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

STATE OF FLORIDA'S OPPOSITION TO GEORGIA'S MOTION TO EXCLUDE OPINIONS AND TESTIMONY BY FLORIDA BASED ON THE "LAKE SEMINOLE" MODEL

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INTRODUCTION AND SUMMARY OF ARGUMENT

The characterization of Dr. George Hornberger's[1] work in Georgia's *Motion to Exclude Opinions and Testimony by Florida Based on the "Lake Seminole" Model* does not remotely resemble the work he actually performed or the substance of Florida's case. Dr. Hornberger's work is based on objective data, including undisputed facts that (**1**) Florida has experienced the lowest Apalachicola River flows in recorded history over the past 16 years—including 8 consecutive months with extreme low flows in 2012 (*see infra*, at 4); and (**2**) Georgia's consumption of water for agricultural, municipal and industrial uses in the Apalachicola-Chattahoochee-Flint River basin (the "ACF") has skyrocketed over recent decades (*see* Attachment 1, Expert Report of George M. Hornberger, Ph.D., M.S.C.E, B.S.C.E. at 1-2 (Feb. 29, 2016) ("Hornberger Report")). Indeed, even Georgia's own retained experts acknowledge that Georgia consumption is having a substantial impact on river flows: for example, Dr. Irmak estimates Flint River basin irrigation in Georgia substantially depleted the Flint River and its tributaries by close to 50% in peak 2012 summer months. *See* Attachment 2 to Florida's Motion *in Limine* to Preclude Expert Testimony by Dr. Suat Irmak, Expert Report of Suat Irmak, Ph.D. at 31 (May 20, 2016) (Dkt. 473). The question in this case is not whether Georgia's consumption is causing depletions in river flow: it is "***by how much?***"

To address that question, Dr. Hornberger began with objective data maintained by the United States Geological Survey ("USGS") and other reliable sources. Then, after confirming the unmistakable impacts of Georgia's consumption, Dr. Hornberger employed well-established hydrological tools to evaluate, in more detail, the impacts of Georgia consumption, and to predict

[1] Dr. Hornberger is an elected member of the National Academy of Engineering. A copy of Dr. Hornberger's curriculum vitae can be found at Attachment 1.

what will happen in the future absent an equitable apportionment. The particular model that is the focus of Georgia's Motion—the Lake Seminole Model—is one of multiple analytical models and tools relied upon by Dr. Hornberger (and other Florida experts), all independently confirming that Georgia's consumption has already severely impacted Florida.

In contrast, Georgia's Motion relies upon three specific erroneous characterizations:

- ***First***, Georgia's Motion attempts to paint the entirety of Dr. Hornberger's scientific process as an effort to conceal what his analysis genuinely found. This contention is demonstrably false: Dr. Hornberger openly and candidly compared various hydrological models. He explained *explicitly in the text of his expert report* precisely why he chose to utilize one reservoir simulation model to address particular issues (the Lake Seminole Model, which was based on *the U.S. Army Corps of Engineers'("Corps") reported flow data and simulates historic droughts*) over another (the ResSim model, which cannot accurately forecast certain drought year summer flows).[2] *See* Attachment 1, Hornberger Report at 47.

- ***Second***, Georgia falsely contends, throughout its motion, that ResSim produces the most accurate results for drought years and suggests the use of any other methodology is flawed. But Georgia's own witnesses *admit* that ResSim does not accurately predict actual drought year summer river flows to Florida because, by design, *the model does not account for the Corps' discretion in operating federal reservoirs, particularly during peak summer low-flow situations*. *See infra*, at 13. Relying on objective data and well-established principles of

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[2] ResSim is modeling software developed by the Corps' Hydrologic Engineering Center to simulate federal reservoir operations. "Data-Driven ResSim" is a version of ResSim employing the Corps' reported data for Lake Seminole and its three upper reservoirs. As explained here, although neither ResSim nor Data-Driven ResSim can accurately predict flows in specific summer months (the relevant topic for purposes of this motion), the models can provide helpful predictions in other contexts.

hydrology, Dr. Hornberger uses the Lake Seminole Model to evaluate how the Corps has exercised its discretion in operating reservoirs during historical low flow periods and predicts how reduced consumption by Georgia would benefit Florida.

- ***Third***, Georgia's Motion fails to disclose the specific role the Lake Seminole Model plays in Dr. Hornberger's analysis, ignoring how that model relates to the other analytical tools upon which he and other Florida experts rely, and how that model uses actual historical data to account for operations of each of the three relevant upstream Corps dams. Moreover, Georgia's "goodness of fit" arguments rely on the *wrong set of data*—data which do not actually reflect the final results of the Lake Seminole Model runs. In fact, the Lake Seminole Model has a much better fit with actual real world observations than does ResSim. Once all those facts are understood, Georgia's strawman attack is exposed.

In short, Georgia cannot articulate any sound legal basis to exclude the Lake Seminole Model. Moreover, Georgia's Motion may mark a turning point in this case. Earlier in this litigation, Georgia argued that any reductions in its consumption were unlikely to benefit Florida because the Corps would simply hold *all* this additional water in upstream federal reservoirs:

> To meet federal statutory purposes, during low-flow or drought conditions the Corps is likely to offset *any* increased flows from the Flint by impounding more water upstream on the Chattahoochee to serve the federal purposes for which the dams and reservoirs in the ACF Basin are operated. [Ga.'s Mot. to Dismiss at 13, n.4 (emphasis added) (Dkt. 48).]

The Corps disagreed, explaining that Georgia was giving "short shrift" to the potential flow benefits to Florida of reduced consumption in the Flint River basin. *See* United States' Brief as Amicus Curiae in Opp'n to Ga's Mot. to Dismiss at 19 (Dkt. 66); *see also id.* at 18-22. And the Court denied Georgia's Motion to Dismiss. Order on Ga's Mot. to Dismiss (Dkt. 128). ***Now***, Georgia seems to concede that, notwithstanding its prior position, Florida ***will*** actually receive additional flows from a consumption cap in *most months* of drought years. At trial, Florida will demonstrate that additional flows resulting from a consumption cap will be much greater than Georgia acknowledges, but Georgia's implicit concession highlights why it is no longer pursuing the theory behind its Motion to Dismiss, and why it did not file a summary judgment motion in this case.

BACKGROUND

To put Georgia's characterizations in an appropriate context, it is necessary to explain more fully how Dr. Hornberger has conducted his hydrologic analyses. Dr. Hornberger's expert analysis begins with objective and unimpeachable data demonstrating the severe low flows on the Apalachicola River over the past 16 years. For example, the USGS maintains a series of river and stream flow gages throughout the ACF basin. The gage just south of the Georgia border on the Apalachicola River is near the town of Chattahoochee, Florida and is known as the "Chattahoochee" gage (although it measures flow on the Apalachicola and not the Chattahoochee River). Attachment 2 contains the USGS record of average monthly flows at the Chattahoochee gage with yellow highlighting for monthly averages that fall below an extreme level of low flows—6000 cubic feet per second ("cfs"). As the objective data demonstrates, monthly average flows below 6000 cfs were extremely rare before 2000 at the Chattahoochee gage (occurring only in a handful of months in the nearly 90-year historical record, including in three prior extreme drought years, 1931 and 1954-1955). *Id.* But since 2000, those extremely low flows have become commonplace, occurring for multiple months of every drought year during that span *and for 8 consecutive months in 2012 alone*. The same unmistakable pattern jumps off the page for the USGS gages in the Flint River basin in Georgia. For example, for the southernmost gage on the Flint River at Bainbridge, Georgia, extreme low flows below 2500 cfs before 2000 are recorded only in 1954 and 1968, but after 2000 are commonplace, also occurring for 8 consecutive months in 2012.[3] *See id*.

By examining the precipitation and stream gage data maintained by USGS, Dr. Hornberger was also able to compare the amount of river flow received in the Apalachicola River in dry and drought years to the amount of precipitation that fell in the ACF basin. He concluded that, in recent drought and dry years, far less river flow reaches Florida per inch of upstream precipitation than occurred in the past.

As just one example: significantly less rain fell in the summer months of 1931 than in 2011 or 2012, and yet in 1931 the river flow on the Apalachicola River at the Chattahoochee gage was roughly 3700 cfs higher. To put that in perspective, 3700 cfs is more than 65% of the average Apalachicola River flow at the state-line for June to September in 2011 and 2012. The same is true when 1954 (the driest year in recorded history in the ACF) is compared to either 2011 or 2012. Many other such comparisons show similar changes.

YEAR	1931	1954	2011	2012
June-September Precipitation (Inches)[4]	12.7	10.4	14.5	16.7
June-September Temperature (Fahrenheit)	80.5	81.0	79.5	77.3
June-September Streamflow (cfs) at the Chattahoochee Gage[5]	9202	8968	5566	5419

[3] Note that the Bainbridge gage has a gap in recorded data from 1971-2001. Other Lower Flint gages without this gap show a similar pattern.

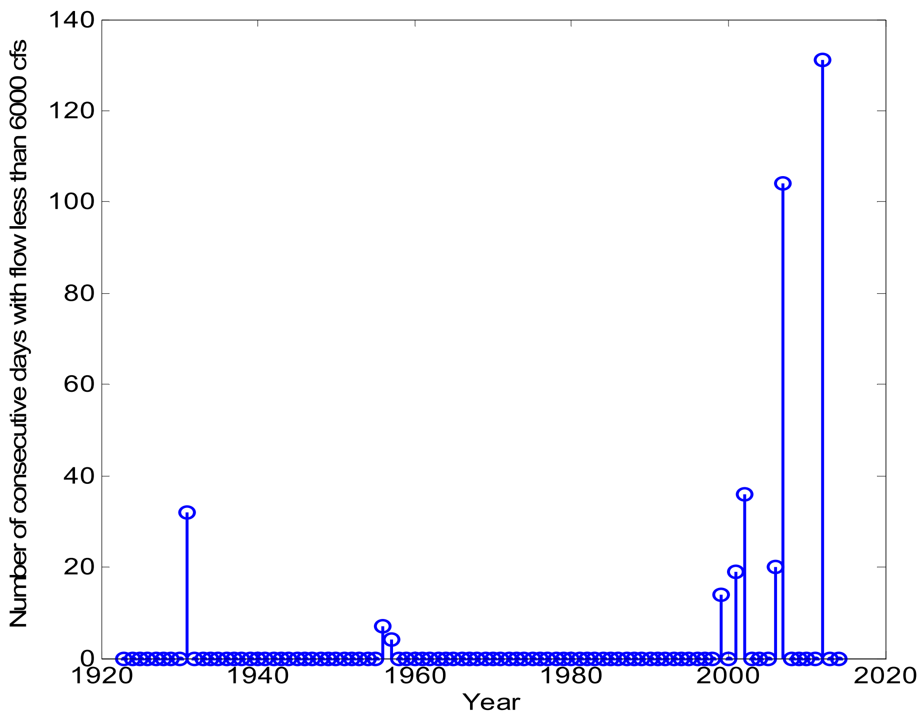
[4] Precipitation and temperature are presented from the dataset used in Dr. Hornberger's expert report (Livneh et al). *See* Attachment 1, Hornberger Report at 27.

[5] Chattahoochee gage data is available from USGS at http://waterdata.usgs.gov/usa/nwis/uv?site_no=02358000.

Dr. Hornberger discussed in his report (at 21-22) exactly what all of these objective data demonstrated. For example, he found (as did USGS) that extreme low flows on the Flint and Apalachicola Rivers were vastly more common and substantially more severe in recent periods, especially in 2011-2012 (when extreme low flows continued for an unprecedented 8 consecutive months):

AVERAGE NUMBER OF DAYS WITH FLOW BELOW INDICATED THRESHOLD AT CHATTAHOOCHEE GAGE				
Threshold Discharge	**1921-1970**	**1970-2013**	**1992-2013**	**2003-2013**
6,000 cfs	5.2	29.8	50.6	71.0
5,500 cfs	2.6	19.0	32.7	54.0

Number of Consecutive Days Below 6,000 cfs at Chattahoochee Gage



Attachment 1, Hornberger Report at 21-22 (excerpting Table 4 and Figure 8).

But Dr. Hornberger did not stop there. After addressing the objective data, he also employed hydrologic modeling tools to further analyze that data and make predictive forecasts. Specifically, using the USGS Precipitation-Runoff Modeling System ("PRMS"), Dr. Hornberger analyzed how much of the flow reductions were due to consumptive uses in Georgia. This type of comparison is often referred to by hydrologists as an "Unimpaired Flow" analysis.

> Differences between observed and [PRMS] modeled flows at Chattahoochee, FL indicate that annual depletions increased by several thousand cfs from 1970 to the present.

Id. at 41.

Thereafter, Dr. Hornberger worked with other Florida expert hydrologists, Dr. David Langseth and Dr. Samuel Flewelling, to demonstrate more precisely how much streamflow impact Georgia municipal, industrial and agricultural consumption (from both groundwater and surface water withdrawals) was having on Georgia streams and rivers in the ACF basin, and thus, the downstream Apalachicola River. This work also demonstrated how much water could be saved under both highly conservative and more realistic modeling approaches by reducing Georgia's consumption in specific ways.

Finally, Dr. Hornberger also worked with another Florida expert hydrologist, Dr. Peter Shanahan, to address Georgia's argument—from its unsuccessful motion to dismiss—that the Corps would, for some reason, seek to annul any benefit of a consumption cap ordered by the Supreme Court by holding more river water upstream in its Chattahoochee River dams. Dr. Shanahan's analysis demonstrated that, even if the Corps were to try to offset the benefits to Florida of a Supreme Court equitable apportionment (which seems exceptionally unlikely), *the Corps could not withhold enough water at Lake Lanier to have a substantial impact on increased flows to Florida from reduced Georgia consumption. Likewise, the Corps would lack any rationale for even trying to do so from the other two dams, neither of which supply Metro Atlanta. See* Attachment 3, Expert Report of Peter Shanahan, Ph.D., P.E. at 1-11 (Feb. 29, 2016) ("Shanahan Feb. 2016 Report"); Attachment 4, Expert Report of Peter Shanahan, Ph.D., P.E. at 1-5 (May. 20, 2016) ("Shanahan May 2016 Report"). Dr. Shanahan demonstrated these principles using multiple tools, including actual data from flow gages, dam elevation readings and other sources. *Id.* The Lake Seminole Model was then developed from this objective data to demonstrate exactly how ***all*** the Army Corps dams were managed in the Chattahoochee basin in historic droughts and how much water entered and was released from Lake Seminole. *See* Attachment 1, Hornberger Report at 42, 91.

Georgia's argument to the contrary is founded, primarily, upon its own runs of the ResSim model employed by the Army Corps as a planning tool in the ACF basin. Although the Corps' operational protocol provides that flows "greater than or equal to" the ResSim minimums will be supplied to the Apalachicola River in certain circumstances, the ResSim model does not attempt to model how much "greater than" the minimum flow the actual flow will be. Attachment 3, Shanahan Feb. 29 Report at 6. As the Corps explains in its own documentation, and as Georgia's own witnesses have acknowledged, ResSim's modeling runs do not account for the Corps' discretion in how it actually operates the dams, and how much water the Corps actually releases in its discretion to achieve its statutory purposes. *See infra*, at 11-13. In short, the objective historical data recording river flows in dry and drought years ***do not match*** the minimum amounts ResSim predicts will be seen on the river during those years. Dr. Hornberger's report explicitly and repeatedly described this issue. *See, e.g.*, Attachment 1, Hornberger Report at 42; *see also* Attachment 5, Hornberger Dep. 69:3-11, 775:18-777:12.

- **ResSim models minimum, not actual, flows**: "The ResSim model appears to mimic the general *patterns* in observed flow at Chattahoochee, FL, ***but does not match observed flows with high accuracy*** (Figure 24). ***During several recent drought years (Figure 25), the ResSim model clearly under predicts observed flows*** and does not respond appropriately to storms (*e.g.*, July and September of 2007)." Attachment 1, Hornberger Report at 45 (emphases added). While ResSim rules encode the minimum flows under the RIOP, the Corps exercises its discretion to release flows above those minima. *See* Attachment 3, Shanahan Feb. 2016 Report at 6-7; Attachment 1, Hornberger Report at 45.

- **ResSim under-predicts reservoir levels and flow releases during dry and drought years**: "Some of the differences between ResSim and actual US ACE [Corps] operations show patterns from year to year. For example, ***ResSim under-predicts the composite storage*** (*i.e.*, ***the combined volume of water stored in lakes Lanier, West Point, and W.F. George***) in the early part of the year (Figure 26)." Attachment 1, Hornberger Report at 46 (emphases added). "[T]he under-prediction of composite storage would artificially mask the extent to which potential future reductions to consumptive water use might increase flows into the Apalachicola River in Florida." *Id.* at 47.

As explained expressly in Dr. Hornberger's report, the "Lake Seminole Model" was intended:

> To match observed US ACE [Corps] reservoir operations more closely, a model of Lake Seminole that can be driven entirely ***by observed data***, *i.e.*, ***data that reflect the actual US ACE*** [Corps] ***reservoir operations***, was developed. The model of Lake Seminole uses the exact same operating rules encoded in ResSim, but provides the flexibility to operate Lake Seminole with observed inflows to the lake and observed composite storage for the reservoir system. Driving the model in this manner results in a close match to observed flows at Chattahoochee, FL, and ensures fidelity with the ***actual system composite storage*** [in all of the three Corps Chattahoochee dams], which is one of the primary factors controlling discharges from Lake Seminole (Figures 27 and 28). *Id.* at 47 (emphases added).

Along with other evidence, the Lake Seminole Model demonstrated that Georgia's reliance on the ResSim model was inappropriate. *See id.* at 43-45; Attachment 5, Hornberger Dep. 69:3-11, 775:18-777:12.

ARGUMENT

Expert testimony is admissible if it is relevant and scientifically reliable. Fed. R. Evid. 702; *Daubert v. Merrell Dow Pharm., Inc.*, 509 U.S. 579, 589 (1993). Testimony is reliable if it is "based on sufficient facts or data" and the "product of reliable principles and methods," that are "reliably applied" to the facts of the case. Fed. R. Evid. 702.

As detailed below, Dr. Hornberger's analysis rests upon objective data and appropriately validated hydrological models that detail the relationship between (**a**) drastic increases in Georgia's consumptive use in the ACF, and (**b**) declining flows into the Apalachicola River.

Georgia's Motion attacks only one of these models, the Lake Seminole Model, and does so through mischaracterization, and by taking it—and the entirety of Dr. Hornberger's work—out of context. Viewed objectively and in the proper context of its discrete role in his analyses, it is clear that the Lake Seminole Model was developed using accepted methods and is based on reliable data.

A. Dr. Hornberger Did Not Hide His ResSim Modeling.

As an initial matter—contrary to the opening paragraphs of Georgia's Motion—Dr. Hornberger did not somehow conceal his use of the ResSim model; *instead, he explicitly addressed it for several pages in his expert report, and provided all the backup model runs and a summary spreadsheet in materials produced with the report on February 29, 2016*. *See* Attachment 1, Hornberger Report 43-47.

Indeed, Dr. Hornberger explained exactly why he based his analysis on the Lake Seminole Model *rather than* Data-Driven ResSim. *Id.* at 45-47 (explaining that ResSim results were materially inaccurate in many drought year summer months). And Florida produced to Georgia on February 29, 2016 Dr. Hornberger's Data-Driven ResSim results for every scenario that he ran. ***Dr. Hornberger did not hide anything.*** Quite the opposite, he evaluated each model in comparison to the underlying data and explained *in detail* in his report and summary sheets why the Lake Seminole Model is superior to ResSim for the purposes for which it is used. *See id.* at 44-47.

Florida has no idea why Georgia insists otherwise. In its Motion, Georgia argues that Dr. Hornberger "admitted" that the ResSim model run results were not "in [his] report." *See* Mot. at 8 (Dkt. 472). That is simply because that information, clearly labeled by file name *with* appropriate tabs to summarize each model run, was supplied *in the materials accompanying his* *report*, as opposed to being literally included in the text of his report. This cannot be described in any possible universe as an attempt to conceal that information.

B. Georgia's Own Experts, Georgia Officials and the Corps All Acknowledge ResSim's Limitations.

The Lake Seminole Model was necessary for one simple reason: ResSim is inaccurate in key dry and drought year periods. This is undisputed. Georgia's own expert, hydrologist Dr. Philip Bedient, testified that ResSim does not match the empirical data well and is therefore used by the Corps for limited purposes only:

> Q 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?
>
> A No. ResSim is a planning tool. That was a good effort, but no. 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.
>
> Q What data were you just referring to in your answer?
>
> A Measured gauge data, for example.

Attachment 6, Bedient Dep. 229:25-230:16. ResSim is not designed to model the exercise of the Corps' discretion to release water above minimum requirements. As Dr. Bedient acknowledged, the Corps has "the ability to do some discretionary releases [from its dams] concerning whatever might be happening downstream." *Id.* at 658:14-25.

Asked about the Corps' ability to release greater than the ResSim minimums, Dr. Bedient further agreed that the Corps "does obviously have discretion to release flow during the summer" and augment for "all kinds of reasons." *Id.* at 749:2-9. In response to a hypothetical, whereby the Corps seeks to avoid the 5000 cfs minimum by releasing additional flows to protect fish and wildlife in the Apalachicola, Dr. Bedient acknowledged that, under the Corps' operations plan, the Corps could release "200, 300, 400" more than 5000 cfs, or even over 6000 cfs—essentially "whatever" volume the Corps chooses to achieve its objectives. *Id.* at 355:13-356:14. And Dr. Bedient agreed that if the Corps chose to release more than 5000 cfs on any given day during which it is in drought operations (when the *minimum* release in the Corps operational rules is approximately 5000 cfs), ***ResSim would be incapable of predicting the Corps' releases above that 5,000 cfs minimum***. *Id.* at 288:12-17.

Similarly, Dr. Hailian Liang of the Georgia Environmental Protection Division, who conducts ResSim modeling for Georgia, acknowledged that the Corps does not rely on ResSim when deciding on flows.

> Q. Do you know if they from time to time release water different than what would be prescribed by the ResSim model?
>
> A. Well, I -- I mean, ResSim model is just a simulation. I don't think Corps will rely on ResSim modeling results to operate their reservoirs. I don't think so. So you're asking whether Corps releasing water more or less by ResSim modeling results, right?
>
> Q. Yes.
>
> A. So I don't think Corps makes decision based on ResSim modeling results. That's my personal, personal opinion, I don't think so. But you need to confirm with Corps, I think.

Attachment 7, Liang Dep. 19:1-4, 107:14-108:2. Dr. Aris Georgakakos of the Georgia Water Resources Institute at Georgia Tech also testified that ResSim differs from actual Corps operations.[6] Likewise, the Corps itself has recognized that ResSim's outputs would not exactly match observed data:

> 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

[6] *See* Attachment 8, Georgakakos Dep. 79:19-24 ("So I think the ResSim is a tool that provides them the normal way of releasing and operating and the root curves and things like that. But the operations are different. They use observations. So they don't rely on the ResSim, I don't think.").

> variations that have occurred over the period of record when responding to real life situations ... it is not possible to produce such outputs in the HEC-ResSim model.

Corps, Draft Environmental Impact Statement ("DEIS") - Vol. 3, App. J, USACE [Corps] August 2015 Response to Draft Fish and Wildlife Coordination Act Report July 2015 at 17, http://www.sam.usace.army.mil/Portals/46/docs/planning_environmental/acf/docs/ACF%20 DEIS%20Vol3_Appendix%20J-N.pdf.

By contrast, the objective data for the relevant gages and reservoir elevations is reliable. *There is no dispute that this objective data shows that the Corps releases more water from Lake Seminole across the state line during summer months than would be predicted under the minimum flow requirements in ResSim and the Corps' operating plan. See* Attachment 3, Shanahan Feb. 29 Report at 6-7. The Corps describes its operating rules currently in effect for the ACF basin:

> The flow rates included in Table 2.1-5 prescribe ***minimum, not target, releases*** for Jim Woodruff Lock and Dam [*i.e.*, Lake Seminole]. Corps, 2015 DEIS – Vol. 1, at 2-72 – 2-73 (Oct. 2015) (emphasis added), http://www.sam.usace.army.mil/ Portals/46/docs/planning_environmental/acf/docs/ACF%20DEIS%20Vol1.pdf.[7]

In other words, the Corps acknowledges that it releases more than the ResSim "minimums" that are assumed by the ResSim model. Thus, ResSim alone could not accurately model this upward discretion, and Dr. Hornberger needed a reliable tool that could account for the Corps' actual historic use of its discretion during low flow periods.

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[7] *See also* U.S. Fish & Wildlife Service, Biological Opinion for Jim Woodruff Dam Revised Interim Operation Plan at 10, 13 (May 22, 2012), https://www.fws.gov/southeast/news/2012/pdf/ woodruffBOFinal.pdf.

C. Development of the Lake Seminole Model Was Appropriate and Necessary Under FRE 702 and Daubert Case Law.

Florida's experts developed the Lake Seminole Model because there was no preexisting model available to them that faithfully represents actual Corps operational practices in the ACF basin in low rainfall years with the level of precision needed to appropriately evaluate possible remedy scenarios from a consumption cap. Georgia points to no authority—nor is there any—that a party is without recourse to develop its own model in such a circumstance. To the contrary, courts routinely acknowledge that under such circumstances, there is a need to develop new models. *See, e.g.*, *Mass Mut. Life Ins. Co. v. DB Structured Prods., Inc.*, No. 11-30039-MGM, 2015 U.S. Dist. Lexis 59998, at *9, 32-33 (D. Mass. May 7, 2015) (finding that expert's particular variant of an accepted pricing model that was "adapted for this action" was admissible); *Animal Sci. Prods. v. Hebei Welcome Pharm. Co.* (*In re Vitamin C Antitrust Litig.*), Nos. 06-MD-1738 (BMC) (JO), 05-CV-0453, 2012 U.S. Dist. LEXIS 181158, at *9, 30-31 (E.D.N.Y. Dec. 21, 2012) (finding an expert's model methodologically sound and admissible where that model was specifically developed to correct the model of the opposing party's expert).

Models are not one-size-fits all circumstances: "Models are not the real world; rather, such models are a reasoned and educated attempt to describe reality by accepted methods of statistical analysis using available real world observations, data, and knowledge." *Falise v. Am. Tobacco Co.*, 258 F. Supp. 2d 63, 67 (E.D.N.Y. 2000). Dr. Hornberger used reliable data, which Georgia does not challenge, to create a model that better fits very low flow periods. And he used the Lake Seminole Model for the specific purpose of evaluating state-line flows under remedy scenarios where Georgia adopts new conservation measures and reduces consumptive use in the ACF basin. Attachment 1, Hornberger Report at 51. Similar models are frequently admitted so long as they use reliable data and apply accepted modeling methodology. *See, e.g.*, *Mass Mutual*, 2015 U.S. Dist. Lexis 59998, at *9, 32-33; *In re Vitamin C Antitrust Litig.*, 2012 U.S. Dist. LEXIS 181158, at *9, 30-31.

While Georgia tries to discredit Dr. Hornberger's model by craftily calling it a "litigation tool" (Mot. at 5), Georgia conspicuously ignores that Dr. Hornberger used the same operating rules for Lake Seminole upon which the ResSim Model itself relies, and that the Lake Seminole model accounts for the Corps historic actual discretionary releases beyond the ResSim minimums. Attachment 1, Hornberger Report at 47, 91. As Georgia accurately describes, reliability requires testimony to be "based on sufficient facts or data" and "the product of *reliable principles and methods*." Mot. at 4 (quoting Fed. R. Evid. 702) (emphasis added). Dr. Hornberger did precisely this, using reliable principles of hydrology and modeling methods to construct a model that more accurately reflects actual Corps historic operations. *See* Hornberger Report at 47.

Ironically, it is Georgia—not Dr. Hornberger—that is "simply ignoring the results" it does not like. *See* Mot. at 14. Georgia's Motion ignores the objective data regarding significant decreases in river flows (identified above, *see supra*, at 4-6) and completely ignores the relevant work of another Florida expert, Dr. Shanahan—which lays the empirical and analytical foundation for the Lake Seminole Model. *See* Attachment 3, Shanahan Feb. 29 Report at 1-11. Dr. Shanahan's work provides the objective data upon which the Lake Seminole Model is grounded, yet Georgia acts as though Dr. Hornberger created the model out of thin air. Georgia either misunderstands Dr. Hornberger's methodology for the Lake Seminole Model or chooses to ignore the model's objective basis in order to try to gain its own litigation advantage.

Likewise, contrary to Georgia's assertion, it is demonstrably untrue that the Lake Seminole Model does not account for all the Army Corps reservoirs. Dr. Hornberger built the Lake Seminole Model in consultation with Dr. Shanahan, who had analyzed in detail the operations of all the Army Corps dams and reservoirs in the ACF, including all the dams on the Chattahoochee River. *See* Attachment 3, Shanahan Feb. 29 Report at 1-11. Dr. Hornberger explains expressly in Appendix C and elsewhere of his report how the Lake Seminole Model is run, specifying that it relied upon both "[o]bserved composite storage" and "[o]bserved inflows to Lake Seminole." Attachment 1, Hornberger Report at 90-91. The first of those two terms "observed composite storage" accounts for the activity of ***all three Corps Chattahoochee dams***—that's what the term "composite storage" means, the water storage levels of all three reservoirs combined. *See id.* at 91; Attachment 5, Hornberger Dep. 794:12-15 (explaining that the Lake Seminole Model uses the observed composite storage); *see also id.* at 59:9-13 ("[I]t's not fair to say that the Lake Seminole model does not account for storage in the other reservoirs. We account for it by using observed data for the entire system ….").

