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

UPDATED PRE-FILED DIRECT TESTIMONY OF FLORIDA WITNESS DR. PETER SHANAHAN

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INTRODUCTION

1. I, Peter Shanahan, have a Ph.D. in Environmental Engineering from the Massachusetts Institute of Technology and over 40 years of experience in hydrology. As a hydrologist, I study the movement of water in rivers and streams, including how federal dams and reservoirs affect this movement, and other issues related to water resources.

2. In my testimony, I use basic data analysis and a variety of standard and reliable methods to evaluate Georgia's claim that the U.S. Army Corps of Engineers ("Corps") would operate the federal reservoir system in the Apalachicola Chattahoochee Flint River Basin (the "ACF" or the "Basin") to hold back any water that Georgia conserves. I understand Georgia predicts that, even if it were to conserve water in its portion of the ACF, the Corps would simply hold this water in its reservoirs, effectively eliminating any benefits that Florida would receive from such conservation. This is incorrect. My study of Corps' operations and the federal reservoir system in the ACF demonstrates that the Corps would not do so. In particular, I conclude the Corps would not operate the reservoir system in the ACF to hold back water and thwart the additional flow benefits Florida would receive from Georgia conservation efforts.

3. In explaining my conclusions, I think it is useful to consider three different portions of the Basin as depicted in Figure 1. These areas are subdivided according to the degree to which the water draining from each is hydrologically regulated by federal reservoirs and are referred to as either "unregulated" or "regulated" depending on whether they contain reservoirs that have the capacity to store water. Areas containing reservoirs without storage capacity are **unregulated**. Areas with reservoirs that have storage capacity are **regulated**.

4. Area A is that portion of the Basin without reservoirs that have storage capacity to hold water for significant periods and which I therefore refer to as "unregulated." In contrast, Areas B and C are "regulated" by major storage reservoirs operated by the Corps. "Regulated"

does not mean that the Corps owns the water, but rather that it regulates the flow of water leaving the dams. Area B is the middle portion of the Chattahoochee River lying upstream of Walter F. George Reservoir and Dam and is regulated by both Walter F. George Dam and West Point Dam. Area C is the most upstream portion of the Chattahoochee River above Lake Lanier and furthest from Florida; it is regulated by Buford Dam.

5. As seen in Figure 1, almost two-thirds (62%) of the Georgia portion of the ACF Basin lies within Area A and is unregulated. This part of the Basin includes all of the Flint River Basin and also the lower Chattahoochee River. (The lower Chattahoochee River is the portion of the basin between the W.F. George Reservoir and Lake Seminole.) Lake Seminole does not provide significant storage and thus does not regulate flow, allowing water to flow to the Apalachicola River in Florida. Figure 1 was prepared by another hydrologist in this case, George Hornberger, and I understand it to be a true and accurate copy of the Georgia portion of the ACF showing major hydrologic features and Areas A, B, and C as defined above.

6. I understand from Dr. Hornberger's testimony that almost all conservation measures that Georgia could implement to reduce irrigation would occur in Area A, as that is where the vast majority of the farming is located. For practical purposes, any water restored to streams in Area A as a result of conservation measures Georgia undertakes in that region would flow directly to Florida without being delayed in storage reservoirs. I recognize that a very small fraction might be lost to evaporation or other minor losses. Other than this small evaporative loss, there is nothing to stop the conserved water from reaching Florida, and it would reach Florida. I therefore conclude that conservation of agricultural water in Georgia would be highly effective at producing water that would reach Florida.

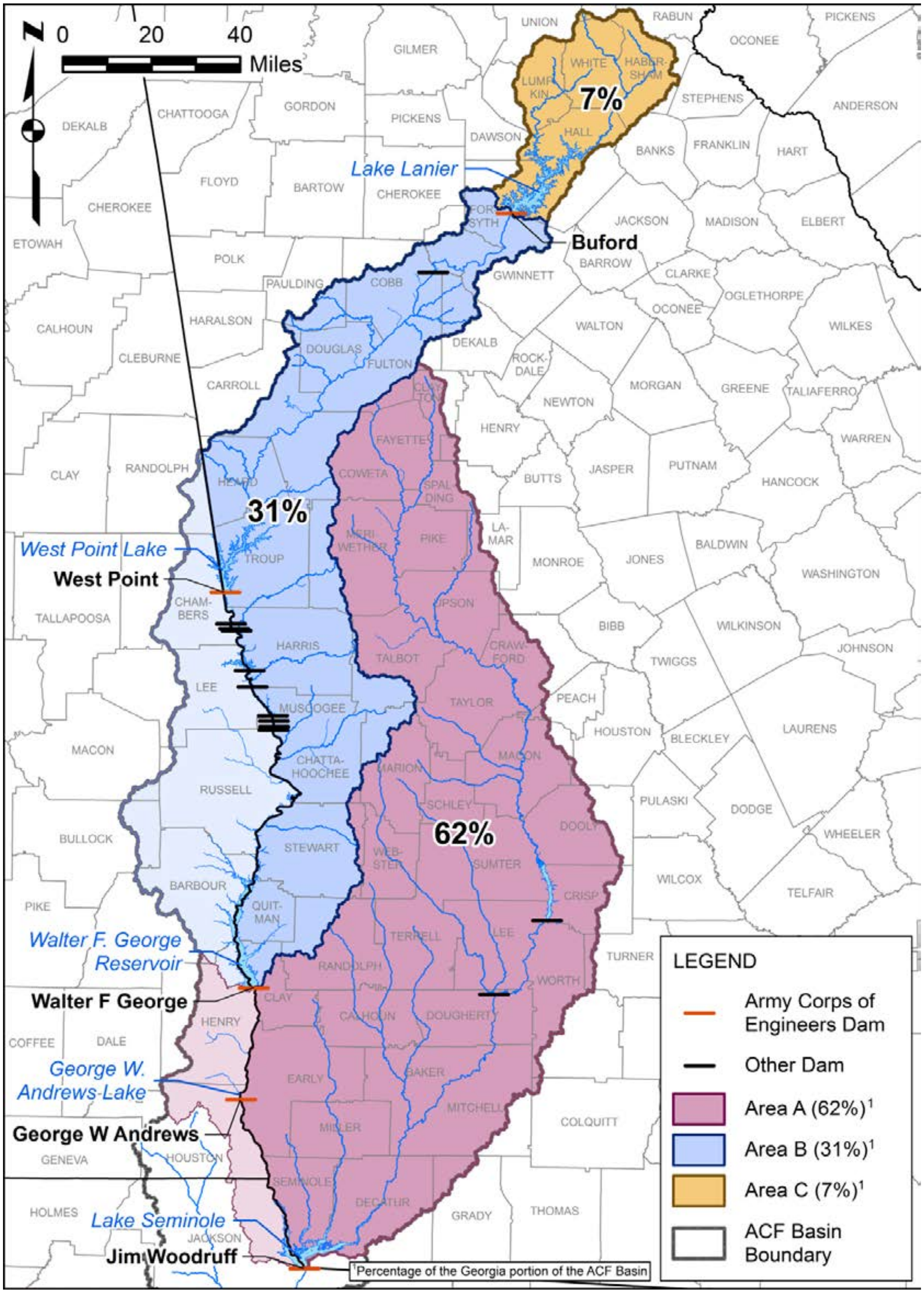


Figure 1. Map of the Georgia portion of the ACF Basin showing unregulated Area A and regulated Areas B and C. (Pre-filed Direct Testimony of Dr. George Hornberger.)

7. I understand that, in this litigation, Georgia claims that the Corps would largely eliminate the short-term benefits of such conservation by acting in anticipation of flows that would be conserved in Area A. In particular, I understand Georgia claims the Corps would 'hold back' water in Areas B and C that otherwise would have been released to Florida if it anticipated Georgia was conserving flows in Area A. Under this theory, the Corps would counteract the newly conserved Area A water by keeping an equivalent amount of water in storage behind the federal dams in Areas B and C. Based on my research and analysis, as well as my scientific training and expertise, I disagree with Georgia's contention on how the Corps would operate. I prepared two expert reports in this case. A true and accurate copy of my February 29, 2016 report ("Shanahan Report") is available at exhibit FX-794. A true and accurate copy of my May 20, 2016 report ("Shanahan Defensive Report") is available at exhibit FX-811.

