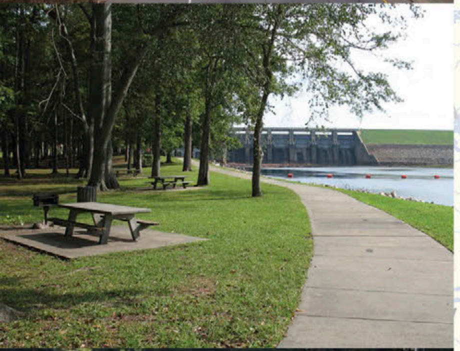
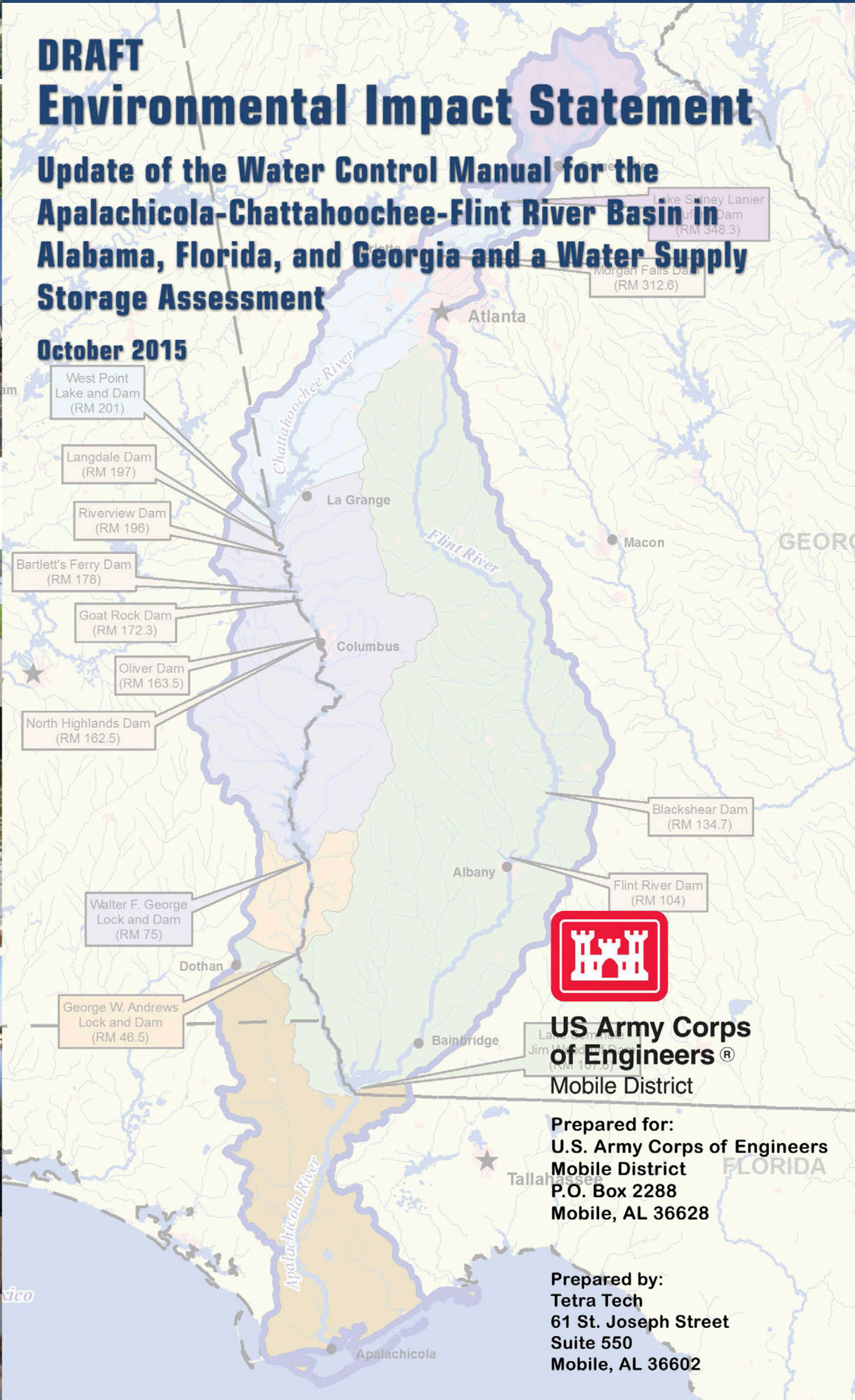





DRAFT
Environmental Impact Statement
Update of the Water Control Manual for the Apalachicola-Chattahoochee-Flint River Basin in Alabama, Florida, and Georgia and a Water Supply Storage Assessment

October 2015



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Appendix J

USFWS Coordination

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USFWS Planning Aid Letter April 2010

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April 2, 2010

Colonel Byron Jorns
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Dear Colonel Jorns:

We are providing your agency with a Planning Aid Letter (PAL) for the proposed Water Control Manual (WCM) Updates for the Apalachicola-Chattahoochee-Flint (ACF) River Basin in Georgia, Alabama, and Florida. The purpose of the updates is to identify operating criteria and guidelines for managing water storage and release of water from Corps reservoirs. In the National Environmental Policy Act (NEPA) review, the Corps will address current operations, proposed changes in water management operations at the reservoir projects within the limits of the existing authorities, as well as potential impacts throughout the basin that would result from implementation of the updated manual.

The purpose of the PAL is to identify resource values and issues, identify endangered species issues, and propose preliminary changes, mitigation, or enhancement opportunities to facilitate your decision-making as it relates to equal consideration of fish and wildlife resources. We submit the following comments and recommendations under the ESA, the Migratory Bird Treaty Act (MBTA)(49 Stat. 755, as amended; 16 U.S.C. § 702 *et seq*.), and the FWCA (48 Stat. 401, as amended; 16 U.S.C. § 661 *et seq*.). These comments are based on previous studies and government documents as well as new datasets and information provided by State and Federal agencies. Although all of the comments from the Florida Fish and Wildlife Conservation Commission (FFWCC) have not been integrated, this final version of the PAL addresses many of the issues that FFWCC raised. We will continue to provide additional expertise and information in the form of another PAL and/or the draft Fish and Wildlife Coordination Act report. A separate consultation will occur regarding the potential impacts of the Corp's proposal on federally-listed threatened and endangered fish and wildlife species protected under the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. § 1531 *et seq*.).

1. Development of Corps Alternatives and Mitigation

We have identified data needs and assessment methods that can help you in developing alternatives that maximize fish and wildlife benefits, and avoid, minimize and compensate for impacts to fish and wildlife resources, where appropriate.

1.1 Flow Regime

The WCM update should include a thorough evaluation of project-related flow regime alterations and the potential to restore flow regime components that have ecological and geomorphic significance. We recommend the Corps develop alternatives that would maximize benefits to fish and wildlife resources in light of other project purposes. To support this effort, we have provided preliminary ecosystem flow guidelines for four river sections; below Buford, West Point, Walter F. George, and Jim Woodruff dams. These flow regime guidelines are guided by the principle that ecosystems evolved as a response to the natural flow regime. Thus, we analyzed river flows and developed flow guidelines based on United States Geological Survey (USGS) flow data that were collected prior to Buford Dam construction in the mid 1950's, a benchmark of the first major river regulation source in the upper Chattahoochee River. Reliance on pre-regulation datasets to derive ecosystem flows is particularly useful for locations where empirically derived ecology-flow relationships are scant (such as the upper Chattahoochee River).

We recognize that complete implementation of all guidelines presented herein is not feasible given the expansive flow alteration and consumptive demands in the ACF River Basin that have occurred since Buford Dam construction. However, restoration of some natural flow regime components presented in these guidelines can restore structural and functional ecosystem elements that were lost or reduced as a consequence of flow regulation. For example, provision of stable flow windows (*sensu* Freeman et al. 2001) in the spring may increase riverine fish recruitment, even though restoration of other naturally occurring flow regime components may not be attainable. Relatively small discharge changes can have substantial ecological effects. For example, the Tennessee Valley Authority's (TVA's) strategy to increase baseflows below Normandy Dam (Figure 1) during the spring and summer mussel recruitment months resulted in biologically and statistically significant increases in mussel diversity and density (Figure 2, Ahlstedt and Johnson 2004).

Development of environmental flow alternatives would include an evaluation of the operational feasibility, constraints, and tradeoffs to providing the different aspects of environmental flow measures that are captured in our guidelines. Explicit magnitude, frequency, duration, timing, and rate of change guidelines are provided to illustrate the types of flow modifications that are likely to benefit the ecosystem and to help inform the development of Corps flow alternatives. However, should the magnitude of a flow guideline be deemed unattainable, we request that the Corps identify a flow magnitude that is attainable or recommend an attainable frequency for the recommended flow magnitude. An explanation for the change also will be helpful. We recognize these guidelines do not define whether the basin is entering a dry, average, or wet month, which are the lines between the lower and upper limits on the flow prescription graphs. We recommend that you work with us to develop appropriate hydrological and meteorological criteria (e.g., basin inflow, precipitation, and reservoir levels) needed to classify the coming month as a dry, average, or wet month.

Successful implementation of ecosystem flows in the Chattahoochee River is challenged by water demand increases, reduced operational flexibility imposed by meeting minimum discharge requirements at downstream locations, and the importance of minimizing high discharge-related

damage to infrastructure. To address these challenges, we considered only the range of flows that were likely to be above minimum flow requirements and less than flows that could cause major infrastructure damage as identified by information provided by the National Weather Service (NWS) Advanced Hydrologic Prediction Service (NWS 2010; Table 1). The ecosystem flow guidelines are preliminary because in instances where water is diverted from the channel, or the channel is anthropogenically altered, natural flows may be insufficient to meet ecological needs.

Successful implementation of ecosystem flows in the Apalachicola River is challenged by the same types of limitations described for the Chattahoochee River. The degree of Apalachicola River channel entrenchment and widening, caused largely by Corps reservoir and dredging operations, varies spatially, but the discharge that is now required to reach bankfull elevation and cause floodplain inundation in the upper portion of the river is generally greater than the discharge that was historically required. However, datasets are available that quantify the amount of floodplain habitat inundated with the current level of entrenchment and over a range of discharges. These datasets, in combination with those that describe flow effects on sturgeon spawning and mussel habitats, will help to inform the development of future ecosystem flow guidelines and the evaluation of alternatives.

Thorough explanations of the physical, chemical, and ecological benefits from base flows, pulses, stable flow windows for spawning, and intra- and interannual flow variation are outside the scope of this letter; however, we refer the reader to Junk et al. 1989, Poff et al. 1997, Richter et al. 1998, Freeman et al. 2001, Postel and Richter 2003, and Mathews and Richter 2007 for fuller descriptions. The importance of baseflows, pulses, and flood flows are described within these resources, and they are quantitatively evaluated using the recently developed Environmental Flow Components (EFCs) in Indicators of Hydrologic Alteration (IHA)(Mathews and Richter 2007). General descriptions of the baseflow, pulse, and high pulse flow guidelines are provided below with general descriptions of the ecological significance of those flow guidelines.

Similar to the Instream Flow Guidelines provided to the ACF Compact's Federal Commissioner (USFWS 1999), the guidelines provided in this letter were developed using IHA, use the pre-dam period of record as a benchmark for comparison of flow alternatives, and rely on percentiles to define the frequency of high and low flow extremes. Using EFCs is recommended because the analysis separates ecologically-relevant hydrograph components (e.g., baseflows from pulses) allowing computation of magnitude, frequency, duration, timing, and rate of change statistics on individual hydrograph components rather than on the entire dataset. Consequently, these hydrograph summary statistics are easily developed, interpreted, and communicated, and have been used successfully to inform flow management downstream from hydropower dams.

1.1.1 Baseflow and small pulses

Baseflows determine the amount of habitat that is available for forage, reproduction, and rearing, which has a substantial influence on the abundance, diversity, and distribution of aquatic fauna. We have provided explicit base flow recommendations for every month in dry, average, and wet water years. Small pulses that do not exceed bankfull elevation provide influxes of upstream

trophic subsidies, and reprieves from low dissolved oxygen and high temperature that sometimes occur during summer months. Small pulses are included in the guidelines with explicit magnitude, frequency, duration, timing, and rate of change recommendations (Figures 3-6).

The flow guidelines were based on average daily flows (Figures 3-6). Average daily flows obscure the diel streamflow variation imposed by hydropower generation. Consequently, hydropower generation at Buford, West Point, Walter F. George, and to a lesser extent, Woodruff Dam, may change discharge two orders of magnitude, and change river stage significantly within a few hours. As a result, habitat availability is limited to periods that are too brief for the completion of essential life history requirements. To mitigate this impact, the provision of non-hydropower peaking “windows” should be evaluated during critical reproductive and rearing periods in order to reestablish native plant, fish, and invertebrate abundance and diversity in river reaches downstream from Corps-operated projects. Generally, this period corresponds to March – May when water temperatures increase. The timing, duration, and magnitude of this window should vary interannually in order to optimize the reproductive requirements of each species every few years. However, the duration of the non-peaking window requires additional research, but we expect that a minimum of 4-6 weeks between March and May are required.

The dry, average, and wet year baseflow guidelines are based on a retrospective analysis of the pre-dam hydrograph (Figures 3-6). It will be necessary to use appropriate hydrological and meteorological criteria to classify the coming month into dry, average, or wet categories. However, average daily baseflows should remain near the dry, average, and wet year flow guidelines depending on the category, and should not fall below the lower limit on any day of any year.

1.1.2 High flow pulses

High flow pulses that exceed bankfull elevation provide important ecological services. A large proportion of sport and non-game fishes rely on floodplain habitats to spawn, rear young, and forage. High flow pulses are also major forces that control nutrient and organic matter dynamics in large rivers, create new habitats, and ultimately affect riverine animal biomass (Junk et al. 1989). However, the spring reservoir refill period extends into the principal spawning season for a high proportion of fishes, meaning that spring flows and floodplain inundation are reduced. Thus, ensuring seasonal high flows and river-floodplain connectivity with the timing, frequency, duration, magnitude, and rate of change necessary to sustain ecological functions and wildlife populations are essential flow management objectives for dams on large rivers.

To provide flows that inundate the floodplain, the potential for reducing the magnitude of the autumn drawdown, changing the order of refill, and/or beginning the spring refill earlier in order to provide fish access to and inundation of the floodplain should be evaluated. Similarly, the Savannah District Corps has operated the Savannah River reservoir system in recent years with reduced winter drawdown to provide spring pulses that meet multiple downriver ecosystem objectives. This evaluation should separately consider flow conditions in wet, average, and dry climatic years. Additionally, it should be noted that relatively small changes in river stage can significantly increase the amount of river-floodplain connectivity. Consequently, minor changes

in dam operation could have large and positive effects on the river-floodplain ecosystem.

Recognizing that there are limits on operational flexibility due to the presence of infrastructure in some floodplains, methods should be evaluated to provide the operational flexibility necessary for floodplain inundation, which falls under the Corps' coequal project purpose of "Fish and Wildlife Resources." Such methods could include 1) protecting structures (e.g. moving to locations of higher elevations or elevating structures using stilts as is done in coastal communities) that may be impacted by 2, 10, 50, and 100-year recurrence interval pre-dam flows during periods of floodplain inundation; and/or 2) the purchase of structures built in the historic floodplain so that the Corps can intentionally provide flows that inundate the floodplain. These analyses should be simple to conduct, and would include acquisition of floodplain maps and identification of anthropogenic structures within the 2, 10, 50, and 100-year floodplains.

1.2 Floodplain inundation assessments

The relationships among the areal extent of Apalachicola River floodplain inundation, channel entrenchment effects, and water releases from Jim Woodruff Lock and Dam were previously assessed and related to discharge using the datasets and summaries provided by Light et al. 1998 and Light et al. 2006. These datasets have informed biologists and the Corps of the effects of flow releases on river-floodplain resources. Due to the difficulty of surveying all floodplain streams, lakes, and forests, Light et al. 1998 used intensive surveys at a subset of sites, general surveys at approximately 300 sites, and Geographic Information Systems (GIS) to assess the effects of hydrogeomorphic alteration on floodplain inundation areal extent. Light et al. 2006 compared pre-dam stage (prior to 1954) and recent stage (1995–2004) at five streamflow gaging stations in relation to discharge at the Chattahoochee gage (USGS gage number 02358000, Apalachicola River at Chattahoochee, FL). These stage-discharge relationships can also be used to calculate area (acres) of aquatic habitat connected to the main channel of the non-tidal Apalachicola River at different discharges for the pre-Lanier (1929-1955) and post-West Point (1975-2007) periods.

More recently, floodplain elevation maps have been generated using Light Detection and Ranging (LIDAR) remote sensing data with <1 ft accuracy and related to Apalachicola River stage-discharge relationships developed by Light et al. 2006 (Ron Bartel, Northwest Florida Water Management District [NWFWMD], 2010, pers. comm.). Stage-based LIDAR data may provide a more thorough and accurate evaluation of river flow effects on river-floodplain connectivity and habitat availability. We recommend that the Corps contact the NWFWMD to confirm that these datasets exist, request permission to access and use these new datasets, or invite collaboration between the Corps and the NWFWMD to evaluate effects of flow alternatives on floodplain resources. Operations in the environmental flow alternatives should be developed that will use reservoir storage at certain times to augment flow and increase Apalachicola floodplain inundation.

1.3 Water Quality

The effects of reservoir operations on water quality should be closely examined in the WCM update, including ongoing and potential future effects to dissolved oxygen (DO), temperature, nutrient and organic material dynamics, and capacity to assimilate industrial and municipal

discharges. We request that the Mobile District use the WCM update to make necessary modifications that will improve water quality downstream of Corps projects, as is being done by TVA and other Corps districts.

1.3.1 Dissolved Oxygen

The Service is most concerned about low DO in project tailwaters. We recommend that the Corps make a concerted effort to ensure that releases from all five ACF dams meet or exceed DO and other applicable water quality standards. An appropriate effort would include first monitoring DO upstream and downstream of Corps reservoirs, experimenting with operational and/or structural modifications to Corps projects to improve DO levels, and conducting post-modification DO monitoring to ensure that DO levels have been improved to State water quality standards. Examples of low DO releases from Buford, West Point, and Walter F. George dams are detailed below.

We urge the Corps to 1) monitor DO upstream and downstream of Lanier Reservoir, West Point Reservoir, Walter F. George Reservoir, and Jim Woodruff Reservoir and 2) experiment with operational and/or structural modifications to improve DO levels, and conduct post-modification DO monitoring to ensure that DO levels increase to state water quality standards. Simple weighted averages that formulate the amount of sluicing necessary to achieve the required downstream dissolved oxygen requirements may be particularly useful. The DO that results from the mixing of two water bodies (DO_{mx}) is a function of the dissolved oxygen (DO_1 and DO_2) and volumes (Q_1 and Q_2) of the two water bodies and is calculated using the following equation:

$$DO_{mx} = \frac{Q_1 * DO_1 + Q_2 * DO_2}{Q_1 + Q_2}$$

1.3.1.1. Buford Dam tailwaters

Low DO levels were recorded by the Georgia Department of Natural Resources-Wildlife Resources Division (GDNR-WRD) just below Buford Dam during 1996-2006. These DO levels affect angler success, GDNR-WRD’s stocking rates, and the native aquatic community. Periodic measurements taken during this period resulted in monthly minimum instantaneous $\leq$ 1.0 mg/L in September through December. Monthly average values were < 5.0 mg/L from August through November (Figure 7; Chris Martin, GDNR-WRD, 2010, pers. comm.). Low DO levels persisted downriver, depending on operational and climatic factors. For example, based on GDNR-WRD measurements on November 5, 2005, DO increased to 5.0 mg/L three miles downriver, and increased to 6.0 mg/L 5.2 miles downriver when releases from Buford Dam were < 2.0 mg/L (Chris Martin, GDNR-WRD, 2010, pers. comm.).

The Corps upgraded the venting capabilities of the Buford Dam turbines over the past few years. However, the upgrades resulted in < 1.0 mg/L increase over previous conditions (Chris Martin, GDNR-WRD, 2010, pers. comm.). The Corps should thoroughly evaluate the effectiveness of these upgrades.

Useful tools to improve DO levels to State standards in Georgia trout waters (6.0 mg/L daily average, 5.0 mg/L instantaneous) include sluicing instead of running discharge through the

penstocks and units, or to use a combination of the two routing methods. For example, on September 15, 2000, GDNR-WRD recorded a DO level of 1.5 mg/L at Buford Dam during a minimum flow release through the house unit. In contrast, DO levels measured on the same date during sluicing indicate that DO remained above 6.0 mg/L (Chris Martin, GDNR-WRD, 2010, pers. comm.). Thus, the Corps has demonstrated that sluicing below Buford Dam is an effective tool to mitigate low DO effects associated with hypolimnetic releases.

1.3.1.2. West Point Dam tailwaters

Dissolved oxygen data collected by the Corps downstream from West Point Dam from 1999 through 2001 indicate that DO levels met or exceeded the Georgia instantaneous standard (4 mg/L) 35% of the monitoring period in 1999, (monitoring from 6/15-9/14), 30% of the monitoring period in 2000 (monitoring from 7/25-9/30), and 4% of the monitoring period in 2001 (monitoring from 6/8-10/5; Georgia Power Company 2002). GDNR-WRD has investigated multiple fish kills below West Point Dam and has concluded that these fish kills are attributable to low dissolved oxygen levels (GDNR-WRD letter to the Corps, November 20, 2008).

1.3.1.3 Walter F. George Dam tailwaters

Low DO levels were associated with minor fish and mussel kills downstream of Walter F. George Dam (Rob Weller, GDNR-WRD, 2008, pers. comm.).

1.3.2 Temperature

The water temperatures of hypolimnetic releases below large dams are lower than would naturally occur during spring and summer months. Low water temperatures negatively affect warmwater fishes that require warmer water temperatures necessary for spawning and growth of young-of-year fishes. Thermal alteration can be ameliorated by structural modification of penstock location in the water column. Another option to moderate thermal alteration is to release (via sluicing) warmer water from a higher elevation in the reservoir’s water column. Once this water mixes with the cold hypolimnetic release, water temperatures more closely approximate natural water temperatures. A recent example of sluicing effects in the Mobile District comes from measurements taken during summer 2009 below Allatoona Dam. Sluicing in June caused water temperatures to increase approximately10ºC (Figure 8). Temperature increases were observed many miles downriver (USFWS 2009 unpublished data).

Similar to DO recommendations, we urge the Corps to monitor water temperature upstream and downstream of the five ACF Corps impoundments, and 1) experiment with operational and/or structural modifications to improve temperature levels, as needed, and 2) conduct post-modification monitoring to ensure that temperatures have been improved. Simple weighted averages that formulate the amount of sluicing necessary to achieve the required downstream temperature requirements may be useful. The seasonal timing of such releases exhibiting modified temperatures is of great importance. For example, the current summer thermal regime on the Etowah River, created by operations at Allatoona Dam, provides cool thermal refuge for striped bass in the upper Coosa River system. A thermal modification during the summer months below Allatoona Dam could be detrimental to fishes such as striped bass and lake sturgeon (Matt Thomas, GDNR-WRD, 2010, pers. comm.). Because the Service and GDNR-

WRD have responsibilities to protect native aquatic communities as well as recreational fisheries, we recommend the Corps explore methods for temperature modifications below their facilities, but coordinate closely with State and Federal agencies to determine the appropriate timing of such alterations.

In addition, it should be noted that the current thermal regime of Lanier Reservoir's tailwater is critical to the Chattahoochee River trout fishery and trout production at GDNR-WRD's Buford Hatchery. The tailwater trout fishery in the Chattahoochee, one of Georgia's premier fisheries, is dependent upon cold, well-oxygenated water releases for the survival of trout. The Buford Trout Hatchery produces 400,000 catchable trout annually and is dependent on Lanier Reservoir coldwater storage to maintain this production. Potential impacts to Chattahoochee River trout waters should be considered when making WCM decisions (Matt Thomas, GDNR-WRD, 2010, pers. comm.). The coldwater trout fishery below Buford Dam is of great importance to GDNR-WRD, and is also a responsibility for the Service as an important recreational fishery. Discussions between GDNR-WRD and the Corps should occur to determine if modifications are possible that avoid trout fishery impacts but also provide benefits to native warmwater fisheries below Buford Dam.

1.4 Fish Passage

Corps ACF dams impede the migration of diadromous and potadromous fishes including striped bass, Alabama shad, American eel, and Gulf sturgeon. Jim Woodruff Dam's impact on diadromous fish passage is large compared to dams on other southeastern rivers because it is located in the lower part of a large river basin. Consequently, there is significant interest in improving fish passage at this facility, as well as the two next upstream Corps facilities, George W. Andrews Lock and Dam and Walter F. George Lock and Dam. We appreciate the Corps' willingness and cooperation to modify operations thus far at Jim Woodruff to maximize fish passage for Alabama shad. Support and facilitation of fish passage research at Woodruff Dam, as well as other ACF Federal dams (notably George W. Andrews Lock and Dam and Walter F. George Lock and Dam) should continue with a goal of identifying and implementing operations and/or modifications that would allow riverine species to travel their historic migratory pathways. Provisions for fish passage should be incorporated in the WCM for Jim Woodruff Lock and Dam, George W. Andrews Lock and Dam, and Walter F. George Lock and Dam, while maintaining the need for operational flexibility.

1.5 Climate Change

The effects of climate change to ACF flow regimes and how to best adapt reservoir operations to the most likely foreseeable changes should be evaluated. It is our understanding that the Corps will be considering sea level rise when developing alternatives (Corps 2009). However, climate change will also affect river flows and the effects of a given set of operating rules will vary depending on whether the basin's climate becomes drier, wetter, more variable, or less variable. In particular, it is vitally important to adapt the level set as the top of conservation (TOC) pool to the long-term hydrology of the basin and the essential purposes the projects serve. In a scenario with greater variability between annual high flows and low flows, for example, it may not be feasible for these projects to simultaneously serve their existing levels of flood control protection and minimum flow support without adapting TOC pool levels to prevailing weather conditions.

The Corps already practices this concept with the multiple action zones and the occasional variances from the rule curves to store water above the TOC pool elevation during dry periods. Several models are developed that will be useful in this analysis and are briefly described in section *2.2 Evaluation of Alternative Models*. In addition to including multiple future climate scenarios into modeled discharge scenarios and Corps alternatives, flow provisions should be created for dry, average, and wet years in order to account for current climate variability.

1.6 Navigation

Navigation is an authorized project purpose for all five ACF Corps dams and the Corps has used reservoir storage in the past to support navigation. In recent years, however, lacking water quality certification to maintain the channel in Florida, we have seen only occasional flow management for the navigation purpose. Current physical channel dimensions dictate the flows that are necessary for navigability. Without providing flows to meet channel depth authorizations, dredging would be necessary to maintain channel navigability. Dredging has significant adverse effects to fish and wildlife. If flows for navigation are included in the WCM update, we recommend that dredging needs, dredging impacts on fish and wildlife, and a cost-benefit analysis be included in an evaluation of the effects of the channel maintenance activities required for navigation flow support. If flows for navigation are not included in the WCM update, improvement or simplification of the four-zone reservoir operational scheme that governs current operation should be considered.

1.7 Reservoir and Riverine Fisheries Management

The Corps follows a draft Standard Operating Procedure (SOP) for “Lake Regulations and Coordination for Fish Management Purposes.” The “fish spawn” SOP goal is to manage for generally stable or rising reservoir levels and for generally stable or gradually declining river levels for about 4 to 6 weeks in the spring months at Corps’ reservoirs. These draft SOPs are protective of reservoir fish spawning; however, stable or rising river levels are also beneficial for riverine sport fisheries. We understand it is not feasible to have stable and/or rising water levels in both the reservoirs and river during times of declining basin inflow. To address this issue, recent reservoir and riverine fisheries literature should be reviewed to evaluate whether a 4-6 week stable or rising reservoir window is supported for reservoir fish spawning and/or potentially detrimental to riverine fish spawning. We also recommend development of an alternative that includes modifying the draft SOPs to occasionally emphasize river spawning over reservoir spawning and define those circumstances where this would occur without unreasonably compromising other project purposes. Finally, we recommend that the Corps identify fish and wildlife recreation facilities that need infrastructure improvements to operate at a wider range of flows and/or reservoir elevations.

1.8 National Wildlife Refuges

The Service previously recommended to the Corps that a seasonal pattern of reservoir levels at W.F. George Reservoir would best accommodate the needs of Eufaula National Wildlife Refuge. Water levels that provide seasonal habitat for a large number of migratory bird species, control the spread of undesirable aquatic vegetation, and allow the manipulation of off-reservoir impoundments for waterfowl are principal concerns of the Refuge. These recommendations, which we included in the draft FWCA report for the Corps' 1998 Draft EIS on ACF water

allocation, were to manage the reservoir so that it behaves more like a river. Reservoir elevations that cycle between the highest levels (190 ft) in the late winter and early spring to the lowest levels (185 ft) in the late summer were recommended. These recommendations remain valid. How the benefits and impacts of such a scheme compare with the existing operating regime and other alternatives should be considered.

1.9 Apalachicola Bay

The predicted levels of freshwater inflow into Apalachicola Bay resulting from Corps alternatives will be of importance to the Service because they may affect salinity levels. Freshwater inflow reductions cause salinity increases and indirectly increase oyster mortality through increased colonization of marine oyster bed predators (Corps 1998). Additionally, juvenile Gulf sturgeons have optimal growth rates at relatively low salinity (9-10 ppt), and periods of extended higher salinities would likely limit feeding habitat availability.

As part of the Comprehensive Study for the Corps' DEIS (1998), the National Ocean Service (NOS) examined the freshwater inflow effects on the water circulation and salinity changes in Apalachicola Bay. Oysters were selected as a biological response variable because of their commercial fishery importance, habitat requirements, and expected response to salinity fluctuations (Corps 1998). A three-dimensional hydrodynamic model produced output that was used in an integrated biological model to assess the effects of potential freshwater inflow changes to Apalachicola Bay salinities and oysters. Predicted oyster mortality and oyster bed growth rates were compared for the various Corps' alternatives.

More recently, Livingston et al. (2000) developed a spatially-explicit hydrodynamic circulation model of the bay that predicts salinity, among other variables, as a function of freshwater inflow. This model has been used to model oyster mortality and growth in relation to freshwater inputs. The Service has used the results of this model to make inferences on the availability of low-salinity bay habitat for Gulf sturgeon. In addition, an alternative Apalachicola Bay salinity model was recently developed by Peter Sheng at the University of Florida (Sheng and Kim 2009). By using the Corps' daily average discharge output from the ResSim model for the Sumatra gage for the various alternatives, the model can compare the spatial extent and temporal duration of low- and high-salinity conditions among the alternative freshwater inflow scenarios. This information can be used to make inferences on the availability of bay habitat for Gulf sturgeon and to model oyster mortality and growth.

We recommend that the Corps or the Corps' consultants (Tetra Tech) contact the NWFWMD and/or the Florida Department of Environmental Protection (FDEP) to request permission to access and use the Livingston et al. models, or invite a collaboration between the Corps and NWFWMD/FDEP to evaluate effects of flow alternatives on Apalachicola Bay resources. The Sheng and Kim (2009) model should also be incorporated in the WCM update process to predict effects to Gulf sturgeon feeding habitat and potentially oyster mortality and growth. If all models are made available to the Corps and the Service, we recommend that the strengths and limitations of each model be evaluated to determine the model that will best suit the assessment requirements. In addition, coordination should occur with FFWCC's Fish and Wildlife Research

Institute to complete analyses of the relationship of freshwater inflow to the benthic communities of Apalachicola Bay and changes in fish and shellfish abundance.

1.10 Decision Support Model to Evaluate Changes to Corps' Operations

It is important to evaluate the effects of management strategies on the riverine ecosystem, recreation, navigation, hydropower, and other uses of Federal dams. Because of the numerous and sometimes competing demands for water, it is difficult to evaluate the effects of proposed management alternatives and to make the evaluation transparent. However, multiple free decision support tools (e.g., Netica) are available to facilitate the evaluation of alternatives. These tools are versatile in the sense that new information that results from monitoring the effects of management strategies is easily integrated into the analysis and decision process. Consequently, a better and more transparent understanding of how Corps operations affect the ecology and use of the ACF system can lead to improved future management. Therefore, a decision support model should be incorporated into the WCM update process.

1.11 Adaptive Management

An adaptive management program should be developed, consistent with the authorized purposes of the ACF reservoirs, for achieving specific ecological and social goals for the management of the ACF system including specific releases for Woodruff Dam. The program would formulate hypotheses about how such benefits might be achieved through dam operations, implement those operations, monitor ecosystem responses, and revise the operations based upon lessons learned.

2. Recommendations for Corps Hydrologic Modeling

2.1 Increasing Consumptive Demands

The impacts of increasing consumptive (municipal, industrial, and agricultural) water demands in the basin should be recognized and considered. This is a variable that an analysis of operational alternatives should incorporate along with climate-driven hydrologic variability. The relationship between increasing consumptive demands in the ACF Basin and effects on various project purposes should be quantified. For example, how is sustainable minimum flow release from Woodruff Dam affected if consumptive demands increase by 25, 50 or 100 percent by the years 2020, 2050, and 2080? We recognize the order made by Judge Magnuson limits operational alternatives for the express purposes of water supply. However, we also recognize that surface and groundwater withdrawals will continue to be made at various points in the system. The Corps alternative analysis must include metrics regarding water supply withdrawals including potential increases. The volume of storage that is being provided for water supply and has been proposed in each project and any limitations due to hydrologic conditions of meeting the water supply storage volume should be documented, as well as any potential changes in agricultural irrigation due to expanded irrigated acres or changes in crop composition.

2.2 Evaluation of Alternative Models

The Corps' unimpaired flows dataset that was used in the 1998 draft EIS was compared to 1) the unimpaired flows dataset that the Corps expects to use for the WCM update and 2) to the pre-Buford Dam USGS streamflow gage data. Aside from the addition of recent flow records, the most recent Corps-modeled unimpaired dataset is essentially unchanged from the 1998 version.

Compared to the USGS gage data, these datasets do not accurately represent the magnitude, duration, timing, and rate of change of flow extremes (i.e., minimum and maximum flows). Because flow extremes play important roles in reservoir operational decisions and in riverine, estuarine, and floodplain ecology, efforts should be made to develop unimpaired flow and alternative flow datasets that more accurately reflect flow extremes. We recommend that the use of alternative models be investigated to develop better unimpaired flow and alternative flow datasets.

Similarly, land cover has changed significantly since the early 20th century in the upper and middle portions of the ACF basin. Prior to both mainstem damming and discharge gaging, expansive agriculture, chestnut blight, fire suppression, and other factors affected land cover in the southern Appalachians, Piedmont, Fall-line Sandhills, and upper Coastal Plain regions. The hydrological consequences of land cover changes could have been manifested in the flow extremes observed during droughts and heavy rain. Nevertheless, the pre-dam hydrologic period of record is presently the best available hydrologic dataset to characterize pre-dam streamflows, develop ecosystem flow alternatives, and with which to compare flow alternatives. Models that predict hydrological alteration that occurs in response to land cover changes could be particularly useful in the development and assessment of flow alternatives.

The United States Geological Survey (USGS) is developing a Precipitation-Runoff Modeling System (PRMS, http://water.usgs.gov/software/PRMS) for the ACF. This watershed model will facilitate the inclusion of impacts of precipitation, climate, and land use changes on streamflow, sediment yields, and basin hydrology. If the PRMS is developed specifically for the ACF in a timeframe useful for the ACF WCM update process, it should be used as an additional evaluation tool. The PRMS output potentially could be used to 1) check the precision of the Corps' unimpaired flows datasets, and 2) supply an alternative unimpaired flow dataset to use based on informed climate and land use change predictions. Use of this model is based on the assumption that the PRMS model results reflect average flows and flow extremes better than existing datasets and other models. The latter analysis may be particularly useful to determine if reservoirs can maintain downstream flows through droughts.

National Oceanic and Atmospheric Administration (NOAA) funded the Georgia Water Resources Institute (GWRI) to complete a historical and future assessment of precipitation, evapotranspiration, soil moisture, and run-off trends in the ACF Basin to support ongoing water resources planning in the region. This method used both historical gage data and the Corps unimpaired flows dataset in a Joint Variable Spatial Downscaling model that incorporated climate change effects. Future stream flow, river flow, reservoir level, and power generation forecasts were made at the sub-basin level for the next 100 years. Coordination with USGS and GWRI should occur regarding these new models to explicitly address climate-based operational flexibility during the development and evaluation of flow alternatives, the WCM update, and the EIS analyses.

Lastly, the Corps' HEC-5Q water quality analyses rely on average daily flow to predict water quality parameters (e.g., temperature and dissolved oxygen) in six hour time steps and at 0.5 mile intervals. Although these model outputs can be used to compare among flow alternatives, they are not expected to accurately predict either the water quality values or the range of values that

are likely to occur in response to hourly discharge changes. Alternative water quality models exist and State resource agencies should be contacted to determine whether water quality models are developed for the ACF Basin. Additionally, regression models that accurately predict water quality parameters (e.g., water temperature and dissolved oxygen) can be developed using a combination of water quality datasets, hourly discharge, and other environmental parameters (e.g., weather and solar exposure). Alternative water quality assessment methods should be considered to accurately evaluate effects of flow alternatives on water quality.

3. Evaluation of Corps Alternatives for FWCA Report

3.1 ResSim Model Output Analyses

It is our understanding that ResSim will be used for the Corps' flow analyses. The flow statistics used by the Service in the past to analyze the resulting datasets were derived by using the Indicators of Hydrologic Alteration (IHA) and the Range of Variability Approach (RVA). Because flow is a master variable in fluvial systems, and because the ecology of fish and wildlife is closely linked to the flow regimes in which they evolved, the current evaluation should continue to rely on tools such as IHA, RVA, and Environmental Flow Components (EFCs) (Mathews and Richter 2007). Specific flow statistics and species-specific flow-ecology relationships (as available) that are important to natural resource sustainability, as well as the ACF Riverine Community Habitat Assessment and Restoration Concept (RCHARC) study (Freeman et al. 1997), should also be considered.

3.2 HEC-5Q Water Quality Model Output Analyses

It is our understanding that HEC-5Q will be used for the Corps' water quality analyses. We understand that this model predicts water quality parameters in six hour time intervals in river and reservoirs. Similar to the analyses contained in the Corps' 1998 draft EIS (Corps 1998), the analyzed data should be composed of summer values (May through October), separated by drought, dry, average, and wet year types for each alternative. The following information should be developed for each alternative to evaluate the effects on water quality and aquatic resources in the modeled tailrace and riverine locations:

- Total number of days with dissolved oxygen below a daily average of 6 milligrams per liter (mg/L) in locations within Georgia trout waters, and below a daily average of 5 mg/L in non-trout waters;
- Total number of instantaneous "measurements" less than 4 mg/L;
- Monthly exceedance figures and box plots with outliers for dissolved oxygen (mg/L);
- Monthly exceedance figures and box plots with outliers for water temperature; and
- Average stream percent wastewater.

For each alternative, the following information should be developed to evaluate the effects on water quality and aquatic resources for the modeled ACF reservoir locations:

- Average values of summer Chlorophyll a (*u*g/L);
- Average summer retention time (days); and

- Average summer phosphorus loading (pounds/acre/month).

3.3 Floodplain Connectivity Analyses

Assessing the extent of floodplain inundation will be a critical component of the alternatives analysis assessment. The Apalachicola River floodplain analysis should be decided following the Corps' attempt to access the river stage-based LIDAR data collected and housed by the NWFWMD. If the data are made available, the Corps should provide these data to the Service and an analysis of the area of aquatic habitat (separated by aquatic habitat type) connected to the Apalachicola River under the range of discharges for the period of record should be evaluated. If LIDAR data are not provided, the magnitude, duration, timing, frequency, and rate of change of Apalachicola River floodplain inundation should be evaluated using the relationships quantified by Light et al. 1998 and Light et al. 2006.

Although the areal extent of the Chattahoochee River floodplain is one-fifth that of the Apalachicola River floodplain (Davis 1997), it likely served multiple important ecological roles prior to flow alteration by multiple mainstem reservoirs. To our knowledge, the Tri-State Comprehensive Study Riparian Wetland Element (Davis 1997) houses the best available dataset for assessing the effects of flow alternatives on the Chattahoochee River floodplain. These data should be used to evaluate the probable extent of floodplain inundation for each flow alternative. However, data are only available for one riverine site in the Chattahoochee River Basin positioned between Jim Woodruff Lock and Dam and G.W. Andrews Lock and Dam. At unsurveyed locations, known river stages at which floodplain inundations occurs should be used to evaluate the frequency, duration, and timing of floodplain inundation for flow alternatives provided by the Corps (see Table 1 and associated information provided by NWS 2010). At sites without this information, the 2-year recurrence interval discharge to approximate the incipient point of flooding should be used to evaluate the frequency, duration, and timing of floodplain inundation. Because channel alteration (e.g., channel incision) can increase the recurrence interval at which flooding occurs and because we have little information on channel alteration, other data sources should be investigated to aid in the floodplain inundation assessment.

3.4 Reservoir Fisheries Analyses

Sport fisheries are important recreational and economic resources in all of the Federal ACF reservoirs. Important sport fishes in all five reservoirs include largemouth bass and crappie, but each reservoir supports a mix of several additional species, including walleye (Lanier Reservoir only), striped bass, bluegill, redear sunfish, and others. Based on interviews of fisheries managers and researchers in the basin, Ryder et al. (1995) identified the species considered critical in an evaluation of operating alternatives and the relative acceptability of reservoir levels for these species. A Delphi technique was used to obtain expert opinion for select reservoirs on reservoir fish guilds, important seasonal periods for those species, and acceptability ratings for various reservoir levels in the ACF and ACT (Ryder et al. 1995). The Service cooperated with the Corps for the 1998 draft EIS for ACF water allocation to develop a reservoir fisheries performance measure using the findings of Ryder et al. (1996). This information was used to create a reservoir fisheries performance measure by looking at the critical spawning and rearing periods, reservoir elevations during these times, and assigning a greater weight to stable or rising elevations during those time periods. The performance measures were then compared for the various alternatives.

The reservoir fisheries performance measure should be updated with additional information, literature, and/or relevant datasets that have been developed in the past ten years, and used to evaluate the relative impacts of the Corps' alternatives on reservoir sport fisheries. Potential new datasets to be included that have been indentified to date include largemouth bass young-of-year data in West Point Reservoir (Brent Hess, GDNR-WRD, 2010, pers. comm.), as well as black basses and crappie data in relation to reservoir retention times and year-class strength in Walter F. George, West Point, and Bartletts Ferry reservoirs (Mike Maceina, Auburn University, 2010, pers. comm.).

3.5 Riverine Fisheries Analyses

Sport fisheries are also important recreational and economic resources in the riverine portions of the ACF project, especially in the Apalachicola River. Reproduction of many fishes is intricately tied to the floodplain, and alteration of flow regimes can affect reproductive success, year-class strength, growth, condition, and other life-history attributes. Data identified to date will be provided by the FFWCC and the USGS and used to evaluate the relative impacts of the Corps' alternatives on riverine sport fisheries. Specific measures to be evaluated include year-class strength versus acres of inundated floodplain spawning habitat, changes in catch rates of sportfishes in various water years, and changes in relative weight (condition) of sportfishes in various water years.

3.6 Apalachicola Bay Salinity Analyses

If a salinity model is incorporated in the WCM update process, as described in Section 1.8 above, the model output should be incorporated in the FWCA evaluation. A list of data needs should be developed to be produced as a result of these analyses. These data should include the spatial extent and temporal duration of low- and high-salinity conditions among the alternative freshwater inflow scenarios and possibly the percent oyster mortality and oyster growth rates.

3.7 Federally-protected Species Analyses

It is our understanding that the Corps will be conducting certain analyses to evaluate the effects of the various alternatives on federally-protected species. These analyses will be contained in the Corps' Biological Assessment (BA) accompanying the draft EIS. The Service will include these analyses in our FWCA evaluation, assuming they are available for us to do so. The types of analyses that should be evaluated are contained in the "*Analyses for the Effects of the Action*" section of the Service's June 1, 2008, RIOP Biological Opinion (USFWS 2008) and are listed below:

Gulf sturgeon

- Frequency (% of days) of Gulf sturgeon spawning habitat availability (acres of potentially suitable spawning substrate inundated to depths of 8.5 to 17.8 feet) on each day March 1st through May 31st, at the two sites that support spawning;
- Frequency (% of years) of Gulf sturgeon spawning habitat availability (maximum acres of potentially suitable spawning substrate inundated to depths of 8.5 to 17.8 feet for at

least 30 consecutive days each year), March 1st through May 31st, at the two sites that support spawning;

- Daily fall rates with respect to exposure of Gulf sturgeon eggs and larvae;
- Maximum number of consecutive days per year less than 16,000 cfs; and
- Departures from average water temperatures between March 1st to May 31st.

Freshwater mussels

- Lowest daily flow for each year;
- Inter-annual frequency of flows less than 5,000-10,000 cfs;
- Maximum number of days per year with flows less than 5,000 – 10,000 cfs;
- Maximum number of consecutive days less than 5,000 – 10,000 cfs;
- Median number of days per year less than 5,000 – 10,000 cfs;
- Frequency (percent of days) of daily stage changes (ft/day); and
- Frequency (percent of days) of daily stage changes (ft/day) when releases at Woodruff Dam are less than 10,000 cfs.

Floodplain connectivity

- Frequency (% of days) of growing season (April-October) floodplain connectivity (acres) to the main channel using Light et al. (1998);
- Frequency (% of years) of growing season (April-October) floodplain connectivity (acres) to the main channel using Light et al. (1998).

4.0 Recommendations for Additional Coordination

This PAL includes comments from the State wildlife agencies in the basin. As is encouraged under the FWCA, we will continue to coordinate with these agencies, and will coordinate with NOAA Fisheries, as we move forward.

To assist in the development of alternatives and mitigation, we have suggested evaluations and analyses that address flow, water quality, fish passage, climate change, navigation, reservoir and riverine fisheries management, impacts to Eufaula National Wildlife Refuge, Apalachicola Bay resources, as well as the inclusion of a decision support model and adaptive management. Our recommendations for hydrologic modeling include addressing the impacts of increasing consumptive demands and evaluating alternative models to reflect flow extremes and climate change. We have identified analyses to evaluate Corps alternatives with respect to flow, water quality, floodplain connectivity, reservoir and riverine fisheries, Apalachicola Bay resources, and federally-protected species. We anticipate that the next step will be for the Corps and the Service to work together to update the interagency SOW to reflect Corps and Service responsibilities for the evaluations and analyses contained in this PAL. As you know, such a division of labor occurred to produce the prior DEIS and FWCA Report (Corps 1998).

We would like to be involved in the development of alternatives, including the development of environmental flows alternatives. The Service would like to assist in the development of such

alternatives to maximize benefits to ecological resources and to gain a better understanding of the consequences of implementing such alternatives on other authorized project purposes and operational constraints. Once all of the alternatives have been analyzed, we anticipate working with the Corps to identify opportunities for restoration, compensation, and enhancement.

We appreciate the opportunity to participate in the planning stages of your project. We would like to stress the Corps water management is not just about avoiding adverse affects, but also to look at opportunities to restore and improve habitat. If you have any questions, please contact Georgia Ecological Services staff biologists Alice Lawrence or Will Duncan at (706) 613-9493, or Panama City Ecological Services staff biologist Karen Herrington at (850) 769-0552 ext. 250.

Sincerely,

Sandra S. Tucker

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Table 1. Locations and river stages in the Chattahoochee River where the National Weather Service Advanced Hydrologic Prediction Service predicts damage to occur. Discharges were calculated using stage-discharge relationships at USGS streamflow gages. Only damage to manmade structures was considered as damage. Flooding of riverwalks, riverwalk structures, yards, and moving of equipment or livestock to avoid inundation was not considered to be damage.

Location (upstream to downstream order	Stage at which damage occurs	Discharge at which damage occurs
Chattahoochee at Norcross	16	20631
Chattahoochee at Roswell	14	29846
Chattahoochee at Atlanta	18	22023
Chattahoochee at Whitesburg	26	49379
Chattahoochee at West Point	21	62530
Chattahoochee at Columbus	41	261407

Figure 1. Histogram of mean + standard error daily discharge values reported in cubic feet per second (cfs) obtained from river gauges on the Duck River at Shelbyville (top) and Columbia (bottom), Tennessee by season. Means represent daily discharge values for each month for 10 years pre and 10 years post Reservoir Release Discharge Initiative (RRI) completed at Normandy Dam beginning in late 1991. Letters atop standard error bars indicate significantly different means as determined by Tukey's a-posteriori test. Results of analysis of variance (F values and p values) are indicated below each graph. Graphs and figure title taken directly from Alstedht and Johnson 2004, and used with permission from Dr. Paul Johnson.

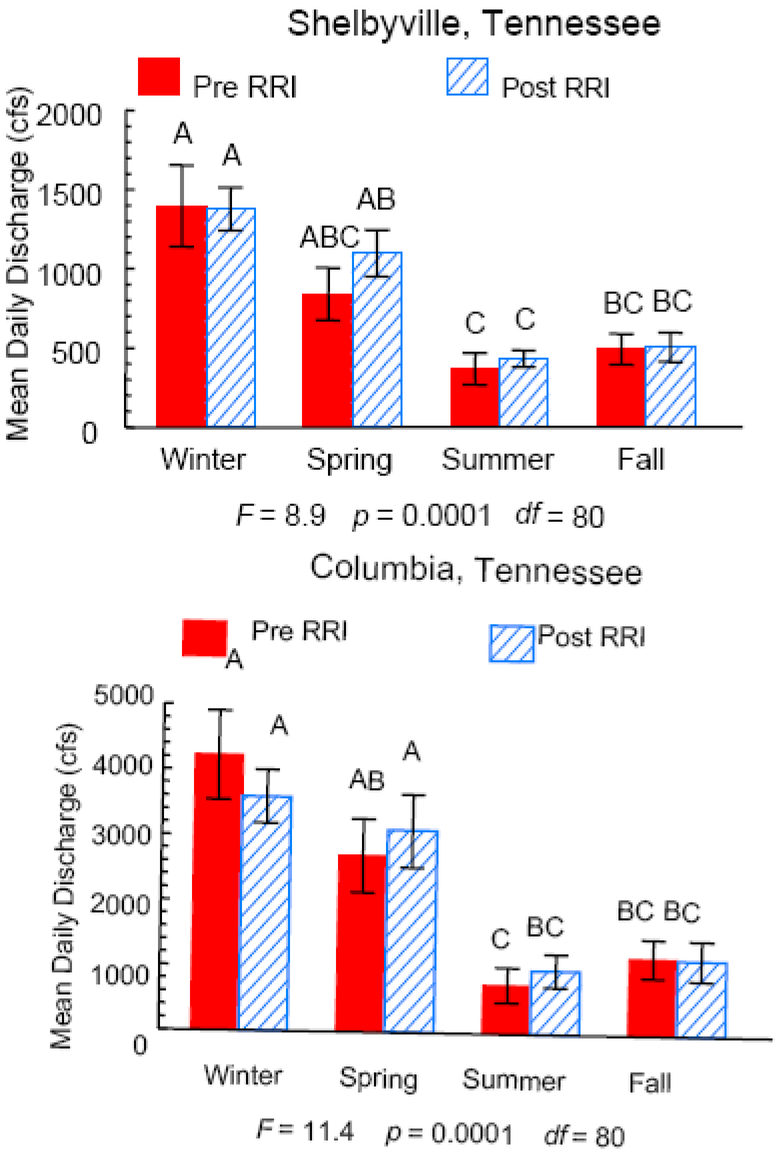


Figure 2. Comparative mean + s.e. of mussel species (top) and mussel number (bottom) sampled from 17 sites in the Duck River in 1977, 1988, and 2002. Letters atop standard error bars indicate statistically different means determined by Tukey's HSD a-posteriori test. Results of analysis of variance (F values and p values) are indicated below each graph. Graphs and figure title taken directly from Alstedht and Johnson 2004, and used with permission from Dr. Paul Johnson.

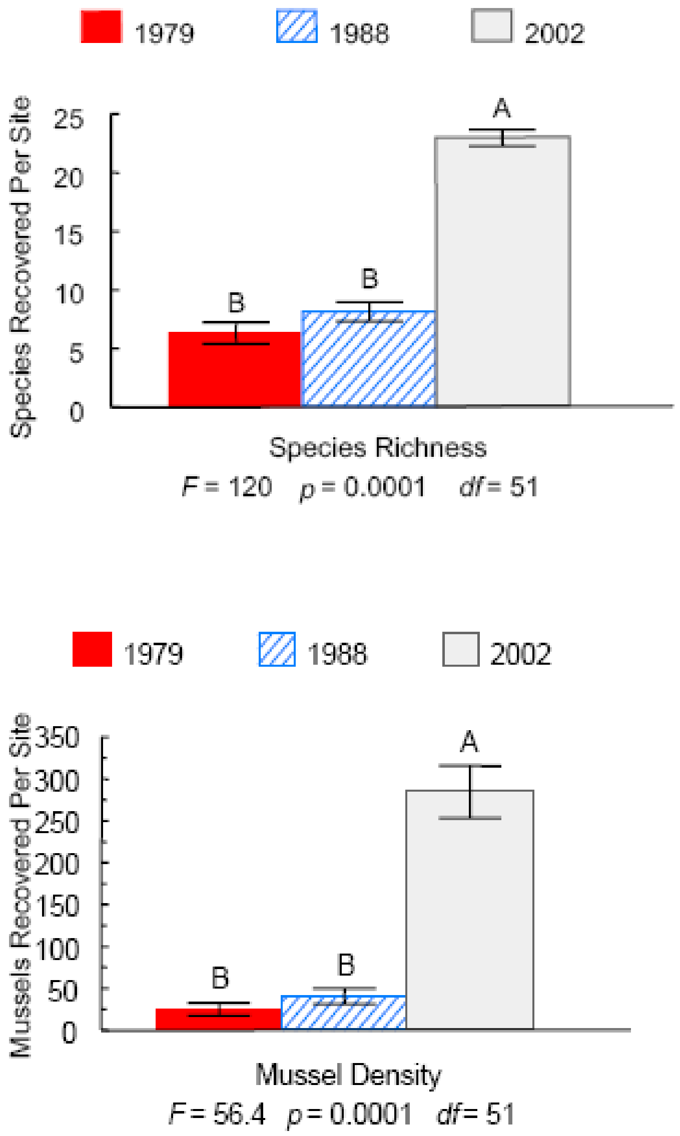
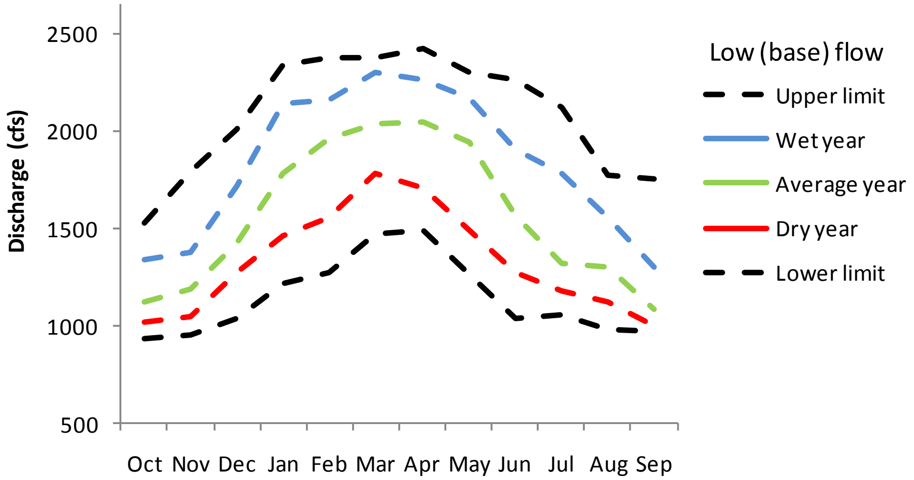


Figure 3. Preliminary a) low (base) flow and b) low and pulse flow guidelines and description for the Chattahoochee River USGS Norcross gage.

a)



b)

Data analyzed: The only pre-Buford dam data that were available for this analysis extended between 1903 and 1946 (44 years) at the Chattahoochee River gage (02335000) at Norcross.

Base flow description

Low (base) flows are defined as all flows that fall below the lower 25th percentile of flows for the pre-Buford dam period at the USGS Norcross gage. The 10th, 25th, 50th, 75th, and 90th percentiles for low flows for each month were then calculated to quantitatively describe the monthly lower and upper base flow limit, and dry, average, and wet year low flow recommendations. Most calculations were derived from Environmental Flow Components in Indicators of Hydrologic Alteration (Version 7-1).

Pulse flow description

High flows were defined as flows that exceeded 75% of the average daily flows for the period of record. Small pulses were defined as all high flows that were lower than the 2-year recurrence interval, and high pulses were defined as high flows that fall between the 2 and 10-year recurrence interval. The 2-year recurrence interval discharge was used as an indication of bankfull discharge because the discharge that corresponds to the incipient point of flooding was unknown. Consequently, small pulses are not expected to exceed bankfull elevation, but high pulses are expected to exceed bankfull elevation and cause floodplain inundation. The recommendations for small and high pulses correspond to the 25th and 75th percentiles of magnitude, frequency, duration, timing, and rise and fall rate values. High pulse recommendations were made only for wet years because more than half of pre-dam years did not contain pulses based on the parameters used to define high pulses in this analysis.

Small pulses

At the Chattahoochee River USGS Norcross gage, 9-18 flow pulses per year should be between 3,658 and 4,980 cfs, should last between 2-3 days, and should occur between mid-March and early June. Rise and fall rates can range between 1,260-2,054 cfs and 1,178-733 cfs, respectively.

High pulses

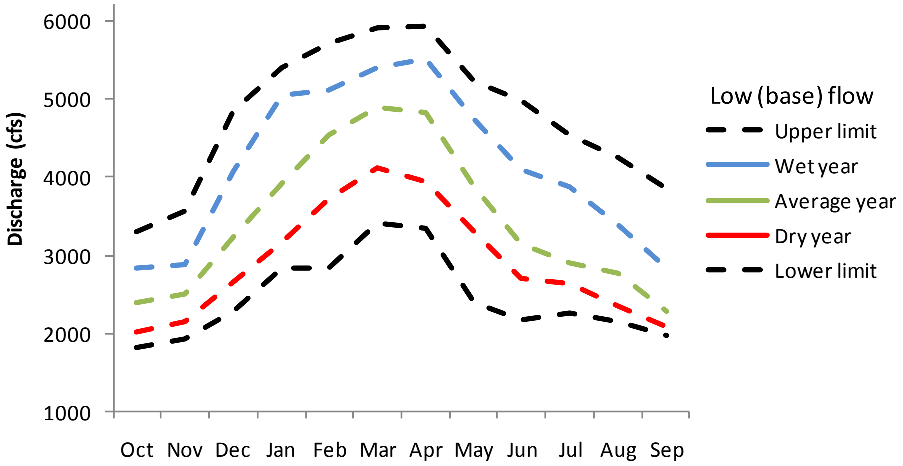
In wet years, a pulse of 17,650-28,080 cfs should last 9-80 days, should occur between early January and early May. Rise rates should range between 697-7518 cfs/day, and fall rates should range between 3376-460 cfs/day.

Non-hydropower peaking window

We recommend that the Corps evaluate the provision of non-hydropower peaking “windows" during critical reproductive and rearing periods for a minimum of 4-6 weeks from March – May.

Figure 4. Preliminary a) low (base) flow and b) low and pulse flow guidelines and description for the Chattahoochee River at the USGS gage below West Point Dam.

a)



b)

Data analyzed: The pre-Buford dam data that were available for this analysis extended between 1896 and 1955 (60 years) at the Chattahoochee River gage (02339500) below West Point Dam.

Base flow description

Low (base) flows are defined as all flows that fall below the lower 25th percentile of flows for the pre-Buford dam period at the USGS West Point gage. The 10th, 25th, 50th, 75th, and 90th percentiles for low flows for each month were then calculated to quantitatively describe the monthly lower and upper base flow limit, and dry, average, and wet year low flow recommendations. Most calculations were derived from Environmental Flow Components in Indicators of Hydrologic Alteration (Version 7-1).

Pulse flow description

High flows were defined as flows that exceeded 75% of the average daily flows for the period of record. Small pulses were defined as all high flows that were lower than the 2-year recurrence interval, and high pulses were defined as high flows that fall between the 2 and 10-year recurrence interval. The 2-year recurrence interval discharge was used as an indication of bankfull discharge because the discharge that corresponds to the incipient point of flooding was unknown. Consequently, small pulses are not expected to exceed bankfull elevation, but high pulses are expected to exceed bankfull elevation and cause floodplain inundation. The recommendations for small and high pulses correspond to the 25th and 75th percentiles of magnitude, frequency, duration, timing, and rise and fall rate values. High pulse recommendations were made only for wet years because more than half of pre-dam years did not contain pulses based on the parameters used to define high pulses in this analysis.

Small Pulses

At the Chattahoochee River gage below West Point, 9-16 flow pulses per year should peak between 8,853 and 11,580 cfs, should last between 3-4 days, and should occur between early March and mid-June. Rise and fall rates can range between 2,483-3,698 cfs/day and 2,256-1,536 cfs/day, respectively.

High Pulses

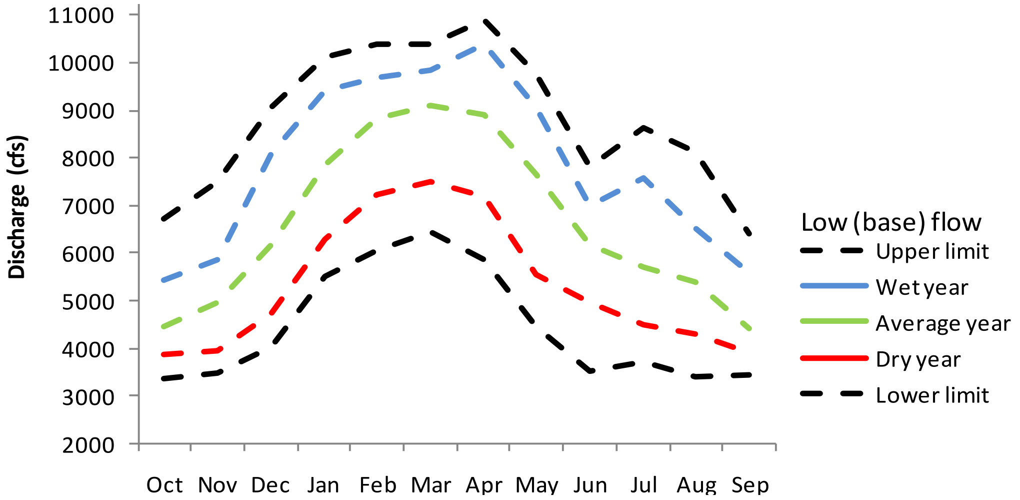
In wet years, a pulse that peaks between 48,830 - 58,950 cfs should last between 19-38 days, and should occur between mid-January and early April. Rise and fall rates can range between 5,563-13,170 cfs/day and 4,230-1787 cfs/day, respectively.

Non-hydropower peaking window

We recommend that the Corps evaluate the provision of non-hydropower peaking “windows" during critical reproductive and rearing periods for a minimum of 4-6 weeks from March – May.

Figure 5. Preliminary a) low (base) flow and b) low and pulse flow guidelines and description for the Chattahoochee River at the Walter F. George Corpsnode.

a)



b)

Data analyzed: ACOE unimpaired flows dataset at the Walter F. George node and inferences from West Point analysis results.

Base flow description

No USGS discharge data for the pre-Buford dam period are available at Walter F. George. However, comparisons between pre-Buford USGS gage data and Corps-modeled "unimpaired flows" data show similar median monthly flows. Thus, we used median monthly flows in the Corps-modeled unimpaired dataset (1936-2006) to calculate the predicted low (base) flows that should occur at the W.F. George node. We excluded 103 negative flow values from the Corps dataset in this analysis.

Low (base) flows are defined as all flows that fall below the lower 25th percentile of flows for the pre-Buford Dam period at the USGS West Point gage. The 10th, 25th, 50th, 75th, and 90th percentiles for low flows for each month were then calculated to quantitatively describe the monthly lower and upper base flow limit, and dry, average, and wet year low flow recommendations. Most calculations were derived from Environmental Flow Components in Indicators of Hydrologic Alteration (Version 7-1).

Pulse flow description

Again, no USGS discharge data for the pre-Buford dam period are available at Walter F. George. Corps-modeled unimpaired flows do not represent the flow extremes (minimum and maximum flow duration, magnitude, timing, frequency, and rate of change) that were observed at USGS gages during the pre-Buford Dam period. Consequently, using the Corps-modeled data to make high pulse recommendations cannot be justified.

Small pulses

We infer from the West Point analysis that used real pre-Buford Dam USGS data, that 9-16 flow pulses per year should peak between 1.8-2.4 times higher than the baseflow river stage (approximately 16,369-21,535 cfs) in March for an average flow year. Pulses should last between 3-4 days, and should occur between early March and mid-June. Rise and fall rates should not exceed rates from other site recommendations.

High pulses

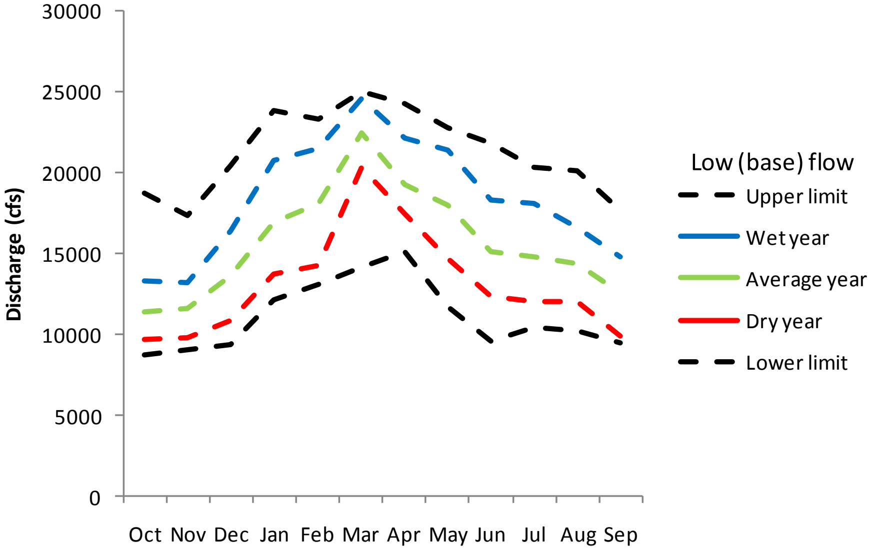
Development of a wet year flow guidelines is complicated by the fact that no stage-discharge relationships are presently known for the river segment between Walter F. George Dam and Woodruff Dam. However, the National Weather Service Advanced Hydrologic Prediction Service indicates that extensive floodplain inundation occurs at a river stage of 150 ft, although no significant damage is predicted to occur up to 160 ft. Consequently, we recommend that the ACOE evaluate wet year releases from Walter F. George that range between 150 and 160 ft. Duration, timing, and rates of change should be similar to the recommendations for West Point Dam.

Non-hydropower peaking window

We recommend that the Corps evaluate the provision of non-hydropower peaking "windows" during critical reproductive and rearing periods for a minimum of 4-6 weeks from March – May.

Figure 6. Preliminary a) low (base) flow and b) low and pulse flow guidelines and description for the Apalachicola River USGS gage at Chattahoochee, FL.

a)



b)

Data analyzed: The pre-Buford dam data that were available for this analysis extended between 1922 and 1955 (34 years) at the Apalachicola River gage (02358000) at Chattahoochee, FL.

Base flow description

Low (base) flows are defined as all flows that fall below the lower 25th percentile of flows for the pre-Buford dam period at the USGS West Point gage. The 10th, 25th, 50th, 75th, and 90th percentiles for low flows for each month were then calculated to quantitatively describe the monthly lower and upper base flow limit, and dry, average, and wet year low flow recommendations. Most calculations were derived from Environmental Flow Components in Indicators of Hydrologic Alteration (Version 7-1).

Pulse flow description

High flows were defined as flows that exceeded 75% of the average daily flows for the period of record. Small pulses were defined as all high flows that were lower than the 2-year recurrence interval, and high pulses were defined as high flows that fall between the 2 and 10-year recurrence interval. The 2-year recurrence interval discharge was used as an indication of bankfull discharge because the discharge that corresponds to the incipient point of flooding was unknown. Consequently, small pulses are not expected to exceed bankfull elevation, but high pulses are expected to exceed bankfull elevation and cause floodplain inundation. The recommendations for small and high pulses correspond to the 25th and 75th percentiles of magnitude, frequency, duration, timing, and rise and fall rate values. High pulse recommendations were made only for wet years because more than half of pre-dam years did not contain pulses based on the parameters used to define high pulses in this analysis.

Small Pulses

At the Apalachicola River gage at Chattahoochee, FL, 3-6 flow pulses per year should peak between 30,950 and 41,110 cfs, should last between 4-13 days, and should occur between mid-February and mid-May. Rise and fall rates can range between 2,493-5,356 cfs/day and 2,353-1,473 cfs/day, respectively.

High Pulses

In wet years, a pulse that peaks between 86,630-122,800 cfs should last between 28-68 days, and should occur between late-February and early April. Rise and fall rates can range between 2,544-8,108 cfs/day and 4,236-2,330 cfs/day, respectively.

Non-hydropower peaking window

We recommend that the Corps evaluate the provision of non-hydropower peaking “windows" during critical reproductive and rearing periods for a minimum of 4-6 weeks from March – May.

Figure 7. Monthly maximum, average, and minimum dissolved oxygen concentrations in the Chattahoochee River at Buford Dam. Data courtesy of Georgia Department of Natural Resources-Wildlife Resources Division.

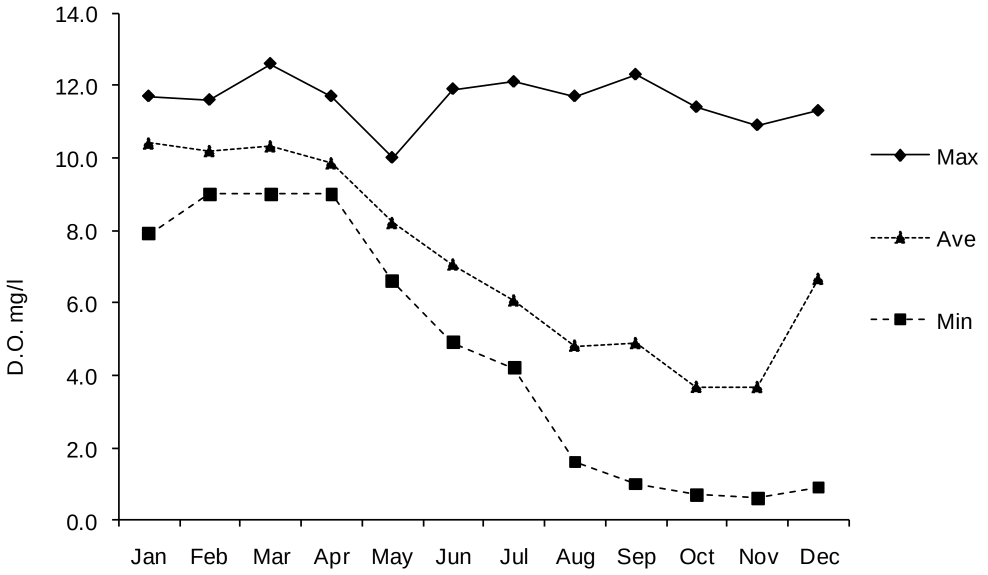
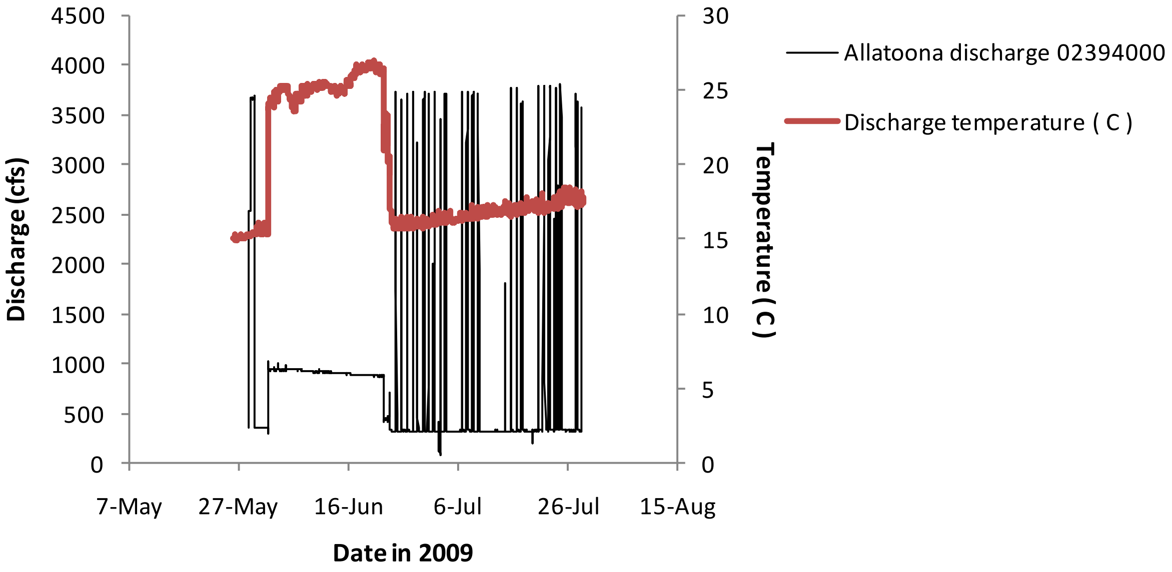


Figure 8. Discharge and water temperature measurements below Allatoona Dam on the Etowah River, Georgia. Sluicing from a location higher in the reservoir's water column occurred in June, causing the observed downriver temperature increases.



USACE Response to Planning Aid Letter January 2011

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DEPARTMENT OF DEFENSE
UNITED STATES OF AMERICA

DEPARTMENT OF THE ARMY
MOBILE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 2288
MOBILE, AL 36628-0001

REPLY TO
ATTENTION OF

JAN 18 2011

Inland Environment Team
Planning and Environmental Division

Ms. Sandra Tucker
Field Supervisor
U.S. Fish and Wildlife Service
105 West Park Drive, Suite D
Athens, Georgia 30606

Dear Ms. Tucker:

This is in response to your April 2, 2010, Planning Aid Letter (PAL) for the proposed Water Control Manual (WCM) Updates for the Apalachicola-Chattahoochee-Flint River Basin in Georgia, Alabama, and Florida. In the PAL, you identified the types of analyses the U.S. Fish and Wildlife Service (FWS) would need to evaluate the WCM alternatives pursuant to the Fish and Wildlife Coordination Act (FWCA - 48 Stat. 401, as amended; 16 U.S.C. § 661 *et seq.*). This letter transmits the results of those analyses.

We stand ready to assist with additional information or analysis. Should you have any questions, comments, or recommendations, please contact Mr. Brian Zettle, (251) 690-2115, Email: brian.a.zettle@sam.usace.army.mil.

Sincerely,

Steven J. Roemhildt, P.E.
Colonel, Corps of Engineers
District Commander

ACF Water Control Manual Update Response to PAL

U.S. Army Corps of Engineers
1/18/2011

Contents

1 Description of the Proposed Action and Alternatives

1.1 Introduction

The Corps proposes to prepare an updated Master Manual for the ACF Basin. A draft was proposed in 1989 as part of a post-authorization change report for Lake Lanier. The draft 1989 Master Water Control Plan described system operations at that time, but it was never finalized because of litigation filed by Alabama. The Corps has been operating projects in the ACF Basin under the draft 1989 Master Water Control Plan on an interim basis pending update of the Master Manual and individual project water control manuals. The component parts of the updated Master Manual would be five project-level water control manuals, presented as appendices:

- Appendix A: Jim Woodruff Reservoir
- Appendix B: Buford Dam
- Appendix C: Walter F. George Dam
- Appendix D: George W. Andrews Reservoir
- Appendix E: West Point Reservoir

Water control manuals contain drought plans and action zones to assist the Corps in knowing when to reduce or increase reservoir releases and conserve storage in the Corps reservoirs. The individual manuals typically outline the regulation schedules for each project, including operating criteria, guidelines, and guide curves, and specifications for storage and releases from the reservoirs. The water control manuals also outline the coordination protocol and data collection, management, and dissemination associated with routine and specific water management activities (such as flood-control operations or drought contingency operations). Operational flexibility and discretion are necessary to balance the water management needs for the numerous (and often competing) authorized project purposes at each individual project. In addition, there is a need to balance basin-wide water resource needs. Project operations also must be able to adapt to seasonal and yearly variations in flow and climatic conditions.

The updated manual would be prepared in compliance with ER 1110-2-240 and all other Corps regulations and policies. The following sections present the No Action Alternative and the Proposed Action Alternative. The proposed action, presented in Section 2.3, is the USACE's Preferred Alternative.

1.2 No Action Alternative

The CEQ regulations require analysis of the *No Action Alternative* 40 CFR.1502.14. On the basis of the nature of the proposed action, the no action alternative represents no change from the current management direction or level of management intensity. This alternative would represent continuation of the current water control operations at each of the federal projects in the ACF Basin. There is not one comprehensive document that reflects the current operational practices. The No Action Alternative reflects operational practices on the ACF Basin as described in the following documents:

- Draft ACF Water Control Plan dated 1989
- Revised Interim Operations Plan and Environmental Assessment, June 2008
- **South Atlantic Division Regulation (DR) 1130-2-16**, *Project Operations, Lake Regulation and Coordination for Fish Management Purposes* and Draft Reservoir Regulation and Coordination for Fish Spawn Management Purposes Standard Operating Plan, (SAM SOP 1130-2-9) February 2005

- Chattahoochee River Management System as described in the Apalachicola Basin Reservoir Regulation Manual, Appendix B, Buford Dam (Lake Sidney Lanier) Chattahoochee River, GA, February 1991
- Project Water Control Manuals for Buford (1991), West Point (1984), Walter F. George (1993), George Andrews (1996), and Jim Woodruff Lock and Dam (1985) projects

The following subsections describe key operational elements that apply to evaluating the No Action Alternative.

1.2.1 General System Operations

The Corps operates five dams in the ACF Basin: (in downstream order) Buford, West Point, Walter F. George, George W. Andrews, and Jim Woodruff. All are wholly on the Chattahoochee River arm of the basin except Jim Woodruff, the most downstream dam, which is immediately below the confluence of the Chattahoochee and Flint Rivers and marks the upstream extent of the Apalachicola River. Andrews is a lock and dam without any appreciable water storage behind it, but Buford, West Point, Walter F. George, and Woodruff dams are impound reservoirs (Lakes Lanier, West Point, Walter F. George, and Seminole, respectively) with a combined conservation storage capacity (relative to the top of each reservoirs' full summer pool) of about 1.6 million ac-ft (1,049,400 ac-ft at Lanier; 306,100 ac-ft at West Point, and 244,400 ac-ft at Walter F. George). Because Jim Woodruff Dam/Lake Seminole is operated as a run-of-river project, only very limited storage is available for support of project purposes.

The Corps operates a series of reservoirs in the ACF Basin to provide for the expressly authorized project purposes of flood damage reduction, hydroelectric power generation, and navigation, as well as for other authorized purposes or incidental benefits including fish and wildlife conservation, recreation, water quality, and water supply. Each of the authorized project purposes is considered when making operational decisions, and these decisions affect how water is stored and released from the projects. In general, to provide the authorized project purposes, flow must be stored during wetter times of each year and released from storage during drier periods of each year. Traditionally, that means that water is stored in the lakes during the spring and released for authorized project purposes in the summer and fall months. In contrast, some benefits such as lakeside recreation, water supply, and lake fish spawn are achieved by retaining water in the lakes, either throughout the year or during specified periods of each year. The flood damage reduction purposes at certain reservoirs require drawing down reservoirs in the fall through winter months to store possible flood waters and refilling of pools in the spring months to be used for multiple project purposes throughout the remainder of the year. The multiple water demands in the basin require that the Corps operate the system in a balanced manner in an attempt to meet all authorized purposes, while continuously monitoring the total system water availability to ensure that project purposes can at least be minimally satisfied during critical drought periods. The balanced water management strategy for the Corps reservoirs in the ACF Basin does not prioritize any project function, but seeks to balance all authorized project purposes. The intent is to maintain a balanced use of conservation storage among all the reservoirs in the system, rather than to maintain the pools at or above certain predetermined elevations.

1.2.2 Action Zones

The *1989 draft ACF Water Control Plan* (USACE, Mobile District 1989a) defines action zones for each of the three major storage projects on the ACF Basin—Lake Lanier (Figure 1.2-1), West Point Lake (Figure 1.2-2), and Walter F. George Lake (Figure 1.2-3). Those zones are used to manage the lakes at the highest level possible while balancing the needs of all the authorized purposes. Zone 1, the highest in each lake, defines a reservoir condition where all authorized project purposes should be met. As lake levels decline, Zones 2 through 4 define increasingly critical system water shortages and guide the Corps in reducing flow releases. Flow releases are reduced as pool levels drop as a result of drier-than-normal or drought conditions. The action zones also provide guidance on meeting minimum hydroelectric power needs at each project, and they determine the amount of storage available for purposes such as flood damage reduction, hydroelectric power generation, navigation, fish and wildlife conservation, recreation, water quality, and water supply.

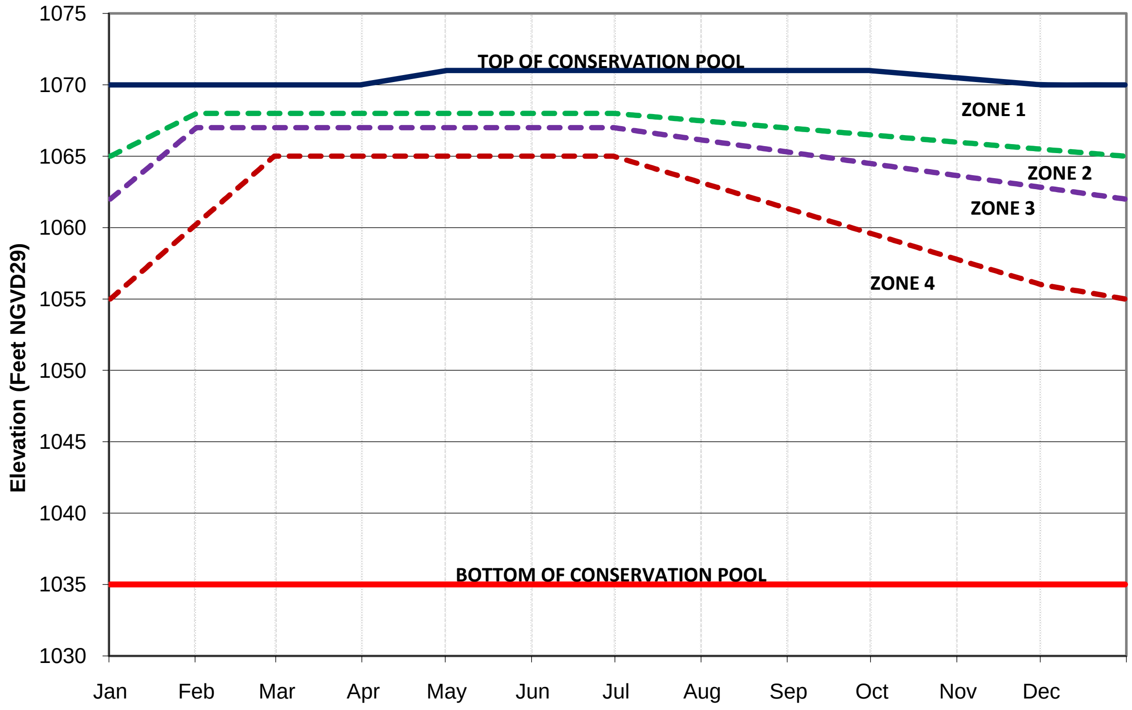


Figure 11.2-1. Lake Lanier water control action zones

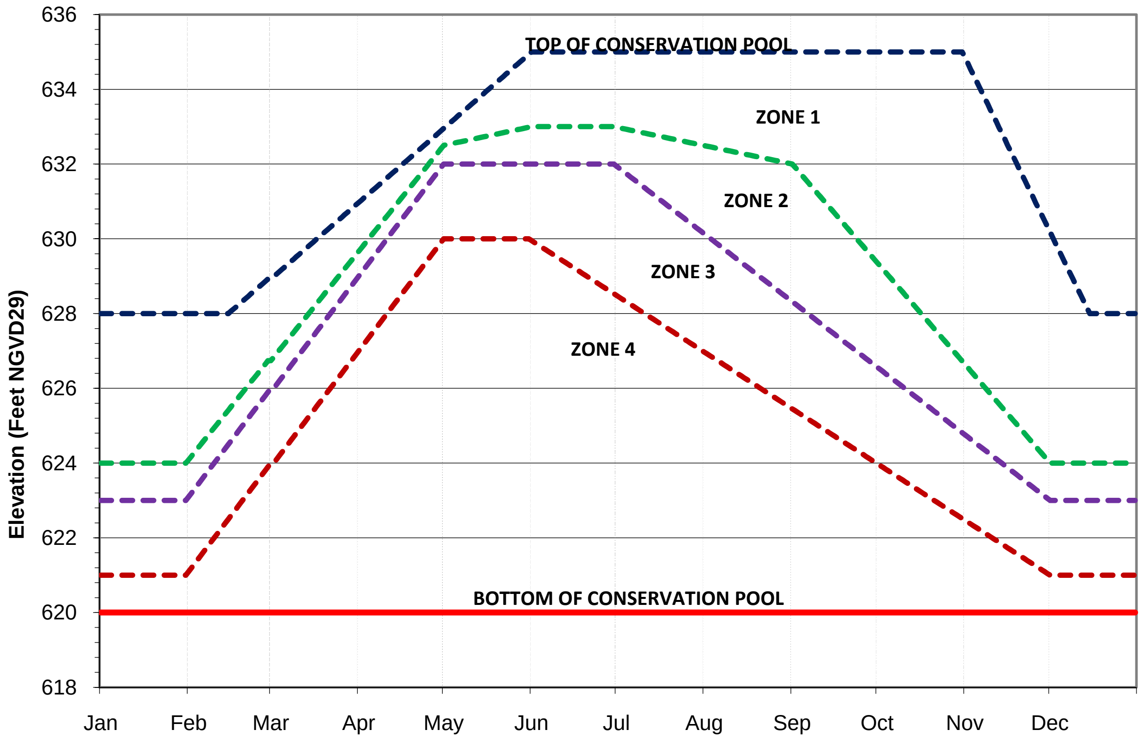


Figure 11.2-2. West Point Lake water control action zones

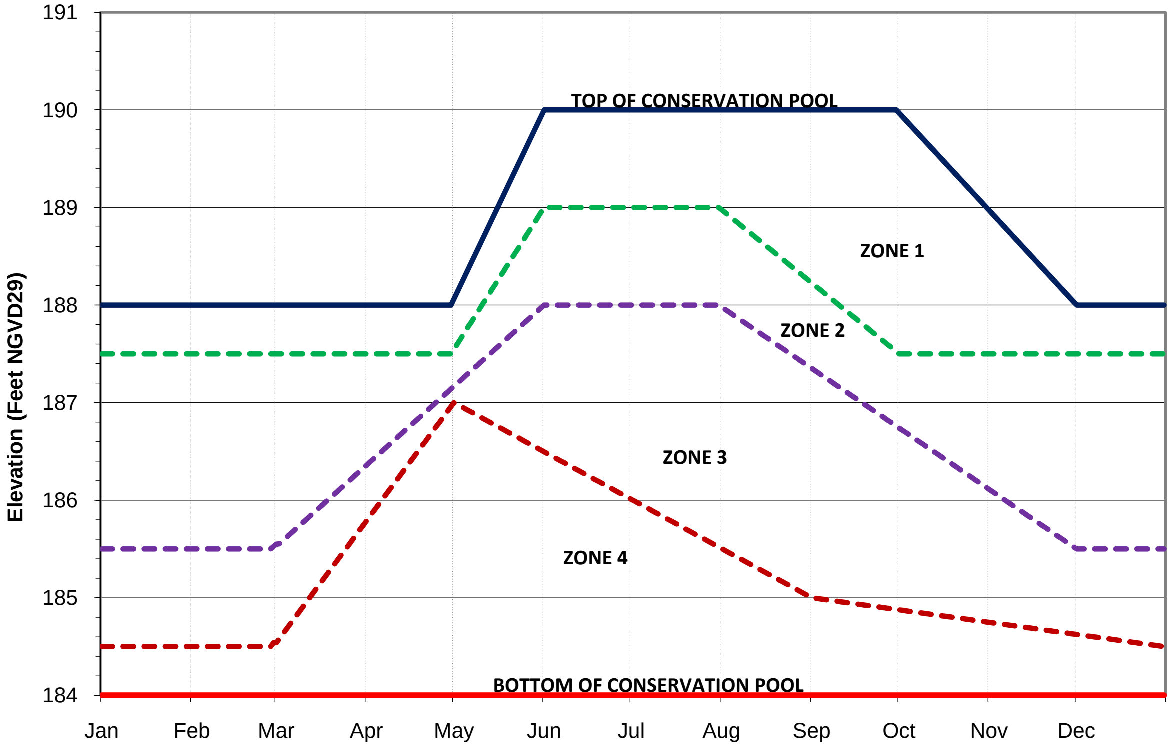


Figure 1.2-3. Walter F. George water control action zones

At the time of development, the zones were derived on the basis of the past operation of the projects, which considered time-of-year, historical pool level/release relationships, operational limits for conservation, and recreational resource impact levels. The action zones are basic guidelines for operating the river system; however, other factors and activities might cause the lakes to operate differently than the zones shown on the charts. Examples of those factors and/or activities may include, but are not limited to: exceptional flood damage reduction measures, fish spawn operations, maintenance and repair of turbines, emergency situations such as a drowning and chemical spills, draw-downs due to shoreline maintenance, releases made to free grounded barges, and other circumstances.

The storage projects are operated to maintain their lake level in the same zones concurrently. However, because of the hydrologic and physical characteristics of the river system and factors mentioned above, there might be periods when one lake is in a higher or lower zone than another. When that occurs, the Corps makes an effort to bring the lakes back into balance with each other as soon as conditions allow. By doing so, effects on the river basin are shared equitably among the projects. The following definitions apply to the action zones:

- Zone 1: Indicates that releases can be made in support of seasonal navigation (when the channel has been adequately maintained), hydroelectric power releases, water quality and, water supply releases. If all lakes are in Zone 1 or above, the river system would operate in a fairly normal manner.
- Zone 2: Indicates that water to support seasonal navigation might be limited. Hydroelectric power generation is supported at a reduced level. Water quality and water supply releases are met. Minimum flow targets are met.

- Zone 3: Indicates that water to support seasonal navigation might be significantly limited. Hydroelectric power generation is supported at a reduced level. Water quality and water supply releases are met. Minimum flow targets are met.
- Zone 4: Indicates that navigation is not supported. Hydroelectric power demands will be met at minimum levels and might occur only for concurrent uses. Water quality and water supply releases are met. Minimum flow targets are met.