D. Georgia's Arguments About Goodness of Fit Are Also Predicated Upon a Mistake.

Georgia also challenges the Lake Seminole Model based on its reading of Dr. Hornberger's statistical assessment of the "goodness of fit" for his model, suggesting that the model does not reflect reality. Mot. at 14. Courts consider the statistical accuracy of a model when assessing the methodology, reliability, and fitness of that model in relation to the expert's opinion. *See Kaiser Found. Health Plan, Inc. v. Pfizer, Inc.* (*In re Neurontin Mktg. & Sales Practices Litigation*), 712 F.3d 21, 41-45 (1st Cir. 2013) (admitting expert opinion and associated statistical model as both methodologically sound and statistically fit). Here, Georgia's argument is premised on a basic error. Georgia assumed incorrectly that an interim step Dr.

Hornberger took in constructing the Lake Seminole Model was instead a set of the final runs of that model. The interim step was a step reflected in Dr. Hornberger's computer code before he fully accounted for the historic discretionary releases the Corps made above and beyond what is inaccurately predicted by ResSim. Once the final analytical steps are taken to account for Corps historical discretionary releases "greater than" the ResSim minimums, the Lake Seminole Model had much better fit with actual flow records than the ResSim model. *See infra*, at 13.

Again, Georgia is well aware of the two-step nature of the Lake Seminole model, yet it again chose to ignore Dr. Hornberger's relevant testimony:

> Q It's the first step?
>
> A Yes.
>
> Q Because if you looked at the second step, you would get an NSE of 1 [perfect goodness of fit], it would be exactly right?
>
> A. Yes.

Attachment 5, Hornberger Dep. 957:16-21. In other words, Dr. Hornberger explained that what Georgia now criticizes is merely his interim baseline run—just the first step in his analysis. Dr. Hornberger's Lake Seminole Model is reliable, and his means of testing it fits well within the statistical methodology and fit assessments under *Daubert* standards. *See* In re *Neurontin Mktg. & Sales Practices Litig.*, 712 F.3d at 45.

E. The Lake Seminole Model Was Not Intended to Model *Increases* in Georgia's Consumption.

Georgia also argues that the Lake Seminole Model crashes when one tries to use it to predict certain outcomes for *future increases* in Georgia consumption. Mot. at 10-11. But the Lake Seminole Model was constructed to answer a specific remedy question at issue here: what would happen, given historic Corps releases, if Georgia's consumption *was **reduced** by a consumption cap?* Georgia's hypothetical, by sharp contrast, assumes that Georgia consumption is *increased, not capped*, in a severe drought scenario. As Dr. Hornberger explained, the Lake Seminole Model is not intended to simulate those types of unprecedented ahistorical circumstances: "I wouldn't use this model for that scenario." Attachment 5, Hornberger Dep. 794:20-21; *see also id.* at 46:17-47:9 (warning in another context that "if you use a wrong equation you will get the wrong answer"). To the extent that Georgia is hypothesizing lower river flows as Georgia's future consumption increases, Georgia is simply proving Florida's case.

F. Finally, Georgia's References to "Zero" Flow Months Are Misleading.

Georgia suggests throughout its Motion that Dr. Hornberger should have ignored the Corps' discretionary releases and instead relied on Data-Driven ResSim. Florida disagrees for all the reasons above, but also notes that even the results of those flawed ResSim scenarios ***are definitively <u>not zero</u>***. In key recent dry and drought years (2000, 2001, 2007, 2008, 2011, and 2012), even Georgia's preferred model produces *important additional flows in drought years for consumption cap scenarios*. For example, monthly additional flows to Florida under the specific scenario identified include: 1140 cfs in July 2001; 1183 cfs in August 2001; 1175 cfs in July 2008; 1276 cfs in August 2008; 679 cfs in June 2011; 746 cfs in August 2012; and 1067 cfs in September 2012. These sample modeling results reflect only one possible remedy scenario and are on a *monthly average* basis, meaning that daily flows during those periods would range substantially higher. Using objective data, an appropriate modeling approach and realistic consumption cap scenarios, Florida will demonstrate at trial that that far greater flows would result.

CONCLUSION AND REQUEST FOR RELIEF

For the foregoing reasons, the Special Master should deny Georgia's motion in its entirety.

Dated: September 30, 2016

Respectfully submitted,

/s/ .

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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 FLORIDA'S OPPOSITION TO GEORGIA'S MOTION TO EXCLUDE OPINIONS AND TESTIMONY BY FLORIDA BASED ON THE "LAKE SEMINOLE" MODEL has been served on this 30th day of September 2016, in the manner specified below:

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No. 142, Original

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Before the Special Master

Hon. Ralph I. Lancaster

ATTACHMENTS TO THE STATE OF FLORIDA'S OPPOSITION TO GEORGIA'S MOTION TO EXCLUDE OPINIONS AND TESTIMONY BY FLORIDA BASED ON THE "LAKE SEMINOLE" MODEL

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September 30, 2016

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Attachment 2: U.S. Geological Survey – Surface Water Monthly Statistics for Florida – Apalachicola River at Chattahoochee Florida (USGS 02358000) and Flint River at Bainbridge, GA (USGS 02356000)

Attachment 3: Excerpts from the Expert Report of Peter Shanahan, Ph.D., P.E. (Feb. 29, 2016)

Attachment 4: Excerpts from the Expert Report of Peter Shanahan, Ph.D., P.E. (May 20, 2016)

Attachment 5: Excerpts from the Deposition Transcripts of Dr. George Hornberger (May 11, 2016 and Aug. 4-5, 2016)

Attachment 6: Excerpts from the Deposition Transcript of Dr. Philip Bedient (May 4, 2016 and June 29, 2016)

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ATTACHMENT 1

Excerpts from the Expert Report of George Hornberger, Ph.D., M.S.C.E, B.S.C.E. (Feb. 29, 2016)

Hydrological Impacts of Georgia's Consumptive Use of Water in the ACF River Basin on the Apalachicola River

Expert Report in the matter of *Florida v. Georgia*, No. 142 Orig.

Prepared by:

____

Dr. George M. Hornberger

Prepared for
Florida Department of Environmental Protection

February 29, 2016

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Summary Statement and Summary of Expert Opinions

Water withdrawals in the Apalachicola-Chattahoochee-Flint (ACF) basin in Georgia increased dramatically in the latter half of the 20th century as the population grew, industrial development proceeded, and irrigated agriculture grew exponentially. A portion – a large portion for some purposes – of this withdrawn water goes to consumptive use (*e.g.*, the water is evaporated) in Georgia and therefore is not available to flow into the Apalachicola River in Florida (referred to as a streamflow depletion). This growth of consumptive water use and resulting streamflow depletions in Georgia has fundamentally changed the hydrology of the ACF basin. Although the mean discharge measured for the Apalachicola River at Chattahoochee, FL near the Florida/Georgia border exceeds 20,000 cubic feet per second (cfs), low-flow periods are marked by flows near or less than 5,000 cfs. This situation renders depletions on the order of 1,000 cfs, or even several hundred cfs, critically important.

This report addresses the hydrological impacts of municipal, industrial, and agricultural water withdrawals in Georgia on flows to the Apalachicola River, particularly during critical summer months in drought years and dry years.[1] My analysis also evaluates the additional adverse impacts that can be expected from increases in water withdrawals by Georgia in the future, as well as the reductions in adverse impacts that can be expected if Georgia reduces water withdrawals and consumptive use under various scenarios. I conducted detailed analysis of available data, reviewed previous reports, and worked with my team to conduct computer modeling to evaluate these topics. My opinions, developed from these multiple lines of evidence, are as follows:

1. Georgia's consumptive water use in the ACF basin has increased dramatically since 1970. Total consumptive water use in the Georgia portion of the ACF basin has increased from a peak monthly value of approximately 440 cfs in 1970 to over 5,000 cfs in 2007. Figure SS.1 illustrates this growth in consumptive water use. A peak value of 5,000 cfs can be greater than the Apalachicola River flow in the summer months of drought years.[2] Florida's consumptive water use in the ACF is very small relative to Georgia's consumptive water use (Flewelling Expert Report, 2016).

[1] We define drought years and dry years using the Standardized Precipitation Index. See Section V.a, Table 6, Table 7, and Figure 14.
[2] The values stated above and illustrated in Figure SS.1 include all consumptive use categories in Georgia except incremental evaporation from federal reservoirs.

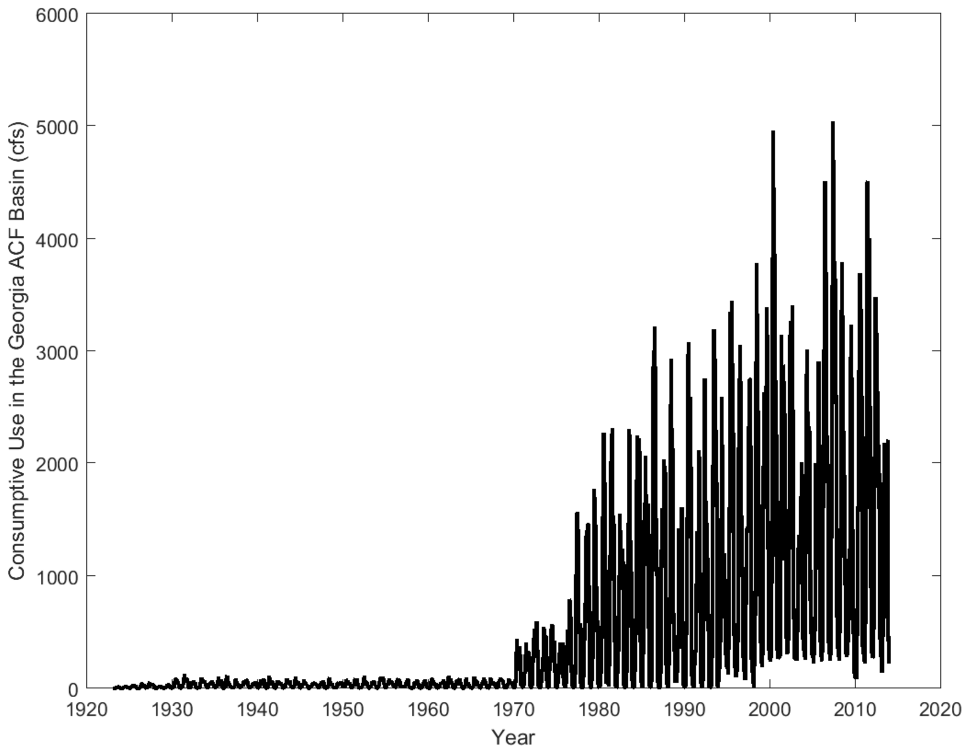

Figure SS.1 Total Monthly Consumptive Water Use in the Georgia ACF Basin from 1923-2013 Using Conservative Assumptions. Source: Flewelling Expert Report (2016).

2. Georgia's consumptive water use has fundamentally altered the hydrology of the ACF basin.
   - Basin yield, the fraction of precipitation over a basin that becomes river flows, has declined significantly in recent decades relative to pre-development conditions. Annual average basin yield has decreased between 1970 and the present. Declines in yield are a fundamental indicator of flow depletions in a basin. Observed yield declines translate to declines in river flow to Florida of over 3,000 cfs on an annual average basis for the period 1992-2013.
   - Summer low flows at the Chattahoochee gage, located just downstream of where the river flows from Georgia to Florida, have declined markedly. The average of the lowest flow for seven consecutive days, which is a widely-used measure of the severity of low-flow conditions, declined by several thousand cfs from 1970 to 2013 compared to the years 1922 to 1955.
   - The average number of days when the flow drops below 6,000 cfs at the Chattahoochee gage has increased markedly. Between 1922 and 1970, the average number of days with flow below 6,000 cfs in a year was 5.2; between 1992 and 2013, the average number of days below 6,000 cfs in a year was 50.6; between 2000 and 2013, the average number of days with flow below 6,000 cfs was 74.6. Similar changes are seen for other flow thresholds; for a flow threshold of 5,200 cfs, there was an average of 1 day per year below this threshold for the period before 1970,

Table 4 Average Number of Days with Flow Below Indicated Discharge at the Chattahoochee Gage

Threshold Q (cfs)	1921-1970	1970-2013	1992-2013	2003-2013
6,000	5.2	29.8	50.6	71
5,500	2.6	19.0	32.7	54.0
5,400	1.9	16.3	28.0	47.2
5,300	1.5	13.1	22.2	37.8
5,200	1.0	11.4	19.3	33.7
5,100	0.2	6.0	9.2	14.8
5,000	0	3.0	3.8	4.5

Table 5 Maximum Number of Days in a Single Year Below Indicated Discharge at the Chattahoochee Gage

Threshold Q (cfs)	1921-1970	1970-2013
6,000	67	250
5,500	34	193
5,400	34	184
5,300	31	178
5,200	31	170
5,100	7	104
5,000	0	34

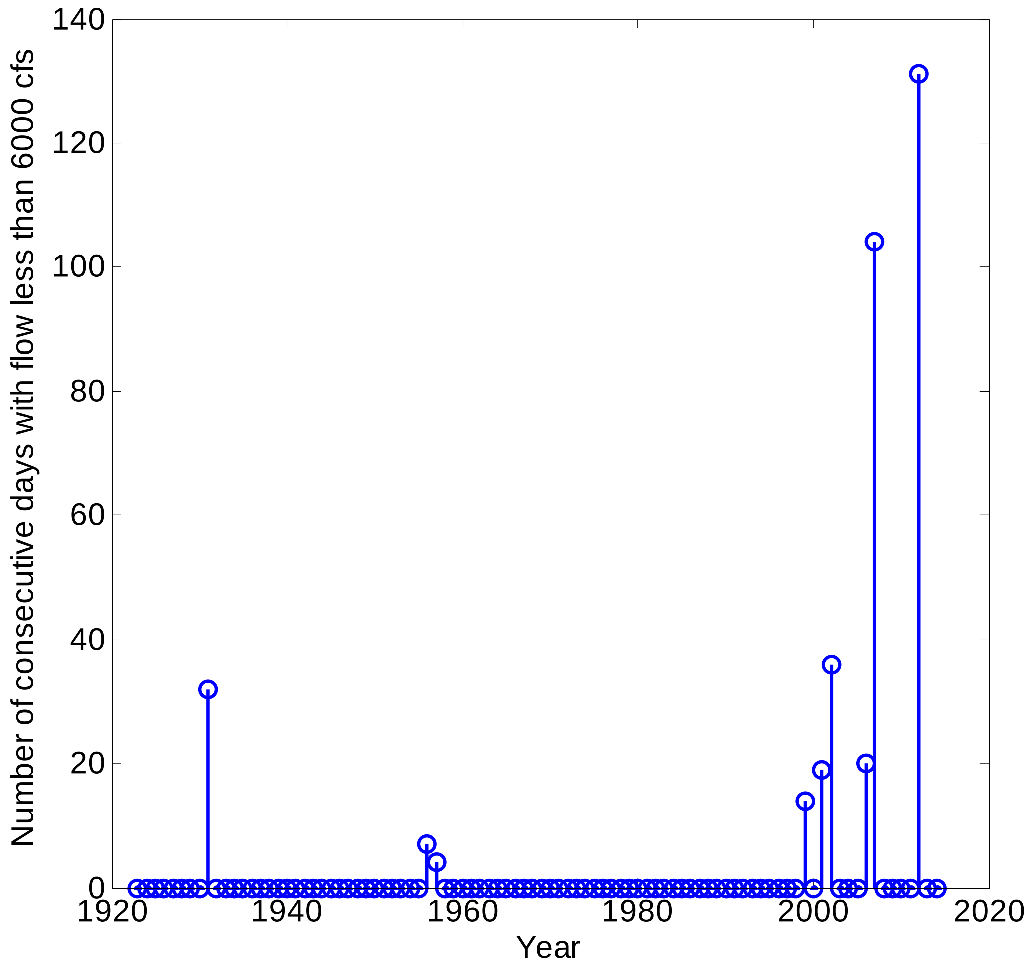

Figure 8 Number of Consecutive Days of Low Flow Below 6,000 cfs in the Apalachicola at Chattahoochee, FL

d. Low flows are now more common in rivers throughout the Georgia portion of the ACF basin.

The hydrological impacts have been felt across the ACF and not just on the Apalachicola River at Chattahoochee, FL. The cause of the impacts lies in the basin upstream of the Apalachicola. The upper portion of the Chattahoochee basin has been impacted significantly by water use in the metropolitan Atlanta region. Records at Whitesburg show declines in the 7-day low flow similar to those recorded for the Apalachicola River (Figure 9).

V. Georgia's Increased Consumptive Uses Are the Main Cause of Streamflow Depletions in the Apalachicola River; Alternative Theories of Causation Are Inconsistent with Observed Data

a. The Data Show that Change in Climate Is Not the Main Factor in Decreasing Stream Flows in the Apalachicola River

As described in the Background section, there is no evidence of a systematic trend in climate that can explain the observed decreases in low flows in the ACF. For example, the standardized precipitation index (SPI) at a 9-month scale (SPI-9) is often used to characterize drought conditions using rainfall measurements (*e.g.*, Gunda *et al.*, 2016). The monthly SPI values using the ACF basin average precipitation shows no trend post 1970 that would explain the flow observations presented above (Figure 13).

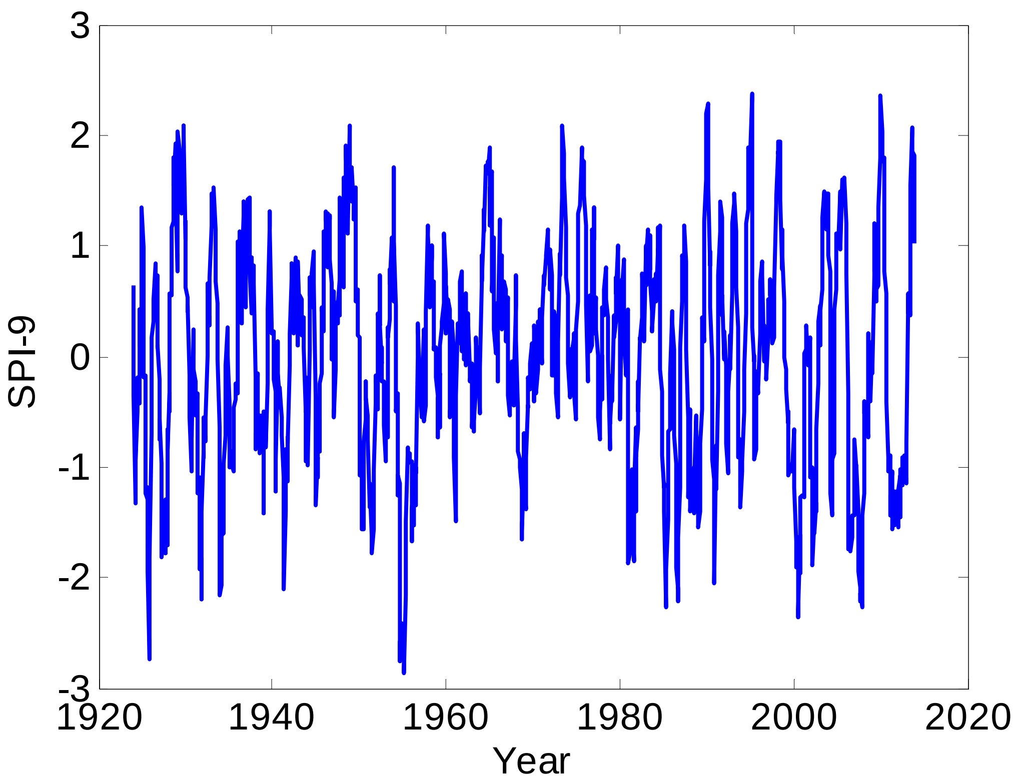

Figure 13 The 9-Month SPI for the ACF Using Basin-Average Precipitation (precipitation from Livneh *et al*., 2014). Drought years show up as low values. A threshold of -2 is typically used to define serious drought.

We use the SPI to define "drought" years and "dry" years. A widely used measure to define "drought" is an SPI less than or equal to minus two. We also adopt a definition of a "dry year" as one where the SPI is greater than minus two but less than or equal to minus 1.5. Using these measures, there are 11 drought years (Table 6) and 11 dry years (Table 7). Drought years and dry years are distributed across the years, with a noticeably less dry period in the 1960s and 1970s (Figure 14). Although the climate record itself does not show trends across the period of record, the observed low flows in the Apalachicola River at Chattahoochee, FL have been lower in uses in Georgia in years following 1955 using the observed climate record for the modern period. These results from the PRMS model represent a relatively unimpaired flow record (UIF) that includes neither major effects of consumptive water use by Georgia nor the effects of the federal reservoirs. (A second PRMS UIF is calculated below to remove the effects of the federal dams and focus on only the effects of consumptive use by Georgia.) Differences between observed and modeled flows at Chattahoochee, FL indicate that annual depletions increased by several thousand cfs from 1970 to the present. Depletions from 2000 to 2012 for the period June through September were in the range of about 4,000 cfs to over 9,000 cfs (Table 8).

Table 8 PRMS-Calculated June-September Streamflow Depletions in the Apalachicola River at Chattahoochee, FL

Year	Observed Mean Seasonal Discharge (cfs)	PRMS UIF (cfs)	Streamflow Depletion (cfs)
2000	5,410	10,788	5,378
2001	11,627	15,698	4,071
2002	6,347	12,424	6,077
2006	6,358	11,193	4,835
2007	5,250	10,062	4,812
2008	8,434	17,445	9,011
2010	9,352	13,968	4,617
2011	5,561	11,794	6,233
2012	5,418	12,037	6,619

Note:
This UIF eliminates effects of both Georgia consumptive use and incremental evaporation from federal reservoirs.

b. <u>ResSim (HEC-ResSim)</u>

Models that support decision rules for operating reservoirs for maximum (multipurpose) benefits have been a staple of hydrological modeling for some time. One of the earliest models for reservoir simulation, HEC-3, was developed by Beard in the late 1960s. These early programs evolved into the version used today, HEC-ResSim. Documentation from the United States Army Corps of Engineers (US ACE) describes the basic operations covered by ResSim as follows.

> The Reservoir System Simulation (HEC-ResSim) software developed by the U.S. Army Corps of Engineers, Institute for Water Resources, Hydrologic Engineering Center is used to model reservoir operations at one or more reservoirs for a variety of operational goals and constraints. The software simulates reservoir operations for flood management, low flow augmentation and water supply for planning studies, detailed reservoir regulation plan investigations, and real-time decision support. HEC-ResSim can represent both large and small scale reservoirs and reservoir systems through a network of elements (junctions, routing reaches, diversion, reservoirs) that the user builds. The software can simulate single events or a full period-or-record using available time-steps. HEC-ResSim is a decision support tool that meets the needs of modelers performing reservoir project studies as well as meeting the needs of reservoir regulators during real-time events. (US

ACE, c. 2016)

There are several reservoirs in the ACF basin that are operated by US ACE (see Figure 1). The reservoirs are situated from upstream to downstream in the following order:

- Lake Lanier—located in the headwaters of the Chattahoochee River;
- Lake West Point—located on the main stem Chattahoochee River;
- Lake W. F. George—located on the main stem Chattahoochee River; and
- Lake Seminole—located at the confluence of the Chattahoochee and Flint rivers.

These reservoirs regulate flows in the basin, serving various purposes (Barton Expert Report, 2016). Reservoir operation is generally governed by a set of guidelines known as the Revised Interim Operating Procedures (RIOP), which were last updated in 2012 (Tetra Tech, 2015). In addition to rule-based guidelines, the RIOP also provides for discretion and other considerations (*e.g.*, weather forecasts) within the operational framework (Shanahan Expert Report, 2016).

As discussed by Shanahan (Shanahan Expert Report, 2016), ResSim provides closer estimations in some circumstances than others. The US ACE uses discretion in its operation of the reservoirs that is not captured by the strictly rule-based simulations of the US ACE ResSim model of the ACF basin. Georgia's own modelers recognize that ResSim is a tool with various shortcomings, as does Dr. Aris Georgakakos (Shanahan Expert Report, 2016).

These shortcomings notwithstanding, ResSim does offer a method by which a relatively unimpaired flow record (UIF) that accounts for incremental additional evaporation from the federal reservoirs can be developed from the PRMS results. The PRMS flows in the period after construction of the reservoirs are routed using ResSim. The modeled seasonal (June to September) streamflow depletions for selected years are many thousands of cfs (Table 9).

Table 9 PRMS/ResSim-Calculated June-September Streamflow Depletions in the Apalachicola River at Chattahoochee, Florida

Year	Observed Mean Seasonal Discharge (cfs)	PRMS UIF with ResSim (cfs)	Streamflow Depletion (cfs)
2000	5,410	9,844	4,435
2001	11,627	14,762	3,134
2002	6,347	11,938	5,591
2006	6,358	10,478	4,120
2007	5,250	9,510	4,259
2008	8,434	15,966	7,532
2010	9,352	12,890	3,538
2011	5,561	11,201	5,640
2012	5,418	11,257	5,838

Note:
This PRMS UIF eliminates effects of Georgia consumptive use but accounts for reservoir operations and incremental evaporation from federal reservoirs.

US ACE uses an unimpaired flow dataset (US ACE UIF), which it developed to run through the ResSim model. Dr. Georgakakos and others have criticized the US ACE UIF on numerous grounds (GWRI, 2012). We ran the ResSim model using observed data, rather than the US ACE UIF due to the deficiencies, as described below (referred to in my report as the "data-driven ResSim model of the ACF Basin"). The US ACE ResSim model of the ACF basin is an attempt to produce an approximate analog of reservoir operations, but to achieve better accuracy for this analysis, we developed an additional model based on ResSim that could more closely match the manner in which the US ACE actually operates the system (referred to in my report as the "data-driven model of Lake Seminole"). Both models used observed data on inflows and outflows, and the Lake Seminole model used additional data on observed storages.

- **A data-driven ResSim model of the ACF Basin**. This model is based on the ResSim model for the ACF basin previously developed by US ACE (Tetra Tech, 2015). Instead of using the same flow data developed by the US ACE to run the model – the US ACE UIF – observed flow data were used to derive incremental flow inputs for the model (see Appendix E). Through that mechanism, this model is driven by observed flow data and hence, is a model of observed flows.
- **A data-driven model of Lake Seminole**. As discussed by Shanahan (Shanahan Expert Report, 2016), the US ACE uses discretion in its operation of the reservoirs, leading to differences between ResSim model predictions and the observed reservoir operations during low-flow periods. To more closely match actual US ACE operations, the rules for Lake Seminole that were programmed into the US ACE ResSim model of the ACF basin were adopted but applied using data rather than the entire ResSim model. Observed data (*i.e.*, composite reservoir storage, observed inflows to Lake Seminole) that reflect the US ACE's reservoir operating decisions were used to drive the model. This modeling procedure produces a model of observed flows that mitigates the differences between ResSim model predictions and observed reservoir operations during dry years.

c. <u>Data-Driven ResSim Model of the ACF Basin</u>

The US ACE previously developed a ResSim model of the ACF basin (Tetra Tech, 2015). The US ACE ResSim model is set up to simulate observed flows by starting with the US ACE's estimated UIFs and then subtracting US ACE's estimated depletions from the stream reaches in the ResSim model. Instead of starting with the US ACE UIFs and estimated depletions (both of which are model results), we used observed data to drive the model.

The US ACE reports observed inflows and outflows for each of its reservoirs in the ACF basin. The ResSim model is not set up to take observed flows as direct inputs, but rather requires the specification of incremental flows into stream reaches in between the reservoirs. These incremental flows represent the amount of water added to each reach from the surrounding landscape. A mass balance calculation was used to estimate incremental flows into the ResSim reaches from the observed flow data. For each pair of reservoirs (one upstream and one downstream), the observed outflow for the upstream reservoir was routed to the downstream reservoir using the same Muskingum routing approach in ResSim in the absence of any incremental inflows from the surrounding landscape (Figure 23). This routed record of inflows was compared to the observed inflows to the downstream reservoir. The observed inflows reflect the routed flow from the upstream reservoir and any incremental inflow from the landscape along the intervening stream reach. The difference between the routed flow from the upstream reservoir and observed inflow to the downstream reservoir is the amount of flow (*i.e.*, incremental flow) added by the landscape between the two reservoirs. These incremental flows were reconstructed from the observed data from 1975 to 2013. For the stream reaches immediately downstream of Buford Dam, the observed flow data from two USGS stream gages (Norcross [02335000] and Atlanta [02336000]) were used to make sure that the incremental flow was distributed appropriately along these downstream reaches. Additional details on this approach are described in Appendix E. The incremental flows were then input to ResSim to provide a model of observed flows. ResSim version 3.1 (revision 3.1.8.73, build: 3.1.8.73R) setup with the 2012 RIOP, as described by US ACE (Tetra Tech, 2015), was used.