8. The major opinions derived from my analyses are the following:

a. The Corps operates the ACF system to store water in reservoirs during the spring and release stored water during the summer and fall. (Shanahan Report, FX-794 at 1, 4, 14.) Trading water conserved in Area A for increased storage in Areas B or C during the summer and fall of dry years is inconsistent with how the Corps has actually operated in the past.

b. The Corps' flow and storage records show that the reservoirs in Area B are not used to store water during the summer and fall but instead are operated largely in pass-through mode in which the water that flows into the reservoir is passed through and then released from the reservoir. Annual local inflows to West Point Lake and W.F. George Lake greatly exceed each reservoir's conservation-storage capacity. (Shanahan Defensive Report, FX-811 at 5.) This fact means that, if Georgia conserves water in Area A creating more flow in the Chattahoochee and Flint Rivers, the Corps would have little or no reason to respond and try to offset this by releasing less from the Area B reservoirs.

c. Records of the storage, flow into, and releases from Lake Lanier show that it is a physical impossibility to offset or trade significant quantities of water conserved in Area A for additional water stored in Lake Lanier (i.e., Area C). (Shanahan Report, FX-794 at 1, 11, 39.) There is not enough water flowing into Lake Lanier to effect this sort of trade between such downstream conservation and upstream storage.

d. The rules and guidelines that govern the operation of the ACF system provide the Corps flexibility to exercise judgment and discretion in carrying out system operations. This discretion has been exercised by the Corps in a manner that is not consistent with Georgia's theory. (*Id.* at 21; Shanahan Defensive Report, FX-811 at 2-4.)

e. Georgia's theory is based largely on a computer model that does not reliably reflect Corps' operations because of inherent limitations. Georgia relies on the Corps' ResSim computer model of the ACF system to try to support its theory, but that model is unable to capture the discretionary decisions made by the Corps in its actual operations. (Shanahan Report, FX-794 at 19-21.) ResSim is a tool used by the Corps' for planning purposes, but it is not used to dictate day-to-day operations of the reservoirs.

f. Records of the ACF system during dry years show that the Corps exercises its judgment in ways that cause consistent departures from the behavior predicted by ResSim. Compared to the behavior predicted by ResSim, the Corps actually stores more water in its reservoirs during the spring and releases more water from those reservoirs during the summer and fall. (*Id.* at 2, 25.)

g. ResSim is designed to simulate the minimum requirements of the operational plan that guides Corps operations, called the Revised Interim Operation Plan ("RIOP"). But the Corps consistently releases from Woodruff Dam more water than these minimum requirements—whether or not there are potentially modifying factors such as local storms. (Shanahan Defensive Report, FX-811 at 2-4.)

h. The Corps' releases above the RIOP's minimum releases cannot be explained by a theory that the Corps only seeks to release some small increment above the minimum as a buffer or margin to ensure the minimum is met. In fact, the Corps has significant incentive, based on the need to protect threatened and endangered species, to release more than the RIOP's minimum releases. (*Id.* at 4.)

I. PROFESSIONAL BACKGROUND

9. I am a consulting hydrologist and environmental engineer. I founded my consulting practice, HydroAnalysis, Incorporated, in 1988. Starting in 1996, I also held a position as a Lecturer in the Department of Civil and Environmental Engineering at the Massachusetts Institute of Technology (MIT) in Cambridge, Massachusetts and then as Senior Lecturer from 2004 to 2013. Since 2013, I have continued to conduct research and advise graduate students at MIT on a part-time basis as a Research Affiliate.

10. I hold four academic degrees in engineering and earth sciences: two Bachelor of Science degrees from MIT, in Civil Engineering (1973) and in Earth and Planetary Sciences

(1973). I hold a Master of Science degree in Applied Earth Sciences with a designation in Environmental Earth Sciences from Stanford University in Stanford, California (1974). I also hold a Doctor of Philosophy in Environmental Engineering from MIT (1982).

11. I have over 40 years of experience, specializing in the analysis of hydrology and environmental water quality. My work has addressed hydrologic problems relating to water supply, flooding, drought, and climate change.

12. While previously employed at Resource Analysis, Inc. (now a part of CDM Smith), I contributed to several projects for the Corps. I was the project engineer on a study of flooding in the Cumberland River system in Kentucky and Tennessee requiring development of a computer program to simulate the basin's hydrology, hydraulics, and reservoir operations. I also was the project engineer on two studies of the internal hydraulics of Corps hydropower projects and co-authored the initial version of the Water Hammer and Mass Oscillation computer code which is still used by the Corps to analyze project hydraulics.

13. At MIT, I was affiliated with a practice-oriented Master of Engineering program and taught graduate and undergraduate courses on environmental engineering and hydrology. I also led graduate students on numerous field projects related to water quality and hydrology. One of the student projects that I directed was a study of the potential presence of so-called emerging pollutants in the Atlanta water supply. During that field study, students and I collected water-quality samples from Lake Lanier and the Chattahoochee River and toured the City of Atlanta's Chattahoochee Water Treatment Plant that provides drinking water to parts of Atlanta.

14. I am a registered Professional Engineer in Massachusetts and Maine and a member of several professional associations including the American Geophysical Union and the American Society of Civil Engineers.

15. I have published over sixty refereed journal articles, conference papers, and book chapters on the subjects of hydrology, water quality, and computer modeling. A complete list of publications is included as part of my curriculum vitae, a true and accurate copy of which is attached to the Shanahan Report. (FX-794.)

II. KEY TERMINOLOGY & CONCEPTS

16. My testimony relies on certain key hydrological terms and concepts. I provide an overview of these terms and concepts below:

Conservation pool: The portion of the space within the reservoir set aside for power production and water supply.

Conservation storage: The volume of water within the *Conservation pool*. The Corps uses that water to meet authorized project purposes other than flood-risk management (e.g., hydropower, water supply, recreation, conservation of fish and wildlife, etc. (USACE 2015, JX-124 at 11-2.) The Corps stores water in conservation storage when it is plentiful and slowly releases it over the summer months when it is needed to meet the Corps' operational objectives. (Shanahan Report, FX-794 at 16.)

Reservoir storage capacity: The amount of water that a reservoir can hold. *Total storage capacity* is the total amount of water that can be held in a reservoir; *Conservation storage capacity* is the same as *Conservation storage* and is the amount of water that can be held in the reservoir's conservation pool.

Usable system capacity: The amount of conservation storage in all reservoirs in the system.

Guide curves: The pool elevation desired in a reservoir at a particular time of year (equal to the top of the *Conservation pool*). (USACE 2015, JX-124 at 11-4.)

Action zones: Action zones corresponding to lower elevations within the conservation pool. Higher action zones correspond to increasingly water-short conditions. Each action zone has a set of specific operational rules or guidelines that guide how the Corps operates the reservoirs. (*Id.* at 11-1.)

Runoff: Portion of precipitation (rain or snow) that does not seep into the ground and instead flows downhill.

Drainage area: "All of the surface area, including land and any water bodies, from which water (*runoff*) upstream of a location on a stream, river, or water body drains to that location." (*Id.* at 11-3.)

Inflow: The amount of water coming into a reservoir during a period of time.

Holdout: The difference between the amount of water coming into the reservoir (the "*inflow*") and the amount of water flowing out of the reservoir (the "outflow"). (*Hold out* is the related verb.)

Run-of-the-river: Describes a dam and reservoir project in which the amount of water in the reservoir does not change appreciably and which does not *hold out* quantities of water.

Minimum flow requirement: "A low river flow at a specified point in a river. The minimum flow may be a regulated minimum flow or a specific level needed for water supply or other purposes." (*Id.* at 11-5.)

RIOP: Revised Interim Operation Plan. A plan developed by the Corps and agreed upon by the U.S. Fish and Wildlife Service in a Biological Opinion (BiOp) for releasing water from Jim Woodruff Dam at various times of the year and depending upon the amount of water available in the ACF Basin. The purpose of the RIOP is to protect downstream endangered species. (*See generally*, USFWS 2012, JX-72; USFWS 2016, JX-168 (2016 BiOp).)

Discretion: The ability of the Corps of Engineers to decide what should be done under particular conditions in order to meet the authorized project purposes. While there are minimum release rules that I discuss below in my testimony, the Corps has significant discretion to deviate from those rules in operating the reservoir system. (Shanahan Report, FX-794 at 2, 6, 19.)

ResSim: A computer program (formally named HEC-ResSim) developed by the Corps for simulating reservoir systems for planning purposes.

III. KEY BACKGROUND ON THE ACF RIVER BASIN SYSTEM

17. The ACF reservoir system consists of five federal reservoir projects that are operated by the Corps (Figure 1). The system includes, from upstream to downstream, Buford Dam (which impounds Lake Lanier and is at the downstream end of Area C), West Point Dam (in Area B) and Lake, W.F. George Dam and Lake (at the downstream end of Area B), George Andrews Dam (in Area A), and Jim Woodruff Dam (which impounds Lake Seminole and is at the downstream end of Area A).

18. The operation of individual federal reservoirs and the ACF system as a whole is carried out by the Corps. The Draft Environmental Impact Statement (DEIS) for the Update of the ACF Water Control Manual prepared by the Corps, describes in detail the operations of the reservoirs. (USACE 2015, JX-124 at Appendix A, Chapters 5 and 6.) Scientists routinely rely on official government reports, and I reviewed and relied on the DEIS, which I obtained from the

Corps' website, to form my opinions in my report and in this testimony.[1] The same DEIS was also produced as an exhibit in this litigation. (JX-124.)

19. The Corps monitors and transmits data on flows and water levels throughout the ACF system on a continuous basis in order to know how the system is currently operating. It also collects data on rainfall and consults short- and long-term forecasts of future rainfall in order to know how much water is likely to come into the reservoirs over the next few days and next few months. Based on the real-time data and forecasts, operational decisions are made with the aim to balance the multiple, and sometime competing, purposes of the ACF System. (USACE 2015, JX-124 at 7-2.) Ultimately, the Corps' operational decisions determine how much water is stored and how much is released from the three federal storage reservoir projects and two non-storage projects.