The action zones have provided a key management tool for more than 20 years. They play a substantial role in several aspects of operating the lakes and dams. Under the No Action Alternative, it is assumed that the action zones would remain in effect unchanged.

1.2.3 Authorized Project Purposes

The following subsections describe each of the operations in the No Action Alternative for the authorized project purposes in more detail.

1.2.3.1 Flood Damage Reduction

The objective of flood damage reduction operations in the ACF Basin is storage of excess flows thereby reducing downstream river levels below flood stage and producing no higher stages than would otherwise occur naturally. Whenever flood conditions occur, operation to reduce flood damage takes precedence over all other project functions. Flood damage reduction is achieved by storing damaging flood waters, thus reducing downstream river levels below those that would have occurred without the dams in place. Of the five Corps reservoirs, Lake Lanier is drawn down one additional foot; West Point Lake is drawn down at least 7 additional feet beginning in the fall, through winter and into the early spring to provide additional capacity to protect life and property in the basin. Walter F. George operates according to specified schedules for flood damage reduction. George W. Andrews and Jim Woodruff Dams operate to pass inflows.

Because flooding usually occurs in the winter and spring when rainfall and runoff are more plentiful and hydroelectric power demands are lower, the *guide curve* operation generally reflects this situation by specifying a lower elevation during such a period. Additional storage for containing flood waters is gained by drawing down the pool in late fall. Those drawdowns can be specifically to reduce flood damage, as at West Point Lake, or coincidentally for other purposes. During the principal flood season, December through April, the regulation plan at Walter F. George Lake provides for lower lake levels to ensure lower reduced peak stages in the reservoir during major floods.

The timing of flood peaks in the system is of considerable importance in determining the effectiveness of reservoir flood damage reduction operations and the degree to which such operations can be coordinated. During a flood event, excess water above normal pool elevation, or guide curve, should be evacuated through the use of the turbines and spillways in a manner consistent with other project needs as soon as downstream waters have receded sufficiently so that releases from the reservoirs do not cause flows to exceed bankfull flows capacity. Such timely evacuation is necessary so that consecutive flood events will not cause flood waters to exceed allocated flood storage capacities and endanger the integrity of the dam. Under the No Action Alternative, it is assumed that the current flood damage reduction operations would remain in effect unchanged.

1.2.3.2 Hydroelectric Power

The Buford, West Point, Walter F. George, and Jim Woodruff projects include hydroelectric power plants. The total generation capacity of the four ACF hydroelectric power plants is 404 MW. Through the Department of Energy’s SEPA, the power plants provide power to more than 300 preference customers throughout the southeastern United States. In 2005 the ACF hydroelectric power plants generated nearly 1.1 million MW-hours, enough electricity to supply approximately 110,000 households in the region. In 2006 the same power plants generated approximately 717,178 MW-hours, which supplied approximately 70,000 households. The decrease in generation was due to a combination of equipment outages and sustained drought conditions. Hydroelectric power generation is achieved by passing flow releases to the maximum extent possible through the turbines at each project, even when making releases to support other project purposes. The Buford, West Point, and Walter F. George projects are operated as *peaking plants*, and provide electricity during the peak demand periods of each day and week. Hydroelectric power peaking involves increasing the discharge for a few hours each day to near the full capacity of one or more of the turbines. Typically, the Buford, West Point, and Walter F. George projects provide a minimum of 2 hours of generation a day for 5 days a week at plant capacity throughout the year, as long as their respective lake levels are in the conservation pool. For example, demand for peak hydroelectric power at Buford Dam typically occurs on weekdays and occasionally weekends from 5:00 a.m. to 9:00 a.m. and from 3:00 p.m. to 10 p.m. between October 1 and March 31, and on weekdays from 1:00 p.m. to 7:00 p.m. between April 1 and September 30. The 2-hour minimums represent releases that normally meet water supply and water quality demands and provide the capacity specified in marketing arrangements. During dry periods, as the lake levels drop below Zone 1, hydroelectric power generation is reduced proportionally as pool levels decline to as low as 2 hours per day generation at each peaking plant project during extreme low flow conditions. Peak generation could be eliminated or limited to conjunctive releases during severe drought conditions. The typical hours of operation by action zone are presented in Table 5.2-1.

Table 5.2-1. Typical Hours of Peaking Hydroelectric Power Generation by Federal Project

Action zone	Lake Lanier (hours of operation)	West Point (hours of operation)	Walter F. George (hours of operation)
Zone 1	3	4	4
Zone 2	2	2	2
Zone 3	2	2	2
Zone 4	0	0	0

In addition to hydroelectric power generation being governed by action zone, there are also physical limitations that factor into the power generation decisions. The main hydroelectric power units and small house unit intakes at Buford Dam are at elevation 919 ft. However, severe cavitations occur in the main hydroelectric power units when the water surface falls to 1,035 ft or below, at which time the units are taken out of service and generation ceases. The small house unit goes off line when water elevations reach 1,020 ft or below. At this time releases are made through the sluicing gate. Water can be released through the sluicing gate down to 920 ft.

Because it does not have the ability to store appreciable amounts of flow, the Jim Woodruff plant is operated as a run-of-the-river plant where inflows are passed continuously and electricity is generated around the clock. The current Revised Interim Operations Plan (RIOP) includes a limited hydroelectric power peaking operation at Jim Woodruff Dam when daily average releases are less than the combined capacity of the powerhouse turbines (about 16,000 cfs) to deliver extra power during hours of peak demand for electricity. Those peaking releases are included in the daily average discharge computations for the RIOP minimum flow provisions. The peaks are also included in the stage computations for the RIOP maximum fall rate schedule; however, the maximum fall rate schedule addresses the difference between the average river stage on consecutive calendar days, not the shorter-term differences that result from peaking operations within a calendar day. The current RIOP includes a provision that discontinues peaking operations at the Jim Woodruff plant as average daily releases approach 6,000 cfs, to maintain instantaneous releases greater than or equal to the 5,000 cfs minimum flow requirement. Under the No Action Alternative, it is assumed that the current hydroelectric power generation operations would remain in effect unchanged.

1.2.3.3 Navigation

The existing project authorizes a 9 ft-deep by 100 ft-wide waterway from Apalachicola, Florida, to Columbus, Georgia on the Chattahoochee River, and to Bainbridge, Georgia, on the Flint River. Conditions on the Apalachicola River have been such in recent years that a 9 ft-deep channel has not been available for much of the year. Because of deteriorating channel conditions and limited channel availability during the low-flow months, navigation windows were routinely scheduled during the low-flow months in the 1990s. Navigation windows were composed of storing water in the upstream reservoirs for several weeks and then making increased releases for a 10-day to 2-week period to allow commercial barge navigation to make a round trip up river for scheduled delivery of commodities. Concerns were raised regarding the fluctuations of both reservoir and river stages associated with navigation window releases, and the continued use of navigation windows became increasingly controversial, especially during sustained, low-flow periods when observed fluctuations were more extreme. As a result of fluctuating river stages during navigation windows, gradual ramping rates were developed in coordination with the USFWS and Florida Fish and Wildlife Conservation Commission, with the goal to provide for ramping down rates of not more than one-half ft/d during fish spawn activities, and no more than one ft/d during other times of the year, whenever flows were below 20,000 cfs.

The last navigation window was provided in the spring of 2000, and it precipitated complaints that the navigation window was scheduled during the period of fish spawn and had adversely affected both reservoir and riverine fish spawn activities. No navigation windows have been scheduled since, and none are planned in the foreseeable future.

Dredging on the Apalachicola River also was reduced since the 1980s because of a lack of adequate disposal area capacity in certain reaches of the river. No dredging was conducted in 2000 or 2002 because of sustained drought conditions in the basin, and only very limited dredging was conducted in 2001 and then was shut down because of sustained, low flow conditions. No dredging has been conducted since for a variety of reasons related to flow or funding levels and has been indefinitely deferred because of denial of a Section 401 water quality certificate from Florida and recent congressional language that limits funding for dredging operations in the ACF Basin.

The lack of dredging and routine maintenance has led to inadequate depths in the Apalachicola River navigation channel, and commercial navigation is possible only seasonally when flows in the river are naturally high, with flow support for navigation suspended during drier times of the year. Specific navigation operations occur on a case-by-case basis, with limited releases for navigation being made for special shipments when a determination can be made that other project purposes will not be significantly affected and any fluctuations in reservoir levels or river stages will be minimal. Over a period of months, the navigation industry in the ACF Basin works closely with the Corps to coordinate these special shipments. Under the No Action Alternative, it is assumed that the current operations in support of navigation would remain in effect unchanged.

1.2.3.4 Fish and Wildlife Conservation

1.2.3.4.1 Fish Spawning

In addition to providing for minimum flow and water quality releases, the Corps operates the system to provide favorable conditions for annual fish spawning, both in the reservoirs and the Apalachicola River. In most water years (October 1 - September 30) it is not possible to hold both lake levels and river stages at a steady or rising level for the entire spawning period, especially when upstream lakes or the Apalachicola River spawning periods overlap. During the fish spawning period for each waterbody (Table 1.2-2), the Corps' goal is to operate for a generally stable or rising lake level and a generally stable or gradually declining river stage on the Apalachicola River for approximately 4 to 6 weeks during the designated spawning period. When climatic conditions preclude a favorable operation for fish spawn, the

Corps consults with the state fishery agencies and the USFWS on balancing needs in the system and minimizing the effects of fluctuating lake or river levels. Those fish spawn operations were incorporated into a draft *Mobile District Standard Operating Procedure* (CESAM SOP 1130-2-9) in February 2005, following consultation since 2002 with USFWS and state fishery management agencies from Alabama, Florida, and Georgia. Under the No Action Alternative, it is assumed that the fish spawn operations would remain in effect unchanged.

Table 1.2-2. Project-specific Principal Fish Spawning Period

Project	Fish spawn period
Lake Lanier	April 1–June 1
West Point	April 1–June 1
Walter F. George	March 15–May 15
Lake Seminole	March 1–May 1
Apalachicola River	April 1–June 1

1.2.3.4.2 Fish Passage

Each spring (since 2005) from March through May, the Corps has operated the lock at Jim Woodruff Dam to facilitate downstream to upstream passage of Alabama shad and other anadromous fishes (those that return from the sea to the rivers where they were born to breed). There are slight differences in the locking technique each year. However, in general two fish locking cycles are performed each day between 0800 - 1600 hours; one in the morning and one in the afternoon. The operation consists of opening the lower lock gates and getting fish into the lock in one of three ways; either by transporting them into the lock by boat (2005), using attraction flows to entice the fish into the lock (2006–2007), or by leaving the lower gate open for a period before a lockage and allowing the fish to move in without an attraction flow (2008). Once the fish are in the lock (or assumed to be in the lock), the downstream doors are closed. The lock is filled to the lake elevation and the upper gates are opened. Studies are ongoing to determine the most appropriate technique and timing for the locks, but the number of lock cycles per day will not change. Under the No Action Alternative, it is assumed that the current fish passage operation would remain in effect unchanged.

1.2.3.4.3 Endangered Species Conservation - Revised Interim Operations Plan

In addition to fish spawn management and fish passage operations, the Corps manages releases from Jim Woodruff Dam to support the federally protected Gulf sturgeon and mussel species (fat threeridge, purple bankclimber, and Chipola slabshell) in the Apalachicola River. That operation is governed by a set of minimum flow and maximum fall rate provisions called the Revised Interim Operations Plan (RIOP).

The RIOP specifies two parameters applicable to the daily releases from Jim Woodruff Dam: a minimum discharge (measured in cfs) and a maximum fall rate (measured in feet per day [ft/d]). However, the RIOP also identifies conditions under which maintenance of the maximum fall rate schedule is suspended and more conservative drought contingency operations begin. The RIOP also places limitations on refill but does not require a net drawdown of composite conservation storage unless basin inflow is less than 5,000 cfs.

Minimum Discharge. The RIOP varies minimum discharges from Jim Woodruff Dam by basin inflow and by month, the releases are measured as a daily average flow in cfs at the Chattahoochee, Florida gage.

Table 1.2-3 shows minimum releases from Jim Woodruff Dam prescribed by the RIOP and shows when and how much basin inflow is available for increasing reservoir storage. The RIOP defines basin inflow threshold levels that vary by three seasons: spawning season (March - May); non-spawning season (June–November); and winter (December - February), and incorporates composite conservation storage thresholds that factor into minimum release decisions. Composite conservation storage is calculated by combining the conservation storage of Lake Sidney Lanier, West Point Lake, and Walter F. George Lake.

Each of the individual storage reservoirs consists of four action zones. The composite conservation storage uses the four zone concepts as well; i.e., Zone 1 of the composite conservation storage represents the combined storage available in Zone 1 for each of the three storage reservoirs. During the spawning season, two sets of four basin inflow thresholds and corresponding releases exist according to composite conservation storage. When composite conservation storage is in Zones 1 and 2, a less conservative operation is in place. When composite conservation storage is in Zone 3, a more conservative operation is in place while still avoiding or minimizing effects on listed species and critical habitat in the river. When composite conservation storage falls below the bottom of Zone 3 into Zone 4 the drought contingency operations are *triggered* representing the most conservative operational plan. A detailed description of the drought contingency operations is provided below. During the spawning season, a daily monitoring plan that tracks composite conservation storage will be implemented to determine water management operations. Recent climatic and hydrological conditions experienced and meteorological forecasts will be used in addition to the composite conservation storage values when determining the appropriate basin inflow thresholds to use in the upcoming days.

During the non-spawning season, one set of four basin inflow thresholds and corresponding releases exists according to composite conservation storage in Zones 1 - 3. When composite conservation storage falls below the bottom of Zone 3 into Zone 4 the drought contingency operations are triggered.

During the winter season, only one basin inflow threshold and corresponding minimum release (5,000 cfs) exists while in composite conservation storage Zones 1–3. No basin inflow storage restrictions are in effect as long as this minimum flow is met under such conditions. When composite conservation storage falls below the bottom of Zone 3 into Zone 4, the drought contingency operations are triggered.

The flow rates included in Table 1.2-3 prescribe minimum, and not target, releases for Jim Woodruff Dam. During a given month and basin inflow rate, releases greater than the RIOP minimum release provisions can occur consistent with the maximum fall rate schedule, described below, or as needed to achieve other project purposes, such as hydroelectric power generation or flood damage reduction.

Table 1.2-3. RIOP Water Releases from Jim Woodruff Dam

Months	Composite conservation storage zone	Basin inflow (BI) (cfs)	Releases from JWLD (cfs)	BI available for storage[a]
March–May	Zones 1 and 2	>= 34,000	>= 25,000	Up to 100% BI > 25,000
		>= 16,000 and < 34,000	>= 16,000 + 50% BI > 16,000	Up to 50% BI > 16,000
		>= 5,000 and < 16,000	>= BI	
		< 5,000	>= 5,000	
	Zone 3	>= 39,000	>= 25,000	Up to 100% BI > 25,000
		>= 11,000 and < 39,000	>= 11,000 + 50% BI > 11,000	Up to 50% BI > 11,000
		>= 5,000 and < 11,000	>= BI	
		< 5,000	>= 5,000	
June–November	Zones 1, 2, and 3	>= 24,000	>= 16,000	Up to 100% BI > 16,000
		>= 8,000 and < 24,000	>= 8,000 + 50% BI > 8,000	Up to 50% BI > 8,000
		>= 5,000 and < 8,000	>= BI	
		< 5,000	>= 5,000	
December–February	Zones 1, 2, and 3	>= 5,000	>= 5,000 (Store all BI > 5,000)	Up to 100% BI > 5,000
		< 5,000	>= 5,000	
At all times	Zone 4	NA	>= 5,000	Up to 100% BI > 5,000
At all times	Drought zone	NA	>= 4,500[b]	Up to 100% BI > 4,500

Notes: a. Consistent with safety requirements, flood-control purposes, and equipment capabilities.

b. Once composite conservation storage falls below the top of the Drought Zone ramp down to 4,500 cfs will occur at a rate of 0.25 ft/d drop.

Maximum Fall Rate. Fall rate, also called down-ramping rate, is the vertical drop in river stage (water surface elevation) that occurs over a given period. The fall rates are expressed in units of ft/d and are measured at the Chattahoochee, Florida USGS gage as the difference between the daily average river stage of consecutive calendar days. Rise rates (e.g., today's average river stage is higher than yesterday's) are not addressed. The RIOP maximum fall rate schedule is provided in Table 1.2-4. When composite conservation storage is in Zone 4 and the drought contingency operation described below is implemented, the maximum fall rate schedule is suspended. Unless otherwise noted, fall rates under the drought contingency operation would be managed to match the fall rate of the 1-day basin inflow.

Table 1.2-4. RIOP Maximum Fall Rate Schedule Composite Conservation Storage Zones 1, 2, and 3[ab]

Release range (cfs)	Maximum fall rate, measured at Chattahoochee gage (ft/d)
> 30,000[c]	No ramping restriction[d]
> 20,000 and <= 30,000[a]	1.0 to 2.0
Exceeds powerhouse capacity (~ 16,000) and <= 20,000[a]	0.5 to 1.0
Within powerhouse capacity and > 8,000[a]	0.25 to 0.5
Within powerhouse capacity and <= 8,000[a]	0.25 or less

Notes: a. Maximum fall rate schedule is suspended in Composite Zone 4.

b. Any changes to the RIOP minimum flows or maximum fall rate provisions resulting from reinitiation of consultation will be incorporated and evaluated.

c. Consistent with safety requirements, flood-control purposes, and equipment capabilities.

d. For flows greater than 30,000 cfs, it is not reasonable and prudent to attempt to control the down ramping rate, and no ramping rate is required.

During the spawning period (March - May), the Corps operations releases from Jim Woodruff Dam to avoid potential sturgeon take. Potential sturgeon take is defined as an 8-ft or greater drop in Apalachicola River stage over the last 14-day period (i.e., is today's stage greater than 8 ft lower than the stage of any of the previous 14 days) when flows are less than 40,000 cfs.

Drought Contingency Operations. Coupled with the action zones defined for the upstream reservoirs, the RIOP incorporates a drought contingency operation (referred to as drought plan) that specifies a minimum release from Jim Woodruff Dam and temporarily suspends the other minimum release and maximum fall rate provisions until composite conservation storage in the basin is replenished to a level that can support them. The minimum discharge is determined in relation to composite conservation storage and not average basin inflow under the drought plan. When conditions dictate, computations of the volumes of the basin inflows and releases are made on a continuous basis and readjustments are made, as necessary, to assure the required flow releases occur. This is volumetric balancing. The drought plan is triggered when composite conservation storage falls below the bottom of Zone 3 into Zone 4. At that time, all the composite conservation storage Zone 1 - 3 provisions (seasonal storage limitations, maximum fall rate schedule, minimum flow thresholds, and volumetric balancing accounting) are suspended, and management decisions are based on the provisions of the drought plan. The drought plan also includes any combination of (1) a temporary waiver from the existing water control plan to allow temporary storage above the winter pool guide curve at the Walter F. George and West Point projects if the opportunity presents itself or (2) begin spring refill operations at an earlier date to provide additional conservation storage for future needs and provide for a minimum releases less than 5,000 cfs from Jim Woodruff Dam.

The drought plan prescribes two minimum releases on the basis of composite conservation storage in Zone 4 and an additional zone referred to as the Drought Zone (Figure 1.2-4). The Drought Zone delineates a volume of water roughly equivalent to the inactive storage in lakes Lanier, West Point, and Walter F. George plus Zone 4 storage in Lake Lanier. The Drought Zone line has been adjusted to include a smaller volume of water at the beginning and end of the calendar year. When the composite conservation storage is within Zone 4 and above the Drought Zone, the minimum release from Jim Woodruff Dam is 5,000 cfs and all basin inflow above 5,000 cfs that is capable of being stored may be stored. Once the composite conservation storage falls below the Drought Zone, the minimum release from Jim Woodruff Dam is 4,500 cfs and all basin inflow above 4,500 cfs that is capable of being stored may be stored. When transitioning from a minimum release of 5,000 to 4,500 cfs, fall rates will be limited to a 0.25 ft/d drop. The 4,500 cfs minimum release is maintained until composite conservation storage returns to a level above the top of the Drought Zone, at which time the 5,000 cfs minimum release is reinstated. The drought plan provisions remain in place until conditions improve such that the composite conservation storage reaches a level above the top of Zone 3 (i.e., in Zone 2). At that time, the temporary drought plan provisions would be suspended, and all the other provisions would be reinstated. During the drought contingency operations, a monthly monitoring plan that tracks composite conservation storage to determine water management operations (the first day of each month will represent a decision point) would be implemented to determine which operational triggers are applied. In addition, recent climatic and hydrological conditions experienced and meteorological forecasts would be used when determining the set of operations to use in the upcoming month.

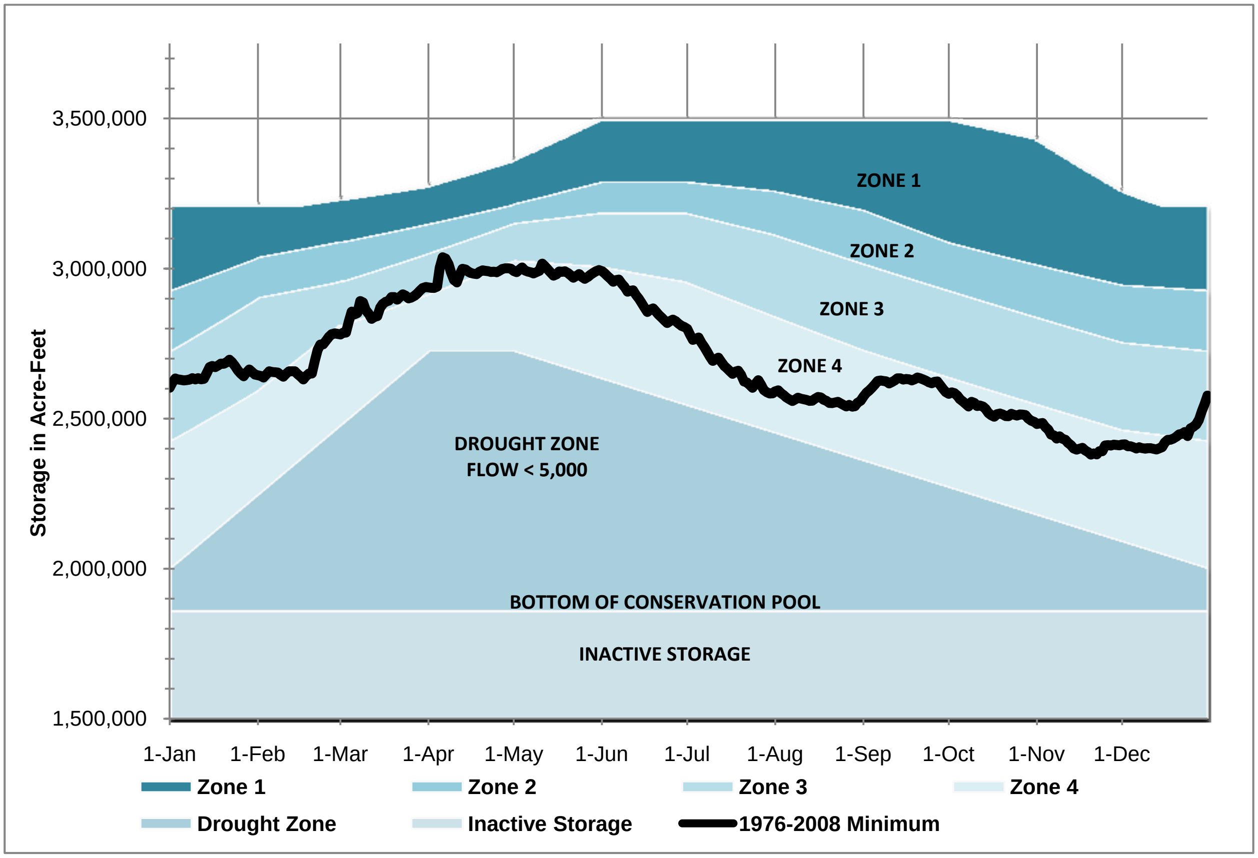


Figure 11.2-4. RIOP Drought Composite Conservation Storage Triggers

Although the drought plan provides for flows lower than 5,000 cfs in the river, incorporation of provisions that allow for reduced flows during the refill period when system storage is lower and storage conservation measures when composite conservation storage is in Zone 4 should result in fewer occasions when such low flows are triggered or in occasions where storage shortages result in flows less than 5,000 cfs.

In the analysis of the No Action Alternative, it is assumed that the current RIOP would remain in effect unchanged. However, based on new information about the distribution and mortality of mussels the Corps requested a reinitiation of consultation for the fat threeridge and RIOP on September 2010. It is not known at this time, whether the results of reinitiation will require additional changes to the RIOP.

1.2.3.5 Recreation

All the Corps lakes have become important recreational resources on the ACF Basin. The five Corps projects in the basin account for 235,291 total acres of land and water. A wide variety of recreational opportunities are provided at the lakes including boating, fishing, picnicking, sightseeing, water skiing, and camping. The reservoirs support popular sport fisheries, some of which have achieved national acclaim for trophy-size catches of largemouth bass. Of the projects, Lake Lanier (Buford Dam) is one of the most visited Corps lakes in the entire United States with more than 7.7 million visitors in 2005. The West Point and Walter F. George Lakes had more than 3.1 and 3.6 million visitors, respectively, in 2005 to also rank among the top 10 most visited Corps lakes in the United States. In addition, Lake Seminole had more than 1.2 million visitors in 2005, and the smaller George W. Andrews project 269,000 visitors. The economic benefits of recreation at the lakes is significant, resulting in visitor spending in 2005 of over $125 million at Lake Lanier, $36 million at West Point Lake, and $111 million at Walter F. George

Lake. Recreation benefits are maximized at the lakes by maintaining full or nearly full pools during the primary recreation season of May 1 through September 8. In response to meeting other authorized project purposes, lake levels can and do decline during the primary recreation period, particularly during drier than normal years. Recreation impact levels have been identified for various lake elevations at each of the reservoir projects (Table 5.2-5).

Table 12-5. Water Levels Affecting Federal Project Recreation

Corps project	Initial impact level (IIL) (ft NGVD)	Recreation impact level (RIL) (ft NGVD)	Water Access Limited Level (WAL) (ft NGVD)
Lake Lanier	1,066	1,063	1060
West Pont Lake	632.5	629	627
Walter F. George Lake	187	185	184
Lake Seminole	76	NA	NA

The first impact level is generally characterized by marginal effects on designated swimming areas, increased safety awareness regarding navigation hazards, minimal effects on Corps boat ramps, and minimal effects on private marina and dock owners. More substantial impacts begin to occur at the second and third impact levels.

When pool levels must be lowered, the rates at which the drawdowns occur are as steady as possible. The action zones are drawn to correlate the line between Zone 2 and Zone 3 to the Initial Impact Level, (IIL), at the beginning of the recreation season (May through early September). If lake levels fall to Zone 3 during the recreation season, releases will normally be limited to 2-hour-a-day generation and minimal navigation support, which tends to stabilize the lake levels until the end of the season. Under the No Action Alternative, it is assumed that recreation operations would remain in effect unchanged.

1.2.3.6 Water Quality

Buford, West Point, and Jim Woodruff Dams all include water quality operations to provide continuous minimum flow releases. There are no minimum flow provisions downstream of Walter F. George Dam. However, when low dissolved oxygen values are observed below the dam, spillway gates are opened until the dissolved oxygen readings return to an acceptable level. Occasional special releases are also made at Buford Dam to ensure adequate dissolved oxygen and water temperature at the Buford Fish Hatchery downstream of the dam. Additionally, self-aspirating turbines were installed at Buford Dam in 2005 to improve dissolved oxygen levels downstream. At Buford Dam, the small turbine-generator is run continuously to provide a minimum flow from the dam, which ranges up to approximately 600 cfs. At West Point Dam, a similar small generating unit provides a continuous release of approximately 675 cfs. In addition to those flows, Buford Dam is operated in conjunction with the downstream Georgia Power Dam at Morgan Falls to ensure a minimum instream flow of 750 cfs on the Chattahoochee River at Peachtree Creek to meet state water quality commitments. A 5,000 cfs minimum flow is maintained as a release from the Jim Woodruff Dam to the Apalachicola River, which assures an adequate water supply for downstream industrial use and water quality. No water quality problems below Jim Woodruff Dam have been identified in association with project operations.

Although there is no Corps requirement to maintain minimum flows for assimilative capacity at Columbus, Georgia, the Georgia Power projects above Columbus are required in their Federal Energy Regulatory Commission (FERC) licenses to provide 1,850 cfs weekly average, 1,350 cfs daily average, and 800 cfs instantaneous minimum flow at Columbus. Releases from the Georgia Power projects are dependent on upstream releases from West Point Dam and, to a limited extent, those requirements are considered when making release decisions for West Point Dam. Georgia Pacific and Farley Nuclear Plant below George W. Andrews Dam have stated a requirement of 2,000 cfs for assimilative capacity needs. Although that is not a Corps requirement, to the extent practicable, the needs are considered in operations at Walter F. George Dam and Jim Woodruff Dam. Under the No Action Alternative, it is assumed that the current water quality operations would remain in effect unchanged.

1.2.3.7 Water Supply

Various municipal and industry (M&I) entities withdraw water directly from Lake Lanier, and others withdraw directly from the Chattahoochee River downstream of Lake Lanier. Reservoir operations are also influenced by agricultural water withdrawals on the Flint River. Agricultural demands vary depending on the climatic conditions but are generally 1.5 to 2 times the withdrawals for M&I (USFWS 2006). Water withdrawals in Georgia are made pursuant to water withdrawal permits issued by the Georgia Department of Natural Resources. Previous water supply contracts issued by the Corps for withdrawals from Lake Lanier expired in 1990 and have not been reissued. The Water Supply Act of 1958 provides authority for reallocation or addition of storage in Corps reservoirs for water supply, with the cost of storage and associated facilities to be reimbursed by a non-Corps entity via water storage contracts; no storage in projects in the ACF Basin is allocated to water supply.

Water management for the water supply/water quality function involves taking water from storage, either directly from the reservoir or through dam releases for downstream interests. Such operations ensure that sufficient drinking water is available for municipal and industrial needs and agreements to provide in-stream flow for water quality are not violated. Releases from projects in the system will be the minimum (capacity) release for hydroelectric power or releases needed for basin-wide water supply/water quality. The water supply users withdrawing water directly from Lake Lanier and their 2006 withdrawal amounts are as follows:

- Gwinnett County—92.91 mgd
- City of Gainesville—18.98 mgd (Includes 8.0 mgd authorized by their relocation contract.)
- City of Cumming—18.79 mgd (Includes water furnished to Forsyth County, GA.)
- City of Buford—1.51 mgd (2.0 mgd authorized by their relocation contract)

In general, Lake Lanier weekly water supply/quality release decisions are based on the Chattahoochee River Management System (as recorded in the *Apalachicola Basin Reservoir Regulation Manual*, Appendix B, February 1991 [USACE, Mobile District 1991]). In coordination with the Atlanta Regional Commission and Georgia Power, the Corps calculates the sum of anticipated downstream water supply river withdrawals by DeKalb County, City of Atlanta, Cobb County/Marietta Water Authority and Fulton County (average annual 291 mgd in 2000), water quality releases to ensure 750 cfs at the Peachtree Creek gaging station (USGS 02336000), minus water returns and inflows between Buford Dam and Peachtree Creek. That approach ensures sufficient water is released from Lake Lanier to allow for Chattahoochee River withdrawals, guarantee sufficient flows to meet 750 cfs at Peachtree Creek, hydroelectric power production and fish and wildlife needs. During the winter and spring, releases from Buford Dam may be reduced because of sufficient downstream tributary flows to meet the Georgia Environmental Protection Division's 750 cfs target water quality flow at Peachtree Creek. To the extent possible, those releases are made in conjunction with peaking power operations to minimize effects on hydroelectric power generation.

Flow releases also support cooling water withdrawals for several industries including critical power plants. Two such facilities are the Farley Nuclear Plant, which requires a minimum elevation of 74.5 ft immediately downstream of George W. Andrews Dam and the Plant Scholtz immediately downstream of Jim Woodruff Dam, which requires a minimum flow of 5,000 cfs but can temporarily operate at water elevation of 37.5 ft (equivalent to flows of 4,200 cfs).

Over 40 percent of Lake Lanier's water is in the *inactive* storage zone (below elevation 1,035 ft). All the water supply users have multiple level intakes in Lake Lanier (in the conservation pool and inactive storage), and several withdraw water from the inactive storage. Gwinnett County has multiple elevation intakes at 1,062, 1,045, and 1,025 ft, and has withdrawn from the 1,025 intake (within the inactive storage zone) for many years. The City of Cumming intakes range from elevation 1,053 down to 1,032 ft. The City of Buford intakes are at elevations 1,062, 1,052, 1,042, and 1,032 ft. The City of Gainesville has three intake structures, each with multiple intake ports ranging from elevation 1,063 down to 1,025 ft. Releases through Buford Dam to the Chattahoochee River draw from the inactive storage zone (releases from the hydroelectric power units and the sluice gates), and the release waters make up the Chattahoochee River that flows downstream to the Atlanta area municipal water intakes downstream. Releases from Lake Lanier also support a number of other downstream M&I water supply needs including the Cities of LaGrange, West Point, Columbus and a number of industries.

Under the No Action Alternative, it is assumed that the current water supply operations between Buford Dam and Peachtree Creek would remain in effect unchanged using 2007 withdrawals of 275 mgd. 2007 was the greatest demand year recorded along this reach.

1.3 Proposed Action Alternative

Under the Proposed Action Alternative, the Corps would continue to operate projects in the ACF Basin in a balanced manner to achieve all authorized project purposes. The following sections identify key elements of the proposed action that differ from the No Action Alternative.

In light of the July 2009 federal district court ruling, under the proposed action withdrawals directly from Lake Lanier would be limited solely to the existing relocation contracts for the Cities of Gainesville and Buford at rates not exceeding 8 and 2 mgd, respectively.

Similarly under the proposed action, the Corps would no longer make releases for water supply and water quality requirements from Buford Dam in accordance with the Chattahoochee River Management System. Instead, off-peak releases for from Buford Dam would be limited to 600 cfs. Water availability for M&I withdrawals on the Chattahoochee River between Buford Dam and Peachtree Creek would be limited to that which is available from the 600 cfs off-peak releases or water incidentally available through peaking hydroelectric power generation, or both.

1.3.1 Action Zones

Under the proposed action, the Corps would modify the action zones for Lake Lanier, West Point Lake, and Walter F. George Lake. The proposed modifications are shown in Figure 1.3-1, Figure 1.3-2, and Figure 1.3-3. The proposed modifications take into account the ability of the reservoirs to refill (considering hydrology, watershed size, and such), recreation effects and hazard levels, and proportionality of zone drawdown between projects.

The following definitions apply to the revised action zones:

- Zone 1: Indicates that releases can be made in support of a navigation season (January–April or May), hydroelectric power releases, water supply, and water quality releases. If all the lakes are in Zone 1 or above, the river system would operate in a fairly normal manner.
- Zone 2: Indicates that releases can be made in support of a navigation season (January - April or May). Hydroelectric power generation is supported at the same or a reduced level. Water supply and water quality releases are met. Minimum flow targets are met.
- Zone 3: Navigation is not supported. Hydroelectric power generation is supported at a reduced level. Water supply and water quality releases are met. Minimum flow targets are met.
- Zone 4: Navigation is not supported. Hydroelectric power demands will be met at a minimum level and might occur only for concurrent uses. Water supply and water quality releases are met. Minimum flow targets are met.

The revised action zones were developed to better:

1. Facilitate refill of each reservoir.
2. Minimize low-water recreational impacts and hazard levels.
3. Balance system storage throughout the basin.
4. Enhance ability to balance refill relative to watershed and hydrology.
5. Achieve proportional drawdown in each reservoir.

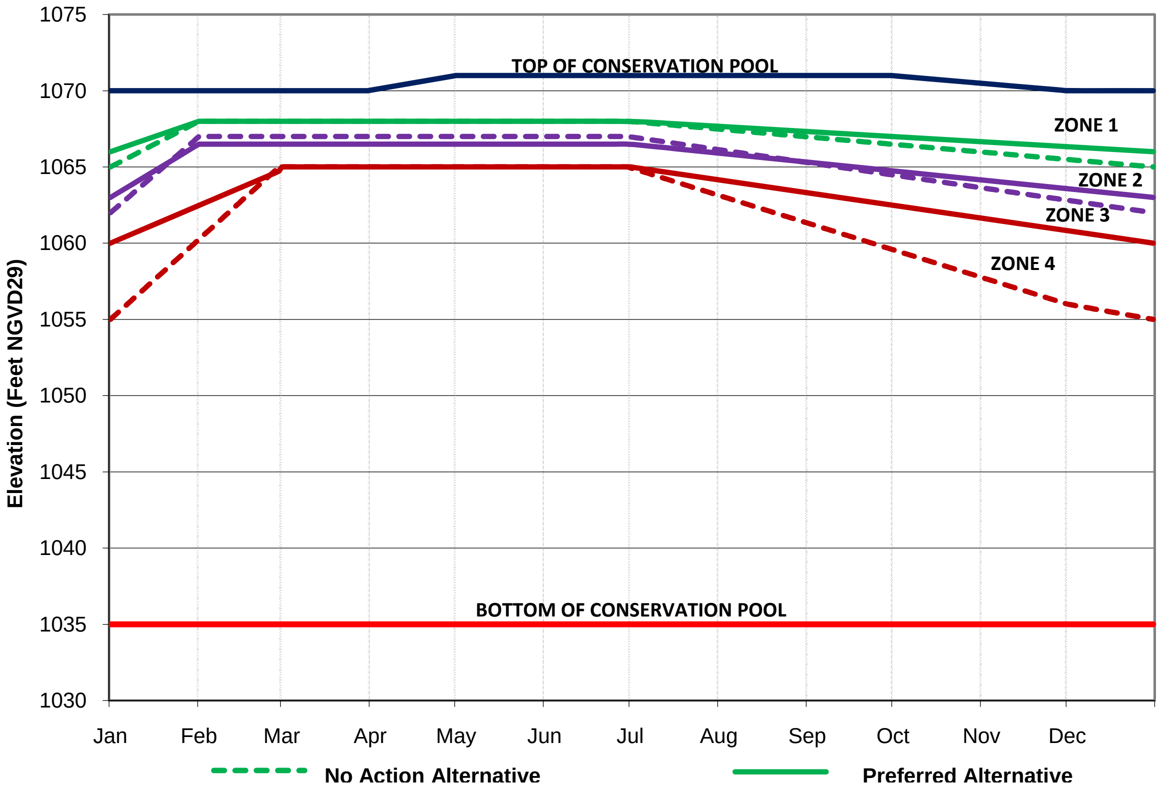


Figure 1.3-1. Lake Lanier Water Control Action Zones

Changes in the Lake Lanier action zones are proposed to facilitate refill and storage of water relative to the watershed size. By increasing Zone 4 to 1,060 ft in January, there will be more water in the reservoir when drought operations go in to effect. This operational change allows for more water storage to balance water management throughout the ACF Basin.

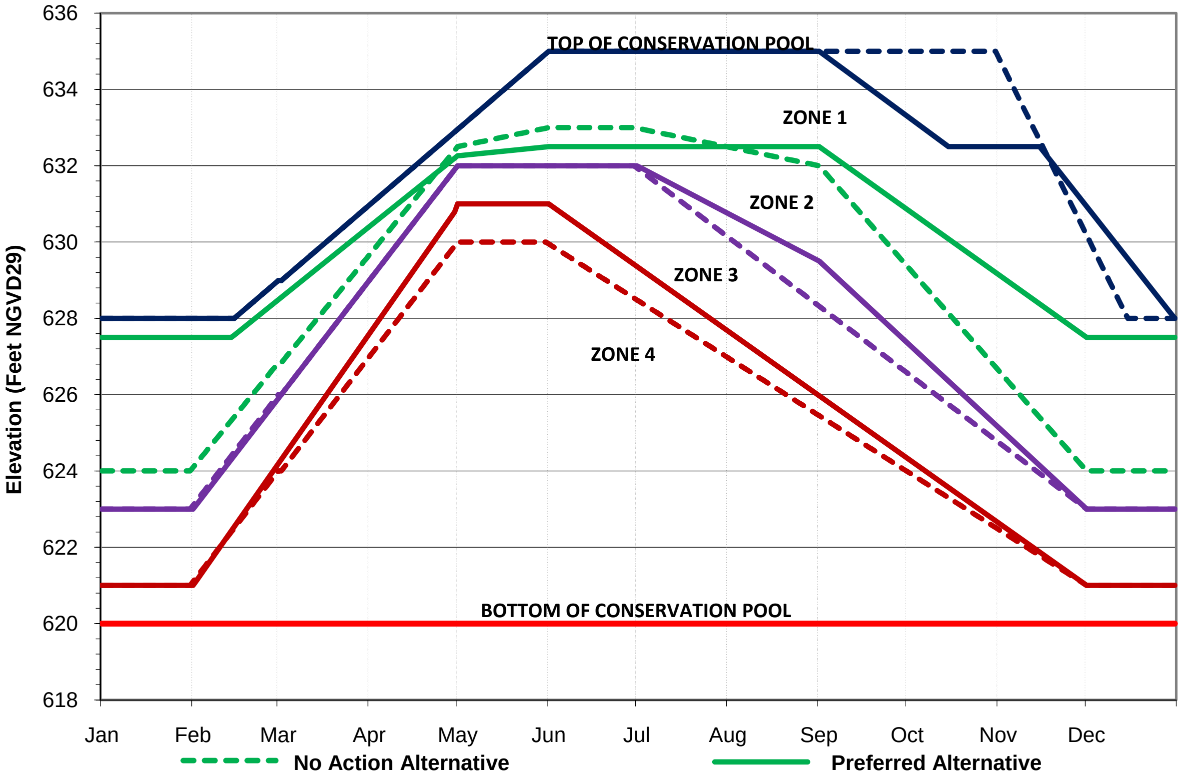


Figure 11.3-2. West Point Water Control Action Zones

The West Point Lake guide curve (top of conservation pool) change is proposed to be maintained at a summer pool level of 635 ft beginning in June and lasting through August. In September, the lake elevation would be gradually drawn down to approximately 632.5 ft by October 1. Lake levels would be held at 632.5 ft until November. In November, another gradual drawdown to winter pool level of 628.0 ft would occur. Winter pool level would be maintained until mid-February. Gradual lake refill would begin in mid-February. Winter pool would be increased through the spring until summer pool elevation is achieved in June.

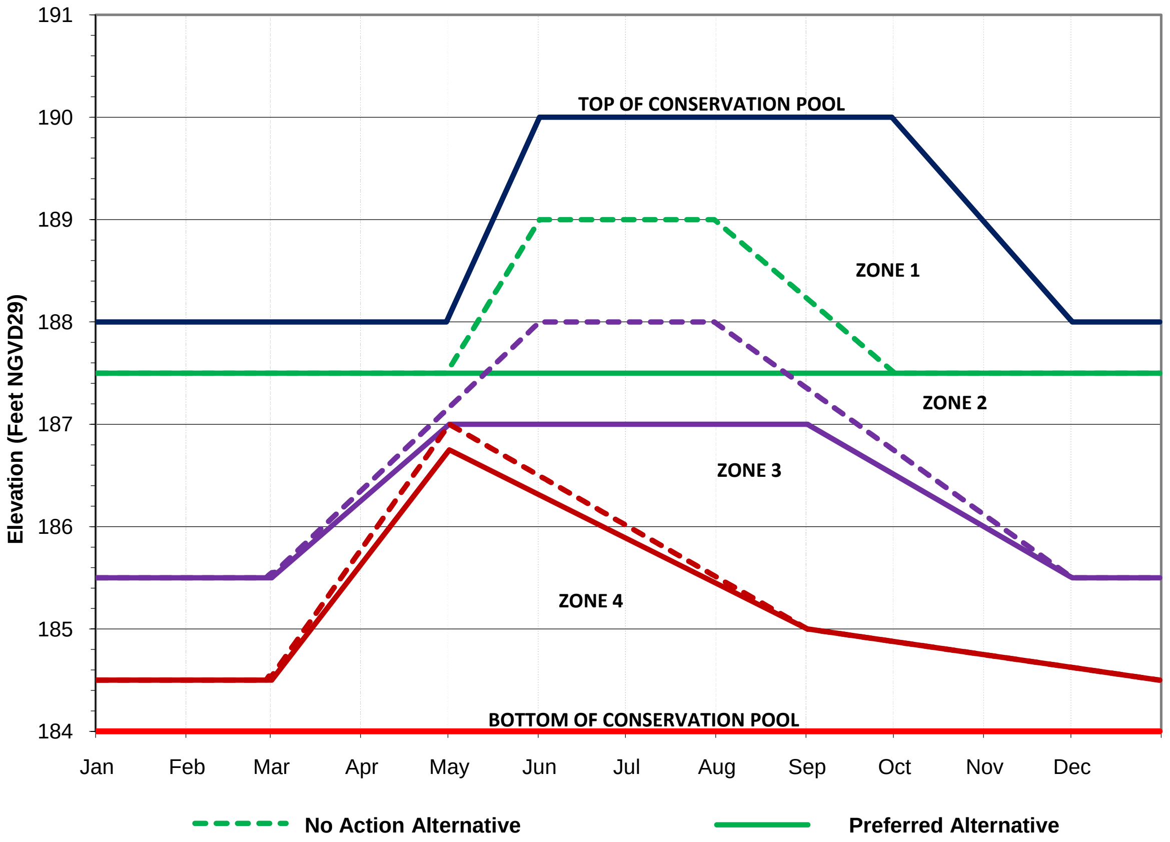


Figure 11.3-3. Walter F. George Water Control Action Zones

Changes to action zones in the Walter F. George project allow use of more available storage in the reservoir to achieve proportional drawdown and balance system storage. Decreasing Zone 2 to 187.5 from May through October and Zone 3 from 188 ft to 187 ft from March through December allows for more storage water to be released downstream during critical low flow periods.

1.3.1.1 Drought Operations

Drought operations are “triggered” when composite conservation storage of the ACF Basin falls below the bottom of Zone 3 into Zone 4, (Figure 1.3-4). At that time all the composite conservation storage Zone 1-3 provisions (seasonal storage limitations, maximum fall rate schedule, minimum flow thresholds, and volumetric balancing accounting) are suspended and management decisions are based on the provisions of the drought plan. The Jim Woodruff Dam minimum discharge is determined in relation to composite conservation storage and not the average basin inflow under the drought plan. The drought plan for the ACF Basin specifies a minimum release from Jim Woodruff Dam and temporarily suspends the other minimum release and maximum fall rate provisions until composite conservation storage within the basin is replenished to a level that can support the minimum releases and maximum fall rates. The drought plan also includes a temporary waiver from the existing water control plan to allow temporary storage above the winter pool guide curve at the Walter F. George and West Point projects if the opportunity presents itself. There is also an opportunity to begin spring refill operations at an earlier date in order to provide additional conservation storage for future needs and to provide for a minimum releases less than 5,000 cfs from Jim Woodruff Dam. Drought operations also include reduced hydropower generation at Lake Lanier as described below.

The drought plan prescribes two minimum releases from Jim Woodruff Dam based on composite conservation storage in Zone 4 and an additional zone referred to as the Drought Zone, Figure 1.3-4. The Drought Zone delineates a volume of water roughly equivalent to the inactive storage in lakes Lanier, West Point and Walter F. George plus Zone 4 storage in Lake Lanier. The Drought Zone line has been adjusted to include a smaller volume of water at the beginning and end of the calendar year. When the composite conservation storage is within Zone 4 and above the Drought Zone, the minimum release from Jim Woodruff Dam is 5,000 cfs and all basin inflow above 5,000 cfs that is capable of being stored may be stored. Once the composite conservation storage falls below the Drought Zone, the minimum release from Jim Woodruff Dam is 4,500 cfs and all basin inflow above 4,500 cfs that is capable of being stored may be stored. When transitioning from a minimum release of 5,000 to 4,500 cfs, fall rates will be limited to a 0.25 ft/day drop. The 4,500 cfs minimum release is maintained until composite conservation storage returns to a level above the top of the Drought Zone, at which time the 5,000 cfs minimum release is re-instated. The drought plan provisions remain in place until conditions improve such that the composite conservation storage reaches a level above the top of Zone 2 (i.e., within Zone 1). At that time, the temporary drought plan provisions are suspended, and all the other provisions are re-instated. During the drought contingency operations a monthly monitoring plan that tracks composite conservation storage in order to determine water management operations (the first day of each month will represent a decision point) will be implemented to determine which operational triggers are applied. In addition, recent climatic and hydrological conditions experienced and meteorological forecasts will be used when determining the set of operations to utilize.

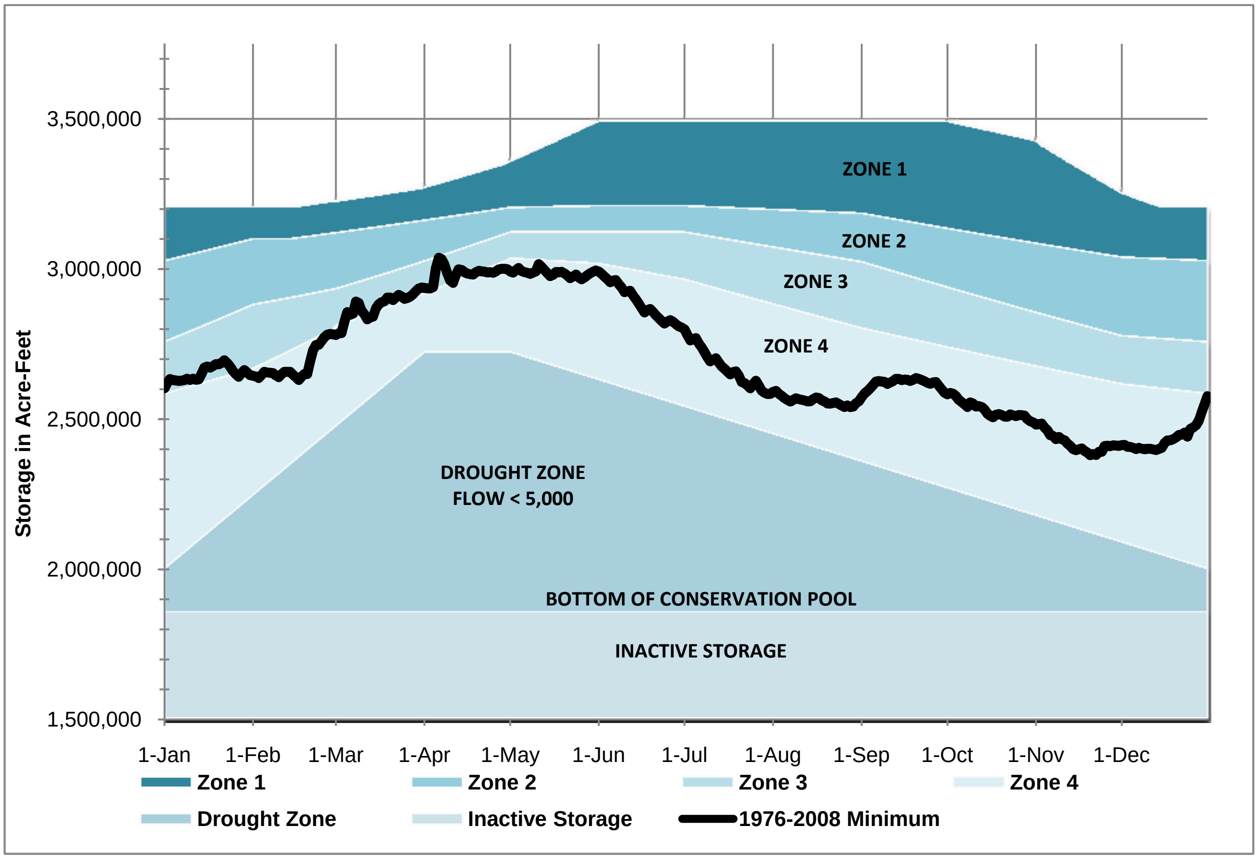


Figure 11.3-4. Drought Composite Conservation Storage Triggers

1.3.1.2 Flood Damage Reduction

The minor guide curve change included in the Proposed Action Alternative for West Point Lake provides an incidental increase in flood storage during the fall drawdown. No changes to the flood damage reduction operations described in the No Action Alternative are proposed. When developing the proposed action, flood damage reduction capabilities and capacities of reservoirs were not reduced.

1.3.1.3 Hydroelectric Power

Under the proposed action, Corps would continue to operate Buford Dam, West Point Dam, Walter F. George Dam, and Jim Woodruff Dam for hydroelectric power generation, as described for the No Action Alternative. The Proposed Action Alternative would not result in changes to hydroelectric power generation operations at West Point Dam, Walter F. George Lock and Dam, or Jim Woodruff Dam, except as might result from changes in the action zones.

Under the Proposed Action Alternative, when Lake Lanier is in Zone 1 or 2 during non-drought conditions, generation would typically be in the hourly ranges shown in the table below. Similarly, during drought operations as described above, generation would typically be reduced to that depicted in Table 1.3-1.

Table 1.3-1. Buford Dam Hydroelectric Power Generation Schedule

Hydroelectric Power Generation hours	No Action	Proposed Action Alternative	
		Non-drought	Drought ops
Zone 1	3	4–2	2
Zone 2	2	4–1	1
Zone 3	2	2–1	1
Zone 4	0	2–1	1

1.3.1.4 Navigation

Under the proposed action, when supported by ACF Basin hydrologic conditions, the Corps will provide a reliable navigation season. In so doing, the goal of the water management is to ensure a predictable minimum navigable channel in the Apalachicola River for a continuous period of time that is sufficient for navigation use.

Assuming basin hydrologic conditions allow, a typical navigation season would begin in January of each year and continue for 4 to 5 consecutive months (January through April or May). During the navigation season the flows at the Blountstown, Florida, USGS gage should be adequate to provide at least a 7 ft channel. The most recent channel survey and discharge-stage rating was used to determine the flow required to sustain a minimum navigation depth during the navigation season. The Corps' capacity to support a navigation season will be dependent upon actual and projected system-wide conditions in the ACF Basin prior to and during the months of January, February, March, April and May. These conditions include, but are not limited to:

1. A navigation season can only be supported when ACF Basin composite conservation storage is in Zone 1 or Zone 2.
2. A navigation season will not be supported when the ACF Basin composite conservation storage is in Zone 3 and below. Provided drought operations have not been triggered, navigation support

will resume when basin composite conservation storage level recovers to Zone 2 and is forecast to remain above Zone 3 for a practicable, continuous period of time.

3. A navigation season will not be supported when drought operations are in effect. Navigation will not be supported after drought operations have ceased until the ACF Basin composite conservation storage recovers to Zone 1.
4. The determination to extend the navigation season beyond April will depend on ACF Basin inflows, recent climatic and hydrological conditions, meteorological forecasts, and basin-wide model forecasts. Based on an analysis of these factors, the Corps will determine if the navigation season will continue through part or all of May.
5. Down ramping of flow releases (regardless of period in the navigation season) will adhere to the Jim Woodruff Dam fall rate schedule (Table 1.3-2) for federally listed species.
6. Releases that augment the flows to provide for the 7 ft navigation channel will also be dependent on navigation channel conditions that ensure safe navigation.

When it becomes apparent that, due to diminishing inflows, downstream flows and depths must be reduced, navigation bulletins will be issued to project users. These notices will be issued as expeditiously as possible in order to give barge owners, and other waterway user's, sufficient time to make arrangements to light load or remove their vessels before action is taken at Jim Woodruff Dam to reduce releases.

Though special releases will not be standard practice, they may occur for a short duration to assist navigation during the navigation season (Figure 1.3-5). For instance, releases may be requested to achieve up to a 9-ft channel. These shall be evaluated on a case by case basis, subject to applicable laws and regulations and the conditions above.

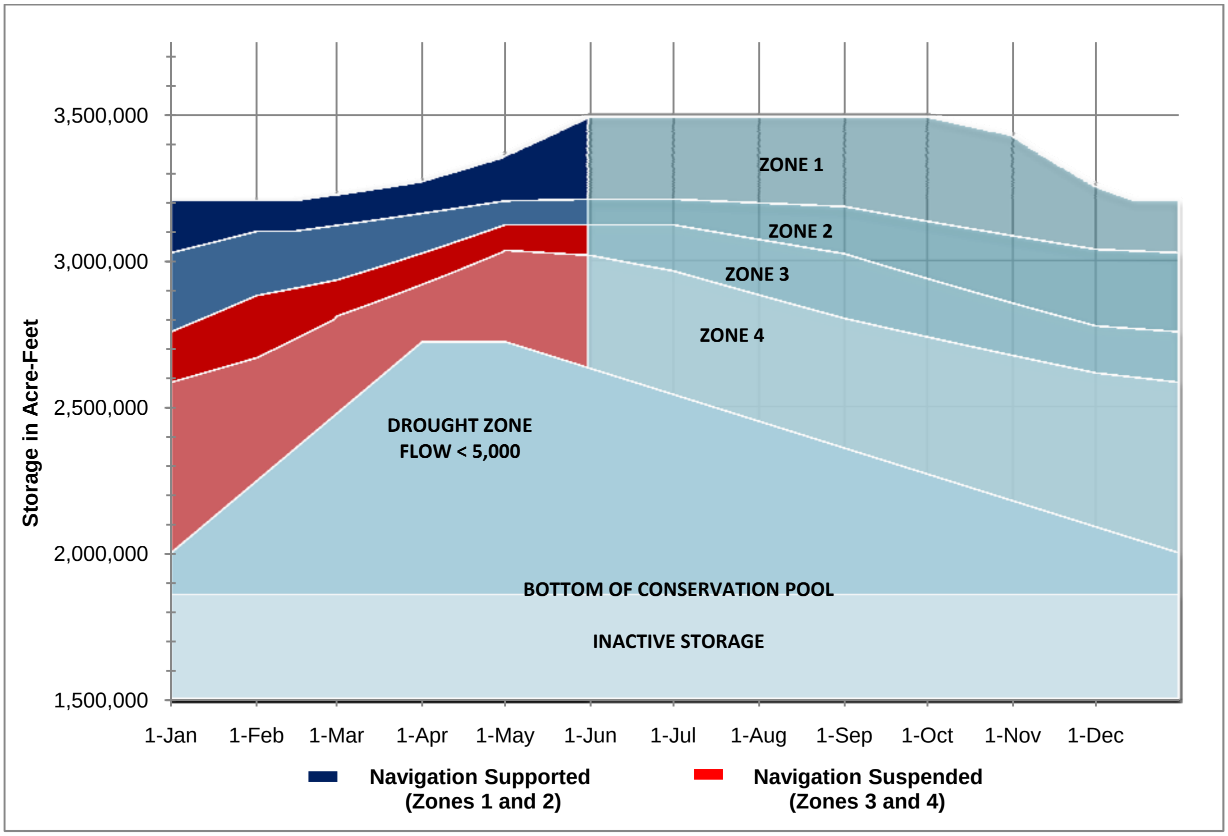


Figure 11.3-5. Composite Conservation Storage for Navigation

1.3.1.5 Fish and Wildlife Conservation

Under the Proposed Action Alternative there are no changes to fish spawn or fish passage operations described in the No Action Alternative.

Federally Listed Species - Under the Proposed Action Alternative, the Corps would continue to make releases for threatened and endangered species below Jim Woodruff Dam on the basis of seasonal requirements (spawning, non-spawning, and winter), composite conservation storage, and basin inflows as discussed in the No Action Alternative with several modifications.

Release requirements dictated by composite conservation storage would be in accordance with the revised action zones discussed above. The Corps would no longer use volumetric balancing and would revise ramping rate requirements when flows are below 30,000 cfs. Those modifications are proposed on the basis of lessons learned after operating under the RIOP for several years and to reduce the likelihood of triggering releases of less than 5,000 cfs from Jim Woodruff Dam.

Table 1.3-2. Maximum Fall Rate Schedule Composite Conservation Storage Zones 1, 2, and 3[ab]

Release range (cfs)	Maximum fall rate, measured at Chattahoochee gage (ft/d)
> 30,000[c]	No ramping restriction[d]
Exceeds powerhouse capacity (~ 16,000) and <= 30,000[a]	Match 1-day basin inflow fall rate
Within powerhouse capacity and > 8,000[a]	0.25 to 0.5
Within powerhouse capacity and <= 8,000[a]	0.25 or less

Notes: a. Maximum fall rate schedule is suspended in Composite Zone 4.

b. Any changes to the RIOP minimum flows or maximum fall rate provisions resulting from reinitiation of consultation will be incorporated and evaluated.

c. Consistent with safety requirements, flood-control purposes, and equipment capabilities.

d. For flows greater than 30,000 cfs, it is not reasonable and prudent to attempt to control the down ramping rate, and no ramping rate is required.

Modifications are proposed to ensure full system recovery after drought operations are implemented. No changes to the drought contingency operations described in the RIOP discussion of the No Action Alternative, with the exception of the following:

1. The drought plan provisions remain in place until conditions improve such that the composite conservation storage reaches a level above the top of Zone 2 (i.e., in Zone 1).

2. Reshaping the Drought Zone as depicted in Figure 1.3-4.

In the analysis of the Proposed Action Alternative, the only changes to the current RIOP operations in support of listed species are those identified above. However, if the on-going reinitiation of consultation for the fat threeridge and RIOP results in additional changes to the RIOP, those changes will need to be considered at a later date.

1.3.1.6 Recreation

The proposed action has no changes to operations in support of recreation from those described in the No Action Alternative.

1.3.1.7 Water Quality

The Corps would no longer operate in accordance with the Chattahoochee River Management System to provide a specific flow for water quality at Peachtree Creek.

In accordance with the July 2009 federal district court ruling, off-peak releases from Buford Dam would be limited to 600 cfs. Water availability on the Chattahoochee River between Buford Dam and Peachtree Creek would be limited to that which is available from the 600 cfs off-peak releases and/or water incidentally available through peaking hydroelectric power generation. Consequently, the water supply providers downstream of Buford Dam will need to limit their withdrawals during off-peak times so that water quality standards in the Chattahoochee River are not violated.

No changes are proposed for releases through the house unit at West Point Dam.

1.3.1.8 Water Supply

Under the Proposed Action Alternative on the basis of the federal district court ruling, water withdrawals directly from Lake Lanier would be limited to the existing relocation contracts for the Cities of Gainesville and Buford at rates not exceeding 8 and 2 mgd, respectively.

The Corps would no longer make releases for water supply requirements from Buford Dam in accordance with the Chattahoochee River Management System. Instead, off-peak releases from Buford Dam would be limited to 600 cfs, pursuant to Judge Magnuson's ruling. Water availability for M&I withdrawals on the Chattahoochee River between Buford Dam and Peachtree Creek would be limited to that which is available from the 600 cfs off-peak releases and/or water incidentally available through peaking hydroelectric power generation. Peaking hydroelectric power generation would occur between 5:00am – 9:00am and 3:00pm – 10:00pm on Monday through Friday between October 1 and March 31 and between 1:00pm – 7:00pm on Monday through Friday between April 1 and September 30.

All other water supply operations in the ACF Basin described in the No Action Alternative would remain the same.

2 RESPONSE TO PLANNING AID LETTER (PAL) SECTION 3

2.1 RESPONSE TO PAL SECTION 3.1 ResSim Model Output Analyses

As requested, Indicators of Hydrologic Alteration (IHA) was used in the development of the analysis of the environmental consequences of the proposed action. This analysis was woven into various sections of water and biological resources analyses. Other tools recommended, Environmental Flow Components (Mathews and Richter 2007) and ACF Riverine Community Habitat Assessment and Restoration Concept (RCHARC), were not used in determining the environmental consequences of the Proposed Action Alternative. Existing data and resources were used in this analysis. Some of the recommended tools would have required more extensive study of current conditions. The IHA analysis provided the necessary output to address all of the questions to follow and additional analysis did not appear to add value given the resources needed to develop and use those tools. In the case of RCHARC, the tool developer was also not supportive of its use for this purpose based on deviations from the original intent of the tool realized during the 1998 Draft Water Allocation EIS (Freeman Pers. Comm).

2.2 RESPONSE TO PAL SECTION 3.2 HEC-5Q Water Quality Model Output Analyses

In consideration of the range of potential responses by the state of Georgia and metropolitan Atlanta water users between Buford Dam and Peachtree Creek to the July 2009 Federal district court ruling, the Corps (in the Proposed Action analysis) modeled two scenarios for minimum flow requirements at Peachtree

Creek for water quality purposes. These scenarios were developed assuming that Atlanta's water withdrawers and dischargers into the Chattahoochee River from Buford Dam to Peachtree Creek would manage their operations to meet minimum flow requirements at Peachtree Creek. Scenario 1 assumes that the water withdrawers and dischargers manage their operations so that a minimum flow of 550 cfs remains in the Chattahoochee River at Peachtree Creek. Scenario 2 assumes that the water withdrawers and dischargers manage their operations so that a minimum flow of 750 cfs is always available at Peachtree Creek. The 550 cfs flow at Peachtree Creek was analyzed based on a previous request from Georgia EPD for temporary relief from the 750 cfs level during the 2006 – 2008 drought and knowledge that flows lower than this level would not meet the current physical constraints of several water supply intakes between Buford Dam and West Point Lake. In the second scenario, water supply and wastewater providers would manage discharges and withdrawals downstream of Buford Dam to ensure that a minimum flow of 750 cfs would be available at Peachtree Creek as defined in the current Chattahoochee River Management System protocols. In the Proposed Action Alternative evaluation, all Corps operations are the same. The two scenarios reflect two separate potential consumption quantities for the reach between Buford Dam and the confluence with Peachtree Creek. In the plots and figures below, the two scenarios are labeled as scenario 1 and scenario 2 or Alt-550 and Alt_750 respectively.

The HEC-5Q modeled output was processed to illustrate variations between the Proposed Action Alternative and No Action Alternative for the ACF Basin. The modeled results were compared longitudinally down the Chattahoochee River of the ACF Basin and as time series in select locations. Longitudinal plots, or system profiles, were initially examined to understand the most critical locations for water quality related to various parameters. Following an evaluation of the range of longitudinal modeled results, specific locations were selected where the range of modeled output was the greatest. The time series of modeled results were plotted at specific locations to illustrate the seasonal response of pollutants.

Model results were output in six-hour time intervals in the river and reservoirs. The results presented below were analyzed at various seasonal intervals, generally, May through October. All model results were reviewed annually, seasonally, and based on dry, average, and wet year types for each alternative. The following plots can be used to address questions presented in the PAL by parameter. Note that the longitudinal figures present the percent occurrence of modeled output; the opposite of the percent exceedence. It was recommended that percent exceedence may assume violation of water quality standards and thus percent occurrence was utilized for the presentation of water quality.

2.2.1 Dissolved Oxygen

- Total number of days with dissolved oxygen below a daily average of 6 milligrams per liter (mg/L) in locations within Georgia trout waters, and below a daily average of 5 mg/L in non-trout waters.

Figures 2.2-1 and 2.2-2 present the variations of dissolved oxygen modeled along the Chattahoochee River. These results do not explicitly define the number of days when concentrations are less than state standards (6 mg/L for secondary trout waters and 5 mg/L) but they do provide insight to where low dissolved oxygen concentrations occur for the period from May through October. Figures 2.2-3 through 2.2-5 present dissolved oxygen occurrence plots at Norcross, Georgia and Morgan Falls Dam. These locations are within the secondary trout waters.

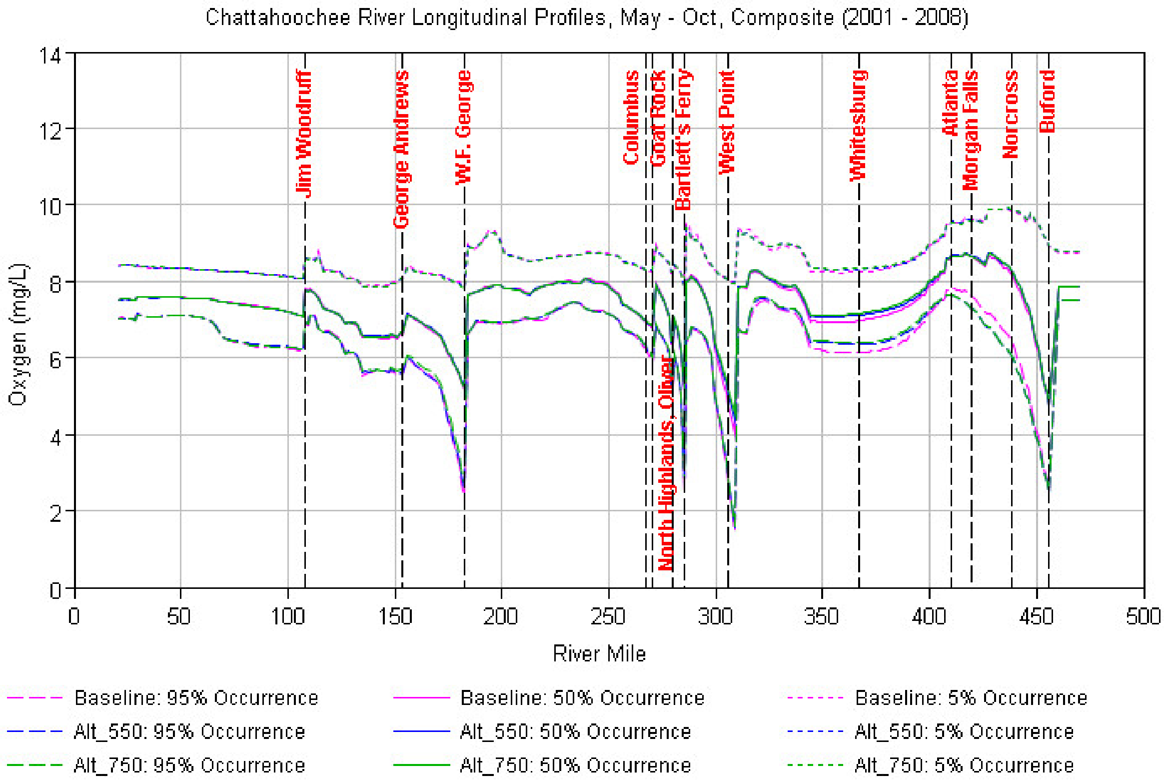


Figure 2.2-1. May – October Dissolved Oxygen for the modeled period from 2001 through 2008.

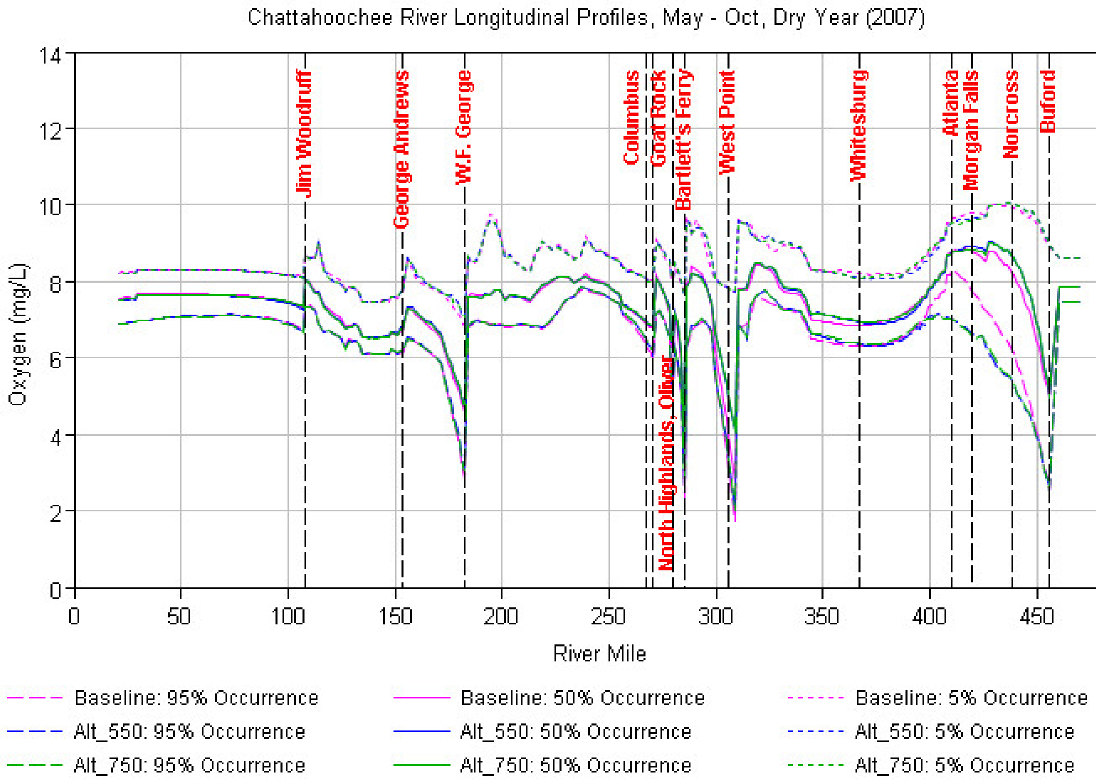


Figure 2.2.-2. May – October Dissolved Oxygen modeled for a representative dry period (2007) when violations would be expected.

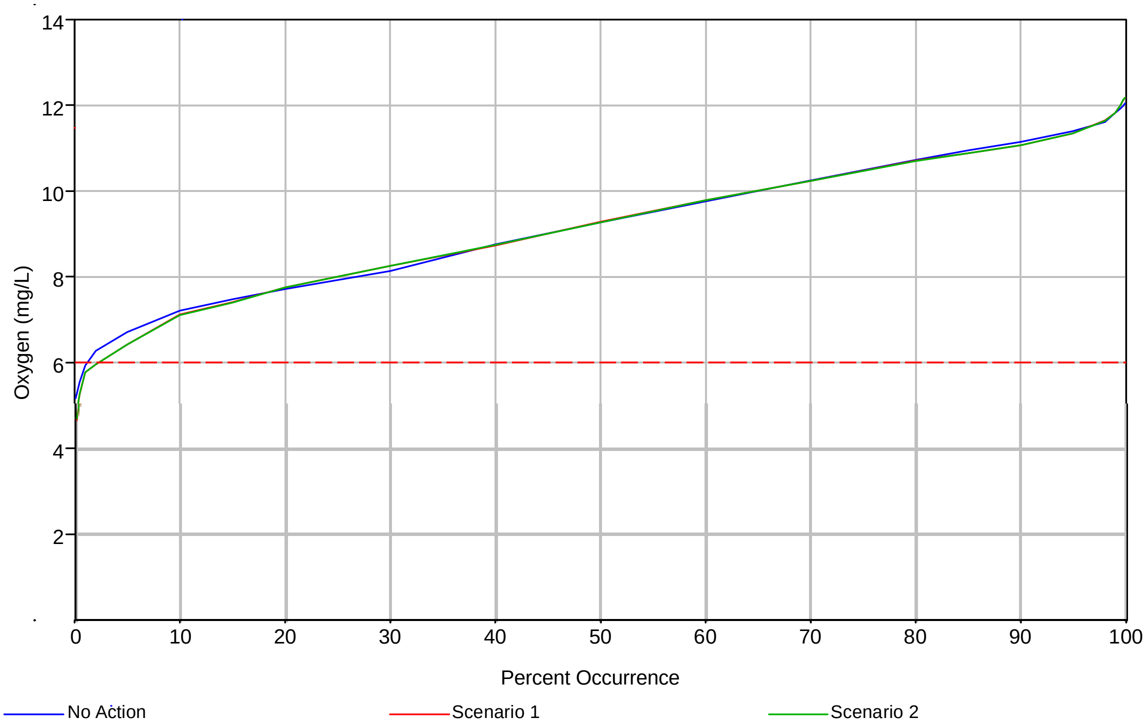


Figure 2.2-3. Occurrence of daily average dissolved oxygen in the Chattahoochee River at Norcross, Georgia, for the period from 2001 through 2008.

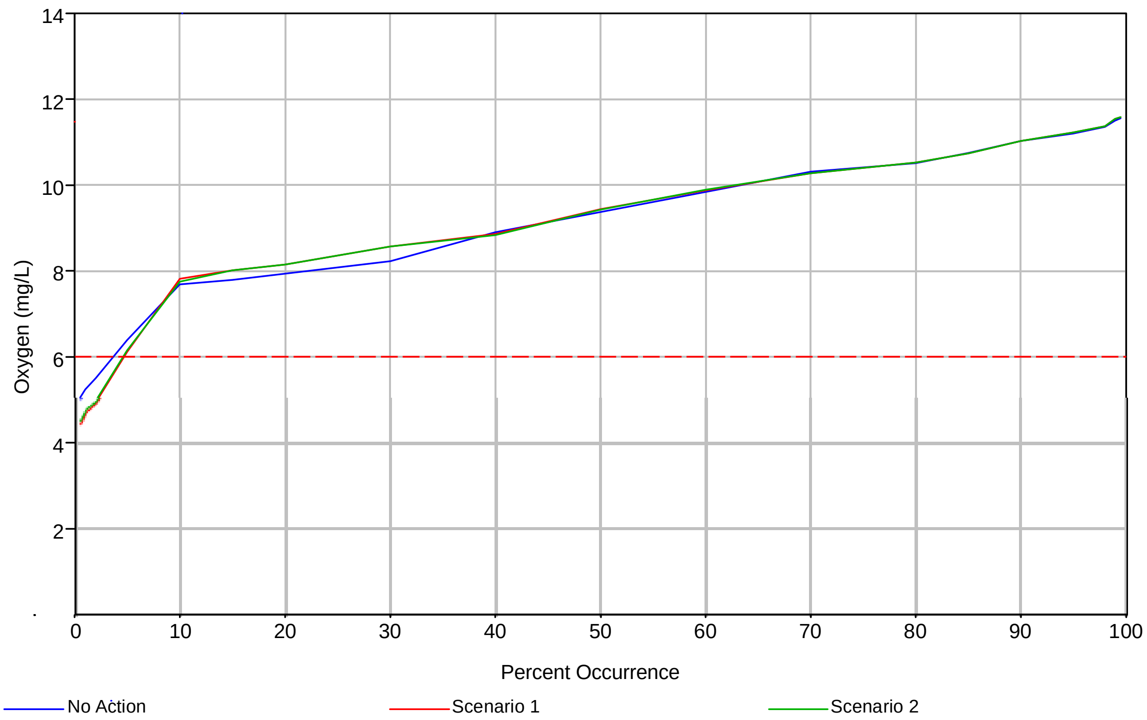


Figure 2.2-4. Occurrence of daily average dissolved oxygen in the Chattahoochee River at Norcross, Georgia, for a representative dry year (2007).

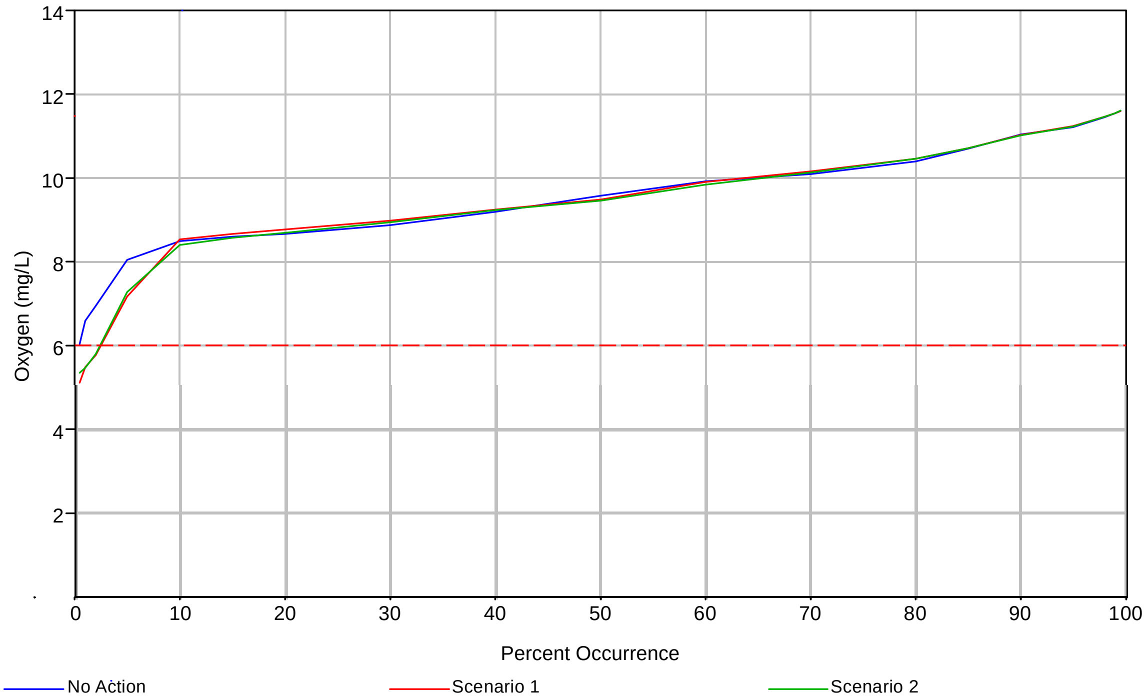


Figure 2.2-5. Occurrence of daily average dissolved oxygen in the Chattahoochee River at Morgan Falls Dam, near Atlanta, Georgia, for a representative dry year (2007).

The occurrence plots to follow (Figures 2.2-6 through 2.2-21) illustrate occurrences of dissolved oxygen at locations where median concentrations are less than state standards from Figures 2.2-1 and 2.2-2. These locations are downstream of Buford, West Point, Bartlett's Ferry, and Walter F. George Dams.

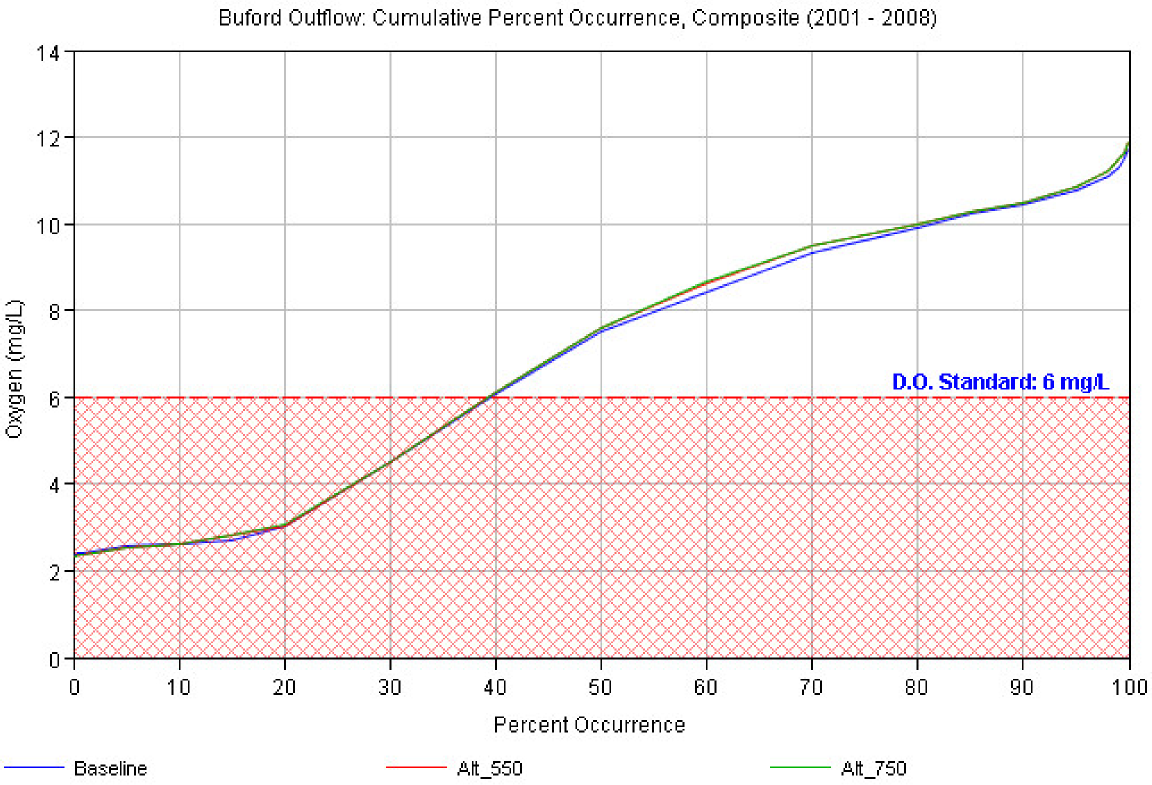


Figure 2.2-6. Dissolved Oxygen occurrence downstream of Buford Dam for the modeled period (2001 – 2008).

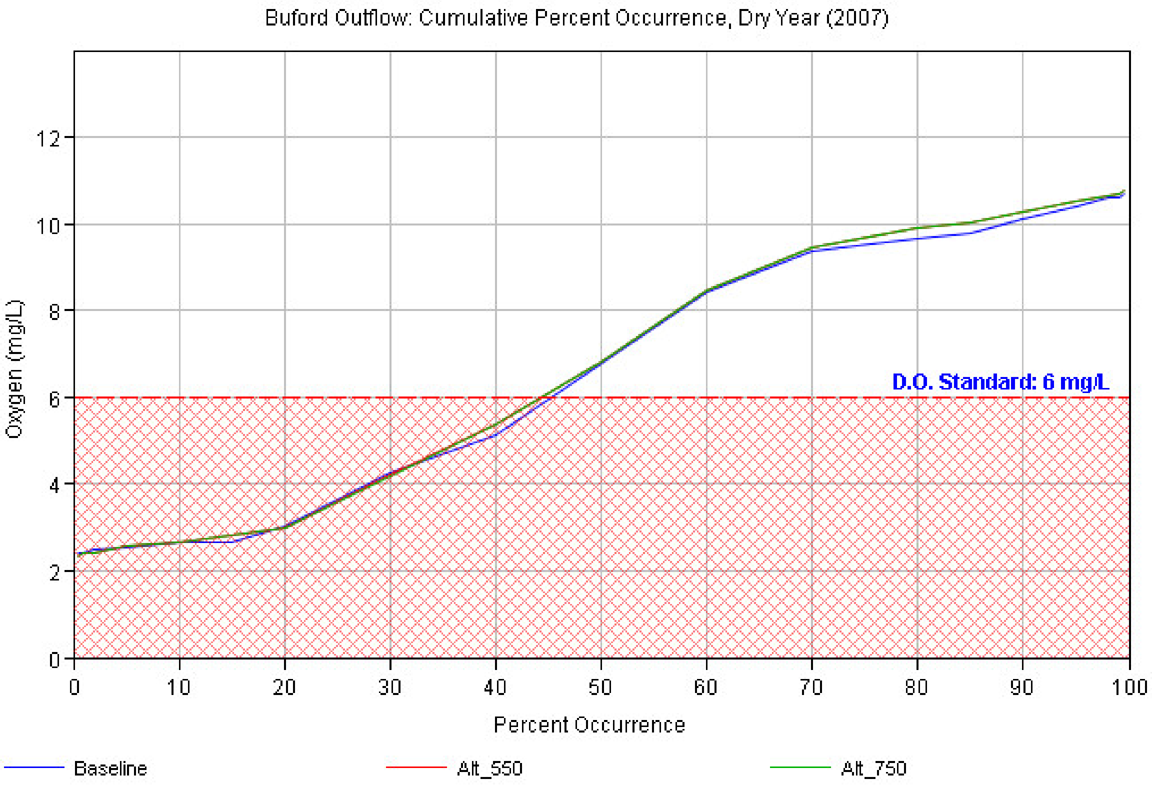


Figure 2.2-7. Dissolved Oxygen occurrence downstream of Buford Dam for a representative dry year (2007).

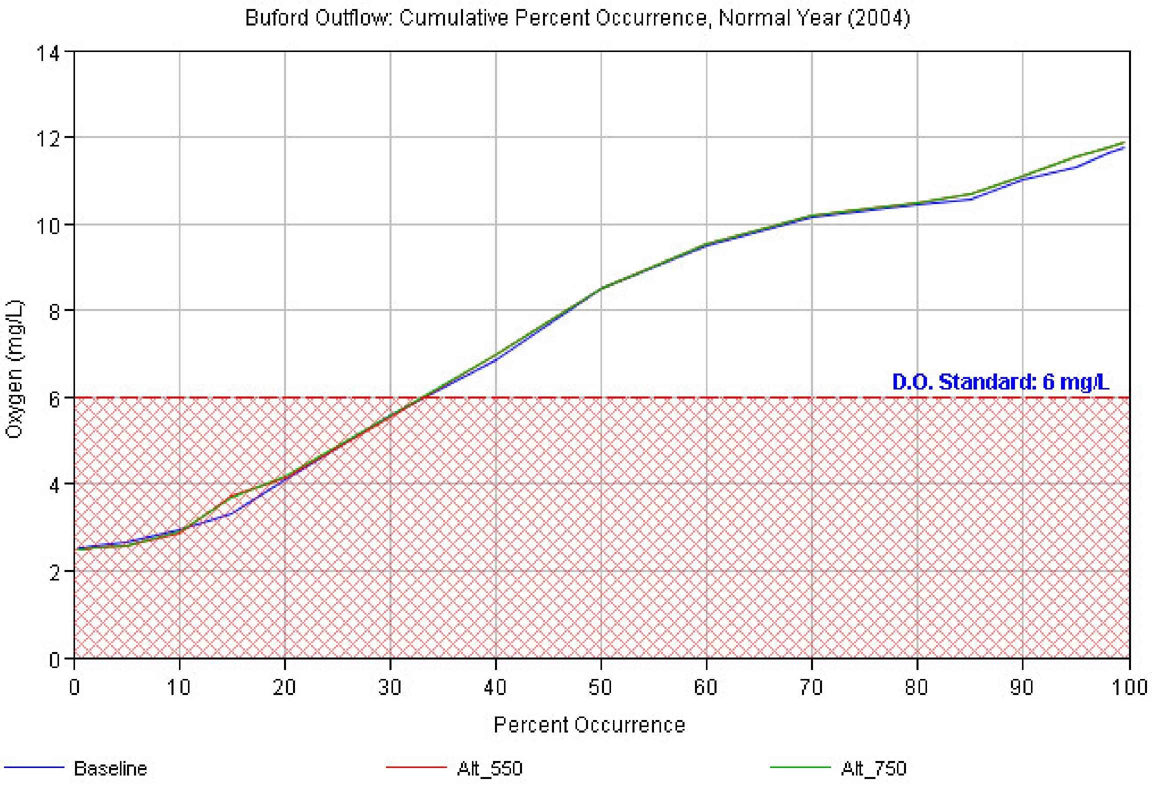


Figure 2.2-8. Dissolved Oxygen occurrence downstream of Buford Dam for a representative normal year (2004).

