groundwater	679	20
Surface water	378	16
Subtotal	1,057	36
Central south Georgia		
Groundwater	912	15
Surface water	659	16
Subtotal	1,571	31
Total	6,985	148

A. **Permitted unmetered and metered agricultural water-use sites**





EXPLANATION

— · · — **Statistical Region boundary**

● **Metered**

● **Permitted unmetered**

Figure 1. Status of the Georgia Agricultural Water Conservation and Metering Program in southern Georgia by year-end 2009; locations of *(A)* permitted unmetered and metered agricultural water-use sites; and metered and telemetered sites located in *(B)* Statistical Region 1, middle-and-lower Chattahoochee and Flint River basins; *(C)* Statistical Region 2, coastal region; and *(D)* Statistical Region 3, central-south Georgia (Georgia Environmental Protection Division and Georgia Soil and Water Conservation Commission, written commun., 2009).

B. **Statistical Region 1, middle and lower Chattahoochee and Flint River basins**

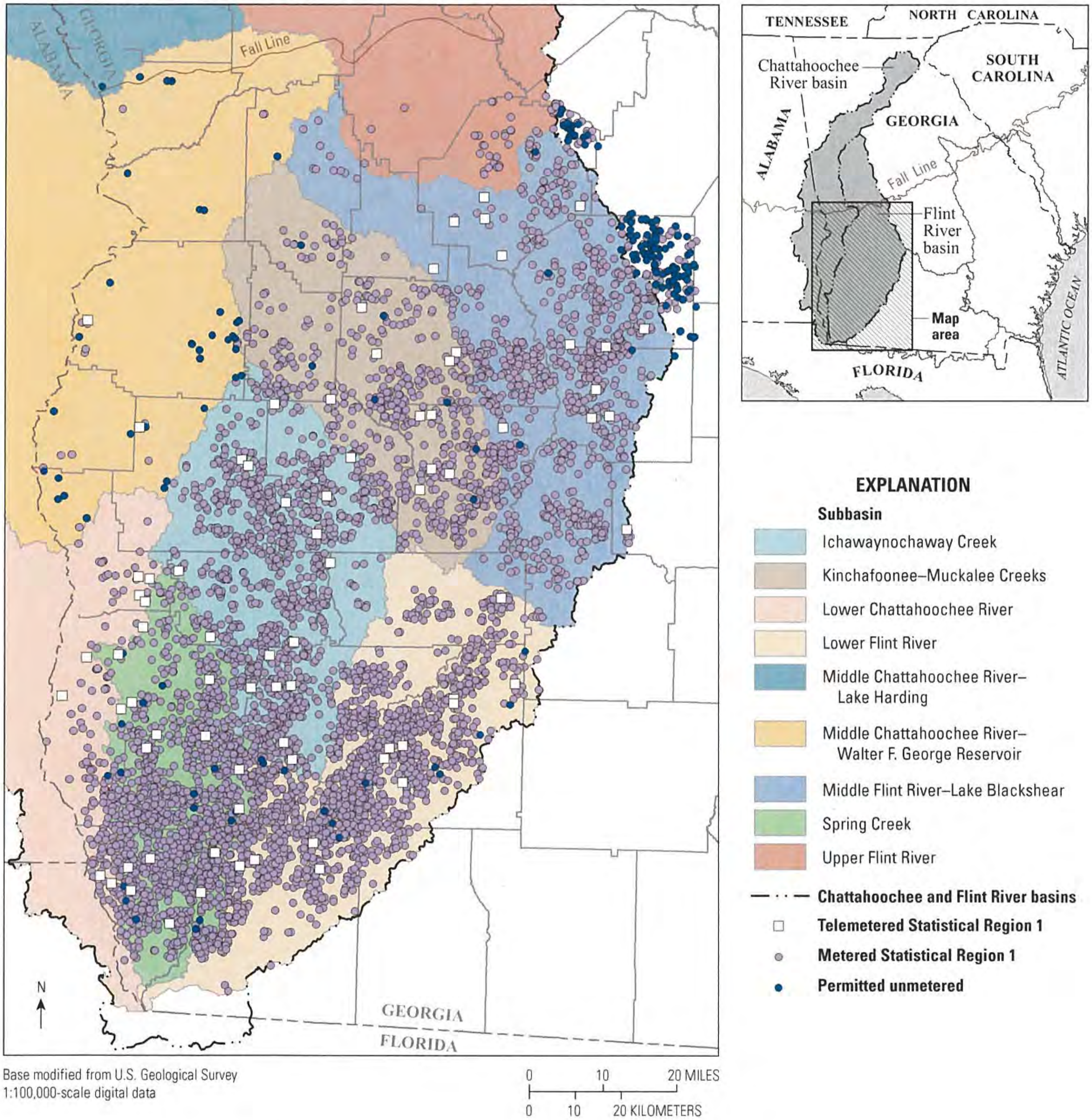


Figure 1. Status of the Georgia Agricultural Water Conservation and Metering Program in southern Georgia by year-end 2009; locations of *(A)* permitted unmetered and metered agricultural water-use sites; and metered and telemetered sites located in *(B)* Statistical Region 1, middle-and-lower Chattahoochee and Flint River basins; *(C)* Statistical Region 2, coastal region; and *(D)* Statistical Region 3, central-south Georgia (Georgia Environmental Protection Division and Georgia Soil and Water Conservation Commission, written commun., 2009).—Continued

C. **Statistical Region 2, coastal region**

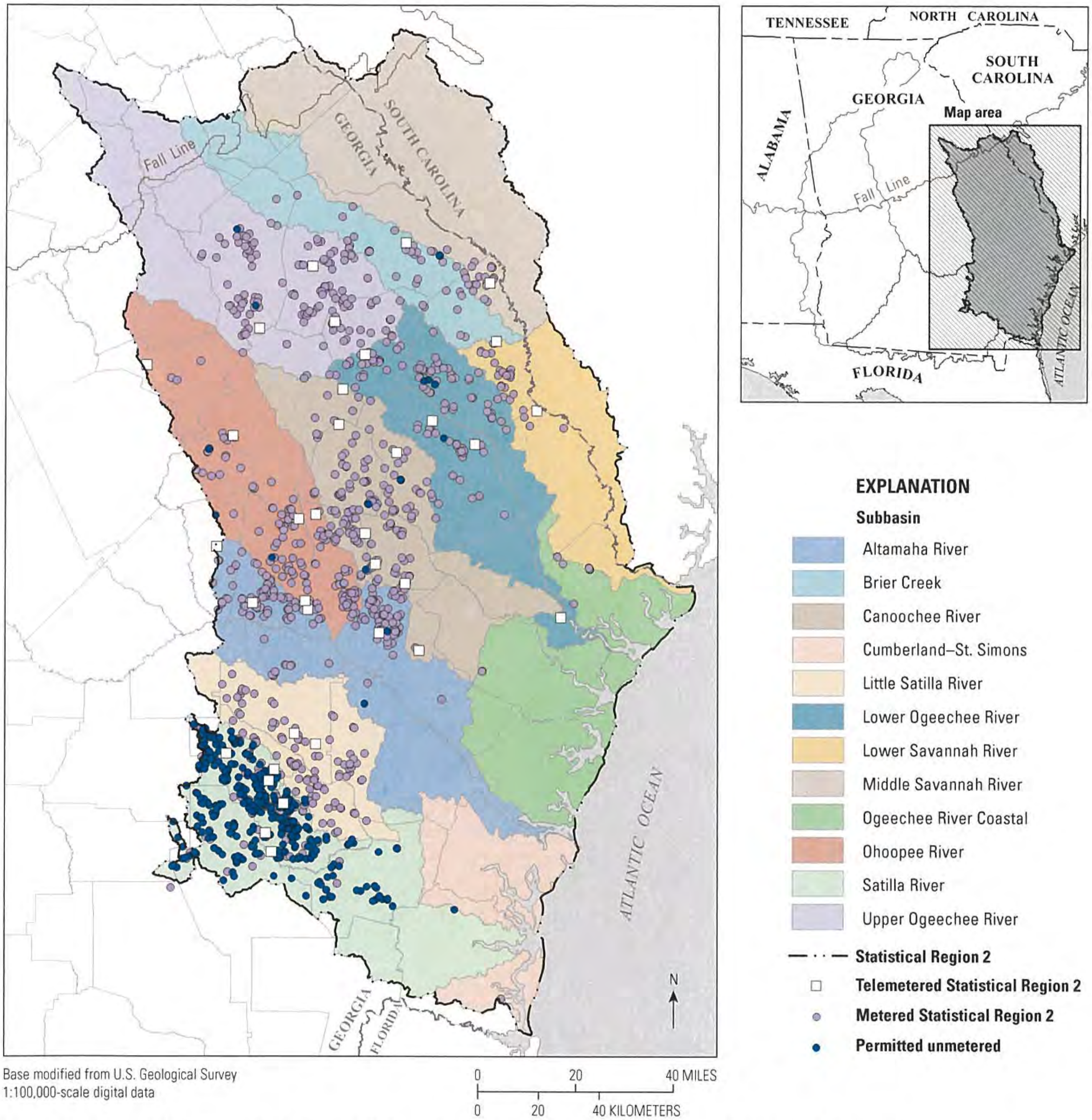
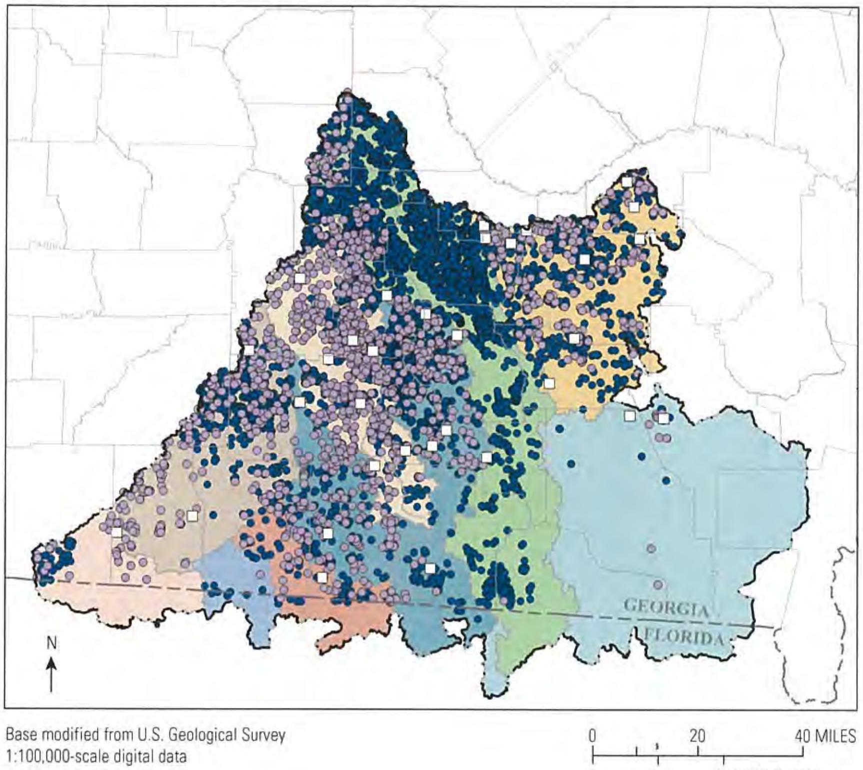


Figure 1. Status of the Georgia Agricultural Water Conservation and Metering Program in southern Georgia by year-end 2009; locations of *(A)* permitted unmetered and metered agricultural water-use sites; and metered and telemetered sites located in *(B)* Statistical Region 1, middle-and-lower Chattahoochee and Flint River basins; *(C)* Statistical Region 2, coastal region; and *(D)* Statistical Region 3, central-south Georgia (Georgia Environmental Protection Division and Georgia Soil and Water Conservation Commission, written commun., 2009).—Continued

D. **Statistical Region 3, central-south Georgia**



EXPLANATION

Subbasin

- Alapaha River
- Apalachee Bay–St. Marks
- Aucilla River
- Little River
- Lower Ochlockonee River
- Satilla River
- Upper Ochlockonee River
- Upper Suwannee River
- Withlacoochee River

Statistical Region 3

Telemetered Statistical Region 3

Metered Statistical Region 3

Permitted unmetered

Figure 1. Status of the Georgia Agricultural Water Conservation and Metering Program in southern Georgia by year-end 2009; locations of *(A)* permitted unmetered and metered agricultural water-use sites; and metered and telemetered sites located in *(B)* Statistical Region 1, middle-and-lower Chattahoochee and Flint River basins; *(C)* Statistical Region 2, coastal region; and *(D)* Statistical Region 3, central-south Georgia (Georgia Environmental Protection Division and Georgia Soil and Water Conservation Commission, written commun., 2009).—Continued

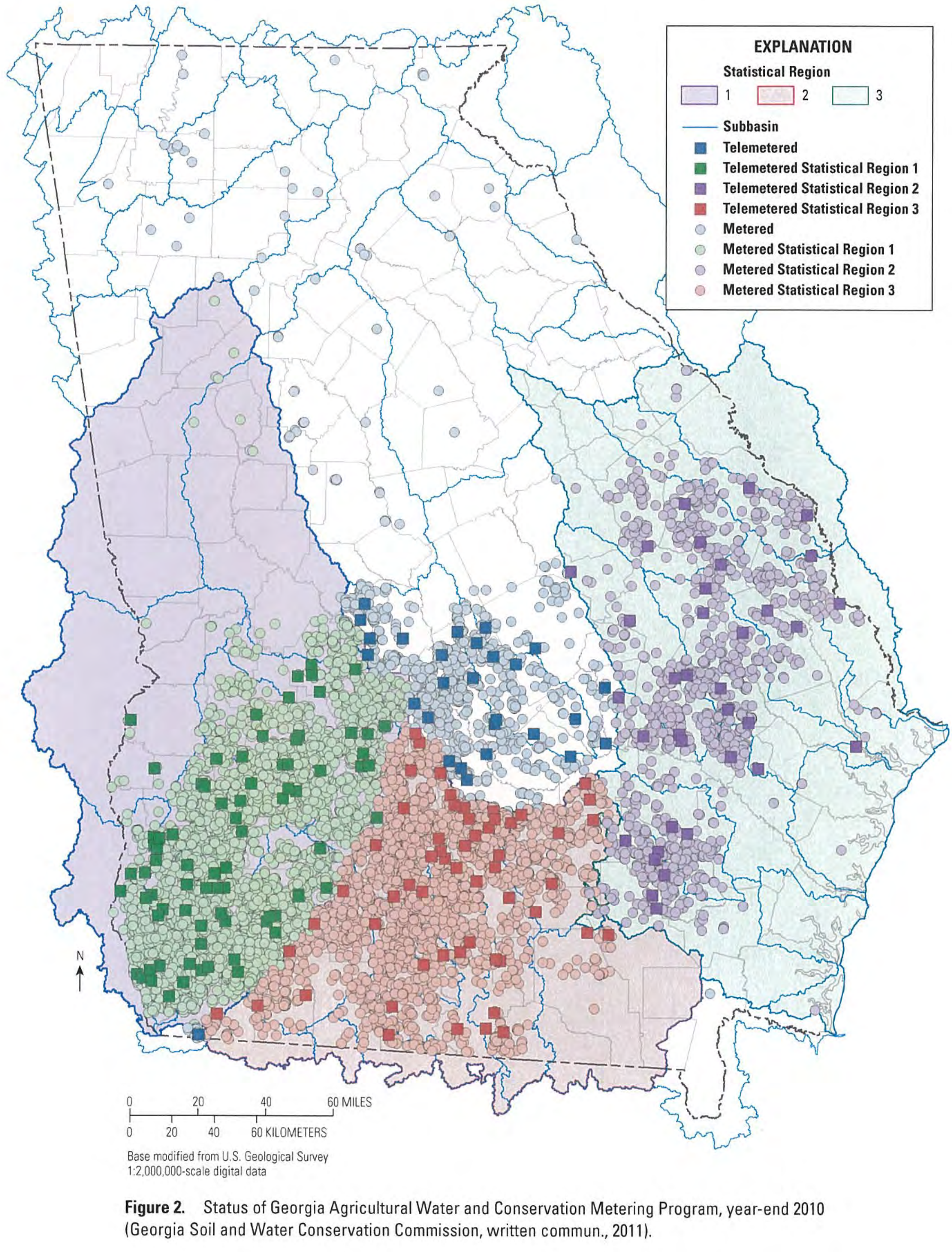


Figure 2. Status of Georgia Agricultural Water and Conservation Metering Program, year-end 2010 (Georgia Soil and Water Conservation Commission, written commun., 2011).

Evaluation of Methods Used to Collect and Analyze Water-Meter Irrigation Data in the Middle and Lower Chattahoochee and Flint River Basins, 2004–2010

Quality assurance, statistical, and geostatistical methods were applied to the annually reported and telemetry water-meter data to verify the accuracy of the metered water-use values and the ability of the meter networks to represent irrigation volumes and depths for the population of irrigation systems located in the middle and lower Chattahoochee and Flint River basins. Quality assurance analyses of water-meter roll back and roll forward (defined in the section "Water Meter Roll Back and Roll Forward") evaluated the integrity of the water meter itself to accurately record irrigation water use. Zero water-use data were analyzed for its effect on annual mean water-use calculations. A two-sample t-test evaluated the ability of the annually reported and telemetry data to represent samples of water use from the total population of irrigation systems including nonmetered systems. Geostatistical methods evaluated spatial trends and characteristics of the metered irrigation water use and the ability of the telemetry network to represent irrigation water use from the annually reported meter network. A telemetry network redesigned on the basis of geostatistical analyses demonstrated the usefulness of these methods for estimating water use from an efficient monitoring network having minimal estimation error.

Quality Assurance of Water-Meter Data

Quality assurance involves the validation of annually reported and telemetered agricultural water-meter data. This validation consisted of identifying water-meter "roll back" or "roll forward," non-water use (meter reading of zero), and zero acreage assigned to a meter. (These validation checks are described in subsequent sections of this report.) Meters were installed either on a distribution line that provided water to one or multiple fields or on a supply line leading from a well, stream, or well-to-pond water source. Most meters registered water-use volume in acre-inches, although some meters reported water use in gallons and others reported in cubic feet.

Water-Meter Roll Back and Roll Forward

Water-meter roll back and roll forward affected some meter readings of annually reported irrigation volumes. Roll back occurs when the impeller of the water meter operates in reverse, causing the meter to operate backwards and the readings to decrease, or roll back. Several conditions in the irrigation system that could cause roll back include the following:

- Suction in the supply pipe that contains the meter, which is caused either by draining or backflow of an irrigation system following pump shutoff. Water flows back to the well causing higher potential head in the distribution pipe than in the well.
- Negative air pressure in a well because of aquifer dewatering, which pulls water from the supply pipe back into the well.

Annually reported meter data compiled for the Chattahoochee–Flint River basin during 2007 indicated a potential for up to 30 acre inches (ac-in) of roll back, eliminating at least 100 water-meter sites from the analyses (table 2). Roll back was assumed to have occurred in water meters that registered close to, or within 30 ac-in of, the maximum meter reading of 9,999.9 ac-in. The bulk of the water meters eliminated because of roll back (99 meters) registered up to 5 ac-in of roll back. The number of water meters registering roll back diminished after about 10 ac-in, and filtering for roll back in excess of 30 ac-in proved non-productive.

Table 2. Mean annual water-use calculations with filtered and non-filtered water-meter data, middle and lower Chattahoochee and Flint River basins, Georgia, 2007.

["Filter" indicates exclusion of specific meter data from analysis: "5, 10, 30" identify acre-inch thresholds for water-use data suspected of containing meter roll back]

Filter, in acre-inches		Mean of metered water use, 2007, in acre-inches (number in parentheses is number of sites)	
		Annually reported	Telemetry
None (non-filtered)		2,323 (4,059)	1,247 (76)
Zero usage		2,429 (3,882)	1,529 (62)
Roll-back analysis			
Filter in acre-inches	Meter reading greater than, in acre-inches	Mean of metered water use, 2007, in acre-inches (number in parentheses is number of sites)	
		Annually reported	Telemetry
5	9,995	1,760 (3,783)	1,529 (62)
10	9,990	1,752 (3,779)	1,529 (62)
30	9,970	1,745 (3,776)	1,529 (62)

Although somewhat easily detected in water meters that did not record water use during a growing season, the potential existed for roll back of up to 5 ac-in in all nonzero, annually reported meter readings. No roll back was detected in the telemetered data. Calculations that included annually reported water-meter data suspected of roll back resulted in a 38-percent overestimation of mean irrigation volume compared with similar calculations that eliminated (filtered out) water-meter readings suspected of roll back (2,429 ac-in compared with 1,760 ac-in; table 2).

Roll forward is the opposite of roll back and results in an erroneous meter reading that indicates a larger irrigation volume than actually was supplied by the metered irrigation system. Positive air pressure in the distribution line, possibly caused by rising groundwater levels after a pump is shut off, or seasonal (or regional) water-level rise could increase water-meter readings from actual water-use values. Clear detection of roll forward occurs when a water meter that has been initialized to zero indicates a small irrigation volume for an irrigation system that has not operated during the growing season. Roll forward of water-meter readings at non-use sites, though possible, did not affect water-use calculations significantly. Roll forward and roll back are difficult, if not impossible, to detect during the growing season at irrigated sites, as meter readings other than zero can be affected unknowingly by these phenomena.

Zero Water Use

Some water meters recorded zero water use (no water use) since the inception of the metering program during 2003. These zero water-use data when combined with non-zero water-use data decreased the value of the mean of metered irrigation volume calculated using annually reported and telemetered data (table 2). Retaining zero-usage values in calculations involving annually reported data resulted in a 4-percent reduction in mean-metered water use, compared with similar calculations with the zero-usage data removed or filtered out (2,429 ac-in compared with 2,323 ac-in). Calculations involving telemetered data that retained the zero-usage values resulted in an 18-percent lower estimate of mean water use, compared with a similar calculation with zero-usage data removed (1,529 ac-in compared with 1,247 ac-in). Sites with zero water use were eliminated from subsequent analyses.

T-Test of Water-Use Mean Values

Two-sample t-tests (Ideal Media, LLC, 2010), or simply t-tests, were performed to determine the effectiveness of the telemetered data, when summed for a growing season, to represent the annually reported data. The t-test addressed the question of whether the means of the telemetry and annually reported meter data represent the same population of water-use data. That is, are the means of the annually reported and telemetry data derived from the same population or different populations of water-meter data, and do the means vary by random chance? The true population mean is unknown, as it would include water use at unmetered sites as well as at metered (and telemetered) sites. The annually reported and telemetry data, therefore, represent two independent samples of water use from the population of metered and unmetered irrigation systems.

The null hypothesis addressed by the t-test states that the means of the annually reported and telemetry data are the same, implying that differences in values of the means occur by random chance, and that the means represent sample means of the entire population of water-use data in the Chattahoochee–Flint River basin. Accepting the null hypothesis implies that the mean of the telemetry network data effectively represents both the mean of the annually reported water-use data and the mean of the entire population of water-use data in the basin. The alternative hypothesis conversely states that the difference between the two means did not occur by random chance; rather, the different values represent sample means derived from two distinct populations. Accepting the alternative hypothesis implies that the mean of the telemetry network data does not effectively represent the mean of the annually reported water-use data, nor does it represent the mean of the entire population of water-use data in the Chattahoochee–Flint River basin.

Other objectives of the t-tests were as follows:

- Determine if the mean water-use volume derived from telemetered data (1,529 ac-in) is statistically different from the mean of the annually reported data (1,745 ac-in);
- Compare mean water-use volumes supplied by groundwater and surface water to determine whether groundwater and surface-water data can be analyzed as if derived from the same population, or whether separate analyses of two distinct populations are required; and,
- Determine if farmers use different application rates for groundwater and surface water—whether groundwater sites denote statistically distinguishable (higher or lower) application rates and volumes from those of surface-water sites.

T-test results indicated a 24-percent probability (p value equals 0.24, table 3) that the difference between the means of the annually reported data and the telemetry data occurred by random chance. That is, nearly a 1 in 4 chance exists of being wrong by rejecting the null hypothesis, which states that the means of annually reported data and telemetry data are the same, implying means are sample means of the same population. Conversely, there is a 1 in 4 chance that the means are not derived from the same population (accepting the alternative

Table 3. T-test results for mean metered water-use volumes from groundwater and surface-water sources obtained from telemetry and annually reported water meters, middle and lower Chattahoochee and Flint River basins, Georgia, 2007.

Data type	Annually reported mean	Telemetry reported mean	T-test results (probability, p)
	Acre-inches (number in parentheses is number of meters)		
Combined groundwater and surface water	1,745 (3,777)	1,529 (62)	0.24
Groundwater	1,817 (3,172)	1,675 (39)	.59
Surface water	1,365 (605)	1,282 (23)	.71

Data type	Ground-water mean	Surface-water mean	T-test results (probability, p)
	Acre-inches (number in parentheses is number of meters)		
Annually reported	1,817 (3,172)	1,365 (605)	0
Telemetry	1,675 (39)	1,282 (23)	0.24

hypothesis). The 0.24 probability exceeds the acceptable level of risk (5 percent, or $p = 0.05$) allowed for accepting the alternative hypothesis that the means represent two distinct populations. Therefore, the telemetry network represents a statistically valid and effective sample of the population containing the annually reported meter data, and both samples are derived from the same population of water-use data. No statistical difference exists between the means of the annually reported data and the telemetry data.

T-test results comparing means of metered water use by source indicated a 24-percent probability ($p = 0.24$) that groundwater and surface-water mean values derived from telemetry data vary by chance and zero probability ($p = 0$) that similar mean values derived from annually reported water-meter data vary by chance (table 3). That is, annual means of applied groundwater and surface-water irrigation volumes calculated by using annually reported meter data represent sample means from two different populations and require independent analyses. Conversely, annual means of applied groundwater and surface-water irrigation volumes calculated by using telemetry data represent sample means from the same population. For this comparison, well-to-pond irrigation systems were combined with groundwater systems to form one dataset, as the assumption was made that wells supplying ponds were pumped to meet irrigation demand.

On average during 2007, the annual metered irrigation volume supplied by groundwater per irrigation system in the middle and lower Chattahoochee and Flint River basins exceeded that supplied by surface water by about one-third (table 3). As stated previously (table 1), five times more metered groundwater systems (3,609) exist in this basin than surface-water systems (748); therefore, metered water-use data indicate that during 2007, groundwater supplied about 6.7 times the irrigation volume of that supplied by surface water (5×1.33).

No statistical difference was noted between the means of water-use calculated using annually read water-meter data and that derived from telemetry for each water source (groundwater and surface water). T-tests yielded high probabilities (59 percent for groundwater and 71 percent for surface water, table 3) that differences in the annual means of water use calculated by the different data networks (annually reported or telemetry) occurred by chance. That is, the telemetry networks for groundwater and surface water effectively represented the same population as corresponding annually reported networks of water meters. Therefore, telemetry and annually reported water-meter data are considered to represent (or sample) the same population of water-use data.

Although t-test results provide statistical validation that the telemetry networks for groundwater and surface water correspond with the same population of water-use data as that sampled from the annually reported water-meter data, mean water use calculated using telemetry-network data consistently underrepresented values calculated using annually reported water-meter data (tables 2, 3). Because the State stipulates that the primary purpose of the metering program is "to obtain clear and accurate information on the patterns and amounts of such [agricultural water] use" (Georgia General Assembly, 2003), geospatial analyses of water-meter data were conducted to identify irrigation patterns and distributions of meters in the annually reported and telemetered networks in an effort to identify the cause(s) for the telemetry network to underrepresent annually reported water use.

Geospatial Analyses of Agricultural Water-Meter Data

Geospatial analyses of telemetered and annually reported water-meter data in the middle and lower Chattahoochee and Flint River basins were performed to evaluate the distribution and randomness of meter locations and their values. The initial telemetry network, although a statistically valid sample of annually reported water-meter data, contained spatial deficiencies (described below) that prohibited the network from representing spatial patterns of agricultural water use as defined by annually reported water-meter data. Hot-spot and cluster and outlier analyses determined the distribution of telemetry sites with regard to annually reported water-meter sites and provided the basis for redesigning the current telemetry network in the middle and lower Chattahoochee and Flint River basins.

Hot-Spot Analysis

The hot-spot analysis, also known as Getis-Ord Gi* analysis (Environmental Systems Research Institute, Inc., 2009b), tested the occurrence of spatial clusters of high and low values of annually reported water use against the random occurrence of such data values. The Getis-Ord Gi* statistic defines a normal z score (or standard score), which is used to assess the distribution of the annually reported water-use values about the mean. Normally distributed z-score values contain a mean of 0 and a standard deviation of 1 (StatTrek.com, 2011). Significant z scores (less than [<] −1.64 or greater than [>] 1.65 standard deviations) of the Getis-Ord Gi* statistic occur in areas containing clusters of either high (positive z scores) or low (negative z scores) irrigation water-use volumes (fig. 3). Separate hot-spot analyses for groundwater and surface water indicated geographic bands of low-to-high agricultural water-use volume that trend northwest to southeast. The location of "hot spots" could relate to water availability in streams, variation in water-producing zones in aquifers, variations in soil type, rainfall variation, or crop distribution.

Cluster and Outlier Analysis

Cluster and outlier analysis, also known as Anselin Local Moran's I (Environmental Systems Research Institute, Inc., 2009a), was used to differentiate groups of annually reported water-use volume containing similar magnitude (clusters) from groups containing dissimilar or heterogeneous values (outliers). Clustering of similar or dissimilar values of annual irrigation volume provides insight into agricultural practices, possibly attributed to water availability from streams or aquifers, numbers of fields or irrigation systems monitored with a single meter, crop types, rainfall distribution, and (or) soil conditions. Clustering or outliers in annual irrigation volume can vary by growing season, and annually reported and telemetered water use can differ in the degree and sign of clustering from year to year.

A normalized z score was used to assess statistical significance of the cluster and outlier statistic, or Local Moran's I, in a similar manner as the z score described previously for the hot-spot analyses. Significant positive z scores (> 1.65 standard deviations) correspond with clusters of similar water use values; significant negative z scores (< −1.65 standard deviations) correspond with areas containing dissimilar values, or outliers (fig. 4). The distribution of significant z-score values derived from annually reported water-use data by source (groundwater and surface water; fig. 4) compared with the distribution of hot spots of annual water-use volume (fig. 3), indicated a concentrated distribution of telemetry sites in areas containing low annual irrigation water use. Although some telemetry sites monitor areas containing clusters of high irrigation water use (positive z scores, fig. 3), the telemetry sites generally underrepresented annually reported water-meter data associated with high water-use volume. This is evident in tables 2 and 3—mean water-use volume calculated with the telemetry network consistently underrepresented mean water-use volume calculated from annually reported water-meter data. Investigation of metered irrigation systems indicated that each telemetry site monitored water use for one irrigation system that served one field, in contrast with annually reported water-meter sites that monitor one or more irrigation systems serving one or more fields. Metered irrigation systems serving more than one field recorded higher water-use volume than telemetered systems, which monitored water use on a single field.

Cluster and outlier analysis in conjunction with hot-spot analysis exposed a shortcoming of the current telemetry network in representing the spatial distribution of the annually reported water-use data. Consistent underrepresentation of mean water-use volume by the current telemetry network indicates a need to better represent the spatial distribution of the annually reported water-use data with a revised telemetry network.

Normalization of Metered Water-Use Data

Normalization of metered water-use data mitigates the effects of design disparities between the annually reported and telemetry networks by factoring out (dividing) acreage from meter readings of water-use volume. Water use, therefore, is expressed as a per-acre irrigation depth (inches) instead of an irrigation volume (ac-in) following normalization. This procedure allowed for evaluation of the patterns and amounts of agricultural irrigation, independent of water source, acres supplied by each system, and volume pumped. Because of differences in the irrigation characteristics at the telemetry and annually reported sites, the groundwater and surface-water means of water-use volume derived from the telemetry network represented samples from a single population, and similar means derived from annually read meters indicated two distinct populations (table 3). Telemetry sites monitored irrigation at one field served by a single, metered water source in contrast to annually reported sites that monitored water use at one or more fields served by one or more metered water sources.

The number of irrigated acres supplied by each metered site affected the mean water-use volume calculated by using telemetered and annually reported water-meter data. Telemetry sites consistently underrepresented mean-irrigation volume (table 2), most likely because each site monitored water use from one irrigation system serving one field. Hot-spot and cluster and outlier analyses indicated a wide range of applied irrigation volume among annually reported metered sites.

The normalized, average irrigation depths for groundwater, surface-water, and well-to-pond metered systems during 2007–2010 indicated that groundwater-supplied fields, which include fields supplied by well-to-pond systems during 2010, received slightly more irrigation per acre than surface-water-supplied fields (table 4). The aggregate value of total metered irrigation volume was divided by total irrigated

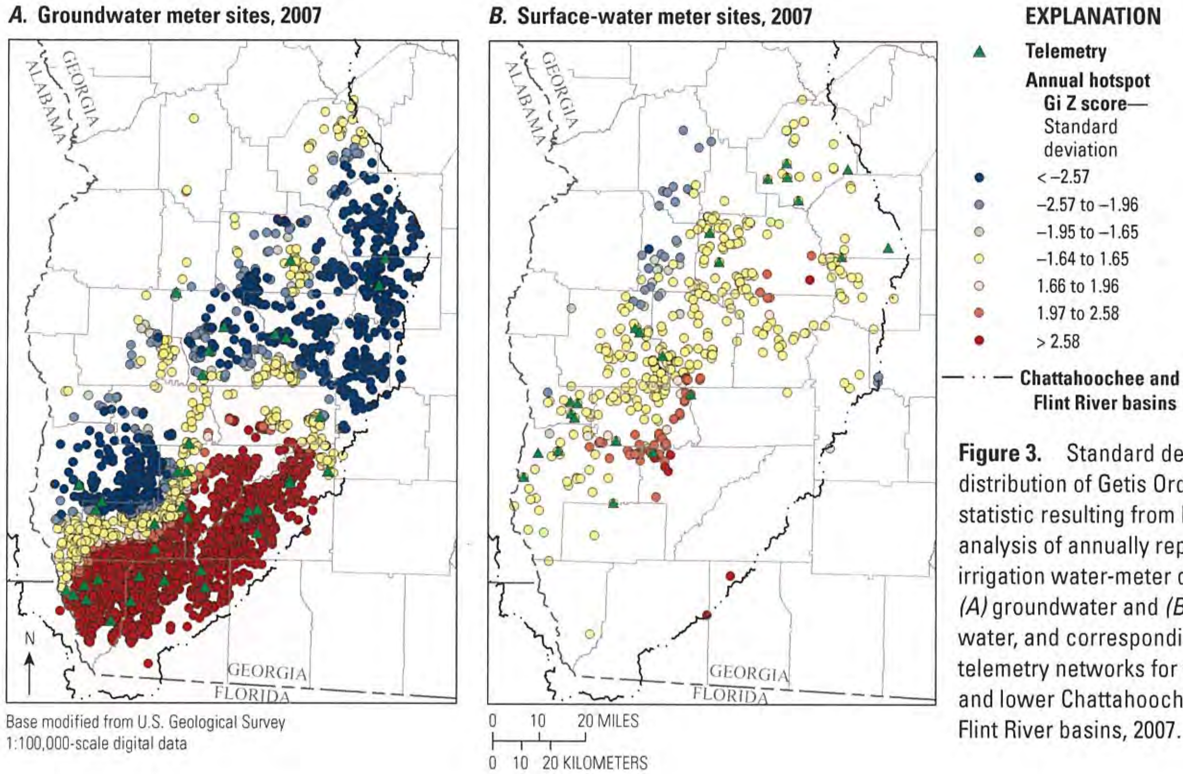


Figure 3. Standard deviation distribution of Getis Ord Gi* statistic resulting from hot-spot analysis of annually reported irrigation water-meter data for *(A)* groundwater and *(B)* surface water, and corresponding telemetry networks for the middle and lower Chattahoochee and Flint River basins, 2007.

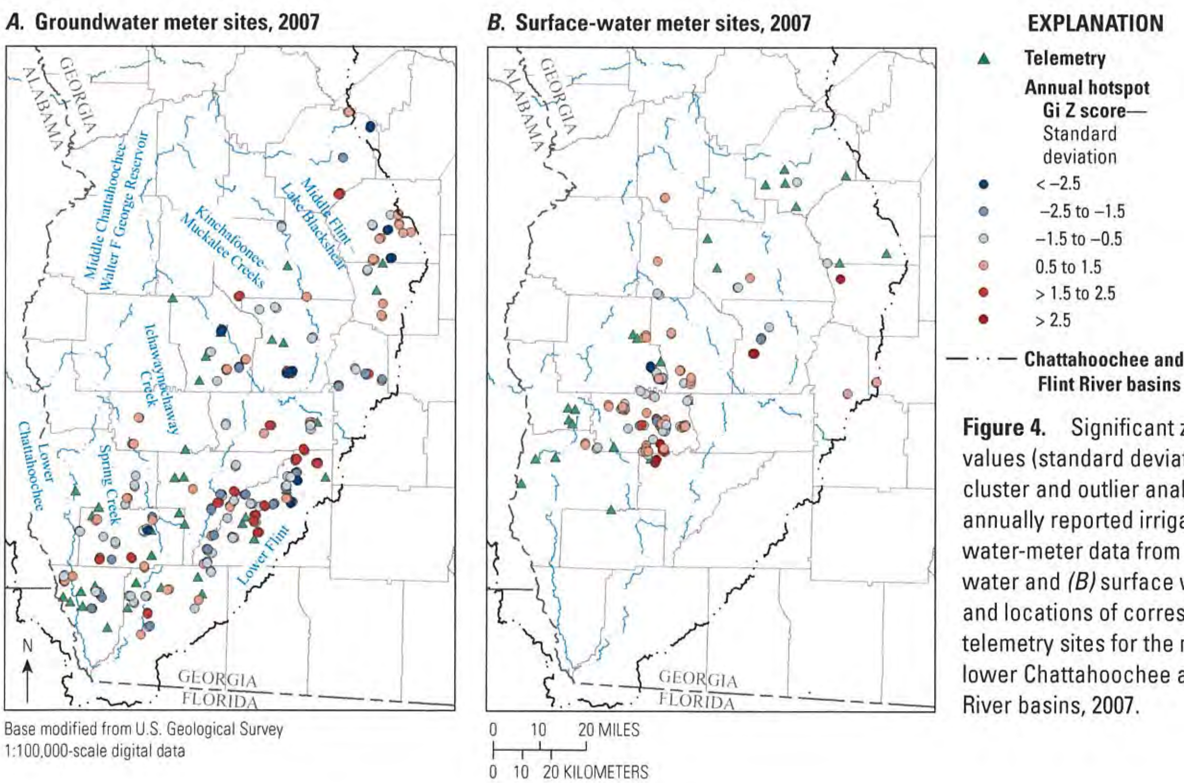


Figure 4. Significant z-score values (standard deviations) from cluster and outlier analysis of annually reported irrigation water-meter data from *(A)* ground-water and *(B)* surface water, and locations of corresponding telemetry sites for the middle and lower Chattahoochee and Flint River basins, 2007.

Table 4. Average irrigation depth at annually reported water-meter sites in the middle and lower Chattahoochee–Flint River basins in Georgia for the 2007–2010 growing seasons.

[N/A, not available]

Source type	Average irrigation depth, in inches, by growing season (number in parentheses is number of meters)			
	2007	2008	2009	2010
Groundwater	14.4 (2,299)	11.0 (2,134)	8.9 (2,069)	11.8 (2,687)[a]
Surface water	11.4 (651)	9.7 (534)	7.9 (510)	11.6 (474)
Well-to-pond	N/A	10.9 (579)	8.9 (580)	[a]

[a] Well-to-pond water-use data combined with groundwater data for average irrigation depth computation.

acres, respectively, for each year 2007–2010, to normalize the metered water-use data and obtain values of irrigation depth listed in table 4. Normalizing meter data by factoring out irrigated acres from the metered water-use volumes nearly eliminated the disparity between volumes of applied irrigation derived from groundwater and surface water (table 3). The normalized water-use data also confirmed the previous assumption that well-to-pond systems supply irrigation at rates similar to groundwater and, therefore, that the well-to-pond irrigation data can be combined with groundwater irrigation data for subsequent analyses. Surface-water availability, governed by the proximity of fields to streams and the amount of streamflow, could explain the remaining differences between irrigation depths supplied by groundwater and the depths supplied by surface water. Average irrigation depths during 2010 indicated an increase from the average irrigation depths during 2008 and 2009, most likely the result of relatively dry conditions during 2010 compared to conditions in 2008 and 2009. Groundwater and surface-water metered irrigation data were combined for further statistical and geospatial analyses.

Telemetry Network Redesign

Computations of mean-metered irrigation volume (table 3) indicated underrepresentation of irrigation volume with the current telemetry network, which has been in operation since 2007, thus demonstrating a need to redesign the telemetry network. Current telemetry network sites each monitored one irrigation system serving one field in contrast to most annually reported water-meter sites that monitored more than one irrigation system or served multiple fields. Normalization of metered water-use data eliminated spatial trends that were indicated with hot-spot and cluster and outlier analyses (figs. 3, 4). Geostatistical methods that evaluated the spatial-correlation structure of normalized, annually reported water-meter data (per-acre irrigation depths) were used to redesign the telemetry network as described in subsequent sections of this report. This revised telemetry network and additional geostatistical methods provided a basis for estimating irrigation water use for unmetered agricultural-irrigation systems.

Geostatistical Analysis of Metered Water-Use Data

Geostatistics (Matheron, 1971; Journel and Huijbregts, 1989) represent a "collection of techniques for the solution of estimation problems involving spatial variables" and employ a "systematic approach to making inferences about quantities that vary in space" (American Society of Civil Engineers Task Committee on Geostatistical Techniques in Geohydrology, 1990a, b). Such quantities vary as a function of spatial coordinates. Water-use estimates in southern Georgia rely heavily on metered and telemetered data consisting of applied irrigation volume; however, as demonstrated previously, spatial variability of water-use data precludes error-free estimation of water use everywhere, not only in areas containing unmetered agricultural systems. Geostatistics provides the tools to (1) calculate the most accurate water-use estimates based on well-defined criteria, measurements, and other relevant information; (2) quantify the accuracy of these estimates; and (3) select the parameters to be measured and determine where and when to measure them, given the opportunity to collect more data (American Society of Civil Engineers Task Committee on Geostatistical Techniques in Geohydrology, 1990a, b).

Geostatistical techniques—autocorrelation or variogram analysis, interpolation (kriging), and cross validation—were applied to the normalized, metered water-use data for the middle and lower Chattahoochee and Flint River basins during the 2007 growing season to

- Evaluate the spatial-correlation structure and regional distribution of annually reported water-meter data, yet preserve local variations of per-acre irrigation depth;
- Revise the 2007 telemetry network using the spatial-correlation model of water use developed from the normalized annually reported meter data, expressed in inches; and
- Quantify and reduce estimation error associated with representing annually reported water-meter sites with a telemetry network, thereby increasing the effectiveness of the telemetry network.

Semivariance: Overview

Water-use data (Z) are spatially correlated based on the separation distance (h) between pairs of data (z_i and z_{i+h}, which are elements of Z) and their difference ($z_i - z_{i+h}$), where "i" indexes each meter. Semivariance, $\gamma(h)$, accounts for the difference in meter values between data pairs ($z_i - z_{i+h}$) located within a distance-class interval h for all $N(h)$ data pairs in the distance class as

$$\gamma(h) = \frac{\sum_{i=1}^{N}(z_i - z_{i+h})^2}{2N(h)}$$

(American Society of Civil Engineers Task Committee on Geostatistical Techniques in Geohydrology, 1990a).

Each distance class h contains semivariance data for all data pairs in the class. A plot of data pairs and corresponding variance values for a specific distance class constitutes a variance cloud and indicates the dispersion of the differences in annual water-use values and corresponding separation distance among data pairs in the distance class. For example, the variance cloud for normalized annually reported water-meter data having a distance class of 450 meters (m; fig. 5) indicates a closely grouped distribution of $\gamma(h)$ values less than about 1.7. Outliers plot away from the clustered $\gamma(h)$ values in the variance cloud and can negatively affect the correlation structure of water-use data by skewing the average $\gamma(h)$ value corresponding with the distance class. The plot of average semivariance by average separation distance for each distance class constitutes the experimental semivariogram, which gives a measure of the spatial correlation structure of the water-use data, as discussed in the following section.

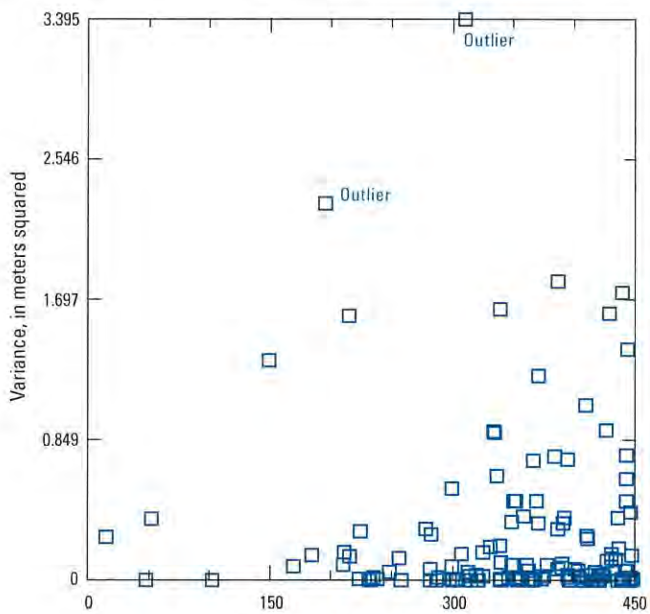


Figure 5. Variance cloud within separation distance of 450 meters derived from normalized annually reported water-meter data in the middle and lower Chattahoochee and Flint River basins for the 2007 growing season.

Semivariogram Development and Geostatistical Estimation: Structural Analysis

A prerequisite to geostatistical estimation of normalized annually reported water-meter data involves assessment of the statistical structure (structural analysis) of the data. The first two statistical moments of the data, namely the mean and covariance (or the semivariogram), constitute the statistics of interest during structural analysis (American Society of Civil Engineers Task Committee on Geostatistical Techniques in Geohydrology, 1990a). The semivariogram consists of a plot of the average semivariance for each distance class (derived from variance clouds, fig. 5) by average separation distance in the class. The resulting plot (symbols, fig. 6) represents the spatial-correlation structure of annually reported water-use data, termed the *experimental semivariogram* or *variogram*. Judicious selection of distance classes yielded a strong correlation structure of water-meter data with distance. A commonly used graphical method for structural analysis consists of fitting a function to the experimental semivariogram to produce a variogram model. An exponential function (exponential variogram model) fits the experimental semivariogram derived from the normalized, annually reported water-use data (fig. 6; American Society of Civil Engineers Task Committee on Geostatistical Techniques in Geohydrology, 1990a).

The exponential variogram model indicates strong spatial correlation among water-meter data where the model is curved; that is, for water-meter sites separated by less than about 2,000 m, or about 1.3 miles (mi; fig. 6). Conversely, no spatial correlation exists between water-meter data separated by more than 2,000 m, which is where the model becomes nearly horizontal. This distance (2,000 m) defines the *range* of correlation for the model. Correlation structure cannot be resolved in water-use data separated by more than about 2,000 m. Consequently, semivariance and the experimental semivariogram is nearly constant beyond this distance. The variogram model could be used in an interpolation process to estimate annual water use at unmetered sites located within about 2,000 m, or about 1.3 mi, of annually reported water meters.

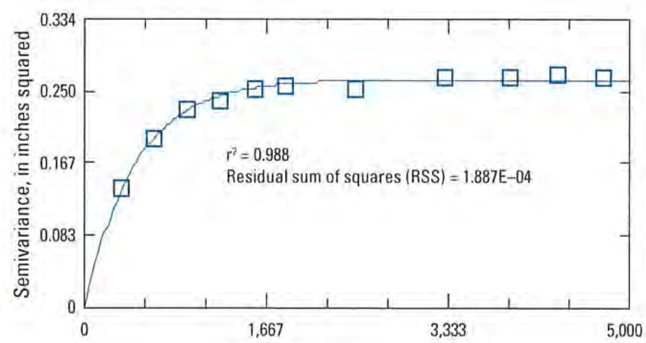
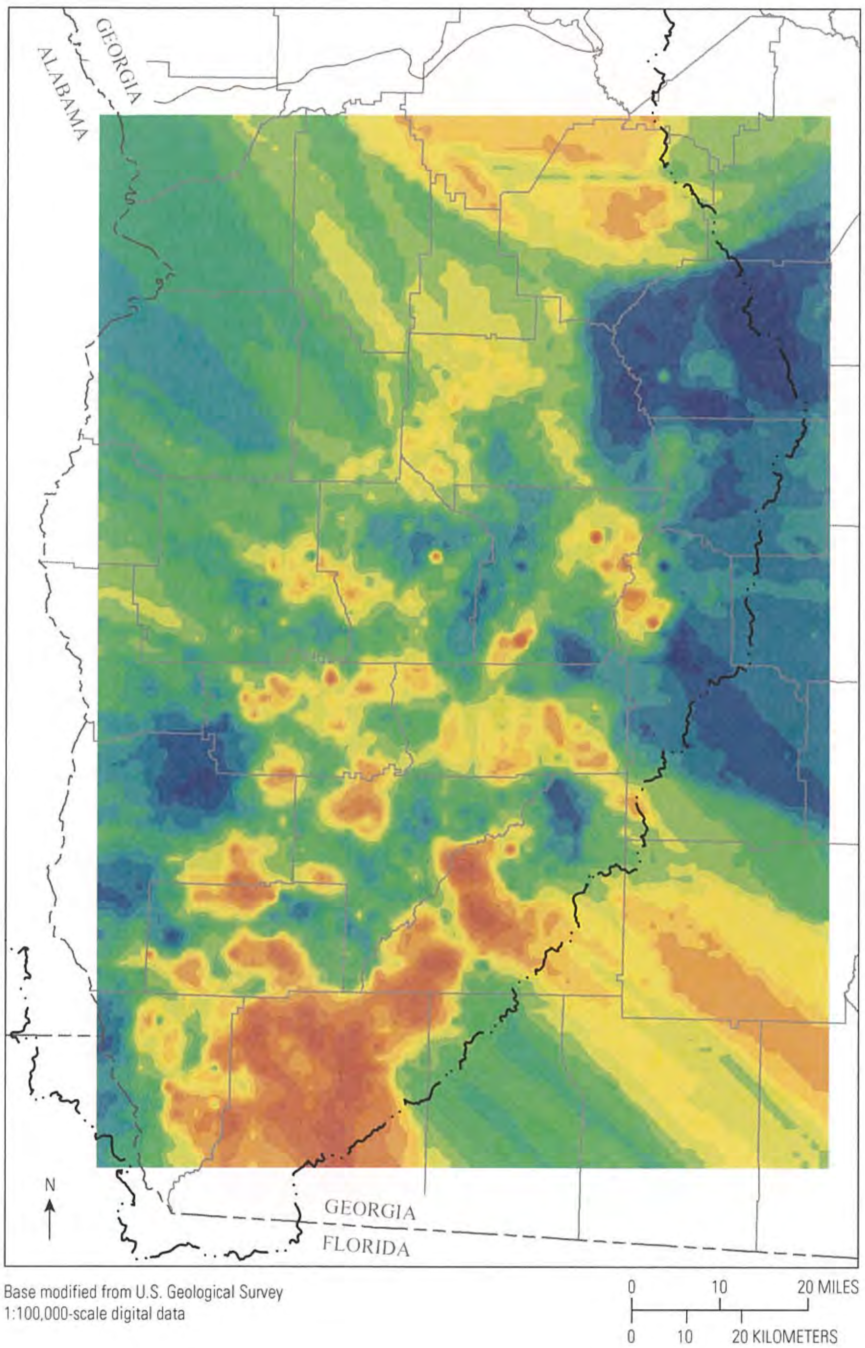


Figure 6. Variogram model derived from normalized, annually reported water-meter data in the middle and lower Chattahoochee and Flint River basins for the 2007 growing season.

Linear Interpolation of Water-Use Data: Kriging

Linear interpolation uses the underlying spatial-correlation structure of the data (variogram model, fig. 6) to estimate expected values of a spatial variable (such as the normalized annual water-meter data) as a weighted sum of the measured data in areas where no measurements have been made. Kriging provides unbiased estimates for the expected values of the spatial variable as a weighted sum of the measured data having minimum estimation variance (American Society of Civil Engineers Task Committee on Geostatistical Techniques in Geohydrology, 1990a).

Kriged estimates of normalized annual irrigation water-meter data indicate a diverse distribution of per-acre water-application rates (or irrigation depth, in inches) in the middle and lower Chattahoochee and Flint River basins (fig. 7). Kriged estimates of per-acre irrigation rates were computed at intersections of a regular grid of 77 rows by 111 columns, or at 8,547 locations in the basin. Each grid block represents a 1,740-m square.



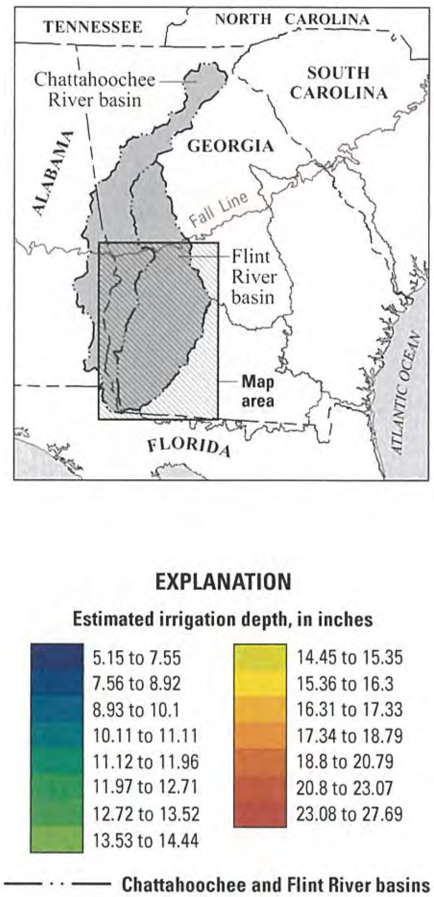


Figure 7. Kriged estimates of normalized annually reported water-meter data in the middle and lower Chattahoochee and Flint River basins for the 2007 growing season.

Evaluating Effectiveness of Variogram Model and Kriging: Cross Validation and Estimation Variance

Cross validation provides a means to evaluate the semivariogram model and parameter selection used in kriging. Cross validation consists of systematically (independently) estimating water use at each annually reported meter location using kriging. This is accomplished by removing measurements associated with annually reported water meters one at a time and estimating the corresponding values with successive applications of the semivariogram model through the kriging process. A plot containing the most accurate (best) 200 estimates of annually reported water use and corresponding meter data for the middle and lower Chattahoochee and Flint River basins demonstrates the effectiveness of the variogram model and kriging to represent the actual data (fig. 8). Water-meter locations associated with these estimates provide the basis for redesigning the telemetry network, discussed in a subsequent section of this report.

The "regression coefficient" identified at the bottom of the graph (fig. 8) represents a measure of the goodness of fit for the least-squares model describing the linear regression equation. A perfect 1:1 fit (without error) would have a regression coefficient (slope) of 1.00, and the best-fit line (solid line) would coincide with the dotted 45-degree line on the graph.

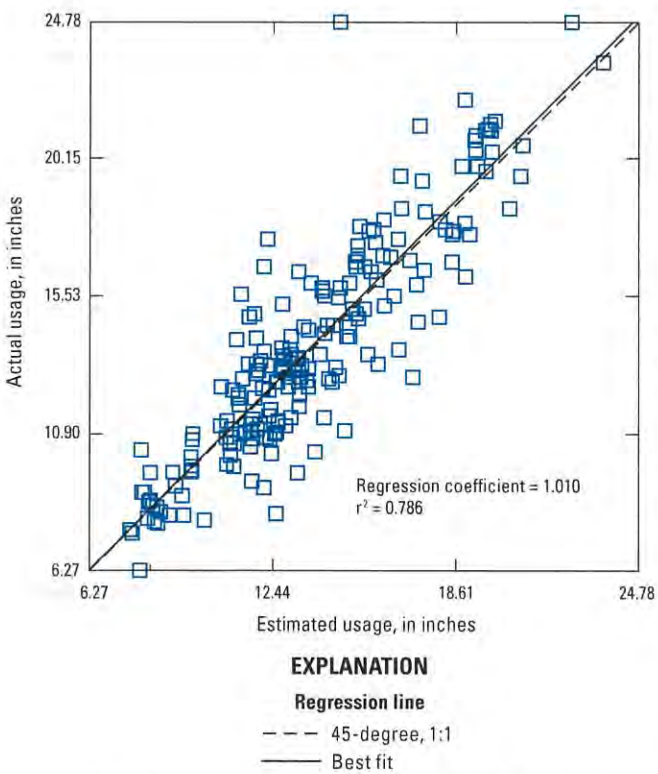


Figure 8. Cross validation of kriged estimates of normalized annual water-meter data in the middle and lower Chattahoochee and Flint River basins for the 2007 growing season.

The standard error (SE = 0.037) refers to the standard error of the regression coefficient (Robertson, 2008) and gives a measure of the amount of sampling error in the regression coefficient; that is, the standard deviation of the regression coefficient (McGraw-Hill, 2003; Siegel and Shim, 2005).

The r^2 value (0.786, fig. 8) gives the proportion of the total variation in normalized annual irrigation water-meter data explained by the regression. It is the square of the sample correlation coefficient, or the coefficient of determination, commonly expressed as R^2. The coefficient of determination indicates a strong correlation (0.887) between the estimates and actual measurements of irrigation water use. The coefficient of determination gives the proportion of variability around the mean, as explained by the regression (in this case 78.6 percent; Montgomery and others, 2006). The y-intercept of the best-fit line also is provided. The SE prediction term is defined as standard deviation (SD) $\times (1 - R^2)^{0.5}$, where the SD corresponds to the actual data (graphed on the y-axis; Robertson, 2008).

A variance map (fig. 9) illustrates the spatial distribution of estimation error inherent to the kriged values of annual water use calculated at locations on the estimation grid of 8,547 points. These variances give a measure of the accuracy of the kriged estimates, which have been shown to be more accurate than estimates associated with the arithmetic mean. The kriged estimates differ substantially from the arithmetic mean, however, and are more consistent with the observed spatial variability than the variability of estimates derived from using arithmetic means (American Society of Civil Engineers Task Committee on Geostatistical Techniques in Geohydrology, 1990a).

Developing a Revised Telemetery Network: Two Approaches using Kriging

The plot of estimated and measured annually reported water-meter data derived from cross validation (fig. 8) provides a means of selecting sites for revising the telemetry network. Plotted values close to the regression line represent the most accurate estimates of normalized annually reported water use; the distribution of the plotted values in the basin can serve as potential sites for a revised telemetry network. The range of spatial correlation associated with the variogram model (fig. 6) that yielded these estimates, however, extended about 2,000 m (about 1.3 mi).

A second approach to revising the telemetry network involves semivariogram analysis using the 200 most accurate water-use estimates derived from cross validation (fig. 8). The resulting variogram model (fig. 10) indicated a spatial correlation distance (or range) of about 59,000 m (about 37 mi), or about 30 times the range associated with the variogram model originally developed using the entire dataset of annually reported water-meter data (fig. 6). Values of the regression parameter ($R^2 = 0.997$) and residual sum of squares (RSS = 1.248E−05) indicate an excellent fit of the variogram model to the annually reported water-meter data.

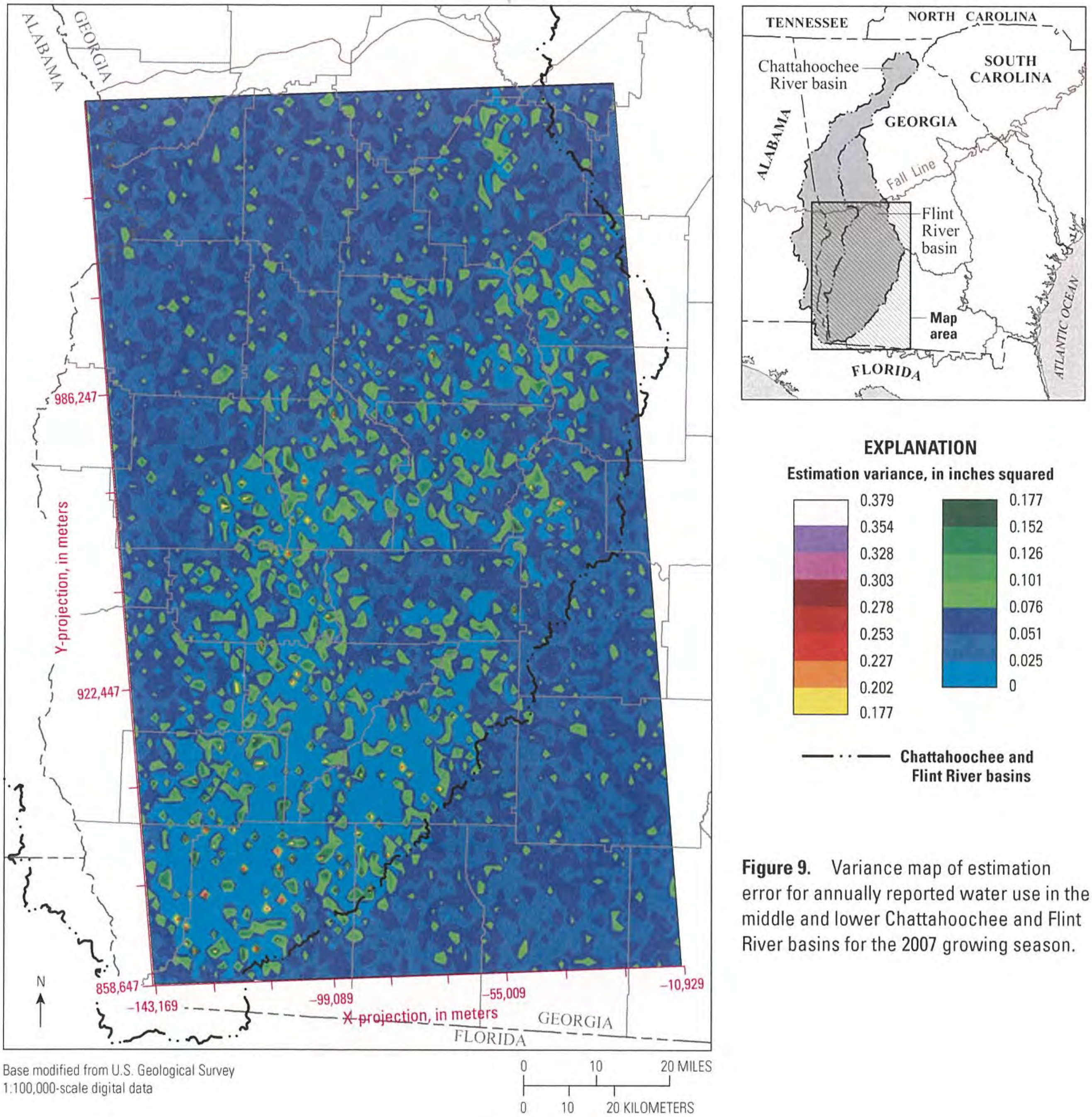


Figure 9. Variance map of estimation error for annually reported water use in the middle and lower Chattahoochee and Flint River basins for the 2007 growing season.

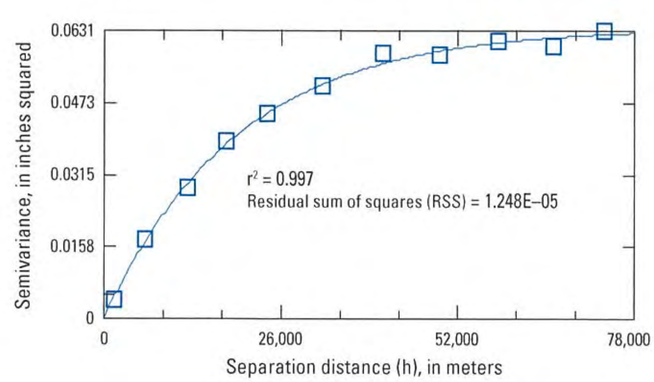


Figure 10. Variogram model resulting from cross validation of annually reported water-meter data from the middle and lower Chattahoochee and Flint River basins for the 2007 growing season.

Estimation-Variance Reduction and the Revised Telemetry Network

The process that repeated the semivariogram development, kriging, and cross validation of normalized annually reported water-meter data using the "best" 200 values from cross validation, as described in the previous section, extended the range of correlation of estimated water-use values to about 37 mi, compared with the 1.3-mi range derived from application of these geostatistical methods to the entire set of annual water-meter data. Using the extended-range semivariogram model as a starting point to the development of the new telemetry network, a second semivariogram model was developed based on the best 100 estimates of annual water use.

Estimation-variance maps derived from semivariogram models using the best 200 values from cross-validation results—that is, the values plotting closest to the regression line in figure 8—and from a second step of semivariogram development, kriging, and cross validation using the best 100 values provided graphical evidence of the reduction in estimation variance attained by the respective semivariogram models (fig. 11). Dark-red to dark-orange colors indicate relatively low estimation variance compared to medium-orange to yellow colors, which indicate relatively high estimation variance. Coalescence of the dark-red to dark-orange colors on the variance map for the best 100 points (fig. 11*B*) compared with the variance map for the best 200 points (fig. 11*A*) indicates a reduction of estimation variance within the distances separating estimation points. These plots demonstrate the utility of geostatistical methods in providing accurate, spatially correlated estimates of water-use in unmetered areas and in developing a telemetry network from the annually reported water-meter network that contains the spatial correlation structure of the annually reported water-meter data.

The revised telemetry network for the middle and lower Chattahoochee and Flint River basins contains a subset of 60 sites from the best 100 points model (fig. 12). Design criteria considered during selection of the 60 sites included (1) number of sites requested by the Commission (60) for the revised network; (2) spatial distribution that avoids clustering and underrepresentation in the basin; and (3) spatial correlation structure of the telemetry network derived from the structure of the annually reported water-meter network.

Comparison of the current and revised telemetry networks in the middle and lower Chattahoochee and Flint River basins (figs. 12, 13) indicates a complete redesign of the current network, which has been operating since 2007; no current telemetry network sites were retained in the revised telemetry network. Sites in the revised telemetry network are dispersed as uniformly throughout the basin as the annually reported water-meter network would allow. The revised telemetry network sites do not exhibit clustering, as occurred in the current telemetry network distribution. Design of the current telemetry network followed an algorithm developed by Fanning and others (2001) for estimating irrigation water use in southern Georgia and used a stratified random sampling of permitted irrigation sites, termed *Benchmark Farms Study sites*.

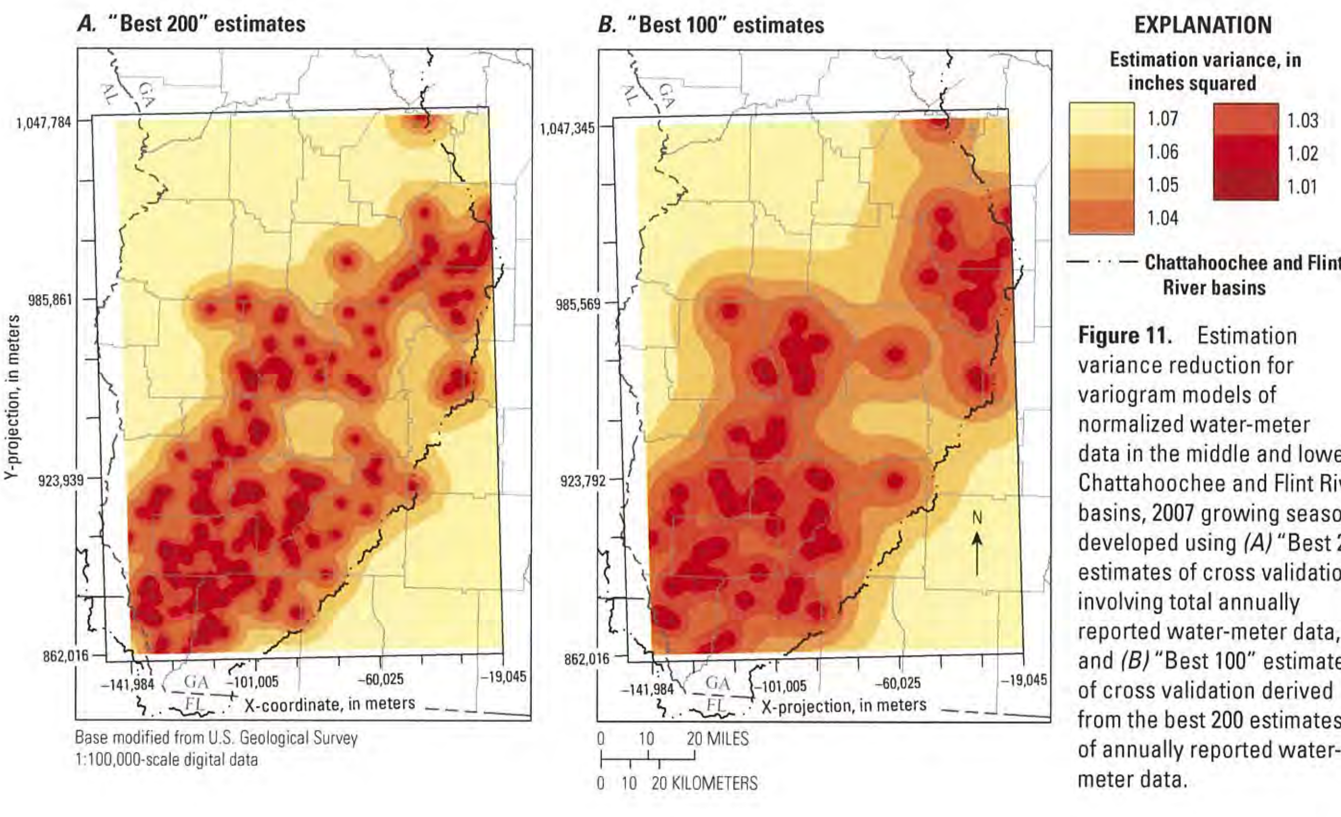


Figure 11. Estimation variance reduction for variogram models of normalized water-meter data in the middle and lower Chattahoochee and Flint River basins, 2007 growing season, developed using *(A)* "Best 200" estimates of cross validation involving total annually reported water-meter data, and *(B)* "Best 100" estimates of cross validation derived from the best 200 estimates of annually reported water-meter data.

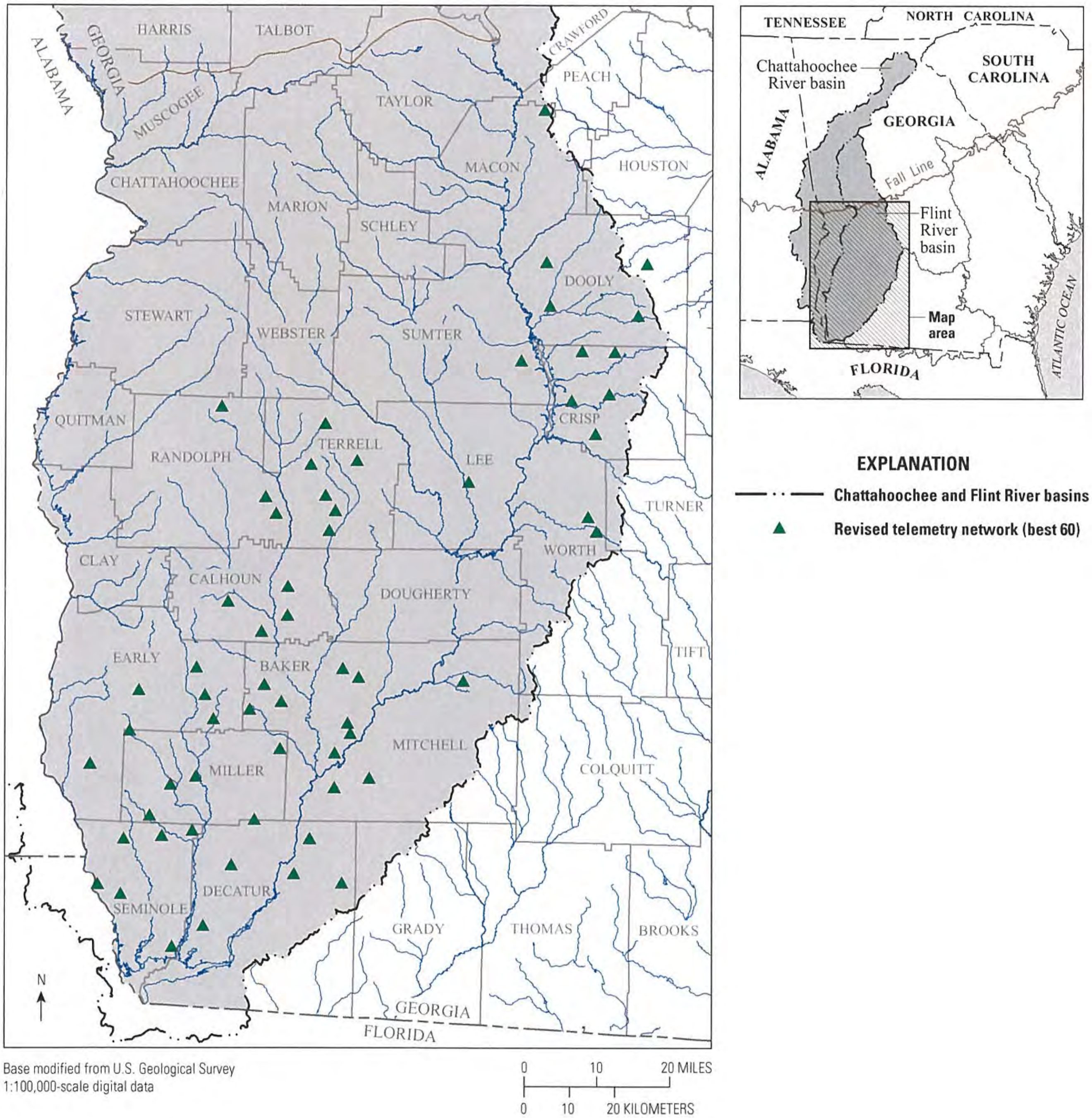


Figure 12. Revised telemetry network for daily water-use data collection and satellite transmission in the middle and lower Chattahoochee and Flint River basins.

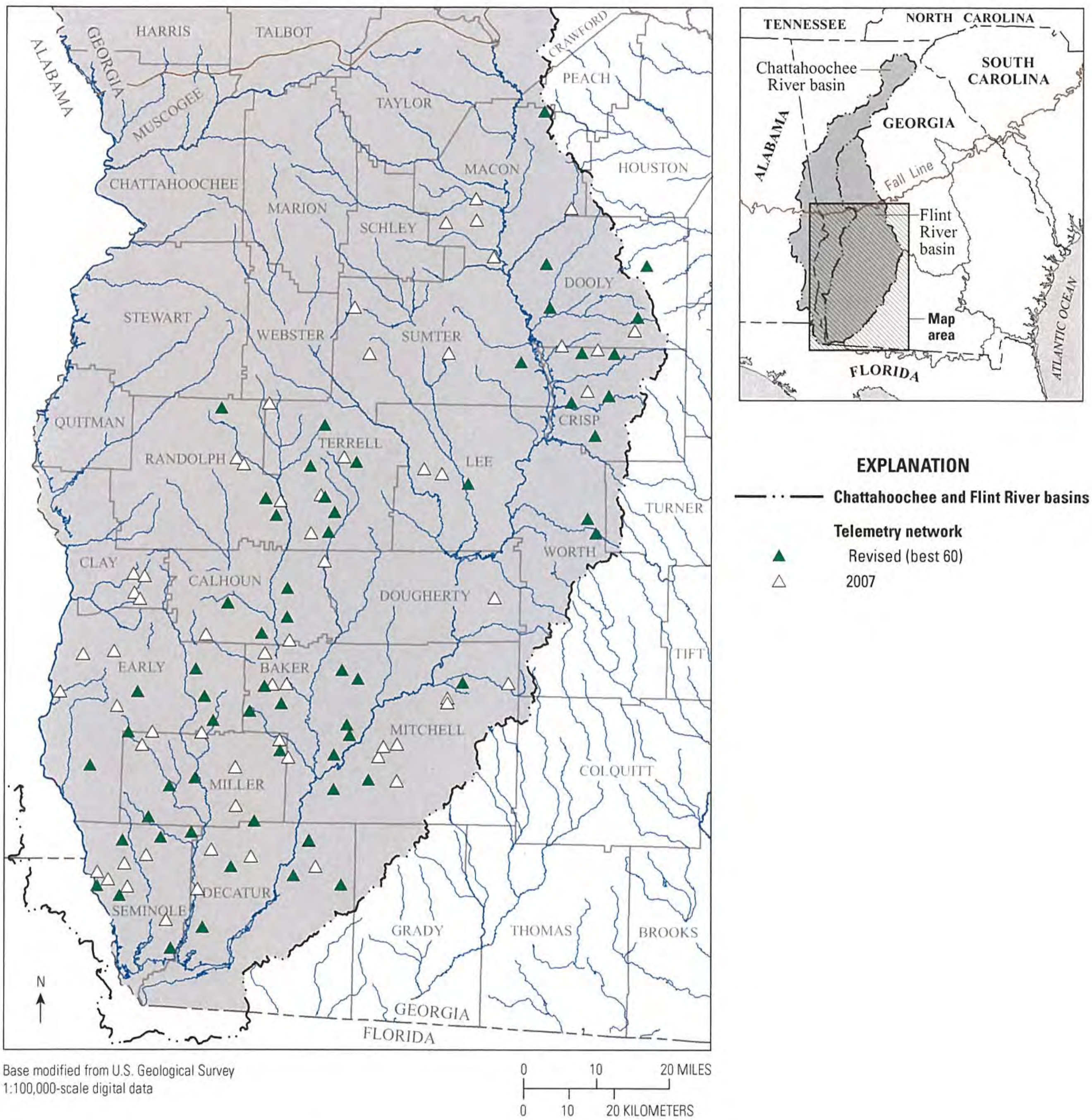
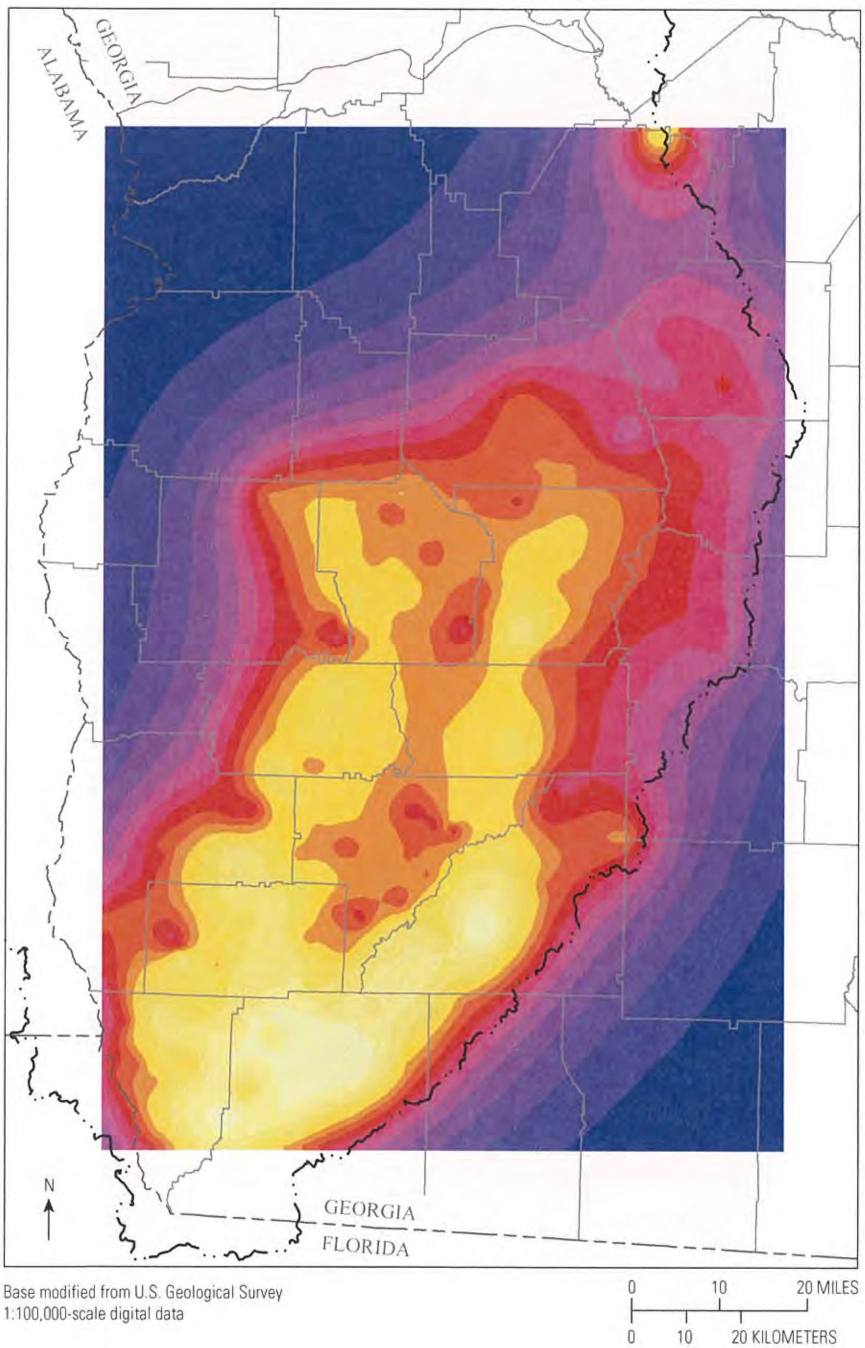


Figure 13. Revised and 2007 telemetry networks for daily water-use data collection and satellite transmission in the middle and lower Chattahoochee and Flint River basins.

Interpolation of Unmetered Water Use by Conditional Simulation

Despite the State's legislative mandate in HB571, which required metering of all irrigation systems, many unmetered systems still exist for which water-use estimates are needed. Conditional simulation involving the variogram model provided estimates of water use for these unmetered irrigation systems. Conditional simulation honors the values of the annually reported water-meter data at each site and uses the spatial correlation structure expressed in the variogram model to estimate values of water use in unmetered areas. Unlike kriging, which smooths out local variations in water use, conditional simulation preserves the spatial complexity and heterogeneity of the water-use data within short distances (fig. 14).

A method to obtain estimates of irrigation depth per acre for unmetered irrigated acres would involve associating the map showing estimates of normalized annually reported water-meter data (irrigation depth in inches, fig. 14) with maps showing unmetered irrigated acres. Knowing the acreage and estimated per-acre irrigation depth of each unmetered irrigated field provides a means of calculating annual irrigated water-use volume.



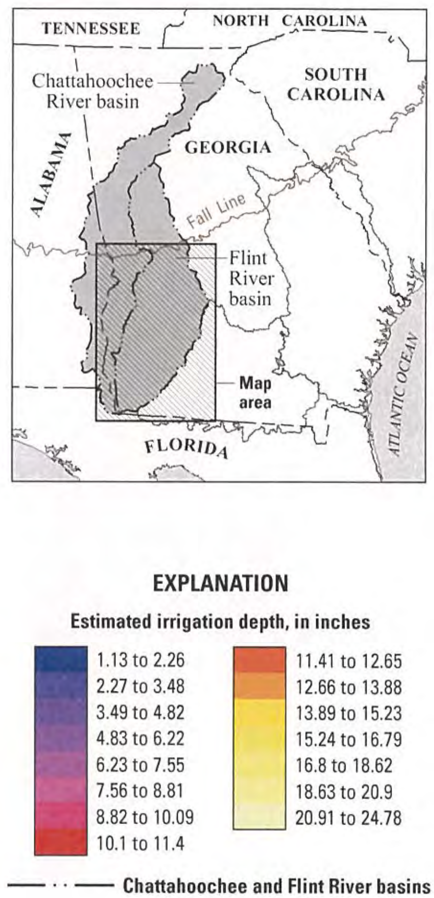


Figure 14. Conditional simulation of normalized annually reported water-meter data in the middle and lower Chattahoochee and Flint River basins for the 2007 growing season.

Importance of Geospatial and Geostatistical Analysis to Agricultural and Water Management in Georgia and the Nation

Geospatial and geostatistical analysis provides an enhanced understanding of the spatial relations among water-meter locations and estimated water use. A revised telemetry network enables more accurate determinations of annual and seasonal water withdrawals than are available with the current telemetry network. The following attributes and applications of the revised telemetry network demonstrate its value for agricultural and water management in Georgia:

- Provides the Commission and agricultural community with data on growing season irrigation rates in near real time. Such information can be used for agricultural management of water resources and for implementing alternative water-management strategies in near real time in the basin.

- Provides a water-use stress component to aid resource managers with decisions to implement the Flint River Drought Protection Act (FRDPA; Georgia General Assembly, 2000). Provisions of the FRDPA state that the director of the Georgia "Environmental Protection Division of the Department of Natural Resources shall each year predict whether drought conditions are likely in the Flint River basin; to provide for an irrigation reduction auction; to provide that certain persons holding water withdrawal permits may offer to cease irrigating a number of acres in exchange for a certain sum of money; to provide for the acceptance of bids; to provide for an order requiring certain permit holders to cease or reduce irrigation…." In support of provisions to the FRDPA, the revised telemetry network could assist in identifying streamflow sensitivity to agricultural pumping. Maps showing such sensitivity could provide an objective, hydrologic basis for accepting auction bids that minimize acreage removed and groundwater-level decline (drawdown) while maximizing streamflow and cost savings in auction awards.

- Uses correlation structure of the telemetry network to estimate growing season pumping rates at annually reported water-meter sites from which the revised telemetry network was derived. These calculations could validate irrigation projections for future years *during the growing seasons that the irrigation data are collected.*

- Assists soil and crop scientists with defining water-use patterns related to soil type, moisture retention, and cropping.

- Provides an unprecedented collection of real-time, spatially correlated water-use data that can be leveraged for future research endeavors related to climate change and developing causal relations between irrigation, climate, soil type, water availability, and soil moisture.

- Provides a tool for assessing agricultural and resource potential for various crop choices that enhance agricultural production and improve the State's energy, water, and financial resources.

The Federal interest in evaluating the Nation's water resources and the potential for water-resources development by agriculture and other entities could be served at local and regional scales nationwide through cooperative programs of comprehensive water-use monitoring and geospatial analysis such as described herein. The near-total coverage of irrigation systems monitored with water meters in southern Georgia and the methods and analyses presented herein have nationwide application to agricultural communities in need of assessing water use and identifying cause-and-effect relations between agricultural water-use stress and hydrologic-system response. Although possible to apply the methods described to other agricultural settings across the Nation, the success of such application would be limited only by the ability of those agricultural settings to provide a representative water-use monitoring network as provided by the Commission through the Georgia Agricultural Water Conservation and Metering Program. A lack of comprehensive water-use-data collection and managing infrastructure limits the usefulness and benefits of geospatial analysis in areas where agricultural water-use data are relatively sparse.

Ongoing and Planned Data Analysis

Ongoing and planned analysis of metered and telemetered agricultural-irrigation data include application of geostatistical techniques to relate water use to crop patterns, groundwater and surface-water availability, soil moisture, and rainfall variation in the middle and lower Chattahoochee and Flint River basins. Other applications of geostatistical techniques could enable estimation of growing season pumping rates at the annually reported water-meter sites.