A. System storage in the ACF Basin is physically constrained such that most water flowing into the river basin is passed through to Florida.

20. The majority of the ACF system's usable reservoir system storage—65%—is in Lake Lanier, Area C. (Shanahan Report, FX-794 at 2, 11, 15.) But Lake Lanier lies at the headwaters of the basin and is fed by runoff (which occurs predominantly during winter and spring) from only Area C, which makes up only 7% of the portion of the ACF Basin in Georgia. The reach of the Chattahoochee River downstream of Lake Lanier is the source of the water supply for the Atlanta Metropolitan Area. Thus, the system's largest storage component (Lake Lanier) is filled by a comparatively modest seasonal inflow but drained by one of the basin's largest and most insistent demands. It is common for scientists in my field to evaluate and rely on statements by environmental regulators and I have evaluated a July 22, 2013 statement to the U.S. Senate

[1] *Available at* http://www.sam.usace.army.mil/Missions/Planning-Environmental/ACF-Master-Water-Control-Manual-Update/ACF-Document-Library/.

Committee on Environment and Public Works by Judson Turner, the Director of the Georgia Department of Environmental Protection. (Turner 2013, JX-94 at 4.) I agree with his conclusion that the proportionally small inflow to Lake Lanier limits the "capacity of Lake Lanier to augment flows hundreds of miles downstream in the Apalachicola River during droughts."

21. Another 19% of the system storage is in West Point Lake, in the upper-middle reach of the Chattahoochee, and a final 15% is in Walter F. George Lake, further downstream on the Chattahoochee main stem. Together, these two reservoirs impound flow from Area B, 31% of the Georgia portion of the ACF Basin. The next downstream project, George W. Andrews Dam, is a "run-of-the-river" project, which means that it simply passes incoming water. The reservoir created by George W. Andrews Dam does not provide significant storage capacity. The downstream-most project in the ACF Basin is Jim Woodruff Dam, which impounds Lake Seminole. The Chattahoochee and Flint Rivers, as well as Spring Creek and several other tributaries, flow into Lake Seminole. The discharge from Lake Seminole forms the Apalachicola River. Lake Seminole has minimal storage capacity and is operated as a run-of-the-river project. (USACE HEC 2014, JX-113 at 8.) As with the DEIS, of which the HEC-ResSim Modeling Report is a part, I obtained this document by downloading it directly from the Corps' official website. I reviewed and relied on this report to form my opinions in my report and in this testimony, which is standard practice for experts in my field. The same report was also produced as an exhibit in this litigation.

22. The system's reservoirs thus provide somewhat lopsided storage capacity: all useful storage capacity is on the Chattahoochee River in Areas B and C, primarily within the upstream reaches of the river in Area C, and none is within the Flint River Basin in Area A. Because there is very little storage on the Chattahoochee River Basin below the W.F. George Dam and no useful

storage capacity on the Flint River Basin, water from 62% of the ACF's watershed area in Georgia (Area A) is unregulated.

23. The storage capacity for each reservoir is summarized in Table 1 below. (USACE 2015, JX-124 at 2-15, 2-24, 2-28, 2-34, 2-41, Appendix A to Appendix A at E-A-2, Appendix D to Appendix A at xi.) Storage volumes are given in acre-feet, the volume of water that would cover an acre of area by a depth of one foot. One acre-foot is equivalent to a little less than 326,000 gallons. The area within the state of Georgia that drains to each reservoir (the "drainage area") is shown in Figure 1.

Table 1. Characteristics of ACF Basin and Reservoir Projects. (USACE 2015, JX-124 at 2-15, 2-24.) This table shows of subset of the data that was included as Table 1 in the Shanahan Report. (FX-794 at 15.)

Project	Total Storage Capacity (acre-feet)	Conservation Storage Capacity (acre-feet)	Percentage of Usable System Capacity
Buford Dam and Lake Lanier	1,955,200	1,087,600	65%
West Point Dam and Lake	604,527	306,131	19%
W.F. George Dam and Lake	934,400	244,400	15%
George Andrews Dam and Lake	18,180	0	0%
Jim Woodruff Dam and Lake Seminole	367,318	0	0%

B. The Corps' operational strategy seeks to operate the ACF System as a coherent whole.

24. The ACF reservoir system is managed in order to fulfill the purposes identified in governing federal law. (USACE 2015, JX-124 at 2-58ff.) These include flood control, hydropower production, maintenance of navigation, conservation of fish and wildlife, recreation, supply of water, and preservation of water quality.

25. In response to the physical constraints of the system, the Corps has developed the following operational strategy: Water is stored during the wetter time of the year (the winter and

early spring) and held until the drier time of the year (the summer and fall) when it is released to meet authorized project purposes. (USACE HEC 2014, JX-113 at 8.) Additionally, the reservoirs are usually drawn down in the fall to make space that may be needed to store flood waters during the winter and spring. The water level desired in each reservoir as a function of the time of year are defined by so-called "guide curves" which are shown in the DEIS. (USACE 2015, JX-124 at 2-29, 2-35, 2-41, 2-72.) When drawing on stored water in the summer and fall, the Corps uses the downstream-most reservoirs first and taps the upstream reservoirs later, keeping more water upstream where there is the most flexibility for dispensing it.

26. The Corps also emphasizes that the system is operated as a whole rather than as disconnected reservoirs. (USACE 2015, JX-124 at 2-62.) They seek to "maintain a balanced use of conservation storage rather than to maintain the pools at or above certain predetermined elevations." (*Id.*) To balance its authorized objectives, the Corps manages the conservation storage within the reservoirs. The guide curves are used to define the conservation storage, which is the amount of water available to be used for meeting the project purposes defined above other than flood control. (*Id.* at 11-2.)

27. The Corps operates the system with an eye to keeping reservoirs filled to the level specified by the guide curves, but that is in fact possible only in the wettest of years. The reservoirs are often below the guide-curve levels, particularly during the summer and fall. Thus, in addition to guide curves, the Corps defines "action zones" corresponding to lower elevations within the conservation pool. (*Id.* at 4-10.) The action zones, which go from Zone 1 to Zone 4 and then the Drought Zone, define increasingly water-short conditions when tradeoffs must be made among authorized purposes and operations must be altered. The Corps states a desire to operate the

reservoirs so that they are always all within the same zone (*Id.* at 4-11); however, examination of the historical record shows that the reservoirs are sometimes in different zones.

28. Droughts are an important consideration in the ACF Basin and the Corps has an operations plan specifically for droughts. (*Id.* at 4-16.) Drought operations commence on the first day of the month after the total system storage drops from Zone 3 to Zone 4. Under drought operations, a number of normal operating rules are suspended and special operations apply for releases from Jim Woodruff Dam as described below. Drought operations remain in place until the composite system storage recovers to a level within Zone 1. (*Id.* at 4-16, 4-17.)

29. The large volume of storage in Lake Lanier provides a reserve of water that creates resilience in the ACF System. According to historical records kept by the U.S. Army Engineers (*Id.* at 2-9), the lowest elevation on record for Lake Lanier is 1050.79 feet which occurred on December 26, 2007 during a multi-year drought. Even at this low point, the reservoir still held in reserve 406,000 acre-feet in the conservation pool and 1,274,000 acre-feet in total storage. The total storage in the reservoir includes 867,600 acre-feet of so-called inactive storage. Although not originally intended for use as water supply, this water could be tapped during extreme droughts, a possibility explored by the Corps during the 2007 drought, but never actually implemented. Scientists routinely rely on government communications such as fact sheets, and I have reviewed and relied upon a fact sheet that the Corps prepared that evaluated the use of this source as a water supply. (USACE 2007, FX-771; FX-494 (transmittal e-mail for fact sheet).)

C. The Corps operates the ACF System in a way that gives them broad discretion to determine flow releases, within certain operational constraints.

30. Some of the purposes designated for the ACF System are manifested in the form of minimum required releases from some of the projects. Buford Dam is required to release enough water to provide for water-supply withdrawals in Metropolitan Atlanta (currently about 429 cubic

feet per second or cfs) and additionally to ensure a minimum flow of 750 cfs where Peachtree Creek enters the Chattahoochee River downstream of Atlanta in order to maintain water quality by ensuring there is enough river water to dilute the sewage discharged from the Atlanta area's sewage treatment plants.

31. A minimum release of 670 cfs is required from West Point Dam to similarly protect downstream water quality.

32. Releases from Jim Woodruff Dam (Lake Seminole) are specified in the 2012 Revised Interim Operation Plan (2012 RIOP) and are designed, among other purposes, to protect endangered species in downstream waters. The 2012 RIOP ties releases to the time of year, the total amount of water stored in the three storage reservoirs (specified through so-called action zones discussed above), and total inflow to the basin. The 2012 RIOP is presented by the Corps in the form of a table of minimum release flows, reproduced here as Table 2. (*See* USACE 2015, JX-124 at 5-35.) The minimum required flow is 4,500 cfs when storage is in the drought action zone and 5,000 cfs otherwise. These minimum flows are required to be met whether or not basin inflow exceeds them. In other words, when total inflow to the basin is less than 5,000 cfs, the system draws from water stored in the reservoirs to maintain a minimum discharge of 5,000 cfs. When basin inflow is higher than these minima, the RIOP requires that a specified portion (which may be 100%) of the basin inflow be released depending upon the time of year and the amount of basin inflow.