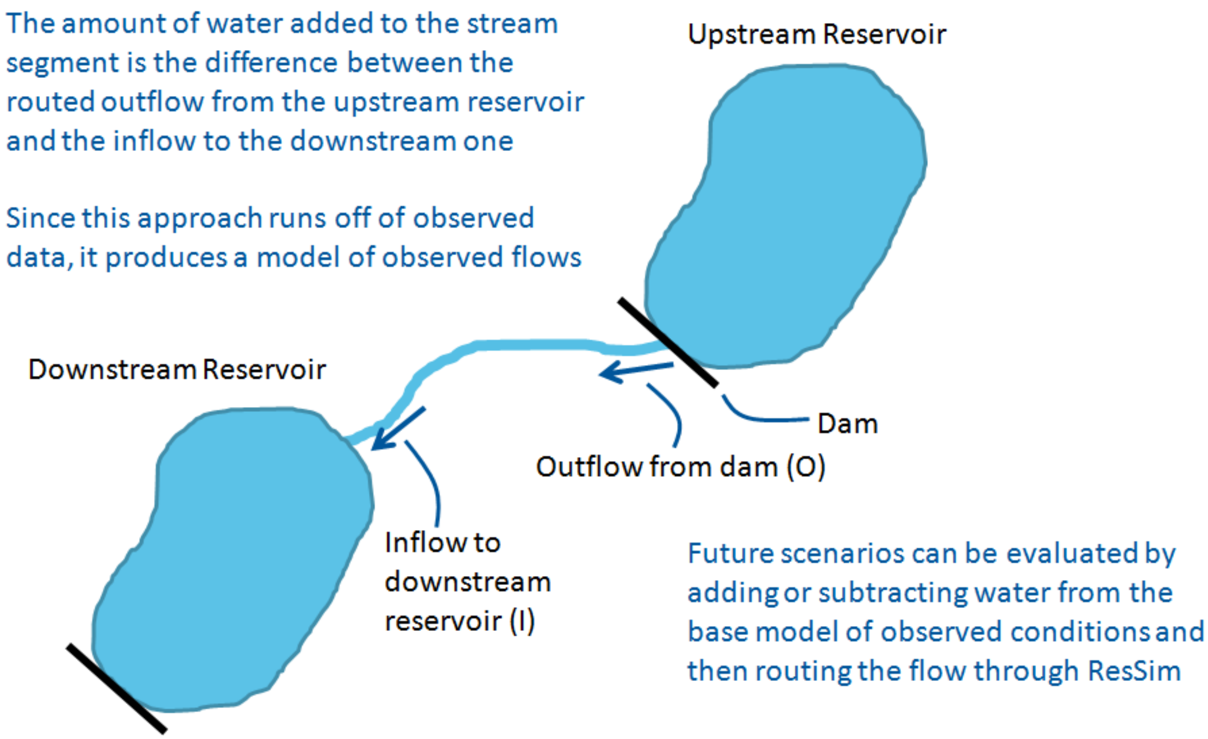

Figure 23 Diagram Illustrating the Procedure for Calculating Incremental Flows for Input to ResSim from Observed Flow Data

The ResSim model appears to mimic the general patterns in observed flow at Chattahoochee, FL, but does not match observed flows with high accuracy (Figure 24). During several recent drought years (Figure 25), the ResSim model clearly under predicts observed flows and does not respond appropriately to storms (*e.g.*, July and September of 2007). Considering that the ResSim model is driven by observed flow data, the differences between the modeled and observed flows most likely represent differences in how ResSim calculates operations of the reservoir system relative to how the US ACE actually operates the reservoir system. As discussed by Shanahan (Shanahan Expert Report, 2016), the US ACE uses discretion in its operations that is not encoded in the rules used by ResSim to simulate the reservoirs.

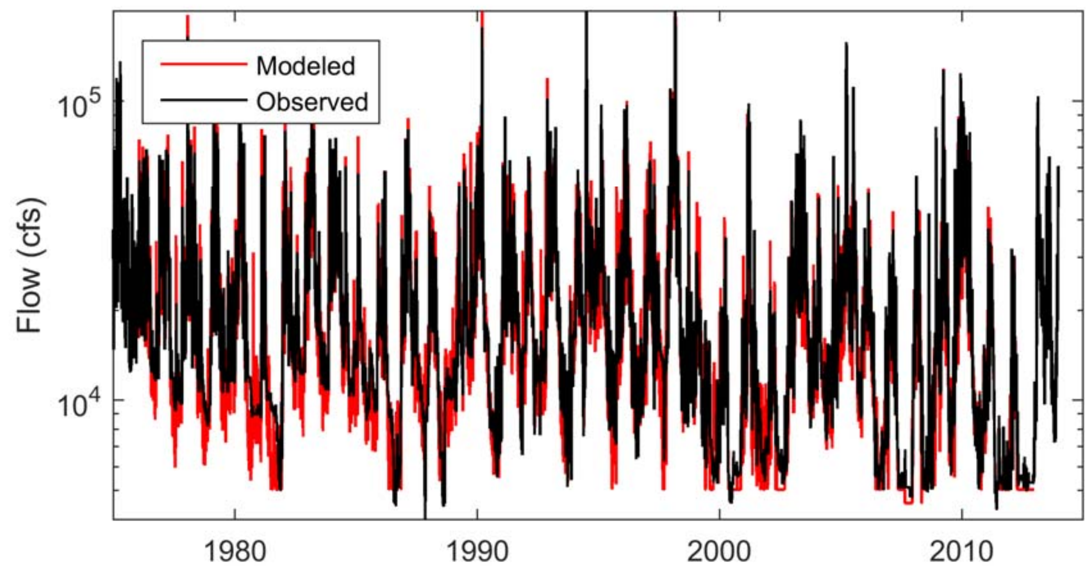

Figure 24 ResSim Model Results from 1976-2013 at Chattahoochee, FL

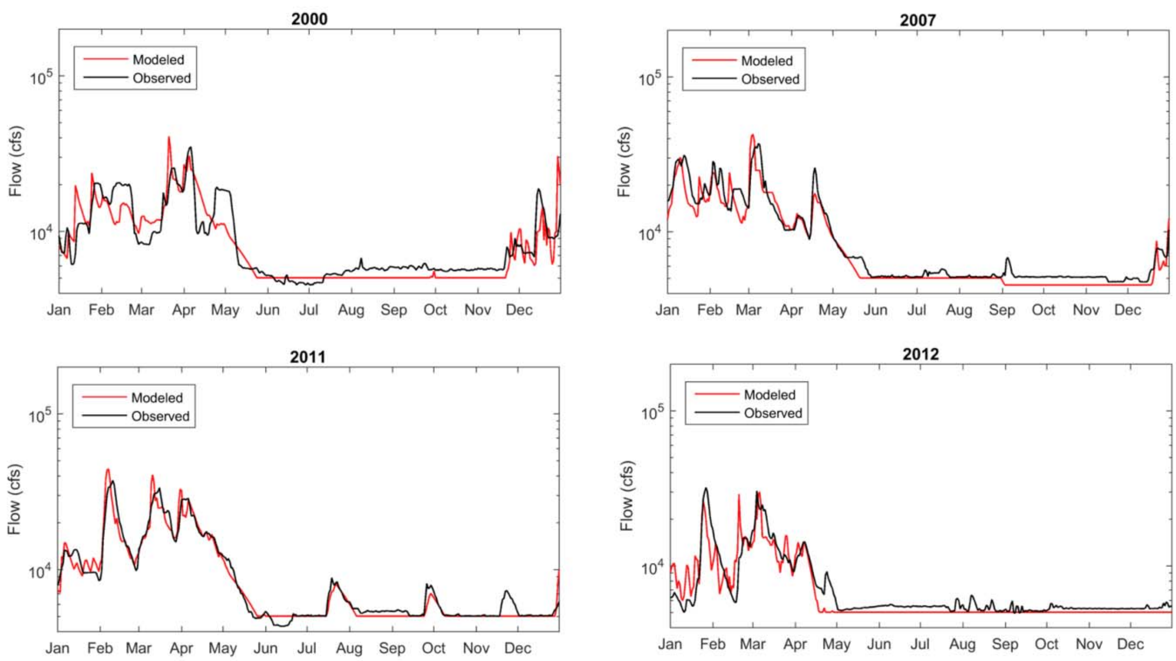

Figure 25 ResSim Model Results for 2000, 2007, 2011, and 2012

Some of the differences between ResSim and actual US ACE operations show patterns from year to year. For example, ResSim under predicts the composite storage (*i.e.*, the combined volume of water stored in lakes Lanier, West Point, and W.F. George) in the early part of the year (Figure 26). The same pattern was found for the pool elevation in Lake Lanier (the dominant location of storage in the system) during other drought years by Shanahan (Shanahan Expert Report, 2016). The effect of ResSim under predicting composite storage is that ResSim shifts the reservoir system into drought management conditions (Zone 4 and the Drought Zone) earlier in the year than actually occurs. For example, in 2011, ResSim predicts that the composite storage drops into Zone 4 in October, whereas the US ACE operated the reservoirs in such a manner to prevent entering the Zone 4 at all that year (Figure 26c). In other years (*e.g.*, 2007), ResSim predicts that the system enters the lower management zones (Zone 4 and the Drought Zone) several months before the observed composite storage actually entered those zones (Figure 26b). (Strictly, the system was not operated under RIOP rules in 2007, however it was operated under the generally similar IOP rules instituted in 2006.) Thus, ResSim may be a general analog of US ACE reservoir operation, but does not accurately reflect how changes in human activities in the basin (*e.g.*, decreased consumptive water use) affect flows out of the reservoir system. In particular, the under-prediction of composite storage would artificially mask the extent to which potential future reductions to consumptive water use might increase flows into the Apalachicola River in Florida.

d. <u>Data-Driven ResSim Model of Lake Seminole</u>

To match observed US ACE reservoir operations more closely, a model of Lake Seminole that can be driven entirely by observed data, *i.e.*, data that reflect the actual US ACE reservoir operations, was developed. The model of Lake Seminole uses the exact same operating rules encoded in ResSim, but provides the flexibility to operate Lake Seminole with observed inflows to the lake and observed composite storage for the reservoir system. Driving the model in this manner results in a close match to observed flows at Chattahoochee, FL, and ensures fidelity with the actual system composite storage, which is one of the primary factors controlling discharges from Lake Seminole (Figures 27 and 28).

One of the key differences between the Lake Seminole model and the ResSim model of the basin occurs when the reservoir system enters into Drought Zone management. The arrows in Figure 26 denote the time when the system entered Drought Zone management according to the ResSim model (blue arrows) and the observed US ACE operations (black arrows; reflected in the Lake Seminole model). As discussed above, the ResSim model under-predicts composite storage and, hence, predicts that the system enters the Drought Zone sooner than it actually does. That issue does not occur in the Lake Seminole model, because it takes the observed composite storage as one of the inputs used to drive the model.

To validate that the Lake Seminole model better predicts flows in the Apalachicola River during drought years than ResSim alone, I compared the ResSim modeled flows on the Apalachicola River to the actual flows on the Apalachicola River for select drought years (Figure 25). I also compared the Lake Seminole model's flows on the Apalachicola River to actual flows on the Apalachicola River for select drought years (Figure 28). As can be seen by visually comparing the two sets of graphs, the Lake Seminole model better predicts flow on the Apalachicola during drought years. This was confirmed by calculating goodness-of-fit metrics that quantify how closely the modeled flows match observed flows (Table 10). The two metrics used are the Nash-Sutcliffe Efficiency (NSE) and the PBIAS (see Appendix A for further description of these metrics). An NSE value of 1 indicates perfect agreement between modeled and observed flows, whereas a PBIAS of zero indicates the model has no tendency to over or under predict observed flows. As shown in Table 10, the NSE for the Lake Seminole model is much closer to 1, meaning that it is a closer match to observed flows. Similarly, the PBIAS statistic is closer to zero for the Lake Seminole model, again indicating that this model tracks the observed flows more closely than the data-driven ResSim model.

Table 10 Goodness-Fit-Metrics for the Data-Driven ResSim and Lake Seminole Models

Model	NSE	PBIAS
Lake Seminole Model	0.908	-0.205
ResSim	0.735	5.125

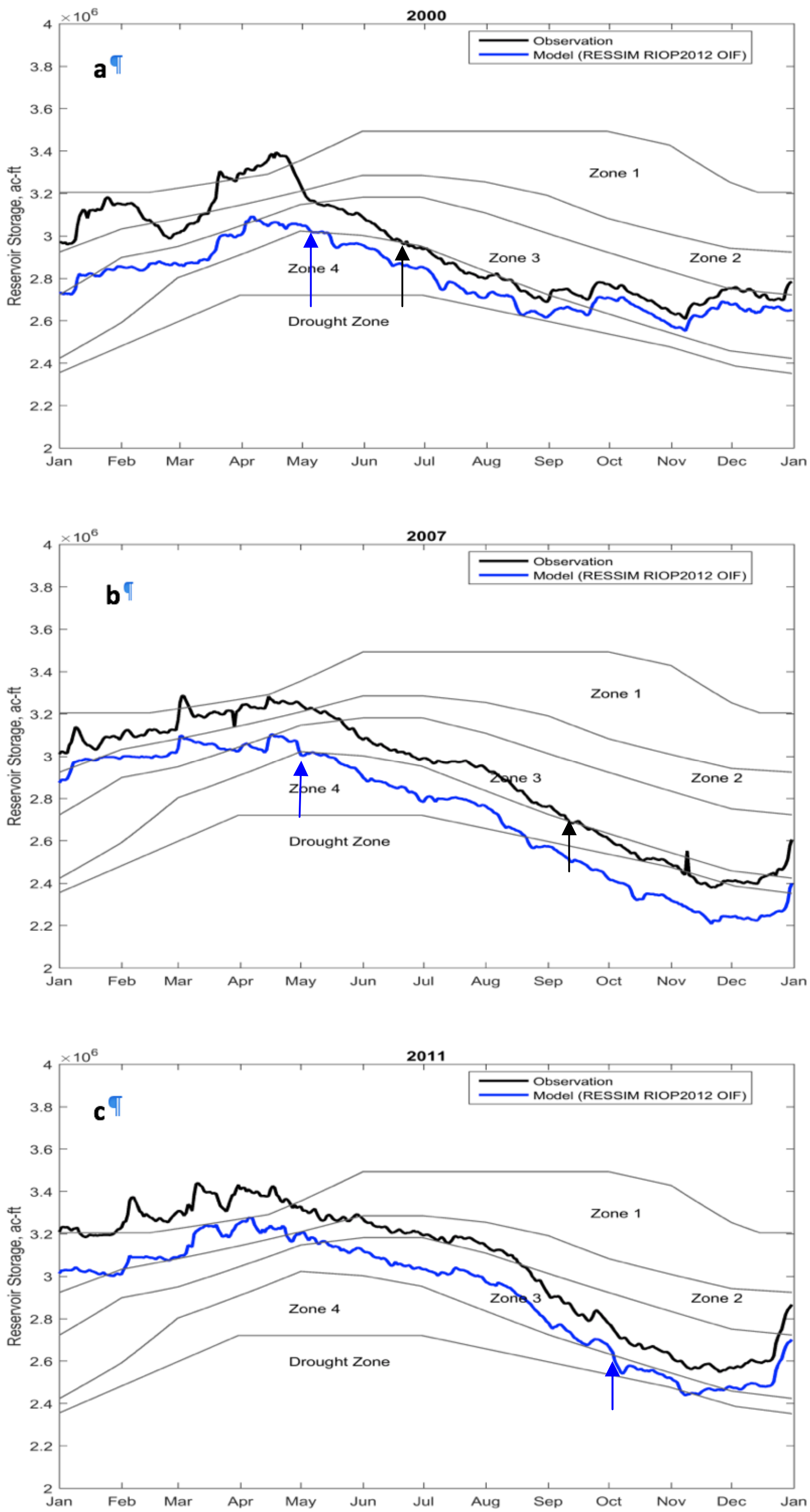

Figure 26 Observed and Modeled Composite Storage for (a) 2000, (b) 2007, and (c) 2011

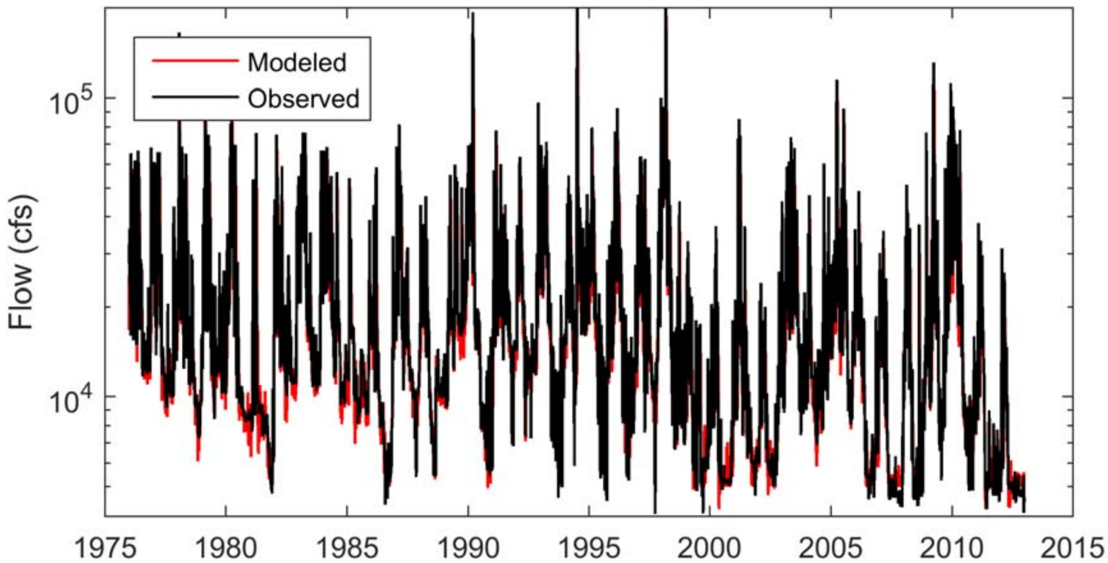

Figure 27 Lake Seminole Model Performance from 1976-2012

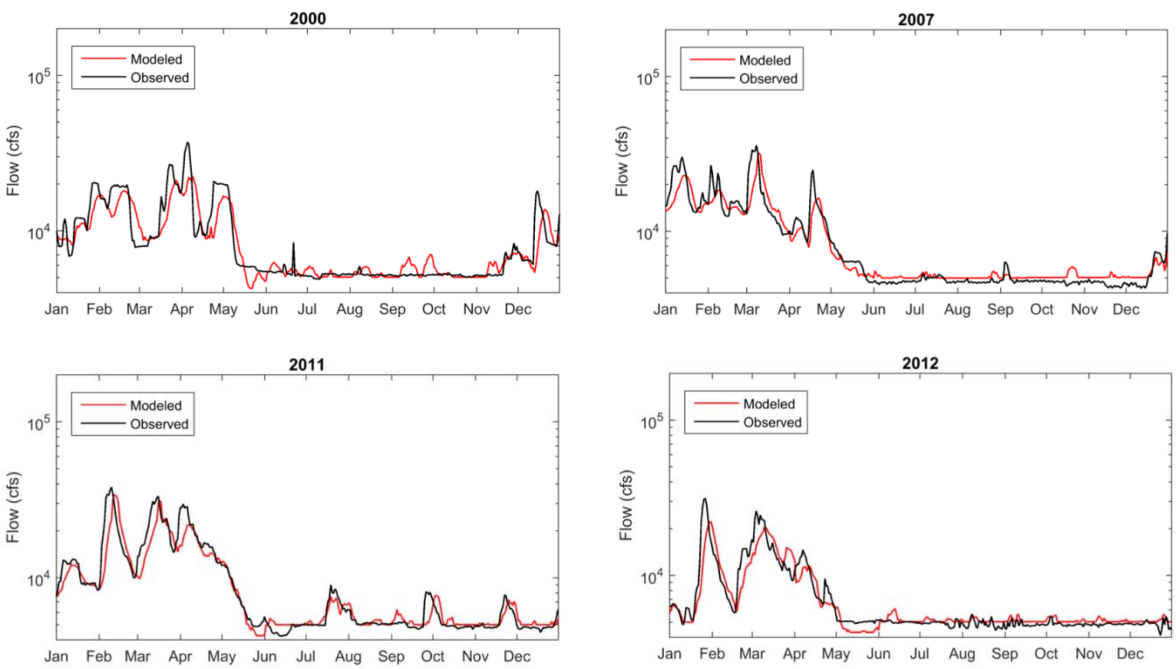

Figure 28 Lake Seminole Model Performance for 2000, 2007, 2011, and 2012

VII. Scenario Evaluation

The effects of changed water use conditions in the future were calculated for several scenarios as described in detail in the Flewelling Expert Report (2016).

1. Additional consumptive use in the Georgia portion of the ACF Basin by the year 2050 as stated in reports by Georgia.
2. Reduction of agricultural water use and small impoundment incremental evaporation in the Georgia portion of the ACF basin.
3. Removal of interbasin transfers out of the GA portion of the ACF basin and reduction of agricultural water use and small impoundment incremental evaporation in the Georgia portion of the ACF basin.

Calculations of future impacts were done by applying appropriate changes in inflows to the data-driven ResSim model and the data-driven Lake Seminole model. Changes in inflows due to consumptive use were based on various sources of information (Flewelling Expert Report, 2016). Estimates of municipal and industrial water use and of interbasin transfers were assembled from reports from Georgia. Consumptive water use by irrigated agriculture was computed by multiplying acreage irrigated by depth of irrigation (Flewelling Expert Report, 2016). Translation from agricultural irrigation to streamflow depletion was adjusted for net groundwater-streamflow change; that is, only a fraction of groundwater pumped is reflected in streamflow depletion (Langseth Expert Report, 2016).

To quantify the impact of water use changes, nine years (2000, 2001, 2002, 2006, 2007, 2008, 2010, 2011, and 2012) were selected to illustrate a range of impacts across years with differing climate conditions. For the 2050 increased consumptive use scenario, inflows to nodes of the data-driven ResSim model were decreased according to estimates of additional consumptive use (translated to increased depletions according to Dr. Langseth's Expert Report, 2016) and the model was exercised to calculate changes relative to observed flow for the selected years. For calculating expected improvements in flow in the Apalachicola River at Chattahoochee FL for the other scenarios, the additional flow increments were added to inflows of Lake Seminole and the data driven Lake Seminole model was used to calculate increased flows. (The data driven ResSim model also can be used to do the calculations, but as noted above, the Lake Seminole model is more faithful to actual operational actions and thus to observed flows.) This modeling work is described in greater detail in Appendix C.

a. Future increases in consumptive water use in the Georgia portion of the ACF would lead to substantial additional streamflow depletions in the Apalachicola River in Florida.

If future increases in water withdrawals and consumptive use in Georgia occur as envisioned in current plans, considerable additional harm in terms of decreasing summer low flows in the Apalachicola will occur. Future planned water withdrawals by Georgia could lead to additional decreases in flow in the Apalachicola River (Appendix B.1). Average additional decreases in flow for June through September under the increased water use scenario range from several hundred cfs to 731 cfs for the years simulated (Table 11).

Appendix C Data-Driven Reservoir Models

C.1 Overview of Procedure

Both of the data-driven reservoir models used in my report predict flows that are tied to the observed flow record in the following way:

- Each data-driven reservoir model is run with observed data to create a baseline model prediction of flows.
- Each data-driven reservoir model is then run for a particular scenario where inflows into the model are increased or decreased according to the scenario being evaluated. Changes to inflows associated with agricultural water use and small impoundment incremental evaporation are applied at the Bainbridge node in ResSim, whereas changes to inflows associated with M&I water use and IBTs are applied at the Columbus node. For the Lake Seminole model, all changes to inflows are applied to the Lake Seminole inflow. These adjusted inflows are then used in the reservoir models to predict flows for that scenario.
- The flows in the scenario are then subtracted from the baseline model to calculate the incremental change in model-predicted flow. This incremental change is then added to the observed flows.

Performing the calculations in the above manner creates a modeled flow record that is inherently linked to the observed flows in the basin. Additional details of the two reservoir models I used in my analysis are described below.

C.2 Data-driven ResSim Model

In order to run the data-driven ResSim model, I needed to process observed flow data to convert it to incremental inflows from the surrounding landscape along stream reaches. Incremental flows used as input to the ResSim model were estimated using observed flow data from USGS stream gages and reservoir inflow and outflow data reported by the US ACE. The incremental flow along a stream can be estimated between an upstream and downstream location that both have observed data. For the stream network in ResSim, incremental flows were computed between the following nodes

- Buford Out (USACE) to Norcross (USGS)
- Norcross (USGS) to Atlanta (USGS)
- Atlanta (USGS) to West Point In (USACE)
- West Point Out (USACE) to WF George In (USACE)
- WF George Out (USACE) to Jim Woodruff In (USACE)
- Chattahoochee (USGS) to Sumatra (USGS)

The observed data at Norcross, Atlanta, Chattahoochee, and Sumatra come from USGS stream gages. Observed data at the remaining locations are from the USACE.

The estimation procedure entails routing observed flow from the upstream location to the downstream location and comparing the routed flow to the observed flow downstream. The incremental flow is the difference between the routed flow from the upstream location and the observed flow at the downstream location. For example, the incremental flow between Buford Out and Norcross was computed as follows:

- Route the USACE observed outflow at Buford Out downstream to the USGS Norcross gage, using the Muskingum routing method with the parameters specified in Table D.1.
- Determine the incremental flow between these locations by subtracting the Buford Out routed flow from the Norcross observed flow.

This procedure was used to compute incremental flows between the six pairs of nodes (using the observed data corresponding to these locations) listed above. These incremental flows were then used as input to our ResSim model.

In the approach above, the USACE reported reservoir inflows are calculated by the Corps in such a way that automatically includes the effects of evaporation and precipitation on the reservoir surface. Thus, when implementing the data-driven ResSim model, evaporation and precipitation are not applied to the reservoir surfaces in the model.

C.3 Data-driven Lake Seminole Model

The data-driven Lake Seminole model has only the following two data inputs:

- Observed composite storage; and
- Observed inflows to Lake Seminole.

All of the above data are recorded and made publicly available by the US ACE. With these inputs, the data-driven Lake Seminole model uses the same reservoir operating rules as encoded in the ResSim model (ResSim version 3.1, revision 3.1.8.73, build: 3.1.8.73R). After running the Lake Seminole model, the predicted flows are routed to Sumatra using the methods and parameters listed in Table D.1.

Appendix F Curriculum Vitae

February 2016

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Education:

Ph.D.	Hydrology	Stanford University	1970
M.S.C.E.	Hydrology	Drexel University	1967
B.S.C.E.		Drexel University	1965

Employment:

2008-	University Distinguished Professor, Craig E. Philip Professor of Engineering, Professor of Civil and Environmental Engineering, Professor of Earth and Environmental Sciences, Director, Vanderbilt Institute for Energy and Environment, Vanderbilt University
2014-2015	Chairman, Department of Earth and Environmental Sciences, Vanderbilt University
2012-2013	Chairman, Department of Civil and Environmental Engineering, Vanderbilt University
1991-2008	Ernest H. Ern Professor of Environmental Sciences University of Virginia
2006-2007	Visiting Professor, University of California at Berkeley
2002-2006	Associate Dean for the Sciences, University of Virginia
2002-2003	Interim Chairman, Department of Statistics, University of Virginia
1997-1998	Visiting Scientist, Institute for Alpine and Arctic Research, University of Colorado
1990-1991	Visiting Scientist, U.S. Geological Survey and, concurrently, Visiting Professor, Stanford University
1984-1990	Professor of Environmental Sciences, University of Virginia
1984-1985	Honorary Visiting Professor of Environmental Sciences, University of Lancaster, Lancaster, U.K
1975-1984	Associate Professor (Department Chairman 1979 - 1984) University of Virginia
1977-1978	Visiting Fellow, Centre for Resource and Environmental Studies, The Australian National University
1970-1975	Assistant Professor University of Virginia

Current Research Interests

My work has centered on the coupling of field observations with mathematical modelling. My current work is broadly interdisciplinary, focusing on coupled natural-human systems. Water resources are under pressure from many human activities, from climate change to urban development. I and my colleagues and students collect and analyze data to understand how climate, groundwater, surface water, and human abstraction of water interact in complex ways. Current projects include work in Sri Lanka on adaptation to drought and in the United States on how cities evolve water conservation practices.