An interactive, on-line accessible map of the middle and lower Chattahoochee and Flint River basins is planned to show a compilation of water-meter data by counties and sub-basins and to provide estimates of growing season pumping rates at unmetered and metered agricultural locations derived from geostatistical modeling. This map is intended to provide scientifically based information on agricultural water use that can be used as a tool for assessing how climate, crop patterns, and soil moisture affect growing season pumping rates; such a tool is essential for informing farmers and water managers about water use, crop selection, and the effects of climate and pumpage change on groundwater and surface-water resources.

The effectiveness of telemetry networks in the coastal region and central-south Georgia (figs. 1*C* and 1*D*, respectively) could be evaluated by applying a regimen of geospatial analysis to annually reported and telemetered water-use data in a manner similar to that applied to water-use data in the middle and lower Chattahoochee and Flint River basins. Conditional simulation using a geostatistical process similar to that described herein could identify gaps and redundancies in the telemetry network that could be rectified through elimination of some sites and deployment of others elsewhere in the basins to reduce estimation variance and improve estimates of growing season pumping rates.

Summary and Conclusions

The following conclusions address previously stated objectives of the U.S. Geological Survey investigation of irrigation data collected by the Georgia Soil and Water Conservation Commission in accordance with and support of the Agricultural Water Conservation and Metering Program. Study objectives are listed below in italics and precede each corresponding conclusion.

Develop a quality-assurance program to ensure completeness and internal consistency of water-meter data. A quality-assurance program consisting of geospatial and non-geospatial statistical methods proved invaluable in verifying the accuracy of metered water-use values and the integrity of the water meter itself to accurately record irrigation water use. Without these statistical evaluations, inconsistencies in reporting irrigation water use would have gone unnoticed and (or) confounded summary statistics of metered water use. Roll back detected at zero-irrigation water-use sites demonstrated the potential to cause up to a 40-percent overestimation of metered, annually reported, irrigation water use. Zero-value meter readings (without roll back) affected annual water-use calculations by only a few percent, and roll forward had a negligible effect on water-use calculations. Cluster and outlier analyses, and hotspot analysis, enabled identification of sites containing potential metering error and of locations where the telemetry network misrepresented the annually reported meter data.

Calculate descriptive statistics of aggregated water-use data. Calculation of mean water-use volumes for the annually reported and telemetry meter networks indicated consistent underrepresentation of the mean by the telemetry network data, despite t-tests that indicated the annually reported and telemetry network data represent valid samples from the same population of irrigation systems in the study area. Normalization of metered water-use data effectively removed the telemetry network bias that resulted in the telemetry data reporting less irrigation water use than reported with the annually reported meter data. Factoring out irrigated acres from the metered-volume data allowed water use to be expressed as an irrigation depth and allowed combining meter data from both networks (annually reported and telemetry) and water sources (groundwater and surface water) for analysis.

Evaluate the potential to relate daily water-use telemetry (telemetered data) to annually reported water-use data through a descriptive statistical model. Descriptive statistics of metered water use indicate a high potential to relate annually reported water-use data to telemetered data, which had been summed to represent annual irrigation volumes. T-tests validated each metering network as representative samples of the entire population of irrigation systems. Geostatistical analyses strengthened the relation between annually reported and telemetered irrigation water-use data by yielding a spatially correlated model of annually reported metering data from which a revised telemetry network was derived. The revised telemetry network, in turn, could be used to define growing season irrigation depths at locations of annually reported water meters.

Identify spatial and temporal distributions of agricultural-irrigation pumpage. Geospatial methods of cluster and outlier analysis, and hot-spot analysis, identified a northwest-to-southeast trend of low-to-high metered irrigation volumes that could signify relations of irrigation volume to water availability, climatic variability, soil-type variation, and cropping patterns. Geostatistical analyses identified a strong spatial-correlation structure within the annually reported water-meter data that could be used to estimate irrigation water use at unmetered agricultural sites. Cross validation and conditional simulation with the geostatistical model demonstrated the robustness of the method to estimate annual irrigation water use with minimal estimation error. A revised telemetry network based on the geostatistical model of the annually reported water-meter data provided the basis for estimating irrigation depths during the growing season at metered and unmetered irrigation sites.

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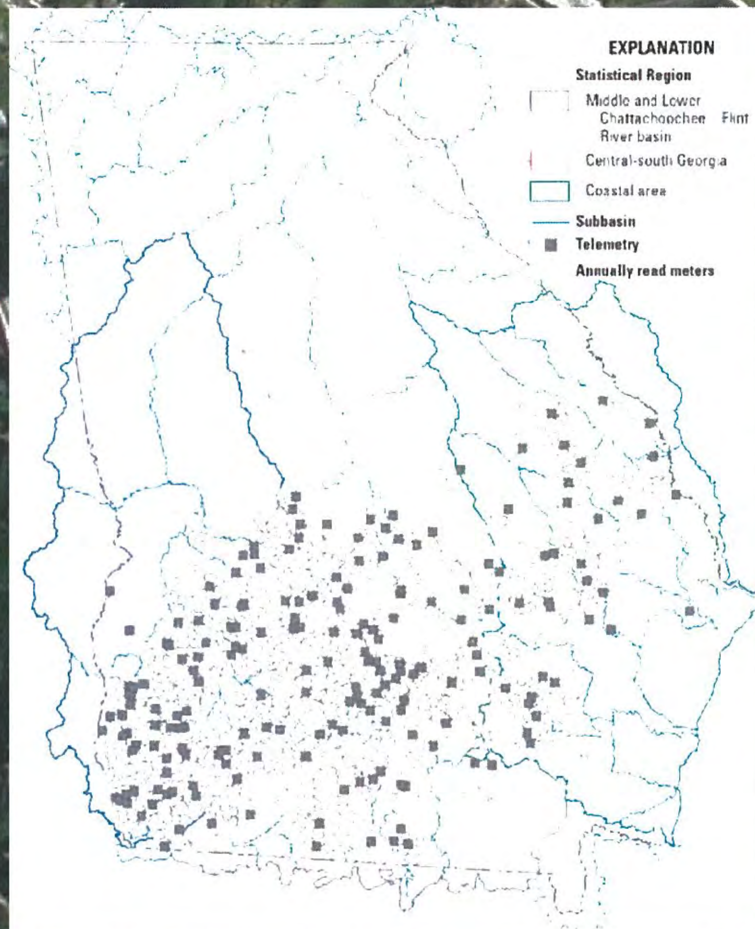
Torak and Painter—**Summary of the Georgia Agricultural Water Conservation and Metering Program and Evaluation of Methods Used to Collect and Analyze Irrigation Data for the Middle and Lower Chattahoochee and Flint River Basins, 2004–2010**—Scientific Investigations Report 2011–5126

Exhibit 65

The Georgia Agricultural Water Conservation and Metering Program—Summary 2004–2010

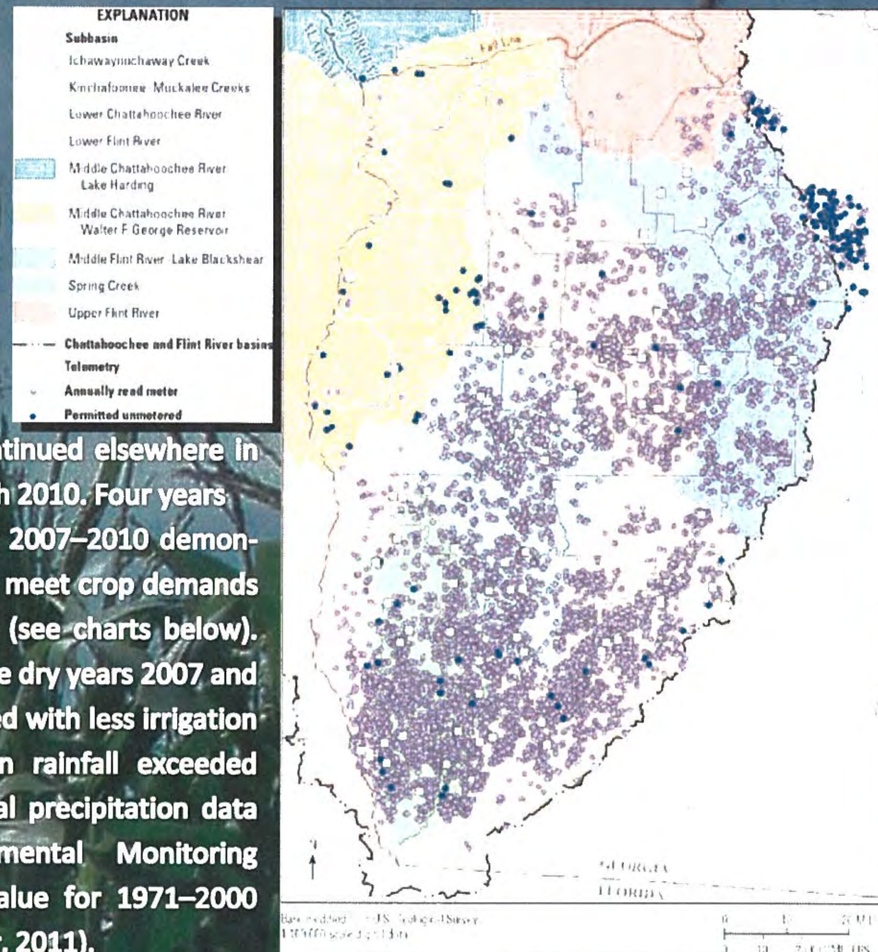
Since the winter of 2003-2004, the Georgia Soil and Water Conservation Commission (GSWCC) has installed more than 10,000 water meters on agricultural irrigation systems in Georgia (see figure to right). Mandated by Georgia House Bill 579, signed into law on June 4, 2003, GSWCC is responsible for *"implementing a program of measuring farm uses of water in order to obtain clear and accurate information on the patterns and amounts of such use, which information is essential to proper management of water resources by the state and useful to farmers for improving the efficiency and effectiveness of their use of water"* (Georgia General Assembly, 2003, 2004).

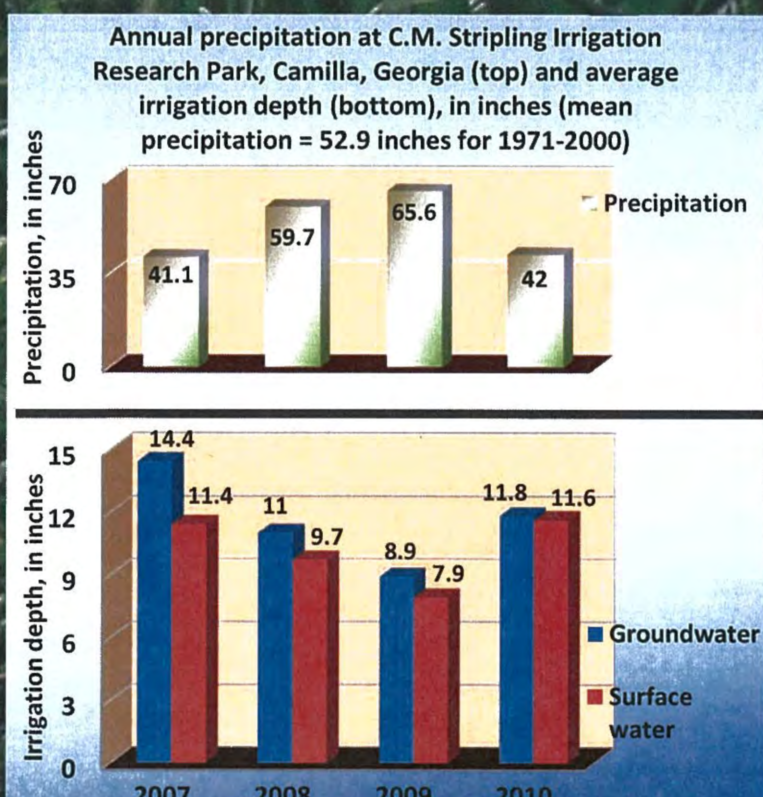
GSWCC has been engaged in cooperative research with the U.S. Geological Survey since 2008 to analyze metered irrigation water-use data as part of the USGS mission to provide *"reliable, impartial, and timely information that is needed to understand the Nation's water resources"* (U.S. Geological Survey, 2011).



Metering Progress

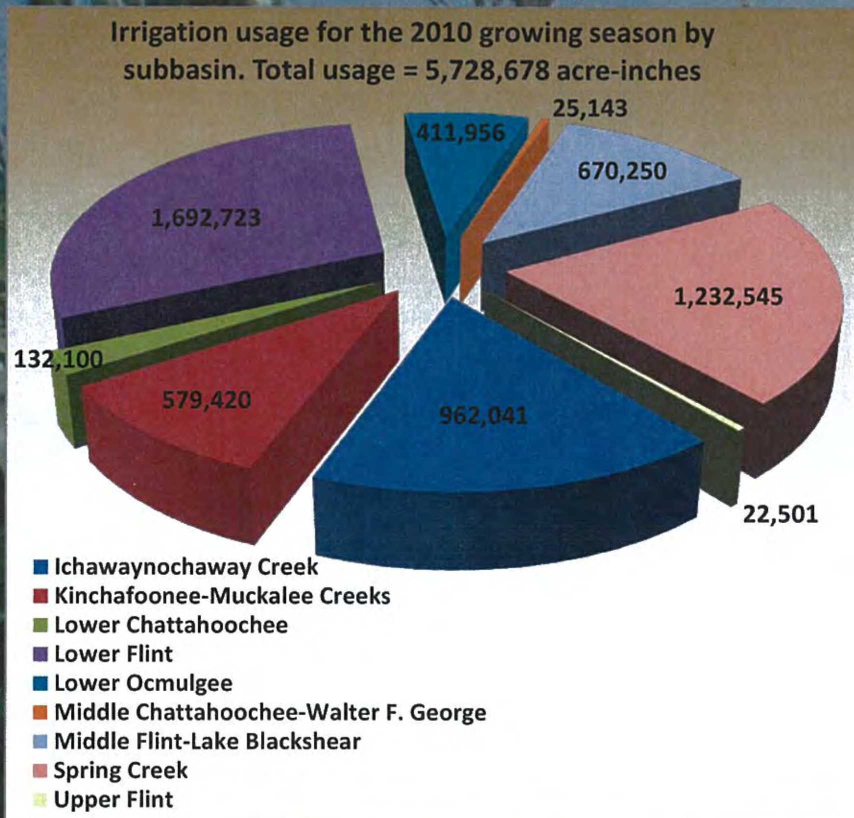
The first agricultural region to be supplied with water meters was the middle and lower Chattahoochee-Flint River basin, consisting of nine subbasins, as shown in the figure to the right. More than 4,300 meters were installed in time to measure water use at the start of the 2007 growing season. Meter installation continued elsewhere in the agricultural fields of Georgia through 2010. Four years of metered data collected here during 2007–2010 demonstrate how farmers rely on irrigation to meet crop demands for water during dry growing seasons (see charts below). Farmers offset rainfall deficits during the dry years 2007 and 2010 with increased irrigation, compared with less irrigation applied during 2008 and 2009, when rainfall exceeded normal amounts for the region (annual precipitation data from Georgia Automated Environmental Monitoring Network, 2011; mean precipitation value for 1971–2000 from Southeast Regional Climate Center, 2011).

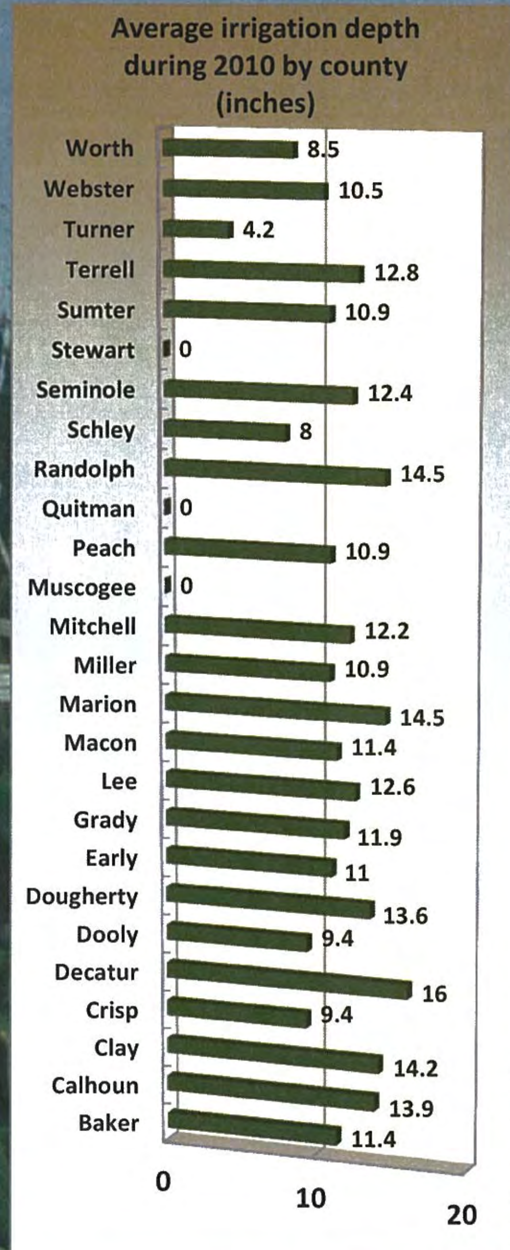




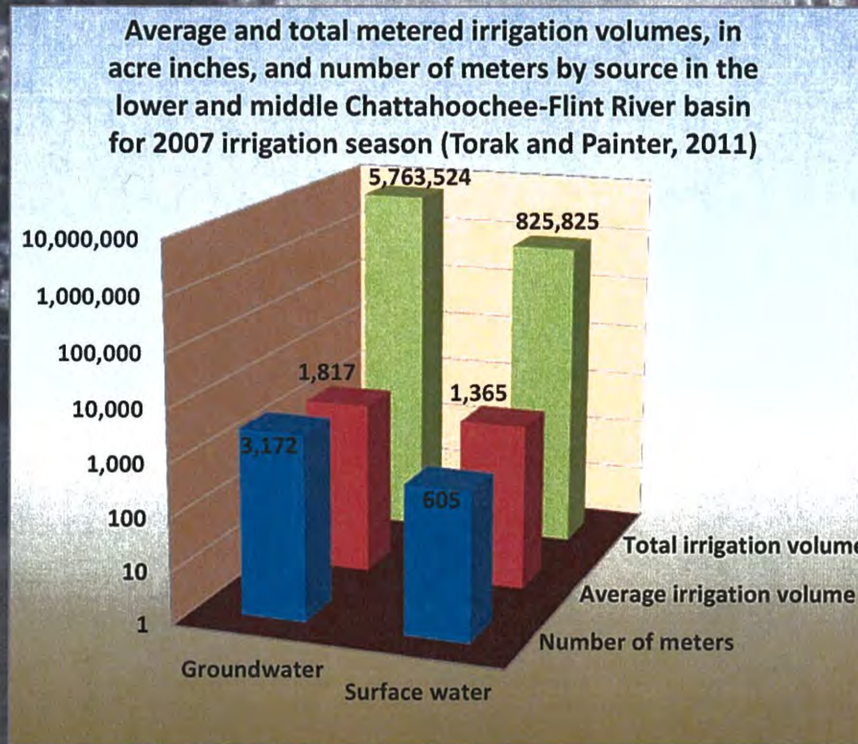
Sizing up Irrigation Water Use in the Middle and Lower Chattahoochee-Flint River Basin

Irrigation depth and usage varied across the subbasins and counties of the middle and lower Chattahoochee-Flint River basin (see charts on this page) because of differences in crops planted, soil type, local rainfall amounts, surface-water availability, and aquifer yield.





On average, farmers applied about one-third more groundwater than surface water per metered irrigation system, owing to the higher capacity of ground-water irrigation systems than surface water (see chart to right). Metered groundwater systems outnumbered that of surface water by five to one. Therefore, groundwater supplied almost seven times more irrigation volume to fields than surface water.

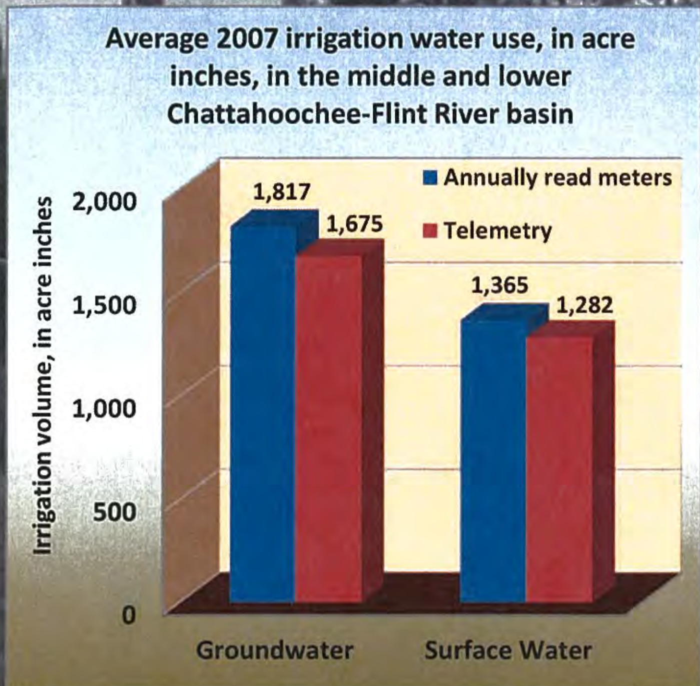


Space-Age Technology for Down-to-Earth Irrigation Metering

The Georgia Soil and Water Conservation Commission has equipped 198 meter locations statewide with satellite data transmitting (telemetry) capability (see photo to left). Irrigation water use and precipitation data are communicated by satellite twice daily from each telemetered site and are reported to GSWCC via internet. The telemetered data help farmers track daily, monthly, and seasonal patterns of irrigation, and enable GSWCC, farmers, and water managers to assess water use in near real time. By comparison, the more numerous, annually read meters provide an understanding of irrigation patterns and variability within a region, such as a subbasin or county.

A comparison of average water use at telemetered sites to the average obtained from the annually read meters in the middle and lower Chattahoochee-Flint River basin indicates that the telemetry represents irrigation water use quite well (see bar graph, top of opposite page to right). Twice-daily telemetry and annually read meters each serve their purpose in providing vital field-to-field information about near real-time and seasonal irrigation practices.

Irrigation Patterns and Trends



Statistical analysis of annually read meter data in the middle and lower Chattahoochee-Flint River basin indicates a distinct geographic pattern of increased irrigation from low volume in the northwestern parts of the basin (blue and yellow dots on maps below, from Torak and Painter, 2011), to high volume (red dots) in the southeast. Although irrigation by surface water (streams) follows this northwest-to-southeast increasing usage pattern, about halfway through the basin in this direction, surface-water sources are almost completely replaced by groundwater (wells and well-to-pond systems). Most likely, this is because wells can be installed to tap the reliable and highly productive Upper Floridan aquifer conveniently where needed—at the field—instead of laying pipe to pump water from the nearest stream, which also might contain little or no flow during severe drought conditions.

On the Horizon for the Metering Program

Continued research and analysis into the patterns and distribution of irrigation water use derived from the meter data will provide farmers and water managers with an important tool to assess Georgia's future water needs. Anticipated results will improve the representative nature of the telemetry network, report on analyses of meter data for other agricultural regions in Georgia (in addition to the middle and lower Chattahoochee-Flint River basin), and identify relations between metered water use and variations in crop and soil type, local rainfall, and water availability.

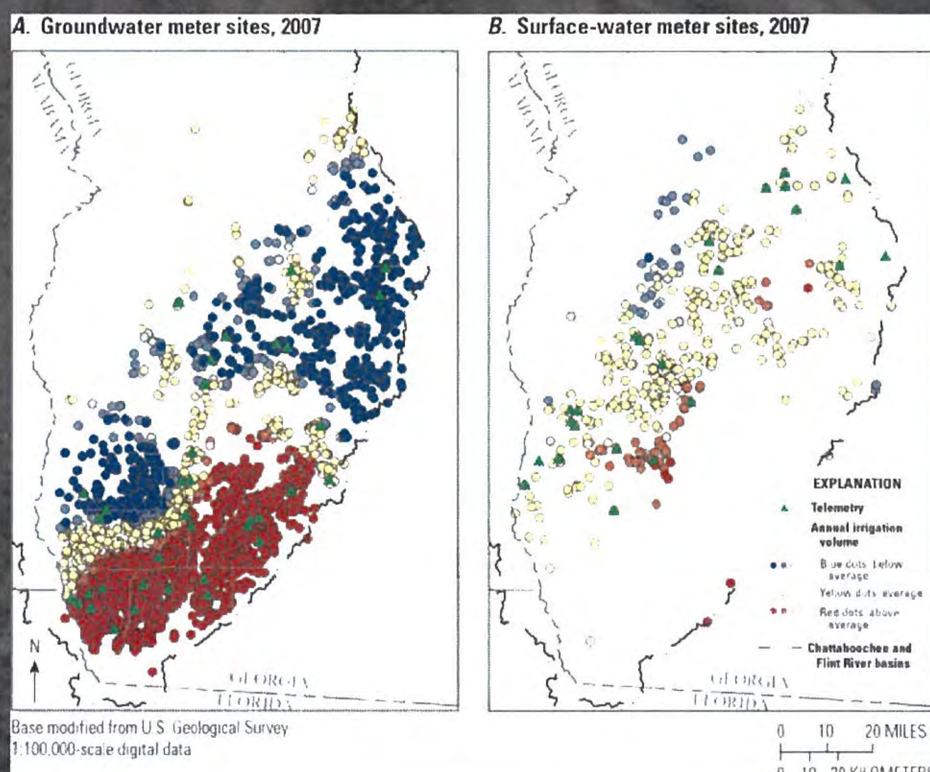


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Exhibit 66

GSWCC Georgia Soil and Water Conservation Commission

Home » Agricultural Conservation Programs » Metering Program

Metering Program

All agricultural irrigation wells and pumps permitted by the Georgia Department of Natural Resources' Environmental Protection Division (GAEPD) must have a measurement device installed, with the Georgia Soil and Water Conservation Commission (GSWCC) having oversight of the program. Since 2003, over 11,000 meters have been installed to monitor agricultural water usage in Georgia.

This irrigation metering program includes installation, inspection and maintenance of meters; as well as regularly collecting data from meters installed on irrigation systems in Georgia.

These data assist policy makers in better understanding agricultural water use in the state and help agricultural producers improve efficiency in their use of water resources.

Update on Current Status

GSWCC collects water usage data from the metered sites between October and January. Permit holders will be mailed a yearly report showing their water-use recorded by each meter. It is anticipated that annual usage letters will be sent to agricultural producers in March.

Information on the 2012 Georgia Agricultural Water Conservation and Metering Program is available on the USGS website.

Individual permit water use data are not released to the public.

Field staff continues to perform inspections and maintenance on meters, as well as rebuilding meters as needed.

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The Metering Program is also doing community outreach to educate citizens on water issues and the metering program.

Background

Under state law HB 579, GSWCC conducts an Agricultural Water Use Measurement Program. HB 579 states that the Commission "shall on behalf of the State purchase, install, operate, and maintain water-measuring devices...," where 'operate' is defined to include "reading the water-measuring device, compiling data, and reporting findings." Data collected contribute to the sound-science initiative.

Example of propeller-style meter

Most irrigation occurs in a six-month period between April 1 and October 1. For total water-use during that period, most meters need only to be read at the completion of the growing season. However, there is interest in water-use during critical periods of low stream flow, such as in August and September. Reading of all meters only after the growing season would miss those critical low-flow periods. Thus, a one percent sample of meters is read on a monthly basis.

The Commission also conducts a series of information sessions for irrigation water managers at the county and watershed level as well as for the general public so that they have a better understanding of the metering program.

Contacts

For questions about the GSWCC Metering Program, contact Antonio Fleming at (229) 995-6001 or email at afleming@gaswcc.org .

Information on Agricultural Water Withdrawal Permitting is available by contacting the Georgia EPD's Agricultural Permitting Unit at (229) 391-2400.

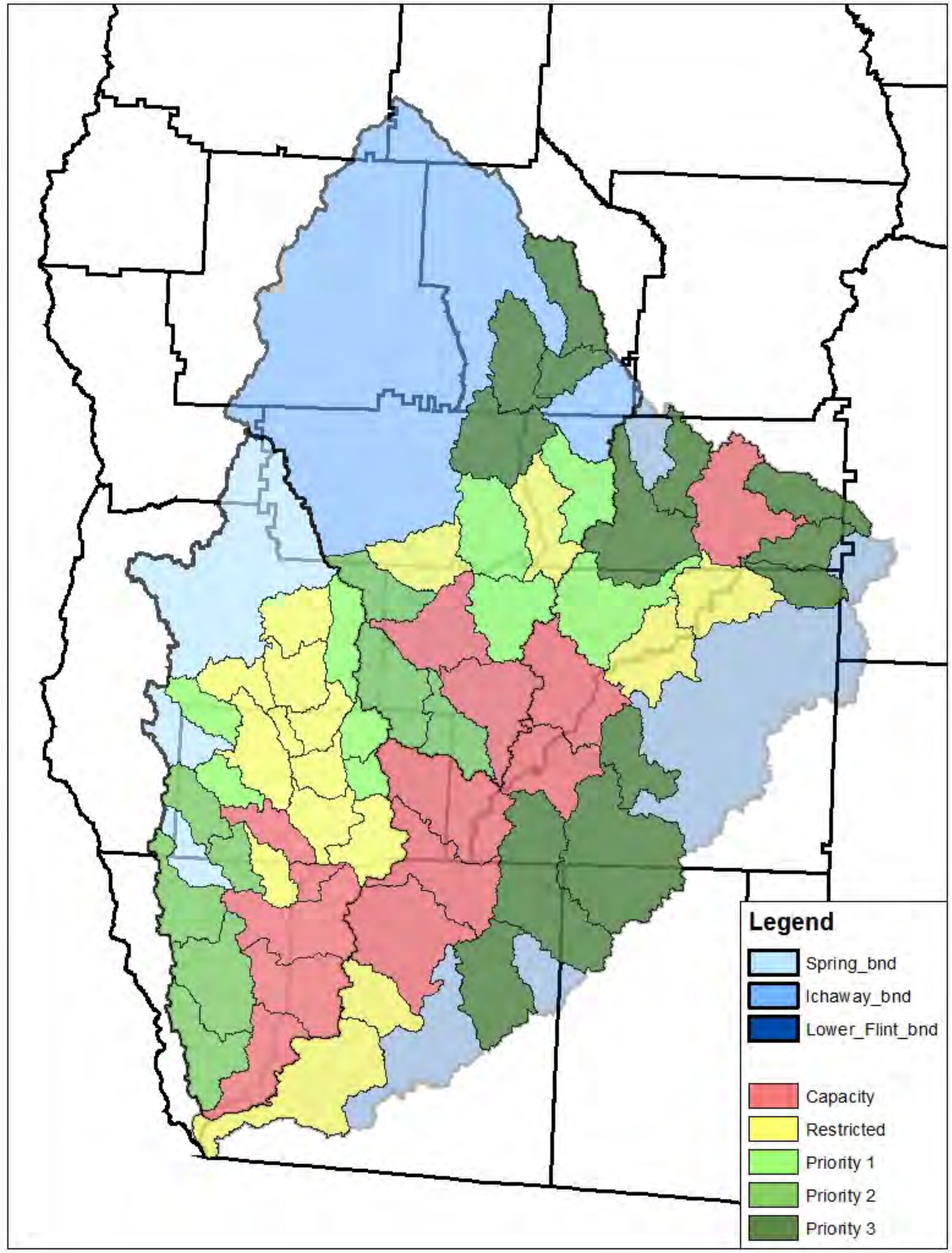
Related Files

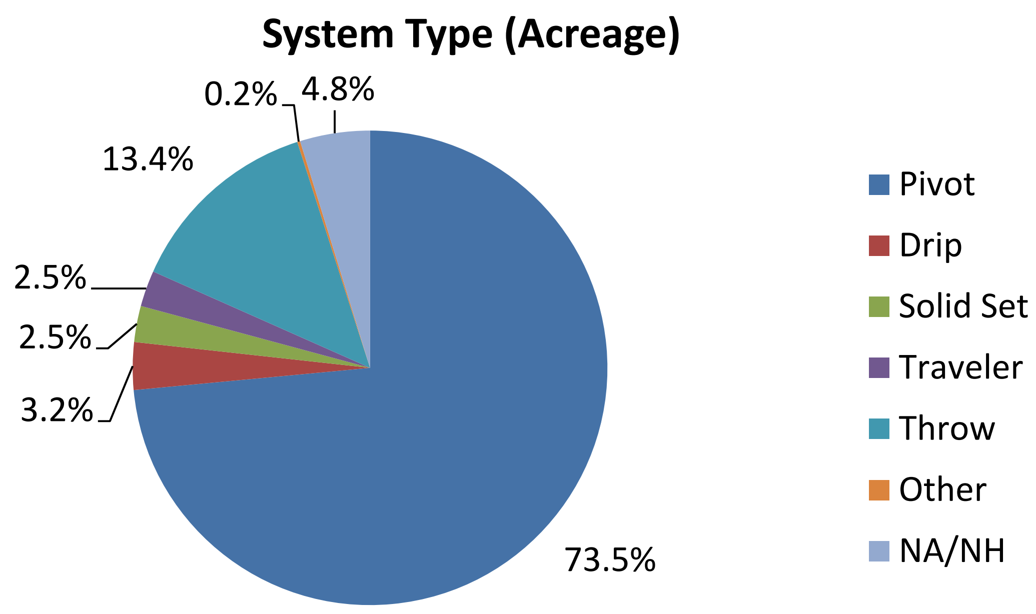
Attachment	Size
Help Us Help You With Your Irrigation Water Meter (PDF)	773.3 KB
Outstanding In Field (PDF)	1.11 MB
water-metering-map.jpg	93.15 KB
GA Ag Water Metering Program Brochure.pdf	2.36 MB
Ag_Meter_Photo.docx	97.11 KB

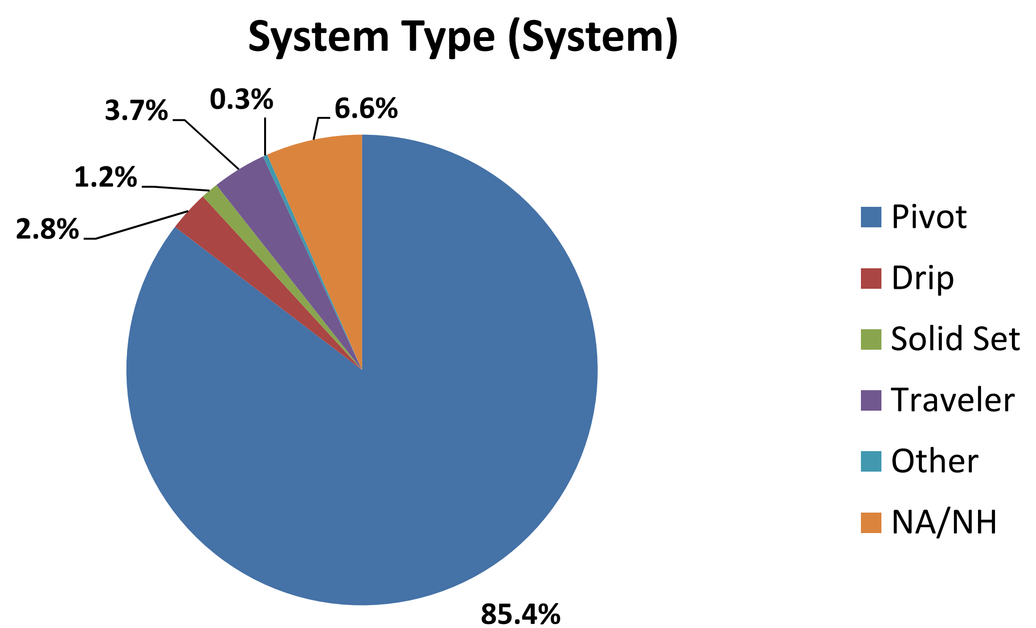
Exhibit 67

GWPPC Field Mapping

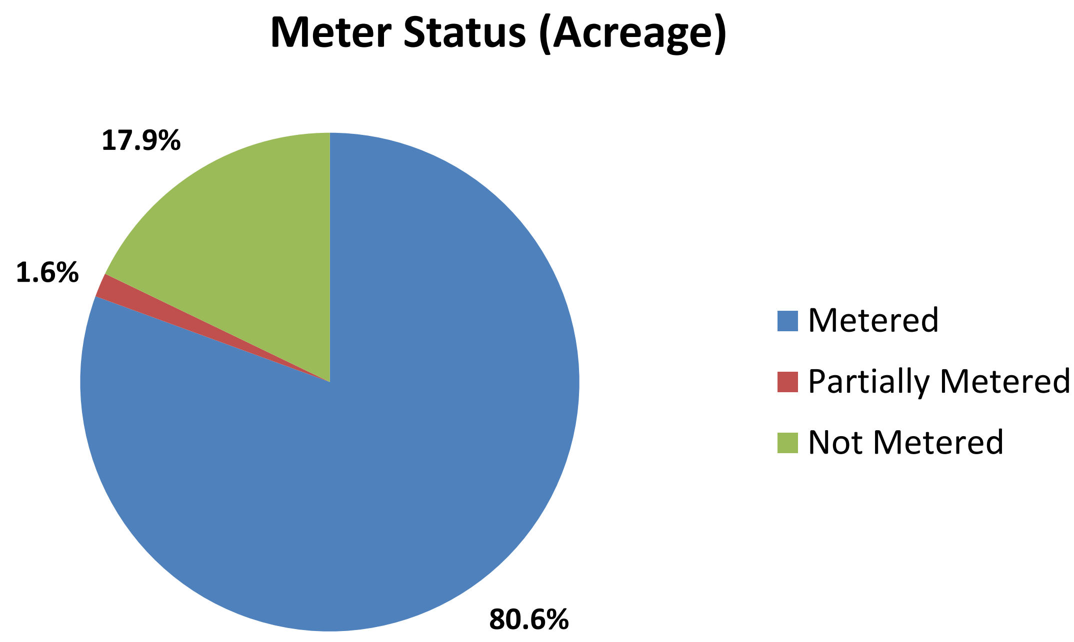
- Performed 2012 – 2015
- Funded via HCP grant, GSWCC and EPD contracts
- Detailed assessment of wetted acreage covering 100% of the Capacity, Restricted and "Priority" HUC 12 watersheds and all SW withdrawals in Spring, Ichaway and Lower Flint.
- Data presented today will focus mainly on center pivots but comprehensive data for all systems was collected.

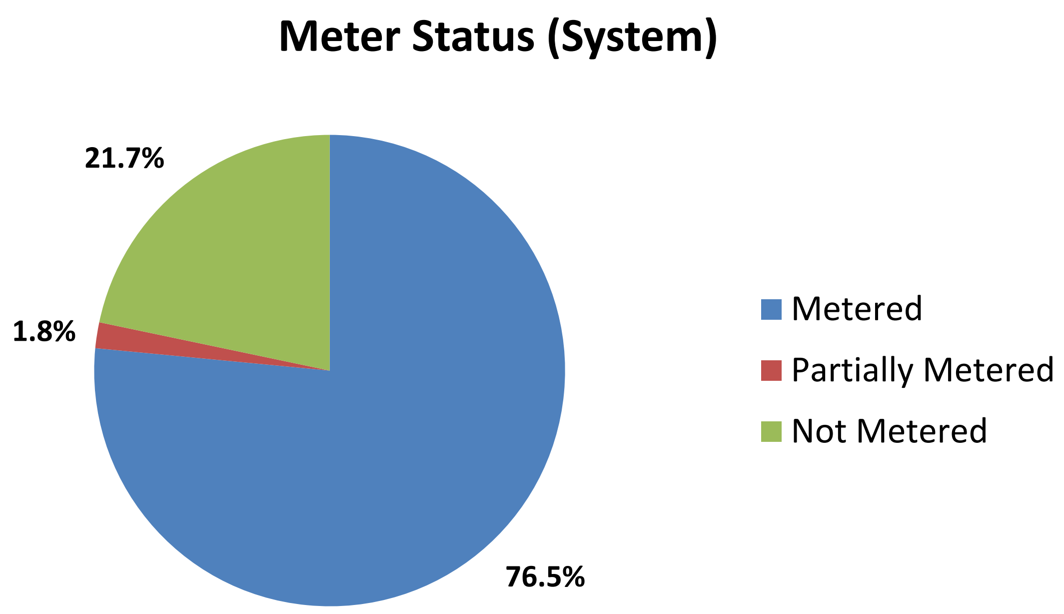




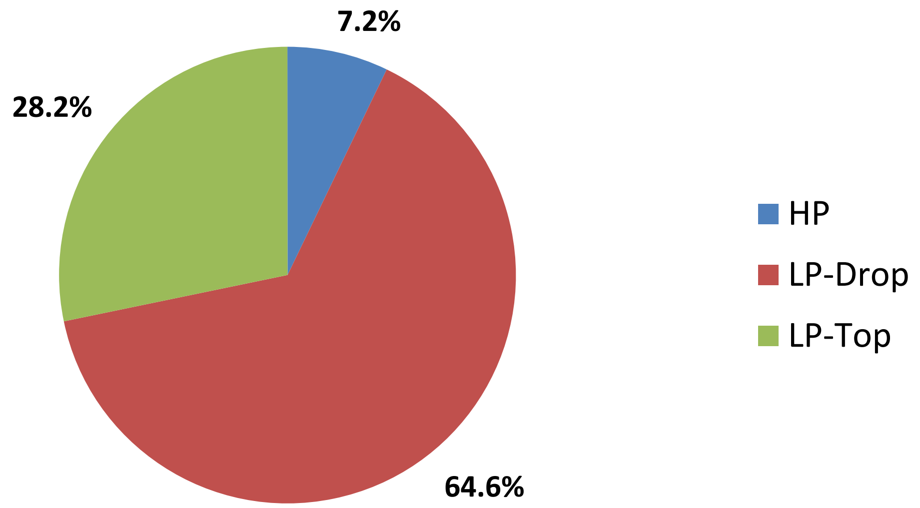


DRAFT - Attorney Client Privileged Work Product

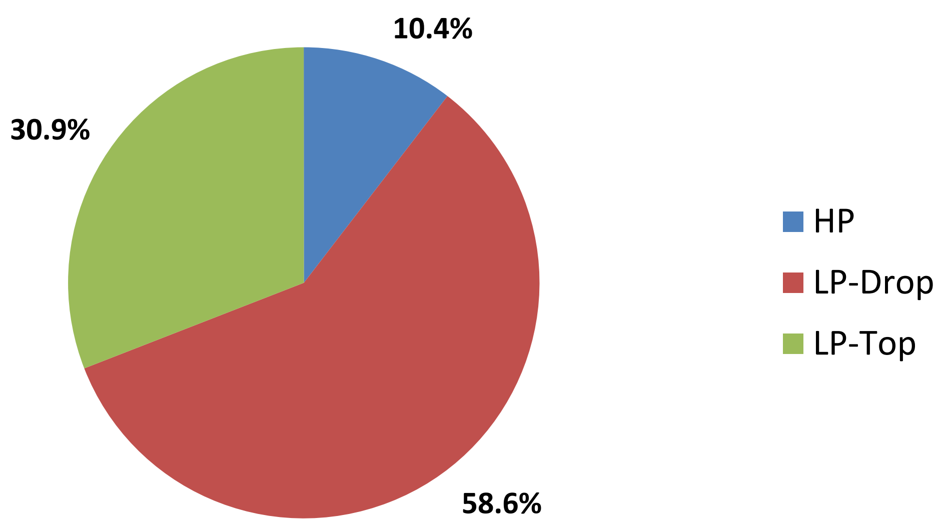

Meter Status (Acreage)
17.9%
1.6%
80.6%
Metered
Partially Metered
Not Metered

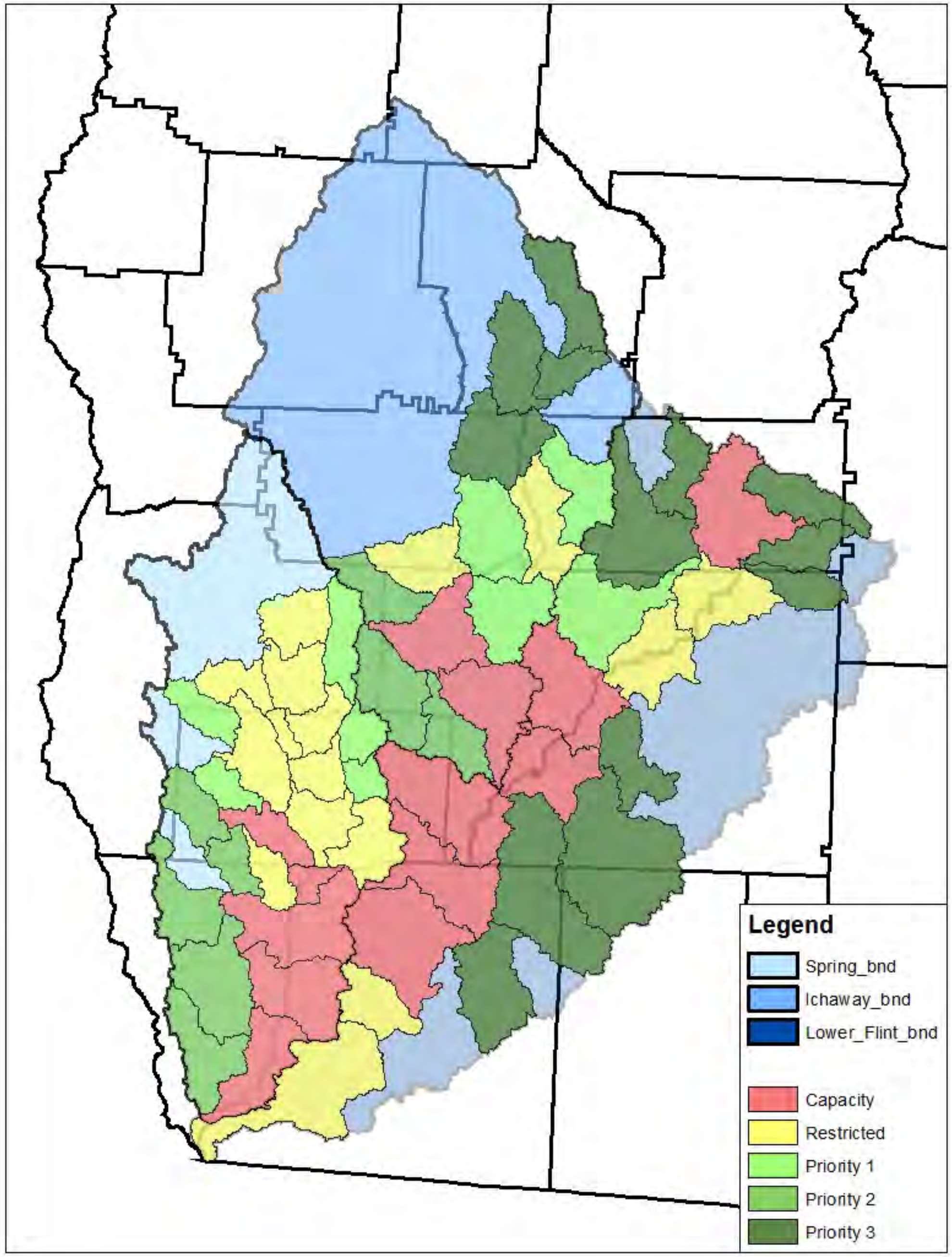

Meter Status (System)
21.7%
1.8%
76.5%
Metered
Partially Metered
Not Metered

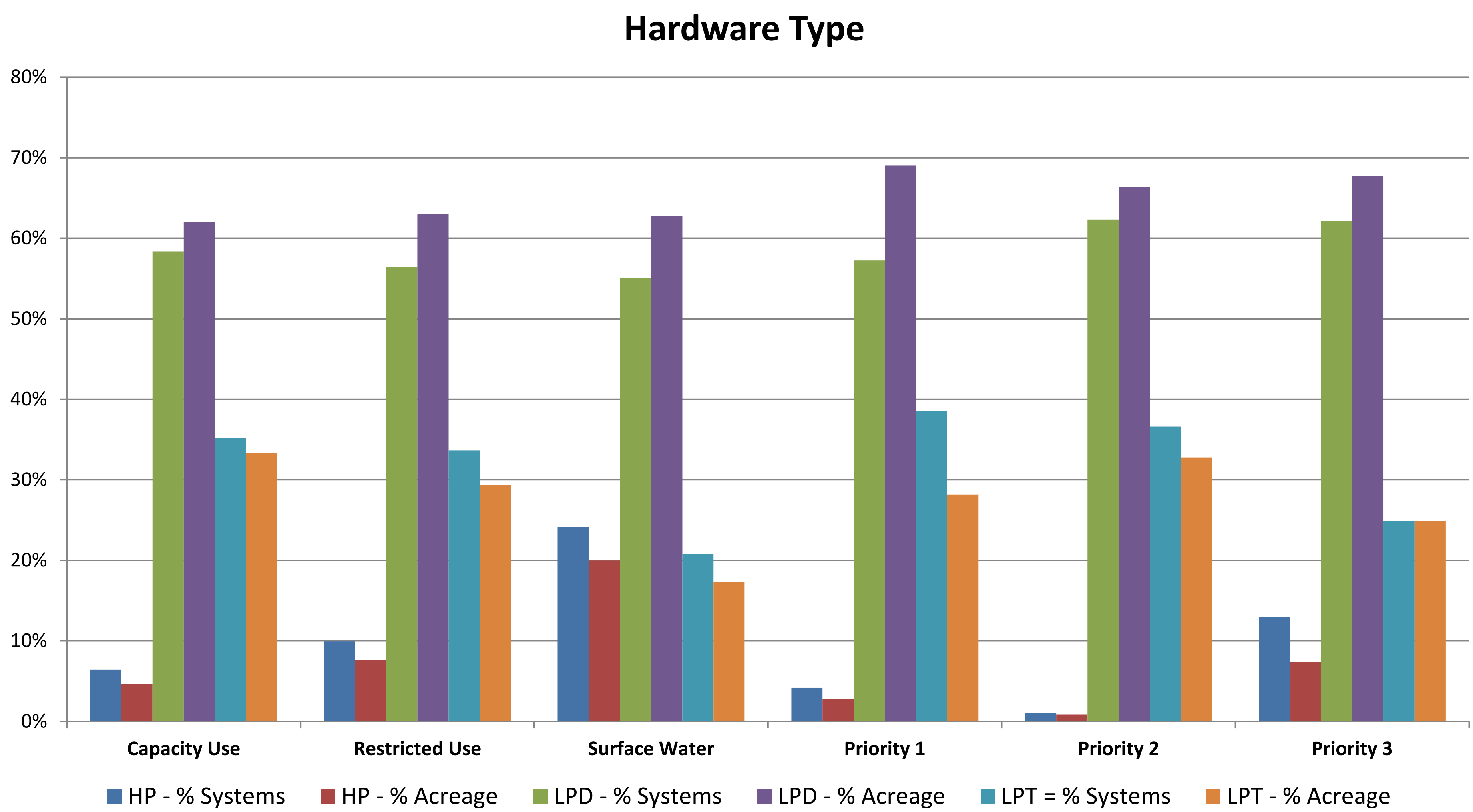
Hardware (Acreage)

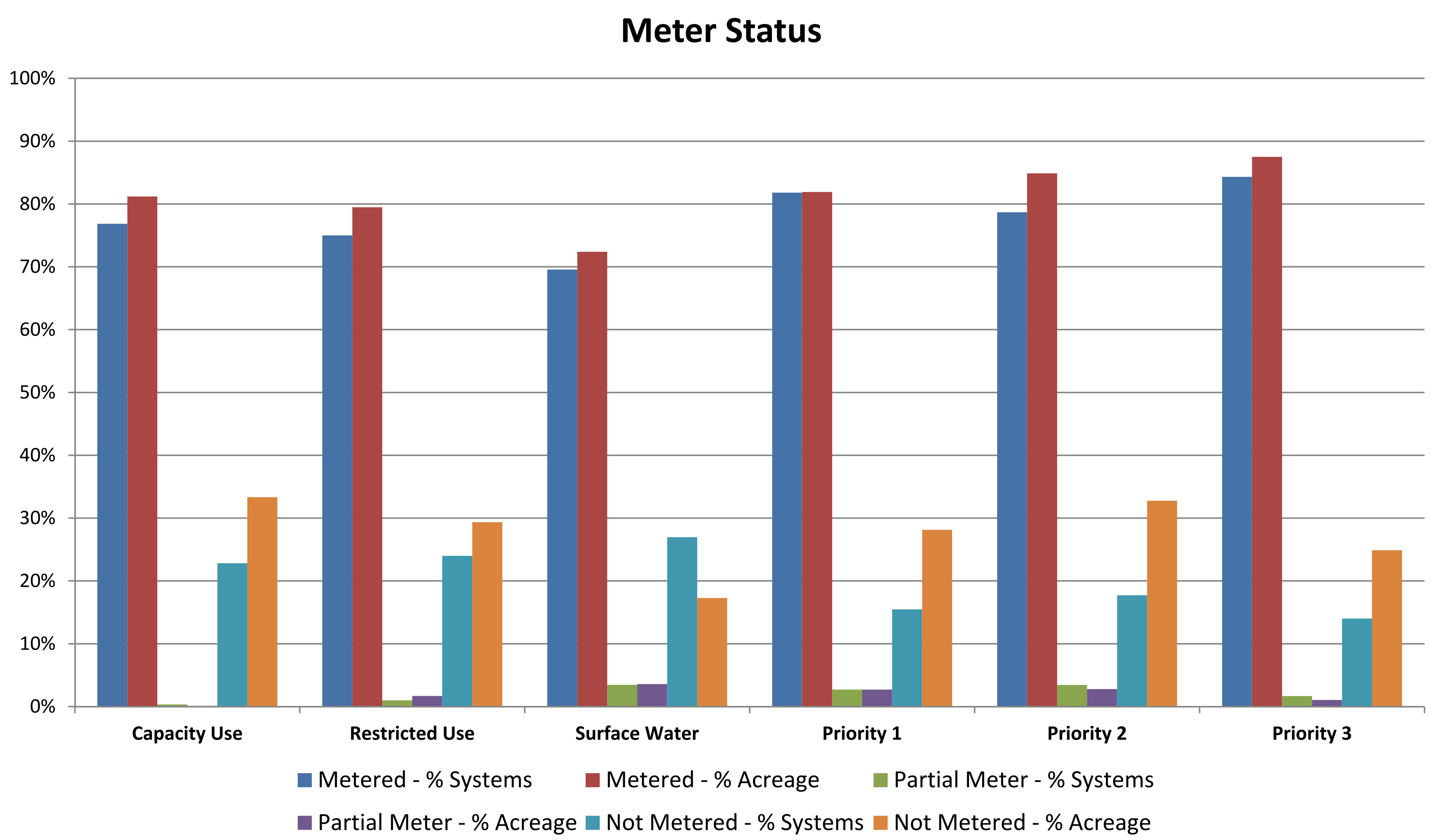


Hardware (System)




Legend
Spring_bnd
Ichaway_bnd
Lower_Flint_bnd
Capacity
Restricted
Priority 1
Priority 2
Priority 3


Hardware Type
80%
70%
60%
50%
40%
30%
20%
10%
0%
Capacity Use
Restricted Use
Surface Water
Priority 1
Priority 2
Priority 3
HP - % Systems
HP - % Acreage
LPD - % Systems
LPD - % Acreage
LPT = % Systems
LPT - % Acreage



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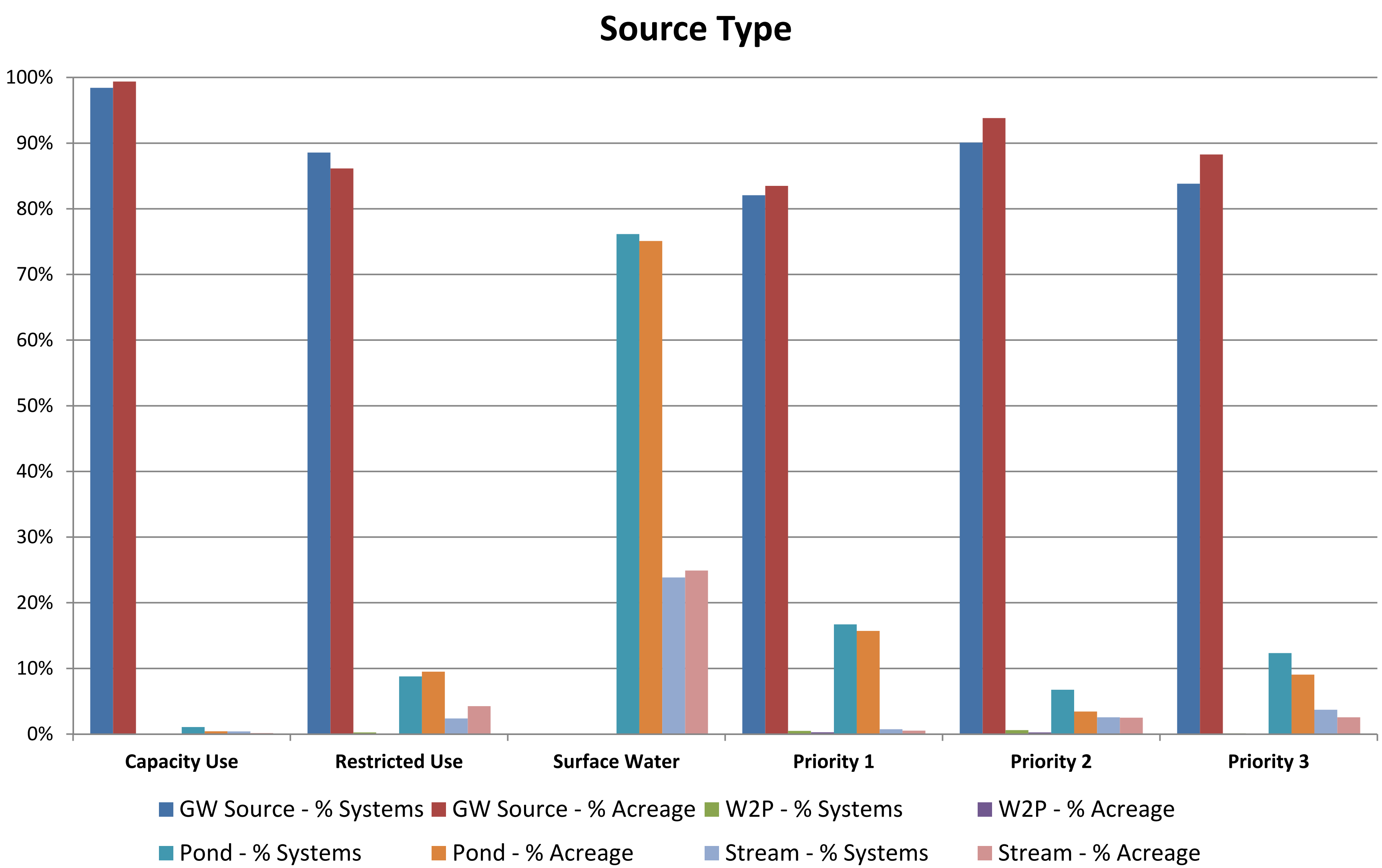

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Exhibit 68

GWPPC Mapped Pivots_Flint Basin.xlsx

(File Provided Natively)

Exhibit 69

Georgia Department of Natural Resources
2 Martin Luther King Jr. Dr., S.E., Suite 1152 East, Atlanta, Georgia 30334-9000
Mark Williams, Commissioner
Judson H. Turner, Director
Environmental Protection Division
404/656-4713
FAX : 404/651-5778

Announcement

To: Interested Parties

From: Judson H. Turner

Date: July 30, 2012

Re: Suspension of Consideration of Agricultural Withdrawal Permits in portions of the Lower Flint and Chattahoochee River Basins

As of this date, I am suspending consideration of applications for agricultural water withdrawal permits in portions of Southwest Georgia. The suspension will affect the following:

- Applications for new permits for withdrawals from the Floridan aquifer or from surface waters in the area known as Subarea 4, where surface water and groundwater are closely interconnected;
- Applications for permit modifications that would increase pump capacity or irrigated acreage associated with withdrawals from the Floridan aquifer or surface waters in Subarea 4;
- Applications for new permits to withdraw surface waters in the Spring Creek, Ichawaynochaway Creek, and Kinchafoonee-Muckalee Creek sub-basins in the Flint River basin; and
- Applications for permit modifications that would increase pump capacity or irrigated acreage associated with withdrawals of surface water in the Spring Creek, Ichawaynochaway Creek, and Kinchafoonee-Muckalee Creek sub-basins in the Flint River basin.

A map of the area affected by the suspension is attached. For more information on specific locations affected by the suspension, contact the Agricultural Permitting Unit in Tifton at 229-391-2400.

Permitting in other parts of the Flint and Chattahoochee River Basins will continue to be conducted following applicable rules and guidance, including the 2006 Flint River Basin Plan and the 2011 Regional Water Plans.

The suspension does not apply to applications already received as of this date. All applications for withdrawals in the affected area received on or before today will be processed following applicable permitting procedures.

I am taking this action under the authority provided by the statutes that regulate water withdrawal permitting in Georgia (O.C.G.A. §§12-5-31, 12-5-96, and 12-5-97).

The water resources affected by the suspension are significant sources of water for irrigation. A continued increase in withdrawals from these resources may ultimately lead to unacceptable impacts to existing users or compromise the sustainable capacities of these resources. Suspending consideration of permit applications in this area will allow time to update the tools used to assess the condition of water resources in the region and evaluate the impacts of increased water use.

The suspension will be re-evaluated annually starting in November 2013. Lifting of the suspension will be dependent on progress in updating of assessment tools and evaluation of the condition of the affected water resources.

I recommend that applications for withdrawals not be filed while the suspension is in effect. A $250 application fee is required for each withdrawal application in the Flint River Basin and those funds cannot be held during the suspension. In addition, the assessment process may well result in changes to the permit application. Consequently, it would be best to wait to file any applications for withdrawals in the affected area until the suspension is lifted.

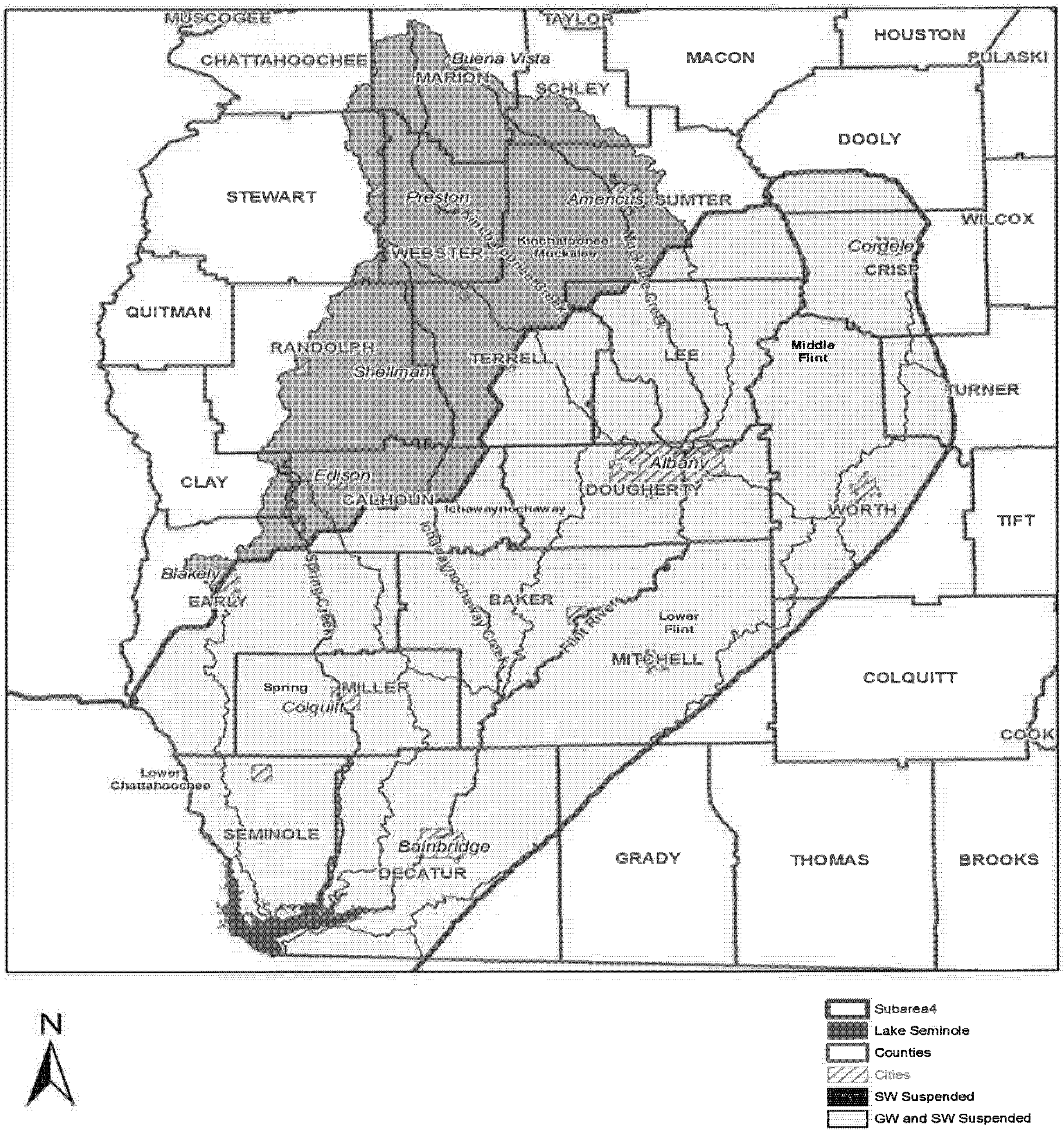

Exhibit 70

Senate Bill 213

By: Senators Tolleson of the 20th, Sims of the 12th, Burke of the 11th, Hill of the 4th, Chance of the 16th and others

AS PASSED

A BILL TO BE ENTITLED
AN ACT

To amend Article 9 of Chapter 5 of Title 12 of the Official Code of Georgia Annotated, the "Flint River Drought Protection Act," so as to clarify legislative intent; to revise definitions; to expand programs; to provide for additional powers of the director; to provide for new irrigation efficiency requirements; to provide for participation in augmented flow programs; to clarify compliance and enforcement provisions; to provide for related matters; to repeal conflicting laws; and for other purposes.

BE IT ENACTED BY THE GENERAL ASSEMBLY OF GEORGIA:

SECTION 1.

Article 9 of Chapter 5 of Title 12 of the Official Code of Georgia Annotated, the "Flint River Drought Protection Act," is amended by revising subsection (b) of Code Section 12-5-541, relating to legislative intent, as follows:

"(b) The General Assembly finds that the use of water resources for the state for agricultural purposes is of vital importance to Georgia and southwest Georgia in particular; the protection of flows in the Flint River ~~flow~~ and its tributaries is necessary for a healthy riverine ecosystem and a healthy population of aquatic life; the use of water resources during drought conditions may interfere with public and private rights; the economic well-being of the State of Georgia is dependent on a strong and efficient agricultural industry; the wise use of water, the protection of stream ~~flow~~ flows, and the economic well-being of the state will be furthered by proper water allocation in periods of drought; and ~~a program providing~~ programs to augment stream flows or provide incentives to ensure that certain irrigated lands are temporarily not irrigated during severe droughts will promote the wise use of water resources, and the protection of stream flows for habitat critical for aquatic life, and the economic well-being of the state."

SECTION 2.

Said article is further amended by revising Code Section 12-5-542, relating to definitions relative to Flint River drought protection, as follows:

"12-5-542.

As used in this article, except where otherwise specifically provided, the term:

(1) 'Acceptable Flint River basin stream ~~flow'~~ flows' means the quantity of stream flows at one or more specific locations on the Flint River or its tributaries which provides for aquatic life protection and other needs as established by the director, based on municipal, agricultural, industrial, and environmental needs. Such tributaries shall not include field drainage systems, wet weather ditches, or any other water body:

(A) In which the channel is located above the ground-water table year round;

(B) For which runoff from precipitation is the primary source of water flow; and

(C) For which ground water is not a source of water flow.

(2) 'Affected ~~area~~ areas' means ~~that portion~~ those specific portions of the state lying within the Flint River basin ~~and areas~~ where ground-water use from the Floridan aquifer can affect ~~the flow in the Flint River or its tributaries~~ stream flow or where drainage into Spring Creek, Ichawaynochaway Creek, Kinchafoonee Creek, and Muckalee Creek occurs.

(2.1) 'Augmentation' means the addition of ground water from one or more aquifers underlying the affected areas into a surface water channel within the affected areas for the purpose of maintaining instream flows.

(3) 'Authority' means the Georgia Environmental Finance Authority created by Chapter 23 of Title 50.

(4) 'Board' means the Board of Natural Resources.

(5) 'Director' means the director of the Environmental Protection Division of the Department of Natural Resources.

(6) 'Division' means the Environmental Protection Division of the Department of Natural Resources.

(7) 'Drought conditions' means any condition which results in a stream flow that is lower than the acceptable Flint River basin stream ~~flow~~ flows.

(8) 'Drought protection funds' means the funds held by the authority as provided in Code Section 12-5-545 for the accomplishment of the purposes of this article.

(9) 'Flint River basin' means the area of land which drains into the Flint River or its tributaries.

(10) 'Floridan aquifer' means those rocks and sediments described in United States Geological Survey Open-File Report 95-321 (1996) that are capable of yielding ground water to wells or discharging water into the Flint River or its tributaries.

(11) 'Irrigated land' means farm land which is irrigated by ground water or surface water pursuant to a water withdrawal permit issued by the director pursuant to Code Section 12-5-31 or 12-5-96.

(11.1) 'Irrigation efficiency' means the percentage of the total amount of water withdrawn from a source which is beneficially used to meet crop water requirements or for other agronomic practices in accordance with applicable best management practices.

(12) 'Irrigation reduction auction' means the procedure established by subsection (b) of Code Section 12-5-546 pursuant to which permittees submit offers to cease irrigation of a specified number of acres in exchange for a certain sum of money.

(13) 'Permittee' means a person holding a valid permit issued before December 1, 2000, pursuant to Code Section 12-5-31 or 12-5-96.

(14) 'Stream flow' means the quantity of water passing a given location of the Flint River or its tributaries over a given time period expressed in cubic feet per second."

SECTION 3.

Said article is further amended in Code Section 12-5-544, relating to powers of the director of the Environmental Protection Division, by revising paragraph (2) and adding a new paragraph to read as follows:

"(2) Establish acceptable Flint River basin stream flows at one or more locations;"

"(9.1) Conduct and participate in studies related to management of the water resources in the Flint River basin;"

SECTION 4.

Said article is further amended in Code Section 12-5-546, relating to drought predictions and irrigation reduction auction, by revising subsections (a), (b), and (e) as follows:

"(a) On or before March 1 of each year, the division ~~will~~ may issue a prediction as to whether severe drought conditions are expected during the year. If the division predicts a severe drought during any particular year, it shall issue such prediction before March 1 of that year. Prediction of severe drought may be based on consideration of historical, mathematical, or meteorological information, including, but not limited to, stream flows, ground-water levels, and precipitation forecasts. Such prediction may also be based on scientific analyses, including, but not limited to, the Palmer Drought Severity Index administered by the National Oceanographic and Atmospheric Administration.

(b) If severe drought conditions are predicted or otherwise declared in accordance with subsection (a) of this Code section, the division ~~will~~ may determine the total number of acres of irrigated land, serviced by irrigation systems located within one or more of the affected areas, that must not be irrigated that year in order to maintain the acceptable Flint

River basin stream ~~flow~~ flows. Upon such determination, the division ~~shall~~ may conduct an irrigation reduction auction whereby a permittee of an irrigation system located within the affected areas is given an opportunity to enter into an agreement with the division, agreeing that in exchange for a certain sum of money per acre of irrigated land serviced by the irrigation system, the permittee will not irrigate those particular acres for the remainder of that calendar year. The authority shall pay the sum so agreed upon when so directed by the director from the unexpended balance of the drought protection funds. In conducting the irrigation reduction auction, the division may establish a maximum dollar amount per acre to be expended from the drought protection funds for such purposes."

"(e) The expenditure of funds under this article as an incentive to permittees not to irrigate lands is deemed by the legislature as a valid use of state moneys to promote valid land use policies that result in the protection of the riverine environment by ensuring that such lands not be irrigated for specified periods of time. No expenditure of funds under this article shall be considered full or partial compensation for any losses, financial or otherwise, experienced due to nonirrigation; a lease or repurchase of any irrigation permit issued by the director~~, nor shall it be considered~~; or an acknowledgment by the State of Georgia of a property right in any permit issued by the director."

SECTION 5.

Said article is further amended by adding new Code sections to read as follows:

"12-5-546.1.

(a) The Department of Agriculture and the State Soil and Water Conservation Commission shall coordinate with the division in examining current practices, programs, policies, rules, and regulations to identify opportunities to enhance programming and incentives that will:

(1) Support implementation of the agricultural water efficiency measures in water conservation or management plans prepared in accordance with Code Sections 12-5-31, 12-5-96, and 12-5-522;

(2) Support implementation of pilot projects demonstrating the efficacy of emerging innovative irrigation technologies where appropriate and affordable;

(3) Identify ways the State Soil and Water Conservation Commission's program for measuring agricultural uses of water as authorized under Code Section 12-5-105 can further enhance efforts to improve agricultural water use efficiency; and

(4) Encourage a scheduled program for the voluntary retirement of unused surface-water and ground-water farm use permits in accordance with Code Sections 12-5-31 and 12-5-105.

(b) The director may modify all active surface-water and ground-water withdrawal permits for farm use in the affected areas to require all irrigation systems applying water withdrawn pursuant to such permits to achieve irrigation efficiencies of 80 percent or greater by the year 2020. The schedule for achieving the irrigation efficiencies provided in this subsection shall be as follows:

(1) Irrigation systems applying water withdrawn pursuant to all active permits issued after 2005 shall achieve a minimum irrigation efficiency of 80 percent by January 1, 2016;

(2) Irrigation systems applying water withdrawn pursuant to all active permits issued from 1991 through 2005 shall achieve a minimum irrigation efficiency of 80 percent by January 1, 2018; and

(3) Irrigation systems applying water withdrawn pursuant to all active permits issued before 1991 shall achieve a minimum irrigation efficiency of 80 percent by January 1, 2020.

(c) Notwithstanding subsection (b) of this Code section, the director may modify specified active surface-water and ground-water withdrawal permits for farm use in the affected areas to require all mobile irrigation systems and solid-set irrigation sprinklers operating under such permits to achieve irrigation efficiencies of 60 percent or greater by the year 2020. The schedule for achieving such efficiencies shall be as follows:

(1) Irrigation systems applying water withdrawn pursuant to all active permits issued after 2005 shall achieve a minimum irrigation efficiency of 60 percent by January 1, 2016;

(2) Irrigation systems applying water withdrawn pursuant to all active permits issued from 1991 through 2005 shall achieve a minimum irrigation efficiency of 60 percent by January 1, 2018; and

(3) Irrigation systems applying water withdrawn pursuant to all active permits issued before 1991 shall achieve a minimum irrigation efficiency of 60 percent by January 1, 2020.

(d) Notwithstanding the irrigation efficiency rates required in subsection (c) of this Code section or any other provision of this Code section to the contrary, the minimum irrigation efficiency rate for mobile irrigation systems and solid-set irrigation sprinklers applying water withdrawn pursuant to new permits shall be 60 percent.

(e) When issuing any permit application for a new surface-water or ground-water withdrawal for farm use in the affected areas, the division shall require that the irrigation system applying water withdrawn pursuant to any such permit has an irrigation efficiency of at least 80 percent.

(f) The division shall, in cooperation with other state and federal agencies, universities, the Georgia Water Planning and Policy Center, the Lower Flint-Ochlockonee Regional Water Council, and other appropriate entities, provide to the board for consideration for adoption pursuant to such permits to achieve irrigation efficiencies of 80 percent or greater by the year 2020. The schedule for achieving the irrigation efficiencies provided in this subsection shall be as follows:

(1) Irrigation systems applying water withdrawn pursuant to all active permits issued after 2005 shall achieve a minimum irrigation efficiency of 80 percent by January 1, 2016;

(2) Irrigation systems applying water withdrawn pursuant to all active permits issued from 1991 through 2005 shall achieve a minimum irrigation efficiency of 80 percent by January 1, 2018; and

(3) Irrigation systems applying water withdrawn pursuant to all active permits issued before 1991 shall achieve a minimum irrigation efficiency of 80 percent by January 1, 2020.

(c) Notwithstanding subsection (b) of this Code section, the director may modify specified active surface-water and ground-water withdrawal permits for farm use in the affected areas to require all mobile irrigation systems and solid-set irrigation sprinklers operating under such permits to achieve irrigation efficiencies of 60 percent or greater by the year 2020. The schedule for achieving such efficiencies shall be as follows:

(1) Irrigation systems applying water withdrawn pursuant to all active permits issued after 2005 shall achieve a minimum irrigation efficiency of 60 percent by January 1, 2016;

(2) Irrigation systems applying water withdrawn pursuant to all active permits issued from 1991 through 2005 shall achieve a minimum irrigation efficiency of 60 percent by January 1, 2018; and

(3) Irrigation systems applying water withdrawn pursuant to all active permits issued before 1991 shall achieve a minimum irrigation efficiency of 60 percent by January 1, 2020.

(d) Notwithstanding the irrigation efficiency rates required in subsection (c) of this Code section or any other provision of this Code section to the contrary, the minimum irrigation efficiency rate for mobile irrigation systems and solid-set irrigation sprinklers applying water withdrawn pursuant to new permits shall be 60 percent.

(e) When issuing any permit application for a new surface-water or ground-water withdrawal for farm use in the affected areas, the division shall require that the irrigation system applying water withdrawn pursuant to any such permit has an irrigation efficiency of at least 80 percent.

(f) The division shall, in cooperation with other state and federal agencies, universities, the Georgia Water Planning and Policy Center, the Lower Flint-Ochlockonee Regional Water Council, and other appropriate entities, provide to the board for consideration for adoption in its rules requirements pertaining to methods an applicant may utilize to demonstrate that the required irrigation efficiency has been achieved. Requirements shall consider current technologies, best management practices, and the effects of soil type and topography, among other factors deemed necessary.

(g) The division shall coordinate with any federal or state agencies offering incentive programs that support the purposes of this article, to identify opportunities to refine and target relevant programs as practicable and to assist permittees with achieving irrigation efficiency requirements.

12-5-546.2.

(a) As used in this Code section, 'permittee' means any person holding a valid permit issued pursuant to Code Section 12-5-31 which provides for the withdrawal of surface water from within the affected areas.

(b) The director shall notify specified permittees downstream of any state funded augmentation project, which shall be operated for the sole purpose of maintaining the minimum stream flows sufficient to protect habitat critical for vulnerable aquatic life within the affected areas. The director may notify specified downstream permittees that, during specified periods of the project's operation for the sole purpose of maintaining such minimum stream flows, the permittee shall let the flow provided by the augmentation project pass his or her point of withdrawal. When specifying those permittees subject to such notification, the director shall also establish, in accordance with the factors that may be considered under paragraph (e) of this Code section, those permittees that shall not be subject to the requirements of this Code section.

same group for "shall" and "may" under (b)

Shall provide notice to "specified permittees" D/S – notice may include "let the flow" pass restriction

(c) Such notification shall be provided in accordance with rules promulgated by the board of natural resources, shall be based on the best available science, and shall, at a minimum, inform the permittees that the upstream project is delivering augmented flows for the sole purpose of maintaining the minimum stream flows sufficient to protect habitat critical for vulnerable aquatic life within the affected areas.

notice shall inform permittees ...

(d) The director's notification shall contain notice of opportunity for a hearing and shall be served by certified mail, return receipt requested, to the most recent address provided by the permittee. Any permittee to whom such notification is directed shall comply therewith immediately, but shall be afforded a hearing within five business days of the director's receipt of a petition filed by such permittee. Such hearing shall be before an administrative law judge of the Office of State Administrative Hearings and shall be conducted in accordance with subsection (c) of Code Section 12-2-2. Based upon findings adduced at such hearing, the notification shall be modified, reversed, or continued by the director.

"may" notice shall contain notice of opportunity for a hearing

(e) In preparing such notification, the director may consider:

(1) The best available modeling and monitoring data for relevant locations and stream reaches;

(2) The appropriate duration of protection of augmented flows;

(3) The distance downstream for which protection of augmented flows is appropriate;

(4) The degree to which protection of augmented flows will assist in mitigating the effects of droughts, provide ecological or other environmental benefits, and ensure sustainable, long-term access to water resources for existing and future water users; and

(5) Any other data or information the director deems relevant.

(f) Nothing in this Code section shall provide authority for the interbasin transfer of any water."

SECTION 6.

Said article is further amended by revising Code Section 12-5-549, relating to compliance and violations, as follows:

"12-5-549.

(a) Except as may otherwise be provided in ~~Code Section 12-5-547~~ this article, whenever the director has reason to believe that a violation of any provision of this article or any rule or regulation adopted pursuant to this article has occurred, he or she shall attempt to obtain compliance therewith by conference, conciliation, or persuasion, if the making of such an attempt is appropriate under the circumstances. If he or she fails to obtain compliance in this manner, the director may order the violator to take whatever corrective action the director deems necessary in order to obtain such compliance within a period of time to be prescribed in such order.

(b) Except as may otherwise be provided in ~~Code Section 12-5-547~~ this article, any order issued by the director under this article shall become final unless the person or persons named therein file with the director a written request for a hearing within 30 days after such order or permit is served on such person or persons.

(c) Except as may otherwise be provided in ~~Code Section 12-5-547~~ this article, hearings on contested matters and judicial review of final orders and other enforcement actions under this article shall be provided and conducted in accordance with subsection (c) of Code Section 12-2-2.

(d) The director may file in the superior court of the county wherein the person under order resides, or if the person is a corporation, in the county wherein the corporation maintains its principal place of business, or in the county wherein the violation occurred or in which jurisdiction is appropriate, a certified copy of a final order of the director unappealed from or a final order of the director affirmed upon appeal, whereupon the court shall render judgment in accordance therewith and notify the parties. Such judgment shall have the same effect, and all proceedings in relation thereto shall thereafter be the same, as though the judgment had been rendered in an action duly heard and determined by such court.

(e) For purposes of this Code section, a violation of an agreement entered into in accordance with Code Section 12-5-546 or an order issued by the director in accordance with Code Section 12-5-547 shall be prima facie established upon a showing that:

(1) During the effective period of the agreement or order, the irrigation system was observed in person or via remote sensing or otherwise established by representatives of the division or others to have been operating and disbursing water; or

(2) During the effective period of the agreement or order, a seal, lock, or other device placed by the division on the system to prevent operation of the system has been broken or otherwise tampered with."

SECTION 7.

All laws and parts of laws in conflict with this Act are repealed.

Exhibit 71

Report of Dr. David L. Sunding

Economic Impacts of Reducing Water Consumption in the Chattahoochee and Flint River Basins of Georgia

Prepared for the State of Florida, Through Its Department of Environmental Protection and Its Counsel, Latham & Watkins LLP

February 29, 2016

THE Brattle GROUP

Table 1: Conservation Scenario Annual Costs

Scenario 1		Gain in Peak Summer Streamflow (cfs)	Cost per Year ($ million)
Deficit Irrigation of Rotation Crops		1,000	64
	Total	**1,000**	**64**
Scenario 2			
High-Value Crops to Deeper Aquifers		337	14
Center Pivot Efficiency Improvements		111	3
Deficit Irrigation of Rotation Crops		552	19
	Total	**1,000**	**35**
Scenario 3			
20% Reduction in Municipal Outdoor Use		100	22
Moderate Municipal Leak Abatement		48	4
Center Pivot Efficiency Improvements		111	3
Deficit Irrigation of Rotation Crops		404	10
High-Value Crops to Deeper Aquifers		337	14
	Total	**1,000**	**53**
Scenario 4			
30% Reduction in Municipal Outdoor Use		150	40
Full Municipal Leak Abatement		95	7
Center Pivot Efficiency Improvements		111	3
Deficit Irrigation of Rotation Crops		519	16
Reduced Early Season Pecan Irrigation		125	0
	Total	**1,000**	**67**

B. DIRECT YIELD LOSSES AND PRODUCER IMPACTS

74. Applying this method to the per acre-foot costs estimated in Section IV, I estimate the total costs associated with reducing dry-year irrigation of corn, cotton, peanuts, and soybeans by 10, 20, 30, 40, and 50 percent of consumptive use.

75. Table 8 summarizes the amount of water saved by each crop in each conservation scenario, as well as net revenue lost. The sum of revenue losses across crops, divided by the sum of water savings across crops, yields the average cost per acre-foot conserved, ranging from $20 to $248 depending on the conservation scenario. The average cost per acre-foot increases as reductions become larger because more valuable uses of water are foregone.

Table 8: Water Savings and Revenue Losses by Crop

	Corn		Cotton		Peanut		Soybean		Total		Average
Scenario	Cutback (AF)	Rev. Loss ($ mill)	Cutback (AF)	Rev. Loss ($ mill)	Cutback (AF)	Rev. Loss ($ mill)	Cutback (AF)	Rev. Loss ($ mill)	Cutback (AF)	Rev. Loss ($ mill)	Rev. Loss ($/AF)
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]
10%	62,961	$1.25	0	$0.00	0	$0.00	0	$0.00	62,961	$1.25	$20
20%	107,766	$8.21	14,973	$2.30	3,183	$0.65	0	$0.00	125,922	$11.16	$89
30%	155,892	$21.13	26,307	$5.26	6,366	$1.50	317	$0.10	188,883	$27.99	$148
40%	185,152	$31.61	41,569	$10.59	17,538	$5.54	7,585	$2.79	251,844	$50.53	$201
50%	208,685	$41.78	59,900	$18.66	30,732	$11.37	15,488	$6.32	314,805	$78.13	$248

Notes:

[1]	Scenario defined as percentage of water demand from corn, cotton, peanuts, and soybeans.
[2], [4], [6], [8], [10]	Total reduction in applied irrigation water.
[3], [5], [7], [9], [11]	Total loss in farm revenue net of pumping costs.
[12]	[11]/[10]

76. To confirm the relatively low values of water and implied costs of conservation resulting from this analysis, I further undertake two econometric studies described in Appendix B. I assess the value of water based on land transactions with and without permits in active moratorium zones, and by relating volumes of groundwater pumped to the costs of pumping. Both of these analyses, which rely on entirely different empirical data sources, suggest values of water in the range of net revenue losses per acre described above.

77. Note that for modest conservation scenarios, peanut irrigation would only be moderately affected. As shown in Table 7, water used to irrigate peanuts tends to be more valuable

than water used to irrigate corn and cotton in otherwise similar contexts. Deficit irrigation of cotton also tends to be a more expensive way of conserving water than deficit irrigation of corn. In the 50-percent conservation scenario, which saves a total of 315,000 acre-feet of water in a dry year, irrigation of corn would be mostly eliminated while irrigation of cotton would be reduced by only one third, and peanut irrigation reduced by only one quarter.