Table 2. May 2012 RIOP for Jim Woodruff Lock and Dam, Apalachicola River Minimum Discharge for Federally-Listed Species by Month and Basin Inflow. (USFWS 2012, JX-72 at 13.)

Months	**Composite Storage Zone**	**Basin Inflow (BI) (cfs)**	**Releases from JWLD (cfs)**	**Basin Inflow Available for Storage**[1]
March - May	Zones 1 and 2	>= 34,000	>= 25,000	Up to 100% BI > 25,000
		>= 16,000 and < 34,000	>= 16,000 + 50% BI > 16,000	Up to 50% BI > 16,000
		>= 5,000 and < 16,000	>= BI	
		< 5,000	>= 5,000	
	Zone 3	>= 39,000	>= 25,000	Up to 100% BI > 25,000
		>= 11,000 and < 39,000	>= 11,000 + 50% BI > 11,000	Up to 50% BI > 11,000
		>= 5,000 and < 11,000	>= BI	
		< 5,000	>= 5,000	
June - November	Zones 1,2, and 3	>= 22,000	>= 16,000	Up to 100% BI > 16,000
		>= 10,000 and < 22,000	>= 10,000 + 50% BI > 10,000	Up to 50% BI > 10,000
		>= 5,000 and < 10,000	>= BI	
		< 5,000	>= 5,000	
December - February	Zones 1,2, and 3	>= 5,000	>= 5,000	Up to 100% BI > 5,000
		< 5,000	>= 5,000	
At all times	Zone 4	NA	>= 5,000	Up to 100% BI > 5,000
At all times	Drought Zone	NA	>= 4,500[2]	Up to 100% BI > 4,500

[1] Consistent with safety requirements, flood control purposes, and equipment capabilities.
[2] Once composite storage falls below the top of the Drought Zone ramp down to 4,500 cfs will occur at a rate no greater than 0.25 ft/day drop.

33. It is important to recognize that the 2012 RIOP specifies minimum flows rather than specific outflow rates. The Corps and U.S. Fish & Wildlife Service consistently describe the releases from Woodruff Dam under the RIOP using the ">=" (greater-than-or-equal-to) symbol to signify that the specified value is a minimum, rather than a target, and even states that the flow rates "prescribe minimum, and not target, releases for Jim Woodruff Dam." (USFWS 2012, JX-72 at 10, 13.) As with the DEIS, I obtained the 2012 Biological Opinion, which contains the 2012 RIOP and was prepared by the U.S. Fish and Wildlife Service, by downloading it directly from the Corps' website. Considering agency opinions of this kind is common practice among experts in my field, and I have reviewed and relied upon this to form my opinions in my report and in my testimony.

34. The Corps invokes still other guidelines and strategies for operating the reservoirs. For example, the West Point, W.F. George, and Jim Woodruff projects must be operated with an eye to the structural stability of the dams. (USACE 2015, JX-124 at Appendix A, 3-9.) And, the 2012 RIOP requires that flow rates from Jim Woodruff Dam not change too quickly. (*Id.* at 5-35 – 5-36.) Finally, the Corps has latitude to depart from normal operations under special circumstances. (*Id.* at 2-80.) Such circumstances include maintenance and repair of turbines, emergency situations such as a drowning or chemical spill, grounded barges, water quality emergencies, and other unusual events.

35. While the reservoir guide curves, action zones, minimum flow requirements, and other controls set boundaries within which the ACF Basin System is normally operated, they leave latitude for the Corps to operate as it deems appropriate within those boundaries.

IV. WATER THAT GEORGIA CONSERVES ON THE FLINT RIVER OR LOWER CHATTAHOOCHEE WILL REACH THE APALACHICOLA RIVER AS INCREASED FLOW

36. The Flint River Basin makes up most of Area A as shown in Figure 1. A small portion of Area A is within the Chattahoochee River Basin below Walter F. George Dam. No major storage dams regulate the water flowing from or within the Area A part of the ACF Basin.

37. Georgia and its experts have asserted that water conserved in the Flint River Basin (and by implication, the rest of Area A) during periods of low river flow would simply be offset by the Corps storing more water in the federal reservoir projects upstream on the Chattahoochee River, with the result of no material benefit to the State of Florida. I have analyzed this claim using several different approaches and conclude that Georgia's theory is wrong: (1) the Corps' existing operations of the ACF reservoir system shows that it does not store additional water in the reservoirs in reaction to additional water on the Flint River; rather, flows on the Flint River are well correlated with releases from Lake Seminole; (2) because there is significant local inflow into

the West Point Lake and W.F. George Lake and these reservoirs are downstream of significant municipal water demands, there is no reason for the Corps to try to offset water conserved on the Flint River or lower Chattahoochee by releasing less water from these reservoirs; and (3) it is physically impossible to offset or trade significant quantities of water conserved during the summer of dry years in the Flint River or lower Chattahoochee River for additional water to be stored in distant Lake Lanier. In summary, aside from minor losses, water that Georgia conserved in Area A would reach the Apalachicola as increased flow.

A. Georgia's theory is inconsistent with actual, historical Corps operations.

38. I analyzed Georgia's theory by first examining the historical record with respect to how the Corps has operated in the past. The lower Chattahoochee and Flint Rivers are subject to occasional rainstorms, after which the flow in the rivers rise for a few days. If the Corps were somehow trading that "extra" water from Area A for reduced releases from the Areas B and C reservoirs, that practice would show up in the "holdout" of those reservoirs. Holdout is the difference between the amount of water coming into the reservoir (the "inflow") and the amount of water flowing out of the reservoir (the "outflow"). Thus, holdout is the amount of incoming water that the Corps retains in the lake and does not immediately pass through as outflow. A positive holdout occurs when inflow exceeds outflow (i.e., when some water is stored), while a negative holdout occurs when outflow is greater than inflow and storage is depleted. If, as Georgia suggests, the Corps were offsetting the additional flow on the Flint River from rain events by storing extra water in the reservoirs in Areas B and C, then holdout would be positively correlated with streamflow on the Flint River. A "positive correlation" means that where there are two variables (in this case, flow on the Flint River as the first and holdout in the reservoirs as the second), if one variable increases then the other increases as well (or, if one variable decreases then the other decreases as well). In our case, therefore, a positive correlation would mean that

holdout would be higher when Flint River flow was higher and would be lower when Flint River flow was lower.

39. I conducted a statistical examination of the correlation between combined summertime holdout in the storage reservoirs and flow from the Flint River Basin and found that no such correlation exists (see Figure 2). If the holdout in the reservoirs exactly matched the increased flow on the Flint River, the correlation would be perfect and the points in Figure 2 would all fall exactly on a straight line angled upwards to the right. Instead, the data points in Figure 2 show more of a "dart-board" appearance, indicating poor correlation. Statisticians use a measure called the coefficient of determination (usually called the R^2 value) to determine whether a positive correlation exists. The closer the R^2 value is to 1.0, the higher is the positive correlation. If the R^2 value is closer to zero, there is no positive correlation. The very low R^2 value in Figure 2 shows that holdout does not increase as flow on the Flint River increases. Figure 2 provides strong evidence that the Corps has not operated in the past so as to trade Flint River flow for upstream storage.

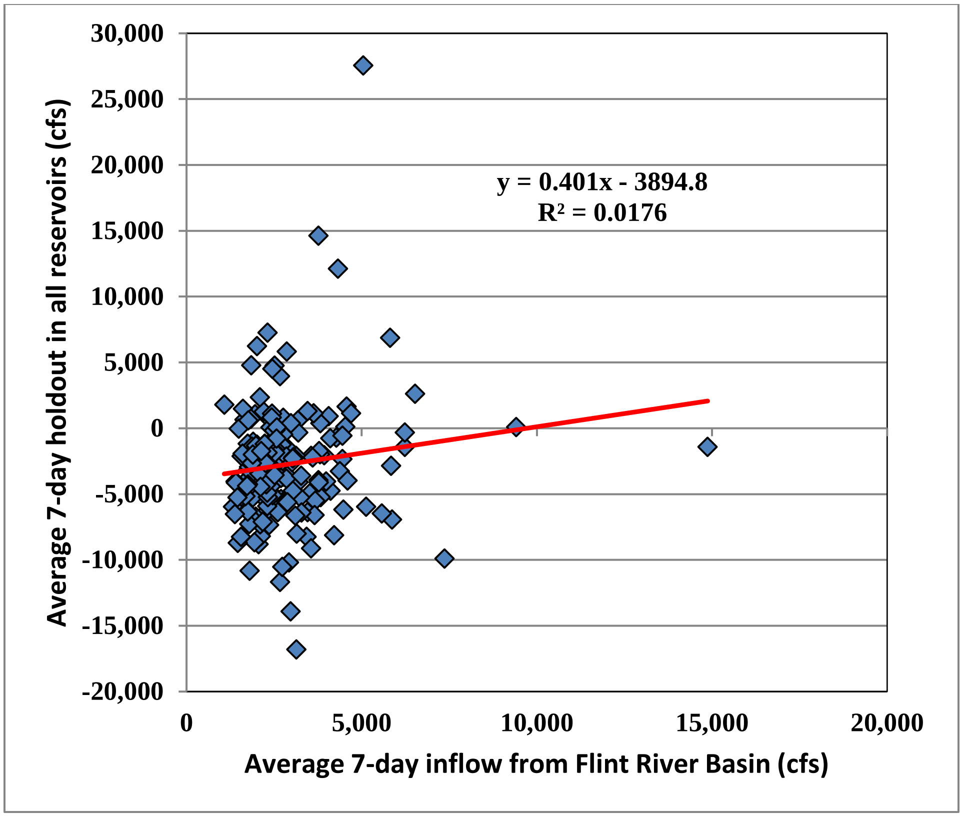


Figure 2. Correlation between 7-day holdout in storage and average inflows from the Flint River Basin during June through September in dry years (*i.e.*, 1981, 1985, 1986, 1988, 1999, 2000, 2002, 2006, 2007, 2008, 2011, 2012). (Similar to Figure 4 from Shanahan Report). (Shanahan Report, FX-794 at 8.) I created this figure using generally accepted scientific principles, Corps records of the inflow and outflow to W.F. George and West Point Reservoirs, and U.S. Geological Survey (USGS) records of streamflow in Spring Creek near Iron City and at Reynoldsville and in the Flint River at Bainbridge.