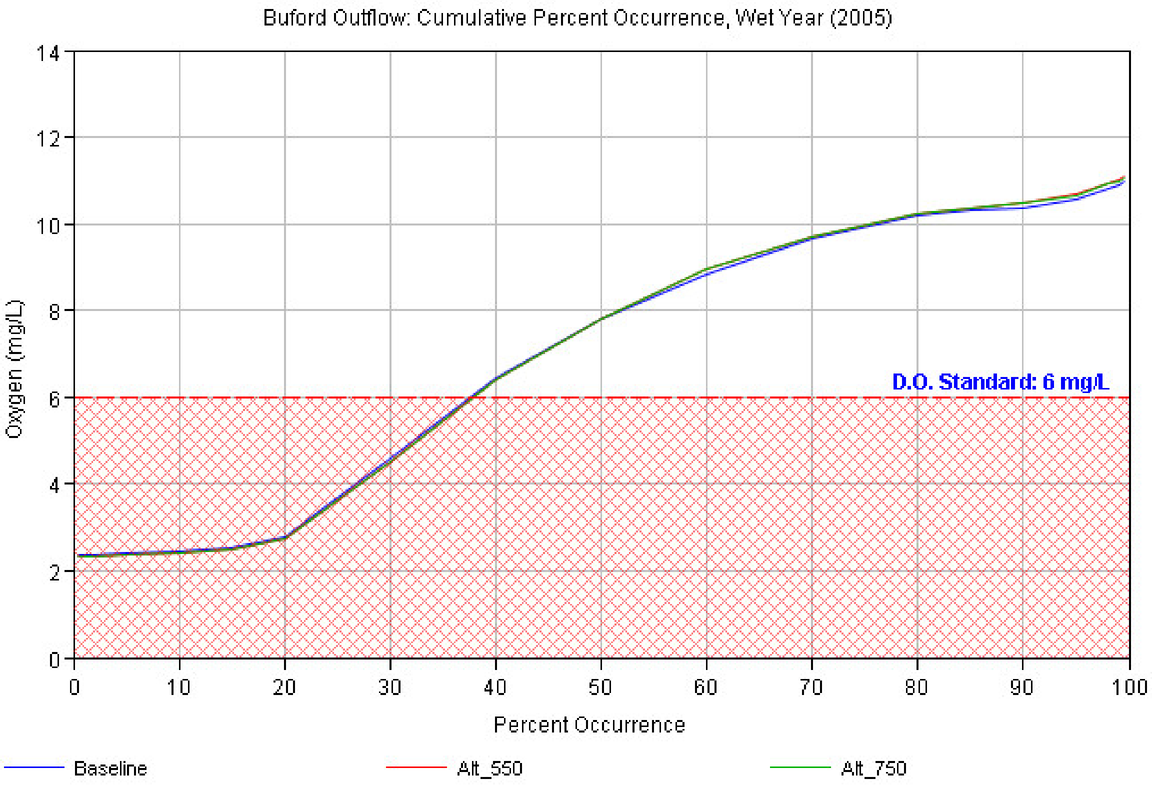


Figure 2.2-9. Dissolved Oxygen occurrence downstream of Buford Dam for a representative wet year (2005).

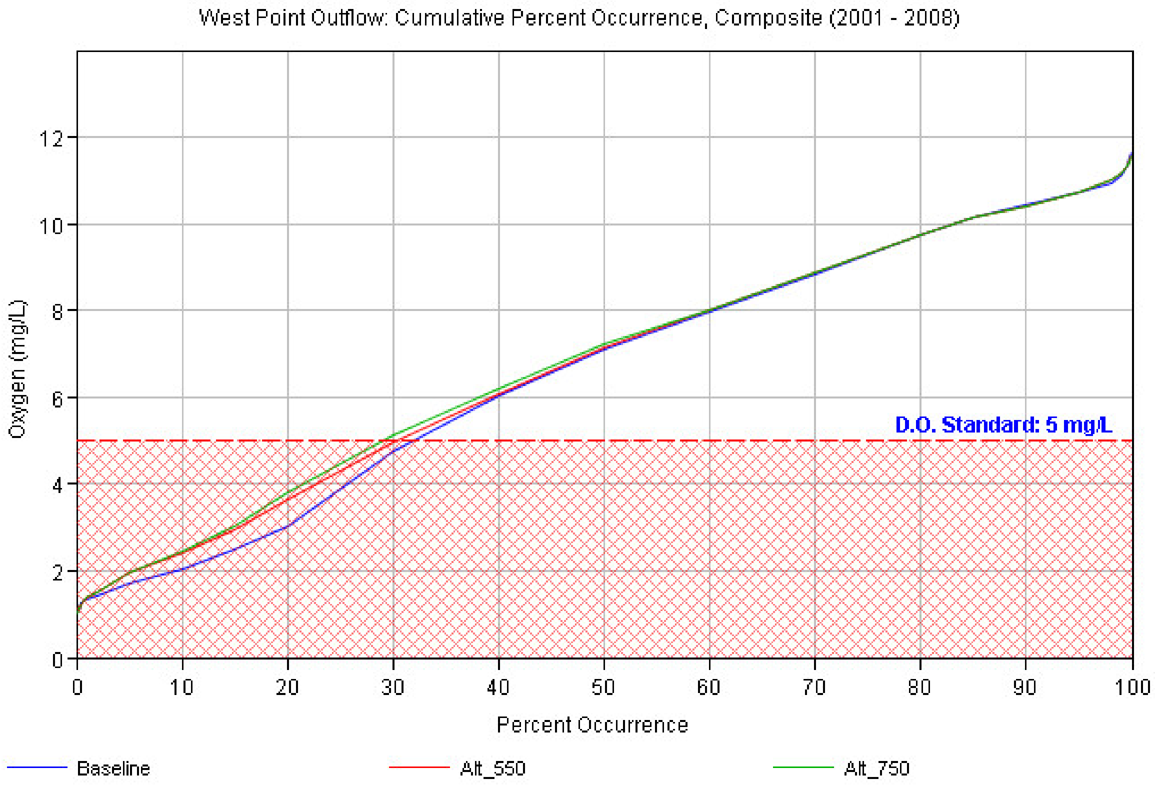


Figure 2.2-10. Dissolved Oxygen occurrence downstream of West Point Dam for the modeled period (2001 - 2008).

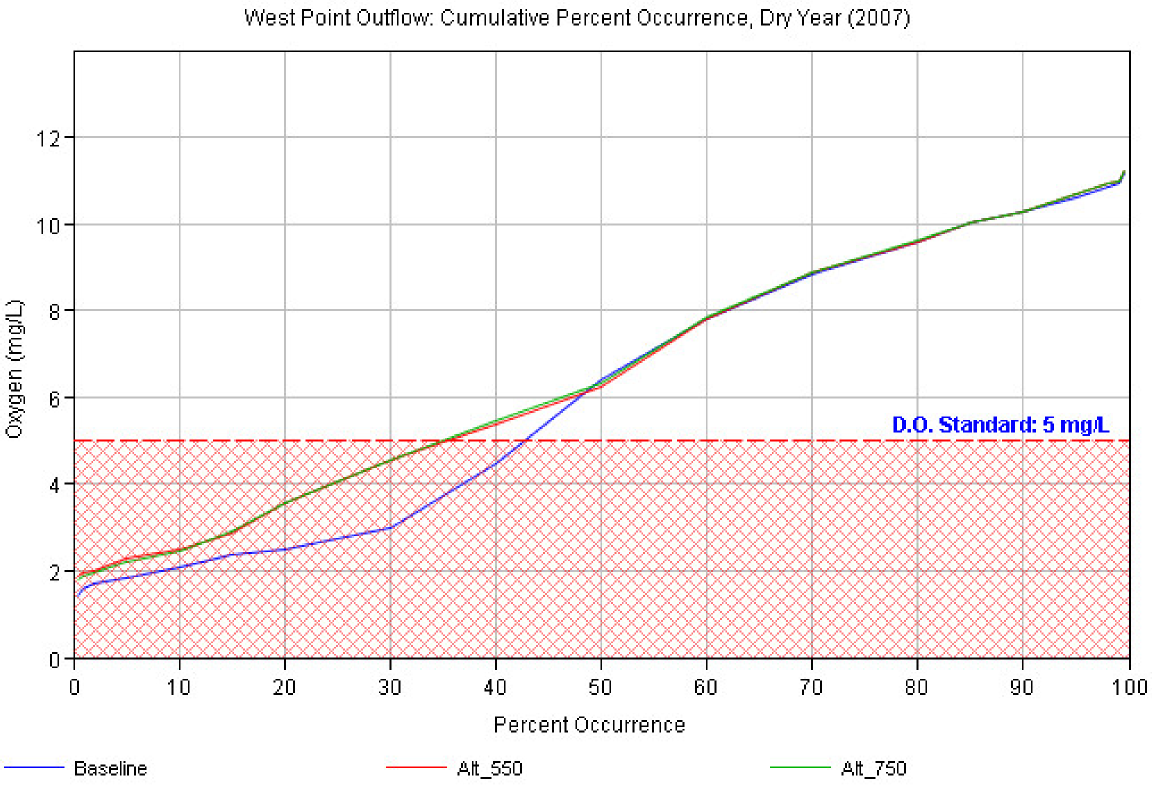


Figure 2.2-11. Dissolved Oxygen occurrence downstream of West Point Dam for a representative dry year (2007).

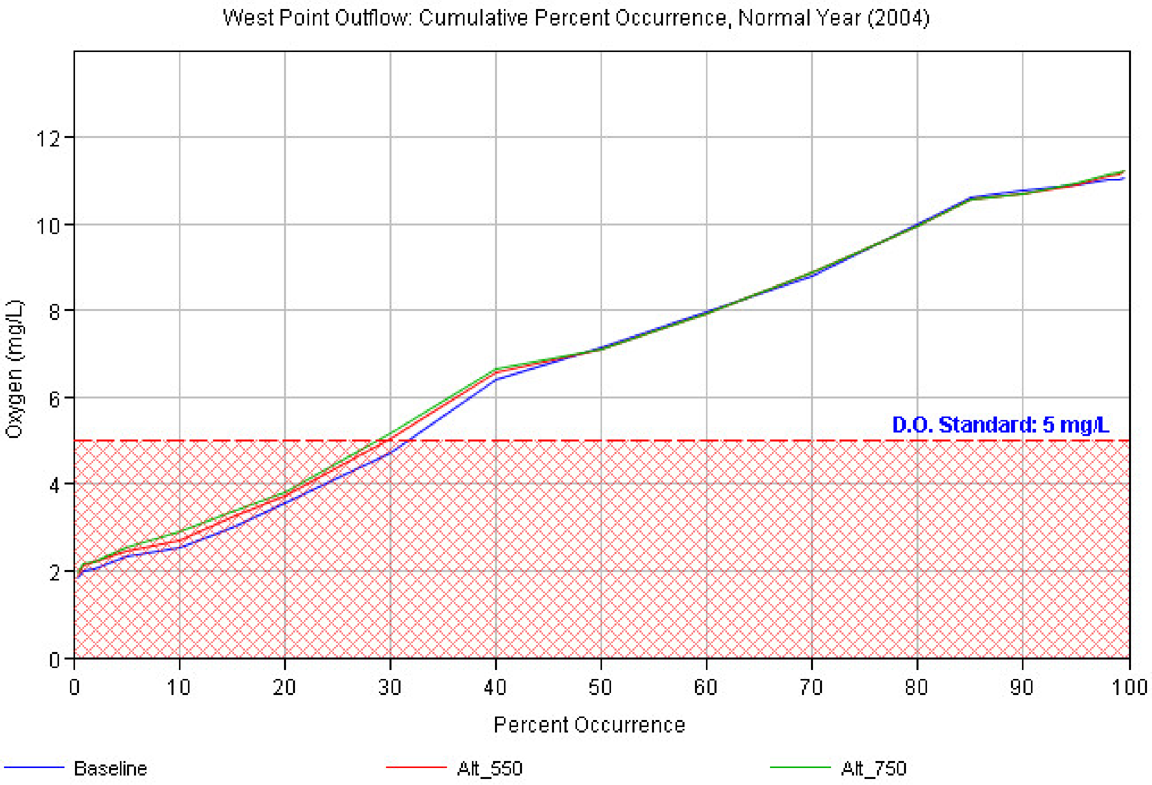


Figure 2.2-12. Dissolved Oxygen occurrence downstream of West Point Dam for a representative normal year (2004).

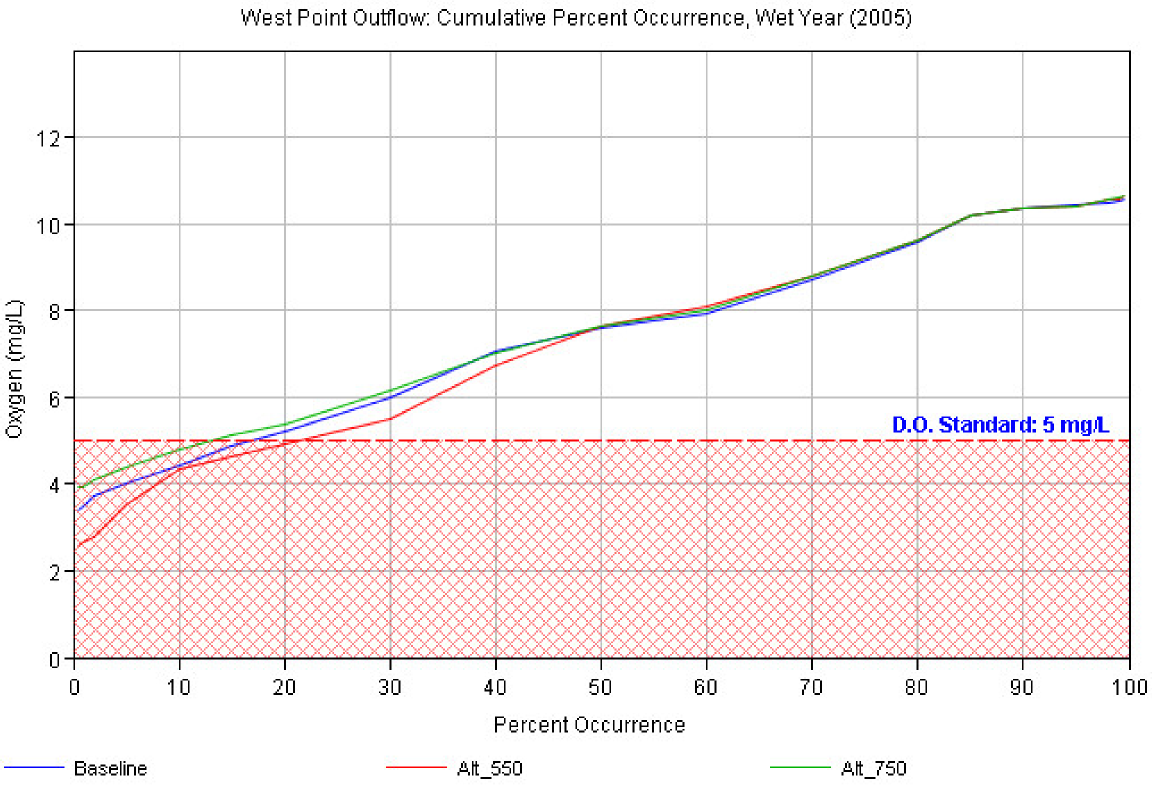


Figure 2.2-13. Dissolved Oxygen occurrence downstream of West Point Dam for a representative wet year (2005).

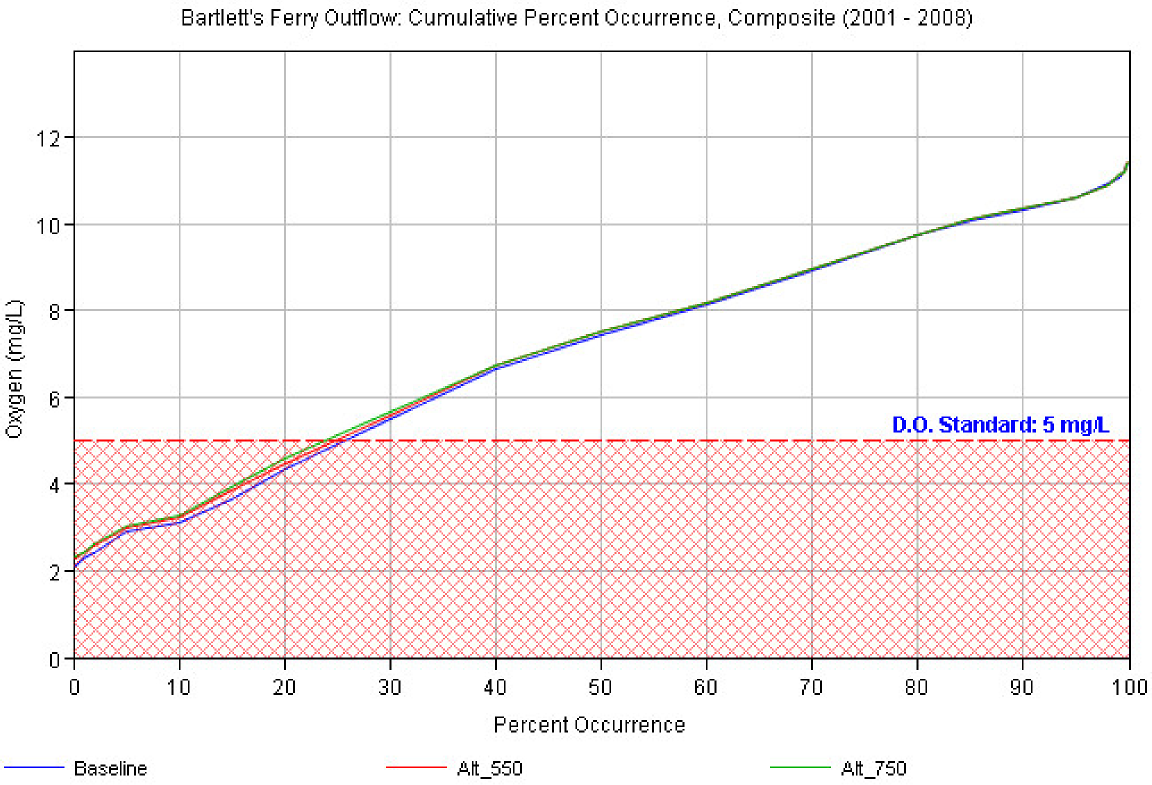


Figure 2.2-15. Dissolved Oxygen occurrence downstream of Barlett's Ferry Dam for the modeled period (2001 - 2008).

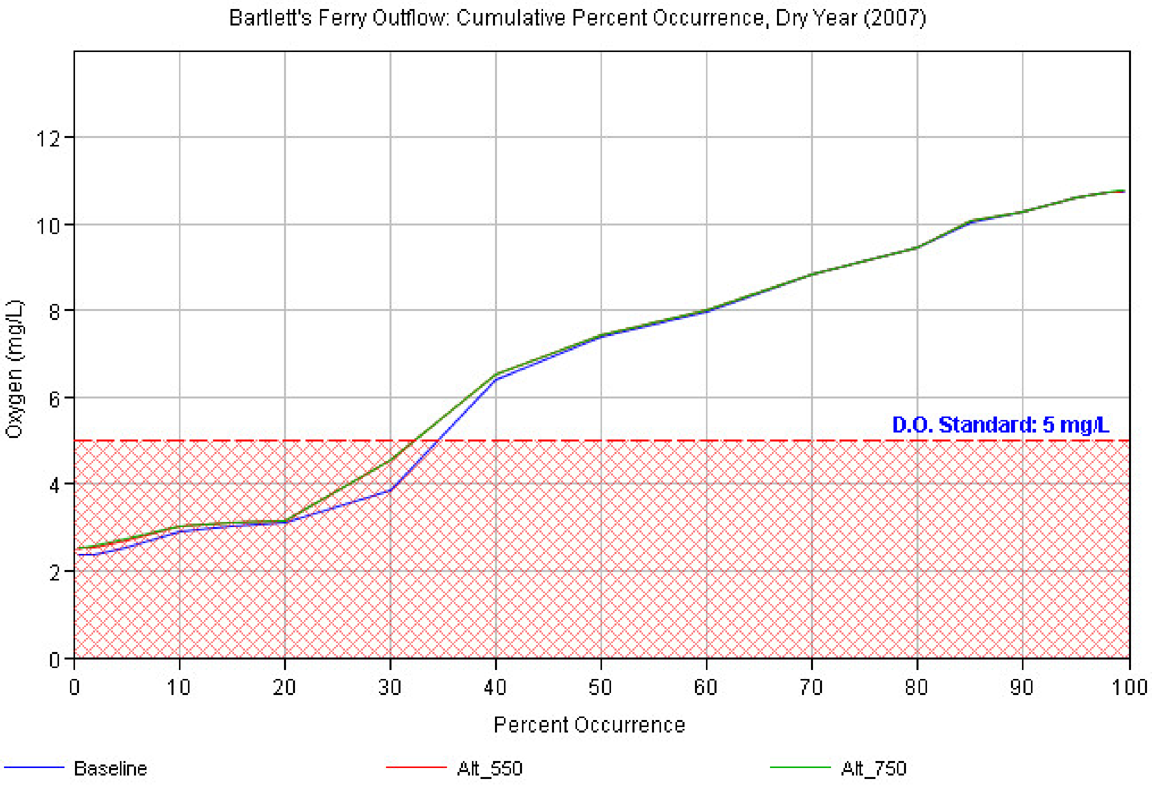


Figure 2.2-16. Dissolved Oxygen occurrence downstream of Barlett's Ferry Dam for a representative dry year (2007).

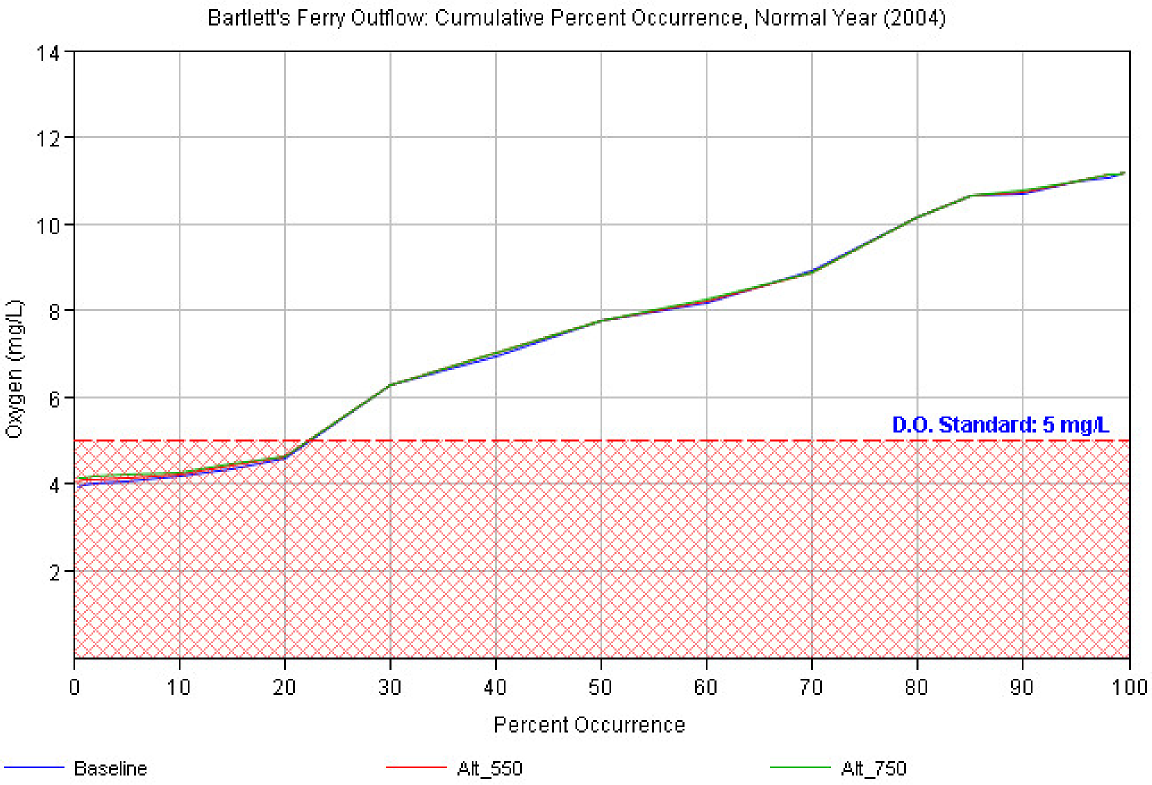


Figure 2.2-17. Dissolved Oxygen occurrence downstream of Barlett's Ferry Dam for a representative normal year (2004).

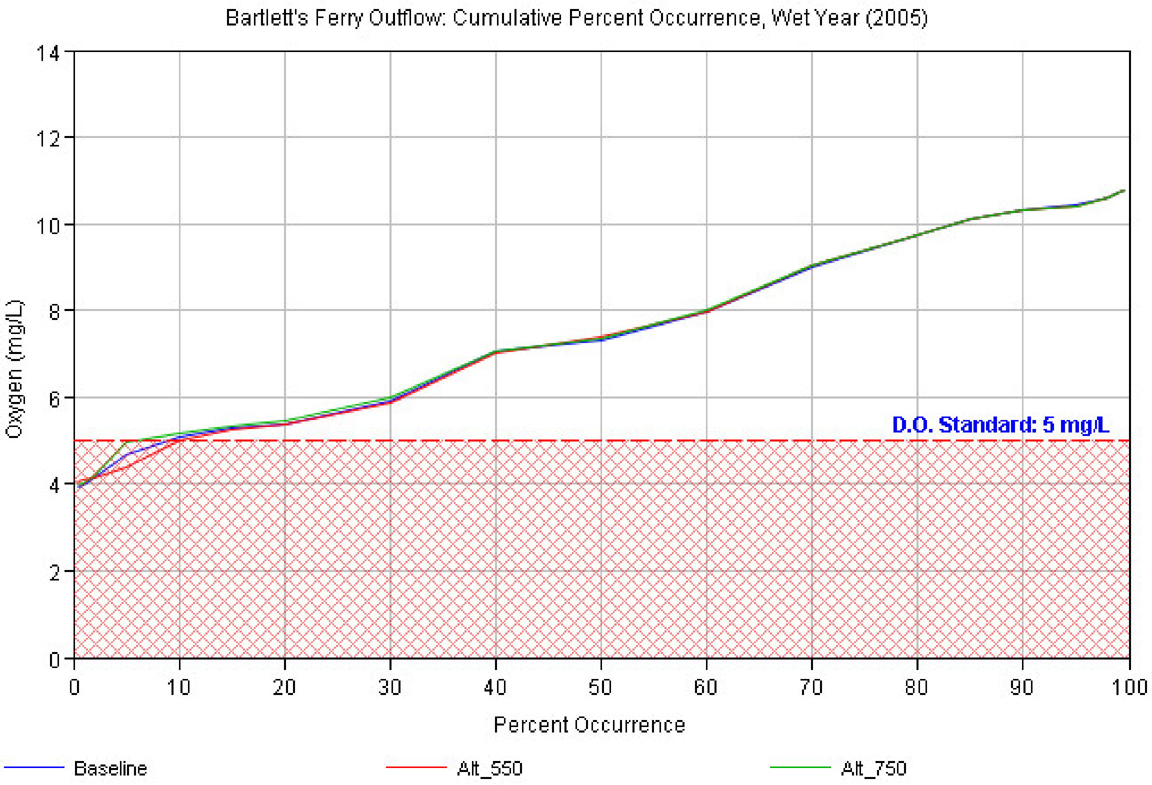


Figure 2.2-18. Dissolved Oxygen occurrence downstream of Barlett's Ferry Dam for a representative wet year (2005).

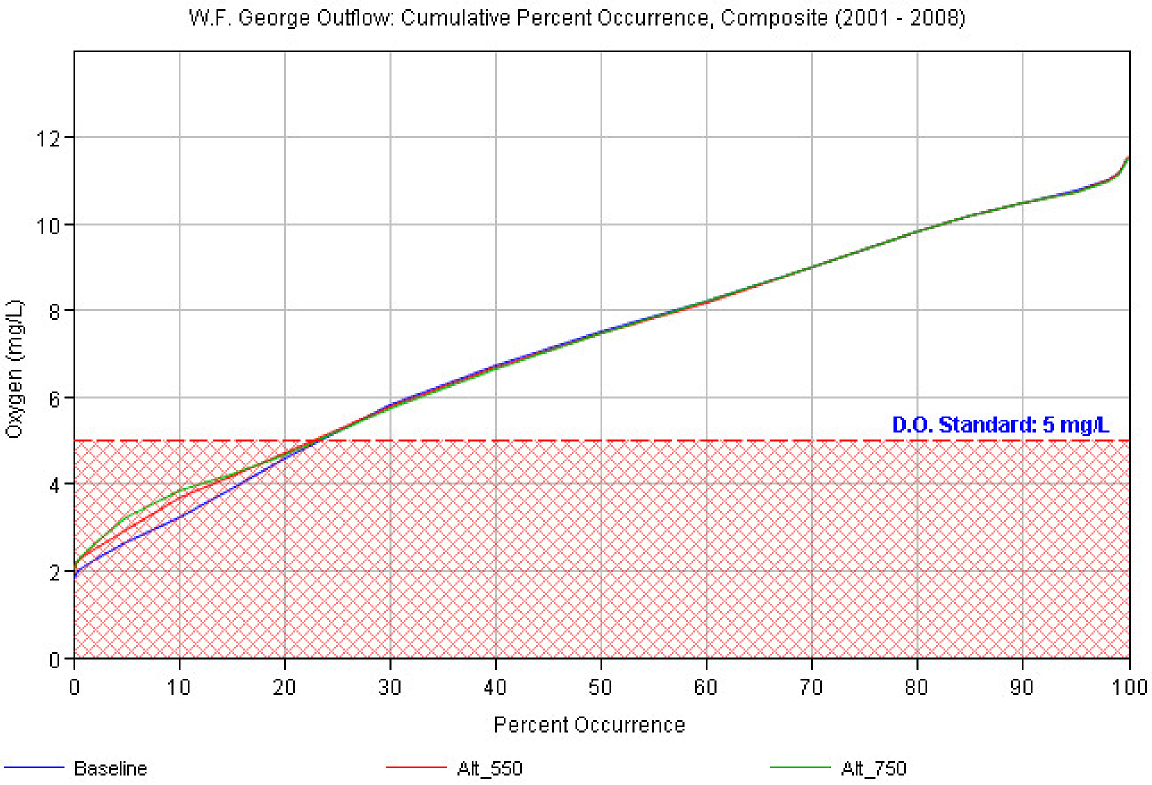


Figure 2.2-19. Dissolved Oxygen occurrence downstream of Walter F. George Dam for the modeled period (2001-2008).

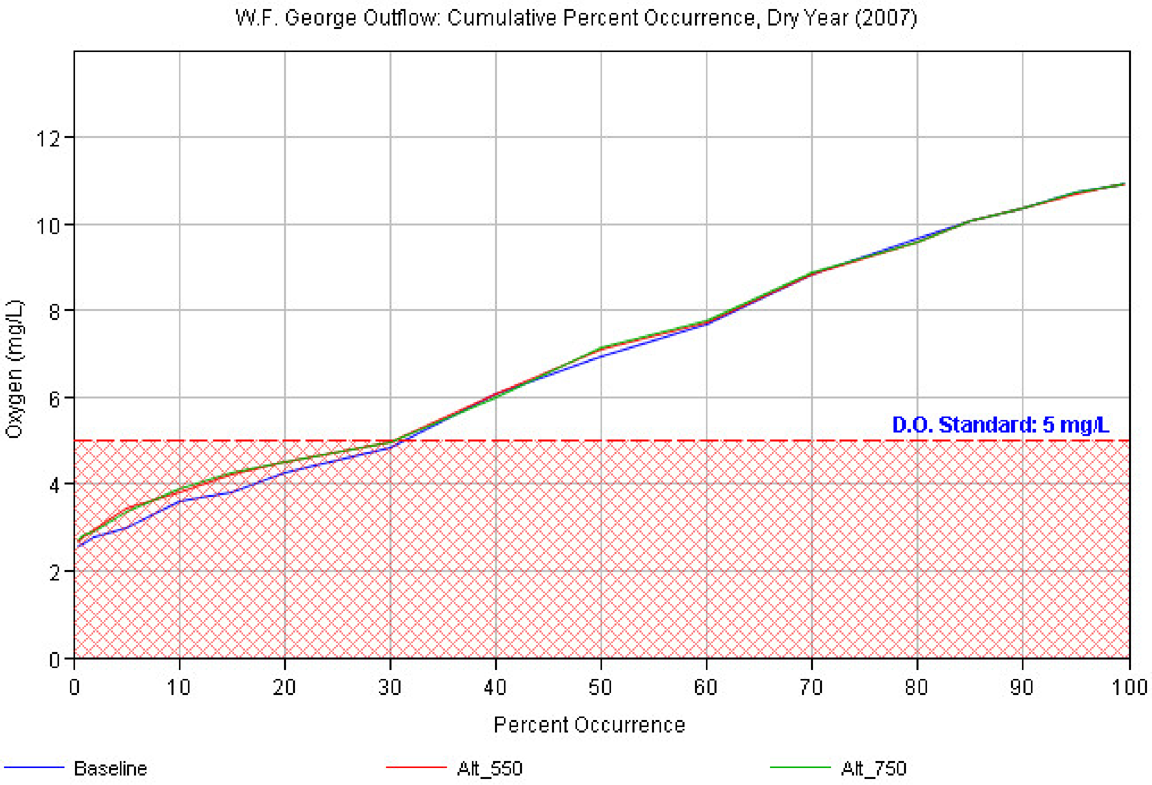


Figure 2.2-20. Dissolved Oxygen occurrence downstream of Walter F. George Dam for a representative dry year (2007).

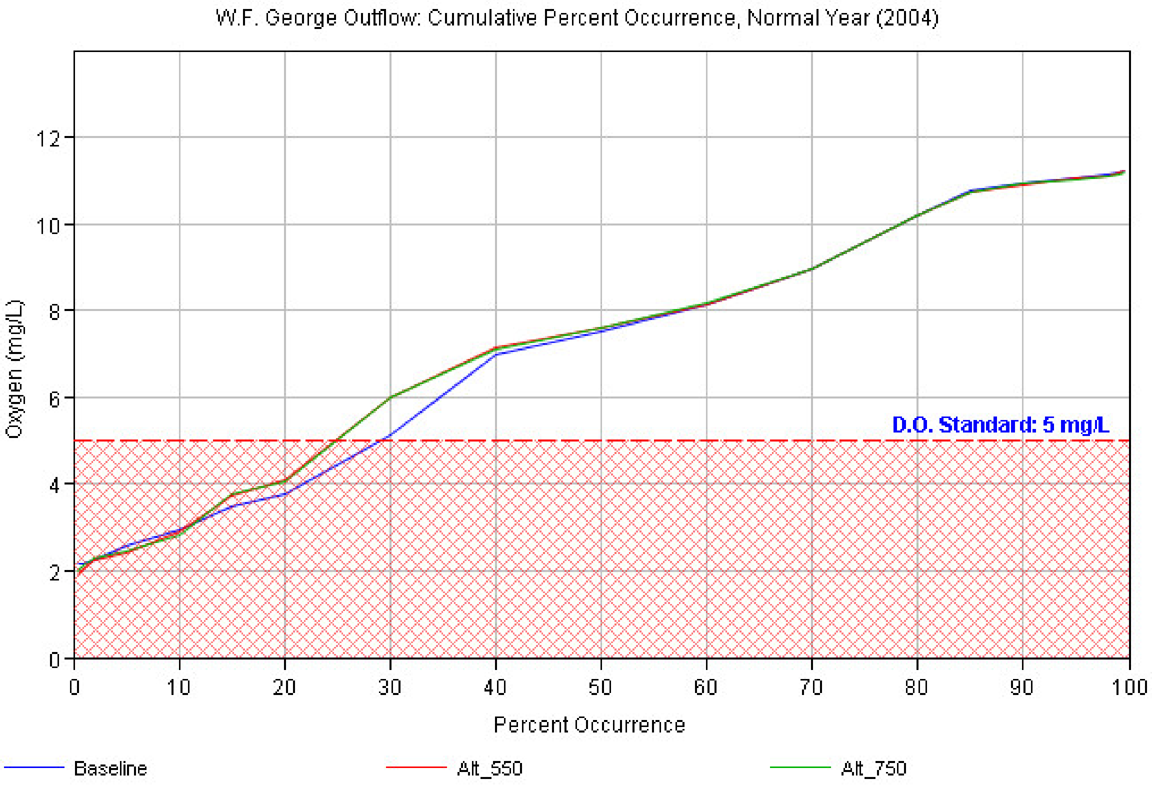


Figure 2.2-21. Dissolved Oxygen occurrence downstream of Walter F. George Dam for a representative normal year (2004).

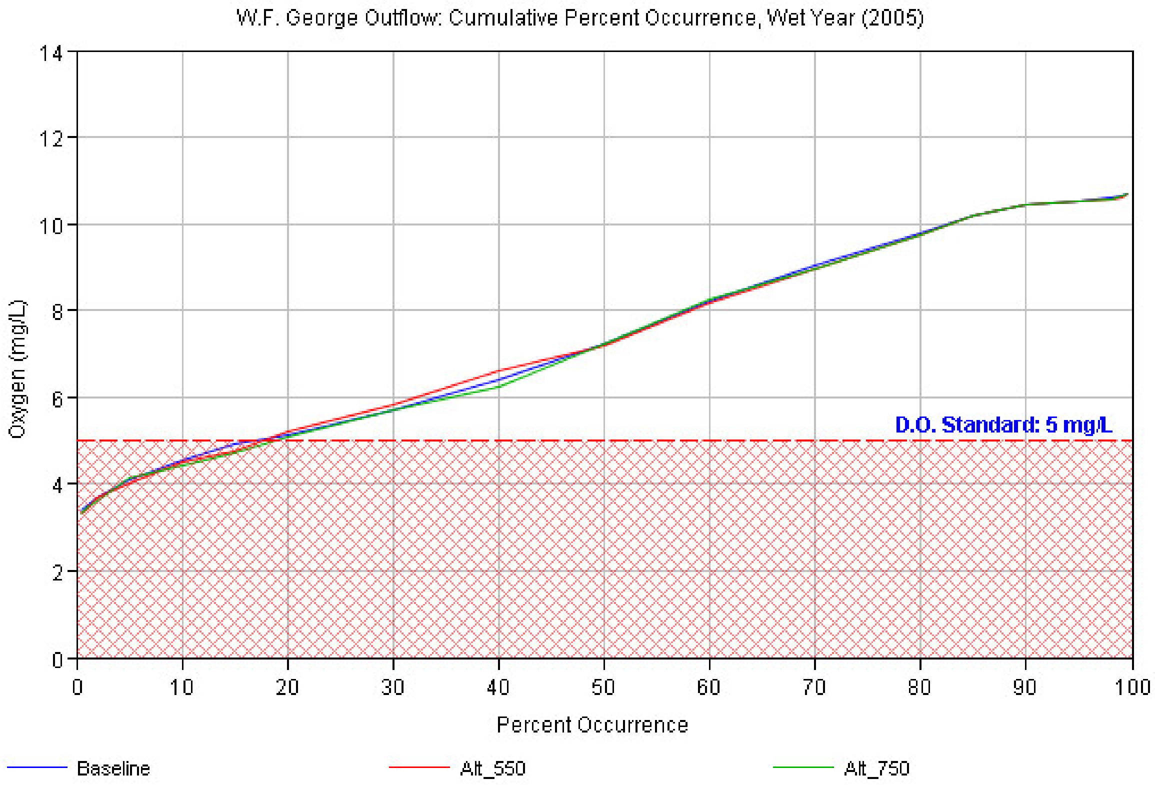


Figure 2.2-21. Dissolved Oxygen occurrence downstream of Walter F. George Dam for a representative wet year (2005).

- Total number of instantaneous “measurements” less than 4 mg/L.

Instantaneous modeled results were not simulated. The river profile simulations suggest that DO values less than 4 mg/L are only expected at several tailrace locations (as illustrated in Figures 2.2-6 through 2.2-21). Time series plots for these locations are also provided below in Figures 2.2-22 through 2.2- 25. Despite low concentrations of dissolved oxygen in dam tailraces, the Proposed Action Alternative generally increases concentrations over the No Action Alternative as illustrated in Figures 2.2-6 through 2.2-21. The exception to this is in periods of wet weather in scenario 1 (Figure 2.2-13), where minimum flows are decreased at Peachtree Creek to 550 cfs but the load transported downstream is not changed. In this scenario concentrations of oxygen consuming pollutants are greater. It may be representative to look at conditions under scenario 2 during wet weather periods. It would be expected that a minimum flow of 750 cfs could be easily achieved at Peachtree Creek during wet weather periods. If instream flows are greater, the concentrations of oxygen consuming pollutants would be more easily assimilated.

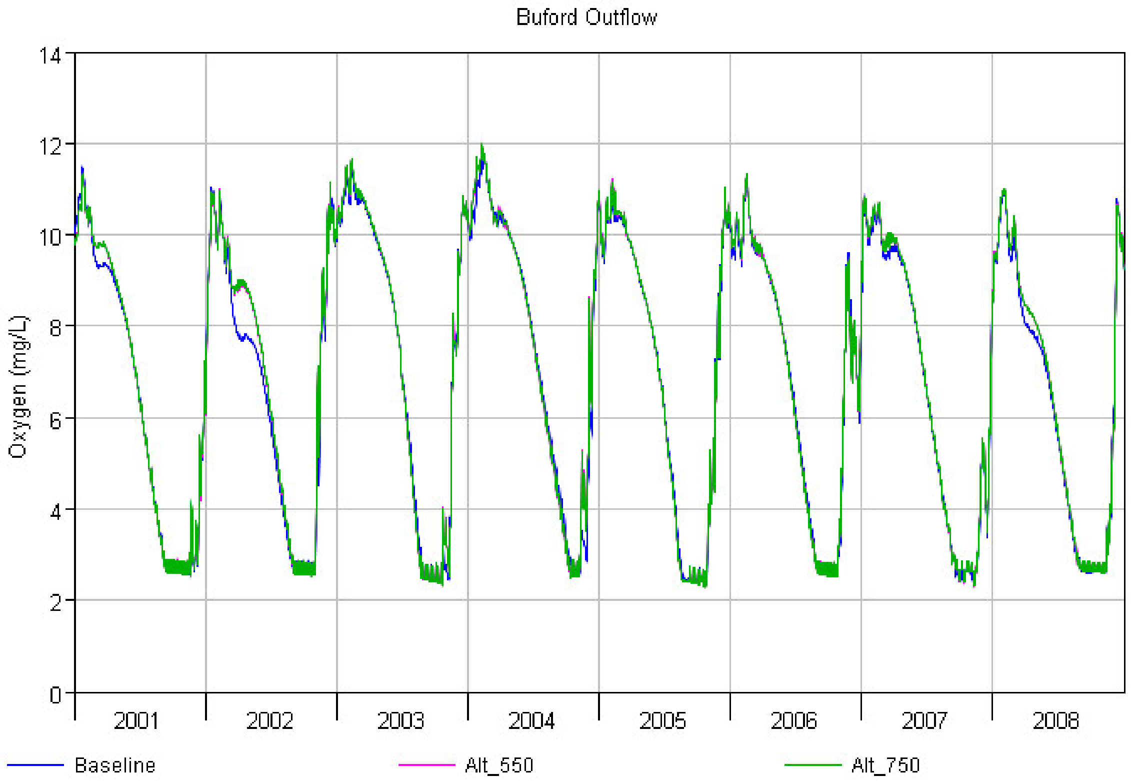


Figure 2.2-22. Time series DO from Buford Dam releases.

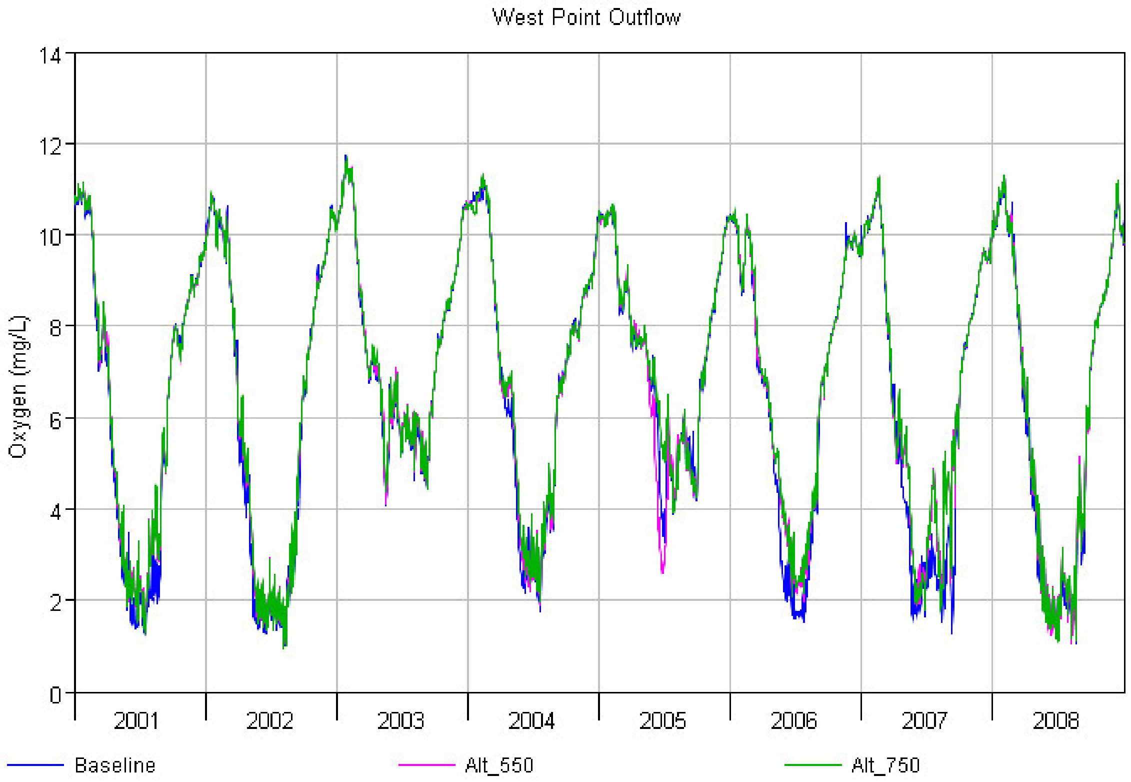


Figure 2.2-23. Time series DO from West Point Dam releases.

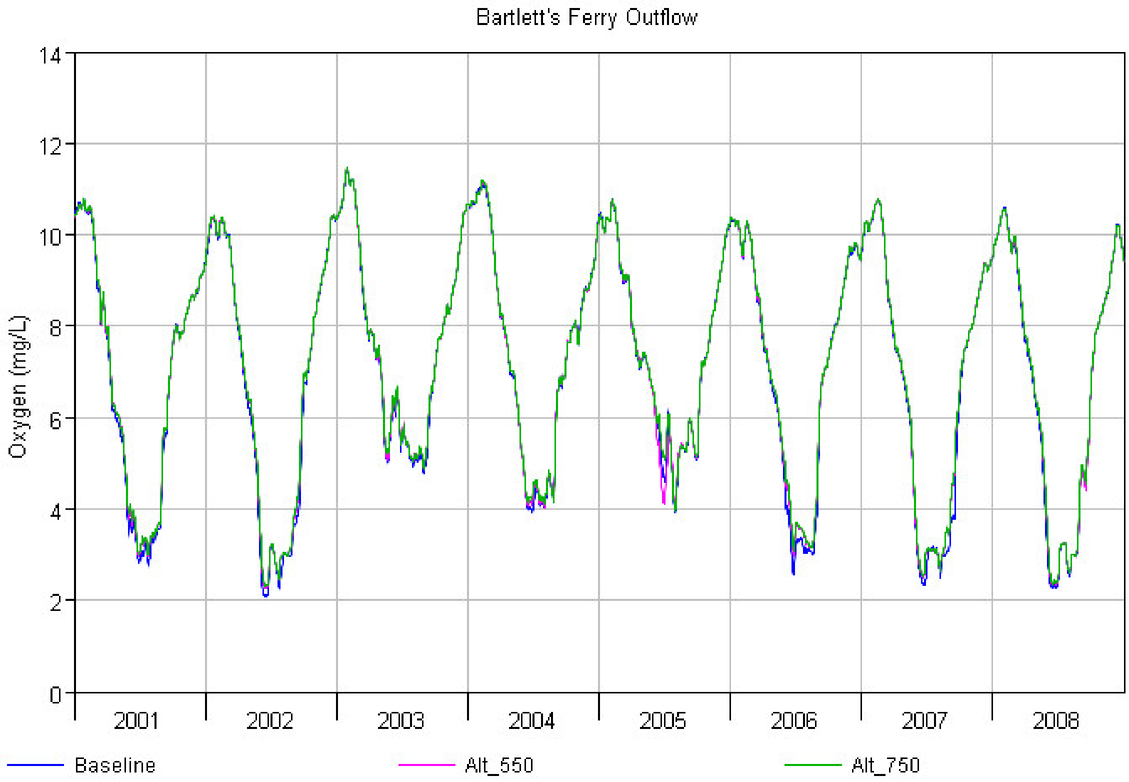


Figure 2.2-24. Time series DO from Bartlett's Ferry Dam releases.

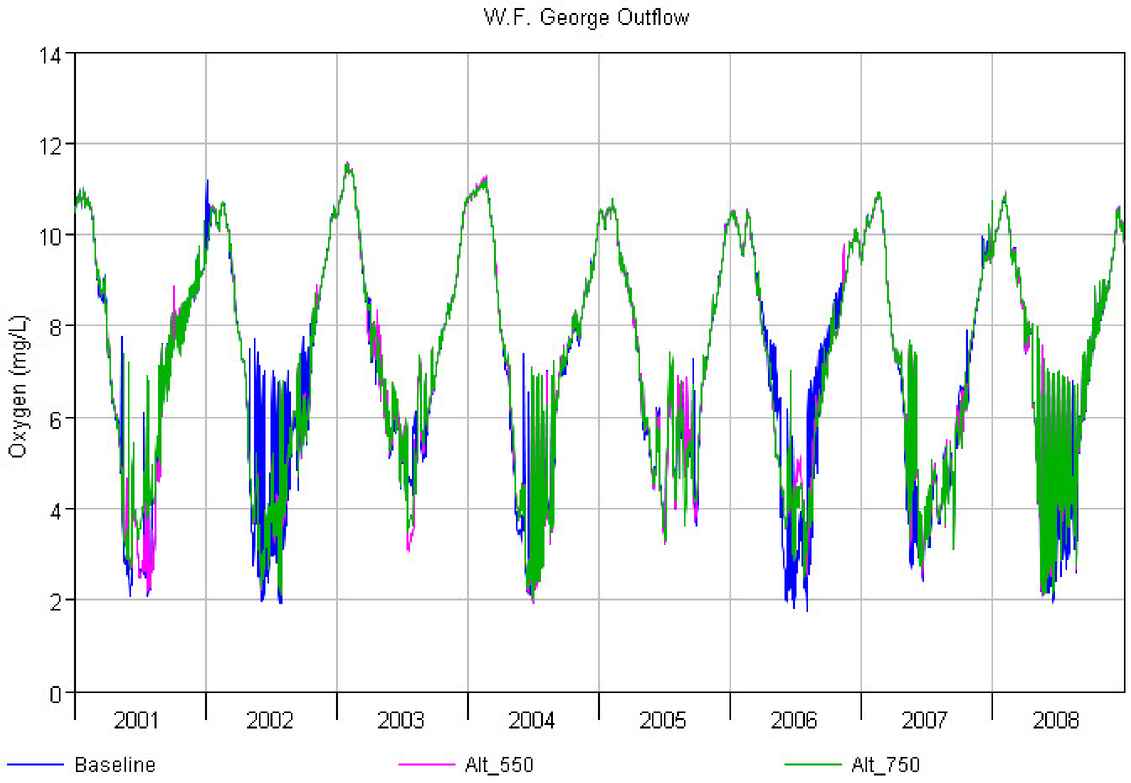


Figure 2.2-25. Time series DO from Walter F. George Dam releases.

- Monthly exceedance figures and box plots with outliers for dissolved oxygen (mg/L).

Monthly exceedance figures for dissolved oxygen were not generated. However, the following figure generally provides the same information in a format we feel is easier to communicate. Figure 2.2-26 illustrates the change in dissolved oxygen values between the No Action Alternative and the Proposed Action (Proposed Action minus No Action is illustrated) at the 5%, 50%, and 95% occurrence intervals. For these DO plots, the 95% occurrence interval means that the values are this number or lower 95% of the simulation at this location (i.e., only 5% of the time the value is higher than this – a rare occurrence). Conversely, the 5% occurrence interval means that the values are this number or lower 5% of the simulation at this location (i.e., 95% of the time the value is higher than this – this too is a rare occurrence). The 50% occurrence represents the average occurrence.

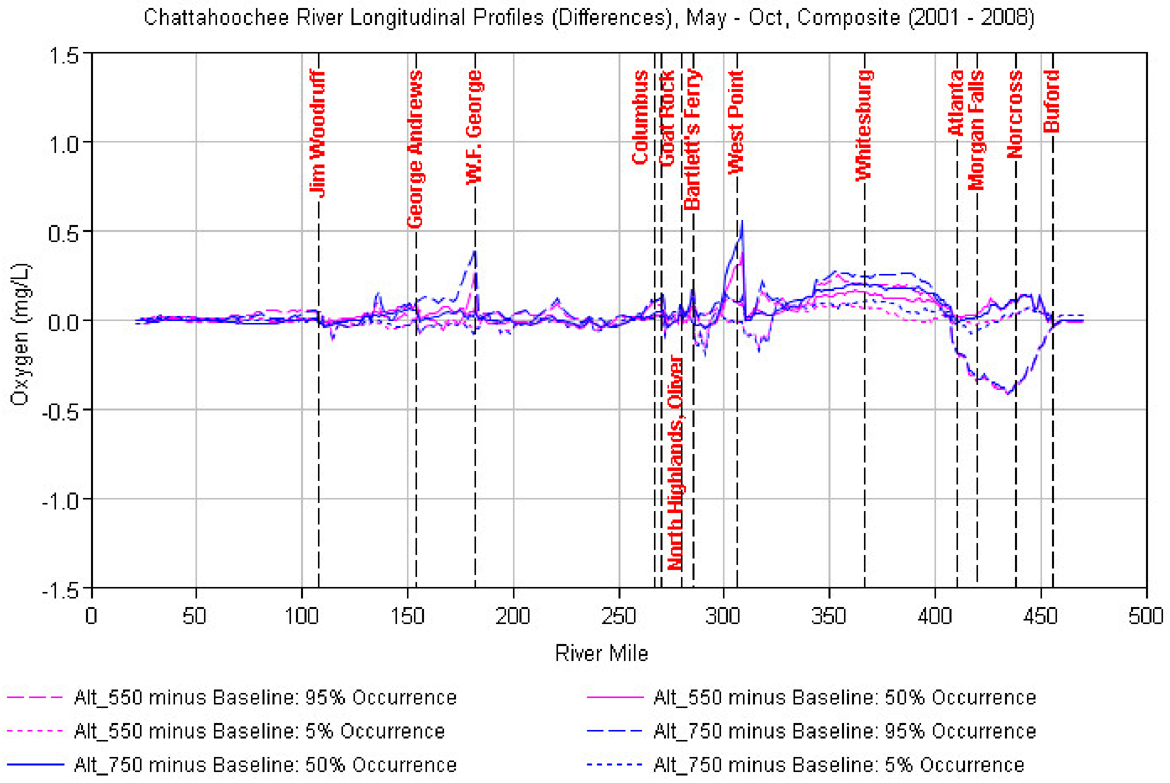


Figure 2.2-26. Changes in longitudinal dissolved oxygen in the Chattahoochee River for a May through October growing season (2001 through 2008).

2.2.2 Water Temperature

- Monthly exceedance figures and box plots with outliers for water temperature; and

Monthly exceedance figures for temperature were not generated. Again, river profiles and occurrence plots illustrated this information more clearly than the box plots. The figures to follow first illustrate temperatures along the riverine profile and then illustrate the change in temperature from the No Action Alternative. (Proposed Action minus No Action is illustrated). The delta profile plots clearly illustrate the magnitude of the change in water temperature of each of the scenarios as compared to the No Action Alternative (baseline condition) illustrated in the plots.

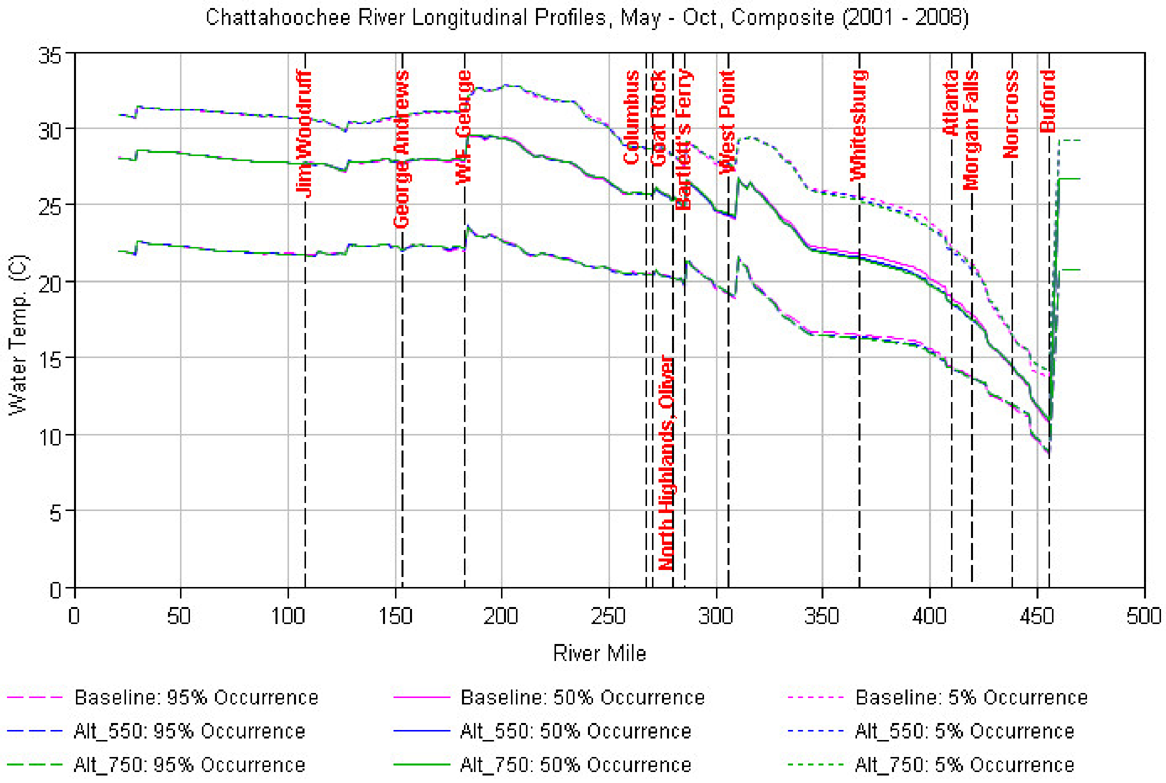


Figure 2.2-26. Temperatures along the Chattahoochee River for the modeled period (2001-2008).

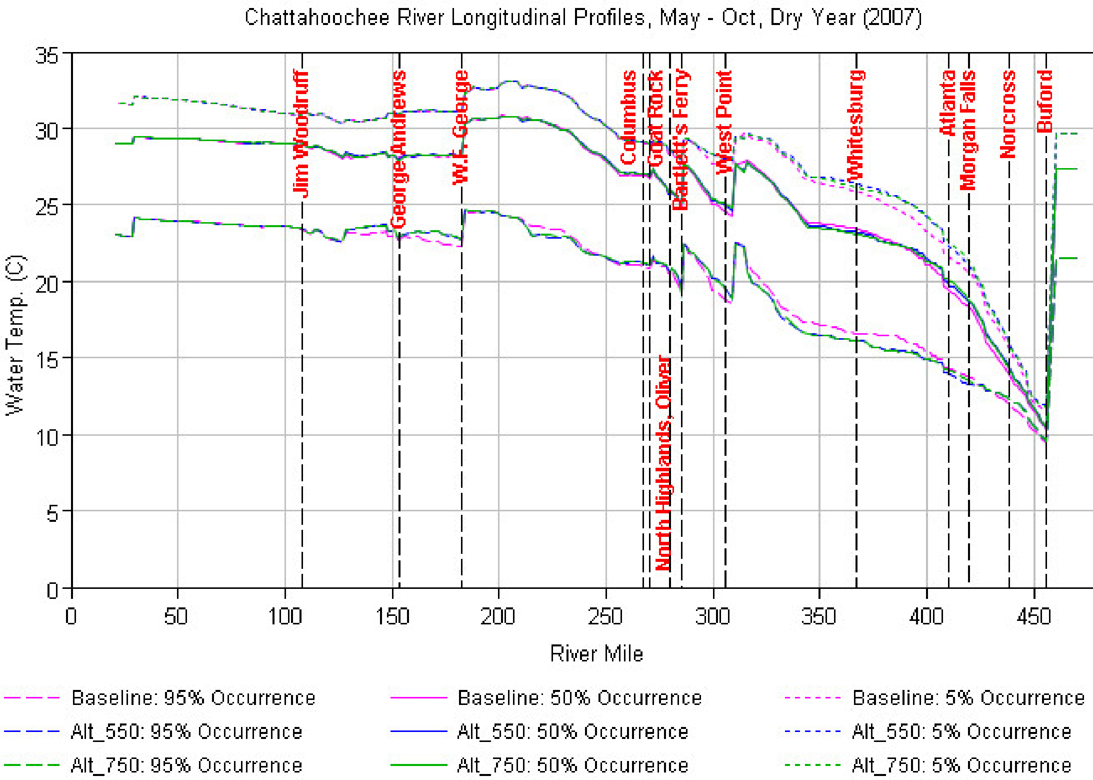


Figure 2.2-27. Temperatures along the Chattahoochee River for a representative dry year (2007).

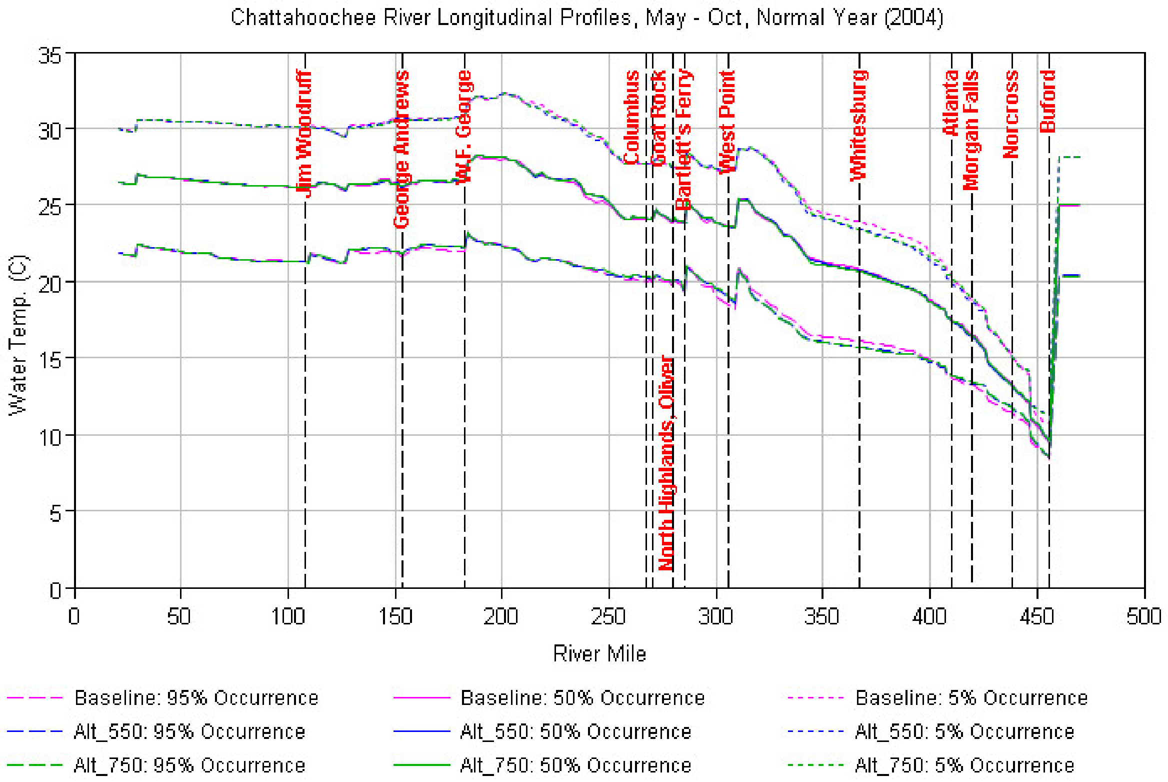


Figure 2.2-28. Temperatures along the Chattahoochee River for a representative normal year (2004).

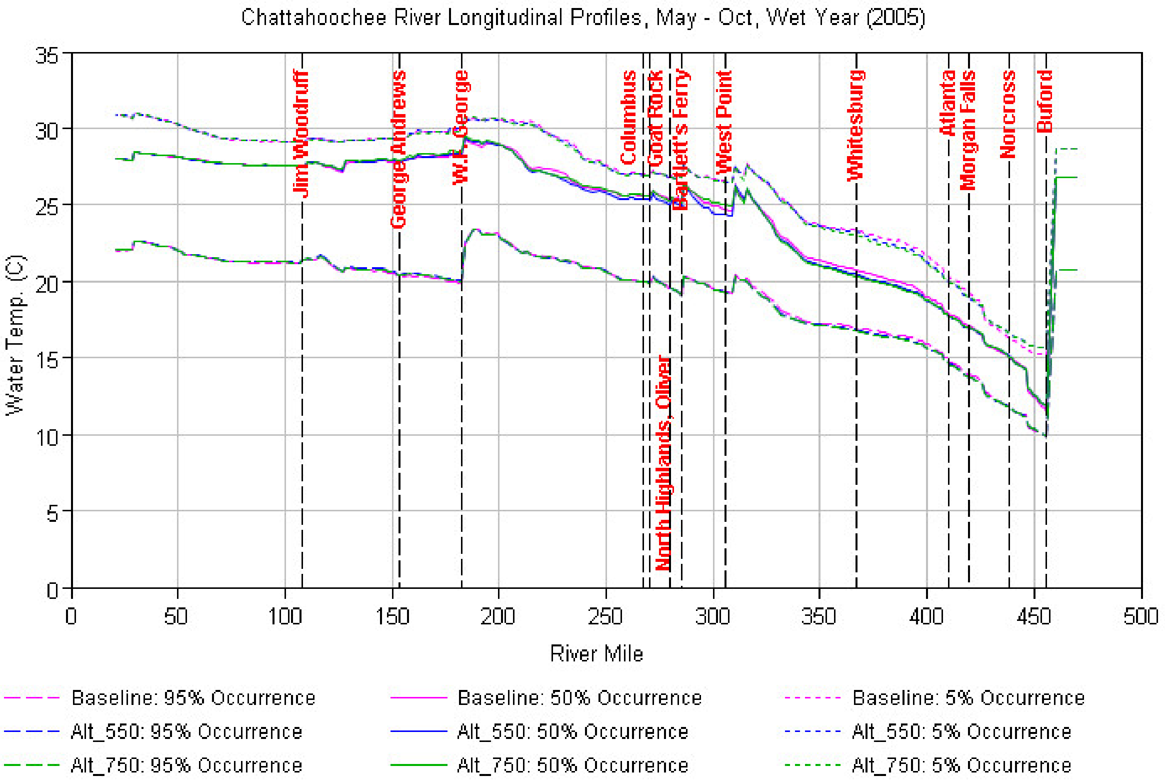


Figure 2.2-29. Temperatures along the Chattahoochee River for a representative wet year (2005).

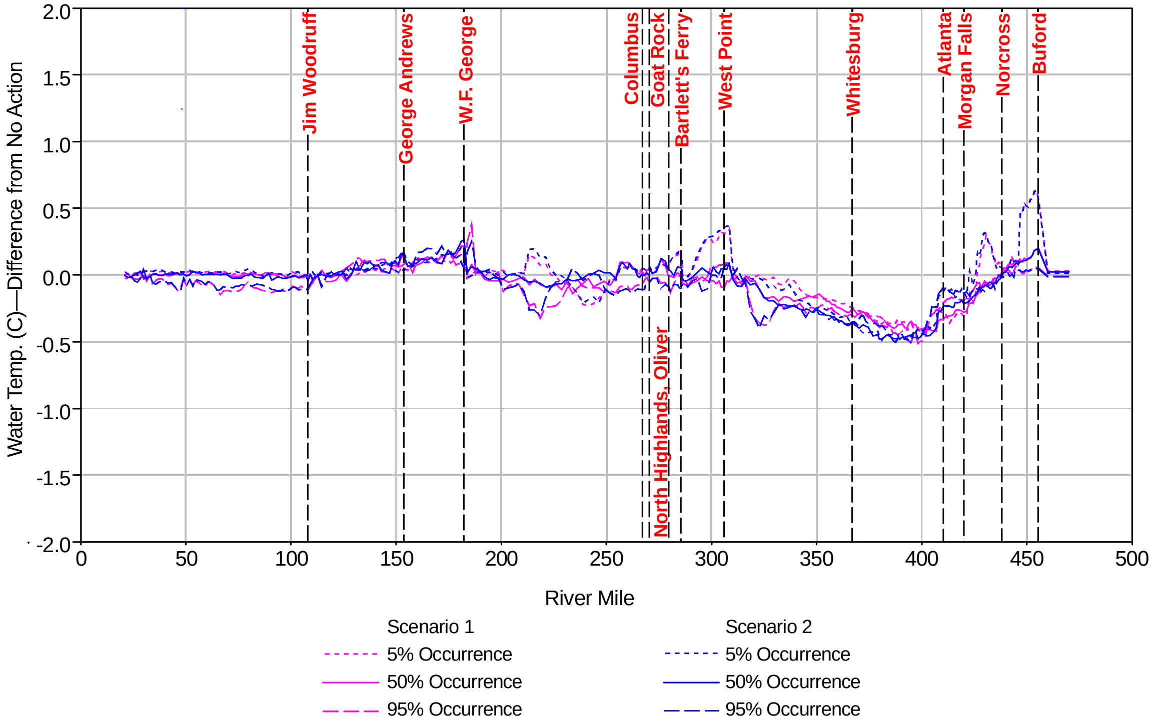


Figure 2.2-30. Changes in longitudinal water temperature in the Chattahoochee River for an April through October growing season representing hydrologic conditions from 2001 through 2008.

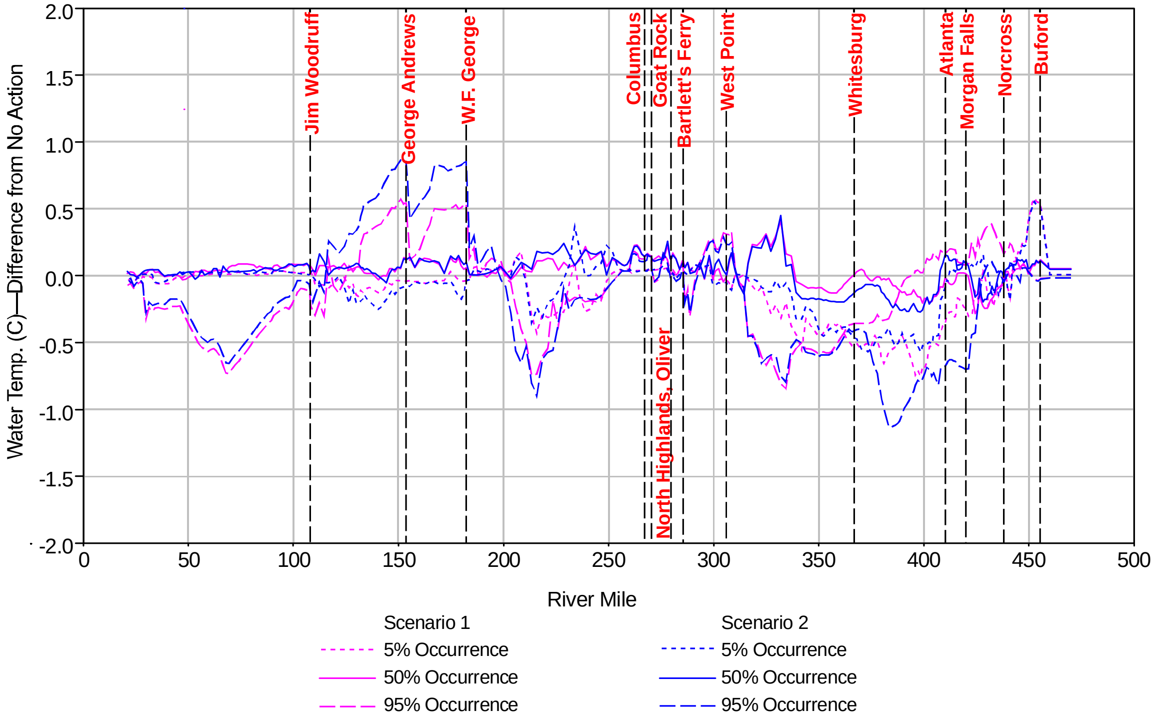


Figure 2.2-31. Changes in longitudinal water temperature in the Chattahoochee River for an April through October growing season representing hydrologic conditions in a normal year (2004).

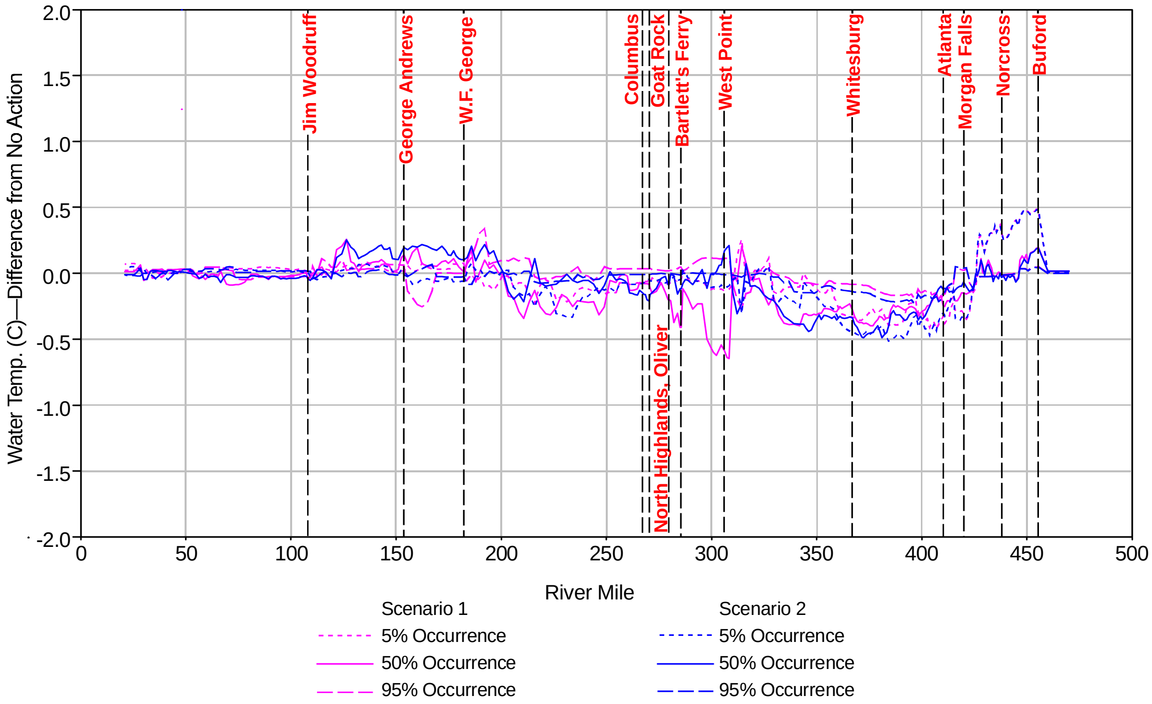


Figure 2.2-32. Changes in longitudinal water temperature in the Chattahoochee River for an April through October growing season representing hydrologic conditions in a wet year (2005).

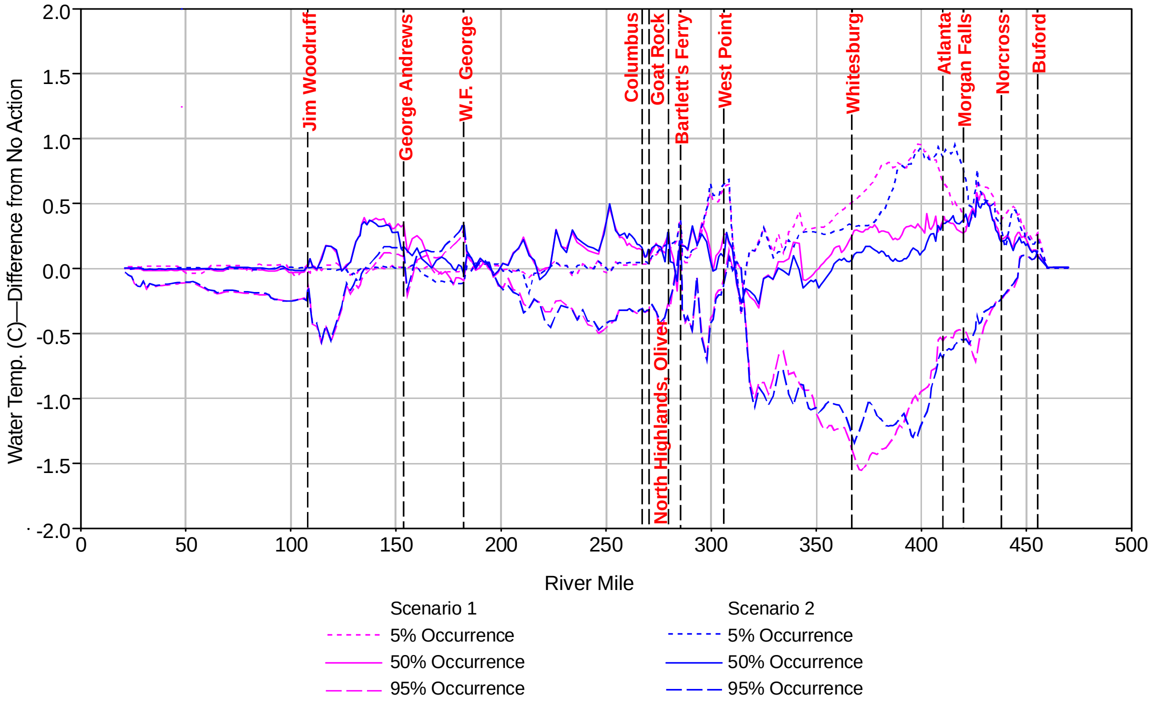


Figure 2.2-33. Changes in longitudinal water temperature in the Chattahoochee River for an April through October growing season representing hydrologic conditions in a dry year (2007).

2.2.3 Wastewater

- Average stream percent wastewater.

Average stream flow percent that is wastewater is presented for May through October in the figures to follow; these figures also present the 5% and 95% occurrences. These results were also output by April through October, as presented in other water quality figures.

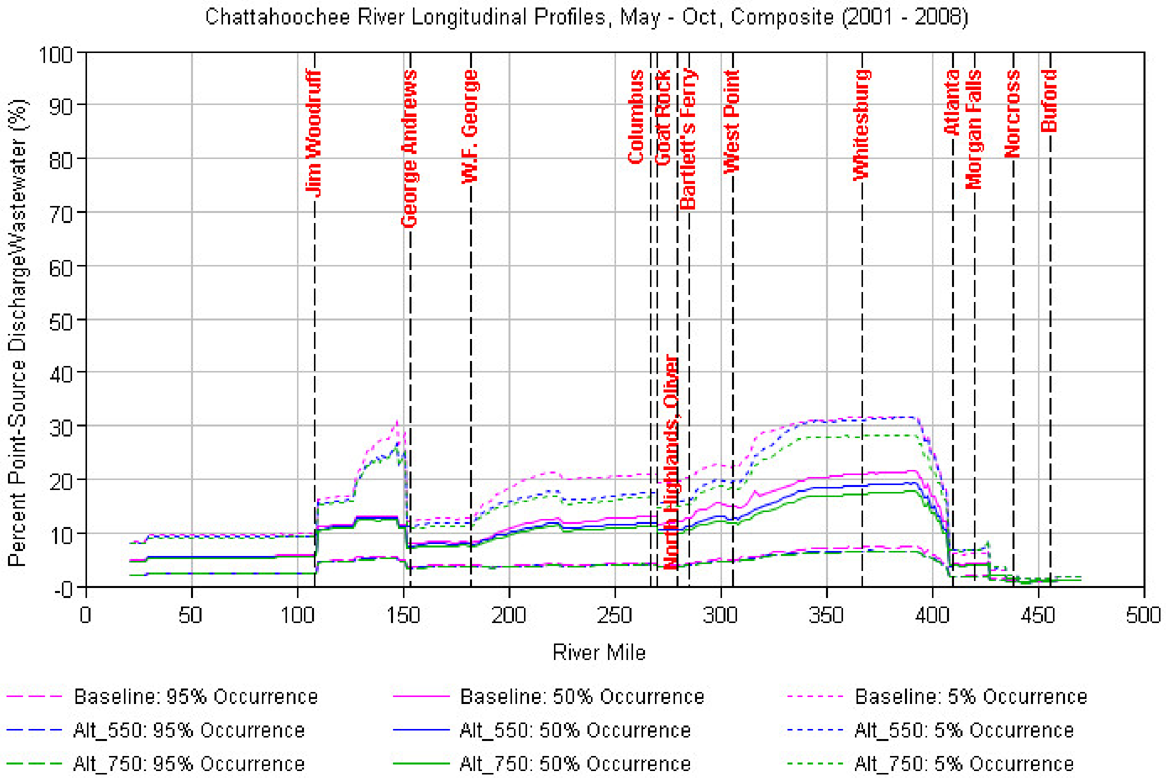


Figure 2.2-34. Percent of total flow that is wastewater along the Chattahoochee River for May through October of the modeled period (2001-2008).

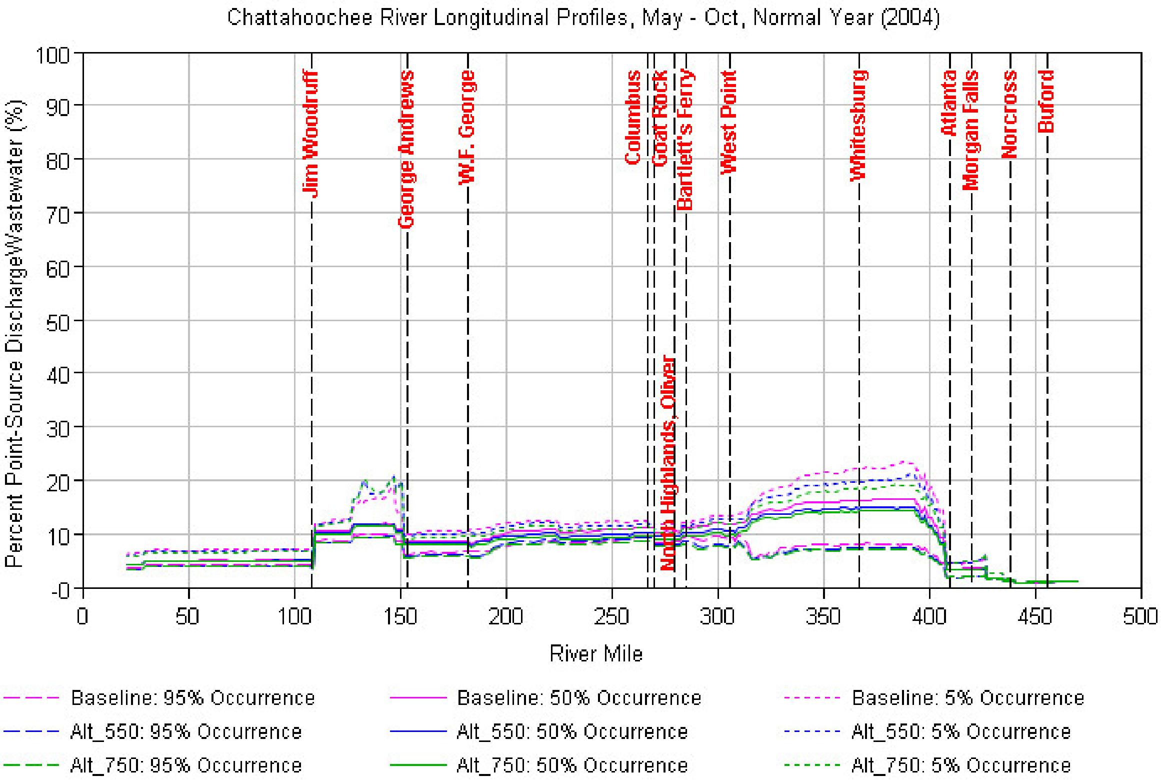


Figure 2.2-35. Percent of total flow that is wastewater along the Chattahoochee River for May through October in a representative normal year (2004).

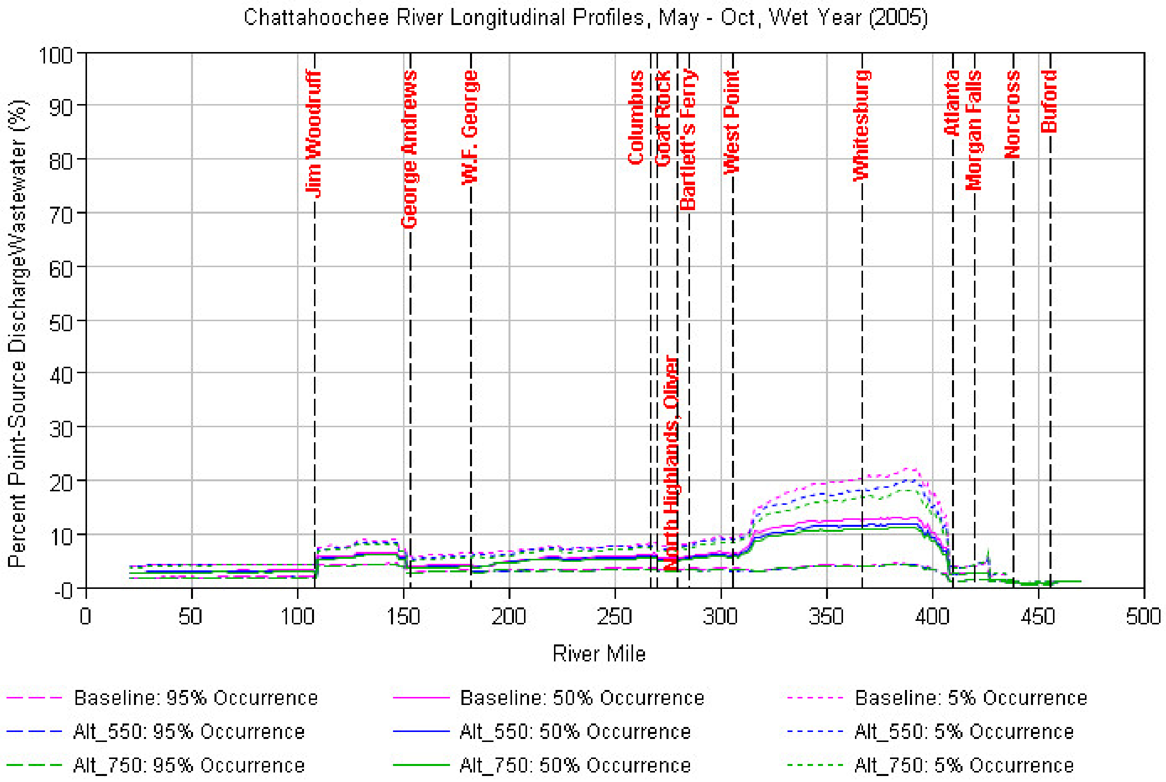


Figure 2.2-36. Percent of total flow that is wastewater along the Chattahoochee River for May through October in a representative wet year (2005).

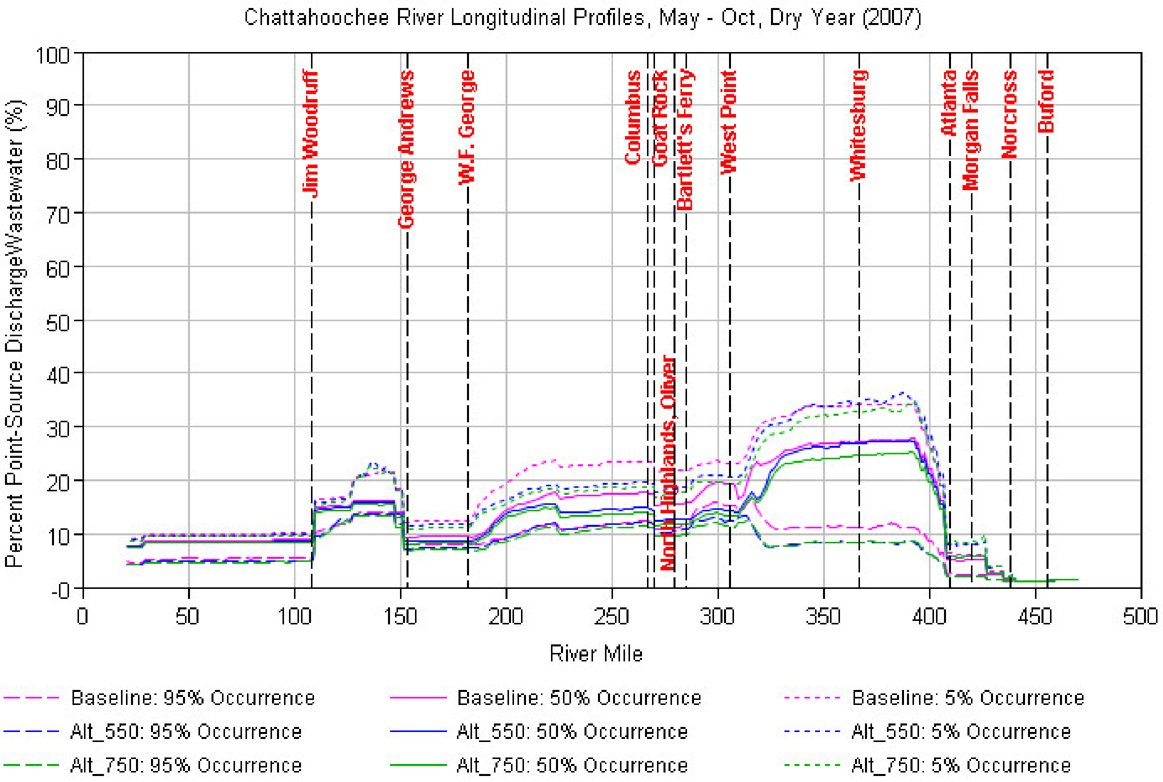


Figure 2.2-37. Percent of total flow that is wastewater along the Chattahoochee River for May through October in a representative dry year (2007).

2.2.4 Chlorophyll a

- Average values of summer Chlorophyll a (*u*g/L)

Chlorophyll a in various rainfall conditions is presented for the system in the figures to follow. Figures are also provided that present areas in the system where the greatest changes would be expected. The greatest changes would be expected in West Point Lake and Walter F. George in extreme conditions.