78. These estimates aggregate over soil groups and water user categories for simplicity of presentation, but the extent of conservation also varies across user types and soil groups. As expected, cutbacks tend to be more concentrated on coarse soils than fine, and among high water users. Indeed, in some cases, cutbacks in water use among high water users are essentially costless, indicating wasted irrigation.

79. The cutbacks considered above are defined in terms of consumptive use, but the relevant outcome for environmental protection is the reduction in peak streamflow depletions. The relationship between the two metrics is specific to the particular location where conservation measures are implemented. To convert annual consumptive use into streamflows, the spatial pattern of hydrological connectivity of the basin must be taken into account. In all subsequent analyses in this report pertaining to irrigation use in the ACF, I rely on the modeling work described in Dr. Dave Langseth's report, which provides groundwater-streamflow connectivity factors across a grid of individual cells of approximately 250 acres each. The model covers an area that largely overlaps with Subarea4, and I conservatively assume no groundwater streamflow connectivity outside of that model domain. Intuitively, for the deficit irrigation scenarios defined in terms of streamflow depletions presented in Section XII, cutbacks are more concentrated on surface water and in high connectivity groundwater zones.

80. As my analyses rely primarily on annual data, I convert annual water volumes to peak summer streamflows using a conversion factor provided by Appendix D of Dr. George Hornberger's report. Based on his modeling work, I use the groundwater and surface water averaged conversion factor for the month of June, equivalent to 2.28. Annual average streamflow depletions of 1 cfs correspond to 2.28 cfs of peak summer depletions, given the concentration of agricultural water use in the summer months.

131. The relatively low estimated price-responsiveness of demand is likely due in part to the conservation measures that have already been implemented in the municipal sector. MNGWPD's Water Supply and Conservation Management Plan includes a requirement that conservation pricing be used by all water district potable supply facilities.[113] The purpose of conservation pricing is to reduce excessive discretionary water use, especially outdoor irrigation. EPD has also implemented statewide water use restrictions to reduce excessive water use, particularly outdoor irrigation.[114]

132. Based on the estimated elasticity of demand for outdoor water use, I construct an aggregate municipal outdoor water demand function calibrated to dry-year price and quantity[115]. I use the averages of 2011 and 2012 values to represent a median dry year. By integrating under this demand function for given percentage cutbacks in outdoor water use and subtracting the costs of service provision[116], I am able to calculate the total economic cost associated with the reduction in use. Again, this cost represents the full value or welfare lost by Georgia households due to conservation, not actual monetary prices paid. Dividing this total cost by the number of acre-feet saved yields the cost on a per acre-foot basis.

133. Table 13 presents the resulting estimated costs per acre-foot, and total water savings in a dry year, associated with 10 to 30 percent cutbacks in outdoor water use by utility. Depending on the percentage cutback considered, the costs per acre-foot conserved range from $1,691 to $2,546. The average cost per acre-foot of conservation in the 20 percent scenario is $2,118. Given the diminishing marginal value of water in the municipal sector, just as in the agricultural sector, the costs per acre-foot are higher for a 20 percent reduction than in the 10 percent cutback scenario.

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113 Water Supply and Water Conservation Management Plan, Metropolitan North Georgia Water Planning District, May 2009, p. 5-2.

114 Outdoor Water Use Information, Georgia Environmental Protection Division, http://epd.georgia.gov/outdoor-water-use-information, accessed September 2, 2015.

115 I assume a linearized demand function for welfare calculations.

116 I use a constant $250 per acre-foot cost of service provision, plus the average sewer bill of my sample as the marginal cost of sewer service.

137. A 2009 report by Georgia's Water Contingency Planning Task Force evaluated options to reduce water use in Georgia, including the costs associated with reducing system losses.[118] Cost estimates from the report show that leak abatement programs are likely to be a fairly costly means of reducing municipal water use, although less so for systems characterized by high water losses. Leak abatement programs include sonar leak detection to identify leaks, managing system pressure to reduce leakage volumes, and improving response times to reported leaks. The report estimates a leak abatement cost of $1,200 per mgd with a yield of 27 mgd.[119] If the variable labor costs associated with leak detection and valve exercising were only incurred in dry years, this conservation measure would provide 95 cfs of peak summer streamflows at a cost of $7 million on an annualized basis.[120]

138. According to the Task Force's report, the cost curve for loss reduction is non-linear. The cost per acre-foot of leak abatement is relatively constant across system loss rates greater than twenty percent, but increases sharply for abatement measures targeting systems with loss rates of twenty percent or less. Water providers with system losses exceeding twenty percent, such as Atlanta Department of Watershed Management, can adopt leak abatement measures to achieve twenty percent system losses at relatively low cost. Note that this loss rate is four percent higher than the reported national average of sixteen percent. If an abatement program only half the scale of that assessed in the Task Force report were implemented, non-linearity in the cost curve implies the costs would be below $3.5 million annually for a 43 cfs reduction in peak summer streamflow depletions.

139. In addition to more rapid-response leak abatement, replacement of aging pipeline infrastructure is another means of addressing system losses. According to the Task Force

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118 Water Contingency Planning Task Force, Appendix III, December 2009. Accessed on January 17, 2015: http://sonnyperdue.georgia.gov/00/channel_modifieddate/0%2c2096%2c78006749_154453222%2c00.html

119 Water Contingency Planning Task Force, Appendix III, page 61.

120 I amortize the full costs of pressure management equal to $37 million over a 25 year lifespan, assuming a five percent discount rate, and add the expected annual variable costs (the annual costs of leak detection and valve exercising multiplied by the probability any year is a dry year of 0.33) to reach an annual cost estimate.

Exhibit 72

Report of Dr. David L. Sunding

Opportunities for Water Conservation in the Flint and Chattahoochee River Basins of Georgia

Prepared for the State of Florida, Through Its Department of Environmental Protection and Its Counsel, Latham & Watkins LLP

May 20, 2016

THE Brattle GROUP

Confidential – S. Ct. 142

failing to implement its own regulatory program to pay farmers to forego irrigation during drought years under the Flint River Drought Protection Act.[4] Growers may also be compensated for declines in crop yield associated with modest degrees of deficit irrigation. As Georgia has already been considering, it may also make the relatively small infrastructure investment needed to shift some water users to deeper aquifers that are not connected to Apalachicola River flows.

6. Taking advantage of all of the opportunities for conservation described above, Georgia may reduce streamflow depletions by up to 2,000 cfs in drought years like 2011. Table 1 summarizes the contributions of each of the measures discussed above, which are further detailed in the remainder of this section.

Table 1: Conservation Measures to Achieve 2,000 Cfs Reductions in Streamflow Depletions in Drought Years

Conservation Measure		Peak Summer Streamflow Saved (cfs)
Curb Municipal Outdoor Water Use during Severe Drought		385
Municipal Leak Abatement to Achieve Return Flows		95
Eliminate Net Basin Exports		66
Eliminate Wasted Irrigation of Rotation Crops		221
Eliminate Wasted Irrigation of Pecans		130
Implement March 2006 Flint River Plan during Severe Drought		322
	Subtotal	1,219
Deficit Irrigation of Rotation Crops during Severe Drought*		408
Switching High-Value Crops to Deep Aquifers**		227
Reduced Evaporation from Small Impoundments		146
	Subtotal	781
	Total	2,000

Notes:
Agricultural measures are relative to a baseline of current irrigated acreage combined with drought year water use per acre, as represented by 2011 observed values.
* Deficit irrigation is assessed after all irrigation water waste has been subtracted out.
** The streamflow savings associated with switching to deeper aquifers are in addition to the savings associated with reduced pecan irrigation.

4 See Ga. Code Ann. §12-5-540 et seq. (2000).

conservation measures that were implemented in 2011, outdoor use across the ACF amounted to approximately 163,000 acre-feet of withdrawals. Note that an outdoor watering ban was not called for in 2011, despite the drought's extreme effect on agriculture, because the Metro North Georgia area was relatively less affected.[9]

Table 2: Outdoor Use in the ACF Basin

Year	Outdoor Use (acre-feet)
[1]	[2]
2008	147,510
2009	136,731
2010	154,948
2011	162,792
2012	154,344
2013	119,909

11. Assuming all municipal water is supplied by surface sources, outdoor water use resulted in approximately 513 cfs of peak summer streamflow depletions in 2011.[10] A 50 percent cutback on municipal outdoor use would thus lead to a reduction in streamflow depletions of 256 cfs, and a 75 percent cutback to a reduction of 385 cfs, in a drought year like 2011.

12. Although these outdoor water use cutbacks and resulting streamflow improvements would not entail any monetary costs beyond those needed to maintain compliance, they would be associated with some "quality of life" impacts, as discussed in my February 2016 report. However, other states such as California have opted to implement such restrictions at greater welfare costs than are implied for Atlanta.[11]

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9 Knox, P. "'Quiet' drought is worse in some areas than 2007-2009 drought". Georgia FACES, December 19, 2012. Available at http://apps.caes.uga.edu/gafaces/?public=viewStory&pk_id=4613.

10 163,000 acre-feet of consumptive use is equivalent to an annual streamflow of 225 cfs. Based on the annual to peak monthly conversion factor of 2.28 provided by Dr. David Langseth, the resulting peak summer month streamflow depletion associated with outdoor use is 513 cfs.

11 Buck, S., et al., "The Welfare Consequences of the 2015 California Drought Mandate: Evidence from New Results on Monthly Water Demand," UC Berkeley, 2016.

Exhibit 73

Expert Report Regarding Water Use in the Apalachicola-Chattahoochee-Flint River Basin for the Supreme Court of the United States of America, in the case of *Florida v. Georgia*, No. 142 Orig.

Prepared by

Samuel A. Flewelling, Ph.D.

Prepared for
Florida Department of Environmental Protection

February 29, 2016

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8.4 Scenario 3 – Combination of Scenario 2 and a 100% Reduction in IBTs

This scenario starts with Future Scenario 2 and then adds 100% of IBT back to the river network as well.

Table 8.3 Potential Water Use in Georgia under Reduction in Agricultural Irrigation and Incremental Evaporation from Small Impoundments with Elimination of IBTs for Drought Year (2007) Conditions

Month	Conservative Georgia Consumptive Water Use in 2007 (cfs)	Conservative Georgia Consumptive Water Use under Conservation Measures with No IBTs (for 2007 Climate Conditions) (cfs)	Water Savings (cfs)
January	278	191	87
February	353	263	90
March	1558	997	562
April	2513	1609	904
May	6024	3813	2211
June	5289	3370	1919
July	3295	2123	1172
August	4495	2913	1582
September	3272	2128	1143
October	2820	1798	1022
November	809	674	135
December	445	346	99

8.5 Limiting Georgia's Water Use to 1992 Levels

This scenario assumes that GA's consumptive water use is limited to 1992 levels. I used the following procedure to estimate water use for this scenario:

- M&I consumptive use data begin in 1994 (GADNR, 2015a), so there are no direct estimates of M&I consumptive use in 1992. As a surrogate, I used M&I consumptive use data from 1994 – a year that was a little wetter than 1992, but the most comparable with respect to the ET deficit (a major driver of consumptive use) during the mid-late 1990s.
- Water losses from federal and non-federal reservoirs were not adjusted (the surface areas have not changed since 1992).
- No data were available for IBTs in 1992; for all post-1992 years with IBT data, I assumed that 100% of the IBTs were added back to the river network.
- For agricultural consumptive use, I fixed the number of irrigated acres to those that occurred in 1992, but allowed the estimated depth of irrigation water to vary with the ET deficit, as described in Section 2.

Depending on the climate conditions, it is possible for some post-1992 months to have lower consumptive water use than the same month in 1992. In those instances, I kept the monthly water use and did not adjust it to the magnitude in 1992. Table 8.4 shows Georgia's consumptive use under this scenario for the climate conditions of the 2007 reference drought year. For the model drought year used in Dr.

Langseth's Expert Report (2016), the agricultural consumptive water use for this scenario is 87.0% of the consumptive use for the baseline model drought year.

Table 8.4 Potential Water Use in Georgia under the 1992 Limit for Drought Year (2007) Conditions

Month	Conservative Georgia Consumptive Water Use in 2007 (cfs)	Conservative Georgia Consumptive Water Use under the 1992 Limit (for 2007 Climate Conditions) (cfs)	Water Savings (cfs)
January	278	186	92
February	353	236	118
March	1558	1226	332
April	2513	2089	424
May	6024	5166	858
June	5289	4556	732
July	3295	2707	588
August	4495	3683	811
September	3272	2656	615
October	2820	2370	450
November	809	598	211
December	445	304	141

8.6 40% Reduction in Irrigated Acres in Two Sub-basins, Spring and Ichawaynochaway Creek Watersheds

In a prior analysis of potential economic effects of reduced irrigation in the ACF Basin, Georgia described a scenario where agricultural irrigation in the Spring Creek and Ichawaynochaway Creek basins would be reduced by 40% (GADNR, 2006, pp. 152-159). I evaluated the change in water use for this scenario by calculating the number of irrigated acres that would be reduced according to the HUC-8 watershed boundaries for these basins and the NESPAL (2010a) map of irrigated fields. Under this scenario, irrigation would be curtailed on 149,734 acres, which is approximately 15% of all irrigated acres in the ACF Basin. To estimate the amount by which irrigation withdrawals would be reduced under this scenario, I multiplied the irrigated acreage taken out of production by the irrigation depths described in Section 2.

Exhibit 74

DEPARTMENT OF THE ARMY
MOBILE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 2288
MOBILE, ALABAMA 36628-0001

December 7, 2007

REPLY TO
ATTENTION OF

Inland Environment Team
Planning and Environmental Division

Ms. Gail Carmody
Field Supervisor
U.S. Fish and Wildlife Service
1601 Balboa Avenue
Panama City, Florida 32405-3721

Dear Ms. Carmody:

This letter provides supplemental information to our previous letter dated November 21, 2007, and an updated trigger to be used to determine when an additional reduction in flows from Jim Woodruff Dam would be prudent in order to manage remaining storage in the Apalachicola, Chattahoochee, Flint Rivers (ACF) basin under the Exceptional Drought Operations (EDO), which were initiated on November 16, 2007. At that time, an initial reduction in flow from 5,000 cubic feet per second (cfs) to 4,750 cfs was initiated subject to meeting the EDO initial trigger. The Amended Biological Opinion (BO) and Conference Report issued by the Service on November 15, 2007 included a reasonable and prudent measure (RPM) that specifies an additional trigger would be developed before implementing the next incremental reduction in flow to 4,500 cfs. Specifically, "RPM6. Minimum Flow Criteria and Triggers," states:

"By December 7, 2007, the Corps shall, in cooperation with the Service, determine appropriate criteria for initiating a reduction from 4,750 cfs to 4,500 cfs in the EDO minimum releases from Woodruff Dam. The criteria shall consider all appropriate monitoring data and models (e.g., survey of mussels mortality under condition 7.4.5.e, composite reservoir storage, climatic and hydrological conditions experienced, hydrological models, meteorological forecasts) to specify when a reduction is needed and the probable impacts to project purposes or other resources avoided by a reduction at that time, including impacts to listed species that would likely occur without the reduction."

Our previous letter proposed a trigger for the incremental reduction to 4,500 cfs that included two components based on a measure of the cumulative basin inflow above Walter F. George Dam (a measure of basin inflow on the Chattahoochee arm that is capable of being stored in the upstream federal storage reservoirs) and the cumulative basin inflow on the Flint River (a measure of basin inflow contributing to meeting the minimum flows below Jim Woodruff Dam, which provides some relief from the demands on storage in the upstream federal storage reservoirs). As a result of continuing consultation discussions with the Service, we now add a third component that reflects the status of Composite Storage within the basin. The proposed trigger for a reduction to 4,500 cfs is revised to reflect three components, as shown below, all of which would need to be met in order to exercise the trigger:

a. Cumulative Annual Basin Inflow above Walter F. George Dam < 5th Percentile Historic Flows: This trigger represents a measure of the amount of inflow received in the three storage reservoirs in the basin, Lake Lanier, West Point Lake and Walter F. George Lake. The trigger is a cumulative annual value designed to capture the importance of sustained low flows on reservoir storage and recovery. Coupled with the Composite Storage Trigger described in paragraph c. below, this trigger indicates a prolonged and sustained reduction in inflows to the storage reservoirs meriting further outflow reductions.

b. Monthly Basin Inflow above the Newton Gage on the Flint River < 5th Percentile Historic Flows: This trigger represents the flow contribution of the uncontrolled Flint River. When combined with the Composite Storage Trigger described in paragraph c. below, and cumulative annual basin inflows on the Chattahoochee River less than the 5th percentile of historic flows described in paragraph a. above, flows less than the 5th percentile on the Flint River represent a continuation of critically low inflows and result in further rapid depletion of the remaining basin storage to meet the downstream flow requirements below Jim Woodruff Dam.

c. Composite Storage Trigger Zone for 4,500 cfs Incremental Reduction in Flow: In addition to the above two components, a third component to the trigger has been identified to reflect that the resulting impact on Composite Storage has reached critical levels, meriting the next incremental reduction in releases. As shown on the enclosed figures, the Composite Storage Trigger Zone is the combined Composite Storage volumes resulting from Lake Lanier/Buford Dam being at the top of Zone 4, and both the West Point and Walter F. George projects being at the bottom of Zone 4/top of inactive storage. This represents a storage condition equivalent to all three reservoirs being within drought management conditions (Zone 4), and all flows in support of meeting the downstream minimum releases being drawn from Lake Lanier.

As noted in the EDO, an evaluation of the status of basin conditions will be conducted at the first of each month to determine whether the trigger components have been met. Once the above three components are all met, then a determination would be made on whether and when the trigger for an incremental reduction to 4,500 cfs release would be exercised. This determination may consider other relevant information, including recent climatic and hydrologic trends and forecasts of climatic and hydrological conditions, or other critical basin needs or anticipated impacts. Once the determination is made to exercise the trigger, releases from Jim Woodruff Dam would be made to meet the 4,500 cfs minimum flow, and storage of inflows above the 4,500 cfs would occur. Additional releases would be made as necessary to maintain head limits or due to other operational constraints, as has occurred during recent rainfall events when the releases resulted in flows over 5,000 cfs. Under the EDO, we would maintain the

4,500 cfs minimum flow once triggered until Composite Storage is restored from Zone 4 into Zone 3, at which time the EDO would return to maintaining the 5,000 cfs minimum flow. Discontinuation of the EDO would occur once Composite Storage is restored from Zone 3 into Zone 2, at which time the operations would return to those specified under the interim operation plan.

Enclosed is an assessment of the current status of each of the three components for a 4,500 cfs flow reduction trigger, effective December 1, 2007. This assessment demonstrates that all three components of the 4,500 cfs flow reduction trigger have been met. This also serves as the monthly update of the status of the hydrology of the system, including composite system storage, as required by RPM1 of the Amended BO.

In further support toward implementation of the next incremental reduction in releases, we offer the following additional information regarding hydrological and climatic trends and forecasts. Enclosed is a summary of hydrological data and modeling information considered in determining the hydrological status for the basin and forecasts relating to impacts on composite storage and the ability to sustain minimum flows, (this information was also used to assist in identifying possible triggers for a reduction in flow support).

- Hydrological Trends. As previously noted, our modeling assessments included in the U.S. Army Corps of Engineer (Corps') Biological Assessment dated November 1, 2007, and in the Service's Amended BO dated November 15, 2007, assumed that the 10th percentile flows would represent the worse case scenario. We determined in forecasts using the 10th percentile flows that maintaining a 4,750 cfs minimum release would not exhaust composite storage for the approximately 2-year period modeled. However, we have since then experienced inflows into the basin during the past several months that are below the 2nd percentile of historic flows. Monthly basin inflows above Walter F. George have been below the 2nd percentile historic flows since August 2007. The accumulated basin inflow above Walter F. George has been below the 2nd percentile of historic flow since late September 2007.

- Multi-year Drought Concerns and Forecast Storage Impacts. If these extreme hydrological conditions were to continue, our modeling results indicate that maintaining the 4,750 cfs minimum release would in fact exhaust composite storage in the basin by the fall of 2008. Although there is a great deal of uncertainty in attempting to project long-term forecasts, our modeling forecasts show that by October 2008 significant shortages in providing the minimum flows on the Apalachicola River would also occur (as measured at the Chattahoochee, Florida gage) once composite storage is exhausted. Exercising the trigger to reduce flows to the 4,500 cfs increment now could defer or avoid the need to exercise the next incremental reduction to 4,150 cfs, as well as minimize the risk of depleting all conservation storage. The enclosed modeling shows that attempts to store more water now would place the ACF storage reservoir in a better position next spring to support a multiple year drought scenario. In the spring of 2007, the Lake Lanier elevation was as high as 1,067.8 feet, but has continued a significant decline since then to a new record low elevation of 1,051.7 feet. The Lake Lanier elevation is expected to continue to decline through the rest of the year. If Lake Lanier begins the spring of 2008 at an elevation near or below 1,050 feet, then the ability to continue to maintain augmentation releases at Jim Woodruff Dam could be significantly at risk if conservation storage becomes depleted.

- Benefits to Project Storage and Purposes. Enclosed is a summary of the project storage benefits accrued since implementation of the EDO on November 16, 2007. Storage benefits include savings of approximately 6,745 acre-feet of composite storage within the basin (which represents approximately 340 day-second-feet or 675 acre-feet per day), and a net increase in storage of approximately 22, 134 acre-feet through December 2, 2007, due to the Thanksgiving week rainfall events. Most of this rainfall was stored in Walter F. George Lake, with lake levels increasing approximately 1.5 feet, but still remaining 1.5 feet below winter pool. West Point Lake levels remain fairly steady and Lake Lanier levels continue to decline. The project storage benefits from storage of increased basin inflows only occur if it rains within the basin and above the storage projects. Unless the increases in basin inflows are significant and sustained, they will provide only short-term limited storage benefits. Lacking rainfall in the basin, additional storage benefits can only be obtained by an additional incremental reduction in releases from the storage reservoirs. The benefits to be gained by an additional 250 cfs reduction of flow (incremental reduction from 4750 cfs to 4500 cfs) is an estimated savings of 250 cfs per day in storage. Saving this storage now prolongs the amount of time releases can be made later, including releases for critical needs such as hydropower, water supply and water quality. At current conditions in Lake Lanier, a savings of 250 cfs is equivalent to approximately 55 megawatts per day in hydropower generation; or to approximately one-third of the daily municipal water supply needs on the Chattahoochee River at Atlanta (estimated daily demand of 750 cfs); or one-third of the daily minimum flow requirement for water quality on the Chattahoochee River at Peachtree Creek (750 cfs). A savings of 250 cfs per day for 90 days (until approximately March 1) would be equivalent to approximately 22,500 day-second-feet, or 44,700 acre-feet. That would equate to a difference in elevation at Lake Lanier of approximately 1.5 feet. Extending this savings in storage for an additional 90 days, until June 1, would provide for a total savings of approximately 45,000 day-second-feet, or 89,400 acre-feet in storage at Lake Lanier.

- Climatic and Hydrological Forecasts. Forecasts provided by the National Weather Service continue to predict that strong LaNiña conditions in the Pacific Ocean will persist and are anticipated to result in increased probabilities of a very warm and dry winter in the ACF basin and continue into the spring months. Our staff meteorologist indicates that this December could be the driest ever recorded. A drought during the winter in the Southeast is extremely rare. The current drought has extended into winter and is forecast to severely impact conditions this spring. The Corps reservoirs are dependent on winter and spring rains to refill to summer levels and provide necessary storage to augment low flows during a dry summer and fall. Without this refill, the Corps ability to augment flows during a dry summer and fall would be significantly jeopardized. Reducing the flow at this time would enable the Corps to maximize the probability that the reservoirs would refill to levels that will allow them to sustain augmentation flows through the current multi-year drought. Under current conditions, Lake Lanier could be five feet lower on June 1, 2008, than predicted in the analysis performed for the Amended BO. This difference represents approximately 150,000 acre-feet less storage, or approximately 14 percent of conservation storage in Lake Lanier. This amount of storage would allow for continued support of the 4,500 cfs flow requirement for an estimated additional 25 days.

- Operations Using Inactive Storage. The current drought has resulted in record use of the total conservation storage from the Federal reservoirs. On November 6, 2007, we reached a new record low in total remaining conservation storage in the ACF Basin. Lake Lanier dropped below the previous record low elevation of 1052.7 feet on November 19, 2007 and continues to fall. It has become increasingly necessary to evaluate the possible consequences of complete use of the system conservation storage, and the need for a possible drought contingency plan for use of inactive storage in the ACF reservoirs. We are in the process of developing such contingency plans at this time, but under such a scenario reservoir operations would necessarily be restricted to meeting the critical needs of the system. Under this contingency scenario, the system needs would be prioritized to meet public health and safety, using the following criteria: maintain structural integrity of the projects; provide water to meet demands of local municipalities; maintain instream water quality; provide sufficient cooling water for the private thermoelectric power plants and support the endangered species in the Apalachicola River. The inactive storage will be subdivided into three action zones, similar to the conservation storage. The action zones would represent triggers to meet highest priority needs. Water managers would restrict releases, based on the above priorities, as storage decreases or falls into lower action zones. For example, if the conservation storage is depleted, some limited support to endangered species and thermoelectric power plants would be provided. As levels within the inactive storage continues to fall below the next lower action zone, then support for these uses would be discontinued and only releases in support of water supply and water quality would continued to be made. As levels continue to drop, only releases for water supply and structural integrity would be made. At some point, only releases for structural integrity would be made. It is clear that once we are restricted to operating in the inactive storage zones of the federal projects that only limited support to endangered or threatened species would be possible, and at some point would be eliminated. We will continue to consult with your agency and others as we continue to develop this contingency plan. For this reason, we are continuing to evaluate necessary actions that would allow some refill of the reservoirs during these exceptional drought conditions and to prevent us from using all conservation storage.

- Monitoring Data on Incidental Take of Mussels Due to 4,750 cfs Incremental Reduction in Flow. Following issuance of the Amended BO by the Service, we initiated the first incremental reduction in flows on November 16, 2007. Prior to the reduction in releases, flows were measured at approximately 5,130 cfs at a stage of 39.15 feet; and were stabilized within the first few hours following the reduction of releases to 4,770 cfs and a gage reading of 38.91 feet as measured at the U.S. Geological Survey (USGS) gage at Chattahoochee, Florida. Stages downstream were measured to be 27.39 feet prior to the reduction in flows, and stable at a reading of 27.29 feet at the Blountstown, Florida gage on November 17, 2007. Prior to reduction in releases, stages were measured at 10.97 feet, with a reading of 10.88 feet at the Wewahitchka, Florida gage once river stages stabilized on November 18, 2007 (All elevations are based on the National Geodetic Vertical Datum of 1929). These gage readings represent a fall in stage of approximately 3 inches in the upper river near Chattahoochee, approximately 1.5 inches near the Blountstown gage, and approximately 1 inch in the middle river near the Wewahitchka gage. Monitoring for incidental take of listed mussels was conducted by the Corps and U.S. Fish and Wildlife Service during November 17-20, 2007 in conformance with the requirements of RPM5.e. in the Amended BO. Sampling was conducted at 44 sites, moving downstream as river flows and stages stabilized. A summary of the monitoring conducted and the computed estimates of incidental take are enclosed.

The Amended BO authorized incidental take for up to 100 purple bankclimber mussels, up to 100 Chipola slabshell mussels, and up to 5,600 fat threeridge mussels for the incremental reduction in flow to 4,750 cfs. Our mussel mortality monitoring found no take of purple bankclimber or Chipola slabshell mussels; but documented an estimated take of 1,469 fat threeridge mussels. This estimate falls well within the estimated take included in the Amended BO. Although additional take of mussels is anticipated to occur with an additional incremental reduction in flow to 4,500 cfs, there is no reason to expect that it would exceed the authorized incidental take included in the Amended BO (i.e., up to a total of 100 individual purple bankclimber mussels, up to a total of 100 individual Chipola slabshell, and up to an additional 15,400 fat threeridge mussels).

We have been discussing with your agency possible revisions to the sampling protocol for estimating the amount of incidental take of mussels for the 4,500 cfs increment, to include the incorporation of additional mussel habitat site information being collected by the Service this week. Some recommended revisions are included in the summary report of incidental take monitoring for the 4,750 cfs incremental reductions in flow. The coordinated revised sampling protocol will be implemented in association with monitoring for incidental take of mussels to be conducted for the 4,500 cfs incremental reduction in flow.

Because of the above factors, we continue to believe that implementation of the second EDO incremental reduction in flows to 4,500 cfs should be implemented.

If you have any questions or require any additional information regarding the enclosed the anticipated exceptional drought impacts, modeling information, or proposed EDO trigger for a reduction to 4,500 cfs, please contact Ms. Joanne Brandt, Senior Environmental Specialist, (251) 690-3260, email: joanne.u.brandt@usace.army.mil; or Mr. Brian Zettle, Biologist, (251) 690-2115, email: brian.a.zettle@usace.army.mil.

Sincerely,

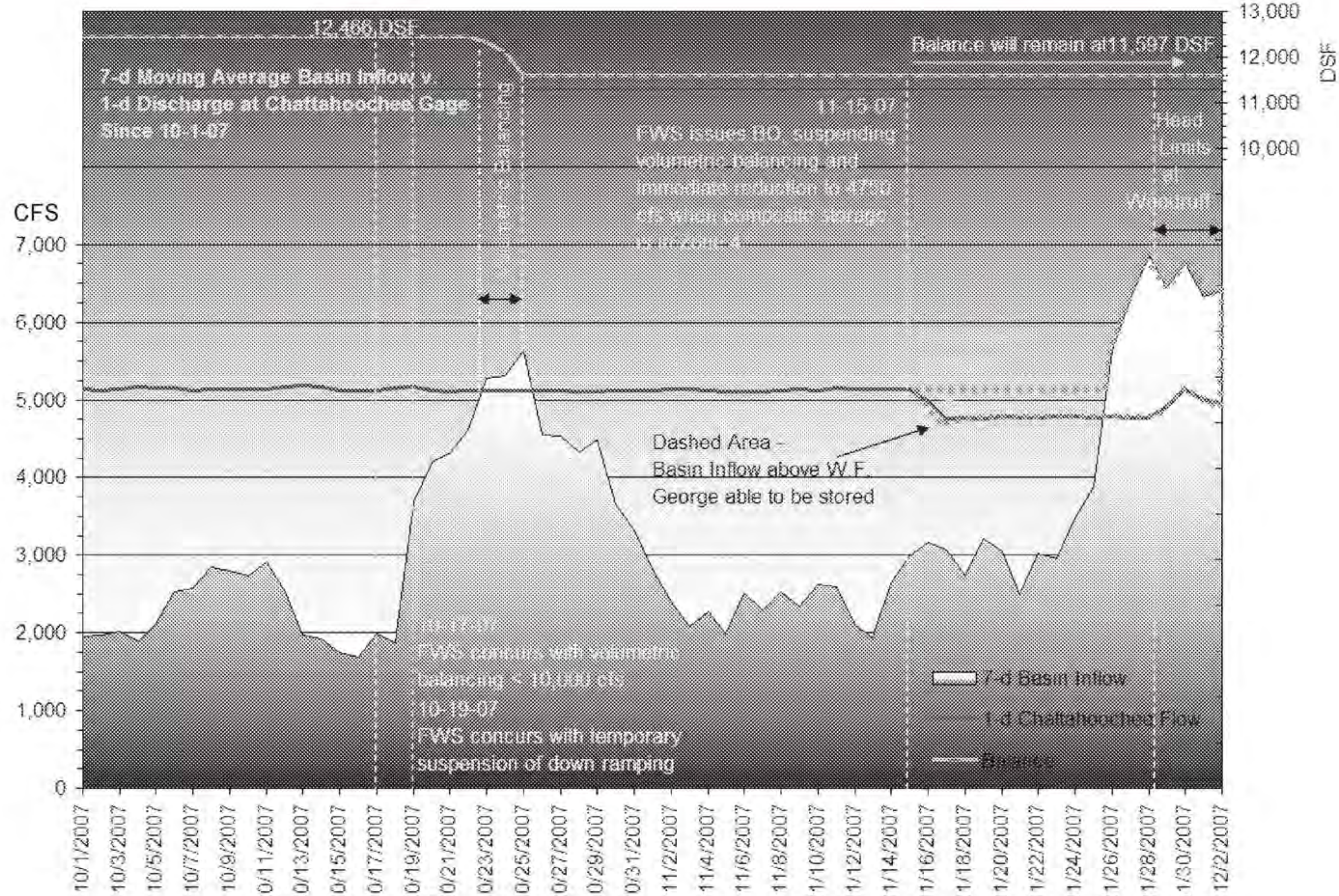
Curtis M. Flakes
Chief, Planning and Environmental
Division

Enclosures

Exhibit 75

EDO Incremental Reduction in Flow to 4,750 cfs

ACF Reservoir Storage Conserved


12,466 DSF
7-d Moving Average Basin Inflow v.
1-d Discharge at Chattahoochee Gage
Since 10-1-07
Balance will remain at11,597 DSF
11-15-07
FWS issues BO, suspending
volumetric balancing and
immediate reduction to 4750
cfs when composite storage
is in Zone 4
Head
Limits
at
Woodruff
Dashed Area -
Basin Inflow above W.F.
George able to be stored
10-17-07
FWS concurs with volumetric
balancing < 10,000 cfs
10-19-07
FWS concurs with temporary
suspension of down ramping
7-d Basin Inflow
1-d Chattahoochee Flow
Balance
CFS
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
13,000
12,000
11,000
10,000
DSF
10/1/2007
10/3/2007
10/5/2007
10/7/2007
10/9/2007
10/11/2007
10/13/2007
10/15/2007
10/17/2007
10/19/2007
10/21/2007
10/23/2007
10/25/2007
10/27/2007
10/29/2007
10/31/2007
11/2/2007
11/4/2007
11/6/2007
11/8/2007
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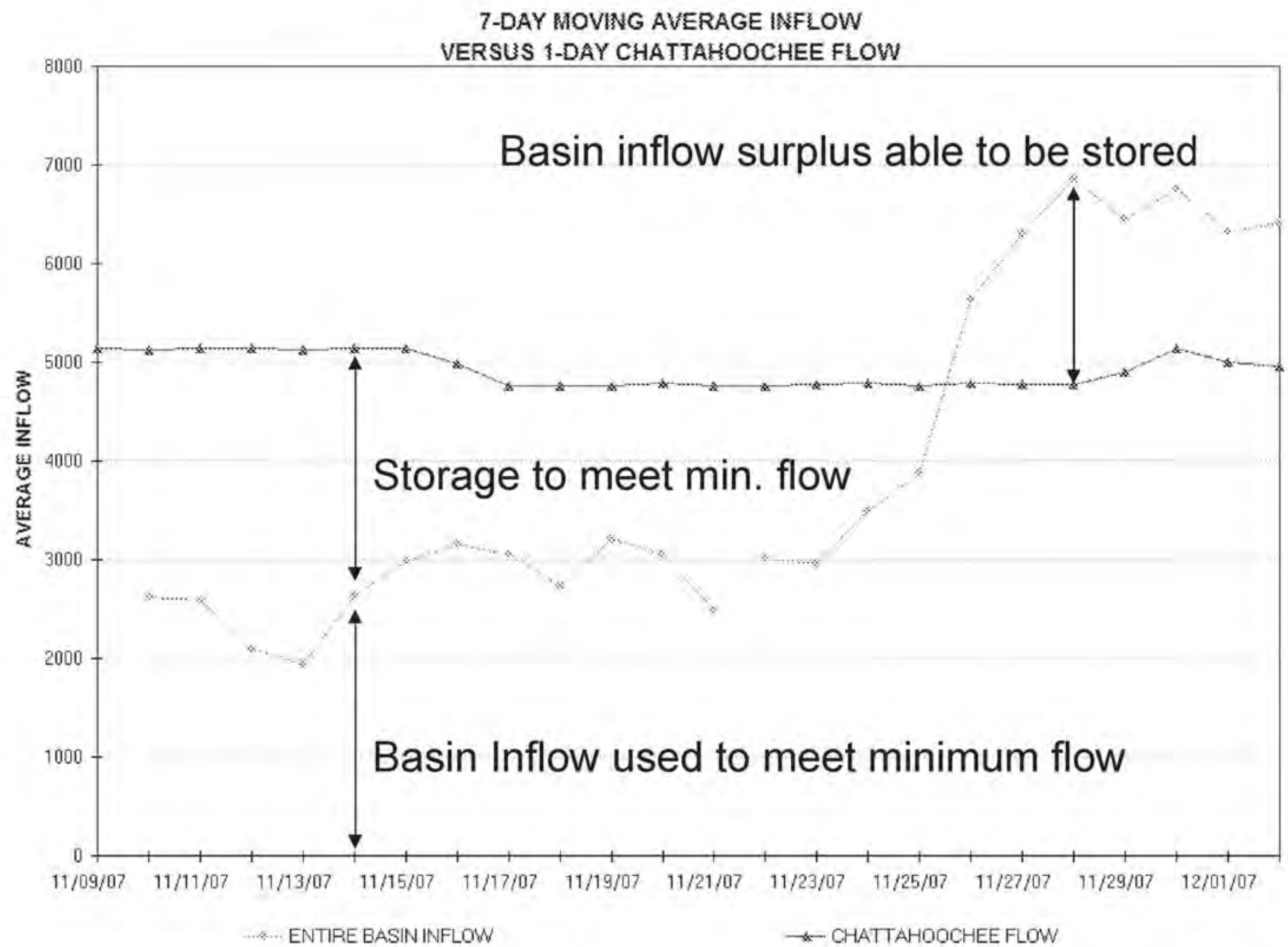
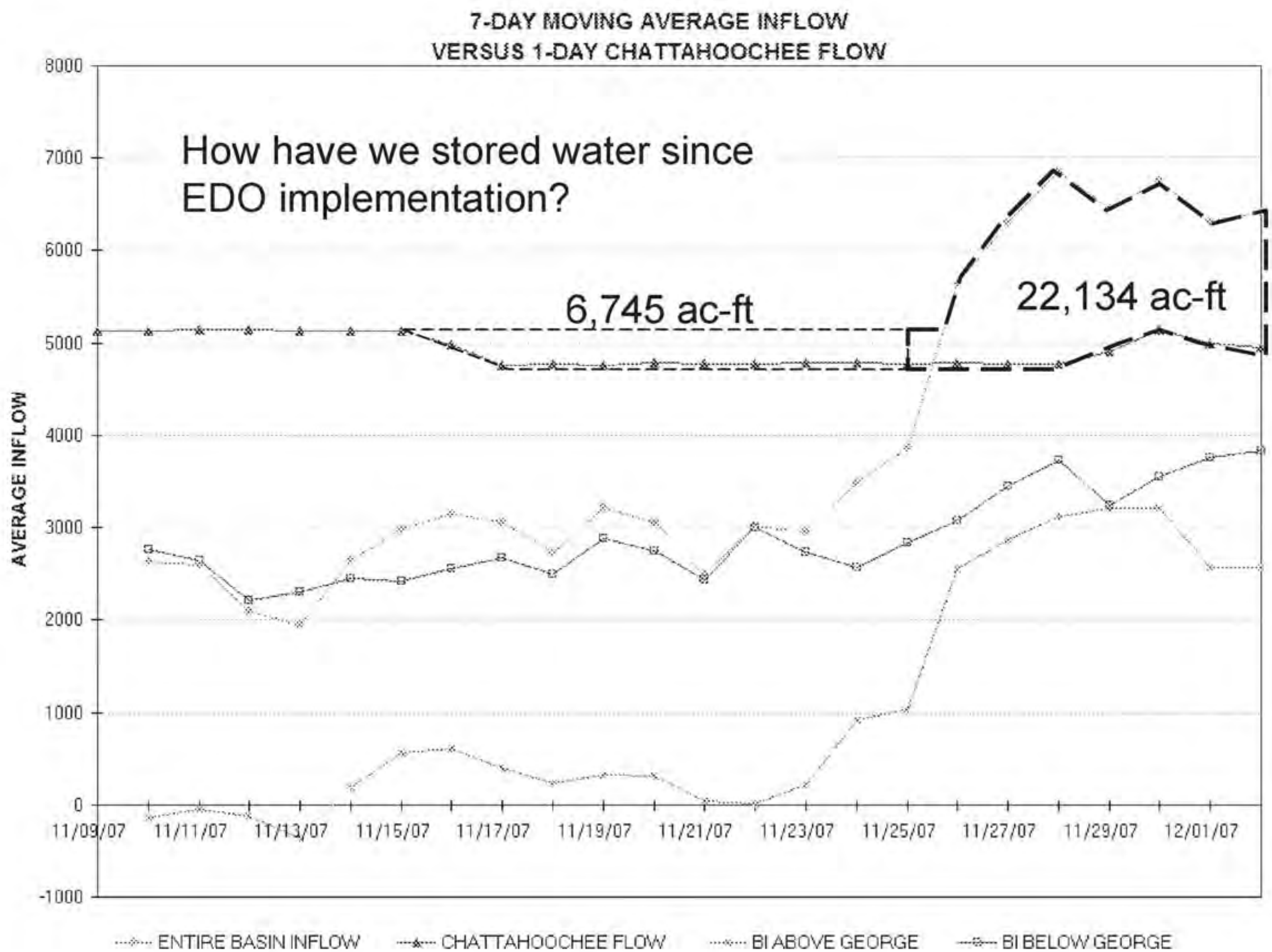
11/26/2007
11/28/2007
11/30/2007
12/2/2007


7-DAY MOVING AVERAGE INFLOW
VERSUS 1-DAY CHATTAHOOCHEE FLOW
AVERAGE INFLOW
8000
7000
6000
5000
4000
3000
2000
1000
0
11/09/07
11/11/07
11/13/07
11/15/07
11/17/07
11/19/07
11/21/07
11/23/07
11/25/07
11/27/07
11/29/07
12/01/07
Basin inflow surplus able to be stored
Storage to meet min. flow
Basin Inflow used to meet minimum flow
ENTIRE BASIN INFLOW
CHATTAHOOCHEE FLOW



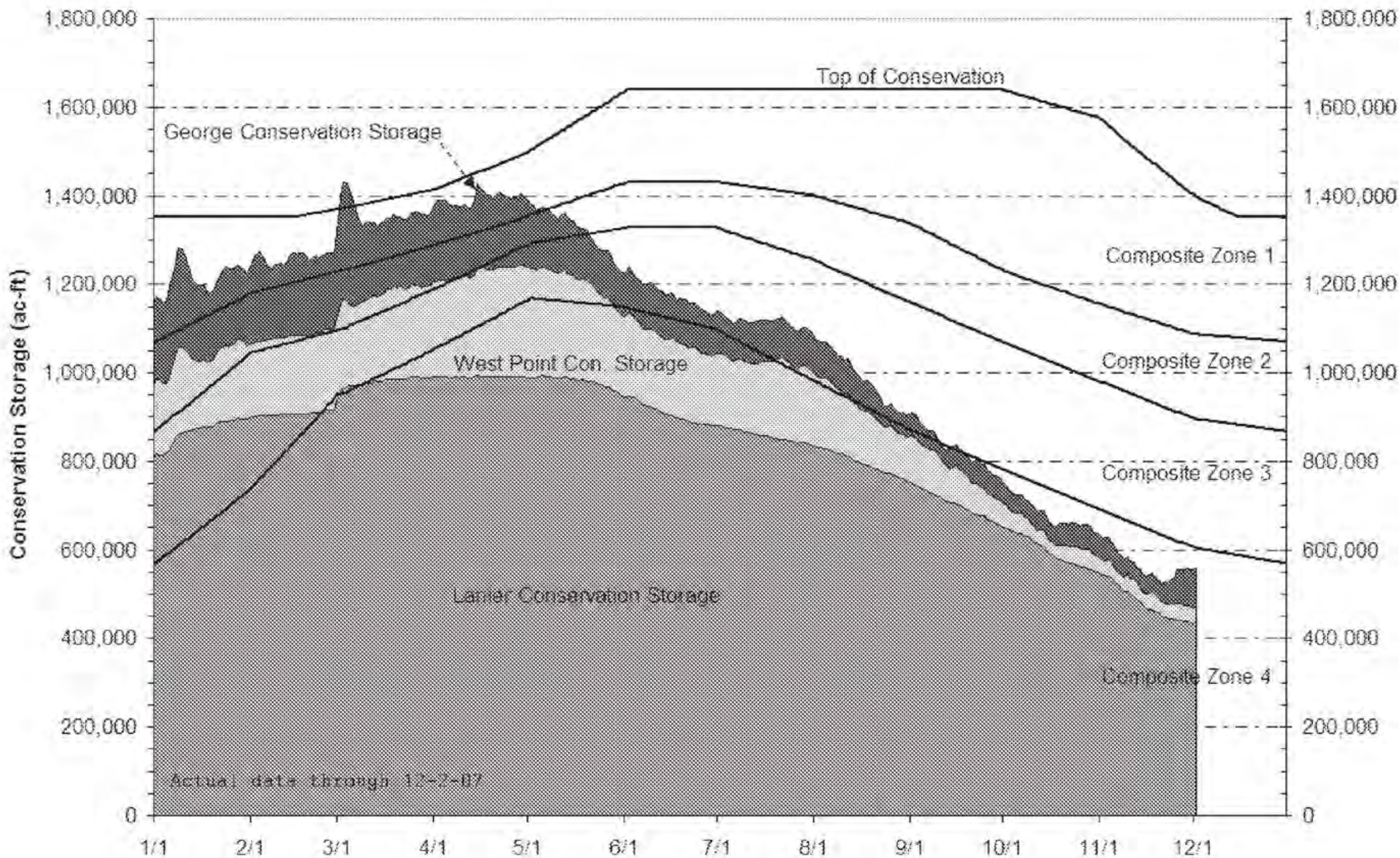
Purple + Green = Total Basin Inflow (Blue)

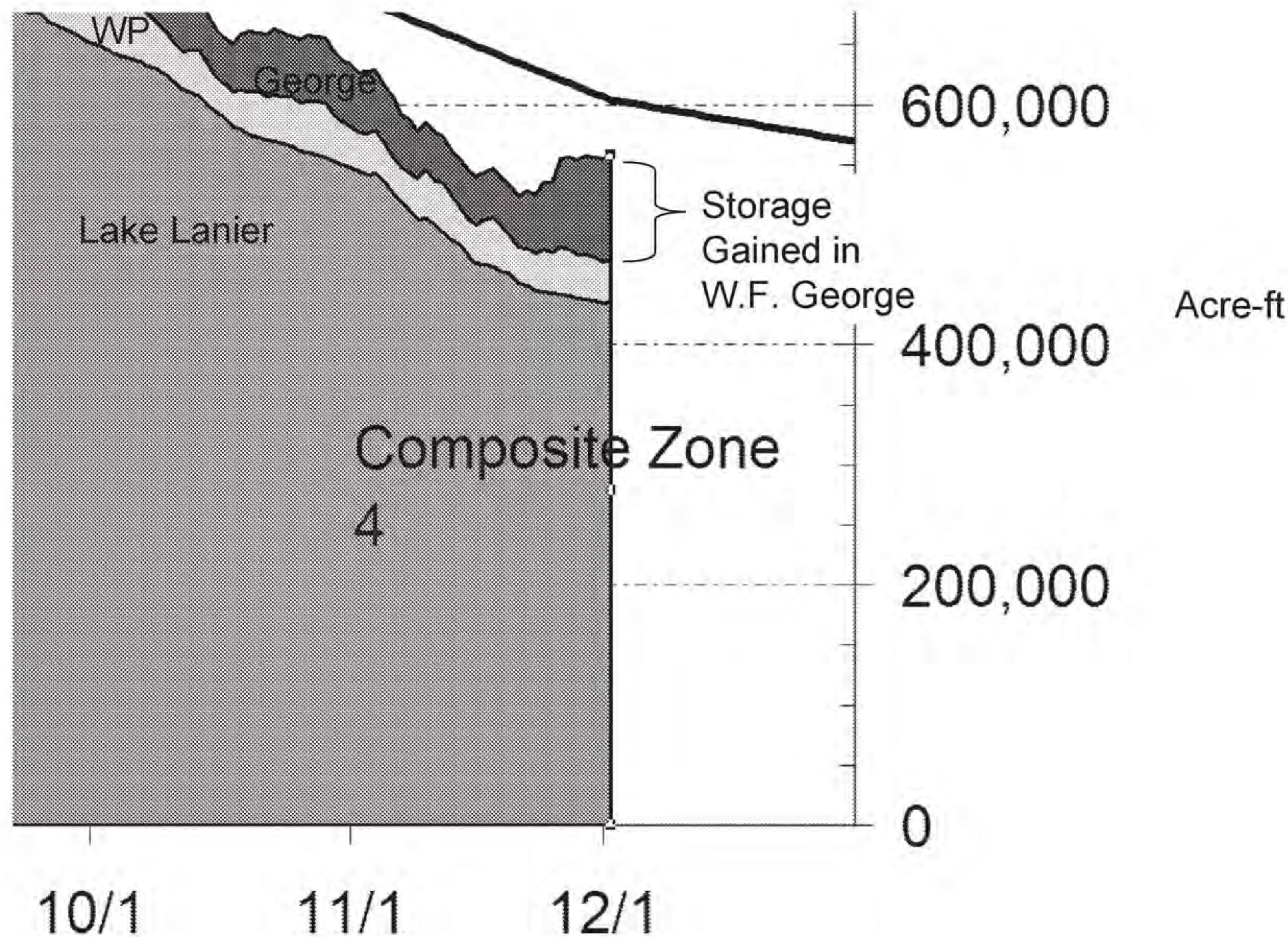
- Since reducing Chatt flows to 4750 cfs, we have kept from releasing 6,745 ac-ft due to the flow reduction, at the rate of ~340DSF (675 ac-ft) / day.
- We have stored 22,134 ac-ft of basin inflow from the recent Thanksgiving and weekend events. This is the net gain in conservation storage from 11-25-07 through 12-2-07
- This is all stored in W.F. George
- This is shown in the following Conservation Storage graph

Apalachicola River at Wewahitchka, FL

Flow ~5,100 cfs

2007 ACF Conservation Storage

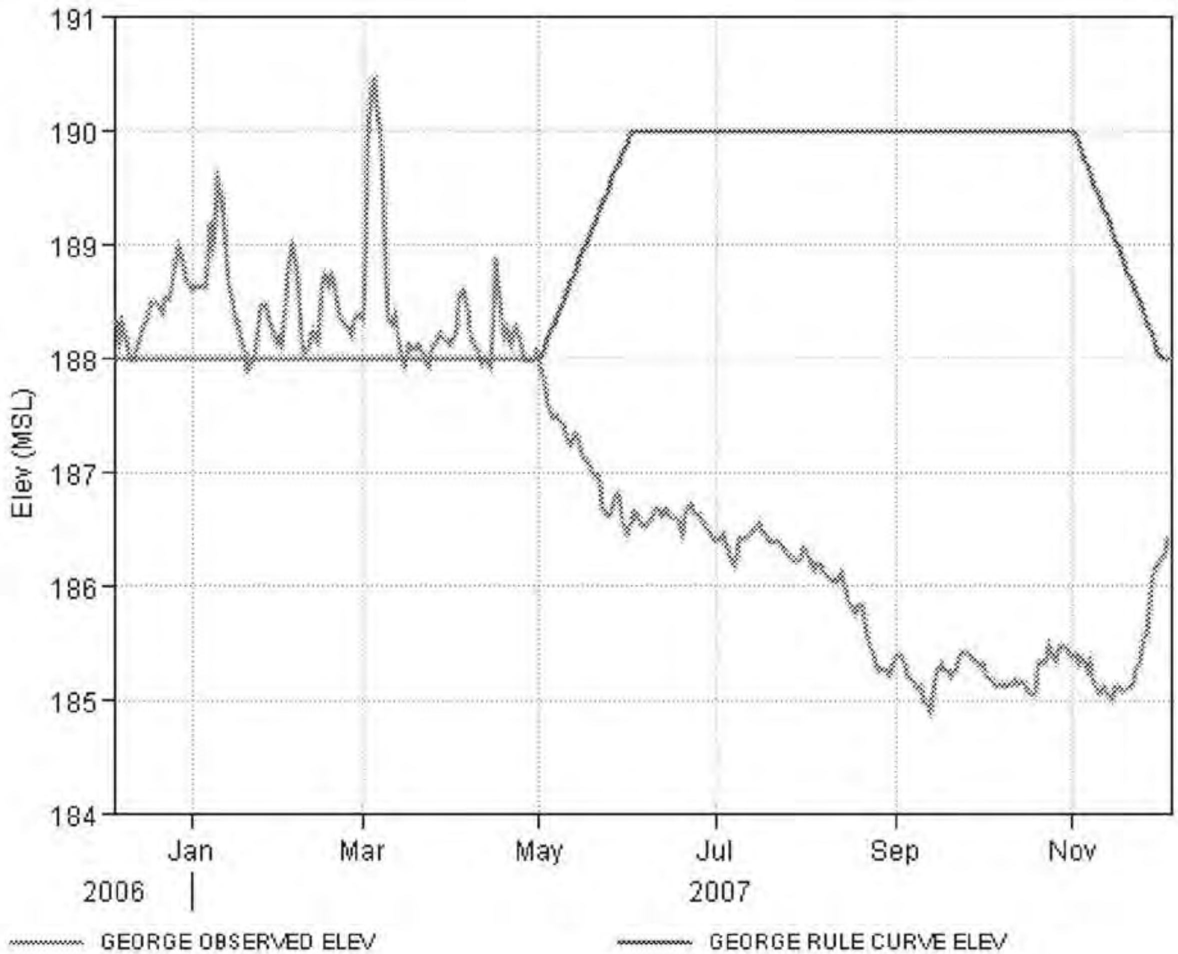



WP
George
Lake Lanier
Storage
Gained in
W.F. George
Composite Zone
4
600,000
400,000
200,000
0
Acre-ft
10/1
11/1
12/1

DATE	Buford Conservation Storage ac-ft	West Point Conservation Storage ac-ft	George Conservation Storage ac-ft	TOTAL ACF Conservation Storage
November-10	504,995	40,366	39,796	585,157
November-11	500,082	35,773	40,951	576,806
November-12	493,415	41,557	38,641	573,613
November-13	487,659	37,305	37,486	562,450
November-14	483,719	30,731	40,566	555,016
November-15	474,025	29,747	40,951	544,723
November-16	468,004	31,548	41,336	540,888
November-17	466,503	37,815	39,796	544,114
November-18	464,704	42,067	39,796	546,566
November-19	460,503	37,305	40,181	537,989
November-20	459,603	31,548	41,721	532,872
November-21	451,804	29,911	42,491	524,207
November-22	448,804	31,548	47,498	527,849
November-23	445,504	30,567	48,653	524,724
November-24	444,004	34,923	56,352	535,280
November-25	442,503	34,923	58,278	535,705
November-26	442,203	39,005	73,678	554,886
November-27	441,017	38,155	76,799	555,971
November-28	439,243	36,114	78,795	554,152
November-29	437,763	36,965	82,784	557,512
November-30	436,283	36,454	83,581	556,318
December-01	434,507	34,923	85,577	555,007
December-02	435,691	35,773	86,375	557,839

Gain in W.F. George

W.F. George



191
190
189
188
187
186
185
184
Elev (MSL)
Jan
Mar
May
Jul
Sep
Nov
2006
2007
GEORGE OBSERVED ELEV
GEORGE RULE CURVE ELEV

Exhibit 76

From: Hrabovsky, Cheryl L SAM
Sent: Thursday, October 25, 2007 9:50 AM
To: Ashley, Jonathan A SAM; Houston, Amber M SAM
Cc: Vaughan, Memphis Jr SAM; Hathorn, James E Jr SAM
Subject: FW: Volumetric Balancing

Amber,

Here the information on using volumetric balancing. I will also send you the reply from FWS.

Cheryl Hrabovsky
Hydraulic Engineer
U.S. Army Corps of Engineers, Mobile District Water Management Section Apalachicola-Chattahoochee-Flint Rivers Basin Manager
251-694-4018

-----Original Message-----
From: Zettle, Brian A SAM
Sent: Wednesday, October 17, 2007 9:12 AM
To: Jerry_Ziewitz@fws.gov; 'Gail Carmody'
Cc: Ashley, Jonathan A SAM; Bradley, Kenneth P SAM; Brandt, Joanne U SAM; Eubanks, Michael J SAM; Feldmeier, Paula M SAM; Flanagan, Patricia A SAM; Hathorn, James E Jr SAM; Hrabovsky, Cheryl L SAM; Otto, Douglas C Jr SAM; Peck, Brian E SAM; Shoemake, Deborah J SAM; Vaughan, Memphis Jr SAM; White, Jonas SAM; Zettle, Brian A SAM; Trawick, Eubie D SAM; Flakes, Curtis M SAM
Subject: Volumetric Balancing

Jerry,

Our meteorologist suggest that portions of the ACF Basin could receive relatively substantial rainfall (up to an inch) this week. Per our conversation earlier today and consistent with the Volumetric Balancing clarifications described in our 16 May 2007 letter to USFWS, I am providing notice that we intend to store basin flows greater than 5,000 cfs if conditions permit. Our current volumetric balancing account has approximately 12,000 dsf credits accumulated since May and due to the drought we have not yet had an opportunity to accomplish recovery of storage used for downramping during this period. We do not anticipate that the forecasted precipitation will result in substantial balancing of the account and it is likely that releases less than the 7-day basin inflow will not be significant. In the letter we agreed to avoid applying volumetric balancing when releases are less than 10,000 cfs to the extent practicable. However, due to the continuing drought we believe it is prudent to recover the storage as opportunties present themselves. Recovery of storage will assist us in continuing to augment flows to meet the 5,000 cfs minimum release requirement at Jim Woodruff Dam in support of listed mussels. We do not believe that releasing less than the 7-day basin inflow at this time will result in additional adverse impacts to listed species in the river. Should you have any comments or questions regarding volumetric balancing please contact me as soon as possible. Thanks.

Brian

Brian Zettle
Biologist
US Army Corps of Engineers

ACE-0118593

(251) 690-2115

Exhibit 77

EXPERT REPORT OF DR. J. WILSON WHITE

In the matter of
State of Florida v. State of Georgia

Prepared for Florida Department of Environmental Protection

Prepared by

J. Wilson White, Ph.D.
Assistant Professor
Department of Biology and Marine Biology
University of North Carolina Wilmington

February 29, 2016

Table 2. Prior distributions used for parameters in the model

Parameter	Distribution	Notes
$F_{1982\text{-}1992}$	lognormal(0.01,1.5)	Relatively flat prior but most density is < 1. Larger values would not be biologically plausible for a weekly harvest rate.
$F_{1992\text{-}1999}$	lognormal(0.01,1.5)	
$F_{1999\text{-}2005}$	lognormal(0.01,1.5)	
$F_{2005\text{-}2009}$	lognormal(0.01,1.5)	
$F_{2009\text{-}2012}$	lognormal(0.01,1.5)	
M_S	normal(1,2)	Expect the parameter to be positive and relatively small, but large standard deviation spans zero allowing estimate of no effect
$\square_a$	inverse gamma(10,0.1)	Relatively flat but most density on values below 10; error is added to every size bin so small values are amplified considerably.
$\square_r$	inverse gamma(10,0.1)	

Model simulations

I performed an IPM model fit to the observed Florida DACS data at Cat Point. The result of this fits was posterior distributions (i.e., model estimates) of the unknown F, M_S, and uncertainty parameters. After obtaining posterior distributions of the parameters from the hindcast fit, I re-ran the model in a non-data-fitting mode to simulate alternative salinity scenarios (though with process error still added in as before). In order to preserve the same sequence of process uncertainty terms in the new scenarios, so that the differences between model runs were deterministic rather than stochastic, I saved the sequence and the particle-filter weightings from the data-fitting run, and then re-used the same uncertainties and weights in the non-data fitting runs. To facilitate this we also initialized the Matlab random number generator with the same seed in each set of runs. Simulations with different random seeds did not produce noticeably different results, so we used the same arbitrarily chosen seed for all simulations presented in the main opinion.

In the alternative scenario we simulated approximated an "unimpacted flow" condition for 2007-2012. A hydrodynamic model of Apalachicola Bay was used to simulate surface temperature and salinity at model nodes throughout the Bay (Greenblatt Expert Report). That model was used to simulate both historical conditions and conditions with all upstream water withdrawals by Georgia removed("unimpacted flow", see Hornberger Expert Report, Greenblatt Expert Report). For the 2007-2012 period in the oyster population model, I used either the historical ("observed") hydrodynamic model output or the unimpacted outputs for the model nodes closest to each study site. Both scenarios used physical data collected at the study site by

Exhibit 78

No. 11-

IN THE

Supreme Court of the United States

IN RE: MDL-1824 TRI-STATE WATER RIGHTS LITIGATION.

On Petition for a Writ of Certiorari to the United States Court of Appeals for the Eleventh Circuit

PETITION FOR A WRIT OF CERTIORARI

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Counsel for City of Apalachicola

QUESTION PRESENTED

The Water Supply Act of 1958 ("WSA"), 43 U.S.C. § 390b, authorizes the Army Corps of Engineers to reallocate federal reservoir storage to support local water supply demands, but requires the Corps to obtain Congressional approval if a reallocation would constitute a "major * * * operational change." *Id.* § 390b(d). Two circuits have rendered conflicting decisions with respect to the WSA as it applies to Lake Lanier, a federal reservoir upstream of Atlanta whose waters flow through the Southeast and have sparked a three-decade water conflict among Georgia, Alabama, and Florida. The D.C. Circuit held that the Corps could not unilaterally reallocate 22 percent of Lanier's storage to Atlanta-area water supply because that would be a "major operational change." In the case below, by contrast, the Eleventh Circuit held that the Corps may be able to reallocate an even larger portion of the reservoir—34 percent—*without* Congressional approval, and that the WSA's "major operational change" limitation may be circumvented by relying on a project's underlying authorization.

The question presented is: Whether the Corps must comply with the explicit statutory limit in the WSA that requires Congressional approval before the Corps undertakes a major reallocation of federal reservoir storage to provide local water supply.

PARTIES TO THE PROCEEDINGS

The Petitioners are the State of Florida and the City of Apalachicola, Florida. Both were appellees below.

Respondents which were appellants/cross-appellees below are the State of Georgia; the City of Atlanta; Fulton County; DeKalb County; the Cobb County-Marietta Water Authority; the City of Gainesville; the Atlanta Regional Commission; the Lake Lanier Association; and Gwinnett County, Georgia. Respondents which were appellees below are the State of Alabama; Alabama Power Company; and Southeast Federal Power Customers, Inc. Respondents which were appellees/cross-appellants below are the U.S. Army Corps of Engineers; John McHugh, in his official capacity as Secretary of the United States Army; Jo-Ellen Darcy, in her official capacity as the Assistant Secretary of the Army-Civil Works; Major General Merdith W.B. Temple, in his official capacity as Acting Chief of Engineers, U.S. Army Corps of Engineers; Brigadier General Todd T. Semonite, in his official capacity as Commander, South Atlantic Division, U.S. Army Corps of Engineers; and Colonel Steven J. Roemhildt, Commander, Mobile District, U.S. Army Corps of Engineers.

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IN THE

Supreme Court of the United States

No. 11-

IN RE: MDL-1824 TRI-STATE WATER RIGHTS LITIGATION.

On Petition for a Writ of Certiorari to the United States Court of Appeals for the Eleventh Circuit

PETITION FOR A WRIT OF CERTIORARI

The State of Florida and City of Apalachicola respectfully petition for a writ of certiorari to review the judgment of the United States Court of Appeals for the Eleventh Circuit.

OPINIONS BELOW

The opinion of the Eleventh Circuit (App. 1a-86a) is reported at 644 F.3d 1160. The opinion of the District Court (App. 87a-187a) is reported at 639 F. Supp. 2d 1308.

JURISDICTION

The Eleventh Circuit entered judgment on June 28, 2011. App. 1a. Rehearing was denied on September 16, 2011. App. 188a. On November 9, 2011, Justice Thomas extended the time to file this petition to February 13, 2011. The jurisdiction of this Court rests on 28 U.S.C. § 1254(1).

STATUTE INVOLVED

The Water Supply Act, 43 U.S.C. § 390b (1958), provides in relevant part:

(b) *Storage in reservoir projects; agreements for payment of cost of construction or modification of projects*. In carrying out the policy set forth in this section, it is provided that storage may be included in any reservoir project surveyed, planned, constructed or to be planned, surveyed and/or constructed by the Corps of Engineers or the Bureau of Reclamation to impound water for present or anticipated future demand or need for municipal or industrial water * * * .

* * *

(d) *Approval of Congress of modifications of reservoir projects*. Modifications of a reservoir project heretofore authorized, surveyed, planned, or constructed to include storage as provided in subsection (b) of this section which would seriously affect the purposes for which the project was authorized, surveyed, planned, or constructed, or which would involve major structural or operational changes shall be made only upon the approval of Congress as now provided by law.

INTRODUCTION

Two Courts of Appeals have issued diametrically opposed decisions with respect to the same body of water—a massive federal reservoir whose outflows serve three states and have triggered a decades-long interstate water war. The divergent decisions were driven by the courts' conflicting interpretations of an important federal statute that this Court has never construed. The Court should grant the writ to resolve the split and clarify the fate of a water source that "is of the utmost importance to * * * millions of power customers and water users" throughout Florida, Alabama, Georgia, and the Gulf Coast. App. 84a.

The case concerns Lake Sidney Lanier, one of the nation's largest federal reservoirs. Lake Lanier sits on the Chattahoochee River above Atlanta. South of the lake, the Chattahoochee runs past Atlanta, along the Georgia-Alabama border, into the Apalachicola River in Florida, and thence to Apalachicola Bay. The waters stored in Lake Lanier are important to generate power, facilitate navigation, and ensure the survival of ecologically sensitive resources downstream in Florida and Alabama. But localities in Georgia seek to use those same waters for local water supply. Those divergent interests have spawned a cross-border water dispute that has produced 13 different decisions in six federal courts.

The essence of the dispute is whether the Army Corps of Engineers may, without Congressional approval, reallocate Lake Lanier's water storage[1] away from its original uses—downstream flows for power generation and navigation—and toward direct withdrawals and releases from the lake for local water supply. Any such reallocation would have a profound effect on downstream interests because water reserved in storage for direct withdrawal is not available for downstream release when needed. It also would unilaterally rebalance the interests weighed by Congress in authorizing the reservoir.

In 2002, the Corps agreed to reallocate to local water supply some 22 percent of Lanier's storage capacity—enough to cover the entire National Mall in water almost 800 feet deep. Florida and Alabama protested, and the D.C. Circuit rejected the plan as

---

[1] In this context, "storage" refers to the amount of space in Lake Lanier allocated to a particular project purpose. App. 10a. As we discuss below, the Corps releases water from the reservoir to serve the purpose for which the space has been allocated.

unlawful under the Water Supply Act ("WSA"). The WSA authorizes the Corps to modify reservoir allocations to allot storage for local water supply. *Id.* § 390b(b). However, it requires Congressional approval if the reallocation would work a "major * * * operational change[ ]" to the reservoir. *Id.* § 390b(d). The D.C. Circuit concluded that a 22 percent reallocation was a major operational change and that the plan accordingly required Congressional approval. *Southeastern Fed. Power Customers, Inc.* v. *Geren*, 514 F.3d 1316 (D.C. Cir. 2008), *cert. denied*, 129 S. Ct. 898 (2009); App. 190a-212a.

The Eleventh Circuit has now issued a decision that contradicts *Geren* and provides the Corps broad discretion to reallocate storage without Congress's approval. Georgia asked the Corps to reallocate *34 percent* of Lanier's storage—a much larger reallocation than the one disapproved in *Geren*—to satisfy Atlanta's water demands. App. 66a. Consistent with its longstanding interpretation of its authority, the Corps refused. It found that such a large reallocation would "involve * * * major operational changes" and required Congress's approval under the WSA. App. 25a. But the Eleventh Circuit has now rejected that view. It held that the Corps has some measure of authority under an earlier statute to reallocate Lanier's storage; that the WSA merely "supplement[s]" that authority; and that the WSA provision requiring Congressional approval for "major operational changes" may be circumvented. App. 64a-67a, 76a-80a. It remanded, having given the Corps a green light to reallocate massive amounts of storage without obtaining Congress's imprimatur.

The decision below directly conflicts with that of the D.C. Circuit. It undercuts Congress's power to control the Nation's reservoirs. It affects the competing interests of three states to a single stream of water—"a necessity of life that must be rationed among those who have power over it." *New Jersey* v. *New York*, 283 U.S. 336, 342 (1931). It will adversely impact important downstream ecologies in the river basin and limit the extent to which downstream states can benefit from hydropower and river navigation. And like an original action, it implicates "the manner of use" of "interstate lakes and rivers." R. Stern et al., *Supreme Court Practice* 242 (9th ed. 2007). This Court should grant the writ and hold that the D.C. Circuit was correct: Before the Corps can fundamentally reallocate a major federal water source to local supply at the expense of downstream needs, it must obtain the approval of Congress.

STATEMENT

A. The Affected Rivers and Lake Lanier.

1. The Chattahoochee River begins as a mountain spring on the Appalachian Trail in northeastern Georgia. App. 5a. Emerging from the Blue Ridge Mountains, the river flows past Atlanta and along the Georgia-Alabama border. *Id.* "At the Florida-Georgia border the Chattahoochee joins the Flint River and they become the Apalachicola River, which eventually flows into the Apalachicola Bay and the Gulf of Mexico." *Alabama* v. *U.S. Army Corps of Eng'rs*, 424 F.3d 1117, 1122 (11th Cir. 2005). The rivers and the areas they drain are referred to as the Apalachicola-Chattahoochee-Flint, or "ACF," Basin.[2]

The Chattahoochee is Atlanta's primary water source. But it is just as important to Florida and

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[2] *See* www.sam.usace.army.mil/pa/acf-wcm/pdf/acf_map.pdf.

Alabama as a source of drinking water, water supply, hydroelectric power, recreation, and sustenance for riverine ecologies. "Southeastern Alabama relies upon the Chattahoochee for much of its water supply[.]" D. Stephenson, *The Tri-State Compact: Falling Waters & Fading Opportunities*, 16 J. Land Use & Envtl. L. 83, 85 (2000). The Apalachicola River "empties into the Apalachicola Bay, which provides approximately 90% of Florida's oyster harvest." *Id.* The Bay, in turn, is a critical nursery for the Gulf of Mexico—and one whose productivity depends on robust river flows. *See infra* 29. And the Apalachicola "has the highest species density of amphibians and reptiles in the North American Continent north of Mexico"; it is home to numerous protected species. *Georgia* v. *U.S. Army Corps of Eng'rs*, 302 F.3d 1242, 1250 n.6 (11th Cir. 2002).

2. Lake Lanier's history dates to 1925, when Congress asked the Corps to consider hydroelectric projects in the area. App. 5a. That led to the idea of a reservoir (Lake Lanier) and dam (the Buford Dam) on the Chattahoochee above Atlanta. App. 5a-6a.

Congress approved the reservoir plan, among hundreds of other reservoir projects, in omnibus authorizing legislation in 1945 and 1946. The second of those acts, the 1946 Rivers and Harbors Act ("RHA"), provided that the Buford project would be "prosecuted * * * in accordance with the report of the Chief of Engineers, dated May 13, 1946." Pub. L. No. 79-525, 60 Stat. 634, 635 (1946). That report, in turn, incorporated a Corps report by Brigadier Gen. James B. Newman Jr., known as the "Newman Report," that set out the details. App. 6a; *see* Docket No. 4 Exh. B, *Georgia* v. *U.S. Army Corps of Eng'rs*, No. 3:07-md-00252 (M.D. Fla. Apr. 12, 2007) (Newman Report's text). The report observed that "[t]he principal value of the Chattahoochee River is as a source of power." App. 93a. It concluded that the Buford site was the best spot for "a large storage-power reservoir[.]" *Id.*

The report noted other "incidental" benefits of a reservoir, *id.*, including water supply for Atlanta. It observed that "[i]f the regulating storage reservoir * * * could be located above Atlanta, it would greatly increase the minimum flow in the river at Atlanta, thereby producing considerable incidental benefits by reinforcing and safeguarding the water supply[.]" App. 94a. Nothing in the report suggested that Congress or the Corps ever contemplated that water supply would be made available through direct withdrawals from storage at Lake Lanier.

3. Lake Lanier was completed in 1957. It had 692 miles of shoreline and conservation storage capacity[3] of 1,049,000 acre-feet—*i.e.*, enough to hold the quantity of water that would submerge 1,049,000 acres of land to a depth of one foot. App. 11a. None of that space was allocated to local water supply. App. 113a. On the contrary, as the District Court found, "both before and during construction of Buford Dam, the Corps consistently described the primary purposes of the project as flood control, navigation, and hydropower," and "the water-supply benefit discussed throughout the legislative history was the regulation of the river's flow." App. 113a, 163a.

B. The Water Supply Act.

In 1958, a year after Lanier was completed, Congress enacted the WSA. The Nation's federally-

[3] Lanier has *total* capacity of 2,554,000 acre-feet. The rest is for flood containment and so-called "inactive" storage.

owned reservoirs historically had not been used to store water for local supply; that was considered a parochial use, and the Corps did not think itself authorized to dedicate space in reservoirs for local use. *See* Docket No. 14-2 at 8 n.1, *In re Tri-State Water Rights Litigation*, No. 3:07-md-01 (M.D. Fla. June 6, 2007) ("*2002 Corps Memorandum*"). The WSA ushered in a sea change in federal water policy, authorizing the Corps to provide storage space for local water supply. 43 U.S.C. § 390(b). But Congress was careful not to give the Corps free rein. Instead, it required that the Corps obtain Congress's approval before agreeing to any storage plan that would effect "major * * * operational changes" at a reservoir:

> *Modifications of a reservoir project* heretofore authorized, surveyed, planned, or constructed to include storage as provided in subsection (b) of this section which would seriously affect the purposes for which the project was authorized, surveyed, planned, or constructed, or *which would involve major structural or operational changes* shall be made only upon the approval of Congress as now provided by law. [*Id.* § 390b(d) (emphases added)].

C. The Shift To Direct Withdrawals at Lanier.

1. The Corps controls water-storage allocations at Lake Lanier, as it does at more than 500 reservoirs nationwide. *See* 33 C.F.R. § 222.5(o), & App. E (2011). The Corps' authority over storage allocations does not mean it owns the water or directly controls who can withdraw it downstream. It means, instead, that the Corps can assign reservoir space to given uses and operate the reservoir to support those uses—but only within limits specified by Congress.

Acting within those limits, the Corps retains or releases water according to plans designed to ensure that users with storage allocations will have water when they need it. App. 137a-138a.

2. For years (and with minor exceptions not relevant here),[4] none of Lake Lanier's storage capacity was dedicated to water supply. App. 113a. Indeed, the Corps explicitly recognized that no storage could be allocated to water supply under the RHA without "additional Congressional authorization." App. 145a. In 1955, for example, Gwinnett County, Georgia, a county northeast of Atlanta, asked permission to make withdrawals from Lanier. The Corps refused. Consistent with its longtime recognition that the intended water-supply benefit of Lanier was merely the regulation of the river's flow, App. 113a, the Corps concluded "that such withdrawals would affect the project's authorized purposes" and that the county "would have to seek permission from Congress for the withdrawals." App. 139a-140a.

Beginning in the 1970s, however, "the Corps's and the Georgia parties' definition of water supply in the Buford project changed considerably." App. 114a. Despite its previous acknowledgment that it could not do so, the Corps began making changes to storage at Lake Lanier, giving priority to local municipalities so they could make direct withdrawals from the lake and withdraw more water downstream. In 1973, the Corps agreed to let Gwinnett County withdraw up to 40 million gallons per day—an amount requiring about 40,000 acre-feet of storage—directly from Lake Lanier. App. 140a. The Corps

[4] Two cities were granted the right to withdraw comparatively small amounts from the lake because the reservoir inundated their existing water-intake facilities. App. 139a.

subsequently agreed to let two other Georgia cities, Cumming and Gainesville, withdraw 10 million and 20 million gallons per day, respectively. App. 141a-142a. And in the 1980s, the agency agreed to alter its operations so the Atlanta Regional Commission ("ARC") could withdraw 377 million gallons per day downstream. App. 141a. That contract was based on the Corps' determination that it could provide, incidental to power generation, 327 million gallons per day with no impact on hydropower. App. 170a-171a. The Corps agreed to provide releases sufficient to accommodate up to 50 million gallons per day *above* that threshold, thus effectively reallocating that amount from hydropower to water supply. *Id.* All of these contracts expired in 1989 but have continued as holdover arrangements. App. 142a.

Meanwhile, the Corps was studying how to meet Atlanta's growing water needs. In a 1989 report, the "draft PAC Report," it suggested formally allocating a massive amount of Lanier's storage—207,000 acre-feet—to local water supply. App. 136a. That would allow localities to withdraw 151 million gallons per day from the lake. It also would provide releases so that localities could withdraw 378 million gallons per day downstream. App. 175a-176a. The report noted the Corps' authority under the WSA, but stated that approval from Congress might be required because the allocation exceeded 50,000 acre-feet. App. 18a. The Corps intended to submit the report to Congress for approval under the WSA. App. 135a.

The draft PAC Report included a water-control plan that illustrates the practical effect of such a dramatic storage reallocation. The plan divided Lake Lanier's conservation storage pool into four levels, or "zones," by depth. App. 138a. In the zone corresponding to the lowest lake levels—*i.e.,* drought periods—local water supply would be the dominant purpose, while hydropower was relegated to a "minimum level." *Id.* In other words, at the very times when water flow was most critical for downstream users, the Corps would be operating the reservoir to benefit Atlanta-area localities instead—a 180-degree change from Lanier's original operations.

D. The D.C. Circuit's Decision in *Geren*.

In 1990, Alabama filed suit in the Northern District of Alabama to challenge the draft PAC Report and Georgia localities' use of Lanier's storage. App. 143a. More litigation followed. In 2000, a group of federal power customers filed suit in Washington, D.C., alleging that the Corps had wrongfully diverted storage from hydropower generation. App. 145a. In 2001, Georgia sued the Corps in the Northern District of Georgia, seeking to compel the agency to agree to an even larger reallocation than that in the draft PAC Report. *Id.* And in 2008, the City of Apalachicola sued the Corps in the Northern District of Florida, alleging that the Corps' allocation changes were reducing flows into Florida and damaging Apalachicola Bay. App. 148a.

The D.C. Circuit's decision in *Geren* arose out of the federal power customers' lawsuit in D.C. federal court. In 2003, the Corps, the power customers, Georgia, and parties aligned with Georgia reached a proposed settlement in that case. App. 145a-146a. The settlement would have formally allocated storage in Lake Lanier for Gwinnett County, Gainesville, and ARC. App. 146a. Under its terms, those three entities would purchase some 240,000 acre-feet of storage, some for withdrawals directly from the lake and some to enable downstream withdrawals in amounts greater than those incident to hydropower generation. *Id.* The settling parties relied on the WSA for authority, arguing that the WSA authorized reallocation for water supply storage and that the proposed reallocation neither "seriously affect[ed] the purposes for which the project was authorized" nor amounted to a "major * * * operational change[.]" 43 U.S.C. § 390b(d); *see* App. 24a. The D.C. District Court approved the settlement in 2004 over Florida and Alabama's vehement objections. App. 147a.

The D.C. Circuit reversed. *Geren*, 514 F.3d 1316; App. 190a-212a. The court observed that the settlement required the Corps to allocate up to "240,858 acre-feet of Lake Lanier's water storage" to local use. App. 194a. That was a reallocation of 22 percent if the water-storage baseline was zero—which the court concluded it was, given that zero was the amount allocated to water supply when the lake began operation—or 9 percent if the baseline was the existing withdrawals under holdover arrangements. App. 202a-203a. Either way, such a large reallocation was a "major * * * operational change" requiring Congressional approval. *Id.* The court wrote that "the WSA plainly states that a major operational change to a project falling within its scope requires prior Congressional approval." App. 200a-201a. And it concluded that "[o]n its face," reallocating more than 22 percent of storage "constitutes the type of major operational change referenced by the WSA[.]" App. 202a. The same conclusion would obtain if the reallocation amounted to 9 percent. App. 203a.

The D.C. Circuit reached this conclusion at Chevron step 1, based on the statute's plain terms, but it also cited other data points to confirm its holding.

First, the Corps had acknowledged at oral argument that a 22 percent reallocation "would be the largest acre-foot reallocation ever undertaken by the Corps without prior Congressional approval." App. 203a. Second, the Corps itself repeatedly had cast doubt on, or flatly rejected, the notion that it could make such massive reallocations without Congressional approval. The Corps acknowledged in the draft PAC Report, for example, "that Congressional approval might be required for reallocation of 207,000 acre-feet"—a smaller reallocation than the one proposed in the settlement. App. 201a. And in 2002, "the Corps rejected Georgia's request" that about 34 percent of Lanier's storage be reallocated to local use, concluding that "Georgia's request was of a magnitude that would 'involve * * * major operational changes' and therefore required prior Congressional approval." *Id.*; *see 2002 Corps Memorandum* at 1. That conclusion, the *Geren* court found, was "consistent with th[e] plain text" of the WSA. *Id.* The court concluded:

> [R]eallocation of over twenty-two percent (22%) of Lake Lanier's storage space * * * is large enough to unambiguously constitute the type of major operational change for which section 301(d) of the WSA requires prior Congressional approval. The same conclusion applies to a reallocation of approximately nine percent (9%) of Lake Lanier's storage space, for it too presents no ambiguity. [App. 205a].

Judge Silberman concurred. He would have found that the baseline water storage amount was 13.9 percent—*i.e.*, the amount Atlanta-area localities had been withdrawing under the holdover arrangements. App. 211a. He nonetheless found, as the majority did in the alternative, that a 9 percent reallocation was a major operational change. App. 212a.

Georgia sought certiorari, arguing that the D.C. Circuit had made inappropriate factual findings. The Corps opposed, pointing out that the D.C. Circuit's "interpretation of the Water Supply Act does not conflict with any decision of * * * any other court of appeals." Br. for the Federal Respondents in Opposition, No. 08-199 (Nov. 17, 2008), 2008 WL 4918013, at *5. Certiorari was denied.

E. The Decision Below.

Meanwhile, the three other Lanier-related lawsuits were transferred to the Middle District of Florida by the Judicial Panel on Multi-District Litigation. App. 24a. Following the D.C. Circuit's remand in *Geren*, that action was consolidated with the others.

One of the issues before the District Court was Georgia's challenge to a related Corps decision involving Lake Lanier water storage. Georgia's governor asked the Corps in 2000, while two of the four Lanier-related lawsuits were pending, to reallocate 34 percent of Lanier's storage to local water supply—a much larger reallocation than the one the D.C. Circuit rejected in *Geren*. App. 178a. The Corps denied the request. *Id.*; *see 2002 Corps Memorandum* at 1. It found that Congress did not include water supply as an authorized purpose at Lanier, and that "Corps analysis of Georgia's request indicates that granting it would seriously affect the purposes for which the project was authorized and would involve major operational changes." App. 25a; *2002 Corps Memorandum* at 2. It accordingly could not "be accommodated without additional Congressional authorization." App. 145a.

The District Court approved the Corps' decision. As it explained, the "fundamental question" was whether a unilateral Corps decision granting Georgia's request would have violated the WSA. App. 89a. The court concluded that it would. After a detailed analysis of the legislative history, the court agreed that Congress did not include water supply as an authorized purpose at Lake Lanier. App. 168a. It also concluded that *Geren* was entitled to collateral estoppel effect as to what constituted a "major operational change": Because the D.C. Circuit had held that a 22 percent reallocation would violate the WSA without Congressional approval, it followed *a fortiori* that a 34 percent reallocation required Congressional approval too. App. 174a-175a.

The Eleventh Circuit reversed. The panel concluded that the Newman Report and similar documents contemplate that Lanier would be used for water supply, and that the amount of water supply might need to be adjusted over time. App. 45a-57a. From that premise, the panel concluded that Brigadier General Newman "intended for water supply to be an authorized, rather than incidental, use of the water stored in Lake Lanier." App. 51a. And because Lake Lanier's authorizing statute—the RHA—referred to a Corps report, and the Corps report in turn incorporated the Newman Report, the panel concluded that Congress shared Brigadier General Newman's intent. App. 47a. Indeed, the panel referred to the Newman Report *itself* as the "statutory language" governing Lake Lanier's operations. App. 50a.

The Eleventh Circuit then took the leap that set it at odds with *Geren*. While *Geren* had held that the WSA requires Congressional approval for "major operational changes," regardless of the Corps' underlying authority to adjust allocations, *see* App. 202a-203a & n.4, the Eleventh Circuit held just the opposite: that to the extent the Corps had underlying authority to adjust allocations, those changes would not count as "changes" at all—much less major operational changes requiring Congressional approval. App. 65a-67a, 76a-80a. Thus, for example, the panel wrote that the Corps erred in rejecting Georgia's request for a 34 percent reallocation because "[i]t failed to recognize that the [RHA] * * * explicitly contemplated that the Corps was authorized to increase water supply usage over time as the Atlanta area grew *and that this increase would not be a change from Congressionally contemplated operations at all*." App. 65a (emphasis added). And it wrote that the Corps should consider only reallocations made "pursuant solely to the WSA"—not reallocations made using the Corps' purported RHA authority—in deciding whether a change constituted a "major operational change." App. 76a n.35. The panel so concluded based on its view that the WSA merely "constitutes a supplement to any authority granted by the 1946 RHA." App. 13a.

According to the Eleventh Circuit panel, then, the WSA—and its mandates, such as the Congressional approval requirement—are a mere second layer of authority; to the extent the Corps may make operational changes at Lanier under the RHA, the WSA is never triggered. Indeed, the panel attempted to distinguish *Geren* on that very basis. It wrote that *Geren*'s 22-percent-reallocation holding was not entitled to collateral-estoppel effect because *Geren* did not consider the extent of the Corps' authority under the RHA. App. 79a. According to the Eleventh Circuit, "this difference means that any water the Corps finds it is authorized to supply pursuant to the RHA is separate from the water it is authorized to supply pursuant to the WSA, *and that this RHA-authorized water supply would not count against the Geren court's 22% limit*." *Id.* (emphasis added).

The Eleventh Circuit remanded to the Corps for a determination of precisely how much reallocation authority the agency has when its purported RHA authority is added to its "supplemental" WSA authority. App. 83a-84a. The court ordered the agency to make that decision within one year. App. 85a.

REASONS FOR GRANTING THE PETITION

1. The Court should grant the writ, and reverse the erroneous decision below, because the Eleventh Circuit "has entered a decision in conflict with the decision of another United States court of appeals on the same important matter"—indeed, a decision with respect to the same body of water. S. Ct. R. 10(a). The Eleventh Circuit's decision cannot be reconciled with the D.C. Circuit's decision in *Geren*. It is in conflict with this Court's cases. And the divide between the circuits is one that time alone will not repair; the conflict will percolate no further because all cases regarding Lanier have been consolidated in the Eleventh Circuit. Instead, without this Court exercising its jurisdiction, the conflict between three sovereign states as to this body of water will fester.

2. Review also is warranted because the issue on which the circuits have divided is an important question of first impression for this Court. The WSA is of national importance: It fundamentally changed the way federal reservoirs are used, and the Corps relies on it to justify water allocations across the nation. This Court has never construed the WSA.

And the Eleventh Circuit has now inappropriately limited it, truncating a provision designed to maintain Congressional control over an important national resource and handing that control to the Corps. This Court's guidance is needed.