Society Memberships

American Geophysical Union
Geological Society of America
American Women in Science
American Water Resources Association

Editorships

Associate Editor, *Water Resources Research*, 1982 - 1984
North American Editor, *J. Hydrological Processes*, 1985-1992
Editor, *Water Resources Research,* January 1993 - January 1997
Editor for Hydrology, Encyclopedia of Inland Waters, Elsevier, 2006-2009
Advisory Editor, Oxford Online Bibliography, 2013-present

Awards and Honors

Virginia Chapter of Sigma Xi, President's and Visitors' Prize, 1986.
Robert E. Horton Award, Hydrology Section, American Geophysical Union, 1993.
Elected Fellow, American Geophysical Union, 1994.
Appointed to five-year Visiting Professorship at University of Reading, UK, 1995
1995 Biennial Medal for Natural Systems, Modelling and Simulation Soc. of Australia
1995 John Wesley Powell Award for Citizen's Achievement (US Geological Survey)
Elected Fellow, Association for Women in Science, 1996
Elected to membership in the National Academy of Engineering, February 1996
1999 Excellence in Geophysical Education Award, American Geophysical Union
Bownocker Lecturer, Ohio State University, May 1999
ISI Highly Cited Researcher, 2000 (http://authors.isihighlycited.com/)
National Associate of the National Academies in recognition of extraordinary service, 2001
Langbein Lecturer, American Geophysical Union, 2002
Elected Fellow, Geological Society of America, 2005
Virginia Outstanding Scientist, 2007
William Kaula Award, American Geophysical Union, 2010

Selected Service on National Committees

Chair, National Research Council, Water Science and Technology Board, 2013-present (member from 2010).
Chair, Advisory Committee for the Geosciences Directorate, NSF, 2014- present (member from 2011)
Chair, Geosciences Policy Committee, American Geosciences Institute, 2011-present
Member, Geology and Public Policy Committee, Geological Society of America, 2013-present
Chair, Health Effects Institute, Special Scientific Committee on Unconventional Oil and Gas Development, 2014-2015.
Chair, National Research Council, Committee on Development of Unconventional Hydrocarbon Resources in the Appalachian Basin: A Workshop, 2013
Chair, Committee of Visitors for Geosciences Education, NSF, May 2013
Member, Advisory Board for the School of Earth Sciences, Stanford, 2004-2014
Member, Nuclear Waste Technical Review Board (Presidential Appointment) 2004-2012
Chair, National Research Council, Committee on Opportunities and Challenges in Hydrologic Sciences, 2010-2012
Member, National research Council, Committee on Analysis of Cancer Risks in Populations near Nuclear Facilities: Phase I, 2010-2012.
Member of Steering Committee on Ecosystems Services, National Academies Keck Futures Initiative, 2011.
Chair, Committee of Visitors for the Surface Earth Processes Section, NSF, June 2011
Member, National Research Council, Report Review Committee, 2004-2009
Member, National Research Council, Science Panel, America's Climate Choices, 2009-2010.
Chair, National Research Council, Board on Earth Sciences and Resources, 2002-2009.
Chair, National Research Council, Committee to Review the NSF "WATERS" Plan, 2007-09
President, Hydrology Section, American Geophysical Union, 2006-2008
Chair, Science Advisory Committee, Berkeley Water Center, 2006-2008
Member, Adaptation for Climate-Sensitive Ecosystems and Resources Advisory Committee (USEPA), 2007-2008.
Member, National Research Council, Committee on Hydrologic Sciences, Aug 2000 – 2008
Member, Hydrology Section Executive Committee, American Geophysical Union, 1994-2009.
Chair, Publications Committee, American Geophys. Union, 2000-04 (member, 1998-2004).
Chair, Advisory Committee on Nuclear Waste, Nuclear Regulatory Commission, 2001-2003 (Vice-chairman, 1997-2000; member 1996-2004)
Member, Board of Trustees, Virginia Museum of Natural History, 2000-2005
Chair, National Research Council, Committee on the Review of EarthScope Science Objectives and Implementation Planning, 2001.
Chair, Water-Cycle Initiative Study Group (Interagency committee appointed to create a science plan for a major federal research initiative on the water cycle), 1999-2001.
Chair, National Research Council Commission on Geosciences, Environment, and Resources 1996-2000, (member from 1994)
Chair, Board of Journal Editors, American Geophysical Union, 1998-2000.
Chair, National Research Council Committee on Water Resources Research (WSTB), 1991-1997 (member from 1990)
Co-convenor AGU Chapman Conference on Hydrochemical Response of Forested Catchments, Bar Harbor, Maine, September 1989
Co-convenor Gordon Conference on Hydrological/Geochemical/Biological Interactions in Forested Catchments, Plymouth, NH, 1-5 July 1991

Publications, George M. Hornberger

1. Books and Book Chapters

Remson, Irwin, G.M. Hornberger and F.J. Molz. 1971. ***Numerical Methods in Subsurface Hydrology***. John Wiley and Sons.

Hornberger, G.M., Raffensperger, J.P., Wiberg, P.L., and K. Eshleman. 1998. ***Elements of Physical Hydrology***. Johns Hopkins Press.

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2. Refereed Articles

Remson, Irwin, A.A. Fungaroli and G.M. Hornberger. 1967. Numerical analysis of soil-moisture systems. ***Proc. ASCE, J. Irr. and Drainage Div.,*** IR3: 153-166.

Hornberger, G.M., Irwin Remson and A.A. Fungaroli. 1969. Numerical studies of a composite soil moisture ground water system. ***Water Resources Research*** 5: 797-802.

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EXPERT DISCLOSURE FOR DR. GEORGE M. HORNBERGER

Dr. George M. Hornberger submits this expert disclosure pursuant to Federal Rule of Civil Procedure 26(a)(2);

1. The Report of George M. Hornberger provides a complete statement of my opinions to date on the matters set forth therein, including their basis and supporting evidence.

2. My *Curriculum Vitae* is attached to my Report as Appendix F, and provides an account of my qualifications.

3. I am being compensated for my time in connection with my Report at the rate of $300 per hour. I am also being compensated for my reasonable out-of-pocket expenses. My compensation is not dependent on the outcome of this matter or on any testimony I may offer.

I declare under penalty of perjury pursuant to 28 U.S.C. § 1746 that the foregoing is true and correct.

Dated: 02/29/2016 By: Dr. George M. Hornberger

ATTACHMENT 2

Attachment 2 contains two historical gage records from the U.S. Geological Survey for monthly mean flows at:

(1) The Apalachicola River at Chattahoochee, Florida

(2) The Flint River at Bainbridge, Georgia

For the first set of readings for the Apalachicola River, we have marked each monthly mean with less than 6,000 cfs extreme low flow with yellow highlighting. A distinct historical pattern can be seen, culminating in the lowest flows on record for the longest period in 2012.

For the second set of readings for the Flint River, the same historical pattern is evident: we have highlighted extreme low flows at less than 2,500 cfs on those pages.

The gage data are available at
http://waterdata.usgs.gov/fl/nwis/inventory/?site_no=02358000&agency_cd=USGS and
http://waterdata.usgs.gov/nwis/inventory/?site_no=02356000&agency_cd=USGS.

USGS Surface-Water Monthly Statistics for Florida

The statistics generated from this site are based on approved daily-mean data and may not match those published by the USGS in official publications. The user is responsible for assessment and use of statistics from this site. For more details on why the statistics may not match, click here.

USGS 02358000 APALACHICOLA RIVER AT CHATTAHOOCHEE FLA

Gadsden County, Florida
Hydrologic Unit Code 03130011
Latitude 30°42'03", Longitude 84°51'33" NAD27
Drainage area 17,200.00 square miles
Gage datum 00.00 feet above NGVD29

Output formats
- HTML table of all data
- Tab-separated data
- Reselect output format

YEAR	00060, Discharge, cubic feet per second, Monthly mean in ft3/s (Calculation Period: 1928-10-01 -> 2016-01-31) Calculation period restricted by USGS staff due to special conditions at/near site											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1928										19,550	13,800	14,170
1929	22,810	38,370	171,600	37,240	36,240	23,850	19,440	15,820	13,790	37,510	28,200	28,150
1930	27,170	35,040	38,620	31,420	18,560	14,340	11,280	11,790	14,910	11,560	28,990	23,420
1931	23,430	19,990	20,210	21,800	19,580	8,898	9,010	11,590	7,235	5,980	5,524	14,870
1932	29,050	28,660	23,490	18,980	15,750	15,470	14,670	17,530	9,827	12,390	15,370	27,350
1933	37,090	43,010	41,050	37,990	21,400	13,810	14,360	12,190	11,380	8,111	7,888	8,906
1934	10,750	11,230	31,040	17,740	17,490	21,200	14,730	13,440	10,030	14,200	8,658	10,580

1935	12,020	13,850	27,450	20,690	14,500	8,905	11,030	11,690	12,670	7,056	9,299	9,688
1936	62,470	64,920	32,760	72,170	20,080	12,860	14,030	24,600	11,710	20,850	12,160	24,790
1937	40,600	41,100	37,350	44,220	34,550	16,500	15,760	15,360	17,630	15,380	17,820	16,890
1938	17,360	14,190	19,220	51,150	17,670	15,280	19,150	16,090	9,610	8,180	7,714	8,670
1939	11,770	27,200	47,610	31,250	20,970	21,810	16,840	26,560	17,520	12,370	9,127	10,170
1940	19,360	36,480	30,250	26,530	15,400	13,060	32,050	14,660	10,370	7,184	9,716	13,400
1941	16,750	14,510	19,060	16,750	9,840	7,148	13,980	11,120	7,562	6,973	6,387	18,740
1942	31,810	31,360	53,100	31,960	16,600	19,660	16,370	18,000	12,920	12,170	10,950	16,470
1943	45,080	32,800	62,780	35,250	24,250	17,060	17,280	15,180	9,753	8,413	9,960	11,010
1944	20,220	23,850	55,540	80,700	42,550	17,380	15,630	15,350	15,550	10,570	9,647	13,430
1945	15,670	29,970	26,660	19,360	27,710	12,490	15,590	14,980	14,580	12,350	13,950	26,680
1946	58,510	38,470	36,370	40,920	38,120	27,670	20,640	24,120	15,080	13,020	13,200	11,930
1947	33,060	22,530	44,650	45,220	28,640	24,880	20,030	17,230	12,000	10,370	26,450	40,840
1948	29,550	47,330	64,940	61,140	20,320	17,540	37,850	29,250	17,100	18,250	28,230	70,390
1949	45,700	53,200	37,870	36,310	39,200	23,040	31,170	23,640	19,720	14,170	13,280	15,230
1950	16,050	17,950	27,040	21,610	15,510	16,090	12,010	11,360	14,390	8,985	8,788	11,730
1951	14,280	13,210	16,260	24,280	13,570	9,547	9,921	8,129	7,304	7,225	11,160	20,540
1952	19,030	29,250	58,860	31,780	19,940	16,930	9,268	9,862	9,708	7,205	7,230	11,600
1953	24,340	28,020	31,830	29,700	44,980	15,630	22,660	14,190	13,430	16,970	11,210	42,900
1954	34,660	23,260	24,390	21,500	13,250	10,860	10,700	8,188	6,092	5,319	5,990	8,798
1955	14,050	19,430	12,780	19,330	12,210	7,892	12,450	10,920	6,850	5,499	5,909	7,991
1956	7,262	20,800	27,680	24,110	13,560	8,594	10,150	7,721	10,540	11,270	7,682	16,370
1957	14,470	13,350	22,720	39,860	23,980	12,630	10,230	7,008	8,567	14,610	19,000	23,970
1958	19,730	29,320	46,220	39,410	18,560	14,360	19,850	15,160	10,580	9,589	9,011	11,310
1959	17,020	37,460	44,010	30,810	18,860	31,900	15,770	12,720	12,330	15,590	16,560	16,970
1960	26,700	48,460	39,770	65,570	20,480	13,790	13,110	13,580	11,980	13,190	10,160	11,600
1961	12,690	32,800	47,440	57,160	29,450	20,030	20,340	16,250	14,100	8,345	8,707	29,270
1962	32,430	30,900	42,050	50,490	17,750	14,920	12,620	10,290	9,514	9,228	10,480	12,560
1963	28,170	30,790	23,860	20,910	20,410	17,890	17,660	12,210	8,841	9,217	9,152	18,900
1964	51,990	48,720	64,920	71,310	53,260	16,820	26,010	27,880	17,680	38,500	21,600	41,330
1965	38,940	52,420	50,700	39,250	17,280	26,320	20,290	14,310	13,100	17,310	13,080	16,030
1966	33,440	57,780	72,670	24,010	27,750	20,980	13,540	16,120	11,570	12,820	20,140	17,280
1967	45,630	35,730	23,920	14,280	13,420	15,960	20,630	16,390	18,390	12,440	16,660	29,880
1968	29,770	17,080	30,310	18,960	13,390	11,960	11,240	10,740	9,125	7,773	8,860	12,860
1969	15,740	18,940	24,330	30,240	21,140	13,420	10,990	12,870	13,980	12,660	11,230	13,410
1970	17,950	23,520	40,300	37,550	13,040	17,700	13,260	17,080	12,970	10,390	15,530	14,890
1971	31,000	38,500	67,350	34,600	30,500	16,070	20,730	25,340	14,280	12,920	12,150	31,410
1972	43,100	41,640	32,140	19,690	14,680	17,280	17,010	13,190	10,410	9,757	10,420	33,670
1973	46,530	59,330	44,480	70,500	38,150	39,460	18,100	18,340	13,670	11,730	12,690	17,020
1974	42,740	58,880	25,820	41,730	18,450	15,790	11,920	14,810	14,760	10,550	10,430	20,270
1975	37,700	53,890	65,070	69,540	26,700	27,620	26,990	29,100	16,590	27,470	23,190	21,920
1976	31,850	33,580	38,920	28,970	36,340	28,700	20,190	13,870	12,480	15,000	18,030	42,260
1977	39,770	22,150	53,120	37,910	14,530	11,890	9,815	12,020	11,240	10,110	25,580	18,580

1978	49,090	42,730	46,070	25,480	36,170	17,840	11,530	19,150	11,610	9,527	8,570	9,401
1979	20,660	41,280	45,030	55,480	26,430	14,950	13,460	12,140	13,490	14,210	16,540	15,820
1980	19,990	25,840	64,040	62,500	33,270	17,440	14,060	11,790	9,669	9,110	9,050	9,096
1981	9,065	28,660	16,030	23,920	10,410	10,210	9,658	9,265	9,066	7,104	5,614	7,614
1982	28,380	48,740	22,190	24,460	18,200	14,020	15,950	21,140	13,380	12,400	12,720	35,630
1983	37,210	50,480	58,760	58,340	22,480	19,620	17,130	13,310	13,130	12,640	14,560	47,220
1984	40,870	37,870	51,160	37,170	32,390	17,490	15,610	30,150	15,060	10,840	11,010	13,650
1985	13,160	32,570	21,360	15,080	12,130	9,877	9,476	13,940	12,430	9,864	11,010	21,760
1986	19,370	29,700	29,460	13,980	9,530	8,779	7,441	5,259	6,421	5,978	12,210	20,850
1987	36,850	36,600	46,000	27,550	15,390	18,900	19,070	11,860	10,640	8,826	7,137	9,250
1988	19,930	24,160	23,570	19,440	15,340	9,377	6,510	4,750	9,477	11,330	11,020	10,530
1989	11,400	10,420	17,420	28,970	14,550	25,080	33,540	15,680	14,270	20,790	18,900	33,180
1990	50,900	53,640	66,920	27,770	17,090	16,380	9,618	8,677	7,912	7,885	9,127	9,733
1991	18,120	30,650	45,400	25,380	38,170	22,540	26,190	21,870	17,530	12,770	9,976	14,860
1992	23,300	39,120	37,700	20,920	12,840	13,170	12,640	12,910	13,740	13,500	31,790	43,530
1993	47,710	33,640	52,080	39,770	21,100	12,890	11,810	11,050	9,566	9,720	13,270	15,220
1994	17,920	33,200	34,750	27,340	15,860	14,630	87,780	31,950	25,440	30,370	21,870	33,930
1995	27,860	57,610	44,600	20,750	15,320	14,430	11,590	11,580	10,140	15,300	20,950	19,950
1996	25,920	48,680	52,220	29,000	19,360	14,450	12,670	10,780	11,020	13,350	11,420	15,720
1997	26,930	39,130	32,780	17,910	22,140	18,950	17,290	14,310	11,180	11,480	19,660	51,660
1998	49,810	67,310	90,330	44,750	28,840	13,010	13,200	12,450	14,560	18,640	15,900	11,510
1999	15,880	22,680	17,280	10,880	8,807	11,040	12,040	10,870	6,548	5,727	6,246	7,576
2000	11,550	16,650	14,570	17,330	8,413	4,826	5,117	5,806	5,889	5,659	6,361	10,300
2001	14,690	11,990	57,190	30,860	11,560	18,600	11,150	9,585	7,173	6,130	5,975	7,337
2002	9,036	13,770	14,770	13,890	8,326	6,578	6,084	5,735	6,991	8,206	17,300	20,130
2003	15,860	23,760	48,700	32,950	43,040	37,120	35,360	25,700	13,970	12,050	13,310	16,790
2004	17,680	30,020	16,390	11,510	9,885	9,458	12,740	9,998	28,410	16,400	20,490	24,730
2005	21,100	24,350	41,760	71,790	21,740	25,520	56,320	32,350	15,090	10,360	11,840	18,430
2006	25,040	23,450	26,530	16,120	13,770	6,953	5,773	5,738	6,969	6,169	12,120	9,153
2007	21,310	18,940	19,490	13,540	6,869	5,153	5,351	5,154	5,343	5,133	4,976	5,981
2008	14,770	28,410	24,020	18,240	9,048	5,405	5,863	13,520	8,945	7,415	10,630	29,420
2009	17,650	11,400	37,120	66,960	22,220	14,520	8,245	8,641	21,890	22,640	36,440	74,950
2010	54,220	61,170	41,840	19,460	29,570	14,130	9,203	8,097	5,977	7,158	7,724	9,836
2011	10,820	20,050	21,960	19,640	7,521	4,781	6,244	5,484	5,734	5,346	5,651	5,196
2012	11,310	11,050	16,240	9,513	5,352	5,525	5,498	5,438	5,212	5,381	5,316	5,418
2013	8,890	45,380	38,270	22,010	21,270	15,220	37,090	32,960	14,870	10,090	9,465	26,760
2014	32,740	35,710	30,270	61,730	29,560	13,490	11,280	8,968	8,759	9,992	10,230	16,630
2015	25,190	20,350	24,850	28,190	16,070	13,080	9,486	8,474	8,723	10,330	28,280	49,810
2016	67,800											
Mean of monthly Discharge	27,100	32,600	39,200	33,400	21,000	15,900	16,500	14,600	12,000	12,000	13,300	20,500

** No Incomplete data have been used for statistical calculation

USGS Surface-Water Monthly Statistics for Georgia

Click to hide state-specific text

- USGS Water Resources of Georgia: the place to start for all USGS water information in Georgia.
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- NEW Statewide Rainfall Map
- Sign up for custom Water Alerts by text or email

The statistics generated from this site are based on approved daily-mean data and may not match those published by the USGS in official publications. The user is responsible for assessment and use of statistics from this site. For more details on why the statistics may not match, click here.

USGS 02356000 FLINT RIVER AT BAINBRIDGE, GA

Available data for this site: Time-series: Monthly statistics GO

Decatur County, Georgia Hydrologic Unit Code 03130008 Latitude 30°54'41", Longitude 84°34'48" NAD27 Drainage area 7,570 square miles Gage datum 57.7 feet above NAVD88	**Output formats** HTML table of all data Tab-separated data Reselect output format

00060, Discharge, cubic feet per second,												
YEAR	Monthly mean in ft3/s (Calculation Period: 1907-10-01 -> 2015-03-31)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1907										7,821	6,075	17,670
1908	22,450	25,870	18,610	19,260	20,980	8,319	7,865	7,026	6,972	4,995	5,294	5,889
1909	6,254	11,820	19,580	10,510	10,080	6,521	6,316	6,219	4,219	3,795	3,670	4,277
1910	4,580	7,308	10,030	7,203	5,256	5,372	7,040	5,052	4,369	3,307	3,233	3,762

1911	5,323	4,701	4,033	5,727	3,896	3,203	3,905	4,077	3,142	3,304	4,173	10,390
1912	23,840	17,690	31,680	30,650	20,290	12,650	12,290	10,440	7,644	9,330	9,348	9,784
1913	10,580	13,320	34,380	18,380	8,340	7,800	6,786	7,501	6,436	5,175	5,004	5,102
1928										10,210	6,486	6,787
1929	10,660	17,940	59,990	16,920	14,710	9,943	8,150	6,362	5,217	17,330	9,530	10,880
1930	11,360	15,230	15,590	14,450	7,445	5,920	4,836	5,775	6,080	4,706	12,960	10,350
1931	10,590	8,415	8,463	8,034	8,259	3,625	3,700	5,123	3,039	2,809	2,593	4,034
1932	10,400	8,856	9,333	6,734	4,879	6,198	6,179	7,726	3,916	4,532	4,867	7,141
1933	12,160	16,400	16,390	13,050	8,108	5,616	5,465	4,591	4,598	3,645	2,991	3,879
1934	4,081	4,700	11,650	7,111	7,084	8,840	5,799	4,731	3,867	4,106	2,933	4,093
1935	4,627	5,165	9,326	7,338	4,507	2,893	4,031	4,364	5,495	3,111	3,180	3,532
1936	19,530	23,140	11,340	26,840	7,201	4,781	4,988	10,570	4,729	7,184	4,767	10,490
1937	12,920	15,680	14,190	16,560	12,090	5,898	6,577	5,855	5,982	5,626	6,467	6,517
1938	6,611	5,626	5,900	16,760	6,408	6,035	6,211	5,416	3,320	3,157	3,335	4,139
1939	5,071	9,496	20,540	12,580	8,183	7,649	6,839	8,162	6,204	4,908	3,565	4,259
1940	7,957	15,560	11,340	10,620	6,367	5,170	10,910	5,881	3,958	3,114	4,702	5,792
1941	7,458	6,585	8,071	7,489	4,357	3,332	5,708	4,237	3,128	4,167	3,406	8,976
1942	16,620	13,280	22,020	12,870	6,410	6,995	6,863	7,631	5,375	5,397	5,177	6,927
1943	17,880	13,830	22,750	14,330	9,863	7,438	6,479	5,533	4,122	3,704	4,080	5,065
1944	7,919	8,212	22,240	33,700	18,340	7,570	6,922	6,153	6,243	4,472	4,619	5,968
1945	6,480	9,647	10,930	7,362	12,280	5,709	7,242	7,106	6,037	5,110	5,744	9,903
1946	23,240	15,000	14,180	16,480	14,950	11,400	9,116	9,067	6,526	5,762	6,006	5,251
1947	10,810	8,701	18,780	18,130	11,470	9,878	8,016	8,427	5,512	5,067	12,180	19,320
1948	14,850	21,010	28,660	28,660	8,958	7,232	11,350	9,763	6,053	7,979	7,611	27,100
1949	18,740	20,500	15,250	13,990	14,310	8,381	10,520	9,443	6,611	5,282	4,792	5,635
1950	5,521	6,258	9,716	8,079	5,759	5,835	4,252	3,984	5,203	3,311	3,338	4,519
1951	5,917	5,014	5,990	8,709	4,859	3,182	3,738	3,289	2,764	3,021	4,639	6,744
1952	7,470	11,920	21,750	12,610	7,239	6,046	3,509	3,938	3,976	3,227	3,165	4,205
1953	8,166	10,650	13,530	11,670	16,890	6,264	9,999	6,116	6,653	9,120	4,930	17,270
1954	14,630	8,852	8,714	7,903	5,293	3,739	3,337	3,052	2,409	2,217	2,424	3,627
1955	4,833	5,895	4,585	8,124	4,297	3,123	4,177	4,100	3,167	2,348	2,600	3,226
1956	3,161	8,371	11,030	10,330	4,713	3,263	4,148	3,452	2,970	5,278	3,582	5,641
1957	8,256	7,049	8,586	15,210	11,040	6,119	4,408	4,250	4,433	7,086	8,049	14,330
1958	10,930	14,380	21,960	19,440	10,090	7,650	9,262	6,871	3,873	3,920	4,095	5,003
1959	6,755	15,890	19,490	14,690	8,653	13,110	6,669	5,563	5,100	6,187	7,210	7,214
1960	9,289	20,030	17,130	26,580	8,697	5,900	5,610	5,583	4,170	5,226	3,768	4,113
1961	4,711	8,123	18,800	23,940	12,890	8,302	7,545	5,831	5,052	3,023	3,315	8,509
1962	11,220	10,350	16,470	20,000	6,604	4,634	4,098	3,468	3,538	4,162	4,499	4,561
1963	10,820	13,020	11,640	7,105	7,059	6,891	7,887	5,027	3,107	4,353	3,203	6,628
1964	21,050	19,980	24,520	22,270	18,630	6,545	11,190	11,580	7,073	13,460	7,680	14,490
1965	16,200	21,290	19,920	15,280	7,204	10,640	9,926	7,384	5,638	7,291	4,971	6,358
1966	13,180	21,340	30,610	10,940	11,390	9,776	5,474	6,564	4,176	4,936	7,318	6,713
1967	18,220	15,420	9,887	6,240	5,149	5,300	6,780	5,527	5,988	3,805	4,975	8,236

1968	9,547	6,175	9,303	5,783	4,582	3,702	3,596	3,339	2,488	2,932	3,865	4,809
1969	5,197	6,191	8,465	8,967	7,435	4,620	3,886	4,661	4,274	3,727	3,025	4,494
1970	6,381	8,360	12,720	17,170	5,717	8,534	5,113	6,812	4,401	3,561	4,896	5,727
1971	11,610	13,870	24,260	15,160	13,800	6,979	8,328	9,418	5,558			
2001								2,865	2,726	2,098	1,897	2,989
2002	3,355	4,934	6,175	5,757	3,314	2,066	2,241	1,839	2,091	3,707	6,643	6,011
2003	6,825	8,449	17,980	13,000	14,550	12,920	10,790	10,460	5,660	4,326	4,506	5,134
2004	5,136	11,500	7,371	4,429	4,454	4,616	4,646	3,534	12,390	8,107	7,015	8,226
2005	7,419	9,742	13,330	29,610	9,127	12,530	20,480	10,930	5,852	4,524	4,259	6,877
2006	9,619	9,178	10,960	5,959	4,400	2,479	2,030	2,331	2,555	2,242	3,797	3,469
2007	7,745	7,796	7,528	5,245	2,545	2,032	2,145	1,807	2,149	1,853	1,694	3,008
2008	7,240	10,300	10,070	7,147	3,712	2,196	2,225	4,218	4,013	3,125	3,634	10,820
2009	6,829	4,988	10,780	29,030	9,774	6,085	3,229	3,485	5,399	6,540	10,960	24,110
2010	20,710	24,030	15,700	9,289	11,220	6,980	4,219	3,459	2,930	2,602	3,689	3,562
2011	4,662	8,605	7,407	6,916	2,746	1,739	2,297	1,836	1,422	1,643	1,672	2,592
2012	3,906	4,510	5,073	3,134	2,170	2,043	1,410	1,658	1,683	1,875	1,655	2,091
2013	3,463	13,660	16,610	9,371	7,373	5,800	10,650	11,870	5,749	3,362	3,318	7,532
2014	13,450	14,180	13,150	24,070	13,450	6,203	4,262	2,696	3,083	3,751	4,043	6,818
2015	11,160	9,256	11,910									
Mean of monthly Discharge	10,100	11,800	15,200	13,700	8,740	6,330	6,350	5,790	4,640	4,860	4,890	7,380

** No Incomplete data have been used for statistical calculation

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ATTACHMENT 3

Excerpts from the Expert Report of Peter Shanahan, Ph.D., P.E. (Feb. 29, 2016)

SUMMARY OF OPINIONS REGARDING RESERVOIR OPERATIONS IN THE ACF RIVER BASIN

FEBRUARY 29, 2016

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SUMMARY OF OPINIONS REGARDING RESERVOIR OPERATIONS IN THE ACF RIVER BASIN

1. SUMMARY OF OPINIONS AND SUMMARY STATEMENT

A. OPINIONS

This report provides a summary of expert opinions developed by Peter Shanahan, Ph.D., P.E., with respect to the U.S. Army Corps of Engineers' operations of reservoir projects in the Apalachicola-Chattahoochee-Flint (ACF) River Basin and computer models used to simulate those operations. I report on analyses of the operations of the ACF River Basin System as described in reports prepared by the U.S. Army Corps of Engineers and as shown by the actual records of flows and storage in the system. I also compare the actual system operations against the system operation simulated by the HEC-ResSim model of the ACF River Basin System. In particular, I examine a proposition put forward by the State of Georgia (2015), that water conserved in the Flint River Basin during periods of low river flow would be simply offset by the Corps of Engineers storing more water in the federal reservoir projects on the Chattahoochee River with the result of no material benefit to the State of Florida.

The major opinions derived from my analyses are the following:

1. 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. The actual behavior of the system as revealed through flow and storage records confirms that this is indeed how the system is operated in practice. Trading conserved water for increased storage during the summer and fall of dry years would be inconsistent with this policy.

2. 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 during the summer and fall of particularly dry years in the Flint River or lower Chattahoochee River for additional water to be stored in Lake Lanier. There is not enough inflow into Lake Lanier to effect this sort of trade between such downstream conservation and upstream storage.

3. The flow and storage records show that the reservoirs downstream of Lake Lanier are not used to store water during the summer and fall but instead are operated in pass-through mode in which the water that flows into the reservoir is passed through and then released

from the reservoir. This conclusion also holds true for the inflow into Lake Seminole from the Flint River Basin.

4. The rules and guidelines that govern the operation of the ACF River Basin System provide the Corps of Engineers a measure of flexibility to exercise judgment and discretion in carrying out the system operations. This discretion has been exercised by the Corps in a manner that is not consistent with Georgia's offset or trading theory.

5. Certain of the rules and guidelines that govern the operation of the ACF River Basin System have been encoded in a simulation model of the system created using the HEC-ResSim model, but that model is unable to capture the discretionary decisions made by the Corps of Engineers in its actual operations.