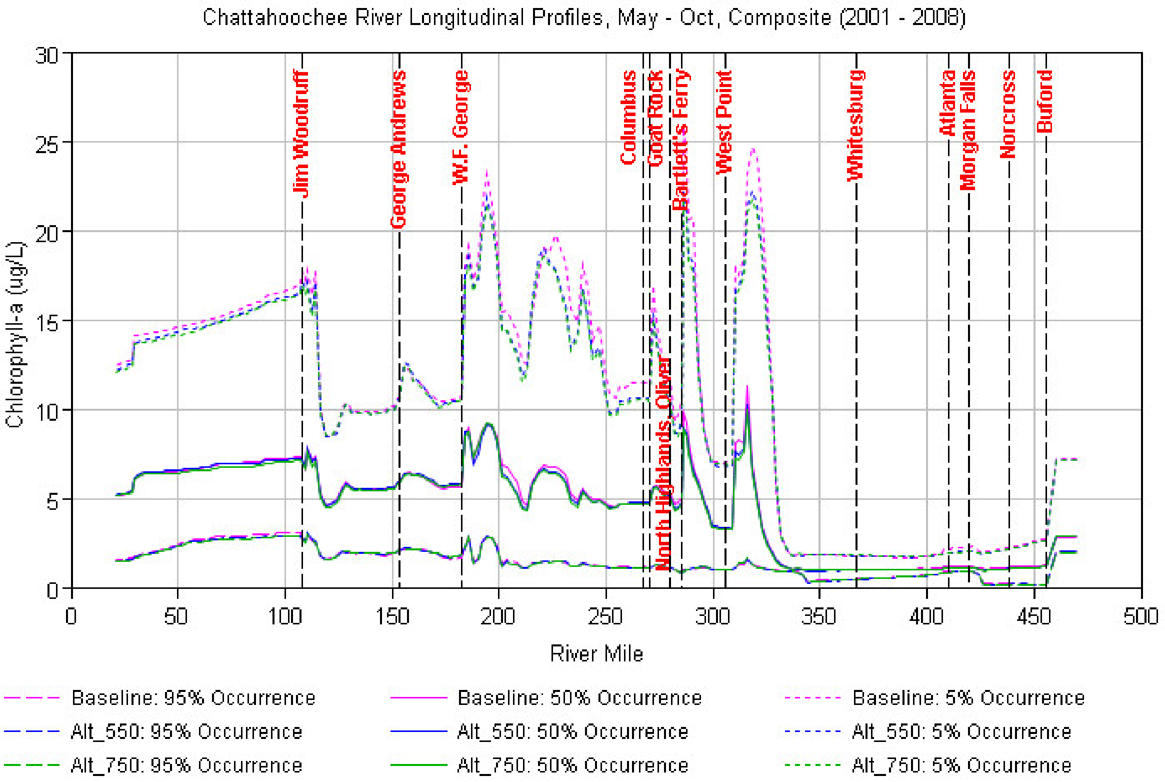


Figure 2.2-38. Chlorophyll *a* along the Chattahoochee River for May through October of the modeled period (2001-2008).

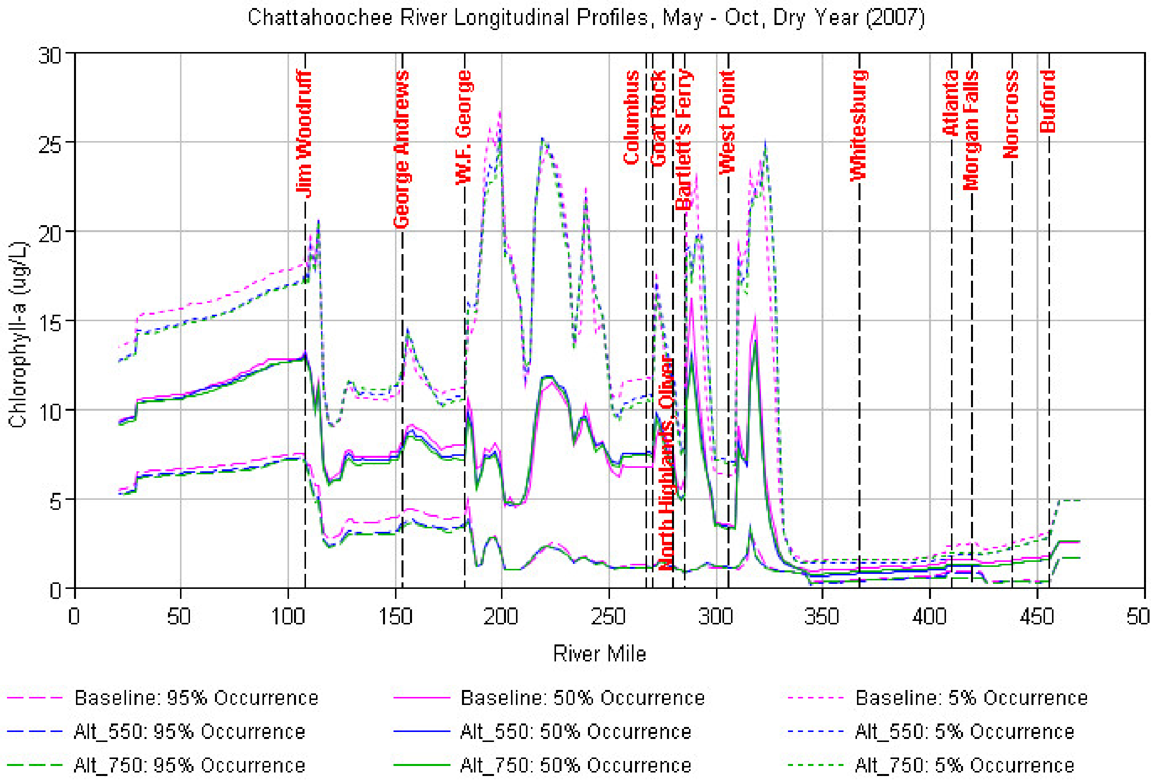


Figure 2.2-39. Chlorophyll *a* along the Chattahoochee River for May through October in a representative dry year (2007).

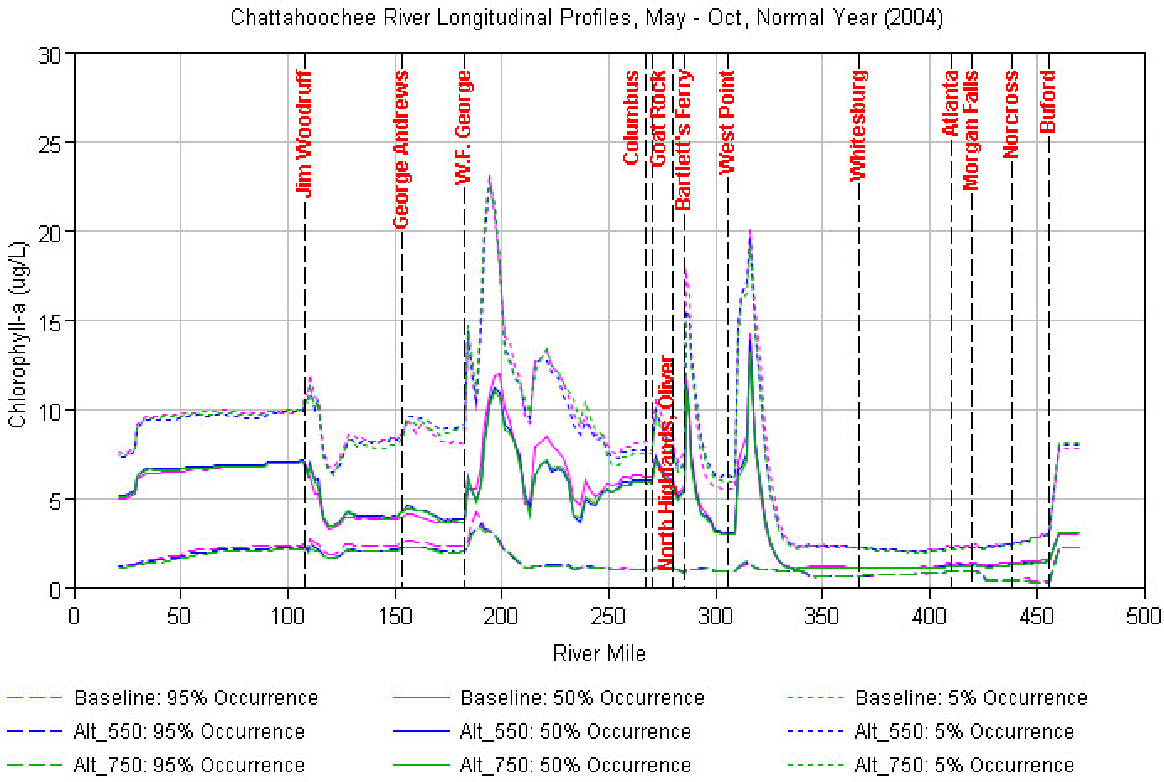


Figure 2.2-40. Chlorophyll *a* along the Chattahoochee River for May through October in a representative normal year (2004).

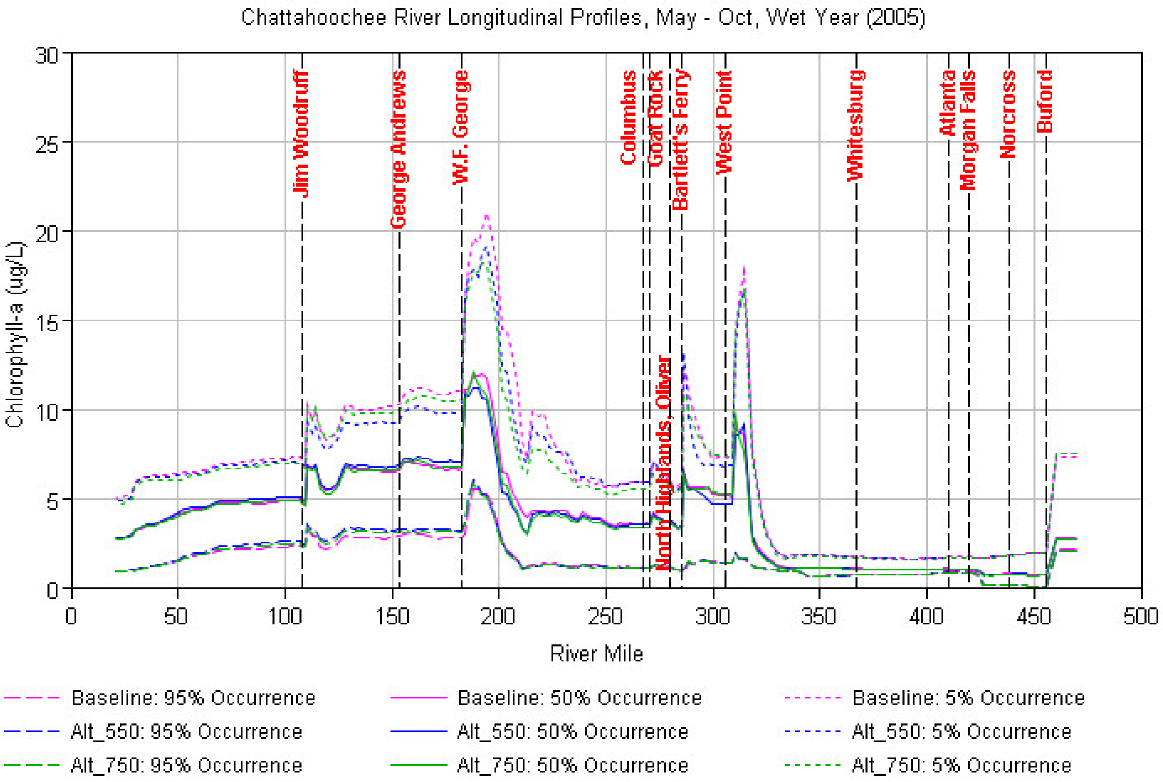


Figure 2.2-41. Chlorophyll *a* along the Chattahoochee River for May through October in a representative wet year (2005).

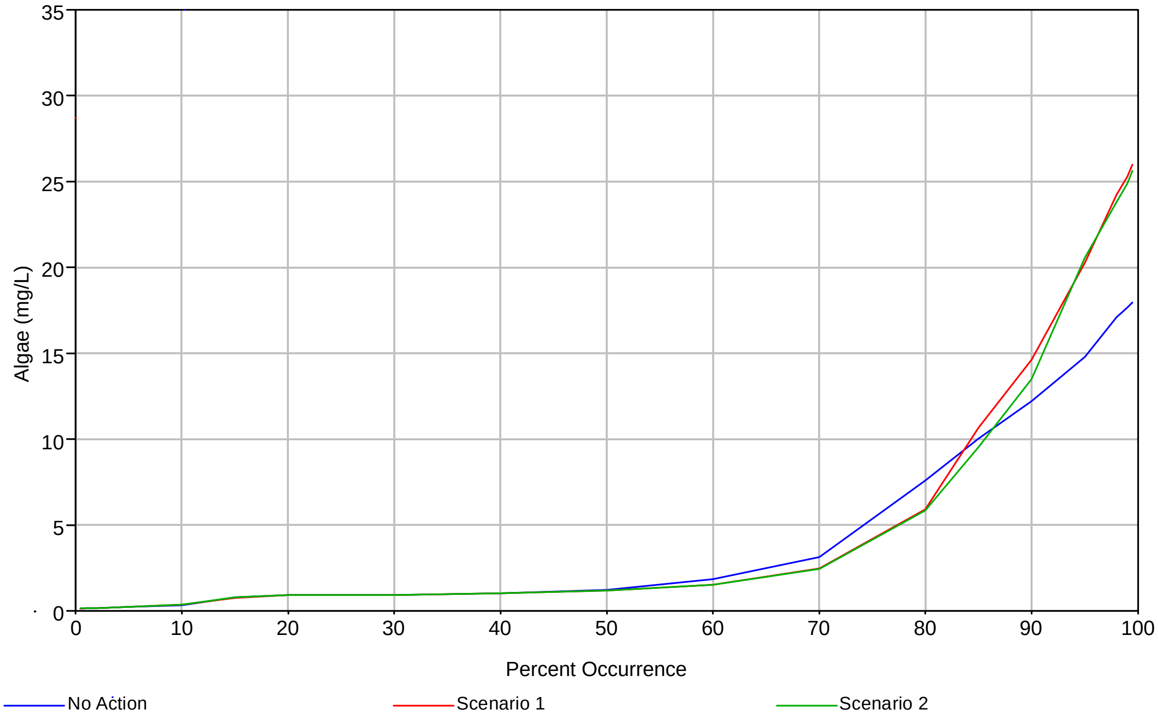


Figure 2.2-42 Occurrence of daily average chlorophyll *a* in a mid-reservoir location of West Point Lake for a representative dry year (2007).

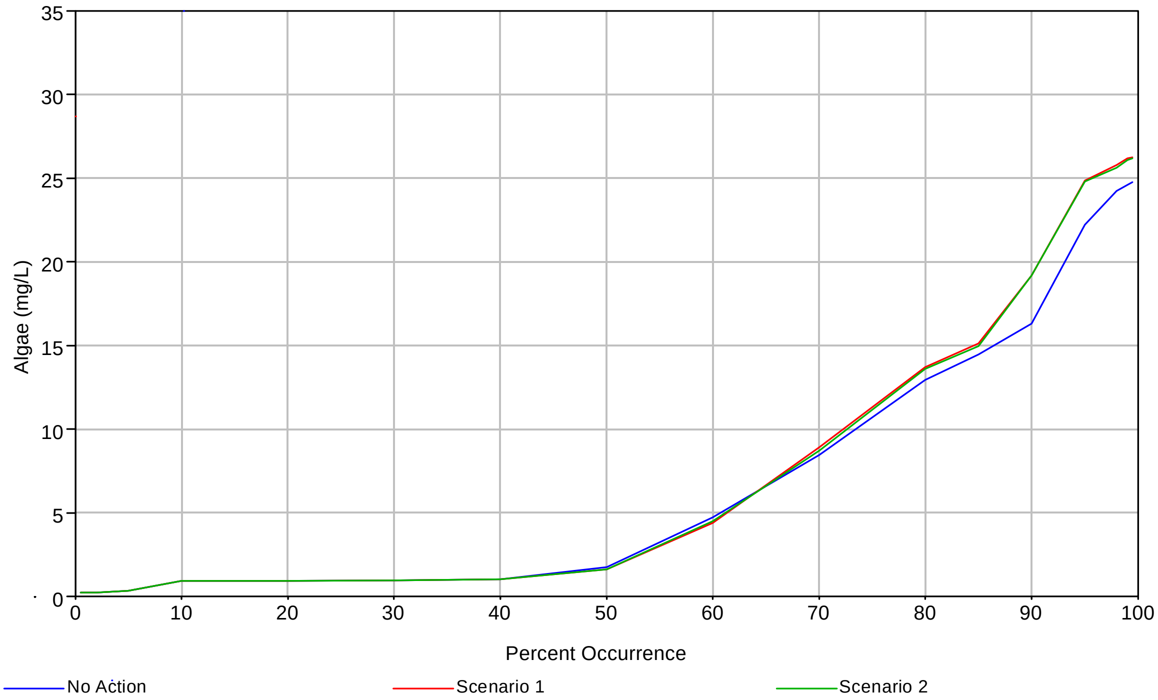


Figure 2.2-43. Occurrence of daily average chlorophyll *a* in a mid-reservoir location of Walter F. George Lake for a representative dry year (2007).

2.2.5 Retention

- Average summer retention time (days).

These results are not available at this time but will be requested for future delivery.

2.2.6 Phosphorus

- Average summer phosphorus loading (pounds/acre/month).

The analysis of phosphorus for the environmental consequences was done to compare changes in the Proposed Action Alternative from the No Action Alternative. Modeling was not conducted for total phosphorus; instead results are presented for ortho-phosphorus. Understanding that chlorophyll growth depends on inorganic phosphorus and that measured ortho-phosphorus was available for comparison, ortho-phosphorus is presented to understand how phosphorus responds to changes in water management. The organic fraction of phosphorus also decays before it can be assimilated in the water column. Delta plots were also created to compare the No Action and Proposed Action results.

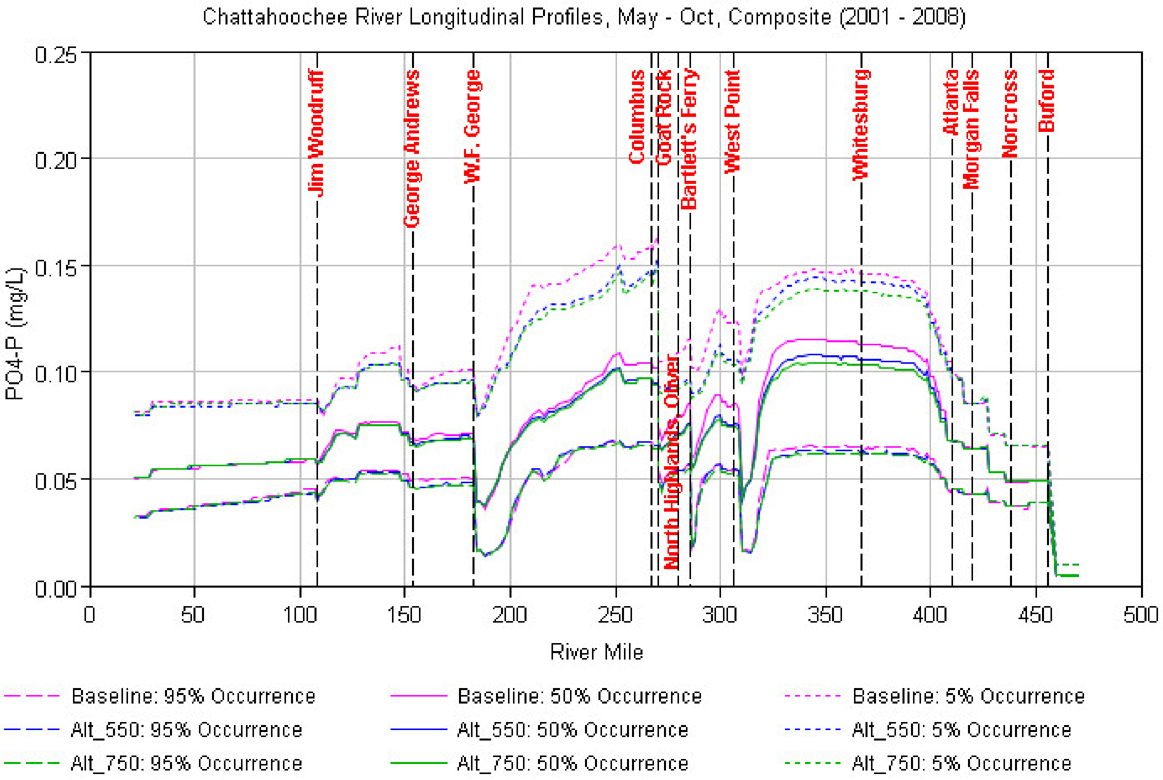


Figure 2.2-44. Ortho-phosphorus along the Chattahoochee River for May through October of the modeled period (2001-2008).

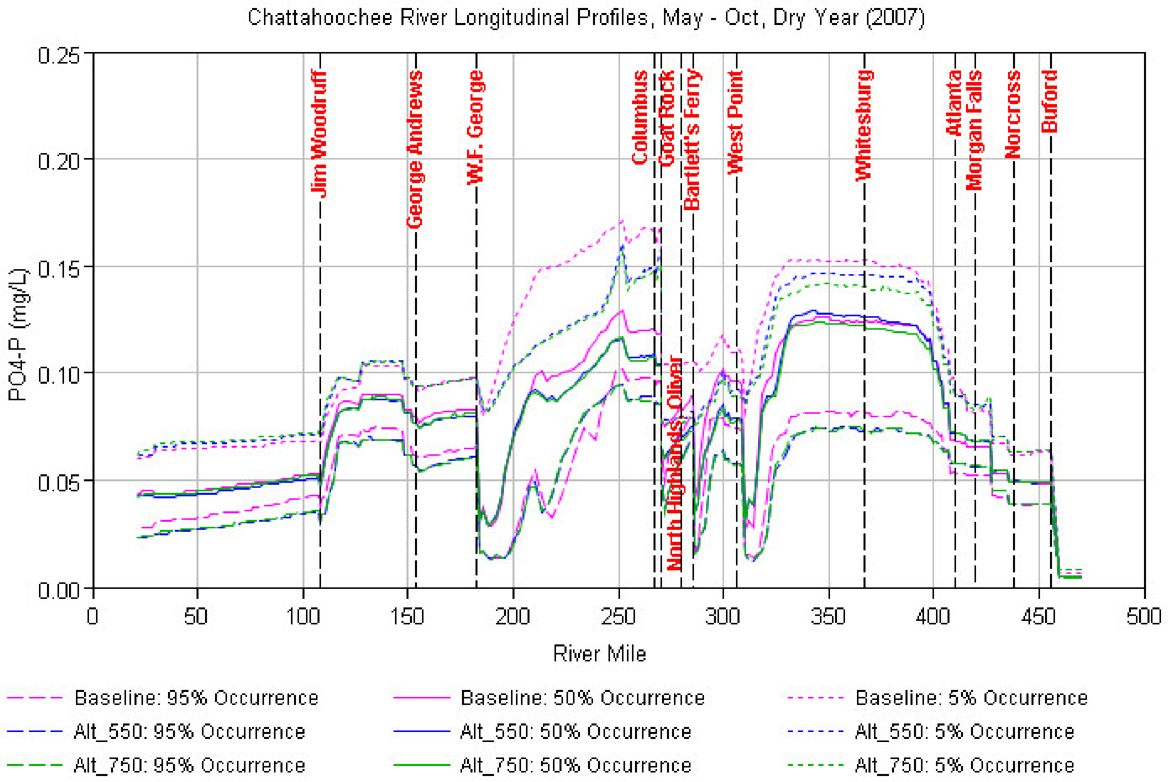


Figure 2.2-45. Ortho-phosphorus along the Chattahoochee River for May through October in a representative dry year (2007).

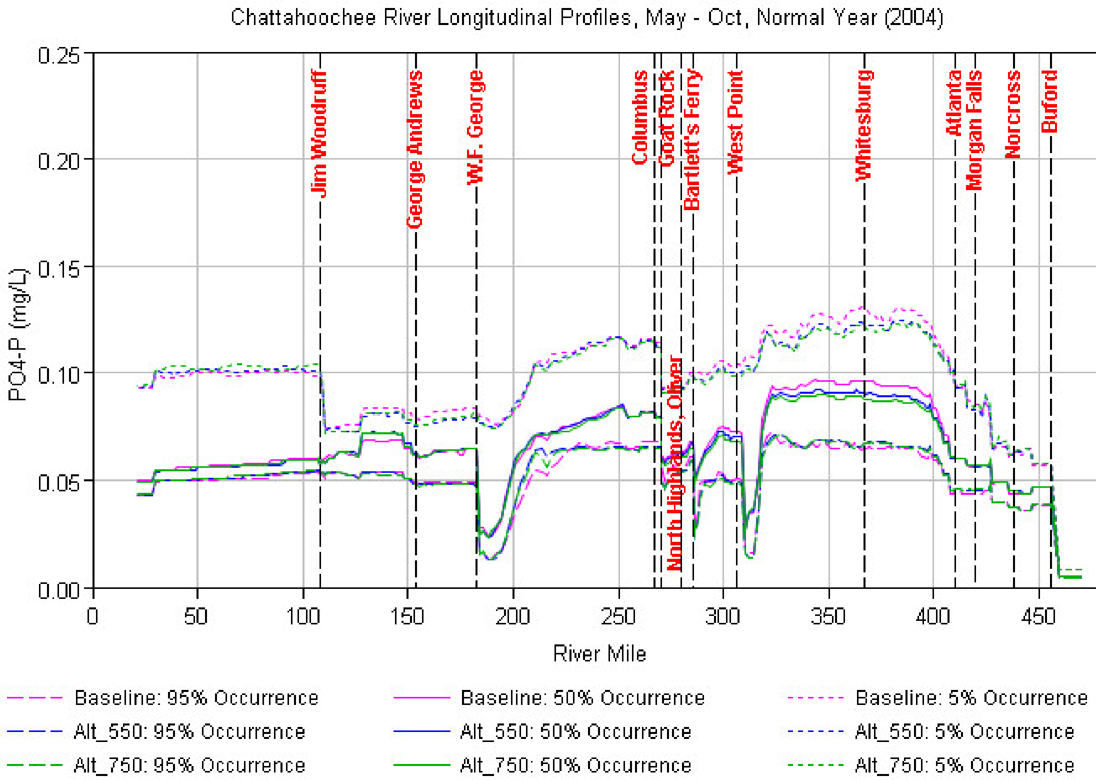


Figure 2.2-46. Ortho-phosphorus along the Chattahoochee River for May through October in a representative normal year (2004).

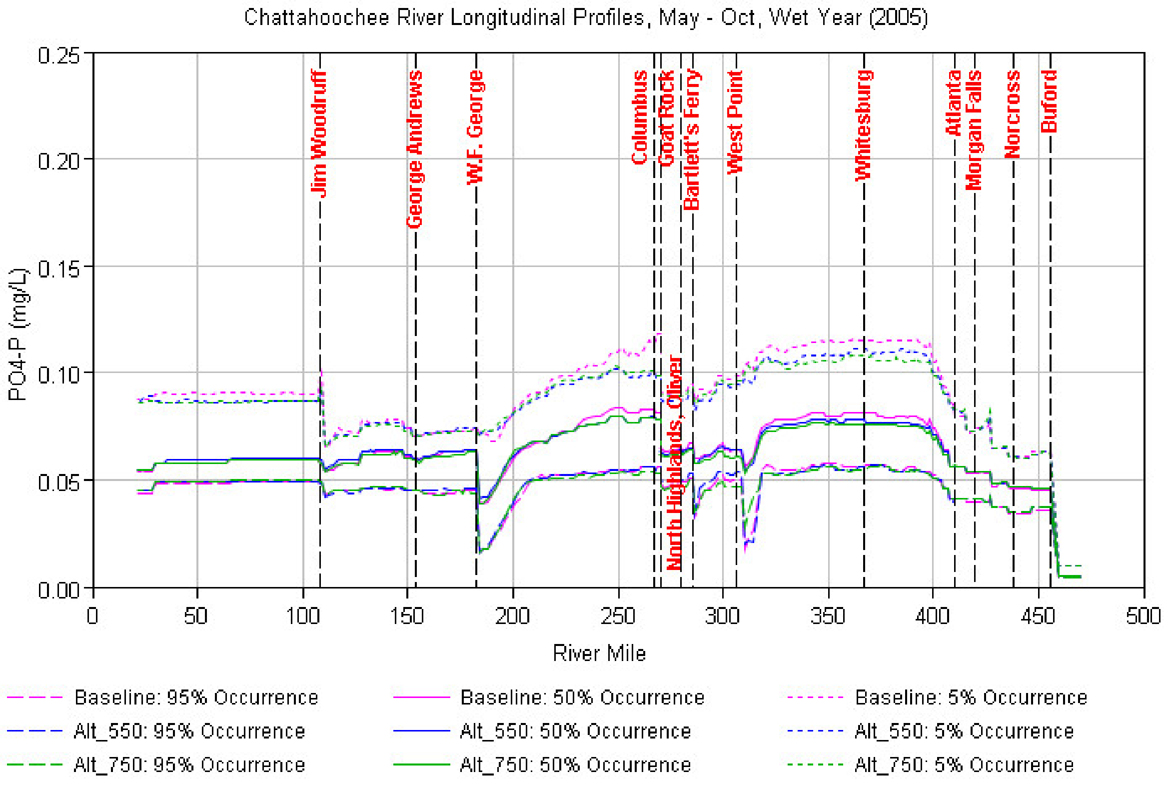


Figure 2.2-47. Ortho-phosphorus along the Chattahoochee River for May through October in a representative wet year (2005).

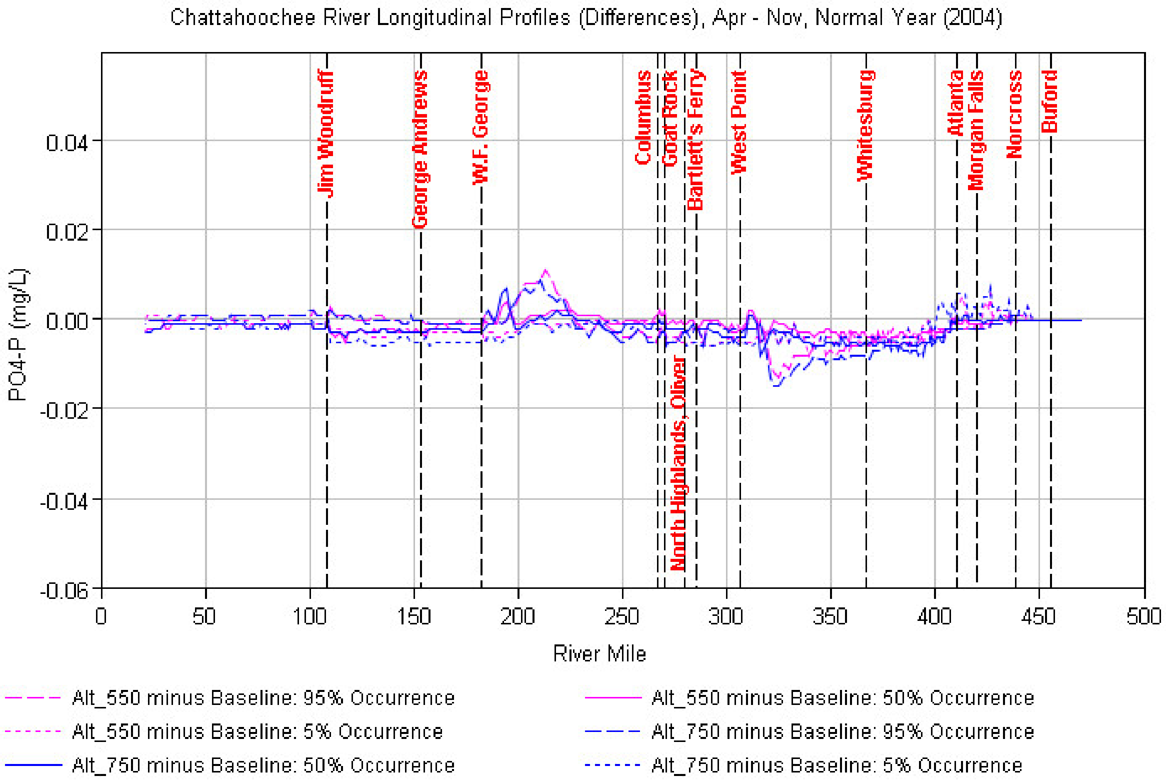


Figure 2.2-48. Changes in longitudinal ortho-phosphorus in the Chattahoochee River for April through October (2001 through 2008).

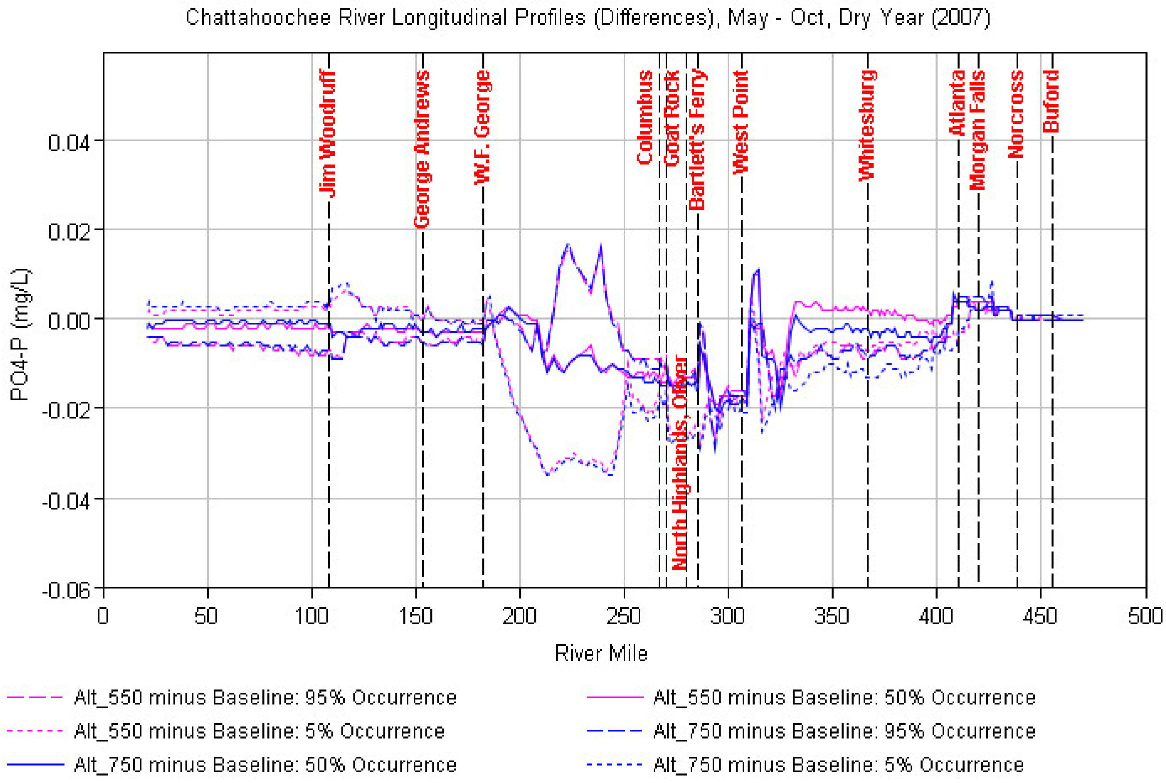


Figure 2.2-49. Changes in longitudinal ortho-phosphorus in the Chattahoochee River for April through October in a representative dry year (2007).

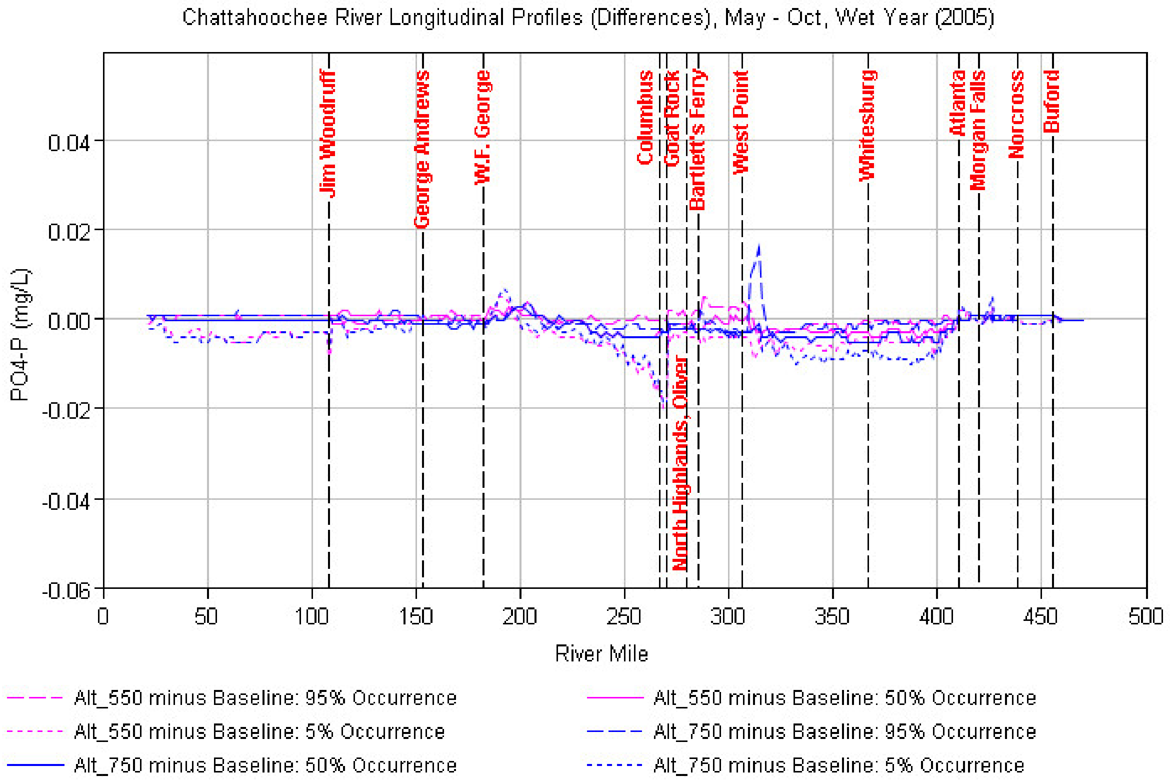


Figure 2.2-50. Changes in longitudinal ortho-phosphorus in the Chattahoochee River for April through October in a representative wet year (2005).

2.3 RESPONSE TO PAL SECTION 3.3 Floodplain Connectivity Analyses

A complete set of the Apalachicola River floodplain LIDAR data is not available and therefore this was not used in this analysis. However, given that conditions in the Proposed Action Alternative are very similar to those for the No Action, little change is expected. Instead, flow ranges from the IHA/RVA models for flooding events were used to evaluate floodplain inundation throughout the system. Using the Range of Variability Approach (RVA; also known as Indicators of Hydrologic Alteration, or IHA) (Richter et al. 1998), the magnitude, frequency, and duration values were calculated for high flows in reaches of the ACF Basin. Comparing those modeling results to the channel capacity allows an estimate of the degree of floodplain (lateral) connectivity, which is a critical component of the ecological function of river systems.

2.3.1 Apalachicola River

Darst and Light (2008) note that water levels have declined in the Apalachicola River basin as a result of local erosion and decreased spring and summer flows from the upstream watersheds. This has led to less frequent floodplain inundation and significantly drier (Darst and Light 2008) forest composition and diminished density of stands than in the past. These affect not only the vegetative makeup of the forest but also the associated wildlife.

The channel capacity of the Apalachicola River at the Chattahoochee, Florida gage is approximately 100,000 cfs. Flow ranges from the IHA/RVA models for flooding events exceed the channel capacity during the same period—early March through early April—in both the No Action and Proposed Action Alternatives (Table 2.3-1). A closer look at the magnitude and duration of maximum flow events indicates that flows would not be expected to exceed the channel capacity for periods of 30 days or more. In the Proposed Action Alternative scenario 1, the channel capacity in maximum flows would likely be exceeded in 20% of events for a 3-day period. In the case of scenario 2, the 3-day maximum flows in 20% of events are slightly lower than the channel capacity. However, the magnitude and duration of floodplain inundations are very similar to those of the No Action Alternative.

Table 2.3-1.
Large flood analysis at Chattahoochee, FL

Chattahoochee, Florida	No Action	Scenario 1	Scenario 2
Peak (cfs)	131400-180300	131400-180400	131400-180800
Duration (days)	41-159	50-158	51-158
Time Frame	Early March–Early April	Early March–Early April	Early March –Early April
Rise Rate (cfs/day)	1490-7350	1310-6945	1327-6962
Fall Rate (cfs/day)	4391-2316	4300-2317	4302-2324

At locations throughout the basin, known river stages at which floodplain inundations occur were used to evaluate the frequency, duration, and timing of floodplain inundation for the Proposed Action and No Action Alternatives.

2.3.2 Chattahoochee River

The approximate high flow capacity of the Chattahoochee River between Lake Lanier and Norcross is 10,000 cfs (USACE, Mobile District 1997). The channel capacity at this location was used as a constraint in the HEC ResSim modeling analysis to ensure that flows did not go higher than 11,000 cfs. Therefore, the modeled IHA/RVA large flood analysis at Norcross indicates peak flows under all conditions are equivalent to 11,000 cfs (Table 2.3-2). The duration of flood events is expected to decrease slightly under the Proposed Action Alternative based on modeling of the 70-year period.

Table 2.3-2.
Large flood analysis at Norcross, GA

Norcross, GA	No Action	Scenario 1	Scenario 2
Peak (cfs)	11000-11000	11000-11000	11000-11000
Duration (days)	34-105	29-79	32-89
Time Frame	Mid-Jan.–Early April	Early Feb.–Early April	Late Jan.–Mid-March
Rise Rate (cfs/day)	259-1124	386-1707	494-1657
Fall Rate (cfs/day)	381-120	530-155	522-117

Overbank flows, and thus floodplain connectivity, have been limited by human structures and flow routing for many years, and the Proposed Action Alternative would not change that. In extreme cases, although rare, there could be brief periods (1–7 days) of riparian inundation over low bank areas into low-lying floodplains and wetlands. At Whitesburg, Georgia, the occurrence of modeled flows exceeding the approximate channel capacity of 18,000 cfs is consistent between the No Action and Proposed Action Alternatives. A magnitude and duration analysis of maximum flows at Whitesburg indicates that the channel is not expected to stay outside its banks for more than 30 days even under the most extreme conditions. In 20% of the maximum modeled flows, the channel capacity could be exceeded for a 7-day period. One- and three-day exceedances of the channel's capacity might occur in 30% of maximum flow events. This is an indication that floodplains and riparian wetlands would likely remain isolated from channel flows in more than 60% of all maximum flow events.

The capacity of the Chattahoochee River channel between West Point and Columbus is around 47,000 cfs. The IHA/RVA indicates that these flows are not expected to occur for more than a 3-day period in 90% of maximum flow events at Columbus, Georgia. The channel capacity is never expected to be exceeded in the Proposed Action Alternative at just downstream of the West Point Dam. Again, the indication is that the floodplains would remain dry with little to no interaction with channel flows.

2.3.3 Flint River

The channel capacity for the Flint River is 30,000–35,000 cfs in the area from Montezuma to Bainbridge. There are two non-Federal impoundments, neither of which substantially alters the flow of the river; nor would they be changed by actions of the USACE. Therefore, there would be no change in lateral (floodplain) connectivity, and no effect on the Flint River would be expected from the Proposed Action Alternative.

2.4 RESPONSE TO PAL SECTION 3.4 Reservoir Fisheries Analyses

The reservoir fisheries performance measure based on the findings of Ryder et al. (1996) that the Service cooperated with the Corps on for the 1998 draft EIS for ACF water allocation was used for this analysis. Unfortunately there is little to no data available to update the reservoir fisheries performance measures. Potential new datasets referenced were reviewed but given the limited resources, the 1998 approach was used.

This assessment focuses on the five reservoirs that are managed by the Corps in the ACF Basin, which are the subject of the water control plan update. The other reservoirs in the basin were excluded from the detailed assessment because most are frequently operated in run of-river modes, which tend to minimize pronounced variations in water levels.

Operational flow changes would affect habitat for reservoir fisheries and other aquatic resources mainly through changes in water levels, changes in reservoir flushing rates (retention times), and associated changes in water quality parameters, such as primary productivity, nutrient loading, dissolved oxygen concentrations, and vertical stratification.

Seasonal water level fluctuations can substantially change the area of shallow-water habitats and inundated shoreline vegetation and, in turn, significantly influence the reproductive success of resident fish populations. High water levels inundating shoreline vegetation during spawning periods frequently have been associated with enhanced reproductive success and strong year class development for largemouth bass, spotted bass, bluegill, crappie, and other littoral species (Ploskey and Reinert 1996; Ryder et al. 1995). Conversely, low or declining water levels can adversely affect reproductive success by reducing the area of available littoral spawning and rearing habitats. In West Point Lake, falling water levels during the rearing season have been correlated with a decline in survival of young-of-year largemouth bass, although surviving fish were larger (Miranda et al. 1984).

In a study of 11 Alabama reservoirs, which included two reservoirs in the ACF Basin, Maceina and Stimpert (1998) found consistent relations between the production of strong crappie year classes and wet winters prior to crappie spawning. Wet winters resulted in shorter retention time (i.e., higher flushing rates) in reservoirs with stable water levels, and higher water levels in fluctuating reservoirs, such as West Point Lake and Walter F. George Lake. High winter inflows may favor crappie production by increasing nutrient loading, which in turn stimulates primary and secondary production later in the growing season (Maceina and Stimpert 1998; Ploskey and Reinert 1996). In reservoirs with stable water levels and low retention, longer post-winter retention also was associated with greater crappie production, possibly related to reduced flushing of young-of-year fish in the discharge from the impoundment and more stable feeding conditions (Maceina and Stimpert 1998).

Substantial daily or weekly fluctuations in reservoir levels associated with hydroelectric power peaking operations may negatively affect reservoir fisheries by dewatering spawning and nursery habitats for littoral species, exposing nests and eggs deposited in shallow-water habitats, and reducing the availability of shoreline cover and its associated invertebrate food supply.

2.4.1 Performance Measures under the Proposed Action Alternative

The performance measures were used to assess relative effects of the No Action Alternative and Proposed Action Alternative on reservoir fisheries habitat, based on the premise that greater departure of reservoir levels from optimum levels for critical guilds of fishes (e.g., littoral spawning, rearing) result in greater impacts to their habitats. All five reservoirs showed higher values for the No Action Alternative, with little or no variation in performance scores between the Proposed Action Alternative scenarios. West Point and Lake Seminole generally operate at closer to optimum water levels for critical fishery guilds with less seasonal fluctuation, as indicated by the median performance scores of 0.67 and 0.70, respectively. Lake Lanier and Walter F. George showed intermediate potential for fisheries impacts related to reservoir levels, as indicated by a performance values of 0.40 and 0.39.

For Lake Lanier and West Point Lake, the Proposed Action Alternative showed the greatest potential for reservoir fisheries impacts (Table 2.4-1). These storage reservoirs exhibit the greatest variation between the No Action Alternative and Proposed Action Alternative. The principal factor contributing to these lower scores under the Proposed Action Alternative is seasonal water level fluctuations, particularly during the spawning period, associated with operations for flood damage reduction (e.g., winter drawdowns), downstream flow targets, hydroelectric power operations, and navigation. The downstream reservoirs of George Andrews and Lake Seminole exhibit a narrower range of scores among the scenarios suggest a lower overall potential for adverse effects due to water level fluctuations.

Table 2.4-1.
Reservoir Fishery Performance Measure Scores

Reservoir	Alternative	Min.	25th Percentile	50th Percentile	75th Percentile	Max.
Lake Lanier	No Action	0.02	0.25	0.40	0.56	0.92
	Scenario 1	0.02	0.23	0.36	0.55	0.89
	Scenario 2	0.02	0.23	0.36	0.56	0.89
West Point Lake	No Action	0.16	0.52	0.67	0.75	0.88
	Scenario 1	0.16	0.53	0.64	0.73	0.82
	Scenario 2	0.16	0.52	0.64	0.72	0.82
W.F. George Lake	No Action	0.20	0.37	0.39	0.41	0.48
	Scenario 1	0.15	0.30	0.36	0.40	0.45
	Scenario 2	0.15	0.31	0.36	0.40	0.45
George F. Andrews Lake	No Action	0.28	0.31	0.33	0.34	0.41
	Scenario 1	0.29	0.31	0.32	0.33	0.39
	Scenario 2	0.29	0.32	0.32	0.33	0.39
Lake Seminole	No Action	0.38	0.64	0.70	0.75	0.95
	Scenario 1	0.36	0.61	0.68	0.73	0.94
	Scenario 2	0.37	0.61	0.68	0.73	0.92

2.4.2 Impacts of Critical Low Flow Periods

The USFWS performance measure provide a means of comparing relative impacts between flow scenarios, but do not distinguish potential impacts resulting from sustained drawdowns covering multiple critical periods, such as spawning seasons. Examination of daily plots of reservoir water elevations for critical low flow periods indicates that, for headwater storage reservoirs, such impacts could be severe (USACE, Mobile District 1998a).

For the purpose of this analysis Lake Lanier was evaluated because it presents the greatest range in water surface elevations. At Lake Lanier, the optimum pool elevation for littoral spawning and rearing guilds of sport fishes is 1,071 ft. Water levels falling 3 ft or more below this elevation (1,068 ft and lower) show acceptability levels of 0.65 and lower, with zero acceptability occurring at water levels of 15 feet or more below optimum (1,056 ft and lower) (Ryder et al. 1995).

Comparison of the modeled flow conditions for the critical low flow years of 1954 through 1960, 1985 through 1989 and 2007 at Lake Lanier shows that reservoir levels during the growing season under the No Action Alternative would decrease below 1,068 ft approximately 68 percent of the time and occur 88 percent of the time during winter drawdown. Departures from the optimum pool elevation average approximately 5 ft during the growing season and 8 ft during winter drawdown. Based on the assumptions of the reservoirs fishery performance measures, these conditions would be expected to impact spawning and rearing seasons for the critical species largemouth bass, spotted bass, white bass, and crappie, resulting in decreased reproductive success and recruitment. However, these conditions have not been documented.

In 2007, conditions were considerably worse than the 1954 and 1989 low flow periods. During this time, pool elevations dropped below 1,071 ft 100 percent of the time, falling nearly 7 ft during the growing season and 11 feet during winter drawdown. Performance measures, which are generally between 0.36 and 0.40, fell to 0.04 to 0.08 during this critical drought period. In 2008, conditions continued to deteriorate with values of 0.21 for No Action Alternative.

In both scenarios of the Proposed Action Alternative, Lake Lanier would decrease below 1,068 ft, 70 percent of the time during the growing season and 90 percent of the time during winter drawdown. Departures from the optimum pool elevation average approximately 5 ft during the growing season and 8 ft during winter drawdown in the No Action Alternative and Proposed Action Alternative. No change from the No Action Alternative would be expected in the impact to spawning and rearing seasons for critical species under the Proposed Action Alternative.

In the worst low flow period, 2007, the Proposed Action Alternative shows slightly improved values over No Action Alternative. In 2008, the Proposed Action Alternative is similar to the No Action Alternative.

2.5 RESPONSE TO PAL SECTION 3.5 Riverine Fisheries Analyses

Sport fisheries are important recreational and economic resources in the riverine portions of the ACF project, especially in the Apalachicola River. The survival and reproduction of many fishes are intricately tied to the floodplain, and alteration of flow regimes can affect reproductive success, year-class strength, growth, condition, and other life-history attributes. There are existing effects of controlled flows in the ACF Basin on lateral connectivity and floodplain inundation. Before the Chattahoochee River became subjected to human controls, there were substantial flows with natural variability in magnitude and seasonal fluctuations (**Error! Reference source not found.** and **Error! Reference source not found.**). The highest baseflows occurred in the spring (January/February to May/June) and ranged from 1,700–2,200 cfs upstream of Atlanta to 7,000–10,000 cfs downstream of Walter F. George Lake. Furthermore, flows in the Apalachicola River ranged from 20,000 to 24,000 cfs. Because of the series of dams now present in the Chattahoochee River system, these baseflows no longer exist and are unlikely to be realized again.

Given the limited availability of data, the IHA baseflow analysis can be used to evaluate the effect to riverine fisheries. Baseflow was compared between pre-dam conditions, the No Action Alternative, and Proposed Action Alternative.

2.5.1 Chattahoochee River downstream of Buford Dam

The No Action Alternative at Norcross, Georgia would have an average year-round baseflow of 1,700–1,800 cfs, with slightly higher values during a short period of mid-summer (in June and July, **Error! Reference source not found.**). During dry years the flow would remain consistent at around 1,500 cfs, whereas in wet years it would be approximately 2,000 cfs, again consistently throughout the year. The lower limit on baseflow would be approximately 1,000 cfs and would continue to support the existing trout and sport fishery in this area.

Under the Proposed Action Alternative at Norcross, there would be somewhat higher flows in average years, ranging from 1,700 to 2,400 cfs, **Error! Reference source not found.**. For wet and dry years there would be consistent year-round flows of 2,400 and 1,500, respectively. Both scenarios of the Proposed Action Alternative would elevate the lower limit of the baseflow to between 1,100 and 1,250 cfs.

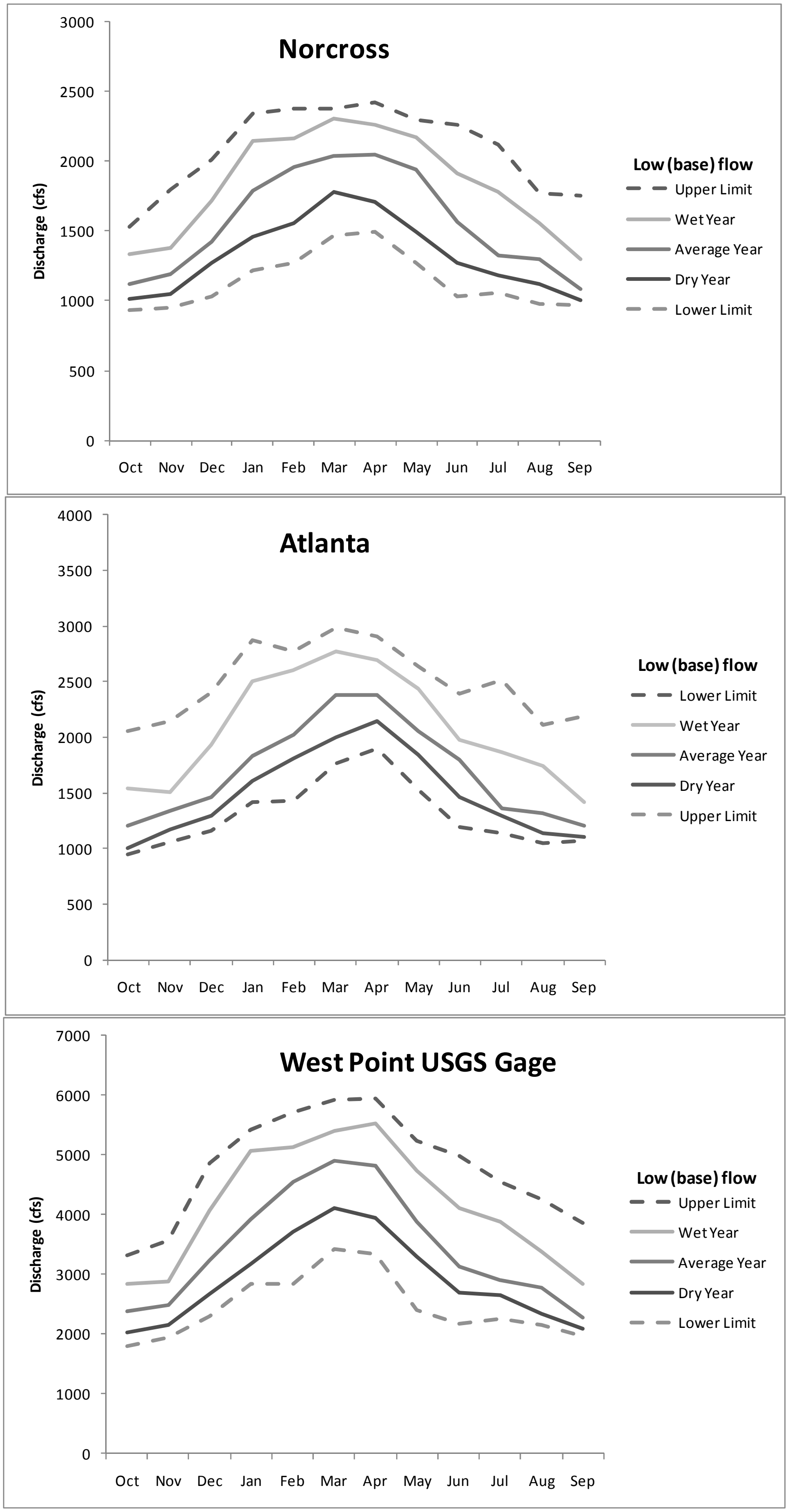


Figure 2.5-1. Pre-dam seasonal baseflow from the Chattahoochee River (top, at Norcross; center, at Atlanta; bottom, downstream of West Point Dam and upstream of Walter F. George Lake).

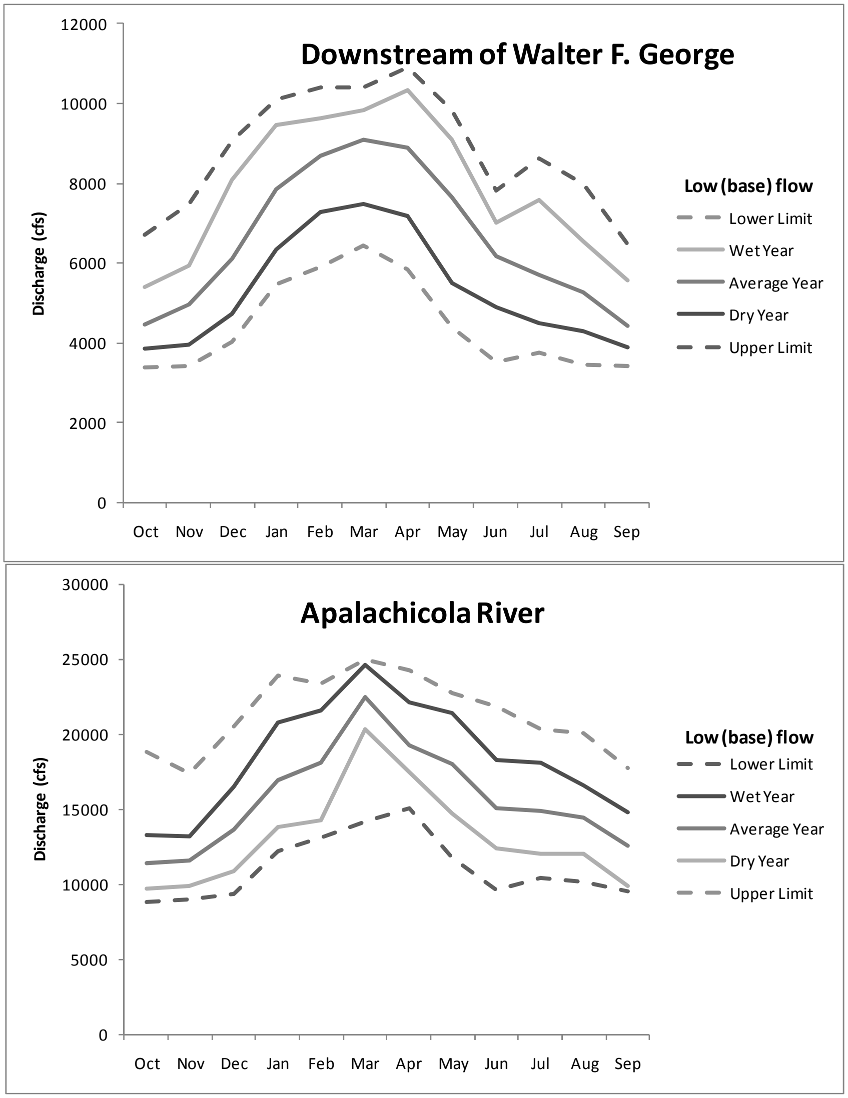


Figure 2.5-2. Pre-dam seasonal baseflow from the Chattahoochee and Apalachicola Rivers (top, downstream of Walter F. George Dam; bottom, Apalachicola River).

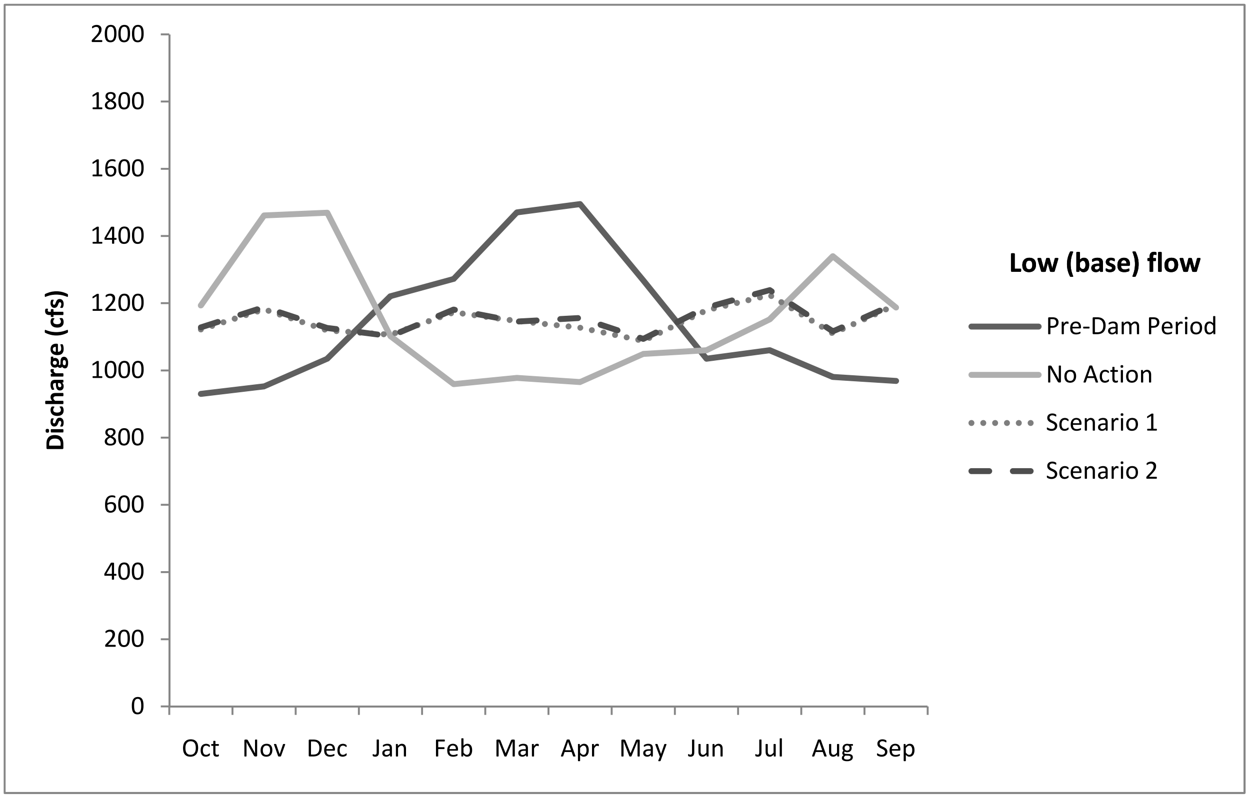


Figure 2.5-3. Norcross, Georgia average baseflow over the modeled period

2.5.2 Chattahoochee River downstream of West Point Dam

Between West Point Dam and Walter F. George Lake, baseline flows during years of average precipitation range from 3,200 to 4,000 cfs, exhibiting little if any seasonal variability in the No Action Alternative (**Error! Reference source not found.**). During dry years, the year-round flows would be only slightly less, on average by approximately 500 cfs. The upper and lower limits of baseflows would range from 3,200–4,800 cfs in the late autumn to 2,000–3,200 cfs in mid- to late summer.

The Proposed Action Alternative between West Point Dam and Walter F. George Lake, although similar in magnitude to the No Action Alternative, exhibits seasonal variability similar to pre-dam conditions (**Error! Reference source not found.**).

2.5.3 Chattahoochee River downstream of Walter F. George Dam

The shapes of the hydrographs downstream of Walter F. George Dam are similar to pre-dam conditions (**Error! Reference source not found.**) for the No Action Alternative, exhibiting similar seasonal patterns with the highest flows in the February–April time frame. The flow magnitude for average years overall, however, is 500–1,000 cfs, reduced from the pre-dam flows.

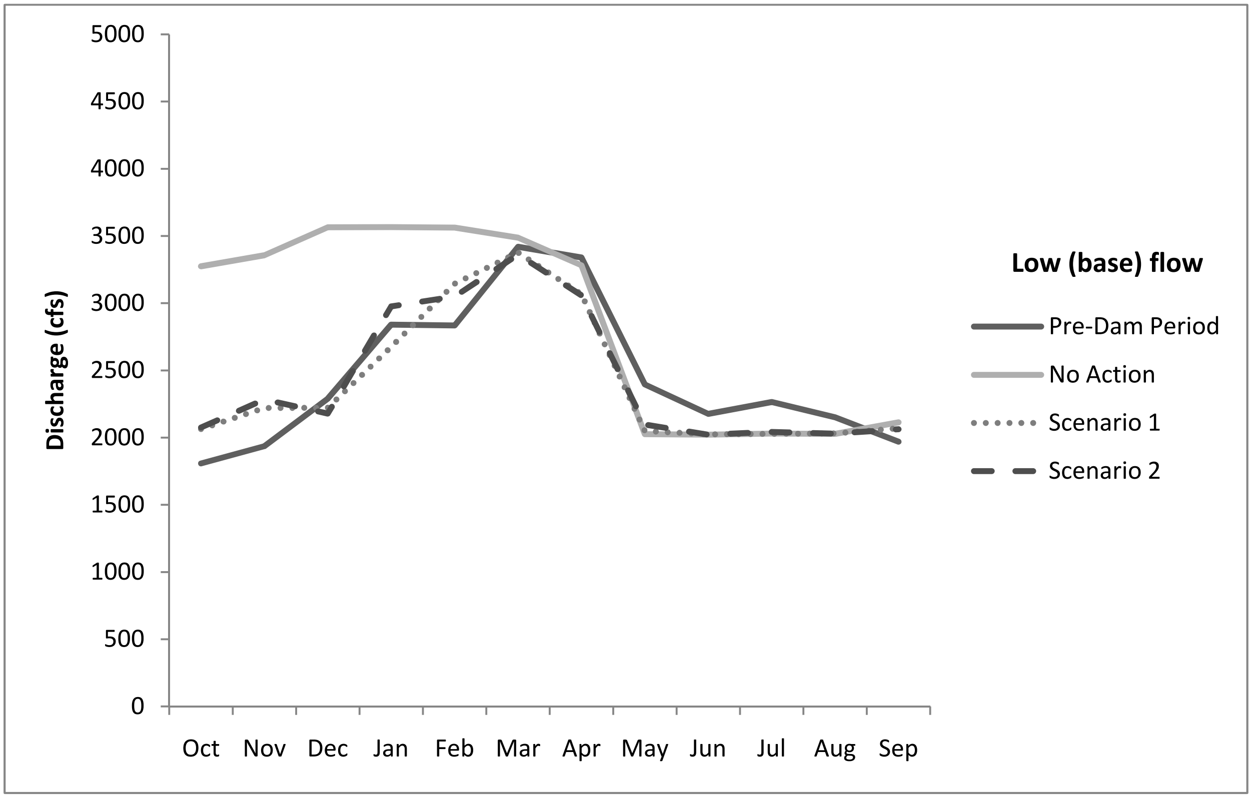


Figure 2.5-4. West Point Dam (UGSG gage location) average baseflow over the modeled period

2.5.4 Apalachicola River

The shapes of the hydrographs downstream of Jim Woodruff Dam are also similar to pre-dam conditions (Figure 2.5-6) for the No Action Alternative, exhibiting similar seasonal patterns with the highest flows in the February–April time frame. The flow magnitude for average years overall, however, is around 500–1,000 cfs, reduced from the pre-dam flows. Nonetheless, the existing fisheries resources would continue to be supported under the No Action Alternative.

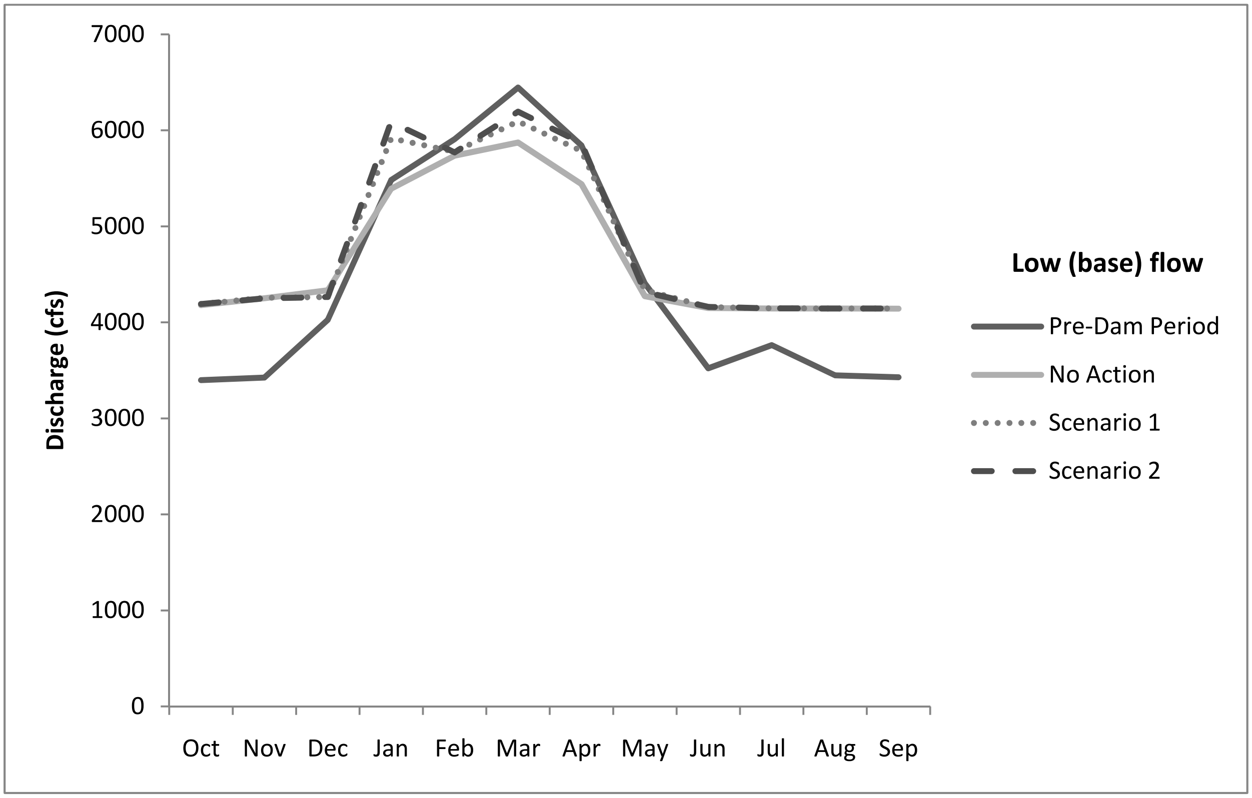


Figure 2.5-5. Average baseflow over the modeled period downstream of Walter F. George Dam

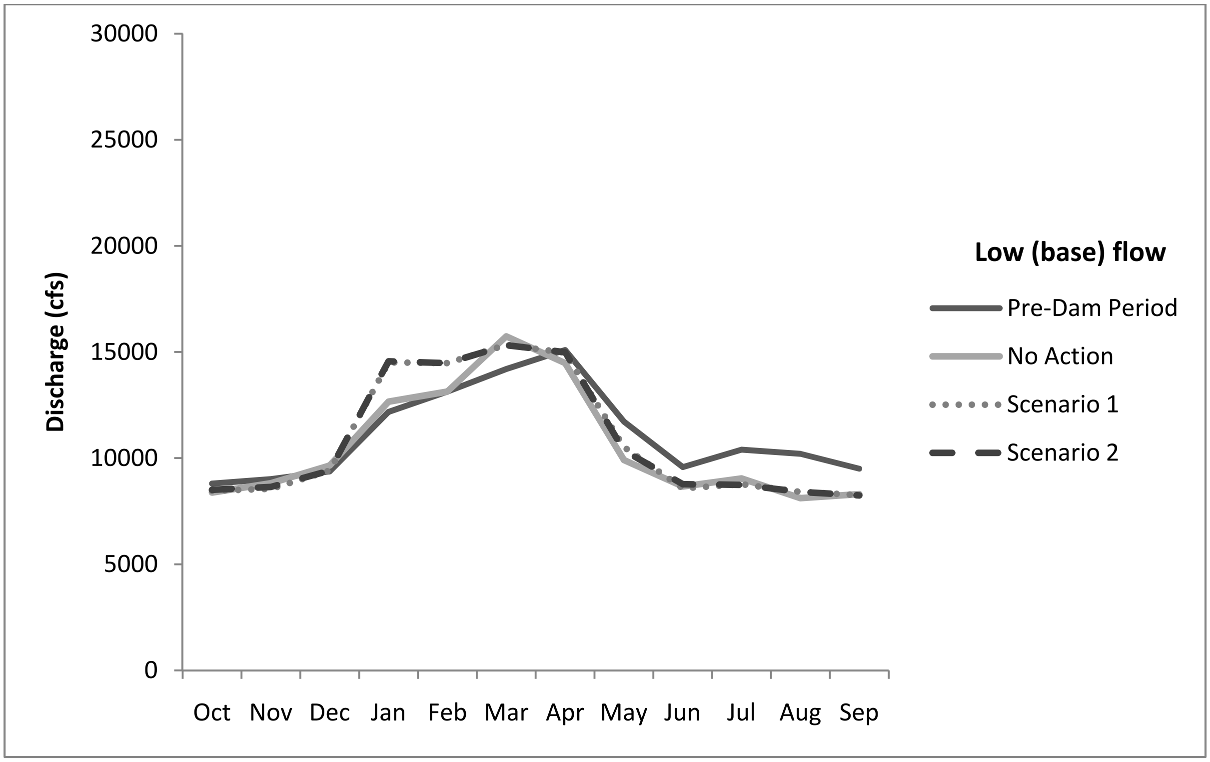


Figure 2.5-6. Average baseflow over the modeled period downstream of Jim Woodruff Dam

2.6 RESPONSE TO PAL SECTION 3.6 Apalachicola Bay Salinity Analyses

The USFWS conducted salinity modeling of the Apalachicola Bay. Based on the preliminary analysis provided by the USFWS, little change in salinity in the Apalachicola Bay would be expected as a result of the Proposed Action Alternative. Freshwater flows are also critical to the protection of the estuarine oyster fishery, which is sensitive to variations in salinity. The oyster fisheries in the estuarine portions of Apalachicola Bay experience impacts from drought and flooding as a result of both natural and unnatural flow variation. The Proposed Action Alternative would present no anticipated change in the flows (wet, dry, or normal) to the estuary from the No Action Alternative, and therefore the Proposed Action Alternative is not expected to change the current state of the oyster fishery.

Similarly, given the absence of appreciable changes in the flow dynamics from the No Action condition, additional impacts on other estuarine species and fisheries are not expected.

2.7 RESPONSE TO PAL SECTION 3.7 Federally-protected Species Analyses

As requested by the USFWS, the Federally-protected species analysis is consistent with the evaluations completed for the RIOP and additional requests by the FFWCC.

2.7.1 Gulf Sturgeon Analysis

2.7.1.1 Spawning Habitat Availability

Gulf sturgeon spawning habitat was quantified at three locations known to support the species using a daily time series analysis of the Proposed Action Alternative. The modeled conditions represent the maximum habitat available during inundation at 8.5- to 17.8-ft depth range from March through May. Similar frequency analyses were completed to depict the amount of continuous habitat available to support the timing of spawning, egg incubation, and early larval development of Gulf sturgeon. Collectively, those stages are estimated to occur over approximately 30 days in the ACF Basin (USFWS 2008b; Pine et al. 2006; Sulak et al. 2004); therefore, the amount of available habitat was estimated to reflect the annual frequency during which conditions range from 8.5 to 17.8 ft for a period of 30 days.

Modeling results indicate that the maximum amount of available habitat ranges from 0 in rare cases to approximately 21 acres and generally shows good agreement among the action alternative flow scenarios (**Error! Reference source not found.**). The median values among the regimes are equivalent, at slightly fewer than 18.0 acres. The annual frequency of flows also shows close correspondence of the action flow alternatives, with a median value of about 18 acres (**Error! Reference source not found.**). All three time series provide nearly 13 acres of habitat in all years.

In both analyses, the Proposed Action Alternative track closely with the No Action Alternative and do not represent an appreciable difference in the availability of Gulf sturgeon spawning habitat. The figures to follow illustrate the No Action Alternative, both scenarios of the Proposed Action Alternative, USGS measured data, and a run-of-river (RoR) regime. The USGS and ROR were included for consistency with completed during the 2008 consultation.

2.7.1.2 Daily Fall Rates With Respect to Gulf Sturgeon

Because Gulf sturgeon spawning most often occurs at depths between 8 and 18 feet, a rapid fall in river stage could result in exposure or stranding of eggs and larvae. A depth of 8 ft over the highest known Gulf sturgeon spawning habitat on the Apalachicola River corresponds to a flow of approximately 40,000 cfs. Under the ACF water control operations, impacts to Gulf sturgeon spawning habitat is not expected. The Jim Woodruff Dam water management operations have mechanisms in place to ensure that when flows are less than 40,000 cfs a decline more than 8 feet in less than 14 days during the months of March, April, and May does not occur. Analysis of the simulated flows verifies that this potential take event does not occur. The Jim Woodruff Dam water management operations also include a fall rate schedule when discharges are within the capacity of the powerhouse that facilitates movement of mussels and host fish as river stages decline.

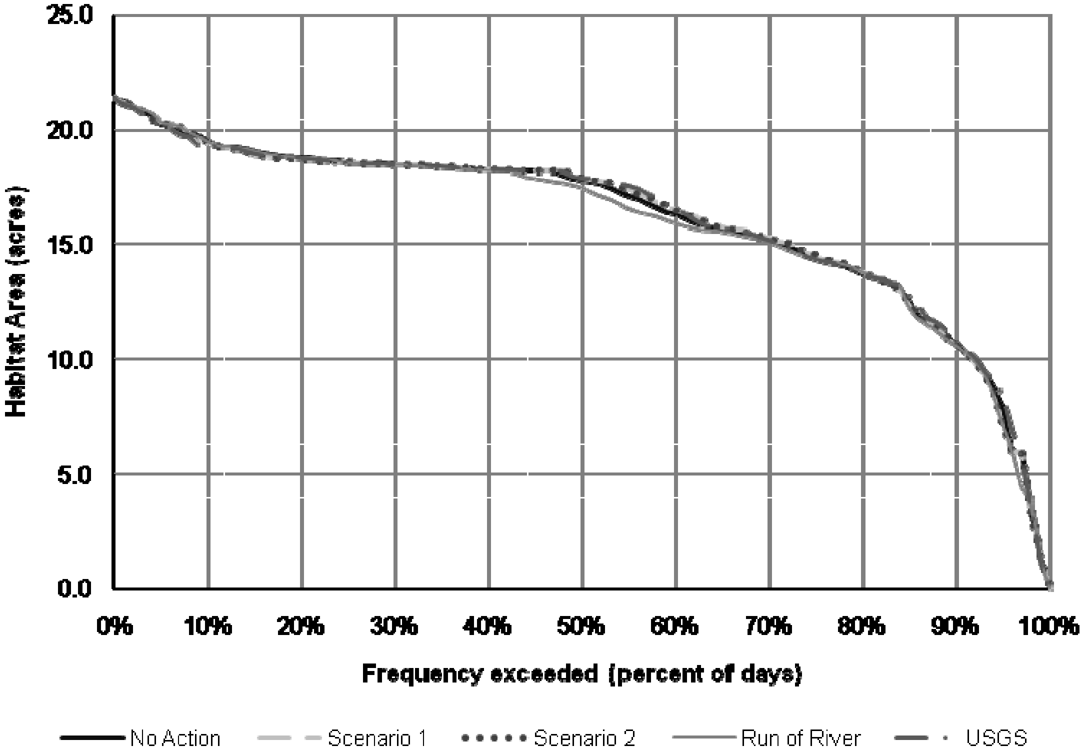


Figure 2.7-1. Frequency (% of days) of Gulf sturgeon spawning habitat availability (acres of potentially suitable spawning substrate inundated to depths of 8.5 to 17.8 feet) on each day March 1 through May 31, at each of the three sites that support spawning. (*Figure 4.2.3.A.* from the 2008 BO.*)*

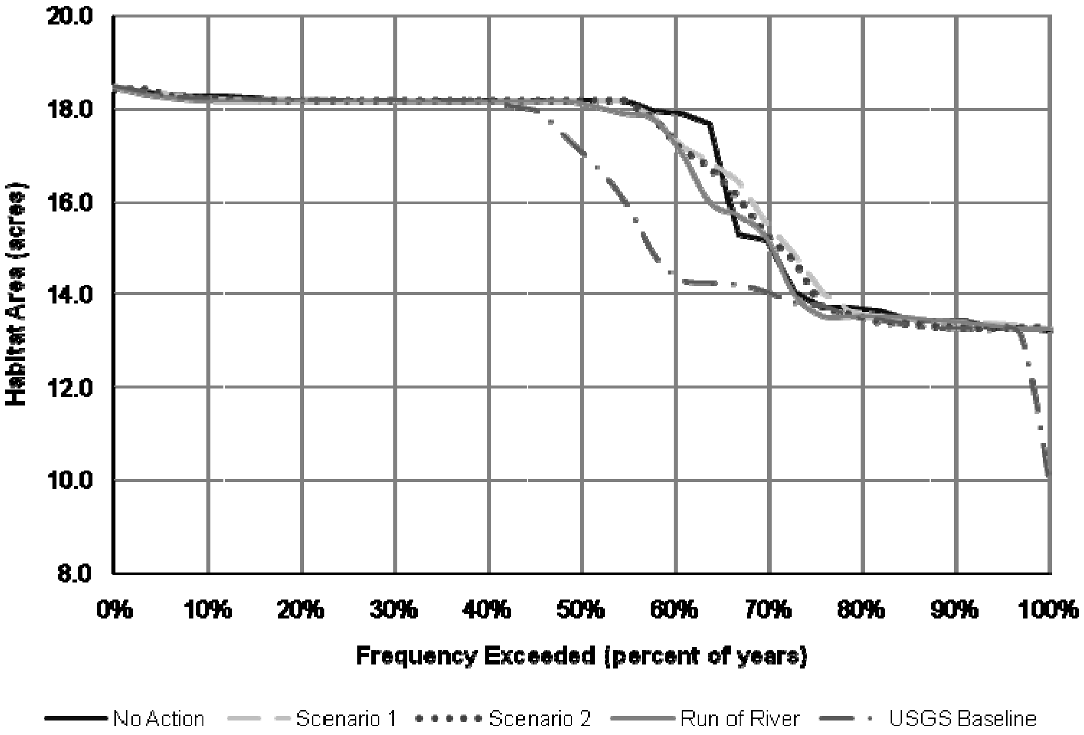


Figure 2.7-2. Frequency (% of years) of Gulf sturgeon spawning habitat availability (maximum acres of potentially suitable spawning substrate inundated to depths of 8.5 to 17.8 feet for at least 30 consecutive days each year), March 1 through May 31, at each of the three sites that support spawning. (*Figure 4.2.3.B.* from the 2008 BO.*)*

2.7.1.3 Maximum Number of Days per Year Less Than 16,000 cfs

Gulf sturgeon are restricted to the Apalachicola River mainstem below Jim Woodruff Lock and Dam, using select areas for spawning and reproduction from March through May. Adults and sub-adults returning from spawning to the estuarine waters of Apalachicola Bay to feed and juveniles encountering that environment for the first time, require a gradual transition to increasing salinity. Altinok et al. (1998) determined that optimal growth rates of juvenile Gulf sturgeon occur at salinity levels of approximately 9 parts per thousand (ppt). Direct transition to salinities greater than 30 ppt is lethal. Flow data from the Apalachicola River at the Chattahoochee gage show a strong association with salinity levels in Apalachicola Bay and indicate that prolonged flows of less than 16,000 cfs generally result in salinity concentrations over 10 ppt (Livingston et al. 2000). The maximum number of days per year in which flows are less than 16,000 cfs is presented below.

The median of the maximum number of days at less than 16,000 cfs is slightly higher for the No Action Alternative than what has been measured by the USGS (**Error! Reference source not found.**).

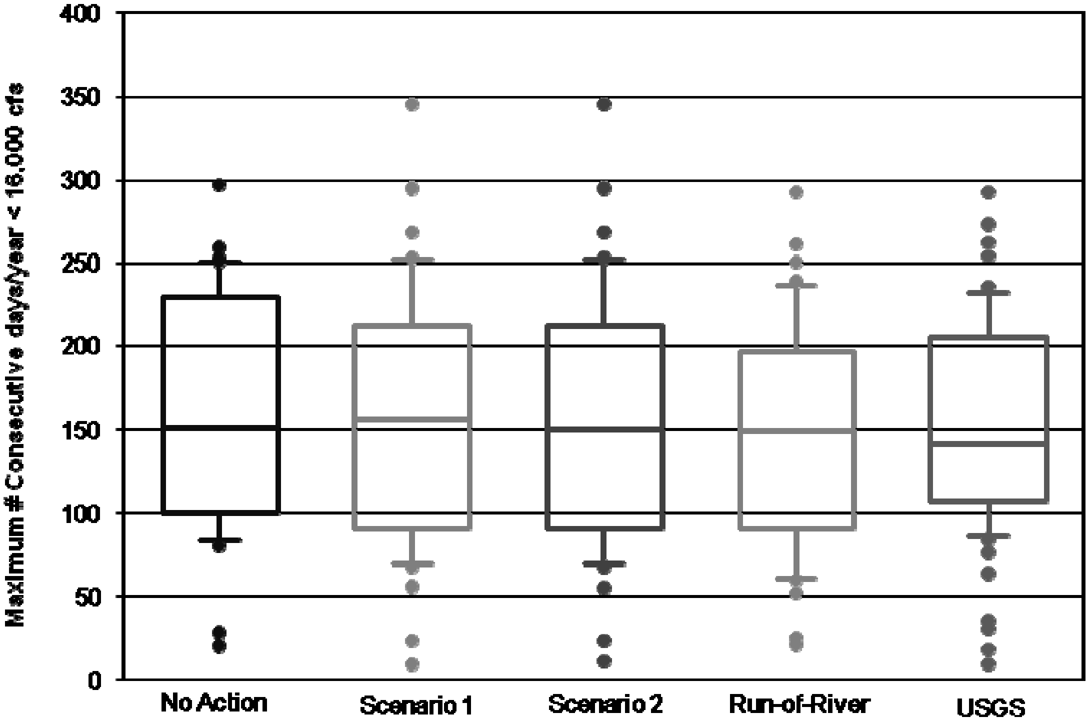


Figure 2.7-3. Range of maximum number of consecutive days per year less than 16,000 cfs with data from 1975 through 2008. (*Figure 4.2.4.A.* from the 2008 BO.*)*

Results of modeling indicate that median values of the maximum number of consecutive days per year where flows are less than 16,000 cfs remains consistent between scenarios for the Proposed Action Alternative and the No Action Alternative at approximately 150 days (**Error! Reference source not found.**). The No Action Alternative 25th and 75th percentile values are approximately 10 and 20 days higher than those represented by the Proposed Action Alternative scenarios. Comparing to the run-of-river (ROR) scenario as presented in USFWS (2008b), the 25th percentile values are similar to the Proposed Action Alternative and 75th percentile values are 16 days higher in the Proposed Action Alternative.

2.7.1.4 Departure from Average Mean Temperature between May 1 and June 31

Water temperatures provide important cues for migration and, particularly for spawning of Gulf sturgeon. Within the Apalachicola River basin, spawning generally occurs during spring as water temperatures approach 17 °C up to 25 °C. Temperature data (2003–2007) from the Blountstown gage were modeled using Hec5Q and are presented below.

The No Action Alternative water temperature conditions are not expected to change. Mean daily water temperature values are nearly identical between the Proposed Action Alternative scenarios and the No Action Alternative, with mean temperatures around 20 °C. The date at which water temperature reaches 17 °C also remained consistent in mid-March and increase to 25 °C in early May.

2.7.2 Freshwater Mussels Analysis

2.7.2.1 Lowest Daily Flow Rate for Each Year

Flow rates, representing the lowest annual levels from 1975 through 2008, were evaluated to determine the potential for exposing and stranding aquatic biota. The results are presented below.

The median low-flow for the No Action Alternative from 1975 through 2008 is 6,043 cfs at Chattahoochee, Florida. Over the period, low-flows are generally low and maintaining the No Action Alternative increases the occurrence of low-flow events over measured data by USGS.

Error! Reference source not found. lists the lowest daily flow rates from 1975 through 2008 for the No Action Alternative and Proposed Action Alternatives. Scenarios 1 and 2 of the Proposed Action Alternative and the No Action Alternative do not include simulated flows less than 5,000 cfs.

Table 2.7-1.
Minimum flow from modeled year.

Year	No Action	Scenario 1	Scenario 2
1975	13986	15005	15061
1976	8115	8971	8999
1977	6022	6051	6073
1978	6651	6651	6651
1979	6433	6472	6478
1980	6114	6115	6115
1981	5049	5049	5049
1982	8401	8388	8386
1983	7946	7928	7928
1984	7652	8070	8070
1985	6174	6321	6381
1986	5049	5049	5049
1987	6064	5786	6021
1988	5050	5050	5050
1989	5735	6415	6346
1990	5435	5491	5433
1991	8763	8749	8747
1992	8086	8205	8208
1993	5877	5873	5803
1994	8472	8624	8596
1995	5500	5433	5477
1996	6680	6648	6664
1997	5775	5757	5758
1998	7530	7699	7677
1999	5018	5021	5001
2000	5050	5029	5029
2001	5050	5050	5050
2002	5050	5025	5009
2003	8751	8533	8543
2004	5993	5781	5787
2005	8921	7435	7435
2006	5050	5050	5050
2007	5034	5050	5050
2008	5050	5050	5050

2.7.2.2 Inter-annual Frequency of Flows less than 5,000–10,000 cfs

Mussels are susceptible to stranding at flows ranging from 5,000 to 10,000 cfs, particularly following high-flow events (> 100,000 cfs) that serve to move individuals into depositional areas (USFWS 2008b). Inter-annual flows, expressed as the frequency of occurrence of the percent of years, were evaluated to address the potential for stranding. The results are presented below.