3. Nor can there be any doubt that this case carries public ramifications sufficiently important to warrant the exercise of certiorari jurisdiction. The case has driven a wedge between three states. As the court below recognized, "[t]he stakes are extremely high" and the case "is of the utmost importance to the millions of power customers and water users that are affected by the operations of the project." App. 84a. Indeed, if the decision below stands, it will have a profound effect on the ACF Basin because water reserved for direct withdrawal is not available for release to support downstream hydropower, navigation, and ecologies. The writ should be granted.

I. THE DECISION BELOW CONFLICTS WITH A DECISION OF THE D.C. CIRCUIT AND CANNOT BE RECONCILED WITH THIS COURT'S CASES.

A. The Decision Below Conflicts With *Geren*.

1. Certiorari review is warranted here "to resolve a conflict among the Circuits." *Erica P. John Fund, Inc.* v. *Halliburton Co.*, 131 S. Ct. 2179, 2184 (2011); S. Ct. R. 10(a). *Geren* and the decision below addressed the same question—namely, the extent of the Corps' authority to unilaterally alter Lake Lanier's storage to provide more water supply for Georgia residents. And they reached diametrically opposed conclusions:

- The D.C. Circuit held that WSA Section 301(d) requires the Corps to obtain Congressional approval for a "major * * * operational change[ ]" involving water supply, regardless of the Corps' authority to adjust water storage allocations as a general matter. App. 201a-203a. The Eleventh Circuit, in direct contrast, held that WSA Section 301(d) imposes no such requirement where the Corps has some independent measure of authority to adjust storage allocations. App. 75a-76a, 79a.

- The D.C. Circuit held that the WSA restricts the Corps' authority to make significant changes from a reservoir's original storage allocation without Congressional approval. App. 201a-203a. The Eleventh Circuit, in direct contrast, held that the WSA is nothing more than a source of "supplemental" authority for the Corps to take such actions. App. 64a, 83a.

- The D.C. Circuit found that the Corps correctly concluded that the WSA required it to obtain Congressional approval before reallocating 34 percent of the lake's storage. App. 201a-202a. The Eleventh Circuit held that the Corps was wrong to so conclude. App. 63a-65a. Indeed, the D.C. Circuit accepted as a correct understanding of the WSA the very Corps analysis—the 2002 Army memorandum—that the Eleventh Circuit *rejected and vacated* in the decision below. *Compare* App. 201a-202a (*Geren*) *with* App. 63a-65a (opinion below).

That is a "direct conflict." *Stern & Gressman* 242. And it has important implications for the division of authority between Congress and an agency, as we discuss *infra* at 25. That sort of disagreement among the circuits about the distribution of federal authority warrants this Court's review.

2. The Eleventh Circuit attempted to distinguish *Geren*, asserting that "a different issue" was presented in that case because "the *Geren* court considered only the Corps' authority under the WSA, not its authority under the RHA." App. 79a. The panel misunderstood the D.C. Circuit's opinion. *Geren* recognized that the Corps might be able to muster authority to make some limited water storage reallocations, but it explicitly declined to consider the question, explaining that it "ha[d] no occasion to opine whether the Corps' previous storage reallocations were unlawful." App. 203a & n.4. Whether the Corps enjoyed such authority was irrelevant because, regardless, the WSA was clear: If the Corps desired to make a *major* operational change, it needed Congressional approval. App. 200a-203a. The D.C. Circuit's conclusion is quite correct, as we discuss *infra* at 21. More important for present purposes, the D.C. Circuit's analysis is squarely at odds with the Eleventh Circuit's holding that the WSA's "major operational change" provision is not implicated to the extent that the Corps has a separate source of authority for water reallocation. Under the Eleventh Circuit's decision, the D.C. Circuit engaged in a pointless exercise in rejecting the far smaller 2004 proposed water reallocation.

3. Review of this circuit split is warranted now because it is already fully articulated and is unlikely to deepen or disappear. This is not a situation where similar cases are working their way through the Courts of Appeals, making it worthwhile for this Court to await " 'further study' " by those intermediate tribunals. *Stern & Gressman* 246 (quoting *McCray* v. *New York*, 461 U.S. 961, 963 (1983) (Stevens, J.)). On the contrary, all cases relating to the

Corps' WSA authority over Lake Lanier—including the case on remand from the D.C. Circuit's decision in *Geren*—have been consolidated in the Eleventh Circuit. App. 26a. That court is the one that created the circuit split, and it has denied a petition for rehearing en banc. The divide between the circuits on the WSA's scope—and accordingly on the degree of control Congress can exercise over federally operated waters—will not be resolved unless this Court resolves it.[5]

B. The Decision Below Is Incorrect And In Conflict With This Court's Cases.

1. Certiorari review is particularly appropriate here because the decision below is incorrect and in conflict with this Court's teachings. The WSA provides that storage-related reservoir modifications for water supply "which would involve major * * * operational changes shall be made *only* upon the approval of Congress as now provided by law." 43 U.S.C. § 390b(d) (emphasis added). That command is simple and broad, as the D.C. Circuit recognized: Any time a storage reallocation to water supply involves "major operational changes," the Corps must obtain Congressional approval, full stop. App. 200a-203a. But the Eleventh Circuit held that the WSA merely "supplement[s]" purported pre-existing Corps authority to allocate reservoir storage for local water supply, and that any changes the Corps was authorized to make under that pre-existing authority

[5] Nor could the issue disappear on remand from the Eleventh Circuit to the Corps. The Corps has been instructed that it possesses the authority to allocate water under the RHA, potentially unconstrained by the WHA's "major operational change" limitation. That instruction renders whatever the agency may do on remand necessarily deficient.

"would not count" in determining whether a major operational change occurred. App. 79a, 83a. It held, in other words, that the Corps must seek Congressional approval for a subset of major operational changes, but not for all of them.

That was error. It is, of course, a "settled principle[ ] of statutory construction" that if "statutory text is plain and unambiguous," courts "must apply the statute according to its terms." *Carcieri* v. *Salazar*, 555 U.S. 379, 387 (2009). Thus where "[n]othing in the statutory context requires a narrowing construction," none is appropriate; the courts "must give effect to the text congress enacted." *Ali* v. *Federal Bureau of Prisons*, 552 U.S. 214, 227 (2008). Here the WSA requires Congressional approval for "major * * * operational changes" involving local water-supply storage. 43 U.S.C. § 390b(d). That means *all* major operational changes, not some. As this Court said in *Maine* v. *Thiboutot*, 448 U.S. 1, 4 (1980): "The question before us is whether the phrase * * * means what it says, or whether it should be limited to some subset[.] * * * Given that Congress attached no modifiers to the phrase, the plain language of the statute" must govern.

2. The Eleventh Circuit's contrary conclusion rests on the notion that if the Corps enjoys authority to change water allocation to some extent, then any change it chooses to make using that authority cannot be "major," and does not count toward any calculus of whether a larger change is "major." App. 65a, 79a; *see supra* at 15-17. That is simply not so. As the D.C. Circuit recognized in *Geren*, whether a change is "major" is a matter of degree having nothing to do with whether some quantum of change was *authorized*. App. 200a-203a.

The Eleventh Circuit also went further, asserting that if the RHA authorizes the Corps to reallocate some storage to water supply, then "such reallocations to water supply *arguably do not actually constitute a 'change' of operations at all*." App. 80a (emphasis added); *see also* App. 65a (asserting that the RHA "explicitly contemplated" that Corps increases to water-supply storage at Lake Lanier "would not be a change from Congressionally contemplated operations at all"). But a change is a change. If the Corps alters the allocation of storage in a reservoir, that is a "change," even if the Corps enjoyed authority under a pre-WSA statute to order it. The Eleventh Circuit's attempt to conflate change with authority is nonsensical. Under the court's reasoning, someone who changes his name has not actually "changed" it, so long as he received prior permission to do so.

The Eleventh Circuit thought its truncated reading of the WSA appropriate because—according to that court—the WSA merely provides additional reallocation authority on top of that provided by the RHA. App. 13a, 68a. The Eleventh Circuit was incorrect about the reallocation authority provided by the RHA, as we discuss below. But assuming *arguendo* that the RHA *did* provide the Corps with reallocation authority, the Eleventh Circuit's conclusion still would not follow. Imagine that the RHA were far more explicit than it actually is about the Corps' authority—that it provided, for example, that "the Corps is authorized to allocate storage to water supply at Lake Lanier." In that scenario the Corps might not need Congressional approval to make operational changes, but it still would need Congressional approval for "*major* * * * operational changes." 43 U.S.C. § 390b(d) (emphasis added). The code could be read to "give effect to both provisions," and accordingly it *must* be so read. *Ricci* v. *DeStefano*, 129 S. Ct. 2658, 2674 (2009); *accord Morton* v. *Mancari*, 417 U.S. 535, 551 (1974) ("[W]hen two statutes are capable of co-existence, it is the duty of the courts * * * to regard each as effective."). The Eleventh Circuit's contrary conclusion was error.

3. The opinion below also is erroneous for a second reason: The RHA does not confer on the Corps the authority to reallocate Lake Lanier's storage for water supply, as the District Court correctly recognized. In an exercise of legislative history run riot, the Eleventh Circuit plucked snippets from various Army Corps reports—which it referred to, inaccurately, as the "statutory language"—and concluded that local water supply was an "authorized * * * use of the water stored in Lake Lanier." App. 50a-51a. But even if the Eleventh Circuit were correct about that—which it was not—it would not follow that the RHA provides the Corps the authority to reallocate water storage for that use. In fact, as the District Court found, a fair reading of the contemporaneous Corps documents reveals that "the water-supply benefit discussed throughout the legislative history" is merely "*the regulation of the river's flow*." App. 113a (emphasis added). The RHA, in other words, contemplated that Atlanta would receive a more regular supply of water from the Chattahoochee River due to the Corps' regular releases from Buford Dam for electrical power generation. That is a far cry from providing the Corps authority to alter storage allocations and to thereby enable massive withdrawals of reservoir water for local water-supply uses. The RHA and the reports to which it refers say nothing about storage for water supply, as the Corps

itself consistently recognized in the decades after the RHA's enactment. *See supra* at 9.

II. THE QUESTION PRESENTED IS AN ISSUE OF FIRST IMPRESSION INVOLVING AN IMPORTANT FEDERAL STATUTE.

Certiorari review is appropriate to resolve "important" statutory questions "of first impression in this Court," *Reading Co.* v. *Brown*, 391 U.S. 471, 475 (1968)—especially when the lower court's decision bears directly on "the scope of the [agency's] authority," *Hodgson* v. *Local Union 6799*, 403 U.S. 333, 336 (1971), and runs counter to the agency's long-held view of its statutory powers. *See*, *e.g.*, *Morton* v. *Ruiz*, 415 U.S. 199, 202 (1974) (granting certiorari "because of the vigorous assertion that the judgment of the Court of Appeals was inconsistent with long-established [agency] policy").

This case meets that description in full. The WSA is an important statute—it ushered in a fundamental change in federal water-supply policy, and the Corps has relied on it to reallocate storage at nearly four dozen reservoirs[6]—and yet this Court has never construed it. And the decision below certainly bears on "the scope of the [Corps'] authority" under the WSA. *Hodgson*, 403 U.S. at 336. Indeed, it dramatically expands that authority, altering the balance of power between Congress and a federal agency. Under the WSA as written, Congress must ensure that storage reallocations that constitute a "major operational change" always meet with its approval—a sensible approach, given the sweeping significance

[6] Congressional Research Serv., *Using Army Corps of Engineers Reservoirs for Municipal & Industrial Water Supply: Current Issues* 2 (Jan. 4, 2010).

of water-storage policies, the intricate balancing that must take place between a variety of interests, and the impacts on downstream states. But under the Eleventh Circuit's novel interpretation, there will be a subset of reallocations that work a "major operational change" under the plain meaning of that term—and yet Congress will have no opportunity to sign off. That approach allows "the administrative agency [to] usurp[ ] the legislative function" by arrogating to itself a decision-making role Congress explicitly chose *not* to delegate. *Textile Mills Sec. Corp.* v. *Commissioner*, 314 U.S. 326, 338 (1941).

Finally, the judgment of the Court of Appeals is "inconsistent with long-established [agency] policy." *Morton*, 415 U.S. at 202. For more than four decades, the Corps consistently explained that a reallocation to local water supply at Lake Lanier—and especially a reallocation of the magnitude sought by Georgia here—"would require Congress's approval" under the WSA. App. 166a; *see also* App. 140a. It reiterated that conclusion in the 2002 memorandum rejecting Georgia's request. App. 25a. The Eleventh Circuit's decision is manifestly at odds with that longtime agency understanding of its own authority. And the court's novel approach has the potential to upset settled expectations across the country: If the Corps can rely on snippets from yellowed engineering reports to blow past the WSA's limits, then it can fundamentally alter storage allocations at reservoirs nationwide without seeking Congress's imprimatur. That is not what Congress envisioned when it carefully calibrated how reservoirs were to be used and placed a hard cap on the Corps' authority to make unilateral changes.

III. THE COURT SHOULD RESOLVE THIS MASSIVE CROSS-BORDER DISPUTE INVOLVING THREE SOVEREIGN STATES AND MILLIONS OF WATER USERS.

Even aside from the stark—and static—conflict between two appellate courts over the extent of the Corps' authority to reallocate water storage, this case is sufficiently important to warrant the Court's exercise of certiorari jurisdiction. Three states have been fighting over a critical resource for decades, billions of dollars are at stake, and there is no end in sight. The Court's guidance is necessary here, just as it is in original-jurisdiction cases involving water rights, to resolve a "controvers[y] between sovereigns which involve[s] issues of high public importance." *United States* v. *Texas*, 339 U.S. 707, 715 (1950).

1. This Court often grants certiorari where the case presents a dispute of public importance. *Pharmaceutical Research & Mfrs.* v. *Walsh*, 538 U.S. 644, 650 (2003); *McGee* v. *Int'l Life Ins. Co.*, 355 U.S. 220 (1957). Specifically, the Court has long recognized that cases involving allocation of natural resources, including land and water, merit its careful review. *United States* v. *Coleman*, 390 U.S. 599, 601 (1968).

This is such a case. Millions of people rely on the water flowing from Lake Lanier. That water is "critically important to communities throughout the region as a primary source of drinking water, hydroelectric power, and local impoundment, as well as industrial transportation, recreation and many other uses." Stephenson, *supra*, at 84. It presently provides the primary water source for metro Atlanta's 4.5 million people. *See supra* at 5. It is a crucial resource for southeastern Alabama. *See supra* at 6.

And in Florida, it is the lifeblood of the highly productive Apalachicola River and Apalachicola Bay.

The Apalachicola River requires vigorous flows to support a diverse array of wildlife, including commercially important fish populations and a number of endangered and threatened species. *See* Docket No. 193 Exh. 2 at 4-8, *In re MDL-1824 Tri-State Water Rights Litigation*, No. 3:07-md-01 (M.D. Fla. Jan. 23, 2009) ("*Light Declaration*"). The Bay, for its part, "is an exceptionally important nursery area for the Gulf of Mexico." Florida Dep't of Envtl. Protection, *About the Apalachicola National Estuarine Research Reserve & Associated Sites*.[7] "Over 95% of all species harvested commercially and 85% of all species harvested recreationally in the open Gulf have to spend a portion of their life in estuarine waters." *Id.* And that productivity "is dependent on the Apalachicola River to carry fresh water and essential nutrients downstream to feed estuarine organisms." Apalachicola Riverkeeper, *Apalachicola River & Bay Facts*.[8] As one commentator observed, "the recreational fishing industry in the eastern Gulf, which accounts for an economy of several billion dollars annually, owes much of its success" to the conditions created by the Apalachicola's flows. J.B. Ruhl, *Water Wars, Eastern Style: Divvying Up the Apalachicola-Chattahoochee-Flint River Basin*, J. Contemp. Water Res. & Educ. (June 2005), at 47. That is why Florida has invested hundreds of millions of dollars to protect the ecological integrity of the River and Bay. *See*, Docket No. 193 Exh. 3 at 3-

[7] *Available at* http://www.dep.state.fl.us/coastal/sites/ apalachicola/info.htm.

[8] *Available at* http://www.apalachicolariverkeeper.org/ Apalachicola%20River%20and%20Bay%20Facts.pdf.

4, *In re MDL-1824 Tri-State Water Rights Litigation*, No. 3:07-md-00001 (M.D. Fla. Jan. 23, 2009).

The reallocation requested by Georgia would severely strain these resources and undermine Florida's investment. The Eleventh Circuit itself has recognized that much of the "water released for municipal purposes is consumed and not discharged into the river," and that such withdrawals "have a practical effect" upon flows at points south. *Georgia*, 302 F.3d at 1251-52. The District Court in this case found that "low flows in the Apalachicola River are at least to some extent caused by the Corps's operations in the [river] basin" and that "those low flows cause harm to the creatures that call the Apalachicola home." App. 157a. Indeed, those low flows "harm not only wildlife," but also "navigation, recreation, water supply, water quality, and industrial and power uses downstream." *Id.*

It also is not simply Georgia's *use* of Lake Lanier's reallocated water that causes ill effects downstream; it is the storage reallocation itself. When the Corps structures its operations to retain water in Lake Lanier and release it for local water supply instead of for hydropower, that affects how much water flows downstream, and at what intervals. The resulting low-flow conditions lead to devastating consequences for the ecology and species of the Apalachicola River and Bay. Among other things, they eliminate those water bodies' hydrologic connections to stream and marshland habitats—thus cutting many species of fish off from habitats they must access to survive—and increase salinity in the Bay and portions of the River. *Light Declaration* at 4-7.

2. These sorts of impacts explain why all parties agree this is a singularly important case. Respondent Georgia told this Court, in the course of seeking review in *Geren*, that "[h]ow the storage capacity of Lake Lanier is to be allocated between conflicting interests is an issue of vital importance to the State of Georgia, the Water Supply Providers, the Power Customers, and the Corps." Pet. for a Writ of Certiorari, No. 08-199 (Aug. 13, 2008), 2008 WL 3833287, at *16. Georgia told the court below that "a failure to allocate storage in Lake Lanier to water supply would cost Georgia 680,000 jobs, $127 billion in wages, and $8.2 billion in state revenues." Br. for Appellants 81, *In re: MDL-1824 Tri-State Water Rights Litigation*, Nos. 09-14657-G *et seq.* (11th Cir. Mar. 31, 2010). And Georgia asserted that any ruling requiring the Corps to go to Congress for reallocation approval would impose "massive," "devastating," "staggering," and "crippling" harm on the Georgia parties. *Id.* at 77-78. Respondents thus can hardly deny that this case has "importance warranting certiorari review." *Stern & Gressman* 268.

* * *

This is a momentous case for all concerned. If it involved a direct contest among the three States for equitable allocation, there is little doubt that the Court would view it as justifying invocation of this Court's original jurisdiction, for it is "a dispute between States of such seriousness that it would amount to *casus belli* if the States were fully sovereign." *South Carolina* v. *North Carolina*, 130 S. Ct. 854, 869 (2010) (Roberts, C.J., concurring in part and dissenting in part) (quoting *Texas* v. *New Mexico*, 462 U.S. 554, 571 n.18 (1983)). The same rationale militates in favor of certiorari review here.

CONCLUSION

For the foregoing reasons, the petition for a writ of certiorari should be granted.

Respectfully submitted,

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APPENDIX A

In the

UNITED STATES COURT OF APPEALS
FOR THE ELEVENTH CIRCUIT

No. 09-14657

In Re:

MDL-1824 TRI-STATE WATER RIGHTS LITIGATION.

Appeals from the United States District Court
For the Middle District of Florida

(June 28, 2011)

Before MARCUS and ANDERSON, Circuit Judges, and MILLS,[*] District Judge.

PER CURIAM:

The Georgia Parties,[1] Gwinnett County, Georgia, and the United States Army Corps of Engineers ("the Corps") appeal from the Middle District of Florida's grant of summary judgment in this consolidated suit. The appeal arises from more than 20 years of litigation involving the above parties as well as the States of Alabama and Florida, Alabama Power Company,

[*] Honorable Richard Mills, United States District Judge for the Central District of Illinois, sitting by designation.

[1] The designation "Georgia Parties" refers to the State of Georgia, the City of Atlanta, Fulton County, DeKalb County, the Cobb County-Marietta Water Authority, the City of Gainesville, the Atlanta Regional Commission, and the Lake Lanier Association. Gwinnett County, Georgia appeals separately and is not included in this denomination.

the City of Apalachicola, Florida, and Southeastern Federal Power Customers, Inc. ("SeFPC"), a consortium of companies that purchase power from the federal government. All of the underlying cases[2] relate to the Corps' authority to operate the Buford Dam and Lake Lanier, the reservoir it created, for local water supply. In its order, the district court found that the Corps' current operation of the Buford Project—Buford Dam and Lake Lanier collectively—had allocated more than 21% of Lake Lanier's storage space to water supply. The court determined that such an allocation exceeded the Corps' statutory authority and ordered the Corps to drastically reduce the quantity of water that it made available for water supply. The court's summary judgment order also affirmed the Corps' rejection of Georgia's 2000 request for additional water supply allocations to meet the needs of the localities through 2030. The court stayed its order for three years to give the parties time to reach a settlement or to approach Congress for additional water supply authority.

On appeal, the parties argue several jurisdictional matters. Alabama and Florida[3] contend that this Court does not have appellate jurisdiction to hear the

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[2] The four underlying cases are *Alabama v. United States Army Corps of Engineers*; *Southeastern Federal Power Customers, Inc. v. Caldera*; *Georgia v. United States Army Corps of Engineers*; and *City of Apalachicola v. United States Army Corps of Engineers*.

[3] The State of Alabama, the State of Florida, Alabama Power Company, and the City of Apalachicola have written a joint brief in this case. The designation "Alabama and Florida" refers to all four parties. The designation "Appellees" in this opinion refers to these four parties and SeFPC. The Corps is also an appellee in *Georgia,* but for the sake of clarity it will always be referred to by name.

appeal of three of the four underlying cases because there is no final judgment in the cases and pendent jurisdiction is inappropriate. The Georgia Parties and the Corps argue that the district court lacked jurisdiction over these three matters because there was no final agency action, and, therefore, the Administrative Procedures Act ("APA") did not provide for judicial intervention at this juncture.

The parties also assert a number of substantive claims. The Georgia Parties argue that the district court erred by concluding that the Corps lacked authority to allocate substantial quantities of storage in Lake Lanier to water supply on the basis of the legislation that authorized the creation of the Buford Project, the 1946 Rivers and Harbors Act ("RHA"), Pub. L. No. 79-525, 60 Stat. 634 (1946). Although not in agreement with the Georgia Parties that water supply for the Atlanta area is an authorized project purpose under the RHA, the Corps does argue that the district court underestimated its authority to accommodate the water supply needs of the Atlanta area. The Georgia Parties and the Corps both assert that the district court erred by misinterpreting the scope of the Corps' authority under the 1958 Water Supply Act. The Georgia Parties and the Corps urge this Court to remand the case to the agency to make, in the first instance, a final determination of its water supply authority. Gwinnett County also individually asserts statutory, constitutional, and contractual claims relating to authority granted to it for its current withdrawals from Lake Lanier.

For the reasons explained below, we hold: First, the district court erred in finding that it had jurisdiction to hear Alabama, SeFPC, and Apalachicola because the Corps has not taken final agency action. The three cases therefore must be remanded to the Corps in order to take a final agency action. Second, the district court and the Corps erred in concluding that water supply was not an authorized purpose of the Buford Project under the RHA. The Corps' denial of Georgia's 2000 water-supply request is therefore not entitled to Chevron deference, and the request must be remanded to the Corps for reconsideration. Third, the district court erred in finding that the 1956 Act, which authorized the Corps to contract with Gwinnett County to withdraw 10 million gallons of water per day, expired after 50 years. Gwinnett County's contractual and just-compensation claims are without merit. Fourth, we also provide certain instructions to the Corps on remand. And finally, the Corps shall have one year to make a final determination of its authority to operate the Buford Project under the RHA and WSA. Our opinion is organized as follows:

FACTS AND PROCEDURAL HISTORY

The facts of this appeal are intertwined with the history of Buford Dam and Lake Lanier. Buford Dam sits on the Chattahoochee River, approximately forty miles upstream of Atlanta. The Chattahoochee's headwaters are in Northeastern Georgia in the Blue Ridge Mountains. The river flows southwest to Columbus and then along much of the length of the Georgia–Alabama border and into the Florida Panhandle, where it combines with the Flint River to form the Apalachicola River. The Chattahoochee, Flint, and Apalachicola Rivers together are referred to as the ACF Basin.

The Corps first began surveying the ACF Basin for suitable sites for hydroelectric facilities at the request of Congress in 1925. River and Harbor Act of 1925, Pub.L. No. 68–585, ch. 467, 43 Stat. 1186, 1194 (Mar. 3, 1925). As a result of this survey, the Corps produced a report in 1939. *See* H.R. Doc. No. 76–342 (1939) [hereinafter "Park Report"]. The Park Report analyzed eleven projects at various stages of development in the ACF basin, including one at Roswell, Georgia, sixteen miles north of Atlanta. *Id.* ¶ 196. District Engineer Colonel R. Park, the report's author, referred to transportation, hydroelectric power, national defense, commercial value of riparian lands, recreation, and industrial and municipal water supply as "principal direct benefits" of the various projects under consideration. Park Report ¶ 243. Col. Park noted that at the time the Atlanta area had no immediate need for increased water supply, though such a future need was "not improbable." Park Report ¶ 260. He stated that a large reservoir might have value as "an assured continuous water supply" due to the "continued rapid growth of the area." *Id.* Though he assigned the other direct benefits a monetary value, he declined to do so for water supply, presumably because the benefit of this purpose, unlike all of the others, could only accrue in the future, rendering any valuation at that time speculative. Congress adopted the Corps' proposals in the Park Report in full in its 1945 RHA. Pub.L. No. 79–14, 59 Stat. 10, 17 (1945).

In 1946, the Corps, in its "Newman Report," recommended certain amendments and revisions to the original plan for the ACF system, including combining several of the hydroelectric sites near Atlanta into one large reservoir at Buford, Georgia to increase power generation and to better regulate flows downstream. H.R. Doc. No. 80–300, ¶ 69 (1947) [hereinafter "Newman Report"]. Division Engineer Brigadier General James B. Newman noted that the Chattahoochee River would be an excellent source of hydropower. Newman Report ¶ 7. According to Newman, a large reservoir—what would become Lake Lanier—was needed to make the locks and dams downstream more effective. The Newman Report noted that the proposed dam at Buford would be valuable for the purpose of flood control because of the frequent flooding in the basin and the severe damage that previous floods had caused. The report also explained that the various dams in the proposal would help keep flows continuous. These continuous flows would benefit navigation because they would allow barges to travel from Atlanta to Columbus and beyond, and they would assure a source of water supply for the City of Atlanta. Just as the Park Report had done before it, the Newman Report attempted to quantify the value of the benefits of the project. Only three value-calculated benefits were listed: power, navigation, and flood control. *Id.* ¶ 98, Table 10. It is probable that Newman, like Park, deemed there to be no immediate benefit from water supply, rendering any benefit purely prospective and any valuation of this benefit entirely speculative.

The Newman Report, at several junctures, spoke of the benefit that the dam would provide for water supply. The report concluded that the project would "greatly increase the minimum flow in the river at Atlanta," which would safeguard the city's water supply during dry periods. *Id.* ¶68. In discussing the operation of the dam, the Newman Report noted that releases of 600 cubic feet per second ("cfs") should be made during off-peak hours[4] in order to ensure a continuous flow of the river at Atlanta of not less than 650 cfs, even though this flow would have a slight detrimental effect on power generation. The report noted that this "minimum release may have to be increased somewhat as the area develops." *Id.* ¶ 80. The Report expected that any decrease in power value would be marginal and outweighed by the

[4] Off-peak hours are those time periods when the demand for power is relatively low. Hydroelectric plants attempt to minimize the amount of water released during off-peak hours so that power generation can operate at maximum levels during peak hours when the demand for power is high.

benefits of an "assured" water supply for the City of Atlanta. *Id.* The 1946 RHA stated that the project would be "prosecuted * * * in accordance with the report of the Chief of Engineers, dated May 13, 1946," Pub.L. No. 79–525, 60 Stat. 634, 635 (1946). Because that report incorporated the Newman Report in full, the Newman Report became part of the authorizing legislation for the project.

Congress continued to consider the purposes of the Buford Dam in debates about appropriations bills for the project's funding. The purposes mentioned most frequently in Congressional hearings were power, navigation, and flood control, but water supply was also discussed with some frequency. Then-mayor of Atlanta, William Hartsfield testified before a Senate subcommittee that water from the Chattahoochee was "necessary" but that Atlanta did not immediately need the water in the same manner as cities in more arid locations. *Civil Functions, Dep't of the Army Appropriation Bill 1949: Hearing Before the Subcomm. of the S. Comm. on Appropriations,* 80th Cong. 644 (statement of William B. Hartsfield, Mayor, Atlanta, Georgia). Congress debated whether Atlanta should be asked to contribute part of the cost of building the Buford Dam. Corps officer Colonel Potter testified that the Corps was not recommending that Atlanta be asked to pay because the services that would be provided in the field of water supply were all incidental to the purposes of hydropower and flood control and would "not cost the Federal Government 1 cent to supply." *Civil Functions, Dep't of the Army Appropriations for 1952: Hearings Before the Subcomm. of the H. Comm. on Appropriations,* 82d Cong. 121–122 (1951) (exchange between Rep. Gerald Ford, Member, H. Comm. on Appropriations, and Col. Potter, Corps officer). Congressman Gerald Ford presciently asked Colonel Potter whether it was foreseeable that one day in the future Atlanta would begin to request greater amounts of water from the project. *Id.* at 122. Col. Potter responded that the Corps would have to study the effect that such a request would have on power production. He said that the Corps would have to obtain additional water supply authorization if a request amounted to "a major diversion of water." *Id.* Ultimately, Atlanta was never asked to, and did not, contribute to the construction costs.

The Corps released its "Definite Project Report" for the project in 1949. The report provided a detailed discussion of the plans for the Buford Project and its operations. The report referred to flood control, hydroelectric power, navigation, and an increased water supply for Atlanta as "the primary purposes of the Buford project." U.S. Army Corps of Eng'rs: Mobile District, *Definite Project Report on Buford Dam Chattahoochee River, Georgia,* ¶ 48 (1949) [hereinafter "Definite Project Report"]. A later passage in the report referred to flood control, power generation, navigation, and water supply as "principle purposes of the Buford project." *Id.* ¶ 115. The report concluded by calculating and explaining the benefits of the various project purposes. As to water supply, it explained that the project would result in "[a] real benefit," but it did not estimate the monetary value because "definite evaluation of this benefit cannot be made at this time." *Id.* ¶ 124.

Buford Dam was constructed from 1950 to 1957, creating the reservoir known today as Lake Sidney Lanier. The Southeastern Power Administration ("SEPA"), the federal government agency from which

SeFPC purchases the power generated at the dam, paid approximately $30 million of the $47 million of construction costs. The creation of Lake Lanier inundated the water intake structures of the Cities of Buford, Georgia and Gainesville, Georgia. As a method of compensation, the Corps signed relocation agreements with the two municipalities authorizing water withdrawals directly from the reservoir—these agreements allowed Gainesville to withdraw 8 million gallons per day ("mgd")[5] and Buford 2 mgd.[6] Although no storage[7] was specifically allocated for water supply, the fact that the dam operated during "off-peak" hours, to the detriment of power generation, demonstrated that downstream water supply was a consideration. In accordance with the recommendations of the Newman Report, the Corps maintained the necessary minimum river flow at Atlanta by making off-peak releases of 600 cfs during these hours of the week.

During construction of the dam, Gwinnett County requested permission from the Corps to withdraw 10 mgd directly from Lake Lanier. The Corps denied the request, explaining that the approval of Congress was required for it to meet such a request. In 1955, the Corps stated to Congress that the proposed withdrawals would be in the public interest and

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[5] A contract to this effect was entered into on June 22, 1953. Contract Between the United States of America and City of Gainesville, Georgia for Withdrawal from Lake Sidney Lanier.

[6] A contract to this effect was entered into on December 19, 1955. Contract Between the United States of America and City of Buford, Georgia for Withdrawal from Lake Sidney Lanier.

[7] Storage refers to the amount of space in Lake Lanier dedicated to a particular project purpose. Lake Lanier is the reservoir for the Buford Project and provides space sufficient to store approximately 2.5 million gallons of water.

would not have a materially adverse effect on downstream interests or power output. F.G. Turner, Ass't Chief, Eng'g Div., U.S. Army Corps of Eng'rs: Mobile District, *Report on Withdrawal of Domestic Water Supply from Buford Reservoir* ¶ 1 (1955). The following year, Congress passed a law that granted the Corps authority to enter into a contract with Gwinnett County for the allocation of 11,200 acre-feet of storage for regulated water supply and granted the county an easement across government property for the construction and maintenance of a pumping station and pipelines. Pub. L. No. 84–841, 70 Stat. 725 (1956).

Construction was completed in 1957. Lake Lanier covers 38,000 acres and has 692 miles of shoreline. The large size of the lake allows for a substantial benefit in the form of recreation.

Lake Lanier is divided into three tiers, or pools, divided by elevation. The first tier extends from the bottom of the lake, at an elevation of 919 feet above sea level, to an elevation of 1,035 feet. This tier holds 867,600 acre-feet of "inactive" storage. The inactive pool is generally left untouched and saved for instances of severe drought. The next tier extends from an elevation of 1,035 feet to an elevation of 1,070 feet (1,071 feet in the summer) and contains 1,049,000 acre-feet (1,087,600 acre-feet in the summer) of conservation storage. The conservation pool generally provides the water that is used for all downstream purposes. The Newman Report contemplated that conservation storage would be used primarily for hydropower and repeatedly referred to it as storage for power. The final tier extends from an elevation of 1,070 feet (1,071 feet in the summer) to an elevation of 1085 feet. This tier provides 598,800 acre-feet of flood storage. The flood pool is generally left empty so that it can accommodate excess water during flood conditions.

Buford Dam was constructed to release water from Lake Lanier through a powerhouse that generates hydropower. The powerhouse contains three turbines. Two of the turbines are large and release about 5,000 cfs when running. These two turbines operate during peak hours, when energy consumption is at its greatest. They are the most efficient source of power generation—generating 40,000 kilowatt hours ("kwh") originally and 60,000 kwh after improvements in 2004—and would be the only turbines used if a minimum off-peak flow at Atlanta were not a project concern. To accommodate this concern, the powerhouse also contains a third, smaller turbine which releases 600 cfs, generating approximately 7,000 kwh. At peak performance, the dam releases approximately 11,000 cfs of water into the river. However, when energy demand is low—so-called off-peak hours—only the small turbine is operated, allowing the dam to produce some energy while providing for a minimal continuous flow. The Corps can also release water through a small sluice gate, but this is typically done only when the small turbine is shut down for repairs or in cases of an emergency. In this manner, Buford Dam was designed to generate maximum power while also ensuring a minimum continuous flow of water downstream to accommodate water supply.

In 1958, Congress passed the Water Supply Act ("WSA"). The statute was designed to allocate some storage in multi-purpose projects like Buford to water supply. The policy underlying the statute was:

> to recognize the primary responsibilities of the States and local interests in developing water supplies for domestic, municipal, industrial, and other purposes and that the Federal Government should participate and cooperate with States and local interests in developing such water supplies in connection with the construction, maintenance, and operation of Federal navigation, flood control, irrigation, or multiple purpose projects.

43 U.S.C. § 390b(a) (2011). To further that policy, Congress authorized the Corps to allocate storage in federal reservoirs for water supply, provided that the localities paid for the allocated storage. *Id.* § 390b(b). However, Congress placed the following limitation on its authorization:

> Modifications of a reservoir project heretofore athorized, surveyed, planned, or constructed to include storage as provided by subsection (b) of this section which would *seriously affect the purposes for which the project was authorized,* surveyed, planned, or constructed, or which would *involve major structural or operational changes* shall be made only upon the approval of Congress as now provided by law.

Id. § 390b(d) (emphasis added). The policy of subsection (a) indicates that Congress aimed only to expand water supply allocations, not contract them by limiting previous authorizations. The articulation of the bounds of the statute's authorization makes no mention of a limit on previously granted water supply authorization. In the case of Buford, the WSA's grant of authority for water supply constitutes a supplement to any authority granted by the 1946 RHA.

In 1959, the Corps issued its Reservoir Regulation Manual for Buford Dam ("Buford Manual") as an appendix to the Corps' 1958 manual for the entire river basin. U.S. Army Corps of Eng'rs: Mobile District, *Apalachicola River Basin Reservoir Regulation Manual,* Appendix B (1959). The Buford Manual has not been updated and remains in effect today. The manual describes the technical features of the dam, including a description of the three tiers and their storage capacities, the size of Lake Lanier, and the general operation of the plant. It states that the project will be run to maximize releases of water during peak hours but will also utilize off-peak releases in order to maintain a minimum flow of 650 cfs at Atlanta.[8] *Id.* at B–13. The manual makes multiple mentions of regulations that are designed to ensure this minimum flow. *Id.* at B–18–19, B–22.

There was very little change in water supply operations at the Buford Project between 1960 and 1973. Only Gainesville and Buford withdrew water directly from Lake Lanier. Gwinnett, with which the Corps was authorized to contract, did not withdraw water directly from the reservoir. In the meantime, the City of Atlanta and DeKalb County withdrew water from the river downstream from the dam but made no recorded requests that the schedule of releases be altered to accommodate their needs. The Atlanta metropolitan area increased its water use from the Chattahoochee by 37% (from 117 mgd to 160 mgd) between 1960 and 1968. U.S. Army Corps of Eng'rs: Mobile District, *Final Environmental Impact Statement: Buford Dam and Lake Sidney Lanier, Georgia*

[8] The Manual categorizes 7 a.m.–11 p.m. on weekdays, 7 a.m.–10 p.m. on Saturday, and 9 a.m.–2 p.m. on Sunday as peak hours (for a total of 100 peak hours per week).

(Flood Control, Navigation and Power), Statement of Findings 14 (1974). This amount was still well below the amount released by the Corps to maintain a minimum off-peak flow. Moreover, between 1956 and 1969, the number of residences within two and a quarter miles of the reservoir doubled. *Id.* at 15. The growing water needs of Atlanta came to the attention of the Senate, which in 1973 commissioned the Metropolitan Atlanta Area Water Resources Management Study ("MAAWRMS") to develop a plan for the long-term needs of the Atlanta area. The study was conducted by the Corps, the Atlanta Regional Commission ("ARC"), the State of Georgia, and the U.S. Environmental Protection Agency in combination.

By the 1970s, it became clear that area localities desired greater access to water in Lake Lanier. The Corps determined that it could not grant permanent water allocation rights to the localities before the completion of the MAAWRMS. While the study was being performed, the Corps entered into a number of interim contracts for water withdrawal. The first water supply contract was given to Gwinnett County and allowed for the withdrawal of up to 40 mgd directly from Lake Lanier during the course of the study. Contract of July 2, 1973, Gwinnett Record Excerpts vol. 1, ACF004024. The contract cited the WSA for authority and was based on findings of the Corps' District Engineer that the proposed withdrawals would not have significant adverse affects on the other authorized purposes of the project. No mention was made of the 1956 Act, possibly because the Act authorized only 10 mgd and thus would not have been sufficient authority for the Corps' actions. In 1975, the county informed its bond investors that the construction costs alone for its water supply facilities would be $28 million.

In 1975, the Corps concluded, and SEPA agreed, that the Buford Project could supply an annual average of 230 mgd of water for downstream withdrawal (with a maximum of 327 mgd in the summer) without significantly affecting hydropower generation. The Corps revised this number in 1979, concluding that by scheduling additional peak weekend releases it could raise the annual average to 266 mgd as an incident of power generation. In 1986, the Corps would again raise the figure for available water supply downstream incident to power generation, concluding that it could guarantee an annual average of 327 mgd by implementing a new water management system that had been proposed in the MAAWRMS.

The final report of the MAAWRMS was issued in September 1981. The report evaluated three alternative plans for dealing with Atlanta's increasing long-term water supply needs. The first alternative was to build a reregulation dam 6.3 miles below the Buford Dam. This new dam would store outflows released from Buford during peak operations and release them as needed for water supply. The study found that this alternative had the highest estimated ratio of benefits to costs. This alternative received the most support from federal and state agencies, and the study concluded it was best. The second alternative was to reallocate storage space in Lake Lanier for water supply. According to the study, in 1980, 10,512 acre-feet had been allocated to water supply, amounting to 14.6 mgd withdrawn directly from Lake Lanier. This alternative called for an increase of allocated storage space to 141,685 acre-feet by the year 2010, allowing for a total withdrawal of 53 mgd from the lake. The final alternative was to dredge the Morgan Falls Reservoir, which lies downstream from Buford, and also reallocate 48,550 acre-feet of storage space in Lake Lanier for water supply by 2010.

In 1986, Congress, in the Water Resources Development Act, authorized the construction of a reregulation dam, the MAAWRMS' favored first alternative. Pub.L. No. 99–662, § 601(a)(1), 100 Stat. 4137, 4140–41. However, the project had previously not received approval from the Office of Management and Budget, which said that state and local money should be used to construct such a project, and Congress did not appropriate any funding towards the construction of the proposed reregulation dam. Shortly thereafter, the Corps determined that the second alternative of the MAAWRMS—reallocating storage in Lake Lanier instead of constructing a new dam—would be more economical. The change was based, at least in part, on an environmental study generated by new computer models that concluded that the costs of acquiring the land flooded by the reregulation dam could rise and make the first alternative less economical than originally thought. U.S. Army Corps of Eng'rs: Mobile District, *Additional Information, Lake Lanier Reregulation Dam* 2 (1988).

In the late 1980s, the Corps began to prepare a Post–Authorization Change Notification Report ("PAC Report") suggesting that the authorization for the new reregulation dam be set aside in favor of the reallocation of storage alternative. A draft of the PAC Report was completed in 1989. The draft recommended that 207,000 acre-feet be allocated to water supply, allowing for 151 mgd to be withdrawn directly from Lake Lanier and 378 mgd (51 mgd more than the 327 mgd that the Corps determined was available as an incident of power supply) from the river downstream. This represented a significant increase from the 142,000 acre-feet of storage recommended by the second alternative of the MAAWRMS. The draft PAC Report also included a draft Water Control Manual that would have replaced the manual from 1958 and governed the Corps' water operations in the ACF basin. In this appeal, the Corps claims that the PAC Report's recommendations would have been made pursuant to authority from the WSA. The draft report itself noted the Corps' authority under the statute but stated that approval from Congress might be required due to the fact that the allocation exceeded 50,000 acre-feet.[9] The draft report estimated that the purchased

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[9] Internal policies require the Corps to obtain the approval of the Secretary of the Army for all storage allocations exceeding 15% of total storage capacity or 50,000 acre-feet, whichever is less. The parties have not made this Court aware of any internal regulations that set a threshold for allocations above which Congressional approval is required. However, the Corps had warned the preceding year that such a reallocation of storage might require Congressional approval:

> The Chief of Engineers has the discretionary authority to approve reallocation of storage if the amount does not exceed 50,000 acre-feet, or 15 percent of total usable storage, whichever is lower, and if the reallocation would not have a significant impact on authorized project purposes. [The reallocation contemplated in the MAAWRMS] would require the reallocation of 202,000 acre-feet of storage to meet the year 2010 peak demand of 103 mgd from the lake and 510 mgd from the river* * *. Therefore, the required reallocation is not within the discretionary authority of the Chief of Engineers to approve. It can only be approved by the [Assistant Secretary of the Army for Civil Works] if impacts are determined to be insignificant. We believe the power losses are significant and

storage in Lake Lanier would cost $49,360,600. The final PAC Report was never completed due to resistance and the initiation of a lawsuit by the State of Alabama.

The Corps followed the recommendation of the MAAWRMS to make water available for water supply in the interim before a long-term solution was reached, as it had done while the study was being completed, and it entered into a temporary water supply contract with the ARC. The contract was based on the Corps' revised determination that it could provide, incidentally to power generation, 327 mgd as a year-round average with no impact on hydropower. The Corps agreed to provide releases sufficient to accommodate up to 50 mgd in withdrawals above this 327 mgd threshold, for which the ARC would pay. The contract was renewed in 1989 but expired in 1990. Since then, the ARC has continued to withdraw water from the Chattahoochee on roughly the same basis as that specified in the contract, though it has generally not needed to withdraw more than 327 mgd.

The Corps signed several other water supply contracts in the 1970s and 1980s, all of which expired in 1990, but which roughly dictate the terms under which the localities have continued to withdraw water from the Buford Project. In 1978, the Corps agreed to terms with the City of Cumming, Georgia for the paid withdrawal of 2.5 mgd. In 1985, the amount was raised to 5 mgd, and in 1987 it was

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expect that Congressional approval would be required for the reallocation.

Letter from C.E. Edgar III, Major Gen., U.S. Army Corps of Eng'rs, to Harry West, Exec. Dir., ARC 5 (Apr. 15, 1988).

raised to 10 mgd. In 1987, the Corps signed a contract with the City of Gainesville, allowing the city to withdraw up to 20 mgd, up from the 8 mgd authorized in 1953 as just compensation. The contract required Gainesville to pay for the water that it withdrew in excess of 8 mgd. In 1988, the 1973 contract with Gwinnett County was supplemented, expanding the cap on withdrawals from 40 mgd to 53 mgd. All of the contracts signed in the 1980s specifically stated that they were interim contracts to satisfy water supply needs while the Corps was studying the issue and determining a permanent plan. As a component of their interim nature, the contracts explicitly stated that they did not create any permanent rights to storage space in Lake Lanier. The Corps originally cited the Independent Offices Appropriations Act of 1952, 31 U.S.C. § 9701, as authority for these contracts, but it later deemed the statute to be ineffective in authorizing such transactions. Later contracts cited the Water Supply Act for authority.

On January 1, 1990, all of the interim contracts expired. The only remaining water supply allocations were the combined 10 mgd granted to Buford and Gainesville in the 1950s by the Corps as just compensation. However, the Corps continued to permit the localities to withdraw water from the Buford Project for water supply. Appellees refer to these water withdrawals as pursuant to "holdover" contracts.

In June, 1990, Alabama filed suit against the Corps in the Northern District of Alabama to challenge a section of the draft PAC Report and the continued withdrawal of water from the Buford Project by the Georgia Parties, which Appellees characterize as a *de facto* reallocation of storage. This suit is the first of the four currently on appeal. In September of 1990, Alabama and the Corps moved jointly for a stay of proceedings, which was granted, to negotiate a settlement agreement. Florida and Georgia later intervened as plaintiff and defendant, respectively. The stay order at issue in *Alabama v. United States Army Corps of Engineers,* 357 F.Supp.2d 1313 (N.D.Ala.2005), required the Corps not to "execute any contracts or agreements which are the subject of the complaint in this action unless expressly agreed to, in writing, by [Alabama] and Florida." *Id.* at 1316. The stay provided that either side could terminate it at will. It did not discuss the continued water withdrawals of the Georgia Parties.

In 1992, Alabama, Florida, Georgia, and the Corps entered into a Memorandum of Agreement ("MOA") authorizing a comprehensive study of the water supply question and requiring the Corps to withdraw the draft PAC Report along with its accompanying Water Supply Reallocation Reports and Environmental Assessments. The MOA contained a "live and let live" provision that allowed the Georgia Parties to continue to withdraw water from the Buford Project at the level of their withdrawals in 1990, with reasonable increases over time. The provision made clear that it did not grant any permanent rights to the water being consumed. The MOA was originally set to last for three years but was extended several times.

In 1997, after the completion of a comprehensive study, the parties entered into the Apalachicola–Chattahoochee–Flint River Basin Compact ("ACF Compact"), which was ratified by Congress and the three states and replaced the MOA. Pub.L. No. 105–

104, 111 Stat. 2219 (1997). The ACF Compact included a provision allowing continued withdrawals similar to the live and let live provision in the MOA. The Compact created an "ACF Basin Commission" composed of the governors of the three states and a non-voting representative of the federal government, to be appointed by the President. The commission was charged with establishing "an allocation formula for apportioning the surface waters of the ACF Basin among the states of Alabama, Florida, and Georgia." *Id.* art. VI(q)(12), 111 Stat. at 2222. Under the Compact, existing water supply contracts would be honored, and water-supply providers could increase their withdrawals "to satisfy reasonable increases in the demand" for water. *Id.* art. VII(c), 111 Stat. 2223–24. The Compact initially was scheduled to expire December 31, 1998, but it was extended several times; it ultimately expired on August 31, 2003, when the Commission failed to agree on a water allocation formula. The stay of the *Alabama* case remained in effect through the duration of the Compact. In the meantime, the Corps continued to allow the Georgia Parties to withdraw water from the Buford Project. Because there were no contracts in place, the Corps froze the rates that it charged for water and continued to proceed on the basis of the prices that were set in the interim contracts of the 1980s. This rate scheme angered hydropower customers who purchased power produced by the project directly or indirectly from SEPA.

In December 2000, SeFPC filed suit under the APA against the Corps in the United States District Court for the District of Columbia, the second of the four suits currently on appeal. SeFPC alleged that the agency had wrongfully diverted water from hydropower generation to water supply, thereby causing SeFPC's members to pay unfairly high rates for their power. SeFPC sought a judicial declaration of the Buford Project's authorized purposes as well as compensation. In March 2001, the district court referred the parties to mediation, and Georgia was joined. In January 2003, SeFPC, the Corps, and the Georgia Parties agreed to a settlement in the case, which called for an allocation of 240,858 acre-feet (estimated to be 22% of conservation storage) to water supply for once-renewable 10–year interim contracts that could be converted into permanent storage if approved by Congress (or if a court deemed Congressional approval unnecessary). In exchange, the Georgia Parties agreed to pay higher rates for water, with the income being applied as a credit against the rates charged to SeFPC's members. The D.C. district court then allowed Alabama and Florida to intervene.

In October 2003, the *Alabama* court enjoined the filing of the settlement agreement in the D.C. case, finding that the agreement violated the stay in its case because the approval of Alabama and Florida was not obtained. The district court in the District of Columbia approved the Agreement in February 2004, contingent upon the dissolution of the Alabama court's injunction, rejecting Alabama and Florida's argument that the Agreement exceeded the Corps' authority conferred by Congress. *SeFPC v. Caldera,* 301 F.Supp.2d 26, 35 (D.D.C.2004). In April 2004, a panel of this Court stayed an appeal of the Alabama court's injunction to allow the Alabama district court to decide whether to dissolve or modify the injunction in light of the D.C. district court's order approving the Agreement. In the meantime, an initial appeal of the D.C. district court's order in *SeFPC* by Alabama and Florida was denied by the D.C. Circuit Court of Appeals for lack of a final judgment. The Alabama district court denied a motion to dissolve the preliminary injunction, *Alabama,* 357 F.Supp.2d at 1320–21, but in September 2005, a panel of this Court held that the district court abused its discretion in granting the injunction and vacated the injunction. *Alabama v. U.S. Army Corps of Engineers,* 424 F.3d 1117, 1133 (11th Cir. 2005). Once this Court dissolved the injunction over the implementation of the Agreement, the D.C. district court in March 2006 entered a final judgment in *SeFPC,* and Alabama and Florida again appealed to the D.C. Circuit.

In *Southeastern Federal Power Customers, Inc. v. Geren,* 514 F.3d 1316, 1324 (D.C.Cir. 2008), the D.C. Circuit held that the settlement agreement exceeded the Corps' authority under the WSA. The parties to the settlement agreement argued that the Corps was authorized to enter into the settlement on the basis of its WSA authority alone, so the court specifically refrained from making any holdings on the basis of the RHA. *Id.* at 1324 n.4. The court found that "[o]n it's face, * * * reallocating more than twenty-two percent * * * of Lake Lanier's storage capacity to local consumption uses * * * constitutes the type of major operational change referenced by the WSA." *Id.* at 1324. After the circuit court's remand, the Judicial Panel on Multidistrict Litigation transferred the case, along with *Alabama* and several others, to the Middle District of Florida.

Meanwhile, in 2000, the State of Georgia submitted a formal request to the Corps to modify its operation of the Buford Project in order to meet the Georgia Parties' water supply needs through 2030. The request was to withdraw 408 mgd from the river and 297 mgd directly from the lake, which, combined, required approximately 370,930 acre-feet of storage. In February 2001, nine months after the request was sent to the Corps and without a response from the Corps, the State of Georgia filed suit in the United States District Court for the Northern District of Georgia seeking to compel the Corps to grant its request, beginning the third of the four underlying cases. The Corps responded in April 2002 with a letter denying the request and an accompanying legal memorandum. Memorandum from Earl Stockdale, Deputy General Counsel, Department of the Army, to Acting Assistant Secretary of the Army for Civil Works: Georgia Request for Water Supply from Lake Lanier 1 (Apr. 15, 2002) [hereinafter "2002 Stockdale Memo"]. The 2002 Stockdale Memo concluded that the Corps lacked the authority to grant Georgia's request without legislative approval. The memo stated that water supply was not an authorized purpose of the Buford Project under the RHA. Further, it stated that even if water supply was authorized, the Corps would still lack the authority to make a storage allocation of the size requested because the reallocation "would involve substantial effects on project purposes and major operational changes." *Id.* The district court denied Florida's and SeFPC's motions to intervene in the case, but this Court reversed the denial and remanded for further proceedings. *Georgia v. U.S. Army Corps of Eng'rs,* 302 F.3d 1242, 1260 (11th Cir. 2002). On remand, Florida moved to dismiss or abate the proceedings; Alabama, Gwinnett County, the City of Gainesville, and the ARC moved to intervene; and Alabama moved to abate or transfer the proceedings. The district court allowed Alabama to intervene as of right and the local governments to intervene permissively, and it held that the case would be abated pending the resolution of the *Alabama* case. *Georgia v. U.S. Army Corps of Engineers,* 223 F.R.D. 691, 699 (N.D.Ga.2004). On appeal, a panel of this Court in an unpublished decision affirmed the district court's decision to abate the case. *Georgia v. U.S. Army Corps of Engineers,* 144 Fed.Appx. 850 (11th Cir. 2005). The case was then consolidated into the multidistrict litigation in the Middle District of Florida.

In January 2008, the City of Apalachicola sued the Corps in the federal district court for the Northern District of Florida. This is the last of the four cases being considered as part of this appeal. This case was also consolidated into the multidistrict litigation.

While the litigation was pending, the Corps began an update of its plans and operations in the ACF Basin with a focus on whether it could continue to meet the current water supply needs of the localities. In order to answer these questions, specifically in light of the D.C. Circuit's *Geren* opinion, the Corps released a new legal memorandum by Earl Stockdale. Memorandum from Earl Stockdale, Chief Counsel, Department of the Army, to the Chief of Engineers: Authority to Reallocate Storage for Municipal & Industrial Water Supply Under the Water Supply Act of 1958, 43 U.S.C. § 390b 1 (Jan. 9, 2009) [hereinafter "2009 Stockdale Memo"]. In this memorandum, the Corps determined that the current water supply withdrawal under the "interim contracts" could be accommodated by a permanent reallocation of approximately 11.7% of the conservation storage in Lake Lanier. The Corps concluded that such a permanent reallocation would not constitute a major operational change, and it would not seriously affect any project purposes.

The Middle District of Florida, in its consideration of the multidistrict litigation, divided the trial into two phases. Phase One, which is at issue here, pertained to the Corps' authority for its operations of the project. The plaintiffs in the four underlying cases moved for summary judgment, and the Corps filed an opposition and cross-motion for summary judgement in each case. On July 17, 2009, the court granted partial summary judgment to the plaintiffs in *Alabama*, *Apalachicola*, and *SeFPC* and to the Corps in *Georgia,* and it denied summary judgment to the Georgia Parties.

The court's order concluded that the Corps had exceeded its authority in its "de facto" reallocation of storage to accommodate current water supply withdrawals. *In re Tri–State Water Rights Litig.,* 639 F.Supp.2d 1308, 1350 (M.D.Fla.2009). The court first held that only two conclusions of the D.C. Circuit had preclusive effect on its judgment under the principle of collateral estoppel: (1) that the WSA applied to interim reallocations of storage; and (2) that a reallocation of 22% of Lake Lanier's total conservation storage was a major operational change under the WSA. *Id.* at 1343. Next, the district court concluded that there was virtually no authorization for the reallocation of water supply storage in the RHA and that the Corps' sole source of authority to allocate storage for water supply was the WSA.

The court went on to hold that the 2009 Stockdale Memo was a litigation document with post hoc analysis that was not part of the administrative record. *Id.* at 1347. Without the memo, the district court concluded that the record contained insufficient support for the Corps' calculations of the amount of storage required for the water supply withdrawals as of 2006. The court attempted its own calculation of this figure and determined that the allocation was for 226,600 acre-feet or 21.5% of Lake Lanier's total conservation storage. *Id.* at 1350. In reaching its conclusion on the amount of storage necessary for the project's current operations, the court rejected several key figures that the Corps had used in making previous calculations, most notably rejecting the Corps' figure for the amount of water available for downstream withdrawal as a byproduct of hydropower operations. The district court held that the 21.5% allocation was a major operational change that exceeded the Corps' WSA authority. The court also concluded that the Corps' current operations exceeded the WSA because they seriously affected the authorized purpose of hydropower generation. Because the Georgia request represented an even larger water supply storage allocation than the current operations, the court also found that it exceeded the Corps' authority.

The district court directed the Corps to limit releases from the Buford Project to 600 cfs during off-peak hours and to discontinue all water supply withdrawals being made directly from Lake Lanier, except for the 10 mgd that Gainesville and Buford had been permitted to withdraw in their 1950s reallocation agreements.[10] The court stayed its order

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[10] The district court failed to state its reasoning for choosing 600 cfs as the level for off-peak releases. Six hundred cfs was the rate of off-peak releases in the 1950s when the plant opened. The Newman Report explicitly contemplated raising off-peak releases so as to provide for a minimum flow of the river at Atlanta of 800 cfs by 1965. Newman Report ¶ 79. The

for three years, until July 17, 2012, to give the parties an opportunity to settle or to seek Congressional approval. In the meantime, the court allowed current withdrawals to continue but forbade any increases without the consent of all of the parties.

DISCUSSION

This opinion will begin by examining threshold jurisdictional questions, then will analyze the primary substantive matters involved, and finally will provide some guidance and instruction for the Corps pertaining to its analysis of its water supply authority on remand.

Part I. *Jurisdictional Matters*

A. Appellate Jurisdiction Over *Alabama*, *SeFPC*, and *Apalachicola*

Alabama and Florida argue that this court lacks appellate jurisdiction over the appeals in *Alabama, SeFPC*, and *Apalachicola*. They note that the district court did not render a final judgment in the cases, as the summary judgment order on the Phase One claims did not resolve the Phase Two claims in those cases. Appellees concede that this court has jurisdiction over the appeal in the *Georgia* case because the district court's order did amount to a final judgment in that case. However, Alabama and Florida argue that the claims in the cases are sufficiently distinct that extending pendent jurisdiction from *Georgia*

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district court fails to explain why it mandated that the level of off-peak releases not be raised from where it stood at the time of the Buford Project's construction in spite of the fact that the RHA explicitly contemplated such a raise and in spite of the additional water supply authority granted to the Corps by the WSA. As our discussion below will make apparent, the district court committed obvious error in this regard. *See infra,* note 19.

over the *Alabama*, *SeFPC*, and *Apalachicola* claims would be inappropriate.[11] We disagree. Issues in the three contested cases and the *Georgia* case are inextricably intertwined, rendering pendent jurisdiction proper. Even if this Court did not have pendent jurisdiction over these claims, this Court would still have jurisdiction because the district court's order amounted to an injunction.

"Pendent appellate jurisdiction is present when a nonappealable decision is inextricably intertwined with the appealable decision or when review of the former decision is necessary to ensure meaningful review of the latter." *King v. Cessna Aircraft Co.,* 562 F.3d 1374, 1379 (11th Cir. 2009) (internal quotation marks omitted). The exercise of such jurisdiction is only appropriate in "rare circumstances" so only "limited factual scenarios" will qualify. *Id.* at 1379–80. Thus, the critical inquiry is whether the appealable issue can be resolved without reaching the merits of the nonappealable issues. *Thomas v. Blue Cross & Blue Shield Ass'n,* 594 F.3d 814, 821 (11th Cir. 2010).

Alabama and Florida argue that the appeal of *Georgia* can be resolved without addressing the issues in the other cases. They argue that the district court found that Georgia's request for a reallocation of 34% of the available storage exceeded the Corps' authority because the argument was simply foreclosed by collateral estoppel and the preclusive

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[11] A panel of this court rejected this argument in a January 20, 2010 order accepting pendent jurisdiction over the district court's entire order because "all issues raised by the appellants are inextricably intertwined." Order of Jan. 20, 2010 at 5. (Citing *Sierra Club v. Van Antwerp,* 526 F.3d 1353, 1359 (11th Cir. 2008); *Summit Med. Assocs., P.C. v. Pryor,* 180 F.3d 1326, 1335 (11th Cir. 1999)). We agree with the findings of the panel on this matter.

effects of the D.C. Circuit's *Geren* decision. Thus, they argue that the merits of the *Georgia* appeal can be determined without considering the underlying issues in the other cases.

Alabama and Florida misread both the district court's opinion and the opinion in *Geren*. The district court did not, and could not, simply dismiss the *Georgia* case on the basis of collateral estoppel. The Corps' authority to allocate storage for water supply depends on an analysis of both the RHA *and* the WSA. As noted above, the district court held that only two issues were precluded, and neither of them were the authority of the Corps under the RHA. In fact, the D.C. Circuit clearly stated that the issue of water supply authority in the RHA was not before it. *See Geren,* 514 F.3d at 1324 n. 4 ("The court, in responding to the Corps' defense of its approval of the Agreement, has no occasion to opine whether the Corps' previous storage reallocations were unlawful."). Thus, it is clear that the holding in *Geren*—i.e. that a 22% reallocation of storage to water supply constitutes a "major operational change" under the WSA—cannot operate as collateral estoppel with respect to the issue of the Corps' combined authority under the RHA *and* the WSA.[12]

Thus, the district court did not apply collateral estoppel in granting summary judgment against the Georgia Parties and holding that Georgia's 2000 request exceeded the Corps' authority. Rather, the district court came to an independent conclusion on this matter and found that water supply was not an authorized purpose under the RHA. *Tri–State,* 639

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[12] Our complete discussion of the collateral estoppel effects of *Geren* can be found *infra* at Part VI.

F.Supp.2d at 1347. This finding was central to the court's holding in all four cases. Ultimately, it is impossible for this Court to rule on the merits of the appeal in *Georgia* without determining whether water supply was an authorized purpose of the Buford Project under the RHA. Thus, the issues raised in the various appeals are inextricably intertwined and pendent jurisdiction is proper in *Alabama*, *SeFPC*, and *Apalachicola*.

As an alternative basis for jurisdiction in the three cases (other than the *Georgia* case), this Court also has appellate jurisdiction over all of the underlying claims because the district court's order was an injunction. The order very clearly directs the parties to act, imposing a set of directives that, if disobeyed, could subject the parties to contempt proceedings. We are granted jurisdiction to review injunctions (or denials thereof) by 28 U.S.C. § 1292(a)(1). Alabama and Florida argue that this statute does not apply in this case because the district court's order is not an injunction. Instead, they argue, the district court merely set aside the Corps' actions because they were not in accordance with the law, and therefore in violation of the APA. *See Citizens to Preserve Overton Park, Inc. v. Volpe,* 401 U.S. 402, 413–14, 91 S.Ct. 814, 822, 28 L.Ed.2d 136 (1971) *overruled on unrelated grounds by Califano v. Sanders,* 430 U.S. 99, 105, 97 S.Ct. 980, 984, 51 L.Ed.2d 192 (1977). This argument is unpersuasive.

The district court's order is "a clearly defined and understandable directive by the court to act or to refrain from a particular action." *Alabama,* 424 F.3d at 1128. The district court mandated the return of operations to the levels of the mid–1970s by 2012, meaning that the Corps was required to set off-peak flows to 600 cfs and only Buford and Gainesville were allowed to withdraw any water directly from Lake Lanier (in the amounts established in their 1950s contracts). *Tri–State,* 639 F.Supp.2d at 1355. The court gave the Corps explicit instruction on how it was to act in the future. The Corps was also prohibited from entering into any new water supply contracts and therefore stripped of any discretion on how to allocate storage space for water supply. The district court did not refer to its order as an injunction, but the district court's intention in this regard is irrelevant. *See Sierra Club v. Van Antwerp,* 526 F.3d 1353, 1358–59 (11th Cir. 2008) (utilizing a functional analysis to determine that the district court order was an injunction in spite of the district court's specific denial in this regard); *United States v. Gila Valley Irrigation Dist.,* 31 F.3d 1428, 1441 (9th Cir. 1994) ("In determining whether or not an order is appealable under § 1292(a)(1), the courts do not look to the terminology of the order but to its substantial effect.") (citation omitted).

The district court's order was also sufficiently definite to be enforced via contempt proceedings. *See Alabama,* 424 F.3d at 1128. Federal Rule of Civil Procedure 65(d) requires that an injunctive order "state its terms specifically" and "describe in reasonable detail * * * the act or acts restrained or required." Alabama and Florida do not question the definitive nature of the order in 2012. Rather, they focus on the court's directives in the interim period: "the parties may continue to operate at current water-supply withdrawal levels but should not increase those withdrawals absent the agreement of all other parties to this matter." *Tri–State,* 639 F.Supp.2d at 1355. Alabama and Florida argue that the order does not state with specificity the amount of water that each of the localities may withdraw. However, this is of no moment because no party would dare risk being held in contempt for violating the court's order by exploiting any of these ambiguities. The practical effect of this order makes it such that none of the localities would withdraw any more water than they did before the order was issued. Furthermore, it is irrelevant whether this injunction was defective under Rule 65(d) because this Court could still exercise jurisdiction under § 1291(a)(1) over a defective injunction. *See Int'l Longshoremen's Ass'n, Local 1291 v. Phila. Marine Trade Ass'n,* 389 U.S. 64, 76, 88 S.Ct. 201, 208, 19 L.Ed.2d 236 (1967). The proper remedy in such a case would be to vacate the injunction and remand the case to the district court.[13] Because pendent jurisdiction is proper in this case and because the district court order is an injunction, this Court possesses appellate jurisdiction and will consider the merits of the issues raised by the parties.

B. Final Agency Action in *Alabama, SeFPC,* and *Apalachicola*

The Corps and the Georgia Parties argue that the district court did not have jurisdiction to hear the

[13] Alabama and Florida also argue that the district court order is not appealable because it is conditional. As a factual matter, this position is incorrect. The court's order, though stayed for three years, does not depend on the happening of a specific event to go into operation. Just the opposite; the injunction was final when issued and would take effect without the occurrence of any contingency whatsoever. Moreover, a portion of the order forbids the parties from increasing withdrawals and the Corps from entering into new contracts without the consent of all of the parties to the litigation. This is a negative injunction which was not stayed until 2012 and took effect immediately.

Alabama case, the *SeFPC* case, and the *Apalachicola* case because the Corps had not taken a final agency action, as required by the APA for judicial review. *See* 5 U.S.C. § 704. In these three cases, Appellees challenge what they have characterized as the "de facto reallocations"—the temporary water withdrawals the Corps has allowed and continues to allow. The Corps argues that it never made a formal reallocation of storage in the reservoir. Instead, it argues that it accommodated water supply under ad hoc arrangements with the localities and a series of agreements among all three States, while launching multiple, ultimately futile, attempts to reach a long-term solution to the issue. The parties all concede that the denial of Georgia's water supply request was a final agency action and that the district court possessed jurisdiction over the *Georgia* case. With respect to the other three cases, we conclude that there was no final agency action, and the district court therefore lacked jurisdiction to review the claims.

The APA states that "final agency action for which there is no other adequate remedy in a court [is] subject to judicial review." 5 U.S.C. § 704. The APA defines "agency action" as including "the whole or a part of an agency rule, order, license, sanction, relief, or the equivalent or denial thereof, or failure to act." 5 U.S.C. § 551(13). Because the definition of action under the APA is so broad, the critical inquiry is whether the action is final. *Whitman v. Am. Trucking Ass'ns,* 531 U.S. 457, 478, 121 S.Ct. 903, 915, 149 L.Ed.2d 1 (2001) ("The bite in the phrase 'final action' * * * is not in the word 'action,' which is meant to cover comprehensively every manner in which an agency may exercise its power* * *. It is rather in the word 'final'* * *.") (citations omitted). The test for finality involves two steps:

> First, the action must mark the "consummation" of the agency's decisionmaking process * * *—it must not be of a merely tentative or interlocutory nature. And second, the action must be one by which rights or obligations have been determined, or from which legal consequences will flow.

Bennett v. Spear, 520 U.S. 154, 177–78, 117 S.Ct. 1154, 1168, 137 L.Ed.2d 281 (1997) (internal quotation marks and citations omitted).

We analyze whether the Corps' actions were final by using the two-step *Bennett* test. The Corps contends that it has not consummated its decisionmaking process because it has not made any final decisions on how to allocate water storage at Buford. The Corps notes that it never made any permanent water supply storage allocations and has not published any implementation guidelines. As evidence that no decisionmaking process has been consummated, the Corps notes that it has not performed the cost analyses or prepared the written reports required by the WSA, the Corps' internal guidelines, and the National Environmental Policy Act to make permanent reallocations. The Corps asserts that it attempted to start the decisionmaking process in 1989 with its draft PAC Report, which included a draft manual for operations in the ACF basin, but that the report was abandoned prior to its completion as part of the negotiations in the *Alabama* litigation.

The "de facto reallocations" do not meet the first prong of the *Bennett* test. They are based on contracts that have all expired and water withdrawals that have been extended on the basis of multi-party agreements and court orders. The various contracts that the Corps entered into with Gwinnett, the ARC, and the Cities of Gainesville and Cumming all specified their interim nature, expired in 1990, and did not purport to provide any permanent right to storage in Lake Lanier. As the Corps notes, these contracts are long expired now and are not themselves being challenged in this litigation.

What is being challenged is the continuous withdrawal of water from the Buford Project over the last forty years. Appellees assert that the Corps has utilized a practice of entering into temporary agreements in order to avoid the appearance of consummating its decisionmaking process. "[A]s a general matter, * * * an administrative agency cannot legitimately evade judicial review forever by continually postponing any consequence-laden action and then challenging federal jurisdiction on 'final agency action' grounds." *Nat'l Parks Conservation Ass'n v. Norton,* 324 F.3d 1229, 1239 (11th Cir. 2003) (citing *Cobell v. Norton,* 240 F.3d 1081, 1095 (D.C.Cir. 2001)). The record in this case demonstrates that the Corps has not acted to avoid judicial review. Rather, the factual history of this case indicates that the Corps has made sincere efforts to effectuate permanent water supply allocations but has been thwarted by the litigation process.

The Corps has been attempting to reach a final decision on water storage allocations in the Buford Project since at least the mid–1980s, when it became aware that a permanent determination of water supply needs was vital. The agency concluded at the time that it was best to wait until the MAAWRMS was complete before making such a determination and to enter into interim contracts that would expire in 1990. Once the study was complete, the Corps embarked on the process of issuing the PAC Report and permanently reallocating certain amounts of storage to water supply—after first proposing and receiving Congressional authorization (but not funding) to build a reregulation dam. However, the Corps' plan to issue the PAC was derailed by developments in the *Alabama* case.

In 1992, the parties agreed to a stay and entered into a Memorandum of Agreement, which required that the Corps withdraw the PAC and prohibited it from entering into any new contracts. Memorandum of Agreement By, Between, and Among the State of Alabama, the State of Florida, the State of Georgia, and the United States Department of the Army 2 (Jan. 3, 1992). The Corps retained permission to continue to accommodate current withdrawal levels. In the memorandum, the parties agreed to conduct a Comprehensive Study, stating that "during the term of the Comprehensive Study, it is premature for the Army to commit, grant or approve any reallocation, allocation, or apportionment of water resources to service long-term future water supply." *Id.* Thus, during the duration of the term of the Memorandum of Agreement, the Corps was restricted from moving toward taking final agency action due to the terms agreed upon by the parties.

The same held true during the period of enforcement of the ACF Compact, the joint resolution that the three states agreed to and Congress ratified in 1997, which replaced the Memorandum of Agreement. The ACF Compact created an ACF Basin Commission charged with the power "to establish and modify an allocation formula for apportioning the surface waters of the ACF Basin among the states of Alabama, Florida and Georgia." 111 Stat. at 2222. The Compact specified that parties could continue withdrawing water but that no vested rights would be granted until the Commission adopted an allocation formula. *Id.* at 2223–24. The Compact provided that the Army Corps of Engineers "shall cooperate with the ACF Basin Commission in accomplishing the purposes of the Compact and fulfilling the obligations of each of the parties to the Compact regarding the allocation formula." *Id.* at 2225. Much like the Memorandum of Agreement before it, the ACF Compact, which remained in effect until 2003, restricted the Corps' ability to consummate a decisionmaking process on its water allocation policy. Thus, from 1992 to 2003, the Corps was operating under agreements signed by all three states that denied it the ability to make any permanent water supply allocations.

By the time the negotiations in the *Alabama* case fell apart in 2003, the Georgia Parties, the Corps, and SeFPC had entered into a settlement agreement in *SeFPC*. In pertinent part, the agreement set forth a process for entering into water supply contracts that could become permanent reallocations of storage. Evaluation of the legality of the settlement agreement in the D.C. district and circuit courts was delayed for several years by a preliminary injunction entered by the Northern District of Alabama. In March 2005, while the injunction was still in effect, the Corps filed a notice in the *Alabama* litigation that it intended to proceed with updating the water control plans and manuals for the ACF Basin. In response, Alabama's Congressional delegation sent a letter to the Corps stating its opposition to such actions during the pendency of the litigation, and the

Corps abandoned its plans.

This Court vacated the *Alabama* court's injunction in late 2005 and the Corps informed the states that it considered the "relevant litigation" concluded and would proceed to update the water control manuals for the ACF Basin. However, on remand, the *Alabama* district court sent the parties into settlement negotiations, and the Corps again agreed to delay the update.

The *SeFPC* settlement was struck down in 2008 and never took effect. The Corps argues that it began the process of updating its operating manuals for the ACF basin almost immediately after the settlement agreement was invalidated. The Corps also issued a legal memorandum on its authority to allocate water storage at Buford, the 2009 Stockdale Memorandum. However, the district court deemed the 2009 Stockdale Memo to be a litigation document and not part of the administrative record. The district court issued its summary judgment order in this case on July 17, 2009, and the Corps asserts that this order once again thwarted it in its attempts to consummate the decisionmaking process. The Corps states that "every single day since 1990 the Corps was either operating under an agreement that barred it from formally taking any steps to reallocate storage, or was actively engaged in a process that could have led to a final agency action reallocating storage." The historical sequence of events supports the veracity of this claim.

This Court has accepted legal and practical barriers to administrative action as legitimate explanations for agency inaction.[14] *See Nat'l Parks,* 324 F.3d at 1238, 1239 (holding that the National Parks Service's delay in implementing a management plan was excusable in part because a judicial order and a legislative mandate had prevented it from taking action). The courts have expressed a legitimate concern for agency avoidance of judicial review through intentional inaction. *Id.* at 1239. In this case, however, the lack of a definitive allocation of storage for water supply is explained by factors beyond the agency's control, rather than the Corps' inaction.

Appellees argue that the Corps has attempted to avoid judicial review of its management of the Buford Project, but they offer almost no evidence to support this contention. Alabama and Florida point out that the Corps, though required by court order not to enter into any new contracts, was not required

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[14] The Corps cites *Home Builders Ass'n of Greater Chicago v. United States Army Corps of Engineers,* 335 F.3d 607, 616 (7th Cir. 2003), for the proposition that the circuits have reached a consensus that agency delay must be "egregious" for it to be considered the consummation of the decisionmaking process. This proposition is not entirely accurate. *Home Builders* was evaluating the second prong of the *Bennett* test, not the first, when it made this statement. Thus, the Seventh Circuit was referring to the manner in which agency inaction determines the rights or obligations of the parties, not whether agency inaction constitutes the consummation of the decisionmaking process. The cases from other circuits cited by that court also deal with the manner in which agency action affects the rights of the parties. There may be some overlap between the two prongs of the analysis, but we need not decide whether the *Home Builders* "egregious" threshold applies also to evaluating delays with respect to the first prong. In this case, the Corps is able to demonstrate that its actions were not only not egregious but also understandable due to the circumstances in this case. Thus, its argument that the first prong of *Bennett* was not met is persuasive even without support from *Home Builders.*

to continue to allow the parties to withdraw water from the project. This argument misses the point. That the Corps chose to continue to permit water supply withdrawals sanctioned by the multi-party agreements does not demonstrate that the Corps effectuated a policy in regard to water supply and was attempting to avoid a judicial review of this policy. The states also note that the Corps had seven years since the time of the expiration of the agreements in 2003 to undertake a formal action. As stated above, the Corps attempted on multiple occasions after 2003 to begin the process of making final decisions on water allocations, but it was consistently thwarted by the litigation process. The Corps' two statements to the parties in 2005 that it intended to move forward with updating the water control manuals, the settlement agreement in *SeFPC*, which was struck down in 2008, and the 2009 Stockdale Memorandum, demonstrate that the Corps intended to move forward in consummating a decisionmaking process after 2003 but could not. Appellees point to no specific final actions on the part of the Corps and there is insufficient evidence to conclude that the agency has attempted to avoid judicial review via incremental changes in operational policy. Thus, Appellees are unable to meet the first prong of the *Bennett* analysis.

The Corps' current operations of the Buford Project also do not meet the second prong of the *Bennett* test because the Corps' alleged "de facto allocations" are not actions "by which rights or obligations have been determined, or from which legal consequences will flow." 520 U.S. at 178, 117 S.Ct. at 1168 (internal quotation marks omitted). Current water supply withdrawals have taken place under the "live and let live" and other similar provisions in the stays, the Memorandum of Agreement, and the ACF Compact. These provisions, like the interim contracts that preceded them, have clearly stated the temporary nature of the allocations being made. As outlined above, the Corps has not had the opportunity to engage in a determination of rights or obligations due to the constraints imposed on it by the specific circumstances of the ongoing litigation. While it is true that access to water has been affected by the Corps' water supply allocations, as Appellees argue, that fact does not demonstrate that any future rights have been determined.[15] Appellees are simply unable to produce evidence of such a determination.

Because there has been no final agency action in the *Alabama*, *SeFPC*, and *Apalachicola* actions, the district court lacked jurisdiction over these claims. Therefore, we vacate the district court's rulings in this regard and remand to the Corps to make final determinations pertaining to its current policy for water supply storage allocation.[16]

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[15] Even if the past withdrawals of water could be deemed sufficient to satisfy the second prong (notwithstanding the absence of any determination of future rights or obligations)—a matter we need not decide—there would still be no final agency action because Appellees have failed to satisfy *Bennett*'s first prong.

[16] Alabama and Florida argue that this issue was decided by this Court and that collateral estoppel bars the Corps and the Georgia Parties from making this claim. In our consideration of the appeal in *Alabama,* we indicated in a footnote that some of the Corps' storage allocations were final agency actions under the APA. 424 F.3d at 1131 & n. 19. However, this issue lacks preclusive effect because it was not actually litigated in *Alabama. See In re Held,* 734 F.2d 628, 629 (11th Cir. 1984).

In *Alabama,* the Georgia Parties argued that the complaint was moot as a result of the fact that Alabama challenged the

PAC Report, a report which had long since been withdrawn by the Corps. We dismissed the mootness argument by noting that Alabama was challenging other Corps actions, namely the ongoing reallocations of storage capacity. With respect to such other Corps actions, this court in footnote 19 commented that Alabama had identified such actions as final agency actions. It is possible that this footnote was not merely a comment on what Alabama had said, but an implied acknowledgment that on-going reallocations of storage capacity were indeed final agency actions. Even if the latter, this court's statement was a passing, bald statement with no discussion at all, and was not the product of an actually litigated issue. Accordingly, the statement does not have collateral estoppel effect. *See id.* The parties did not brief the issue and there is no evidence that the question of final agency action was litigated at all. The matter was addressed as an afterthought to the rejection of a wholly separate, tangential argument. Having heard full and thorough argument on the matter by the parties, we conclude that the action alleged in these appeals was not final.

Even if collateral estoppel did apply and the district court did have jurisdiction, we would still be required to vacate the order and remand the case to the Corps, because of the numerous errors of the district court. Although we need not enumerate each error, we note the overarching error in conducting *de novo* factfinding of issues that must be considered by the Corps in the first instance. In an administrative case, the Supreme Court has said, "[t]he reviewing court is not generally empowered to conduct a *de novo* inquiry into the matter being reviewed and to reach its own conclusions based on such an inquiry." *Fla. Power & Light Co. v. Lorion,* 470 U.S. 729, 744, 105 S.Ct. 1598, 1607, 84 L.Ed.2d 643 (1985). The wisdom of that decree is apparent in this case. The Corps has yet to undertake any final, well-reasoned actions in regard to current water supply withdrawals at the Buford Project. As a result, the judicial record in this case is incomplete. Because this record is incomplete, the district court undertook on its own to perform calculations to determine the percentage of Lake Lanier's storage space currently being allocated to water supply. As part of this determination, the court substituted its judgment for that of the Corps on a number of highly technical matters better left to the expertise of the agency. First and foremost, the court rejected several determinations by the Corps of the baseline amount of water available for downstream water withdrawal as a byproduct of power generation. Second, it used data from expired contracts even though there were no

Part II. *Georgia's 2000 Request: The Corps' Water Supply Authority Under the RHA*

With respect to the merits, we turn first to the appeal in the *Georgia* case. This Court previously summarized Georgia's 2000 request of the Corps as follows:

1. Allow municipal and industrial withdrawals from Lake Lanier to increase as necessary to the projected annual need of 297 mgd in 2030;

2. Increase the water released from the Buford Dam sufficiently to permit municipal and industrial withdrawals in the Chattahoochee River south of the dam to be increased as necessary to the projected annual need of 408 mgd in 2030;

3. Enter into long-term contracts with Georgia or municipal and industrial water users in order to provide certainty for the requested releases;

4. Ensure that sufficient flow is maintained south

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binding commitments, rather than using figures of actual water withdrawals, allegedly compounding this mistake by double-counting the City of Gainesville's withdrawals. Finally, the court took no account of return flows even though the return of those flows directly to the lake would offset the effect on the power interest. The expertise of the Corps renders it better equipped to handle such questions than a court. The district court should not have usurped the agency's fact-finding role. Without identifying each error of the district court, suffice it to say that the district court's overarching error in engaging in *de novo* fact-finding would have required remand even if there had been final agency actions.

Moreover, the district court also erred in failing to recognize that water supply for the Atlanta area was an authorized purpose of the RHA. *See* Part II, *infra*. The fact that water supply is an authorized purpose of the Project has the potential to cause significant changes in the relevant calculations, and thus constitutes an independent basis for requiring a remand to the Corps for *de novo* reconsideration.

of the Buford Dam to provide the requisite environmental quality—that is, assimilate discharged wastewater; and

5. Assess fees on the municipal and industrial water users in order to recoup any losses incurred by a reduction in the amount of hydropower generated by the dam as a result of the increased withdrawals or releases.

Georgia, 302 F.3d at 1247–48.

The parties agree that the Corps' rejection of Georgia's 2000 request constituted a final agency action, of which both the district court and this Court have jurisdiction to review. Central to the Corps' rejection was the Corps' conclusion that water supply was not an authorized purpose of the Buford Project. We now hold that the Corps erred in drawing this conclusion. The text of the 1946 Rivers and Harbors Act—specifically, the Newman Report, whose language is incorporated into the statute—clearly indicates Congress' intent to include water supply as an authorized purpose in the Buford Project.

The 1945 and 1946 Rivers and Harbors Acts authorized the building of the Buford Project and serve as the baseline for the Corps' authority to operate the dam.[17] The Georgia Parties contend that the district court seriously erred in its interpretation of the scope of its authority under the Act and neglected to note the specific authorization for water supply

[17] The 1945 RHA is less pertinent to the analysis than the 1946 Act because the final plans for the Buford Project, most notably its location and size, were not determined until the writing of the Newman Report, which post-dated the 1945 statute. Therefore, the majority of the discussion in this opinion centers on the 1946 RHA and any mention of the RHA without a specific year is a reference to the 1946 statute.

in the statute. The district court rejected this argument and held that water supply was only intended to be an incidental benefit of other operations and that the RHA did not authorize any storage for water supply in Lake Lanier.

The RHA authorized the development of the ACF Basin "in accordance with the report of the Chief of Engineers, dated May 13, 1946." 60 Stat. at 635. The Chief of Engineers Report incorporated the Division Engineer's Report—i.e. the Newman Report. Thus, the statute fully incorporated the terms of the Newman Report. The Newman Report specifically modified the recommendations of the Park Report—the foundational report for the 1945 RHA—by proposing the building of a single multi-purpose reservoir upstream of Atlanta instead of three separate reservoirs. One advantage of such a move was that the new dam could more easily accommodate water supply needs.

As the Newman Report made clear, the dam was designed with water supply specifically in mind. At times, water supply was even to be accommodated at the expense of optimal hydropower generation. The Newman Report explained:

> If operated at 100–percent load factor, the Buford development would provide a minimum continuous flow of 1,634 second-feet,[18] more than sufficient for the water needs of the Atlanta area. However, if the plant were operated on peak loads, as it should be for maximum power value, it would be shut down during week ends and week-day off-peak periods; as a result of those shut-downs, the minimum flow at Atlanta from the area below Buford

[18] "Second-feet" is another way of saying cfs.

> Dam would be only about 50 second-feet. Under the same conditions of operation, the maximum flow at Atlanta at the daily peak of the load would be over 3,000 second-feet. In order to meet the estimated present needs of the city, and to prevent damage to fish, riparian owners, and other interests by complete shutdowns of the Buford plant during the daily and week-end off-peak periods, varying flows up to a maximum of 600 second-feet should be released from Buford so as to insure at all times a flow at Atlanta not less than 650 second-feet. This flow could be used to operate a small generator to generate off-peak power as secondary energy, reserving the remaining storage for peak operation. This minimum release may have to be increased somewhat as the area develops. This release at Buford would not materially reduce the power returns from the plant, and would not affect the power benefits from plants downstream; the benefits to the Atlanta area from an assured water supply for the city and Georgia Power Co.'s steam plant would outweigh any slight decrease in system power value.
>
> Newman Report ¶ 80.

There are several critical provisions in this paragraph of the report. First, Congress contemplated that "the estimated present needs of the city" for water supply would be met by the initial Project by "insur[ing] at all times a flow at Atlanta not less than 650 second-feet." *Id.* Indeed, Congress provided in the construction of the project that, in addition to the two large turbines, there would be "a small generator to generate off-peak power as secondary energy, reserving the remaining storage for peak operation." *Id.* This small turbine was constructed for the sole purpose of providing off-peak releases of 600 cfs (without completely losing the value of these releases for power generation). If operated for maximum power value, the dam would be shut down during off-peak hours and would release no water, limiting water flow at Atlanta to a rate of 50 cfs. Such an operational scheme would not require a small turbine at all. Thus, the design of the project and the operational scheme were influenced by water supply concerns.