40. Further, since Lake Seminole cannot hold out appreciable amounts of water, the flow out of Lake Seminole correlates strongly with the flow in from the Flint River Basin. In other words, the Corps operates the reservoir system so that when more water enters Lake Seminole from the Flint River, more water leaves Lake Seminole and becomes flow on the Apalachicola River. (Shanahan Report, FX-794 at 35.) This is shown in Figure 3, a plot showing the relationship of monthly average outflow from Lake Seminole to monthly average inflow from the Flint River Basin. Unlike Figure 2, Figure 3 shows an R^2 value of 0.93, nearly 1.0—demonstrating very strong positive correlation.

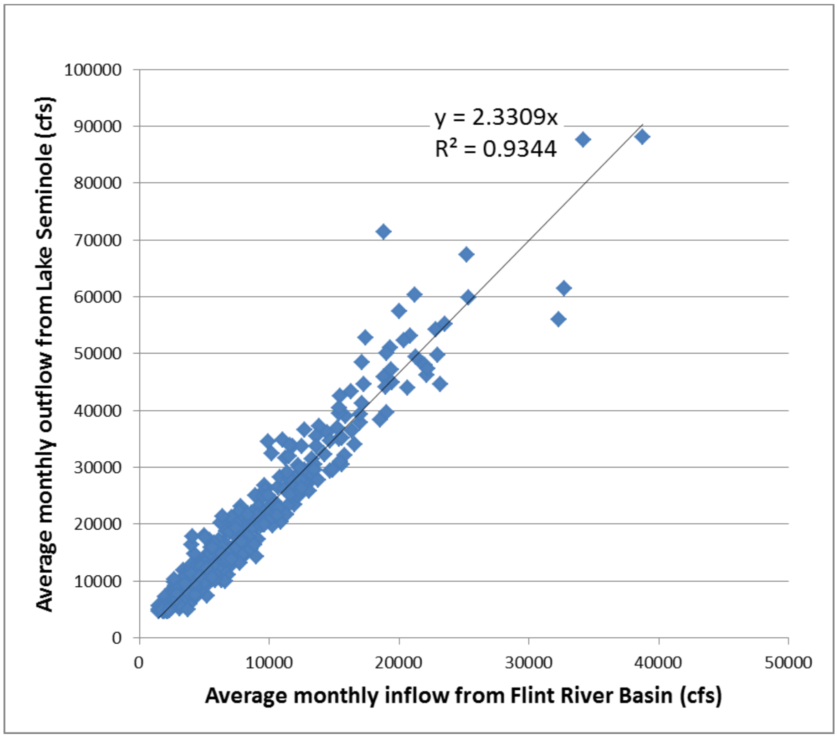
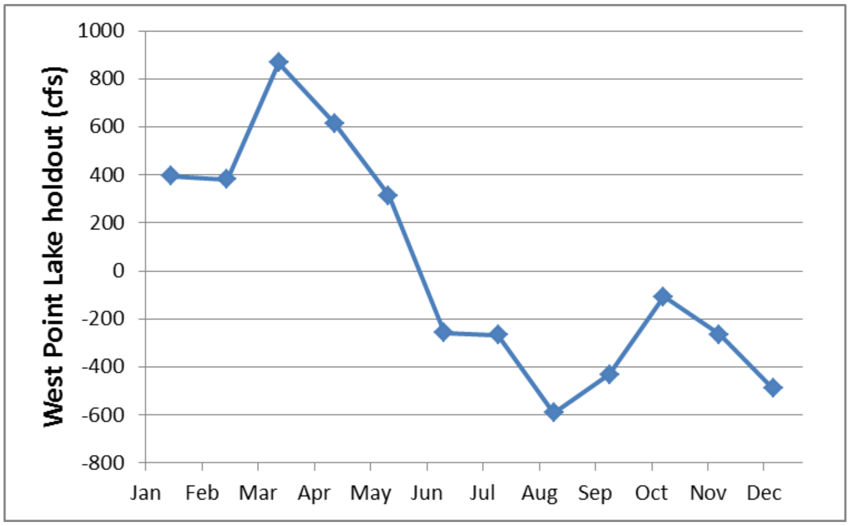
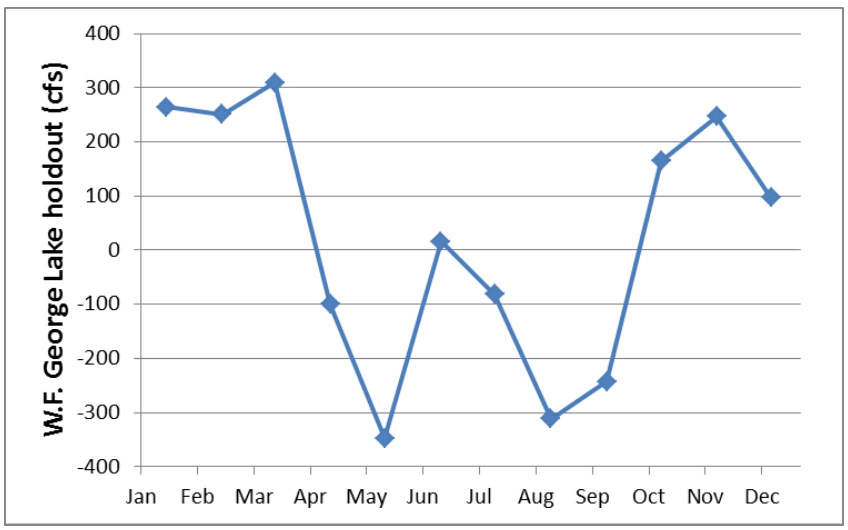


Figure 3. Correlation between average monthly outflows from Lake Seminole and average monthly inflows from the Flint River Basin from 1980 through 2012. (Figure 11 from Shanahan Report.) (Shanahan Report, FX-794 at 35.) I created this figure using generally accepted scientific principles, Corps records of the outflow from Jim Woodruff Dam, and USGS records of streamflow in Spring Creek near Iron City and at Reynoldsville and in the Flint River at Bainbridge.

41. In addition to looking at holdout on a 7-day basis, I also analyzed the holdout for the reservoirs in Area B from 1980 to 2012 on a monthly basis (see Figure 4). During the months of October through March, W.F. George Lake (in Area B) is filled and the holdouts are positive (meaning the Corps is holding back water in these reservoirs for storage). Upstream West Point Lake (also in Area B) is filled later in the wet season, between January and May. The lakes are then drained (holdouts are negative) during the summer, as the stored water is slowly released for downstream use. The negative holdouts in the reservoirs in July, August, and September show that the Corps does not use these reservoirs in any significant way for summertime storage. Summer is the time that the Corps slowly but consistently empties the three storage reservoirs in the ACF system.



a) West Point Lake



b) Walter F. George Lake

Figure 4. Average monthly holdouts in West Point Lake, and W.F. George Lake from 1980 through 2012 (Figure 10 from Shanahan Report). (Shanahan Report, FX-794 at 31.) I created this figure using generally accepted scientific principles and Corps records of the inflow and outflow to W.F. George and West Point Reservoirs.

B. There is no reason for the Corps to store conserved water in West Point Lake and W.F. George Lake (i.e., in Area B).

42. I next looked at whether any water that might be conserved in Area A could be stored in Area B. This inquiry is also relevant to the question of whether any water that might be conserved in Area B under a conservation cap could be stored in Area B.

43. As discussed above (paragraph 41), the Corps generally slowly releases water from West Point Lake and W.F. George Lake over summer months. An analysis of the local inflow into the reservoirs demonstrates that there would be no sound reason for the Corps to change this practice and release less water from these reservoirs in reaction to new water from conservation measures on the Flint River.