Evaluation of the inter-annual frequency of flows less than 10,000 cfs indicates a close correspondence of the No Action Alternative and both scenarios of the Proposed Action Alternative (**Error! Reference source not found.**). The lowest flows, including the frequency of those below 5,000 cfs, are most often associated with the run-of-river regime. None of the proposed flow scenarios fall below 5,000 cfs, compared to approximately 56 percent of the run-of-river regime. Both of the Proposed Action scenario simulations provide results consistent with those of the No Action Alternative.

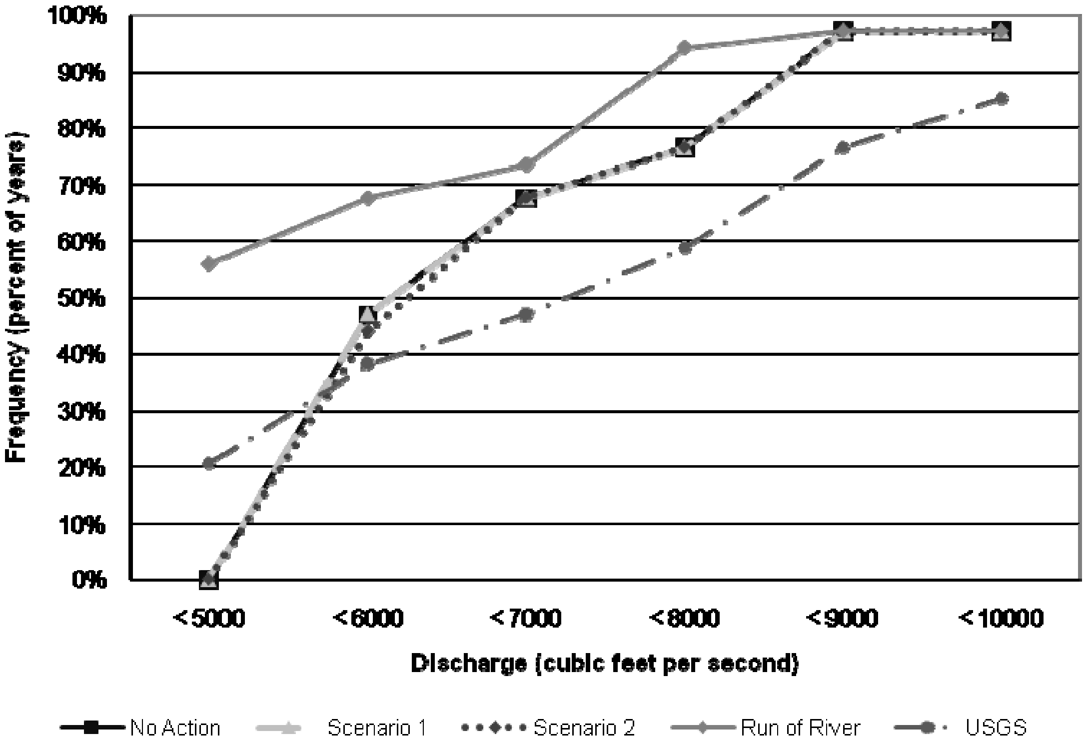


Figure 2.7-4. Inter-annual frequency of flows between (5,000-6,000), (6,000-7000), and (8,000-10,000) cfs based on 1975 – 2008 (*Figure 4.2.5.A.* from the 2008 BO.*)*

2.7.2.3 Maximum Number of Days per Year Flows less than 5,000–10,000 cfs

The maximum number of days per year with flows less than 5,000–10,000 cfs provides an estimation of the most severe conditions aquatic biota will experience under the proposed flow regimes.

The modeled No Action Alternative tracks closely with the run-of-river in discharges greater than 6,000 cfs (**Error! Reference source not found.**). Though mussels can survive brief periods of stranding by closing their shells or burrowing in substrate, mussels would not be expected to survive long durations of exposure at flows less than 5,000 cfs (as simulated for the RoR condition).

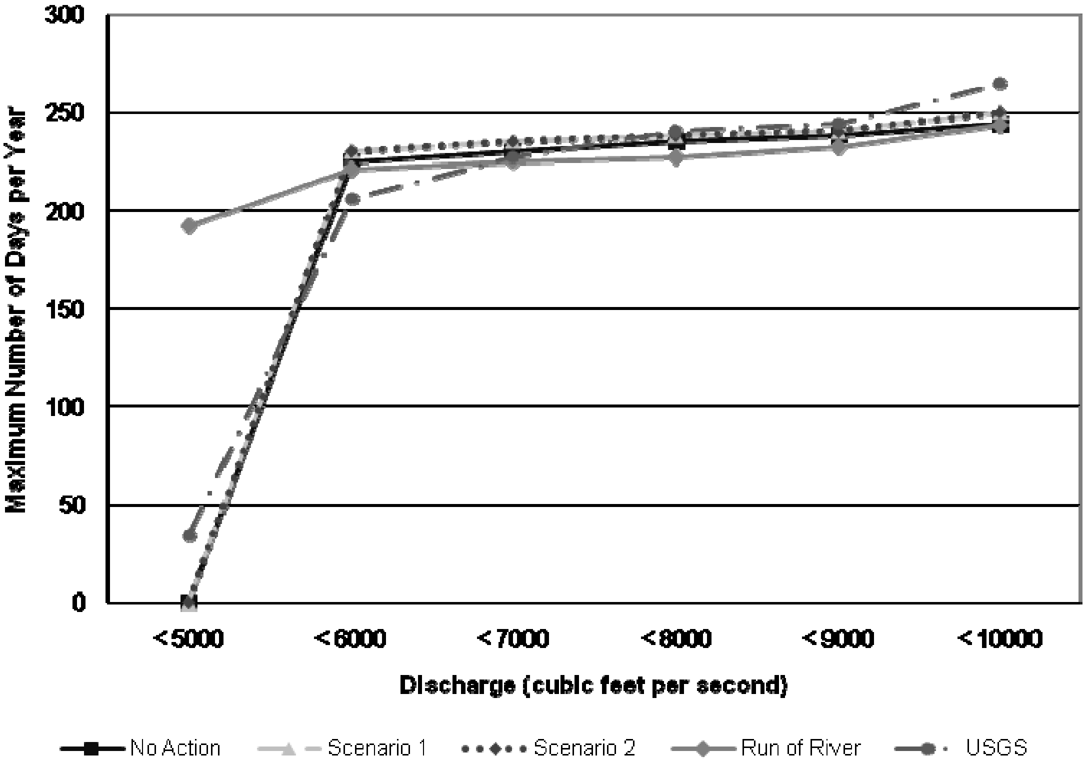


Figure 2.7-5. Maximum number of days per year with flows between (5,000-6,000), (6,000-7000), and (8,000-10,000) cfs from 1975 – 2008 (*Figure 4.2.5.B.* from the 2008 BO.*)*

At flows above 6,000 cfs, all scenarios are more than 200 days, with the run-of-river estimates falling slightly lower than that of the Proposed Action Alternative (**Error! Reference source not found.**). However, the Proposed Action Alternative flows never fall below 5,000 cfs, in contrast to the run-of-river regime, which is estimated to occur approximately 185 days annually. The Proposed Action Alternative is consistent with the No Action Alternative.

2.7.2.4 Maximum Number of Consecutive Days less than 5,000 - 10,000 cfs

Mussels can survive brief periods of stranding by closing their shells or burrowing in substrate. Thus, without extreme water temperatures, mussel survival from stranding is most likely a function of exposure duration (USFWS 2008b). To address that, the maximum number of consecutive days of flows between 5,000 and 10,000 cfs was evaluated.

Error! Reference source not found. shows the maximum number of consecutive days of flows at less than 5,000–10,000 cfs is similar in the Proposed Action Alternative to the No Action Alternative. The No Action Alternative and Proposed Action Alternative are comparable at all flows and offer a beneficial effect from having no occurrence of flows below 5,000 cfs. In contrast, the run-of-river regime provides a slightly lower number of maximum consecutive days with exception to flows below 5,000 cfs, which occur approximately 125 days annually. The No Action and Proposed Action Alternative simulations include no consecutive days with flows less than 5,000 cfs. The Proposed Action Alternative is consistent with the No Action Alternative.

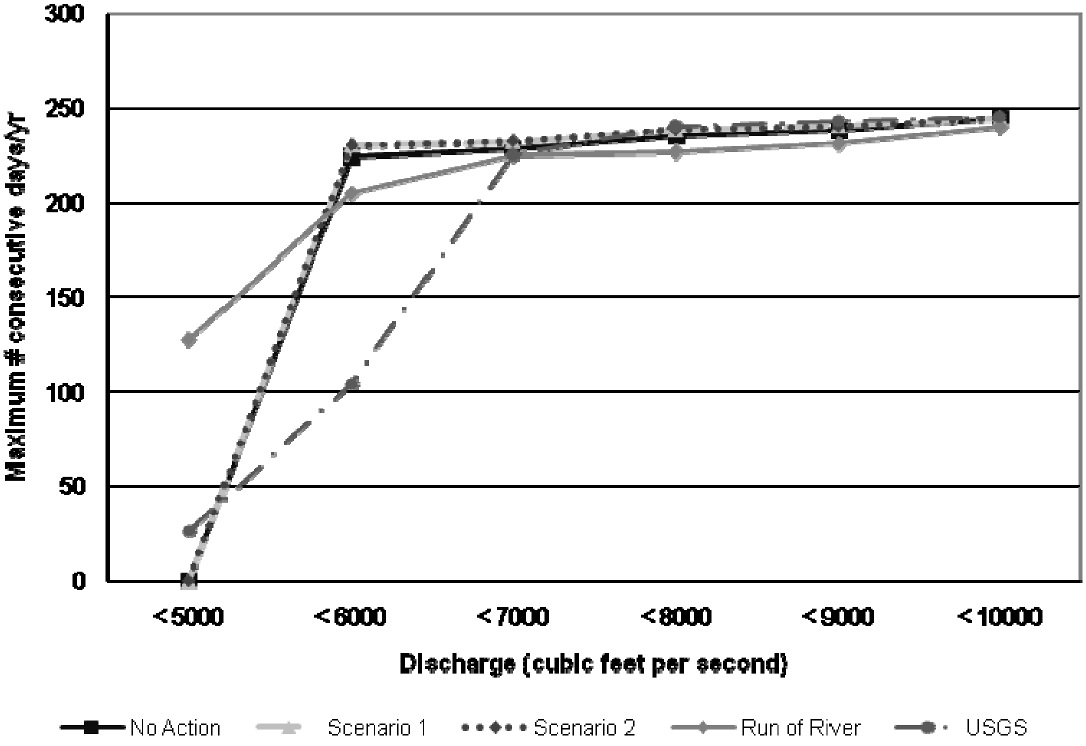


Figure 2.7-6. Maximum number of consecutive days with flows between (5,000-6,000), (6,000-7000), and (8,000-10,000) cfs (*Figure 4.2.5.C.* from the 2008 BO.*)*

2.7.2.5 Median Number of Days per Year Flows less than 5,000–10,000 cfs

The duration of moderate low-flow periods are also an important consideration for the survival of mussels and other aquatic biota. Chronic low-flow events occur with greater frequency than extreme events and, despite the less severe conditions, serve to decrease habitat availability, increase physiological stress, and increase both exposure-related and predatory mortality.

Median flows below 7,000 cfs occur but are limited in the No Action Alternative (**Error! Reference source not found.**). The Proposed Action Alternative offers the lowest median number of days per year at levels less than the 5,000–10,000 cfs thresholds (**Error! Reference source not found.**). The scenarios show no occurrences below 6,000 cfs and, with exception to the < 10,000 cfs value, generally maintain an average of approximately 5 days less than the run-of-river scenario. Only at 9,000 cfs would the Proposed Action Alternative be increased from the No Action Alternative.

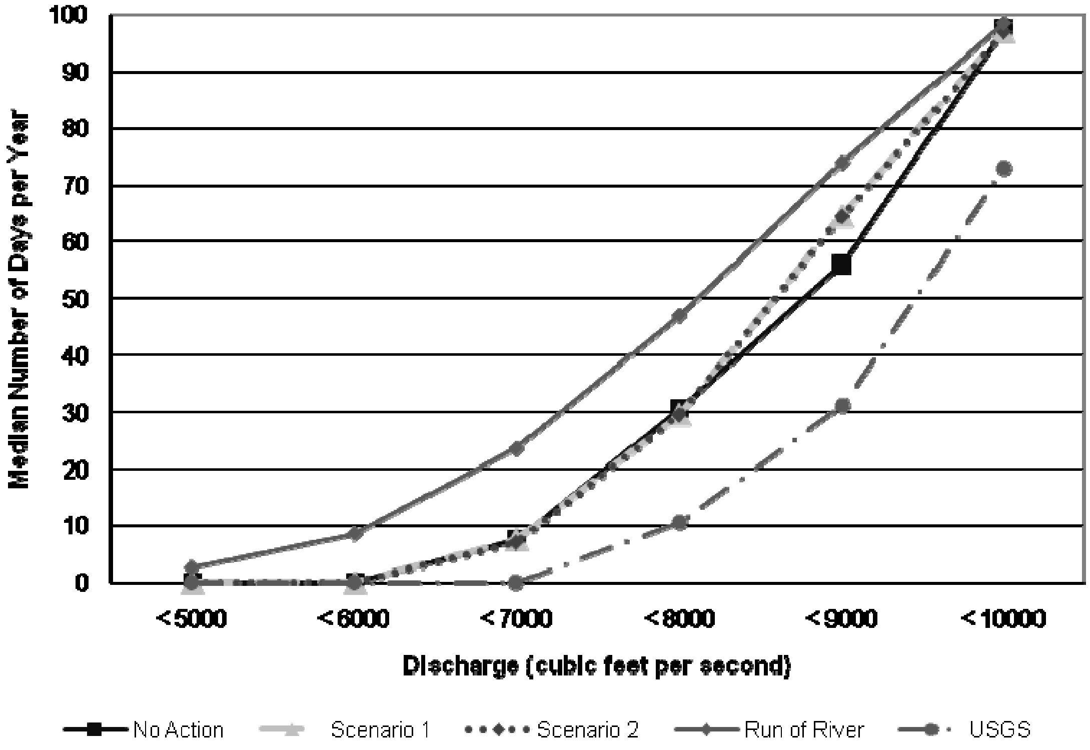


Figure 2.7-7. Median number of days per year with flows between (5,000-6,000), (6,000-7000), and (8,000-10,000) cfs (*Figure 4.2.5.D.* from the 2008 BO.*)*

2.7.2.6 Frequency (Percent of Days) of Daily Stage Change Expressed as ft/Day

The current RIOP maximum fall rate schedule was established to avoid extreme declines in daily river stage levels and decrease the risk of exposure or stranding of aquatic biota. Declining river stages are moderated by operating schedules to provide an attenuation of flows that allow for more gradual fall rates as flows decline. Those rates were evaluated to determine the effect of the Proposed Action Alternative strategies by using frequency histograms of the rate of change in the following categories: <= 0.25 ft/day, > 0.25 to <= 0.50 ft/day, > 0.50 to <= 1.00 ft/day, > 1.00 to <= 2.00 ft/day, and > 2.00 ft/day.

The No Action and Proposed Action fall rates are generally consistent and provide for higher frequencies of fall rates in the lower categories than the observed and RoR (**Error! Reference source not found.**). However, the No Action and Proposed Action simulations generally provide for lower frequencies of fall rates in the higher categories (>1.00 ft/day). Among the falling days the rates of less than 0.25 ft/day are the most common of the action flow scenarios, occurring approximately 25 percent of days. Collectively, the run-of-river fall rates above 0.25 ft/day occur with greater frequency than the Proposed Action Alternative and the No Action Alternative. Those rates increase the risk of exposure or stranding of aquatic organisms; however, because the majority of occurrences are within the 0.25- to 0.50-ft range, the effect of the water level changes is minimized.

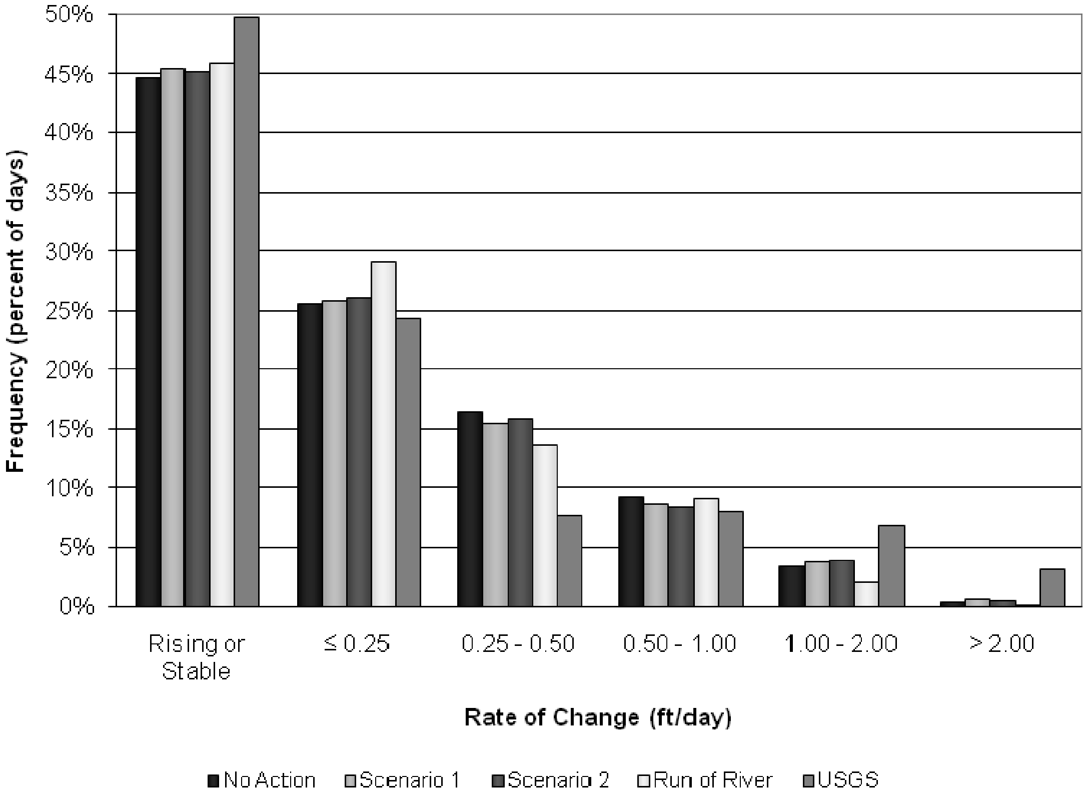


Figure 2.7-8. Frequency (percent of days) of daily stage changes (ft/day) from 1975–2008. (*Figure 4.2.5.E.* from the 2008 BO.*)*

2.7.2.7 Frequency (Percent of Days) of Daily Stage Change Expressed as Ft/Day when Releases at Woodruff Dam are less than 10,000 cfs

A second fall rate analysis was performed to evaluate whether an increase in the percentage of days with rates greater than 0.25 ft/day would affect federally listed mussel species. The evaluation is restricted to periods when releases from Jim Woodruff Dam are less than 10,000 cfs. The results are provided below.

The number of days in the greater than 0.25 ft falling rate categories of the No Action Alternative is nearly double that of measured USGS data (**Error! Reference source not found.**). The Proposed Action Alternatives had a similar number of days in the greater than 0.25 ft falling rate categories as the No Action Alternative. However, as discussed above, the majority of these days occur in the lower fall rate categories. Those results suggest that the Proposed Action Alternative is consistent with the No Action Alternative.

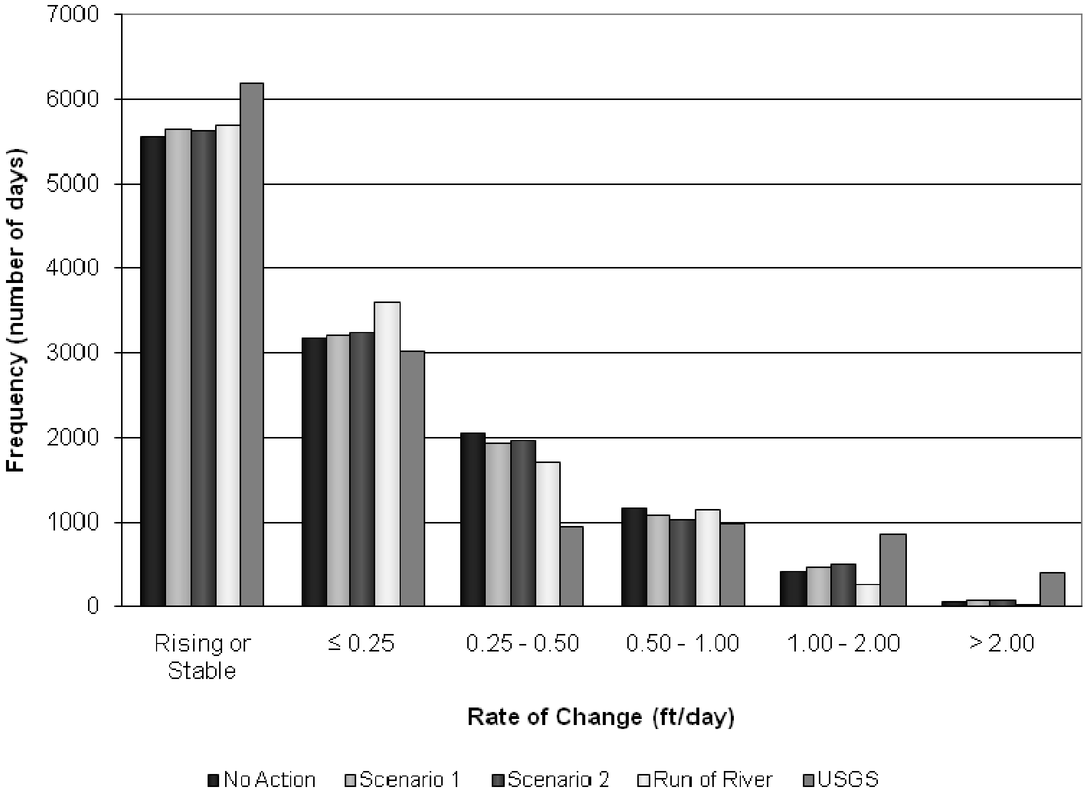


Figure 2.7-9. Frequency (# of days) of daily stage changes (ft/day) when releases at Woodruff Dam are less than 10,000 cfs from 1975-2008. (*Figure 4.2.5.F.* from the 2008 BO.*)*

2.7.3 Floodplain Connectivity Analysis

2.7.3.1 Frequency (% of days) of growing season (April - October) floodplain connectivity (acres) to the main channel using Light et al. 1998

Our analysis uses the relationship documented by Light et al. (1998) between total area of nontidal floodplain area inundated and discharge at the Chattahoochee gage. Figure 2.7-10 displays a frequency analysis (percent of days) during the growing season months (April – October) of connected floodplain area for the No Action Alternative, Proposed Action Alternative scenarios, RoR, and observed. The general area/frequency pattern of the No Action and Proposed Action Alternatives is comparable to the observed and RoR. However, the amount of habitat connected to the main channel at a given frequency for both of these is consistently less than the RoR. Figure 2.7-11 provides a similar analysis as this, but with an extended growing season as requested by the FWCC in their April 2010 supplemental letter to the PAL. The results of that analysis are consistent with those observed in Figure 2.7-10.

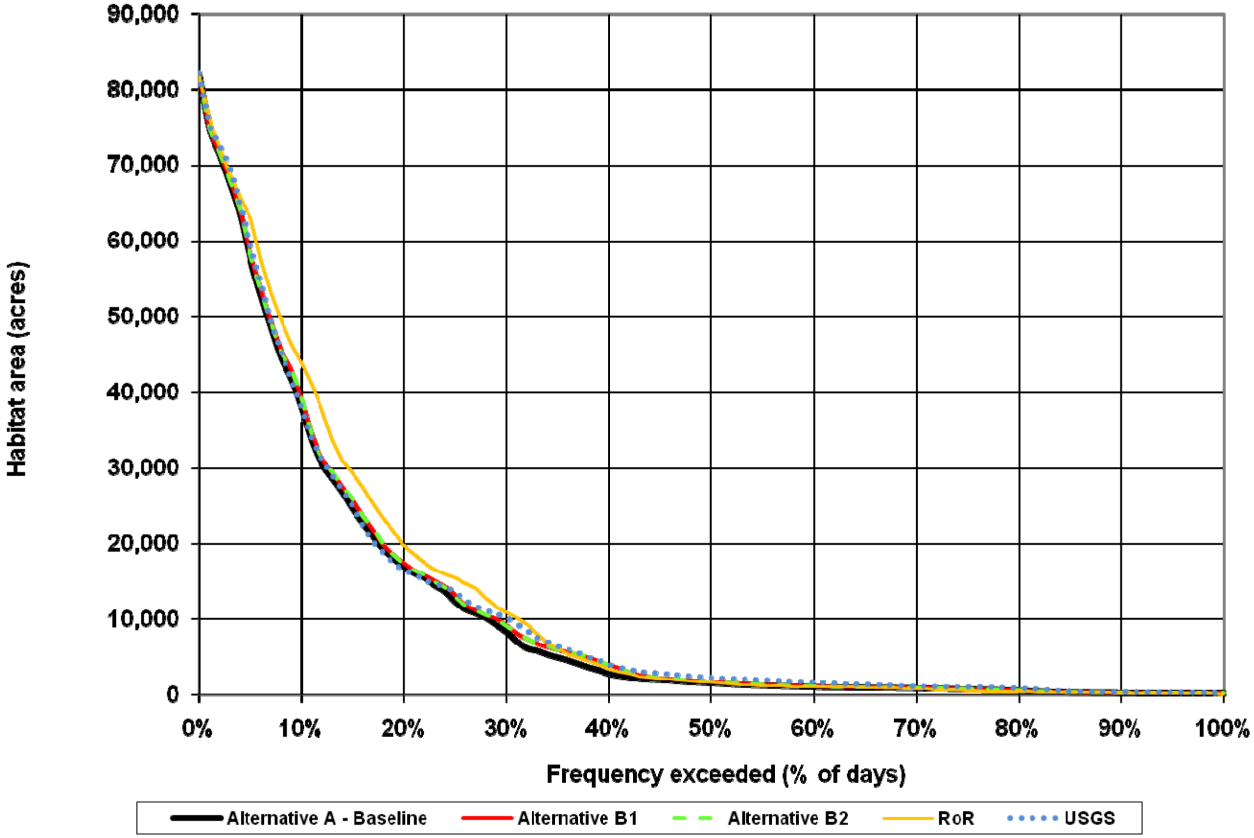


Figure 2.7-10. Frequency (% of days) of growing season (April - October) floodplain connectivity (acres) to the main channel using Light et al. 1998 (*Figure 4.2.6.A.* from the 2008 BO.*)*

2.7.3.2 FWCC Request - Frequency (% of days) of growing season (March-November) floodplain connectivity (acres) to the main channel using Light et al. 1998

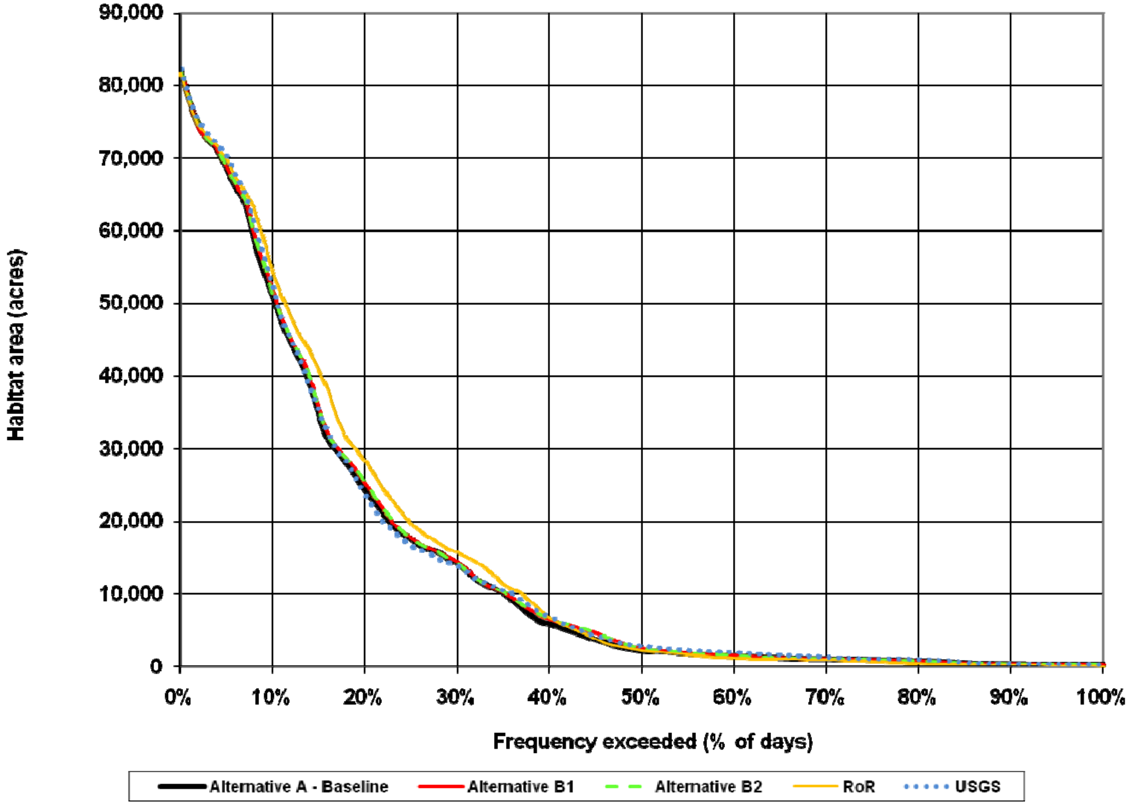


Figure 2.7-11. Frequency (% of days) of growing season (March - November) floodplain connectivity (acres) to the main channel using Light et al. 1998.

2.7.3.3 Frequency (% of years) of growing season (April – October Maximum) 30-day Continuous floodplain connectivity (acres) to the main channel using Light et al. 1998

In order to interpret biological impacts, it is also important to consider the temporal pattern of floodplain inundation. The growing season floodplain inundation was analyzed using a 30-day moving minimum to represent this aspect of habitat availability. The maximum acreage inundated for at least 30 days each year was then identified and illustrated in Figure 2.7-12. Annual 30-day continuous connectivity is roughly comparable between the No Action and the Proposed Action Alternative scenarios, but both are consistently less than the RoR flow regime. The observed flow regime consistently provided less 30-day continuous connectivity than the No Action and the Proposed Action Alternative scenarios.

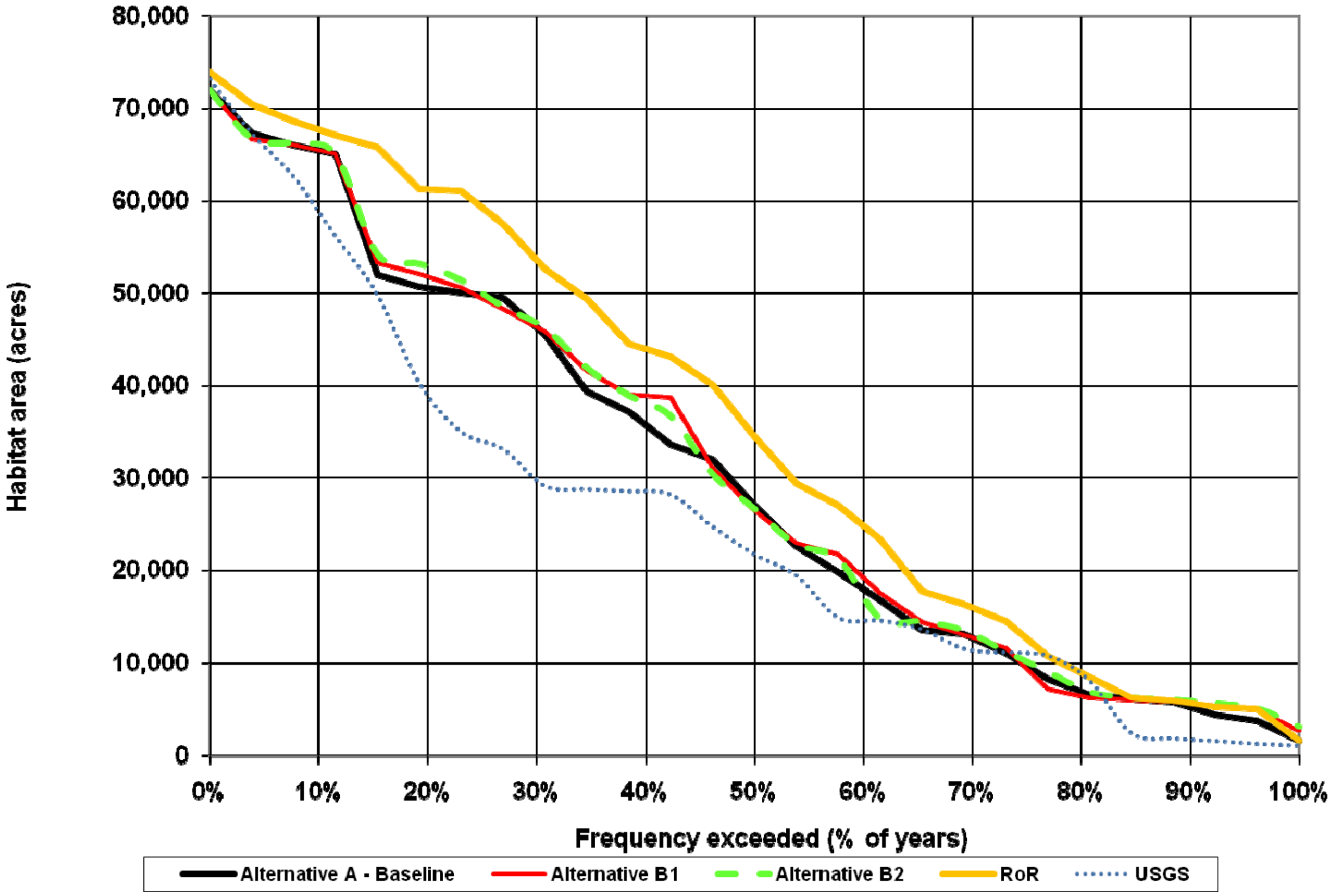


Figure 2.7-12. Frequency (% of years) of growing season (April – October Maximum) 30-day Continuous floodplain connectivity (acres) to the main channel using Light et al. 1998.

2.7.3.4 FWCC Request - Frequency (% of years) of growing season (March-November Maximum) floodplain connectivity (acres) to the main channel using Light et al. 1998.

Figure 2.7-13 provides a similar analysis as the previous section, but with an extended growing season as requested by the FWCC in their April 2010 supplemental letter to the PAL. The results of that analysis are consistent with those observed in Figure 2.7-12.

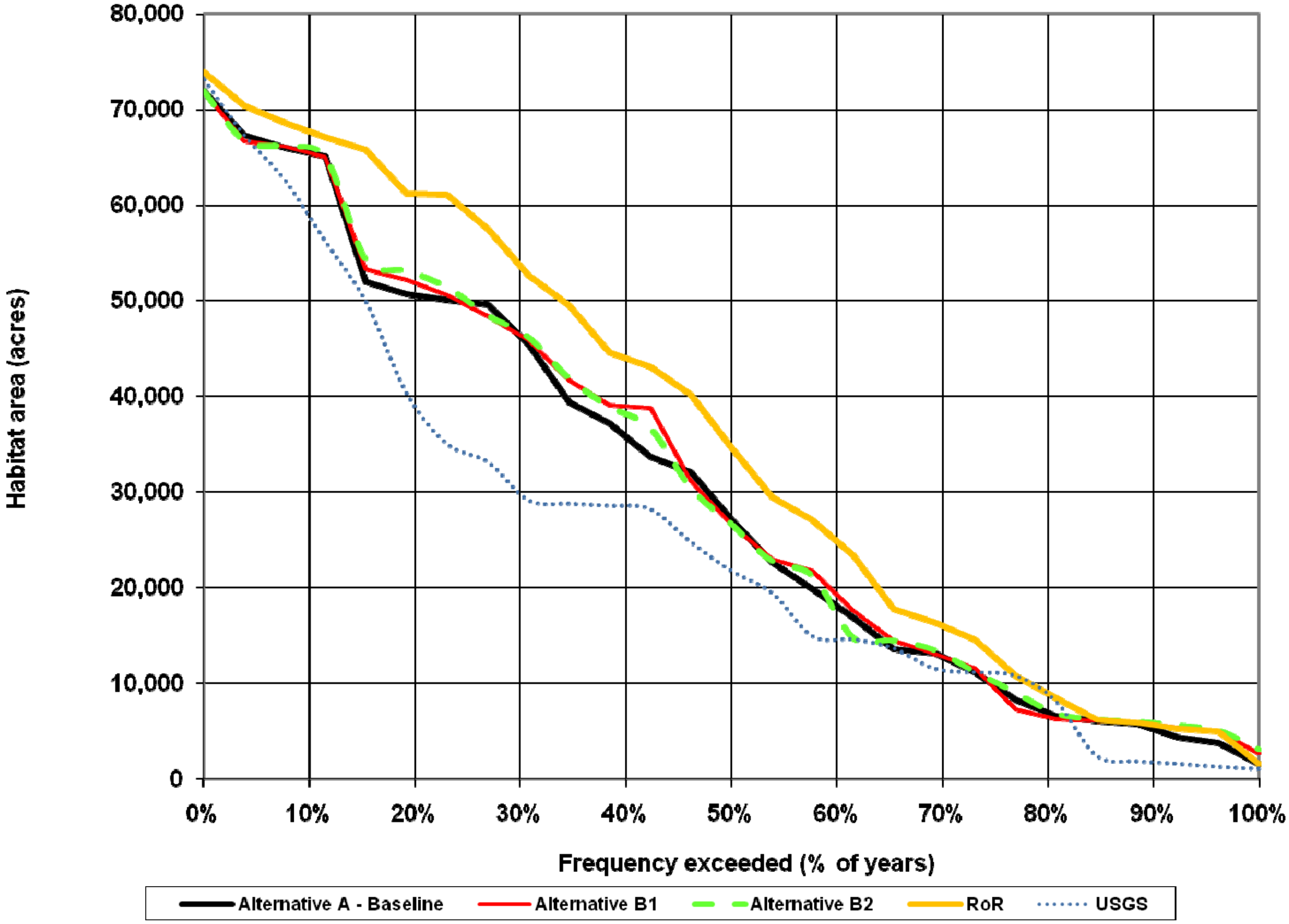


Figure 2.7-13. Frequency (% of years) of growing season (March-November Maximum) floodplain connectivity (acres) to the main channel using Light et al. 1998.

2.7.3.5 FWCC Request - Frequency (% of days) of growing season (March - November) with flows between 12,000 and 30,000 cfs (Tupelo/Cypress Swamps) Darst and Light, 2008

In their April 2010 supplemental letter to the PAL, the FWCC requested that we evaluate the frequency (% of days) of an extended growing season (March-November) with flows between 12,000 and 30,000 cfs. The general area/frequency pattern of the No Action and Proposed Action Alternatives is comparable to the observed and RoR.

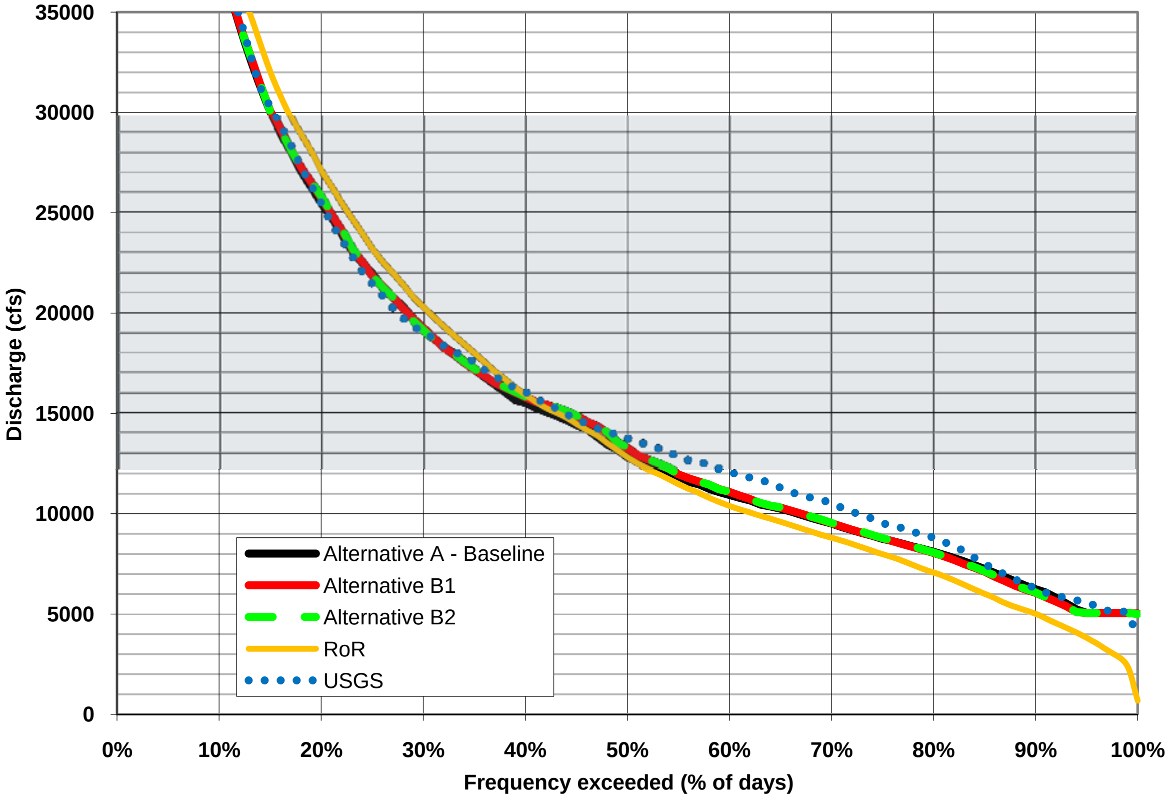


Figure 0-13. Frequency (% of days) of growing season (March - November) with flows between 12,000 and 30,000 cfs (Tupelo/Cypress Swamps) Darst and Light, 2008.

2.8 Additional Analysis - Fish and Wildlife Management Facilities

2.8.1 Eufaula National Wildlife Refuge

The potential impacts on Eufaula National Wildlife Refuge (ENWR) are primarily related to reservoir level fluctuations at W.F. George Lake, influencing the refuge in three critical areas (USFWS 1998): (1) direct effects on habitat availability for wildlife; (2) effects on vegetation communities, particularly with respect to invasive species; and (3) the availability of water during October and November to off-reservoir impoundments that support waterfowl habitat management.

Reservoirs are generally associated with large watersheds and tributaries because of their engineered purpose of providing flood damage reduction, hydroelectric power, and navigation. As a result, they are characterized as receiving large organic and inorganic inputs, high nutrient loads, and contaminants

(Miranda et al. 2010). Depositional filling effectively limits surface area and volume, thereby creating isolation of backwater areas, promoting habitat degradation, and decreasing overall depth (Patton and Lyday 2008).

Water-level fluctuation, common in reservoir settings, also limits the formation of persistent species associations and assemblage structure, especially in vegetation and open littoral zones. Drennen (1995) noted the importance of proper reservoir management strategies in the ACF Basin in support of wood duck (*Aix sponsa*) brooding and rearing habitat, heron rookeries, and foraging habitat for bald eagles, wood storks, and migratory species. Other species, including Florida softshell (*Apalone ferox*), common snapping turtle (*Chelydra serpentine)*, and common slider (*Trachemys scripta*) have been observed nesting in sandbars and mudflats when reservoir levels are below 186 feet (USACE, Mobile District 1998a).

Several factors influence the success of exotic introductions, including habitat connectivity and propagule pressure, disturbance and environmental variability, and species diversity and biotic interactions (Davis et al. 2000; Elton 1958). Davis and colleagues (2000) established the concept of fluctuating resources availability (FRA), which suggests that communities become more susceptible to invasions in response to the amount of unused resources. Disturbances may temporarily reduce the number of native species and thus provide an opportunity for invasive species. The FRA hypothesis specifically predicts that systems with fluctuating resources or elevated productivity will be more susceptible to invasive species. Within the ENWR, alligatorweed (*Alternanthera philoxeroides*) has become the most prolific invader of ephemeral wetlands in response to fluctuating water levels (USFWS 1998). Other undesirable species include black willow (*Salix nigra*), *Sesbania*, and cutgrass (*Leersia* spp.).

Reservoir levels lower than 186 feet provide important wading bird habitat during spring and fall and serve to concentrate waterfowl during the winter months. These habitats, not usually available at higher water levels, provide important forage and nesting areas. For example, Drennen (1995) observed ring-billed gulls feeding on mussels along flats that had become exposed during low-water conditions. However, in contrast, the ability to supply water to off-reservoir impoundments requires reservoir levels above 185 feet (Ziewitz and Luprek 1996). This also allows gravity-flow flooding, which provides a more precise and cost-effective means of adjusting water levels in the impoundments. The sections to follow describe how changes in operations under the No Action and Proposed Action Alternatives influence these factors in the ENWR

Under the No Action Alternative, no changes would be expected. The ability of W.F. George Lake to provide 13.4 mgd to support waterfowl at off-reservoir impoundments would continue.

The two scenarios for the Proposed Action Alternative show only minor differences in water level changes from the No Action Alternative, suggesting a similarly low potential of effect on the shoreline vegetation and wildlife communities at ENWR. Additionally, inspection of water surface elevation plots at Walter F. George Lake for critical low-flow periods indicate that, with the exception of August through November when surface elevation drops to 184.50 ft, if ever, reservoir levels always remain above 185 feet under the Proposed Action Alternative. Thus, W.F. George Lake is expected to continue to provide 13.4 mgd of water to support waterfowl at off-reservoir impoundments.

The USFWS asked that the Corps consider cycling surface elevations at W.F. George to the highest levels (190 ft) in the late winter and lowest levels in early spring (185 ft). This operation was considered but deemed to not represent a viable operating alternative (USFWS 2010). Current reservoir operations use winter draw-downs to accommodate flood releases from upstream projects and higher basin inflow during the wet season (2.8-1). Refilling usually occurs during the spring, typically at the end of the wet season, to provide storage to meet authorized project purposes and augment flows downstream of the project as needed. Holding the reservoir at higher elevations during the winter wet season would increase induced surcharge and the frequency of damaging downstream flows causing bank erosion and channel modifications below the project. Maintaining low elevations during the summer dry season would remove composite conservation storage from the system at a time when it is most critically needed for flow augmentation and hydroelectric power production. Additionally, this proposed operation contradicts the current fish spawning standard operating procedure for the reservoir, which calls for steady to increasing pool elevations during the spring.

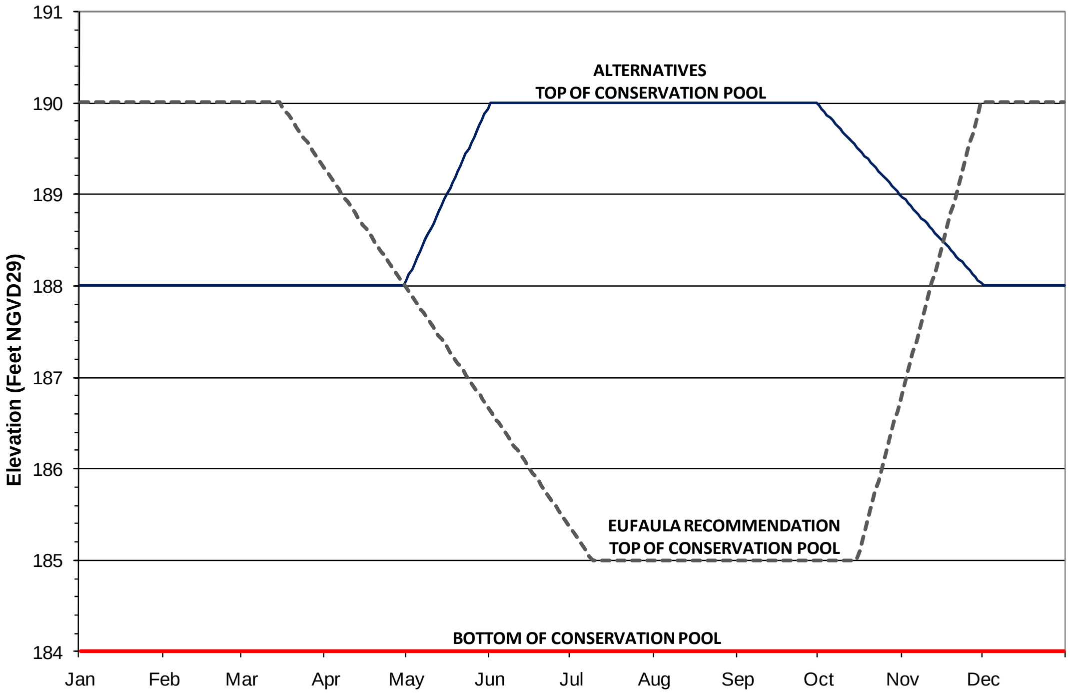


Figure 2.8-1. Eufaula National Wildlife Refuge recommended water surface elevation compared with the No Action and Proposed Action Alternatives top of conservation pool elevation.

2.8.2 Fish hatcheries

There are four fish hatcheries in the ACF Basin. The discussion below describes how changes to operations at Federal reservoirs would affect the hatcheries.

Under the No Action Alternate, no changes would be expected at any of the hatcheries.

Three of the hatcheries in the ACF Basin use groundwater. These hatcheries would not be affected by the Proposed Action Alternative.

Buford Trout Hatchery withdraws about 7 mgd (11 cfs) of flow from the Chattahoochee River below Buford Dam year-round (Ziewitz and Luprek 1996). The results of the HEC-5Q water quality modeling for the period from 1975 through 2008 indicate only minor changes in the Proposed Action Alternative from the No Action Alternative with respect to water temperature and the dissolved oxygen concentrations of coldwater bottom discharges from Lake Lanier through Buford Dam. Therefore, no effects on the Buford trout Hatchery's operation would be expected as a result of the Proposed Action Alternative.

2.9 Response to 27 May 2010 FWS Email

1. Apalachicola River- We would like to examine effects of maintaining 15,400 cfs (Chattahoochee gage) for Navigation through May 15 as a guaranteed continuous minimum flow, and a similar

> analysis through May 31. We would also like to know under which zones you intend to operate for navigation. During our telephone conversation, you indicated that the Corps has modeled a 15,400 cfs navigation season from January 1 through April 30, but that the Corps will not maintain a minimum 15,400 cfs discharge unless requested to do so. Thus, it is unclear whether the baseline and two alternatives represent anticipated operations with or without a request for a 15,400 cfs discharge. If the RES-SIM model does not include a guaranteed continuous minimum flow of 15,400 cfs through April 30, we would like to examine the RES-SIM output for 15,400 cfs extending through April 30, May 15, and May 31 (within the same navigation operating zones) so that we can evaluate the effects of these changes on system operation.

During development of the Navigation Season operation, the Corps simulated various navigation depth scenarios and season length scenarios. At that time, it was assumed that a 7 foot stage at Blountstown provided a 7 foot depth navigation channel, which corresponded to a 15,400 cfs flow. The model simulations considered navigation seasons from December through April; January through April; and December through May. Under these scenarios, navigation support was limited to times when composite conservation storage was in zones 1 or 2. Once composite conservation storage fell below zone 2, the navigation season was no longer supported and additional support could not occur until the composite conservation storage had recovered to above zone 2 (i.e. within zone 1). In evaluating the impacts of implementing the navigation season concept, we analyzed how providing the 15,400 cfs minimum flow impacted the number of times that drought operations were triggered in the basin. The December through May navigation season triggered drought operations approximately twice as often (for the period of record simulation) as the January through April navigation season. The January through April navigation season was more closely in line with the number of times drought operations were triggered under the current operations (Baseline).

We recently completed updated channel surveys of the Apalachicola River. Based on the results of those surveys we have adjusted the navigation flow to 16,200 cfs to provide a 7 foot navigation channel without dredging support during the navigation season. Due to the increased flow necessary to provide the 7 foot channel, we again ran simulations to test the viability of implementing a navigation season. The updated model simulations considered navigation seasons from January through April and January through May. All other rules and triggers remained the same. These simulations demonstrated that extending the navigation season through May does not increase the number of times that drought operations were triggered in the basin as compared to the January through April navigation season and the Baseline. Thus the preferred alternative will include a navigation season that provides for a navigation flow of 16,200 cfs at the Blountstown Gage from January through April/May of each year (as long as the composite conservation storage constraints are not violated).

It should be noted that in all the simulations, as long as the appropriate triggers and conditions were met, the navigation season flows were always supported. This represents the scenario that would demand the most storage to augment flows, and thus was used to test the viability of implementing a navigation season. This is also a good representation of the way we intend to operate in support of navigation. However, in addition to the conditions described above, the determination to extend the navigation season beyond April will depend on ACF basin inflows, recent climatic and hydrological conditions, meteorological forecasts, and basin-wide model forecasts. The Corps will determine if the navigation season will continue through part or all of May based on an analysis of these factors. As with all operations, we reserve the flexibility to shorten, interrupt, or cancel a navigation season due to safety, physical, or mechanical constraints. Since the updated model simulations indicate that a navigation flow of 16,200 cfs is viable from January through May 31, we will not run additional simulations evaluating the viability of a navigation season from January through May 15.

2. Chattahoochee River (Norcross and West Point)- We recommend that the Corps use the RES-SIM model to evaluate the provision of non-hydropower peaking ”windows” during critical reproductive and rearing periods for a minimum of 4 weeks from March – May. Reiterating several points from our conference call, a non-peaking hydro window does not mean that power cannot be generated. It simply means that the Corps operate the reservoir in a manner that reduces hydrograph fluctuations that are, in part, due to power generation.

The most important thing to consider in this request is that the Buford and West Point projects were designed to operate as peaking hydropower projects. The District Court specifically addressed this issue in its July 17, 2009 Order (page 93). To meet your requested flow targets the Corps would have to forgo operating the large generators at both dams for 30-60 days. This would cause a tremendous loss of hydropower production at the projects and we believe such a loss of hydropower is not supported by the project authorizations.

However there are also physical, safety, and logistical limitations to operating the projects in a non-hydropower peaking mode for any amount of time, much less 30-60 days. Therefore, to thoroughly address your request (despite the District Court’s decision and the required temporary abandonment of an authorized project purpose), we gathered the appropriate PDT members together to discuss the realities of trying to implement the type of operation you requested. First, it is our understanding, based on the PAL, that the target range of flows for the March through May period would be approximately 1,800-2,000 cfs for an average year (as measured at the Norcross Gage below Buford) and approximately 4,500-5,000 cfs for an average year immediately below West Point. Thus we discussed the viability of providing those flows without peaking operations for a minimum 30 day period.

At Buford, releases are made either through one/both of two main units (approximately 4,500-6,200 cfs capacity each), the small unit (approximately 600 cfs capacity), or one of the two jet flow valves installed in the sluice gates (approximately 600 cfs capacity each). Because there is only one emergency gate, only one sluice gate or jet valve is used at a time due to safety constraints. The emergency gate is used whenever releases are made from the jet flow valves or sluice gate to provide a secondary flow shut off should a valve or gate get stuck open. Given the two large units design, they cannot be utilized to meet the target flow. A combination of the small unit and one of the two valves will yield approximately 1,200 cfs. This is less than the target flow for an average or a dry year, but all that is feasible under the current operating procedures for the project. In order to make releases of 1,800 cfs, a combination of the small unit and one partially opened sluice gate would be required. However, the new sluice gates have not been tested for partial openings above the minimum 600 cfs flow. Considerable vibration occurs when the sluice gates are only partially opened which results in increased wear on the gates and the risk of failure. The jet flow valves were installed to eliminate the need for partial gate openings and reduce this risk. Therefore, operations involving extended periods of time with partially opened sluice gates are not advised.

Theoretically, a range of flows between 600 cfs (just the small unit) and 1,200 cfs could be released. However, this range would be lower than the target range for an average or dry year. Managing releases in this fashion, although potentially feasible from a purely mechanical standpoint, also raises serious concerns regarding safety, storage, and hydropower generation. Safety is always the biggest concern when operating equipment differently than the intended purpose and the chance for unforeseen problems is magnified. Finally, as discussed above, the proposed operation inherently impacts hydropower generation both through the cessation of peaking operations and through the use of potentially significant amounts of storage. During dry springs with little to no local inflows, the target flow would require approximately 200 cfs more per day (during the week) and 1,200 cfs more per day (during the weekends) than the peaking operation. This equates to approximately 30,000 acre-feet of water, equivalent to roughly a 1-foot drop in the lake surface elevation. The issue is compounded more by the fact that the operation takes place during the refill period for the project. For all these reasons, we feel it is not prudent to further evaluate non-hydropower peaking ”windows” at the Buford project even if it would not constitute a significant loss to the authorized purpose of hydropower generation.

At West Point, releases are made either through one/both of the two main units (approximately 6,800-7,800 cfs capacity each), the small unit (approximately 675 cfs capacity), or the six spillway gates (capacity of the spillway gates is based on head differential, but generally is about 800 cfs for pool levels during this time of year). Given this design, the main units cannot be utilized to meet the target flow. A combination of the small unit and 5-6 of the spill gates could potentially yield the target flow of approximately 5,000 cfs. Although, the West Point project does not have the mechanical limitations regarding the target flow that exist at Buford Dam, operating as requested in the PAL would raise serious concerns regarding safety, project/downstream recreation, and storage/hydropower generation.

Again, safety is always the biggest concern when operating equipment differently than the intended purpose and the chance for unforeseen problems is magnified. Leaving spillway gates open for extended periods of time increases the possibility of debris getting lodged in the gate and damaging the equipment and produces increased maintenance costs due to additional wear and tear. This is especially problematic since the West Point project is operated remotely from the Walter F. George project site. Finally, this operation inherently impacts hydropower generation both through the cessation of peaking operations and through the use of potentially significant amounts of storage. Generally, the target flow would require higher releases than the peaking operation. The issue is compounded more by the fact that the operation takes place during the refill and active flood control period for the project. For all these reasons, we feel it is not prudent to further evaluate non-hydropower peaking ”windows” at the West Point project, even if it would not constitute a significant loss to the authorized purpose of hydropower generation.

3. Chattahoochee River (Norcross and West Point)- We recommend that the Corps use the RES-SIM model to evaluate the provision of a seasonally varying baseflow hydrograph that more closely approximates natural conditions. Understandably, there are constraints imposed by meeting downstream discharge/water quality requirements and the flexibility of dam operations. Thus, we expect that part of this analysis and modeling effort may include synthesizing information that describes the range of flows that can be delivered from each turbine, and supplementing those flows using alternative methods (e.g., through sluicing).

We discuss the range of flows that can be delivered by each unit at the Buford and West Point projects in the previous response. As suggested in the PAL, we plotted the no action (baseline) and alternative scenario hydrographs for comparison to the pre-dam or “natural” condition base flow hydrographs provided in the PAL (Figures 1 and 2). This comparison illustrates that the presence of the dams and their operation has altered the pre-dam flow regime by generally providing a more stable flow pattern with higher base flow and lower peak flows. Both of these projects were designed to provide flood damage reduction and thus the alteration of seasonal variability and reduction of higher peak flows is not surprising. Evaluating the lower limits against one another provides a quick illustration of the general trends for the various scenarios compared to the more natural flow regime (Figure 3). In the Norcross comparison, the Alternative B scenarios level the hydrograph shape as compared to the Baseline condition. However, they do not mimic the “natural” flow regime. In the West Point comparison, the Alternative B scenarios also generally improve upon the Baseline condition and come closer to mimicking a “natural” hydrograph shape for this location. Additional improvements to either of the hydrographs would require more discussions between our agencies on the most critical aspects and to what extent, if any, the Corps can further modify the proposed operation to meet those needs. Based on our previous discussions, it is agreed that operating to match the “natural” flow regime is not possible at these multipurpose projects since they were designed and built to alter the “natural” flow regime. Defining a real life operation that meets the authorized project purposes and better meets the “natural” hydrograph and then translating that operation into code for the reservoir simulation is a large undertaking. To the extent that FWS feels more needs to be done, we request additional guidance and support.

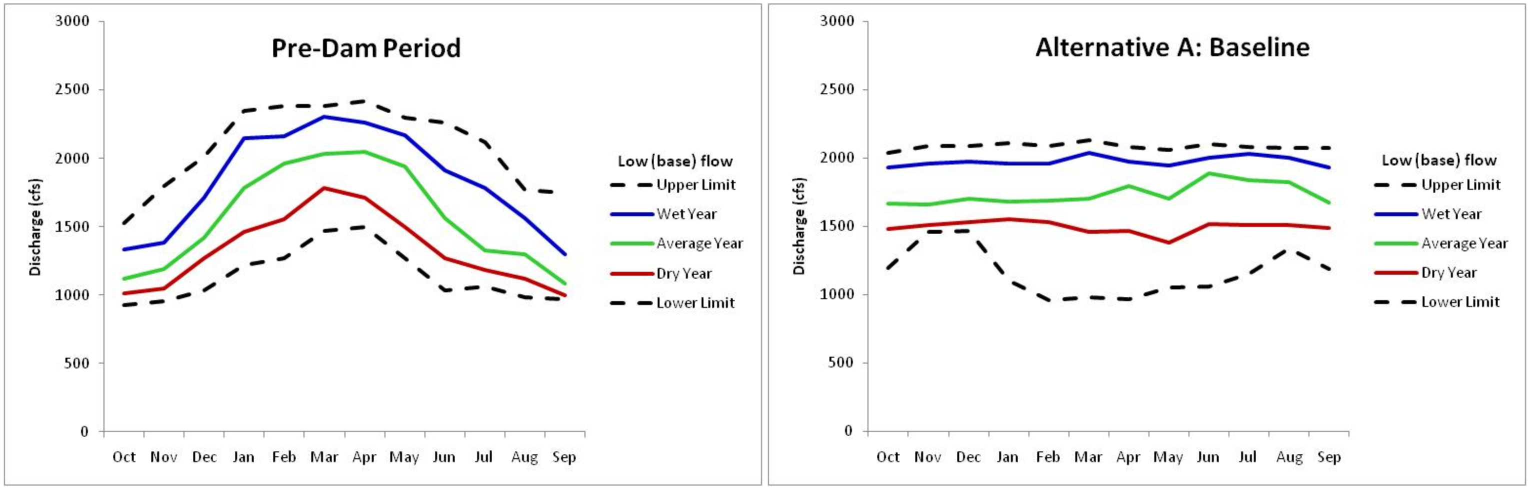
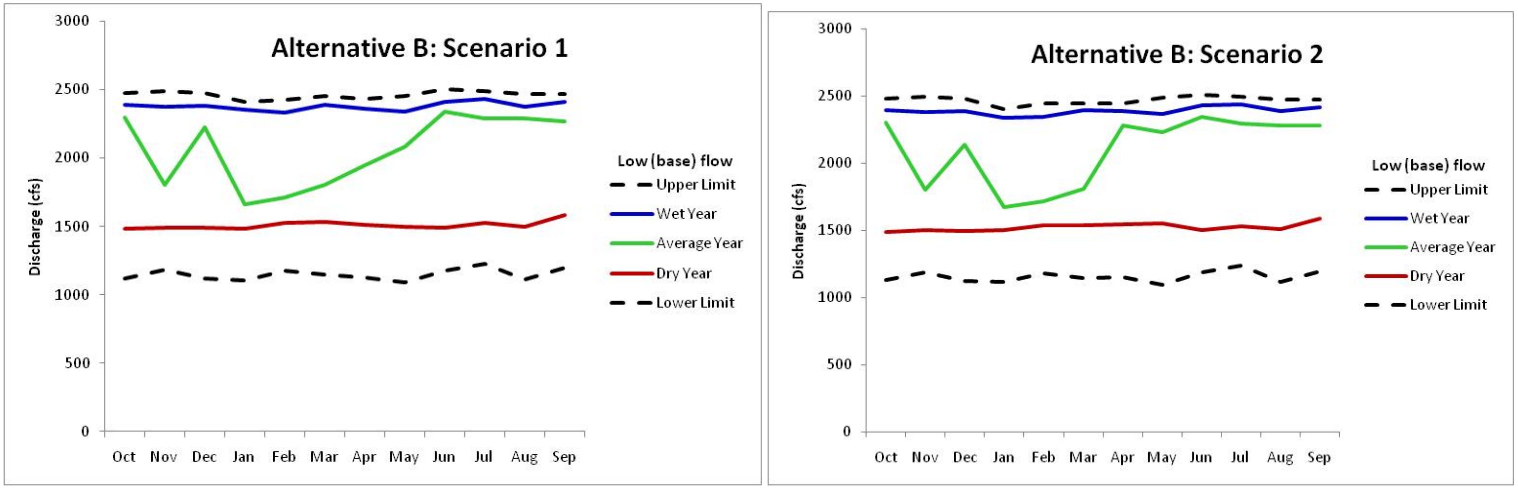

Pre-Dam Period
Alternative A: Baseline
Discharge (cfs)
0
500
1000
1500
2000
2500
3000
Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep
Low (base) flow
Upper Limit
Wet Year
Average Year
Dry Year
Lower Limit

Figure 1


Alternative B: Scenario 1
Alternative B: Scenario 2
Discharge (cfs)
0
500
1000
1500
2000
2500
3000
Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep
Low (base) flow
Upper Limit
Wet Year
Average Year
Dry Year
Lower Limit

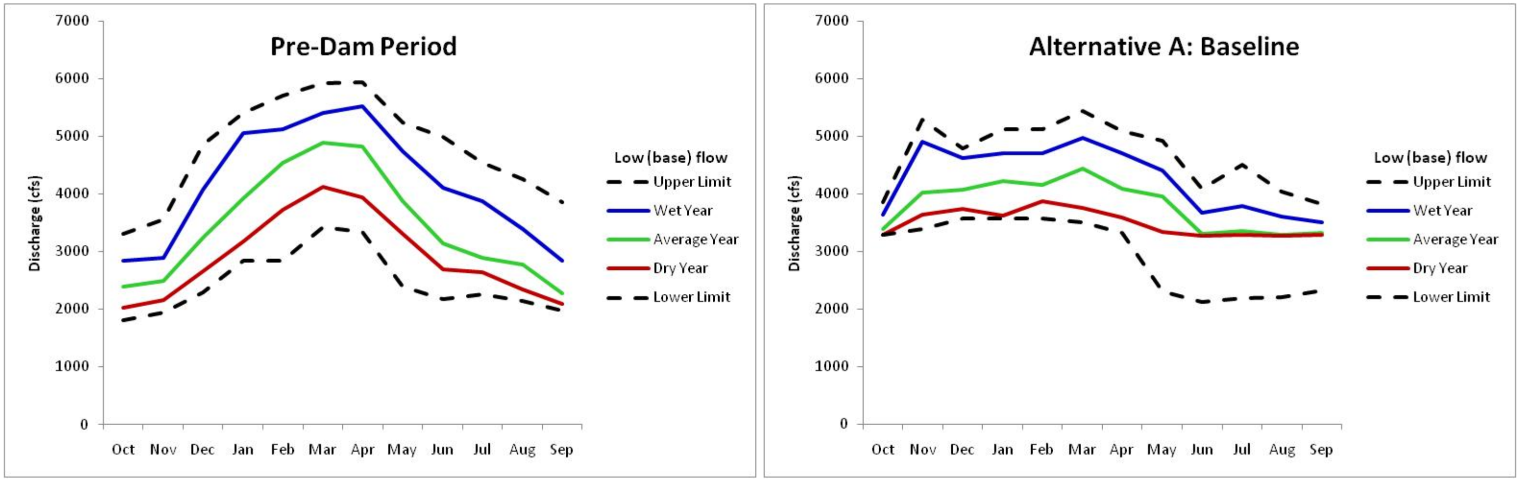
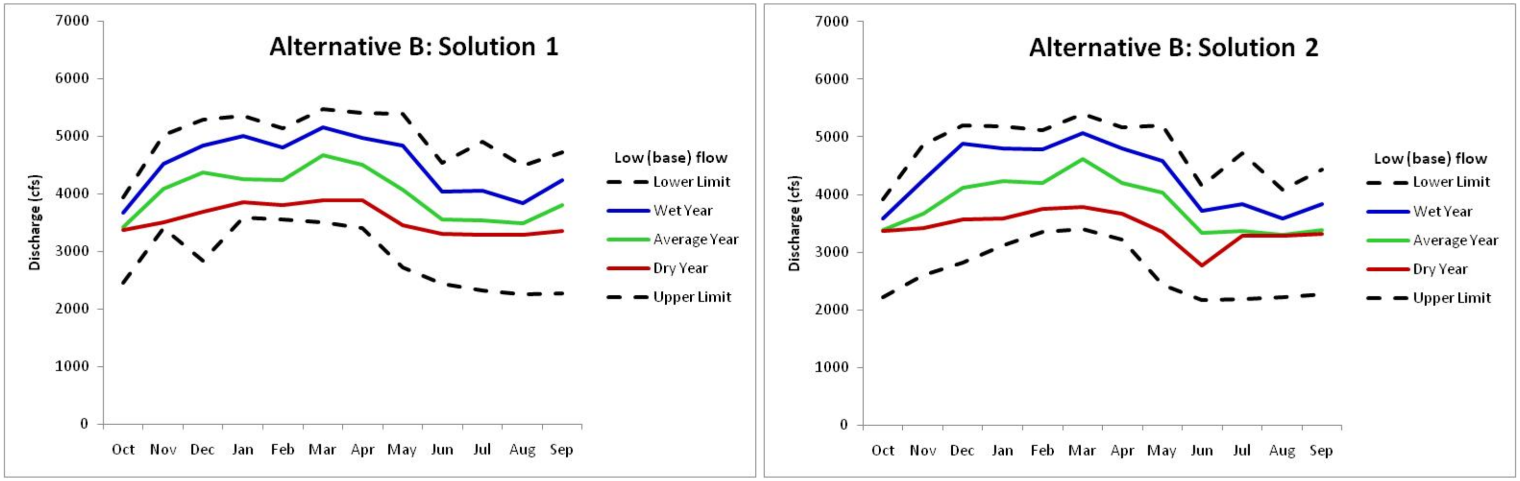

Pre-Dam Period
Alternative A: Baseline
Discharge (cfs)
7000
6000
5000
4000
3000
2000
1000
0
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Low (base) flow
Upper Limit
Wet Year
Average Year
Dry Year
Lower Limit

Figure 2


Alternative B: Solution 1
Alternative B: Solution 2
Discharge (cfs)
7000
6000
5000
4000
3000
2000
1000
0
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Low (base) flow
Lower Limit
Wet Year
Average Year
Dry Year
Upper Limit

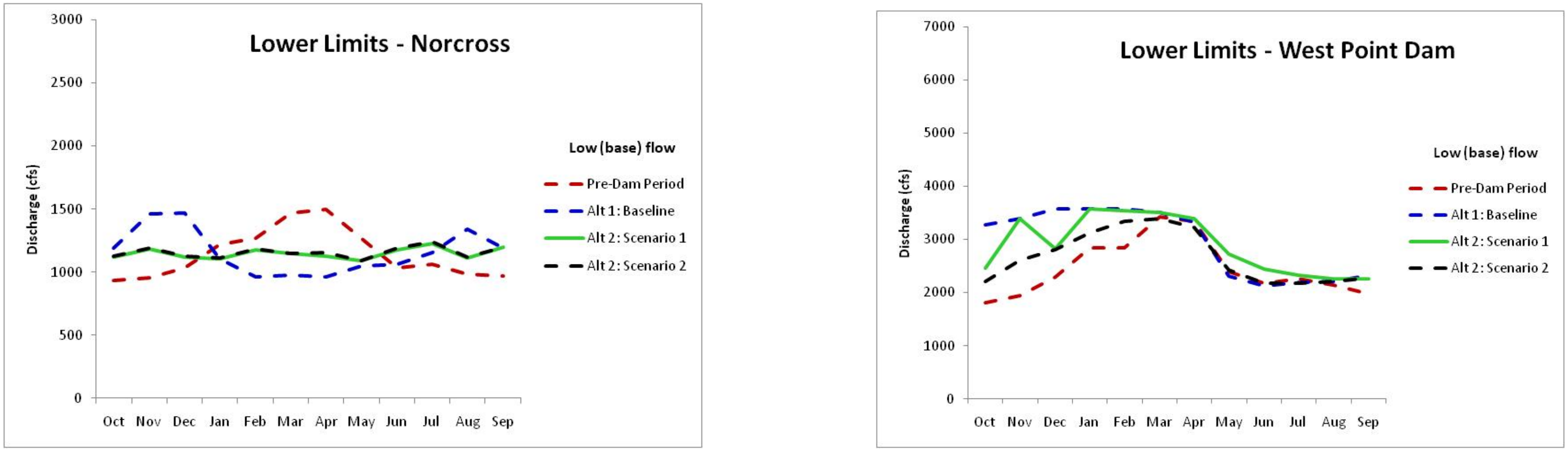

Lower Limits - Norcross
Discharge (cfs)
3000
2500
2000
1500
1000
500
0
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Low (base) flow
Pre-Dam Period
Alt 1: Baseline
Alt 2: Scenario 1
Alt 2: Scenario 2
Lower Limits - West Point Dam
Discharge (cfs)
7000
6000
5000
4000
3000
2000
1000
0
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Low (base) flow
Pre-Dam Period
Alt 1: Baseline
Alt 2: Scenario 1
Alt 2: Scenario 2

Figure 3

4. Chattahoochee River (Norcross and West Point)- Our preliminary analysis of the Baseline, RPLAN550WQ0, and RPLAN750WQ0 alternatives indicates that the timing, duration, and frequency of the small flow pulses is similar to the unimpaired and/or unregulated (pre-Buford Dam USGS data) flow datasets at Norcross for the January 1- March 31 and April 1- June 30 periods. However, the magnitude of the small pulses is smaller than both the unimpaired and unregulated flow datasets. Thus we recommend that the Corps use RES-SIM to model the provision of small pulses with magnitudes that are more similar to the Unimpaired and/or Unregulated flow datasets. Preliminary analysis of flow alternatives at the West Point gage indicates that there is essentially no provision for small pulses, and we recommend that the Corps use RES-SIM to model the provision of small pulses with magnitudes, frequencies, durations, and timings that are more similar to the Unimpaired and/or Unregulated flow datasets at the West Point node.

-And-

5. Chattahoochee River (Norcross and West Point)- Our preliminary analysis indicates that there are no provisions for high pulses in the Unimpaired, Baseline, RPLAN550WQ0, and RPLAN750WQ0 datasets for the January 1- March 31 and April 1- June 30 periods at Norcross and West Point. High pulses wouldn't naturally occur every year, but they would occur in < ½ of the years during this period. Thus, we recommend that the Corps use RES-SIM to model the provision of high pulses, and for the Corps to refer to the Planning Aid Letter to guide the development of RES-SIM model parameters for high pulses.

Again, we request your assistance in defining an operation that meets the authorized project purposes and better meets the small and high flow pulses evident in a natural flow regime.

6. Chattahoochee River (Walter F. George) – We recommend that the Corps use RES-SIM to model the provision of a seasonal pattern of reservoir levels at Walter F. George to best accommodate the needs of Eufaula National Wildlife Refuge (Refuge). As we stated in the PAL, water levels that provide seasonal habitat for a large number of migratory bird species, control the spread of undesirable aquatic vegetation, and allow the manipulation of off-reservoir impoundments for waterfowl are principal concerns of the Refuge. We have recommended reservoir elevations that cycle between the highest levels (190 ft) in the late winter and early spring to the lowest levels (185 ft) in the late summer. The Corps has stated that this type of operation would impact the Corps' ability to comply with the RIOP. We would like to examine the RES-SIM output for this provision so that we can evaluate the effects of these changes on system operation.

As we discussed before, the Corps has serious misgivings regarding operating the Walter F. George project in this fashion. Our concerns are based on two inherent problems with your proposal from a water management standpoint. To illustrate our concerns and your proposal please reference Figure 2.8-1 above. As you can see, during current operations the reservoir is drawn down in the winter to accommodate flood releases from the upstream projects and higher basin inflow during the wet season. The project is refilled during the spring (typically the end of the wet season) to provide storage to meet authorized project purposes and augment flows downstream of the project as needed. This is a typical reservoir operation and works rather nicely based on the seasonality of the rainfall and the size of the basin. The proposed operation is opposite of how a reservoir is intended to work and essentially removes the reservoir from the system (operationally-not physically). By holding the reservoir higher during the winter wet season, induced surcharge and damaging downstream flows are increased resulting in bank erosion and channel modifications below the project. By holding the reservoir low during the summer dry season, a significant amount of the composite conservation storage is removed from the system during the time when it is most critically needed from both a flow augmentation and hydropower production standpoint. In fact, WFG is typically the first reservoir used to provide flow augmentation under the RIOP. In addition, by moving the refill period to the late summer/fall there is a chance that the project may not refill and extended years of this scenario would stress the remaining storage in the system and the project. The proposed operation also contradicts the current fish spawn SOP for the reservoir which calls for steady to increasing pool elevations during the spring. Given the demands of the system, including the minimum flow provisions of the RIOP, the proposed operation would have significant impacts on the authorized project purposes as well as the structural stability and safety of the dam. For these reasons, we do not believe it is prudent to simulate the inherently significant impacts associated with the proposed operation.

USFWS Addendum to Planning Aid Letter March 2011

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March 1, 2011

Colonel Steven J. Roemhildt
US Army Corps of Engineers, Mobile District
P.O. Box 2288
Mobile, AL 36628-0001

Dear Colonel Roemhildt:

We are providing an Addendum to the U.S. Fish and Wildlife Service (Service)'s April 2, 2010, Planning Aid Letter (PAL) for the proposed Water Control Manual (WCM) Updates for the Apalachicola-Chattahoochee-Flint (ACF) River Basin in Georgia, Alabama, and Florida. The purpose of the WCM Updates is to identify operating criteria and guidelines for managing water storage and release of water from United States Army Corps of Engineers (Corps) reservoirs. In the National Environmental Policy Act (NEPA) review, the Corps will address current operations, proposed changes in water management operations at the reservoir projects within the limits of the existing authorities, as well as potential impacts throughout the basin that would result from implementation of the updated manual.

The purpose of the Service's 2010 PAL was to identify resource values and issues, identify endangered species issues, and propose preliminary changes, mitigation, or enhancement opportunities to facilitate your decision-making as it relates to equal consideration of fish and wildlife resources. Based on recent analyses conducted by the Service, we submit the following addendum under the Fish and Wildlife Coordination Act (FWCA) (48 Stat. 401, as amended; 16 U.S.C. § 661 *et seq*.). This addendum solely addresses ecosystem flow guidelines -- all other information and recommendations in the PAL are still applicable. In the future, we will provide additional information in the form of a draft Fish and Wildlife Coordination Act report. A separate consultation will occur regarding the potential impacts of the Corps' proposal on federally-listed fish and wildlife species protected under the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. § 1531 *et seq*.).

Rationale for revision of ecosystem flow guidelines

The ecosystem flow guidelines that were delivered in the PAL were developed with the aid of Indicators of Hydrologic Alteration (IHA; TNC 2007). Although the IHA methodology is scientifically defensible, subsequent examination of IHA methodology and output revealed several concerns that could affect possible incorporation of the guidelines in the Corps' operations. Therefore, the Service is providing revised low and high flow guidelines (Figures 1-4 and Tables 1-4).

We had two reasons for revising the flow guidelines. First, the default IHA parameters used for the PAL initially separated the flow data into high and low flows using a percentile of the pre-Buford period of record. This method resulted in representation of low-flow discharges in summer-fall months by many values, and representation of low flows in winter-spring months by fewer values. This means that some months in some years were not represented in subsequent analyses. For example, historic low flows in the Apalachicola River remained above the 75th percentile or above flood stage for prolonged time periods, meaning that those periods were not represented in the low flow analysis. Thus, if the historic flow regime is to be used to help guide low flow alternative development, evaluation, and implementation, the low flow analysis should examine the entire range of low flows that occurred in every month of every year before construction of Buford Dam.

Second, the low and high flow analyses in IHA calculate summary statistics using median values (for non-parametric analyses) to represent each year (TNC 2007). For example, IHA calculates the annual median high pulse magnitude, and uses the median values from every year to calculate summary statistics. While this is a statistically valid approach to summarizing large datasets, summarizing multiple intra-annual pulses by a single value results in a narrower range of magnitude, duration, timing, and rate of change values. Because the intent of the analysis is to quantify a range of discharge values that are likely to be beneficial to riverine habitat and fauna and to facilitate planning for high flows in the Corps' operations, we calculated the following high-flow guidelines by including each high flow event in summary statistic calculation (e.g., percentiles representing upper and lower limits, and dry, average, and wet years). With the exception of not using annual medians to calculate percentiles, the revised method for high flow guideline development is analogous to the "non-advanced" method for high flow analysis in IHA.

Low flow analysis methodology

1. In Microsoft Excel, the seven smallest values from each month in every year were extracted for analysis. We chose multiple values to represent each month so that the overall results are less likely to be influenced by an aberrant value (i.e., less likely to be skewed by one value), especially in future analyses that may examine and compare Corps' modeled flow alternatives which are likely to occasionally contain negative discharge values. A comparison of the effects of one, seven, and ten minimum flow values to represent low flows in each month showed little difference in overall low flow hydrograph shape, similar flow magnitudes throughout the year, and minor differences in winter 90th percentile flow magnitudes. These results also generally correspond to the Web-based Hydrograph Analysis Tool (WHAT Local Minimum Method; Lim et al. 2005) output for baseflow generation. Collectively, these results lend greater support for the decision to use the seven lowest values to characterize low flows.

2. The 10th, 25th, 50th, 75th, and 90th percentiles for each month were calculated on the extracted data to define the lower limit, dry year, average year, wet year, and upper limit, respectively.

3. The Walter F. George low flow guidelines were calculated slightly differently. A long-term period of pre-Buford Dam discharge data was not available below Walter F. George. As a proxy

for actual data, the Corps' unimpaired flows dataset was used. As referenced in the PAL, the unimpaired flows datasets do not accurately represent the magnitude, duration, timing, and rate of change of flow extremes (p. 14 in April 2, 2010 PAL). Thus, these low flow guidelines should be treated as estimates.

4. Note that in this low flow analysis, in cases where an entire month is above flood stage, the lowest values are flood-related values. A strength of the low flow analysis is that the user can characterize the entire range of the lower flows that occur in every month of the user's flow dataset.

High flow analysis methodology

1. In Microsoft Excel, the 75th percentile of all flows in the time series was used as the flow threshold to separate high flows from the remainder of the flow dataset. Because this is consistent with our understanding of the meteorological conditions that should cause pulses to occur, the 75th percentile is a valid threshold to separate low and high flows.

2. The following parameters were then calculated: The duration of each high flow event, the maximum discharge in each sequence of high flows, the date of the initial high flow value, the rise rate (calculated as the difference between the preceding low flow value to the maximum flow divided by the number of time steps (n-1)), and the fall rate (calculated as the difference between the maximum flow and the following low flow value, divided by the number of time steps (n-1)).

3. The 2-year and 10-year recurrence interval discharges were calculated using the following methodology: Maximum discharge was calculated for every year, and the 50th and 90th percentiles in Excel were used to calculate approximations of the 2- and 10-year recurrence intervals, respectively. This is a close approximation to the IHA method, but not as sophisticated as the USGS PeakFQ calculation (Flynn et al. 2006). Nevertheless, these percentiles provide close approximations of these recurrence interval discharges. Although bankfull discharge in the Coastal Plain physiographic province tends to occur more frequently than every two years, we used an approximate 2-year recurrence interval basinwide as a consistent guide.

4. The 2-year and 10-year recurrence interval discharges were used to further separate high flows into small pulses, high pulses, and floods (note: these are the default values used in IHA to separate high flow data). Maximum high flow values between the 75th percentile and the 2-year recurrence interval were classified as small pulses (analogous to High Pulses in IHA). Values between the 2- and 10-year recurrence interval were classified as high pulses (analogous to small floods in IHA), and values greater than the 10-year recurrence interval were classified as floods. With the exception of the Apalachicola River analysis, floods greater than the 10-year recurrence interval were excluded from this letter because they exceed the discharge stages that are predicted to cause damage according to the National Weather Service Advanced Hydrologic Prediction Service (Table 1 in April 2, 2010 PAL).

5. The range of discharge values that were used to define small and high pulses are presented in the tables. Similar to the PAL, we also provide the 25th and 75th percentiles of the magnitudes, frequencies, durations, rise rates, and fall rates which were calculated separately for small pulses,

high pulses, and floods. These values correspond to the high flow guidelines presented in Tables 1-4. Timing values were visually estimated from histograms of pulse or flood occurrence by month.

6. The Walter F. George high flow guidelines were calculated slightly differently. As referenced in the PAL, the unimpaired flows datasets do not accurately represent the magnitude, duration, timing, and rate of change of flow extremes (p. 14 in April 2, 2010 PAL). Consequently, using the Corps-modeled data to make high pulse recommendations cannot be justified. Thus, high pulse frequency, duration, timing, and rate of change calculations were used from the West Point analysis. To calculate magnitudes, however, the West Point analysis indicated that pulses should peak 1.6-3.5 times higher than the low flow river discharge in March [7,720-16,500 cubic feet per second (cfs)]. Assuming that pulses at Walter F. George should also peak 1.6-3.5 times higher than March low flow (derived from the Corps' unimpaired flows model output), small pulses below Walter F. George should peak between 14,161-30,978 cfs.

Figure 1. Low flow guidelines for the Chattahoochee River near Norcross, GA (USGS 02335000).

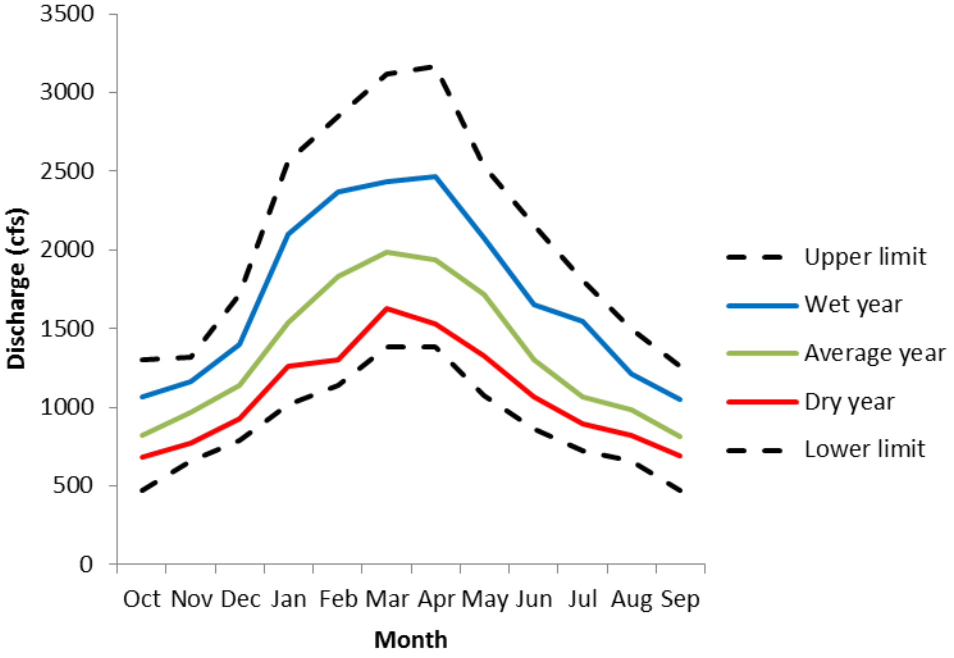

Figure 2. Low flow guidelines for the Chattahoochee River at West Point, GA (USGS 02339500).

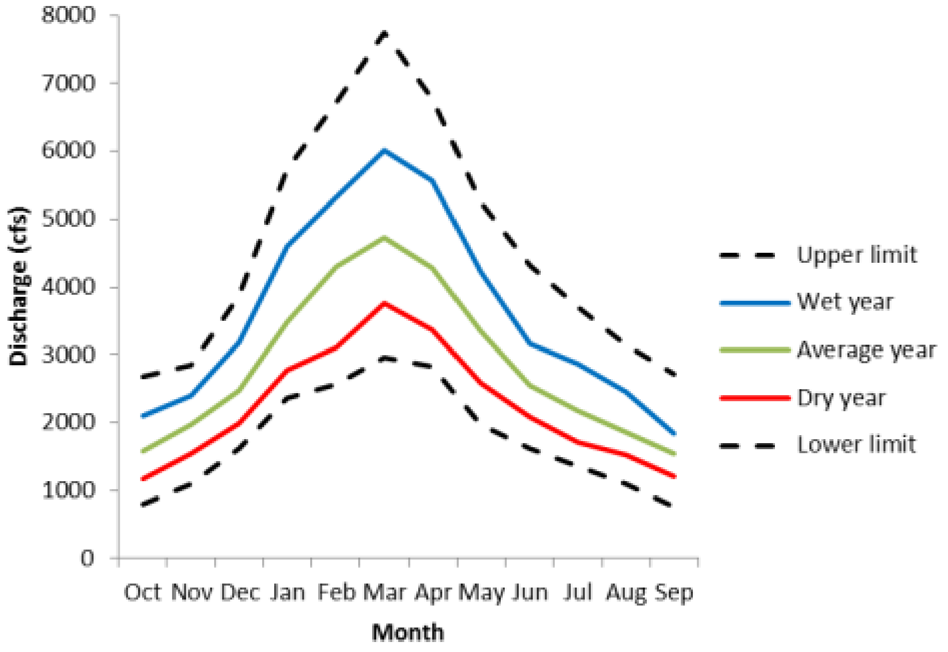

Figure 3. Low flow guidelines for the Chattahoochee River at Walter F. George using the Corps' unimpaired flows dataset.

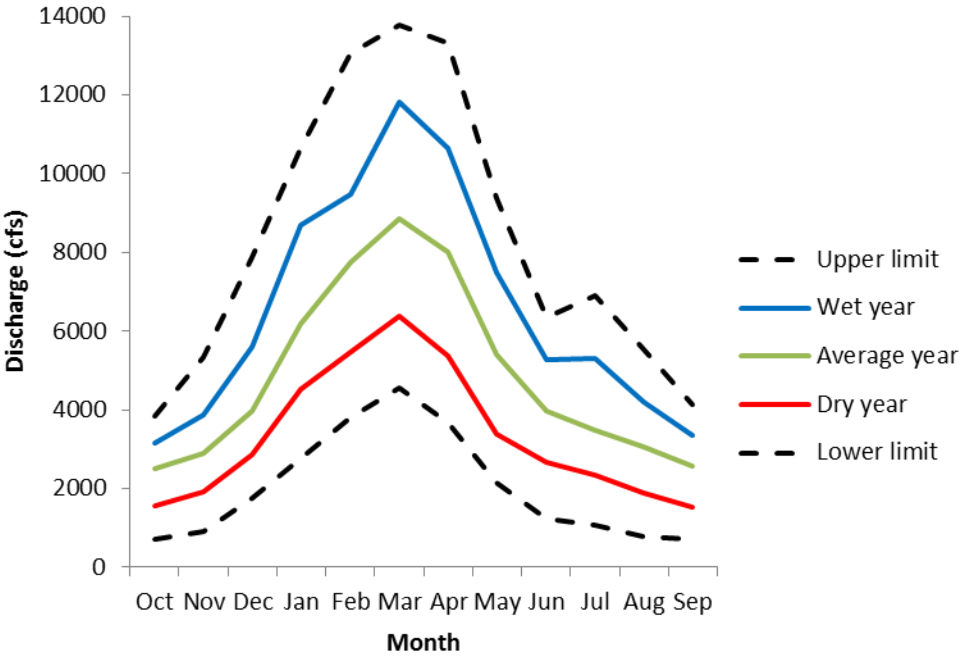

Figure 4. Low flow guidelines for the Apalachicola River at Chattahoochee, FL (USGS 02358000).