Second, the minimum flow was provided for notwithstanding the clear Congressional intent that it would be at the expense of "maximum power value." *Id.* Congress recognized that shutting down all water releases during off-peak hours would create an insufficient flow in the river downstream at Atlanta to meet the city's water supply needs. Therefore, even though Congress recognized that there would be some detriment to power generation, it nevertheless provided for a minimum flow of 650 cfs at Atlanta. The Newman Report, and thus the authorizing legislation itself, explicitly stated as much. The legislation provided, in connection with the initial minimum release requirement and the contemplated increases thereof, that "the benefits to the Atlanta area from an assured water supply for the city * * * would outweigh any slight decrease in system power value." *Id.*

Third, Congress recognized that "[t]his minimum release may have to be increased somewhat as the area develops." *Id.* Indeed, in the immediately preceding paragraph, the authorizing legislation considered the growing need for water supply to the metropolitan area over a future 19–year period and spoke of increasing off-peak releases to accommodate the water supply needs of the Atlanta area in 1965. That future water supply need was estimated to require a river flow at Atlanta of 800 cfs. *Id.* ¶ 79. Thus, the original authorizing legislation expressly contemplated a very substantial increase in the operation of the Buford Project to satisfy the water supply needs of the Atlanta area (i.e., from 650 cfs to 800 cfs in the river flow at Atlanta).[19]

In light of the foregoing statutory language, and particularly Congress' intent that the Corps should have authority to accommodate the Atlanta area's water supply needs at the expense of some detriment to "system power value," we cannot conclude that

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[19] The language of the paragraph reads:

> Local interests state that, in 1941, 70 second-feet of water were required for domestic and industrial purposes at Atlanta, and 415 second-feet for condensing water at the Atkinson steam-electric plant of the Georgia Power Co. on the river bank near mile 299.5; that an additional unit since installed has raised the total requirement of the steam plant to 565 second-feet; and that the total requirement for the Atlanta area for 1965, based on a population of 600,000 at that time, will be 600 second-feet for condensing water, 120 second-feet for municipal supply, and 80 second-feet of raw water for industries—a total of 800 second-feet.

Newman Report ¶ 79. Thus, as of the time of the 1946 statute, it seems that domestic and industrial water supply needs at Atlanta required a minimum river flow at Atlanta of 635 cfs (70 + 565). And the authorizing legislation contemplated that 19 years hence, in 1965, that requirement would increase to 800 cfs, a substantial increase. In evaluating the extent of the Corps' authority to satisfy the water supply needs of the Atlanta area, it is clearly relevant that Congress explicitly contemplated this substantial increase in water supply. The district court's injunction, limiting off-peak releases to 600 cfs, is obviously inconsistent with this contemplated increase in water supply. The 600 cfs level was the initial mandate in the authorizing legislation, *id.* ¶ 80, and Congress explicitly contemplated substantial increases. *Id.* ¶¶ 79, 80; *see also, supra,* note 10.

Congress intended for water supply to be a mere incidental benefit. By definition, one purpose that is to be accomplished to the detriment of another cannot be incidental.[20] Thus, the language of Sections 79 and 80 clearly indicates that Congress intended for water supply to be an authorized, rather than incidental, use of the water stored in Lake Lanier.[21]

Appellees argue that the Newman Report's references to water supply as "incidental" demonstrates

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[20] The adjectival forms of the term "incident" can mean "subordinate to something of greater importance; having a minor role" or "dependent upon, subordinate to, arising out of, or otherwise connected with." Black's Law Dictionary 830 (9th ed.2009). The superiority of water supply to hydropower in certain instances demonstrates that it could not have been a purely subordinate purpose. Likewise, the superiority of water supply under certain circumstances demonstrates that it was not meant to be fully dependent upon hydropower.

[21] In *Alabama,* we stated, "Lake Lanier was created for the explicitly authorized purposes of flood control, navigation, and electric power generation." 424 F.3d at 1122. We went on to say, "the Corps has historically maintained that water supply use is an 'incidental benefit' flowing from the creation of the reservoir." *Id.* These statements were mere dicta. The issue on appeal in *Alabama* was whether the district court's enjoining of the proceedings in the D.C. District Court (halting the finalization of the settlement agreement in *SeFPC*) was proper. The parties did not brief the issue of the Corps' water supply authority and this Court gave the topic no discussion, save for that quoted above. Thus, these statements were not the product of actual litigation, were not a "critical and necessary part of the judgment," and have no preclusive effect on the decision in this case. *See Christo v. Padgett,* 223 F.3d 1324, 1339 (11th Cir. 2000) (quotation omitted). The current appeal has allowed the Court to scrutinize more closely the Corps' water supply authority. After a full analysis of the language and legislative history of the RHA and consideration of the arguments of the parties, we conclude that Congress intended for water supply to be included as an authorized purpose of the Buford Project.

that water supply was not an authorized purpose of the Buford Project. This is an attractive proposition due to its simplicity, but the context of these references undermines this claim. The language in question is as follows:

> The city of Atlanta and other local interests in that area have strongly urged that the Roswell development, 16 miles upstream of Atlanta, or one or more other reservoirs above Atlanta, be provided first, in order to meet a threatened shortage of water, during low-flow periods, for municipal and industrial purposes. If the regulation storage reservoir required for the economical operation of the proposed developments below Columbus could be located above Atlanta, it would greatly increase the minimum flow in the river at Atlanta, thereby producing considerable *incidental benefits* by reinforcing and safeguarding the water supply of the metropolitan area.

Newman Report ¶ 68 (emphasis added). We conclude that this single reference to water supply as an "incidental benefit" was an explanation for why the dam would be built above Atlanta and was not meant to confer a subordinate status.

The Corps in the Park Report proposed the construction of three dams at Cedar Creek, Lanier, and Roswell. *Id.* The Corps subsequently determined in the Newman Report that the system of dams in the ACF Basin would operate substantially more efficiently if one large dam was built instead. The agency decided to locate the dam at Buford, approximately 47 miles upstream of Atlanta. Paragraph 68 was an explanation for why the Corps deemed it beneficial to build the dam at this location; the explanation: water supply. An upstream location would allow the Corps to secure Atlanta's water supply as an incident of the other authorized purposes. That is to say that the aim of benefitting water supply could be accomplished without any significant detriment to hydropower, navigation, or flood control. The report stated that the revised location and size of the dam and reservoir would result in "greatly increase[d] * * * minimum flow in the river at Atlanta, thereby * * * reinforcing and safeguarding the water supply of the metropolitan area." *Id.* This benefit would be incidental to power generation because the water constituting the river flow at Atlanta would have generated power as it passed through the generators. There is no indication that the use of the word "incidental" in Paragraph 68 was meant to describe the importance of water supply to the project or even the importance of water supply vis-a-vis the other project purposes.

This reading is further supported by the phrase "safeguarding the water supply of the metropolitan area." *Id.* The fact that references to incidental benefits and the safeguarding of water supply were made in the same breath demonstrates that the Newman Report did not use the term as an indication of a subordination of the importance of water supply. Instead, the "safeguarding" language of Paragraph 68 indicates the critical nature of the water supply purpose to the project. In fact, the Newman Report went on to describe the importance of the Buford Project for the protection and assurance of Atlanta's water supply on at least four other occasions. *Id.* ¶¶ 73 ("would ensure an adequate water supply for the rapidly growing Atlanta metropolitan area"), 80 ("insure at all times a flow at Atlanta") ("the benefits to the Atlanta area of an assured water supply for the city"), 100 ("would ensure an adequate municipal and industrial water supply for the Atlanta area"). Congress' focus on the need to ensure the Atlanta area's water supply serves as strong evidence of the primary role given to water supply in the project.

The only other reference in the authorizing legislation to water supply as incidental appears in the Newman Report at Paragraph 100.[22] There, the final sentence of the paragraph begins with the word "incidentally" and lists several project benefits that would not significantly harm other project purposes. One of the listed benefits is flood control, which

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[22] The language of this paragraph reads:

> The foregoing results cannot be secured by the plants below Columbus proposed herein unless a considerable storage be provided upstream to increase the minimum regulated flow and the firm capacities at those plants; without such upstream storage, the developments would not be economically justified. The best development for that purpose is that at Buford proposed herein. Provision of that development as part of the system would increase the minimum monthly flow at the Upper Columbia site from about 1,300 second-feet to 6,040 second-feet, with a corresponding increase at the Junction site. It would greatly increase both the quality and quantity of the energy output at existing plants above Columbus. It would simplify the reregulation of flows at Junction to provide a more adequate continuous flow at all times in the Apalachicola River for navigation. Without Buford, about 4,000,000 cubic yards of excavation would be required in the Apalachicola River below Junction to provide a channel 9 feet deep; with Buford, the excavation required would be reduced to about one-half that amount. *Incidentally,* it would ensure an adequate municipal and industrial water supply for the Atlanta area, would produce large benefits in the way of recreation, fish and wildlife conservation, and similar matters, and would, with the added flood-control storage proposed herein, contribute to the reduction of floods and flood damages in the basin below.

Id. ¶ 100 (emphasis added).

Appellees concede is an authorized purpose. This use of the term "incidentally" cannot be construed to mean that water supply was intended to be a subordinate use because flood control is referred to in the same manner in the sentence. This fact is further illustrated by yet another reference to the protection of water supply in the same sentence—"would ensure an adequate municipal and industrial water supply for the Atlanta area." *Id.* ¶ 100. Again, as in Paragraph 68, the meaning conveyed in Paragraph 100 is a description of how the several authorized purposes could be accomplished harmoniously and the manner in which all were better served by locating the project at Buford. For these reasons, and especially because of the clear language in Paragraphs 79 and 80 of the authorizing legislation, we do not read the sparse use of the term "incidental" as indicative of the status of water supply as an authorized use *vel non.*

Appellees argue that the original project did not contemplate storage in Lake Lanier for water supply and that this is an indication that Congress did not intend for water supply to be an authorized purpose. We disagree. The lack of storage allocation for water supply sheds no light on the intentions of Congress. No storage allocation was specified for navigation in the Newman Report even though navigation is universally accepted as an authorized purpose of the Buford Project. *See* H.R. Doc. No. 80–300, Letter from Lieutenant General R.A. Wheeler, Chief of Engineers, ¶ 11(d). Furthermore, no storage was needed at the time for water supply. Almost all of the Atlanta area's water supply requirements could be met at the time as an incident to, or byproduct of, the generation of power. Thus, the lack of initially allocated storage for water supply is not at all inconsistent with the Congressional intent that water supply was an authorized purpose.

For the same reason, we believe that the fact that the localities were not asked initially to contribute to the costs of the project is of no moment in determining Congress' intent with respect to water supply authorization. Georgia, in 1946, did not require a significant amount of water beyond that which was provided by normal project operations for power generation, so a request for state contribution to the project would not have made sense. It would have meant asking the state to pay for a service that the Corps could provide essentially without cost. Moreover, at that time, Atlanta's current water supply usage required a flow of the river at Atlanta of 635 cfs.[23] Even "[d]uring the extremely low-flow month of October 1941, the average flow for the month was 493 second-feet, and the minimum daily flow [was] 422 second-feet." *Id.* ¶ 79. In other words, before the Buford Dam was built, the river was providing the water supply needs of the Atlanta area. The requirement in the legislation that the Corps make releases "so as to [e]nsure at all times a flow at Atlanta not less than 650 second-feet," *id.* ¶ 80, merely provided water supply roughly commensurate to that which the river was already providing. It is not likely that the Corps or Congress would have thought it appropriate to charge Atlanta for con-

[23] *See* Newman Report ¶ 79 ("70 second-feet of water were required for domestic and industrial purposes at Atlanta." In addition, the Atkinson steam-electric plant had recently installed an "additional unit * * * [that] raised the total requirement of the steam plant to 565 second-feet." The two requirements total 635 cfs.).

struction costs of a project that merely replaced its currently available water supply.

The Corps could potentially have asked Georgia to pay on the basis of future water supply needs that would affect project operations, but it was not at all clear how much water would be needed in the future.[24] After all, it would be almost 30 years after the Newman Report before the Corps would sign its first water supply contract—excluding the small relocation contracts made as compensation for inundating the intakes of Gainesville and Buford. Divining the value of water supply to the localities in the future would have resulted in speculative and potentially misleading results.[25] Similarly, the fact that in its cost-benefit analysis, the Newman Report did not assign a particular dollar amount to water supply is

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[24] In 1949, the Corps stated that the Buford Project's assurance of Atlanta's water supply would be a "real benefit" but that it was premature to attempt a specific calculation of that benefit. Definite Project Report ¶ 124.

[25] The 1937 Flood Control Act ("FCA") allowed states and localities to request that the Corps, prior to construction of a flood control project based on a given set of plans, modify those plans for the inclusion of storage for water supply. The act required that localities pay the full cost of such increased storage capacity. Alabama and Florida argue that it is inconceivable, in light of the framework of the FCA, the only general statutory grant of water supply authority to the Corps in 1946, that Congress would authorize water supply storage in Lake Lanier without requiring contribution from the localities. The FCA itself is not applicable to this project because Buford was designed to be a multi-purpose project, and not merely a flood control project. Furthermore, it was not inconsistent for Congress to request contribution for projects that had to be altered to accommodate water supply, but not to request contribution for projects which merely replaced water supply already provided by the river, which water supply could be provided by the project as a by-product of power generation and with little detriment to other project purposes.

not an indication that it was not authorized because the benefits of water supply were indeterminate at the time.[26]

One final point merits mentioning. Before the Dam was built, or even planned, the Chattahoochee provided almost all of the City of Atlanta's water supply. The building of the dam could have been a potential threat to the city's ability to withdraw water from the river because the Corps had an incentive—optimal power generation—to shut off all water flow in the river for long stretches of time. Congress responded to this concern by establishing a minimum flow requirement and noting that this requirement might have to be increased over time. Congress also clearly indicated that the Buford Project was intended to benefit the Atlanta area's needs by assuring the water supply. If water supply had been deemed a subordinate purpose by Congress, the Buford Project would have been detrimental, rather than beneficial, to the Atlanta area's water supply needs. That is to say, if the only water being supplied was to be a subordinate byproduct of power generation, then the City of Atlanta would have eventually found itself able to withdraw less water from the river than it would have been had no dam been built at all. In light of the repeated references in the authorizing legislation to safeguarding and ensuring an adequate water supply for Atlanta, Congress very clearly did not intend the dam to harm the city's water supply.

The language of the RHA clearly indicates that water supply was an authorized purpose of the

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[26] It bears noting that the Corps was not required to conduct cost-benefit analyses on all project purposes until 1952. *See* Bureau of Budget, Executive Office of the President, Budget Circular A–47 (Dec. 31, 1952).

Buford Project. Appellees' arguments to the contrary are unconvincing for all of the reasons mentioned above. Thus, we conclude that water supply was an authorized purpose of the RHA and that the RHA authorized the Corps to allocate storage in Lake Lanier for water supply.

Part III. *Georgia's 2000 Request Must be Remanded to the Corps*

The Corps argues that its interpretation of the RHA in the 2002 Stockdale Memo, which supplied the legal reasoning for the denial of Georgia's water supply request, is entitled to deference from this Court. The RHA authorized the Corps to build the Buford Project in accordance with the Corps' plans and "with such changes therein as in the discretion of the Secretary of War and the Chief of Engineers may be advisable." H.R. Doc. No. 80–300, Letter from Lieutenant General R.A. Wheeler, Chief of Engineers ¶ 16. The Corps asserts that this gives the agency wide latitude in its interpretive authority. Additionally, the Corps argues that because it prepared the reports which comprise the language of the RHA, its "interpretation of the statute merits greater than normal weight because it was the [Corps] that drafted the legislation and steered it through Congress with little debate." *Howe v. Smith,* 452 U.S. 473, 485, 101 S.Ct. 2468, 2476, 69 L.Ed.2d 171 (1981). Despite the high level of respect owed to the Corps' interpretations with regard to the RHA due to its unique role in shaping the statute, we cannot defer to the Corp's interpretation of its water supply authorization in this instance. Even heightened deference cannot lead this Court to ignore the plain and express will of Congress, especially where, as here, the Corps' interpretation has not been consistent.

Under the APA, reviewing courts must set aside agency action that is "arbitrary, capricious, an abuse of discretion, or otherwise not in accordance with law." 5 U.S.C. § 706(2)(A). The denial of Georgia's request was based on a clear error of law—the Corps' misinterpretation of the RHA. Therefore, the Corps' interpretation cannot be granted deference, in spite of the agency's role in drafting the language of the legislation.

The seminal case *Chevron, U.S.A., Inc. v. Natural Resources Defense Council, Inc.,* 467 U.S. 837, 842–44, 104 S.Ct. 2778, 2781–82, 81 L.Ed.2d 694 (1984), set up a two-step framework for evaluating whether a court must defer to an agency's construction of a statute it is charged with administering. Deference from the court is due if (1) Congress has not spoken directly on the precise question at issue and its intent is unclear, and (2) the agency's interpretation is based on a permissible construction of the statute. *Id.* The argument for *Chevron* deference in this case fails at both steps because Congress made clear its intention that water supply was an authorized purpose of the Buford Project. As discussed above, the Newman Report repeatedly stated that the Buford project would protect and assure the water supply of the Atlanta metropolitan area. Furthermore, the Report authorized the use of water for water supply at the expense of maximum hydropower generation. Congress' acknowledgment that water supply, in certain instances, was to be provided at the expense of maximum power generation necessitates the conclusion that water supply was not to be subordinate to other project purposes and was instead an authorized purpose in its own right. The Corps' interpretation that the RHA relegated water supply to incidental status cannot be reconciled with the plain language of the statute. The clear Congressional intent in the 1946 RHA was that water supply was to be an authorized purpose, and the Corps' contrary interpretation is erroneous and cannot be accepted by this Court.[27]

A significant fact undermining any deference to the Corps on this issue is the fact that the Corps has also been inconsistent in its statements about whether water supply was an authorized purpose. The 2002 Stockdale Memo concluded (incorrectly) that water supply was not an authorized purpose, but this is not consistent with previous Corps statements on the matter. In the Corps' 1949 Definite Project Report, the Corps referred to water supply as one of the "primary purposes" and one of "the princip[al] purposes of the Buford Project." ¶¶ 48, 115. This 1949 Report was a formal pronouncement on the issue, and the one most nearly contemporaneous to the actual enactment. In a 1987 regulation, 33 C.F.R. §

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[27] The Corps concedes that the 2002 Stockdale Memo might not be entitled to *Chevron* deference because it may be deemed an internal guidance document that does not decide legal rights. *See Christensen v. Harris Cnty.,* 529 U.S. 576, 587, 120 S.Ct. 1655, 1662–63, 146 L.Ed.2d 621 (2000). If this is the case, then the Corps' legal interpretations in the document deserve *Skidmore* deference, meaning that the interpretations are "entitled to respect * * * but only to the extent that those interpretations have the power to persuade." *Id.* (internal quotation marks and citations omitted). Because the clear intent of the RHA forecloses the higher *Chevron* level of deference, it follows that *Skidmore* deference is also not applicable to the facts of this case. In light of Congress' intent to include water supply as an authorized purpose, the Corps' contrary determination is not at all persuasive. Since neither type of deference can be given to the Corps' legal determinations, we need not decide whether the *Skidmore* or *Chevron* framework is applicable on the instant facts.

222.5, App'x E, the Corps listed water supply as a project purpose for Buford. In the Corps' comprehensive 1994 report to Congress, which listed the authorized purposes for Corps projects across the country, water supply was included as an authorized purpose of Buford under the RHA.[28] U.S. Army Corps of Eng'rs: Hydrologic Engineering Center, Authorized and Operating Purposes of Corps of Engineers Reservoirs E–94 (1994). That report also defined the term "incidental benefits" and stated that incidental benefits, though they were important, were not the subject of the report and would not be listed. *Id.* at 3–4. The Corps and the Appellees offer no explanation for why the Corps indicated that water supply was an authorized purpose in 1949, 1987, and 1994 but took a contrary position in 2002.[29]

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[28] Recreation and fish and wildlife are also listed as authorized purposes in the report. However, the authorizing statute listed in the report for water supply is the RHA. Recreation and fish and wildlife are listed as being authorized by statutes not at issue in this case.

[29] The Corps argues that any inconsistency in its interpretation is irrelevant to the deference analysis, citing *National Cable & Telecommunications Ass'n v. Brand X Internet Services,* 545 U.S. 967, 981, 125 S.Ct. 2688, 2699–2700, 162 L.Ed.2d 820 (2005). However, the holding of *Brand X* does not go quite this far. The case merely states that *Chevron may* be applicable to instances in which the agency has changed its position "if the agency adequately explains the reasons for a reversal of policy." *Id.* at 981, 125 S.Ct. at 2699. This Court has also noted that an agency must be allowed to shift its position over time and that such shifts should even be accorded deference by reviewing courts. *Friends of the Everglades v. S. Fla. Water Mgmt. Dist.,* 570 F.3d 1210, 1219 (11th Cir. 2009). But in this case, the Corps has given no explanation for the reasoning behind any changes in policy. Also, the Corps' position has not merely changed; rather, it has been in such a constant state of flux that it appears to have not yet fully formed. In any event, the authorizing legislation itself is sufficiently clear; water

The Corps argues that even if it erred in its interpretation of the RHA, its rejection of Georgia's water supply request should be allowed to stand. The Corps suggests that it accounted for the possibility that water supply was an authorized purpose of the Buford Project and still concluded that the request exceeded its authority. In support of this contention, the Corps points to the following language in the Stockdale Memo: "Even if water supply were a specifically authorized purpose of the reservoir (and the 1958 Act did not apply), the state's request would require substantial changes in the relative sizes of project purposes. This would represent a material alteration of the project, which would require congressional action." 2002 Stockdale Memo at 11 (internal quotation marks omitted).

The Corps argues that this constitutes an alternative conclusion and that there is no reason to believe that it is incapable of considering a legal hypothetical. It argues that remanding the case for a consideration that it already gave would be duplicative. However, an administrative agency's alternative explanation for denying a state's request is "arbitrary, capricious * * * or otherwise not in accordance with law" if it is based on an impermissible reading of the authorizing statute or statutes. *See Massachusetts v. Envtl. Prot. Agency,* 549 U.S. 497, 532–34, 127 S.Ct. 1438, 1462–63, 167 L.Ed.2d 248 (2007) (holding that the EPA's reading of a statutory phrase in its alternative explanation for why it did not regulate greenhouse gas emissions was not in conformity with the statute, and thus remanding to the EPA). The Corps' hypothetical, which is reiterated

supply is an authorized purpose.

almost verbatim in the conclusion of the memo, 2002 Stockdale Memo at 13, rests squarely on an erroneous legal proposition. In this alternative hypothetical, the Corps mistakenly assumes that the WSA would not apply to the agency's determination of its authority to grant the Georgia request if water supply were authorized by the RHA. This assumption has no foundation in law. The WSA nowhere indicates that it is superceded by, or supercedes, original authorizations for water supply. The Act was merely intended to offer greater water supply authority in federal water projects than had previously existed. For that authority to be supplemental to authority already extant in a given project is perfectly consistent with the language and purpose of the statute. To assume, as the Corps has in its alternative conclusion, that the WSA does not apply to the Buford Project merely because the authorizing statute included water supply as an authorized purpose is not supported by the language of the WSA or by its intended aim of increasing water supply authority in federal projects. The Corps' holding in the alternative must be rejected because it misinterprets the scope of the WSA.

The Corps' alternative conclusion is also undermined because, despite the Corps' contentions otherwise, its misinterpretation of the RHA was essential to its conclusion that it lacked authority to grant Georgia's request. The majority of the memorandum is devoted to the potential effects of granting the request and whether these effects would be consistent with the Corps' authority under the WSA. The discussion of the agency's authority under the WSA is predicated on the assumption that the baseline level of authorization from the RHA is zero and that no storage may be allocated to water supply pursuant to the RHA. It is only at the very end of the discussion of the Corps' authority that the agency considers *arguendo* the possibility that the RHA authorized water supply. Its brief discussion of this alternative is flawed in two respects. First, as noted above, the Corps erroneously assumes that if the RHA included water supply as an authorized purpose, the WSA would not be applicable at all. Second, although purporting to assume water supply was an authorized purpose of the RHA, the Corps nevertheless underestimated its RHA authority. It failed to recognize that the authorizing legislation in 1946 not only included water supply as an authorized purpose but explicitly contemplated that the Corps was authorized to increase water supply usage over time as the Atlanta area grew and that this increase would not be a change from Congressionally contemplated operations at all. Thus, the Corps never considered its authority under the RHA to substantially increase its provision of water supply and reallocate storage therefor—authority which we hold today was granted by the RHA. And the Corps never considered its WSA authority to provide water supply as an addition to (or as supplementing) its RHA authority. The failure of the Corps in these respects renders its alternative reason for denying Georgia's request arbitrary, capricious, or otherwise not in accordance with the law.[30]

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[30] For example, in the portion of the 2002 Stockdale Memo dealing with the alternative rationale, Stockdale 2002 at 11, the Corps spoke of the general limitation on its discretionary authority to make post-authorization changes in projects without seeking additional Congressional authority—i.e., the Corps' lack of authority to make substantial changes in the relative sizes of project purposes—without any recognition of

Several other factors also indicate that the Corps' rejection of the water supply request should be remanded for further consideration. First, attached to the 2002 Memo is a "preliminary analysis of the impacts of Georgia's water supply request on authorized project purposes and operations." The Corps' analysis on the effects of the Georgia request was thus incomplete. Because the Corps' authority to grant the request may be dependant on the precise size and effect of the request, it is crucial that the Corps complete its evaluation of the request. The need for further study recommends remand to the Corps.

Second, it is also apparent that the Corps' views regarding its authority to allocate storage in Lake Lanier to water supply are evolving and that it has not come to a final, determinative decision regarding the issues underlying this authority. There are several pieces of evidence for this. In 2002, the Corps rejected the Georgia request, asserting that it did not have sufficient authority to reallocate 34% of conservation storage. However, in 2004, it agreed to settle the *Geren* case, in part by reallocating what the settling parties determined at that time to be 22% of the conservation storage. The Corps determined that it could make such a reallocation on the basis of its WSA authority alone. Though these decisions are not directly conflicting, the Corps never explained why it believed that the 12% storage allocation difference

the fact that the authorizing legislation here already gave the Corps authority to increase the water supply purpose at the expense of the hydropower purpose and without recognition of the fact that the legislation explicitly contemplated a considerable such increase to meet the water supply needs estimated 19 years in the future. *See* Newman Report ¶¶ 79, 80.

between the two caused it to exceed its authority. If the RHA authorizes some storage reallocation to water supply, as we hold today that it does, then the Corps should explain why this difference in allocated storage between the Georgia request and the settlement agreement pushed it beyond the boundaries of its authority. Additionally, the Corps has revised its figures for how much storage must be allocated to accommodate current levels of water supply withdrawal. In the 2002 memo, the Corps asserted that current withdrawals required a 13% reallocation of conservation storage. On appeal, the Corps claims that the current withdrawal levels are only 11.7%. It appears that the Corps may no longer conclude that Georgia's request would require an allocation as large as 34%. Any such decrease in the Corps' projection of the amount of storage it deems required for water withdrawals could also affect its determination of its authority over the Georgia request.[31]

[31] The Corps' position in this appeal seems to favor evaluating water supply authority via an analysis of the detrimental effect of increased water supply on the production of hydropower as an alternative to an analysis predicated solely on the percentage of conservation storage being reallocated. *See* Brief of U.S. Army Corps of Eng'rs, et al. at 99–100, Tri–State Water Rights Litigation, No. 09–14657 (11th Cir. May 3, 2010) (explaining that the "de facto" reallocations of storage to account for current water supply uses causes a systemwide reduction of hydropower of only 1%). The present discussion of percentage allocations is not meant to be an endorsement of this method of evaluating the Corps' authority. It is merely meant to describe the evolving nature of the Corps' stated reasoning for its conclusions with respect to the bounds of its authority. In fact, the Corps' former reliance on percentage-based allocations and its seeming current reliance on effects on project purposes may also represent a shift in policy. We conclude that the D.C. Circuit's *Geren* opinion does not foreclose the Corps from fully exploring this issue. *See infra,* Part VI. On remand, the Corps should determine the optimal methodology for measuring its authority over water supply allocations.

Finally, because the other matters in this appeal must be remanded to the Corps, it is sensible and efficient for the agency to consider the overlapping issues that are common to *Georgia* and the other cases together as part of a comprehensive decision about the Corps' future water supply operations. The conclusions that the Corps reaches with respect to the questions at issue in the other cases will provide it with a more complete analysis of the issues in *Georgia,* as well. For example, the Corps' determinations of its authorization over current water supply withdrawals will necessitate a thorough study of the amount of storage required for water supply. Also, this appeal represents the first opportunity for a court to consider the Corps' authority under both the RHA and the WSA. Our holding—that water supply is an authorized purpose under the RHA, that the Corps does have some authority under the RHA to balance as among the authorized uses and increase the water supply purpose at the expense of the power purpose and to reallocate storage therefor, and that the Corps' authority under the WSA is in addition to its authority under the RHA—constitutes a clarifica-

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A companion consideration in the Corps' WSA analysis is the concept of compensating the power users for the detrimental effects of water supply on the power purpose. The Corps accepted the notion of such compensation in the proposed settlement in *Geren,* though the record shows no preceding endorsement of this concept. Because the RHA authorized the accommodation of some water supply needs at the expense of the power purpose, the Corps must determine the proper balance between water supply and power. Consequently, the Corps must analyze whether compensation is a factor in determining the extent of the Corps' authority under the RHA, whether under the WSA a reallocation of storage is an operational change, and whether such a change is major. *See infra,* Part VI, note 41, indicating that *Geren*'s comments on the compensation concept have no collateral estoppel effect.

tion of the legal environment which will aid the Corps in its analysis on remand. For these reasons, we conclude that the Corps must reexamine the request in light of its combined authority under the RHA and WSA.[32]

Part IV. *Gwinnett County's Claims Not Involving Authorization Under the RHA and WSA.*

Gwinnett County asserts three claims that are distinct from the claims of the Georgia Parties and the Corps. First, the county asserts that a 1956 Act of Congress authorized the Corps to contract with it for 10 mgd for water supply. Second, Gwinnett asserts that the Corps contracted with it to provide permanent storage for roughly 40 mgd. Finally, the county asserts that the Buford Project rendered its intake facility at Duluth, Georgia inoperable and that it is therefore entitled to water withdrawal rights as just compensation. We find merit in the first of these claims but reject the final two.

A. The Expiration of the 1956 Act

In 1956, Congress passed an act, in part, stating the following:

> [T]he Secretary of the Army is hereby authorized to contract with Gwinnett County, Georgia, upon such terms and for such period not to exceed fifty years as he may deem reasonable for the use of storage space in the Buford Reservoir for the purpose of providing said county a regulated water supply in

[32] It should also be noted that the Corps was granted additional water supply authority in the 1956 Act. *See infra,* Part IV Section A. References in this opinion to the Corps' authority under the RHA and the WSA are not to be construed as negating its additional authority under the 1956 Act.

an amount not to exceed eleven thousand two hundred acre-feet of water annually* * *.

Pub.L. No. 84–841, 70 Stat. 725. The district court noted in a footnote that Gwinnett had not contracted with the Corps pursuant to this authorization and held that the authorization "expired in 2006." *Tri–State,* 639 F.Supp.2d at 1350 n. 24. The district court has misread the plain language of the statute. The fifty-year limitation in the Act refers to the duration of any contract with Gwinnett, not to the expiration of the Act itself. The phrase "not to exceed fifty years" immediately follows the words "contract * * * upon such terms and for such period" and there is no grammatical cue that it should not be read as modifying this phrase. The district court offers no explanation for its unnatural reading of the statute and none is evident to this Court. Moreover, the Act also authorized the Corps to enter into a perpetual easement with Gwinnett, authorizing Gwinnett to build the necessary facilities to withdraw water directly from Lake Lanier on the Corps' land. 70 Stat. at 725. It would be illogical for Congress to give Gwinnett a perpetual easement to implement an authorization that would expire in fifty years. The district court's interpretation of the Act, which is espoused by Appellees in this appeal, is inconsistent with the Act's language and its grant of an easement in perpetuity.

To date there has not been a single contract between the Corps and Gwinnett predicated on the authority of the 1956 Act. Such a contract in the future would not be a reallocation of storage under the WSA or the RHA because it is directly authorized by Congress.

B. Forty mgd from the 1974 Supplemental Agreement to the Corps' Contract

Gwinnett argues that in 1974 the Corps granted the county the right to 38,100 acre-feet of permanent storage so that it could withdraw roughly 40 mgd directly from Lake Lanier. In 1973, Gwinnett and the Corps entered into an interim water contract for 40 mgd. The following year, the parties revised Article 9 of the contract to provide:

> Upon expiration of the period of contract * * * the User shall have the right to acquire from the Government * * * the right to utilize storage space in the project containing at least 38,100 acre feet (which is estimated to be adequate to yield approximately 40 MGD of water).

Supplemental Agreement No.1 to Contract No. DACW01–9–73–624 Between United States and Gwinnett County, Georgia for Withdrawal of Water from Lake Sidney Lanier (Apr. 29, 1974). The contract stated that this revision was being made "in order to facilitate the sale of bonds to finance [Gwinnett's] proposed water works facilities." *Id.* Subsequent supplemental agreements extended the life of the contract until it was finally allowed to expire in 1990.

The contract gave Gwinnett the "right to acquire" the storage space at the time of the expiration of the contract. Thus, Gwinnett possessed an option (an offer) to purchase storage space at the time of the contract's expiration, which the parties agree occurred in 1990. "If no time is prescribed for accepting an offer, it must be done within a reasonable time." *Wilkins v. Butler,* 187 Ga.App. 84, 369 S.E.2d 267, 268 (1988) (quotation omitted); *see Home Ins. Co. v.*

Swann, 34 Ga.App. 19, 128 S.E. 70, 72 (1925); Restatement (Second) of Contracts § 41 (1981). Gwinnett has not demonstrated that it exercised its acceptance of the option in 1990 or at any time since then. More than twenty years have elapsed since the time that the option became available, and the right to accept the Corps' offer to acquire the 38,100 acre-feet of storage clearly has lapsed.[33]

C. Just Compensation for Relocation of the Duluth Intake

On appeal, Gwinnett argues that it should have been compensated because the creation of the Buford Project led to contamination of its intake structure at Duluth, which had to be abandoned in the early 1970s. Gwinnett failed to make this argument before the district court. We generally do not consider arguments raised for the first time on appeal and need not do so here. *Peek–A–Boo Lounge of Bradenton, Inc. v. Manatee Cnty.,* 630 F.3d 1346, 1358 (11th Cir. 2011).

In any event, this argument is meritless. Gwinnett fails to discuss the rights of the federal government to make alterations to navigable waters. The federal government possesses what is known as a navigational servitude, "the privilege to appropriate without compensation which attaches to the exercise of

[33] Gwinnett argues that any challenges to its right to storage under the 1974 supplement are barred by the six-year statute of limitations for actions against the United States. 28 U.S.C. § 2401(a). Though the statute has been extended to suits under the APA, it is clearly inapplicable here. Appellees, and/or the Corps, have nothing to challenge here, and consequently nothing that they are barred from challenging, because the Corps merely granted Gwinnett an unexercised option. No permanent storage rights were ever conferred on Gwinnett by the Corps.

the power of the government to control and regulate navigable waters in the interest of commerce." *United States v. Va. Elec. & Power Co.,* 365 U.S. 624, 627, 81 S.Ct. 784, 787–88, 5 L.Ed.2d 838 (1961) (internal quotation marks omitted). The navigational servitude is a dominant servitude, trumping all competing and conflicting rights to the waterway. *Id.* This servitude extends to the entire river and the riverbed lying below the high-water mark. *United States v. Rands,* 389 U.S. 121, 123, 88 S.Ct. 265, 267, 19 L.Ed.2d 329 (1967). It is anchored in Congress' commerce clause power. "The power to regulate commerce comprehends the control for that purpose, and to the extent necessary, of all the navigable waters of the United States. For this purpose they are public property of the nation, and subject to all the requisite legislation by Congress." *Id.* at 122–23, 88 S.Ct. at 266–67 (alteration omitted) (internal quotation marks omitted).

The federal government does not execute a taking of riparian interests by altering rivers for navigational purposes. The government's dominant right to make use of these waterways means that its actions do not amount to an appropriation. This premise has been explicitly stated several times in the context of hydropower interests: The federal government is not required to give compensation for water power when it takes riparian lands in accordance with the navigational servitude. *E.g., Va. Elec.,* 365 U.S. at 629, 81 S.Ct. at 788; *United States v. Twin City Power Co.,* 350 U.S. 222, 226–27, 76 S.Ct. 259, 262, 100 L.Ed. 240 (1956); *United States v. Appalachian Elec. Power Co.,* 311 U.S. 377, 424, 61 S.Ct. 291, 307, 85 L.Ed. 243 (1940); *United States v. Chandler–Dunbar Water Power Co.,* 229 U.S. 53, 73–74, 33 S.Ct. 667, 676, 57

L.Ed. 1063 (1913). Gwinnett offers no explanation for why this principle should not be applied to the riparian interest in water supply.

Because of the federal government's dominant right to make alterations in the river, the effect on Gwinnett's riparian interests is not a taking. Thus, even if Gwinnett had not abandoned its claim, the claim would not be compensable.

Part V. *Remand Instructions to the Corps*

On remand, the Corps is to reconsider Georgia's request, as well as its authority with respect to the current provisions for water supply, in light of its authority under the RHA as well as the WSA and the 1956 Act. In particular, it should consider several important factors with respect to the Newman Report (i.e., the RHA). First, the Corps should take into consideration that water supply for the Atlanta metropolitan area was an authorized purpose of the Buford Project as well as hydroelectric power, flood control, and navigation. Second, Congress contemplated that the Corps would be authorized to calibrate operations to balance between the water supply use and the power use. Third, because Congress explicitly provided that the "estimated present needs" of the Atlanta area for water supply be satisfied at the expense of "maximum power value," Newman Report ¶ 80, we know that the water supply use is not subordinate to the power use. Fourth, from Paragraphs 79 and 80 of the Newman Report, we know that Congress contemplated that water supply may have to be increased over time as the Atlanta area grows.

However, the authorizing legislation is ambiguous with respect to the extent of the Corps' balancing authority—i.e., the extent of the Corps' authority under the RHA to provide water supply for the Atlanta area. On the one hand, the authorizing legislation recognized that the Chattahoochee River was the source of the water supply for the Atlanta area, and the legislation repeatedly referred to safeguarding or assuring the water supply of the metropolitan area. *See* Newman Report ¶¶ 79 and 80. It also recognized that the minimum releases initially provided by the legislation to satisfy the present water needs "may have to be increased somewhat as the area develops." *Id.* ¶ 80. On the other hand, the legislation also contemplates that assuring such water supply for the Atlanta area can be done with a "slight decrease in system power value." *Id.*[34] We conclude that the Corps, the agency authorized by Congress to implement and enforce this legislation, should, in the first instance, evaluate precisely what this balance should be.[35]

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[34] Adding to the possible ambiguity, the quoted phrase from Paragraph 80 refers to a "slight decrease in system power value," but Congress contemplated, in the preceding Paragraph 79, a considerable increase in the river flow at Atlanta during off-peak hours in order to provide for Atlanta's water supply needs nineteen years in the future. Paragraph 79 contemplated increasing the river flow at Atlanta from 650 cfs to 800 cfs.

[35] The Georgia Parties specifically assert that the Corps has authority under the RHA to increase releases from the dam in order to provide water supply to downstream users, and to reallocate storage for this purpose, an assertion with which we agree today. However, The Georgia Parties do not specifically assert that, in addition to the foregoing authority, the RHA also gives the Corps authority to make direct withdrawals from Lake Lanier for water supply. Although the authorizing legislation recognized that the Chattahoochee River was the source of water supply for the Atlanta area, and although Congress specifically contemplated ensuring and safeguarding the area's water supply, the only way that the RHA mentions for ensuring the water supply of the Atlanta area is by means of

Once the Corps has determined the extent of its authority under the RHA, it should then determine its authority pursuant to the WSA. The authority under the WSA will be in addition to the Corps' authority under the RHA and the 1956 Act.

It is apparent from the record and the evolving position of the Corps that the Corps has not arrived at a final, definitive determination of the scope of its authority to allocate storage to water supply. For example, it is not clear whether the Corps has arrived at a firm calculation of how many gallons per day can be provided for the Atlanta area's water

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increasing releases from the dam for the purpose of downstream withdrawals. It also appears that the Corps' position has been more consistent with respect to its lack of authority under the RHA to provide direct withdrawals than it has in other regards. *See* F.G. Turner, U.S. Army Corps of Eng'rs: Mobile Division, *Report on Withdrawal of Domestic Water Supply from Buford Reservoir* (1955) (stating that the Corps advised Gwinnett County that it did not have the authority at that time—i.e., before the 1958 WSA—to grant a request for direct withdrawals for water supply and recommending that Congress provide the Corps with the additional authority necessary to grant this request). Finally, because it is unclear at this point precisely how much of the Atlanta area's water supply the Corps will determine on remand it can provide pursuant to its clear RHA authority to increase releases for downstream water supply, because the 1956 Act clearly gives the Corps authority for a specific amount of direct withdrawals for Gwinnett County, and because the WSA clearly provides the Corps authority for direct withdrawals from the Lake (as long as the cumulative exercise of such Corps authority pursuant solely to the WSA does not constitute a "major operational change" or "seriously affect the purposes for which the project was authorized"), it is not clear that the issue of RHA authority for direct withdrawals is a live issue in this case. For all of the foregoing reasons, we express no opinion on whether the RHA could be construed to provide authorization for the Corps to satisfy the authorized water supply purpose, not only by increasing releases for downstream withdrawal but also by direct withdrawals from the reservoir.

supply needs as a mere incident to, or byproduct of, power generation. The Corps' latest figure, developed in 1986, in this regard has been 327 mgd; however, at oral argument the Corps asserted that the calculation was not definitive and deserved more study. Also, it is apparent that the Corps has not arrived at a definitive, final determination of whether, and to what extent, storage reallocation would be necessary for RHA-authorized releases from the dam primarily for water supply purposes (and how to factor in the fact that these releases will still generate some power, though not of peak value). It is also unclear whether the Corps has arrived at a final determination of the appropriate measure for determining under the RHA what the impact of increased water supply use on power is, or the appropriate measure for determining under the WSA what constitutes a "major operational change."[36] Finally, the Corps has not yet articulated a policy on whether to account for return flows, and if so, how to differentiate between flows returned directly to the lake and flows returned downstream from the dam. These are some of the questions that the Corps should answer on remand, although we make no attempt to be exhaustive in that regard.

As part of the final, definitive statement of the Corps' water supply analysis, if the agency ultimately concludes that it does not have the authority to grant the Georgia request, it nevertheless should

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[36] In this regard, for example, the Corps should consider whether, and to what extent, considerations such as the following are relevant: percentage reallocation of conservation and/or other storage, measurements of decreases in systemwide power, and compensation to power customers. *See also supra,* note 31.

indicate the scope of the authority it thinks it does have, under the RHA, the WSA, and the 1956 Act. This way, the parties will have some further instruction, based on sophisticated analysis, of what the Corps believes to be the limitations on its power.

Part VI. *Collateral Estoppel Effects on Remand Instructions*

To assist the Corps in making these determinations on remand, we address here whether certain statements from this Court's decision in *Alabama* or the D.C. Circuit's decision in *Geren* carry the force of collateral estoppel. Specifically, we discuss whether either of the two claims found to have preclusive force by the district court in the instant case is binding on the Corps and whether any of Alabama and Florida's additional collateral estoppel arguments have merit. At the outset, we note that collateral estoppel applies only if (1) the issue at stake is identical to the one involved in the prior proceeding; (2) the issue was actually litigated in the prior proceeding; (3) the determination of the issue was critical and necessary to the earlier judgment; and (4) the party against whom collateral estoppel is asserted had a full and fair opportunity to litigate the issue in the prior proceeding. *Christo v. Padgett,* 223 F.3d 1324, 1339 (11th Cir. 2000).

The district court found collateral estoppel, preclusive effect in the D.C. Circuit's conclusion that the WSA applied to interim reallocations of storage. *Tri–State,* 639 F.Supp.2d at 1343. We take no issue with this application of collateral estoppel. On remand, the Corps will determine the extent of its authority to supply the current water supply needs of the Atlanta area, combining its authority under the 1956 Act, the RHA, and the WSA. The Corps' authority under the WSA (as well as the statutory limits thereto) are applicable to the Corps' determination of its authority to supply current water supply needs, whether by force of collateral estoppel or clear statutory meaning or both.

The district court also found preclusive effect in the D.C. Circuit's holding that the reallocation of 22% of Lake Lanier's conservation storage is a major operational change on its face. *Id.* Several aspects of this holding merit discussion. First, and foremost, the *Geren* court considered only the Corps' authority under the WSA, not its authority under the RHA.[37] Accordingly, a different issue is presented here. At the very least, this difference means that any water the Corps finds it is authorized to supply pursuant to the RHA is separate from the water it is authorized to supply pursuant to the WSA, and that this RHA-authorized water supply would not count against the *Geren* court's 22% limit.[38]

It is also possible that our reading of the authority provided by the RHA fundamentally changes the WSA analysis, given that the RHA congressionally authorizes the Corps to increase water supply in its

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[37] The settling parties—the Corps, SeFPC, and the Georgia Parties—did not make an issue of the Corps' authority under the RHA because they were not in full agreement on whether water supply was an authorized purpose of the Buford Project. As settling parties defending a settlement, they had no incentive to assert issues about which they disagreed.

[38] Of course, the authority granted under the 1956 Act for Gwinnett County also would not count against the *Geren* court's 22% limit. Likewise, the parties and the courts have consistently assumed, and so do we, that the 10 mgd in compensatory withdrawals by Buford and Gainesville do not affect the amount of water that the Corps is authorized to supply under the various statutory grants.

balancing of hydropower and water supply needs, meaning that such reallocations to water supply arguably do not actually constitute a "change" of operations at all, and that the issue is therefore entirely different than the one presented to the *Geren* court. In other words, it is possible that the 22% holding has no preclusive force at all. However, because it is not clear that the *Geren* court's 22% limit will be reached in this case,[39] we expressly decline to address the collateral estoppel effect of the *Geren* court's 22% limit.[40]

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[39] There are two reasons the 22% limit may not be reached. First, the Corps has yet to determine the extent of its authority to allocate water to water supply under the RHA. The 22% limit would not be reached unless the water allocated under the WSA represented at least a 22% reallocation above whatever allocation is authorized under the RHA. Second, as discussed in the two paragraphs immediately following this paragraph, percent reallocation of conservation storage may not be the correct or sole measure of operational change.

[40] We do, however, expressly address the collateral estoppel effect of *Geren*'s alternative holding—that even a 9% increase in storage for water supply is a major operational change. The district court did not find preclusive effect to this holding. Alabama and Florida do not argue in their briefs that this holding is entitled to collateral estoppel, and Alabama and Florida expressly abandoned any such claim at oral argument. Nonetheless, we consider this issue in order to provide complete remand instructions to the Corps. Because the issue arose in *Geren* for the first time at oral argument, the Corps and the Georgia Parties had no opportunity to brief the issue. This alternative, and secondary, holding therefore wholly fails the "actually litigated" requirement for collateral estoppel. *See Chi. Truck Drivers, Helpers & Warehouse Union (Independent) Pension Fund v. Century Motor Freight, Inc.,* 125 F.3d 526, 530 (7th Cir. 1997) (expressing doubt that the issue of a regulation's validity was actually litigated when it emerged only at the reply brief stage and received little discussion in the opinion, notwithstanding the fact that the party against whom collateral estoppel was asserted had raised the application of the regulation in its earlier response to summary judgment).

Second, it is clear that the question of whether percent reallocation of storage is the correct or sole measure of operational change was not actually litigated. Examination of the parties' briefs in *Geren* makes clear that the parties assumed, but did not put at issue, the question of whether percent reallocation of storage is the correct or sole measure of operational change. Similarly, because the parties merely assumed that percent reallocation was the appropriate measure, the *Geren* court made the same assumption in its opinion, without any discussion of the issue. When an issue is merely assumed, it does not meet the actual litigation requirement for collateral estoppel. *See Fields v. Apfel,* 234 F.3d 379, 383 (8th Cir. 2000) (finding no issue preclusion with respect to whether a particular method for calculating disability benefits applied, because its applicability had merely been assumed by the court and both parties in a prior case and not placed at issue). The fact that the *Geren* court ruled "without thoroughly examining" the issue further undermines the preclusive effect of the ruling. *A.J. Taft Coal Co. v. Connors,* 829 F.2d 1577, 1581 (11th Cir. 1987) (declining to apply collateral estoppel where the issue was not fully litigated, which resulted in the prior court tendering a conclusion "without thoroughly examining" the issue). Moreover, in this case, the district court did not hold that percent reallocation of storage is, as a matter of collateral estoppel, the correct or sole measure, and Appellees do not argue on appeal that we are bound by collateral estoppel to hold that percent reallocation of storage is the only appropriate measure of operational change. We conclude, for the foregoing reasons, that collateral estoppel does not bar the Corps from determining the appropriate measure of operational change on the basis of its own expertise. The Corps is free to consider on remand whether other measures, such as impact on hydropower,[41] should be considered instead of or in addi-

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[41] It may be that the percent impact on hydropower is significantly less than the percent of storage reallocated to water supply under a given allocation scheme. For example, the Corps' brief at 99–100 explained that the "de facto" reallocations of storage to account for current uses causes a systemwide reduction of hydropower of only 1%.

Another aspect of the evaluation of detriment to hydropower is whether compensation to power users can be considered to mitigate any detriment. Although the *Geren* court rejected the idea that compensation to hydropower users might be relevant under the WSA, *see Geren,* 514 F.3d at 1324, Alabama and Florida do not argue that this rejection gives rise to collateral estoppel. We consider the issue nonetheless in order to provide complete remand instructions to the Corps. For the following reasons, we conclude that collateral estoppel does not preclude the Corps from considering compensation to power users as a mitigating factor in its analysis of detriment to hydropower, if the Corps finds it appropriate to consider compensation for this purpose based on the exercise of its expertise. The concept of compensating power customers presents a different issue than the one considered in *Geren* because the D.C. Circuit failed to recognize the Corps' authority under the RHA. As we hold today, the RHA authorizes the Corps to increase water supply at the expense of hydropower, and it contemplates that, in balancing the water supply and hydropower interests, the Corps should consider the magnitude of the detriment to hydropower. Because the *Geren* court failed to recognize this authority, it treated the proposed change in storage, and flow through, as a major operational change without considering the magnitude of the effect on hydropower and without considering whether financial compensation is relevant to that inquiry. Accordingly, the *Geren* court did not face the same issue with respect to the effect of compensation on the Corps' authority as this Court. Because the issue is different, collateral estoppel does not apply. *See Christo,* 223 F.3d at 1339. The Corps on remand may therefore make a fresh determination regarding whether financial compensation to power customers is material for the purpose of evaluating the magnitude of the detriment to hydropower.

tion to percent reallocation of storage.

Third, examination of the briefs in *Geren* also shows that the parties merely assumed that conservation storage was the appropriate frame of reference against which percent reallocation should be calculated, and the court likewise made this assumption. Accordingly, the actual litigation requirement is not met and the Corps is free to consider on remand whether some other portion of the dam's capacity should also be considered. For instance, it may be that the flood control storage, which sometimes contains excess water that could be released to satisfy water supply needs, should be factored into the calculation.

Alabama and Florida advance two collateral estoppel arguments in addition to those already covered above. First, they argue that the *Geren* court decided that, for purposes of the WSA analysis, the baseline for storage against which major operational change should be measured is zero. They further argue that the decision has the effect of collateral estoppel. We disagree. As noted above, the *Geren* court expressly made no decision with respect to the Corps' authority to allocate storage to water supply under the RHA.[42] It addressed the issue of the appropriate baseline for the WSA analysis only in the context of rejecting the settling parties' argument that the interim reallocation level prior to the settlement was the correct

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[42] Accordingly, Alabama and Florida are plainly wrong to the extent they argue that this aspect of *Geren* establishes collateral estoppel for purposes of finding that the RHA authorizes no storage for water supply. Likewise, Alabama and Florida are wrong to the extent that they argue that *Geren* establishes estoppel for the proposition that grants of authority under the RHA and WSA are not supplemental. *Geren* made no such holdings.

baseline. A wholly different issue is presented in this appeal, in which we are required to assess the Corps' authority under the RHA to reallocate storage or otherwise provide water supply, and to factor this authority into the WSA analysis. Thus, the *Geren* court's decision with respect to the baseline for storage reallocation has no collateral estoppel effect in this case.

Second, Appellees argue that this Court's earlier statement in *Alabama,* that water supply is not an authorized purpose of the Buford Project, is preclusive. As noted earlier in this opinion, this statement does not give rise to collateral estoppel because it was not actually litigated and it was mere dicta and therefore was not critical or necessary to the judgment. *See supra,* note 21. In conclusion, the Corps is not bound by collateral estoppel in making the aforementioned determinations and should make its decisions on remand on the basis of its own reasoned analysis.

Part VII. *One-Year Time Limitation on Remand.*

This controversy has lasted a very long time. Since 1990, litigation related to this controversy has taken place in the Northern District of Alabama, the District Court for the District of Columbia, the Northern District of Georgia, the Northern District of Florida, the Middle District of Florida, the District of Columbia Circuit, and now five times in the Eleventh Circuit, and various attempts at compromise have been initiated and abandoned. Progress towards a determination of the Buford Dam's future operations is of the utmost importance to the millions of power customers and water users that are affected by the operations of the project. The stakes are extremely high, and all parties are entitled to a prompt resolution. Accordingly, the process for arriving at a conclusion of the bounds of the Corps' authority should be as swift as possible without sacrificing thoroughness and thoughtfulness. Given the importance of this case, the length of time it has been bouncing around the federal courts, and the amount of resources the parties and the courts have already expended, we believe that one year is sufficient for the Corps to complete its analysis of its water supply authority and release its conclusions. This panel will retain limited jurisdiction to monitor compliance with this time frame. At the end of this one-year period, we expect the Corps to have arrived at a well-reasoned, definitive, and final judgment as to its authority under the RHA and the WSA.

Conclusion

The Corps' did not consummate its decision-making process in the *Alabama*, *Apalachicola*, and *SeFPC* cases. Therefore, the district court lacked jurisdiction to hear these claims. The Corps' denial of Georgia's 2000 water supply request did constitute final agency action, and the district court's conclusion that it had jurisdiction to hear the *Georgia* case was proper. However, the court erred in its analysis of the Corps' rejection of the request. The decisions of the District Court and the Corps were based on a clear error of law—the determination that water supply was not an authorized purpose of the RHA. Furthermore, the Corps failed to reach a final, determinative position about its water supply authority before rejecting the state's request. Consequently, we reverse the district court's order granting the Corps summary judgment, and conclude that the Corps' decision was arbitrary and capricious or not otherwise in accordance with the law. All four cases are remanded to the district court with instructions to remand to the Corps for reconsideration. This panel will retain limited jurisdiction to monitor the one-year time limit.

Accordingly, the judgment of the district court is reversed, its findings of fact and conclusions of law in all four cases are vacated, and these cases are remanded to the district court with instructions to remand to the Corps for further proceedings not inconsistent with this opinion.

REVERSED, VACATED, AND REMANDED; LIMITED JURISDICTION RETAINED.

APPENDIX B

United States District Court,
Middle District of Florida

In re TRI-STATE WATER RIGHTS LITIGATION.

No 3:07-md-01 (PAM/JRK) | July 17, 2009

MEMORANDUM AND ORDER

PAUL A. MAGNUSON, District Judge.

In the Rivers and Harbors Acts of 1945 and 1946 ("1945 RHA" and "1946 RHA"), Pub.L. No. 79-14, 59 Stat. 10, 10-11 (1945 RHA); Pub.L. No. 79-595, 60 Stat. 634, 640 (1946 RHA), Congress authorized the United States Army Corps of Engineers (the "Corps") to begin construction of a dam and reservoir on the Chattahoochee River north of Atlanta, Georgia. Construction on the project finished in approximately 1960. The dam was christened the Buford Dam; the reservoir was named Lake Sidney Lanier.

At issue in this Multi-District Litigation ("MDL") is the Corps's operation of Buford Dam and Lake Lanier. The parties to the various member cases are the states of Alabama, Florida, and Georgia; the Southeastern Federal Power Customers ("SeFPC"); the cities of Apalachicola, Florida, and Atlanta, Columbus, and Gainesville, Georgia; the Georgia counties of Gwinnett, DeKalb, and Fulton; the Atlanta Regional Commission ("ARC"); the Cobb County-Marietta Water Authority; the Lake Lanier Association;[1] the Alabama Power Company ("APC"); the

[1] The Court will refer to Atlanta, Columbus, Gainesville, Gwinnett County, DeKalb County, Fulton County, the ARC, the Cobb County-Marietta Water Authority, and the Lake Lanier Association collectively as "the Georgia parties."

Columbus Water Works ("CWW"); the Middle Chattahoochee River Users; and the Corps and several Corps officers.[2]

After the cases were consolidated by the Judicial Panel on Multidistrict Litigation, the parties agreed that the Court should consider the claims in two phases. Because some of the claims were similar or identical to claims pending before the United States Court of Appeals for the District of Columbia Circuit, the Court scheduled the proceedings on those claims second, awaiting that court's resolution of the claims. Thus, the first scheduling orders in the MDL case contemplated that the Court would first entertain environmental claims, such as claims that the Corps's operations in the Apalachicola-Chattahoochee-Flint ("ACF") river basin violate the Endangered Species Act ("ESA"), 16 U.S.C. § 1531 *et seq.,* and other environmental laws and regulations. Left for phase two were the overarching claims of the Corps's authority (or lack thereof) for its operations in the basin in general, such as claims that the Corps is violating the Water Supply Act and the Flood Control Act.

The D.C. Circuit ruled on claims similar to the so-called "overarching" claims in 2008. Thereafter, the "overarching" claims became ripe for this Court's resolution, and the Court therefore ordered that the phases be "flipped" so that the parties would present the statutory authorization and related issues first.

[2] The Court will refer to the Corps and the Corps's officers collectively as the "Federal Defendants." The United States Fish and Wildlife Service ("USFWS") and a USFWS official also are defendants in one of the member cases (3:07-250), but the claims against USFWS are not at issue in this phase of the litigation.

(Aug. 11, 2008, Order.) The issues for resolution in the new Phase One include: (1) whether the Corps's operations in the ACF basin, including the execution of water-supply contracts and installation of water intake structures in Lake Lanier, the alleged preference of water supply over other purposes, and the denial of Georgia's water-supply request violate the Administrative Procedures Act ("APA"), 5 U.S.C. § 701 *et seq.,* the National Environmental Policy Act ("NEPA"), 42 U.S.C. § 4321 *et seq.*; the Flood Control Act ("FCA"), 33 U.S.C. § 708 *et seq.*; the Water Supply Act ("WSA"), 43 U.S.C. § 390 *et seq.*; the Coastal Zone Management Act ("CZMA"), 16 U.S.C. § 1451 *et seq.*; and other congressional enactments; and (2) whether the water control plans and manuals, reservoir regulation manuals, action zones, recreation impact levels, and the Upper Chattahoochee Management Plan/River Management System violate federal law.

The fundamental question in the case is whether, by taking or failing to take the actions complained of in the various lawsuits, the Corps violated § 301 of the WSA, which provides:

> Modifications of a reservoir project heretofore authorized, surveyed, planned, or constructed to include storage [for water supply] which would seriously affect the purposes for which the project was authorized, surveyed, planned, or constructed, or which would involve major structural or operational changes shall be made only upon the approval of Congress* * *.

43 U.S.C. § 390b(d). In general, Florida, Alabama, APC, and the SeFPC contend that the Corps was obligated to seek Congressional approval for actions the Corps has taken with respect to water supply in

Lake Lanier, because those actions allegedly affect the purposes for which the Buford Dam project was authorized or constitute major structural or operational changes. The Georgia parties and the Corps argue that Congressional approval is not required because the project's purposes include water supply and because, in any event, the Corps's operations have not amounted to a major structural or operational change in the project. To resolve these differences, the Court must examine the history of the Buford Dam and Lake Lanier.

BACKGROUND

A. Legislative History

1. Authorization

Although the 1945 and 1946 RHAs officially authorized the construction of Buford Dam, the Corps had been examining the feasibility of such a project for many years prior to 1945. Indeed, as early as 1925,[3] Congress asked the Corps to work with the Federal Power Commission (the predecessor to the Federal Energy Regulatory Commission) to examine the development of hydroelectric facilities on waterways nationwide, including in the ACF basin. River & Harbor Act of 1925, Pub.L. No. 68-585, ch. 467, 43 Stat. 1186, 1186, 1194 (March 3, 1925). In 1938, in response to a House resolution regarding the ACF basin, a Corps district engineer, Colonel R. Park, prepared a report to Congress outlining in great detail the geography and history of the basin and

[3] Congressional inquiries into the uses for the Apalachicola and Chattahoochee Rivers began even earlier than 1925, but most of these inquiries sought only to examine the rivers' usefulness for navigation. *See* George W. Sherk, *Buford Dam and Lake Lanier: Statutory Perspectives and Limitations* 11-34 (2000) [hereinafter "Sherk, *Buford Dam* "].

making recommendations for potential improvements in the basin. *See* H.R. Doc. No. 76-342, at 9-87 (1939) [hereinafter "Park Report"] (ACF000126-65).[4] It was in the Park Report that the project as eventually completed began to take shape.

The Park Report discussed a multitude of options for the development of rivers in the ACF basin and detailed eleven sites that could support a dam project to benefit hydroelectric power plants and navigation on the rivers. One of the eleven sites was the "Roswell" site "located on the Chattahoochee River 16 miles north of Atlanta, Ga., and about 2.5 miles upstream from the highway bridge at Roswell." Park Report ¶ 196, at 66 (ACF000155). The Roswell site is approximately where Buford Dam was eventually located.

The Park Report detailed both the costs and benefits of each of the eleven sites. Colonel Park considered the following "direct benefits" for all of the proposed sites:

(a) Savings to the public in transportation charges.

(b) Value of hydroelectric power developed.

(c) Value as a facility for national defense.

(d) Increased commercial value of riparian lands.

(e) Recreational value.

(d) Value as a source of industrial and municipal water supply.

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[4] The voluminous administrative record in this matter is divided into the original record and the supplemental record. The Corps has consecutively stamped each portion of the record, with the original record bearing the prefix "ACF" and the supplemental record having the prefix "SUPPAR." When possible, the Court will endeavor to cite not only to the document itself, but to its place in the administrative record.

Id. ¶ 243, at 77 (ACF000160). The Park Report assigned an approximate dollar value to each "direct benefit." For example, in Colonel Park's estimation, the value of hydroelectric power if all eleven projects had been built would have been worth $6.5 million annually. *Id.* ¶ 247, at 78 (ACF000161). Similarly, Colonel Park assigned a value of $25,000 to national defense, and $50,000 as a two-reservoir system's recreational value. *Id.* ¶¶ 250-51, 259, at 79, 80 (ACF000161-62). For the proposed projects' value as a water-supply source, however, Colonel Park assigned no monetary value, noting that "[t]here is apparently no immediate necessity for increased water supply in this area though the prospect of a future demand is not improbable." *Id.* ¶ 260, at 80 (ACF000162). Water supply was the only potential benefit assigned no monetary value in the Park Report. *Id.* ¶ 261, at 81 (ACF000162).

After the Park Report was submitted to Congress, the Corps continued to evaluate the ACF basin for potential improvements. A so-called "interim" plan was submitted to the Chief of Engineers in December 1942, but was never submitted to Congress. *See* Sherk, *Buford Dam,* at 45 & n. 190 (noting that the interim report itself is not available, likely because it was withdrawn before being submitted to Congress). The interim report recommended two potential dam sites, including the Lanier site, " 'principally in the interest of hydropower.' " *Id.* at 45 (quoting Memorandum from P.A. Feringa, Colonel, Corps of Eng'rs, to Chief of Eng'rs (Oct. 28, 1943)). The Chief of Engineers sent the report back to the district engineer, asking him to revise the report to include an analysis of the benefits to navigation and flood control. *Id.*

The 1945 RHA stated specifically that the ACF project was authorized "in accordance with the plans" in the Park Report. 1945 RHA, ch. 19, 59 Stat. at 12, 17. Because the Park Report had not established where in the ACF basin the dam or dams would be built, the Corps continued to study the matter. The first result of this study was the report of Brigadier General James B. Newman, Jr., submitted to Congress in 1947. H.R. Doc. No. 80-300, at 10-40 (1947) [hereinafter "Newman Report"] (ACF000644-74).

General Newman noted that "[t]he principal value of the Chattahoochee River is as a source of power." *Id.* ¶ 7, at 13 (ACF000647). He described the Park Report as evaluating the rivers in the ACF basin "in the combined interest of navigation and power." *Id.* ¶ 47, at 22 (ACF000656). The majority of the Newman Report consists of detailed evaluations of the hydropower and navigation benefits of the alternatives discussed in the Park Report. General Newman concluded that the locks and dams proposed by the Park Report for the southern portion of the Chattahoochee, below Columbus, Georgia, would not be economically efficient unless a "considerable flow regulation were provided by a large storage-power reservoir upstream." *Id.* ¶ 67, at 27 (ACF000661). That reservoir would become Lake Lanier.

General Newman also noted other "incidental" benefits of a reservoir at the Lanier site.[5] He discussed Atlanta's urging that a reservoir north of Atlanta be constructed before other elements of the ACF basin project, "in order to meet a threatened

[5] The Newman Report also refers to the Lanier site as the Buford site. *See, e.g.,* Newman Report ¶ 69, at 27 (ACF000661).

shortage of water, during low-flow periods, for municipal and industrial purposes." *Id.* ¶ 68, at 27 (ACF000661). Specifically, "[i]f the regulating storage reservoir * * * could be located above Atlanta, it would greatly increase the minimum flow in the river at Atlanta, thereby producing considerable incidental benefits by reinforcing and safeguarding the water supply of the metropolitan area." *Id.* General Newman therefore concluded that the Lanier site should be developed as outlined in the Park Report and in his own report. He determined that the construction of a dam at the Lanier site, along with the proposed developments at Junction and Upper Columbia, would "create an effective and economical system for the production of power, in addition to providing * * * for navigation* * *. The system would also contribute to the reduction of floods and flood damages in the Chattahoochee River valley, and would ensure an adequate water supply for the rapidly growing Atlanta metropolitan area." *Id.* ¶ 73, at 28-29 (ACF000662-63). The Newman Report recognized that releases from the proposed dam for downstream water supply might have to be increased as the Atlanta area developed, although the Newman Report emphasized that such an increase "would not materially reduce the power returns from the plant." *Id.* ¶ 80, at 34 (ACF000688).

As with the Park Report, the Newman Report estimated the dollar value of the various annual benefits from the construction of a dam and reservoir at the Lanier site. The Newman Report, however, listed only three valuable benefits: power, navigation, and flood control. *Id.* ¶ 98, at 38 (ACF000672). The Newman Report also allocated the estimated costs of building the Buford project, a total of more than $17 million. Of this, $16 million was allocated to power, none to navigation, and the remainder to flood control. *Id.* ¶ 97, at 38 tbl. 9 (ACF000672). The Southeastern Power Administration ("SEPA"), from which the SeFPC purchases the power generated by the Buford Dam, ultimately paid approximately $30 million toward the total construction cost of $47 million for the dam. SeFPC Am. Compl. ¶ 32; *see also* U.S. Army Corps of Eng'rs, *Survey Report on Apalachicola, Chattahoochee and Flint Rivers, Alabama, Florida and Georgia* ¶ 49, at 15 (1973) (total cost of Buford Dam was $47,059,711) (ACF003968). The 1946 RHA adopted the Newman Report's recommendation that the project be limited to three dams, including the Buford dam. U.S. Army Corps of Eng'rs, *Definite Project Report on Buford Dam: Chattahoochee River, Georgia* ¶ 7, at 4 (1949) [hereinafter "*Definite Project Report*"] (ACF001449).

2. Planning

The initial authorization in the 1945 and 1946 RHAs did not end Congress's involvement in the Buford Dam project. The project required money, and that money had to be appropriated by Congress each year. Thus, once the project entered initial planning stages and during the construction of the project, Congress held yearly hearings on the progress of the project and on the Corps's use of funds. For fiscal year 1948, Congress considered the Corps's request for funding for the planning of the project. Georgia Representative James C. Davis asked the Appropriations Committee to recognize the "critical necessity" of the project, which he described as a "multi-purpose dam * * * for the purpose of generating power, flood control, and water supply for the city of Atlanta, as well as a regulated flow of water of the Chattahoochee River* * *." *War Dep't Civil Functions Appropriation Bill 1948: Hearing on H.R. 4002 Before the Subcomm. of the S. Comm. on Appropriations,* 80th Cong. 697 (1947) (statement of Rep. James C. Davis, Georgia). In addition, Atlanta's Mayor William B. Hartsfield testified that the undependable nature of the flow in the Chattahoochee had likely already caused severe economic losses in the Atlanta area. *Id.* at 700 (statement of William B. Hartsfield, Mayor, Atlanta, Georgia). He asked that the Buford project be given priority over other dams proposed for the Chattahoochee. *Id.*

The following year, the House Subcommittee on Appropriations submitted a report about the funding the Corps had requested for that fiscal year, including funding for the Buford Dam project. *See* H.R.Rep. No. 80-1420, at 5-8 (1948). The report recommended reducing the Corps's request for plans for the Buford project by $67,000. According to the report:

> While the Buford Dam may be an important part of the comprehensive river system plan for the Apalachicola, Chattahoochee, and Flint Rivers its construction will provide a source of water for the city of Atlanta that witnesses from that part of the country indicate is greatly needed. The city of Atlanta is not, however, providing any contribution toward the construction of this dam and inasmuch as it stands to benefit to a great extent it appears that some substantial contribution should be made toward the ultimate cost of the dam, and in future planning it is suggested that this feature be given careful consideration and an opportunity be afforded the city of Atlanta to make a contribution comparable to the benefits to be received.

Id. at 8.

In January 1948, the House Subcommittee on Appropriations heard testimony from several members of Georgia's Congressional delegation about the various projects in the ACF basin. Representative Stephen Pace led the delegation and described the ACF projects as having three purposes: navigation, power, and flood control. *Civil Functions, Dep't of the Army Appropriation Bill for 1949: Hearing on H.R. 5524 Before the Subcomm. of the H. Comm. on Appropriations,* 80th Cong. 723 (1948) (statement of Rep. Stephen Pace, Georgia). Representative Pace also testified that the project had "two additional purposes": to "serve as a reservoir for the entire system in the event of dry spells and floods," which would "assure[ ] the navigability of the entire project"; and "to meet the very critical shortage of water in the city of Atlanta." *Id.* He also emphasized the area's "crying need for an abundance of hydroelectric power." *Id.* at 724.

Many of the witnesses testified about the navigation and transportation benefits of the projects proposed for the ACF basin. Among them was J.W. Woodruff, for whom the ACF's southernmost dam, the Jim Woodruff Dam, is named. He envisioned the navigation made possible by the projects in the ACF basin as an economic engine that would drive industrial and commercial development in the region, allowing goods to be shipped from the area around the world. *Id.* at 750-51 (statement of J.W. Woodruff, Atlanta, Georgia).

Other participants addressed their testimony specifically to the proposed Buford project. Representative John S. Wood of Georgia spoke about the need for flood control in an area that could receive more than eight inches of rain in a 24-hour period. *Id.* at

777 (statement of Rep. John S. Wood, Georgia). Both Mayor Hartsfield and Representative Davis again testified about the multi-purpose nature of the project, pointing out its benefits for power, navigation, flow regulation, and pollution control, and as a source of water supply for Atlanta. *Id.* at 778 (statement of Rep. James C. Davis, Georgia), 782 (statement of William B. Hartsfield, Mayor, Atlanta, Georgia). In his statement to the Senate Subcommittee on Appropriations, however, Mayor Hartsfield deemphasized Atlanta's need for water supply from the Chattahoochee. He characterized Atlanta's need for the water as "necessary" but stressed that Atlanta should not "be put in the category with such cities as are in arid places in the West or flat plain cities where there is one sole source of water * * *." *Civil Functions, Dep't of the Army Appropriation Bill 1949: Hearing Before the Subcomm. of the S. Comm. on Appropriations,* 80th Cong. 644 (statement of William B. Hartsfield, Mayor, Atlanta, Georgia). Mayor Hartsfield stated:

> We need flood control; we need the increased power; we need badly some sort of water recreation in that section. We need, of course, the promotion of navigation* * *.
>
> We need the promotion of regular flow not only for Atlanta's water supply, but to enable others, as I said, to use the river, industries to use it, which they are not now able to do.

Id. at 646.

As part of the record at the hearing, the Corps filed a report describing the Buford project:

> The Buford Reservoir will provide flood protection to the valley below it; provide a large block of pow-

> er to an area where there is a power shortage; provide an increased flow which is essential to provision of a 9-foot depth for navigation in the Apalachicola River; assure an adequate water supply for municipal and industrial purposes in the Atlanta metropolitan area; and provide recreational facilities for the area surrounding the reservoir.

Id. at 648 (report of P.A. Feringa, Colonel, Corps of Eng'rs).

At the end of February 1948, apparently in response to the questions raised about Atlanta's willingness to pay for part of the Buford project, Representative Davis wrote to Mayor Hartsfield. In this letter, Representative Davis stated that the Subcommittee's desire to have Atlanta fund some of the construction cost of the dam was not unprecedented, noting that the city of Dallas had recently contributed more than $2 million to a reservoir project in Texas. Letter from Rep. James C. Davis, Ga., to William B. Hartsfield, Mayor, Atlanta, Ga. (Feb. 27, 1948) (SUPPAR000420). Mayor Hartsfield responded negatively to the suggestion that Atlanta should bear some of the costs of the Buford Dam:

> Frankly, in our zeal I think we have just laid too much emphasis on the Chattahoochee as a water supply* * *.
>
> * * *.
>
> In our case the benefit so far as water supply is only incidental and in case of a prolonged drought. The City of Atlanta has many sources of potential water supply in north Georgia. Certainly a city which is only one hundred miles below one of the greatest rainfall areas in the nation will never find itself in the position of a city like Los Angeles* * *.

> * * *.
>
> [I]n view of other possible sources of Atlanta's future water we should not be asked to contribute to a dam which the Army Engineers have said is vitally necessary for navigation and flood control on the balance of the river.

Letter from William B. Hartsfield, Mayor, Atlanta, Ga., to Rep. James C. Davis, Ga. (Mar. 1, 1948) (SUPPAR001063). Atlanta did not contribute to the construction costs of the Buford Dam.

In preparation for the start of construction, the Corps prepared the Definite Project Report. (ACF001436). This report described the project's "principle purposes" as: "to provide flood control; to generate hydroelectric power; to increase the flow for open-river navigation in the Apalachicola River below Jim Woodruff dam; and to assure a sufficient and increased water supply for Atlanta." *Id.* ¶ 115, at 41 (ACF001486). The Definite Project Report addressed only one specific water-supply issue: the city of Gainesville's water-pumping station, located on the Chattahoochee. *Id.* ¶ 95, at 29 (ACF001474). The report noted that the entire station would require relocation, as it would be inundated on completion of the dam. *Id.* ¶ 96, at 29 (ACF001474). On June 22, 1953, the Corps and Gainesville executed a contract whereby the Corps paid Gainesville $300,000 for the land to be taken by the reservoir and Gainesville was given the right to withdraw eight million gallons per day from the reservoir. Contract between U.S. Army Corps of Eng'rs & City of Gainesville, Ga. (June 22, 1953) (ACF014457-63).[6]

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[6] The City of Buford executed a similar contract because its waterworks facilities were also inundated by the waters of Lake

In its discussion of reservoir regulation, the Definite Project Report noted that the power plant would operate as a "peaking plant to provide maximum possible power during the hours of greatest demand." *Definite Project Report* ¶ 120, at 42 (ACF001487). At off-peak times the plant would operate only a smaller generator, "to provide flow to meet municipal and industrial requirements at Atlanta." *Id.* When water levels in the reservoir fell below a certain level, however, "only prime power [would] be generated." *Id.*

The Definite Project Report estimated the total cost of the Buford project at $35.6 million. *See id.* ¶ 104, at 32-37 tbl. 1 (ACF001477-82). The "primary benefits" of the project were "flood control and production of hydroelectric power." *Id.* ¶ 123, at 44 (ACF001489). The report calculated the flood-control benefit as worth $163,000 annually. *Id.* Power benefits were valued at $1.7 million on site, with the potential for up to $3.2 million in power benefits if all downstream plants were modified as proposed. *Id.* ¶ 123, at 45 tbl. 3 (ACF001490). The report calculated the potential annual benefit to transportation at almost $1.4 million. *Id.* ¶ 124, at 45 (ACF001490). The benefit to recreation was calculated at $196,000 annually. *Id.* ¶ 125, at 46 (ACF001491). The Definite Project Report noted that a "real benefit will also result from assurance of sufficient water for municipal and industrial requirements at Atlanta" but it did not make any estimate of the value of that benefit. *Id.* ¶ 124, at 46 (ACF001490).

Lanier. *See* Contract between U.S. Army Corps of Eng'rs & City of Buford, Ga. (Dec. 19, 1955) (ACF014450-56) (allowing Buford to withdraw two million gallons per day from the reservoir).

The question of Atlanta's contribution to the costs of the Buford project surfaced again in the hearings on the 1952 Army Appropriation Bill, H.R. 4386. Corps officer Colonel Potter testified that "[t]he purpose of the project is flood control, water supply for the city of Atlanta, which is growing by leaps and bounds, and the production of power." *Civil Functions, Dep't of the Army Appropriations for 1952: Hearings Before the Subcomm. of the H. Comm. on Appropriations,* 82d Cong. 118 (1951) (statement of Col. Potter, Corps officer) (SUPPAR026654). A member of the Subcommittee asked Colonel Potter if Atlanta was "cooperating in this project in any way." *Id.* at 120 (question of Rep. Davis) (SUPPAR026656). Colonel Potter responded:

> No, sir; because this is not a problem of furnishing water directly or furnishing storage for that purpose; it is the regulation of the river that gives [Atlanta] a constant supply over the up-and-down supply now existing during the year* * *. With this dam letting out a constant supply of water every day their water-supply problem is reduced immensely* * *.

Id. (statement of Col. Potter, Corps officer). Other committee members questioned Colonel Potter further on Atlanta's need for, and contribution to, the project:

> *Mr. Ford*: Where you have a project such as this particular project and water supply is part of the justification for a community, does not the community make any contribution to the project?
>
> *Col. Potter*: Yes, sir, normally, but not in this case* * *.
>
> This dam furnishes Atlanta with water due to the

> fact that it regulates the discharge of floods. When a flood comes, it comes down in a certain set period-say a week. We store that week's terrific runoff of water and then let it out gradually* * *. Hence we discharge that flood, we will say, for 3 months.
>
> Then, in the production of electricity, we can discharge somewhere in the neighborhood of 4,000 to 5,000 second-feet constantly. That [water] will always be flowing by Atlanta; so that now they won't have the river partially dry or full of mud in the summer, but they will have a more or less constant flow of the river past their door and will always be able to pull water out of it.
>
> It did not cost the Federal Government 1 cent to supply that service, because it was an adjunct to the power supply and flood control. Had we put in some storage purely for water supply, which they would tell us to release at certain intervals, we would then charge them for it, and they would have to pay for the difference of that construction cost.

Id. at 121-122 (exchange between Rep. Gerald Ford, Michigan, and Col. Potter, Corps officer) (SUPPAR026657-58).

In a prescient question, Representative Ford then asked, "Is it not conceivable in the future, though, when this particular project is completed, that the city of Atlanta will make demands on the Corps because of the needs of the community, when at the same time it will be for the best interests of the overall picture * * * to retain water in the reservoir?" *Id.* at 122 (SUPPAR026658). Colonel Potter's response is illuminating: "The first thing we do is to decide, after a study, whether or not the water supply is more valuable to use for the production of electricity. If it is, then we would have to come back, I believe, to Congress to alter the authorization of that project, were it a major diversion of the water." *Id.* He noted that the Corps "take[s] a very dim view of changing a project to the subsequent needs without Congress having a hand in it." *Id.*

3. Construction

In 1952, at the beginning of construction of the dam, Georgia's Representative Davis and the Corps's General Chorpening appeared at a hearing of the House Subcommittee on Appropriations to ask Congress for $8.5 million for the Buford project. Representative Davis described the project as providing flood control, power, and navigation benefits. *Civil Functions, Dep't of the Army Appropriations for 1953: Hearings on H.R. 7268 Before the Subcomm. of the H. Comm. on Appropriations,* 82d Cong. 1196-97 (1952) (statement of Rep. Davis, Georgia) (SUPPAR026679-80). Neither Representative Davis nor General Chorpening mentioned any water-supply benefits from the project.

The next year, two Corps officers testified before the Senate Subcommittee on Appropriations in support of the Corps's request for another $8.5 million in funding for the Buford project. Colonel Paules described the project as "a combination flood control-power project which will assist navigation downstream by the regulation of the river flows." *Civil Functions, Dep't of the Army Appropriations, 1954: Hearings on H.R. 5376 Before the Subcomm. of the S. Comm. on Appropriations,* 83d Cong. 480 (1953) (statement of Col. Paules, Corps officer) (SUPPAR026685). Colonel Paules and General Chorpening also testified before the House Subcommittee on Appropriations regarding the requested funding for the Buford project. Colonel Paules discussed the anticipated completion dates for the project, including when the power plant was expected to be operational. He noted, "[t]he project has a total capacity of some 2 million acre-feet for flood control and power, and incidentally would supply additional water downstream for the benefit of the municipalities along the river* * *." *Civil Functions, Dep't of the Army Appropriations for 1954: Hearings on H.R. 5376 Before the Subcomm. of the H. Comm. on Appropriations,* 83d Cong. 503 (1953) (statement of Col. Paules, Corps officer) (SUPPAR026688). Representative Davis asked whether Atlanta was contributing to the cost of the project. The Corps officers responded, "While the city of Atlanta is not contributing to this, they get benefits from it, incidentally, as the result of the controlled release of floodwaters, and as the water is released through the powerplant." *Id.* General Chorpening explained:

> [T]here would be no legal way to collect payment from the city of Atlanta, since, as was just stated, there is no additional cost being included for the construction of this project to provide the more uniform flow of water which will pass the city of Atlanta. In other words, the building of the project, with its power production and flood control and navigation benefits will not make available any more water than is now going past Atlanta. It is only going to make it flow by at a more uniform rate.

Id. (statement of Gen. Chorpening, Corps officer).

The Corps requested an additional $5.8 million for the Buford project in fiscal year 1955. *Civil Functions, Dep't of the Army Appropriations, 1955: Hear-*

ings on H.R. 8367 Before the Subcomm. of the S. Comm. on Appropriations, 83d Cong. 324 (1954) (statement of Col. Whipple, Corps officer) (SUPPAR026698). Colonel Whipple told the Subcommittee that "[t]he project provides a considerable amount of flood control, but its main purpose is the output of power to the area." *Id.* He also testified that the project's "additional benefits" would include "increas[ing] the flow of water downstream which improves the water supply at Atlanta, and the project is unusually well situated for recreational use." *Id.* at 325 (SUPPAR026699). Again, the committee members asked about whether Atlanta would contribute toward the cost of the project. Colonel Whipple responded, "We understand not, sir* * *. There are no additional costs for [Atlanta's water supply]. It is purely an incidental benefit on account of the power releases which does not require any storage to be devoted to that purpose." *Id.*

In the next several years, Georgia's Representative Davis appeared in similar hearings before the House and Senate Subcommittees on Appropriations. He testified consistently that the purposes of the Buford project were flood control, navigation, and hydroelectric power, mentioning water supply only occasionally. *See, e.g., Public Works Appropriations for 1956: Hearings on H.R. 6766 Before the Subcomm. of the S. Comm. on Appropriations,* 84th Cong. 307-09 (1955) (statement of Rep. James Davis, Georgia) (SUPPAR026713-15) (stating that the Buford project is a "multi-purpose" project that will provide flood protection, "will augment the low water flow of the river" to support navigation and to assist in the generation of power downstream, will generate "810 million kilowatt-hours of electrical energy annually and the additional water supply for the growing metropolis of Atlanta"); *Public Works Appropriations for 1957: Hearings Before the Subcomm. of the H. Comm. on Appropriations,* 84th Cong. 355-57 (1956) (statement of Rep. James Davis, Georgia) (SUPPAR026720-22) (discussing flood control, navigation, and power benefits but not mentioning water supply benefits).

During construction of the dam, Gwinnett County asked the Corps for permission to withdraw water from the reservoir for water supply. F.G. Turner, Ass't Chief, Eng'g Div., *Report on Withdrawal of Domestic Water Supply from Buford Reservoir* ¶ 1, at 1 (1955) (SUPPAR005459). The Corps responded:

> that the primary authorized purposes of the Buford project were flood control, power and low-flow regulation for navigation and other purposes, and that diversion of flows from the reservoir would, in some degree, adversely affect one or more of these purposes. [The Gwinnett County representatives] were informed that additional legislation would be necessary* * *.

Id. ¶ 2, at 1 (SUPPAR005459). The Corps noted that the project "will provide storage for flood control, hydro-electric power and increased flow for water supply at Atlanta, Georgia, and for navigation in the Apalachicola River." *Id.* ¶ 5, at 2 (SUPPAR005460). The report examined the "Provision for water supply in the Atlanta Area," discussing Atlanta's concern that the Corps maintain minimum flows in the river to meet Atlanta's water requirements. *Id.* ¶¶ 7-8, at 3 (SUPPAR005461). It also noted that Gwinnett County requested initial withdrawals of four million gallons per day from the reservoir and ultimate withdrawals of ten million gallons per day. *Id.* ¶ 9, at

3 (SUPPAR005461). The report predicted that "[t]he granting of permission to Gwinnett County to withdraw water for domestic water supply as requested will no doubt establish a precedence [sic] for possible like requests from other communities within the area* * *." *Id.* The report commented that Gainesville, Georgia, had been granted permission to withdraw a maximum of eight million gallons per day from the reservoir. *Id.* ¶ 9, at 4 (SUPPAR005462). As noted above, Gainesville had a water intake structure on the Chattahoochee River that was inundated by Lake Lanier, and thus had a pre-existing right to withdraw water.

In 1956, Congress granted the Corps permission to contract with Gwinnett County for the use of up to 11,200 acre-feet of storage in Lake Lanier annually, for a period not to exceed fifty years. Act of 1956, Pub.L. No. 84-841, 70 Stat. 725 (1956) (amending 1946 RHA). There is no evidence in the record that the Corps and Gwinnett County ever entered into the contract contemplated by this statute. Although the Corps and Gwinnett County did execute a water-supply contract in the 1970s, neither the original contract nor any supplement or extension thereto invoked the authority of the 1956 statute but rather relied on the more general authority of the WSA. *See, e.g.,* Supplemental Agreement No. 1 to Contract No. DACW01-9-73-624 Between the U.S. & Gwinnett County, Ga. for Withdrawal of Water from Lake Sidney Lanier, at 1 (Apr. 29, 1974) (ACF004022) (providing that, on expiration of the contract, Gwinnett County "shall have the right to acquire from the Government, under the provisions of the Water Supply Act of 1958, Public Law No. 85-500, the right to utilize storage space in the project * * *"). Moreover, the Corps's first agreements with Gwinnett County were, by their terms, "interim" contracts pending the completion of a study of the Atlanta area's water-supply needs. Contract Between the U.S. & Gwinnett County, Ga. for Withdrawal of Water from Lake Sidney Lanier, at 2 (July 2, 1973) (ACF004025); *see also infra* section C.1. As the Georgia parties admit, all of the Corps's contracts with Gwinnett County have expired. (Ga.'s Mot. for Summ. J. Factual App. ¶¶ 7.23, 7.33.)