44. Table 3 illustrates that West Point Lake and W.F. George Lake receive local inflow many times greater than their conservation storage. Table 3 is a simplified version of Table 1 from my defensive report (a non-substantive typo in the original that does not affect the results is also corrected), which I created using generally accepted scientific principles. (Shanahan Defensive Report, FX-811 at 5.) Thus, for example, the mean annual inflow to W.F. George Lake is enough to fill the conservation storage almost 17 times over. This relationship holds up even in the driest of years—the analysis that produced Table 3 shows that the year in which the mean annual inflow to West Point was the least (water year 2008), the inflow was 2.5 times the conservation storage. During the year of least inflow to W.F. George Lake (water year 2012), the flow was 4.1 times the conservation storage. (The water year I selected considers the hydrologically convenient year that runs from June 1 to May 31, with the year number taken from the calendar year of the May in which it ends.) Thus, the Corps has reasonable assurance that these lakes will be refilled multiple times over the course of a year. (USACE 2015, JX-124 at 4-11.) This relationship is one factor that allows the Corps to consistently release more from Woodruff than the RIOP minimum. In addition, there are limited local water-supply demands on these reservoirs.

Table 3. Comparison of ACF reservoir conservative storage with mean annual inflow. (Water Year June 1, 1976 through May 31, 2013)

Reservoir	Conservation storage (acre-feet)	Conservation storage (cfs-days)	Mean annual local basin inflow 1976-2013 (cfs)	Mean annual local basin inflow 1976-2013 (cfs-days)	Mean annual local basin inflow as multiple of conservation storage
Lake Lanier	1,087,600	548,300	1,792	645,500	1.2
West Point Lake	306,100	154,300	2,831	1,034,200	6.7
W.F. George Lake	244,400	123,200	3,897	1,423,200	11.6

45. There would be no sound reason for the Corps to try to offset increased conservation in Areas A or B by releasing less water from these lakes. Attempting such an offset would be unnecessary to fill the lakes (as adequate basin inflow is typically available) and it would be unnecessary for local water-supply needs around those two lakes (which needs are limited).

C. It is physically impossible to offset or trade significant quantities of water conserved during the summer of dry years in Area A for additional water to be stored in Lake Lanier (Area C).

46. In addition to examining the Corps' historical operations, I also examined whether extra downstream water from Area A (and specifically, in the Flint River) could somehow be stored upstream in Lake Lanier (i.e., Area C). (Shanahan Report, FX-794 at 8.) However, it would be impossible to physically move water conserved on the Flint River to Lake Lanier. Lake Lanier is too distant and at too high a relative elevation to do that economically and there is no infrastructure available today to accomplish this. Rather, the amount of water conserved on the Flint would somehow need to be matched by an equal amount of water conserved in Lake Lanier instead.

47. The only water available to be conserved at Lanier is water that can be saved by reducing the amount released through the Buford Dam. The minimum release requirements for

Buford Dam, discussed in Paragraph 30 above, put a floor under the amount of water released from the dam. Only amounts in excess of that floor could in theory be traded for water conserved downstream. I have computed that excess amount over past dry years and have called that quantity the "discretionary release." These calculations are not based on a model but rather on a straightforward bookkeeping of the actual flows observed in the past. These calculations are described in detail in my report. I found that the potential to conserve water is minimal because the discretionary releases from Lake Lanier are small during dry years. For example, Figure 5 shows the discretionary releases for a four-week period beginning on Sunday, June 29 and continuing through Saturday, July 26 in the drought year of 2008. On most of the days, there is no discretionary release (shown by the orange bars in Figure 5). On these days, the release from Lake Lanier was equal to the amount needed to meet downstream minimum flow requirements, and there was no excess release. As a result, there was no "extra" water released from Lake Lanier that could have been conserved and thus no possibility to trade water conserved on the Flint River for water held back in Lake Lanier.

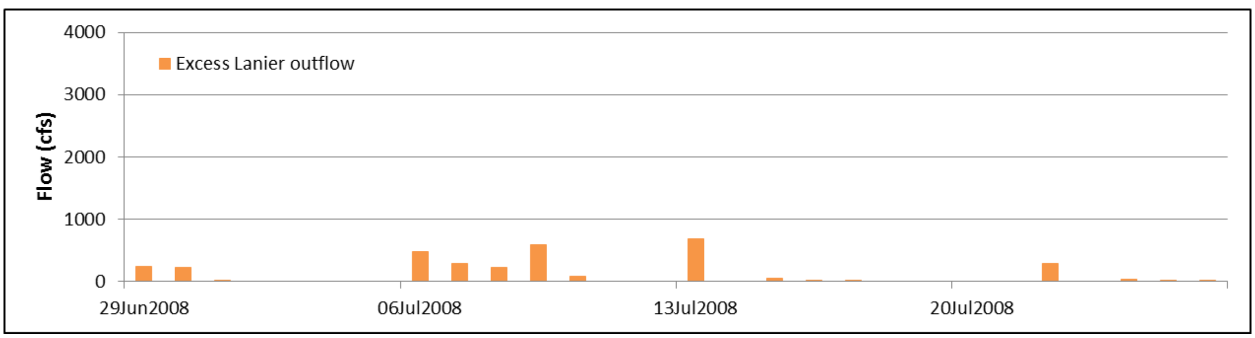


Figure 5. Discretionary release from Lake Lanier during July 2008 (Figure 5c from Shanahan Report). (Shanahan Report, FX-794 at 10.) I created this figure using generally accepted scientific principles and Corps records of the outflow from Buford Dam.

48. During the very dry years, 1988, 2002, and 2008, the amount of water that could be physically traded from the Flint River to Lake Lanier was only 184, 53, and 259 cfs, respectively,

on an annual-average basis—that is, there was no actual physical capability to store more than these small quantities of water during those very dry years.

49. The average amount of water that could be traded over the twelve driest years since 1980 was only 341 cfs. Even this flow exceeds the inflows to Lake Lanier during the dry years. The net inflow to Lake Lanier in excess of the minimum required releases averages only 89 cfs over the twelve driest years.

50. In the final analysis, any scheme to try to conserve more water in Lake Lanier is largely thwarted by the hydrology of the system. Lake Lanier is at the headwater of the basin and has limited contributing watershed area. Although it accounts for 65% of the storage capacity in the system, it drains only 7% of the Georgia portion of the ACF Basin. This mismatch between contributing area and storage capacity, together with the minimum release requirements at Lake Lanier, frustrates any schemes to use less water elsewhere in the basin as a means to save more water in Lake Lanier. Lake Lanier simply does not receive enough water in excess of its required minimum releases to enable significant additional water storage.

51. My analysis is consistent with what the United States has stated to this court: "*Georgia gives the Flint River short shrift, suggesting in a footnote that the Corps would increase impoundments upstream to offset increased flows from the Flint River. But that speculation is entirely unwarranted, particularly where the current operational protocols provide for matching basin inflows during most flow conditions.*" (United States' Brief as *Amicus Curiae* in Opposition to Georgia's Motion to Dismiss for Failure to Join a Required Party at 19 (March 11, 2015).) While the United States dismisses Georgia's theory of water storage as "speculation" my analysis shows that to be a generous description—Georgia's theory in fact defies physical possibility.

D. My conclusions are confirmed by other researchers.

52. It is common for scientists to evaluate and rely on work by other scientists, and my conclusion that water conserved on the Flint River and Lower Chattahoochee will become additional flow on the Apalachicola River is also confirmed by results obtained by the Georgia Water Resources Institute ("GWRI") for the ACF Stakeholders. (Georgakakos *et al.* 2013, FX-524.) In an August 15, 2013 draft memo titled Executive Summary—First Round Scenario Assessment, scientists from GWRI predicted that a 30% decrease in basin-wide consumptive use (which decrease equals 401 cfs in their analysis) would increase releases from Woodruff Dam by 400 cfs during May through September of dry years (which included 1941, 1951, 1955, 1981, 1985, 1986, 1988, 1999, 2000, 2002, 2006, 2007, and 2008 in their analysis). Thus, Georgakakos et al. (2013) predicted that water conservation of 401 cfs would be passed through Lake Seminole and released from Jim Woodruff Dam. I analyzed the GWRI report and this finding is consistent with my findings here.

V. RESSIM DOES NOT CAPTURE HOW THE CORPS REGULATES THE BASIN IN PRACTICE

53. Georgia has argued that "[a]ny reduction in Georgia's consumptive use would not result in additional streamflow at the Georgia-Florida state line during seasonal low-flow or drought periods, due to USACE's reservoir operations." (Bedient Expert Report, February 29, 2016, at 8.) Georgia relies almost entirely on modeling results from ResSim for this conclusion. This reliance is misplaced and leads to flawed conclusions, because it fails to account for the model's limitations.

A. ResSim's interpretation of the 2012 RIOP is constrained by the model's significant limitations.

54. ResSim is a computer program that was developed by the Corps to simulate reservoir systems for planning purposes. The programmed rules, which are necessarily very tightly

prescribed, may provide a reasonable basis for planning studies, but cannot and do not include the Corps' routine exercise of discretion or the Corps' normal daily and hourly operational decisions.

55. Used with an understanding of its limitations, the ResSim model may be a useful planning tool. But it is a model and not the actual system, and as a model necessarily has limitations and deviates from reality. In particular, the ResSim model uses a "rule-based" representation of how the system is operated that assumes absolute rigidity in the application of those rules. (Here, the word "rule" is used in a computer-programming sense and not a legal or regulatory sense.) In contrast, the Corps operates with much more flexibility, applying their judgment about the system and hydrological conditions to exercise discretion.