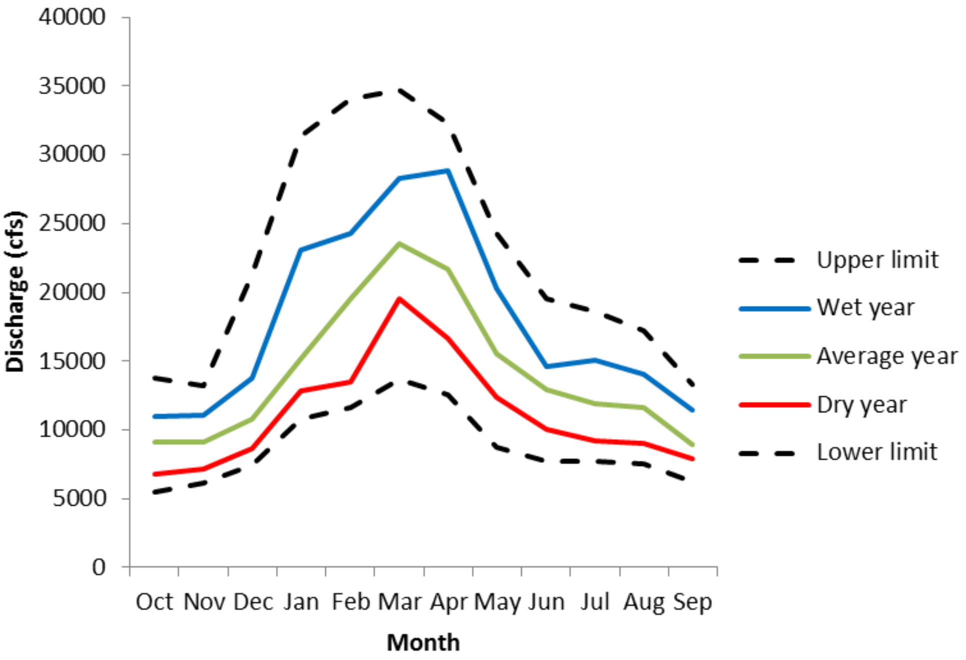

Table 1. High flow guidelines for the Chattahoochee River near Norcross, GA developed from USGS gage 02335000 for the pre-Buford Dam period from January 1, 1903 to September 30, 1946.

	Small pulse	High Pulse
Range used (cfs)	2550-17249	17250-33549
Magnitude (cfs)	3105-6787.5	19000-28900
Frequency (# events/year)	9-18	0-1
Duration (days)	1-5	11-72
Rise Rate (cfs/day)	770-2775	927-7830
Fall Rate (cfs/day)	507-1452	459-2193
Timing	Oct-Sep	Dec- Mar

Table 2. High flow guidelines for the Chattahoochee River near West Point Dam developed from USGS gage 02339500 for the pre-Buford Dam period from August 1, 1896 to December 31, 1955.

	Small pulse	High Pulse
Range used (cfs)	6250-45649	45650-71079
Magnitude (cfs)	7720-16500	51150-60825
Frequency (# events/year)	10-15	0-1
Duration (days)	2-6	17-39
Rise Rate (cfs/day)	1605-5118	5336-12509
Fall Rate (cfs/day)	1092-2850	1622-4472
Timing	Oct-Sep	Dec- Mar

Table 3. High flow guidelines for the Chattahoochee River at Walter F. George Dam developed from low flow analysis on the Corps' unimpaired flow dataset, and inferences from Chattahoochee River at West Point Dam high flow analysis. See text for additional details.

	Small pulse	High Pulse
Range used (cfs)	N/A	N/A
Magnitude (cfs)	14,161-30,978	95598-114187
Frequency (# events/year)	10-15	0-1
Duration (days)	2-6	17-39
Rise Rate (cfs/day)	1605-5118	5336-12509
Fall Rate (cfs/day)	1092-2850	1622-4472
Timing	Oct-Sep	Dec- Mar

*Upper range of high pulse values may need to be reevaluated to ensure that damage to structures is avoided. The stage discharge relationship (used to ensure that guidelines do not cause damage) was calculated using available data between 79 ft (6,510 cfs) and 110 ft (90,200 cfs; USGS gage 02343805), meaning that discharge calculations above this range of values are extrapolations and should be used cautiously.

Table 4. High flow guidelines for the Apalachicola River near Chattahoochee, FL developed from USGS gage 02358000 for the pre-Buford Dam period from July 1, 1922 to December 31, 1955.

	Small pulse	High Pulse	Flood
Range used (cfs)	25800-73799	73800-150499	≥ 150500
Magnitude (cfs)	28600-43475	85650-116500	201500-268500
Frequency (# events/year)	3-6	0-1	≥ 10 year RI
Duration (days)	3-15	32.5-68.5	49.5-89.5
Rise Rate (cfs/day)	2166-5606	2763-8056	7650-8761
Fall Rate (cfs/day)	1250-2615	1916-3811	4527-5795
Timing	Dec-Sep	Jan-Mar	Jan-Apr

Thank you for your January 18, 2011, response to the Service's PAL-requested analyses. We are currently reviewing the information that you provided, but recommend using ecosystem flow guidelines as calculated in the manner outlined above. As we continue to review the information you have produced, additional addendums or information requests may be supplied by the Service. We appreciate the opportunity to participate in the planning stages of your project and look forward to exploring opportunities to restore and improve habitat. If you have any questions, please contact Georgia Ecological Services staff biologists Will Duncan or Alice Lawrence at (706) 613-9493, or Panama City Ecological Services staff biologist Karen Herrington at (850) 769-0552 ext. 250.

Sincerely,

Sandra S. Tucker

Sandra S. Tucker
Field Supervisor

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S. Cook, ADCNR, Montgomery, AL
T. Hoehn, FFWCC, Tallahassee, FL
P. Gagliano, EPA, Atlanta, GA
D. Bernhart, NOAA, St. Petersburg, FL

Literature Cited

Flynn, K.M., Kirby, W.H., and Hummel, P.R. 2006. User's manual for program PeakFQ, Annual Flood Frequency Analysis Using Bulletin 17B Guidelines: U.S. Geological Survey Techniques and Methods Book 4, Chapter B4, 42 pp.

Lim, K.J., B.A. Engel, Z. Tang, J. Choi, K. Kim, S. Muthukrishnan, and D. Tripathy. 2005. Web GIS-based Hydrograph Analysis Tool, WHAT. Journal of the American Water Resources Association 41(6): 1407-1416.

The Nature Conservancy (TNC). 2007. Indicators of Hydrologic Alteration Version 7 User's Manual. 70 pp.

USFWS Questions to USACE Response

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USFWS Questions regarding the ACOE January 18, 2011 Correspondence:

1. In our PAL and the May 27, 2010 email from Will Duncan, we requested that you use the environmental flow guidelines to develop an environmental flow alternative or use the guidelines to analyze your alternatives and to identify the constraining authorization (if present) that impairs the Corps ability to achieve the recommended flow targets. You have provided some of those analyses in this report, but have you completed these analyses and identified the constraints for the remaining flow recommendations for the four river sections (below Buford, West Point, Walter F. George, and Jim Woodruff dams)?
2. How was the RES-SIM model developed and how well does it (ie. the baseline) conditions represent actual operations? Has this type of assessment been completed, specifically for parameters that are biologically relevant? Could the model output be updated through 2010?
3. To gain a better understanding of the constraints that you have, and so we don't continue stating the same thing on every document, can we obtain a copy of your agreement(s) with SEPA in the ACF? For similar reasons, may we also view the original language that describes the "flood damage reduction" authorized purpose?
4. Page 1-7: Why don't the numbers on Table 5.2-1 correspond with the hours of operation in the text above the table? Do the numbers in the text correspond to longer periods (e.g. 11 hours total at Buford on weekends) within which Buford Dam will generate power for e.g. three hours?
5. Page 1-9: When the fish spawn SOP was developed, why did it not include river segments below the major dams? Would a similar SOP for riverine habitats be of interest to the ACOE in the Chattahoochee River?
6. Page 1-14: It is stated that W.F. George currently has no minimum flow requirement, but when low dissolved oxygen values are observed below the dam, spillway gates are opened until the DO readings return to an acceptable level. How often is DO actually measured at this location?
7. Page 1-16: What is your reasoning for assuming that current water supply operations for Buford and Peachtree Creek would remain constant with 2007 demand data for your 10 to 15-year WCM Planning Window?
8. Page 1-16 and 1-21: It appears that the preferred alternative includes increased hydropower generation at Buford. What is the purpose or impetus for this increase (e.g., request from SEPA? Atlanta water supply? etc.)
9. Page 1-17: You mention that increasing Zone 4 would result in more water available, but there is no discussion of how frequently the drought operations were triggered with and without this change. In general, we would like to see your thought process for alternative development (e.g., were you trying to minimize the number of times drought ops were triggered?, etc.) and the results of these analyses (e.g., how did this change affect the occurrence frequency of the drought trigger).
10. Page 1-19: You mention volumetric balancing accounting but state elsewhere in the document that there will be no volumetric balancing in your preferred alternative. Is this a typo?
11. Page 1-20, Figure 11.3-4: Can you please show us a direct comparison of composite storage zones (similar to figs 11.3-1 to 11.3-4) under the no action alternative and preferred alternative? Or possibly a table with values if this figure would be too busy? Specifically, a summary of the composite zone changes (whether each zone is larger or smaller, time of year, reason for change, etc.) would be helpful. It would also be helpful to understand how often your model results indicate that you will operate in the various zones.

12. Page 1-20: You state that the drought plan revisions will remain in place until composite conservation storage reaches Zone 1. As in question #4 above, what is the thought process here and what are the results of the analyses you ran to make this decision?
13. Page 1-21: With what frequency and duration have each of the projects operated in each zone historically, and for each modeling scenario (baseline, alternative 1, and alternative 2)? How often in zone 4 was there peaking (number of peaking events/day) below each project?
14. Page 1-23: It is stated that there will be no changes to fish spawn or fish passage operations under the Proposed Action Alternative. Regardless, new language for fish spawn operations at JWLD will be included in this WCM update though, correct?
15. Page 1-23: You state that RIOP modifications (especially the fall rate and drought zone changes) were based in part on reducing the likelihood of triggering releases less than 5,000 cfs. Again, as in questions 4 & 6, what analyses did you run here to test/justify these decisions and what were the results?
16. Page 2-28: How would results be different if hourly data were used? What are the minimum DO observations observed and how well do the model results stack up against observed DO? Is it appropriate to have all dry years represented by 2007 and normal years by 2004? Same issues apply to temperature analyses on page 2-55.
17. Page 2-49: What is meant by the term "occurrence **interval**?" Where is the interval? Also, page 2-25 mentions that "It was recommended that percent exceedence may assume violation of water quality standards and thus percent occurrence was utilized for the presentation of water quality." Exceedence is a statistical term adopted for use in water policy. Regardless, it is more appropriate in this case to use exceedence. Just be clear that you are not using the term "exceedence" in a policy sense.
18. Page 2-60: The term "rainfall conditions" is used to identify specific years for detailed analyses. Similarly, the terms dry year and average year are used throughout the document without clear explanation regarding what constitutes a dry and average year. This needs to be made very clear. How were they defined, and does the term "rainfall conditions" actually mean a discharge-related variable?
19. Page 2-65: Based on the model input, what are the major drivers of algae change over time? Y-axes should be chlorophyll-a, not algae.
20. Pages 2-72 to 2-76: We had many comments, questions, and concerns about this section. Most concerns centered on the ambiguity of the analysis and the derivation of reported numbers. Because of these problems, we are hard-pressed to provide meaningful review and feedback. However, related to the baseflow analysis, we recommend an alternative analysis for depicting low flows that are likely to occur for each alternative. That analysis and associated rationale is included in the PAL addendum. Such an analysis is more intuitive and should take no more than a day for multiple nodes alternatives. Thus, we strongly encourage the ACOE to complete this analysis in lieu of the results reported in these sections.
21. Page 2-73: "The channel capacity at this location was used as a constraint in the HEC ResSim modeling analysis to ensure that flows did not go higher than 11,000 cfs." Why are the modelers unwilling or unable to model flows greater than 11,000 cfs?
22. Page 2-73: How is channel capacity defined, and where did the number come from?
23. Page 2-76: Can you please fix the figure references throughout the document ie. "Error! Reference source not found?" Does "upstream of Atlanta" refer to Norcross? Please use gage numbers and gage names to identify sites. How were these values determined? Are they percentiles of minimum flows or some annualized metric? How is "Dry year" defined in the

subsequent page? Many of these concerns will be addressed once the revised analysis is implemented.

24. For much of the flow analyses performed, you compare model output from the pre-dam period, no action, scenario 1, and scenario 2. Please provide the range of years and specific datasets used for each scenario.
25. Figures 2.7-1 to 2.7-13 and Table 2.7-1: We understand that direct comparisons cannot be made due to channel bed degradation and removal of hard bottom habitat; however, is it possible to add the pre-dam scenario to these figures?
26. Page 2-80: This statement is inaccurate: "The flow magnitude for average years overall, however, is 500–1,000 cfs, reduced from the pre-dam flows." Baseflows in the summer and fall seasons (including a portion of spawning season) are elevated, not reduced. Graphs depict reported values as averages, but could they be medians based on the non-parametric RVA in IHA?
27. Page 2-83, Figure 2.7.1.1: Spawning Habitat Availability- Overall, there is very weak treatment regarding what data is being conveyed on the graphs. For example, our initial review indicated that the analysis had been cut and paste from the 2008 BO. On the graphs and in legends and text, can you please define ROR, the intent of using USGS data and ROR, and the period of record used. Remember, if we (agencies with previous involvement) are unable to correctly interpret the results, it is unlikely that others will. This needs to be crystal clear. There are also grammatical problems in this section.
28. Page 2-87, Table 2.7-1: Why were there no flows lower than 5,000 cfs? Does that mean the drought plan was never triggered in these scenarios? If not during the exceptionally severe 2007 drought, what hydrologic conditions would it take to trigger the drought zone?
29. Page 2-92: We expect that the fall rates associated with pulses will differ from the RIOP. The RIOP was intended to be protective of organisms at a lower range of flow, and the pulse flow recommendations consider a large range of flows that are relevant to other ecosystem attributes.
30. Page 2-99: Could you please clarify this? "This operation was considered but deemed to not represent a viable operating alternative (USFWS 2010)." Did USFWS request it and then deem it as not a viable option? This is difficult to interpret without having a references section. Please include a references section.
31. Page 2-99: It is stated that "Holding the reservoir at higher elevations during the winter wet season would increase induced surcharge and the frequency of damaging downstream flows..." Damaging to what? Can you please share the modeling output that demonstrates this?
32. Page 2-101: You discuss analyzing how providing a minimum flow of 15,400 cfs impacted the number of times the drought zone was triggered. As in questions 4, 6, & 7, it would be helpful for us to know what analyses you have completed on triggers and how results influenced your alternative development. For example, it seems unusual that a minimum flow of 15,400 cfs would trigger drought operations more often than a minimum flow of 16,200 cfs.
33. Page 2-101: We appreciate the evaluation of a longer navigation season and feel it would also benefit riverine fishes. Please tell us if this will be a guaranteed minimum flow to provide a 7 ft channel or if it will be only "as requested" by navigation interests. How will this "navigation season" be different from the old navigation windows that were 10 days to a two-week period? Will this be a continuous minimum flow for months? If so, we assume that you are anticipating that you will be able to balance the fish spawn SOP and this new navigation flow, in light of the fact that the prior navigation windows prompted complaints that the windows had adversely affected reservoir fish spawn activities.

34. Page 2-102: W.F. George is also a peaking plant (Page 1-7) but was not included in the discussion of why non-hydropower peaking windows cannot be implemented at ACOE hydropower peaking facilities. It also needs to be addressed.
35. Page 2-109: Where's the references section?

Other Important considerations:

36. The ACOE used HEC-5Q to model daily change in water quality parameters. Are we correct in that the model input used average daily discharge to calculate water quality parameters for each time step? If so, we think it would be wise for the ACOE to acknowledge that daily fluctuations in WQ may be obscured by this simplification, but that this model represents the best available information on water quality responses to instream flow changes.
37. Similarly, it would be wise for the ACOE to propose a coarse plan of action for addressing DO issues caused by ACOE projects (e.g., propose potential collaborations, funding sources, and general steps, and rough timeline needed to do so).
38. Page 1-5: "the river system would operate in a fairly normal manner." Please clarify this.
39. Page 1-6: "…enough electricity to supply approximately 110,000 households." This is important to consider, but is more useful when context is provided. For example, 110,000 households is 3.65% of Georgia households or X% of Florida households.
40. Page 1-15: "Reservoir operations are also influenced by agricultural water withdrawals…" This is an important component of this section, and it needs additional (minor) elaboration so that your point isn't lost. Is the point that water removed from the Flint is offset by reservoirs in the Chattahoochee to meet flow needs in the Apalachicola- especially during low flow periods? If so, that point is lost in this section.
41. Page 2-25: Repeatedly throughout the document, the ACOE uses different terms to describe the alternatives (e.g preferred vs proposed ; scenario 1 vs. alternative 550 vs Alternative B1 or B2); It would be beneficial if consistent terms are used to describe each modeling scenario.
42. Page 2-26: The term "baseline" is used for 24 pages before it is defined on page 2-50. Also, it had been indicated that the methods used to develop all output would be included in this document and they aren't.
43. Page 2-75: It would be appropriate to explain to readers that values closer to "1" are better.
44. Page 2-76: "2.4.2 Impacts of Critical Low Flow Periods" could use improvement. We'd all be better served with a table showing comparisons of the results.

USFWS Coordination Act Report June 2011 with Appendices

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Draft Fish and Wildlife Coordination Act Report

On

Water Control Manual Updates for the Apalachicola-Chattahoochee-Flint River Basin in Georgia, Alabama, and Florida

Prepared by:

Georgia Ecological Services
Athens, Georgia

and

Panama City Ecological Services
Panama City, Florida

and

Southeast Regional Office
Atlanta, Georgia

U.S. Fish and Wildlife Service
Southeast Region
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June 2011

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June 17, 2011

Colonel Steven J. Roemhildt
US Army Corps of Engineers, Mobile District
P.O. Box 2288
Mobile, AL 36628-0001

Dear Colonel Roemhildt:

We are providing your agency with a Draft Fish and Wildlife Coordination Act Report (DFWCAR) for the proposed Water Control Manual (WCM) updates for the Apalachicola-Chattahoochee-Flint (ACF) River Basin in Georgia, Alabama, and Florida in partial fulfillment of Section 2(b) of the Fish and Wildlife Coordination Act (FWCA) (48 Stat. 401, as amended; 16 U.S.C. § 661 *et seq*.). The purpose of the WCM updates is to identify operating criteria and guidelines for managing water storage and release of water from US Army Corps of Engineers (Corps) reservoirs. We submit the following comments and recommendations under the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. § 1531 *et seq*.), the Migratory Bird Treaty Act (MBTA) (49 Stat. 755, as amended; 16 U.S.C. § 702 *et seq*.), and the FWCA. A separate consultation will occur regarding the potential impacts of the Corps' proposal on federally-listed threatened and endangered fish and wildlife species protected under the ESA. We anticipate providing comments on the draft Environmental Impact Statement (DEIS) that the Corps is preparing to support its decision regarding the WCM update, and it is our understanding that the Corps intends to include this DFWCAR as an appendix to the DEIS. Delivery of the final version of this report will depend upon the Corps' schedule.

The DFWCAR outlines the fish and wildlife concerns and planning objectives that were provided in our April 2, 2010, Planning Aid Letter (PAL) and March 1, 2011 PAL addendum to you, along with our understanding of the Corps' responses to our concerns and objectives. The DFWCAR describes the alternatives and evaluates the anticipated impacts of the selected plan. The Service does not support the proposed alternative. However, our report provides the Corps with fish and wildlife conservation measures and recommendations. We urge the Corps to consider additional alternatives for analysis that would address our concerns about water quality in project tailraces, alterations of flow regimes that adversely affect fish and wildlife, etc., and could lead to formulation of an environmentally preferable alternative in the Corps' decision-making process for the operations of the ACF reservoirs. We respectfully remind the Corps that

Federal regulations under the National Environmental Policy Act (NEPA) require that, in cases where an EIS has been prepared, the Record of Decision must identify all alternatives that were considered, ". . . specifying the alternative or alternatives which were considered to be environmentally preferable" (40 CFR Section 1505.2(b)). The environmentally preferable alternative is the alternative that will promote the national environmental policy as expressed in NEPA's Section 101. It is our view that by analyzing only one alternative to “no action”, in this case an alternative that does not incorporate reasonable options for mitigating all potentially significant impacts to the environmental resources identified through scoping and through the FWCA planning process, the Corps would not fulfill the intent of NEPA or the FWCA.

A draft version of the DFWCAR was distributed to the National Oceanic and Atmospheric Administration (NOAA), Georgia Department of Natural Resources- Wildlife Resources Division (GDNR-WRD), Alabama Department of Conservation and Natural Resources (ADCNR), and Florida Fish and Wildlife Conservation Commission (FFWCC). The U.S. Fish and Wildlife Service (Service) received notification of no additional comments from ADCNR, comments from GDNR-WRD, FFWCC, and NOAA, and GDNR-Environmental Protection Division (EPD). If you have any questions, please contact Georgia Ecological Services staff biologists Alice Lawrence or Will Duncan at (706) 613-9493, Panama City Ecological Services staff biologist Karen Herrington at (850) 769-0552, or Southeast Regional Office staff biologist Jerry Ziewitz at (850) 553-3646.

Sincerely,

Sandra S. Tucker
Field Supervisor

cc: K. Herrington, USFWS, Panama City, FL
D. Imm, USFWS, Panama City, FL
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P. Brownell, NOAA, Charleston, SC

EXECUTIVE SUMMARY

In January 2008, the Secretary of the Army directed the Corps to develop updated WCMs for the ACF River Basin. The purpose of the WCM updates is to identify operating criteria and guidelines for managing water storage and release of water from Corps reservoirs. This DFWCAR outlines the Service's fish and wildlife concerns and planning objectives that were previously provided to the Corps, along with our current understanding of the Corps' position on each PAL recommendation. The DFWCAR also describes the alternatives and evaluates the anticipated project impacts of the selected plan.

The Corps' proposed action alternative would limit withdrawals directly from Lake Lanier solely to the existing relocation contracts for the Cities of Gainesville and Buford at rates not exceeding 8 and 2 million gallons per day (mgd), respectively. The Corps would no longer make releases for water supply and water quality requirements from Buford Dam. Off-peak releases from Buford Dam would be limited to 600 cubic feet per second (cfs), and water availability for municipal and industrial withdrawals on the Chattahoochee River between Buford Dam and Peachtree Creek would be limited to the 600 cfs off-peak releases or water incidentally available through peaking hydroelectric power generation. There would no longer be specific flows released by the Corps for water quality at Peachtree Creek.

The proposed alternative is comprised of two minimum flow scenarios for the Chattahoochee River at Peachtree Creek. Scenario 1 assumes that the water withdrawers and dischargers manage their operations so that a minimum flow of 550 cfs remains in the Chattahoochee River at Peachtree Creek. Scenario 2 assumes that the water withdrawers and dischargers manage their operations so that a minimum flow of 750 cfs is always available at Peachtree Creek.

Under the proposed action alternative, the Corps would modify the action zones for Lake Lanier, West Point Reservoir, and Walter F. George Reservoir. Drought plan provisions would remain in place until conditions improve such that composite conservation storage reaches a level above the top of Zone 2 (i.e., within Zone 1), versus the no action alternative in which drought plan provisions remain in place until composite conservation storage reaches a level above the top of Zone 3 (i.e., within Zone 2). The Drought Zone would also be reshaped as part of the proposed action alternative.

No changes to flood damage reduction operations would occur, although there is a proposed minor guide curve change for West Point Reservoir that provides an incidental increase in flood storage during the fall drawdown. There would be no change to hydropower production at West Point Reservoir, WFGLD, or JWLD, except as would result from changes in the guide curves for the action zones. The designated amount of hydropower production at Buford Dam would change for all four action zones, and this amount of production would depend on if the Corps is in non-drought or drought operations at a given point in time.

Under the proposed action alternative, the Corps would provide a reliable navigation season. If hydrologic conditions allow, a typical navigation season would extend from January through April or May. Providing a navigation season would only be supported when the ACF Basin composite storage is in Zones 1 or 2, not in Zone 3 or below. The navigation season would not be supported when drought operations are in effect and would not be supported after drought operations have ceased until the ACF Basin composite conservation storage recovers to Zone 1.

Releases for federally-listed species below JWLD would be modified in that the maximum fall rates would be different from the no action alternative when releases were between 16,000 cfs and 30,000 cfs. The no action alternative has a maximum fall rate of 0.5 to 2.0 feet per day during that range, depending on the amount of the release, whereas the proposed action alternative would match the 1-day basin inflow fall rate. Additionally, drought provisions could affect changes in releases at JWLD.

The Service does not support the Corps' proposed action alternative for many reasons including a failure to address conservation measures identified in the Planning Aid Letter (PAL; Appendix V), modeling developed from short-term planning horizons and a single consumptive use scenario, increased frequency of low flows, increased storage resulting in lower annual releases to the rivers and bay, and inadequately evaluated impacts to mussels, fisheries, and habitats due to proposed changes from the 1989 draft WCM and the Revised Interim Operating Plan (RIOP).

We do, however, provide the Corps with recommendations intended to benefit fish and wildlife. The Service has suggested evaluations and analyses that address flow, water quality, fish passage, climate change, navigation, reservoir and riverine fisheries management, Apalachicola Bay resources, as well as the inclusion of a decision support model and adaptive management. Our recommendations for hydrologic modeling include addressing the impacts of increasing consumptive demands and evaluating alternative models to reflect flow extremes and climate change. The intent of these evaluations and analyses is to inform the development of alternatives and to address the impacts of the proposed action alternative.

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Appendices

I. GDNR’s May 23, 2011, review of the Service’s draft DFWCAR.

II. FFWCC’s May 23, 2011, review of the Service’s draft DFWCAR.

III. ADCNR’s May 26, 2011, email notification of no additional comments on the Service’s draft DFWCAR.

IV. NOAA’s June 10, 2011, review of the Service’s draft DFWCAR.

V. Service’s April 2, 2010, Planning Aid Letter to Corps.

VI. Service’s March 1, 2011, Planning Aid Letter addendum to the Corps.

VII. FFWCC letter to Donald Imm, Service Field Supervisor, and Major General Todd T. Semonite, Corps, February 22, 2011.

VIII. University of Florida’s April 27, 2011, Draft interim report to the Service entitled, *Simulating the impact of USACE operating alternatives on salinity and oyster populations in Apalachicola Bay, FL.*

IX. Service’s March 9, 2011, USFWS Questions regarding the ACOE January 18, 2011 Correspondence.

X. Service comparison of the Corps baseline model output and observed data for a comparable period.

INTRODUCTION

Purpose, Scope, & Authority

In January 2008, the Secretary of the Army directed the Corps to develop updated WCMs for the ACF River Basin. The following is taken from the Corps' response to the Service's PAL (Corps 2011):

"The Corps proposes to prepare an updated Master Manual for the ACF River Basin. A draft was proposed in 1989 as part of a post-authorization change report for Lake Lanier. The draft 1989 Master Water Control Plan described system operations at that time, but it was never finalized because of litigation filed by Alabama. The Corps has been operating projects in the ACF Basin under the draft 1989 Master Water Control Plan on an interim basis pending update of the Master Manual and individual project water control manuals. The component parts of the updated Master Manual would be five project-level water control manuals, presented as appendices…"

Water control manuals contain drought plans and action zones to assist the Corps in knowing when to reduce or increase reservoir releases and conserve storage in the Corps reservoirs. The individual manuals typically outline the regulation schedules for each project, including operating criteria, guidelines and guide curves, and specifications for storage and releases from the reservoirs. The water control manuals also outline the coordination protocol and data collection, management and dissemination associated with routine and specific water management activities (such as flood-control operations or drought contingency operations). Operational flexibility and discretion are necessary to balance the water management needs for the numerous (and often competing) authorized project purposes at each individual project. In addition, there is a need to balance basin-wide water resource needs. Project operations also must be able to adapt to seasonal and yearly variations in flow and climatic conditions."

The Service's involvement in this project is authorized by the FWCA. The FWCA establishes fish and wildlife conservation as a co-equal purpose or objective of federally-funded or permitted water resource development proposals or projects. This DFWCAR constitutes the report of the Secretary of the Interior as required by Section 2(b) of the FWCA.

FWCA Agency Coordination

The Service distributed a draft of the DFWCAR on May 9, 2011, to GDNR-WRD, ADCNR, FFWCC, and NOAA for their review. We received comments from GDNR-WRD and FFWCC on May 23, 2011, notification of no additional comments from ADCNR on May 26, 2011, and comments from NOAA on June 10, 2011. The Service also received comments from GDNR-EPD on May 23, 2011. However, because the FWCA requires that the Service coordinate with fish and wildlife agencies in order to ensure that fish and wildlife needs receive equal consideration, we will address GDNR-EPD's comments in a correspondence separate from the FWCA process.

Because many of the FFWCC comments should be more appropriately addressed by the Corps, we have separated the FFWCC comments below into those that are to be addressed by the Corps and those addressed by the Service. We encourage the Corps to review these agency correspondences and consider them in their decision-making process. We have addressed recommendations directed to the Service in the body of this DFWCAR. The agency responses to a draft of the DFWCAR are attached as Appendices I- IV and a summary of the correspondences is as follows:

GDNR-WRD

GDNR-WRD emphasizes the importance of the current water temperatures in the Chattahoochee River below Lanier Reservoir as they relate to the trout fishery and the Buford Trout Hatchery, as well as the Chattahoochee River below Morgan Falls Dam as a coolwater refuge during the summer months for striped bass (*Morone saxatilis*). GDNR-WRD agrees with the Service that improvement of dissolved oxygen (DO) downstream of Corps' reservoirs is important and beneficial to aquatic resources, and that this process may present opportunities/options to improve DO conditions. Lastly, they consider the Corps' Fish Spawn SOP to be important and that it should continue, when possible.

FFWCC comments for the Corps

FFWCC considers the Corps' no action alternative and the proposed action alternative to be unacceptable. They state that threatened and endangered species conservation is compromised by the arbitrary storage thresholds in Corps' reservoirs, the full storage capacity of these projects is not being used as Congress intended, and that the balance being struck by the Corps is unreasonable. FFWCC agrees with the Service that the proposed action alternative will be more detrimental for threatened and endangered mussel species in the Apalachicola River and they suggest that all efforts should be made to maintain flows above 6,000 cubic feet per second (cfs) at all times. They state that the proposed action alternatives do not include a true conservation alternative designed to serve the needs of fish and wildlife and related habitats in the Apalachicola River Basin.

FFWCC generally supports the Service's ecosystem flow guidelines and concurs, with modifications, that these guidelines should be used as the yardstick against which to measure any alternative's ability to meet the needs of fish and wildlife in the basin. FFWCC recommends ecosystem flow guidelines based on pre-dam flows be added to all graphs related to fish and wildlife resources, and incorporated into all levels of analysis and decision-making. They recommend that daily pre-dam flow data be used directly to serve as an ecosystem flow guideline in every case, regardless of the type of statistic or graphical display used in the evaluation. FFWCC also recommends that the Run of River (RoR) flow data that is displayed in numerous graphs in the Corps PAL Response should be removed because it is not an appropriate basis for analyses or decisions related to ecosystem protection. They recommend the RoR flow data should be removed and replaced with ecosystem flow guidelines based on pre-dam flows.

FFWCC recommends the analysis of frequency in percent of years of the annual maximum of 30-day minimum acres of inundated floodplain should be replaced with hydrographs. They state that hydrographs provide a more useful tool than frequency curves for assessing critical flows throughout the entire year. In addition, they state that the Corps makes an erroneous assumption in the PAL Response regarding floodplain connectivity. The Corps states that floodplain inundation occurs when flows reach 100,000 cfs in the Apalachicola River; FFWCC identifies much lower flows when floodplain inundation occurs at various reaches of the river.

FFWCC disagrees with the Service's conclusion that the Corps has provided the Service with pertinent Apalachicola River floodplain inundation stage-discharge analyses in their PAL Response. Per FFWCC's comments above, the analyses should be revised to include comparisons to ecosystem flow guidelines in every graph, hydrographs showing seasonality, duration of flows, and inundated area throughout the year, and expanded views of frequency curve data at the low-flow end. In addition, they state that LIDAR data are now available for the entire Apalachicola River and should be used for more accurate future analysis.

FFWCC remarks that while they appreciate the Service's recommendation to incorporate adaptive management into this process, the Corps has not shown a willingness to modify its behavior in response to monitoring data that show negative impacts on species. For success, clear objectives, sound monitoring, and specific response alternatives should be identified and are necessary components of an adaptive management program.

They also agree that the Corps should explore fish passage operations for anadromous fish species, such as the Alabama shad (*Alosa alabamae*) as part of the WCM update.

FFWCC comments for the Service

As stated above, FFWCC generally supports the Service's ecosystem flow guidelines and concurs, with modifications, that these guidelines should be used as the yardstick against which to measure any alternative's ability to meet the needs of fish and wildlife in the basin. FFWCC proposes a slightly modified ecosystem flow guideline that is calculated from all the data resulting in daily exceedance hydrographs, rather than the Service's current methodology. This recommendation is addressed in the *Conservation Measures Included from the Service's PAL & PAL Addendum* section of the DFWCAR.

FFWCC states that there should be additional analyses of the impact of proposed and existing operations on juvenile Gulf sturgeon (*Acipenser oxyrhinchus desotoi*) in Apalachicola Bay. They generally agree with the conclusions contained in the Apalachicola Bay section of the Service's DFWCAR, but would like to see additional details about potential impacts to estuarine sentinel species, such as Eastern oysters (*Crassostrea virginica*) or white shrimp (*Litopenaeus setiferus*).

FFWCC states that the DFWCAR should address the minimum flows needed to mitigate the impacts of saltwater incursion due to sea level rise.

NOAA

NOAA emphasizes the impacts to fishery and aquatic resources that have been caused by dam construction and operation, including fragmentation of riverine habitats, inundation of habitat, and altered flow conditions. They support the Service's sections of the DFWCAR on "Evaluation of the Selected Plan" and "Fish and Wildlife Conservation Measures and Recommendations" with regard to fishery and aquatic resources under their authority.

Prior Studies and Reports

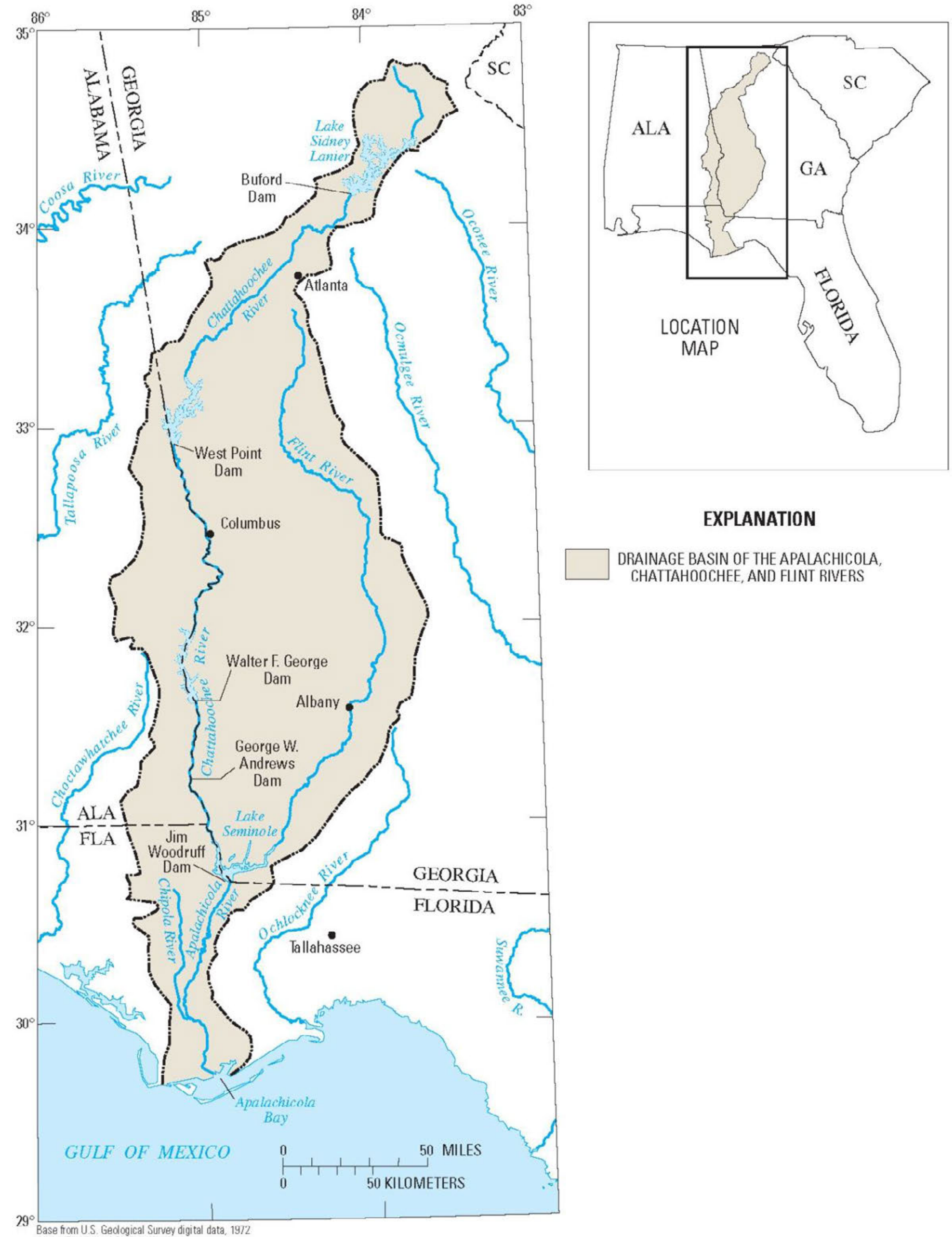
The following studies and/or reports are the most pertinent documents involved in producing this DFWCAR:

- Corps' April 15, 2008, description of proposed action modification to the Interim Operations Plan at Jim Woodruff Dam;
- Service's June 1, 2008, biological opinion for the Corps' Revised Interim Operations Plan;
- Service's April 2, 2010, PAL to the Corps (Appendix V);
- Corps' June 1, 2010, alternatives development and screening process informal synopsis to the Service;
- Corps' January 18, 2011, response to the Service's PAL;
- Service's March 1, 2011, PAL addendum to the Corps (Appendix VI);
- FFWCC's February 22, 2011, correspondence to Donald Imm, Service Field Supervisor, and Major General Todd T. Semonite, Corps titled *The Impact of Reduced Flows on the Apalachicola River and Bay Ecosystems (*Appendix VII*);* and
- University of Florida's April 27, 2011, draft interim report to the Service entitled, *Simulating the Impact of USACE Operating Alternatives on Salinity and Oyster Population in Apalachicola Bay, Florida* (Sheng et al. 2011; Appendix VIII).

DESCRIPTION OF STUDY AREA

The 19,910 square mile (mi^2) ACF River basin stretches from north central Georgia to the eastern border of Alabama to the Gulf coast through the central Florida panhandle. The drainage principally comprises the Chattahoochee (8,770 mi^2) and Flint (8,460 mi^2) rivers, which meet to form the Apalachicola River (2,680 mi^2) near the border of Florida and Georgia. Water resources in the ACF River basin have been developed to meet various demands for municipal and industrial water supply, flood control, hydropower, navigation, fish and wildlife conservation, recreation, and agricultural water supply (Corps 1998).

There are currently 16 reservoirs impounding the mainstem ACF river system, of which five are federally-owned and 11 are privately-owned projects. Thirteen reservoirs are located on the Chattahoochee River, two on the Flint River, and one, Jim Woodruff Lock & Dam (JWLD), is located near the confluence of the Chattahoochee and Flint rivers which forms the Apalachicola River. The federally-owned projects include JWLD, as well as four projects along the mainstem Chattahoochee River: George W. Andrews Lock & Dam (GWALD), Walter F. George Lock & Dam (WFGLD), West Point Dam, and Buford Dam (Figure 1).



Base from U.S. Geological Survey digital data, 1972
Albers Equal-Area Conic projection
Standard Parallels 29°30′ and 45°30′, central meridian -83°00′

Figure 1. Map of the ACF Basin showing location of the Corps' dams (source: Light et al. 2006).

FISH AND WILDLIFE CONCERNS AND PLANNING OBJECTIVES

The Service's fish and wildlife concerns, planning objectives, recommendations and requested analyses have been previously described in detail to the Corps in our April 2, 2010, PAL and March 1, 2011, PAL addendum. Our recommendations identified in the PAL and PAL addendum collectively reflect the Service's concerns and planning objectives. These were addressed by the Corps and we have included a summary of our current understanding of the Corps' position on each issue in the Fish and Wildlife Conservation Measures Section (Conservation Measures Included from the Service's PAL & PAL Addendum).

DESCRIPTION OF CORPS' SELECTED PLAN

No Action Alternative

The Corps' no action alternative represents continuation of the current water control operations at each of the Federal projects in the ACF Basin. There is not one comprehensive document that reflects the Corps' current operational practices; instead they are described in multiple Corps documents including:

- 1989 Draft ACF Water Control Plan;
- June 2008, Revised Interim Operations Plan (RIOP) and Environmental Assessment;
- February 2005, South Atlantic Division Regulation (DR) 1130-2-16, Project Operations, Lake Regulation and Coordination for Fish Management Purposes and Draft Reservoir Regulation and Coordination for Fish Spawn Management Purposes Standard Operating Plan, (SAM SOP 1130-2-9);
- February 1991, Chattahoochee River Management System as described in the Apalachicola Basin Reservoir Regulation Manual, Appendix B, Buford Dam (Lake Sidney Lanier) Chattahoochee River, GA; and
- Project WCM s for Buford (1991), West Point (1984), Walter F. George (1993), George Andrews (1996), and Jim Woodruff Lock and Dam (1985) projects.

The no action alternative as it dictates general system operations, action zones, and authorized project purposes is described in detail in the Corps' response to the Service's PAL (Corps 2011).

Proposed Action Alternative

The proposed action alternative as it dictates general system operations, action zones, and authorized project purposes is also described in detail in the Corps' response to the Service's PAL (Corps 2011). The proposed action alternative, in light of the July 2009 Federal district court ruling, would limit withdrawals directly from Lake Lanier solely to the existing relocation contracts for the Cities of Gainesville and Buford at rates not exceeding 8 and 2 million gallons per day (mgd), respectively. The Corps would no longer make releases for water supply and water quality requirements from Buford Dam in accordance with the Chattahoochee River Management System. Off-peak releases from Buford Dam would be limited to 600 cubic feet per second (cfs), and water availability for municipal and industrial withdrawals on the Chattahoochee River between Buford Dam and Peachtree Creek would be limited to the 600 cfs off-peak releases or water incidentally available through peaking hydroelectric power generation.

There would no longer be specific flows released by the Corps for water quality at Peachtree Creek.

The proposed alternative is comprised of two minimum flow scenarios for the Chattahoochee River at Peachtree Creek. The Corps provided the following rationale for the two scenarios:

> "Scenario 1 assumes that the water withdrawers and dischargers manage their operations so that a minimum flow of 550 cfs remains in the Chattahoochee River at Peachtree Creek. Scenario 2 assumes that the water withdrawers and dischargers manage their operations so that a minimum flow of 750 cfs is always available at Peachtree Creek. The 550 cfs flow at Peachtree Creek was analyzed based on a previous request from Georgia EPD for temporary relief from the 750 cfs level during the 2006 – 2008 drought and knowledge that flows lower than this level would not meet the current physical constraints of several water supply intakes between Buford Dam and West Point Lake."

Under the proposed action alternative, the Corps would modify the action zones for Lake Lanier, West Point Reservoir, and Walter F. George Reservoir. Drought plan provisions would remain in place until conditions improve such that composite conservation storage reaches a level above the top of Zone 2 (i.e., within Zone 1), versus the no action alternative in which drought plan provisions remain in place until composite conservation storage reaches a level above the top of Zone 3 (i.e., within Zone 2). No changes to flood damage reduction operations would occur, although there is a proposed minor guide curve change for West Point Reservoir that provides an incidental increase in flood storage during the fall drawdown. There would be no change to hydropower production at West Point Reservoir, WFGLD, or JWLD, except as would result from changes in the guide curves for the action zones. The designated amount of hydropower production at Buford Dam would change for all four action zones, and this amount of production would depend on if the Corps is in non-drought or drought operations at a given point in time. Table 1.3-1 in the Corps' response to the Service's PAL (Corps 2011) outlines those changes.

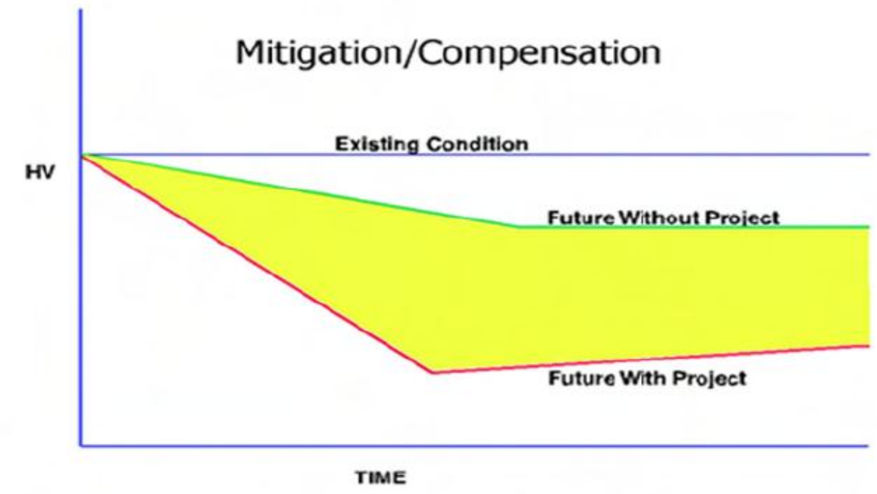
Under the proposed action alternative, the Corps would provide a reliable navigation season. If hydrologic conditions allow, a typical navigation season would extend from January through April or May. During this navigation season the flows at the Blountstown, Florida USGS gage would provide at least a 7-foot channel. Providing a navigation season would only be supported when the ACF Basin composite storage is in Zones 1 or 2, not in Zone 3 or below. The navigation season would not be supported when drought operations are in effect and would not be supported after drought operations have ceased until the ACF Basin composite conservation storage recovers to Zone 1. The determination to extend the navigation season beyond April would depend on inflows, climatic and hydrological conditions, and meteorological and basinwide forecasts. Downramping of flow releases would adhere to the JWLD fall rate schedule. Releases to provide for the 7-foot navigation channel would also be dependent on navigation channel conditions that ensure safe navigation.

Under the proposed action alternative, there would be no changes to fish spawn, fish passage, or recreational operations. Releases for federally-listed species below JWLD would be modified in that the maximum fall rates would be different from the no action alternative when releases were between 16,000 cfs and 30,000 cfs. The no action alternative has a maximum fall rate of 0.5 to 2.0 feet per day during that range, depending on the amount of the release, whereas the proposed action alternative would match the 1-day basin inflow fall rate. Additionally, drought provisions could affect changes in releases at JWLD. As mentioned above, drought plan provisions would remain in place until conditions improve such that composite conservation storage reaches a level above the top of Zone 2 (i.e., within Zone 1), versus the no action alternative in which drought plan provisions remain in place until composite conservation storage reaches a level above the top of Zone 3 (i.e., within Zone 2). The Drought Zone would also be reshaped as part of the proposed action alternative.

FISH AND WILDLIFE RESOURCES WITHOUT THE PROJECT

A fundamental component of the FWCA Report is the evaluation of resources with and without the project, so that impacts to fish and wildlife habitats and populations, human uses of resources, and other habitat values lost or gained can be quantified, negative impacts avoided or minimized, and unavoidable impacts mitigated. It is standard practice for such analyses to include evaluations and comparisons of long- and short-term future resource conditions with and without the project and for mitigation to be based on projections of future resource conditions (Figure 2).

Figure 2. Mitigation and compensation of habitat values (HV) lost for a hypothetical water resource project. Yellow area projects future habitat values lost and mitigation/compensation needs.



Changes in future resource conditions include changes related to water consumption, water quality, climate change, and associated effects on habitat and biota. For these reasons, we asked the Corps in the PAL to include in their modeling efforts 1) increases in consumptive uses in the ACF basin that are expected to occur and 2) multiple future climate scenarios that could affect lake levels, river discharges, and estuary inflow. The Corps did not incorporate increases in consumptive uses or multiple climate scenarios into their modeling, thereby complicating comparisons between the future conditions with and without the proposed action alternative. In this instance, the future without the project is continued operation of Federal projects in the ACF River Basin in a manner that is consistent with existing operations. Existing operations are modeled by the Corps as the no action alternative, which is problematic because the 2009 ruling by U.S. District Court Judge Magnuson decision renders the no action alternative illegal in the

ACF Basin. However, given no other option, we use the no action alternative to evaluate future fish and wildlife resources without the proposed action alternative, while considering the ecological consequences of unmodeled, long-term changes in consumptive uses and river flows.

A multitude of fish and wildlife resources are dependent upon discharge and have been affected by long-term discharge changes. FFWCC provided a summary and comparison of pre-Buford Dam and post-West Point Dam conditions that exhibit discharge and salinity changes in the Apalachicola River and Bay ecosystems (FFWCC letter to Donald Imm, Service Field Supervisor, and Major General Todd T. Semonite, Corps, February 22, 2011; Appendix VII). Although the interpretations of the analyses were made by FFWCC and not the Service, impacts identified (hypothesized, realized, or modeled) in FFWCC's correspondence are relevant because operational changes at Corps facilities have the potential to ameliorate, exacerbate, or have no effect on such project-induced impacts and impacts associated with other changes in future resource conditions. Apalachicola River and Bay impacts addressed in the FFWCC letter include:

- Long-term decreases in river flow, especially spring and summer low flows during dry conditions
- Decreases in floodplain inundation and associated changes in forest composition, ichthyofauna, and invertebrates
- Gulf sturgeon spawning and rearing habitat reductions, and population effects as a consequence of barrier construction (JWLD) and flow reductions
- Fish spawning habitat reductions as a consequence of reduced river flows
- Mussel habitat reductions and population effects
- Modeled estuary salinity changes as a response to Apalachicola River discharge changes and upstream flow depletions
- Influence of floodplain organic matter on oyster diet and estuary productivity
- Changes in oyster drill (*Dermocystidium marinum*) prevalence in oysters as a function of estuary inflow and salinity over multiple years.

Negative impacts of current operations on aquatic resources in other portions of the basin include:

- Loss of riverine habitat and fluvial species assemblages, including federally-listed mussel species and Gulf sturgeon that are now thought to be extirpated from the mainstem Chattahoochee River
- Loss of unimpeded passage for migratory fishes
- Fragmentation of aquatic populations in the mainstem and tributaries
- Significantly altered dissolved oxygen and temperature regimes
- Highly altered flow regimes that affect assemblages of riverine aquatic biota in the remaining flowing river segments below dams.

It is reasonable to expect that future conditions with increased population growth, consumptive demands, wastewater input, changes in climate, and continued operation of Federal projects will show increasing impacts to these natural resources. Based on correspondence with the Corps and with the States as part of the FWCA process, we have addressed or are currently addressing the types of impacts that could potentially occur as a consequence of changes in current project operations. However, because the Corps has not provided an evaluation of project impacts associated with a more accurate projection of future conditions, direct comparisons of the future of the resource with and without the project are hampered. Consequently, we emphasize that the Corps should develop and quantify projected positive and negative impacts for 'with the project' and 'without the project' scenarios based on more accurate projections of future conditions so that appropriate mitigation measures can be developed and included in your National Environmental Policy Act (NEPA) documents.

PROJECT IMPACTS & EVALUATION METHODOLOGY

Project impacts are identified by comparing future resource conditions under the no action alternative to future conditions with the Corps' proposed action alternative. Impacts can theoretically be beneficial, adverse, or have no appreciable differences, but are limited to fish and wildlife resources that could be affected by Corps project operation changes. Thus, the intent of this section is to describe effects of project operations on biologically relevant parameters. The overall biological interpretation of the results (e.g. descriptions of whether the proposed action alternative is beneficial, adverse, or no difference compared to the no action alternative) is reserved for the *Evaluation of the Selected Plan* section below.

Analyses Provided by the Corps

In response to the Service's April 2, 2010, PAL, the Corps completed several requested analyses to support the Service's and State's comparison of the no action and proposed action alternatives (Corps 2011). The Corps relied on HEC-ResSim to simulate management alternatives and evaluate the resulting effects to reservoir levels, river stages, and river discharge. Although a thorough explanation of the modeling procedure has not yet been provided, we expect that the modeling procedure was similar to that used in prior consultations. Namely, calculations of basin inflow from January 1939 through December 2008 were determined and anthropogenically-influenced variables (e.g. consumption levels, reservoir evaporation and release schedules) were used to create synthetic flow and discharge datasets that simulate expected conditions under the no action and proposed action alternatives. One strength of this approach lies in the fact that the period between 1939 and 2008 encompassed a broad range of hydrologic conditions (i.e. basin inflows) that may be experienced in the future, thereby providing an opportunity to evaluate effects of management alternatives under a variety of hydrologic conditions.

For many of the analyses, the Corps evaluated a composite period from 2001-2008, but also extracted a subset of the data to represent dry (year 2007), normal (2004), and wet (2005) hydrologic year types. We refer to all of these analyses as 'year types'. Data were further extracted to examine only the months of April or May (depending on the analysis) through October or November in order to examine effects during critical low flow and fish spawning periods. [Note: Although not all graphs indicated that the April or May through October or November period was used, we assume this to be the case.] While these analyses are useful and statistically valid, we caution the reviewers regarding the following. When data are lumped for multiple months into a single graph, and when percentiles are used to characterize multi-month datasets, the high and low extremes that occur in a *single* month may be obscured by the data associated with all other months. For example, values for modeled chlorophyll-*a* could actually be higher than the values represented on the graphs. We emphasize that this is not a failing of the Corps' analysis, but it does identify an area of investigation for which additional model data are available. We recommend that time series plots also be used (similar to dissolved oxygen plots in Figures 2.2-22 to 2.2-25 of the Corps' Response to PAL) to illustrate variation that is likely to occur.

The Corps' analyses frequently used percent occurrence to characterize distribution of model output. The Corps states "that the longitudinal figures present the percent occurrence of modeled output; the opposite of the percent exceedance. It was recommended that percent exceedance may assume violation of water quality standards and thus percent occurrence was utilized for the presentation of water quality." In recent email correspondence with the Corps (Appendix IX), we recommended using exceedance plots to facilitate interpretations of the data using standard hydrological and statistical approaches because of several important and confusing issues. First, no definition is provided for percent occurrence or for its calculation. Second, we are unable to reconcile seemingly conflicting graphs depicting model output. For example, the 5% occurrence for dissolved oxygen at Norcross for the no action alternative is ~10 mg/L in Figure 2.2-1 in the Corps' Response to the PAL, but the 5% occurrence at Norcross on Figure 2.2-3 is ~6.5 mg/L. Conflicts such as these confound interpretation of approximately 40 graphs of model output throughout the document. We attempted to gain clarification through additional discussion with the Corps (B. Zettle, Corps, April 2011, pers. comm.), but have not received additional clarification to date. However, we have made an attempt to evaluate model output.

As with any model, there are limitations and caveats associated with model development and use, all of which should be acknowledged by the Corps. As an example, we have provided the results of a statistical and qualitative analysis that evaluates congruency between actual operations as measured by discharge at USGS gages and model output of existing operations (i.e., the no action alternative) for the comparable post-RIOP period (Appendix X). The analysis shows a high degree of similarity for many components of the hydrograph at most locations, but also several exceptions. Statistical differences between measured discharge and modeled discharge for existing operations include:

> Chattahoochee at Norcross: pulse duration and frequency, and number of reversals;
>
> Chattahoochee at West Point: pulse magnitude, duration, and rise rate, and number of reversals;
>
> Apalachicola at Chattahoochee: number of reversals.

HEC-5Q was used to model water quality. Impacts assessed at multiple locations throughout the basin included effects on dissolved oxygen, water temperature, wastewater, Chlorophyll-*a*, reservoir retention time, phosphorus, floodplain connectivity and reservoir fisheries performance measures. Additional analyses on the Apalachicola River included Gulf sturgeon and freshwater mussel habitat, and the provision of navigation flows below JWLD. Effects on shoreline vegetation and wildlife at Eufaula NWR, as well as water quality at Buford Fish Hatchery were also assessed.

Below, we assess impacts of the proposed action alternative relative to the no action alternative using the Corps analyses. General descriptions of the analyses are presented, but more thorough descriptions of the Corps methodologies and graphical depictions of output may be found in the

Corps' response to the Service's PAL (Corps 2011). Values presented below are approximations based on visual interpretations of graphs provided by the Corps.

Dissolved Oxygen

Suitable dissolved oxygen levels are critical for fish and invertebrates. Simulated daily average dissolved oxygen values varied along the longitudinal river profile, with May-October median and/or 5% occurrence values falling below State standards below Corps projects at Buford, West Point, and WFGLD. The largest differences between the no action and the proposed action alternatives were the following:

> Norcross: The proposed alternative resulted in 0.5 mg/L lower dissolved oxygen levels (lowest: 4.5 mg/L) compared to the no action at the < 5% occurrence level in a dry year (2007).
>
> Morgan Falls: The proposed alternative resulted in 1.0 mg/L lower dissolved oxygen levels (lowest: 5.0 mg/L) compared to the no action at the < 10% occurrence level in a dry year (2007).
>
> Buford Dam downstream: The proposed alternative and no action results were similar. Both were less than the State standard of 6 mg/L at 40% occurrence for the composite 2001-2008 period and 45% for a dry year (2007).
>
> West Point Dam downstream: The proposed alternative and no action results were similar. Both were less than the State standard of 5 mg/L at ~30% occurrence for the composite 2001-2008 period and 35% (proposed alternative)-43% (no action) for a dry year (2007). The proposed alternative consistently had 0.5-1.0 mg/L higher dissolved oxygen between 20-40% occurrence in a dry year (2007).
>
> Bartlett's Ferry: The proposed alternative and no action results were similar. Both were less than the state standard of 5 mg/L at ~25% occurrence for the composite 2001-2008 period, and ~32% in a dry year (2007). The proposed alternative was 0-0.5 mg/L higher than the no action between 20-40% occurrence in a dry year (2007).
>
> Walter F. George downstream: The proposed alternative and no action results were similar. Both were less than the state standard of 5 mg/L at ~23% occurrence for the composite 2001-2008 period, and ~32% in a dry year (2007). The proposed alternative was 0-0.25 mg/L higher than the no action between 0-30% occurrence in a dry year (2007).

Water Temperature

Alteration of water temperature can greatly affect the persistence and abundance of aquatic species in a given location. Most notably, suitable water temperatures are critical for aquatic reproduction. Simulated water temperature for the no action and proposed action alternative varied along the longitudinal river profile, with the largest temperature drops below Buford Dam (16 °C) and West Point Dam (3 °C) for modeled period between 2001-2008 in May through October. Similar trends were observed in representative wet, dry and normal years. The no action and proposed action alternative model results were similar along the longitudinal river profile in wet, dry, and normal years and in the 2001-2008 composite from May through October, with infrequent deviations less than 1°C. The April through October period results were similar, with model output for the no action and proposed action alternatives remaining within 1.5 °C of one another.

Wastewater

In the absence of quantitative models that describe water quality changes in response to flow management alternatives, percent wastewater can serve as a proxy. As percent wastewater increases, wastewater-associated substances are expected to increase. Simulated average stream percent wastewater varied along the longitudinal river profile, with the largest percent wastewater downstream from Atlanta (the maximum reported no action value was 30% wastewater for the 5% occurrence value) and GWALD (the maximum reported no action value was 30% wastewater for the 5% occurrence value) modeled period for the May through October 2001 - 2008 composite period. Similar trends were observed in representative wet, dry and normal years. The no action and proposed action alternative model results were similar along the longitudinal river profile within each year type. Downstream from Atlanta, the percent wastewater in the proposed action alternative model output was 1-3% less than the no action alternative for the 2001-2008 May through October composite and the wet, dry, and normal years.

Chlorophyll *a*

Chlorophyll-*a* is correlated with algal biomass. Because algal mats can cause nuisance conditions in lakes, it is considered to be less desirable in lentic systems. Simulated chlorophyll *a* varied along the longitudinal river profile, with peak concentrations in reservoirs. Similar trends were observed in the 2001-2008 composite and in the wet, dry, and normal years. Results were similar between the no action and proposed action alternative within each year type. However, at occurrences greater than 80-90% in a dry year type, the proposed action alternative had daily average algal concentrations 1-8 mg/L higher than the no action alternative in West Point Reservoir and 1-2 mg/L higher in Walter F. George Reservoir.

Reservoir Retention Time

Higher retention rates may result in decreased reservoir water quality. The Corps did not provide data to assess retention time.

Ortho-phosphorus

Algal growth is stimulated by increases in phosphorus. Simulated ortho-phosphorus varied along the longitudinal river profile, with peak concentrations downstream from Atlanta and Columbus. Similar trends were observed in the 2001-2008 composite and in the wet, dry, and normal years. Results were similar between the no action and proposed action alternative within each year type. However, the no action alternative model output frequently produced concentrations 0-0.02 mg/L greater than the proposed action alternative in the 2001 to 2008 composite. We were unable to interpret the importance of longitudinal plots showing the differences between the no action and proposed action alternative because of the obscure percent occurrence definition and seemingly conflicting modeled results provided to us.

Floodplain Connectivity- Chattahoochee and Apalachicola Rivers

The Service's PAL used Environmental Flow Components (EFCs) in the Indicators of Hydrologic Alteration (IHA) to develop the magnitude, duration, timing, rise rate, and fall rate guidelines for pulses from the pre-Buford Dam period of record. The Corps used the IHA Range of Variability Approach to describe and compare alternatives in their response to the Service's PAL. The methods are not comparable. However, subsequent analysis of the methodology and results by the Service led to a revised method analogous to the IHA EFC method, but computed in Excel, and better suited to Corps and Service analysis needs. Rationale for the revision and methodology is outlined in detail in the Service's March 1, 2011, PAL addendum. Output from the revised methodology is not yet available for the comparison of the no action alternative, proposed action alternative, and pre-Buford period. However, a floodplain connectivity analysis for the Apalachicola River based on prior consultations for endangered freshwater mussel impacts is provided below (see Freshwater Mussels section).

Reservoir Fisheries

The impacts of the no action and proposed action alternative on reservoir fisheries were based on the premises that reservoir water level fluctuations can impact reproductive success of game fishes. The reservoir fisheries performance measure scores indicate that the no action alternative produced better conditions for fisheries reproduction compared to the proposed alternative.

The Corps completed a second analysis to examine effects on reservoir fisheries during critical low flow periods. The Corps stated that the analysis was completed only on Lanier Reservoir because it experiences the greatest fluctuations in reservoir levels. Based on the low flow period for Lanier Reservoir, the Corps states that "In the worst low flow period, 2007, the Proposed Action Alternative shows slightly improved values over No Action Alternative. In 2008, the Proposed Action Alternative is similar to the No Action Alternative."

Riverine Fisheries

The riverine fisheries analysis relied on IHA output to compare baseflows. Similar to the floodplain connectivity analysis, output from the revised methodology has not yet been provided by the Corps for the comparison of the no action alternative, proposed action alternative, and pre-Buford Dam period. The analysis that was provided did not include the average and wet year low flow values for the pre-dam period in the comparison with the no action and proposed action alternative, a deficit that should be rectified in future correspondence.

Federally-protected Species in the Apalachicola River

Gulf Sturgeon:

The four analyses provided to us that examine impacts of project operations on Gulf sturgeon include spawning habitat availability, daily fall rates, the maximum number of days per year <16,000 cfs, and departure from average mean temperature during the sturgeon spawning season. Spawning habitat availability in the Apalachicola River for Gulf sturgeon was nearly identical between the no action and proposed action alternative. The Corps indicates that discharge fall rates were modeled such that rapid falls in river stage do not result in exposure or stranding of eggs and larvae of Gulf sturgeon. The maximum number of consecutive days <16,000 cfs was calculated because discharges <16,000 cfs cause estuary salinity levels to increase above 10 ppt, thereby creating suboptimal conditions for juvenile Gulf sturgeon growth. The median of the maximum number of consecutive days <16,000 cfs was about 5 days higher for the proposed alternative (Scenario 1 with a 550 cfs target at confluence with Peachtree Creek). However, the 75th percentile of the maximum number of consecutive days <16,000 cfs in the proposed action alternative was about 15 days lower than the no action alternative, meaning that in some years (presumably drier years) there are fewer days per year where estuary inflow creates suboptimal habitat for juvenile Gulf sturgeon. The Corps stated that the average of the mean daily water temperature during the spawning season was nearly identical between the no action and proposed action alternative, meaning that there are no differences in the temperature aspect of spawning cues for Gulf sturgeon.

Freshwater Mussels:

Low flows in the Apalachicola River have the potential to reduce habitat, and expose and strand freshwater mussels. Thus, we requested that the Corps provide several low flow analyses, similar to those provided in the 2008 Biological Opinion (Service 2008). The Corps compared the lowest annual discharges from 1975 through 2008 for the no action and proposed action alternatives. Annual low flows were similar, with the proposed alternative having lower (38% of years), higher (41% of years), or the same (21% of years) annual low flow values compared to the no action alternative. With the exception of 1975, annual low flows from the model output remain below the 50th percentile of September-October (lowest flow months) low flows that occurred pre-Buford Dam (see PAL addendum, Apalachicola low flow graph).

Differences between the no action and proposed action alternative were indistinguishable for the interannual frequency, the maximum number of days per year, or the maximum number of consecutive days per year where flows were less than 5000 cfs, 5000-6000 cfs, 6000-7000 cfs, 7000-8000 cfs, 8000-9000 cfs, and 9000-10,000 cfs. Flows never fell below 5000 cfs for either the no action or proposed action alternative simulations.

River stage fall rates were examined because rapidly declining river stages have the potential to increase the risk of mussel exposure and stranding. Histograms comparing fall rates for the no action and proposed action alternative for all flows combined and flows <10,000 cfs indicate a high degree of similarity, with the $\leq$ 0.25 category comprising the largest proportion of fall rates. Although the no action had approximately 50 more days in middle fall rate categories (0.25-0.50 ft/day and 0.50-1.00 ft/day) compared to the proposed action, the proposed action alternative had about 50 more days in the 1-2 ft/day category than the no action.

Apalachicola River Floodplain Connectivity

The Apalachicola River and floodplain ecosystems depend on seasonal flooding and connectivity to maintain forest community structure, ensure availability of spawning and rearing habitats, export detritus and nutrients to fuel higher trophic levels in the river and estuary, and support biodiversity in the region. Consequently, effects of project operations on the frequency, magnitude and timing of floods were evaluated. Frequency exceedance plots (percent of days) of floodplain habitat area connected to the Apalachicola River during the growing season (April-October and March-November) and the percent of years during the growing season (April-October and March-November) with 30 days of continuous floodplain connectivity to the main channel were similar between the no action and proposed action alternative. However, in the proposed action alternative, slightly more floodplain acreage is connected to the river for a minimum of 30 days at exceedance frequencies (% of years) less than 45% during the growing season. An additional frequency exceedance plot (percent of days) during the growing season with flows between 12,000 and 30,000 cfs showed indistinguishable differences between the no action and proposed action alternatives.

<u>National Wildlife Refuges and Fish Hatcheries</u>

The Service requested several analyses of impacts to hatcheries and Eufaula NWR, and an evaluation of potential management options that could benefit Eufaula NWR. In response to that request, the Corps provided the following:

> *Eufaula NWR:* "Under the No Action Alternative, no changes would be expected. The ability of W.F. George Lake to provide 13.4 mgd to support waterfowl at off-reservoir impoundments would continue. The two scenarios for the Proposed Action Alternative show only minor differences in water level changes from the No Action Alternative, suggesting a similarly low potential of effect on the shoreline vegetation and wildlife communities at ENWR. Additionally, inspection of water surface elevation plots at Walter F. George Lake for critical low-flow periods indicate that, with the exception of August through November when surface elevation drops to 184.50 ft, if ever, reservoir levels always remain above 185 feet under the Proposed Action Alternative. Thus, W.F. George Lake is expected to continue to provide 13.4 mgd of water to support waterfowl at off-reservoir impoundments.
>
> The USFWS asked that the Corps consider cycling surface elevations at W.F. George to the highest levels (190 ft) in the late winter and lowest levels in early spring (185 ft). This operation was considered but deemed to not represent a viable operating alternative (USFWS 2010). Current reservoir operations use winter draw-downs to accommodate flood releases from upstream projects and higher basin inflow during the wet season. Refilling usually occurs during the spring, typically at the end of the wet season, to provide storage to meet authorized project purposes and augment flows downstream of the project as needed. Holding the reservoir at higher elevations during the winter wet season would increase induced surcharge and the frequency of damaging downstream flows causing bank erosion and channel modifications below the project. Maintaining low elevations during the summer dry season would remove composite conservation storage from the system at a time when it is most critically needed for flow augmentation and hydroelectric power production. Additionally, this proposed operation contradicts the current fish spawning standard operating procedure for the reservoir, which calls for steady to increasing pool elevations during the spring."
>
> *Fish Hatcheries:* "There are four fish hatcheries in the ACF Basin. The discussion below describes how changes to operations at Federal reservoirs would affect the hatcheries. Under the No Action Alternate, no changes would be expected at any of the hatcheries.

> Three of the hatcheries in the ACF Basin use groundwater. These hatcheries would not be affected by the Proposed Action Alternative.
>
> Buford Trout Hatchery withdraws about 7 mgd (11 cfs) of flow from the Chattahoochee River below Buford Dam year-round (Ziewitz et al. 1996). The results of the HEC-5Q water quality modeling for the period from 1975 through 2008 indicate only minor changes in the Proposed Action Alternative from the No Action Alternative with respect to water temperature and the dissolved oxygen concentrations of coldwater bottom discharges from Lake Lanier through Buford Dam. Therefore, no effects on the Buford trout Hatchery's operation would be expected as a result of the Proposed Action Alternative."

University of Florida Analyses of Apalachicola Bay

A 3D curvilinear-grid hydrodynamic salinity model was developed to simulate the flow and salinity dynamics inside Apalachicola Bay (Sheng et al. 2011; Appendix VIII). The model showed satisfactory performance with observed salinity collected by the Apalachicola National Estuarine Research Reserve in 2004. Specific details on model development and performance are provided in the report. The authors also developed an oyster population dynamic model similar to the one described by Wang et al. (2008), and coupled it with the hydrodynamic-salinity model to assess the impact of freshwater alteration on oyster populations in Apalachicola Bay. Four discharge scenarios were considered in the 10 year (1999-2008) simulations: 1) observed data from the USGS gaging station 02359170 near Sumatra, Florida, 2) no action alternative (i.e., current operations), 3) proposed alternative minimum flow scenario 1 (550 cfs target at Peachtree Creek), and 4) proposed alternative minimum flow scenario 2 (750 cfs target at Peachtree Creek).

The Service requested that the authors provide various analyses of model output specific to oysters and Gulf sturgeon with the assumption that optimal salinities for oysters are less than 26 ppt (Livingston et al. 2000; Huang 2010), and juvenile Gulf sturgeon require salinities less than 10 ppt (Altinok and Grizzle 2001; Sulak et al. 2009). To assess the impacts of the four discharge scenarios on oysters, we requested that comparisons be made at Dry Bar (an oyster bar with strong river influence) and Cat Point (an oyster bar with little river influence). These analyses included salinity exceedance probabilities, summary statistics and exceedance probabilities for oyster growth rates, and salinity contour maps with associated acreages for the total number of days when salinity exceeded 26 ppt in a wet, dry, and average year. For Gulf sturgeon, we requested salinity contour maps describing the total number of days salinity exceeded 10 ppt from 1 October- 31 March for the following years for all 4 scenarios in a dry, wet, and average year.

Analyses indicate that there will be no appreciable difference in the magnitude or timing of estuary freshwater inflow between the no action and proposed action alternatives (Sheng et al. 2011; see Appendix VIII). There is little difference in salinity or oyster growth rates in any of the various analyses; however, simulated salinities and oyster growth rates between the no action and the proposed action alternatives differed from the observed Sumatra discharge data. However, in general, the Corps' simulated flow scenarios resulted in salinities that had slightly higher highs and lower lows than salinities estimated using Sumatra discharge data. Oyster growth rates were also slightly lower in the Corps' modeled scenarios compared to the observed Sumatra discharge data, especially in August, which is considered the peak growth period for oysters in Apalachicola Bay (Huang 2010). Similarly, the amount of habitat available for Gulf sturgeon was slightly lower in the no action and proposed action alternatives than the observed discharge data at Sumatra.

These effects on the bay relative to historic operations result from changes in the volume and timing of freshwater inflow due to the reservoir operations of the RIOP and the proposed WCM alternatives, and less so to apparent changes in consumptive water uses. Historic basin inflow rates (the Corps' reported daily project inflow data) from 1976 to 2008 are roughly equivalent with the basin inflow data used in the modeled scenarios (unimpaired flow minus consumptive water uses), and the modeled basin inflow data is actually slightly higher overall (period-of-record average daily basin inflow values are 34 to 103 cfs greater) than the historic data. Therefore, the differences in the bay salinity results do not appear related to any simulated increase in consumptive water demands. However, average annual releases (1976-2008) from Woodruff Dam are about 400 to 500 cfs less than historic under the no-action and proposed alternatives, and average monthly composite reservoir storage is about 35,000 to 111,000 acre feet greater than historic levels in the months of August through October. Although salinities and oyster growth rates are similar between the no action and proposed action alternatives, all model outputs indicate that flows will continue to be lower than what historically and even recently occurred (i.e., pre-IOP in 2006) and thereby continuing suboptimal conditions for oysters, Gulf sturgeon, and other fish and wildlife in Apalachicola Bay.

In their May 23, 2011, correspondence to the Service, FFWCC states that there should be additional analyses of the impact of proposed and existing operations on juvenile Gulf sturgeon in Apalachicola Bay. They generally agree with the conclusions contained in the Apalachicola Bay section of the Service's DFWCAR, but would like to see additional details about potential impacts to estuarine sentinel species, such as eastern oysters or white shrimp. The Service agrees with FFWCC that additional datasets should be sought or generated to quantify impacts to juvenile Gulf sturgeon, eastern oysters, white shrimp, and other species. The Service searched for additional analyses and new datasets prior to drafting the PAL but located few. Thus, the Service welcomes additional information that FFWCC can provide to assess impacts of proposed and existing operations.

FFWCC also states that the DFWCAR should address the minimum flows needed to mitigate the impacts of saltwater incursion due to sea level rise. Thus, we recommend that the Corps capitalize on existing datasets to evaluate the effects of sea level rise on estuary-riverine salinities, and to quantitatively evaluate the discharges required to minimize saltwater incursion. This modeling effort should include both short- and long-term planning horizons.

EVALUATION OF THE SELECTED PLAN

The purpose of this section is to evaluate the relative merits of the no action and proposed action alternative and ultimately determine their acceptability from the standpoint of the Service's responsibilities under the FWCA and our mission to conserve, protect, and enhance fish and wildlife resources. To that end, we succinctly describe the impacts of the proposed action alternative relative to the no action alternative in terms of each biological and/or habitat parameter considered. Each parameter is described as an improvement (+), a negative impact (-), or no change (0) over the no action, regardless of the magnitude of the difference between the no action and proposed action alternative. Scores were determined by assigning values of 1 for + signs, -1 for negative impacts, 0 for no change, and summing values for each reach (Table 1). Larger sums indicate that the proposed alternative is beneficial, without assigning a relative weight to the parameter or reach being considered. We emphasize that this approach is one method to evaluate the proposed action alternative, and it is not meant to be the sole deciding factor in the Service's evaluation. Rationales for the individual assignment of signs are provided in the text below Table 1. The Corps' provided the Service little to no interpretation to accompany their analyses in their Response to the Service's PAL; therefore, the evaluation below is solely based on the Service's interpretation.

Table 1. Scoring of impacts to fish and wildlife resources resulting from the Corps' proposed action alternative relative to the no action alternative. The proposed alternative is better (+), worse (-), or the same (0) as the no action alternative for fish, wildlife or habitat. NAE indicates that the Corps has not adequately evaluated the parameter or the analysis is ongoing, and N/A indicates that the analysis is not applicable. All symbols are applicable to the reach below the dam, except variables shaded in grey are applicable to the reservoir upstream from the dam.

	Buford	West Point	W.F. George	J. Woodruff
Dissolved Oxygen	-	+	+	0
Temperature	-	0	0	0
Waste water	+	+	+	0
Chlorophyll-*a*	NAE	-	-	NAE
Reservoir Retention Time	NAE	NAE	NAE	NAE
Ortho-phosphorus	0	+	+	0
Floodplain connectivity- Chattahoochee and Apalachicola	NAE	NAE	NAE	NAE
Reservoir Fisheries	-	-	-	-
Riverine Fisheries	NAE	NAE	NAE	NAE
Salinity	N/A	N/A	N/A	0
Gulf sturgeon	N/A	N/A	N/A	+
Freshwater mussels	N/A	N/A	N/A	-
Floodplain connectivity- Apalachicola	N/A	N/A	N/A	+
Eufaula NWR	N/A	N/A	0	N/A
Buford Fish Hatchery	-	N/A	N/A	N/A
Score:	-3	1	1	0

Dissolved Oxygen

Higher dissolved oxygen levels are considered to be better for fish and invertebrates, but frequently fell below State standards for both the no action and proposed action alternatives below Buford Dam, West Point Dam, and WFGLD. For the composite period, compared to the no action alternative, the proposed action alternative exhibited lower dissolved oxygen levels immediately below Buford Dam and then transitioned to higher dissolved oxygen levels below Atlanta. Higher proposed action alternative dissolved oxygen levels occurred below West Point Dam and WFGLD, and approximately the same levels between the two alternatives occurred below JWLD. However, the differences between the alternatives were small and occurred at low occurrence levels, meaning that both the no action and proposed action alternatives frequently provide poor conditions for fish and wildlife.

Water Temperature

Temperatures were expected to be similar throughout the ACF Basin, with differences between the no action and proposed action alternative fluctuating between approximately +/- 0.5 degrees C for the composite period. However, when normal, wet, and dry years are separated, the proposed action alternative shows the most drastic deviation from the no action alternative from Buford Dam to West Point Reservoir. In this reach, temperatures under the proposed action alternative were expected to drop up to 1.5 degrees C from the no action alternative with the greatest temperature difference exhibited between Atlanta and West Point Reservoir. The following fisheries information is taken largely from Georgia Power (2006):

Historically a warmwater river, the mainstem Chattahoochee River tailrace became an artificially created coldwater river following the construction of Buford Dam. Bottom releases from Buford Dam create coldwater releases suitable for a non-native brown (*Salmo trutta*) and rainbow trout (*Oncorhynchus mykiss*) fishery in a 48-mile section of river extending downstream to Peachtree Creek.

GDNR has historically stocked this section of river with rainbow and brown trout and manages the trout fishery in two distinct segments: the Buford Dam tailwater extending 30 river miles downstream to Georgia Highway 400; and the Morgan Falls Dam tailwater extending 12 miles downstream to Peachtree Creek. The first segment is colder with greater flow fluctuations and the second segment is warmer with less fluctuations.

Water temperature is of great concern to GDNR in this section of the Chattahoochee River. They are very interested in maintaining the cold temperature regime for the trout fishery, the most popular sport fishery in this section of the Chattahoochee River. They report that high summer water temperatures potentially detrimental to trout have been occurring more frequently in recent years in the Morgan Falls Dam tailwater, and that nonpoint stormwater runoff from impervious surfaces in tributary watersheds appears to contribute to these conditions.

As summer maximum water temperatures have become more marginally suitable for trout, GDNR has diversified its management objectives downstream of Morgan Falls Dam to include restoration of native shoal bass (*Micropterus cataractae*), a warmwater bass species endemic to the ACF River basin. Under the no action alternative, GDNR considers the reach to be a transition zone capable of supporting both coldwater and warmwater fisheries and has initiated a stocking program for shoal bass in the reach of the Chattahoochee River below Morgan Falls Dam. GDNR, along with other State and Federal agencies including ADCNR, the Service, and the National Park Service (NPS) have been involved with restoration and research activities to improve the status of the species.

GDNR has also reintroduced striped bass (*Morone saxatilis*) into what is now West Point Reservoir. Striped bass restoration in the ACF Basin is a collaborative effort between the conservation agencies in Georgia, Alabama, Florida, and the Service, with the goal of restoring a self-sustaining population to the maximum extent possible. The group meets on an annual basis to set goals and discuss ongoing management and research for striped bass in the ACF system. West Point Reservoir is currently designated as a potential broodfish repository and is one of the highest priority reservoirs to receive stocked striped bass.

Because striped bass exhibit upstream migrations to spawn in riverine conditions, a striped bass fishery has developed in the Chattahoochee River downstream of Morgan Falls Dam, the first upstream barrier to striped bass migrating upstream from West Point Reservoir. Persistence of a small population in West Point Reservoir suggests that striped bass in the river are capable of limited natural reproduction. However, coldwater releases from Buford Dam during the spring spawning period of striped bass, and abrupt decreases in water temperature that occur with Buford Dam peaking operations, have been identified as critical factors inhibiting striped bass spawning and adversely affecting survival of eggs and larvae in the upper Chattahoochee River near Morgan Falls Dam (Hess and Jennings 1999). Their movement upstream to Morgan Falls increases as summer progresses, indicating that the water temperatures in the summer serve as a coolwater refuge. GDNR-WRD considers this “coolwater refuge” effect to be of significant importance to the survivability of adult striped bass.

Because the proposed action alternative exhibits colder water temperatures below Buford Dam to West Point Reservoir, most notably the reach below Morgan Falls Dam to West Point Reservoir, the Service views the proposed action alternative as less favorable than the no action alternative. Although the colder temperatures may be more beneficial to the artificial trout fishery, they represent a greater deviation from natural warmwater conditions and a native warmwater fishery in the Chattahoochee River, especially from Morgan Falls Dam to West Point Reservoir. However, the Service proposes that elements of both a coolwater and warmwater fishery potentially could be supported if water quality and flows are improved.

Wastewater

The no action and proposed action alternative model results were similar along the longitudinal river profile within each scenario, with the average stream percent wastewater in the proposed action alternative model output typically 1-3% less than the no action alternative. These modeled results suggest that the proposed action alternative would be slightly more favorable than the no action alternative.

Chlorophyll-*a*

Chlorophyll-*a* is correlated with algal biomass. Because algal mats can cause nuisance conditions in lakes, it is considered to be less desirable in lentic systems. Chlorophyll-*a* was similar between the no action and proposed action alternatives throughout the river system, but slightly larger differences were observed in reservoirs. Under the proposed action alternative, occurrence plots exhibit slightly higher chlorophyll-*a* concentrations within West Point and Walter F. George reservoirs; this indicates that the proposed action alternative is slightly less favorable when compared to the no action alternative. Occurrence plots were not available for Lanier or Jim Woodruff reservoirs. Therefore, occurrence plots should be developed for Lake Lanier and Jim Woodruff reservoirs to assess differences in chlorophyll-*a* between the no action and proposed action alternative.

Reservoir Retention Time

Higher retention rates may result in decreased reservoir water quality. The Corps did not provide data to assess retention time. Therefore, data to assess retention time should be developed to assess differences between the no action and proposed action alternative.

Ortho-phosphorus

Algal growth is stimulated by increases in phosphorus. Thus, phosphorus levels were modeled and compared between the no action and proposed action alternative. Phosphorus levels were slightly lower in the proposed action alternative below West Point Dam and WFGLD and approximately the same below Buford Dam and JWLD. Therefore, the proposed action alternative is slightly more favorable than the no action alternative in certain reaches of the project area.

Floodplain Connectivity- Chattahoochee and Apalachicola Rivers

Indicated previously, the Corps has not yet provided output from the revised flow guideline development methodology for the comparison of the no action alternative, proposed action alternative, and pre-Buford period. However, a floodplain connectivity analysis for the Apalachicola River based on prior consultations for endangered freshwater mussel impacts is provided below (see *Apalachicola River Floodplain Connectivity* section). The Corps should provide output from the revised flow guideline development methodology for the comparison of the no action alternative, proposed action alternative, and pre-Buford period.

Reservoir Fisheries

Differences between the no action and proposed action alternative reservoir fisheries scores were generally $\leq$ 0.04, suggesting low potential for realized fisheries differences between the two alternatives. However, fishery scores for the proposed action alternative were slightly lower than the no action alternative for all reservoirs. Therefore, the proposed action alternative is slightly less favorable than the no action alternative.

Riverine Fisheries

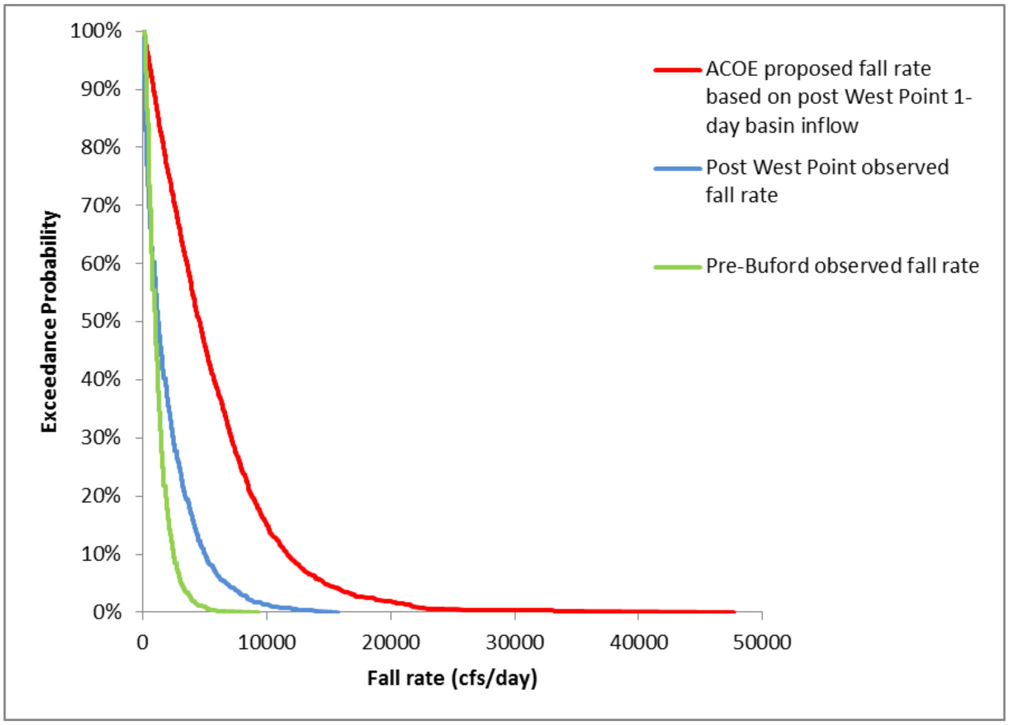
The riverine fisheries analysis provided by the Corps relied on IHA output to compare baseflows. Similar to the floodplain connectivity analysis, output from the revised methodology has not yet been provided by the Corps for the comparison of the no action alternative, proposed action alternative, and pre-Buford Dam period. The analysis that was provided did not include the average and wet year low flow values for the pre-dam period in the comparison with the no action and proposed action alternative, a deficit that should be rectified in future correspondence.

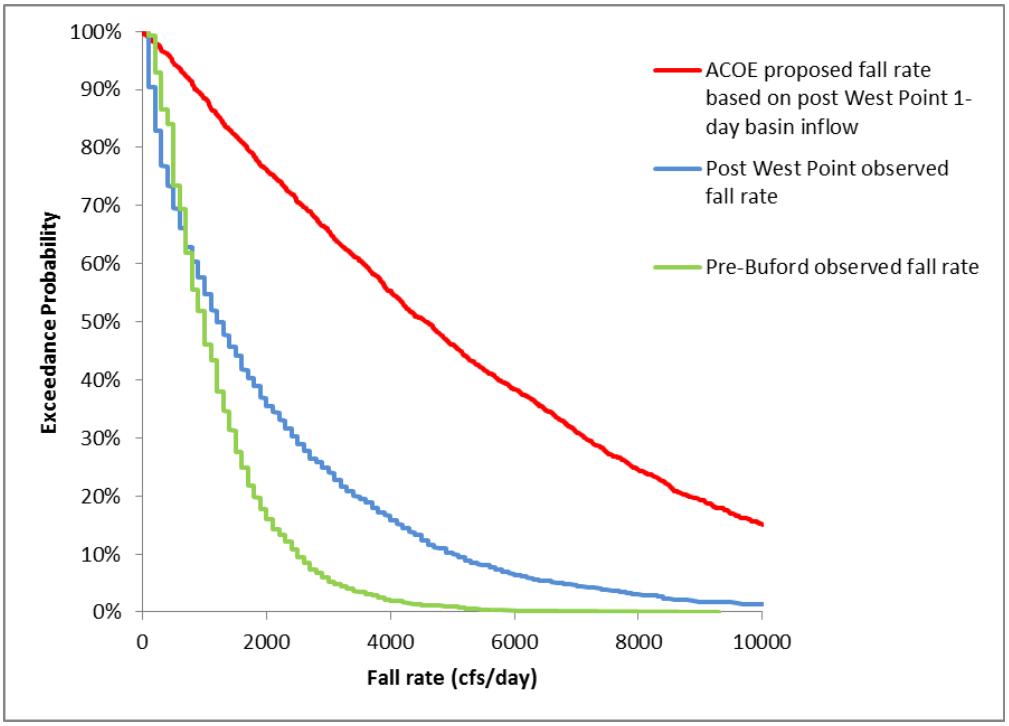
Therefore, the Corps should provide output from the revised ecosystem flow guidelines for the comparison of the no action alternative, proposed action alternative, and pre-Buford Dam period.