In 1958, as the Buford Dam neared completion, the Corps promulgated the *Apalachicola River Basin Reservoir Regulation Manual.* U.S. Army Corps of Eng'rs, *Apalachicola River Basin Reservoir Regulation Manual* (1958) [hereinafter "1958 Manual"]. (ACF001640.) The 1958 Manual is a detailed description of the geography and hydrography of the ACF basin, including all federal projects undertaken in the basin. It describes Buford Dam as "a multiple-purpose project with major uses of flood control, flow regulation for navigation, and power." 1958 Manual ¶ 85, at 27 (ACF001677). The 1958 Manual does not specifically describe the operation of the Buford project; rather, the regulation manual for the Buford project, which was completed in October 1959, is appended to the 1958 Manual as Appendix B.[7] *Id.* app. B (ACF001776); *see also id.* app. B ¶ 43, at B-21 (ACF001804) (listing October 1959 completion date). The Corps has never updated the 1958 Manual or the Buford Reservoir Regulation Manual ("Buford Manual"), and thus these manuals are the current regulation manuals for the ACF basin and Buford

[7] Appendix A to the 1958 Manual is the regulation manual for the Jim Woodruff Reservoir on the Apalachicola River. (ACF001722.).

dam.

The Buford Manual lists the elevation for the top of the flood-control pool as 1085 feet above sea level. *Id.* app. B, at B-1 (ACF001784). The elevation of the top of the power pool is 1070 feet, and the bottom of the power pool is 1035. *Id.* The reservoir's flood-control storage (elevation 1085 to 1070) is 637,000 acre-feet. *Id.* Power storage is listed as 1,049,400 acre-feet. *Id.* The manual also noted that the reservoir reached full power pool on May 25, 1959, and that the President had signed a bill naming the reservoir Lake Sidney Lanier on March 29, 1956. *Id.* app. B ¶¶ 8-9, at B-5 (ACF001788).

The Buford Manual describes the project:

> Buford is a multiple-purpose project with principal purposes of flood-control, navigation and power. It reduces flood stages in the Chattahoochee River as far downstream as West Point, Georgia, 150 miles below the dam; provides an increased flow for navigation in the Apalachicola River below Jim Woodruff Dam during low-flow seasons; and produces hydroelectric energy, operating as a peaking power plant. The increased flow in dry seasons also provides for an increased water supply for municipal and industrial uses in the metropolitan area of Atlanta, and permits increased production of hydroelectric energy at downstream plants.

Id. app. B ¶ 12, at B-6 (ACF001789). The Buford Manual also details the regulation of the project:

> Normally, the Buford project will be operated as a peaking plant for the production of hydroelectric power with minimum releases during the daily and weekend off-peak period which will be sufficient, with local inflows added, to supply the Atlanta area

> with not less than 600 cfs. During low-water periods such regulation will provide increased flow downstream for navigation, water supply, pollution abatement, and other purposes* * *. [T]he primary purpose of the project is flood control, and a storage of 637,000 acre-feet between elevations 1,070 and 1,085 has been reserved exclusively for the detention storage of flood waters.

Id. app. B ¶ 29, at B-13 (ACF001796). The Corps contracted with the SEPA to provide 142,000 kilowatts of "dependable" power capacity from the project. *Id.* app. B ¶ 31, at B-13 (ACF001796). The Corps gave SEPA minimum declarations of energy the dam would produce each month. *Id.* app. B ¶ 31, sec. 2. 1, at B-15 (ACF001798). The Corps also noted its commitment to keep the flow at Atlanta at a minimum of 600 cfs. *Id.* app. B ¶ 33, at B-18 to 19 (ACF001801-02).

Enacted in 1958, the Water Supply Act ("WSA"), Pub.L. 85-500, tit. III, 72 Stat. 319, changed the way the Corps funded dam-building projects. Specifically, the WSA required the Corps to allocate the costs of each project to the benefits of the project so that, for example, if a project benefitted primarily hydroelectric power, the power interests would pay a proportionate share of the cost of that project. *See* WSA § 301(b), 72 Stat. at 319. The Buford project was well into construction by the time the WSA's cost allocation requirements took effect, but the Corps endeavored to comply with those requirements by issuing cost allocation studies for the projects in the ACF basin in 1959. Mobile Dist., U.S. Army Corps of Eng'rs, *Cost Allocation Studies, Apalachicola, Chattahoochee and Flint Rivers Projects, Basis of All Allocations of Costs for Buford and Jim Woodruff*

Projects Adopted by the Chief of Engineers 21 (1959) (ACF002103) (noting that according to an agreement between the Department of Interior, Department of the Army, and the Federal Power Commission, "costs of a multiple-purpose project shall be allocated among the purposes served in such a manner that each purpose will share equitably in the savings resulting from combining the purposes in a multiple-purpose development").

This study report introduced the projects in the ACF basin: "The primary benefits provided by the ACF project are flood control, navigation and hydroelectric power. The incidental benefits are low-water regulation for water supply and pollution abatement at Atlanta, Georgia and public use with facilities for recreation* * *." *Id.* at 2 (ACF002086); *see also id.* at 5 (ACF002089) (stating that the project "will be operated for the primary purposes of flood control, power, and navigation"). Although the report analyzes in detail the cost of the three benefits of flood control, power, and navigation, it does not attribute any costs to the "incidental" benefits of water supply, pollution abatement, or recreation. *Id.* at 20 (ACF002102).

The report gives the total "first" cost of the Buford project as $43,601,500. *Id.* at 23 (ACF002105). The portion of this total allocated to navigation was $1,518,200; to flood control, $3,402,600; and to power, $38,680,100. *Id.* No portion of the project's costs was allocated to water supply.

Appendix A of the report is the cost allocation study specifically for the Buford project. It states that "[t]he primary purposes of the Buford project are flood control and the generation of hydroelectric power. Incidental uses attributable to the operation of the project for power include flow regulation for navigation in the Apalachicola River and water supply and pollution abatement in the Atlanta area." *Id.* app. A, at A-1 (ACF002108). The report notes that full-scale power operation began at Buford in July 1958. *Id.* app. A, at A-2 (ACF002109).

Table Four of the Appendix shows the "average annual benefits" of the Buford project. The annual benefit to navigation is listed as $75,900, to flood control is $193,000, and total power benefits (including benefits at site and downstream) are $2,476,200. *Id.* app. A tbl. 4 (ACF002127). There are no benefits calculated for any other purpose.

4. Water Supply

The various Corps reports and Congressional testimony discussed above show the original role of the Buford project in supplying water to Atlanta. At the time Buford Dam was authorized, planned, and constructed, the Corps did not anticipate any water-supply withdrawals from the reservoir itself, with the exception of the water withdrawn by the cities of Gainesville and Buford. Nor did the Corps or any other entity set aside any portion of Lake Lanier's storage for water supply. Rather, the water-supply benefit discussed throughout the legislative history was the regulation of the river's flow. A more regular flow was seen as providing Atlanta both with a reliable flow in the Chattahoochee from which to withdraw water, and more certainty diluting the wastewater Atlanta discharged into the river. Throughout the 1940s and 1950s, when water supply is mentioned in connection with the Buford project, that water supply is in the form of Atlanta's withdrawals from the river itself, far below the proposed dam.

In the decades after the Buford Dam was built, however, the Corps's and the Georgia parties' definition of water supply in the Buford project changed considerably. The origin of this change is difficult to pinpoint. However, at some point after the dam was completed, both the Corps and the municipal entities in the Atlanta area began to envision the water supply benefit as a storage-and-withdrawal benefit. In other words, water supply came to mean not flow regulation in the river but water withdrawals from the lake.

B. Operation of Buford Project

1. 1970s

Once construction on the Buford project was complete, the record reflects very little activity until the early 1970s. In 1974, in accordance with NEPA, the Corps prepared a final environmental impact statement ("EIS") "for continued operation and maintenance of the existing Buford Dam and Lake Sidney Lanier." Mobile Dist., U.S. Army Corps of Eng'rs, *Final Environmental Impact Statement, Buford Dam and Lake Sidney Lanier, Georgia (Flood Control, Navigation and Power),* Statement of Findings (1974) [hereinafter "*Final EIS* "] (ACF004338). The preliminary statement in the EIS reported that the "[a]uthorized project purposes provide peaking hydroelectric power, flood control, and low flow augmentation." *Id.* The preliminary statement added that "[a]dditional benefits derived from operation of the project are recreation and water supply." *Id.* The summary states:

> The project provides an average annual benefit of $638,400 in flood control. The hydroelectric facilities have a capacity of 86,000 kw and are operated

> to meet peak demands for electricity in the service area. Low-flow augmentation provides water for navigation, industrial and municipal uses downstream. The reservoir provides a source of water supply for public water users. Over 15 million visitors utilized the recreational facilities of the lake in 1972. The benefit-to-cost ratio is 3.6 to 1.

Id. at i (ACF004339). The EIS's description of the project notes that the "principal purposes" of the project are flood control, navigation, and power. *Id.* at 1 (ACF004342). The description explains the project's effect on the principal purposes, adding that the "increased flow in dry seasons also provides for an increased water supply for municipal and industrial uses in the metropolitan area of Atlanta, and permits increased production of hydroelectric energy at down-stream plants." *Id.* The EIS recognizes that "recreation was not a primary purpose for which the project was authorized," but that recreation had become a significant part of the use of the reservoir, with Lake Lanier the most used Corps lake in the United States. *Id.* at 12 (ACF004353).

The total storage of the reservoir is 2,554,000 acre-feet, with 637,000 acre-feet of flood-control storage and 1,049,400 acre-feet of power storage. *Id.* at 4 (ACF004344). The EIS does not list any storage for water supply, but does note that Gwinnett County, Gainesville, and Buford "obtain water directly from the reservoir." *Id.* at 14 (ACF04355). In addition, "[t]he Atlanta metropolitan area increased its water use from the river 37% (from 117 mgd to 160 mgd)[8] between 1960 and 1968." *Id.* The EIS also discusses the changes in population in the area around the

[8] Million gallons per day is often abbreviated "mgd" or "MGD."

lake, stating that "[t]he number of residences within 2 ¼ miles of the lake * * * doubled from the time of completion of the project in 1956 through 1969." *Id.* at 15 (ACF004356). Such increases in population are not without consequences, of course: "Wastes [sic] treatment plants in the Atlanta metropolitan area have failed to keep pace with the expanding population, and the increased low flows with a 650 cfs minimum flow at Atlanta have provided some relief in improving stream water quality below Atlanta." *Id.* at 17 (ACF004358). The EIS also notes that "[i]ncreased low flows have created a more dependable water supply for the Atlanta metropolitan area, thus helping to insure an adequate source of water for the expanding population. Storage in Lake Lanier has increased the dependability of a source of water for Gainesville, Gwinnett County, and Buford, Georgia." *Id.*

Both the EIS and the comments thereto reference a study of Atlanta's water quality and water supply underway at the time the EIS was prepared. *See, e.g., id.* at 26-27 (comments of the Environmental Protection Agency) (ACF004367-68). This study, referred to in the EIS as the "Atlanta Urban Study" or the "Atlanta Water Resources Study," was a joint project of the Corps, the state of Georgia, and the ARC. *Id.* at 30 (ACF004371). Because the study was not completed in time for the EIS, the EIS stated that a new EIS should be written when the study was finished. *Id.* This study was not completed until the early 1980s, and is discussed below as the Metro Atlanta Area Water Resources Management Study ("MAAWRMS"). No new EIS has been completed since 1974.

Also in 1974, the Corps prepared a "Report on Consolidation of Existing Program Documents." Boyce J. Christiansen, Consultant, U.S. Army Corps of Eng'rs, *Report on Consolidation of Existing Program Documents, Lake Sidney Lanier (Buford Dam) Georgia* (1974) (ACF004096). This report specifically addresses water supply in three different sections. In the first section on "Facilities," the report states:

> Two cities, Gainesville and Buford, obtain water directly from the reservoir. These cities relocated their water works facilities with new or an addition to these facilities. No storage space is allocated to either Gainesville or Buford in these water supply contracts. The Gainesville and Buford contracts provides [sic] for the maximum withdrawal of 8,000,000 and 2,000,000 gallons of water respectively from the reservoir in any 24 hour period. Gwinnett County on [sic] June 1971 initiated a request which would permit withdrawal direct from the reservoir of 40,000,000 gallons per day by 1990. In a contract dated July 2, 1973 no storage space is allocated to the county for water supply, but the user will have the privilege of withdrawing water not to exceed that rate until such time as the Government studies of the areas [sic] water supply needs is [sic] completed. Withdrawal is not expected to be initiated for two or three years. Lake Lanier with its large water storage maintains a minimum flow of 650 cfs on the Chattahoochee River at Atlanta. The City of Atlanta and De Kalb County water systems draw their entire water supply from the Chattahoochee.

Id. at 32 (ACF004149).

In the section on "Trends," the report noted that neither Gainesville nor Buford pays anything for the water each withdraws from the reservoir, but that "in the event the city desires to exceed th[e] [contractual] limitation an agreement will be necessary to provide payment for additional quantities withdrawn." *Id.* at 54 tbl. 15 (ACF004180). The section also discussed Gwinnett County's request for water supply withdrawals, stating that the requested withdrawal "would require a study of municipal and industrial water needs and a possible redistribution of project costs to include water supply as a project cost therefore a temporary contract on an interim basis was entered into." *Id.* at 54-55 tbl. 16 (ACF004180-81).

Finally, the report noted in the "Benefits" section that no revenues had yet been collected from Gwinnett County for the water-supply withdrawals. *Id.* at 63 (ACF004197).

In 1979, scientists at Georgia State University issued a report to the Corps on the environmental impacts of four of the alternatives being considered by the MAAWRMS mentioned above. Ga. State Univ. Team Project No. 834, *Preliminary Environmental Impact Assessment of Water Supply Alternatives for the Atlanta Metropolitan Area* (1979) (ACF006918). The alternatives under consideration were raising the water elevation of Lake Lanier, phasing out power generation at Buford Dam, constructing a second dam below Lake Lanier to further regulate the flows in the Chattahoochee River for the benefit of Atlanta's water supply and waste treatment, and dredging the Morgan Falls reservoir. *Id.* at 33 (ACF006955). The report described Buford dam as a "multipurpose project, built 1) to control floods, 2) to improve water quality by means of flow augmentation, 3) to insure sufficient riverflow in the Chattahoochee River before Columbus, Georgia, and 4) to produce hydroelectric power." *Id.* at 21 (ACF006943). The report did not mention Lake Lanier as an independent source of water supply, nor did it discuss the environmental impact of large-scale water-supply withdrawals from Lake Lanier. *See, e.g., id.* at 37 ("In addition, no attention has been given to the effects of additional water intakes, increases in allowable supplies taken through existing intakes, etc. Such factors will affect the flow in the river and should be analyzed.") (ACF006959).

2. Drought Operations

Although flood control was a primary concern of both the Corps and Congress before and during construction of the Buford project, a drought in 1980 and 1981 caused the Corps to re-evaluate its operation of the project. The Corps formulated a "Drought Contingency Plan" to examine the operation of the ACF projects during the drought and "to explore alternative operational procedures during future periods of extreme drought." U.S. Army Corps of Eng'rs, *Drought Contingency Plan, Apalachicola, Chattahoochee, and Flint Rivers, Florida and Georgia* ¶ 2, at 1 (1982) (ACF008205). The Drought Contingency Plan was required because, during the 1981 drought, "not all project functions were met* * *. Functions that were not fully provided were navigation and contractual hydropower requirements." *Id.* ¶ 18, at 6 (ACF008210). The Plan did not comment on the fact that navigation and hydropower were two of the Congressionally mandated project purposes.

The Drought Contingency Plan described an agreement between Georgia Power and the Corps to provide minimum releases from Buford Dam of 1750 cfs at the request of Georgia Power each year between June 15 and September 15, to aid both water supply and water quality. *Id.* ¶ 14(b), at 5 (ACF008209). The previous release requirements for the dam were 600 cfs, 1958 Manual app. B ¶ 33, at B-18 to -19 (ACF001801-02), although in the mid-1970s the Corps had agreed to increase the minimum releases to 650 cfs. *Final EIS* at 17 (ACF004358). In addition, the Drought Contingency Plan described water supply as a "principal function" of the ACF basin projects, stating that water supply "must always have a high priority in drought operations." *Id.* ¶ 26, at 12 (ACF008216).

> Municipal and industrial water supplies which are derived from the Chattahoochee River can probably be adequately supplied during a drought. * * *. Even if Lake Lanier were drawn to elevation 1035 for other purposes there is still sufficient stored water which could be released through the low level sluice to meet the water supply requirements.
>
> No difficulty is contemplated in meeting water supply volume requirements in a drought that is no worse than those which have occurred in the past. There may be, however, difficulty with particular pumping installations. For example, within Lake Lanier there are several withdrawal facilities which could not get water if the pool were drawn to unusually low levels. River pumping stations could face the same problem. For this reason conservation of water should be promoted by local government.

Id. At the time the plan was drafted, communities surrounding Lake Lanier withdrew approximately fifty-five million gallons per day from the lake. Memorandum from Acting Commander, S. Atl. Div. (Apr. 23, 1982) (ACF008230).

In what appears to be an earlier version of the plan, called the "Drought Contingency Report," the Corps stated that the "project purposes specified in the authorizing document included flood control, hydropower, and streamflow regulation for navigation." U.S. Army Corps of Eng'rs, *Drought Contingency Report, Apalachicola, Chattahoochee, and Flint Rivers, Florida and Georgia* ¶ 3, at 1 (ACF008241). Under the heading "Project Purposes" the Drought Contingency Report provided: "Project costs for the Buford project have been allocated between the three legislatively authorized purposes. Prior to May 1979, recreation, water supply and water quality have always been considered to be functions of the Buford project and were accommodated as much as possible." *Id.* ¶ 4, at 1-2 (ACF008241-42). The Drought Contingency Report noted that in a recent public notice the Corps had recommended that "recreation, water supply, and water quality control be acknowledged as full project purposes of the Lake Lanier project* * *." *Id.* ¶ 5, at 2 (internal quotation and citation omitted) (ACF008242). The public notice also provided that "[a]ny significant change (in operation) would require reconsideration of cost-sharing requirements for the total project." *Id.* (internal quotation and citation omitted). According to the draft Drought Contingency Report, "[i]n other words, any 'significant' change favoring recreation, water supply or water quality over the three legislatively authorized purposes would require Congressional approval." *Id.*

3. MAAWRMS

As discussed briefly above, in the early 1970s the United States Senate directed the Corps and other entities to engage in a study of Atlanta's water resources. This study lasted from 1972 to 1981 and was published in September 1981 as the Metropolitan Atlanta Area Water Resources Management Study, or MAAWRMS. U.S. Army Corps of Eng'rs, *Metropolitan Atlanta Area Water Resources Management Study: Final Report and Final Environmental Impact Statement* (rev. ed. Sept.1981) [hereinafter "MAAWRMS"] (SUPPAR001951). The final version of the MAAWRMS evaluated three "long-range water supply alternatives." *Id.* at I-16 (SUPPAR001978). The alternatives were: (1) construction of a reregulation dam below Buford Dam, (2) reallocation of storage at Lake Lanier, or (3) dredging the reservoir at Morgan Falls and reallocating Lake Lanier storage. *Id.*

The MAAWRMS noted that the Chattahoochee and Lake Lanier supply more than 90 percent of the total water supply for the metropolitan Atlanta area. *Id.* at II-16 (SUPPAR001996). Lake Lanier "provides storage for flood control, power, navigation, recreation, industrial and domestic water supplies, and low-flow augmentation." *Id.* at II-37 (SUPPAR002017). However, the project costs, totaling more than $55 million, were allocated to only four project purposes or uses: hydropower, navigation, flood control, and recreation. *Id.* at II-39 tbl. II-6 (SUPPAR002019). Of these four purposes/uses, hydropower had borne the lion's share of the costs, paying more than $44 million.[9]

[9] The MAAWRMS characterized recreation as an "authorized project purpose under general legislation, the 1944 Flood Control Act and the Federal Water Project Recreation Act of 1965." MAAWRMS at II-40 (SUPPAR002020). Because of the Court's resolution of the water-supply issue, it is not necessary to reach the issue of whether recreation is indeed an authorized project purpose.

The MAAWRMS recognized that changes in the operation of the Buford project would require Congressional approval. For instance, the study noted that one of the proposed alternatives was construction of a new reregulation dam below Buford Dam. *Id.* at II-48 (SUPPAR002028). If this construction was undertaken by local governments and not by the Corps, it would be the only alternative that would not require Congressional approval. *See id.* ("[I]t was considered that a reregulation dam constructed by local governments would be the most probable alternative to the other long-range alternatives which would require Congressional authorization for changes in operation of the Buford project.").

The MAAWRMS also contained a list of the existing water-supply contracts for withdrawals from Lake Lanier. *Id.* at II-51 tbl. II-8 (SUPPA002031). Despite the fact that only Gainesville and Buford had received Congressional authority to withdraw water from Lake Lanier, both Gwinnett County and the city of Cumming had also contracted with the Corps for these withdrawals. *Id.* The total withdrawals from the lake for water supply were given as 52.5 million gallons per day, with Gwinnett County receiving the majority of these withdrawals at 40 million gallons per day. *Id.* Although in this litigation the Corps characterizes Gwinnett County's and Cumming's water-supply contracts as "interim," the MAAWRMS states that "[o]nly the method and rate of payment are of an interim nature." *Id.* at II-51.

In 1975, to meet an immediate increased need for water supply, the state of Georgia asked the MAAWRMS group to develop an interim water-supply plan that would allow the state to approve additional withdrawals from the river and provide a flow of 750 cfs at all times. *Id.* at II-60. The Corps agreed to a plan that allowed additional water releases from Buford Dam. *Id.* That plan required the hydropower interests to schedule peak releases from the dam on weekends. *Id.* at II-62 (SUPPAR002042). The power company agreed to this schedule only until 1983. *Id.*

The interim MAAWRMS, released in 1978, also recommended the imposition of a short-term water-supply plan in the event the MAAWRMS was not completed by 1983. *Id.* at II-69 (SUPPAR002049). This short-term plan "include[d] raising the normal pool at Lake Lanier by [one] foot and increasing off-peak releases from Buford Dam." *Id.* According to the MAAWRMS, the short-term plan "would necessitate reallocation or joint use of storage at the Lake Lanier project* * *." *Id.* at II-71 (SUPPAR002051). This plan provided for an average annual withdrawal of 33 million gallons per day directly from Lake Lanier, and the maintenance of a 750 cfs flow at Atlanta. *Id.* at II-72 (SUPPAR002052). The MAAWRMS recognized that the change in operations would have a negative effect on hydropower generation at Buford Dam, but calculated that hydropower would lose only one percent in benefits, and that raising the pool elevation one foot "would have a mitigating effect on this loss." *Id.* at II-74 (SUPPAR002054). The short-term plan was included as a recommendation of the Corps when the interim MAAWRMS was submitted in 1978. *Id.* at II-78 (SUPPAR2058).

The final MAAWRMS stated that the "primary purpose of all long-range alternatives was to enhance water supply benefits through increased water supply availability from the Chattahoochee River." *Id.* at II-83 (SUPPAR002063). Thus, "[a]lthough consideration was given to the impacts of each alternative on other water related uses of the lake and river," any harm to those other uses was considered "incidental to formulation of each alternative for water supply." *Id.* The MAAWRMS acknowledged, however, that "[a]ny proposed change in the operation of Buford Dam which would significantly impact on authorized project purposes would require Congressional approval." *Id.* at III-2 (SUPPAR002074).

The MAAWRMS considered in detail three alternatives. The first alternative was the construction of a 4100 acre-foot reregulation reservoir and dam on the Chattahoochee six miles below Buford Dam. The second was a reallocation of storage at Lake Lanier. The third was a combination of dredging the Morgan Falls reservoir (to increase storage at that reservoir) combined with a reallocation of storage at Lake Lanier. *Id.* at IV-3 (SUPPAR002105). In evaluating these alternatives, the MAAWRMS considered as a "base" condition average annual water-supply withdrawals of 14.6 million gallons per day from Lake Lanier, with projected average annual withdrawals from the lake of 53 million gallons per day by 2010. *Id.* at IV-7 tbl. IV-2 (SUPPAR002109).[10] The study also pointed out "how the increasing withdrawals from Lake Lanier result in a decrease in the dependable peak energy from Buford Dam." *Id.* at IV-7 to -8 tbl. IV-3 (SUPPAR002109-10). According to the MAAWRMS, such decreases were acceptable because the Corps report on which Congress based its initial

[10] Although the analysis was "based on the assumption that [water-supply] withdrawals are part of a base condition," the MAAWRMS also assumed that "a separate contract would be entered into for such demands." *Id.* app. C, at C-58 (SUPPAR002643).

authorization of the project contemplated some increase in releases from the dam to support water supply. *Id.* at IV-9 (SUPPAR002111). The Corps report from 1947 stated that these increased releases "would not materially reduce the power returns" from the dam, and opined that the benefits of an assured water supply " 'would outweigh any slight decrease in system power value.' " *Id.* (quoting Newman Report ¶ 80, at 34 (ACF000668).). Although withdrawals of 53 million gallons per day would result in average annual power loss of $583,700 (in 1980 dollars), the MAAWRMS nevertheless considered 53 million gallons per day as the "base" withdrawal and "an integral part of each alternative." *Id.* at IV-17 (SUPPAR002119).

The first alternative the MAAWRMS suggested was the construction of a reregulation dam 6.3 miles below Buford Dam. *Id.* at IV-24 (SUPPAR002126). This reregulation dam would store outflows from Buford Dam until those outflows were needed for water supply. *Id.* at IV-31 (SUPPAR002133). The total cost of this alternative was estimated at approximately $17.5 million. *Id.* at IV-44 tbl. IV-10 (SUPPAR002146). However, this alternative mitigated somewhat the lost power benefits assumed by the "base" scenario of increasing water-supply withdrawals from Lake Lanier. The power benefits gained in this alternative were estimated at $1.2 million annually. *Id.* at IV-50 tbl. IV-14 (SUPPAR002152). The MAAWRMS estimated that the increase in net benefits (for water supply, recreation, and power) under the first alternative would be $1.2 million annually, for a benefit-cost ratio of 1.75. *Id.* This alternative had the greatest annual net benefits of any of the final three alternative plans.

Id. at IV-64 to 65 (SUPPAR002166-67). It also received the most support, from both federal and state agencies. *Id.* at VI-1 (SUPPAR002238). Should the federal government build the reregulation dam, the Corps would be required to seek Congressional authorization for the project. *Id.* at IV-81 (SUPPAR002183).

The second alternative called for reallocating storage at Lake Lanier from power to water supply. *Id.* at IV-86 (SUPPA002188); *see also id.* at IV-97 (SUPPAR002199) (describing alternative as involving "reallocating storage in Lake Lanier from power to water supply"). According to the MAAWRMS, water-supply storage in Lake Lanier amounted to 10,512 acre-feet in 1980, with 14.6 million gallons per day withdrawn from the lake. *Id.* at IV-87 tbl. IV-19 (SUPPAR002189). Under the second alternative, such storage would increase to 141,685 acre-feet by 2010, with 53 million gallons withdrawn. *Id.* Power generation would decrease from more than 123 million kilowatt-hours in 1980 to 97.7 million kilowatt-hours in 2010. *Id.* "Losses in power benefits * * * would occur primarily due to the need for scheduling additional weekend releases from Buford Dam for water supply." *Id.* at IV-92 (SUPPAR002194). The MAAWRMS estimated the total net annual benefit of the second alternative as $475,100, with a benefit-cost ratio of 1.42. *Id.* Finally, the MAAWRMS acknowledged that "Congressional authorization would be required for reallocation of storage to water supply." *Id.* at IV-97 (SUPPAR002199).

The final alternative was to dredge the downstream Morgan Falls Reservoir and also reallocate storage at Lake Lanier for water supply. *Id.* at IV-99

(SUPPAR002201). The loss of power benefits under this alternative was not as great as under the second alternative, from 124.5 million kilowatt-hours in 1980 to 112 million kilowatt hours in 2010. *Id.* at IV-100 tbl. IV-23 (SUPPAR002202). The annual net loss in power benefits would be $284,600. *Id.* at IV-112 (SUPPAR002214). The Lake Lanier storage reallocated to water supply would rise from zero acre-feet in 1980 to 48,550 acre-feet in 2010.[11] *Id.* at IV-100 tbl. IV-23 (SUPPAR002202). The dredging of the Morgan Falls Reservoir would result in increasing that reservoir's storage capacity to 3200 acre-feet, with maintenance dredging required to maintain that capacity. *Id.* at IV-100 (SUPPAR002202). The MAAWRMS calculated the net annual benefit of the third alternative as either $875,000 if the dredged material could be sold, or $312,000 if that material could not be sold. *Id.* at IV-114. The benefit-cost ratio varied from 2.13 to 1.23. *Id.* As with the second alternative, "Congressional authorization would be required for reallocation of storage to water supply." *Id.* at IV-119 (SUPPAR002221).

As discussed above, the MAAWRMS assumed a baseline for all alternatives of phased-in reallocations of storage at Lake Lanier from power to water supply. This phased-in reallocation, however, can skew the benefit-cost analysis. *See id.* at V-4 (SUPPAR002228) ("Non-phasing also reflects a more equal comparison of the costs of the three plans* * *."). When the MAAWRMS analyzed the three alter-

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[11] The MAAWRMS does not explain why the second alternative plan assumes that approximately 10,000 acre-feet at Lake Lanier were allocated to water-supply storage in 1980, but the third alternative assumes that Lake Lanier had no storage allocated to water supply in 1980.

natives, assuming that all reallocations would occur at present to meet the future water-supply needs, the costs of the second and third alternatives rose and the net benefits decreased significantly. *Id.* at V-4 to -5 tbl. V-3 (SUPPAR002228-29). Thus, if the Corps did not have the authority to reallocate storage even in the limited way envisioned by the "baseline" of the MAAWRMS, the alternatives the study recommended were in general no longer cost-effective.

Ultimately, the MAAWRMS recommended the adoption of the first alternative. *Id.* at VI-4 (SUPPAR002241). According to the Corps, the first alternative was best suited "to provide a long-range water supply, improvement in water quality and the net positive contribution to the goal of National Economic Development." *Id.* at EIS-1 (SUPPAR002256). The final recommendation of the MAAWRMS included a recommendation to Congress that "[r]ecreation, water supply, and water quality control should be acknowledged as full project purposes of the Lake Lanier project along with power, flood control, and navigation, and * * * all of these purposes [should] be fully considered in future decisions affecting the use or operation of the project." *Id.* ¶ 15, at IX-4 (SUPPAR002327).

4. Reregulation Dam to Reallocation of Storage

Congress considered the Corps's recommendation with respect to the reregulation dam in 1982. *Proposed Water Resources Dev. Projects of the U.S. Army Corps of Eng'rs: Hearings Before the Subcomm. on Water Resources of the H. Comm. on Public Works and Transp.,* 97th Cong. 713 (1982). At least one member of the Subcommittee expressed an unwillingness for the federal government to fund a project primarily for local water supply. *See id.* at 718 (statement of Rep. Edgar, Pennsylvania) (SUPPAR001443) ("Can you tell me when the corps got involved in providing local water supplies?"); *id.* at 719 (SUPPAR001443) (asking why the people of Atlanta did not construct the proposed dam "rather than the Federal Government coming in and providing the construction costs"); *id.* at 720 (SUPPAR001444) ("I am just wondering whether or not we are providing a subsidy to Atlanta at the Federal expense * * *."). Unlike during the construction of Buford Dam, however, Atlanta expressed its intention to share in the costs of the reregulation dam. *Id.* at 2459 (SUPPAR001451) (Letter from Andrew Young, Mayor, Atlanta, Ga., to Harry West, Exec. Dir., ARC (July 14, 1982)).

Not all testimony supported the proposed project, however. Nancy Wylie of the Georgia Conservancy testified against the reregulation dam, noting that some local governments in the area did not support that alternative and that even the Atlanta City Council had not strongly supported the project. *Id.* at 2508 (SUPPAR001476) (testimony of Nancy Wylie, Georgia Conservancy). Ms. Wylie also pointed out that neither Atlanta nor Georgia had made any binding financial commitments to fund the project. *Id.* Other participants in the MAAWRMS characterized the reregulation dam option as the preferred option of the Corps and one that essentially had been foisted on the other study participants. *Id.* at 2499-2500 (SUPPAR001471-72) (testimony of David Dingle, Chairman, MAAWRMS Citizen's Task Force). Mr. Dingle supported the reallocation-of-storage alternative, noting that such reallocation would require including water supply as an authorized project purpose. *Id.* at 2502 (SUPPAR001473).[12]

The Chair of the Subcommittee offered his thoughts on the project, asking that Georgia and Atlanta give the Subcommittee a firmer commitment to the proposed reregulation dam. *Id.* at 2520 (SUPPAR001482) (statement of Rep. Robert Roe). He also predicted what has come to pass:

> [W]ater resources and the need for water quality and water supply in this Nation is extraordinary.
>
> Power is vital to the Nation, but water is absolutely essential, so that you are facing enormous competition for resources available * * *. [O]ne of the tragedies of our time is that it takes so long to get anything achieved * * *.
>
> I think it would be a shame to allow this to get away from [Georgia] and 5 or 7 years from today * * * that you would not have the natural resources to be able to provide the economic resources required for the project.

Id.

In November 1984, the President's Office of Management and Budget ("OMB") declined to support the proposed project. "The plan * * * appears to be a desirable project that would go a long way toward meeting water supply demand in the Atlanta area. However, * * * non-federal development of the same reregulating dam [is] the most likely alternative to a Federal project for water supply." Letter from Frederick N. Khedouri, Assoc. Dir., OMB, to Robert K.

[12] Others also recognized that water supply was "not specifically authorized as a purpose" of the Buford project. *Id.* at 3251 (SUPPAR001491) (Letter from W.T. Bush, co-chairman, Gwinnett County Water & Sewerage Auth. to Sen. Sam Nunn, Ga. (Aug. 21, 1980)).

Dawson, Assistant Sec'y of the Army-Civil Works (Nov. 7, 1984) (SUPPAR036642). The letter emphasized the Administration's policy of encouraging "non-Federal development of water resources * * *." *Id.* In January 1985 the Corps wrote to Congress, stating that it concurred with the OMB's opinion on the proposed reregulation dam project. Letter from Robert K. Dawson, Assistant Sec'y of the Army-Civil Works, to Sen. Robert T. Stafford, Chairman, S. Comm. on Env't and Pub. Works, at 2 (Jan. 8, 1985) (ACF010341).

Despite the lack of support from the Administration and the Corps, Congress authorized the construction of the reregulation dam in the Water Resources Development Act of 1986 ("1986 WRDA"), Pub.L. No. 99-662, tit. VI, § 601(a)(1), 100 Stat. 4137, 4140-41. The 1986 WRDA required that the project meet certain criteria, including a general design memorandum and supplemental environmental impact statement prepared and "jointly approved" by the Corps and Georgia. *Id.* It also provided that the dam could be constructed by Georgia or other local interests "at local cost." *Id.* 100 Stat. at 4141. Congress did not appropriate any money to fund any construction costs for the reregulation dam.[13]

Shortly thereafter, the Corps determined that real-

[13] In the design memorandum Congress required when it authorized the reregulation dam, the Corps determined that the most economical alternative was no longer a reregulation dam, but was instead reallocation of storage at Lake Lanier. Memorandum from Ralph V. Locurcio, Colonel, U.S. Army Corps of Eng'rs, to Commander, S. Atl. Div. (Oct. 13, 1988) (SUPPAR035867). This memorandum recommended that the Corps prepare "a Post-Authorization Change Report recommending reallocation of storage in Lake Lanier * * * for submittal to Congress for authorization." *Id.* ¶ 3.

location of storage at Lake Lanier was a more feasible alternative than the construction of a reregulation dam. A March 25, 1988, report prepared by the Corps's South Atlantic Division and entitled "Additional Information Lake Lanier Reregulation Dam," stated that if the costs of acquiring the land that would be inundated by the dam rose, the reallocation alternative would become the most economic alternative. U.S. Army Corps of Eng'rs, *Additional Information, Lake Lanier Reregulation Dam* 2 (1988) (SUPPAR016865). The report warned that "[t]he storage to be reallocated under [the second MAAWRMS alternative] is beyond the approval authority of the Chief of Engineers." *Id.* The Corps told ARC the same thing:

> The Chief of Engineers has the discretionary authority to approve reallocation of storage if the amount does not exceed 50,000 acre-feet, or 15 percent of total usable storage, whichever is lower, and if the reallocation would not have a significant impact on authorized project purposes. Plan B [the second MAAWRMS alternative] would require the reallocation of 202,000 acre-feet of storage to meet the year 2010 peak demand of 103 mgd from the lake and 510 mgd from the river. The reallocation of 202,000 acre-feet is much greater than the criteria of 50,000 acre-feet. Therefore, the required reallocation is not within the discretionary authority of the Chief of Engineers to approve. It can only be approved by the ASA(CW) [Assistant Secretary of the Army-Civil Works] if impacts are determined to be insignificant. We believe the power losses are significant and expect that Congressional approval would be required for the reallocation.

Letter from C.E. Edgar III, Major General, U.S.

Army Corps of Eng'rs, to Harry West, Exec. Dir., ARC, at 5 (Apr. 15, 1988) (SUPPAR017113). The Corps estimated that the cost of the storage reallocation would be more than $42 million. *Id.* at 6 (SUPPAR017114).

The Corps also provided a memorandum with a "chronology" of the Lake Lanier Reregulation Dam noting, among other events, a story in the May 31, 1988, edition of the *Gwinnett Daily News* that the Corps was considering supporting the reallocation alternative rather than the reregulation dam alternative. Memorandum, *Lake Lanier Reregulation Dam Chronology,* to Joseph A. Goode 2 (Aug. 16, 1988) (SUPPAR016869). Several weeks later, the Corps informed Georgia that it would recommend "that the water supply needs be provided through reallocation of storage in Lake Sidney Lanier." Letter from R.M. Bunker, Major General, U.S. Army Corps of Eng'rs, to J. Leonard Ledbetter, Comm'r, Ga. Dep't of Natural Res. (Sept. 1, 1988) (SUPPAR016870). The Corps acknowledged the switch in an internal memorandum, characterizing the decision to promote storage reallocation as "a political decision." Memorandum from James Couey, Chief of Eng'rs, to District Eng'r, U.S. Army Corps of Eng'rs, 1 (Sept. 6, 1988) (SUPPAR017083). This memorandum stated that the "next step" would be "for the Corps to prepare a storage reallocation report to submit through channels to the Secretary of the Army and Congress." *Id.*

While the Corps prepared a Post-Authorization Change Report, Georgia prepared legislation to submit to Congress authorizing the reallocation of storage in Lake Lanier. On September 23, 1988, Georgia Governor Joe Frank Harris sent proposed reauthorization legislation to Georgia Senator Sam Nunn. Letter from Joe Frank Harris, Governor, Ga., to Senator Sam Nunn, Ga. (Sept. 23, 1988) (SUPPAR014842). The proposed legislation provided that the Buford project be "modified to provide that the Secretary is authorized to reallocate permanently from hydropower storage to water supply storage up to an additional 300,000 acre-feet for municipal water systems in the State of Georgia, at a total one-time cost not to exceed $29,000,000." *Id.* at 2 (SUPPAR014843).

The Corps issued its "Draft Post-Authorization Change Notification Report For The Reallocation of Storage From Hydropower To Water Supply at Lake Lanier, Georgia" ("PAC Report") in October 1989. Mobile Dist., U.S. Army Corps of Eng'rs, *PAC Report* (1989) (ACF041152). The PAC Report's purpose was to recommend that Congress rescind its approval of a reregulation dam and instead approve a reallocation of storage in Lake Lanier to water supply. *Id.* at 1 (ACF041165). The PAC Report endeavored

> to fully evaluate the future water supply demands for the Atlanta region to the year 2010, the storage needed from Lake Lanier to satisfy these projected demands, and to identify the associated impacts to all the project purposes, both upstream and downstream of Buford Dam, of reallocating storage from hydropower to water supply.

Id. at 6 (ACF041170).

According to the PAC Report, Lake Lanier has a total storage capacity of 2,554,000 acre-feet. *Id.* at 12 (ACF041176). However, 867,600 acre-feet of that amount is considered "inactive" storage, 637,000 acre-feet is allocated to flood control, and 1,049,400 acre-feet is allocated to conservation storage. *Id.* The Report calculated that water supply demands in 2010 would require a reallocation of 207,000 acre-feet of storage, and recognized that "congressional approval may be required" for that reallocation. *Id.* The cost of the reallocation was estimated at $49.3 million. *Id.* at 21 (ACF041185).

Appendix A to the PAC Report was a draft Water Control Plan for the ACF basin ("WCP"). *Id.* app. A, at A-1 (ACF041197). The WCP's objectives included balancing operations to meet the projects' purposes. *Id.* app. A, at A-4 (ACF041200). The "purposes cited in the projects' original authorizations" were "[f]ish and wildlife management, flood control, hydropower and navigation." *Id.* In addition, "over the years a variety of activities (industrial and municipal water supply, instream recreation, water quality, etc * * *) have become dependent upon the operational patterns of these projects." *Id.*

The WCP set forth, apparently for the first time, so-called "action zones" for each of the reservoirs in the basin. *Id.* app. A, at A-11 (ACF041207). According to the Corps, these action zones "are to be used to determine minimum hydropower generation at each project, as well as the maximum possible assistance to navigation from conservation storage." *Id.* The action zones took into consideration other factors, such as the time of year, historical pool levels, and "Resource Impact Levels" or "RILs." *Id.* The RILs were the Corps's attempt to quantify the effect on recreation of the various reservoir operations. *Id.* app. A, at A-8 (ACF041204). The RILs included: "Initial Impact Level," defined as "the level where recreation impacts are first observed (i.e., some boat-launching ramps are unusable, most beaches are unusable or minimally usable and navigation hazards begin to surface)"; "Recreation Impact Level," which is "the level where major impacts to concessionaires and recreation are observed (more ramps are not usable, all beaches are unusable, boats begin having problems maneuvering in and out of marina basin areas, loss of retail business)"; and the final level, "Water Access Limited Level," defined as "all or almost all boat ramps [are] out of service, all swimming beaches [are] unusable, major navigation hazards occur, channels to marinas are impassable and/or wet slips must be relocated, and a majority of private boat docks are unusable." *Id.* For Lake Lanier, the Initial Impact Level was pool elevation 1066, Recreation Impact Level occurred at elevation 1063, and Water Access Limited Level was elevation 1060. *Id.* app. A, at A-9 (ACF041205). The normal elevation of Lake Lanier is 1070.

The "Water Control Guidelines" in the WCP listed objectives for all of the project purposes, including those initially authorized and those subsequently developed. Thus, the WCP outlined management for general hydropower operations, navigation, recreation, and water supply/water quality, among others. *Id.* app. A, at A-12 to -16 (ACF041202-12). For water supply, management "involves taking water from storage, either directly from the pool or through releases for downstream interests. Of primary concern is that sufficient drinking water is available for urban needs and that agreements to provide instream flow for water quality are not violated." *Id.* app. A, at A-15 (ACF041211). "Releases from projects in the system will be the minimum (capacity) release for hydropower or releases needed for basin-wide water quality/water supply, whichever is greater."

Id.

Although the WCP did not fully explain the "action zones" on which it based the ACF basin operations, the Corps uses the action zones "to manage the lakes at the highest level possible for recreation and other purposes that benefit from high lake levels." Memorandum, U.S. Army Corps of Eng'rs, ACF Drought Conference, at 11 (Sept. 20, 2007) (SUPPAR035773). The Corps describes those action zones as follows:

> **Zone 1** indicates that releases can be made in support of seasonal navigation [ ]when the channel has been adequately maintained, hydropower releases, and water supply, and water quality releases. If all the lakes are in Zone 1 or above, the river system would operate in a fairly normal manner.
>
> **Zone 2** indicates that water to support seasonal navigation may be limited. Hydropower generation is supported at a reduced level. Water supply and water quality releases are met. Minimum flow targets are met.
>
> **Zone 3** indicates that water to support seasonal navigation may be significantly limited. Hydropower generation is supported at a reduced level. Water supply and water quality releases are met. Minimum flow targets are met.
>
> **Zone 4** indicates that navigation is not supported. Hydropower demands will be met at minimum level and may only occur for concurrent uses. Water supply and water quality releases are met. Minimum flow targets are met.

Id. (alterations in original). The WCP's RILs and "action zones" highlight the shift in operations at Buford from hydropower, flood control, and navigation to water supply and recreation.

The draft WCP was never finalized or adopted, because in 1990 the state of Alabama filed a lawsuit challenging the WCP and various water-supply withdrawal contracts between the Corps and Georgia communities.

C. History of the Litigation

From the time the Buford Dam was constructed and Lake Lanier filled, municipal entities had requested and received permission to withdraw water from the lake. Initially, only Gainesville and Buford, whose water intake structures on the Chattahoochee River had been inundated by Lake Lanier, withdrew water directly from the lake. The withdrawals were relatively small-eight million gallons per day for Gainesville and two million gallons per day for Buford-and amounted to slightly more than 10,000 acre-feet[14] of Lake Lanier's "conservation" storage; storage that the Corps deemed usable storage, for hydropower or for purposes other than flood control.

1. Water-Supply Contracts

In the 1950s, Gwinnett County asked permission to make withdrawals from the lake. The Corps refused the request at that time, saying that such withdraw-

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[14] One million gallons per day is equal to 1.547 cfs of flow. *See* MAAWRMS at III-6 (SUPPAR002078). According to the Corps, during normal operations, 1600 cfs equal one acre-foot of storage. The conservation storage of Lake Lanier is 1,049,400 acre-feet. Therefore, the total storage used between Gainesville and Buford is 10,146 acre-feet. (10 mgd x 1.547 cfs / 1600 = .00966875. And .00966875 x 1,049,400 = 10,146 acre-feet.) Under the conditions present in the 1986-1988 drought, during which 1485 cfs equaled one acre-foot, the storage necessary for 10 million gallons per day would be 10,932 acre-feet. The WCP uses a different figure for storage in which 1734 cfs equals one acre-foot. *See* WCP app. C, at C-4 (ACF041302). Using this figure, 10 million gallons per day is equal to 9,362 acre-feet.

als would affect the project's authorized purposes and that Gwinnett County would have to seek permission from Congress for the withdrawals. F.G. Turner, Ass't Chief, Eng'g Div., *Report on Withdrawal of Domestic Water Supply from Buford Reservoir* ¶ 2, at 1 (1955) (SUPPAR005459). Congress ultimately authorized Gwinnett County to use storage space "in an amount not to exceed eleven thousand two hundred acre-feet of water annually," Pub.L. No. 84-841, 70 Stat. 725 (1956) (amending 1946 RHA), but the Corps and Gwinnett County did not enter into any contracts at that time.[15] As discussed previously, in 1973, without invoking the authority provided by the 1956 statute, the Corps and Gwinnett County contracted for withdrawals of 40 million gallons per day from Lake Lanier pending the completion of the MAAWRMS and the adoption of the study's recommended plan. Contract Between the U.S. and Gwinnett County, Ga., for Withdrawal of Water from Lake Sidney Lanier at 2 (July 2, 1973) (ACF004025). Forty million gallons per day amounts to almost 37,500 acre-feet of storage using the 1734 yield figure, and more than 43,700 acre-feet using the current 1485 figure. In 1985, Gwinnett County agreed to pay $5.40 per million gallons, or $216 per day, for the 40 million gallons it was allowed to withdraw daily from the lake. Dist. Eng'r, U.S. Army Corps of Eng'r Dist.-Mobile, *Civil Works Projects Water Supply Contract Status Report-Gwinnett County* (1987) (SUPPAR014884). The Corps's Status Report for this contract noted that the Corps's South Atlantic Divi-

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[15] 11,200 acre-feet of storage would provide approximately 10.2 million gallons per day of water, using 1485 cfs as the yield figure. Assuming 1734 as the yield, 11,200 acre-feet provides almost 12 million gallons per day.

sion had approved a supplement to this contract increasing the withdrawals to an annual average rate of 53 million gallons per day. *Id.* The Status Report also noted that the Gwinnett County contract was an "interim" contract "until 1 July 1989 to allow time for local interests to determine whether they will fund construction of a re-regulation dam downstream of Buford Dam." *Id.*

The status reports for the other water-supply contracts similarly note the "interim" nature of the contracts. The ARC's contract is for 377 million gallons per day, at a charge of $5.79 for each million gallons in excess of 327 million gallons per day. Dist. Eng'r, U.S. Army Corps of Eng'r Dist.-Mobile, *Civil Works Projects Water Supply Contract Status Report* (1988) (SUPPAR014880); *see also* Contract, Supplemental Agreement No. 1 to Contract No. DACW01-9-86-145 Between the U.S. and the Atlanta Reg'l Comm'n for Withdrawal of Water from the Chattahoochee River Downstream from Lake Sidney Lanier, Ga., at 1 (June 17, 1986) (ACF011978). Gainesville's contract, dated May 27, 1987, is for 20 million gallons per day, at a charge of $12.44 for each million gallons in excess of the Congressionally authorized 8 million gallons per day. Contract Between the U.S. and City of Gainesville, Ga. for Withdrawal of Water from Lake Sidney Lanier, at 2-3 (May 28, 1987) (ACF014383). Buford had no new contract aside from the initial authorization of 2 million gallons per day. Dist. Eng'r, U.S. Army Corps of Eng'r Dist.- Mobile, *Civil Works Projects Water Supply Contract Status Report-Buford* (1988) (SUPPAR014882). The Status Report provided that Buford must enter into a new agreement if it wanted to withdraw more than 2 million gallons per day. *Id.* The Status Report for

Cumming showed two contracts, one from 1978 and another from 1985. Dist. Eng'r, U.S. Army Corps of Eng'r Dist.-Mobile, *Civil Works Projects Water Supply Contract Status Report-Cumming* (1988) (SUPPAR014883). The 1978 contract allowed withdrawals of 2.5 million gallons per day; the 1985 contract allowed 5 million gallons per day. *Id.* The Corps charged Cumming $7.88 for each million gallons per day. *Id.* A contract dated November 16, 1988, allowed Cumming to withdraw 10 million gallons per day. Contract, Supplemental Agreement No. 2 to Contract No. DACW01-9-77-1096 Between the U.S. and the City of Cumming, Ga. For Withdrawal of Water from Lake Sidney Lanier, Ga., at 3 (Nov. 16, 1988) (ACF014401).

All of these "interim" water-supply contracts (save Buford's and Gainesville's Congressionally authorized withdrawals of two million and eight million gallons per day, respectively), expired on January 1, 1990. *See, e.g.,* Contract, Supplemental Agreement No. 5 to Contract No. DACW01-9-73-624 Between the U.S. and Gwinnett County, Ga. For Withdrawal of Water from Lake Sidney Lanier, at 3 (July 24, 1989) (ACF004006). However, the municipal entities continue to withdraw water pursuant to these contracts. Alabama and Florida therefore characterize the continuing withdrawals as occurring pursuant to "holdover" contracts. In addition, Alabama and Florida contend that the storage required by the "holdover" contracts has, for all intents and purposes, been reallocated to water-supply storage. They call this "de facto" reallocation.

The Eleventh Circuit Court of Appeals described the Corps's decisionmaking with respect to the water-supply contracts:

> Beginning in the 1970s, in accordance with the Corps' view that water supply was an appropriate "incidental benefit" of the creation of [Lake Lanier], the Corps entered into interim contracts with local government entities in Georgia to allocate storage capacity in the Lake for local water supply * * *. As demand for water increased and the local governmental entities desired an assured permanent supply, the Corps in 1989 announced plans to seek congressional approval in accordance with the Water Supply Act of 1958 ("WSA"), 43 U.S.C. § 390b (2003), to enter into permanent water storage contracts with the local governmental bodies, proposing [the PAC Report] for congressional approval.

Alabama v. U.S. Army Corps of Eng'rs, 424 F.3d 1117, 1122 (11th Cir. 2005).

2. Pre-MDL Litigation

On June 28, 1990, the state of Alabama filed a lawsuit against the Corps in the United States District Court for the Northern District of Alabama challenging the water-supply contracts and the draft WCP.[16] Shortly after the case was filed, the state of Florida moved to intervene as a plaintiff and the state of Georgia moved to intervene as a defendant. In September 1990, however, before the court ruled on the intervention motions, the parties requested that the court stay the matter pending settlement negotiations. As part of the joint motion to stay, the Corps agreed that it would not "execute any contracts or agreements which are the subject of the complaint in

[16] Originally, the lawsuit challenged not only the Corps's operations in the ACF basin, but also the operations in the Alabama-Coosa-Tallapoose ("ACT") basin. The claims involving the ACT basin are no longer part of this case.

this action unless expressly agreed to, in writing, by Plaintiff [Alabama] and Florida." (Ex. A to Docket No. 20 in Case No. 3:07-md-00001 at 2.) The stay also provided that either party could terminate the stay by so notifying the court, the parties, and the proposed intervenors. (*Id.* at 2-3.) In 1992, the parties negotiated a Memorandum of Agreement ("MOA") that temporarily resolved the parties' differences.[17] The stay, however, remained in place.

In 1997, Congress ratified the ACF Compact. Pub.L. No. 105-104, 111 Stat. 2219 (1997). This Compact created an "ACF Basin Commission" composed of the Governors of Florida, Georgia, and Alabama, and a non-voting representative of the federal government, to be appointed by the President. *Id.* art. VI(b)-(c), 111 Stat. at 2221. The Commission was charged with establishing "an allocation formula for apportioning the surface waters of the ACF Basin among the states of Alabama, Florida and Georgia." *Id.* art. VI(q)(12), 111 Stat. at 2222. The Compact did not nullify or otherwise modify any existing water-supply contract, but rather provided that, until a water allocation formula was developed, existing water-supply contracts would be honored and, further, that water-supply providers could increase the amount of water they withdrew from the ACF basin's waterways "to satisfy reasonable increases in the demand" for such water. *Id.* art. VII(c), 111 Stat. at 2223-24. The right to use the water pending the allocation formula did not, however, create any permanent or vested rights to the water. *Id.* art. VII(c), 111 Stat. at 2224. The Compact was to

[17] According to the Court of Appeals, the MOA required the Corps to abandon the PAC Report. *Alabama,* 424 F.3d at 1123.

expire on December 31, 1998, but was extended several times. *Id.* art. VIII(a)(3), 111 Stat. at 2224. The Compact finally expired on August 31, 2003, when the Commission was not able to agree on a water allocation formula. *Alabama,* 424 F.3d at 1123. The stay of the Alabama case remained in effect during the pendency of the Compact.

In 2001, the Georgia parties filed their own lawsuit against the Corps in the United States District Court for the Northern District of Georgia. *Georgia v. U.S. Army Corps of Eng'rs,* No. 2:01-CV-26 (N.D. Ga. filed Feb. 7, 2001) ("*Georgia I* "). This lawsuit challenged the Corps's denial of Georgia's water-supply request, which sought a permanent reallocation of storage in Lake Lanier for water supply. (Comp.¶ 1.) In denying that request, the Corps found that the reallocation Georgia requested would "affect authorized project purposes" and that it "cannot be accommodated without additional Congressional authorization." Letter from R.L. Brownlee, Ass't Sec'y of the Army (Civil Works), to Roy E. Barnes, Governor, Ga. (Apr. 15, 2002) (ACF036354).

Meanwhile, the SeFPC filed its own lawsuit against the Corps in the United States District Court for the District of Columbia. *Se. Fed. Power Customers v. Caldera,* No. 1:00-cv-2975 (D.D.C. filed Dec. 12, 2000). The SeFPC alleged that the Corps's decision to reallocate water supply to municipal entities in Georgia harmed the SeFPC's ability to produce power from Buford Dam and increased the cost of that power. The Georgia parties intervened but Alabama and Florida did not intervene. The parties dispute whether Alabama and Florida were informed about the pendency of the case.

In 2003, before the ACF Compact expired, the

Corps, the SeFPC, and the Georgia parties settled the SeFPC's lawsuit and also resolved at least some of the issues pending in Georgia's lawsuit. The Settlement Agreement required the Corps to negotiate interim contracts for the purchase of storage in Lake Lanier with Gwinnett County, Gainesville, and ARC. Settlement Agreement § 3.1, at 4 (SUPPAR024052). Under the terms of the Settlement Agreement, Gwinnett County would purchase 175,000 acre-feet of storage, which would provide a withdrawal of 152.4 million gallons per day from the lake. *Id.* § 3.1.1(a), at 5 (SUPPAR024053). Gainesville would purchase 20,675 acre-feet, or 18 million gallons per day, also from the lake. *Id.* § 3.1.1(b), at 5 (SUPPAR024053). ARC would purchase 45,183 acre-feet of storage, which would allow ARC to withdraw 367 million gallons per day from the Chattahoochee. *Id.* § 3.1.1(c), at 5 (SUPPAR024053). The Corps would calculate a credit to the SeFPC for hydropower benefits foregone, not to exceed the revenues received from the interim contracts. *Id.* § 4.1, at 13 (SUPPAR024061). The agreement also required the Corps to seek Congressional approval to make the interim contracts permanent, unless a court determined that the Corps was not required to secure Congressional approval for the permanent reallocation of storage. *Id.* § 3.1.4(a), at 10 (SUPPAR024058); *see also Se. Fed. Power Customers, Inc. v. Caldera,* 301 F.Supp.2d 26, 33 (D.D.C.2004). The agreement provided for a stay of its provisions pending the Corps's completion of a NEPA review of the contracts. Settlement Agreement § 5.1.1, at 14 (SUPPAR024062).

In October 2003, the *Alabama* court enjoined the filing of the Settlement Agreement in the D.C. case, finding that the Corps had violated the terms of the stay in the *Alabama* case by entering into the Settlement Agreement without first seeking Alabama and Florida's approval. *See Alabama v. U.S. Army Corps. of Eng'rs,* 357 F.Supp.2d 1313, 1316 (N.D.Ala.2005) (quoting 1990 Joint Motion to Stay). The court enjoined the Corps from filing or implementing the Settlement Agreement or entering into any new storage or withdrawal contracts affecting the ACF water basin without court approval. *Id.* at 1320-21. The Corps appealed the decision to the Eleventh Circuit Court of Appeals.

In February 2004, the *Southeastern Federal Power Customers* court approved the Settlement Agreement subject to the condition that the agreement not be implemented until the preliminary injunction in *Alabama* was dissolved. *Se. Fed. Power Customers, Inc. v. Caldera,* 301 F.Supp.2d at 35. The *Alabama* court refused to modify or vacate the preliminary injunction. *Alabama,* 357 F.Supp.2d at 1320.

In September 2005, the Eleventh Circuit Court of Appeals vacated the *Alabama* court's preliminary injunction. *Alabama v. U.S. Army Corps of Eng'rs,* 424 F.3d 1117, 1133-36 (11th Cir. 2005). The *Southeastern Federal Power Customers* court then entered final judgment, declaring the Settlement Agreement valid. Mem. & Order at 16, *Se. Fed. Power Customers, Inc. v. Caldera,*301 F.Supp.2d 26 (D.D.C. 2004). Alabama and Florida appealed that decision to the District of Columbia Circuit Court of Appeals. While the appeal was pending, the D.C. district court stayed the implementation of the Settlement Agreement to allow the Corps to complete the required NEPA processes. Mem. & Order at 1, *Se. Fed. Power Customers, Inc. v. Caldera,* No. 1:00-cv-2975 (D.D.C.

Jan. 20, 2006).

In March 2007, the Judicial Panel on Multidistrict Litigation transferred the *Alabama* and *Georgia* cases and two other related cases (*Florida v. U.S. Fish & Wildlife Serv.,* No. 4:06-410 (N.D. Fla. filed Sept. 6, 2006) and *Georgia v. U.S. Army Corps of Eng'rs,* No. 1:06-1473 (N.D. Ga. filed June 20, 2006) ("*Georgia II* ")) to this Court for resolution. The Panel did not transfer the *Southeastern Federal Power Customers* case, because that case was pending before the Circuit Court of Appeals and such transfers exceed the Panel's authority. Since that time, three more cases have been transferred into the MDL: *City of Columbus, Ga. v. U.S. Army Corps of Eng'rs,* No. 4:07-125 (M.D. Ga. filed Aug. 13, 2007); *City of Apalachicola, Fla. v. U.S. Army Corps of Eng'rs,* No. 4:08-23, 2008 WL 460750 (N.D. Fla. filed Jan. 15, 2008); and finally, after the D.C. Circuit remanded the case to the district court, *Se. Fed. Power Customers, Inc. v. Caldera,* No. 1:00-2975 (D.D.C. filed Dec. 20, 2000).

3. Southeastern Federal Power Customers

As discussed briefly above, the *Southeastern Federal Power Customers* case and the attempted settlement of that case generated a flurry of litigation. Similarly, the D.C. Circuit's decision on the legality of the Settlement Agreement in that case has generated much briefing and argument here. At least according to the parties, this Court's interpretation of and deference to the D.C. Circuit's opinion will dictate the outcome of the pending Motions.

In *Southeastern Federal Power Customers v. Geren,*[18] 514 F.3d 1316 (D.C.Cir. 2008) ("*SeFPC* "), the

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[18] Peter Geren was the Secretary of the Army at the time the

D.C. Circuit Court of Appeals considered whether the Corps exceeded its statutory authority by entering into the Settlement Agreement that required the Corps to reallocate some of the storage in Lake Lanier to water supply. The court held that the reallocation accomplished by the terms of the Settlement Agreement violated the requirements of § 301(d) of the WSA, 43 U.S.C. § 390b(d), because that reallocation was a "major operational change on its face." *Id.* at 1318. The Corps's failure to secure the approval of Congress before entering into the Settlement Agreement required, in the D.C. Circuit's opinion, that the Agreement be set aside. *Id.*

The D.C. Circuit noted that the reallocations required by the Settlement Agreement amounted to more than twenty-two percent of Lake Lanier's total conservation storage of 1,049,400 acre-feet, and was nine percent more than the storage space allocated to water supply in 2002. *Id.* at 1319-20. The court then turned to the statutory requirements for water supply. It noted that the WSA authorizes storage for water supply " 'in any reservoir project surveyed, planned, constructed or to be planned * * * by the Corps of Engineers * * *' so long as the costs of construction or modification are adequately shared by the beneficiaries." *Id.* at 1321 (quoting WSA § 301(b), 72 Stat. at 319 (codified at 43 U.S.C. § 390b(b))). The court quoted WSA § 301(d), which requires that any modification that "would seriously affect the purposes for which the project was authorized, surveyed, planned, or constructed, or which would involve major structural or operational chang-

D.C. Circuit considered the *SeFPC* case. He was preceded in that position by Louis Caldera.

es shall be made only upon the approval of Congress * * *." *Id.* at 1321-22 (quoting WSA § 301(d), 72 Stat. at 320 (codified at 43 U.S.C. § 390b(d))).

Alabama and Florida argued that the Settlement Agreement's reallocations of storage constituted a "major operational change" within the meaning of the WSA. The appellees, who were the Georgia parties, the SeFPC, and the Federal Defendants, argued that the Settlement Agreement was not an operational change but merely preserved the status quo of allowing " 'incremental increases in withdrawal amounts * * *.' " *Id.* at 1322 (quoting Appellees' Br. at 37). The appellees also argued that because the Settlement Agreement provided for temporary contracts of two 10-year periods, the contracts did not require Congressional approval. *Id.*

The D.C. Circuit rejected the appellees' arguments:

> On its face, then, reallocating more than twenty-two percent (22%, approximately 241,000 acre feet) of Lake Lanier's storage capacity to local consumption uses constitutes the type of major operational change referenced by the WSA; the reallocation's limitation to a "temporary" period of twenty years does not change this fact. Even a nine percent (9%, approximately 95,000 acre feet) increase over 2002 levels for twenty years is significant. Appellees' contrary arguments are unpersuasive.

Id. at 1324 (citation omitted). The court also stated that "the appropriate baseline for measuring the impact of the Agreement's reallocation of water storage is zero, which was the amount allocated to storage space for water supply when the lake began operation." *Id.*

The court concluded:

> In other circumstances it is conceivable that the difference between a minor and a major operational change might be an ambiguous matter of degree, where the Court would consider whether [the Corps's] authoritative interpretation should be accorded deference * * * in defining the term "major operational change." But the Agreement's reallocation of over twenty-two percent (22%) of Lake Lanier's storage space does not present that situation. It is large enough to unambiguously constitute the type of major operational change for which section 301(d) of the WSA, 43 U.S.C. § 390b(d), requires prior Congressional approval.

Id. at 1325. The court thus reversed the district court's approval of the Settlement Agreement and remanded the case. Shortly thereafter, the MDL Panel transferred the *Southeastern Federal Power Customers* case into this Tri-State Water Rights litigation.

The administrative record is complete and the parties' Motions for Summary Judgment are fully briefed.[19] The matter is now ripe for the Court's resolution.

DISCUSSION

A. Standard of Review

The Administrative Procedures Act ("APA") waives

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[19] None of the parties addresses any statute of limitations issues in their extensive briefing on these Motions, although some of the contracts Alabama and Florida challenge were first executed in the 1970s. However, due to the "renewing" nature of the contracts and the PAC Report's acknowledgment in 1989 that the Corps was attempting to create a new scheme for the allocation of storage in Lake Lanier, the Court would find that Alabama and Florida's claims are within the statute of limitations in any event.

a government agency's traditional sovereign immunity by providing that "[a] person suffering legal wrong because of agency action, or adversely affected or aggrieved by agency action within the meaning of a relevant statute, is entitled to judicial review thereof." 5 U.S.C. § 702. The statute also proscribes limits to this general rule. First, an agency action must be final to be reviewable: "A preliminary, procedural, or intermediate agency action * * * is subject to review [only] on the review of the final agency action." *Id.* § 704. In addition, relief under the APA is limited: a court may "compel agency action unlawfully withheld or unreasonably delayed," *id.* § 706(1), and may

> hold unlawful and set aside agency action, findings, and conclusions found to be-
>
> (A) arbitrary, capricious, an abuse of discretion, or otherwise not in accordance with law;
>
> (B) contrary to constitutional right, power, privilege or immunity;
>
> (C) in excess of statutory jurisdiction, authority, or limitations, or short of statutory right; [or]
>
> (D) without observance of procedure required by law * * *.

Id. § 706(2).

Because the agency action at issue here requires review of the agency's interpretation of a statute-namely the Corps's determination as to whether the storage reallocations require Congressional approval under the WSA-the Court must engage in a two-step analysis:

> First, * * * is the question whether Congress has directly spoken to the precise question at issue. If the intent of Congress is clear, that is the end of

> the matter; for the court, as well as the agency, must give effect to the unambiguously expressed intent of Congress. If, however, the court determines Congress has not directly addressed the precise question at issue * * * the question for the court is whether the agency's answer is based on a permissible construction of the statute.

Chevron U.S.A, Inc. v. Natural Res. Def. Council, 467 U.S. 837, 842-43, 104 S.Ct. 2778, 81 L.Ed.2d 694 (1984) (footnote call numbers omitted). The Court is not required to set aside the agency's construction merely because the Court's interpretation differs from the agency's. *Id.* at 843 n. 11, 104 S.Ct. 2778. However, the Court, not the agency, "is the final authority on issues of statutory construction and must reject administrative constructions which are contrary to clear congressional intent." *Id.* at 843 n. 9, 104 S.Ct. 2778. Moreover, "a reviewing court 'must reject administrative constructions * * * that are inconsistent with the statutory mandate or that frustrate the policy that Congress sought to implement.' " *Sierra Club v. Johnson,* 541 F.3d 1257, 1265 (11th Cir. 2008) (quoting *Sec. Indus. Ass'n v. Bd. of Governors of Fed. Reserve Sys.,* 468 U.S. 137, 143, 104 S.Ct. 2979, 82 L.Ed.2d 107 (1984)).

The first step in the *Chevron* analysis is to determine Congressional intent using the "traditional tools of statutory construction." *Chevron,* 467 U.S. at 843 n. 9, 104 S.Ct. 2778. "These tools include examination of the text of the statute, its structure, and its stated purpose." *Miami-Dade County v. U.S. Envtl. Prot. Agency,* 529 F.3d 1049, 1063 (11th Cir. 2008). If the examination of Congress's intent does not resolve the matter, the Court then proceeds to the second step, which involves examining the Corps's construction of the statute. That construction is "deemed reasonable if it is not arbitrary, capricious, or clearly contrary to law." *Ala. Power Co. v. Fed. Energy Regulatory Comm'n,* 22 F.3d 270, 272 (11th Cir. 1994) (citing *Chevron,* 467 U.S. at 844, 104 S.Ct. 2778). "Unexplained inconsistency is * * * a reason for holding an interpretation to be an arbitrary and capricious change from agency practice under the [APA]." *Nat'l Cable & Telecomms. Ass'n v. Brand X Internet Servs.,* 545 U.S. 967, 981, 125 S.Ct. 2688, 162 L.Ed.2d 820 (2005)

B. Standing

As they have in nearly every motion brought before this Court and other courts involved in litigating the issues in this case, the Georgia parties contest Alabama and Florida's standing to bring this litigation.[20] *See, e.g., Alabama,* 424 F.3d at 1130 (holding that Alabama and Florida have standing because "Corps management of Lake Lanier that violates federal law may adversely impact the environment and economy downstream in the ACF Basin, thereby injuring Alabama and Florida"); *SeFPC,* 514 F.3d at 1322 (holding that Alabama and Florida have standing to assert "major operational change" because they assert "that the proposed reallocation of water storage will result in 'diminish[ed][ ] flow of water reaching the downstream states' " (quoting Appellant's Br. at 2)).

Standing is both a doctrine reflecting "prudential considerations that are part of judicial self-government" and "an essential and unchanging part of the case-or-controversy requirement of Article III."

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[20] The Corps has not challenged Alabama and Florida's standing.

Lujan v. Defenders of Wildlife, 504 U.S. 555, 560, 112 S.Ct. 2130, 119 L.Ed.2d 351 (1992). The

> irreducible constitutional minimum of standing contains three elements. First, the plaintiff must have suffered an injury in fact-an invasion of a legally protected interest which is (a) concrete and particularized * * * and (b) actual or imminent, not conjectural or hypothetical. Second, there must be a causal connection between the injury and the conduct complained of * * *. Third, it must be likely, as opposed to merely speculative, that the injury will be redressed by a favorable decision.

Id. at 560-61, 112 S.Ct. 2130 (citations and internal quotation marks omitted). "The party invoking federal jurisdiction bears the burden of establishing these elements." *Id.* at 561, 112 S.Ct. 2130. Moreover, at the summary judgment stage, it is a plaintiff's burden to prove that genuine issues of material fact exist as to whether or not plaintiff can prove standing. *See Mize v. Jefferson City Bd. of Educ.,* 93 F.3d 739, 742 (11th Cir. 1996) (concluding that summary judgment is appropriate when " 'there is no genuine issue as to any material fact' ") (quoting Fed.R.Civ.P. 56(c)); *see also Lujan,* 504 U.S. at 561, 112 S.Ct. 2130 (noting that each element of standing must be proved "in the same way as any other matter on which the plaintiff bears the burden of proof, i.e., with the manner and degree of evidence required at the successive stages of the litigation").

The Georgia parties contend that Alabama and Florida cannot establish any injury in fact, as *Lujan* requires. They argue that there is no evidence that the Corps's support of water supply and recreation in Lake Lanier has resulted in any "discernable reduction in flows downstream in Alabama or Florida."

(Ga.'s Mem. in Opp'n to Ala. & Fla.'s Mot. for Partial Summ. J. at 68.) In support of this statement, they cite to an affidavit, a declaration, and a publication that is not part of the administrative record. (*Id.* (citing Ga.'s Mot. for Summ. J. Factual App. at ¶¶ 2.7-2.9).)

On a motion for summary judgment, such evidence might be sufficient to find no genuine issue of fact as to injury if the opposing party had no evidence to support its claimed standing. Such is not the case here. Alabama and Florida have cited declarations stating the opposite of the declarations and affidavits the Georgia parties cite. (Ala. & Fla.'s Reply Mem. in Supp. of Mot. for Partial Summ. J. at 35 (citing Ala. & Fla.'s Factual App. in Supp. of Mot. for Partial Summ. J. ¶¶ 1132-1226).) It is not the province of the Court, on a motion for summary judgment, to weigh the evidence and determine which evidence to credit. *Mize,* 93 F.3d at 742.

Alabama and Florida have come forward with evidence sufficient to support their contention that they have suffered harm because of the Corps's operations in the ACF basin. For example, the Biological Opinion for the Jim Woodruff Dam ("BiOp") notes that the lower flows in the Apalachicola in the spring and summer are likely due to "a combination of climatic differences * * *, higher consumptive uses, as well as reservoir operations." U.S. Fish & Wildlife Serv., *Biological Opinion on the U.S. Army Corps of Engineers, Mobile District, Revised Interim Operating Plan for Jim Woodruff Dam and the Associated Releases to the Apalachicola River* 56 (2008). The BiOp states that low flows "are likely among the most stressful natural events faced by riverine biota." *Id.* at 57. In other words, according to government documents, low flows in the Apalachicola River are at least to some extent caused by the Corps's operations in the ACF basin and consumptive uses of the water in the basin, and those low flows cause harm to the creatures that call the Apalachicola home. According to the evidence to which Alabama and Florida cite, low flows harm not only wildlife, but also harm navigation, recreation, water supply, water quality, and industrial and power uses downstream. Even if annually the average flows are reduced by only a small amount, as the Georgia parties argue, the actual variation in flows can wreak havoc on the downstream uses of the water.

Alabama and Florida have standing to bring their claims. Georgia's Motion on this point is denied.

C. Effect of D.C. Circuit's decision in *SeFPC*

Alabama, Florida, and the SeFPC urge this Court to find that the Corps and the Georgia parties are bound under the doctrine of collateral estoppel by the decision of the D.C. Circuit Court of Appeals in *SeFPC*. In that case, the Court of Appeals held that a reallocation of the magnitude contemplated by the invalidated Settlement Agreement constitutes a major operational change on its face. *SeFPC,* 514 F.3d at 1318. Not surprisingly, the Georgia parties and the Corps contend that the D.C. Circuit's holding in *SeFPC* does not address many of the issues presented by this case, determining conclusively only that the Settlement Agreement was invalid under the WSA. The Georgia parties in particular contend that the D.C. Circuit limited its holding to a determination of the reallocation's legality under the WSA and did not discuss what the Georgia parties believe is the authority provided by other federal statutes in combination with the WSA for the reallocation Georgia requests.

The law governing issue preclusion is well settled:

> The doctrine of collateral estoppel [issue preclusion] bars relitigation of an issue if three requirements are met:
>
> (1) that the issue at stake [is] identical to the one involved in the prior litigation;
>
> (2) that the issue [was] actually litigated in the prior litigation; and
>
> (3) that the determination of the issue in the prior litigation [was] a critical and necessary part of the judgment in that earlier action.

In re Held, 734 F.2d 628, 629 (11th Cir. 1984). The Court has previously determined that Florida and Alabama could not relitigate here their claims that the Settlement Agreement in *Southeastern Federal Power Customers* was invalid. (Mem. & Order 8, October 22, 2007.) Thus, the *SeFPC* court's holding that the Settlement Agreement is invalid is binding on all parties to this litigation.

However, Alabama and Florida do not limit their contentions to the validity of the Settlement Agreement. They argue that all of the following determinations from *SeFPC* are binding in this litigation:

1. No storage for water supply has ever been allocated by Congress at Lake Lanier.

2. The correct "baseline" for measuring the Corps's proposed and "de facto" reallocations is zero.

3. To determine whether the proposed and "de facto" reallocations constitute major operational change, the Court must evaluate the percentage of conservation storage reallocated.

4. To calculate the percentage of storage reallocated, the Court must compare the amount of reallocated storage to the total conservation storage.

5. The WSA applies to both interim and permanent reallocations of storage.

6. As of 2002, approximately thirteen percent of Lake Lanier's conservation storage was allocated to water supply.

7. The Corps has never reallocated 95,000 acre-feet or more in a federal reservoir without seeking Congressional approval.

8. A reallocation of twenty-two percent of Lake Lanier's conservation storage is a major operational change on its face.

The D.C. Circuit stated all of these things in its opinion in *SeFPC*. However, it is not the case that all of these statements were "critical" and "necessary" parts of the judgment in *SeFPC*. Indeed, only two conclusions were necessary to the holding in *SeFPC* that the Settlement Agreement was invalid. First, the D.C. Circuit concluded that the WSA applied to interim reallocations of storage. *SeFPC,* 514 F.3d at 1324-25 ("[I]t is unreasonable to believe that Congress intended to deny the Corps authority to make major operational changes without its assent, yet meant for the Corps to be able to use a loophole to allow these changes as long as they are limited to specific time frames, which could theoretically span an infinite period."). Without this conclusion, the court could not have determined that the Settlement Agreement violated the WSA, because the Settlement Agreement involved temporary reallocations of storage for water supply.

The second conclusion that was critical and necessary to the *SeFPC* holding is that a reallocation of twenty-two percent of Lake Lanier's total conservation storage is a major operational change on its face. *Id.* at 1324. This conclusion is the underpinning of the judgment in *SeFPC* that the Settlement Agreement is invalid under the WSA.

The remaining determinations are not, however, binding on the parties or on this Court. This is not to say that the D.C. Circuit's comments about the appropriate "baseline" for evaluating storage reallocations and its calculations regarding storage reallocations are not persuasive authority, for those comments certainly are persuasive. This Court will not, however, blindly accept the *SeFPC* court's conclusions; instead, the Court will make its own determination of the evidence and how that evidence affects the legal decisions to be made here.

D. The Water Supply Act of 1958

In 1989, the Corps decided that the WSA did not require it to seek Congressional authorization for the reallocation of significant amounts of Lake Lanier's storage to water supply. Under the APA and *Chevron,* this Court must determine whether that decision was arbitrary and capricious. To make that determination, the Court must first examine the statute itself to determine whether Congress has spoken to the precise question at issue before the Court: whether the reallocations undertaken prior to and those proposed by the PAC Report or Georgia's 2000 water supply request constituted a major operational change or seriously affected the purposes for which the Buford Dam was authorized.

The WSA provides in relevant part:

(a) Declaration of policy

> It is * * * declared to be the policy of the Congress to recognize the primary responsibilities of the States and local interests in developing water supplies for domestic, municipal, industrial, and other purposes and that the Federal Government should participate and cooperate with States and local interests in developing such water supplies in connection with the construction, maintenance, and operation of Federal navigation, flood control, irrigation, or multiple purpose projects.

WSA § 301(a), 72 Stat. at 319 (codified at 43 U.S.C. § 390b(a)).

> In carrying out the policy set forth in this section, it is * * * provided that storage may be included in any reservoir project surveyed, planned, constructed or to be planned, surveyed, and/or constructed by the Corps of Engineers or the Bureau of Reclamation to impound water for present or anticipated future demand or need for municipal or industrial water, * * *. *Provided,* That the cost of any construction or modification authorized under the provisions of this section shall be determined on the basis that all authorized purposes served by the project shall share equitably in the benefits of multiple purpose construction * * *.

Id. § 301(b), 72 Stat. at 319 (codified at 43 U.S.C. § 390b(b) (emphasis in original)).

> Modifications of a reservoir project heretofore authorized, surveyed, planned, or constructed to include storage [for water supply] which would seriously affect the purposes for which the project was authorized, surveyed, planned, or constructed, or which would involve major structural or operational changes shall be made only upon the approval of

Congress * * *.

Id. § 301(d), 72 Stat. at 320 (codified at 43 U.S.C. § 390b(d)).

Thus, the WSA provides that the Corps may set aside storage for water supply in a previously constructed reservoir as long as (1) the beneficiaries of that storage pay a proportionate share of the costs of the project, and (2) the modification does not seriously affect the project's purposes or constitute a major structural or operational change. There can be no debate that the water-supply users have not paid a proportionate share of the project's costs, although the record is less clear whether they would be willing to do so were the Court to find that Congressional approval for the requested storage reallocations was not required. The Court will assume for the purposes of the instant Motions that the beneficiaries of the proposed and "de facto" reallocations would pay a proportionate share of the cost of the Buford project.

1. Authorized Project Purposes

The WSA inquiry is academic if water supply was an authorized project purpose of the Buford project, either from the initiation of the project or made so by Congress at some point after the project began. The Georgia parties contend that water supply was always a purpose of the Buford project, as evidenced by the sign at an observation point above Lake Lanier, reproduced on the first page of nearly every one of the Georgia parties' briefs. This sign states that the "PRIMARY PURPOSES" of Buford Dam are "FLOOD CONTROL-POWER-WATER SUPPLY-INCREASED FLOW FOR NAVIGATION." (Ga.'s Mem. in Supp. of Summ. J. at 1 (SUPPAR005533).) This sign, however, is not authoritative legislative history, and it is legislative history that the Court must examine to determine whether water supply, in the form of large withdrawals from Lake Lanier itself, was an authorized project purpose.

The legislative history of the Buford project is set forth in detail above and will not be repeated here. It is worth noting that, both before and during construction of Buford Dam, the Corps consistently described the primary purposes of the project as flood control, navigation, and hydropower. *See, e.g.,* F.G. Turner, Ass't Chief, Eng'g Div., *Report on Withdrawal of Domestic Water Supply from Buford Reservoir* ¶ 2, at 1 (1955) (SUPPAR005459) (Corps told Gwinnett County that "the primary authorized purposes of the Buford project were flood control, power and low-flow regulation for navigation and other purposes"); 1958 Manual ¶ 85, at 27 (ACF001677) (describing Buford Dam as "a multiple-purpose project with major uses of flood control, flow regulation for navigation, and power"); U.S. Army Corps of Eng'rs, *Cost Allocation Studies, Apalachicola, Chattahoochee and Flint Rivers Projects, Basis of All Allocations of Costs for Buford and Jim Woodruff Projects Adopted by the Chief of Engineers,* app. A, at A-9 (1959) (ACF002116) (allocating costs to the "primary purposes of the Buford project": navigation, flood control, and power). Others also recognized that the purposes of the project did not include water supply. *See, e.g., Civil Functions, Dep't of the Army Appropriation Bill for 1949: Hearing on H.R. 5524 Before the Subcomm. of the H. Comm. on Appropriations,* 80th Cong. 723 (1948) (statement of Rep. Stephen Pace, Georgia) (SUPPAR026606) (describing the ACF projects as having three purposes: navigation, power, and flood control); *Civil Functions, Dep't of the Army, Appro-*

priations, 1953: Hearings on H.R. 7268 Before the Subcomm. of the H. Comm. on Appropriations, 82d Cong. 1196-97 (1952) (statement of Rep. Davis, Georgia) (SUPPAR026679-80) (describing the project as providing flood control, power, and navigation benefits); *Public Works Appropriations for 1957: Hearings Before the Subcomm. of the H. Comm. on Appropriations,* 84th Cong. 355-57 (1956) (statement of Rep. James Davis, Georgia) (SUPPAR026720-22) (discussing flood control, navigation, and power benefits); *Proposed Water Resources Development Projects of the U.S. Army Corps of Eng'rs: Hearings Before the Subcomm. on Water Resources of the H. Comm. on Public Works and Transp.,* 97th Cong. 3251 (1982) (Letter from W.T. Bush, Co-Chairman, Metro Atlanta Water Managers Assoc., Gwinnett County Water & Sewerage Auth., to Sen. Sam Nunn, Ga., at 1 (Aug. 21, 1980) (water supply "not specifically authorized as a purpose" of the Buford project)) (SUPPAR001491).

In the decades after Buford Dam was completed, the Corps continued to describe the project's purposes as hydropower, flood control, and navigation. *See, e.g., Final EIS* Statement of Findings (1974) (ACF004338) (Buford Dam's "[a]uthorized project purposes provide peaking hydroelectric power, flood control, and low flow augmentation"); *Drought Contingency Report, Apalachicola, Chattahoochee, and Flint Rivers (A-C-F), Florida and Georgia* ¶ 4, at 1-2, *in* U.S. Army Corps of Eng'rs, *Drought Contingency Plan, Apalachicola, Chattahoochee, and Flint Rivers* (1982) (ACF008241-42) (stating that costs at Buford project "have been allocated between the three legislatively authorized purposes" of flood control, navigation, and hydropower).

There is also no doubt that both Congress and the Corps anticipated some benefits to water supply from the project. *See, e.g.,* Park Report ¶ 243, at 77 (ACF000160) (describing water supply as "direct benefit" but ascribing no monetary value to water supply benefit); Newman Report ¶ 68, at 27 (ACF000661) (noting that water supply was "incidental benefit[ ]" of Buford project); Definite Project Report ¶ 115, at 41 (ACF001486) (describing project's "principle purposes" as: "to provide flood control; to generate hydroelectric power; to increase the flow for open-river navigation in the Apalachicola River below Jim Woodruff dam; and to assure a sufficient and increased water supply for Atlanta"). As discussed previously, however, the water supply benefit was not from storage for water supply provided by Lake Lanier. Rather, the water supply benefit derived from the regulation of the Chattahoochee River's flow provided by the dam and the releases for hydropower. *Civil Functions, Dep't of the Army, Appropriations for 1952: Hearings Before the Subcomm. of the H. Comm. on Appropriations,* 82d Cong. 120, 121-22 (1951) (statement of Col. Potter, Corps officer) (SUPPAR026656, SUPPAR026657-58) ("[The Buford project does not] furnish [ ] water directly or furnish[ ] storage for that purpose * * *. [Water supply is] an adjunct to the power supply and flood control. Had we put in some storage purely for water supply, which they would tell us to release at certain intervals, we would then charge them for it."); *Civil Functions, Dep't of the Army Appropriations for 1954: Hearings on H.R. 5376 Before the Subcomm. of the H. Comm. on Appropriations,* 83d Cong. 503 (1953) (statement of Gen. Chorpening, Corps officer) (SUPPAR026688) ("[The project] will not make available any more water than is now going past Atlanta. It is only going to make it flow by at a more uniform rate."); *Civil Functions, Dep't of the Army Appropriations, 1955: Hearings on H.R. 8367 Before the Subcomm. of the S. Comm. on Appropriations,* 83d Cong. 325 (1954) (statement of Col. Whipple, Corps officer) (SUPPAR026699) (stating that water supply "is purely an incidental benefit on account of the power releases which does not require any storage to be devoted to that purpose").