6. Records of the ACF River Basin System during dry years show that the Corps of Engineers exercises its judgment in ways that cause consistent departures from the behavior predicted by the HEC-ResSim model. Compared to the behavior predicted by HEC-ResSim model, the Corps stores more water in its reservoirs during the spring and releases more water from those reservoirs during the summer and fall.

B. SUMMARY STATEMENT

This report utilizes historical records of flow and reservoir water-surface elevations in the Apalachicola-Chattahoochee-Flint (ACF) River Basin to evaluate how the system is operated by the Corps of Engineers. While the Corps has provided detailed and explicit descriptions for its planned mode of future operation in the Draft Environmental Impact Statement for the Update of the Water Control Manual (USACE, 2015), there is no comparably description for current and past modes of operation and those must be inferred from the historical records.

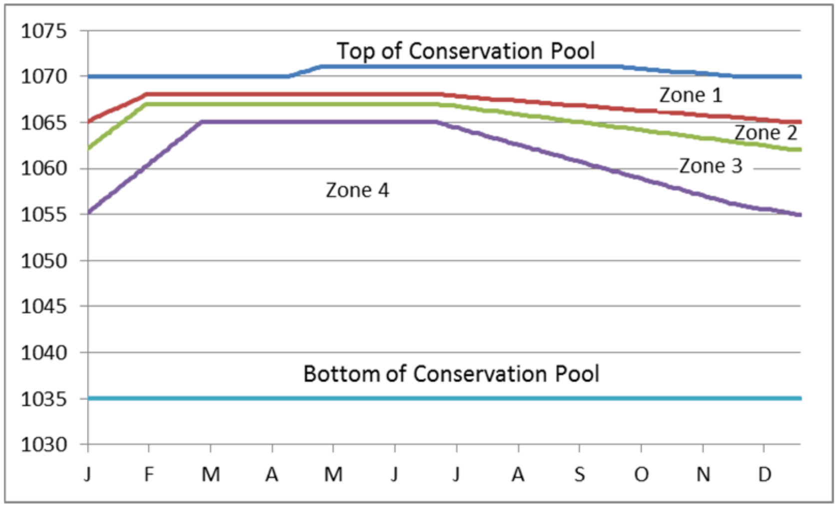
The ACF Basin System consists of five federal reservoir projects that are operated by the U.S. Army Corps of Engineers (Figure 1). The system includes, from upstream to downstream, Buford Dam (which impounds Lake Lanier), West Point Dam and Lake, W.G. George Dam and Lake, George Andrews Dam, and Jim Woodruff Dam (which impounds Lake Seminole). Of these five projects, the three upstream reservoirs provide the vast majority of the system's storage capacity. The majority, 65%, of the usable storage capacity lies in Lake Lanier with the remainder in West Point Lake (19%) and W.F. George Lake (15%).

Figure 1. Map of ACF Basin (USACE, 2004)

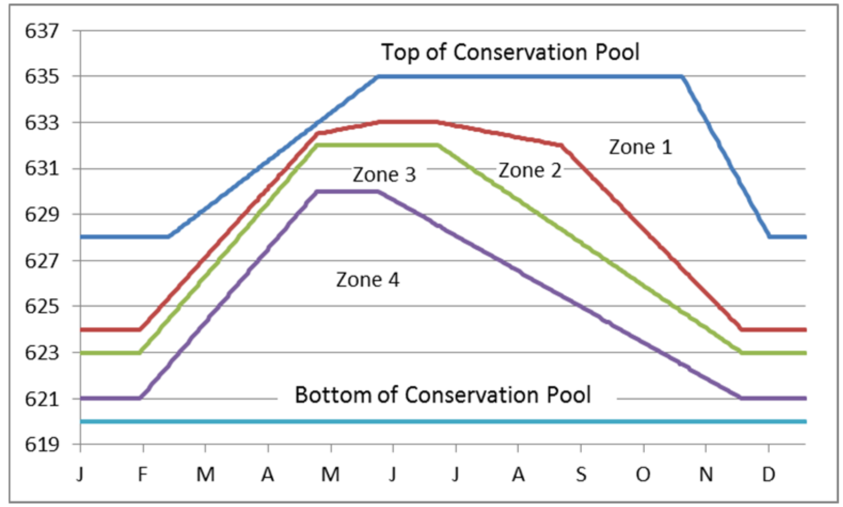
There are some inherent inconsistencies in the ACF Basin System. Lake Lanier provides the majority of the system's storage capacity, but lies at the headwaters of the basin and is fed by runoff (which occurs predominantly during winter and spring) from only 5% of the ACF watershed's area. Further, the 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 is filled by a comparatively modest and intermittent inflow but drained by one of the basin's largest and most insistent demands. The remaining two storage reservoirs provide only marginal additional capacity: only 38% of the basin's drainage area lies upstream of at least one of those reservoirs, the two reservoirs provide only 35% of the system's storage capacity, and the reservoirs lie downstream of Metropolitan Atlanta's demands.

In response to these geographical constraints, the Corps of Engineers has developed the following operational strategy. The Corps takes advantage of the typical abundance of rainfall in the winter and early spring to fill the storage reservoirs as much as possible while still retaining needed storage capacity to mitigate potential springtime floods. The water accumulated during the wet time of year is then dispensed during the drier summer and fall. The Corps draws on water stored in the downstream-most reservoirs first and taps the upstream reservoirs later, keeping more water upstream where there is the most flexibility for dispensing it. This mode of operation is captured in so-called guide curves set for each reservoir by the Corps of Engineers (Figure 2). The guide curves specify the desired water level in each reservoir as a function of the time of year, with higher levels in the summer and lower levels in the winter and spring.

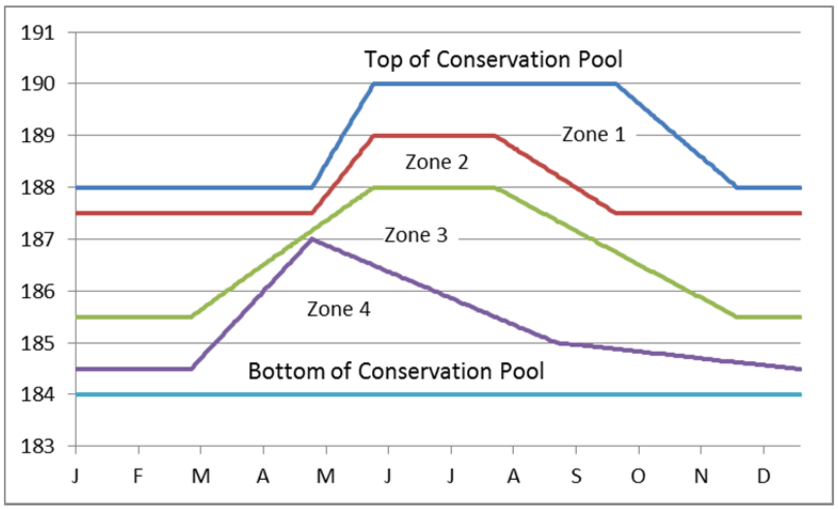
How the reservoirs are operated is informed by guidelines and procedures established by the Corps of Engineers. The Corps operates the system so as to balance benefits among the authorized purposes of the projects, which include flood control, hydropower production, maintenance of navigation, conservation of fish and wildlife, recreation, preservation of water quality, and supply of water for municipal, industrial, and agricultural use. Some of these requirements 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. A minimum release of 670 cfs is required from West Point Dam for protection of downstream water quality.



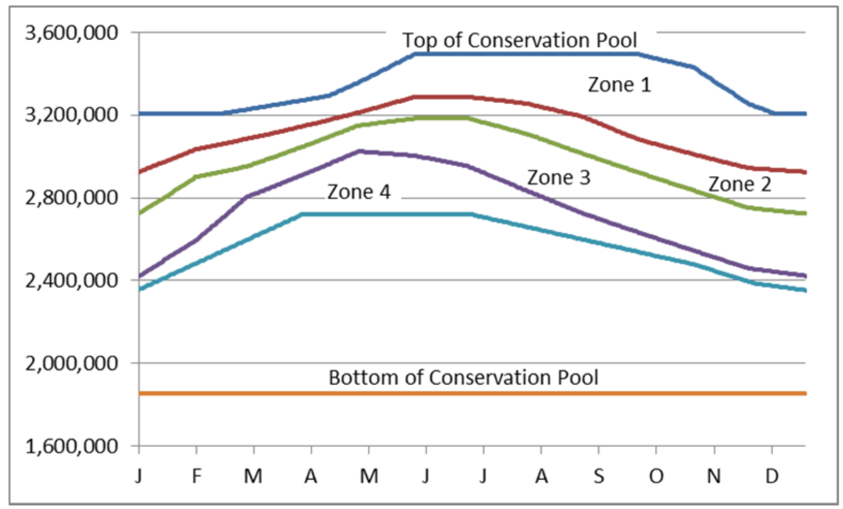
a. Buford Dam and Lake Lanier



b. West Point Dam and Lake



c. Walter F. George Dam and Lake



d. Composite storage

Figure 2. Guide curves and action zones for ACF reservoirs (USACE, 2012b, pg. 21-22, 29)

Releases from Jim Woodruff Dam are specified in the 2012 Revised Interim Operation Plan (2012 RIOP) and are designed 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), and total inflow to the basin. 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.

While the reservoir guide curves, action zones, and minimum flow requirements set boundaries within which the ACF Basin system must be operated, they leave latitude for the Corps of Engineers to operate as it deems appropriate within those boundaries. A review of the historical record shows that the Corps exercises such discretion. A measure of that discretion is afforded by comparing the Corps' computer simulations of the system with the actual historical record. The Corps has used the HEC-ResSim computer program to simulate the system under the 2012 RIOP and the similar 2008 RIOP. As is necessary in a computer code, the model of the system makes precise specifications for how the system will be operated as a function of system conditions. Comparison of historical records to model results for Lake Lanier shows that the Corps has tended to store more water in the spring and early summer of dry years than HEC-ResSim rules would indicate—Figure 3 shows an example for the year 2011. Lake Lanier is fuller than HEC-ResSim predicts during the early part of the year, but then releases more water than predicted by HEC-ResSim and ends the year with less stored water than HEC-ResSim predicts. This practice is evident in dry years prior to the 2008 RIOP and has been generally continued in dry years since 2008.

Waters from the part of the Chattahoochee River Basin below the W.F. George project and the entirety of the Flint River Basin cannot be stored as can waters upstream of the storage reservoirs. Although the Chattahoochee and Flint Rivers both flow into Lake Seminole, the lake has limited storage and operates as a "run-of-the-river" project—that is, water that flows into Lake Seminole simply runs through the lake and is released rather than stored. As a consequence, water from 62% of the ACF's watershed area is essentially unregulated. Nonetheless, it is worth examining the theoretical possibility than water from this lower part of the basin could be traded for water that might otherwise be released from the storage reservoirs. For example, if conservation measures were instituted in the agricultural areas of the Flint River Basin such that the flow in the Flint was increased, could that "extra" water somehow be used to reduce releases from the upstream reservoirs?

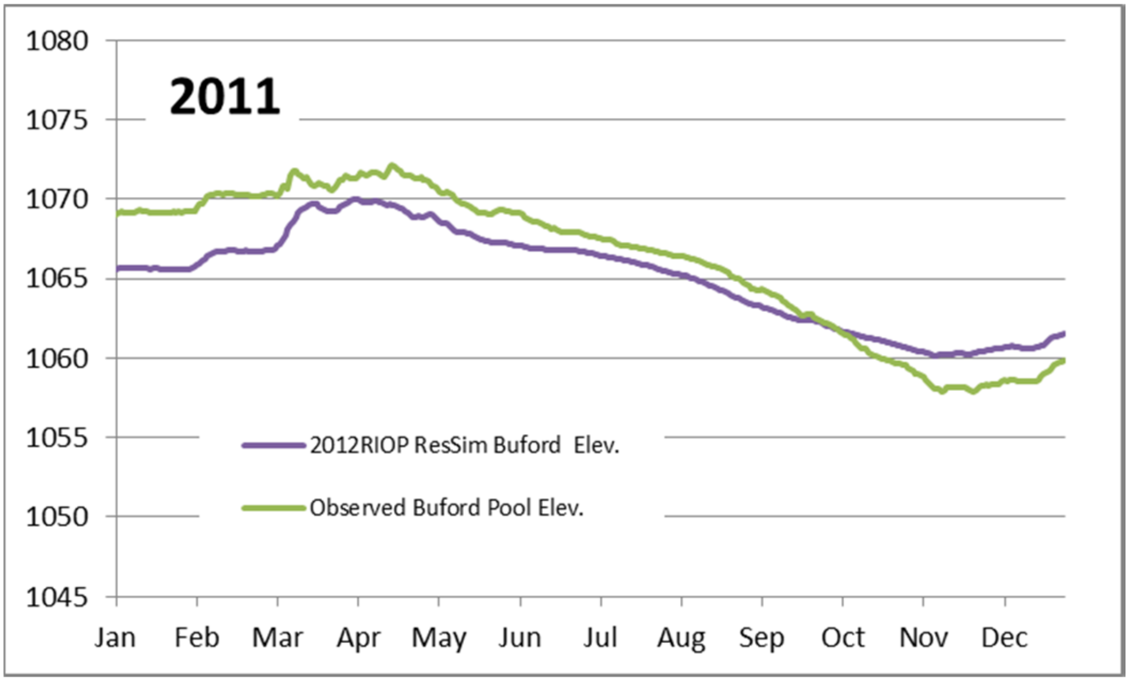


Figure 3. Comparison of observed water levels in Lake Lanier (in feet above mean sea level) with those predicted by the U.S. Army Corps of Engineers HEC-ResSim models

I answered this question 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 in the rivers for reduced releases from the storage reservoirs, that practice would show up in the "holdout" of the storage reservoirs. Holdout is the difference between reservoir inflow and reservoir outflow—it is the amount of incoming water retained in the lake and not immediately passed 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 stormflow on the Flint River was used by the Corps as a means to reduce reservoir outflows, then holdout would be positively correlated with streamflow on the Flint River—that is, holdout would be higher when Flint River flow was higher and would be lower when Flint River flow was lower. A statistical examination of the correlation between combined summertime holdout in the storage reservoirs and flow from the Flint River Basin shows that no such correlation exists (Figure 4). Evidence in Figure 4 of this lack of correlation is the low slope of the red least-squares regression line, which shows that holdout does not increase as flow on the Flint River increases. Additional evidence is the "dart-board" appearance of the data points and low value of the coefficient of determination ($R^2 = 0.0017$). If the Corps stored water in the reservoirs as hypothesized by the State of Georgia, the regression correlation line in Figure 4 would slope much more strongly upwards to the right and the data points would be less scattered. This is strong evidence that the Corps has not operated in the past so as to trade Flint River flow for upstream storage.

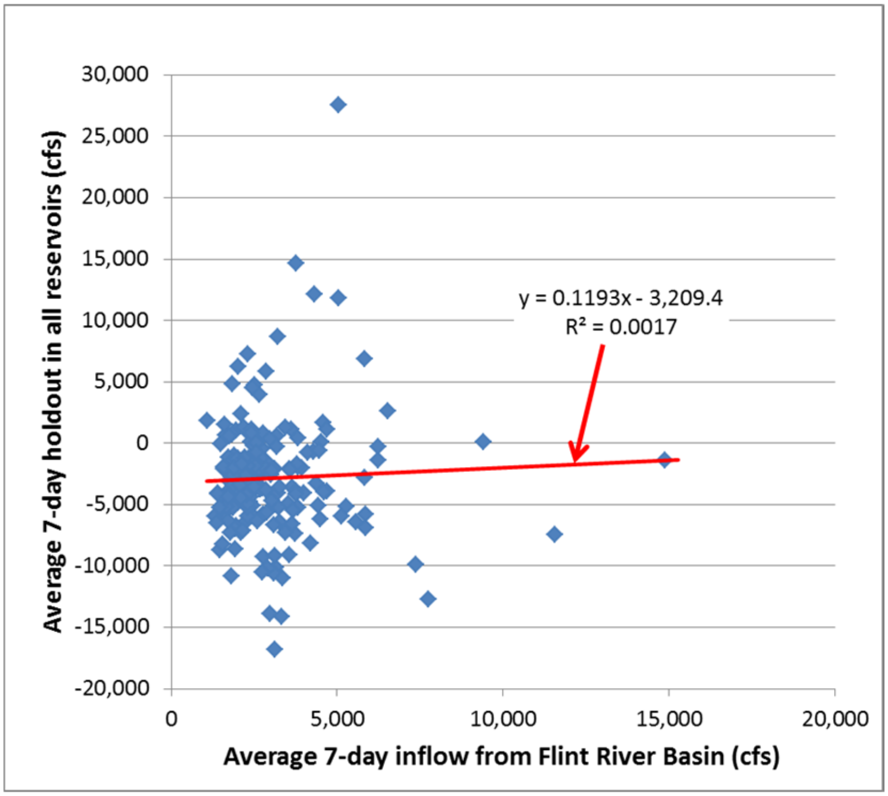


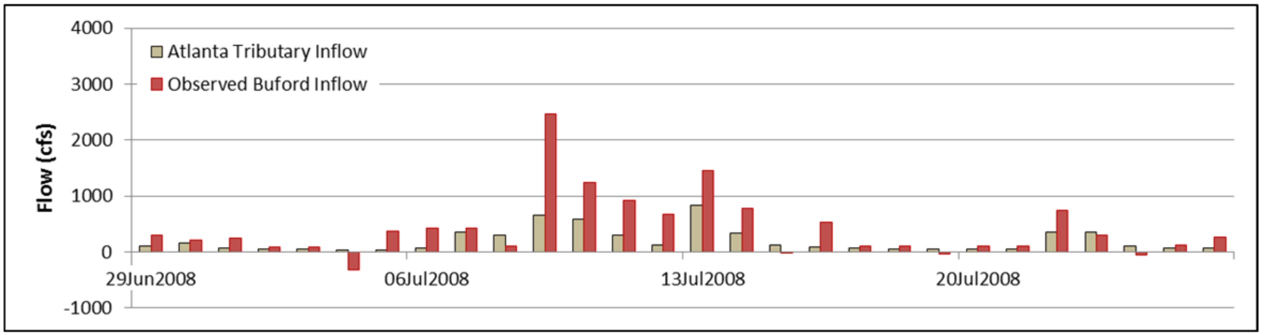
Figure 4. Correlation between 7-day holdout in storage and average inflows from the Flint River Basin during June through September from 1980 through 2012

I also examined the question as to whether extra downstream water could somehow be stored upstream by considering the physical possibility of trading water flowing in the downstream portions of the basin, such as the Flint River, for water stored in the upstream portions of the basin. The most desirable place to store water is in Lake Lanier, upstream of the large and continuous demands of Metropolitan Atlanta. The capability to store in Lake Lanier water conserved on the Flint River obviously cannot rely upon the physical movement of Flint River water. Lake Lanier is too distant and at too high a relative elevation to move the water from the Flint to Lake Lanier economically and there is no infrastructure available today to accomplish this. Rather, water conserved on the Flint would need to be traded for water conserved at Lanier. However, 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 above, put a floor under the amount of water released from the dam, but any amount in excess of that floor could in theory be traded for water conserved downstream. (Exceptions are those occasions when the reservoir is filled to the level specified by its guide curve and water must be released at greater than the minimum release rates to prevent overfilling the reservoir.) I therefore completed calculations of the extent to which releases from Lake Lanier in past dry years have exceeded the minimum required releases 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. I found that the potential to conserve water is minimal because the discretionary releases from Lake Lanier are small during dry years. In particular, 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. The average amount of water that could be traded over the twelve driest years since 1980 was only 341 cfs. Even these minimal amounts exceed 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.

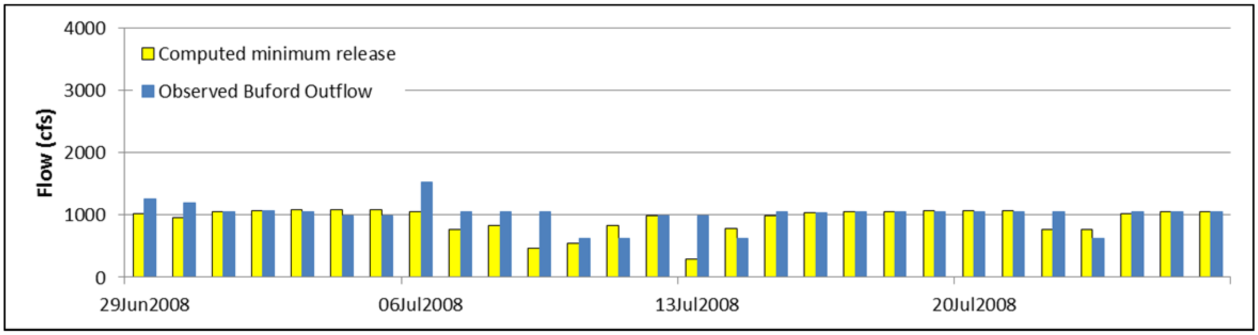
Figure 5 illustrates these relationships during a four-week period beginning on Sunday, June 29 and continuing through Saturday, July 26 in the very dry year of 2008. Figure 5a shows the inflows of surface water to the Chattahoochee River in the Atlanta area. The red bars show daily net inflow to Lake Lanier and the light brown bars show daily flows from local tributaries into the stretch of the Chattahoochee River between Lake Lanier and Peachtree Creek. Both sets of flows show an up-and-down pattern. On many days there is minimal inflow to Lake Lanier and on some (for example, July 4) there is actually negative flow, showing that withdrawals and evaporation from Lake Lanier were greater than the inflows. There are taller bars between July 9 and 14—this uptick in flow occurred following a stretch of rainy days between July 5 and 10.

The shorter light brown bars in Figure 5b show that the area downstream of Lake Lanier experiences similar weather as the area above Lake Lanier and that local tributary inflow into the Chattahoochee River follows a generally similar pattern as the flow into Lake Lanier. On days during which the local tributary inflow was higher, there was less need to release water from Lake Lanier, since the necessary minimum flow of about 1,000 cfs at Peachtree Creek could have been at least partially met by local inflows rather than Lake Lanier releases. This is shown in Figure 5b. The yellow bars in Figure 5b show what I calculate to be the minimum release needed from Lake Lanier after taking into account the local tributary inflows. On most days the minimum needed release is about 1,000 cfs, but on some days, such as the rainy stretch during the second week of July, smaller releases are needed. The actual amounts released by the Corps of Engineers from Lake Lanier during July 2008 are also shown in Figure 5b with blue bars. On most days the actual release is about the same as the minimum needed release, but on a few days the actual release is higher.

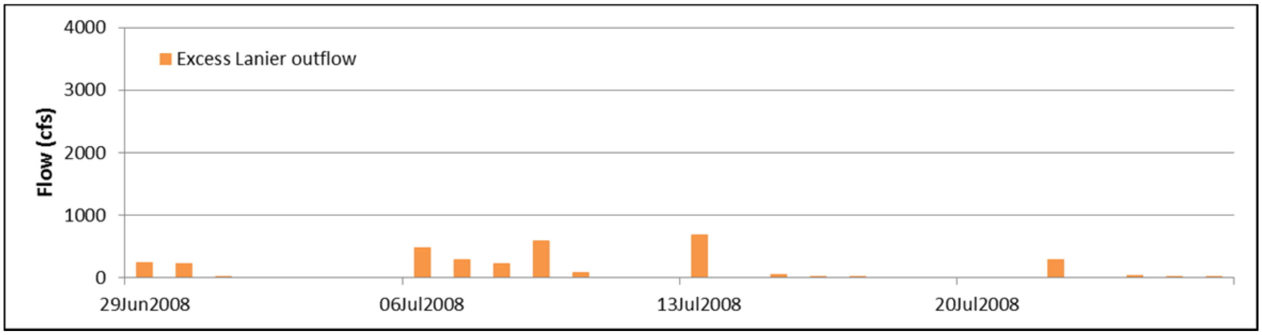
The "discretionary release"—the amount of water released from Lake Lanier that was greater than needed to ensure a minimum flow of 750 cfs at Peachtree Creek—is shown in Figure 5c. The orange bars in Figure 5c equal the difference between the blue and yellow bars in Figure 5b when the blue bar is greater than the yellow bar—i.e., when the actual release is greater than the minimum required release. The orange bars thus represent the water that was released from Lake Lanier that could have been held back. This is the only water for which it was physically possible to have traded water in Lake Lanier for water conserved in the Flint River. On most of the days, there is no orange bar. On these days, the release from Lake Lanier was equal to the amount needed to meet downstream minimum flow requirements. There was no "extra" water in Lake Lanier that could have been conserved and no possibility to trade water conserved elsewhere in the basin for water held back in Lake Lanier.



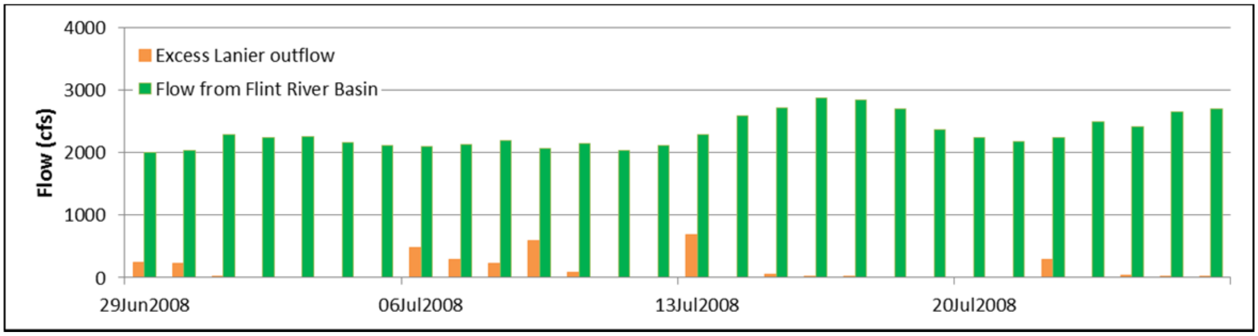
a. Inflows to Lake Lanier and Chattahoochee River



b. Computed minimum release and observed release from Lake Lanier



c. Discretionary release from Lake Lanier



d. Inflows to Lake Lanier and Chattahoochee River

Figure 5. Inflows and outflows to Lake Lanier during July 2008

Figure 5d shows a comparison of the discretionary release from Lake Lanier with the flow in the Flint River during the same time period. The flow in the Flint is considerably greater than the discretionary release from Lake Lanier. This shows the fallacy in the notion that water conserved on the Flint River can somehow be traded for water conserved in Lake Lanier. Even if somehow the flow on the Flint River were increased by conservation, there simply is not enough water being released (or flowing into) Lake Lanier to carry out this hypothetical trading.

The conclusion to be drawn from this analysis is that 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 5% of the watershed area. This mismatch between contributing area and storage capacity 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.

In summary, expectations that water conserved in the lower reaches of the ACF Basin can somehow be stored in the upstream storage reservoirs are misguided in several respects. First, this type of operation would represent a significant change from how the Corps has operated in the past—there is no expectation or indication that the Corps would make such a change in the future. Such a change would in fact skew the balance in the Corps' operations toward water supply and away from the other purposes of the ACF Basin System. Second, it is a physical impossibility to hold back appreciably more water in Lake Lanier (where storage is most needed) during dry years (when storage is most needed). Third, storage downstream of Lake Lanier would accomplish little: there is less demand for water downstream on the Chattahoochee and there would be little purpose to hoarding water in West Point Lake and W.F. George Lake during a dry summer.

2. PERSONAL QUALIFICATIONS

I am a consulting hydrologist and environmental engineer. My business is incorporated in Massachusetts as HydroAnalysis, Incorporated. HydroAnalysis is located at 481 Great Road, Suite 3, Acton, Massachusetts. I founded HydroAnalysis in January 1988 and this business was my primary employment until September 2004. Between September 2004 and June 2013, I divided my working time more or less equally between HydroAnalysis and a second position at MIT. Since June 2013, HydroAnalysis is again my primary employer.

I am retired from a position as Senior Lecturer in the Department of Civil and Environmental Engineering at the Massachusetts Institute of Technology (MIT) in Cambridge, Massachusetts. I was appointed a part-time Lecturer at MIT in September 1996 and was appointed a Senior Lecturer with full-time academic-year duties beginning in September 2004. At MIT, I taught graduate and undergraduate courses on environmental engineering, hydrology, and the fate and transport of chemicals in the environment. I also supervised research

ATTACHMENT 4

Excerpts from the Expert Report of Peter Shanahan, Ph.D., P.E. (May 20, 2016)

SUMMARY OF OPINIONS REGARDING RESERVOIR OPERATIONS IN THE ACF RIVER BASIN

DEFENSIVE EXPERT REPORT

MAY 20, 2016

Prepared by:

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1. SUMMARY OF OPINIONS AND SUMMARY STATEMENT

This report provides a summary of my expert opinions addressing certain theories advanced by the State of Georgia concerning the U.S. Army Corps of Engineers' ("Corps") operations of federal reservoir projects in the Apalachicola-Chattahoochee-Flint ("ACF") River Basin. Based on my review of data on actual Corps operations, as described further below, I conclude that:

1. The Corps consistently releases from Woodruff Dam more water than is required by the Revised Interim Operation Plan (RIOP)—whether or not there are local storms. This is true under both the 2008 and the 2012 RIOP, both of which I analyzed for this report for the years each was applicable.