In addition, the change to the RIOP in the proposed alternative that requires fall rates to match the 1-day basin inflow below JWLD may result in additional impacts to riverine fishes in the Apalachicola River. Fall rate analyses provided by the Corps indicate that there are slightly more days with fall rates in the 1-2 ft decline per day. We conducted an additional analysis to further evaluate the impacts of such a change. Because we do not have data to analyze the no action and proposed action differences, we compared pre-Buford declines in daily discharge at the Chattahoochee gage to declines in 1-day basin inflow (as computed by the Corps) from 1976 through May 2008 when releases were between 16,000 cfs and 30,000 cfs (Figure 3). Basin inflow was calculated as the sum of daily local inflow at Buford, West Point, WFGLD, and JWLD. This basin inflow calculation method was chosen because it is analogous to the calculation method that the Corps proposes to use to manage fall rates below JWLD. We were unable to compare actual stage declines because basin inflow is not derived from a single gage measurement. The fall rates from the basin inflow data are very different from pre-dam fall rates (e.g., basin inflow fall rates exceeding 1,000 cfs happen more than 87% of the time, compared to 43% of the pre-Buford Dam period). We do not support the use of the 1-day basin inflow fall rate because it may result in less floodplain connectivity in this range of releases, resulting in more floodplain stranded fishes of all ages and smaller year classes.

The Corps has recently provided USFWS with a new Run of River (ROR) scenario. The intent of the ROR scenario is to isolate the impacts of Corps reservoir management on flows, while maintaining the influence of consumptive use activities, including evaporative loss. Thus, the ROR scenario maintains reservoir pool elevations, and quantifies discharge that would otherwise pass Corps reservoirs. We suggest that an additional analysis be conducted to compare fall rates under the ROR scenario to the pre-Buford, post-West Point, and proposed alternative fall rates.

Figure 3. Comparison of declines in daily discharge when releases were between 16,000 and 30,000 cfs in the Pre-Lanier record (Chattahoochee gage 1922-1955) to the 1-Day Woodruff Dam Basin Inflow post-construction of West Point Dam (1976-2008).





Federally-protected Species in the Apalachicola River

Gulf sturgeon

Gulf sturgeon spawning habitat availability was nearly identical between the no action and proposed action alternative. However, the number of consecutive days per year where flows were less than 16,000 cfs was lower for the proposed action alternative, meaning that conditions provided by the proposed action alternative are probably slightly better for spawning Gulf sturgeon.

Freshwater mussels

The only freshwater mussel analysis was for the river segment below JWLD. Although low flows are similar between the no action and proposed action alternative, both model outputs indicate that annual low flows will continue to be lower than what historically occurred and thereby continuing stressful conditions for mussels. Most of the comparisons of project impacts on mussels showed nearly identical results. However, the proposed action alternative had approximately 50 more days in the higher fall rate category, and occasionally had lower annual minimum flows than the no action alternative, meaning that there is a slightly higher potential for mussel stranding under the proposed action alternative. As discussed in the Riverine Fisheries Section, the change to the RIOP in the proposed alternative that requires fall rates to match the 1-day basin inflow below JWLD may result in additional impacts to riverine fishes in the Apalachicola River. Mussel population viability is intricately tied to host fish density (Watters 1997; Haag and Warren 1998). Because many of the fish species dependent on the floodplain serve as host fish to freshwater mussels in the Apalachicola River, freshwater mussels may also be impacted by this change to the RIOP. In addition, the change to the RIOP in the proposed alternative that requires drought plan provisions remain in place until composite conservation storage reaches Zone 1 would result in freshwater mussels being subjected to low flows for longer periods of time than under the no action alternative. Another potential impact to freshwater mussels could result from the effects of the reshaped Drought Zone as part of the proposed action alternative, but the Corps has not provided analysis of this potential impact. Therefore, the proposed action alternative is less favorable than the no action alternative.

Apalachicola River Floodplain Connectivity

The assessment of floodplain connectivity on the Apalachicola River indicated that both alternatives were similar. However, in the proposed action alternative, slightly more floodplain acreage is connected to the river for a minimum of 30 days at exceedance frequencies (% of years) less than 45% during the growing season. This suggests more floodplain would be available as fish habitat, and potentially more inundation of tupelo-cypress swamps, as well as potentially higher fish and invertebrate productivity. Therefore, in the Apalachicola River, the proposed action alternative is slightly more favorable than the no action alternative. However, additional analyses need to be conducted to describe how floodplain connectivity is impacted by the change to the RIOP; specifically those changes that require fall rates to match the 1-day basin inflow below JWLD when releases are between 16,000 and 30,000 cfs.

National Wildlife Refuges and Fish Hatcheries

Eufaula NWR

The Service had requested the examination of alternate Walter F. George Reservoir management strategies to accommodate the request and freshwater needs of Eufaula NWR. The Corps indicated that they are unable to meet that request, meaning that there is no change in reservoir levels and therefore, no change to Eufaula NWR.

Fish Hatcheries

Buford Fish Hatchery relies on a freshwater intake below Buford Dam to support fish rearing. Although there is similar water availability for Buford Fish Hatchery for both alternatives, dissolved oxygen levels were slightly lower below Buford Dam in the proposed action alternative. Therefore, the proposed action alternative is slightly less favorable than the no action alternative.

University of Florida Analyses of Apalachicola Bay

Salinity was modeled in Apalachicola Bay relative to oysters and Gulf sturgeon (Sheng et al. 2011; Appendix VIII). Although analyses indicate that there will be no appreciable difference in salinities in the action and proposed action alternatives (Table 1), simulated salinities between the no action and the proposed action alternatives differed from the observed Sumatra discharge data, resulting in lower oyster growth rates and less available habitat for Gulf sturgeon. This indicates that flows will continue to be lower than what historically and even recently occurred (i.e., pre-IOP in 2006) and thereby continuing suboptimal conditions for oysters, Gulf sturgeon, and other fish and wildlife in Apalachicola Bay.

FISH AND WILDLIFE CONSERVATION MEASURES AND RECOMMENDATIONS

The intent of this section is to identify measures that should be taken to prevent the loss of or damage to fish and wildlife resources and to provide for the improvement of such resources. In the PAL and PAL addendum, we identified resources and analyses that would be necessary in order to address planning objectives. Although some planning objectives were addressed by Corps analyses as described in prior sections, many were not adequately addressed. We review our current understanding of the Corps' position on each issue and note whether the planning objectives were adequately addressed. Those planning objectives that were not adequately addressed are conveyed here as conservation measures, or recommendations, that should be taken to benefit fish and wildlife.

Conservation Measures Included from the Service's PAL & PAL Addendum

Flow Regime

- Develop an alternative or suite of alternatives that would maximize benefits to fish and wildlife resources in light of other project purposes.

  This has not been completed and should be developed. Although the PAL provided sets of low and pulse flow guidelines from which alternatives could be developed and *compared, and requests for modeling non-hydropower peaking windows, the Corps did not develop alternatives based on those guidelines because of management limitations cited in their response to the Service's PAL (Corps 2011). However, within the Service's PAL, we stated:*

"We recognize that complete implementation of all guidelines presented herein is not feasible given the expansive flow alteration and consumptive demands in the ACF River Basin that have occurred since Buford Dam construction. However, restoration of some natural flow regime components presented in these guidelines can restore structural and functional ecosystem elements that were lost or reduced as a consequence of flow regulation."

We reiterate to the Corps that achieving a natural hydrograph in its entirety is not the goal, but providing for some components of the natural hydrograph could be beneficial. To date, none of the natural flow regime components have been incorporated into the flow alternative development, and only low flows guidelines were given treatment in a comparison of alternatives for Buford and West Point dams.

- Conduct ecosystem flow analyses using the methodology cited in the Service's PAL addendum should be conducted at four nodes (below Buford, West Point, WFGLD, and JWLD) for the no action and proposed action alternatives and compared with the Service's ecosystem flow guidelines. We also recommend the Corps evaluate the provision of non-hydropower peaking "windows" during critical reproductive and rearing periods for a minimum of 4-6 weeks from March-May.

  In the Service's PAL addendum, we provided updated ecosystem flow guidelines representing natural conditions, as well as updated methodology for the Corps to analyze their low and high flow releases under the no action alternative and proposed action alternative. Such analyses have not been provided to the Service.

  FFWCC generally supports the Service's guidelines, but also recommends a modified approach to the development of low flow guidelines. The Service used the seven lowest values from every month in every year to characterize low flows in dry, average, and wet months for the pre-Buford period. FFWCC proposed that daily exceedance values based on all the pre-Buford hydrology, including baseflows, pulses, and floods, be used to develop guidelines. Subsequent analyses by the Service show that the 90% exceedance roughly corresponds to the lower limit and dry month flow guidelines, and the 50% exceedance values track the wet year flow guidelines, with the exception of the wetter months, lending some support to this alternative approach. We agree with FFWCC that this type of analysis has merit for comparing flow alternatives and characterization of flow data. However, the Service views this method as complementary but not substitutive for flow guideline development.

  1. *Exceedance plots include all flows including pulses and floods. Therefore, low flow guidelines that could come from exceedance plots are potentially influenced by high flows, thereby inflating low flow guideline values. This is particularly evident with exceedance probabilities less than 75%, and in wetter months. One intent of the*

Service's flow guideline development was to separate multiple flow components (low flows, pulses, and floods) and illustrate the inter- and intra-annual variation in flows. Exceedance plots blur the distinction between low flows, and pulses and floods which is one reason why exceedance plots were not used initially.

2. *Daily exceedance plots show a large amount of daily variation. Similar to the Service's flow guidelines, this variation illustrates that a range of low flow values may be beneficial for fish and wildlife resources. However, one intention of the Service's guidelines was to provide managers and modelers real values to evaluate and/or incorporate into a flow alternative. Although selecting the seven lowest values for every month of every year to characterize dry, average, and wet months is a simplification of the pre-Buford hydrology, the Service expects that there is a higher likelihood of successful incorporation of the Service's 60 low flow guideline values (represented by the lower and upper limit, and dry, average, and wet conditions for each of 12 months), than the 365 values required for one year type using the exceedance probability method.*

The Corps addressed the feasibility of providing non-hydropower peaking windows from March to May (4-6 weeks) at Buford Dam and West Point Dam in their response to the Service's PAL (Corps 2011). The Corps states that a loss of hydropower production, as well as physical, safety, and logistical limitations would prohibit the implementation of non-hydropower peaking windows at these facilities. We note that fish and wildlife and hydropower production are coequal purposes at these facilities and under both the no action alternative and the proposed action alternative; benefits to riverine fauna are sacrificed at the expense of hydropower production. While the Corps has repeatedly stated that revised water control operations shall reflect existing structural and physical constraints (e.g., no consideration of structural improvements), there is no funding for structural improvements, and such improvements are outside the WCM update process, the Service continues to recommend that the Corps explore options to alter downstream flow releases to minimize impacts to or benefit riverine aquatic resources below their projects in the ACF Basin. Such changes in operation do not necessarily come at the cost of reduced hydropower production.

- Evaluate the potential for reducing the magnitude of the autumn drawdown, changing the order of refill, and/or beginning the spring refill earlier in order to provide fish access to and inundation of the floodplain.

  Per the Corps' June 1, 2010, informal synopsis of the Corps' alternatives development and screening process provided to the Service, the Corps considered slight adjustments to the top of conservation pool guide curves at West Point and Walter F. George Reservoirs that included an earlier spring refill. However, no explanation has been provided as to why those adjustments were not included in the preferred alternative. We continue to recommend the Corps address and evaluate all of these options listed above.

- Evaluate methods to provide the operational flexibility necessary for floodplain inundation, which could include 1) protecting structures (e.g. moving to locations of higher elevations or elevating structures using stilts as is done in coastal communities) that may be impacted by 2, 10, 50, and 100-year recurrence interval pre-dam flows during periods of floodplain inundation, and/or 2) the purchase of structures built in the historic floodplain so that the Corps could intentionally provide flows that inundate the floodplain.

  This has not been completed. The Corps states that one of their guiding principles for the WCM update process is that the flood control capabilities and capacities of the reservoirs will not be reduced (see Decision Support Model to Evaluate Changes to Corps' Operations below). Corps projects are managed in part for flood damage reduction, the objective of which is "storage of excess flows thereby reducing downstream river levels below flood stage and producing no higher stages than would otherwise occur naturally." The methods suggested by the Service would not reduce the flood control capabilities and capacities of the reservoirs. First identifying and then protecting or purchasing structures that may be impacted by floods at naturally-occurring discharges could actually reduce potential flood damage, increase operational flexibility, as well as benefit aquatic resources. Thus, we encourage the Corps to continue investigating those methods listed above.

- Evaluate the operational feasibility, constraints, and tradeoffs to providing different component(s) of environmental flow measures that are captured in our guidelines.

  These analyses have not been conducted by the Corps. The Corps stated in the PAL Response that "Defining a real life operation that meets the authorized project purposes and better meets the "natural" hydrograph and then translating that operation into code for the reservoir simulation is a large undertaking. To the extent that FWS feels more needs to be done, we request additional guidance and support."

  As stated in the PAL, we stress to the Corps that achieving a natural hydrograph in its entirety is not the goal, but providing for some components of the natural hydrograph could be beneficial. The specific components of the ecosystem flow guidelines were meant to be reviewed and considered for implementation on an individual basis by the Corps rather than collectively considered as a whole.

  Updated ecosystem flow guidelines for four locations in the ACF Basin were provided to the Corps in our March 1, 2011 PAL addendum. We agree that it is a potentially large undertaking to include flow guidelines, but we emphasize that the WCM update is itself a large undertaking that is worthy of a critical evaluation of the feasibility, constraints, and tradeoffs to providing environmental flow measures.

- Work with the Service and others to develop appropriate hydrological and meteorological criteria (e.g., basin inflow, precipitation, and reservoir levels) needed to classify the coming month as a dry, average, or wet month.

The Corps states that they have been engaged in conversations with entities such as the National Weather Service, but indicates that they do not have the reliable science to accurately make these predictions for operation of the ACF Basin system. However, we recommended that the Corps work with the Service so that we could collectively develop reasonable methods for defining hydrological conditions useful for reservoir and ecosystem management. To date, these conversations have not occurred.

<u>Floodplain inundation assessments</u>

- Use LIDAR or stage-discharge relationships to calculate area (acres) of aquatic habitat connected to the main channel of the non-tidal Apalachicola River at all four different flow scenarios including the magnitude, duration, timing, frequency, and rate of change of Apalachicola River floodplain inundation.

  It was the Service's and the Corps understanding that full LIDAR coverage of the Apalachicola River was not available at the time the Corps developed their response to the Service's PAL, but stage-discharge relationships were available. The Corps provided the Service with pertinent Apalachicola River floodplain inundation stage-discharge analyses in their response to the PAL. However, in FFWCC's May 23, 2011, review of the Service's DFWCAR, FFWCC states that data are now available for the entire Apalachicola River and should be used for more accurate future analysis. The Corps should use the LIDAR data, if they can be applied, to supplement existing analyses of floodplain inundation in the Apalachicola River.

<u>Dissolved Oxygen</u>

- Ensure that releases from all five ACF dams meet or exceed water quality standards, including monitoring water quality upstream and downstream of Corps reservoirs, experimenting with operational and/or structural modifications to Corps projects to improve water quality, and conducting post-modification water quality monitoring to ensure that levels have been improved to State water quality standards.

  The Corps states that they currently monitor water temperature, pH, conductivity, and DO below Lanier and West Point, and DO seasonally below Walter. F. George. They state that one of their guiding principles for the WCM update process is that revised water control operations shall reflect existing structural and physical constraints (e.g., no consideration of structural improvements, there is no funding for structural improvements, and such improvements are outside the WCM update process (see Decision Support Model to Evaluate Changes to Corps' Operations below). Subsequently, because the no action and proposed action alternatives significantly affect water quality, do not comply with State standards, and do not meet the designated project purpose of fish and wildlife, we requested that as part of the WCM update the Corps outline the steps that would be necessary on part of the Federal government and other entities to improve water quality below Federal projects in the ACF (Appendix IX). The Corps needs to make it a priority to ensure that releases from all five ACF dams meet or exceed DO, temperature, and other applicable water quality standards. GDNR-

WRD agrees that improvement of DO downstream of Corps reservoirs is important and would be beneficial to aquatic resources. We are available to assist the Corps in exploring alternate funding opportunities.

- Evaluate the effectiveness of the upgraded venting capabilities at Buford turbines.

  The Corps states that research is outside the scope of this WCM update. As stated above, we continue to recommend that the Corps needs to make a concerted effort to ensure that releases from all five ACF dams meet or exceed DO and other applicable water quality standards. We are available to assist the Corps in exploring alternate funding opportunities.

Temperature

- Monitor water temperature upstream and downstream of the five ACF Corps impoundments, and 1) experiment with operational and/or structural modifications to improve temperature levels, as needed, and 2) conduct post-modification monitoring to ensure that temperatures have been improved.

  As noted above, the Corps states that the revised water control operations shall reflect existing structural and physical constraints, that there is no funding for structural improvements, and such improvements are outside the WCM update process. The Corps needs to make it a priority to manage temperature levels to benefit aquatic life in accordance with resource agency management objectives. We are available to assist the Corps in exploring alternate funding opportunities.

Fish Passage

- Provisions for fish passage should be incorporated in the WCM for JWLD, GWALD, and WFGLD, while maintaining the need for operational flexibility.

  We are unsure whether the Corps will be including formal language in the WCM update for fish locking at JWLD (Appendix IX). The Corps states that they will not be including similar language for GWALD or WFGLD. They state that 1) just because it is not explicitly stated in the updated version of the manuals does not mean that operations cannot change in the future, and 2) not including language in the manual does not preclude lockings at GWALD or WFGLD, as well as modifications to lockings at JWLD in the future. However, we continue to recommend formal language be included in the WCM update. There is ample evidence that fish passage operations at the lock at JWLD are passing Alabama shad upstream, and the species may benefit from passage at these other Corps lock and dam facilities. FFWCC also agrees that the Corps should explore fish passage operations for anadromous fish species, such as the Alabama shad as part of the WCM update.

Climate Change

- In addition to considering sea level rise, include multiple future climate scenarios into modeled discharge scenarios and Corps alternatives and create flow provisions for dry, average, and wet years in order to account for current climate variability.

  The Corps states that they have considered climate change to some extent in the form of sea level rise. Their evaluations have determined that sea level rise is not projected to affect JWLD, the lowermost Corps' project in the ACF Basin. No consideration was given to the impact of climate change on hydrology. However, because climate change will potentially affect river flows and Corps operations, the Corps should include future climate scenarios over short and long terms, and flow provisions for dry, average, and wet years.

Navigation

- If navigation is included in the WCM update, evaluate the effects of channel maintenance activities required for navigation support by including an analysis of dredging needs, dredging impacts on fish and wildlife, and a cost-benefit analysis.

  A navigation window has been included in the Corps' preferred alternative. The Corps has informed us that there are no plans for dredging in the Apalachicola River but that they will dredge portions of the Chattahoochee River. Dredging needs, dredging impacts on fish and wildlife, and a cost-benefit analysis have not been included by the Corps in an evaluation of the effects of the channel maintenance activities required for navigation flow support. Therefore, we continue to recommend that dredging needs, dredging impacts on fish and wildlife, and a cost-benefit analysis be included in an evaluation of the effects of the channel maintenance activities required for navigation flow support.

- If flows for navigation are not included in the WCM update, consider improvement or simplification of the four-zone reservoir operational scheme that governs current operation.

  Navigational flows are included in the Corps' preferred alternative. However, it is uncertain whether the navigation season will be a guaranteed minimum flow to provide a seven foot channel or if it will be only "as requested" by navigation interests. It is unclear how this flow window was modeled in ResSim.

Reservoir and Riverine Fisheries Management

- Review recent fisheries literature for additional information regarding detrimental impacts to riverine fish spawning due to a 4-6 week stable or rising reservoir window, per the Corps' draft Standard Operating Procedure (SOP) for "Lake Regulations and Coordination For Fish Management Purposes."

  The purpose of this literature search is to critically evaluate the relative merits and costs of operating projects for the benefit of reservoir and riverine fisheries so that the best *available science can be integrated into an informed management approach.*

In ResSim model simulations that were run by the Corps using the entire period of record, the fish spawn SOP governed less than 1% of releases at Corps reservoirs in the ACF Basin. The Corps states this is because fish spawn operations are largely the same as operations that are already conducted for higher priority purposes at their reservoirs.

The Corps states that the fish spawn SOP has been in operation since the 1970's and the operating windows were based on water temperatures. The Corps states that the window is determined by dates because it is labor intensive to base the window on water temperatures. A reservoir fisheries literature search was recently conducted for the Corps by TetraTech but no pertinent research was found. GDNR-WRD believes that the fish spawn SOP is important and should continue. However, additional data should be collected and analyses conducted to support, modify, or reject this management strategy concurrent with SOP implementation.

A literature search has not been conducted regarding downstream flows during the fish spawn SOP period and the resulting impacts to riverine fish spawning. However, FFWCC recently provided the Corps and the Service with riverine spawning information specifically for the Apalachicola River (FFWCC letter to Donald Imm, Service Field Supervisor, and Major General Todd T. Semonite, Corps, February 22, 2011; Appendix VII). The report details how decreased spring flows have resulted in less aquatic floodplain habitats in the Apalachicola River floodplain system during critical spawning and nursery periods.

We continue to recommend a literature search be conducted for additional supporting information, especially applicable to areas upstream of the Apalachicola River.

- Investigate modifying the Fish Spawn SOPs to occasionally emphasize river spawning over reservoir spawning and define those circumstances where this would occur without unreasonably compromising other project purposes.

The Corps states that the existing fish spawn SOP language already indicates they can or will emphasize benefits to river spawning over reservoir spawning if riverine fishes have experienced unfavorable conditions for several years. The existing language in the fish spawn SOP is as follows:

"An imbalance of prey and forage fish could occur following the second or third year of poor or unsuccessful spawning and recruitment, leading to poor sport fishing. Areas where the spawns were recently unsuccessful should be given higher priority for fish management operations under low water conditions." It is unclear in the documentation provided by the Corps how determinations will be made to ensure that river spawning takes precedence over reservoir spawning, and how operations will be modified to facilitate river spawning.

To the Service, the existing language does not seem to pertain to riverine habitats and *instead appears to remain focused on reservoir fisheries. Per our recommendation in the PAL, periodic emphasis of riverine spawning should be included in the fish spawn SOP.*

- Identify fish and wildlife recreation facilities that need infrastructure improvements to operate at a wider range of flows and/or reservoir elevations.

  The Corps states that one of their guiding principles for the WCM update process is that revised operations shall reflect existing structural and physical constraints. They state that there is no funding for structural improvements and such improvements are outside the WCM update process. However, this recommendation could lead to increased operational flexibility for the Corps in the future. We are available to assist the Corps in exploring alternate funding opportunities.

National Wildlife Refuges

- Manage Walter F. George Reservoir so that it behaves more like a river to benefit Eufaula National Wildlife Refuge (NWR). Reservoir elevations that cycle between the highest levels (190 ft) in the late winter and early spring to the lowest levels (185 ft) in the late summer are recommended to provide seasonal habitat for a large number of migratory bird species, control the spread of undesirable aquatic vegetation, and allow the manipulation of off-reservoir impoundments for waterfowl.

  In May 2010, after talking with the Corps regarding the recommendations in the Service's PAL, the Service provided the Corps with a set of specific flow tweaks that we would like the Corps to model that could potentially result in more environmentally beneficial flow alternatives. We included the above recommendation as one of the tweaks to be modeled, so that we could examine the ResSim output and evaluate the effects of these changes on system operation. The Corps states that the Walter F. George Reservoir is the first line of defense to provide flow at JWLD for the Revised Interim Operations Plan (RIOP) operations. The Corps also states that holding Walter F. George Reservoir higher in the winter wet season would increase the frequency of damaging downstream flows and maintaining low elevations during the summer dry season would remove storage from the system when it is most critically needed for flow augmentation and hydropower production. This issue has been addressed and is no longer a conservation measure.

Apalachicola Bay

- Incorporate the Sheng and Kim (2009) Apalachicola Bay salinity model in the WCM update process to predict effects to Gulf sturgeon feeding habitat and potentially oyster mortality and growth.

  The Corps has allowed the Service to use a portion of the Corps transfer funding, previously supplied to the Service for FWCA responsibilities pertaining to the ACF WCM updates, to fund Sheng's work. His modeling results are incorporated into this DFWCAR (above). We recommend that the Corps incorporate modeling results not only to evaluate *effects of their project operations, but also to inform their development of proposed alternatives.*

- Coordinate with FFWCC's Fish and Wildlife Research Institute to complete analyses of the relationship of freshwater inflow to the benthic communities of Apalachicola Bay and changes in fish and shellfish abundance.

  FFWCC provided pertinent analyses to the Service and to the Corps comparing the pre-dam and post-West Point periods of record, but did not include analyses for future actions, such as the WCM proposed alternatives or other future Corps' proposed actions. In that correspondence FFWCC provides updated research that raises "significant hydrologic and biological concerns applicable to any alternative [Corps] operation departing from the historic flow regime of the Apalachicola River" (Appendix VII). We recommend the Corps move forward by coordinating with FFWCC to complete similar analyses on the WCM proposed alternatives and other future Corps' proposed actions.

Decision Support Model to Evaluate Changes to Corps' Operations

- Incorporate a decision support model into the WCM update process to evaluate the effects of management strategies on the riverine ecosystem, recreation, navigation, hydropower, and other uses of Federal dams.

  The Corps stated that they have used a decision support approach on a coarse scale and subsequently shared a synopsis of their decision-making process with the Service. Their June 1, 2010, synopsis indicates that their Modeling Team and Project Delivery Team have developed internal guiding principles for the revised WCM and an iterative process for the development of their alternative(s), which relies heavily on ResSim outputs. The Corps' guiding principles are as follows:

  1. *Flood control capabilities and capacities of the reservoirs will not be reduced (e.g. no measure is acceptable if it raises the likelihood, frequency, or severity of flooding).*
  2. *The ACF will continue to be operated as a system. The balancing of water control operations to achieve each of the project purposes will continue to vary between the individual projects and the time of year. Operation of the projects will continue to usually be performed in a manner which represents a consideration of these oftentimes competing purposes and, whenever possible, reservoir operations are scoped to accommodate these purposes in a complimentary fashion (balancing).*
  3. *The revised water control operations shall be within existing project purposes and authorities.*
  4. *The revised water control operations shall reflect existing structural and physical constraints (e.g. no consideration of structural improvements).*
  5. *The revised water control operations shall meet the existing Endangered Species Act requirements.*
  6. *The fish spawn SOP will continue to be implemented within the reservoirs.*

7. *Reallocation of storage to meet current water supply demands [where current equaled the highest levels of consumption experienced to date] at Lake Sidney Lanier for municipal and industrial (M&I) water supply shall be evaluated in conjunction with revised water control operations. (This guiding principle was subsequently revised to account for a district court ruling in Phase 1 of the consolidated ACF litigation, 17 July 2010 ("Phase I Ruling").*
8. *The revised water control operations will not adversely alter the water quality in Corps reservoirs.*

Ultimately, the Corps feels that the selected alternative reflects the combination of measures necessary for balancing system operations. This decision-making process should be more transparent to stakeholders, both in the WCM update process and in future proposed Corps' actions.

Adaptive Management

- Develop an adaptive management program, consistent with the authorized purposes of the ACF reservoirs, for achieving specific ecological and social goals for the management of the ACF system including specific releases for Woodruff Dam.

  The Corps states that the periodic updating of the WCM is a form of adaptive management and should be practiced. The Corps states that litigation has prohibited adaptive management from occurring on a periodic basis. While we understand the litigation history surrounding water management in the basin, we continue to recommend that the Corps develop an adaptive management program. We urge the Corps to consider a management approach that fosters implementation of an operational strategy with clearly defined goals or hypotheses, an evaluation to assess outcomes of the operation, and integration of the knowledge gained from that operation into management. Such operational changes do not necessarily occur outside of existing project authorizations and should therefore be of less litigation concern.

  The Corps should also consider that there is at least one consensus-driven stakeholder group working towards a water management solution in the ACF Basin. This group may be able to provide valuable information and insight as a starting point for an adaptive management program.

Increasing Consumptive Demands

- Recognize and consider the impacts of increasing consumptive (municipal, industrial, and agricultural) water demands in the basin and incorporate it into analysis of operational alternatives along with climate-driven hydrologic variability. Quantify the relationship between increasing consumptive demands in the ACF Basin and effects on various project purposes.

  This has not been completed and the Corps is using currently permitted withdrawals and a planning horizon of 10-15 years with the intent of the manuals being updated again within that timeframe. However, there is a precedent that shows that 10-15 year *planning horizon is short-sighted. The last attempted update of the WCM was 23 years ago and it was not completed. We are concerned that the likelihood of updating the WCM in 10-15 years is small due to the issues at hand, large number of stakeholders, and potential for litigation. Therefore, projected future increases in withdrawals should be included in the Corps' analyses.*

- Include metrics regarding water supply withdrawals, including potential increases, in the alternatives analysis. The volume of storage that is being provided for water supply and has been proposed in each project and any limitations due to hydrologic conditions of meeting the water supply storage volume should be documented, as well as any potential changes in agricultural irrigation due to expanded irrigated acres or changes in crop composition.

  The Corps states that they are using the currently permitted withdrawals to date and that current usage has not yet reached the level of currently permitted withdrawals. As stated above, although the Corps intends to update the manuals again within the next 10-15 years, we are concerned that the likelihood of that being achieved is small due to the issues at hand, large number of stakeholders, and potential for litigation. Long-term goals of sustainable water management could go unrealized using short-term visions. Therefore, projected future increases in withdrawals should be included in the Corps' analyses.

Evaluation of Alternative Models

- Investigate the use of alternative models to develop better unimpaired flow and alternative flow datasets. Compared to the USGS gage data, the unimpaired flow dataset does not accurately represent the magnitude, duration, timing, and rate of change of flow extremes (i.e., minimum and maximum flows). Because flow extremes play important roles in reservoir operational decisions and in riverine, estuarine, and floodplain ecology, efforts should be made to develop unimpaired flow and alternative flow datasets that more accurately reflect flow extremes.

  Fundamental differences in output between the USGS gage data and the no action alternative (ie. current operations) are described in Appendix X. The Corps states that at this point in the process they are locked into using ResSim and HEC-5Q. They state that the 2010 Corps' Federal Storage Reservoir Critical Yield Analyses for the ACT and ACF Basins contains a description of how the datasets were developed and can be found on their website. Although HEC-ResSim has enabled the Corps to model several alternatives, they have indicated that it is difficult and labor intensive to try alternative management scenarios. We encourage the Corps to investigate alternative models that enable greater flexibility in model use and alternative development, while retaining the utility of HEC-ResSim. We recommend the use of alternative models be investigated as soon as possible, to inform the Corps not only for the WCM update process but also for future Corps' proposed actions.

- If the United States Geological Survey's (USGS) Precipitation-Runoff Modeling System (PRMS, http://water.usgs.gov/software/PRMS) is developed specifically for the ACF in a timeframe useful for the ACF WCM update process, use it as an additional evaluation tool to 1) check the precision of the Corps' unimpaired flows datasets, and 2) supply an alternative unimpaired flow dataset to use based on informed climate and land use change predictions.

  It is our understanding that the PRMS model is not ready for use at this time. However, if and when it is developed specifically for the ACF it should be used by the Corps as an additional evaluation tool for the WCM update process and future Corps' proposed actions.

- Coordinate with USGS and Georgia Water Resources Institute (GWRI) regarding new models to explicitly address climate-based operational flexibility during the development and evaluation of flow alternatives, the WCM update, and the EIS analyses.

  The Corps states that they coordinate with Georgia Department of Natural Resources-Environmental Protection Division (GEPD), who uses some of GWRI's work, and that time will not allow for ResSim to be changed at this point in the process. We continue to recommend that the Corps coordinate directly with GWRI to address climate-based operational flexibility as soon as possible, to inform the Corps not only for the WCM update process but also for future Corps' proposed actions.

- Consider alternative water quality assessment methods to accurately evaluate effects of flow alternatives on water quality. Because the HEC-5Q water quality model outputs are not expected to accurately predict either the water quality values or the range of values that are likely to occur in response to hourly discharge changes, consider using existing alternative water quality models or develop regression models to accurately predict water quality parameters using a combination of water quality datasets, hourly discharge, and other environmental parameters (e.g., weather and solar exposure).

  The Corps states that HEC-5Q is advantageous because it considers the system holistically; they also cite similar results between their simulated output to their observed tailrace data. Because HEC-5Q relies on daily average flow it does not accurately reflect water quality values that are likely to occur in response to hourly discharge changes. We continue to recommend alternative water quality assessment methods to accurately evaluate the effects of Corps operations on water quality.

Additional Conservation Measures Developed from the Corp's PAL Response

- There are no minimum flow provisions downstream of WFGLD. When low dissolved oxygen values are observed below the dam, the Corps states that spillway gates are opened until the dissolved oxygen readings return to an acceptable level. The Service has not seen actual data that exhibit an improvement in dissolved oxygen levels using this methodology. However, if this methodology is in fact effective, the Corps should evaluate modifying WFGLD's operations to provide a continuous minimum flow release instead of operating in a "reactive response" mode. Continuous minimum flow releases are already implemented at the other four other Corps' ACF Basin projects.

- Consider other options for operational flexibility that do not include changing the drought provisions or the fall rates when releases are between 16,000 and 30,000 cfs from the RIOP.

- Complete analyses to assess differences between the no action and proposed action alternative relative to chlorophyll-*a* and retention time.

- In your NEPA documentation, the impacts of the proposed action alternative on fish and wildlife resources should not only be described and quantified, but the Corps should also outline your approach to mitigation. Mitigation measures should be based upon more accurate projections of future projected resource conditions with and without the project.

SUMMARY AND FWS POSITION

The Service does not support the Corps' proposed action alternative for many reasons including a failure to address conservation measures identified in the PAL (Appendix V), modeling developed from short-term planning horizons and a single consumptive use scenario, increased frequency of low flows, negative impacts to mussels due to reduced low flows, increased storage resulting in lower annual releases to the rivers and bay, failure to address conservation measures identified in the PAL, and inadequately evaluated impacts to mussels, fisheries, and habitats due to proposed changes from the 1989 draft WCM and the RIOP.

In accordance with the FWCA and Service mitigation policy (FR 46(15):7644-7663; January 23, 1981), we identified steps that should be taken to ensure that fish and wildlife resources are protected or improved. We identified additional conservation measures and steps that should be taken as part of an update to the WCM. Although the Corps stated that consideration and modeling of other flow alternatives using HEC-ResSim is a potentially large undertaking, we emphasize again that the WCM update is itself a large undertaking that is worthy of a critical evaluation of the feasibility, constraints, and tradeoffs to providing environmental flow measures. To date, no aspect of the flow guidelines provided in the PAL or PAL addendum have been integrated into the Corps' modeled alternatives.

The Corps has not provided an evaluation of project impacts associated with a more accurate projection of future conditions, and therefore direct comparisons of the future of the resource with and without the project are hampered. Consequently, we emphasize that the Corps should develop and quantify projected positive and negative impacts for 'with the project' and 'without the project' scenarios based on more accurate projections of future conditions so that appropriate mitigation measures can be developed and included in your National Environmental Policy Act (NEPA) documents.

We also emphasize that the Corps' impact to water quality, primarily dissolved oxygen, below several projects in the ACF Basin is unacceptable. The Corps needs to seek authorization and appropriations to ensure that water quality standards are met below these projects.

Finally, the Service reminds the Corps that when a water body is proposed to be controlled or modified “for any purpose whatever” by a Federal agency, the action agency is required *first* to consult with wildlife agencies (Federal and State) “with a view to the conservation of fish and wildlife resources.” Although discussions occurred regarding the WCM update and resource concerns in the ACF Basin, the Corps developed all alternatives well before the Service and State agencies were informed of the proposed action. We understand that the Corps had to move quickly to meet the 2012 deadline laid out by Judge Magnuson’s July 2009 ruling; however, proceeding in this manner is not consistent with the purpose of the FWCA, and consequently has hampered consideration and integration of fish and wildlife planning objectives and concerns. To date, all analyses provided by the Corps consist of evaluations of the effects of flow alternatives developed by the Corps with little consideration of project operation enhancement to benefit fish and wildlife. To ensure sustainability for these resources, the Service will continue to work cooperatively with the Corps and all stakeholders. In particular, the Service needs to be an integral member of the Corps’ team when formulating and evaluating operational alternatives. We encourage the Corps to follow the recommendations and conservation measures included in this document, and are ready to assist in the development of a WCM that is protective of fish and wildlife resources in the ACF River Basin.

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GEORGIA
DEPARTMENT OF NATURAL RESOURCES
MARK WILLIAMS, COMMISSIONER

May 23, 2011

Sandra S. Tucker, Field Supervisor
Fish and Wildlife Service
105 West Park Drive, Suite D
Athens, Georgia 30606

Dear Ms. Tucker,

Thank you for the opportunity to review the Fish and Wildlife Service's Draft Fish and Wildlife Coordination Act Report (DFWCAR) to the Corps of Engineers regarding the Water Control Manual update for the Apalachicola-Chattahoochee-Flint (ACF). The DFWCAR discusses several issues related to fisheries management issues important to WRD and we offer the following comments for your consideration in development of the final DFWCAR.

Water Temperature

The current thermal regime in the Chattahoochee River tailwater below Lanier is of considerable importance to the Georgia Wildlife Resources Division (GAWRD). The trout fishery on the Chattahoochee River has existed for nearly 50 years and is considered to be one of the premier fisheries in Georgia (approx. 90,000 trips per year). The fishery is dependent upon cold well-oxygenated water for the survival of both wild brown trout and stocked trout. In addition, the Buford Trout Hatchery, located less than two miles downstream of Buford Dam produces 400,000 catchable trout annually and is dependent upon cold water in the river to maintain this production.

On Page 18: The DFWCAR discusses water temperature in the Chattahoochee River tailrace as it relates to fisheries management efforts, and we offer the following comments to this section for clarification.

The DFWCAR is correct in stating that water temperatures are of significant concern to GAWRD in this Section of the Chattahoochee River and our interest in maintaining the cold temperature regime to support the popular trout fishery in this section of the River. Because summer maximum temperatures can become marginal for trout survival below Morgan Falls, GAWRD has diversified fishery management strategies in this reach. GAWRD is currently stocking shoal bass below Morgan Falls as we have seen sporadic/inconsistent shoal bass reproduction in this section and have determined that annual supplemental stockings are necessary to maintain a fishery.

The paragraph referencing striped bass stocking on West Point Reservoir should be expanded upon to fully describe the Gulf Striped bass restoration effort. Gulf Striped bass restoration in the ACF is a collaborative effort between the conservation agencies in Georgia, Alabama, Florida, and the FWS with the goal of restoring a self-sustaining population to the maximum extent possible. The group meets on an annual basis to set goals and discuss ongoing management and research for Gulf striped bass in the ACF system. West Point Reservoir is currently designated as a potential broodfish repository and is one of the highest priority reservoirs to receive stocked striped bass.

While the DFWCAR is correct in stating that striped bass exhibit upstream migrations from West Point Reservoir to spawn and that a (summer/early fall) fishery has developed in the Chattahoochee River downstream of Morgan Falls, the DCFWCAR does not mention the significant importance of cool-water refuge upon the survivability of adult striped bass. The movement of striped bass upriver to Morgan Falls is thought to be largely related to water temperature (thermal refuge), as their abundance below Morgan Falls increases as summer progresses.

Dissolved Oxygen

Page 25-26: The DFWCAR identifies the occurrence of low D.O. below reservoirs as an important issue related to this process. WRD agrees with the DFWCAR that improvement to D.O. downstream of the reservoirs is important and beneficial to aquatic resources, and that this process may present opportunities or options to improve D.O. conditions.

Recreational Fishing

Recreational fishing is a very important use of these reservoirs and provides fishing opportunities to Georgia's one million plus anglers. Currently, the USACE implements a fish spawning Standard Operating Procedure (SOP) whereby water levels are managed for stable or rising conditions during a spring period to enhance spawning success and fish recruitment. GAWRD feels that the spawning SOP is important and should continue, when possible.

If you have any questions, please contact Matt Thomas at (770) 918-6406.

Sincerely,

Mark Williams

MW/cb

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May 23, 2011

Ms. Alice P. Lawrence
Fish and Wildlife Biologist
United States Fish and Wildlife Service
105 Westpark Drive, Suite D
Athens, Georgia 30606

RE: Florida Fish and Wildlife Conservation Commission's Comments on Draft Fish and Wildlife Coordination Act Report.

Dear Ms. Lawrence;

The State of Florida, through its Fish and Wildlife Conservation Commission ("Commission") submits the following comments on the *Draft Fish and Wildlife Coordination Act Report on the Water Control Manual Updates for the Apalachicola-Chattahoochee-Flint River Basin in Georgia, Alabama and Florida* ("Draft Report") shared with us on May 9, 2011. We previously provided comments on your April 2010 Planning Aid Letter ("PAL"), and supplied additional information relevant to the Draft Report in our paper entitled *The Impact of Reduced Flows on the Apalachicola River and Bay Ecosystem* (February 2011). We have since reviewed (but were not afforded an opportunity to comment on) your March 2011 PAL Addendum. Florida commends the Service for identifying a number of key concerns shared by the Commission and agrees with the Service's general assessment that the Corps of Engineers' proposed alternatives, as reflected in the Corps' January 2011 response to the PAL ("PAL Response"), are unacceptable.

We wish to underscore the importance of consistent, transparent communication among the Corps, the Service and the Commission. As you correctly note, the Fish and Wildlife Coordination Act ("FWCA"), 16 U.S.C. §§ 661 *et seq.*, requires the Corps to consult with the Service and the Commission, Draft Report at 35, but such coordination has not occurred. The Corps has, in fact, refused to coordinate directly with the Commission, instead directing us to funnel our input through the Service. This is not consistent with the Corps' obligations and hinders our ability to conduct our analyses. For instance, the Service apparently has had the PAL Response since January 2011, but was only authorized by the Corps to share it with the Commission in April 2011. We are now forced to comment on the Draft Report in less than three weeks. Better coordination is required.

Nevertheless, we offer the following comments on the Draft Report and, as appropriate, the PAL Response. We trust the Service will continue to convey Florida's concerns in its discussions with the Corps.

The No Action/Baseline alternative is not acceptable.

The No Action/Baseline Alternative is a continuation of existing operations dictated in large measure by the 1989 Draft Water Control Plan ("DWCP") as modified by a series of *ad hoc* operational protocols. As a preliminary matter, it is important to note that this set of operations has never been subjected to FWCA analysis and has similarly eluded consultation requirements imposed by Section 7 of the Endangered Species Act ("ESA"), 16 U.S.C. §§ 1531 *et seq.* It is imperative that the No Action/Baseline Alternative be scrutinized meaningfully and not accepted merely because it constitutes a continuation of the *status quo*.

To that end, threatened and endangered species conservation is compromised by the arbitrary storage thresholds described on pages 1-9 to 1-11 of the PAL Response. These "Actions Zones" reflect interim operational practices implemented through the Revised Interim Operating Plan. Continued adherence to the Action Zones precludes the Corps from using the full conservation storage capacity for all the purposes authorized by Congress when the lakes were constructed, and thereafter. That water should be made available to bring flows more in keeping with the Service's Environmental Flow Guidelines ("Guidelines") as identified in the PAL and PAL Addendum.

For example, year-2000 flow and lake storage hydrographs (Slides 2-7) show that when Apalachicola River flows were 2,000-3,000 cfs lower than the lower limit Guidelines and 5,000-6,000 cfs lower than the dry-year Guidelines, the lakes were still holding 800,000-1,200,000 acre feet of conservation storage plus an additional 1,856,000 acre feet of inactive storage. Existing operations model run (Baseline-0) shows that during the lowest lake levels reached in the entire period (2007), the lakes still held more than 500,000 acre feet of conservation storage plus the inactive storage.

The full storage capacity of these Federal projects is not being used as Congress intended. The balance being struck by the Corps is unreasonable, as threatened and endangered species conservation is being undermined to support, among other things, recreation and sport fishing under present Corps protocols.

For example, Florida has long expressed concerns with the Standard Operating Procedure ("SOP") governing reservoir fish spawning. The SOP deprives the Apalachicola River and its threatened and endangered species of water during the critical spawning period ostensibly for the protection of sport fish spawning in the reservoirs. Yet, there is no credible evidence that a one-foot drop in lake levels has a significant impact on year-class strength in reservoirs. In contrast, we have documented a direct correlation between year-class strength and river flow in the Apalachicola. The water withheld upstream to support sport fish spawning would make a tremendous difference in providing a longer duration of floodplain inundation in April and May to support spawning (including Gulf sturgeon and host fish for threatened and endangered mussel species) in the Apalachicola River.

Finally, analyzing the No Action/Baseline alternative (and all others), the Corps assumes that maximum upstream consumption will occur at all times. This assumption is incorrect, as consumptive use changes seasonally and in response to climatic variation. Some account should be made for this variation in all analyses.

The "Action" Alternatives are not acceptable.

The incremental differences among the No Action/Baseline alternative and the action alternatives is meaningless. These alternatives are so similar in nature, and their effects so indistinguishable, that they would not survive the most basic NEPA challenge. *See, e.g., Muckleshoot Indian Tribe v. U.S. Forest Service*, 177 F.3d 800 (9th Cir. 1999) (holding unlawful NEPA analysis that considered only no action and two virtually identical action alternatives). In fact, the proposed alternatives are little more than a gloss on the No Action/Baseline alternative.

The proposed action alternatives will actually be *worse* for threatened and endangered mussel species due to the increase in storage (and corresponding decrease in flow) caused by raising the Action Zones. While we understand that the final operating criteria chosen will be subject to ESA Section 7 consultation, we agree with the Service that the proposed changes in the reservoir Action Zones, drought protocols, and ramping rates would result in freshwater mussels being subjected to low flows for a greater duration than previously experienced. This is unacceptable, particularly given the repeated culling of mussel populations experienced over the last 5 years. For this reason, we suggest all efforts be made to maintain flows above 6,000 cfs at all times.

Moreover, the proposed action alternatives do not include a true conservation alternative designed to serve the needs of fish and wildlife and related habitats in the Apalachicola River Basin. Rather, all the alternatives are merely variations on a theme of perpetuating existing operations. As you correctly point out, fish and wildlife is a co-equal purpose under the FWCA. Draft Report at 1. The Corps does not acknowledge this, and each of the proposed action alternatives renders fish and wildlife subservient to all other uses.

In its PAL Response, the Corps completely dismisses the notion of developing an operating protocol based on replicating a more natural hydrograph that reflects the importance of the Guidelines. The Commission disagrees that such a protocol is too difficult to justify analysis. That said, the difficulty associated with developing an alternative that actually complies with the FWCA and ESA is irrelevant. The Corps is legally obligated to evaluate at least one alternative that recognizes the co-equal priority of fish and wildlife (and related habitat) maintenance.

The Guidelines (modified as per the Commission's suggestions herein) should be the foundatiou of all analyses of the Corps operations.

We generally support the Service's Guidelines and concur that these guidelines (as modified below) should be used as the yardstick against which to measure the relative "success" or "failure" of any alternative's ability to meet the needs of fish and wildlife in the Basin. Flow guidelines based on pre-dam flows need to be added to all graphs related to fish and wildlife resources, and incorporated into all levels of analysis and decision-making. To accomplish this, we have the following suggestions.

The Guidelines are calculated using only the lowest 7 days in each month, which makes it difficult to directly compare other flow data and constrains the applicable guideline to a single number for each month. To make "apples-to-apples" comparisons, one must convert all other flow data to the lowest 7 days per month before comparing them to the Guidelines, which is unnecessarily complex and prevents the Guidelines from being used in all analyses as intended. For hydrograph-type analyses, the Commission proposes a slightly modified flow guideline that is calculated from <u>all the data</u>, such as the 90% exceedance hydrograph shown on Slide 1. Other daily exceedance hydrographs, such as 75% (blue line, Slide 13), could also be used. An additional benefit of using daily exceedance hydrographs is that they better match conditions in April and May, which typically have much higher flows at the beginning of the month than at the end.

More importantly, however, none of the analyses in Section 2.7 of the PAL Response include pre-dam "guideline" data. Because the Corps did not use hydrographs, neither the Guidelines nor the Commission's exceedance hydrograph alternative can be adapted and added to the Corps' graphs. We recommend that daily pre-dam flow data be used directly to serve as an ecosystem flow guideline in every case regardless of the type of statistic or graphical display used in the evaluation. We provide an example of this in the frequency curves on Slides 9-11 and 17-19, which have a pre-dam "guideline" shown in blue on every graph. Similarly, pre-dam "guideline" flow data should be added to all of the graphs in Section 2.7 of the PAL Response, which display various frequency and "number of days per year" analyses. Calculating various statistics with the pre-dam flow data it is a much more flexible approach that allows an ecosystem guideline to be added to every graph.

Finally, the Corps continues to employ the misguided Run of River ("RoR") rubric in numerous graphs in the PAL Response. All RoR flow data should be removed because it is not an appropriate basis for analyses or decisions related to ecosystem protection. River-floodplain biota has never experienced natural conditions remotely resembling those of the RoR flow regime. Minimum flow in the RoR regime is 34 cfs. Furthermore, RoR flow in late summer and early fall of 2007 averaged 2,700 cfs for a continuous duration of 2.5 months, which represents conditions that riverine biota could not survive. In all graphs related to fish and wildlife resources or ecosystem protection, the RoR rubric should be removed and replaced with an ecosystem guideline based on pre-dam flows (as described in our suggestions above).

Floodplain Inundation Analyses are inappropriate.

Analysis of frequency in percent of years of the annual maximum of 30-day minimum acres of inundated floodplain is not useful and should be replaced with hydrographs similar to Slides 21 and 22. Hydrographs provide a more useful tool than frequency curves for assessing critical flows throughout the entire year, as the Service notes on pages 8-9 of the Draft Report. Because duration and timing of seasonal flow and habitat requirements vary for each species, hydrographs showing the full year are the preferred method for either describing long-term summaries of flow (Slides 13-14) or area data (Slides 21-22), or for focusing on selected individual dry years (Slides 3-5). Hydrographs allow analysis of sturgeon and other fish spawning conditions in the spring, mussel habitat conditions in the summer, and a variety of other biological requirements using the same graph.

In addition, the PAL Response (2-73) contains an erroneous assumption regarding floodplain connectivity. The Corps indicates floodplain inundation in the Apalachicola River does not occur until flows reach 100,000 cfs. However, the approximate flows at which significant floodplain inundation begins in each reach can be estimated from the breaks in the curves in Figure 27B of Light et al., 1998, as follows:

Upper Reach – 28,000-29,000 cfs
Middle Reach – 13,000-14,000 cfs
Nontidal Lower Reach – 13,000-14,000 cfs

It appears the Corps incorrectly assumed that the floodplain is not inundated until river levels exceed top of bank elevations in the upper reach. This assumption is incorrect for two reasons: First, the greatest proportion of floodplain area in the Apalachicola River is in the middle and lower reach where top of bank elevations are much lower (relative to river levels) than in the upper reach. Second, during rising river flow, movement of river water into the floodplain through numerous breaks in the levee at stream and slough mouths allows almost unimpeded connections between the river and floodplain in all reaches. Thus nearly all of the floodplain forest becomes inundated long before the top of bank elevations are overtopped.

Analyses of Bay species should be augmented.

Juvenile Gulf sturgeon analyses are scant. There should be additional analyses of the impact of proposed and existing operations on juvenile sturgeon in the Bay. While we agree generally with the conclusions contained in the Bay section of the Draft Report, we encourage the Service to provide additional details about potential impacts to estuarine sentinel species (e.g., Eastern oysters, *Crassostrea virginica* or White shrimp, *Litopenaeus setiferus*).

Floodplain Inundation Stage Discharge Analyses are inadequate

We disagree with the following statements on Page 25 of Draft Report: *"The Corps provided the Service with pertinent Apalachicola River floodplain inundation stage-discharge analyses in their response to the PAL. This has been adequately addressed and is no longer a conservation measure."* The analyses conducted were inadequate and should be revised to include comparisons to ecosystem guidelines in every graph, hydrographs showing seasonality and duration of flows and inundated area throughout the year, and expanded views of frequency curve data at the low-flow end. We have provided some examples of each in the attached slides.

In addition, for your information, LIDAR data are now available for the entire Apalachicola River and should be used for more accurate future analysis.

Adaptive Management only works if operations are modified as necessary.

The Draft Report contains a recommendation to implement Adaptive Management. Fundamentally, this concept is about taking action to improve progress toward desired outcomes. The key to successful adaptive management, therefore, is to modify operations that are shown, through monitoring, to be detrimental to species. While the Commission appreciates the Service's recommendation to incorporate adaptive management principles into the Water Control Planning process, the Corps has not shown a willingness to modify its behavior in response to monitoring data that show negative impacts on species.

For adaptive management to succeed, clear objectives (e.g., restoration of a viable reproductive mussel population in Swift Slough) must be identified. Sound monitoring techniques must be employed, and the data reviewed regularly to ascertain whether the goals are being met. Finally, specific response alternatives should be identified in the event the stated goals are not being met. Each of these three elements is a necessary component of any adaptive management program.

Climate Change Analysis

One of the impacts of climate change is an anticipated rise in sea levels. The Draft Report should address the minimum flows needed to mitigate the impacts of salt water incursion due to sea level rise.

Fish Passage

We agree that the Corps should look at fish passage operations for anadromous fish species, such as the Alabama shad, as part of the Water Control Manual update.

We thank you for the opportunity to comment and your attention to this matter. Again we hope for improved coordination in the future.

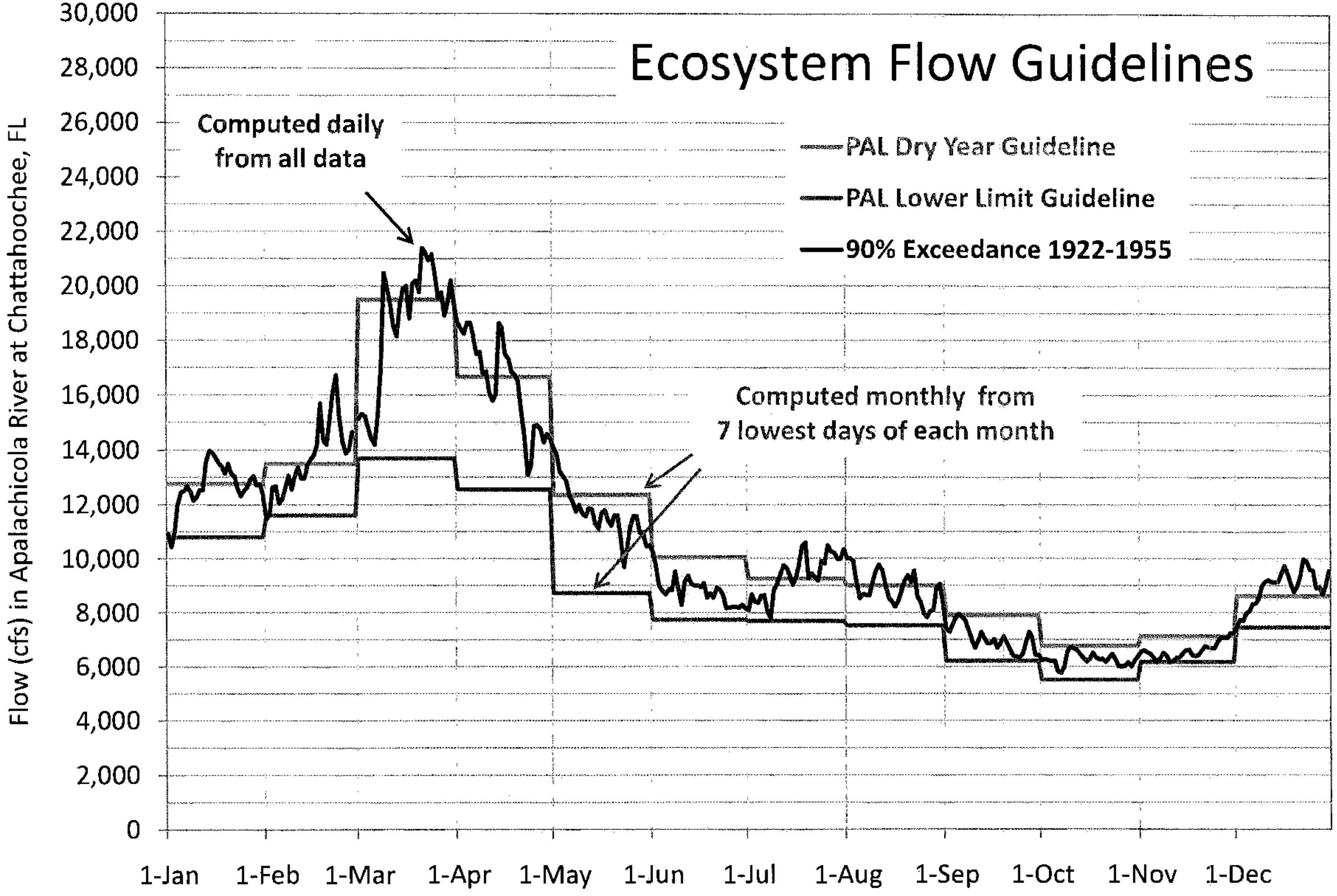
Respectfully,

Harold G. Vielhauer
General Counsel

cc: Mr. Don Imm
USFWS-Panama City Field Office

Ms. Sandy Tucker
US Fish and Wildlife Service

Encl.



Ecosystem Flow Guidelines

Computed daily from all data

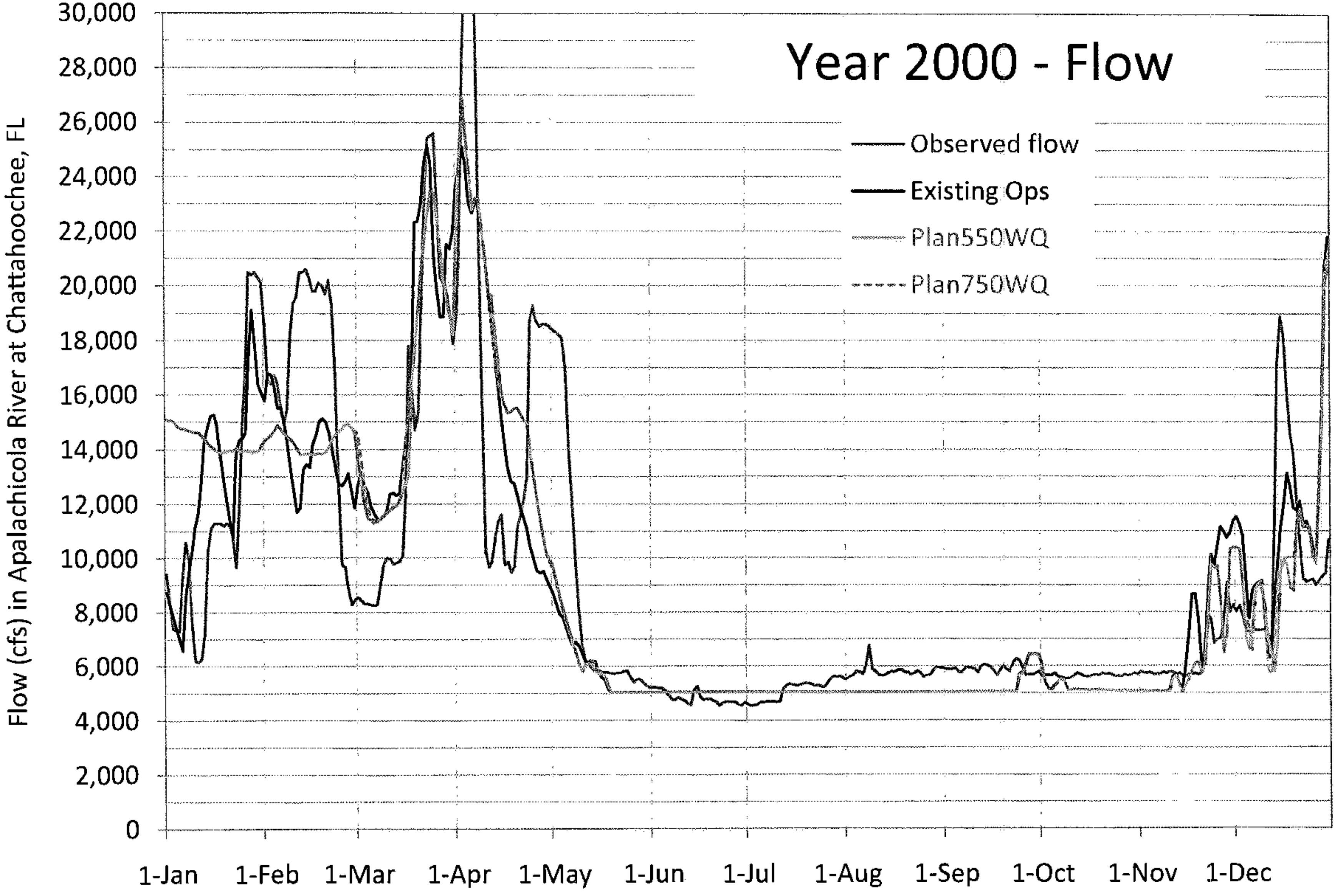
Computed monthly from 7 lowest days of each month

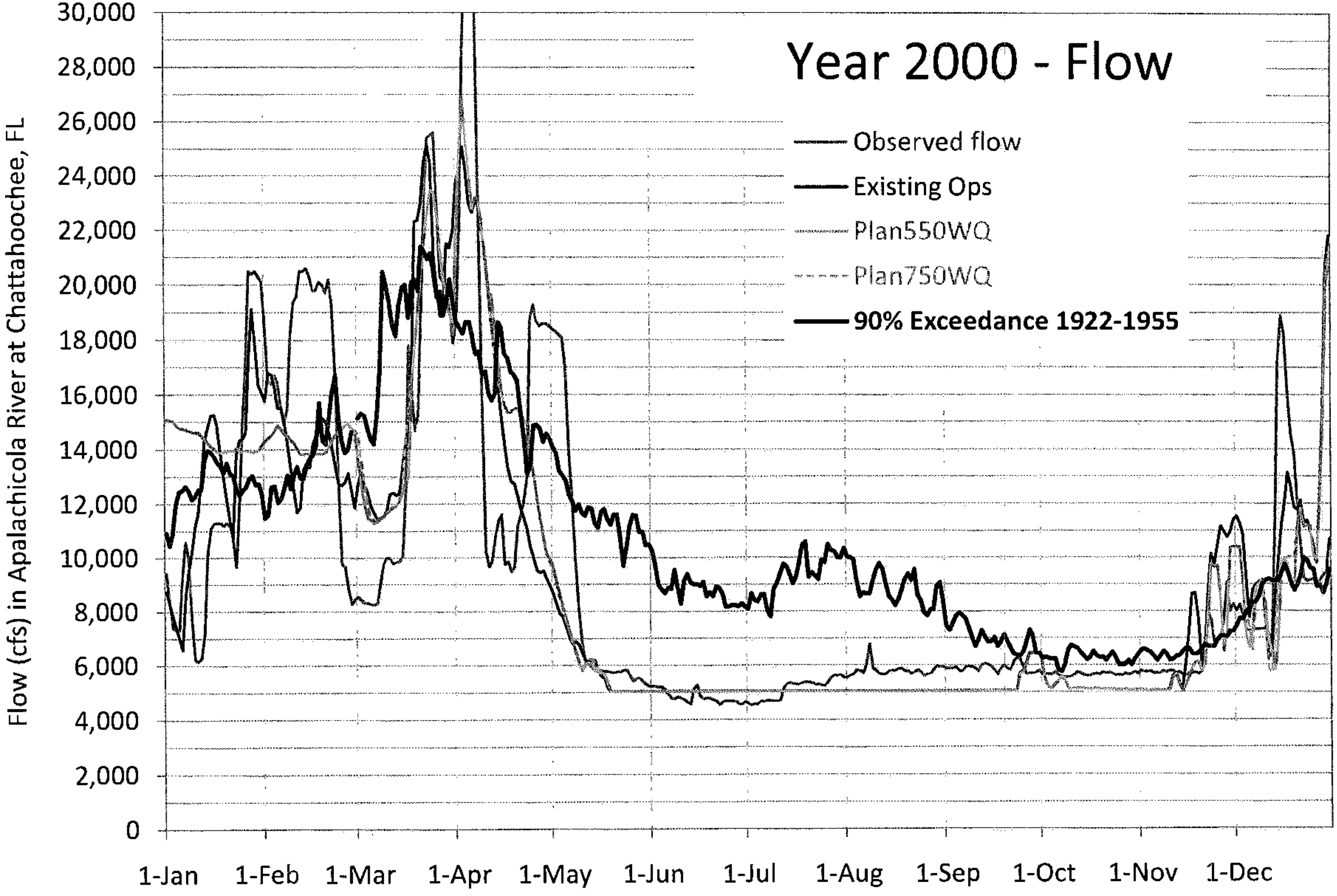
Flows Vs Lake Storage

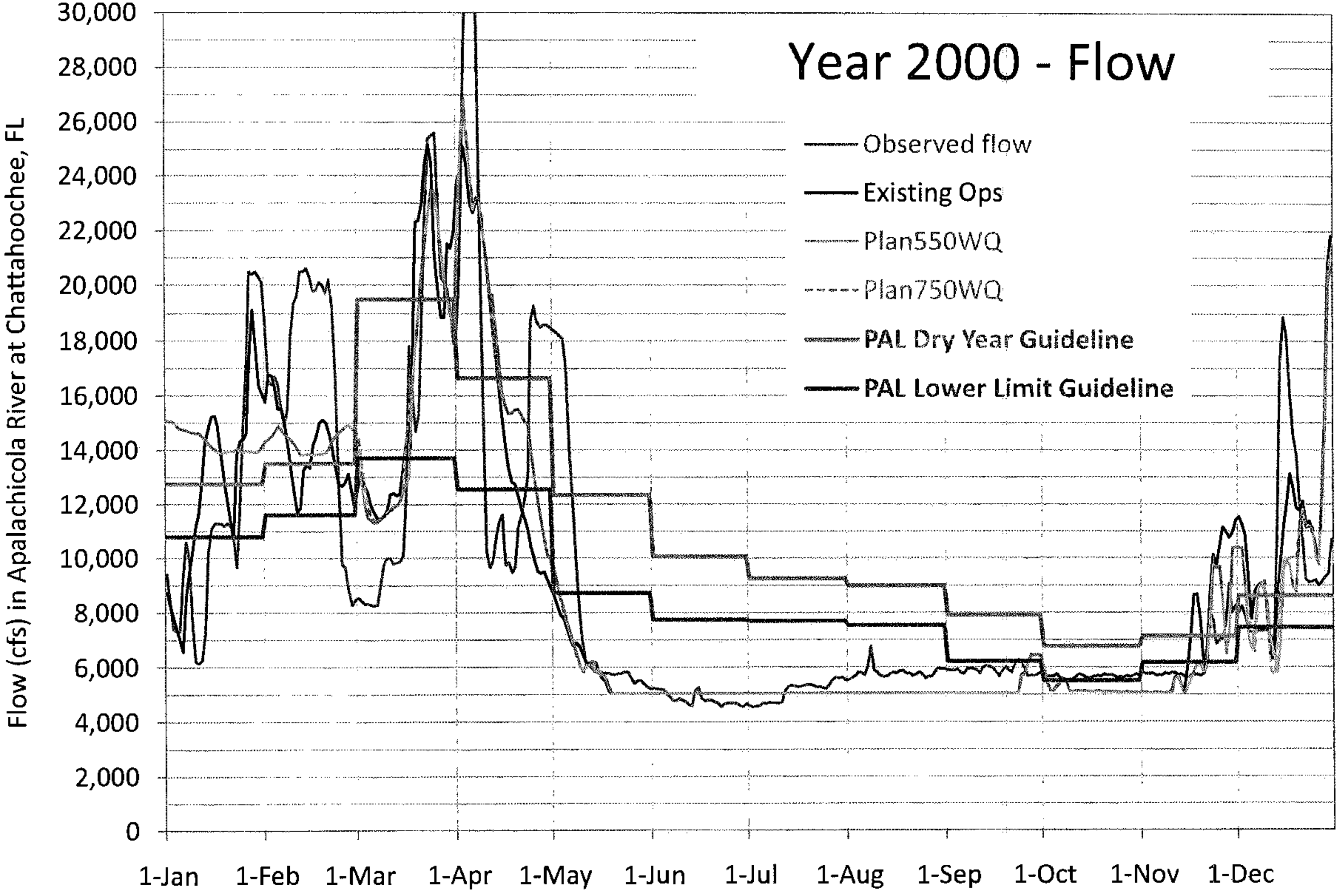
*At times when Ecosystem Flow Guidelines are **not** met, what is the Total Composite Storage (TCS) in the Federal Reservoirs?*

Year 2000 is provided in the following example.

Data source: 8-20-2011 Corps model output


Year 2000 - Flow
Observed flow
Existing Ops
Plan550WQ
Plan750WQ
Flow (cfs) in Apalachicola River at Chattahoochee, FL
30,000
28,000
26,000
24,000
22,000
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec


Year 2000 - Flow
Observed flow
Existing Ops
Plan550WQ
Plan750WQ
90% Exceedance 1922-1955
Flow (cfs) in Apalachicola River at Chattahoochee, FL
30,000
28,000
26,000
24,000
22,000
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec


Year 2000 - Flow
Observed flow
Existing Ops
Plan550WQ
Plan750WQ
PAL Dry Year Guideline
PAL Lower Limit Guideline
Flow (cfs) in Apalachicola River at Chattahoochee, FL
30,000
28,000
26,000
24,000
22,000
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1-Jan
1-Feb
1-Mar
1-Apr
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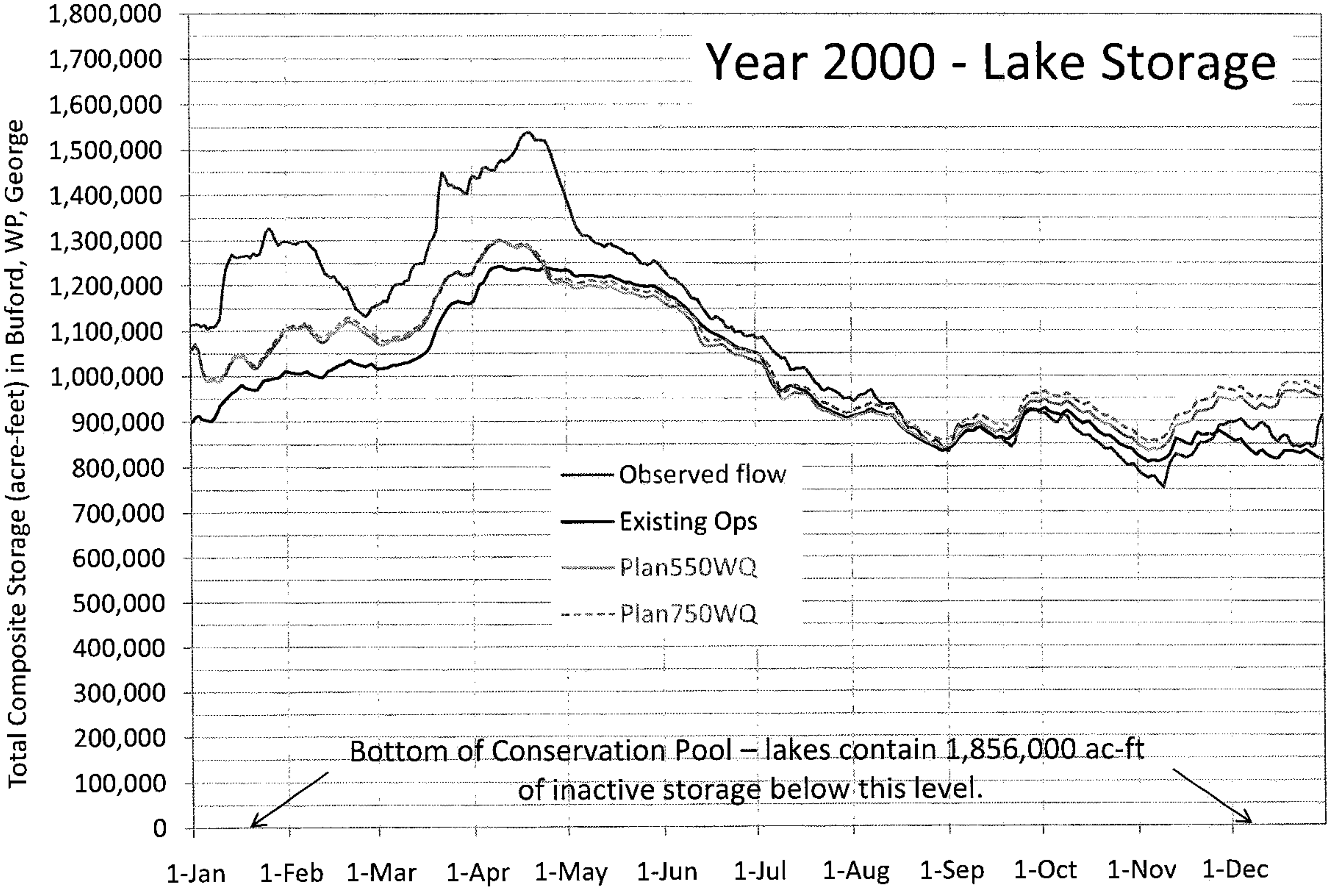
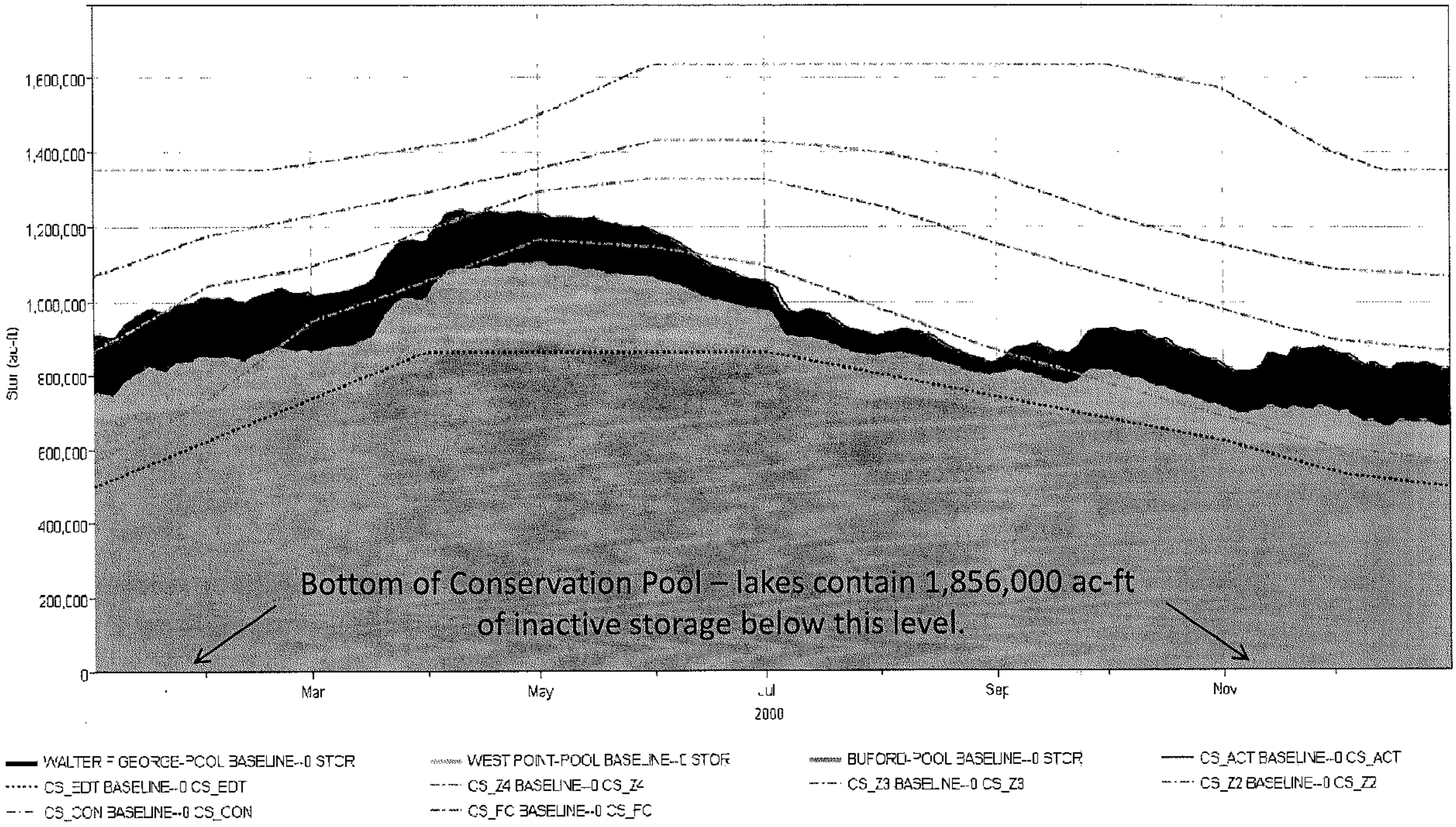
1-Nov
1-Dec


Year 2000 - Lake Storage
Total Composite Storage (acre-feet) in Buford, WP, George
1,800,000
1,700,000
1,600,000
1,500,000
1,400,000
1,300,000
1,200,000
1,100,000
1,000,000
900,000
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
Observed flow
Existing Ops
Plan550WQ
Plan750WQ
Bottom of Conservation Pool – lakes contain 1,856,000 ac-ft
of inactive storage below this level.

Year 2000 - Lake Storage (Existing Ops only)



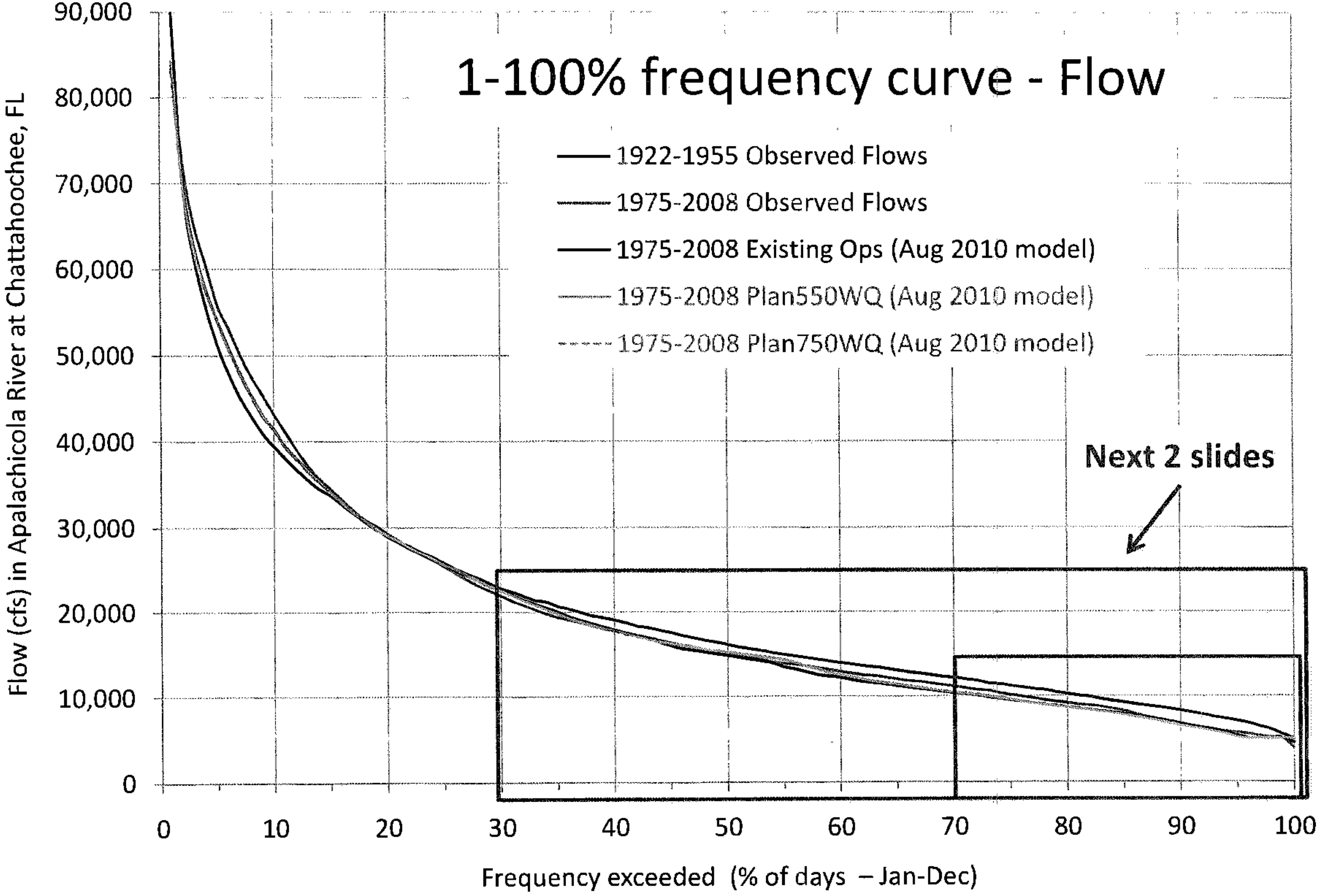
Bottom of Conservation Pool – lakes contain 1,856,000 ac-ft of inactive storage below this level.

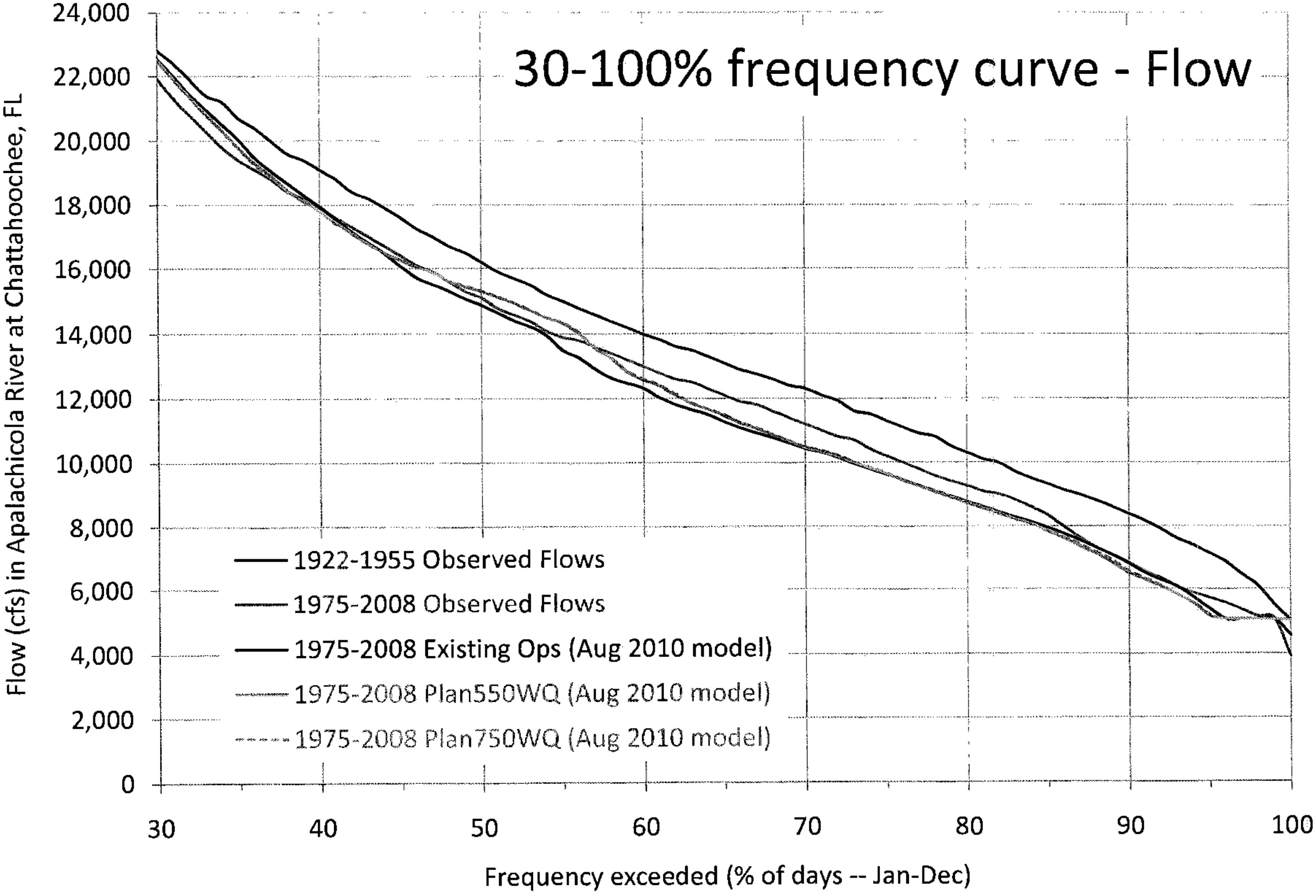
Flow Frequency Curves

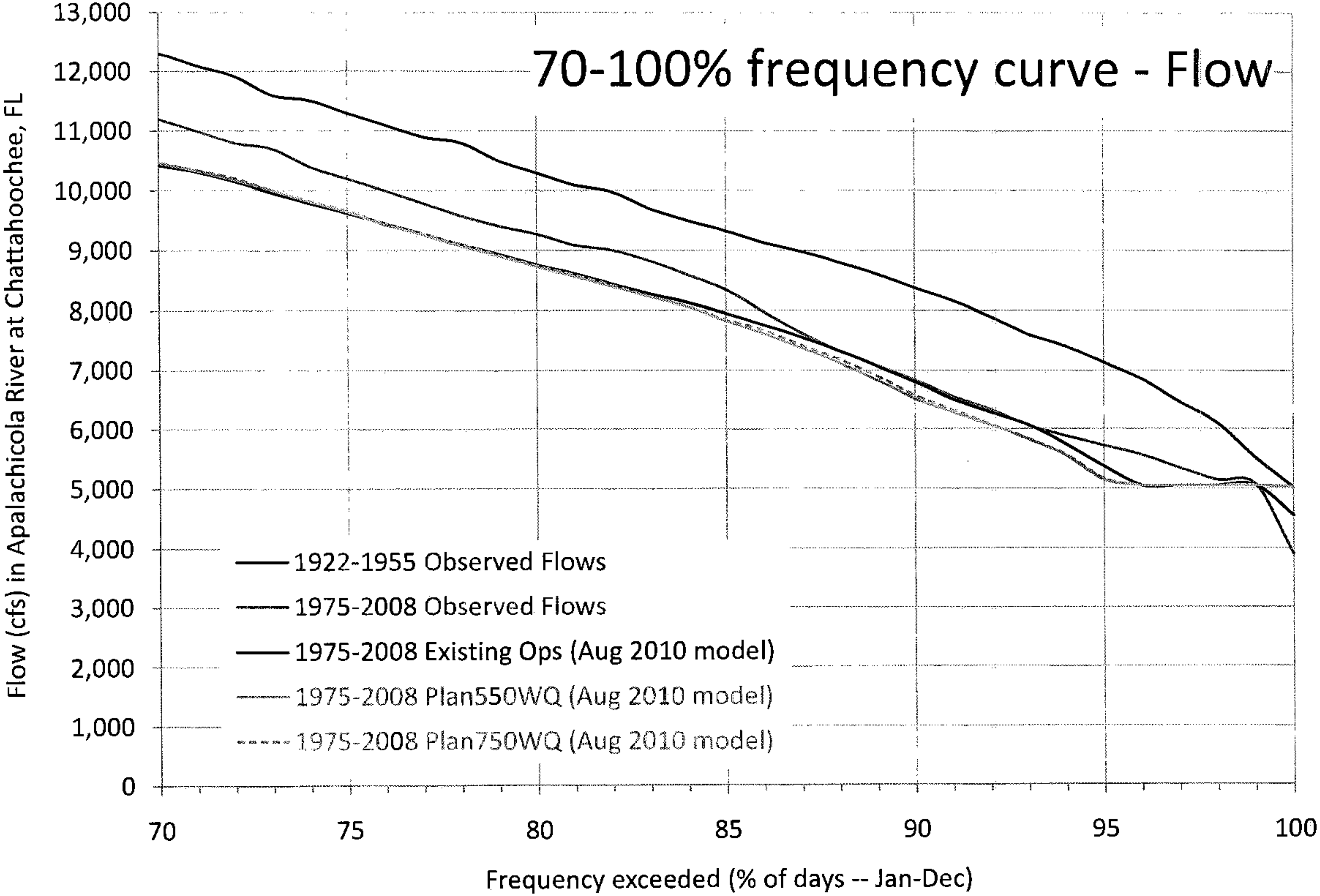
Frequency that flows are exceeded
(% of days -- Jan-Dec)*

**To distinguish from growing season only (Mar-Nov)*

1-100% frequency curve - Flow



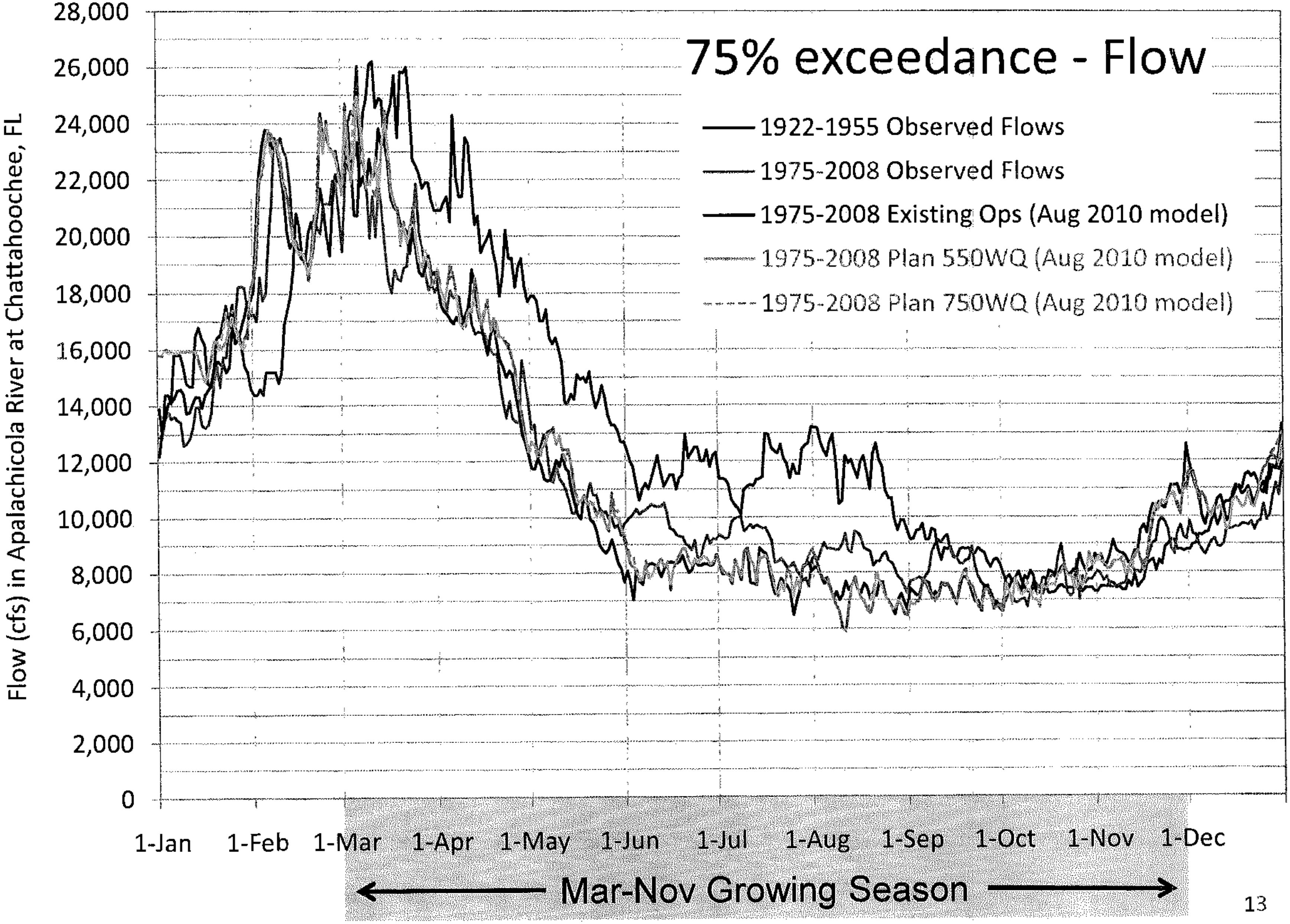

30-100% frequency curve - Flow
Flow (cfs) in Apalachicola River at Chattahoochee, FL
24,000
22,000
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
30
40
50
60
70
80
90
100
Frequency exceeded (% of days -- Jan-Dec)
1922-1955 Observed Flows
1975-2008 Observed Flows
1975-2008 Existing Ops (Aug 2010 model)
1975-2008 Plan550WQ (Aug 2010 model)
1975-2008 Plan750WQ (Aug 2010 model)


70-100% frequency curve - Flow
Flow (cfs) in Apalachicola River at Chattahoochee, FL
13,000
12,000
11,000
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
70
75
80
85
90
95
100
Frequency exceeded (% of days -- Jan-Dec)
1922-1955 Observed Flows
1975-2008 Observed Flows
1975-2008 Existing Ops (Aug 2010 model)
1975-2008 Plan550WQ (Aug 2010 model)
1975-2008 Plan750WQ (Aug 2010 model)

Flow Exceedance Hydrographs

Daily exceedance flows for
selected frequencies:
75 and 90%

Full year (Jan-Dec) included on all graphs, with
growing season (Mar-Nov) indicated by shading on axis.