Indeed, from 1955, when the Corps told Gwinnett County that Congressional authorization would be required to accommodate the county's water-supply request, until at least 1988, when the PAC Report sought Congressional approval for the reallocation of storage in Lake Lanier to water supply, the Corps recognized that allowing water-supply withdrawals from the lake was not an authorized purpose of the project and would require Congress's approval. Even in 2002, long after this litigation began, Earl Stockdale, the Corps's Deputy General Counsel, concluded that Georgia's 2000 water-supply request "would result in serious impacts on other project purposes" so that the Corps could not grant that request "absent legislative authority." Memorandum from Earl Stockale, Deputy General Counsel, Civil Works & Env't, to Acting Ass't Sec'y of the Army for Civil Works 2 (Apr. 15, 2002) [hereinafter "2002 Stockdale Memorandum"] (ACF036355). The 2002 Stockdale Memorandum determined that, even if water supply was a specifically authorized project purpose, the Corps would still lack the authority to grant Georgia's request without Congressional approval because the Corps did not "have the authority to reorder specifically authorized project purposes without additional Congressional authorization." *Id.* at 13 (ACF036367); *see also* Memorandum from E. Manning Seltzer, General Counsel, U.S. Army Corps of Eng'rs, to Special Assistant to Sec'y of the Army for Civil Functions ¶ 4, at 2 (Jan. 21, 1969) (SUPPAR001361) ("[T]he discretionary authority given the Chief of Engineers to make post-authorization changes in projects extends only to what might be termed engineering changes * * * [such as] minor variations in the allocation of storage for the various project purposes * * *.").

At some point between the 2002 Stockdale Memorandum and the present Motion, the Corps changed its mind on this important issue. Attached to the Corps's brief in this matter is a new memorandum from Mr. Stockdale which concludes that the Corps does have the authority to reallocate storage in Lake Lanier to water supply and that Congressional authorization is not required. Memorandum from Earl Stockdale, Chief Counsel, to the Chief of Engineers (Jan. 9, 2009) [hereinafter "2009 Stockdale Memorandum"]. The 2009 Stockdale Memorandum is not part of the administrative record in the case, but the Corps urges the Court to accept the memorandum as part of that record, because it allegedly is an "extra-record document that helps explain complex facts provided in the administrative record and helps explain the Corps' past and present legal interpretation of its governing statutes and regulations." (Corps's Mem. Supp. Mot. for Summ. J. at 3 n.4.) As stated at the hearing on these Motions, however, the Court will not make the 2009 Stockdale Memorandum part of the administrative record in this case. It does not shed any light on the Corps's decisionmaking with respect to the actions challenged here. Nor does the memorandum explain any complex facts that the Court is unable to understand without such assistance. Moreover, the memorandum is clearly a document prepared for litigation purposes only; large sections of the memorandum appear verbatim in the Corps's brief with no attribution. The 2009 Stockdale Memorandum does little more than justify the Corps's current legal position. The merits of that position are for the Court, not the Corps, to decide.

Having thoroughly reviewed the legislative history and the record, the Court comes to the inescapable conclusion that water supply, at least in the form of withdrawals from Lake Lanier, is not an authorized purpose of the Buford project. Therefore, if the Corps's actions to support water supply constitute "major structural or operational changes" or "seriously affect" the project's authorized purposes, the Corps was required to seek Congressional approval for those actions and its failure to do so renders the actions illegal. WSA § 301(d), 72 Stat. at 320 (codified at 43 U.S.C. § 390b(d)).

2. Major Operational Change

The Corps's actions to support water supply in Lake Lanier have taken the form of reallocations of the lake's storage capacity to water supply. In other words, by committing to allow municipal entities to withdraw a certain amount of water from Lake Lanier, the Corps has either explicitly or effectively allocated some of Lake Lanier's storage to those withdrawals. Because water supply is not an authorized purpose of Lake Lanier, if any of these reallocations constitute a major structural or operational change or seriously affect the purposes for which the project was authorized, the Corps must seek Congressional approval for the reallocations.

Alabama, Florida, and the SeFPC challenge several of the Corps's water-supply reallocations. The first are what Alabama and Florida call "de facto" reallocations. Prior to the initiation of this lawsuit in 1990, the Corps had entered into water-supply contracts with several Georgia entities: ARC, Gwinnett County, Gainesville, Buford, and Cumming. While all of these contracts expired in 1989 or 1990, there is no dispute that the Corps continues to allow these entities to withdraw water pursuant to the contracts today. In fact, the amount of water these entities presently withdraw far exceeds the amount they were entitled to under the so-called "holdover" contracts. With the exception of the withdrawal amounts approved by Congress in the 1950s, Alabama and Florida contend that all of the "holdover" contracts require an illegal reallocation of storage to water supply. The Corps maintains that these contracts were interim only and that no permanent reallocations were intended or accomplished under the pre-1990 contracts. However, the Corps is bound by the D.C. Circuit's determination in *SeFPC* that interim contracts are subject to the strictures of the WSA. Thus, the "de facto" reallocations accomplished by the "holdover" contracts must be evaluated under the WSA.

The PAC Report endeavored to make permanent these "de facto" reallocations and some additional reallocations of storage. The PAC Report's reallocations are the second type of reallocations at issue.

The final reallocations that must be evaluated under the WSA are the reallocations requested by Georgia in the 2000 water-supply request. These reallocations are the largest of the three reallocations at issue. Thus, if the Court determines that either the "de facto" reallocations or the PAC Report's reallocations violate the WSA, then the water-supply request's reallocations likewise violate the WSA.

a. "De facto" reallocations

Starting in the early 1970s, the Corps began allowing municipalities surrounding Lake Lanier to withdraw water directly from the lake. Two of these municipalities, Buford and Gainesville, had a preexisting right to withdraw some water from the lake because their previous water intake structures on the Chattahoochee River were inundated by Lake Lanier. The Corps recognized that it could not unilaterally determine that the remaining municipalities were allowed to withdraw large amounts of water from the lake, and thus characterized the various contracts as "interim." For example, the Corps told Gwinnett County in 1973 that it could withdraw water from the reservoir, pending the completion of the MAAWRMS and the changes in the project that the Corps expected to result from that study.

By 1990, contracts were in place for reallocations that would allow 85 million gallons per day to be withdrawn from Lake Lanier and 50 million gallons per day to be withdrawn from the Chattahoochee River.[21] In 2006, the average daily withdrawals from the lake totaled 141 million gallons per day. Report, Water Withdrawals-Lake Sidney Lanier (Buford

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[21] ARC's contract with the Corps provided for 50 million gallons per day in addition to what the Corps considered the "incidental benefit" from releases for power of 327 million gallons per day. As discussed *infra,* the Corps's conclusion that 327 million gallons per day is available incidentally to power operations is not supported by the record.

Reservoir), Georgia-Chattahoochee River-ACF Basin 1-8 (no date) (ACF044236-43). The ARC's average daily withdrawal was 316 million gallons per day.[22] *Id.* at 9.

Under normal operations, the contracted-for withdrawal amounts equal approximately 86,200 acre-feet of storage for the lake withdrawals, and approximately 50,700 acre-feet for the excess river withdrawals. (*See supra* n. 14.) In 2006, the actual withdrawals required 143,000 acre-feet of storage for the withdrawals from the lake. Although the ARC did not require the additional 50 million gallons per day in its contract with the Corps, by virtue of the Corps's commitment to provide that amount (should ARC need it), the additional 50 million gallons per day, or 50,700 acre-feet, were nevertheless held in water-supply storage and were unavailable for other uses. Thus, the average daily total amount of storage in Lake Lanier dedicated to water supply was 193,700 acre-feet under normal conditions, or 18.5% of Lake Lanier's conservation storage of 1,049,400 acre-feet. If the Corps's "critical yield" calculations are used, however, the amount of storage dedicated

[22] The Georgia parties argue that the Court must take into account return flows, which are water the municipal entities return to the lake and the river in the form of highly treated wastewater. According to the Georgia parties, "[o]mitting return flows is a major omission, and error, because storage utilization is a function of net, and not gross, withdrawals of water." (Ga.'s Mem. in Opp'n to SeFPC's Mot. at 41.) However, none of the municipal entities is required to return any water to Lake Lanier or the Chattahoochee River, but the Corps is required by the various water-supply contracts to allow the entities to withdraw a certain amount of water from the lake and river. The Court must evaluate the Corps's obligations, independent of any voluntary return flows, because regardless of the return flows the Corps's obligations remain the same.

to water supply rises to an average of slightly more than 208,800 acre-feet. The Corps generally calculates storage requirements using critical yield, as opposed to normal operations. *PAC Report,* app. C, at C-1 (ACF041299) (stating that to determine storage-yield relationship, the Corps selects a severe drought period "during which the project will be expected to provide a 'firm' yield"); *see also* Steven R. Cone, Team Leader, Planning & Pol'y Div., U.S. Army Corps of Eng'rs, *Summary of "Technical Data" on Impacts of GA Request for WS at Lake Lanier* ¶ 1 (2002), *in* 2002 Stockdale Memorandum, enclosure (SUPPAR005092) (using "critical period" yield for storage calculations).

According to the Corps's storage calculation method, the reallocation accomplished by virtue of the "holdover" contracts is 208,100 acre-feet, or 19.8% of Lake Lanier's conservation storage. This calculation assumes that 327 million gallons per day in the ARC's river withdrawals are indeed "incidental" to the power operations at the dam, a point that the parties vigorously dispute. It also assumes that the "baseline" for operations in Lake Lanier is zero storage for water supply. The D.C. Circuit concluded that zero storage was the correct baseline but, as discussed above, neither the Court nor the parties are bound by that conclusion.

The base of operations at Buford Dam was to provide 600 cfs of flow past Atlanta and to allow Buford and Gainesville to withdraw a total of 10 million gallons per day from Lake Lanier. *1958 Manual* app. B, at B-13 (ACF001796) (providing for flows of 600 cfs to Atlanta). In 1975, the Corps, Atlanta, and Georgia Power Company agreed that "existing practices" allowed an average annual downstream withdrawal of 230 million gallons per day. (Corps's Mem. Supp. Mot. Summ. J. at 31) (citing Letter from Edwin C. Keiser, Col., U.S. Army Corps of Eng'rs, to Leonard Ledbetter, Dir., Ga. Dep't of Natural Res. (July 21, 1975) (SUPPAR036976-77).) In 1979, the same parties determined that "an annual average of 266 million gallons per day * * * could be withdrawn from flows that occur incidentally as a result of project operations." (*Id.* at 47 n. 34 (referencing the 1979 Modified Interim Plan, described in MAAWRMS at 8 (ACF015500), but not included in the administrative record).)[23] Withdrawals of 266 million gallons per day would, however, require operational changes. (*Id.* at 32 (citing Letter from Kenneth E. McIntyre, Brigadier Gen., U.S. Army Corps of Eng'rs, to Leonard Ledbetter, Dir., Ga. Envt'l Protection Div. (Apr. 27, 1979) (SUPPAR036997-37002)).)

Thus, the Corps determined in 1975 that the "baseline" for operations was 230 million gallons per day downstream, plus the 10 million gallons per day Gainesville and Buford were Congressionally authorized to withdraw from the lake. This "baseline"

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[23] In 1986, the Corps revised this number to the 327 million gallons per day figure it uses today. There is no explanation in the record as to how the incidental benefits of regular power operations at the dam would increase from 230 million gallons per day in 1975 to 327 million gallons per day in 1986. Even the Corps appears to recognize that 327 million gallons per day is at best an estimate, stating that it "expects that further analysis * * * would validate the Corps' 1986 determination that up to 327 mgd could be provided on an annual average basis from flows that occur incidentally as a result of project operations." *Id.* at 47 n. 34. The Court must rely on the data that is supported by the record, however, not data that the Corps expects, at some point in the future, to be borne out by "further analysis."

amounted to slightly less than 224,700 acre-feet of storage, using the 1734 cfs yield figure. The 1979 baseline of 266 million gallons per day for downstream withdrawals required storage of almost 258,400 acre-feet. In 2006, the Corps allowed an average of 141 million gallons of water to be withdrawn daily from the lake, and committed to 377 million gallons per day for the ARC's use downstream. *See* Report, Water Withdrawals-Lake Sidney Lanier (Buford Reservoir), Georgia-Chattahoochee River-ACF Basin 1-9 (Corps document listing total withdrawals from 1987 through September 2007) (ACF044236-44). These commitments amount to almost 485,000 acre-feet of storage using the 1734 cfs yield (and 566,300 acre-feet using the more current 1485 cfs yield figure). This is 226,600 acre-feet more than the "base" operations the Corps described in 1979 and 260,300 acre-feet more than the 1975 base operations.[24] Whichever baseline is used, the difference is more than 21.5% of Lake Lanier's total conservation storage. Thus, without any Congressional authorization, the Corps has reallocated nearly a quarter of Lake Lanier's conservation storage to support water supply.

That this reallocation is a major operational change

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[24] Adding the 11,200 acre-feet Congress allocated to Gwinnett County in 1956 increases the 1975 baseline to 235,900 acre-feet, and the 1979 baseline to 269,600 acre-feet. As noted above, however, Gwinnett County did not begin to withdraw water from Lake Lanier until sometime in the 1970s, pursuant to contracts that did not purport to be based on the 1956 legislation and which allowed far greater withdrawals than Congress envisioned. The inclusion of Gwinnett County's original authorization does not, however, significantly change any of the Court's calculations. Moreover, Gwinnett County's Congressionally authorized use of 11,200 acre-feet of storage expired in 2006.

is self-evident. The D.C. Circuit held that a reallocation of twenty-two percent of Lake Lanier's conservation storage was a major operational change "on its face" and, as discussed previously, the parties are bound by this holding. The WSA requires the Corps to seek Congress's authorization before effecting any major changes to project purposes. The Corps failed to do so and thus the so-called "de facto" reallocations violate the WSA.

b. PAC Report

The PAC Report recommended that Congress approve a reallocation of 207,000 acre-feet of storage in Lake Lanier to support water supply. *PAC Report* at 12 (ACF041176). Under the Corps's calculations, this amounts to 19.7% of the total conservation storage in Lake Lanier.

The PAC Report assumed that by 2010, water-supply withdrawals from Lake Lanier would reach 151 million gallons per day. *Id.* app. C, at C-2 (ACF041300). The projected downstream needs were 378 million gallons per day. *Id.* Using a "firm yield" figure of 1734 cfs from the 1939-1942 drought,[25] 151 million gallons per day of lake withdrawals requires 141,700 acre-feet of storage. *Id.*[26]

To calculate the storage required for downstream withdrawals, the Corps assumed that 200 million gallons per day were available for withdrawal down-

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[25] The Corps recognized that the 1986-1988 drought would likely result in a lower "firm yield" than the 1939 drought, and estimated that the new yield figure would be 1455 cfs. *Id.* Actual yield from the 1986 drought has been set at 1485 cfs. *See supra* n. 14.

[26] The Court's own calculation of the storage required for 151 million gallons per day yields a slightly different figure of 141,370 acre-feet.

stream during the 66-hour off-peak (weekend) generation period, as a result of the smaller turbine's releases of 600 cfs during this period. The Corps calculated that the storage necessary to accommodate the extra 178 million gallons per day, or 275 cfs, necessary for downstream water supply during this off-peak period was 65,225 acre-feet. *Id.* app. C., at C-4 (ACF041302). To achieve this number, the Corps did not perform the usual calculation.[27] Rather, the Corps assumed that 378 million gallons per day could be accommodated by existing operations during peak generation periods. According to the Corps, the only withdrawal that would require a reallocation of storage was the 178 million gallons per day in non-incidental withdrawals that occurred during the off-peak generation period of 66 hours, or 2.75 days. Thus, the Corps multiplied the cfs required for 178 million gallons per day (calculated as 178 x 1.547) by 2.75 to give a "dsf" figure.[28] The dsf were then divided by 7 days to give a daily cfs rate of 108 cfs. The Corps then performed the usual calculation (108/1734 x 1,049,400) to determine that 178 million gallons per day of off-peak withdrawals would require storage of only 65,225 acre-feet.

The assumption that 378 million gallons per day is available downstream as incidental to the peak operation of the dam is, however, far greater than any assumption the Corps has ever made regarding "incidental" operation of the project. If 378 million gallons per day is "incidentally" available for 4.25 days every week, with 200 million gallons per day

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[27] The usual storage calculation would have been 178 mgd x 1.547 cfs/1734 x 1,049,400. Under this formula, 178 million gallons per day requires 166,600 acre-feet of storage.

[28] The Corps nowhere defines this term.

available for 2.75 days, the average daily "incidental" benefit is more than 308 million gallons per day, which is 68 million gallons per day more than the 1975 "baseline" average and 42 million gallons per day more than the Corps's 1979 assumptions. The Corps does not explain this large discrepancy.

Using instead the "baseline" average of 230 million gallons per day available incidentally to downstream users, the PAC Report's reallocations are much greater. To accommodate the projected need of 378 million gallons per day minus the incidentally available 230 million gallons per day would require an average of 148 million gallons per day, or 138,500 acre-feet of storage using the 1734 cfs yield figure. Using the more recent critical yield figure of 1485 cfs, the PAC Report's reallocations for downstream use is almost 161,800 acre-feet. When added to the acknowledged 141,000 acre-feet necessary to support in-lake withdrawals, the total reallocation requested by the PAC Report is 279,500 acre-feet, or 302,800 acre-feet using current yield figures. The percent of storage reallocated under the PAC Report is 26.6% to almost 28.8% of Lake Lanier's total conservation storage.

Whether the Court uses the Corps's calculations of a 19.7% reallocation or its own calculations, however, is of no moment to the WSA analysis. As the Corps itself acknowledged when sending the PAC Report to Georgia's Senator Nunn, the reallocations recommended by the PAC Report would require Congressional authorization under the WSA. Letter from Louis J. Martinez, Lt. Col., U.S. Army Corps of Eng'rs, to Sen. Sam Nunn, Ga., at 2 (Dec. 29, 1989) (SUPPAR011719). Before the Corps can implement any of the recommendations in the PAC Report, it must secure Congress's approval to do so.

c. Georgia's 2000 Water-Supply Request

In May 2000, Georgia Governor Roy E. Barnes sent a formal request to the Corps to allow withdrawals from Lake Lanier of up to 297 million gallons per day by 2030, and to provide sufficient releases from the dam to allow downstream withdrawals of 408 million gallons per day by 2030. Letter from Roy E. Barns, Governor, Ga., to Joseph W. Westphal, Asst. Sec'y of the Army for Civil Works, at 1 (May 16, 2000) (ACF042582). The Corps denied the request, stating that the requested withdrawals would require a reallocation of 370,930 acre-feet of storage, or more than thirty-four percent of the total conservation storage in Lake Lanier.[29] 2002 Stockdale Memorandum at 9 (SUPPAR001050).

Given that the D.C. Circuit in *SeFPC* determined that a reallocation of twenty-two percent of Lake Lanier's conservation storage was a major operational change that required Congressional approval, there can be no doubt that Georgia's request to reallocate thirty-four percent of Lake Lanier's con-

[29] The 2002 Stockdale Memorandum stated that the total conservation storage in Lake Lanier is 1,087,600 acre-feet. 2002 Stockdale Memorandum at 8 (SUPPAR001049). The Corps uses this figure throughout its briefing on the instant Motions. From the time of Buford Dam's construction, the Corps has calculated the conservation storage as 1,049,400 acre-feet. It appears that the 1,087,600 acre-feet figure is in fact a seasonal variation-during the summer months the Corps increases the conservation pool from elevation 1070 to 1071. *See Apalachicola Basin Reservoir Regulation Manual* app. B, at B4-1(ACF018475). Because the larger storage amount is a short-term variation from the usual conservation storage figure, the Court has used the well-documented, historical storage amount in its calculations. However, the use of the larger storage amount would not significantly change the calculations.

servation storage likewise requires Congressional authorization.

3. "Seriously Affect" Project Purposes

The Corps contends that any storage reallocation to accommodate existing water-supply needs will have an insignificant impact on the project's authorized purposes of hydropower generation and downstream navigation. According to the Corps, the reallocations will cause only a one percent reduction in hydropower generation. (Corps's Mem. Supp. Mot. Summ. J. at 60.) However, as discussed above, the Corps's calculations of the storage required to meet current needs are suspect: according to the Corps, existing needs require only 122,714 acre-feet of storage for in-lake withdrawals and no storage for downstream withdrawals, because those withdrawals are within the 327 million gallons per day of alleged incidental benefit from operation of the dam. The Corps uses the wrong baseline, however, assuming not only that 327 million gallons per day are available downstream, but also assuming that the "baseline" for in-lake withdrawals is considerably higher than the 10 million gallons per day allowed by the 1950s contracts.

As noted above in footnote 23, the Corps determined in 1986 that 327 million gallons per day were available incidental to hydropower generation at Buford Dam. The Corps's conclusion was not, however, that more water was somehow going through the turbines to allow for the increased downstream withdrawals. Rather, the Corps determined that allowing downstream withdrawals of 327 million gallons per day would not seriously affect the hydropower benefits. In other words, the Corps determined in 1986 that 327 million gallons per day for downstream withdrawals was "the point at which the Lake Lanier project authority ends." (Corps's Mem. Supp. Mot. Summ. J. at 33.) Because the Corps has not sufficiently supported its conclusions with respect to the 327 million gallons per day figure, the Court has used an earlier Corps determination that 230 million gallons per day is available as truly incidental to power generation at the dam.

Not only has the Corps failed sufficiently to support the 327 million gallons per day figure, but its incremental increases of the alleged water-supply benefit incidental to hydropower illustrate a fundamental problem with the Corps's arguments regarding when its authority under the WSA ends. To take the Corps's arguments to their logical conclusion, the Corps may allow small changes in operations year after year, without seeking any Congressional approval for those changes. Thus, if hydropower is affected only one percent this year, another one percent next year, and so on, the Corps would argue that no Congressional authorization is required. But if the cumulative effect on hydropower throughout the years adds up to twenty percent, then the question becomes at what point Congress must be consulted. As the D.C. Circuit stated, "it is unreasonable to believe that Congress intended to deny the Corps authority to make major operation changes without its assent, yet meant for the Corps to be able to use a loophole to allow these changes" to occur incrementally, rather than all at once. *SeFPC,* 514 F.3d at 1324-25. The Court must evaluate the cumulative effect of all of the changes in operations at Lake Lanier. In doing so, the Court has determined that 327 million gallons per day are not available as incidental to the operations of Buford Dam as Congress, the Corps, and the hydropower interests envisioned. Rather, as the Corps determined in 1975, 230 million gallons per day are available as a result of the normal operation of the Buford Dam.

In the original Cost Allocation Studies for the Buford project, the Corps computed the available power benefits from Buford Dam as 170,000,000 kilowatt hours ("kwh"), or 170,000 megawatt hours ("mwh"). U.S. Army Corps of Eng'rs, *Cost Allocation Studies, Apalachicola, Chattahoochee and Flint Rivers Projects, Basis of All Allocations of Costs for Buford and Jim Woodruff Projects Adopted by the Chief of Engineers* 19 (1959) (ACF002101). According to the SeFPC, one way the harm to hydropower can be calculated is by comparing the actual annual generation to the benefits the Corps believed would be available from the project. Only four times since 1994 has the Buford Dam generated 170,000 mwh or more; and in five different years, power generation has fallen below 100,000 mwh. According to the SeFPC, the total value of the loss of hydropower benefits at Buford Dam is more than 60,000 mwh, which is worth $59 million. Now the Corps and the Georgia parties take issue with the SeFPC's calculation of its damages. However, in the 2002 Stockdale Memorandum the Corps stated that the expected loss of hydropower benefits from the reallocations Georgia requested were more than 95 mwh per day, or a $3 million annual reduction in benefits. 2002 Stockdale Memorandum at 9 (SUPPAR001050).

Another way to look at the harm to hydropower is in the change from peak operations to non-peak operations. From the beginning of the Buford project, the purpose of weekend release was to support water supply. Thus, the generation figures demonstrate that releases were much lower on weekends for the first decades of the project's operation. *See, e.g.,* Report, 24 Hour-Actual Generation at Buford, 1960 Water Year 3 (SUPPAR026251) (showing weekend generation figures that are hundreds of mwh lower than weekday figures). In 1989, only nine percent of the energy generated by the Buford project was generated on Saturdays and Sundays. By 2007, however, weekend energy generation constituted nineteen percent of the total power generated by the dam. (Ala. & Fla.'s Factual App. ¶ 750 (citing Report, 24 Hour-Actual Generation at Buford 1-51 (SUPPAR026249-99)).) Because non-peak power is much less valuable than peak power, the harm to hydropower from this change in operations is obvious.[30]

The SeFPC argues that, if the Court orders the Corps to put in place the "crediting mechanism" described by the *Southeastern Federal Power Customers* Settlement Agreement, the serious effect on hydropower will be remedied. (*E.g.,* SeFPC's Resp. Mem. to Mot. for Summ. J. and Opp'n filed by Corps at 1.) It is far from clear that Congress intended that the Corps could sidestep the Congressional-authorization requirement of the WSA by merely paying off the interests seriously affected. Such a remedy is, in the Court's opinion, for Congress to consider when it evaluates the proposed changes in the project's operation.

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[30] That hydropower has been harmed is relevant in determining whether the Corps's operation of the project to support water supply has seriously affected the Congressionally authorized purposes. However, this does not mean that the SeFPC has any monetary claim for lost hydropower benefits. As the Court has made clear in previous rulings, the Court will not consider arguments regarding remedies at this time.

The Corps's decision to support water supply has seriously affected the purposes for which the Buford project was originally authorized. The Corps is therefore in violation of the WSA.

E. Combined Authorities

The Georgia parties claim that the WSA, 1944 FCA, 1946 RHA, the 1956 statute that allowed the Corps to contract with Gwinnett County for water-supply withdrawals, and the Corps's contracts with Gainesville and Buford (the "relocation contracts"), taken together, establish that water supply is an authorized purpose of the Buford project. The Court has addressed the legislative history of the Buford project, including the 1946 RHA, the relocation contracts, and the Gwinnett County water-supply request and resulting Congressional enactment. *See supra* pp. 1310-22. Contrary to the Georgia parties' argument, taken together the relevant statutes and legislative history point to only one conclusion: water supply, in the form of withdrawals from Lake Lanier and large-scale withdrawals from the Chattahoochee River, was not an authorized purpose of the Buford project. The Georgia parties' argument that a combination of authorities allows the water-supply withdrawals is without merit.

F. Remaining Claims

The parties claim that the Corps's operations of the Buford project violate NEPA, the 1944 FCA, the CZMA, and other statutes, and that the various manuals, plans, and other methods through which the Corps operates the Buford project also violate federal law. Because the Court has determined that the Corps must seek Congressional authorization before it can reallocate storage in Lake Lanier to water supply, the parties' remaining Phase 1 claims regarding the Corps's operations and the plans for those operations are moot. *See Envtl. Def. Fund, Inc. v. Alexander,* 467 F.Supp. 885, 888 (N.D.Miss.1979) (noting that, if a project is not legally authorized, "all other issues are mooted until such time as proper authorization may be obtained from Congress").

G. Operations Going Forward

The Court recognizes that it will take time to secure the required Congressional authorization for the changes to the operation of the Buford project. In addition, the municipal entities that withdraw water from Lake Lanier and the Chattahoochee River cannot suddenly end their reliance on that water merely because a federal court has determined that the Corps failed to comply with its statutory obligations. Thus, the Court will stay Phase 1 of this litigation for three years, to allow the parties to obtain Congress's approval for the operational changes the water-supply providers request. During the stay, the parties may continue to operate at current water-supply withdrawal levels but should not increase those withdrawals absent the agreement of all other parties to this matter. The Court does not believe that a stay of Phase 2 is warranted at this time, and therefore will consider the Phase 2 claims in accordance with the most recent scheduling order.

At the end of three years, absent Congressional authorization or some other resolution of this dispute, the terms of this Order will take effect. For Atlanta and the communities surrounding Lake Lanier, this means that the operation of Buford Dam will return to the "baseline" operation of the mid-1970s. Thus, the required off-peak flow will be 600 cfs and only Gainesville and Buford will be allowed to withdraw water from the lake. The Court recognizes that this is a draconian result. It is, however, the only result that recognizes how far the operation of the Buford project has strayed from the original authorization.

As the Court stated at the hearing, the slow pace at which the Corps operates has only served to further complicate and provoke this already complicated and inflammatory case. It is beyond comprehension that the current operating manual for the Buford Dam is more than 50 years old. Certainly, the pendency of this litigation has made the Corps's completion of plans and manuals more difficult. However, the states and municipalities that rely on the ACF basin for water cannot determine how the operation of the project will affect their interests if they do not understand how the Corps intends to operate the project. The uncertainty created by the Corps's alarmingly slow pace only adds to the frustration of all parties involved in this litigation. The Court encourages the Corps to complete its plans for the ACF basin as quickly as possible, to allow the parties and Congress to analyze more effectively the future of this vital resource.

The blame for the current situation cannot be placed solely on the Corps's shoulders, however. Too often, state, local, and even national government actors do not consider the long-term consequences of their decisions. Local governments allow unchecked growth because it increases tax revenue, but these same governments do not sufficiently plan for the resources such unchecked growth will require. Nor do individual citizens consider frequently enough their consumption of our scarce resources, absent a crisis situation such as that experienced in the ACF basin in the last few years. The problems faced in the ACF basin will continue to be repeated throughout this country, as the population grows and more undeveloped land is developed. Only by cooperating, planning, and conserving can we avoid the situations that gave rise to this litigation.

CONCLUSION

As we all learned in grade school, the separation of powers is fundamental to our federal government: a power reserved to one branch may not be usurped by another. This litigation presents a case study in the need for this tripartite federal system. Congress authorized and paid for the Buford Dam, and gave the Corps authority to operate the dam. Congress specified, however, that the Corps's authority was not without limits. If the Corps believes that it must operate the project in a manner contrary to Congress's initial authorization of the project, it must so inform Congress and secure Congress's permission to do so. Congress has made no exceptions for situations such as the present, when the need for the change is great: the WSA does not provide that "changes shall be made only upon the approval of Congress unless it is inconvenient to do so." Congress reserved to itself the power to change the purposes for federal projects such as the Buford Dam project. The executive branch simply may not circumvent that authority. Congressional approval of the reallocation of storage in Lake Lanier is required.

The Court is sympathetic to the plight of the Corps, which is faced with competing and legitimate claims to a finite resource. Neither the Corps nor the Court can make more water. However, as the D.C. Circuit remarked, "Congress envisioned that changed circumstances or 'difficult situations' might arise and specified that any solution involving 'major operational * * * changes' required its prior authorization." *SeFPC,* 514 F.3d at 1325 (citations omitted). The Corps's failure to seek Congressional authorization for the changes it has wrought in the operation of Buford Dam and Lake Lanier is an abuse of discretion and contrary to the clear intent of the Water Supply Act. As such, the Corps's actions must be set aside.

Accordingly, **IT IS HEREBY ORDERED** that:

1. Alabama and Florida's Motion for Summary Judgment (Docket No. 191) is **GRANTED in part** and **DENIED in part;**

2. The Georgia parties' Motion for Summary Judgment (Docket No. 195) is **DENIED;**

3. The SeFPC's Motion for Summary Judgment (Docket No. 238 in Civ. No. 3:08-640) is **GRANTED in part** and **DENIED in part;**

4. The Corps's Motion for Summary Judgment (Docket No. 227) is **DENIED;**

5. APC's Motion for Summary Judgment (Docket No. 86 in Civ. No. 3:07-249) is **DENIED;**

6. Columbus and Columbus Water Works' Motion for Partial Summary Judgment (Docket No. 22 in Civ. No. 3:07-1033) is **DENIED;**

7. Apalachicola's Motion for Summary Judgment (Docket No. 190) is **GRANTED in part** and **DENIED in part;** and

8. The claims raised in Phase 1 of this litigation are hereby **STAYED** for a period of three (3) years.

APPENDIX C

In the

UNITED STATES COURT OF APPEALS
FOR THE ELEVENTH CIRCUIT

No. 09-14657-GG

In Re:

MDL-1824 TRI-STATE WATER RIGHTS LITIGATION.

On Appeal from the United States District Court
For the Middle District of Florida

FILED
U.S. COURT OF APPEALS
ELEVENTH CIRCUIT
SEP 16 2011

ON PETITION(S) FOR REHEARING AND PETITION(S) FOR REHEARING EN BANC

Before MARCUS and ANDERSON, Circuit Judges, and MILLS,* District Judge.

PER CURIAM:

The Petition(s) for Rehearing are DENIED and no Judge in regular active service on the Court having requested that the Court be polled on rehearing en banc (Rule 35, Federal Rules of Appellate Proce-

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* Honorable Richard Mills, United States District Judge for the Central District of Illinois, sitting by designation.

dure), the Petition(s) for Rehearing En Banc are DENIED.

ENTERED FOR THE COURT:

/s/ R. Lanier Anderson_____________

UNITED STATES CIRCUIT JUDGE

APPENDIX D

United States Court of Appeals,
District of Columbia Circuit

SOUTHEASTERN FEDERAL POWER CUSTOMERS, INC., Appellee

v.

Peter GEREN, Secretary of the United States Department of the Army, et al., Appellees

State of Florida, Appellant.

Nos. 06-5080, 06-5081 | Argued Nov. 16, 2007 | Decided Feb. 5, 2008.

Before: ROGERS and KAVANAUGH, Circuit Judges, and SILBERMAN, Senior Circuit Judge.

Opinion

ROGERS, Circuit Judge.

This case arises out of the requirements of three States for water stored in a federal reservoir. The States of Alabama and Florida appeal the order of the district court approving a Settlement Agreement between Southeastern Federal Power Customers, Inc. ("Southeastern"), a group of Georgia water supply providers ("Water Supply Providers"), the U.S. Army Corps of Engineers (the "Corps"), and the State of Georgia. The Agreement provides for a ten or twenty year "temporary" reallocation of over twenty percent (20%) of the water storage in the Lake Lanier reservoir, which is located in the State of Georgia and operated by the Corps. Alabama and Florida contend that the Agreement violates the Water Supply Act ("WSA"), 43 U.S.C. § 390b(d), the

Flood Control Act ("FCA"), 33 U.S.C. § 708, and the National Environmental Protection Act ("NEPA"), 42 U.S.C. § 4321 et. seq. We need address only one of the statutory challenges. Under the WSA, the Corps must obtain prior Congressional approval before undertaking "major * * * operational changes." § 301(d), 43 U.S.C. § 390b(d). Because the Agreement's reallocation of Lake Lanier's storage space constitutes a major operational change on its face and has not been authorized by Congress, we reverse the district court's approval of the Agreement.

I.

The setting for this case is Lake Sidney Lanier, a federally owned reservoir operated by the Corps and located in Georgia. It was created by the construction of the Buford Dam on the Chattahoochee River, approximately fifty miles northeast of the city of Atlanta. To the south of the Buford Dam, the Chattahoochee joins the Flint River and the two become the Apalachicola River, which flows through northern Florida and eventually into the Gulf of Mexico. The three river systems make up the Apalachicola-Chattahoochee-Flint river basin ("ACF Basin"), which includes counties in Alabama.

Congress authorized the Corps to design and build Buford Dam in 1946, and the project was completed in the mid-1950s. Beginning in the 1970s, the Corps entered into a series of five-year renewable contracts that allowed some of Lake Lanier to be used for storage of local water supply. *See Se. Fed. Power Customers, Inc. v. Harvey,* 400 F.3d 1, 2 (D.C.Cir. 2005). The last of the local water storage contracts expired in 1990, but the Corps has permitted the withdrawal of water, in increasing amounts, under the terms of the expired contracts. *Id.*

In 1989, before the expiration of the last temporary local water storage contract, the Corps transmitted a report to Congress recommending that 207,000 acre-feet of storage in Lake Lanier be reallocated from hydropower to local consumption, noting that this might require Congressional approval. USACE, POST AUTHORIZATION CHANGE NOTIFICATION REPORT FOR THE REALLOCATION OF STORAGE FROM HYDROPOWER TO WATER SUPPLY AT LAKE LANIER, GEORGIA ("PAC REPORT") 1, 12, 26 (1989). In response, Alabama sued the Corps in the federal district court in the Northern District of Alabama, seeking to enjoin reallocation of Lake Lanier's storage space to water supply. This litigation resulted in a stay order, *Alabama v. USACE,* No. CV90-H-1331-B (N.D.Ala. Sept. 19, 1990), and no permanent water storage reallocation was undertaken despite the recommendations of the PAC REPORT. In 1992, Alabama, Florida, Georgia and the Corps entered into a Memorandum of Agreement allowing existing withdrawals to continue or increase in response to reasonable demand; in 1997, the same three States and Congress approved the Apalachicola-Chattahoochee-Flint River Basin Compact ("Compact") to facilitate water storage allocation, planning and dispute resolution in the ACF Basin. Pub.L. No. 105-104, 111 Stat. 2219. The Compact, which did not assign rights to any quantity of water, *id.* at 8, terminated on August 31, 2003, without resulting in an agreement on the allocation of water storage resources.

In 2000, Southeastern sued the Corps in the federal district court in the District of Columbia, challenging the Corps' statutory authority to divert water from Lake Lanier to the detriment of hydropower users and alleging economic injury stemming from increased withdrawals of water from Lake Lanier, which allegedly compromised use of Lake Lanier's water for power generation. Georgia thereafter petitioned the Assistant Secretary of the Army for Civil Works to formally reallocate reservoir storage space for local consumption-effectively requesting a threefold increase in the amount of space devoted to local water supply. In 2001, not having received a response to its request, Georgia sued the Corps in the federal district court in the Northern District of Georgia. In 2002, Georgia's request was denied. By letter of April 15, 2002, the Acting Assistant Secretary of the Army for Civil Works explained that because "[t]his request involves substantial withdrawals from Lake Lanier and accommodating it would affect authorized project purposes * * * [the matter had been referred to] the Office of the Army General Counsel, [and t]hat office has * * * concluded that it cannot be accommodated without additional Congressional authorization." Letter from R.L. Brownlee, to Hon. Roy E. Barnes, Governor of Georgia (Apr. 15, 2002), *citing* Memorandum of Earl Stockdale, Deputy Gen. Counsel, Dep't of the Army, regarding Georgia Request for Water Supply from Lake Lanier (Apr. 15, 2002) ("Army Legal Memorandum"). The Georgia lawsuit is currently abated. *Georgia v. USACE,* 223 F.R.D. 691, 699 (N.D.Ga.2004).

Meanwhile, in March 2001, the D.C. district court referred the parties to mediation, where they were eventually joined by Georgia and the Water Supply Providers. The parties negotiated the Agreement at issue and signed it in January 2003. The Agreement specifies that Lake Lanier's storage space is 1,049,400 acre-feet. It requires the Corps to allocate between 210,858 and 240,858 acre-feet of Lake Lanier's water storage to local municipal and industrial uses for a once-renewable period of ten years; the exact amount of space allocated depends on whether Gwinnett County chooses to purchase all of the storage space to which it is entitled. If, under the Agreement, all of the storage space that may be officially dedicated to local consumption is, then the reallocation constitutes more than twenty-two percent (22%) of the total storage space in Lake Lanier and approximately nine percent (9%) more of the total storage space than was being allocated for local use in 2002. *Compare* Agreement at 5, *and* Army Legal Memorandum at 8, *with* Agreement at 6. The interim ten-year leases will become permanent if Congress approves the change in use or a final court judgment holds that such approval is not necessary, Agreement at 10, and the Corps commits to recommending that Congress formally "make the storage covered by the Interim Contracts available on a permanent basis," *id.* at 11. The Agreement also provides hydropower generators with payments in the form of "credit to be reflected in hydropower rates," based on "revenues paid into the United States Treasury [under contracts based on the Agreement]," to compensate for lost opportunities related to its reallocation of water storage rights. *Id.* at 13.

In October 2003, after the Agreement was signed, the D.C. district court allowed Alabama and Florida to intervene and denied the motions to transfer the case to the Georgia district court; Alabama and Florida also resuscitated the Alabama lawsuit that was filed in 1990. On October 15, 2003, the Alabama district court entered a preliminary injunction, preventing the Agreement from being implemented. The D.C. district court approved the Agreement on February 10, 2004, contingent upon the "dissolution of the [Alabama district court's] injunction." *Se. Fed. Power Customers v. Caldera,* 301 F.Supp.2d 26, 35 (D.D.C.2004). The district court rejected Alabama's and Florida's argument that the Agreement exceeded the authority conferred on the Corps by Congress, including applicable provisions of the WSA, the FCA and NEPA. *Id.* at 31. It also concluded that while the Agreement would affect hydropower generation, an original purpose of Lake Lanier, the assent of the hydropower generators meant that Congressional approval for the allocation of storage space was not required. *Id.* at 31-32. The district court quoted the WSA's "operational change" provision, but did not explicitly address this issue. *See id.*

This court dismissed the initial appeal filed by Alabama and Florida for lack of a final order, in view of the conditional nature of the district court's approval of the Agreement. *Se. Fed. Power,* 400 F.3d at 5. Following the dissolution of the Alabama district court's injunction, *Alabama v. USACE,* 424 F.3d 1117, 1136 (11th Cir. 2005), the D.C. district court, on March 9, 2006, entered a final judgment that is the basis for this appeal by Alabama and Florida.

II.

Alabama and Florida contend that the Agreement should be set aside because it violates the WSA, the FCA, and NEPA. They maintain that the reallocation in the Agreement requires Congressional approval under the WSA because it both constitutes a major operational change and seriously affects project purposes. They also contend that the Agreement violates the FCA because it allows only the short-term sale of surplus water, whereas the Agreement is a long-term transaction involving water that is not surplus; because the FCA prohibits negatively affecting existing uses of affected water; and because the Agreement is contrary to the Corps' internal FCA contracting guidelines. Finally, they contend that the Agreement violates NEPA by "irrevocably committ[ing] [the Corps] to executing the [Agreement] at the completion of its NEPA analysis," Appellants' Br. at 48, effectively bypassing the statute.[1]

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[1] Alabama's and Florida's contention that the district court abused its discretion in denying the motion to abate or transfer this case to the Alabama district court is without merit. They note that the Georgia district court abated the case before it in favor of the prior-filed Alabama case, *Georgia,* 223 F.R.D. at 697-99, and that they urged the D.C. district court to do likewise on the grounds that the Alabama and D.C. cases involve substantially the same parties and subject matter, the Alabama lawsuit was first filed, the Alabama court is more convenient, and the "equities weigh in favor of abatement." Appellants' Br. at 58. However, the district court adequately justified its denial of the motion and did not abuse its discretion. *See Handy v. Shaw, Bransford, Veilleux & Roth,* 325 F.3d 346, 349 (D.C.Cir. 2003). The district court explained that "more entities purporting to be affected by the manner in which the Corps makes disposition of the water storage capacity * * * in Lake Lanier are now subject to the jurisdiction of this [district c]ourt than are before [the Alabama district court]," and reasonably concluded that the prospects of "duplicative litigation and inconsistent adjudicative results" were reduced by its review of the Agreement. *Caldera,* 301 F.Supp.2d at 31. Hence, because reversal is not justified, the court need not decide whether 28 U.S.C. § 2105, which precludes reversal by "a court of appeals for error in ruling upon matters in abatement which do not involve jurisdiction," prevents review of the abatement motion. *Cf. Nascone v. Spudnuts, Inc.,* 735 F.2d 763, 771 (3d Cir. 1984); *see also* 15A CHARLES ALAN WRIGHT, ARTHUR R. MILLER, EDWARD H. COOPER, FEDERAL

The court reviews the fairness of a settlement agreement for abuse of discretion. *Moore v. Nat'l Ass'n of Sec. Dealers, Inc.,* 762 F.2d 1093, 1106 (D.C.Cir. 1985). Although there are few precedents on review of a settlement agreement for compliance with statutory requirements, the district court could hardly approve a settlement agreement that violates a statute, *see, e.g., Sierra Club, Inc. v. Elec. Controls Design, Inc.,* 909 F.2d 1350, 1355 (9th Cir. 1990), and this court owes the district court no deference in its legal interpretations. Our statutory review then is *de novo,* although this is largely a matter of semantics: "A district court by definition abuses its discretion when it makes an error of law," *Koon v. United States,* 518 U.S. 81, 100, 116 S.Ct. 2035, 135 L.Ed.2d 392 (1996); *see also Donovan v. Robbins,* 752 F.2d 1170, 1178 (7th Cir. 1984). In considering the Corps' interpretation of its statutory authority to enter into the Agreement, the court applies the familiar two-step analysis under *Chevron, U.S.A., Inc. v. Natural Resources Defense Council, Inc.,* 467 U.S. 837, 104 S.Ct. 2778, 81 L.Ed.2d 694 (1984).

> [Where] Congress has directly spoken to the * * * issue * * * that is the end of the matter; for the court, as well as the agency, must give effect to the unambiguously expressed intent of Congress * * * if the statute is silent or ambiguous with respect to the specific issue, the question for the court is whether the agency's answer is based on a permissible construction of the statute.

Id. at 842-43, 104 S.Ct. 2778.

Section 301 of the WSA, 43 U.S.C. § 390b, addresses the development of "water supplies for

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PRACTICE AND PROCEDURE § 3903 (3d ed.2007).

domestic, municipal, industrial, and other purposes," specifically acknowledging that primary responsibility for their development is lodged in States and localities. *Id.* § 301(a), § 390b(a). It authorizes storage "in any reservoir project surveyed, planned, constructed or to be planned * * * by the Corps of Engineers or the Bureau of Reclamation" so long as the costs of construction or modification are adequately shared by the beneficiaries. *Id.* § 301(b), § 390b(b). The WSA provides, however, that:

> Modifications of a reservoir project heretofore authorized, surveyed, planned, or constructed to include storage as provided in subsection (b) of this section which would seriously affect the purposes for which the project was authorized, surveyed, planned, or constructed, or which would involve *major* structural or *operational changes* shall be made only upon the approval of Congress as now provided by law.

Id., § 301(d), § 390b(d) (emphasis added).

Alabama and Florida contend that the Agreement's reallocation of up to 240,858 acre-feet of storage space to the Water Supply Providers constitutes a "major * * * operational change[ ]" and thus requires Congressional approval. They point to previous analyses prepared by the Corps and the Office of the Army General Counsel indicating that operational changes on a similar scale would require Congressional approval. *See, e.g.,* PAC REPORT at 12; Army Legal Memorandum at 12. Appellees offer that the Agreement "merely leaves in place * * * [t]he status quo [of] incremental increases in withdrawal amounts by the Water Supply Providers as those increases are permitted by Georgia," Appellees' Br. at 37, and thus does not constitute an operational change. They would distinguish the 2002 Army Legal Memorandum on the basis that Georgia's request involved a larger percentage of Lake Lanier than the storage allocated by the Agreement and included projections that were thirty as opposed to ten years in the future. Appellees further offer that the Agreement provides for compensation payments to hydropower producers, thus "retaining the hydropower benefit and adding the water benefit," *id.* at 38. Finally, Appellees offer that the reallocation is temporary rather than permanent, and thus does not require Congressional approval.

1.

As a threshold matter, we hold that Alabama and Florida have standing to challenge the Agreement insofar at it constitutes a major operational change to the Lake Lanier reservoir.[2] They credibly claim to fear that the proposed reallocation of water storage will result in "diminish[ed][ ] flow of water reaching the downstream states." Appellants' Br. at 2. The Agreement does potentially reduce the amount of water flowing downstream, Agreement at 5; *Alabama,* 424 F.3d at 1122, and the ACF basin would thereby be affected by changes to the quantity of water in the Chattahoochee River for as long as twenty years, *see, e.g.,* Agreement at 10; *cf. Georgia v. USACE,* 302 F.3d 1242, 1252 (11th Cir. 2002). As the ACF basin includes parts of both Alabama and Florida, they would be directly impacted by the Agreement's proposed changes to water storage uses;

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[2] The court, therefore, has no occasion to consider whether Alabama and Florida would have standing to challenge the Agreement as "seriously affect[ing]" the original Congressionally authorized purposes of Lake Lanier. *Cf.* Opinion Concurring in the Judgment (hereinafter, Concurring Op.) at ----.

in its complaint, Florida alleged various negative environmental impacts from reduced water flow. In addition, the states' quasi-sovereign interests entitles them to "special solicitude" in standing analysis. *See Massachusetts v. EPA,* 549 U.S. 497, 127 S.Ct. 1438, 1455, 167 L.Ed.2d 248 (2007). To the extent the Agreement provides that "entering into the storage contracts described in this Agreement * * * potentially gives rise to certain obligations under NEPA," Agreement at 14, any attendant delay due to the Corps' compliance with NEPA does not affect the imminence of the claimed injury. The Agreement commits the Corps to use its "best efforts to complete any applicable requirements of NEPA as expeditiously as practicable." *Id.*; *cf. Massachusetts,* 127 S.Ct. at 1456. In addition, the Agreement states that its NEPA compliance provision "does not apply to the Supplement to Relocation Contract" between the Corps and the City of Gainsville allowing removal of water from Lake Lanier from the date of settlement, Agreement at 12, 14.

Alabama and Florida thus show both the imminence of injury-in-fact and its causation, and reversing the approval of the Agreement would provide redress to their injury. *See generally Lujan v. Defenders of Wildlife,* 504 U.S. 555, 560-61, 112 S.Ct. 2130, 119 L.Ed.2d 351 (1992). Alabama's and Florida's prudential standing is likewise established because they come within the zone of interests that Congress could reasonably have intended to protect. *See Clarke v. Sec. Indus. Ass'n,* 479 U.S. 388, 399-401, 107 S.Ct. 750, 93 L.Ed.2d 757 (1987).

2.

Section 301 of the WSA plainly states that a major operational change to a project falling within its scope requires prior Congressional approval.[3] Consistent with this plain text, the Corps has long recognized that its discretion to alter a project's operations without Congressional approval is limited to non-major matters. It acknowledged in the 1989 PAC REPORT, at 12, that Congressional approval might be required for reallocation of 207,000 acre-feet, or approximately twenty percent (20%) of Lake Lanier's total current storage as specified in the Agreement. In 2002, on the basis of a legal opinion from the Office of the Army General Counsel, the Corps rejected Georgia's request that 370,930 acre-feet, approximately thirty-five percent (35%) of Lake Lanier's total storage, be reallocated to local use. That legal opinion concluded that Georgia's request was of a magnitude that would "involve substantial effects on project purposes and major operational changes" and therefore required prior Congressional approval. Army Legal Memorandum at 1; *see also id.* at 9, 13. This conclusion was based on a comprehensive analysis: The Army Legal Memorandum identified the "specifically authorized purposes [of Lake Lanier] * * *. [as] navigation, hydropower generation, and flood control-with water supply as an incidental benefit," *id.* at 6; reviewed relevant congressional authorizations, beginning with the Rivers and Harbor Acts of 1945, noting that, according to engineers' reports, water supply was an "incidental benefit" of the Dam; and cited statutory limitations on the Corps' authority to modify any existing project

[3] The Corps has not suggested that "the approval of Congress" required by the statute means anything other than a bill or resolution passed by both Houses that is either signed by the President or passed by two-thirds of both Houses over the President's veto. *Cf.* U.S. CONST. art. I, § 7.

under the WSA, *id.* at 3-9, referencing a House subcommittee report contrasting the Corps' authority to make "minor modifications" as distinct from "major changes in a project" and observing that "[t]he Corps' view of its discretionary authority in this area comports with that of Congress," *id.* at 10-11 (quoting U.S. HOUSE COMM. ON PUBLIC WORKS, SUBCOMM. TO STUDY CIVIL WORKS, REPORT ON THE CIVIL FUNCTIONS PROGRAM OF THE CORPS OF ENGINEERS, 82ND CONGRESS at 22 (1952)). The Corps' legal defense of then-existing water withdrawals was limited to a footnote, without citation to authority, which stated that "the agency does have the discretionary authority to meet the current water supply needs of the municipalities surrounding the reservoir," *id.* at 8 n. 2.

On its face, then, reallocating more than twenty-two percent (22%, approximately 241,000 acre feet) of Lake Lanier's storage capacity to local consumption uses, *see* Agreement at 5-6, constitutes the type of major operational change referenced by the WSA; the reallocation's limitation to a "temporary" period of twenty years does not change this fact. Even a nine percent (9%, approximately 95,000 acre feet) increase over 2002 levels for twenty years is significant. Appellees' contrary arguments are unpersuasive.

First, Appellees maintain that the Agreement simply reflects the status quo of gradual water storage reallocation, and consequently does not constitute a major operational change. But the appropriate baseline for measuring the impact of the Agreement's reallocation of water storage is zero, which was the amount allocated to storage space for water supply when the lake began operation. Otherwise, under Appellees' logic, even if the Agreement had simply kept in place a series of interim agreements that allocated all of Lake Lanier to storage for local consumption, no major operational change would have occurred-a chain of logic that would effectively bypass section 301(d) of the WSA, 43 U.S.C. § 390b(d).[4] Even taking the status quo as the consumption level in 2002, the reallocation of approximately nine percent (9%, approximately 95,000 acre feet) of storage space for a twenty-year period is still significant. As the Corps acknowledged during oral argument, the change from current local usage storage to the storage levels envisioned by the Agreement would be the largest acre-foot reallocation ever undertaken by the Corps without prior Congressional approval. Oral Arg. Tape (Nov. 16, 2007) at 45:16.5.

Second, Appellees maintain both that the amount of storage space reallocated by the Agreement is too limited to qualify as a major operational change, and that the Agreement's compensation of hydropower users prevents the reallocation from constituting a major operational change. But in defending the Agreement, Appellees provide no rational reason to explain why a reallocation of approximately thirty-

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[4] The court, in responding to the Corps' defense of its approval of the Agreement, has no occasion to opine whether the Corps' previous storage reallocations were unlawful. *See* Concurring Op. at 1326-27. The court relies only on initial allocations of water storage-a more limited issue than would be presented were the court to address the original Congressional purposes of Lake Lanier alluded to by our colleague, *see id.* at 1326-27. In any event, it is hardly "draconian," *id.* at 1327, to follow Congress' explicit instructions for prior approval of major operational changes.

five percent (35%) of total storage, taking into account thirty years of future local needs, constitutes a major operational change, *see* Army Legal Memorandum at 9, 12; Agreement at 6, whereas a reallocation of more than twenty-two (22%) of total storage, taking into account twenty years of future local needs, does not. *See* Agreement at 5-6, 10. In suggesting that the Agreement's compensation for the loss of hydropower uses is meaningfully different from Georgia's reallocation request in 2000, Appellees ignore the fact that even if compensation provides hydropower producers the full financial benefit they would have received from use of Lake Lanier in the absence of the water storage reallocation, a major operational change still occurs because there is less flow through as a result of increased water storage for local use.

Third, Appellees maintain that the absence of a permanent reallocation under the Agreement removes the need for prior congressional approval. But it is unreasonable to believe that Congress intended to deny the Corps authority to make major operational changes without its assent, yet meant for the Corps to be able to use a loophole to allow these changes as long as they are limited to specific time frames, which could theoretically span an infinite period. Appellees' attempt to respond by suggesting a time period of ninety-nine years " 'might cause a serious impact,' " Appellees' Br. at 38 n. 6 (quoting counsel for the Corps during oral argument before the D.C. district court, Transcript of Oral Argument (Feb. 8, 2005) at 30, *Se. Fed. Power Customers v. Caldera,* 301 F.Supp.2d 26 (D.D.C.2004)), fails to explain why a twenty year term would not cause the same "serious impact."

In other circumstances it is conceivable that the difference between a minor and a major operational change might be an ambiguous matter of degree, where the Court would consider whether an agency's authoritative interpretation should be accorded deference under *Chevron* step two in defining the term "major operational change," *cf.* Concurring Op. at 1327-28. But the Agreement's reallocation of over twenty-two percent (22%) of Lake Lanier's storage space does not present that situation. It is large enough to unambiguously constitute the type of major operational change for which section 301(d) of the WSA, 43 U.S.C. 390b(d), requires prior Congressional approval. This conclusion is reinforced by the Corps' prior consideration of reallocation proposals, *see* PAC REPORT at 12; Army Legal Memorandum at 8-12. The same conclusion applies to a reallocation of approximately nine percent (9%) of Lake Lanier's storage space, for it too presents no ambiguity. This is illustrated by the Corps' acknowledgment of the reallocation's unprecedented scale, Oral Arg. Tape (Nov. 16, 2007) at 45:16.5. Vaguely committing to request Congressional approval of the reallocation at some future date, *see, e.g.,* Agreement at 11; Oral Arg. Tape (Nov. 16, 2007) at 47:00.0, does not accord with the plain text of the WSA.

The Corps may understandably be of the view that it faces a "difficult situation," Oral Arg. Tape (Nov. 16, 2007) at 51:38.8, and is attempting to balance multiple interests and achieve a "creative solution," *id.* at 52:04.2. However, Congress envisioned that changed circumstances or "difficult situations" might arise and specified that any solution involving "major operational * * * changes" required its prior authorization. WSA § 301(d), 43 U.S.C. § 390b(d). We therefore need not reach the other contentions of Alabama and Florida. The Agreement's reallocation of Lake Lanier's storage capacity to local consumption is a major operational change that under section 301(d) of the WSA, 43 U.S.C. § 390b(d), may not occur without Congress' prior authorization. Accordingly, because no authorization has been obtained, we hold that the district court erred in approving the Agreement and reverse.

SILBERMAN, Senior Circuit Judge, concurring in judgment:

I agree with the majority's conclusion that, notwithstanding our limited scope of review of a district court's approval of a settlement agreement, we are obliged to reject this one. I write separately to discuss issues appellants raise which I think should be disposed of-and should be rejected so as not to complicate any further possible litigation-and to disagree with my colleagues on one important point.

Appellants argued that the Agreement violated the Flood Control Act ("FCA"), as well as the Water Supply Act ("WSA"). I think that alternative claim is quite weak. The relevant provision of the FCA states:

> **Sale of surplus waters for domestic and industrial uses; disposition of moneys** - The Secretary of the Army is authorized to make contracts with States, municipalities, private concerns, or individuals, at such prices and on such terms as he may deem reasonable, for domestic and industrial uses for surplus water that may be available at any reservoir under the control of the Department of the Army: *Provided,* that no contracts for such water shall adversely affect then existing lawful uses of such water * * *.

33 U.S.C. § 708. By its plain terms, this provision sets the conditions under which the Secretary may sell "surplus water." However, the Corps does not contend that the Settlement Agreement disposes of "surplus" water. The Agreement does *reallocate* a certain amount of reservoir capacity to water storage, but reallocations are governed by the Water Supply Act, not the Flood Control Act. Section 301(d) of the WSA requires Congressional approval of "[m]odifications of a reservoir project * * * which would involve major structural or operational changes * * *." 43 U.S.C. § 390b(d). It is abundantly clear, then, that the Water Supply Act, not the Flood Control Act, is the statute that governs the Corps' actions in this case, and I would accordingly explicitly reject the appellants' FCA claims.

Turning to the WSA, appellants argued-indeed, it was their main argument-that the Agreement was unlawful under that statute, not just because it constituted a "major operational change," but also because it was inconsistent with the project's authorized purposes. 43 U.S.C. § 390b(d). The Buford Dam was constructed to improve navigation, generate hydroelectric power, and control flooding. *Alabama v. U.S. Army Corps of Engineers,* 424 F.3d 1117, 1122 (11th Cir. 2005). (For many years, the Corps has maintained that an incidental benefit of the project was to provide metropolitan Atlanta with water supply.) *Id.* One of the project's primary purposes, thus, was to provide hydroelectric power to downstream users. The Agreement, it is contended by Alabama and Florida, will reduce the amount of water released from the reservoir which will, in turn, reduce the water available for Alabama's and Florida's power requirements. Appellees responded that the Agreement's compensation mechanisms met the hydroelectric purposes of the project.

Under those mechanisms, the water supply providers will pay substantially higher rates for water storage, and the resulting revenue will be credited to hydropower customers to compensate them for the reduced water flows through the dam. The Corps, the power customers, and the water supply providers all agree that this compensation mechanism will ensure that the Agreement does not have an adverse effect on hydropower generation.

I would not reach the merits of this argument because I do not think Florida and Alabama have standing to raise it. The two states have not identified any cognizable injury attributable to this claim. They do not assert that they or their citizens will pay any more for electricity as a result of the Agreement. Indeed, the hydroelectric companies supplying Florida and Alabama customers-the members of the Southeastern Federal Power Customers-support the Agreement because the compensation mechanism does adequately offset the reduction in water supply. To be sure, Florida and Alabama do have standing-as the panel concludes-to object to the alleged "major operational change" because the decreased water supply will have environmental impacts on Florida and Alabama. However, standing must be established for each claim, *The Wilderness Society v. Norton,* 434 F.3d 584, 591 (D.C.Cir. 2006), and appellants lack standing to assert that the Agreement will "seriously affect" the project purposes of the reservoir.

* * *

My fundamental disagreement with my colleagues' determination that the Agreement works a "major operational change" is with their conclusion that the appropriate baseline for measuring the impact of the Agreement's reallocation of water storage is zero. That seems to imply that the project was never intended to provide water to the city of Atlanta, which is in tension with the 11th Circuit's observation mentioned *infra,* and is an issue which the settling parties agreed was not determined by the Agreement; it is an open question that has not really been briefed.

Beginning in the 1970s, the Corps allocated a steadily increasing volume of storage space to the water supply providers. *Alabama v. U.S.A.C.E.,* 424 F.3d at 1122. It does not appear that Alabama and Florida challenged this policy until 1990, when the Corps was seeking Congressional approval to enter into permanent water supply contracts. *Id.* at 1122-23. Thus, for over a decade, the appellants acquiesced to a policy of increasingly large withdrawals. Even after Florida and Alabama initiated litigation in 1990, the states entered into two agreements that allowed the Corps to increase water withdrawals "to satisfy reasonable increases in [ ] demand" while settlement negotiations were pending.[1]

[1] These agreements do contain disclaimers that they "shall not be construed as granting any permanent, vested or perpetual rights to the amounts of water used" during settlement negotiations. (It would appear that the word "used" in the agreements only refers to the water withdrawn during the settlement negotiations, and not to reservoir space that had been allocated to water storage prior to those agreements.) Moreover, the 1992 agreement states that it shall not be construed as "changing the status quo as to the Army's authorization of water withdrawals." This implies that-at the very least-Florida and Alabama did not contest the amount of storage that had been authorized by the Corps *prior* to 1992.

By asserting that the baseline is zero, the majority implicitly suggests that for many years some amount of water stored for (and supplied to) the city of Atlanta was illegal. That is a draconian conclusion I do not think warranted by the record.

I nevertheless agree with the majority's determination that the Settlement Agreement is unlawful. To be sure, the definition of *major* operational change is by no means clear. Typically we would defer to an agency's interpretation of that ambiguous term, but we cannot do so here because we are not reviewing an agency rulemaking or adjudication, but only a settlement agreement (which does not even purport to interpret the crucial language). *See United States v. Mead Corp.,* 533 U.S. 218, 230, 121 S.Ct. 2164, 150 L.Ed.2d 292 (2001). We have given deference to agency interpretation of settlement agreements when Congress has granted the agency "an active role in approving the agreement." *Nat'l Fuel Gas Supply Corp. v. FERC,* 811 F.2d 1563, 1571 (D.C.Cir. 1987). But we have also emphasized that such deference is inappropriate where-as here-"the agency itself [was] an interested party to the agreement." *Id.* In such cases, "deference might lead a court to endorse self-serving views that an agency might offer in a post hoc reinterpretation of its contract." *Id.* The government seems to have implicitly interpreted the term "major" in its brief-as not including incremental changes-but we do not defer to mere litigating positions. *Bowen v. Georgetown Univ. Hosp.,* 488 U.S. 204, 213, 109 S.Ct. 468, 102 L.Ed.2d 493 (1988).

The Agreement appears to me to constitute a "major operational change" because it substantially increases the amount of reservoir space allocated to water supply compared to the allocation *in 2002,* which is all we have to conclude. The total storage capacity of Lake Lanier is 1,049,400 acre-feet. In a 2002 memorandum regarding Georgia's request for more water storage, the General Counsel of the Department of the Army stated that, "[c]urrently, municipal and industrial interests, through direct withdrawals and releases from the reservoir, utilize the equivalent of 145,460 acre-feet of storage in Lake Lanier for water supply." Thus, in 2002, approximately 13.9% of the reservoir's capacity was being used for water supply. Under the Settlement Agreement, up to 240,858 acre-feet of the reservoir would be set aside for water storage (175,000 acre-feet for Gwinnett County, 20,675 acre-feet for the City of Gainesville, and 45,183 acre-feet for the Atlanta Regional Commission). This represents an increase of 95,398 acre-feet, which is a 65.6% increase over the 2002 level. Put another way, under the Agreement, approximately 9% more of Lake Lanier's total capacity will be set aside for water storage-in 2002, 13.9% of the total capacity was allocated to water supply, but under the Agreement that figure increased to 22.9%. Like the majority, I also find it noteworthy that the storage levels permitted by the Agreement "would be the largest acre-foot reallocation ever undertaken by the Corps without prior Congressional approval." Maj. Op. at 1324.

At oral argument, counsel for the Corps acknowledged that the Settlement Agreement would increase the amount of reservoir space allocated to storage by approximately 100,000 acre-feet (or 10% of total reservoir capacity), compared to the status quo prior to the Agreement. Tr. of Oral Arg. at 43:20. Counsel then conceded that a *permanent* reallocation of 10% of the reservoir's capacity would constitute a "major operational change." *Id.* at 49:08. In a letter dated December 13, 2007, the Corps attempted to retract this concession, noting that it was "in error." But the logic of this concession was ineluctable. The Corps argued, however, that even if a *permanent* reallocation of 10% of the reservoir would be deemed "major," the Settlement Agreement does not require Congressional approval because it is only an *interim* measure. That is not persuasive. The requirements of the Water Supply Act apply to "major structural or operational changes"-the text of that statute draws no distinction between interim and permanent changes.

The Corps argues that the burden was on Florida and Alabama to show that the Settlement Agreement was unlawful, and that the plaintiffs-appellants failed to offer sufficient evidence to meet this burden. But as explained above, the record-including the Corps' own documents-shows that the Agreement would allocate an additional 95,398 acre-feet of reservoir capacity to water storage, and would increase the share of the reservoir allocated to water storage from 13.9% to 22.9%. I simply do not see how we can conclude that is not a *major* change.

Exhibit 79

UNITED STATES DISTRICT COURT
MIDDLE DISTRICT OF FLORIDA
JACKSONVILLE DIVISION

IN RE TRI-STATE WATER RIGHTS LITIGATION	:	Civil Action File No. 3:07-MD-1-PAM/JRK

RESPONSE OF THE STATE OF FLORIDA AND
THE CITY OF APALACHICOLA TO THE NON-FEDERAL PARTIES'
MOTIONS FOR SUMMARY JUDGMENT ON PHASE 2 CLAIMS

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GLOSSARY

ACF	Apalachicola-Chattahoochee-Flint
ACF Basin	Apalachicola-Chattahoochee-Flint River Basin
Alabama	State of Alabama
APA	Administrative Procedure Act, 5 U.S.C § 551 *et seq.*
Apalachicola Species	Gulf sturgeon Fat threeridge Purple bankclimber
BiOp	Biological Opinion
cfs	Cubic Feet Per Second
City	City of Apalachicola
Consultation Handbook	Fish and Wildlife Service Endangered Species Act § 7 Consultation Handbook
Corps or USACE	United States Army Corps of Engineers
EA	Environmental Assessment
EIS	Environmental Impact Statement
ESA	Endangered Species Act, 16 U.S.C. § 1531 *et seq.*
Federal Defendants	U.S. Army Corps of Engineers United States Fish and Wildlife Service and individually named Defendants
Florida	State of Florida
Florida Parties	State of Florida and City of Apalachicola
FONSI	Finding of No Significant Impact
FWS or Service	Fish and Wildlife Service

Georgia	State of Georgia
Georgia Parties	State of Georgia Atlanta Regional Commission City of Atlanta, Georgia Fulton County DeKalb County Cobb County-Marietta Water Authority City of Gainesville, Georgia Gwinnett County Lake Lanier Association
IOP	Interim Operations Plan
MDL	Multidistrict Litigation
MGD	Million Gallons Per Day
M&I	Municipal and Industrial
MSL	Mean Sea Level
NEPA	National Environmental Policy Act, 42 U.S.C. § 4321 *et seq.*
PAC Report	1989 Draft Post Authorization Change Notification Report For The Reallocation of Storage From Hydropower To Water Supply At Lake Lanier, Georgia
Phase 1 Order	*In re Tri-State Water Rights Litig.*, 639 F.Supp.2d 1308 (M.D. Fla. 2009)
RIOP	Revised Interim Operations Plan
RPA	Reasonable and Prudent Alternatives
RPM	Reasonable and Prudent Measures
SeFPC	Southeastern Federal Power Customers, Inc.
WCM	Water Control Manual, typically referred to in context of WCM Update
WCP	1989 Draft Water Control Plan

WSA	Water Supply Act of 1958, 43 U.S.C. § 390b
Water Supply Providers	Atlantic Regional Commission City of Atlanta Fulton County DeKalb County Cobb County-Marietta Water Authority City of Gainesville

INTRODUCTION

The State of Florida ("Florida") and the City of Apalachicola ("the City") (collectively the "Florida Parties"), 1/ hereby oppose the State of Georgia, Water Supply Providers, Lake Lanier Association, and Gwinnett County, Georgia's (collectively the "Georgia Parties") Motion for Summary Judgment on Phase 2 Claims and Brief in Support, DE 307 ("Ga. Br."), as well as the Georgia Parties' Factual Appendix in Support of Motion for Summary Judgment on Phase 2 Claims, DE 308 ("Ga. FA"). The Florida Parties also oppose City of Columbus and Columbus Water Works' ("Columbus") motion for summary judgment on Phase 2 claims and related memorandum, to the extent it raises arguments that were disposed of in this Court's Phase 1 Order. 2/

The Georgia Parties' Motion, Brief, and Factual Appendix generally support the determination made in the 2008 Biological Opinion ("BiOp") of the U.S. Fish & Wildlife Service ("FWS" or the "Service") that the United States Army Corps of Engineers (the "Corps") did not violate Section 7 of the Endangered Species Act, 16 U.S.C. § 1531 *et seq*.

1/ Citations to the Florida Parties' Joint Motion and Memorandum in Support of Joint Motion for Summary Judgment on Phase 2 Claims (DE 309) ("Motion") appear as "Fla. Br. at ___". Citations to the Florida Parties' Factual Appendix in Support of Joint Motion for Summary Judgment on Phase 2 Claims (DE 310) appear as "Fla. FA2 ¶ __". Citations to the Phase 2 Administrative Record appear as "Doc. No. 1, FWS AR Page ___" (FWS documents), "GAII000001-___" (Georgia II documents), "Doc. 1, ____" (USACE documents) or "Doc. 1, USACE PH 1 AR ___" (USACE documents) as each document is so stamped by the Federal Defendants in the administrative record. *See* Order dated November 2, 2009, DE 297 at 7. Citations to the Phase 1 Administrative Record appear as "ACF___" or "SUPPAR___" as each document is so stamped by the Federal Defendants in the administrative record. All other citations adhere to bluebook standards or as indicated in any stipulation related to such document.

2/ To the extent the Florida Parties do not address assertions in the other parties' briefs or factual appendices, such omission should not be construed as a concession or endorsement.

(the "ESA") in implementing its Revised Interim Operations Plan ("RIOP") 3/, but claim that the Service erroneously found the Corps' operations would result in an incidental "take" of the Apalachicola Species, 4/ arguing that the Apalachicola Species instead suffered "natural mortality." The Georgia Parties support the unlawfully narrow scope of agency action considered in the consultation, and endorse the Federal Defendants' use of a uniformly-rejected, so-called "comparative analysis" rather than the aggregate analysis required by Federal regulations and case law. The aggregate analysis requires the Service and the Corps to take a holistic view of the ACF Basin and the discretionary activities of the Corps in order to ensure the survival *and* recovery of listed species and the preservation of critical habitat. Upon that all-embracing assessment, the ESA imposes on the Corps, as stated by counsel for the Corps in one of these Multidistrict Litigation ("MDL") cases, "an affirmative obligation to go out and do whatever is required to protect the species[.]" Transcript of Hearing on Florida's Renewed Motion for Temporary Restraining Order on July 24, 2006, DE 507, Case No. 90-cv-1331 (N.D. Ala.) ("7/24/06 Hrg. Tr."), at 113; *see also infra* footnote 29 and accompanying text.

In arguing that the Service erroneously found incidental "take," and that everything and anything *but* the Corps' operations cause the demise of the Apalachicola Species, the Georgia Parties mischaracterize the facts. The Florida Parties will not respond to every

3/ The term "RIOP" incorporates the Corps' Interim Operations Plan ("IOP") submitted to the Service on March 7, 2006 and its subsequent modifications, including the RIOP upon which the subsequent 2008 BiOp is based. *See* Fla. FA2 ¶¶ 383-945.

4/ The Apalachicola Species are those endangered and threatened species inhabiting the Apalachicola River, including the threatened Gulf sturgeon and two mussel species, the endangered fat threeridge and the threatened purple bankclimber.

factual mischaracterization of the Georgia Parties, and will instead only address those relevant to our Argument. The Florida Parties do, nevertheless, here raise the Georgia Parties' most egregious mischaracterization: that respecting the "natural" flows of the river.

The Georgia Parties argue that the Corps' hypothetical, imaginary construct, referred to in the 2008 BiOp as run-of-river ("RoR Model"), should have been employed as the environmental baseline against which the RIOP should have been compared to demonstrate a net benefit to the Apalachicola Species. The Georgia Parties characterize this RoR Model as a "natural" flow, despite the Service's clear statement to the contrary and the BiOp's acknowledgement that the RoR Model was designed to isolate the impact of upstream consumptive uses. Rather than illustrating what a "natural" hydrograph would provide, the RoR Model *deducts* from simulated flows all consumptive uses, inter-basin transfers, as well as the evaporation from the large number of man-made reservoirs in the ACF Basin, reducing the simulated flows in the RoR Model far below what could accurately be considered "natural" flows and, in certain circumstances, by over 50%. 5/ Comparison of the RIOP impacts to those associated with RoR Model flows thus artificially portrays the Corps' RIOP as a benefit for the Apalachicola Species and their habitat, when, in fact it, and the Corps' 1989 draft Water Control Plan ("WCP") of which it is a modification, are contributing to the decline of the Apalachicola Species and adverse modification of their critical habitats.

By advocating use of the RoR Model as a baseline, the Georgia Parties ask this Court to dictate that the Service effectively grandfather in all upstream water uses when the Basin's

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5/ In depicting typical flows in a dry month, the BiOp illustrates that consumptive uses and evaporation reduced flows from June 2000 by 52%. *See* Doc. No. 510, FWS AR Page 013638. These *reduced* June 2000 flows, according to model description, were incorporated into and become part of the RoR Model. *Id.* at FWS AR Pages 013610-13.

water resources are strained. Contrary to the Georgia Parties' arguments, the ESA was established to provide for the survival and recovery of the species—not to facilitate their extinction.

ARGUMENT

At the outset, the Georgia Parties agree with the Service's determination that the Corps' RIOP is *not*, in the words of ESA Section 7(a)(2), "likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of habitat of such species." *See* 16 U.S.C. § 1536(a)(2). The Service's error in reaching this conclusion was addressed in the Florida Parties' Motion. *See* Fla. Br. at 36-46. The Georgia Parties then attack the Service's authority and rationale for issuing an Incidental Take Statement ("ITS") that allows the Corps to "take" certain numbers of the Apalachicola Species while concurrently requiring the Corps to implement terms and conditions to minimize such "take." In so doing, they advance several legal arguments, each deeply flawed in its logic and contrary to settled principles governing implementation of the ESA.

Before addressing the Parties' differences, however, we note several facts and legal principles on which the Georgia and the Florida Parties *agree*:

- Flow in the Apalachicola River is controlled by the combined operation of five upstream Corps reservoirs (not just releases from Woodruff Dam), Ga. FA ¶ 9; Ga. Br. at 3, and those operations are conducted pursuant to the WCP. Ga. Br. at 8.

- The listing of the Apalachicola Species and designation of their critical habitat triggered the Corps' obligation for Section 7 consultation with regard to the effects of their ACF reservoir operations on the Species. Ga. Br. at 8.

- When determining whether the Corps' operations will jeopardize species, adversely modify their critical habitat, or result in "take," the Corps' ongoing discretionary actions cannot be included in the "environmental baseline." Ga. Br. at 25.

- In examining the environmental impacts of the Corps' ACF operations, the 1989 WCP and the RIOP must be "taken together" and analyzed as a single operational plan. Ga. Br. at 41.

While the Georgia and the Florida Parties agree on the forgoing, they differ as to what the ESA requires of the Corps as a consequence. As the Florida Parties demonstrated in our Motion and the Georgia Parties indirectly concede, 6/ the ESA requires the Federal Defendants to evaluate the 1989 WCP and the RIOP collectively as part of a single action. This single action must be considered in the context of an already degraded environmental baseline and myriad cumulative impacts, including diminished flows attributable to upstream consumption. Using this "aggregate" analysis, it becomes apparent that the Corps' action (when properly defined) is not in accordance with the needs of the Apalachicola Species and their designated critical habitat. Had FWS analyzed the effects of the 1989 WCP and RIOP together with the environmental baseline and cumulative impacts as required by law, it would have concluded that the adverse impact of the Corps' ongoing reservoir operations has been much greater than that analyzed pursuant to Section 7 in the challenged BiOp. 7/

6/ As explained in Section I.A. below, the scope of a NEPA analysis, which the Georgia Parties agree should have included the entirety of the Corps' operations, including at a minimum the 1989 WCP, applies with equal force to the Federal Defendants' obligations under the ESA.

7/ The Florida Parties are not responsible for conducting the Section 7 analysis, and do not here attempt to determine what the outcome of such a consultation should be. While we believe a proper Section 7 analysis would result in violations of the "no jeopardy" and "no adverse modification" prohibitions, consistent with the APA, the Florida Parties seek only a remand of the BiOp, with instructions for a proper consultation, including use of an "aggregate analysis."

In contrast, the Georgia Parties contend that the perilous condition of the Apalachicola Species is due to anything *but* the Corps' reservoir operations, and therefore, the Corps has *no obligations* under the ESA. The Georgia Parties reach this remarkable result by advocating application of a discredited so-called "comparative approach" that evaluates only the incremental impact of the RIOP in isolation from the 1989 WCP and cumulative impacts. The Georgia Parties argue *all* Corps reservoir operations (their so-called "Regulated Condition") 8/ must be seen as beneficial to the listed species because, when *compared* with the RoR Model as a baseline, both the Regulated Condition and the RIOP result in modeled flows that appear to *improve* habitat conditions in the Apalachicola River. This argument assumes that the impacts of the Corps' actions are to be segregated from their context (although the Georgia Parties later concede that the 1989 WCP and the RIOP should be "taken together"), and that federal agencies need only address the *incremental* effects of their actions. If accepted, this position would turn the ESA on its head and effectively exempt the Corps from meaningful ESA compliance in the ACF Basin and elsewhere.

As shown below, the Georgia Parties' argument fails, because it: (1) erroneously endorses the unlawfully narrow delineation of the "agency action" on which the Corps and the Service chose to consult; (2) relies on the so-called "comparative approach" that has been rejected by the courts and defies reason; and (3) argues for a construct of an environmental baseline that bears no relation to reality or the requirements of the Service's regulations. By

8/ The "Regulated Condition" is what the Service utilizes as the Baseline in the BiOp, and consists of the observed flows of the river from calendar years 1975-2007 or, in other words, the observed flows "since the full complement of the Corps' reservoirs were completed." Doc. No. 510, FWS AR Page 013610. The "Regulated Condition" is dominated by operational changes articulated in the 1989 WCP. *See*, *e.g.*, Phase 1 Order at 1331-33.

employing a lawful scope of the agency action, and by utilizing the required aggregate analysis, a proper biological opinion likely would conclude that the Corps' shift in reservoir operations to support water supply, *see* Phase 1 Order at 1333, embodied in its 1989 WCP (as adjusted by the RIOP), has been a significant cause of jeopardy to the listed species, has adversely modified their critical habitat, and stands as a formidable barrier to their recovery. 9/

Finally, in keeping with their "comparative approach," the Georgia Parties contend the Corps cannot be seen as causing incidental "take" when it reduces flows in the Apalachicola River to 4,500 cfs under the RIOP, thereby killing thousands of protected mussels, because the Service did not prove that such flow reductions were caused solely by Corps' operations. This argument reverses the ESA's concepts of causality and defies the clear distinction between causation under ESA Section 7 and ESA Section 9.

First, the Georgia Parties' causation arguments have no place in the Section 7 context. 10/ Rather, under Section 7, the Service is required to determine whether "jeopardy" or "adverse modification" will result from the aggregate of the "agency action"

9/ As described in our Motion, a comparison of pre-WCP flows to post-WCP flows during drought conditions demonstrates that decreased flows since the implementation of the WCP have caused a 91% reduction in floodplain habitat during the April-May reproductive period; a 100% reduction of minimal slough connection during the secondary spawning and host fish nursery season; an 80% loss of connection of Swift Slough (a key slough which supported a large mussel population) during the low-flow season; a 78% loss of inundation of suboptimal Gulf sturgeon spawning habitat during spawning season; and a 90% loss of tolerable salinity levels in the Apalachicola Bay during the low-flow season. Fla. Br. at 13-17, 45-46; *see also* Fla. FA2 ¶¶ 149-72.

10/ We note that, although the Georgia Parties label their causation argument as a challenge to the Service's ITS issued pursuant to Section 9, in their conclusion, the Georgia Parties request that the Court hold the Service used the wrong standard of causation to determine that the Corps actions resulted in "adverse effects," which is a Section 7 analysis. GA Br. at 48. As described in detail below, the concept of "causation" that the Georgia Parties advocate is inapplicable in the Section 7 context, as well as inappropriate in a Section 9 analysis.

and its "effects" (both direct and indirect) together with environmental baseline conditions and cumulative impacts. In a Section 7 analysis, an acting agency will be found to have caused "jeopardy" or "adverse modification" when the agency fails to exercise its discretion to reduce or prevent the resulting effects. The concept of "causation" put forth by the Georgia Parties simply does not apply in the Section 7 context.

Second, to the extent causation is an element in the context of Section 9, the Corps' operations need not be the *sole* cause of the Apalachicola Species' imperilment in order to be a cause of their decline. Rarely do complex events have single causes. There is no question that the Corps' ACF reservoir operations are *among* the causes of the Apalachicola Species' decline and are continuing to adversely affect those species. Doc. No. 510, FWS AR Pages 013524, 013539, 013657-64. This is all that is required to impose on the Corps an obligation to avoid "taking" members of the Apalachicola Species. Fundamentally, flow reductions under the RIOP will not occur unless the Corps affirmatively decides to curtail releases from conservation storage in upstream reservoirs. The Corps' decision to store water upstream is largely dictated by its Action Zones in the 1989 WCP (which have never been subjected to formal ESA consultation). As long as conservation storage remains available in those reservoirs, the Corps is making discretionary decisions to retain it or release it, and the Corps' decision to retain that storage upstream so as to reduce releases at Woodruff Dam below 5,000 cfs must be seen as *a* cause of resulting mussel mortality.

In advocating their distorted notions of agency action and causation, the Georgia Parties, through their motion, seek only to ensure that the WCP's impact on the Apalachicola Species will *never* be reviewed by the Service and that what minimal operations are in place to send flows for the benefit of the Apalachicola Species are diminished. To achieve their desired result, the Georgia Parties ask this Court to depart from the ESA's statutory provisions, FWS's regulations, applicable case law and the foundational purpose of the ESA. That purpose is not just to protect the Apalachicola Species from extinction, but also to facilitate their recovery.

I. The ESA Requires a Comprehensive Analysis of the Corps' ACF Operations

A. The Scope of the Agency Action Was Unlawfully Narrow

All of the Georgia Parties' ESA arguments are premised on the proposition that the Federal Defendants lawfully limited their consultation to the RIOP (and its variations) rather than the Corps' comprehensive, basin-wide reservoir operations conducted under the WCP, within which the narrow RIOP is confined. Ga. Br. at 23 (equating "effects of the action" with "reservoir operations under the RIOP"). But as our Motion shows, the ESA, its implementing regulations and extensive and uniform case law confirm that the Corps has a duty to consult on its *entire* action, not merely some segmented portion of it, and that the Service must insist that this be done even if the Corps proposes an inappropriately narrow scope of the consultation. *See* Fla. Br. at 24-31. The Georgia Parties' various arguments concerning the environmental baseline are premised on this fundamental flaw in the consultation itself.

Given this threshold error, it is ironic that the Georgia Parties—and indeed the other parties that have addressed ESA issues in the briefing thus far—*agree* about most of the legal building blocks supporting the conclusion that this consultation was unlawfully narrow. 11/ First, the Georgia Parties accept that all federal agencies must enter into consultation "before undertaking any discretionary action that 'may affect' a listed species or its critical habitat." Ga. Br. at 19. Second, the Georgia Parties argue, and thus concede, that the Corps' reservoir operations are discretionary within the meaning of the ESA. Ga. Br. at 25. Third, the extensive record in this case, including the Service's listing decisions and its critical habitat designations, establish beyond doubt that the Corps' discretionary reservoir operations not only "may affect" the Apalachicola Species, but rank among the principal causes of their decline. *See, e.g.*, Fla. FA2 ¶¶ 146-344. Finally, the Service has repeatedly demanded that the Corps consult on its entire reservoir operating regime, pointing out the pressing need to do so because of impacts on the Apalachicola Species, 12/ and the Corps has agreed that it will do so following unspecified future revisions, Fla. FA2 ¶¶ 353, 390, 648, 775, 788, 790, 934, confirming their view that the scope of mandatory ESA consultation must be far broader than has occurred thus far.

11/ Alabama, in its Motion for Partial Judgment on All Phase 2 Claims and Supporting Memorandum ("Ala. Br."), correctly argues that the Service's limitation of the scope of the agency action is in contravention of the ESA and is arbitrary and capricious. Ala. Br. at 17-23. Alabama accurately observes that an evaluation of the modification of the WCP, *i.e.* the RIOP, cannot be adequate without the evaluation of the underlying WCP. *Id.*

12/ The Service made repeated requests of the Corps to initiate consultation, including, for example, on August 10, 2000, Fla. FA2 ¶ 356; on August 12, 2002 (advising "the Corps not to wait before initiating consultation on the existing water control operations, especially in light of new information related to possible impacts to sturgeon spawning habitats," Fla. FA2 ¶ 362); in October 2002 (receiving the Corps' agreement to consult "on the effects of current water control operations on the Gulf sturgeon spawning activities," Fla. FA2 ¶ 365); and again in May 2005 (reminding the Corps that because no formal consultation had taken place, "any takings due to discretionary actions by the Corps would be considered an unauthorized taking under the [ESA]," Fla. FA2 ¶ 377). *See generally* Fla. FA2 ¶¶ 348-82.

The Georgia Parties also confirm that the scope of this ESA consultation was unlawfully narrow. In their extensive discussion of requirements for agency analysis under the National Environmental Policy Act ("NEPA"), 42 U.S.C. § 4321, *et seq.*, they state that:

> NEPA requires the preparation of an EIS before undertaking any 'major Federal action[ ] significantly affecting the quality of the human environment.' Reservoir operating plans clearly trigger this requirement . . . . The Corps has never done this for the ACF Basin. It has never completed an EIS for any aspect of its ACF reservoir operations. It did not do an EIS for the 1989 Water Control Plan . . . or any other operating plan. Whatever the reasons for this failure, it is a clear violation of NEPA.

Ga. Br. at 34-35. The Georgia Parties further clarify that the 1989 WCP and the IOP/RIOP must be "taken together." Ga. Br. at 41.