2. The Corps' releases above the RIOP's minimum releases cannot be explained by a theory that the Corps only seeks to release some minimal 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 avoid the minimum releases under the RIOP.

3. Local inflows to West Point Lake and W.F. George Lake greatly exceed each reservoir's conservation-storage capacity. This means that, if Georgia conserves water on the Flint River, the Corps would have little or no reason to respond by releasing less from these reservoirs.

2. ENGAGEMENT AND QUALIFICATIONS

I have been retained to review information and formulate opinions regarding reservoir operations in the ACF basin. I am being compensated at the rate of $360 per hour for my time in completing my review and any testimony that may be required. Compensation is not contingent upon the outcome of the litigation. A description of my qualifications is included in my February 29, 2016 report and a copy of my curriculum vitae is included as Attachment 1 of this report. A list of my expert testimony during the past five years is included as Attachment 2.

3. OPINIONS

3.1 The Corps routinely releases more than the minimum specified by the RIOP—whether or not there are local storms

The State of Georgia has presented a theory that "Any 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 the USACE's reservoir operations" (Bedient, 2016a). Georgia's theory is that releases from Woodruff Dam would be no greater than the minimum required under the 2012 Revised Interim Operation Plan (2012 RIOP).

When presented with evidence that the Corps routinely releases more water than the minimum specified by the RIOP, Georgia's expert attributed those releases to rainstorms (Bedient, 2016b, pg. 81). (This seemingly contradicts a statement in his report (Bedient, 2016a, pg. 20-21) that "[F]or 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.")

Contrary to Georgia's expert, historical hydrologic records show that the Corps routinely releases more than the minimum under the RIOP—both when there are rainstorms and when there are not. The year 2008 provides just one example of releases in excess of the minimum under the 2008 RIOP that coincided with a rainstorm. In 2008, a minimum flow of 5,000 cfs was in effect during the entirety of June through September 2008. Despite this, the Corps maintained flows well above 5,000 cfs throughout much of June and July (Figure 1). The observed flow at Chattahoochee fluctuates gently in response to local rainfall as reflected by the occasional upswings in the Woodruff local inflow, but local rainfall alone cannot account for flows above 5,000 cfs. In other words, in 2008, the Corps released water during rainstorms in excess of the RIOP minimum.

At other times, the Corps operated in drought-contingency mode but released more than the RIOP minimum—again, even when there were no apparent storms. As just one example, the Corps formally declared drought operations on May 1, 2012 (USACE, 2012). Composite reservoir storage did not return to Zone 1 until February 26, 2013. Thus, there was an extended period from May 2012 to February 2013 when the RIOP minimum was 5,000 cfs. Hydrographs of basin inflow and local inflow to Woodruff Dam for May through December 2012 (Figure 2) reveal several passing storms including for example one in mid-June. But the Corps released approximately 5,500 cfs at a steady rate from late May through mid-July, rain storms or not. Thus, the Corps maintained flow rates substantially higher than the RIOP minimum for reasons other than flow from passing storms.

In sum, Georgia's theory that the Corps' release of water from Woodruff Dam in excess of the RIOP minimum is due to rainstorms is incorrect. The actual records of the Corps' operations demonstrate that the Corps routinely releases more than the RIOP minimum—both during rainstorms and when there are no rainstorms.

3.2 The above-minimum releases cannot be explained by a theory that the Corps is operating with a buffer or margin of safety

In the ResSim model of the ACF Basin, the 5,000-cfs RIOP minimum is programmed as a release of 5,050 cfs to capture "conservative operations in place to avoid violating the 5,000 cfs minimum flow provision." (HEC, 2014, pg. 36). But the historical record indicates that when operating under the 5,000-cfs minimum, the Corps consistently releases significantly more than the 50-cfs safety margin encoded in ResSim. The amount released in excess of 5,000 cfs cannot be explained by the theory that the Corps is targeting a "margin of safety" of 50 cfs or any other similar number.

Comparing basin inflow to the Corps' actual releases illustrates this. From June 2008 to December 2014, the RIOPs provided for minimum releases of at least 5,000 cfs on many occasions when basin inflow was less than 5,000 cfs. Recorded flow in Apalachicola River at Chattahoochee show that during these periods, the Corps routinely released well above 5,000 cfs. The releases varied from just over 5,000 cfs to nearly 9,000 cfs, indicating that there was not some margin of safety of 25 cfs, 100 cfs, or any other similar number that the Corps was trying maintain.

Figures 3-8 are histograms that show the frequency with which basin inflow and Jim Woodruff releases occurred in the calendar years 2008 through 2015. To construct a histogram, data are "binned"—that is, separated according to magnitude. For Figures 3-8, the bin size is 50 cfs and the lower bound is a greater-than value. For example, the first bin at the far left of the chart would contain values greater than 0 cfs but less than or equal to 50 cfs. Figures 3-8 consider those historical situations in which basin inflow was less than or equal to 5,000 cfs; at these flows, the minimum RIOP release is 5,000 cfs. The record for 2008 includes only June through December, the part of the year during which the 2008 RIOP was in effect. There were no occasions in 2009 when basin inflow was less than or equal to 5,000 cfs. In 2013 there was only one such occasion: on November 14 basin inflow was 4,761 cfs and a flow of 7,880 cfs was released.

Each of Figures 3-8 includes two graphs. The upper graph shows the frequency at which basin inflows less than or equal to 5,000 cfs occurred. The lower graph shows the frequency distribution of releases from Jim Woodruff Dam (as recorded at the Chattahoochee gauge) on the same set of days included in the upper graph. The distance by which bars on the lower graph are to the right of 5,000 cfs shows the extent to which observed flows exceeded the minimum release specified by the RIOP.

The histograms show that the observed flows were typically well above 5,000 cfs. The flow above 5,000 cfs is not a token amount to ensure compliance with the 5,000-cfs minimum. These flows vary—from just over 5,000 cfs to nearly 9,000 cfs—in a manner that is inconsistent with some targeted margin of safety.

Figures 3-8 address instances where basin inflows were below 5,000 cfs and the Corps released more than the 5,000-cfs RIOP minimum. The historical record indicates that there were also many days when the Corps was operating in drought-contingency mode and basin inflows exceeded 5,000 cfs. Under those circumstances, state-line releases often substantially exceeded the 5,000-cfs RIOP minimum. These flow records further refute Georgia's theory that the Corps would maintain flows at 5,000 cfs until drought operations concluded.

Finally, in addition to all the indications of how the Corps uses its discretion, there is more than ample information in the historic and current regulatory documents, including the Biological Opinion (USFWS, 2012), that the Corps has the incentive to maintain flows above the RIOP minimums. The Biological Opinion by the U.S. Fish and Wildlife Service (USFWS) makes clear that a "take" (i.e., killing or other harm) of protected mussels may occur when releases from Woodruff Dam are below 10,000 cfs (USFWS, 2012, pg. 144). According to the 2012 BIOP, affected mussel populations can tolerate mortality that can occur with a minimum flow of 5,000 cfs, but only if such low-flow mortality events occur very infrequently (USFWS, 2012, pg. 142). The 2012 BIOP further provides that the mussel populations can tolerate the mortality associated with extreme low flows at a minimum of 4,500 cfs to the extent such flows occur only once every 69 years. Consultation on a new USFWS Biological Opinion will soon commence, as the current Biological Opinion will expire in 2017 (USFWS, 2012, pg. ii). Any flows lower than 10,000 cfs have the potential to kill mussels, and dropping flow to 5,000 cfs too frequently could cause mortality that calls into question the validity of the RIOP's assumptions, require extensive new analysis, and create new limits on the Corps' operations. These and other factors indicate that the Corps is incentivized to continue to operate the dams to avoid consistent minimum flows.

3.3 Local inflows to West Point Lake and W.F. George Lake greatly exceed each reservoir's conservation-storage capacity

Table 1 illustrates that West Point Lake and W.F. George Lake receive local inflow many times greater than their conservation storage. Thus, the Corps has reasonable assurance that these lakes will be refilled multiple times over the course of a year (USACE, 2015, pg. 4-11). In addition, there are limited local water-supply demands on these reservoirs. This relationship is one factor that allows the Corps to consistently release more from Woodruff than the RIOP minimum.

It also demonstrates that there would be no sound reason for the Corps to try to offset increased flows on the Flint River (such as would occur if Georgia implemented conservation measures) 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).

Table 1. Comparison of ACF reservoir conservative storage
with mean annual inflow

Reservoir	Conservation storage (acre-feet)	Conservation storage (cfs-days)	Mean annual inflow 1976-2013 (cfs)	Mean annual inflow 1976-2013 (cfs-days)	Mean annual inflow as multiple of conservation storage
Lake Lanier	1,987,000	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	5,681	2,074,900	16.8
Total	2,537,210	825,800			

4. OTHER OPINIONS

The preceding text provides a summary of my major opinions regarding the hydrology and reservoir operations of the ACF Basin. I may form additional opinions in light of new information that I may receive.

Peter Shanahan, Ph.D., P.E.

Confidential – S. Ct. 142

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ATTACHMENT 1

PETER SHANAHAN

EDUCATION

1982	Ph.D.	Environmental Engineering	Massachusetts Institute of Technology
1974	M.S.	Environmental Earth Sciences	Stanford University
1973	B.S.	Civil Engineering	Massachusetts Institute of Technology
1973	B.S.	Earth and Planetary Sciences	Massachusetts Institute of Technology

PROFESSIONAL HISTORY

1988-date	HydroAnalysis, Inc.
2004	Tufts University
1996-date	Massachusetts Institute of Technology
1981-1988	ERT, Inc. (now ENSR Corporation)
1980	International Institute for Applied Systems Analysis, Laxenburg, Austria
1978-1981	Massachusetts Institute of Technology
1976-1979	Resource Analysis/Camp Dresser & McKee Inc.
1974-1976	Bechtel, Inc.

AFFILIATIONS

Fellow, American Society of Civil Engineers (Committee on Hydrologic Transport and Dispersion, 1988-1993, Chairman 1989-1990)
International Water Association (Task Group on River Water Quality Modeling, 1996-2002; Specialist Group on Systems Analysis and Integrated Assessment, 2000-2013)
Water Environment Federation (Committee on Research, 1986-1992)
Association of Ground Water Scientists and Engineers (Editorial Board, Journal of Ground Water, 1990-1992)
American Geophysical Union
American Water Resources Association
Conservation Commission, Acton, Massachusetts, 1990-1996

REGISTRATION

Professional Engineer (Civil), Massachusetts
Professional Engineer, Maine

REPRESENTATIVE EXPERIENCE

Dr. Shanahan has directed or been a major contributor to a wide variety of projects involving analysis and computer modeling of environmental water quality, hydrology, and hydraulics. These studies have included engineering analysis and design of water-pollution controls, hazardous waste site remedial actions, flooding and drainage controls, and water-resources development. Dr. Shanahan is an experienced expert witness and has represented clients in courtroom testimony, administrative hearings, negotiations with regulatory agencies, and public meetings. Dr. Shanahan recently retired from a position as Senior Lecturer in the Department of Civil and Environmental Engineering at the Massachusetts Institute of Technology where he taught both graduate and undergraduate subjects in environmental engineering. As a Research Affiliate at MIT, he continues to conduct research and supervise environmental engineering graduate students.

Hydrology and Hydraulics

Dr. Shanahan has completed technical analyses and developed and applied models to a wide variety of hydrologic and hydraulic problems. Past projects include:

Lake Balaton, Hungary	Developed MITLAKE model for three-dimensional wind-driven circulation in shallow lakes
Cumberland River, Kentucky and Tennessee	Developed computer code to model rainfall runoff, reservoir operation, and flood flow
Oahe Dam, South Dakota	Modeled hydropower plant hydraulic transients
Fitchburg, Massachusetts	Developed stormwater management model for combined sewer system
Henrico County, Virginia	Managed comprehensive drainage and flooding model development project
Development sites in Massachusetts	Applied the SCS TR-20 model for stormwater analysis and design
Nuclear waste repository, Texas	Served as principal investigator for water resources site study

Dr. Shanahan is also a co-author of the U.S. Army Corps of Engineers generalized model for hydraulic transients in hydropower systems, WHAMO (Water Hammer and Mass Oscillation).

Water Quality

Dr. Shanahan's water-quality experience includes academic research to develop modeling approaches and engineering experience analyzing information and using models in practical applications. Project experience includes a wide range of contaminants in rivers, lakes, and coastal environments. Representative examples include:

Lake Balaton, Hungary	Eutrophication model development
Mississippi River, Mississippi	Model of dissolved solids plume
Wateree River, South Carolina	Permit application for paper mill discharge
Conowingo Reservoir, Pennsylvania	Model of power plant thermal plume
Fishkill Creek, New York	Permit application for industrial discharge
East Machias River, Maine	Model of fish hatchery discharge
Westfield River, Massachusetts	Model of paper mill discharge
Ohio River, West Virginia	Model of phenol and ammonia plume
Strait of Malacca, Indonesia	Analysis of LNG plant thermal discharge
Fort Point Channel, Boston, Massachusetts	Model of cooling water discharge
Lake Galena, Pennsylvania	Model of lake eutrophication
Lake North Anna, Virginia	Model of cooling lake
Snake River, Idaho and Washington	Model of temperature and dissolved oxygen
Worcester, Massachusetts	Model of nonpoint source pollution and runoff

Dr. Shanahan has also served as a consultant to the U.S. Environmental Protection Agency advising on wasteload allocation, total maximum daily loads, effects of climate change, and other topics in water quality.

Ground-Water Hydrology

Dr. Shanahan's experience includes a wide variety of projects involving the assessment and modeling of ground-water hydrology and quality, as well as using models to design remediation measures for contaminated ground water. Example projects include:

Reilly Tar & Chemical Superfund Site, St. Louis Park, Minnesota	Modeled ground-water flow in multiple aquifers affected by coal-tar compounds; developed model for design of gradient and source control wells.
Burkeville, Alabama	Modeled the hydrologic impacts of planned industrial supply well
Baltimore, Maryland	Modified USGS MOC ground-water contaminant transport model to assess DNAPL transport from manufactured gas plant site
Brainerd, Minnesota	Modeled contaminant transport to design ground-water remedy at Superfund site
More than twenty Massachusetts municipalities	Employed ground-water flow models to delineate Massachusetts aquifer protection Zone II

Dr. Shanahan also authored the section on modeling inactive hazardous waste sites in the Handbook on Manufactured Gas Plant Sites published by the Edison Electric Institute.

Hazardous Waste Site Consultation

Dr. Shanahan has served as a consultant on the investigation, remediation, and regulation of Superfund, RCRA, and other hazardous waste sites. Typical assignments include critical review of RI/FS documents, technical evaluation of hydrogeologic and modeling studies, and oversight of technical contractors. Representative past projects include:

Low-Level Radioactive Waste Site, Clark County, Illinois	Served as principal hydrologist for characterization of proposed waste disposal site
Stringfellow Acid Pits, California	Participated on technical committee as representative of one of the named site generators
Wells G&H, Woburn, Massachusetts	Managed ground-water remediation task for site Remedial Design/Remedial Action program
Slatersville and Forestdale Reservoirs, Rhode Island	Evaluated potential impact of Superfund sites on proposed water-supply development
Koppers Superfund Site, Galesburg, Illinois	Managed ground-water remediation task for site Remedial Design/Remedial Action program
Los Alamos National Laboratory, New Mexico	Assessed ground-water contamination by radionuclides, organic chemicals, and explosives as part of a comprehensive site-wide risk assessment and model
Massachusetts Military Reservation	Completed studies of effects of contaminated ground-water inflow on Ashumet and Johns Ponds on behalf of citizen’s group

In other project assignments, Dr. Shanahan has assisted industrial groups and trade associations in critically reviewing and submitting comments to government agencies on proposed regulations governing Natural Resource Damage Assessments under CERCLA and Hazardous Waste Characterization under RCRA.

Contaminated Sediments

Dr. Shanahan has consulted on a number of sites at which sediments contaminated by PCBs, metals, and other chemicals have been an issue. Example projects include:

Fox River, Wisconsin	Modeled the fate and transport of sediments and PCBs as influenced by river flow and lake seiche
Newark Bay, New Jersey	For an industrial client, oversaw a team of technical specialists assessing patterns of organic chemical contamination
Passaic River, New Jersey	For an industrial client analyzed patterns of mercury contamination and potential for contribution to contaminated sediments
Paoli Rail Yard Superfund Site, Paoli, Pennsylvania	Retained as expert witness and provided analysis of the extent and causes of soil and stream sediment contamination at PCB-contaminated site
Pompton Lakes Works, Pompton, NJ	Developed and applied stream flooding model to determine extent of past flooding as cause of sediment contamination by lead and mercury

Peer Review

Dr. Shanahan has provided expert peer review to a variety of governmental and other clients. Selected assignments include:

Housatonic River, Massachusetts	Served on EPA panel providing peer review of the modeling framework design for a two-dimensional hydrodynamic, sediment transport, and water-quality model of PCBs
Massachusetts Estuaries Program	Served on panel conducting an independent, scientific review of the MEP Linked Watershed Embayment Model, a key component of a large number of nutrient TMDLs in the Cape Cod and Buzzards Bay region
Review of EPA Silver Study	Provided a formal peer review of the draft report "Silver Waste Stream: Management Practices, Risks and Economics" for the U.S. EPA

Expert Testimony and Agency Negotiation

Dr. Shanahan has represented clients in courtroom testimony, public meetings, agency negotiations, a press conference, and other forums on a variety of technical issues associated with hazardous waste, ground water, and surface water. Dr. Shanahan has provided expert testimony at ten trails, twelve adjudicatory hearings, and thirty-six depositions. Dr. Shanahan has provided expert testimony on ground-water contamination and transport, surface-water flooding, surface-water quality, and hazardous waste site remediation.

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Shanahan, P., "Directions in Superfund Response Actions: Investigation, Treatment Alternatives and Cleanup Standards," lecture at the 1986 Environmental Law Institute, Minnesota Institute for Legal Education, Minneapolis, Minnesota, March 20, 1986.

Shanahan, P., "Type B Natural Resource Damage Assessment: Overview" and "Surface Water and Geologic Resources," presented at the 1986 Washington Conference on Damages to Natural Resources, The Center for Energy and Environmental Management, Alexandria, Virginia, November 18, 1986.

Shanahan, P. and R.J. Fine, "Trends in Superfund Response Actions," Paper No. 87-17.2, presented by P. Shanahan at the 80th Annual Meeting and Exhibition, Air Pollution Control Association, New York, New York, June 22, 1987.

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Shanahan, P., "Drainage: Basic Functions," workshop presented at the Massachusetts Association of Conservation Commissions 1991 Annual Meeting, Worcester, Massachusetts, March 2, 1991.

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Shanahan, P. Ground Water and Cities—Hydrological and Historical Perspectives. Presented at Fall 2008 Seminar Series, Center for Urban Environmental Research and Education, University of Maryland, Baltimore County. October 24, 2008

TEACHING

Course 1.725J, Chemicals in the Environment: Fate and Transport, Department of Civil and Environmental Engineering, Massachusetts Institute of Technology. 2005-2012 academic years.

Course 1.013, Senior Civil and Environmental Engineering Design, Department of Civil and Environmental Engineering, Massachusetts Institute of Technology. 2007-2012 academic years.

Course 1.782, Environmental and Geoenvironmental Engineering M.Eng. Project, Department of Civil and Environmental Engineering, Massachusetts Institute of Technology. 1996-2013 academic years.

Course 1.083, Environmental Health Engineering, Department of Civil and Environmental Engineering, Massachusetts Institute of Technology. 2006-2011 academic years.

Radiological Risk Assessment for Decision Making, Compliance, and Emergency Response. Risk Assessment Corporation. Washington, DC. March 5-9, 2012 and March 4-8, 2013.

Radiological Risk Assessment and Environmental Analysis Course, Bristol, United Kingdom. ITC School - Meiringen, Switzerland. June 22-26, 2009.

Course 1.34, Waste Containment and Site Remediation Technology, Department of Civil and Environmental Engineering, Massachusetts Institute of Technology. 2001-2009 academic years.

Environmental Risk Assessment Analysis Course, U.S. Nuclear Regulatory Commission, Bethesda, Maryland. January 26-30, 2009.

Course 1.85, Water and Wastewater Treatment Engineering, Department of Civil and Environmental Engineering, Massachusetts Institute of Technology. 2004-2007 academic years.

Course 1.096, Environmental Engineering Clinic, Department of Civil and Environmental Engineering, Massachusetts Institute of Technology. 2005-2006 academic year.

Course ESD 1.7, Water Pollution Analysis, Master's course in Engineering for Sustainable Development, Cambridge University, Cambridge, United Kingdom. 2004-2005 academic year.

Ground-water Transport and Computer Codes for Estimating Transport, Emerging Topics in Radiation Protection and Risk Assessment, Kiawah Island, South Carolina. Risk Assessment Corporation. March 17, 2004.

Course CEE172, Fate and Transport of Chemicals in the Environment, Department of Civil and Environmental Engineering, Tufts University. 2003-2004 academic year.

Course 1.061/1.61, Transport Processes in the Environment, Department of Civil and Environmental Engineering, Massachusetts Institute of Technology. 2001-2002 academic year.

Specialty Course on Diffuse Pollution Management, Vancouver, British Columbia, Canada. Technomic Publishing Company, Inc. June 25-26, 1998.

HONORS AND AWARDS

Maseeh Excellence in Teaching Award, Department of Civil and Environmental Engineering, MIT, May 2006.

American Society of Civil Engineers 2011 Outstanding Reviewer, April 2012.

THESES SUPERVISED

Julia Choi, 1997. The Study of Biological Interactions using Water Quality Modeling: Massachusetts Military Reservation, Ashumet Pond. Master of Engineering, MIT.

Seth J. Schneider, 1997. Hydrothermal and Water Quality Modeling for Evaluation of Ashumet Pond Trophic State. Master of Engineering, MIT.

Tina L. Lin, 1997. Analysis of Geologic Parameters on Recirculating Well Technology Using 3-D Numerical Modeling: Massachusetts Military Reservation, Cape Cod. Master of Engineering, MIT.

Amy M. Rolfs, 1998. Interactive GIS Approach to Generate Capture Curves at the Massachusetts Military Reservation, Cape Cod, Massachusetts. Master of Engineering, MIT.

Elizabeth Shea, 2000. Optimization Study of a Pump-and-Treat System at Massachusetts Military Reservation. Master of Engineering, MIT.

Daniele S. Lantagne, 2001. Trihalomethane Production in Household Water Filtration Systems in Rural Haiti. Master of Engineering, MIT

Ka Yan Leung, 2001. One-Dimensional Model of Fecal Coliform in Nahr Ibrahim River (Lebanon). Master of Engineering, MIT.

Peter M. Oates, 2001. Solar Disinfection for Point of Use Water Treatment in Haiti. Master of Engineering, MIT.

Nadine van Zyl, 2001. Sodium Hypochlorite Generation for Household Water Disinfection in Haiti. Master of Engineering, MIT.

Farzana S. Mohamed, 2001. Household-level point-of-use water filtration system in Haiti : strategies for program management and sustainability. Master of City Planning, Department of Urban Studies and Planning, and Master of Engineering, Department of Civil and Environmental Engineering, MIT.

Arjun A. Nair, 2002. Implementation of the IWA River Water Quality Model No. 1 in US EPA WASP 5.0. Master of Engineering, MIT.

Liam Bossi and Donald Rose, 2003. Hydrologic and Chemical Analysis of Salt Ponds on St. John, U.S. Virgin Islands. Master of Engineering, MIT.

Geneviève Brin, 2003. Evaluation of the Safe Water System in Jolivert Haiti by Bacteriological Testing and Public Health Survey. Master of Engineering, MIT

Julianna B. Connolly and Devin L. Shaffer, 2003. Development and Application of a Spatially-Explicit Nitrogen Mass-Balance Model for the Wood River Valley Watershed, Idaho. Master of Engineering, MIT.

Alexa Gangemi, 2003. Ecological Assessment of Salt Ponds on St. John, USVI. Master of Engineering, MIT.

Matthew B. Andrews, 2004. Natural Attenuation of Organophosphates in River Systems: Chattahoochee River Case Study. Master of Engineering, MIT.

Samuel F. Haffey, 2004. Numerical Model of Phosphate Esters in the Chattahoochee River. Master of Engineering, MIT.

Joseph C. Lin, 2004. Determining the Removal Effectiveness of Flame Retardants from Drinking Water Treatment Processes. Master of Engineering, MIT.

James E. Brown, Jr., 2005. Encouraging Low-Impact-Development Stormwater-Management Practices: Assabet River Watershed Sub-Basin Case Study. Master of Engineering, MIT.

Brian J. Friedlich, 2005. Low-Impact Development in the Assabet River Watershed: Site Hydrologic Design and Watershed-Scale Implications. Master of Engineering, MIT.

Brian M. Loux, 2005. Spirasol: Improvements to Semi-Continuous Solar Disinfection Water Treatment Systems. Master of Engineering, MIT.

Najwa Obeid, 2005. Modeling and Analysis of Phosphorus Reduction by Rain Gardens and Other BMPs in Stormwater Runoff from Small Urban Developments. Master of Engineering, MIT.

Olympia Galenianou, 2006. Effects of Adding Wash Tower Effluent to Ano Liossia Landfill to Enhance Bioreaction. Master of Engineering, MIT.

Tia M. Trate, 2006. Nutrient Load Analysis of Lago de Yojoa, Honduras. Master of Engineering, MIT.

Mira Chokshi, 2006. Temperature Analysis for Lake Yojoa, Honduras. Master of Engineering, MIT.

Daria Cresti, 2007. Analysis and Design of Household Rainwater Catchment Systems for Rural Rwanda. Master of Engineering, MIT.

Helen F. McCreery, 2007. The Effect of Anthropogenic Development on Sediment Loading to Bays on St. John, U.S. Virgin Islands. Master of Engineering, MIT.

Alfred Patrick Navato, 2007. The Effect of Development on Nitrogen Loading on St. John, U.S. Virgin Islands. Master of Engineering, MIT.

Jeffrey D. Walker, 2007. Modeling the Fate and Transport of Nitrogen and Sediment within Coastal Embayments on St. John, U.S. Virgin Islands. Master of Engineering, MIT.

Christiane A. Zoghbi, 2007. Rural Groundwater Supply for the Volcanoes National Park Region, Rwanda. Master of Engineering, MIT.

Kelly C. Doyle, 2008. Sizing the First Flush and its Effect on the Storage-Reliability-Yield Behavior of Rainwater Harvesting in Rwanda. Master of Science, MIT.

Mary Pierce Harding, 2008. GIS Representation and Assessment of Water Distribution System for Mae La Temporary Shelter, Thailand. Master of Engineering, MIT.

Sameer A. Kamal, 2008. Development of a Landslide Hazard Map for the Island of Puerto Rico. Master of Engineering, MIT.

Percy Anne Link, 2008. Improving Parameterization of Scalar Transport through Vegetation in a Coupled Ecosystem-Atmosphere Model. Master of Engineering, MIT.

Navid Rahimi, 2008. Modeling and Mapping of MaeLa Refugee Camp Water Supply. Master of Engineering, MIT.

Katherine A. Vater, 2008. Appropriate Technology Water Treatment Processes for MaeLa Temporary Shelter, Thailand. Master of Engineering, MIT.

Cameron C. Dixon, 2009. Microbial Risk Assessment for Recreational Use of the Kranji Reservoir, Singapore. Master of Engineering, MIT.

Carolyn Hayek, 2009. Maintaining Rainwater Harvesting in Southern Lebanon: the kaza of Tyre. Master of Engineering, MIT.

Kathleen B. Kerigan and Jessica M. Yeager, 2009. Bacteria Attenuation Modeling and Source Identification in Kranji Catchment and Reservoir. Master of Engineering, MIT.

Gianna D. Leandro, 2009. Water Quality and Sedimentation Implications of Installing a Hydroelectric Dam on the Rio Baker in Chilean Patagonia. Master of Engineering, MIT.

Sameer A. Kamal, 2009. The Use of a Distributed Hydrologic Model to Predict Dynamic Landslide Susceptibility for a Humid Basin in Puerto Rico. Environmental Engineer, MIT.

Kevin J. Foley, 2010. Wastewater Treatment and Energy: An Analysis on the Feasibility of Using Renewable Energy to Power Wastewater Treatment Plants in Singapore. Master of Engineering, MIT.

Erika C. Granger, 2010. Water Quality Modeling in Kranji Catchment. Master of Engineering, MIT.

Jean Pierre Nshimyimana, 2010. Evaluating Human Fecal Contamination Sources in Kranji Reservoir Catchment, Singapore. Master of Science, MIT.

Adriana Mendez Sagel, 2010. Water Quality Studies in Kranji Catchment, Singapore: Use of Organic Tracer and PEDs for Identifying Potential Sewage Sources. Master of Engineering, MIT.

Ryan C. Bossis, 2011. Application of the SWAT Model to Bacterial Loading Rates in Kranji Catchment, Singapore. Master of Engineering, MIT.

Genevieve E. Ho, 2011. Analysis of Wet and Dry Weather Bacterial Concentrations within Kranji and Marina Catchments, Singapore. Master of Engineering, MIT.

Yangyue Zhang, 2011. Water Quality Prediction for Recreational Use of Kranji Reservoir, Singapore. Master of Engineering, MIT.