56. Thus, while the 2012 RIOP specifies minimum flows and allows for greater discretion, the rule-based requirements of the ResSim model are such that the model simply sets outflows from Jim Woodruff Dam at the minimum values specified in the RIOP (with the addition of a 50-cfs buffer). This limitation of the model fails to recognize that the Corps has discretion, which it regularly exercises, to discharge more than the minimum flow allowed under the RIOP. In other words, even though the ResSim model might predict that the Corps would have released 5,050 cfs from Lake Seminole on a given day, that in no way means that the Corps did not actually release more on that day. In fact, the Corps typically did release more than would have been predicted by ResSim.

57. Based on simulations with the (imperfect) ResSim model, Georgia has advanced the theory that releases from Woodruff Dam would be no greater than the minimum required under the 2012 RIOP. However, this theory is contradicted by the facts, which demonstrate that the Corps routinely releases more water—often significantly more water—than the minimum set by the RIOP. For example, a review of summer 2012 USGS flow data from the Chattahoochee

streamflow gaging station, just below the outflow from Woodruff Dam, reveals that during a period of Corps drought operations, when the RIOP-specified minimum flow was consistently 5,000 cfs, the Corps released over 5,000 cfs nearly every single day. (*See* Shanahan Defensive Report, FX-811 at 2-3.) The actual releases are shown as the dark blue line in Figure 6, which shows Chattahoochee flow significantly above the 5,000-cfs minimum for nearly every day in this period.

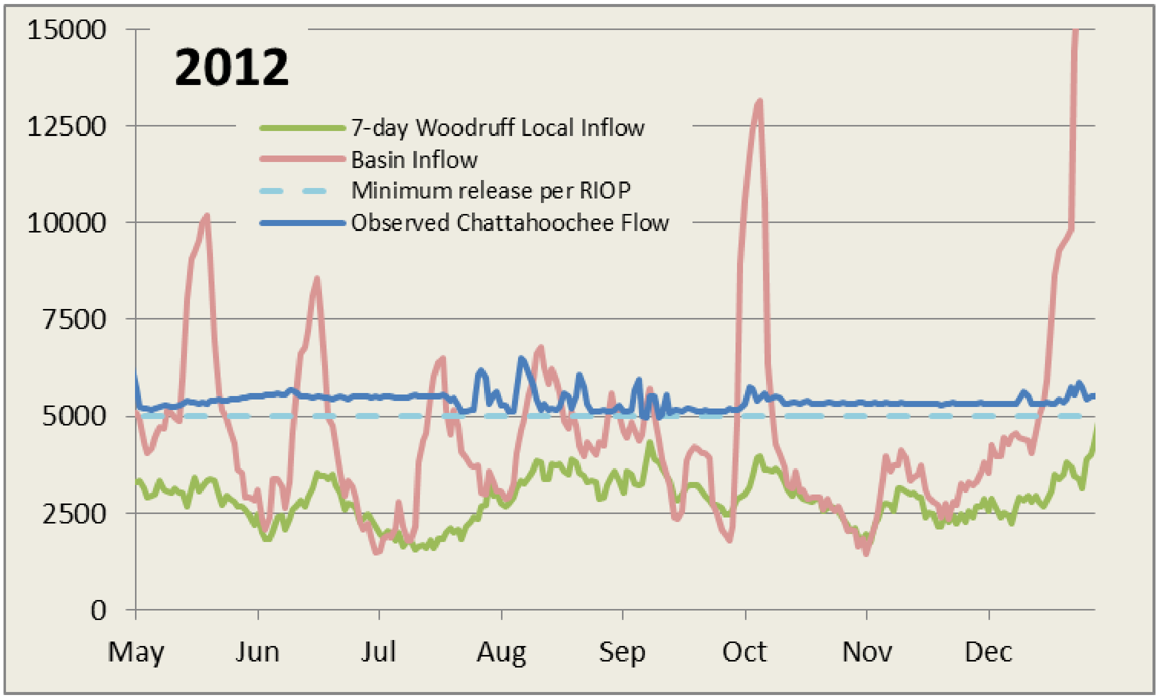


Figure 6. Observed flow in Apalachicola River at Chattahoochee vs. minimum release per RIOP (in cfs) – May-December 2012 (Figure 2 from Shanahan Defensive Report). (Shanahan Defensive Report, FX-811 at 20.) I created this figure using generally accepted scientific principles, Corps records of the inflows to the ACF reservoirs, and USGS records of streamflow in the Apalachicola River at Chattahoochee.

58. When confronted with evidence from the Corps' own guidance documents (discussed below) that ResSim minimum flow estimates do not reflect actual Corps' practice, Georgia's expert Dr. Philip Bedient argued, in seeming contradiction of his initial report, that releases above the minimum are attributable to rainstorm events. (*See* Bedient Defensive Expert Report, May 20, 2016, at 110.) Once again, however, actual data fail to bear out this theory. Using

the summer of 2012 as an example once again, comparing basin inflow (pink line in Figure 6 above) to outflow from Woodruff Dam (dark blue line), one can observe several spikes in inflow which would have been caused by storm events. For example, one such rainfall spike is seen in mid-June. Nevertheless, the Corps released approximately 5,500 cfs at a steady rate from late May through mid-July, regardless of rainstorms.

59. Likewise, the Corps' releases above 5,000 cfs during periods when that value is established by the RIOP as the minimum flow cannot be explained by the fact that the Corps has programmed a 50-cfs "buffer" into ResSim "to avoid violating the 5,000 cfs minimum flow provision." (USACE HEC 2014, JX-113 at 35.) Recorded flow values at the Chattahoochee Gage demonstrate that, even during periods when basin inflow was less than 5,000 cfs, the Corps routinely released flows that varied from 5,000 cfs to nearly 9,000 cfs. Flows during these periods have typically been well above 5,000 cfs, indicating that the Corps' actions are not governed by an effort to maintain some margin of safety. (*See* Shanahan Defensive Report, FX-811 at 21-26, Figures 3-8.)

60. I also completed an analysis of the magnitude of the departure between the RIOP minimum flows and what the Corps actually released from Woodruff Dam during the drought operations of 2012-2013. (ResSim uses the RIOP minimum plus a 50-cfs buffer, thus this analysis speaks to the limitations of ResSim.) My findings are presented in Table 4, below. Table 4 was created using generally accepted scientific principles, Corps records of the inflows to the ACF reservoirs, and USGS records of streamflow in the Apalachicola River at Chattahoochee. The amount of water released from Jim Woodruff Dam in excess of the minimum flows used by ResSim is 1,115,009 cfs-days, equivalent to 2.2 million acre-feet, or roughly twice the conservation storage of Lake Lanier.

Table 4. Magnitude of Difference Between Minimum Flows Under the 2012 RIOP and Actual Observed Flows from Jim Woodruff Dam During 2012-2013 Drought Operations (Ex. 48 to Deposition of Dr. Bedient, May 5, 2016, FX-504).

2012/2013 Flow Volume Differentials (Chattahoochee)	**Month**	**Difference (cfs-days)**	**Average Difference (cfs per day)**
Spawning Season	May-12	10,920	352
Non-Spawning Season	Jun-12	15,740	525
	Jul-12	15,450	438
	Aug-12	13,590	453
	Sep-12	6,370	212
	Oct-12	11,810	381
	Nov-12	9,490	316
	Subtotal	72,450	
Winter-Refilling Season	Dec-12	12,960	418
	Jan-13	120,600	3,890
	Feb-13	898,079	32,074
	Subtotal	1,031,639	
	Overall Total	1,115,009	

61. Others who have studied this basin have noted the disconnect between the RIOP minimum releases and what the Corps actually releases from Jim Woodruff Dam. In 2015, the hydrologist Steve Leitman, a longtime observer of the ACF Basin, prepared a slide show titled "Reservoir Management in the Apalachicola-Chattahoochee-Flint Basin" that I reviewed. (Ex. 35 to Deposition of Dr. Bedient, May 5, 2016, JX-118.[2]) Mr. Leitman noted this "disconnect" and presented calculations showing "the vast majority of the time that the drought relief trigger is in effect Jim Woodruff outflow is far greater than the prescribed minimum flow." Mr. Leitman ascribes these Corps operations to findings similar to mine, stating that "half the basin being unregulated (the Flint portion)" is a significant driver of this disconnect. (*Id.* at 40.) (As I've

[2] This document was introduced during the Deposition of Dr. Philip Bedient on May 5, 2016. Dr. Bedient identified the document as a copy of a management study that he had analyzed for purposes of preparing his February 29, 2016 report (*see* 368:17—369:3).

described above, it is actually 62% of the basin that is unregulated and not "half," the rough number given by Leitman.)

B. Both the Corps and Georgia's own hydrologists and experts have recognized the limitations on ResSim's utility.

62. My assessment of the flaws inherent in ResSim is not controversial. Indeed, Georgia's own expert, Dr. Bedient, also acknowledged during his deposition that ResSim is just a planning tool and does not dictate daily operations: Question: "Is it—is it your understanding that the Corps runs ResSim on a very routine, perhaps daily basis, takes the results, gives it to its operators and says, here, reproduce this?" Answer: "No. ResSim is a planning tool…. It's just a planning device that doesn't match very well with data. They have said that themselves. It's used for comparison of alternatives. That is strictly all that that model is used for." (Bedient Dep. Tr. (May 4, 2016), 229:25-230:16.)