As the Eleventh Circuit instructs in *Florida Key Deer v. Paulison*, 522 F.3d 1133 (11th Cir. 2008), the required scope of NEPA analysis applies with equal force to the Federal Defendants' obligations under the ESA. In *Key Deer*, the Eleventh Circuit considered the scope of consultation requirements under ESA Section 7(a)(2) with respect to the National Flood Insurance Program ("NFIP") administered by the Federal Emergency Management Agency ("FEMA"). *Key Deer*, 522 F.3d at 1141-44. That Court held: "[t]his statutory and regulatory framework for determining when an agency action requires Section 7(a)(2) consultation *is materially indistinguishable from the framework of the National Environmental Policy Act* . . . considered by the Supreme Court in *Department of Transportation v. Public Citizen*, 541 U.S. 752 . . . (2004)." *Id*. at 1143 (emphasis added). Relying on *Public Citizen*, the court concluded that ESA Section 7(a)(2) consultation is required, just as NEPA analysis is required, *whenever the action agency has the authority to conduct its program in a fashion that addresses adverse effects on the listed species, or in the*

NEPA context, on the environment. Id. at 1144. In contending that a comprehensive NEPA analysis was "clearly" required for all of the Corps' "reservoir operating plans," (Ga. Br. at 34-35), the Eleventh Circuit tells us that the Georgia Parties have conceded that ESA consultation for those plans likewise was required.

Because the Corps and the Service have violated their duties to properly consult on the entire agency action in a timely fashion, 13/ the resulting unlawful BiOp can hardly serve as a springboard for the Georgia Parties' attacks on the Service's analytical baseline. As we demonstrate below, and as discussed in our Motion, *see* Fla. Br. at 36-46, the Federal Defendants have (1) placed the major portion of the relevant agency action into their baseline and (2) avoided consultation on that portion by employing a comparative analysis rather than the required aggregate approach. Consequently, the Georgia Parties' arguments about a proper baseline for analyzing the remaining, minor portion of the action (RIOP impacts) are simply untenable. 14/

13/ Section 7 consultation should occur "at the earliest possible time" and should not, as in this case, be unlawfully delayed. *See In re: Am. Rivers & Idaho Rivers United*, 372 F.3d 413, 419 (D.C. Cir. 2004) (agency's failure to respond to petition to initiate Section 7 consultation for six years constitutes unreasonable delay); *Center for Biological Diversity v. Leavitt*, No. C 02-01580JSW, 2005 WL 2277030, *5 (N.D. Cal. Sept. 19, 2005) (finding Section 7 violation where EPA failed to review the impact of pesticide registrations on threatened species, and observing that "such review to commence nearly 10 years after the listing of the species does not appear to be the 'earliest possible time'" required by the ESA regulations); *Silver v. Babbitt*, 924 F. Supp. 976, 986 (D. Ariz. 1995) (BIA action that "allowed continuation of timber harvest activities . . . despite the lack of . . . consultation with the FWS" violates ESA); *see also* Fla. Br. at 26, 65-67.

14/ In advocating for the hypothetical, imaginary RoR Model as a baseline, the Georgia Parties argue that discretionary federal actions, such as operations under the draft WCP, "must be *excluded* from the baseline." Ga. Br. at 25 (emphasis added). But if this be so, then, those same discretionary federal actions, which have not undergone Section 7 consultation, should *a fortiori* be *included* in the agency action. 50 C.F.R. § 402.02. In either case, they must be *considered* in the consultation.

B. The BiOp Is Irreparably Flawed By Its Unlawful Comparative Analysis

Compounding their erroneous view of the scope of agency action for consultation, the Georgia Parties then argue that the effects of the action should be *compared* with baseline effects. Ga. Br. at 23-24. This position has been rejected by the courts. As we demonstrated in our Motion, the case law demands an aggregate approach under which the effects of the action, *together with* baseline effects, must form the basis for the Service's Section 7(a)(2) analysis. Fla. Br. at 28-29, 40-46. The Service itself confirms that:

> The conclusion section [of a biological opinion] presents the Services' opinion regarding whether the *aggregate* effects of the factors analyzed under "environmental baseline," "effects of the action," and "cumulative effects" in the action area – when viewed against the status of the species or critical habitat as listed or designated – are *likely to jeopardize the continued existence of the species or result in destruction or adverse modification of critical habitat*.

Consultation Handbook at 4-31, Doc. No. 314, FWS AR Page 7490 (emphases added). 15/

The Georgia Parties cite the Service's regulations and two judicial opinions—*Miccosukee Tribe of Indians of Fla. v. U.S. Fish & Wildlife Serv.*, 566 F.3d 1257 (11th Cir. 2009) and *In re: Operation of the Missouri River Sys. Litig.*, 421 F.3d 618 (8th Cir. 2005) ("*Missouri River*")—in support of their contrary position. Ga. Br. at 23. None of these authorities advances their position.

First, the Georgia Parties point to the regulatory definition of "effects of the action" at 50 C.F.R. § 402.02, claiming that it requires consideration of such effects "in relation to" the

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15/ As noted in our Motion, the Eleventh Circuit has confirmed that the *Consultation Handbook* has the force of a regulation. *See* Fla. Br. at 27 n.15 (citing *Miccosukee Tribe of Indians of Florida v. U.S. Fish & Wildlife Serv.*, 566 F.3d 1257, 1273 (11th Cir. 2009) concluding that the *Handbook* is entitled to *Chevron* deference).

environmental baseline. *Id*. The regulation does no such thing. To the contrary, it plainly and expressly requires the Service to examine effects "that will be *added* to the environmental baseline." *Id.* (emphasis added). As the Service explains in its *Handbook*, quoted above, this means that the analysis of whether there will be jeopardy or adverse modification of critical habitat must consider the aggregate effects of the baseline added to the agency action, not the latter in relation to the former. 16/

In *Nat'l Wildlife Fed'n v. Nat'l Marine Fisheries Serv.*, 524 F.3d 917 (9th Cir. 2008), the Ninth Circuit considered and explicitly rejected the argument asserted here by the Georgia Parties, which had been advanced there by the National Marine Fisheries Service ("NMFS"). Relying on 50 C.F.R. § 402.02—the same provision underlying the Georgia Parties' position here—NMFS asserted that "it may satisfy the ESA by comparing the effects of proposed [reservoir] operations on listed species to the risk posed by baseline conditions." *Id*. at 930. The court held NMFS's "comparative analysis" to be incompatible with the ESA, explaining that the aggregate approach *was mandated* by the regulations:

> [The ESA] simply requires that NMFS appropriately consider the effects of its actions "within the context of other existing human activities that impact the listed species.". . . This approach is consistent with our instruction . . . that "[t]he proper baseline analysis is not the proportional share of responsibility the federal agency bears for the decline in the species, but what jeopardy might result from the agency's proposed actions *in the present and future human and natural contexts*." *Pac. Coast Fed'n*, 426 F.3d at 1093 (emphasis added).

16/ The Georgia Parties also cite 50 C.F.R. § 402.14(g) for support. However this provision, which describes the Service's responsibilities during formal consultation, says nothing about a "comparative analysis."

Id. (citations omitted); *see also Aluminum Co. of Am. v. Adm'r, Bonneville Power Admin*., 175 F.3d 1156, 1162 & n.6 (9th Cir. 1999) (agency may not simply "stay the course" when more is required to avoid jeopardy and adverse modification); *see also California Sportfishing Prot. Alliance v. F.E.R.C.*, 193 Fed. Appx. 655 (9th Cir 2006). As we explained in our Motion, other courts addressing this issue have reached the same conclusion. Fla. Br. at 42-44.

Nor do the decisions cited by the Georgia Parties lend support to their position. In *Miccosukee*, the Tribe criticized the Service for failing to analyze aggregate impacts, but the court found, "[t]o the contrary," that the BiOp did precisely that in its extensive consideration of impacts caused by prior and ongoing activities. *Miccosukee*, 566 F.3d at 1268-69. The Eleventh Circuit accepted that the Service should consider aggregate impacts and held that the Service had sufficiently done so.

Turning to *Missouri River*, the parties there never asked the Eighth Circuit to decide whether the ESA requires a comparative analysis or an aggregate approach. As this was not an issue in the case, that court's discussion of baseline considerations, 421 F.3d at 632, merely accepted the Service's comparative analysis as an unchallenged facet of the case.

Moreover, the Eighth Circuit evaluated a Corps-Service consultation that differed fundamentally from the circumstances here. That litigation exhaustively examined the Corps' operation of an *entire river system* pursuant to formally adopted master manuals and updates that served congressionally authorized purposes. *All* Corps operations were included in the agency action subject to ESA consultation. Consequently, the Service's evaluation of proposed system-wide operations in relation to a baseline 17/ had the effect of analyzing the *aggregate* impact of all discretionary actions implemented by the Corps. Here, the Service's comparison of RIOP impacts with the impacts of a regulated-condition baseline has the opposite effect—instead of aggregating the effects of Corps actions and other impacts, it omits from the jeopardy analysis any evaluation of the Corps' ongoing, basin-wide operations that will continue to affect the species. As discussed above, a comparison of the effects of their narrow RIOP action with a baseline is unlawful; only an aggregate analysis can properly capture the overall effects on the species of all of the Corps' discretionary actions.

Finally, the Eleventh Circuit's application of the law and common sense in *Key Deer* supports an aggregate analysis. As noted, the Eleventh Circuit decided that the scope of ESA consultation is co-extensive with an action agency's discretion to avoid adverse impacts to the species and their habitats. *Key Deer*, 522 F.3d at 1144. Just as NEPA requires analysis of all of the Corps' discretionary operations throughout the ACF Basin, as the Georgia Parties accept and agree, the ESA demands a consultation that addresses all of those comprehensive, basin-wide operations. *See id*. at 1143-44. Comparing a narrow slice of operations at Woodruff Dam to an arbitrary baseline comes nowhere near meeting these requirements.

C. The RoR Model Is Not A Proper Environmental Baseline

The Georgia Parties argue at length that the Service employed an improper environmental baseline. Ga. Br. at 23-27. However, until the Federal Defendants consult on

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17/ As discussed below, the Eighth Circuit also did not hold, as the Georgia Parties suggest, that a run of the river baseline is required for ESA consultations involving reservoir operations.

the proper scope of agency action, nothing is gained by parsing arguments about the appropriate baseline for evaluating the narrow RIOP action unlawfully considered here. Consideration of an appropriate baseline is overwhelmed by the choice of a proper analytical approach. Using the proper *aggregate* approach, as mandated by the Service's *Handbook* and the case law, entails *adding* baseline effects to the impacts expected from a proposed action in order to assess the issues of jeopardy and destruction or adverse modification in a current, real-world context. Whether the impact of a discretionary action is included in the baseline or evaluated as part of the action under review has no effect on *whether it is considered* via the consultation in making these important decisions. 18/ By contrast, the so-called "comparative approach" places great weight on the definition of the baseline, as it allows the Service to assign significant impacts to the baseline, artificially segregating them from the action being evaluated, and to regard the agency's residual action as minor by comparison, as it has done here. Such segregation is unacceptable.

Semantic arguments over what constitutes "baseline" can hardly overcome the fact that the very purpose of the ESA has been thwarted by an outcome that threatens the extinction of the Apalachicola Species. The evidence compiled by the Service in the BiOp makes abundantly clear that the Corps' reservoir operations over the past several decades (as "tweaked" by the RIOP) have:

18/ This is not to imply that the baseline is irrelevant. In a circumstance such as this, however, where the agency failed to consult on a past, yet ongoing, discretionary action (*i.e.*, it violated the law by failing to consult when legally required to do so), the baseline loses its utility since the past, unconsulted discretionary action by definition cannot be part of the baseline, yet is not facially included in the proposed agency action. Failing to require consultation on the agency's ongoing action *along with* the proposed agency action would allow ongoing discretionary actions to escape review, and would thwart the purposes of the ESA.

- Killed thousands of supposedly protected mussels and promise to kill more. Fla. FA2 ¶¶ 428-40, 846-78, 900-01.

- Devastated an important subpopulation (Swift Slough), securing the viability of which was the cornerstone of the Service's so-called "recovery" plan. Fla. FA2 ¶¶ 275-82, 312-15, 428-40.

- Damaged important components of mussel critical habitat. Fla. FA2 ¶¶ 156-62, 293-311, 879-93.

- Substantially degraded critical habitat for the Gulf sturgeon by reducing flows during the important spawning season, thereby reversing the Service's stance that such areas should receive "maximum protection." Fla. FA2 ¶¶ 163-71, 233-35, 243-46, 281; GAII000677-78.

A proper Section 7 analysis would *start with* these determinations, not an arbitrary baseline definition, and then determine the extent to which the Corps' discretionary reservoir operations might be changed to reduce or avoid these impacts. If operational adjustments can be made, then they must be. *See Key Deer*, 522 F.3d at 1145-47. Quibbles over comparisons to hypothetical baselines have no place in such an evaluation because the action agency's legal responsibility in a Section 7(a)(2) consultation is to reduce adverse impacts on species and habitats to the full extent of its discretion to act, not to the extent those adverse impacts have been caused by its new, proposed activities as compared to impacts already caused by unreviewed prior conditions.

In their attempt to eradicate even the meager conditions placed on the Corps' operations via the Service's ITS, the Georgia Parties offer that "natural" conditions should serve as the baseline, and then argue that the Corps' RoR Model *is* a natural condition. As noted above, it most certainly is not a natural condition. Moreover, the Georgia Parties mistakenly rely on decisions by the Eighth and Ninth Circuits to argue that RoR Model conditions must be used as the baseline in any consultation involving reservoir operations.

First, the Eighth Circuit's *Missouri River* decision did *not* hold that RoR Model conditions always must serve as the baseline. Rather, it decided the very narrow question of whether the Service erred by excluding a specific operating parameter from the baseline. The Missouri and Nebraska parties had argued that the Service erred by not including in the baseline certain navigation-related flow requirements that (they asserted) were non-discretionary with the Corps because those requirements were dictated by the Flood Control Act of 1944 ("FCA"). *Missouri River*, 421 F.3d at 629, 632-33. The MDL court had concluded that the FCA did not limit the Corps' discretion in that fashion, and the Eighth Circuit agreed. *Id*. at 629. 19/ The Court of Appeals explained that inclusion of such discretionary actions in the baseline would "tend to eliminate a finding of jeopardy for any proposed action," *id*. at 632, and said: "[a]s the district court recognized, this argument is essentially a different twist on the argument that the Corps has no discretion in operating the reservoir system." *Id*. at 633. 20/ The court's reasoning was based on the fact that, in that case, the Corps was consulting on its proposal to *completely replace* its old 1979 Master Manual with a new 2004 Master Manual *for the entire river system*. *Id*. at 625. All aspects of its discretionary manual update therefore constituted the agency action, not the baseline.

19/ These parties also argued that *no ESA consultation* was required for the Missouri River system because navigation flows were non-discretionary. *Missouri River*, 421 F.3d at 630-31. The MDL court rejected this argument, and the Eighth Circuit concurred. *Id*. at 631.

20/ As discussed above and in our Motion, Fla. Br. at 36-46, in this case the Service has done precisely what the Eighth Circuit rejected in *Missouri River*—assigned a large portion of the Corps' action to the baseline. And the results were just what the Eighth Circuit anticipated and disapproved—adverse impacts were assigned to the baseline so as "to eliminate a finding of jeopardy for any proposed action." *Missouri River*, 421 F.3d at 632; *see also Nat'l Wildlife Fed'n*, 524 F.3d at 928-29 (finding that jeopardy cannot be avoided by game-playing tactics such as inappropriately labeling discretionary actions).

In two fundamental respects, the consultation here differs dramatically from the situation in *Missouri River*. First, *most* of the Corps' discretionary action—its operation of the upstream reservoirs pursuant to the draft 1989 WCP—is excluded from the action subject to this consultation, whereas in *Missouri River* it was the *focus* of the consultation. Second, whereas in *Missouri River* the Corps had discretion under the FCA to operate the Missouri River system for all of the purposes captured by its master manuals (and thus those operations were excluded from the baseline), this Court has determined that the Corps has been operating primarily to serve unlawful purposes that are *outside* its discretion because they were not *authorized*. As we demonstrated in our Motion, post-WCP flow reductions in the Apalachicola River have resulted in substantial loss of the Apalachicola Species and critical habitat. Fla. Br. at 45-46; *see also supra* footnote 9. And yet, unlike *Missouri River*, where *all* discretionary action was subject to consultation, here even the Corps' *ultra vires* conduct was excluded from consultation by both the Corps and the Service. The Georgia Parties' reliance on *Missouri River* to support their RoR Model-baseline argument cannot be reconciled with these basic differences.

As we have shown, *Nat'l Wildlife Federation v. Nat'l Marine Fisheries Service* makes clear that an aggregate approach is required and a comparative analysis is in error. *See* 524 F.3d at 929-31. The Georgia Parties cite that decision as also sanctioning an RoR Model scenario. Their reliance is misplaced. In *Nat'l Wildlife Federation*, the Ninth Circuit held that, while nondiscretionary actions are excluded from ESA requirements, Section 7(a)(2) consultation *must include all* discretionary agency actions: "neither the ESA nor *Home Builders* permits agencies to ignore potential jeopardy risks by labeling parts of an action nondiscretionary. We cannot approve NMFS's interpretation of this rule as excluding from the agency action under review discretionary agency actions taken pursuant to a broad congressional mandate." *Nat'l Wildlife Fed'n*, 524 F.3d at 928 (citing *Nat'l Ass'n of Home Builders v. Defenders of Wildlife*, 551 U.S. 644 (2007)). Contrary to the Georgia Parties' assertion, the Ninth Circuit did not sanction use of any run of the river model as the environmental baseline; it merely held that discretionary operations cannot be included in the baseline. *Id*. at 930-31.

Finally, ignoring the past 20 years, during which the Apalachicola Species have been faced with the threat of extinction, the Georgia Parties erroneously contend that "reservoir operations have been good, not bad, for the species," and that any "take" of the listed species must have been caused by "nature," not the Corps. Ga. Br. at 26-28. To construct this argument, the Georgia Parties focus on the RoR Model. But, in truth, the RoR Model is a hypothetical construct created by the Corps and used by the Service as a comparative tool. 21/ It was never what the Georgia Parties assert that it represents: natural flow conditions on the River. When the ACF Basin system operated naturally, the Apalachicola Species persisted; it is inappropriate to argue the Apalachicola Species are better off now. Having made their false representation, the Georgia Parties then compare the RoR Model to the RIOP and maintain the Service blamed "natural mortality" on the Corps' incidental take.

21/ The RoR Model is a hypothetical construct created by the Corps that the Service employed in order to "isolate the effects of the present level of consumptive water use on the flow." Doc No. 510, FWS AR Page 013610. In its attempt to "isolate" consumptive uses by eliminating Corps' operations from its modeling, the Service assumed that the Georgia Parties could withdraw water from Lake Lanier even though the Corps could not store any water under the RoR Model for their consumptive use. The Service's assumption, and the Georgia Parties' reliance on that assumption, is contradictory, and thus makes no sense.

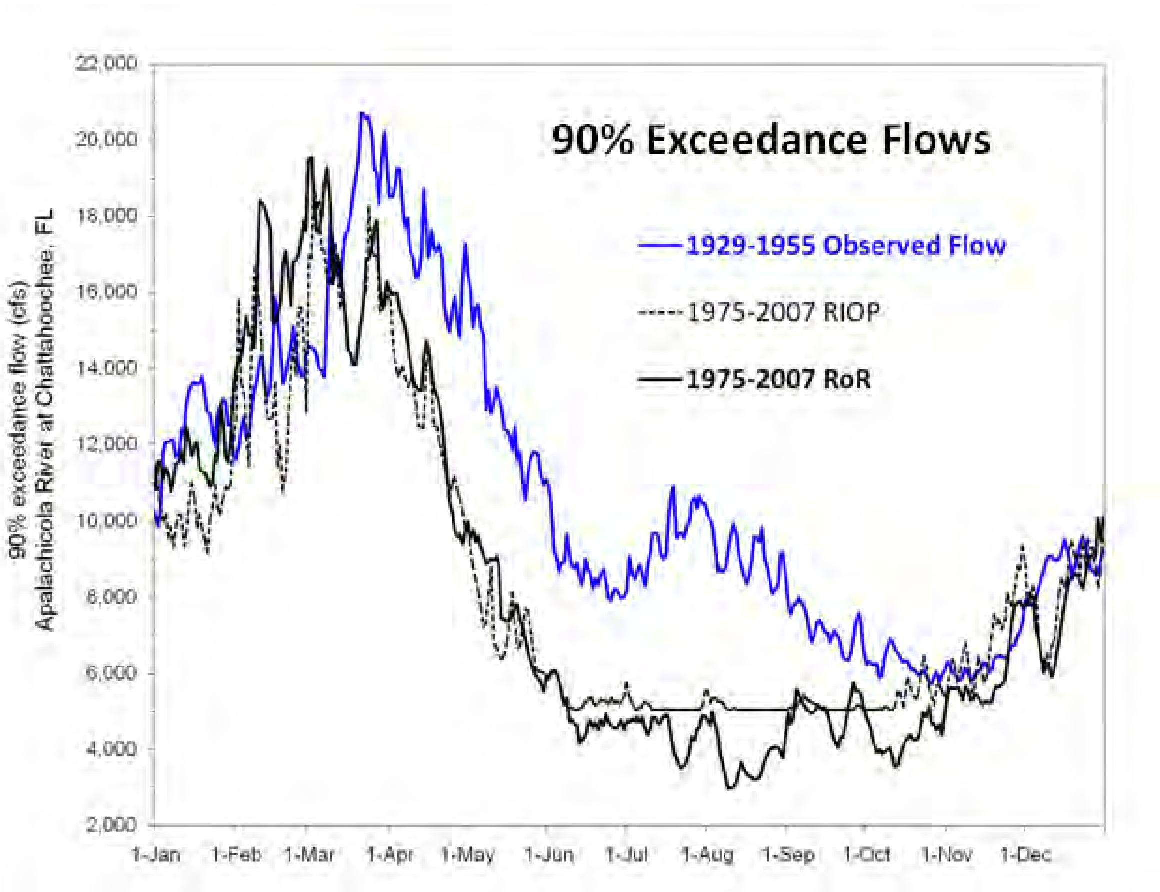
As noted above, the RoR Model differs markedly from the natural flow of the river and was never intended to be used as a surrogate for such flows. The Service explains that the RoR Model is "the constant release of basin inflow." Doc No. 510, FWS AR Page 013610. But the Service used *net* basin inflow, a concept that detaches its RoR Model from reality. The Service says: "[b]asin inflow is *not the natural flow* of the basin at the site of Woodruff Dam, because it reflects the influences of reservoir evaporative losses, inter-basin water transfers, and consumptive water uses, such as municipal water supply and agricultural irrigation." *Id.* at FWS AR Page 013611 (emphasis added). In other words, the Service's RoR Model effectively takes natural basin inflow and subtracts Georgia's consumptive uses as well as other losses (including evaporation), producing a flow regime in the Apalachicola River against which *any scenario* involving the use of storage to augment downstream flows (which Congress contemplated) would have to compare favorably. The surreal nature of this exercise is apparent by comparing the RoR Model with the authentic natural flows of the River—those flows which occurred between 1929-55, prior to construction of the dams and prior to any flow regulation.

Figure 1 displays the RoR Model, the RIOP flows and the unregulated 1929-55 pre-dam flows. 22/ There is a vast difference between this natural pre-dam flow of the river and the RoR Model. Especially during the critical low-flow season when water is necessary for mussel survival, summer spawning and fish host nursery habitat, the pre-dam flows in the Apalachicola River during drought conditions were higher than the simulated flows of the

22/ The 1929-55 observed flow data are from the USGS website, *see* Fla. FA2 ¶ 148(a), and the RoR and RIOP (Concept 6) flow data are from administrative record spreadsheets, *see* Doc. No. 875.17. The 90% exceedance flows in these three datasets were calculated by the methods described in the Florida Parties' Factual Appendix. *See* Fla. FA2 ¶ 148.

RoR Model by thousands of cfs. And the true "natural" flows not only exceeded the RIOP flows by a substantial margin, but also provided the flow *variation* during the summer and fall that is absent in the virtually flat line of the RIOP flows—variation that established the habitat conditions on which the River's ecology, and the listed species' needs, were built. 23/

FIGURE 1



Furthermore, even using the same time period to compare so-called "natural" flows to the RIOP flows refutes the Georgia Parties' contention that the Corps lacks responsibility for

23/ Moreover, the error in treating the RoR Model as a representation of "natural" flows is underscored by the fact that annual precipitation in low-flow years was *higher* during the 1975-2007 RoR Model period than during the 1929-55 pre-dam, unregulated period. *See* Fla. FA2 ¶ 181 & Figure 16.

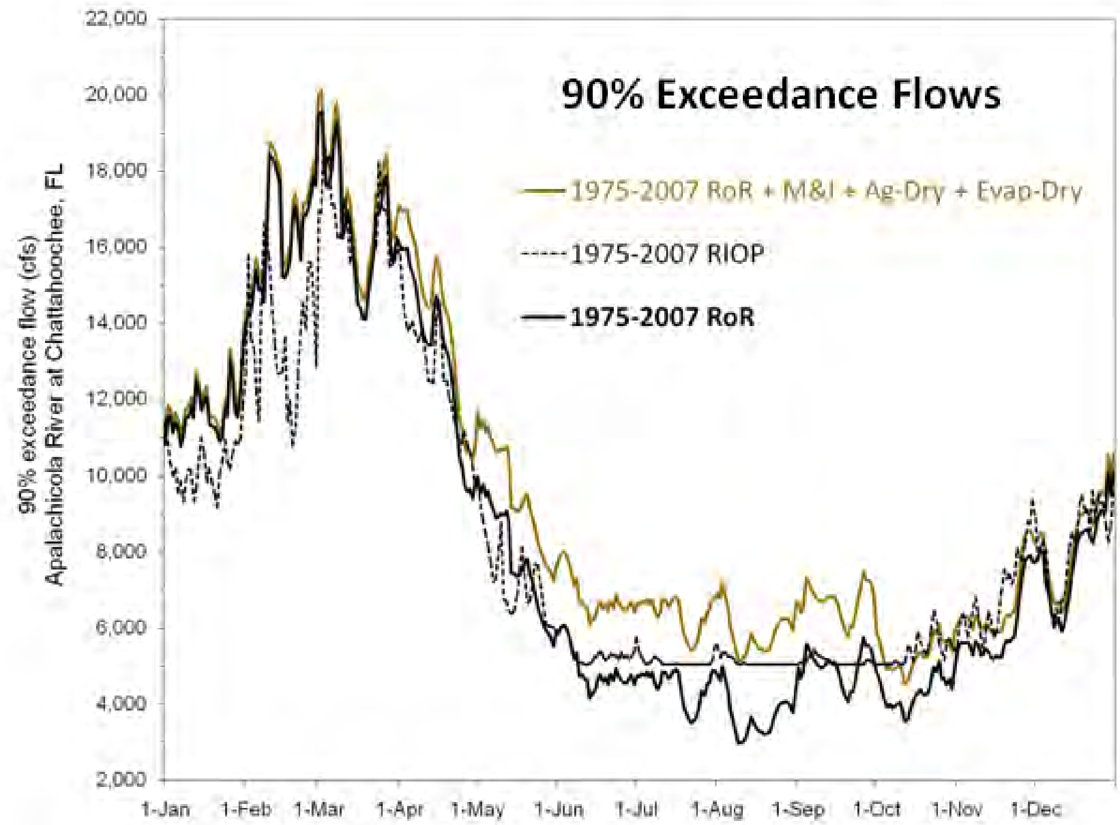
any "take" of the species. Because the RoR Model assumes that M&I consumption, agricultural consumption and reservoir evaporation will continue unabated, it comes nowhere near representing what nature would provide to the Apalachicola River absent these upstream uses. By adding current demands (designated as "M&I + Ag-Dry + Evap-Dry") to the RoR flows, one can come closer to a "natural" condition. 24/ Figure 2 displays the RoR Model, the RIOP flows and the "RoR + M&I + Ag-Dry + Evap-Dry" flows. 25/ Although the "RoR + M&I + Ag-Dry + Evap-Dry" underestimates "natural" flows, 26/ Figure 2 still illustrates that the RIOP, and not nature, consistently produces adverse effects—lower flows and lack of variability—to the flow regime.

24/ M&I, Ag-Dry, and Evap-Dry data are contained in Table 4.2.1.A of the BiOp. Doc. No. 510, FWS AR Pages 013611, 013633. For purposes of this analysis, the Florida Parties do not dispute the underlying data contained in the BiOp. However in so doing, they do not validate the data, since, for example, the Florida Parties believe that evaporation is significantly understated.

25/ The Florida Parties utilize the RoR Model and the RoR + M&I + Ag-Dry + Evap-Dry flows for demonstrative purposes and in no way accept the legitimacy of either flow regime.

26/ This estimate includes evaporation from Corps model data based only on the four major reservoirs. Doc. No. 510, FWS AR Page 013611. No attempt has been made by the Corps to account for evaporative losses from the over 20,000 additional reservoirs, including smaller reservoirs and irrigation, stock and farm ponds, in the basin upstream from Woodruff or other human activity which is known to affect streamflow. *See* Doc. No. 232, FWS AR Page 4171.

FIGURE 2



90% Exceedance Flows
1975-2007 RoR + M&I + Ag-Dry + Evap-Dry
1975-2007 RIOP
1975-2007 RoR
90% exceedance flow (cfs) Apalachicola River at Chattahoochee, FL
22,000
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec

II. The Georgia Parties Drought-Causation Argument Is Erroneous and Largely Irrelevant

The Georgia Parties contend that the Service erred in concluding that incidental "take" would occur when the Corps' RIOP causes flows in the Apalachicola River to be reduced to 4,500 cfs, thereby killing thousands of protected mussels. 27/ They argue that the Service failed to prove that the flow reduction and ensuing mortality would be caused by the Corps' operations rather than the low-flow periods with which the RIOP was designed to deal. This argument is redundant since the RIOP's reduction of flows is not triggered unless low-flow periods have occurred. In any case, however, the Service has no obligation to show that the Corps' action is the *only* cause of mussel mortality. While the Georgia Parties' drought-causation argument, which appears to be a Section 9 argument, 28/ is premature at this stage of the litigation, it is nonetheless wrong.

At this stage, this is primarily an ESA Section 7 case, not an ESA Section 9 case. In 2008 the Eleventh Circuit defined "causation" in the context of ESA Section 7 and held that an agency action is *a relevant cause* of effects on a listed species if the agency—there FEMA, here the Corps—has any ability to prevent the effects of its action, either direct or indirect, by altering its operations. *See Key Deer*, 522 F.3d at 1144. The Eleventh Circuit thus clarified that "causation" in the Section 7 context simply depends on whether the action agency retains

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27/ The Georgia Parties also object to the Services' conclusion that "take" of Gulf sturgeon could occur when flows are less than 40,000 cfs and the stage of the River falls 8 feet or more in 14 days, suggesting that resulting sturgeon mortality could be due to storms or other non-Corps actions. Ga. Br. at 32. As detailed below, such assertions are irrelevant since the Corps' action—ongoing operation of the ACF reservoirs as a system—constitutes *a* cause of the flow and/or stage reductions, whether or not it is the principal cause.

28/ *See supra* footnote 10.

discretion to reduce harm to listed species. As the Federal Defendants' attorney has made clear, under Section 7, the Corps is *required* "to take affirmative action to ensure that its actions are not likely to jeopardize the continued existence of the species." 29/ After all, the plain intent of the ESA is "to halt and reverse the trend toward species extinction." *Key Dee*r, 522 F.3d at 1138 (quoting *Tenn. Valley Auth. v. Hill*, 437 U.S. 153, 184 (1978)). The Georgia Parties make no mention of *Key Deer*, and rely only on Section 9 cases. Accordingly, the Georgia Parties' causation argument greatly diverges from the Eleventh Circuit's approach.

To the extent the Court undertakes a review of the ITS, a Section 9 "causation" analysis would then be relevant, but only to establish whether the Service was arbitrary and capricious in determining that the Corps' actions constitute *a* relevant cause—and not *the sole* cause—of reduced flows and resulting species "take." Since Section 9 involves "harm," some tort-type concept of causation is relevant to the Service's Section 9 decisions. But

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29/ THE COURT [JUDGE BOWDRE]: Doesn't the ESA, though, require the Corps in this instance to take affirmative action to ensure that its actions are not likely to jeopardize the continued existence of the species?

MR. MAYSONETT: It does, Your Honor, under Section 7. I understand that the motion that Florida has brought solely under Section 9, which is the prohibition against take, and I think Mr. Wilmoth summarized them pretty well when he said *what Section 7 requires is that the Corps do whatever is required to avoid jeopardy*. And what Section 9 requires is the Corps avoid take…Instead they chose to proceed solely under Section 9.

So that affirmative obligation to go out and do whatever is required to protect the species doesn't arise under Section 9.

* * * *

THE COURT: Do you disagree with Mr. Wilmoth's argument that the Corps has an affirmative duty to take charge of the dams and release more water if necessary to protect the endangered species?

MR. MAYSONETT: The Corps has affirmative duties that are under Section 7.

7/24/06 Hrg. Tr. at 112-13, 119 (emphasis added).

neither tort law, nor the ESA, requires an agency action to be the *sole* cause of harm of the species. The Corps' operations of the ACF reservoirs result in reduced flows downstream, and thus cause harm to the Apalachicola Species, no matter what tort-type label might attach to the causation of that harm.

A. The Corps' Actions Meet the Causation Element of Section 7

1. Section 7 Must Be the Primary Analysis At This Stage

The primary analysis at this phase of this case is whether the Federal Defendants have completed a proper consultation pursuant to ESA Section 7. Until a proper Section 7 analysis has been completed, one does not know the nature or extent of any "take" that might occur under Section 9. For all the reasons detailed above, the Service has yet to complete a proper consultation, and therefore, the Florida Parties are requesting the Court to remand to the Service with instructions to produce a new BiOp using the aggregate analytical approach, taking into consideration the Corps' operations in the entire ACF Basin.

In the Section 7 context, *Key Deer* posed the question of whether the ESA required FEMA, in administering the National Flood Insurance Act, to consult with the Service and take action to prevent harm to the Florida Key Deer. The Eleventh Circuit there made clear that both subsection 7(a)(1) and subsection 7(a)(2) have operative significance and impose affirmative duties on action agencies (in our case, the Corps). 30/ With respect to the Section 7(a)(2) duty to consult, FEMA argued that the ESA did not apply because the ESA applied only to discretionary acts and FEMA had no discretion *not* to provide flood insurance. The Eleventh Circuit emphatically held FEMA did have such discretion. *Id.* at 1141-43. The court first stated the contention, as it related to ESA Section 7 "causation":

> FEMA and the FWS alternatively argue that even if FEMA has the requisite discretion to consider the effects of its administration of the NFIP on listed species, the issuance of flood insurance is not a legally relevant "cause" of the development in the Florida Keys that threatens the listed species. *We are not persuaded.*

Id. at 1143 (emphasis added). It then said precisely why it was not persuaded:

> Here, FEMA has the authority in its administration of the NFIP. . .to prevent the indirect effects of its issuance of flood insurance by, for example, tailoring the eligibility criteria that it develops to prevent jeopardy to listed species. Therefore, its administration of the NFIP is *a relevant cause* of jeopardy to the listed species.

Id. at 1144 (emphasis added).

The Eleventh Circuit thus established that an agency's discretion is the controlling factor, and to the extent a "causation" test exists for Section 7, the only issue is whether a discretionary agency action is *a* cause of direct or indirect effects on listed species. In *Key Deer*, real estate development was the ultimate cause of harm to the species, but development

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30/ While Section 7(a)(2) requires consultation, "Section 7(a)(1) of the ESA imposes a separate obligation upon federal agencies and, in relevant part, states that all federal agencies 'shall' . . . 'utilize their authorities in furtherance of the purposes of this chapter by carrying out programs for the conservation of [listed species].'" *Key Deer*, 522 F.3d at 1145. The Eleventh Circuit concluded that it need not decide whether this statutory obligation of all Federal agencies "imposes species- or location-specific obligations." *Id*. at 1146. But it was clear that "[t]otal inaction is not allowed." *Id*. The Georgia Parties are therefore in error in asserting: "There is no mandate [in Section 7(a)(1)] requiring the agency to benefit protected species to the detriment of other objectives." Ga. Br. at 22. We take *Key Deer*'s "obligation" to have the same meaning as "mandate."

was facilitated by FEMA's application of the national insurance program. *Id.* at 1142. And that was enough. 31/

The Eleventh Circuit's causation standard for Section 7 is founded on the extraordinarily strong policies underlying the statute itself. The Supreme Court has emphasized that, when considering the issue of causation, "courts must look to the underlying policies or legislative intent in order to draw a manageable line between those causal changes that may make an actor responsible for an effect and those that do not." *Public Citizen*, 541 U.S. at 767 (citations omitted). The underlying policies and legislative intent behind the ESA could not be clearer.

The ESA's primary purpose is "to prevent animal and plant species endangerment and extinction caused by man's influence on ecosystems, and to return the species to the point where they are viable components of their ecosystems." H.R. REP. NO. 95-1625, at 5 (1978), *reprinted in* 1978 U.S.C.C.A.N. 9453, 9455. In *Tenn. Valley Auth.*, the Supreme Court recognized that "[t]he plain intent of Congress in enacting this statute was to halt and reverse the trend toward species extinction, whatever the cost. This is reflected not only in the stated policies of the Act, but in literally *every* section of the statute." 437 U.S. at 184 (emphasis added); *see also Key Deer*, 522 F.3d at 1138 (quoting same). In *Key Deer*, the Eleventh Circuit concluded that, "[i]n short, the preservation of endangered species was to be

31/ The only case cited by the Georgia Parties involving ESA Section 7 is *Center for Biological Diversity v. U.S. Dep't of Housing & Urban Dev.*, 541 F. Supp. 2d 1091 (D. Ariz. 2008). In that case, the court determined that the mortgage insurance program there involved gave automatic entitlement to veterans and afforded the agency no discretion or control. *Id.* at 1094. That court distinguished *Nat'l Wildlife Federation v. FEMA*, 345 F. Supp. 2d 1151 (W.D. Wash. 2004), which dealt with the same flood insurance program as did *Key Deer* and reached the same result because of FEMA's discretion. *Id.* at 1098-99.

considered 'the highest of priorities.'" *Key Deer*, 522 F.3d at 1138 (quoting 16 U.S.C. § 1531(b) and *Tenn. Valley Auth.*, 437 U.S. at 184). These considerations controlled the Eleventh Circuit's definition of Section 7 causation.

2. The Record Demonstrates that the Corps' Discretionary Operations Meet the "Causation" Test for Section 7

The consequences of the Corps' discretionary actions here are clear. The Corps' operation of the ACF reservoirs are *among* the primary causes of the Apalachicola Species' decline. *See, e.g.*, Fla. FA2 ¶¶ 14, 231, 232, 289, 294 (the listings); ¶¶ 324, 334 (Instream Flow Guidelines); ¶ 343 (USGS Report); ¶¶ 355-56, 361, 364, GAII001448-49, GAII005064-66, Doc. No. 90, FWS AR Pages 960-61 (FWS requests for consultation); Fla. FA2 ¶¶ 495, 498-99, 514-15, Doc. No. 1, FWS AR Pages 326-29 (2006 BiOp); Fla. FA2 ¶¶ 785-89, 819-23, Doc. No. 510, FWS AR Pages 013657-64 (2008 BiOp); Fla. FA2 ¶¶ 528, Doc. No. 347, FWS AR Pages 9449, 9455-60, 9479 (2006 EA); Fla. FA2 ¶¶ 761-62, Doc. 90, at 013742-43, 013776-81, 013873-74 (2008 EA). *See also* 72 Fed. Reg. at 64,310 ("Actions that would significantly alter the flow regime . . . include, but are not limited to, the construction and operation of dams, water withdrawals, water diversions . . . ."). Indeed, the State of Florida informed the Service of its conclusion that the Corps' operations jeopardize the continued existence of the Apalachicola Species and adversely modify their critical habitat, only to have its comments rejected as outside the scope of the IOP/RIOP consultation, which, of course, excluded the WCP. *See, e.g.*, Doc. No. 96, FWS AR Pages 990, 998, 1000 (comments on IOP); GAII007829-31 (comments on RPM3); Doc. No. 473, FWS AR Pages 012734-36 (comments on EDO); Doc. 34, 012904-05 (comments on RIOP). The Service was instructed by the Corps, and accepted, that the impact of the WCP and of its Action

Zones in low flow periods were not to be considered. *See* Fla. FA2 ¶¶ 571-74, 578-79, 590-92.

Pursuant to the Eleventh Circuit's holding in *Key Deer*, the operative question is whether the Corps has discretion to reduce effects on listed species and designated critical habitat. If that discretion exists, it is the exercise of that discretion (or refusal to exercise that discretion) which becomes a relevant cause of any harm occasioned. 32/ Dams, including those on the Chattahoochee River, are built to control flows so as to impound and store water at time of high flows and to augment low flows when needed. The Corps' exercise of its discretion to store water upstream rather than support downstream flows was thus *a direct* and *an indirect* cause of impact on the Apalachicola Species. And *Key Deer* teaches us that when discretionary agency actions adversely impact listed species or their critical habitat, then such impacts are the result of—caused by—those discretionary actions.

32/ As *Key Deer* confirmed, this is unlike the situation in *Public Citizen*, where the agency there involved (the Federal Motor Carrier Safety Administration) had no authority to prevent the environmental effects at issue since it was *required* to authorize Mexican motor carriers that met certain requirements to operate in the U.S. and had no authority to prevent such operation. *See* 541 U.S. at 766-67; *see also Key Deer*, 522 F.3d at 1143-44 (distinguishing the situation in *Public Citizen*); *accord Sierra Club v. Mainella*, 459 F. Supp. 2d 76 (D.D.C. 2006) and *Humane Soc'y v. Johanns*, 520 F. Supp. 2d 8 (D.D.C. 2007). As described above, the Corps in this case, as in *Missouri River*, has discretion, within its statutory limitations, to reduce and/or prevent adverse effects on listed species through its use of storage and operation of the upstream ACF reservoirs. *Cf. Klamath Water Users Protective Ass'n v. Patterson*, 204 F.3d 1206, 1213 (9th Cir. 1999) ("Because Reclamation retains authority to manage the Dam, and because it remains the owner in fee simple of the Dam, it has responsibilities . . . [that] include taking control of the Dam when necessary to meet the requirements of the ESA, requirements that override the water rights of the Irrigators. Accordingly, we hold that the district court did not err in concluding that Reclamation has the authority to direct Dam operations to comply with the ESA.").

B. To the Extent Relevant, Even in the Section 9 Context, the Corps' Actions Are A Cause of Species "Take"

The Georgia Parties assert that the Service has an obligation to prove that the Corps' actions are *the sole* cause of flow reduction in and around the Apalachicola River. Ga. Br. at 23-33. This assertion is wrong. *Key Deer* is definitive as to Section 7. If the Corps' actions are "*a* relevant cause" of flow reduction causing jeopardy, as the administration by FEMA was "a relevant cause of jeopardy" in *Key Deer,* the inquiry ends. The same is true of any tort-type "causation" standard that may apply to ESA Section 9. *See, e.g., Cox v. Adm'r U.S. Steel & Carnegie*, 17 F.3d 1386, 1399 (11th Cir. 1994) ("A proximate cause is not…the same thing as a sole cause"); *Loggerhead Turtle v. County Council of Volusia County, Fla.*, 148 F.3d 1231, 1251 n.23 (11th Cir. 1998) (quoting *Cox*); Restatement (Third) of Torts § 26 at 347-48 ("An actor's tortious conduct need only be ***a*** factual cause of the other's harm. The existence of other causes of the harm does not affect whether specified tortious conduct was a necessary condition for the harm to occur.") (emphasis in original).

As noted, the Georgia Parties decline to even cite *Key Deer*. Instead they cite ESA Section 9 cases and argue that the correct standard of causation is "but for." This contention is based on a footnote from *Babbitt v. Sweet Home Chapter Of Communities For A Great Oregon*, 515 U.S. 687 (1995) and on Judge Bowdre's decision denying injunctive relief in

Alabama v. U.S. Army Corps of Eng'rs, 441 F. Supp. 2d 1123 (N.D. Ala. 2006), which cited the *Sweet Home* footnote. 33/

For these purposes, we may ignore the fact that the Eleventh Circuit has described the "but for" language in *Sweet Home* (which Judge Bowdre cited as her source) as probable *dicta*, 34/ and simply observe that all of the cases on which the Georgia Parties rely, other than the one case referenced in footnote 31, involved Section 9, not Section 7. 35/

But to the extent the tort-type "causation" standard articulated in *Sweet Home* applies to the Service's determination that an incidental "take" would occur under the RIOP, that

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33/ Contrary to the Georgia Parties' assertions, Ga. Br. at 31-32, the situation before this Court is not the same as that faced by Judge Bowdre. In *Alabama*, Judge Bowdre dealt with Florida's request under Section 9 for preliminary injunctive relief against harm, first to the Gulf sturgeon, then to mussels. *See* 441 F. Supp. 2d at 1130. As she noted, FWS and the Corps were then engaged in Section 7 consultation, but no BiOp had yet been issued or administrative record prepared. At that point in time, before the validity of the Corps' retention of water in Lake Lanier for water supply had been tested, the court applied the "but for" language of the *Sweet Home* footnote, and concluded that Florida had not met its burden of proof to be awarded injunctive relief that drought had not caused the reduction in flows and resulting Section 9 harm asserted. *Id.* at 1134. This decision likely was mooted and subject to vacatur by the Services' issuance of the BiOp, as suggested by the Eleventh Circuit's granting of Florida's motion to dismiss the appeal of Judge Bowdre's decision as moot following issuance of the 2006 BiOp. *See* Order Granting Appellant's Motion to Dismiss Appeal as Moot dated November 3, 2006 in *State of Alabama v. U.S. Army Corps of Eng'rs,* Case No. 06-14211, Eleventh Circuit Court of Appeals, DE 561 in Case No. 90-cv-1331 (N.D. Ala.).

34/ *Loggerhead Turtle*, 148 F.3d at 1251 n.23 ("…this portion of *Sweet Home* is likely dicta since the only dispute in that case was a facial one . . . .").

35/ *See Cold Mountain v. Garber*, 375 F.3d 884 (9th Cir. 2004) (action by environmental groups asserting Federal agencies had "taken" protected bald eagles); *Pyramid Lake Paiute Tribe of Indians v. U.S. Dep't of Navy*, 898 F.2d 1410 (9th Cir. 1990) (plaintiff failed to show Federal agency action had "taken" protected cui-ui fish); *Morrill v. Lujan*, 802 F. Supp. 424 (S.D. Ala. 1992) (court found listed species did not exist on property so could not have been "taken"); *Arizona Cattle Growers' Ass'n. v. U.S. Fish and Wildlife Service*, 273 F.3d 1229 (9th Cir. 2001) (same); *Pacific Shores Subdivision Cal. Water Dist. v. U.S. Army Corps of Eng'rs*, 538 F. Supp. 2d 242, 261-62 (D.D.C. 2008) (Section 9 not violated when Corps permitted breach of sand bar when plaintiffs argued different breach would be less harmful).

standard is here met. 36/ *Sweet Home* involved a facial challenge to the Service's definition of the term "harm," asserting it to be overbroad because it contemplated a "take" resulting indirectly from habitat modification, as opposed to direct force—specifically, "significant habitat modification or degradation where it actually kills or injures wildlife." 515 U.S. at 687. The Supreme Court upheld the regulation against the facial attack. *Id*. at 707. The dissent attacked the decision as ignoring a requirement of causation in order to find liability for harm to listed species. *Id*. at 715-716, 732-35. The majority rejected the dissent's effort to "impose on § 9 a limitation of liability to 'affirmative conduct intentionally directed against a particular animal or animals.'" *Id*. at 702 (citation omitted). The Court observed that "activities that cause minimal or unforeseeable harm" might not violate the Act, but since this was a facial, not an as-applied challenge, this issue need not be reached. *Id*. at 699-700. In a footnote, the majority observed that the regulation did not ignore "ordinary requirements of proximate causation and foreseeability…Nothing in the regulation purports to weaken those requirements." *Id*. at 700 n.13. Noting that the regulation refers to "actually" killing or injuring, the Court continued: "The Secretary did not need to include 'actually' to connote 'but for' causation, which the other words in the definition obviously require." *Id.* Returning to text, the majority stated: "Congress had in mind foreseeable rather than merely accidental effects on listed species." *Id.* at 700.

36/ The principal case cited by the Georgia Parties relating to an arguably erroneous Service finding of incidental "take" was *Arizona Cattle Growers' Ass'n.* There the court concluded the Service had failed to show any of the purportedly "taken" species ever existed in the area in question. 273 F.3d at 1244. Nobody doubts the Apalachicola Species exist in the Apalachicola River Basin, albeit in drastically reduced numbers.

In her concurring opinion, Justice O'Connor provided a more detailed analysis of the role of causation, specifically stating: "[T]he regulation's application is limited by ordinary principles of proximate causation, which introduce notions of foreseeability." *Id.* at 709. After confirming that harm may be indirect as well as direct, she concluded: "Proximate causation depends to a great extent on considerations of the fairness of imposing liability for remote consequences." *Id.* at 713. To her, at least, proximate cause equated with foreseeability.

The majority and concurrence's discussion in *Sweet Home* is consistent with traditional tort principles of "causation" as an element of liability. To be sure, the principles have been variously articulated. The term "but for" (used in the *Sweet Home* footnote) is properly cast as "cause-in-fact" or "factual cause," while "proximate" or "legal cause" has evolved into concepts of foreseeability and scope of liability. 37/ As reflected in the majority and concurring opinions of *Sweet Home*, both concepts are at play in the ESA Section 9 inquiry.

The Eleventh Circuit elucidates the relationship among these various concepts in *Jackson v. Sauls*, 206 F.3d 1156 (11th Cir. 2000), a § 1983 civil rights case. In *Jackson*, the Eleventh Circuit described that "[u]nder traditional tort principles, causation has two required

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37/ Notably and correspondingly, the Restatement of Torts substitutes the term "factual cause" for the phrase "but-for cause." Restatement (Third) of Torts §§ 26-27. The Restatement also indicates that "the term 'proximate cause' is a poor one to describe limits on the scope of liability," and omits proximate or "legal cause" terminology in favor of "scope of liability" and the "risk standard." *Id*. § 29 cmt. b; *see also id*. Ch. 6 special note on proximate cause. Specifically, the Restatement comments that "the term 'proximate cause' implies that there is but one cause—the cause nearest in time or geography to the plaintiff's harm—and that factual causation bears on the issue of scope of liability. Neither of those implications is correct. Multiple factual causes always exist and multiple proximate causes are often present." *Id*. § 29 cmt. b (citing § 26 cmt. c).

elements: cause-in-fact and legal or proximate cause." *Id.* at 1168 n.16 (citing W. Page Keeton, et al., *Prosser and Keeton on Torts*, §§ 41-42 at 263-80 (5th ed.1984)). Cause-in-fact is established by a showing that, except for the tort, "such injuries and damages would not have occurred." *Id.* An act or omission is a proximate or legal cause if the injury or damage was a reasonably foreseeable consequence of the act. *See id.* 38/ We know that the devastation of the listed mussels and the negative impact on the spawning by Gulf sturgeon would not have occurred—at least to the extent it did—*but for* the Corps exercising its discretion to hold water in storage in Lake Lanier to promote water supply over species needs. *See, e.g.*, Fla. FA2 ¶¶ 785-89, 819-23. So the Corps' exercise of discretion was a "factual cause" of the adverse result to the Species. In addition, it was of course foreseeable that the Corps' decision to maintain water levels in the upstream reservoirs would reduce flows in the Apalachicola River and thus constitute *a* cause of Apalachicola Species mortality. Even if the Corps' release of stored water would not have eliminated *all* negative impacts on mussels, certainly the harm inflicted would have been reduced, something the Corps is duty bound to accomplish. Nothing further is required under *Sweet Home* or pursuant to traditional tort law principles.

38/ The Restatement, in omitting use of the term "proximate" or "legal cause," employs a "risk standard" whereby "[a]n actor's liability is limited to those harms that result from the risks that made the actor's conduct tortious." Restatement (Third) of Torts § 29. The Restatement acknowledges that courts have struggled in applying various standards to determine an actor's responsibility and that none of the standards are entirely satisfactory. "There is, in short, much play in the proximate-cause joints. The appropriate scope of liability and responsibility is inherently a subject resistant to any rigorous formulation, and it is a mistake to expect any more precision than a subject will bear." *Id.* § 29 reporter notes cmt. e (citations omitted); *see also* W. Keeton, D. Dobbs, R. Keeton, & D. Owen, *Prosser and Keeton on Torts* § 41 at 264 (5th Ed. 1984) ("Often . . . scope of liability is associated with policy—with our more or less inadequately expressed ideas of what justice demands, or of what is administratively possible or convenient.").

The Eleventh Circuit has explicitly confirmed that an action need not be the *sole* cause of an injury to constitute a *proximate* cause of that injury. *Cox*, 17 F.3d at 1399. The Court there explained that *"[a] proximate cause is not . . . the same thing as a sole cause.* Instead, a factor is a proximate cause if it is 'a substantial factor in the sequence of responsible causation.'" *Id.* (emphasis added), quoting *Hecht v. Commerce Clearing House, Inc.*, 897 F.2d 21, 23-24 (2d Cir. 1990). 39/

Thus, the mere fact that an additional factor (*e.g.*, drought or upstream consumption, etc.) might have contributed to the problem confronting the protected mussels in this case does not absolve the Corps of responsibility for its operating decisions. The existence of drought in no way diminishes the fact that the Corps' operations are "a substantial factor in the sequence of responsible causation" leading to mussel deaths. *Cox*, 17 F.3d at 1399. During drought conditions, the Corps, operating according to its Action Zones, exercises its

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39/ Other Section 9 cases assign liability for agency action that constitutes only one cause of a species' "take," including an indirect or third party cause. *See, e.g.*, *Strahan v. Coxe*, 127 F.3d 155, 163-64 (1st Cir. 1997), *cert. denied*, 525 U.S. 830 (1998) (rejecting interpretation of common law proximate causation that did not include "indirect causation" and holding that state agency's licensing of use of gillnets and lobster pots "in a manner likely to result" in "take" of northern right whale violated the ESA); *Defenders of Wildlife v. E.P.A.*, 882 F.2d 1294, 1300-01 (8th Cir. 1989) (holding that agency's decision to register strychnine caused "take" of black-footed ferret and reasoning that since strychnine could only be distributed if registered the "relationship between the registration decision and the deaths of endangered species is clear"); *Animal Prot. Inst. v. Holsten*, 541 F. Supp. 2d 1073, 1078-80 (D. Minn. 2008) (holding that state's licensure of trapping that could "take" threatened lynx constituted a "taking" under ESA Section 9 and rejecting argument that trappers were independent intervening cause removing state's liability); *Animal Welfare Inst. v. Martin*, 588 F. Supp. 2d 70, 99-100 (D. Me. 2008) (ruling that the state's authorization of trapping, which could trap endangered lynx along with intended animals, violated the ESA). *See also Loggerhead Turtle*, 148 F.3d at 1250-51 & n.23 (addressing causation in the context of a standing analysis and noting that the Supreme Court in *Sweet Home* stated that the ESA "encompasses *indirect* as well as direct injuries" and that even if the concept of proximate causation governed the analysis "[a] proximate cause is not . . . the same thing as *a sole* cause") (citations omitted) (emphases added). Here, the Corps is *directly* responsible for adverse effects and species "take," as opposed to merely producing indirect effects.

discretion to maintain higher water levels in its reservoirs rather than release water sufficient to prevent the death or other injury to the protected Apalachicola Species.

The Georgia Parties go out of their way to suggest any other potential cause of species "take" and to misdirect the Court away from the Corps' ongoing operation of the ACF reservoirs. In so doing, they resort to the irrelevant (*i.e.*, references to invading clams, Ga. FA ¶ 86, over-zealous biology students and shell collectors, Ga. FA ¶¶ 87-88); the inaccurate (*i.e.*, claims that pollution in Florida causes mussel mortality, 40/ Ga. Br. at 5-6, that there is an "enormous diversion" of flow into the Chipola Cutoff, 41/ Ga. Br. at 44, that Georgia's consumption has a negligible effect on Apalachicola flows, 42/, Ga. Br. at 29; Ga.

40/ Ignoring that the BiOp refers mainly to the Chattahoochee and Flint Basins as sources of contaminants in the Apalachicola River, Doc. No. 504.84, at 57, the Georgia Parties wrongly imply that the Record supports an inference that water quality issues related to the protection of aquatic life and attributable to Florida's regulation of discharges to the river or its tributaries (rather than other causes, such as low flows or upstream contaminants) may contribute to the decline of listed species. However, they have failed to demonstrate any injury to listed species from the limited set of water quality data to which they refer, or even to correlate any water quality data (past or present) applicable to the protection of aquatic life to segments of the Apalachicola River found to contain listed mussels or their necessary habitat preferences. *See, e.g.*, Doc. 510, FWS AR Pages 013596, 013602.

41/ This "enormous" diversion, that the Georgia Parties assert claims a 40% and "ever-increasing" share of the mainstream river and affects Swift Slough more than any of the Corps' operations, is proportionally *the same amount* of water which flowed from the Apalachicola River into the Chipola Cutoff *prior to the construction of the dams*. *See* ACF001564 (demonstrating that pre-dam flows in the Chipola Cutoff were 40% of the flows measured in the Apalachicola River above the Chipola Cutoff).

42/ As the BiOp illustrates by example, in low flow periods M&I depletions can reduce unimpaired flows by 15%. *See* Doc. No. 510, FWS AR Page 013638 (using a pie chart to illustrate that in June 2000, M&I depletions reduced unimpaired flows of 4,491 cfs by 665 cfs, and that overall net depletions of 2,328 cfs (including M&I and agricultural withdrawals and evaporation) reduced unimpaired flows by over 50%). The Georgia Parties' reference to impacts on "average flows," Ga. FA ¶ 272, is irrelevant. The negative impacts on the Apalachicola Species, as all know, occur at times of low flow, so low flow impacts are all that matter. And Corps' decisions as to necessity of storage for water supply can have even greater impacts than actual water supply use.

FA ¶ 272); and the farfetched (*i.e.*, an implication that one of the mussels should be delisted, 43/ Ga. Br. at 8; Ga. FA ¶¶ 91-97).

In addition, the Georgia Parties suggest that the Administrative Record contains insufficient evidence linking the Corps' reservoir operations to the decline of the Apalachicola Species. *See, e.g.*, Ga. Br. at 6; Ga. FA ¶¶ 57, 59, 72, 78. For example, they contend that there is no evidence that Gulf sturgeon are affected by salinity levels in Apalachicola Bay, including areas of designated critical habitat. Ga. FA ¶ 72. This is patently false, as the data show juvenile Gulf sturgeon are affected by salinity levels in the Bay, and that elevated levels can kill juvenile sturgeon that are not yet sufficiently adapted to salt water. *See, e.g.*, Doc. No. 557, FWS AR Pages 014678-85 (Altinok et al., *Ionic and Osmotic Regulation Capabilities of Juvenile Gulf of Mexico Sturgeon*, devoted entirely to the topic of salinity tolerance of juvenile Gulf sturgeon). 44/ The Georgia Parties simply choose to ignore the science that contradicts their claims.

To cast further doubt on the Record evidence, the Georgia Parties also employ non-sequitur conclusions, including that there is "no direct evidence that the number of [mussel] host fish has been reduced" in the Apalachicola River. Ga. Br. at 6. This misses the mark.

43/ The opinion of a lone Corps consultant to this effect is irrelevant. As long as a species is listed, the legal requirements of the ESA attach to it and its designated critical habitat. There simply is no such thing as a "sort of" endangered species.

44/ *See also* Doc. No. 744, FWS AR Pages 019603-20 (Paruka et al., *Movement and Habitat Use of Subadult Gulf Sturgeon in Choctawhatchee Bay, Florida*); Doc. No. 863, FWS AR Pages 024398-413 (Wooley & Crateau, *Movement, Microhabitat, Exploitation, and Management of Gulf of Mexico Sturgeon, Apalachicola River, Florida*); Doc. No. 877.6 (Florida Fish and Wildlife Conservation Commission correspondence dated 11/7/07); Doc. No. 510 (2008 BIOP) at FWS AR Pages 013501, 013543, 013566 and internal references therein; Doc. No. 753, FWS AR Pages 019801-953 (Putland, *Ecology Of Phytoplankton, Acartia Tonsa, And Microzooplankton In Apalachicola Bay, Florida*) (explaining impact of salinity of food web that supports juvenile Gulf sturgeon).

The relevant question is not whether the absolute number of host fish (a primary constituent element of designated mussel critical habitat) are increasing or decreasing. The relevant question is whether the Corps is supporting water levels necessary to facilitate host fish access to relevant mussel beds so those host fish can *act as hosts*, an act which is dependent on the elevation of the River, which in turn depends on River flows. The Record demonstrates that mussel survival and recovery are directly dependent on this relationship, which in turn is adversely impacted by low flows. *See* Doc. No. 295, FWS AR Page 6713. 45/ As described above, the Record contains ample evidence that the Corps' operation of the ACF reservoirs are *among* the causes of the Apalachicola Species' decline. *See supra* Section II.A.2.

Finally, it must be noted that, in making their drought-causation argument, the Georgia Parties studiously ignore this Court's Phase 1 determination that water supply is not an authorized purpose of Buford Dam. Yet they acknowledge that the ACF Basin reservoirs must be viewed as an overall system. *See* GA Br. at 3; GA FA ¶ 9. The Georgia Parties also deliberately ignore the fact that during dry periods the WCP *requires* storage in Lake Lanier

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45/ "The reproducing mussel requires sufficient water velocity to suspend the [group of larval mussels] in the water column until a host fish attempts to eat it, which begins the process of incubating the larval mussels. The incubation stage on a host fish . . . is obligatory in the mussel's life cycle. If current velocities are too low during the reproductive period, the [larvae] will not be suspended in the current and reproduction would be impaired." Doc. No. 295, FWS AR Page 6713. That said, contrary to the Georgia Parties' implication, the record does reflect the fact that reduced Apalachicola River flows will adversely impact the absolute number of host fish in the River. Doc. No. 846, at 1 (Walsh et al, *Fishes of the Apalachicola River Floodplain; Role of Habitat and Hydrology to Recruitment*) ("Spawning and recruitment are linked to the annual hydrologic cycle and reproductive success and year-class strength are ultimately dependent on flow conditions that maximize availability of floodplain resources . . . Low flows during spring and summer months are predicted to limit reproductive success and likely to reduce growth, survivorship, and year-class strength.").

to protect an unauthorized purpose—water supply—and effectively abandons the authorized purposes of power production and navigation, which would result in releases that augment downstream flows. 46/ Phase 1 Order at 1321, 1332-33; Fla. FA2 ¶¶ 53-101.

Consequently, the Georgia Parties' drought-causation argument employs the same myopic view of the "agency action" that is unlawful under Section 7. By focusing on the operation of Woodruff Dam, the Georgia Parties seek to show that flow reductions and resulting mussel mortality are really caused by drought conditions, rather than the Corps' operations, narrowly viewed. This narrow view of agency action presumes—as the Corps stated and the Service accepted—that avoidance of upstream drought-related impacts to water supply uses is a given, rather than discretionary. Rather than supporting their causation position, this argument illustrates precisely why the Federal Defendants should have consulted on *all* of the Corps' ACF reservoir operations under the 1989 WCP in the context of the environmental baseline and cumulative impacts that are attributable directly to Georgia's upstream consumption.

III. This Court Should Defer to the Remedies Portion of This Case A Remedy For the Corps' Violations of NEPA

All of the non-Federal parties contend that NEPA has been violated. If this Court agrees and finds a NEPA violation, naturally, the appropriate remedy is to remand to the Corps to perform a proper NEPA evaluation. However, practical realities and limitations of time in this instance make such action fruitless. Any NEPA remedy that postpones

46/ The IOP and RIOP incorporate the WCP's Action Zones, Fla. FA2 ¶¶ 400, 482, 490, 522, 732, 737, and only deviate from the WCP during such periods when the Corps wants to provide *less* than 5,000 cfs downstream (*i.e.*, the 4,500 cfs provision of the RIOP).

addressing the substantive ESA issues would leave without remedy the Apalachicola Species, whose survival and recovery are dependent on this Court's findings on the ESA claims. For this Court to favor the NEPA remedy over the ESA claims would leave the Apalachicola Species in the same precarious position they currently occupy, undermining the focus of Phase 2 of this litigation and the protections and priorities afforded to endangered species under the ESA. *See Loggerhead Turtle*, 148 F.3d at 1246 ("To be sure, protecting troubled wildlife is serious business. . . '[T]he language, history, and structure of the [Endangered Species Act] indicates beyond doubt that Congress intended endangered species to be afforded the highest of priorities'") (quoting *Tenn. Valley Auth.*, 437 U.S. at 174).

The procedural considerations of NEPA were not intended to supplant substantive obligations under other statutes. *See U.S. v. Students Challenging Regulatory Agency Procedures (SCRAP)*, 412 U.S. 669, 694 (1973) ("NEPA was not intended to repeal by implication any other statute."). Consequently, strict compliance with NEPA may be foregone where requiring compliance with NEPA would create an "'irreconcilable and fundamental conflict' with other statutory obligations" and "in instances where failure to take quick action would have significant negative consequences." *In re: Operation of the Missouri River Sys. Litig.*, 305 F. Supp. 2d 1096 (D. Minn. 2004) (citing *Flint Ridge Dev., Co. v. Scenic Rivers Ass'n*, 426 U.S. 776, 788-89 (1976)); s*ee also Natural Res. Def. Council v. Houston*, 146 F.3d 1118, 1131 (9th Cir. 1998) (ruling on substantive ESA violations and finding NEPA claim moot). Significant negative consequences to the endangered and threatened Apalachicola Species will occur if the Court allows NEPA compliance efforts to perpetuate the Federal Defendants' non-compliance with the ESA. In order to fulfill the mandate of the ESA, this Court should prioritize the substantive ESA claims over the related procedural NEPA claims, and should order a proper Section 7 consultation and analysis to be complete within the 135-day time frame provided for by the regulations. 50 C.F.R. § 402.14.

IV. The Brief Submitted by the City of Columbus and Columbus Water Works Inappropriately Raises Phase 1 Arguments

Finally, the brief of the Columbus Parties is directed to arguments addressed in Phase 1 of this litigation. 47/ Specifically, Columbus argues that the Corps is operating the ACF System reservoirs inconsistently with "its repeated assurances" and asks the Court to order the Corps to develop a water control plan within specific parameters. *See* Col. Br. at 2-6, 8-9. In its Phase 1 Order this Court addressed both challenges to the Corps' authority for its operations in the Basin and the plans and manuals through which the Corps operates. Phase 1 Order at 1310, 1354-55. To the extent that Columbus asserts arguments in this Phase 2 that the Court has addressed in its Phase 1 Order, such arguments must be disregarded.

CONCLUSION

For the foregoing reasons, this Court should deny the Georgia Parties' motion in full and Columbus' motion to the extent that it addresses Phase 1 issues.

47/ Citations to Columbus' Phase II Motion for Summary Judgment and Memorandum of Law in Support (DE 302) appear as "Col. Br. at ___".

Respectfully submitted this 10th day of February, 2010.

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CERTIFICATE OF SERVICE

I HEREBY CERTIFY that the foregoing was filed with the Clerk of the Court using the CM/ECF system, and was served upon counsel of record and all parties to this proceeding registered with the federal court system by electronic means on February 10, 2010.

/s/ James T. Banks

Exhibit 80

Exhibit 80

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3900 Commonwealth Boulevard
Tallahassee, Florida 32399-3000

Charlie Crist
Governor

Jeff Kottkamp
Lt. Governor

Michael W. Sole
Secretary

June 12, 2007

Col. Peter Taylor
Commander and District Engineer
Department of the Army
Mobile District, Corps of Engineers
190 Saint Joseph Street
Mobile, Alabama 36602-3630

RE: Corps Operation of Dams, Reservoirs and Related Facilities Under Modified Interim Operations Plan (IOP)

Dear Colonel Taylor:

The State of Florida hereby notifies the United States Army Corps of Engineers ("Corps") that the Corps' operation of dams, reservoirs and related facilities pursuant to the Interim Operations Plan for Jim Woodruff Lock and Dam as modified on February 28, 2007 ("Modified IOP"), currently affects, and will continue to affect, land and water use, as well as natural resources, of the coastal zone of the State of Florida. Such effects of a federal agency activity require that the Corps furnish Florida with a determination that these activities are consistent to the maximum extent practicable with the enforceable policies of the Florida Coastal Management Program ("FCMP").

Coastal Zone Management Act Requirements

The Coastal Zone Management Act ("CZMA") requires that federal agency activities that affect "any land or water use or natural resource of the coastal zone [ ] be carried out in a manner which is consistent to the maximum extent practicable with the enforceable policies of approved State management programs." 16 U.S.C. § 1456(c)(1)(A); 15 CFR 930.32(a)(1). Accordingly, each federal agency carrying out an activity that affects a state's coastal zone "shall provide a consistency determination to the relevant State agency . . . before final approval of the Federal activity unless both the Federal agency and the State agency agree to a different schedule." *Id.* § 1456(c)(1)(C).

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The Corps' operations pursuant to the Modified IOP fall squarely within these provisions. Florida's coastal management program, the FCMP, is a federally-approved program. 46 F.R. 48742-01; 53 F.R. 50069-01. The Corps' activities on the Chattahoochee River under the Modified IOP constitute a series of events that have foreseeable effects on Florida's coastal resources in the Apalachicola River Basin and the Apalachicola Bay. *See* 15 C.F.R. § 930.31(a) (broadly defining "Federal agency activity").

Corps Activities Under the Modified IOP

The Corps created the original IOP in response to Florida's demands to consult with the U. S. Fish & Wildlife Service ("FWS" or the "Service") pursuant to the Endangered Species Act ("ESA"), 16 U.S.C. §§ 1531 *et seq.* Fundamentally, the original IOP (and subsequent Modified IOP) addresses the operational parameters of discharges made by the Corps into the Apalachicola River. As a result of the consultation between the Corps and the Service regarding the impact of the original IOP on the endangered and threatened species inhabiting Florida's Apalachicola River and their habitat, the Service issued a Biological Opinion containing an incidental take statement ("ITS") (collectively, the "BiOp"). The ITS included in the BiOp contains certain reasonable and prudent measures to be followed by the Corps. One of the reasonable and prudent measures, RPM3, requires the Corps to "[d]evelop modifications to the IOP that provide a higher minimum flow to the Apalachicola River when reservoir storage and hydrologic conditions permit." The Corps ultimately submitted for the Service's approval a proposed means of complying with RPM3, which the Corps termed "Concept 5." Concept 5 modifies the original IOP significantly by allowing the Corps to diminish flows in the Apalachicola River through storage of water during the spring Gulf sturgeon spawn, ostensibly to ensure a higher minimum flow for threatened and endangered mussels later in the year. The Service approved this modification to the IOP and on March 6, 2007, the Corps issued an Environmental Assessment/Finding of No Significant Impact ("EA/FONSI") for the Modified IOP, ending the series of events constituting the federal agency activity. The decision to modify the IOP required a consistency review prior to making the final decision.

Impacts on Florida

The Corps' agency activity affects Florida's coastal resources in the Apalachicola River Basin and Apalachicola Bay. The Modified IOP provides inadequate water deliveries to the Apalachicola River and thereby affects, and will continue to affect, land and water use and the natural resources of the coastal zone of the state of Florida. Specifically, and among other things, the Modified IOP:

1. Affects biological communities, including fishes (importantly host fishes for federally-designated endangered and threatened mussels), aquatic invertebrates, other river-floodplain animals, and floodplain vegetation through changes in the frequency, duration, magnitude, and timing of the inundation and saturation of aquatic habits in the river and floodplain caused by the Corps' activities.

2. Affects the Apalachicola River, the designated critical habitat for the Gulf sturgeon. The Gulf sturgeon is designated as a "threatened" species under the ESA and as a species of special concern under Florida law. Flow reductions and modifications caused by the Corps' activities render portions of this critical habitat unusable or diminish its value, likely take members of this species, and may jeopardize the species' continued existence.

3. Affects the annual floods which help to maintain the Apalachicola floodplain, the largest forested floodplain in Florida. Lower flows caused by Corps activities decrease the ability of floodplain soils to retain water after the flood season ends; increase the frequency and severity of drought-like conditions; isolate aquatic habitats from the main river channel; and cause degradation in water quality from decreases in dissolved oxygen.

4. Reduces the floodplain habitat and results in loss of habitat for spawning, feeding, and nursery areas for fish and wildlife, including species listed under Florida law as of special concern, such as, but not limited to shoal bass, Barbour's map turtle, alligator snapping turtle, and Suwanee cooter.

5. Affects fisheries by disrupting spawning activities and causing the stranding of juveniles and adults in the backwaters and floodplains, resulting in loss of year-class and potential spawning adults.

6. Alters the forest composition and increases the risk of invasion by exotic plants through the hydrologic alterations in the floodplains.

7. Affects the commercial harvests of blue crabs and oysters which correlate with reductions in freshwater flows into the Apalachicola Bay. Low-flow, high salinity conditions cause increased mortality of juvenile oysters.

8. Affects the Apalachicola Bay estuaries which provide primary nursery habitat for a variety of marine and estuarine species and, key to the nursery function, sufficient nutritional input for the developing larvae and

juveniles. This nutrient input is primarily derived from phytoplankton, which depend in large part on freshwater flows from the upper watershed. Departures from the natural variation of hydrological regimes, caused by Corps activities, likely affect estuary productivity.

Consistency Determination

Because the Corps' current and proposed activities affect resources of Florida's coastal zone, the Corps must prepare and submit to Florida a determination that the activities are consistent to the maximum extent practicable with the enforceable policies of the FCMP before engaging in or approving these activities. In accordance with 15 CFR 930.32(a)(1), the Corps' activities must be fully consistent with the Florida Coastal Management Program unless full consistency is prohibited by federal law. Enforceable policies include those "which are legally binding through constitutional provisions, laws, regulations, land use plans, ordinances, or judicial or administrative decisions, by which a State exerts control over private and public land and water uses and natural resources in the coastal zone." 16 U.S.C. § 1453(6a); *see also* FDEP, Coastal Management Program, 23 Statutes of the FCMP, http://www.dep.state.fl.us/cmp/federal/23_statutes.htm.

Enforceable policies of the FCMP which the Corps should consider include, but are not limited to, the following statutes: §§ 373.016, 373.019(7), 373.171, 373.223, 373.233, 373.239(3), Fla. Stat. (regulating uses of water) (implemented by Fla. Admin. Code R. 62-40.410, 40A-2.301, 40A-2.311, 40A-2.381); §§ 373.413, 373.414, 373.416, Fla. Stat. (regulating water storage and maintenance of reservoirs) (implemented by Fla. Admin. Code R. 40A-4.011, 40A-4.301); § 373.430(1)(a), Fla. Stat., §§ 403.021, 403.031(7), 403.061, 403.0615, 403.161, Fla. Stat (prohibiting pollution, which is broadly defined as any human-induced impairment of water); §§ 258.36, 258.37, 258.39, Fla. Stat. (protecting Apalachicola Bay as an aquatic preserve); §§ 253.034, 259.032, Fla. Stat. (protecting submerged lands and lands purchased for conservation) (implemented by Fla. Admin. Code R. 62-302.700 (protecting Outstanding Florida Waters, including Apalachicola River and Bay)); § 370.025, Fla. Stat. (protecting marine fisheries), §§ 372.072, 372.0725, Fla. Stat. (protecting species which are endangered, threatened, or of special concern) (implemented by Fla. Admin. Code Rule 68A-1.004).

Ongoing Activities

Pursuant to the CZMA, the Corps is required to provide Florida with a federal consistency statement and determination explaining how the proposed activity is consistent with the authorities and policies of the FCMP at least 90 days prior to final approval of the activity. 16 U.S.C. § 1456(c)(1)(C). As the final decision documented in the Corps' EA/FONSI was premature and bypassed the required compliance with CZMA, the Corps is in violation of this obligation. Florida demands that the Corps (1) immediately cease activities, as described above, that affect Florida's coastal resources and that are inconsistent with the FCMP; and (2) not resume activities that affect Florida's coastal zone until the Corps has modified those activities and provided Florida with a consistency determination as required by the CZMA. Such determination must contain documentation necessary to demonstrate consistency, to the maximum extent practicable, as defined in 15 CFR 930.32(a)(1), with the enforceable policies of the FCMP. Please reply to confirm that the Corps will act accordingly.

Sincerely,

Sally B. Mann

Sally B. Mann, Director
Office of Intergovernmental Programs

SBM/tm

Exhibit 81

FLORIDA

Department of Environmental Protection

Jeb Bush
Governor

Marjory Stoneman Douglas Building
3900 Commonwealth Boulevard
Tallahassee, Florida 32399-3000

Colleen M. Castille
Secretary

January 6, 2005

Col. Peter Taylor
Commander and District Engineer
Department of the Army
Mobile District, Corps of Engineers
190 Saint Joseph Street
Mobile, Alabama 36602-3630

Re: Corps' Operation of Dams, Reservoirs and Related Facilities in the ACF Basin

Dear Colonel Taylor:

The State of Florida hereby notifies the Army Corps of Engineers that the Corps' operation of dams, reservoirs and related facilities within the Apalachicola-Chattahoochee-Flint River Basin, as described below, currently affect and will continue to affect land and water use, as well as natural resources, of the coastal zone of the State of Florida, requiring that the Corps furnish Florida with a determination that these activities are consistent to the maximum extent practicable with enforceable policies of Florida's Coastal Management Program (FCMP). By letter of February 5, 1990, Florida notified the Corps that the activities proposed in the Corps' Draft Post Authorization Change Notification Report for the Reallocation of Storage from Hydropower to Water Supply at Lake Lanier, Georgia (PAC report) were inconsistent with enforceable policies of the FCMP, and that Florida therefore objected to the conclusory assertion of consistency in the PAC report's Environmental Assessment.[1] Although the PAC report was subsequently withdrawn, the Corps' current and proposed activities, as described below, continue to affect Florida's coastal resources and therefore require a consistency determination. The consistency determination must be provided before these activities are approved and carried out.

CZMA Requirements

The Coastal Zone Management Act (CZMA) requires every federal agency to conduct its activities that affect "any land or water use or natural resource of the coastal zone" - including activities outside a state's coastal zone - "in a manner which is consistent to the maximum extent practicable with the enforceable policies of approved State management programs." 16 U.S.C. § 1456(c)(1)(A). The CZMA further requires that each federal agency carrying out, or proposing,

[1] This conclusory assertion failed to constitute a consistency determination within the meaning of the Coastal Zone Management Act. Nevertheless, the State notified the Corps of the PAC report's inconsistency with the FCMP.

an activity that affects a state's coastal zone "shall provide a consistency determination to the relevant State agency . . . at the earliest practicable time, but in no case later than 90 days before final approval of the Federal activity unless both the Federal agency and the State agency agree to a different schedule." 16 U.S.C. § 1456(c)(1)(C). Florida has a coastal management program approved by NOAA, and the Corps' operations described below are federal activities within the meaning of the CZMA. *See* 15 C.F.R. § 930.31(a) (broadly defining "Federal agency activity").

Corps Activities

The following Corps activities on the Chattahoochee River affect Florida's coastal resources in the Apalachicola River Basin and Apalachicola Bay[2]:

1. By 1986, the Corps had entered into water supply contracts with the City of Cumming, Georgia; the City of Buford, Georgia; the City of Gainesville, Georgia; Gwinnett County, Georgia; and the Atlanta Regional Commission (collectively, the "water supply providers") for withdrawals from Lake Lanier for municipal and industrial (M&I) purposes totaling approximately 85 million gallons per day (mgd), or more than 95,000 acre-feet per year, and withdrawals from the Chattahoochee River of approximately 377 mgd, or more than 422,000 acre-feet per year, which are dependent upon releases of water from Lake Lanier. Although all M&I contracts with the water supply providers, except for the Buford contract, expired by 1990, the Corps continues to take discrete actions to grant permission and confer benefits to the same water supply providers, without interruption and in increasing quantities, in the form of M&I withdrawals from storage in Lake Lanier and M&I withdrawals from the Chattahoochee River dependent on releases from storage in Lake Lanier.

2. In October of 1989 the Corps issued the PAC report in order to convert the water withdrawal contracts with the water supply providers into permanent water storage contracts, proposing a 327 mgd reallocation of storage in Lake Lanier, with projected increases to 529 mgd by 2010. Although the PAC report was later withdrawn, the Corps continues to take actions that permit an ever increasing amount of water to be withdrawn and released from Lake Lanier for M&I purposes, substantially in the manner anticipated in the PAC report, with amounts being withdrawn and released approximating 430 mgd in 1999.

3. On January 9, 2003, the Corps consented to water supply withdrawals and releases from Lake Lanier as part of an agreement to settle claims against it in *Southeastern Federal Power Customers, Inc. v. Caldera*, Case No. 1:00CV02975 (D.D.C.). In that settlement agreement the Corps agreed to

[2] This list is not exclusive. There may be other Corps activities that also affect the Apalachicola River Basin and Apalachicola Bay.

reallocate storage in Lake Lanier in order to allow withdrawals and releases of at least 537.4 mgd, and agreed that all return flows from the signatory water supply providers[3] would be available only for M&I purposes.

4. The Corps meets regularly with the water supply providers and other Georgia users of water from Lake Lanier in order to make decisions concerning withdrawals and releases from Lake Lanier for water supply. During dry-weather periods, the Corps' policy and practice is to assign the highest priority to storing water for M&I uses, at the expense of Lake Lanier's authorized purposes.

5. The October 1989 draft ACF Water Control Plan, issued in connection with the PAC report, adopted a policy to manage storage in Corps reservoirs on the Chattahoochee River to support recreation, at the expense of authorized project purposes and in disregard of downstream interests. Despite withdrawal of the PAC report, the Corps continues to reserve storage in its reservoirs to benefit recreation, including boating and recreational fishing of non-native fish, to the detriment of downstream habitats.

6. In the past the Corps endeavored to provide a steady and predictable outflow from Lake Seminole to ensure a steady and predictable navigation depth. However, the Corps' more recent and current practice is to manipulate storage in Corps reservoirs on the Chattahoochee River in order to provide limited "navigation windows" below Jim Woodruff Lock and Dam in the spring, releasing large pulses of water for brief periods, followed by rapid dewatering of important aquatic habitats.

7. The October 1989 draft ACF Water Control Plan adopted a policy of reducing releases from Lake Seminole to 5,000 cubic feet per second in conditions of extreme drought, to the detriment of downstream habitats. This policy continues to be in effect.

Impacts on Florida

The Corps' above-described activities affect Florida's coastal resources in the Apalachicola River Basin and Bay, including but not limited to the following impacts:

A. Apalachicola River System

1. Changes in the frequency, duration, magnitude, and timing of inundation and saturation of aquatic habits in the river and floodplain, caused by

[3] The signatories included all water supply providers named above except for the cities of Buford and Cumming.

Corps activities, impact biological communities including fishes, aquatic invertebrates, other river-floodplain animals, and floodplain vegetation. For example, the life cycle of fishes is dependent on seasonal flows in the river.

2. The Apalachicola River has been designated a critical habitat for Gulf sturgeon, designated a "threatened" species under the Endangered Species Act and a species of special concern under Florida law. Flow reductions and modifications caused by Corps activities render this critical habitat unusable, likely take members of this species, and may jeopardize the species' continued existence.

3. Annual floods help to maintain the Apalachicola floodplain, the largest forested floodplain in Florida. Lower flows caused by Corps activities decrease the ability of floodplain soils to retain water after the flood season ends; increase the frequency and severity of drought-like conditions; isolate aquatic habitats from the main river channel; and cause degradation in water quality from decreases in dissolved oxygen.

4. Reduced floodplain habitat, caused by Corps activities, results in loss of habitat for spawning, feeding, and nursery areas for fish and wildlife, including species listed under Florida law as of special concern: shoal bass, bluestripe shiner, Barbour's map turtle, alligator snapping turtle, and Suwannee cooter.

5. Dramatic changes in flow and stage caused by the Corps' use of navigation windows affect fisheries by disrupting spawning activities and can also lead to stranding of juveniles and adults in the backwaters and floodplains, resulting in loss of year-class and potential spawning adults.

6. Hydrologic alterations in floodplains caused by Corps activities may alter forest composition and increase the risk of invasion by exotic plants. River bed degradation resulting from scour below Corps dams also is likely to alter forest composition.

B. Apalachicola Bay

1. Commercial harvests of blue crabs and oysters correlate with reductions in freshwater flows into the Bay. Low-flow, high salinity conditions cause increased mortality of juvenile oysters.

2. Estuaries provide primary nursery habitat for a variety of marine and estuarine species, and a key component of this nursery function is the provision of sufficient nutritional input for the developing larvae and juveniles.

This nutrient input is primarily derived from phytoplankton, which depend in large part on freshwater flows from the upper watershed. Departures from the natural variation of hydrological regimes, caused by Corps activities, likely affect estuary productivity.

Consistency Determination

Because the Corps' current and proposed activities affect resources of Florida's coastal zone, the Corps must prepare and submit to Florida a consistency determination under the CZMA before engaging in or approving these activities. Enforceable policies of the FCMP which the Corps should consider include, but are not limited to, the following statutes: §§ 373.016, 373.019(5), 373.171, 373.223, 373.233, 373.239(3), Fla. Stat. (regulating consumptive uses of water) (implemented by Fla. Admin. Code R. 62-40.410, 40A-2.301, 40A-2.311, 40A-2.381); §§ 373.413, 373.414, 373.416, Fla. Stat. (regulating water storage and management of reservoirs) (implemented by Fla. Admin. Code R. 40A-4.011, 40A-4.301); § 373.430(1)(a), Fla. Stat., §§ 403.021, 403.31(7), 403.061, 403.061, 403.161, Fla. Stat. (prohibiting pollution, which is broadly defined as any human-induced impairment of water); §§ 258.36, 258.37, 258.39, Fla. Stat. (protecting Apalachicola Bay as an aquatic preserve); §§ 253.034, 259.032, Fla. Stat. (protecting submerged lands and lands purchased for conservation) (implemented by Fla. Admin. Code R. 62-302.700 (protecting Outstanding Florida Waters, including Apalachicola River and Bay)); § 370.025, Fla. Stat. (protecting marine fisheries), §§ 372.072, 372.0725, Fla. Stat. (protecting species which are endangered, threatened, or of special concern) (implemented by Fla. Admin. Code Rule 68A-1.004(26),(73),(77)).

Ongoing Activities

Pursuant to the CZMA, the Corps is obliged to provide Florida with its consistency determination before undertaking activities affecting Florida's coastal resources, including the activities described above. 16 U.S.C. § 1456(c)(1)(C). The Corps is in violation of this obligation. Florida demands that the Corps (1) immediately cease activities, as described above, that affect Florida's coastal resources and that are inconsistent with the FCMP; and (2) not resume activities that affect Florida's coastal zone until the Corps has modified those activities and provided Florida with a consistency determination as required by the CZMA. Such determination must contain documentation necessary to demonstrate consistency, to the maximum extent practicable, with the enforceable policies of the FCMP. Please reply to confirm that the Corps will act accordingly.

Sincerely,

Lynn Griffin

for Sally B. Mann, Director
Office of Intergovernmental Programs

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