Janhvi Doshi, 2012. An Investigation of Leaky Sewers as a Source of Fecal Contamination in the Stormwater Drainage System in Singapore. Master of Engineering, MIT.

Kathyayani Shobhna Kondepudi, 2012. Analysis of the Efficacy of a Constructed Wetland in Treating Human Fecal Contamination. Master of Engineering, MIT.

Suejung Shin, 2012. An Analysis of Spatial and Temporal Variation in Fecal Indicator Concentrations in Singapore. Master of Engineering, MIT.

Laurie Kellndorfer, 2012. A Hydrologic Calibration of the SWAT Model in Kranji Catchment, Singapore. Master of Engineering, MIT.

Tsung Hwa Burkhart, 2013. Biofilms as Sources of Fecal Bacteria Contamination in the Stormwater Drainage System in Singapore. Master of Engineering, MIT.

Ndeye Awa Diagne, 2013. Evaluation of Sewer Leakage into the Stormwater Drainage System in Singapore Master of Engineering, MIT.

Margaret A. Hoff, 2013. Control of Agricultural Nonpoint Source Pollution in Kranji Catchment, Singapore. Master of Engineering, MIT.

Anna C. Kelly, 2013. Finite Element Modeling of Flow Through Ceramic Pot Filters. Master of Engineering, MIT.

Halle Ritter, 2013. Nitrogen Chemistry in an Urban Bioretention System in Singapore. Master of Engineering, MIT.

Eveline Ekklesia, 2014. Identification of Suitable Indicators for Tracing Human Faecal Contamination and Sewage in Urban Catchments. Doctor of Philosophy, Nanyang Technological University.

Justin Victor V. Angeles, 2014. Water Quality Modelling for Recreational Use in the Kallang River Basin, Singapore. Master of Engineering, MIT.

Riana Larissa Kernan, 2014. Denitrification in a Best Management Practice Bioretention System. Master of Engineering, MIT.

Tina Y. Liu, 2014. Enteric Adenovirus and Coliphage as Microbial Indicators in Singapore's Kallang Basin. Master of Engineering, MIT.

Allison Park, 2014. Microbial Risk Assessment for Recreational Use of the Kallang Basin, Singapore. Master of Engineering, MIT.

ATTACHMENT 5

Excerpts from the Deposition Transcripts of Dr. George Hornberger (May 11, 2016 and Aug. 4-5, 2016)

IN THE SUPREME COURT OF THE UNITED STATES

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STATE OF FLORIDA, :

Plaintiff, :

v. : CASE NO. 142

STATE OF GEORGIA, :

Defendant. :

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Videotaped Deposition of GEORGE HORNBERGER, PH.D.

Washington, D.C.

Wednesday, May 11, 2016

9:10 a.m.

Reported by:

Cassandra E. Ellis, RPR

Job No.: 16321

THE VIDEOTAPED DEPOSITION OF GEORGE HORNBERGER, PH.D., taken on May 11, 2016, at Kirkland & Ellis, LLP, 655 15th Street, Northwest, Suite 1200, Washington, D.C. 20004, before Cassandra E. Ellis, Registered Professional Reporter, Certified Court Reporter, Certified Livenote Reporter, Realtime Systems Administrator, and Notary Public within and for the District of Columbia.

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C O N T E N T S

E X H I B I T S

(Attached to the Transcript)

EXHIBITS CONTINUED

(Attached to the Transcript)

PROCEEDINGS

THE VIDEOGRAPHER: Good morning. This is the beginning of disc number one in the deposition of Dr. George Hornberger, taken in the matter of the State of Florida, plaintiff, versus the State of Georgia, defendant, with a Case Number of 142, held in the Supreme Court of the United States.

Today's date is May 11th, 2016, and the time on the monitor is 9:10 a.m. My name is Joseph Ellis, I am the videographer, the court reporter is Cassandra Ellis, and we are here with Transperfect Legal Solutions.

If counsel would please introduce yourselves, and whom you represent, after which the court reporter will swear the witness

and you may proceed.

MR. SINGARELLA: Good morning, Paul Singarella, here, with Dr. Hornberger, on behalf of the State of Florida, and my colleague, Devin O'Connor, is here with me to my left.

MS. ALLON: Devora Allon, from Kirkland Ellis, for the State of Georgia, with me is Andrew Pruitt, from Kirkland and Ellis, also for the State of Georgia, Larry Dunbar, John Allen, also for the State of Georgia.

GEORGE HORNBERGER, PH.D.
having been sworn, testified as follows:

EXAMINATION

BY MS. ALLON:

Q Good morning, Dr. Hornberger. How are you?
A I'm well. And you?
Q I'm good.

Are you familiar with the law of conservation of mass?
A Yes.
Q What is it?
A It basically says that mass is neither created nor destroyed with the exception of nuclear reactions.
Q And because -- mass -- mass is neither created nor destroyed if -- if you have a closed system the law of conservation of mass would say the mass of that system has to remain constant; is that fair?
A Yes.
Q Would you agree that the law of conservation of mass is a fundamental principle in physics?
A Yes.
Q And engineering?
A Yes.
Q Would you agree that the law of conservation of mass is a fundamental

form, incomplete hypothetical.
A So again, I'm struggling a bit, because we've already discussed the script as written. There are lines that you pointed to that, in fact, do represent the results that I have in my report.
The particular lines of code that you point to were not used in the results in my report.
Q Okay. So let me ask my question a little bit more precisely.
If these particular lines of code had been used to generate the results in your report you would agree with me that that, those particular equations, would violate the principle of conservation of mass?
MR. SINGARELLA: Object to form. Do you mean the top -- top line and the bottom line, those two lines?

MS. ALLON: I do.
MR. SINGARELLA: I mean, I'm not sure what you mean by those.
MS. ALLON: I mean the equations we talked about on this page.
MR. SINGARELLA: Object to form, vague.
A The equations that you referred to were not used to generate results from my report. And so they could not have been part of the code that was exercised for my report.
Q Okay. So -- so I'm allowed to ask hypotheticals.
A That's fine.
Q But let me ask it this way: The reason you didn't use or you -- you are testifying that you didn't use these equations in -- in doing the calculations that form the basis of your report is because if you had used them you would

have been relying on a model that violated the law of conservation of mass?
MR. SINGARELLA: Object to form, incomplete hypothetical.
A Yes. So let me, again, try to characterize. It -- it's not so much -- we run models in different ways, okay? And the particular -- one way is to simulate an entire period, say a year, and another way we run a model is what we call one step ahead forecast.
And in a one step ahead forecast you preserve conservation of mass for the one step but then you go back and adjust your model.
So the lines of code you pointed to don't, in and of themselves, violate conservation of mass. They are an adequate representation for a one step ahead model.
Q I understand that it's your

testimony that what you used them for was adequate for the purposes you used them.
A Right.
Q I'm asking you to assume a different hypothetical.
A (Nodding.)
Q And in that hypothetical you used these equations, this calculation of storage was used to model the baseline scenario for the results that you discuss in your report; are -- are you with me on that hypothetical?
MR. SINGARELLA: Object.
BY MS. ALLON:
Q So they weren't used, like you said, of an adequate representation of a way to adjust your model, but they were actually used in the model, the results of which you discuss in your report. Are you with me on that hypothetical?
MR. SINGARELLA: Object to form.

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A So you're saying that the hypothetical is if I used a set of equations that I did not use then I would have been in error; is that the implication?
Q Yeah, well, you'll agree with me that for your report, for the --
A Right.
Q -- conclusions that you reach in your report, you have to model or you have to come to a value for storage; right?
A Yes.
Q Change in storage, you agree with me?
A (Nodding.)
Q And all I'm asking is, if you had used these equations to calculate that change in storage do you think that would have been in error?
MR. SINGARELLA: Object to form, asked and answered.

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A So again, to flesh it out, you're saying that if I had used those equations for an entire period of record, without thinking about whether it was right or wrong, would the results have been erroneous?
Q Yep.
A Absolutely, if you use a wrong equation you will get a wrong answer.
Q Now, you model a number of different scenarios that reflect Georgia's reduced water use; is that right?
A Correct.
Q Okay. And before you do that you model a baseline scenario that reflects historic water use?
A Correct.
Q Okay. And then the difference between the baseline and the reduction scenarios is the amount of water that you claim or that other Florida experts claim

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is saved by Georgia cutting its use; is that right? That's the difference between the scenarios?
MR. SINGARELLA: Object to form.
A Maybe you could be -- explain to me what you mean by saved.
Q Sure. The -- the difference between your baseline, the rod --
A The baseline calculated flows at the Chattahoochee gage on the Apalachicola River?
Q Yes.
A Okay.
Q And the scenario runs?
A Right.
Q The difference is in the inflow, right, that's what the difference is between those two groups?
A Yes.
Q Okay. So when you model the scenarios where Georgia's water use has

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been reduced you have higher inflow?
A Correct.
Q Okay. Are there any other differences between the baseline scenario and the reduction scenario besides for the inflow?
A No.
Q Okay. So -- so the model structure is the same for both of them?
A Yes.
Q Okay. The only difference is the inflow data?
A Yes.
Q Okay. Now, let's go back to the code.
A Okay.
Q And I want to look at the next equation, where it says, "Current volume plus"; do you see that?
A Yes, I do.
Q Okay. Is that the equation that you use to calculate storage in your

observed flow as the observed flow, okay, and then we're calculating an increment.
Q So you're -- you're not counting an incremental flow over your baseline scenario, you're calculating an incremental flow over observed flow?
MR. SINGARELLA: Object to form.
A It's a calculated increment on the observed, correct.
Q Now, your Lake Seminole model only simulates the federal project of Jim Woodruff for Lake Seminole; right?
A Correct.
Q Okay. It -- it doesn't look at any of the reservoirs, like Lanier or West Point; right?
A It doesn't look at them in the sense of doing a calculation.
Q Right, it didn't simulate anything from that?
A It doesn't simulate.

Q Okay. It -- it -- it doesn't -- your -- your Lake Seminole model doesn't take into account the ACF reservoir system's ability to store water in upstream reservoirs; is that right?
MR. SINGARELLA: Object to form, assumes facts, incomplete hypo.
A The -- so it's not fair to say that the Lake Seminole model does not account for storage in the other reservoirs. We account for it by using observed data for the entire system, so in other words, our aim is to recreate operations at Jim Woodruff as the Army Corps actually did them, ac- -- actually how they performed.
Q Well, when you say you used observed data for the entire system, what you're actually using is inflow to Woodruff; right?
A No, we used composite storage.

MR. SINGARELLA: Objection.
BY MS. ALLON:
Q So it -- what do you mean when you say composite?
MR. SINGARELLA: Want a break? Want a glass of water? Can we go off the record?
MS. ALLON: Sure. And we can also -- anytime you need a break we can go off the record.
THE WITNESS: No, that's fine. I just need a glass of water.
BY MS. ALLON:
Q So -- so you said we used composite storage and my question is, what do you mean by that?
A Oh, so the Army Corps keeps track of how much water is in each of the reservoirs, and they have a term that is called -- that basically reflects how much water is in the whole system.

Q And -- and they're zones; right?
A Mm-hmm.
Q They're composite storage zones?
A Mm-hmm.
Q And the input into your model isn't an amount of storage in acre feet, it -- it's a zone, one through four?
A No, I don't think that that is -- oh, how we use it? I see. We -- it -- it actually is an amount in acre feet, that is, that is reported.
Q Of course, I understand the absolute sense storage is made up in acre feet, but I'm talking about the actual input into your model is just a zone, so your model says we're at zone one, we're at zone two, we're at zone three?
A Right.
MR. SINGARELLA: Objection to form.

recognize that different models have strengths and limitations. So we also used what we referred to as a data-driven ResSim model that actually accounted for all of the upstream reservoirs, and so we did those calculations and came away confident that the best representation for how the Army actually operates isn't something the way we think they operate, but what the data say is how they operated, and that's why we -- we took the approach we did.

Q I'm asking about the Lake Seminole model specifically.

A Okay.

Q And I'm just asking a very discrete question, which is, does your Lake Seminole model have the ability, mathematically, to evaluate the possibility of additional inflow on the flint affecting storage at upstream reservoirs?

A No.

MR. SINGARELLA: Object to form.

BY MS. ALLON:

Q Now, you -- you said before that -- I think you said before, but tell me if I'm wrong, that you think your Lake Seminole model or your Lake Seminole model was designed to be a better way of capturing actual Corps operations; is that right?

A That's correct.

Q And you think it's better than the Corps' ResSim model at doing that?

MR. SINGARELLA: Object to form, misstates.

A So is the question related to The Corps' ResSim model as presented by The Corps in various reports and is -- is the question do we represent flows in the Apalachicola River, the Chattahoochee gage, better than The Corps' ResSim model

run with their UIFs?

Q Yeah, the question is did you design your model to be a better reflection of actual releases than the Corps' ResSim model?

A And I guess what I'm trying to do is figure out by the Corps' ResSim model, exactly what do you mean, because the Lake Seminole model embodies how The Corps represents Lake Seminole in -- in ResSim.

Q Well, it -- it represents some of ResSim, but it also substitutes a different dataset as an inflow; is that right?

A Yes, we use observed data.

Q So -- so -- so my question is, do you think your Lake Seminole model, using observed data, does a better job of capturing or predicting or modeling actual releases than The Corps' ResSim model which uses The Corps' unimpaired

flow as the inflow?

A Yes.

Q And you also say that your Lake Seminole model captures what you call The Corps' discretion in how it operates; is that right?

A It reflects The Corps' discretion because we're using observed data, and the observations of the data are a reflection of how The Corps actually operated the reservoir.

Q Now, I think we -- we -- we talked about this before, but your Lake Seminole model, as an input, uses recorded inflows as Lake Seminole; right?

A The -- they're actually calculated, so there's not a gage for -- that measures flow into Lake Seminole, it's -- it's a calculation that the Army Corps reports, they report inflows into their reservoirs. We use reported inflows to Lake Seminole.

IN THE SUPREME COURT OF THE UNITED STATES

- - - - - - - - - - - - - - -

STATE OF FLORIDA,

Plaintiff,

vs. Case Number 142

STATE OF GEORGIA,

Defendant.

- - - - - - - - - - - - - - -

VOLUME II

CONTINUED VIDEOTAPED DEPOSITION

of

GEORGE M. HORNBERGER, Ph.D.

New York, New York

Thursday, August 4, 2016

9:06 a.m.

Reported by:

Robin LaFemina, RPR, CLR

Job No. 16739

August 4, 2016
9:06 a.m.

CONTINUED VIDEOTAPED DEPOSITION of GEORGE M. HORNBERGER, Ph.D., held at the offices of Kirkland & Ellis, 601 Lexington Avenue, New York, New York, pursuant to Notice, before Robin LaFemina, a Registered Professional Reporter, Certified LiveNote Reporter and Notary Public within and for the State of New York.

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THE VIDEOGRAPHER: This is media number 1, Volume II of the video deposition of Mr. George Hornberger in the matter of Florida versus Georgia, #142 Original in the Supreme Court of the United States on August 4, 2016 at approximately 9:06 a.m.

My name is Alinson Gonzalez and I am the legal video specialist. The court reporter today is Ms. Robin LaFemina.

Will counsel please introduce themselves beginning with the party noticing the proceeding.

MS. ALLON: Devora Allon from Kirkland & Ellis for the State of Georgia.

MR. PRUITT: Andrew Pruitt, Kirkland & Ellis, for the State of Georgia.

MR. SINGARELLA: Latham & Watkins for Florida.

MS. O'CONNOR: Devin O'Connor, Latham & Watkins, State of Florida.

Hornberger

you used it for. I'm asking do you stand by the results that are reflected in the Excel spreadsheet that is Exhibit 29 that is on the computer in front of you?
A. Not as a representation for what the -- how the Army Corps would operate Lake Seminole under that -- those conditions.
Q. Can you explain to me why does Lake Seminole in your view work accurately for assessing reductions in consumptive use but not for assessing increases in consumptive use?
MR. SINGARELLA: Misstates. Object to form.
A. I believe I probably already answered that. We do not believe that reductions in inflow could be adequately handled by an independent operation of Lake Seminole, so it's not appropriate for that. For add-back scenarios, we have, for example, in the -- the Fish & Wildlife BiOp saying, hey, Georgia, go find a way to reduce consumptive use in the Flint because that will allow the Corps to pass it through. We

Hornberger

believe that's how the Corps operates Jim Woodruff.
Q. I think I understand what you're saying. When you say independent operations of Lake Seminole, you mean as opposed to reservoir basin-wide operations?
A. Correct.
Q. Okay.
The Lake Seminole model is only considering operations with respect to Lake Seminole?
A. Using --
MR. SINGARELLA: Object to form. Vague.
A. Using data for the upstream reservoirs.
Q. Right. But it's not, for example, we talked about this last time --
A. Yes, we did.
Q. Right.
-- allowing for increased storage --
A. Correct.
Q. -- in the upstream reservoirs?

Hornberger

A. It is not.
Q. And it's your opinion that when you are modeling reductions to inflow, you do need to look at operations basin-wide?
A. Yes.
Q. And because your Lake Seminole model doesn't do that, it is not appropriate for that access?
A. Correct.
Q. Okay.
Now, with respect to -- oh, I said it wrong. Let me ask it again.
MR. SINGARELLA: How far do you have to go?
MS. ALLON: One question. One question.
Q. I said reductions instead of increases. I don't even think you meant to say yes. I said it wrong.
A. Okay.
Q. So let me just say it one more time.
Is it your opinion that when you are modeling increases to inflow -- to

Hornberger

consumptive use, you need to look at operations basin-wide? No?
A. Increases in consumptive use would be the same as decreases in inflow, and that would not be appropriate to use the Lake Seminole model.
Q. Then I asked it right. Good.
Okay. Now, let's talk about the scenario where you were looking at decreases in consumptive use.
A. Right.
Q. Okay.
And in that scenario, you do believe Lake Seminole is appropriate?
A. Yes.
Q. Okay.
Why in that scenario is it your opinion that you do not need to look at operations basin-wide and you can just look at Lake Seminole operations?
MR. SINGARELLA: Misstates. Object to form.
A. The -- you know, our entire analysis when I say the team including Dr.

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Hornberger

Shanahan's analysis of the way the Corps of Engineers operates Lake Seminole leads us to believe that additional water entering from the Flint will in very large part be passed through, and the Lake Seminole model is appropriate for such a model.

Q. Is it fair to say that you built the Lake Seminole model to be reflective of your view of how the Corps operates, how the Corps would operate if consumptive use was decreased?

MR. SINGARELLA: Object to form. Vague.

A. So -- and belief is a funny thing. It could be misread as to just be wishful thinking.

Q. Okay. So let me rephrase it then because I don't want to fight about the word belief. I didn't want to be argumentative. Can I say view instead of belief? Would that make you feel better?

A. Yes. I was just going to expand. The view was based on not just thinking about it. It is looking, for

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Hornberger

example, at the Fish & Wildlife instructions to the Corps in terms of releasing water, it's looking at the historical record of all of the flows and the fact that the Corps does release more than the RIOP, and we believe that increases coming down -- there's belief for you -- we believe that on the basis of all that evidence, that the Corps would in fact operate Lake Seminole, Jim Woodruff to basically largely pass through those flows.

Q. And, again, I wasn't asking you for your backup for why you believe that, I wasn't making a qualitative judgment about the validity of your belief. I think it's invalid, but I wasn't making that judgment in my question. My question was just: Is it fair to say that you built your Lake Seminole model to operate in the way you think the Corps would operate if consumptive use was decreased?

MR. SINGARELLA: Object to form. Argumentative. Vague.

A. Consumptive use in the Flint to

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Hornberger

increase flows to Lake Seminole, yes.

Q. You think the Corps would treat reductions in consumptive use differently than it would treat increases in consumptive use from the perspective of how much got released at the state line?

MR. SINGARELLA: Vague.

A. It almost has to because if there's less water, the Corps has to adjust. It has to meet their, you know, legal requirements, and so they would have to adjust. They can't just simply say, oh, Fish & Wildlife can make due with 3,000 cfs. It's not going to fly.

Q. Which requirements are you talking about?

A. Well, legal requirements, I'm out of my element, but sort of the Endangered Species Act that the Fish & Wildlife Service -- actually I -- so, for example, this is just out of the RIOP, and this is instructions, the Service, the Fish and Wildlife Service recommends that the Mobile District of the U.S. Army Corps of

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Hornberger

Engineers work in consultation with the states and other stakeholders to assist in identifying ways to reduce overall depletions in the ACF basin, particularly the Flint River. For example, if water users and managers can work together to identify alternatives to agricultural use or incentives to reduce agricultural use of water in the Flint River basin, inputs from the Flint River will increase base flow to the Apalachicola River. This would improve the status of the listed mussel species and reduce the Corps' reliance on upstream system storage to meet minimum flows below Jim Woodruff Dam.

Q. Is it your view that what you just read is a legal requirement on the Army Corps?

A. No. It's -- but I do believe that the Army Corps pays attention to Fish & Wildlife.

Q. So before you said legal requirements.

A. I misspoke. I'm not a legal

Hornberger
to explain what it is?
A. Well, for example, if you divide
a number by zero, you try to divide it by
zero, that's not a number.
Q. Okay.
A. So, I mean, in a sense you can't
do that computation, so that's fair.
Q. Okay.
Now, if you scroll down to -- if
you look at 3,199, your column J --
A. Yes.
Q. -- which we said is your modeled
volume, right, your modeled lake volume?
A. Yes.
Q. Column J goes negative; right?
A. Yup.
Q. So on October 2, 1984, your Lake
Seminole model has allowed Lake Seminole to
go dry under your 2050 scenario; right?
A. Correct.
Q. That's what your model shows?
A. Correct.
Q. But at the same time if we go to
column I, which is your releases under your

Hornberger
model, at the same time that the reservoir
is literally running dry, your model is
still discharging thousands of cfs from Lake
Seminole?
A. It's calculating a discharge; yes.
Q. And even after it runs dry, your
model is discharging hundreds of thousands
of cfs from Lake Seminole?
A. That's the calculation.
Q. Okay.
Is it your testimony that this
is faithful to actual operational actions of
the Corps?
A. No. As I said, this is not a
model that we used for the scenario of
decreasing inflows to Lake Seminole because
we don't think it's an appropriate model.
This sort of demonstrates it's not an
appropriate model.
Q. The reason your Lake Seminole
model is allowing the discharge of thousands
of cfs despite how low the reservoir is is
because your model can't actually change
composite storage; right?

Hornberger
A. The model does not change
composite storage, and, therefore, it
doesn't change the inflow from upstream.
Q. Right. So your model actually
doesn't know that the reservoir is running
dry?
A. That's right. Well, the model
sort of knows it, but it's not --
Q. It's not taking account of it?
A. It's not a model that can adjust.
Q. Right. Your model assumes a
constant composite storage?
A. Not a constant, but the observed
composite storage.
Q. You don't think in real life
that if Lake Seminole was running dry, the
Corps would be releasing hundreds of
thousands of cfs; right?
A. Absolutely not. I wouldn't use
this model for the scenario for this case.
Q. This is premarked. This was
marked at the last deposition as Exhibit 2
and this is your MATLAB code; right?
A. (Witness nods head.)

Hornberger
Q. Okay.
And this is the MATLAB code that
was produced to Georgia along with your report;
right?
MR. PRUITT: Here is the original.
A. You want this back? You want
this?
THE REPORTER: You can just put
it down.
Q. Just so we're clear about what's
what here, if I compared Exhibit 2 with
Exhibit 30, this is the same thing; right?
A. It certainly should be.
Q. Now, the MATLAB code in Exhibit
2 can be run as is; right?
A. Yes.
Q. And if it's run as is, it will
generate model outputs?
A. Yes.
Q. Is it your testimony that you
did not run the Lake Seminole model in the
form reflected in Exhibit 2 for any of the
model runs in your report?
MR. SINGARELLA: Object to form.

IN THE SUPREME COURT OF THE UNITED STATES

- - - - - - - - - - - - - - -

STATE OF FLORIDA,

Plaintiff,

vs. Case Number 142

STATE OF GEORGIA,

Defendant.

- - - - - - - - - - - - - - -

VOLUME III

CONTINUED VIDEOTAPED DEPOSITION

of

GEORGE M. HORNBERGER, Ph.D.

New York, New York

Thursday, August 5, 2016

10:02 a.m.

Reported by:

Robin LaFemina, RPR, CLR

Job No. 16740

August 5, 2016
10:02 a.m.

CONTINUED VIDEOTAPED DEPOSITION of GEORGE M. HORNBERGER, Ph.D., held at the offices of Kirkland & Ellis, 601 Lexington Avenue, New York, New York, pursuant to Notice, before Robin LaFemina, a Registered Professional Reporter, Certified LiveNote Reporter and Notary Public within and for the State of New York.

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JOHN C. ALLEN

THE VIDEOGRAPHER: This is media number 1, Volume III of the video deposition of Mr. Georgia Hornberger in the matter of Florida versus Georgia, Number 142 Original, in the Supreme Court of the United States on August 5, 2016 at approximately 10:02 a.m.

My name is Alinson Gonzalez and I am the legal video specialist. The court reporter today is Ms. Robin LaFemina.

All present will be noted on the transcript.

The witness has already been sworn.

GEORGE M. HORNBERGER, Ph.D.,
recalled as a Witness, having been previously duly sworn by Robin LaFemina, a Notary Public within and for the State of New York, was examined and testified as follows:

CONTINUED EXAMINATION
BY MS. ALLON:

Q. Good morning, Dr. Hornberger.

Hornberger

A. That's what I've been trying to say.

Q. There's step 1 where you calculate the RIOP releases?

A. Yes.

Q. And there's step 2 where you true up those RIOP releases to match --

A. Well, the true up is on the volume reduction, but we then later add the operator discretion.

Q. To equal observed?

A. Yes.

Q. Okay.

What you report as your model output is the first step?

A. Yes.

Q. So MOD_FLOW is without -- MOD_FLOW which you have said is the output of your Lake Seminole model is without the discretion added back in?

A. Yes.

Q. And then what do you use the second step for?

A. The second step we use for the

Hornberger

scenarios -- the scenarios for evaluating changes in consumptive use.

Q. When we were talking before about mass balance; right?

A. Yes.

Q. And you were explaining in your view that with respect to the reduction scenarios, you couldn't just look at inflow minus outflow equals change in storage because there's actually other pieces to it; right?

MR. SINGARELLA: Argumentative.

A. You do look at inflow minus outflow equals change in storage, but you have to be careful not to use the wrong outflow.

Q. But for your baseline, right, where you just said to me I don't have to worry about this AddBack piece because you're not counting it, right, for output all you're doing is saying what would the RIOP say; right?

MR. SINGARELLA: Vague.

Q. Why in the baseline scenario

Hornberger

can't I just look at the volumes you call inflow, outflow and change in storage?

MR. SINGARELLA: Compound.

A. So suppose the -- okay. Well, I'll try to make it simple. The calculations done with the RIOP are for minimum flows. We don't anticipate that the minimum flows will match the observed flows. So if we use the minimum flows and that isn't what the Corps did, we couldn't possibly then compare the measured outflows with what the Corps might have done had they not used discretion and assume that the difference would be zero. Currently the difference isn't zero because the Corps does not operate that way.

Q. When you want to calculate ultimately how a given reduction scenario, what the difference will be, you're comparing against the baseline; right?

A. Yes.

Q. And then you compare it against the baseline and then you add back in an operator deviation or whatever this is, this difference discretion or whatever we're

Hornberger

calling it?

A. No.

Q. It's not operator deviation, you add back in the true up?

A. Right.

Q. Right?

A. Well, we don't have to do that for the other scenarios because the observed flows are used directly.

Q. Then what do you -- when do you -- what do you need this for?

MR. SINGARELLA: Vague.

A. What do I need what for?

Q. Okay. We're in the baseline and there's two steps. There's the first step that you're calling your model output; right? That's just the RIOP release.

A. Right.

Q. And you said there's a second step and you said the second step is used for evaluating the scenarios, the reduction scenarios?