63. Similarly, Prof. Aris Georgakakos of Georgia Tech and the Georgia Water Resources Institute stated in his deposition that operations differ from model simulations and the Corps uses observations to make operational decisions. (*See* Georgakakos Dep. Tr. (February 11, 2016), 78:23-79:24.) Likewise, the Hydrology Unit of Georgia EPD has been closely monitoring Corps operations since 2006: Dr. Wei Zeng of Georgia EPD testified that he followed Corps operations closely and would complain if the Corps exercised discretion to make what Zeng called "over releases"—*i.e.*, project releases greater than the minimum specified in the RIOP or its predecessor operational regimes. (*See* Zeng Dep. Tr. (Feb. 17, 2016), 237:22-266:19; Zeng Dep. Tr. (Feb. 19, 2016), 832:1-834:5; Zeng 2014, JX-115 (e-mail from Wei Zeng to James Hawthorn of Corps complaining of "over-releasing").) It is common in my field to evaluate and rely on statements by environmental regulators and other scientists. The fact that Dr. Wei Zeng observed

that the Corps releases more than the minimum required by the RIOP is confirmation of my findings.

64. The Corps itself also acknowledges the limitations to ResSim. For example, in a January 2015 planning aid letter written by the Corps and included in the Draft Environmental Impact Statement, the Corps asserts that: "The HEC-ResSim and HEC-5Q models were not developed or ever intended to produce outputs that matched exactly the observed data. Given the multitude of operational variations that have occurred over the period of record when responding to real life situations (equipment malfunctions, gage errors, and approved variances to operating rules) it is not possible to produce such outputs in the HEC-ResSim model." (USACE 2015, JX-124 at Vol. 3, App. J, Tab 12, 17.)

65. In the ResSim user's manual, the Army Corps includes a yellow caution sign, warning the user of a fundamental limitation important in this case. That warning is reprinted in Figure 7 below. This warning concerns the type of rule in the computer program that the Corps uses to model minimum releases from Jim Woodruff Dam to the Apalachicola River. The technical note in Figure 7 warns that ResSim is "very restrictive" and requires the user to specify a "single value," "neither more or [sic] less," rendering that value "effectively both a minimum and a maximum limit at the same time." What this requires is that, in the computer program, a single value must be substituted for the range of flows that the Corps is allowed to release under the RIOP (">=5,000" cfs or "greater than or equal to 5,000 cfs" as shown in Table 2 above). The Corps uses 5,050 cfs for this single value, adding a 50-cfs margin of safety to the 5,000 cfs minimum. Just as the caution note warns, what this does is treat the 5,000 minimum not as a minimum, but as the minimum and the maximum. This creates the fiction that the maximum (and

only) amount of water the Corps will ever release from Lake Seminole when the guideline is in effect is artificially limited to 5,050 cfs.

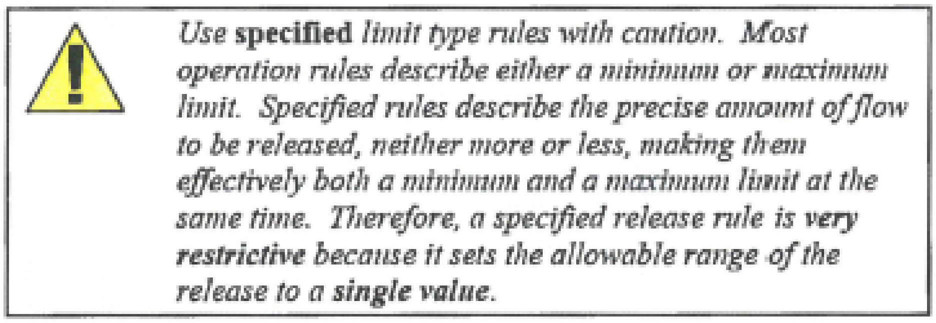

Use **specified** *limit type rules with caution. Most operation rules describe either a minimum or maximum limit. Specified rules describe the precise amount of flow to be released, neither more or less, making them effectively both a minimum and a maximum limit at the same time. Therefore, a specified release rule is* ***very restrictive*** *because it sets the allowable range of the release to a* ***single value****.*

Figure 7. Warning from *ResSim User's Manual: Version 3.1*, "Chapter 11 – Defining Reservoir Operations Data." (USACE 2010, JX-46 at 11-15, 11-17.)[3]

66. Thus, the shortcomings in the ResSim model are readily apparent. Georgia's insistence, based on their inappropriate use of this model, that the minimum flow values allowable under the 2012 RIOP are the Corps' targeted flows—in spite of substantial evidence to the contrary and compelling reasons for the Corps to avoid minimum flows (as discussed below)—has no basis in actual Corps operations or in fact.

VI. THE CORPS IS INCENTIVIZED TO AVOID MINIMUM FLOWS IN ORDER TO COMPLY WITH THE ENDANGERED SPECIES ACT

67. My analysis above demonstrates that, under the Corps' existing practices, water conserved on the Flint River or the Lower Chattahoochee River in Areas A or B will become additional flow on the Apalachicola River. This is a consequence of the system's configuration and mode of operation, and thus no deliberate action by the Corps would be needed to ensure that water conserved for purposes of environmental enhancement of the Apalachicola would reach the Apalachicola. (Shanahan Defensive Report, FX-811 at 4.)

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[3] As with the DEIS, I obtained this document by downloading it directly from the Corps' official website; it is available at http://www.hec.usace.army.mil/software/hec-ressim/documentation.aspx.

68. Although no deliberate action would be required of the Corps, there is every reason to believe that the Corps would account for the fact that the new water was being made available in summer months expressly for environmental purposes. The Corps has stated that, where "other agencies and entities have identified flow targets or goals at various points in the basin . . . USACE operations will generally support these targets or goals as long as authorized project purposes are not adversely affected." (USACE 2015, JX-124 at 6-35.)

69. The Corps already has significant incentive under the 2012 RIOP to allow water that Georgia conserves to become flow on the Apalachicola River. The goal of the U.S. Fish and Wildlife Service (FWS)'s 2012 Biological Opinion and Incidental Take Statement (BiOp) is to ensure that the Corps' RIOP operations do not result in the unpermitted take (i.e., killing or other harm) of federally listed endangered or threatened species living in and around the Apalachicola River, including several listed species of mussels. Failure to comply with the 2012 BiOp would be illegal under the Endangered Species Act.

70. In September 2016, FWS issued a new Biological Opinion and Incidental Take Statement (2016 BiOp), which continues to require the Corps to operate in a manner to avoid unauthorized take or harm of the three listed species of mussels found in the Apalachicola River. The 2016 BiOp also requires the Corps to operate in a manner to avoid unauthorized take of the threatened Gulf sturgeon found in the Apalachicola River and Bay. (2016 BiOp at 2-3, JX-168.) I located the 2016 BiOp on FWS's website, and I reviewed and relied on this BiOp to form my opinions in this testimony.[4]

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[4] *Available at* https://www.fws.gov/panamacity/resources/USFWSBiologicalOpinionforACFWaterControlManual2016.pdf.

71. In its conservation recommendations in the 2016 BiOp, FWS recommended that the Corps "[i]dentify and implement water conservation measures in the basin to avoid impacts to fish and wildlife resources by working with municipal, agricultural, and industrial water users to reduce consumptive uses to develop additional drought response strategies" and that the Corps "[a]ssist stakeholders to plan future water management to minimize water consumption thus minimizing detrimental effects to species." (*Id.* at 203.)

72. While FWS allows for flows from Lake Seminole of 5,000 cfs or less, the 2016 BiOp makes clear that a low flow of 4,500 cfs should occur with a probability of no more than twice every 74 years. (*See id.* at 188.) The 2016 BiOp sets absolute numerical limits on mussel harm or mortality and, if those limits are exceeded, the Corps must reinitiate consultation with FWS under the Endangered Species Act. (*See id.* at 193.) This would require extensive new analysis and create new limits on Corps operations. The reason for these limits is that recent low-flow events have revealed that listed mussel species are harmed when flows are below 10,000 cfs. (*See id.* at 192.) The 2016 BiOp also requires that the Apalachicola River floodplain be inundated by river water during particular times of the year in order prevent harm to the Gulf sturgeon. (*See id.* 192.) If there is insufficient floodplain inundation, the Corps must reinitiate consultation under the Endangered Species Act.

VII. CONCLUSION

73. Georgia acknowledges that its theory about Corps strategy necessarily is inaccurate over the long term since any conserved water must at some time flow downstream to Florida (*See* Bedient Dep. Tr. (June 29, 2016), 720:15-729:18). The principal disagreement between Florida and Georgia is whether the Corps would implement a strategy over the short term to frustrate relief to Florida from Georgia conservation during dry and drought summer months when irrigation

pressure is at its peak. My study of Corps operations and the federal reservoir system demonstrates that the Corps would not counteract the benefits to Florida from Georgia conservation.