A. Yes.

Q. But I thought you just said we

Hornberger
don't need anything else in the reduction scenarios because we're just going to use observed.
A. What I said is -- I don't -- if I said anything else, that isn't what I meant. We do not need to true up in the reduction scenarios because we're adding the increments to the observed flows.
Q. Is your goodness-of-fit analysis a goodness-of-fit analysis with respect to your baseline run or your scenario run?
A. The goodness-of-fit is the baseline using the RIOP rules to project one day ahead.
Q. It's the first step?
A. Yes.
Q. Because if you looked at the second step, you would get an NSE of 1, it would be exactly right?
A. Yes.
Q. In Figures 27 and 28 that you were pointing to me before, what's the red line?
A. The red line is the modeled

Hornberger
flow.
Q. Right. So we had a lot of confusion and you renamed it, but what -- is the red line the results of this first step, is it the results of a reduction scenario, what is it with respect to the modeling we were just talking about?
A. This is what you're referring to as the first step, the modeled output for what you're calling the first step.
Q. If at the end of the day you're just going to use observed when you get to the reduction scenarios, why is it relevant to you that with respect to the first step of your model, so to speak, Lake Seminole has better goodness-of-fit in your view than data-driven ResSim model? Why does that matter?
A. Our objective was to develop a model that we thought best represented how the Corps operated Lake Seminole. We used that model then for the reduction scenarios to provide our estimates of how the Corps would operate the reservoir under those

Hornberger
reduction scenarios. That was the entire purpose of developing the Lake Seminole model.
Q. So you care about how faithfully your step 1 reproduces RIOP operations because you're going to use your step 1 in your reduction scenarios, even though you have a step 2, you're still using the step 1?
MR. SINGARELLA: Compound. Vague.
Q. Even though you're going to use a true up or even though you're going to use observed at the end of the day, your first step for the reduction scenario is the same first step for the baseline, so you care that that first step accurately reflects the RIOP?
MR. SINGARELLA: Vague.
A. Yes. So the first step for the reduction scenarios actually, you know, is for the increased inflows. So yes, we -- we don't -- we don't go back to observed flows because we don't have observed flows for the reduction scenarios.
Q. The first step of the baseline is the same as the first step of the

Hornberger
reduction scenarios?
A. What you're referring to as the first step; yes.
MR. SINGARELLA: Vague.
Q. The second step is different, what we have been calling the second step is different as between the baseline and the reduction scenarios?
A. No, there is no difference.
Q. So you said in the baseline scenario, the first step is the RIOP release and then the second step is trueing up that RIOP release to match observed; right?
A. The -- we do that to -- so for the reduction scenario, so that we are adding increments, deltas, to the observed flow, but the steps are the same for the baseline and for the reduction scenarios, it just so happens for the baseline scenario, the reductions are zero.
Q. Just try to answer my question. My question was: Do you agree with me that the second step of your baseline scenario is this true up? Forget -- we're not up to the

ATTACHMENT 6

Excerpts from the Deposition Transcript of Dr. Philip Bedient (May 4, 2016 and June 29, 2016)

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

VIDEOTAPED DEPOSITION OF

PHILIP B. BEDIENT, Ph.D., P.E.

New York, New York

May 4, 2016

Reported by: BONNIE PRUSZYNSKI, RMR, RPR, CLR

JOB NO. 106213

May 4, 2016
9:03 A.M.

VIDEOTAPED DEPOSITION OF PHILIP B. BEDIENT, Ph.D., P.E., held at the offices of Latham & Watkins, 885 Third Avenue, New York, New York, before Bonnie Pruszynski, a Registered Professional Reporter, Registered Merit Reporter, Certified LiveNote Reporter, and Notary Public of the State of New York.

A P P E A R A N C E S:

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BY: PAUL SINGARELLA, ESQ.
BY: GARRETT JANSMA, ESQ.

KIRKLAND & ELLIS
Attorneys for Defendant
601 Lexington Avenue
New York, New York
BY: DEVORA ALLON, ESQ.

Also Present:
John Allen, Deputy Director, Special Assistant Attorney General
Larry Dunbar
Carlos Lopez, Videographer

THE VIDEOGRAPHER: This is the start of tape labeled number one of the videotape deposition of Dr. Philip Bedient in the matter the State of Florida versus the State of Georgia in the matter -- I'm sorry.
This deposition is being held at 885 Third Avenue, New York, New York, on May 4th, 2016, at approximately 9:03 a.m.
My name is Carlos Lopez. I'm the legal video specialist, with TSG Reporting, Inc. The court reporter is Bonnie Pruszynski, in association with TSG Reporting.
Will counsel please introduce yourself for the record.
MR. SINGARELLA: Good morning, Doctor.
Paul Singarella for the State of Florida.
MR. JANSMA: Garrett Jansma on behalf of the State of Florida.
MS. ALLON: Devora Allon from Kirkland & Ellis for the State of

P. Bedient

Georgia.
MR. ALLEN: John Allen on behalf of the State of Georgia.
THE VIDEOGRAPHER: Will the court reporter please swear in the witness?
(Witness sworn.)
PHILIP B. BEDIENT, Ph.D., P.E.
called as a witness, having been first duly sworn, was examined and testified as follows:
EXAMINATION
BY MR. SINGARELLA:
Q Good morning, Doctor.
A Good morning.
Q Could you please state and spell your name for the record?
A It's Philip Bedient. P-H-I-L-I-P. B-E-D-I-E-N-T.
Q And where do you live?
A I live in Sugar Land, Texas, which is near Houston.
Q Who is your employer?
A I'm employed at Rice University in Houston.

P. Bedient

A You mean summer of 2015?
Q Yes.
A No, I'm not aware. I haven't studied what the Fish and Wildlife Service has either said or commented on in this document.
Q Just -- just for a minute going back to the water supply request, are you conducting or have you conducted any independent evaluation of Georgia's water supply request for purposes of your work in this case?
MS. ALLON: And again, let me just instruct the witness that it's fine to answer that question as to the last report.
A I just -- I don't know the answer to that. You know, we are working on obviously a report for May 20, and I don't know whether that's part of that activity or not. I just forget.
(Bedient Exhibit 24, Document, Problems regarding United States Army Corps of Engineers (Corps) alternatives

P. Bedient

selection process for Apalachicola-Chattahoochee-Flint (ACF) Water Control Manual update, July 31, 2015 marked for identification, as of this date.)
Q Have you ever seen Exhibit 24?
A No. No, I have not.
Q You don't recognize this as part of the DEIS?
A No, not these specific six or seven pages. I know that there are comments in the DEIS from Fish and Wildlife. I just haven't reviewed that part of it.
Q Have you studied any of the comments on the draft EIS?
A I have glanced over some of them, but again, just in passing. Just in passing.
Q How much of the draft EIS have you read?
A I have read the whole document, and then I have read some of the exhibits specifically pertaining to my expertise. It's such a gargantuan document, that I have left other, other, you know, appendices, I

P. Bedient

think, to other experts that are more qualified in ecological and fisheries areas.
Q So, Exhibit 24 is a Fish and Wildlife Service document --
A Right.
Q -- regarding problems with the Corps' alternative selection process for the water control manual update.
Do you see that, sir?
A Yes. I see they have some issues, yes.
Q And you understand that the water control manual update is the update of the Corps operating manuals to accommodate Georgia's water supply request; correct?
A Right.
Q And you understand that the draft EIS process is a regulatory process to examine the potential environmental impacts associated with that update; correct?
A Oh, yes. Oh, yes.
Q You know how all that ties together?
A Oh, yes. It's all related, because

P. Bedient

it's a comprehensive system. It's an integrated, balanced ACF Basin approach.
Q And in that balancing, do you understand that the general philosophy is that the Corps stores in the winter and releases in the summer?
A Well, the RIOP, the current operating system, there is -- there is what I would refer to as a winter refilling season, and then there is this March to May spawning season, and then a non-spawning season, and then finally you have this issue with respect to droughts.
And so, it's not as simple as what you have just said. It follows -- it follows this very complex table. And so under -- and in particular, under drought conditions. Once that kicks in, and as we have seen earlier today, you -- you don't come out of drought conditions until those reservoirs are back up and completely full.
So, that's as I understand the operations.
Q Is it -- is it your understanding

P. Bedient

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?

A No. ResSim is a planning tool. That was a good effort, but no. 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.

Q What data were you just referring to in your answer?

A Measured gauge data, for example. I'm sorry.

Q Okay. So on page two of this exhibit, Exhibit 24 --

A Okay.

Q -- I want to talk about this first paragraph that start with "the FWCA."

Do you see that?

A Um-hum.

Q Yes?

A Yes.

P. Bedient

Q And do you know what the FWCA is?

A I'm thinking it's the Florida Water, or it's Fish and -- it's a new version for Fish and Wildlife Service. I would assume it's Fish and Wildlife.

Q A reference to the Service itself?

A Yeah, I think it is. These federal groups keep changing their initials through the years, like the SCS and others that have changed their initials.

I think that is what that is.

Q Do you know when Fish and Wildlife Service changed its acronym?

A I do not. But that was a pretty good guess, you have to admit. Fish and Wildlife.

Q Okay. Are you sure of that?

A I'm pretty sure that's what it is.

Q Okay. And then at the end of that paragraph, the Service says, "Under the current timeline."

Do you see that?

A Yes.

Q "The Corps is scheduled to release

P. Bedient

the DEIS based on a methodology that ultimately may have led to the possible incorrect selection of a PAA."

Do you see that?

A I do.

Q Is that the first time you are aware of that, sitting here today?

A It is. It is.

Q Did you -- did you analyze any alternatives to the PAA?

A You mean separate alternatives that aren't in the PAA?

Q Yes.

A Oh, no. I just -- we just took the -- literally took the Corps models of those various alternatives and ran them. That's -- and that's all we did in that section in our report.

Q And do you see the last sentence there in that carryover paragraph? "The Service refers to the severity of its concerns."

Do you see that?

A Is that still in the top paragraph?

P. Bedient

Q It is. The very last sentence.

A Oh, yes. Yes, I see it.

Q In order for you to predict the future operational scheme for the ACF, is it important for you to understand the Service's concerns as expressed here?

A Well, it is certainly a viable concern. It's just that it's not represented as a stated alternative that I know how to compare or analyze. Once that comes to pass, then I can put that into the analysis, and would probably do that. But it's -- I haven't seen anything on that yet.

Q You are not aware that the Service has its own alternative and that it's been studied by the Corps?

A There is an alternative that is associated with Fish and Wildlife in this -- in this grouping, and I don't know whether -- but what I don't know is whether or not the concerns have been -- have been represented in that alternative that we have run. I don't know the answer to that.

Q Have you heard of an alternative

PHILIP B. BEDIENT, Ph.D., P.E.

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

DEPOSITION OF PHILIP B. BEDIENT, Ph.D., P.E.

JUNE 29, 2016

9:04 A.M.

Volume 3

Reported by: Michele E. Eddy, RPR, CRR, CLR

JOB NO. 108985

PHILIP B. BEDIENT, Ph.D., P.E.

JUNE 29, 2016
9:04 A.M.

Deposition of PHILIP B. BEDIENT, Ph.D., P.E. held at the offices of Latham & Watkins, LLP, 555 Eleventh Street, Northwest, Suite 1000, Washington, D.C., pursuant to notice, before Michele E. Eddy, a Registered Professional Reporter, Certified Realtime Reporter, and Notary Public of the states of Maryland, Virginia, and the District of Columbia.

PHILIP B. BEDIENT, Ph.D., P.E.
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BY: ANDREW PRUITT, ESQUIRE

ALSO PRESENT
Mr. John Allen
Mr. Larry Dunbar
Adolph Green, Videographer

PHILIP B. BEDIENT, Ph.D., P.E.
THE VIDEOGRAPHER: This is the start of tape labeled number 1 for the videotaped deposition of Dr. Philip Bedient in the matter of State of Florida versus State of Georgia in the Supreme Court of the United States, Case Number 142.
This deposition is being held at 555 11th Street, Northwest, Washington, D.C., on June 29th, 2016, at approximately 9:04.
My name is Adolph Green from TSG Reporting, and I am the legal video specialist. The court reporter is Michele Eddy in association with TSG.
Will counsel please identify yourself.
MR. SINGARELLA: Good morning. Paul Singarella for Florida.
MR. JANSMA: Good morning. Garrett Jansma for Florida.
MS. ALLON: Devora Allon, from Kirkland & Ellis, for the State of Georgia.
MR. PRUITT: Andrew Pruitt, Kirkland

PHILIP B. BEDIENT, Ph.D., P.E.
& Ellis, for the State of Georgia.
MR. ALLEN: John Allen for the state of Georgia.
THE VIDEOGRAPHER: Will the court reporter please swear in the witness.
- - -
PHILIP B. BEDIENT, Ph.D., P.E.,
having been duly sworn, testified as follows:
EXAMINATION
BY MR. SINGARELLA:
Q Good morning, Doctor.
A Good morning.
(Exhibit 51 was marked for identification.)
Q I've placed in front of you what we've marked as Exhibit 51 to your deposition. This is a version of your May 20, 2016, report that we received last Friday from your counsel. Do you recognize this document, sir?
A I do.
Q Did you prepare a redline version of your May 20, 2016, report, sir?
A Yes.
Q Is this it?
A It is.

PHILIP B. BEDIENT, Ph.D., P.E.
implemented by the Corps, you would end up with this condition in figure 35, correct?
A That is correct, sir.
Q So PAA is not going to help Florida, right, avoid this condition depicted --
A Not under this particular extreme condition here. It's a serious drought, and it drops down for a couple of months there. But -- yeah, that's my answer.
Now, I would add to that, that the Army Corps of Engineers, as they operate these reservoirs, they do have the ability to alter flows and change flows under extreme conditions depending upon what's happening downstream. So I don't know whether they would, you know, have the ability to alter this. This is just what the output of the model generated for this particular series of runs.
Q If they didn't exercise any discretion, we would end up with the condition depicted in figure 35, correct?
A That is correct.
Q Do you have an appreciation as to

PHILIP B. BEDIENT, Ph.D., P.E.
how bad this scenario is that you're -- that you're predicting here, how bad it is for Florida?
MS. ALLON: Object to form.
A I know it's below 5,000, and I know that's a cause for concern. From a hydrologic standpoint, that's all I've been asked to look at. I can't comment and I don't know anything about, sort of, the badness or the harm or anything else. That's beyond my scope for this project.
Q You can fairly assume that Florida would not like to see this scenario. So let me just ask you, what can Florida do to prevent your prediction from actually coming true?
MS. ALLON: Object to form.
A Well, I think that it's -- it's not so much what Florida can do. It's more what the Army Corps of Engineers can do within their operational scheme. And I do believe that they have the ability to do some discretionary releases concerning whatever might be happening downstream. How that works

PHILIP B. BEDIENT, Ph.D., P.E.
in detail, I don't know, of course, but I read that in the DEIS.
Q Do you know of anything that the State of Georgia could do to prevent the condition you're predicting in figure 35?
A Well, the Army Corps runs these reservoirs based upon the RIOP that's in place at that particular point in time. And, again, it's really -- this is really driven by Army Corps of Engineers. So I don't know what Georgia could do to alleviate this, off the top of my head.
Q Would it alleviate this, referring to, of course, your condition depicted in figure 35, if the State of Georgia were to withdraw its pending water supply request of the Army Corps?
A The pending water supply request from what year?
Q Well, it's a combination of 2013 and 2015, as you know, correct?
A Maybe I do.
Q You agree, right?
A I know that there was a 2013 --

PHILIP B. BEDIENT, Ph.D., P.E.
Q Yes.
A -- and I know that there was a follow-up, 2015.
Q Yes.
A But we've run a whole series of analyses looking at caps on consumptive use and, you know, things that Georgia, if you will, might do or might implement. We've run a whole series of those analyses and really have found that under those conditions, especially in these low flow time periods in and around the 2007 scenario, that even with as high as a 30 percent reduction in consumptive use, you're still, as shown, for example, in figure -- in figure 41 for baseline 2011 and even looking at a 30 percent cut, you still see it falling below in -- well, actually, in those -- in those scenarios you see that you've -- let me just check this -- you actually get some improvement. You can elevate it to 5,000 under certain circumstances there. But you still have -- you still have some issues. You still fall below.

ATTACHMENT 7

Excerpts from the Deposition Transcript of Dr. Hailian Liang (Feb. 9, 2016)

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

VIDEOTAPED DEPOSITION OF
HAILIAN LIANG, PH.D.
FEBRUARY 9, 2016
9:00 A.M.

CARLTON FIELDS JORDEN BURT
ONE ATLANTIC CENTER
1201 WEST PEACHTREE STREET N.W.
ATLANTA, GEORGIA

REPORTED BY:
STEVEN S. HUSEBY, RPR
CCR-B-1372

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Videographer: Damon Okoro

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P R O C E E D I N G S

THE VIDEOGRAPHER: This is the beginning of Disc Number 1 in the deposition of Hailian Liang, in the matter of State of Florida versus State of Georgia, et al., Case Number 142.

Today's date is February 9, 2016, and the time on the monitor is 9:04 a.m.

My name is Damon Okoro, I'm the videographer. The court reporter is Steve Huseby. We're with Huseby Global Litigation.

Counsel, please introduce yourselves, after which the court reporter will swear in the witness.

MR. SINGARELLA: Good morning. Paul Singarella here on behalf of the State of Florida here today.

MS. DESANTIS: Good morning, Karen McCartan DeSantis on behalf of the State of Georgia.

THE WITNESS: Good morning. This is Hailian Liang. I'm an employee of Georgia EPD.

HAILIAN LIANG, PH.D.,

being first duly sworn, was examined and testified as follows:

EXAMINATION

Page 8

BY MR. SINGARELLA:

Q. Good morning.

A. Good morning.

Q. As I said, my name is Paul Singarella. Do you go by Miss or Ms. Liang?

A. It doesn't matter.

Q. Okay. And could you just spell your name for the record?

A. Yes. My first name is H-A-I-L-I-A-N, last name is L-I-A-N-G.

Q. Thank you. And you said you work at the Georgia EPD. How long have you worked at Georgia EPD?

A. I started working at EPD in April 2010.

Q. And what is your current position at the EPD?

A. I'm a modeler.

Q. And you're in the hydrological analysis unit?

A. Yes.

Q. And where is your place of business, what's the address for the EPD?

A. It's 2 Martin Luther King, Jr. Drive, city is Atlanta, zip code is 30334. Yeah, I need to remember that. Usually we don't use it.

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Q. Okay. No problem. And where do you live?

A. Oh, I live in Marietta, Georgia.

Q. Marietta?

A. Yes.

Q. Okay. So I don't know if you've had your deposition taken before. Have you?

A. No, no.

Q. I'll just go over some of the ground rules so you can understand how things work during a deposition. So we have a stack of documents in front of you.

A. Yes.

Q. And most of these are documents that have been produced by the State of Georgia to the State of Florida in the case, and characteristically what lawyers do when producing documents is they put what we call a Bates stamp on the documents. So you can see on this first document here in the lower right-hand corner --

A. Uh-huh.

Q. -- you see it says GA211819?

A. Uh-huh.

Q. That's just an example of a Bates stamp. So you'll see that on a lot of documents. And sometimes I might reference the actual Bates stamp

A. Also from Clemson.
Q. And an undergrad from where?
A. From China, the China University of Geosciences.
Q. So if we turn the page, you can see that this carryover sentence says, "The results have been incorporated in the package for you to make a case to the Georgia legislature on potential management options." Do you see that?
A. Yes, I see the sentence.
Q. Do you know what that package refers to there?
A. Again, I'm not very -- I'm not clear about this, just like I said, my work involving groundwater model is just one tiny bit piece of work that's helping Menghong so --
Q. And then the next paragraph talks about your surface water modeling and it says that you've become one of the pillars of Wei Zeng's unit. Do you see that?
A. Yes, I see that.
Q. It's very complimentary of you. And with regard to analyzing and modeling the ACF Basin, do you see that?
A. Yes.

Q. What models have you applied with regard to your modeling work of the ACF Basin?
A. Oh, it's ResSim model. It's H-E-C, HEC-ResSim model.
Q. Anything else?
A. Besides ResSim model, I touch a little bit HEC-5, HEC-5 model, but not for ACF.
Q. And for how many years have you been running the ResSim model?
A. Oh, since 2010, since I started here.
Q. Are you still working with it today?
A. ResSim? Yes. That's the most important tool.
Q. And why is it the most important tool?
A. Well, it's a tool that software developed by Army Corps of Engineers. It's well recognized, well acknowledged, well used in surface water modeling area.
Q. And I noticed from some of the materials that you made some recommendations to the Army Corps that resulted in their making certain revisions --
A. Yes.
Q. -- to ResSim, right?
A. Yes. I mean, it's a software, it's not perfect, right? It always have little bugs there.

So during the work we found, based on that kind of small bugs, then we report to HEC and they kind of fixed the problem to make software better and better.
Q. And who is your primary contact at the HEC?
A. So far I only contact with Joan, I believe it's Joan, her name is Joan. She's the one that developed -- developed this HEC-ResSim model.
Q. And with regard to the software changes that you recommended to Joan and HEC, were any of those with respect to the ACF Basin?
A. No. It's in other basin.
Q. Other basins?
A. Not ACF.
Q. Okay. Then this paragraph has a lot in it. I want to focus on the second half of the paragraph where it refers to you as the modeler who developed the scenarios in Georgia's 2013 ACF Water Supply Request. Do you see that?
A. Yes.
Q. And we're familiar with a 2013 water supply request. Can you look at the next document.
(Exhibit Number 2 marked for identification).

BY MR. SINGARELLA:
Q. Is Exhibit 2 the 2013 ACF Water Supply Request that you worked on?
A. You mean Exhibit 2?
MS. DESANTIS: Mr. Singarella, I think in my stack we go right to something that's Exhibit 5. But is this what you want to mark as Exhibit 2 for this? It's an old mark.
MR. SINGARELLA: It's Exhibit 5 to some other deposition.
MS. DESANTIS: Okay, so it's this January 11, 2013 letter.
THE WITNESS: Oh, Exhibit 2 here, oh, I didn't notice this. I was looking for the attachment.
BY MR. SINGARELLA:
Q. Some of these will have multiple exhibit stamps on them now because they have been used before.
A. Thank you, Karen.
Q. I'm sorry for the confusion about that. So is this the 2013 ACF Water Supply Request upon which you worked?
A. Yeah, I'm looking at this document. I have been working on 2013 Georgia's Water Supply

see that, right?
A. Yes.
Q. Do you understand that to be the case?
A. Yes.
Q. And who at EPD is responsible for closely observing the Corps operations in the ACF Basin?
A. I think -- I mean, I don't know other group, but in my group we closely take a look of Corps' release from the federal reservoirs, like Lanier, like Jim Woodruff, like West Point, yeah, from federal reservoirs.
Q. And so Dr. Zeng in the second sentence says, "It has been brought to my attention." Do you see that?
A. Yes, I see that.
Q. Do you know who would have brought this to his attention?
A. Maybe Wei just look at Corps' website and look at some of the number, caught his attention.
Q. And then he goes on to say the Corps has been releasing into the Apalachicola River much more water than what is prescribed in the RIOP, I'm paraphrasing, but do you see that?
A. Yes, I see that.
Q. And he says this has been occurring in

recent weeks, right?
A. Yes, I see that.
Q. Do you have an understanding as to that having happened?
A. You mean for this particular case?
Q. Yes.
A. No, not for this particular case. I'm not the one to schedule to closely take a look at ACF Basin.
Q. Do you know of any other cases in which the Corps released water into the Apalachicola over the amounts prescribed by the RIOP?
A. No. I haven't paid attention to that.
Q. Do you know if they from time to time release water different than what would be prescribed by the ResSim model?
A. Well, I -- I mean, ResSim model is just a simulation. I don't think Corps will rely on ResSim modeling results to operate their reservoirs. I don't think so.
So you're asking whether Corps releasing water more or less by ResSim modeling results, right?
Q. Yes.
A. So I don't think Corps makes decision based on ResSim modeling results. That's my

personal, personal opinion, I don't think so. But you need to confirm with Corps, I think.
Q. There's a modeling team at the Army Corps, right?
A. Yeah.
Q. You've talked to Joan there, right?
A. Well, Joan is not specifically modeling the ACF Basin. She's the one developed the software. Yeah, she's the one developed the software.
Q. And where is she located?
A. In California, Davis.
Q. In Davis?
A. Yeah, Davis.
Q. So is there an Army Corps person who's assigned to running ResSim for the ACF Basin?
A. Maybe, maybe James Hathorn, maybe. You know, right, you know James Hathorn?
Q. I don't know him. Only by some of these documents.
A. I just heard his name. But I -- I'm not very sure. Please don't rely on my information. I'm just -- I know he's in the Mobile district, but I don't know whether he's the person to run the model or not.

Q. And then there's a group of Army Corps individuals that actually operate the ACF reservoir system, correct?
MS. DESANTIS: Objection, foundation.
THE WITNESS: I don't know. I've never physically visited their reservoir.
BY MR. SINGARELLA:
Q. You didn't take the Operator For a Day course?
A. Operator For Day course?
MS. DESANTIS: Objection, foundation.
THE WITNESS: I didn't get you.
BY MR. SINGARELLA:
Q. Oh, because you took a course from the Army Corps, but that was on the modeling, right?
A. Yeah, that's the modeling workshop.
Q. Apparently they have some other class you can go take, it's called Operator For a Day.
A. I don't know whether they have that kind of class or not. No, I don't know.
Q. Okay.
A. No.
Q. Maybe I'll see you there.
A. Well --
Q. Okay. Let's go to 21.

ATTACHMENT 8

Excerpts from the Deposition Transcript of Dr. Aria Georgakakos (Feb. 11, 2016)

ARIS P. GEORGAKAKOS, Ph.D.

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

CONFIDENTIAL

DEPOSITION OF ARIS P. GEORGAKAKOS, Ph.D.

FEBRUARY 11, 2016

9:07 A.M.

Volume 1

Reported by: Michele E. Eddy, RPR, CRR, CLR

JOB NO. 103211

ARIS P. GEORGAKAKOS, Ph.D.

February 11, 2016

9:07 A.M.

Deposition of ARIS P. GEORGAKAKOS, Ph.D., held at the offices of Latham & Watkins, LLP, 555 Eleventh Street, Northwest, Suite 1000, Washington, D.C., pursuant to notice, before Michele E. Eddy, a Registered Professional Reporter, Certified Realtime Reporter, and Notary Public of the states of Maryland, Virginia, and the District of Columbia.

ARIS P. GEORGAKAKOS, Ph.D.

APPEARANCES:

Latham & Watkins
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     ANDREW PRUITT, ESQUIRE
     ZACHARY AVALLONE, ESQUIRE

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ARIS P. GEORGAKAKOS, Ph.D.

ATTENDANCE, Continued

ALSO PRESENT

Peter Shanahan, Ph.D., P.E.

John C. Allen, Deputy Director

Jordan Mummert, Videographer

ARIS P. GEORGAKAKOS, Ph.D.

THE VIDEOGRAPHER: This is the start of the tape labeled number 1 of the videotaped deposition of Aris Georgakakos in the matter State of Florida versus State of Georgia. This deposition is taking place at 555 11th Street, Northwest, Washington, D.C., on February 11th, 2016, at approximately 9:07 a.m.

My name is Jordan Mummert from TSG Reporting, Inc. I'm the legal video specialist. The court reporter is Michele Eddy in association with TSG Reporting.

Will the counsel please introduce yourselves.

MR. SINGARELLA: Good morning, Dr. Georgakakos. Paul Singarella here today on behalf of the State of Florida. I'm with the law firm of Latham & Watkins, and my colleague down here to my left is Ben Lawless. He's also from Latham & Watkins. And I think you know Dr. Shanahan.

THE WITNESS: Yes.

MS. DESANTIS: Karen McCartan

ARIS P. GEORGAKAKOS, Ph.D.

DeSantis, from Kirkland & Ellis, representing the State of Georgia.

MR. PRUITT: Andrew Pruitt, Kirkland & Ellis, on behalf of the State of Georgia.

MR. ALLEN: John Allen on behalf of the State of Georgia.

MR. SINGARELLA: Could you swear in the witness.

THE REPORTER: Can we go off the record.

THE VIDEOGRAPHER: The time is 9:08. We're off the record.

(Discussion off the record.)

THE VIDEOGRAPHER: The time is 9:13. We're on the record.

- - -

ARIS P. GEORGAKAKOS, Ph.D., having been duly sworn, testified as follows:

EXAMINATION

BY MR. SINGARELLA:

Q Good morning, Doctor.

A Good morning.

Q I do know of you, not only from this case, but because we're both fellow Parsons lab alumni, but we go through certain formalities at the beginning of a deposition.

A Of course.

Q I'm going to ask you to just please state your full name and then spell it for the record, please.

A So my name is Aris Georgakakos, and the first name is spelled A-R-I-S and the last name is G-E-O-R-G-A-K-A-K-O-S.

Q Thank you. I understand you're a professor at Georgia Tech, correct?

A Yes.

Q Are you a full professor at Georgia Tech?

A Yes.

Q How long have you been a full professor?

A Since 1994, so that would be 12 years.

Q 2004, then?

A No, 1996 actually, 1996, since 1996.

Q So 20 years.

A So it's 20 years. Time is flying, yes.

ARIS P. GEORGAKAKOS, Ph.D.

think so. It's just that it's -- you know, the problem is complex. I mean, you need to have better data. We need to have better data. In the absence of better data, the ResSim doesn't have, like, a means to say I want to use a monthly time scale. So they have the daily, I think the daily time-step, if I recall what is encoded into how the model works. So they have to use that daily time-step that's available to them. But then the data they have are monthly. So they use this because that's what they have available.

So I think it's not a matter of intentionally they're making a mistake. It's just that they have available this model. They have the data. They use it to try to figure out. But I think -- the point is that the model does produce good results, but we have to focus on the proper time scale. That's my point. And then we can make comparisons that make sense.

Q Do you understand that the Corps tries to make up for the ResSim limitations through its operational decision making?

ARIS P. GEORGAKAKOS, Ph.D.

MS. DeSANTIS: Objection, form.

A They should. I don't know, but they should. And, you see, these are planning models and then operations is a different ball game, so to speak. Because we have observations that we obtain, and then they can update their plan, for example, of releases based on the observations. So I think they're doing that, especially during flooding, because that's one of the primary missions that the Corps has in the ACF, to try to protect from flooding. So they must be doing that. But they do that not by using the model, but looking at the observations and then trying to model the system -- or to understand how the response of the system is based on what you observe throughout.

So I think the ResSim is a tool that provides them the normal way of releasing and operating and the root curves and things like that. But the operations are different. They use observations. So they don't rely on the ResSim, I don't think.

Q Do you understand that the Corps does