75% exceedance - Flow
1922-1955 Observed Flows
1975-2008 Observed Flows
1975-2008 Existing Ops (Aug 2010 model)
1975-2008 Plan 550WQ (Aug 2010 model)
1975-2008 Plan 750WQ (Aug 2010 model)
Flow (cfs) in Apalachicola River at Chattahoochee, FL
28,000
26,000
24,000
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18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1-Jan
1-Feb
1-Mar
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1-May
1-Jun
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1-Aug
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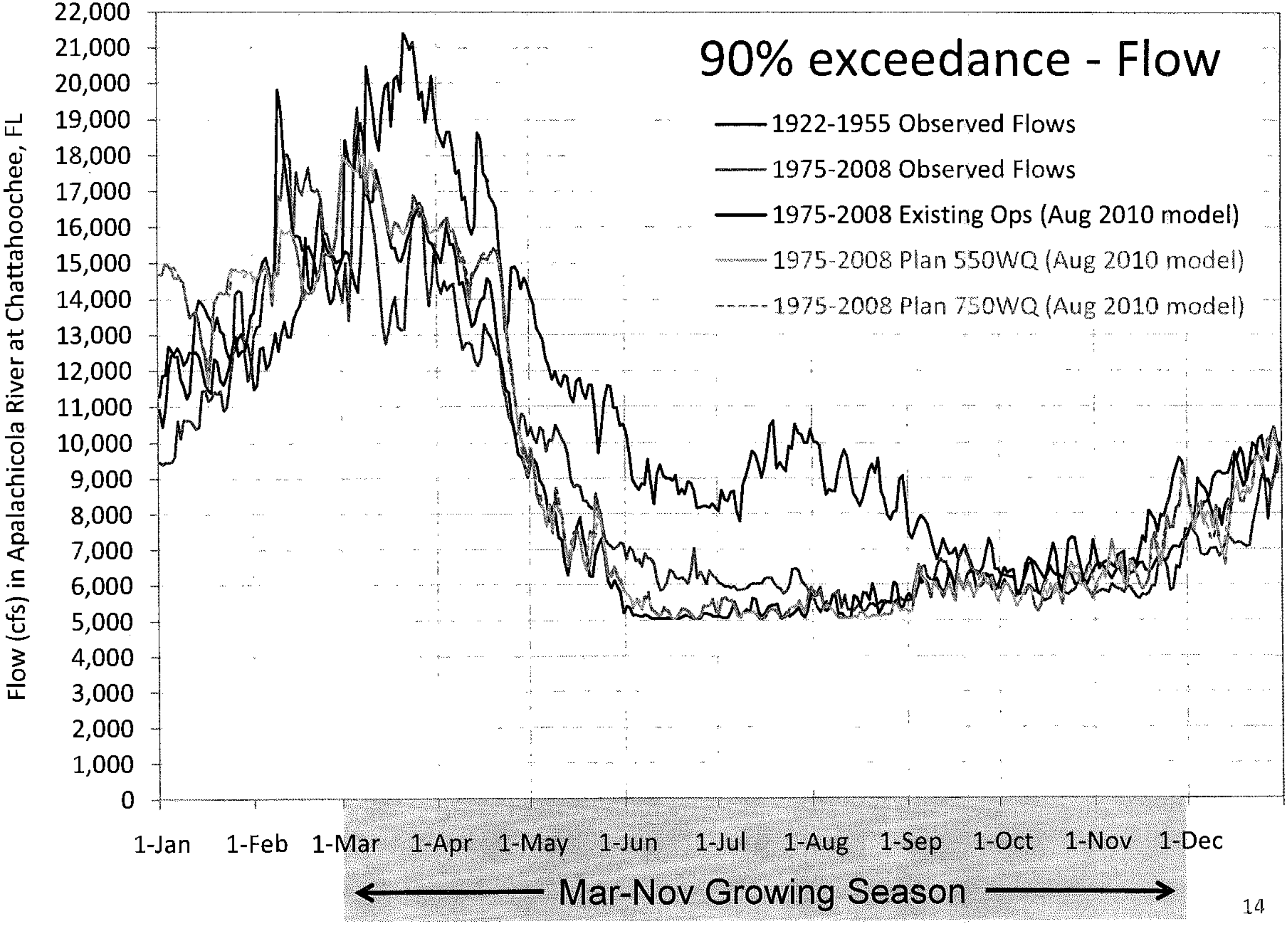
1-Oct
1-Nov
1-Dec
Mar-Nov Growing Season

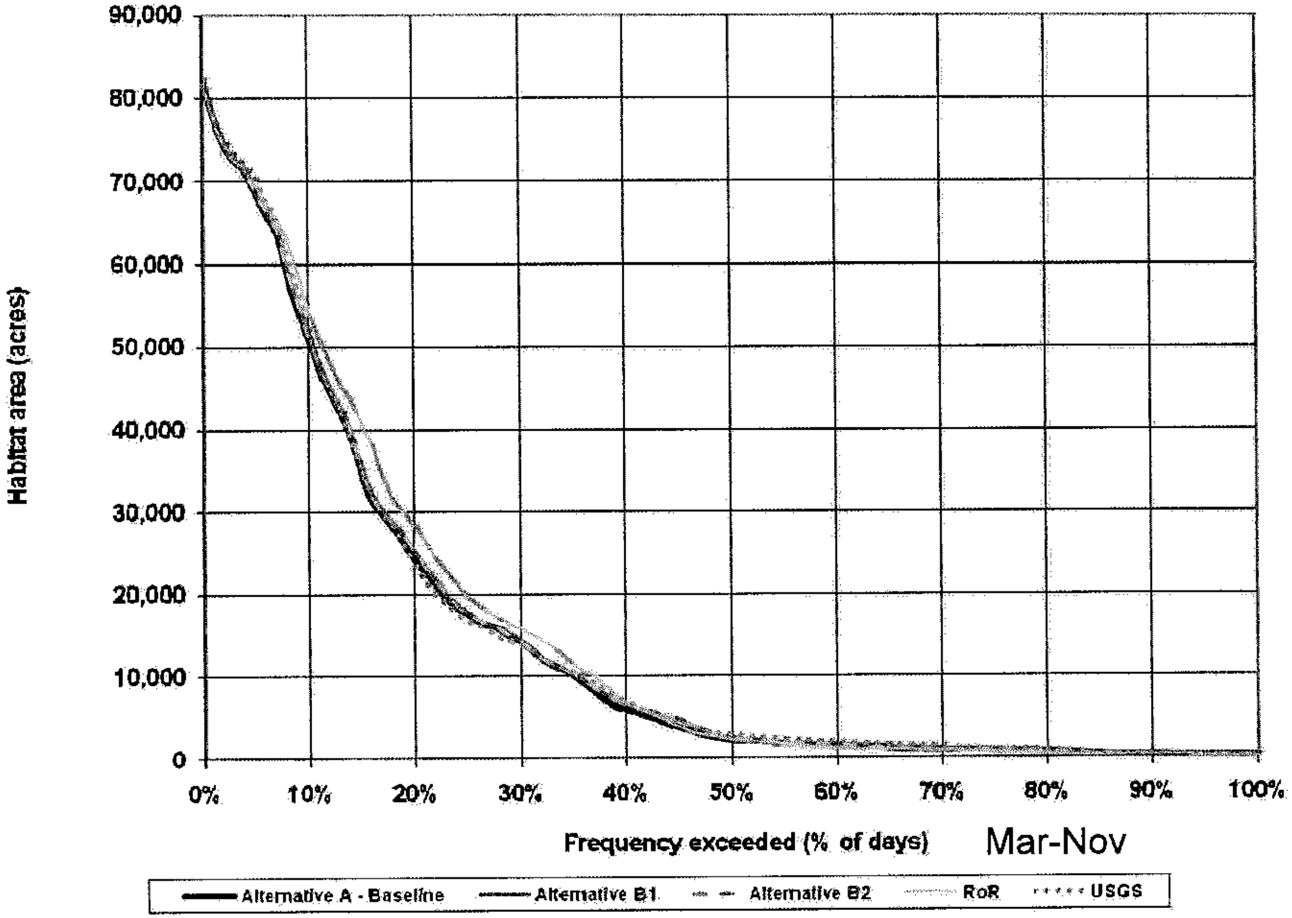

90% exceedance - Flow
1922-1955 Observed Flows
1975-2008 Observed Flows
1975-2008 Existing Ops (Aug 2010 model)
1975-2008 Plan 550WQ (Aug 2010 model)
1975-2008 Plan 750WQ (Aug 2010 model)
Flow (cfs) in Apalachicola River at Chattahoochee, FL
22,000
21,000
20,000
19,000
18,000
17,000
16,000
15,000
14,000
13,000
12,000
11,000
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
Mar-Nov Growing Season

Area Frequency Curves

Frequency that acres of inundated floodplain
are exceeded in the growing season
(% of days – Mar-Nov)

Analysis provided by Corps

Graph from Corps 1/18/2011 Response to PAL, page 2-95:



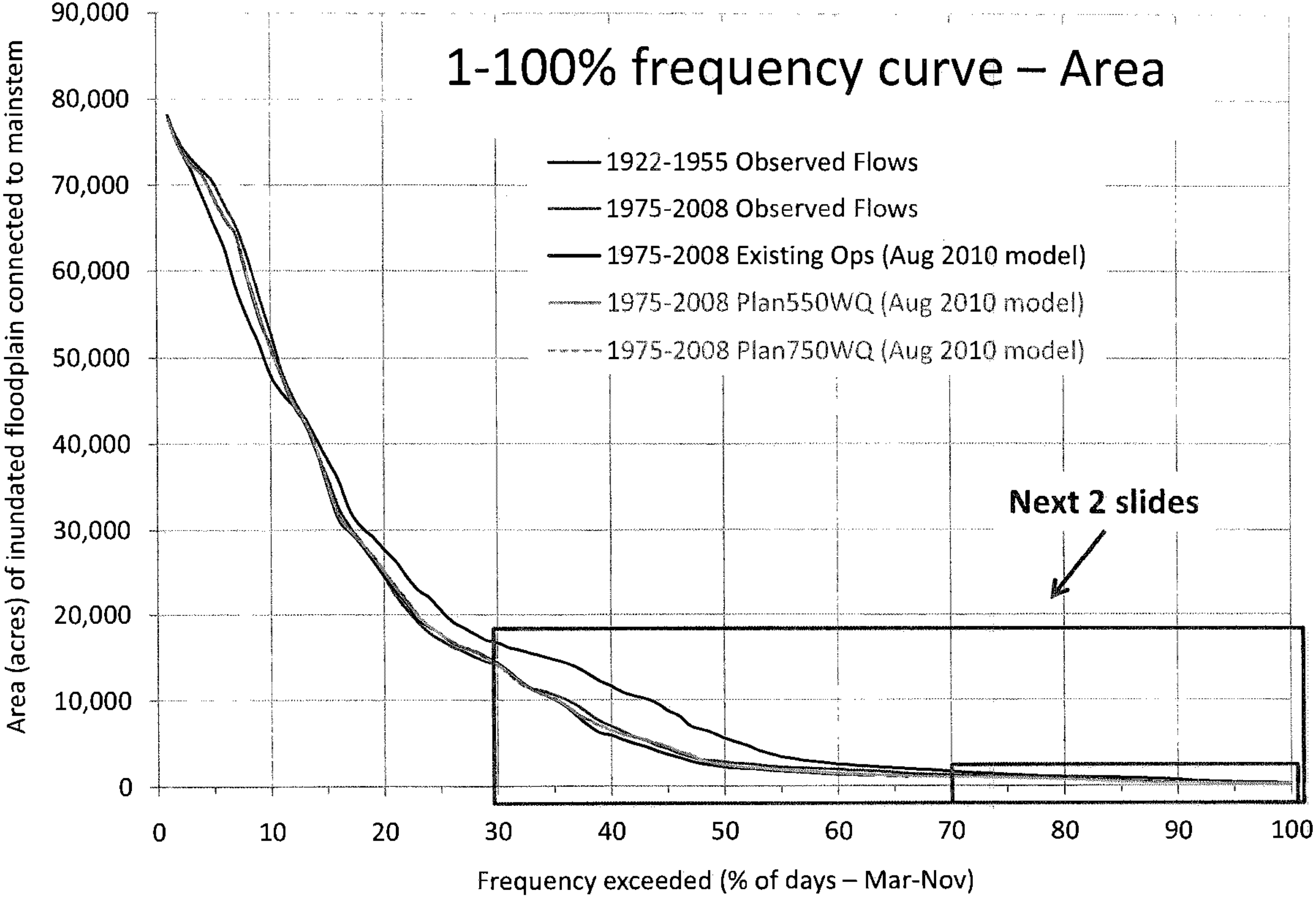
This graph was created by the Corps in response to FFWCC request.

Suggested revisions:

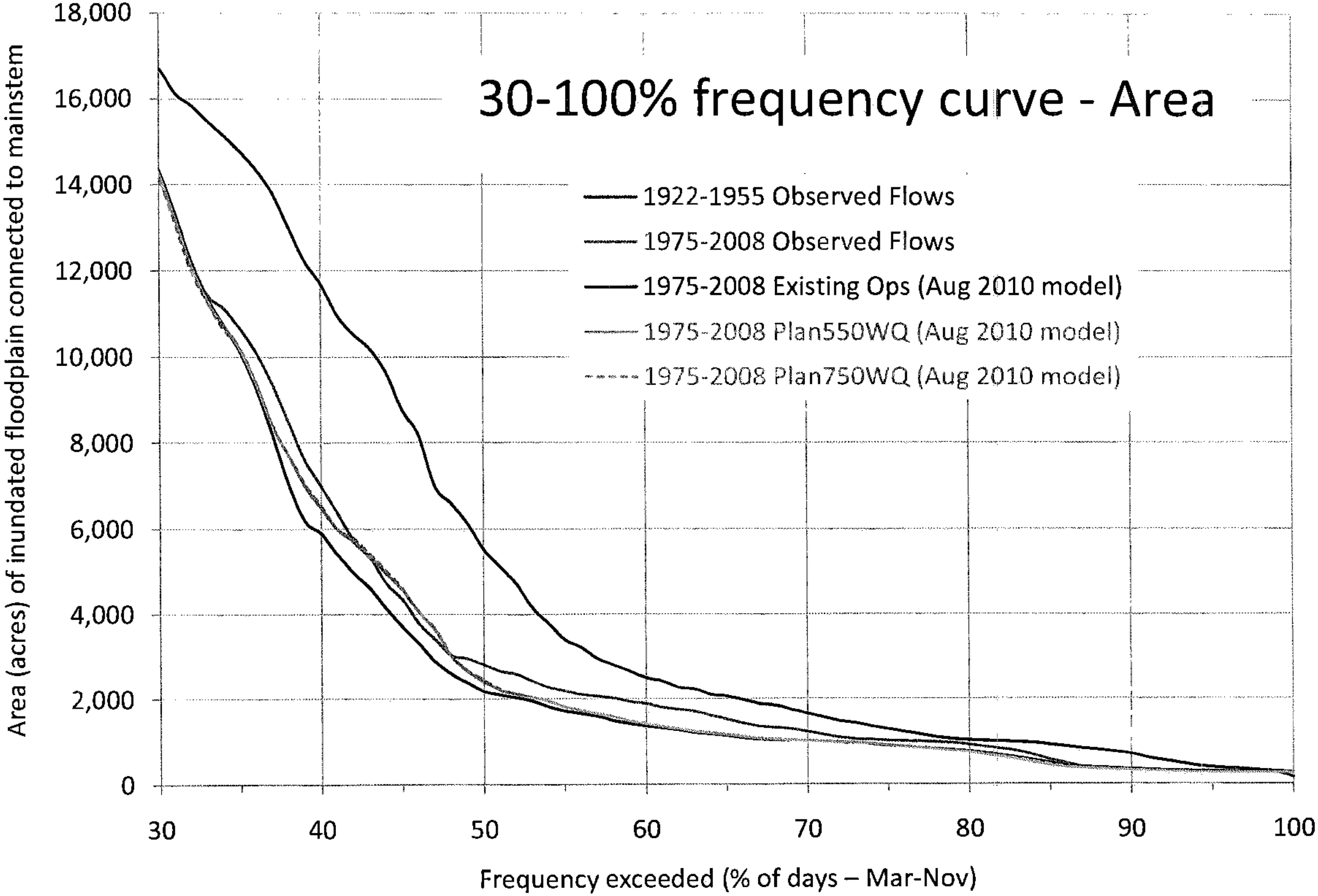
-- Remove RoR and replace with appropriate ecosystem flow guideline (1922-1955 observed flow)

-- Expand data at low end

1-100% frequency curve – Area



**Differences in area among flow regimes is due *solely to changes in flow* (not channel changes) because all flow data, including 1922-1955 observed flows, were converted to inundated areas based on present-day channel conditions using "Recent" stage-discharge ratings in Light et.al., 2006.



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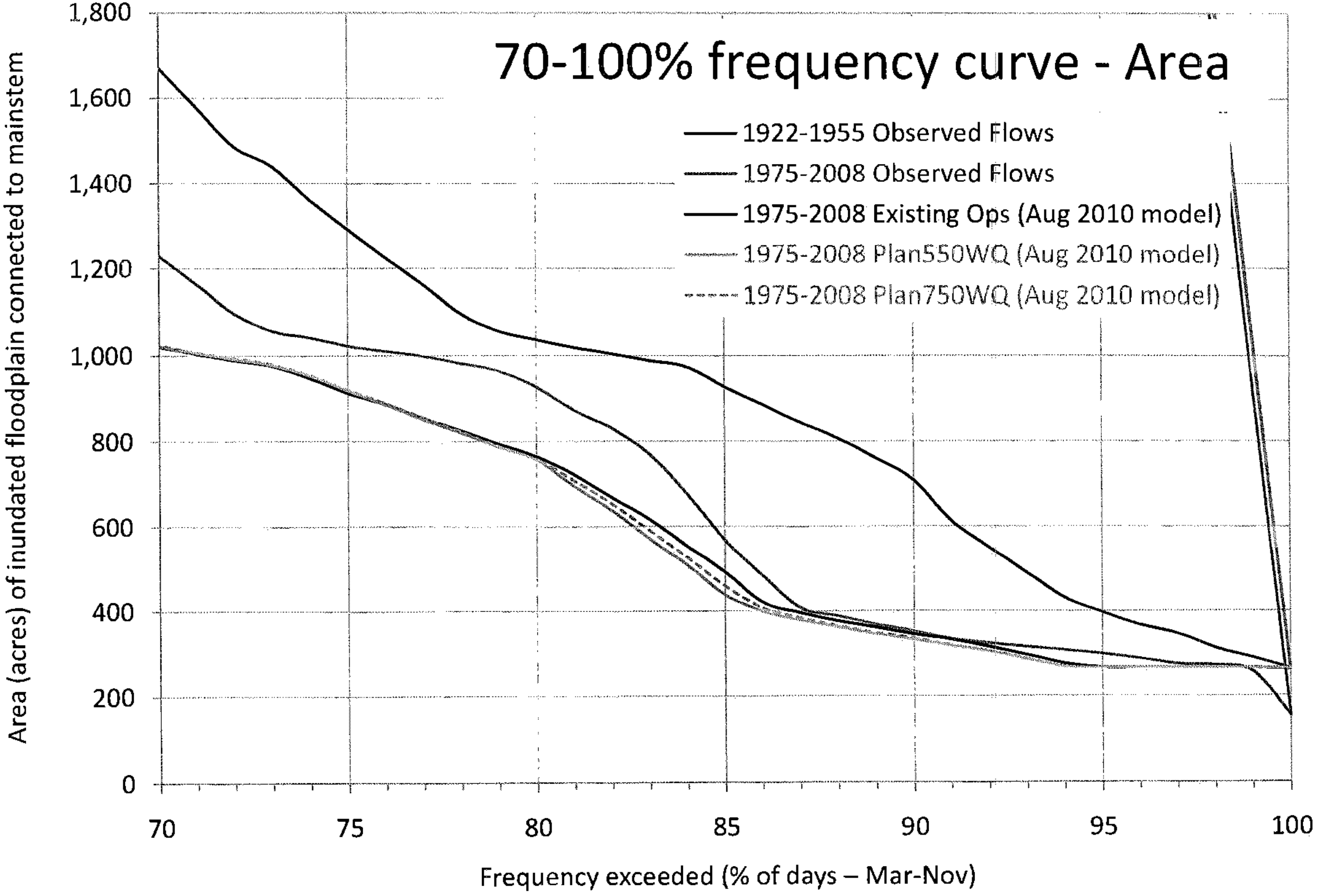

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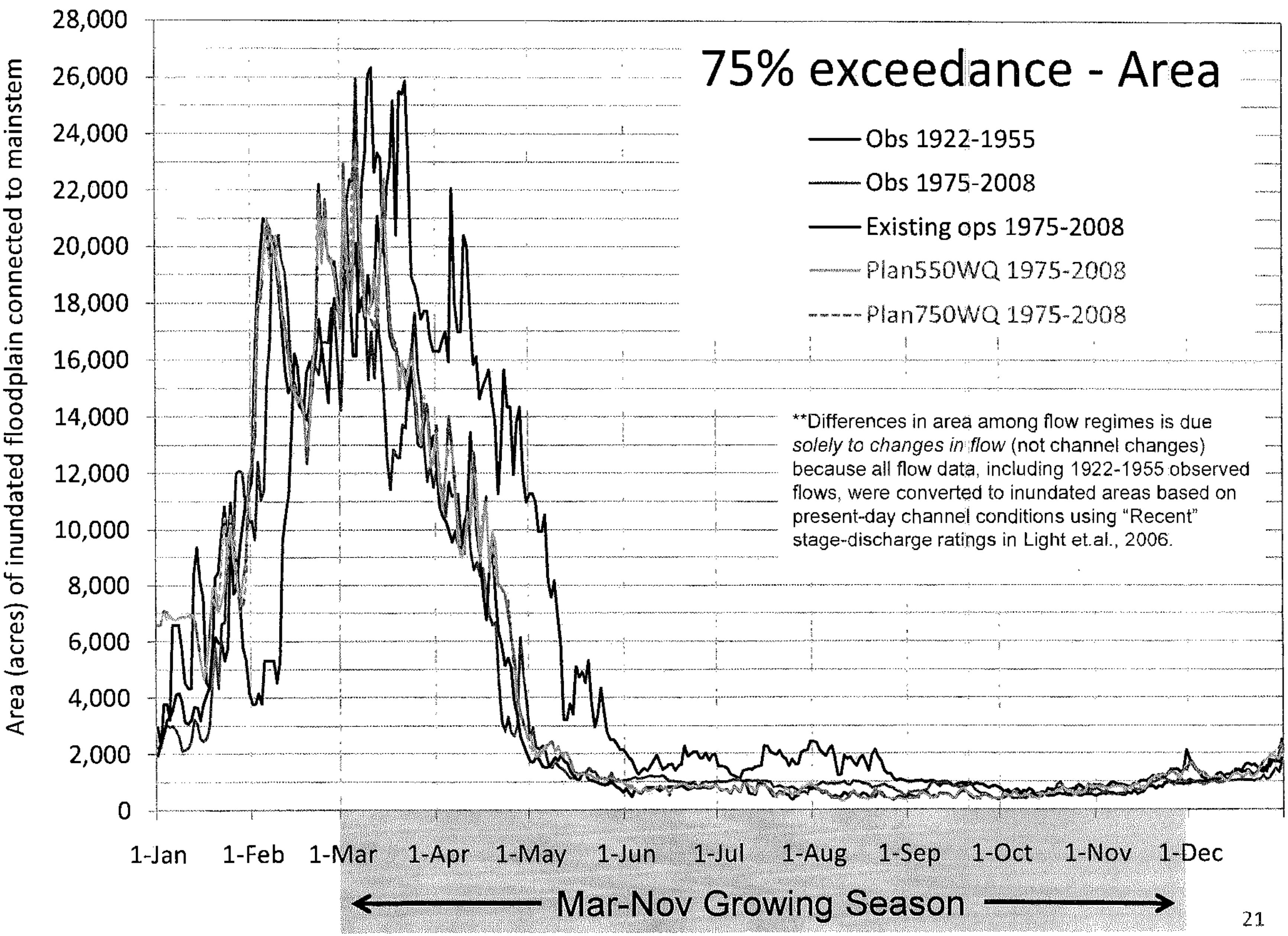
Area Exceedance Hydrographs

Daily exceedance for acres of inundated floodplain at selected frequencies:
75 and 90%

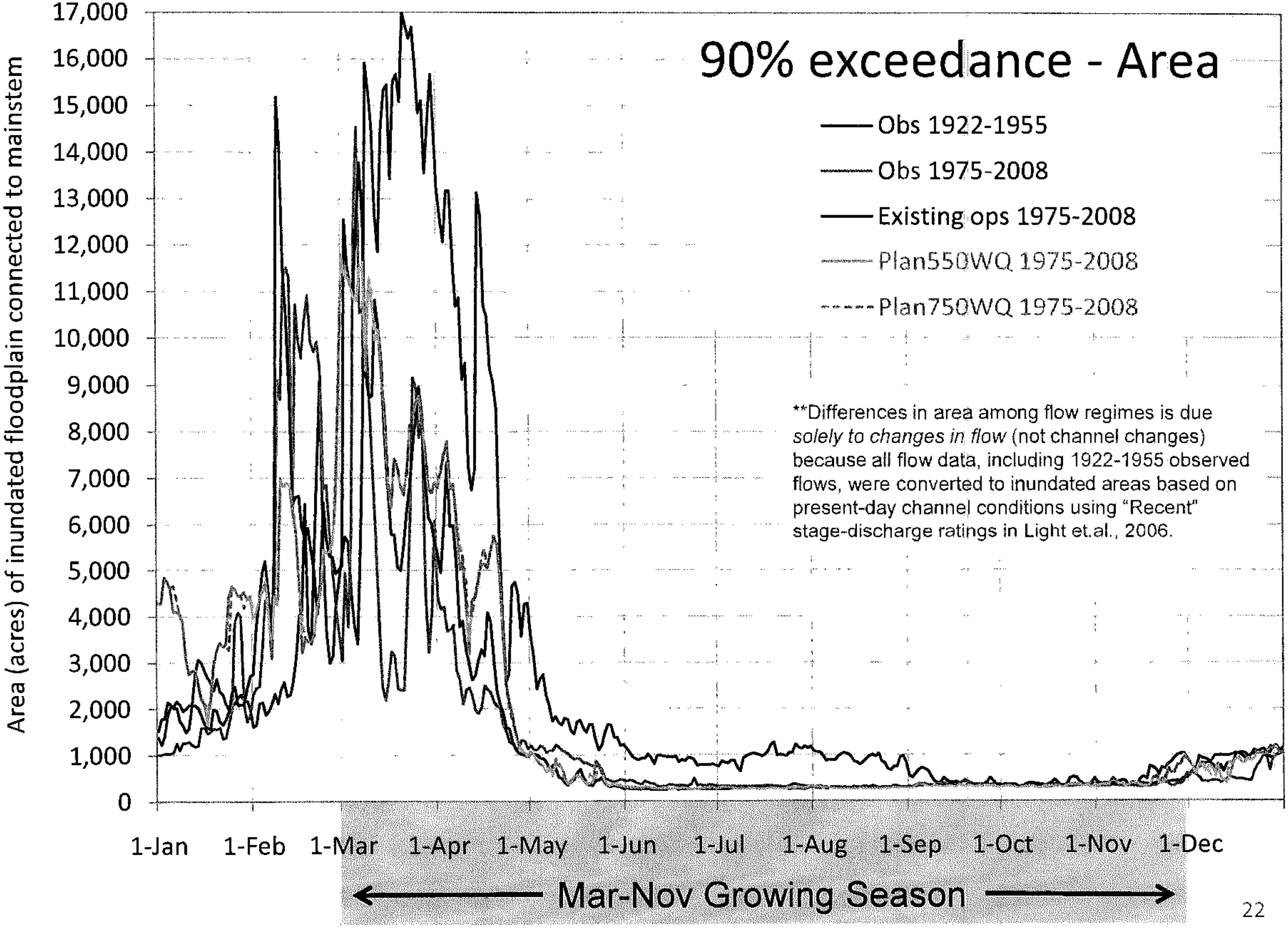
Full year (Jan-Dec) included on all graphs, with growing season (Mar-Nov) indicated by shading on axis.



75% exceedance - Area

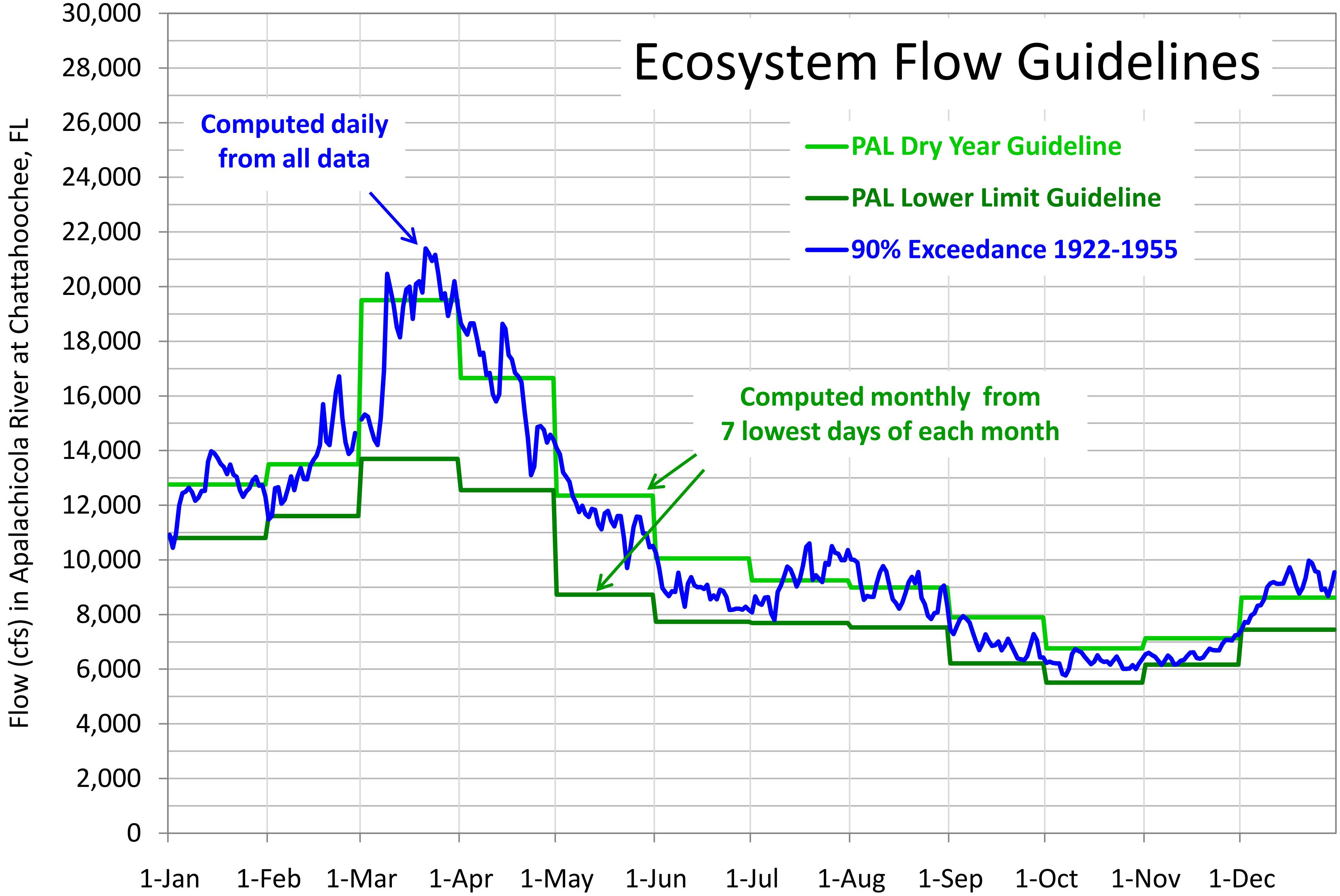
**Differences in area among flow regimes is due *solely to changes in flow* (not channel changes) because all flow data, including 1922-1955 observed flows, were converted to inundated areas based on present-day channel conditions using "Recent" stage-discharge ratings in Light et.al., 2006.

90% exceedance - Area



**Differences in area among flow regimes is due *solely to changes in flow* (not channel changes) because all flow data, including 1922-1955 observed flows, were converted to inundated areas based on present-day channel conditions using "Recent" stage-discharge ratings in Light et.al., 2006.

Ecosystem Flow Guidelines



Computed daily from all data

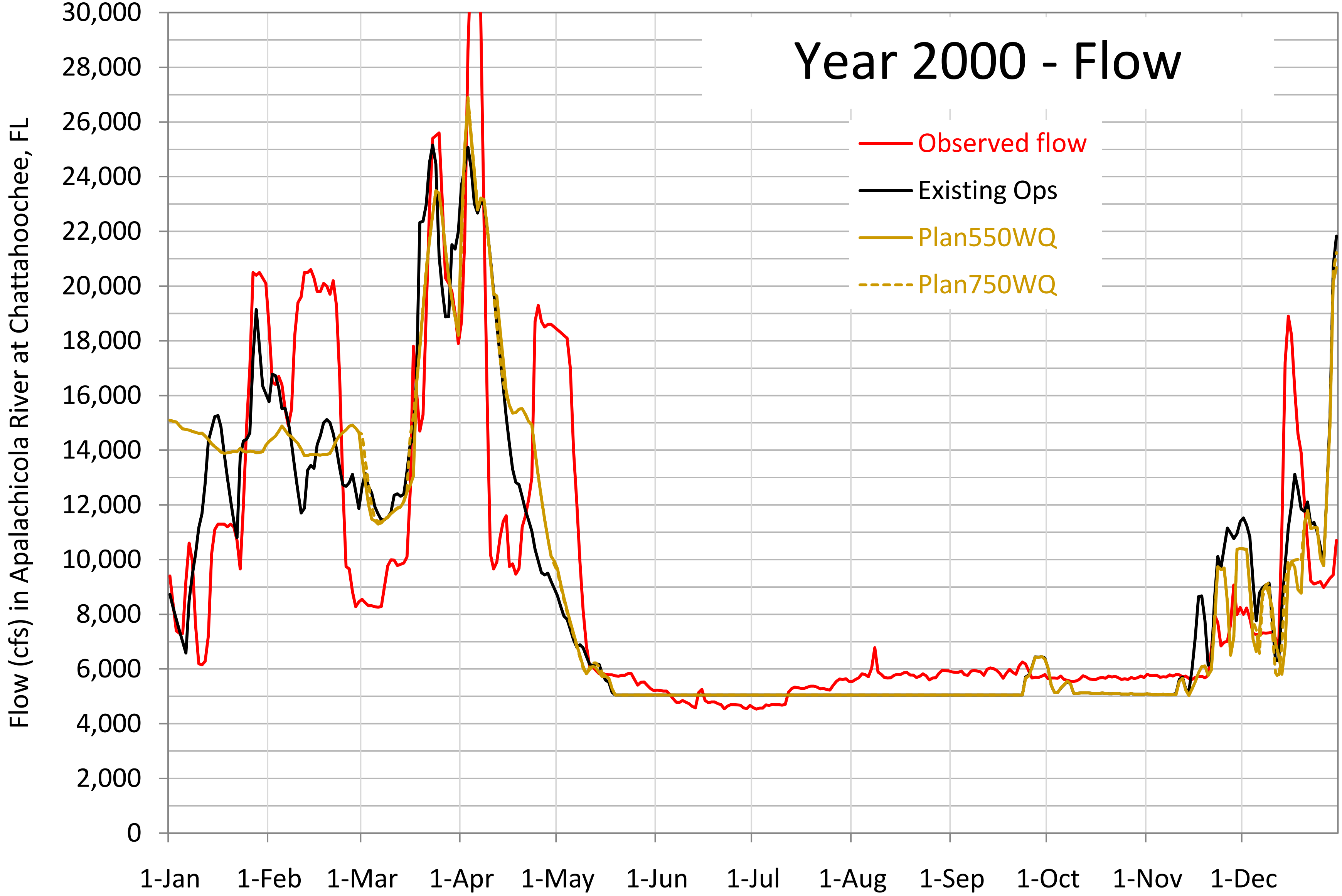
Computed monthly from 7 lowest days of each month

Flows Vs Lake Storage

*At times when Ecosystem Flow Guidelines are **not** met, what is the Total Composite Storage (TCS) in the Federal Reservoirs?*

Year 2000 is provided in the following example.

Data source: 8-20-2011 Corps model output


Year 2000 - Flow
Observed flow
Existing Ops
Plan550WQ
Plan750WQ
Flow (cfs) in Apalachicola River at Chattahoochee, FL
30,000
28,000
26,000
24,000
22,000
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1-Jan
1-Feb
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1-May
1-Jun
1-Jul
1-Aug
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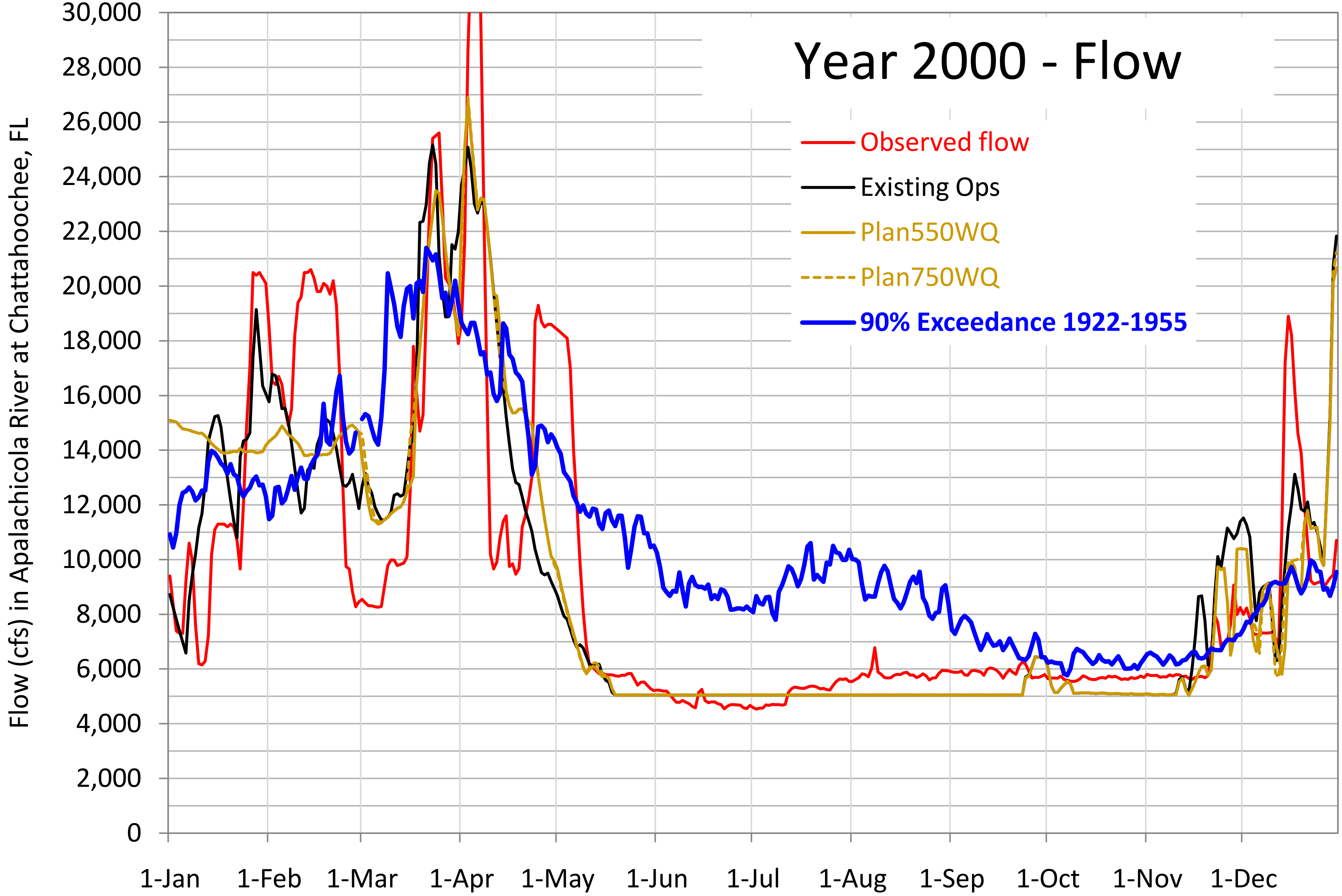
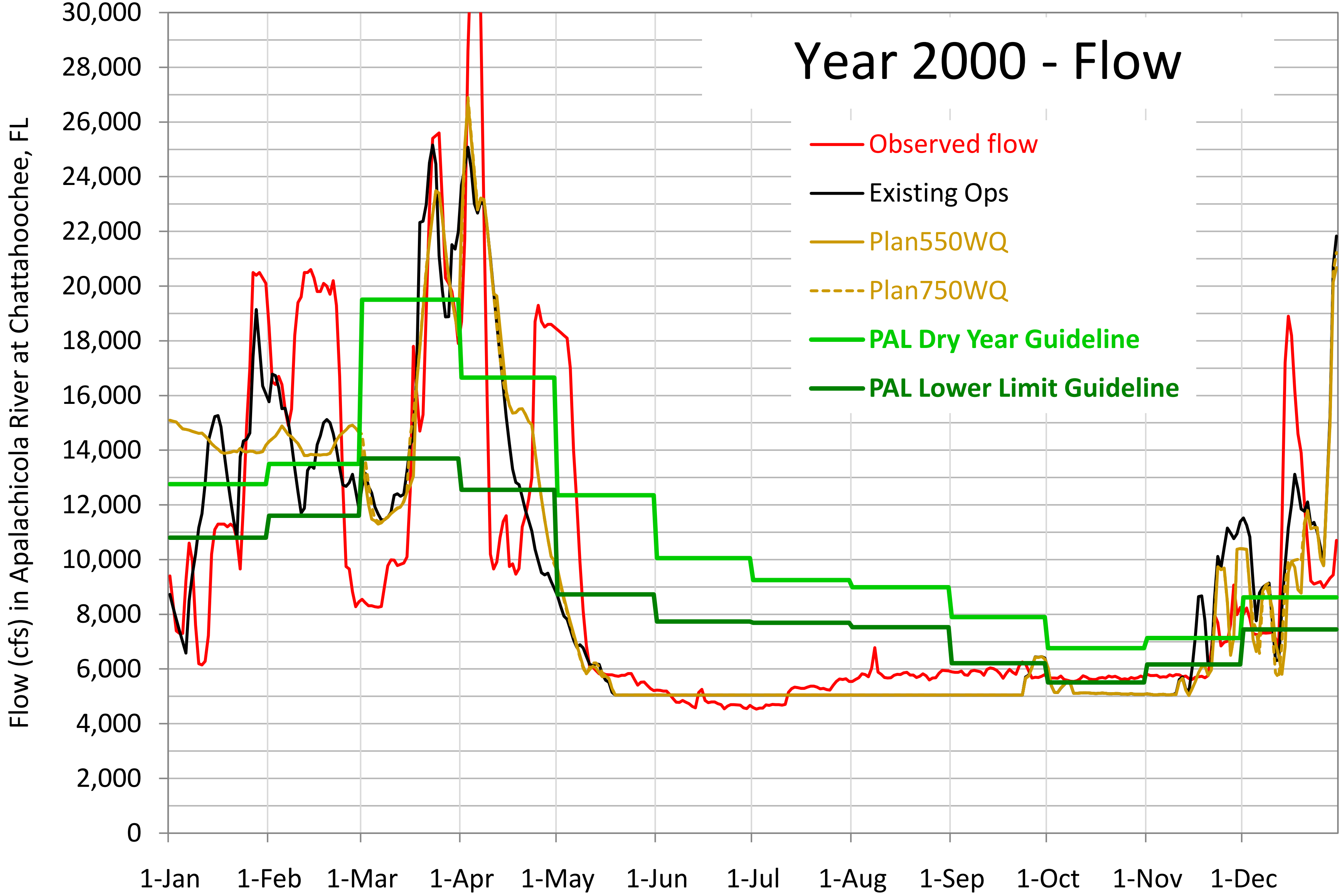
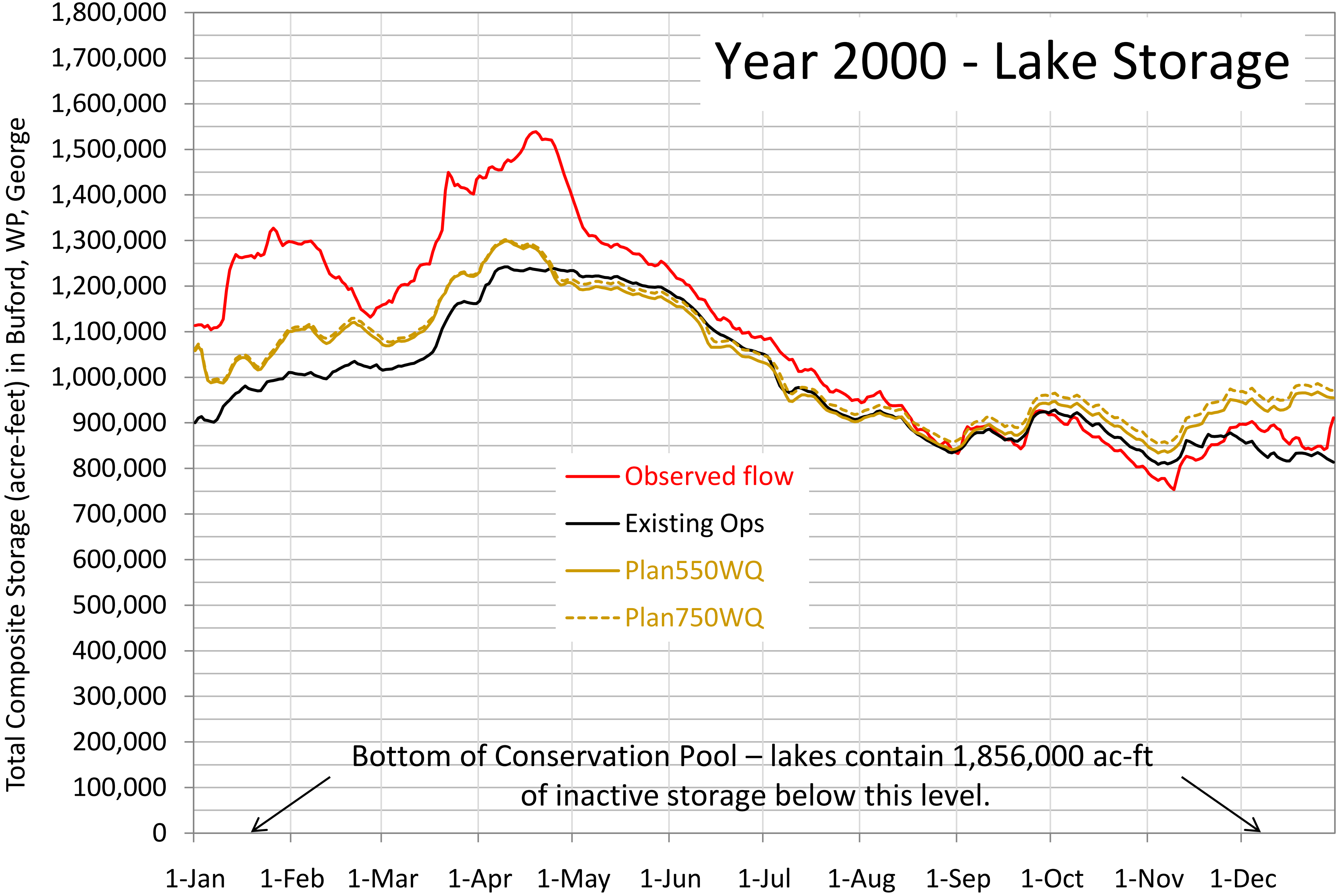
1-Oct
1-Nov
1-Dec

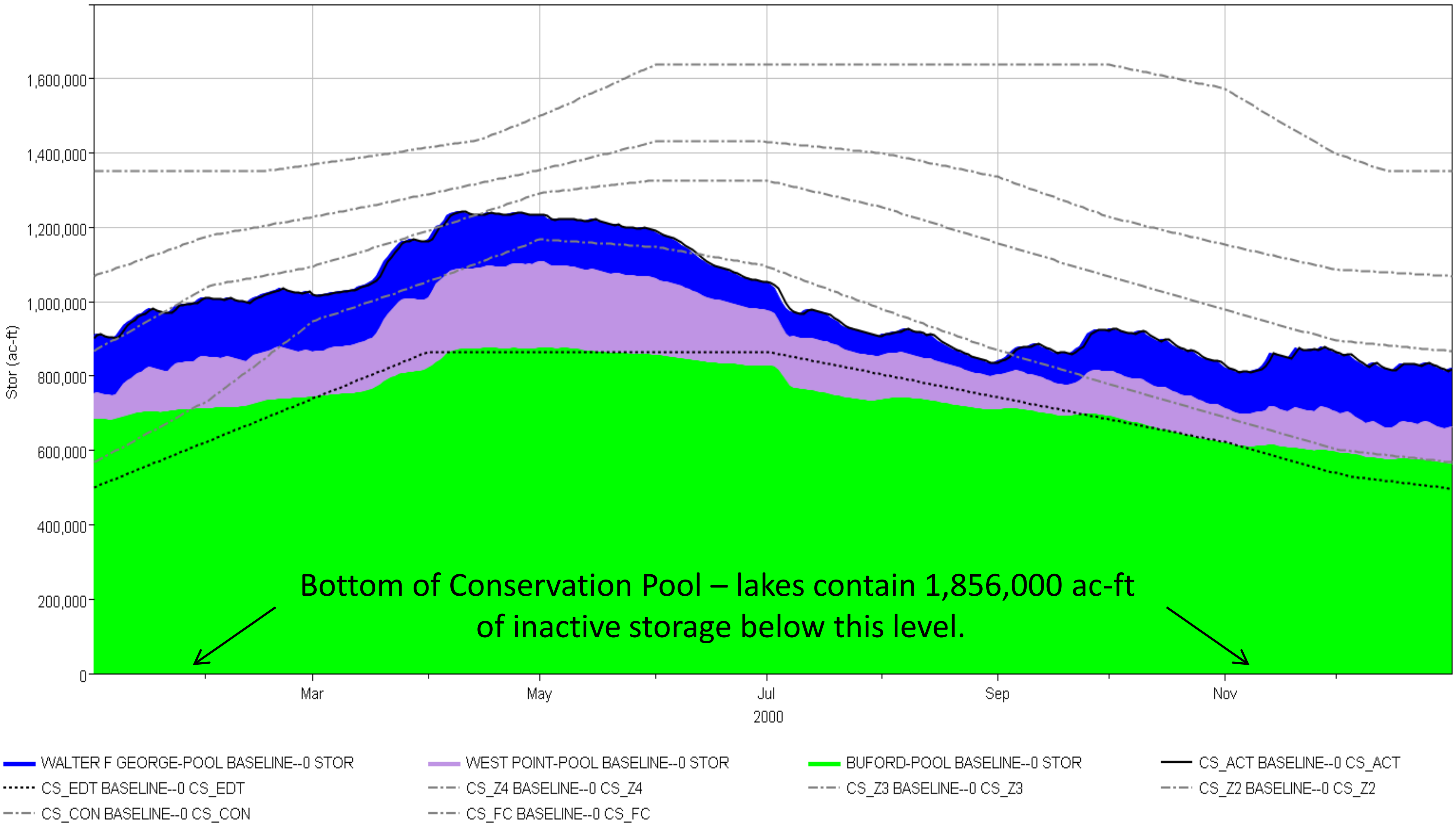

Year 2000 - Flow
Flow (cfs) in Apalachicola River at Chattahoochee, FL
30,000
28,000
26,000
24,000
22,000
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
Observed flow
Existing Ops
Plan550WQ
Plan750WQ
90% Exceedance 1922-1955


Year 2000 - Flow
Flow (cfs) in Apalachicola River at Chattahoochee, FL
30,000
28,000
26,000
24,000
22,000
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
Observed flow
Existing Ops
Plan550WQ
Plan750WQ
PAL Dry Year Guideline
PAL Lower Limit Guideline



Bottom of Conservation Pool – lakes contain 1,856,000 ac-ft of inactive storage below this level.

Year 2000 - Lake Storage (Existing Ops only)



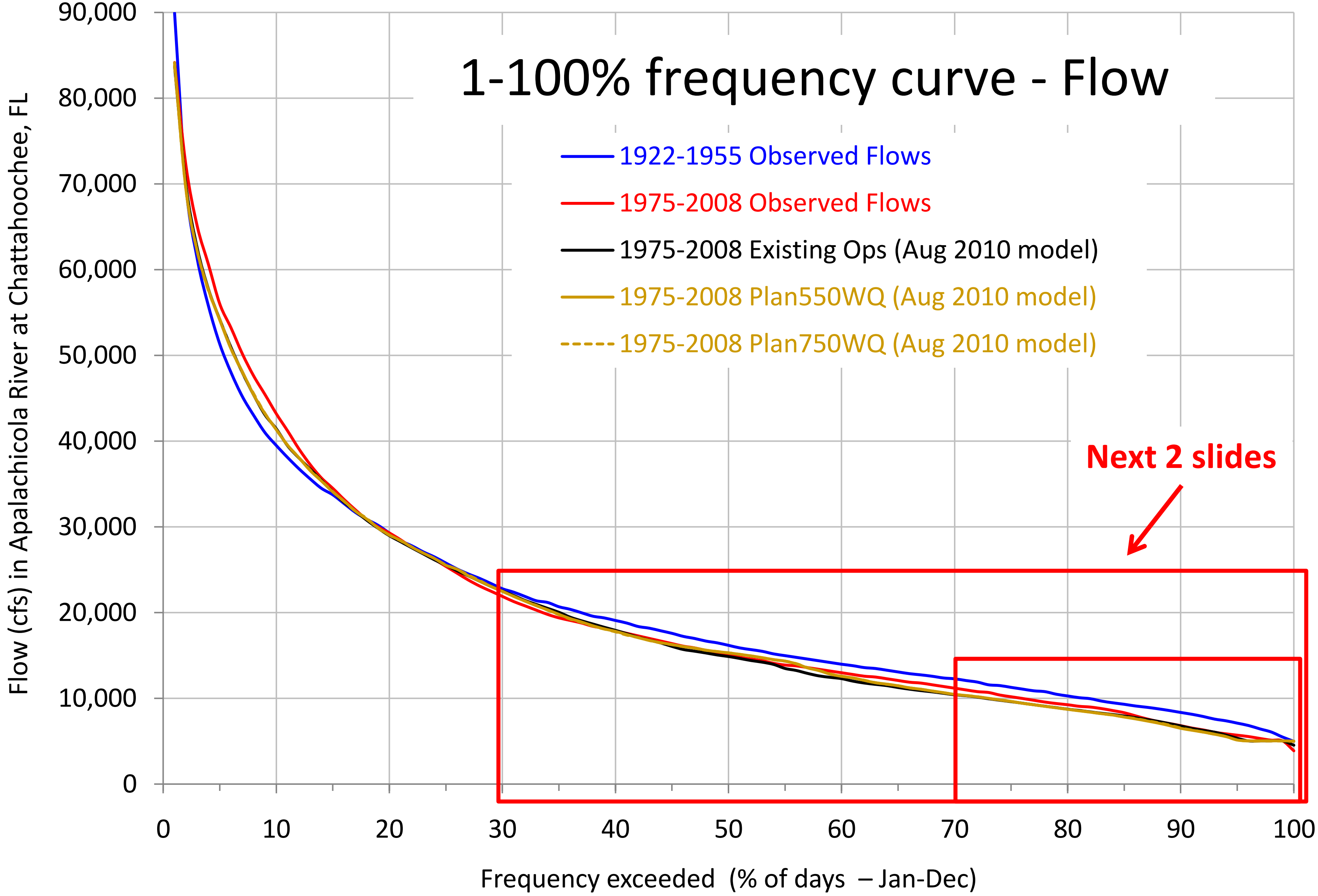
Bottom of Conservation Pool – lakes contain 1,856,000 ac-ft of inactive storage below this level.

Flow Frequency Curves

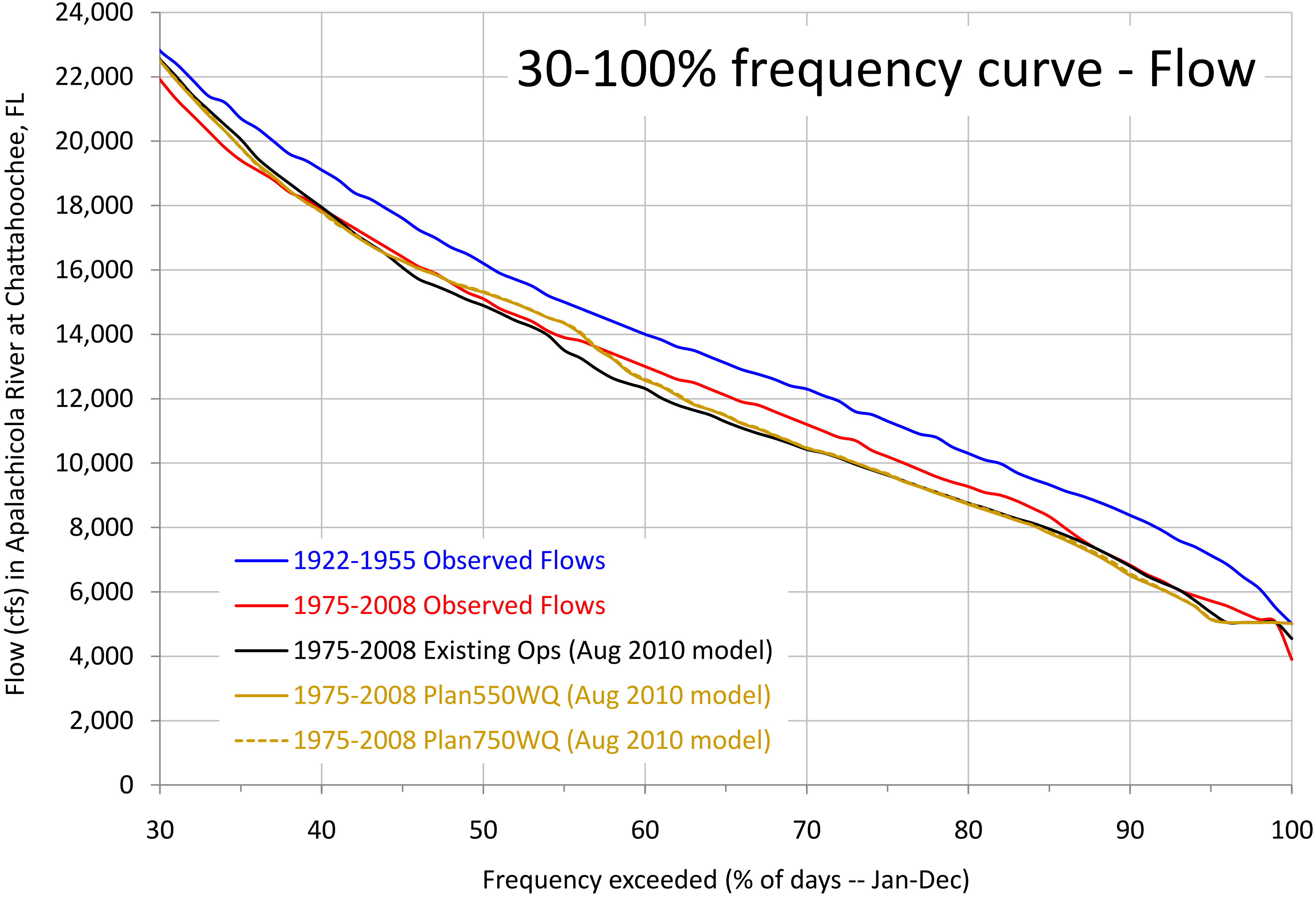
Frequency that flows are exceeded
(% of days -- Jan-Dec)*

**To distinguish from growing season only (Mar-Nov)*

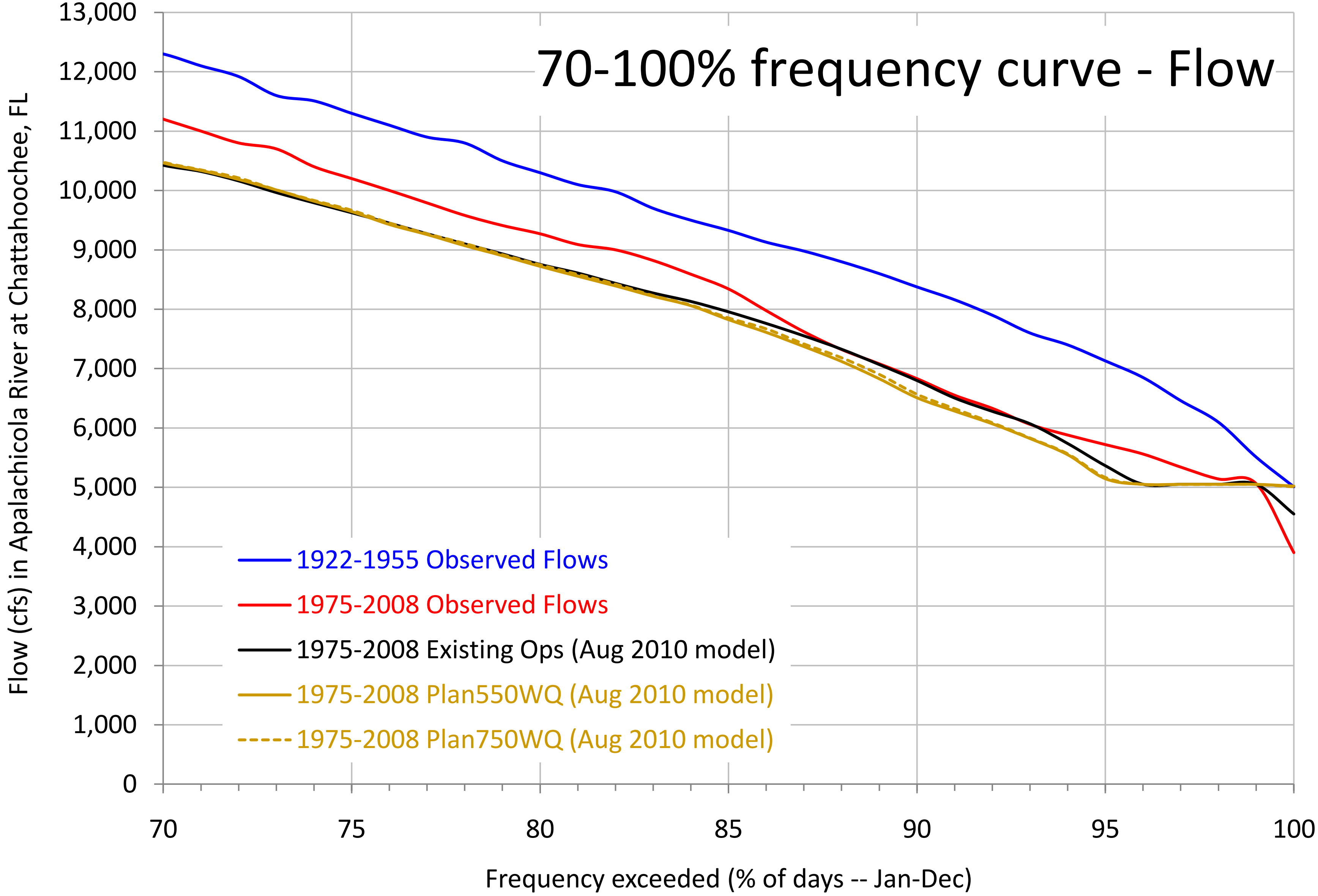
1-100% frequency curve - Flow



Next 2 slides



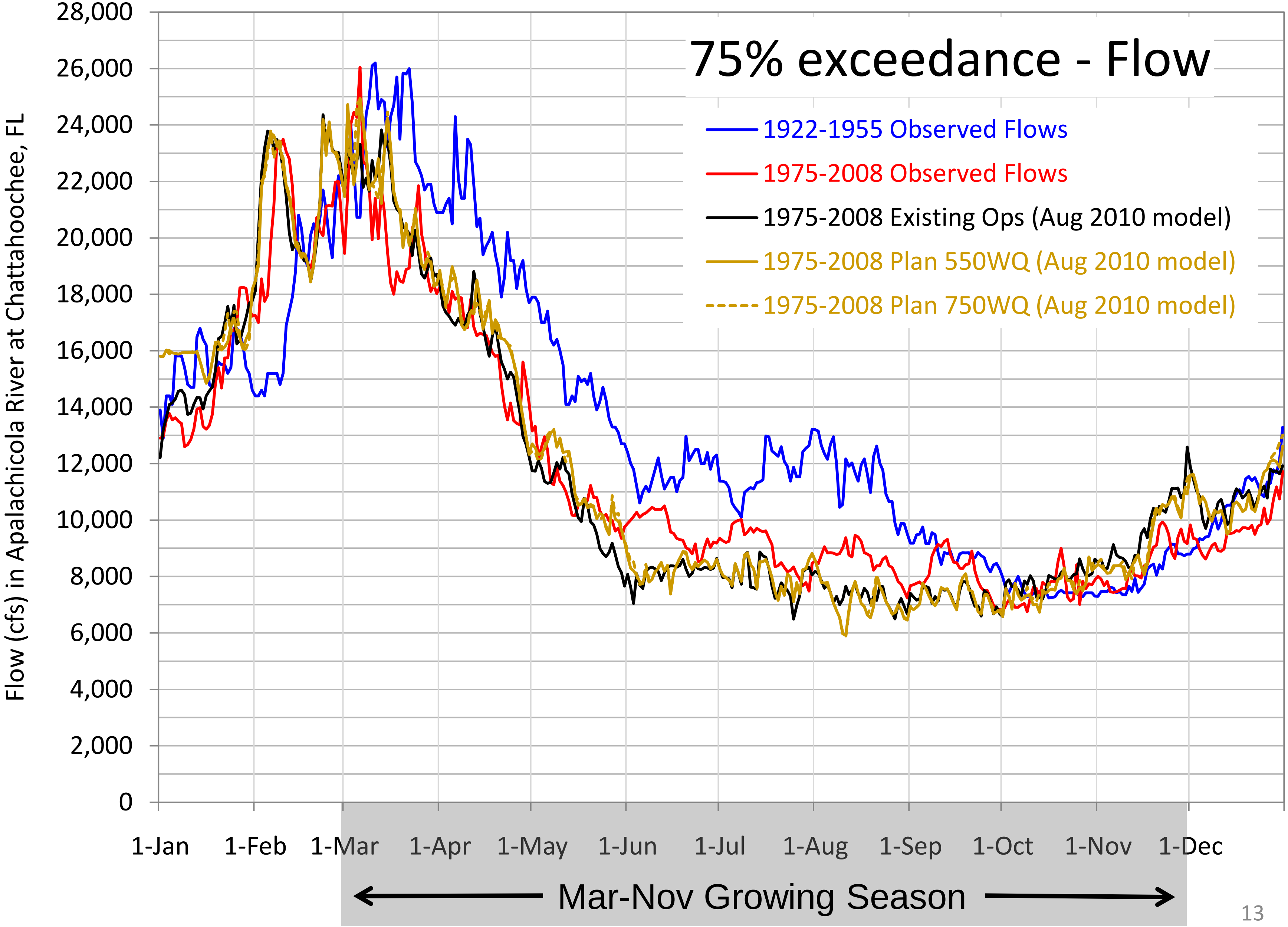
30-100% frequency curve - Flow


70-100% frequency curve - Flow
Flow (cfs) in Apalachicola River at Chattahoochee, FL
13,000
12,000
11,000
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
70
75
80
85
90
95
100
Frequency exceeded (% of days -- Jan-Dec)
1922-1955 Observed Flows
1975-2008 Observed Flows
1975-2008 Existing Ops (Aug 2010 model)
1975-2008 Plan550WQ (Aug 2010 model)
1975-2008 Plan750WQ (Aug 2010 model)

Flow Exceedance Hydrographs

Daily exceedance flows for
selected frequencies:
75 and 90%

Full year (Jan-Dec) included on all graphs, with
growing season (Mar-Nov) indicated by shading on axis.


75% exceedance - Flow
1922-1955 Observed Flows
1975-2008 Observed Flows
1975-2008 Existing Ops (Aug 2010 model)
1975-2008 Plan 550WQ (Aug 2010 model)
1975-2008 Plan 750WQ (Aug 2010 model)
Flow (cfs) in Apalachicola River at Chattahoochee, FL
28,000
26,000
24,000
22,000
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1-Jan
1-Feb
1-Mar
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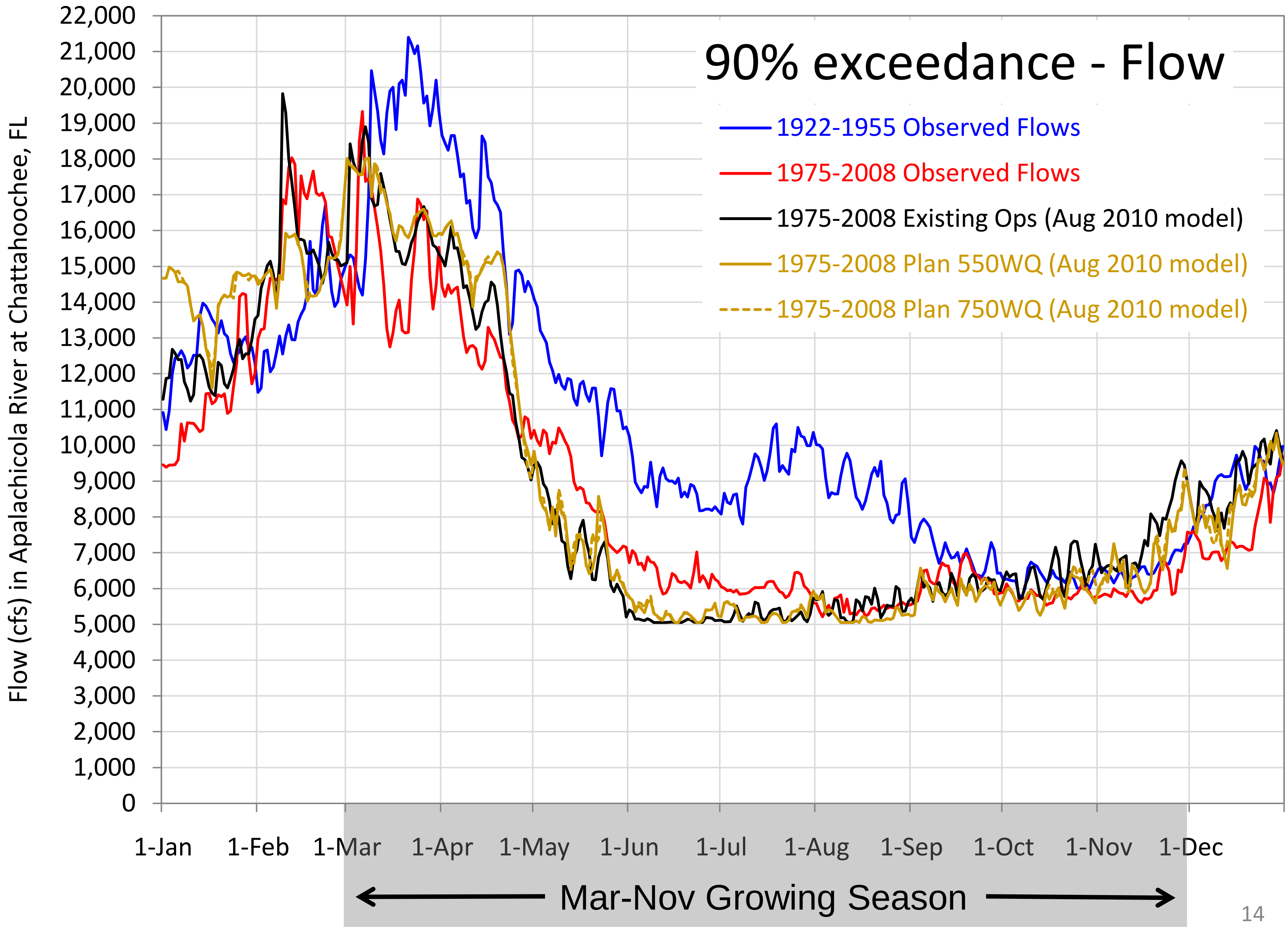
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
Mar-Nov Growing Season

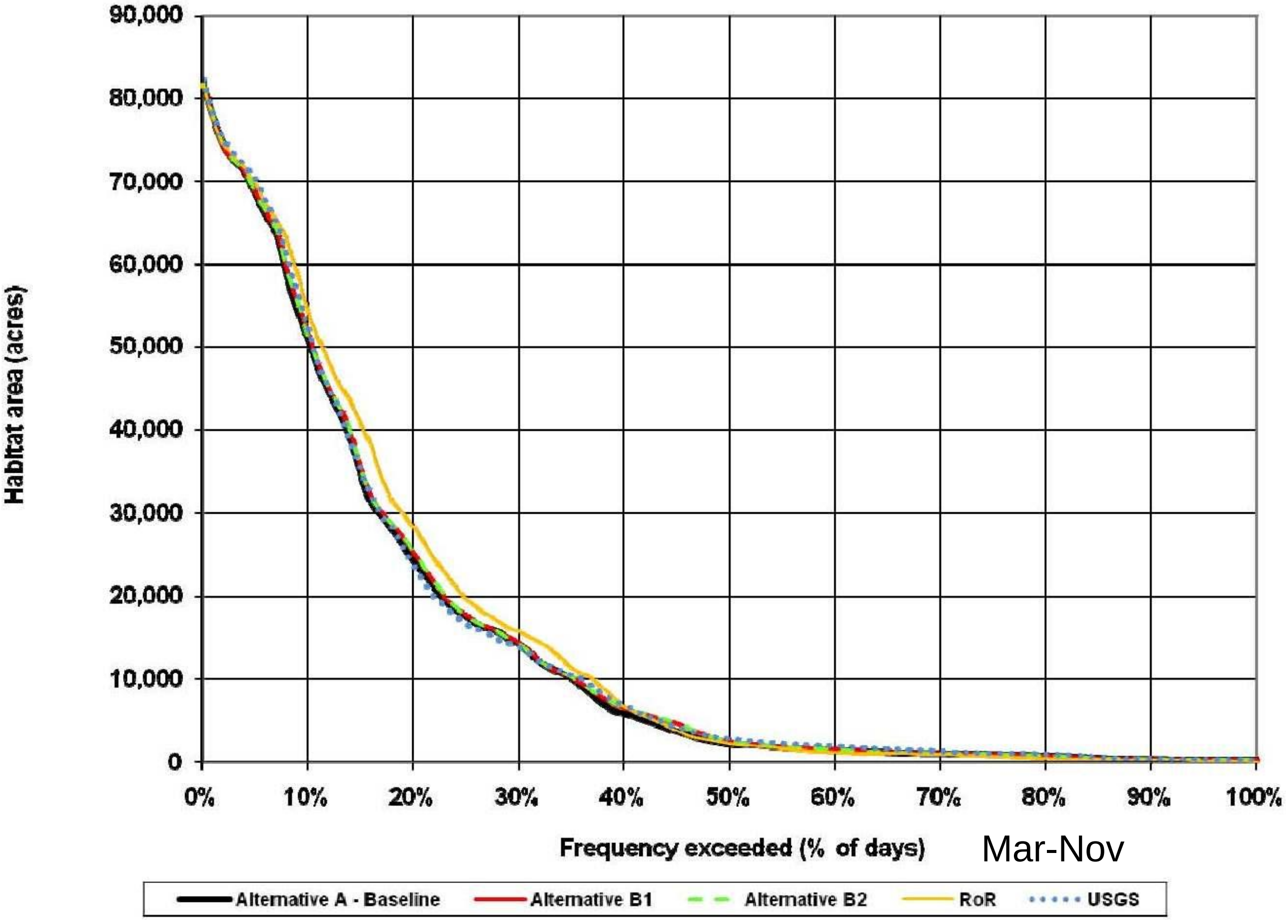

90% exceedance - Flow
1922-1955 Observed Flows
1975-2008 Observed Flows
1975-2008 Existing Ops (Aug 2010 model)
1975-2008 Plan 550WQ (Aug 2010 model)
1975-2008 Plan 750WQ (Aug 2010 model)
Flow (cfs) in Apalachicola River at Chattahoochee, FL
22,000
21,000
20,000
19,000
18,000
17,000
16,000
15,000
14,000
13,000
12,000
11,000
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
Mar-Nov Growing Season

Area Frequency Curves

Frequency that acres of inundated floodplain are exceeded in the growing season (% of days – Mar-Nov)

Analysis provided by Corps

Graph from Corps 1/18/2011 Response to PAL, page 2-95:



Mar-Nov

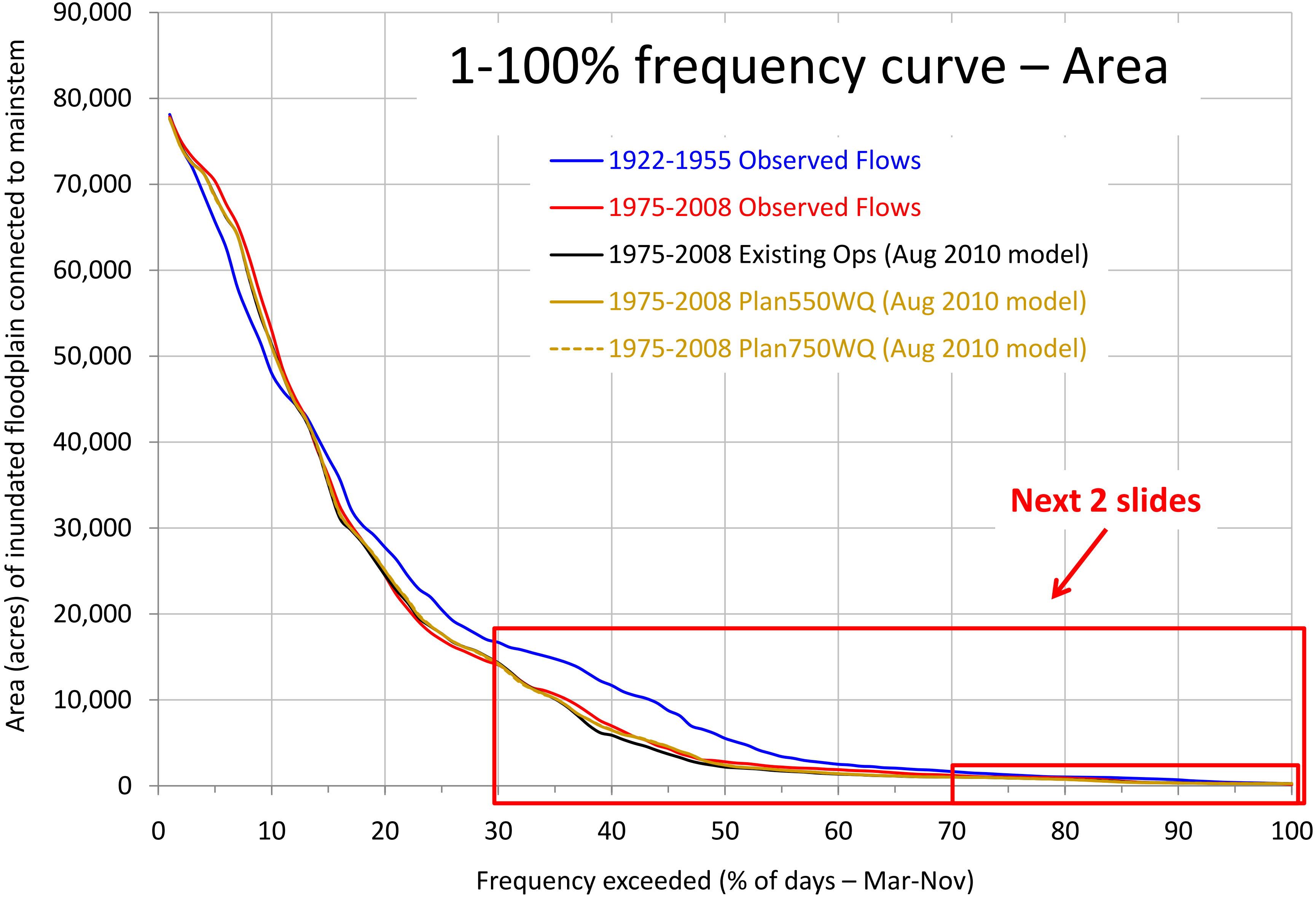
This graph was created by the Corps in response to FFWCC request.

Suggested revisions:

-- Remove RoR and replace with appropriate ecosystem flow guideline (1922-1955 observed flow)

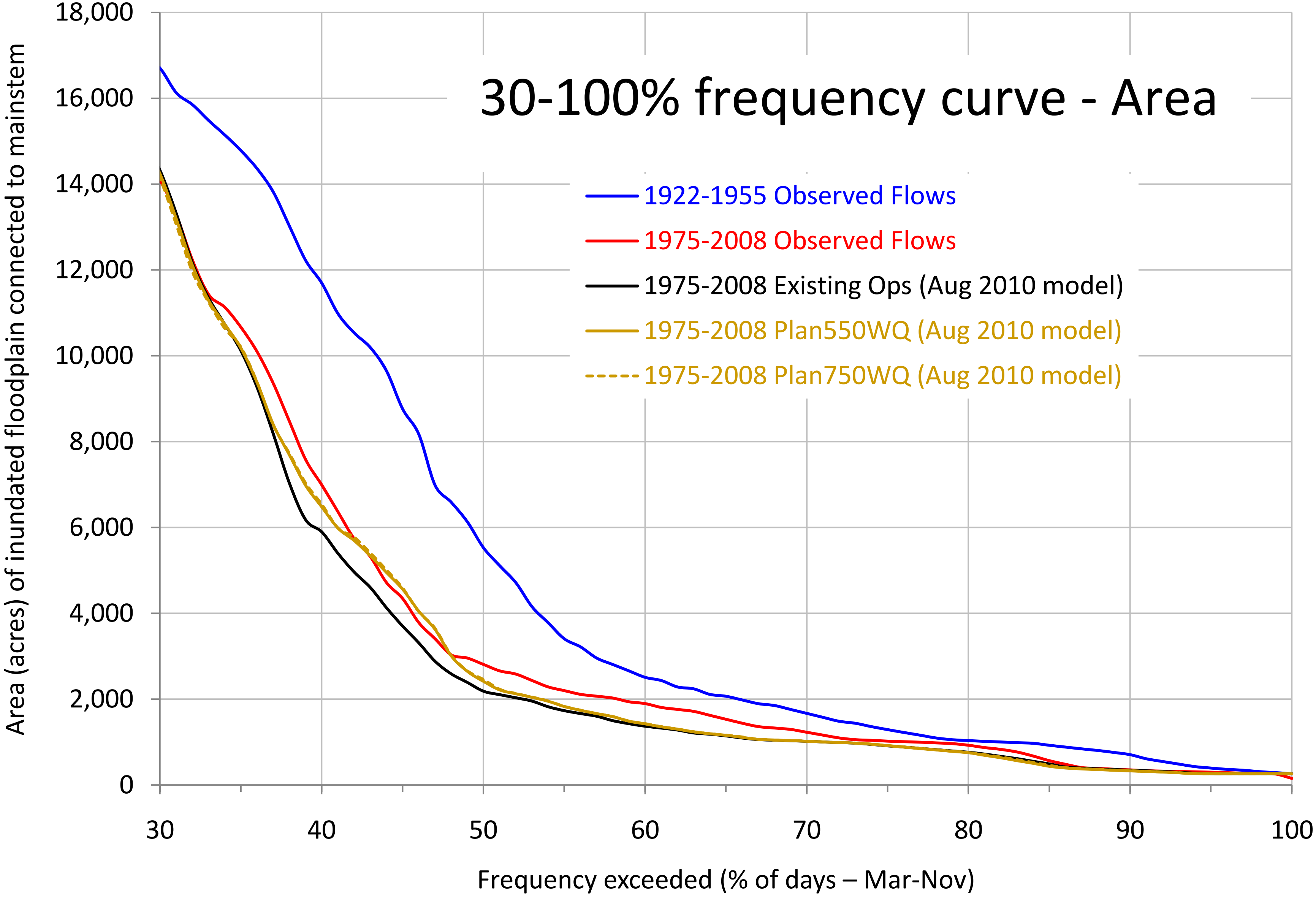
-- Expand data at low end

1-100% frequency curve – Area



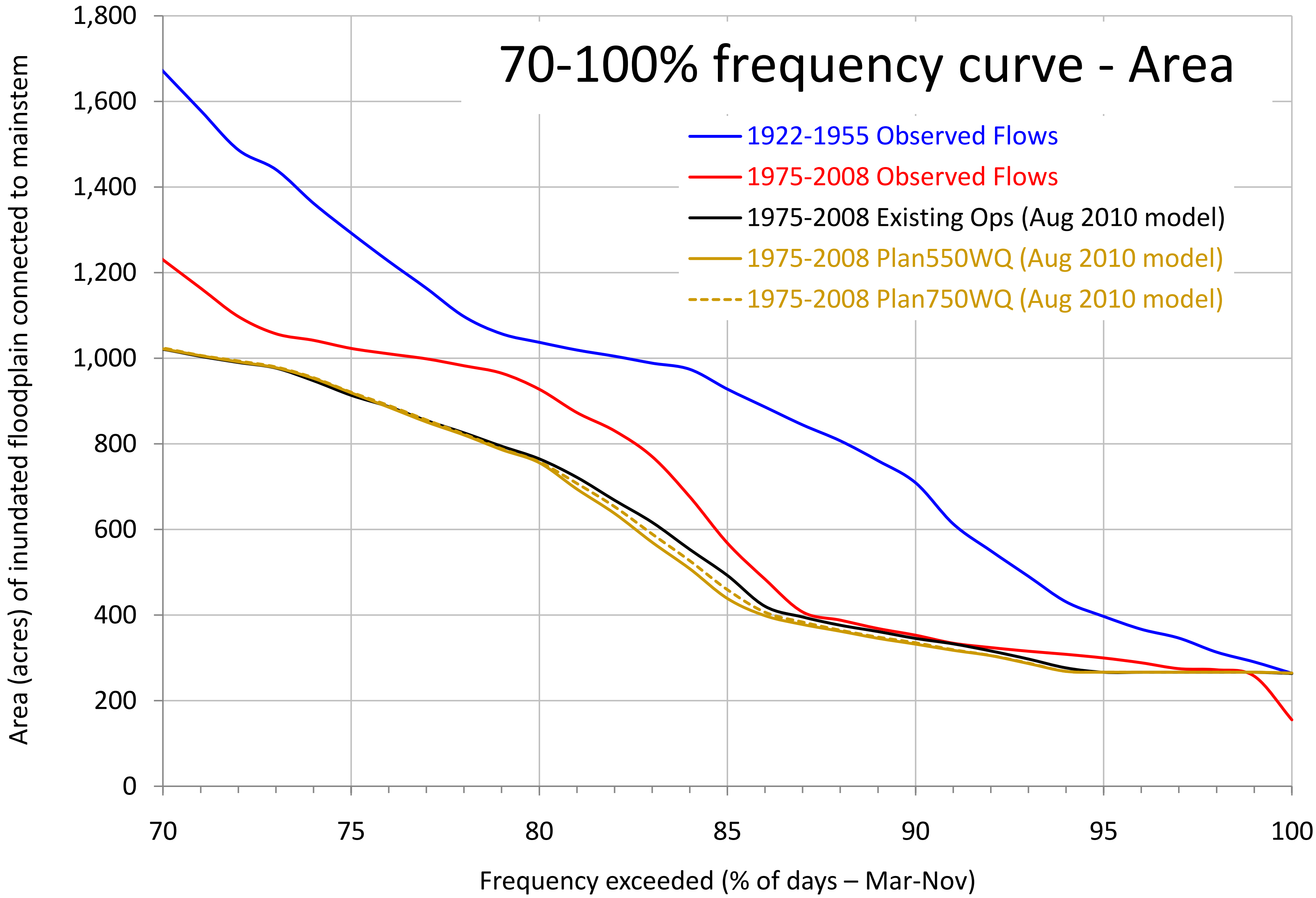
Next 2 slides

**Differences in area among flow regimes is due *solely to changes in flow* (not channel changes) because all flow data, including 1922-1955 observed flows, were converted to inundated areas based on present-day channel conditions using “Recent” stage-discharge ratings in Light et.al., 2006.



**Differences in area among flow regimes is due *solely to changes in flow* (not channel changes) because all flow data, including 1922-1955 observed flows, were converted to inundated areas based on present-day channel conditions using “Recent” stage-discharge ratings in Light et.al., 2006.

70-100% frequency curve - Area



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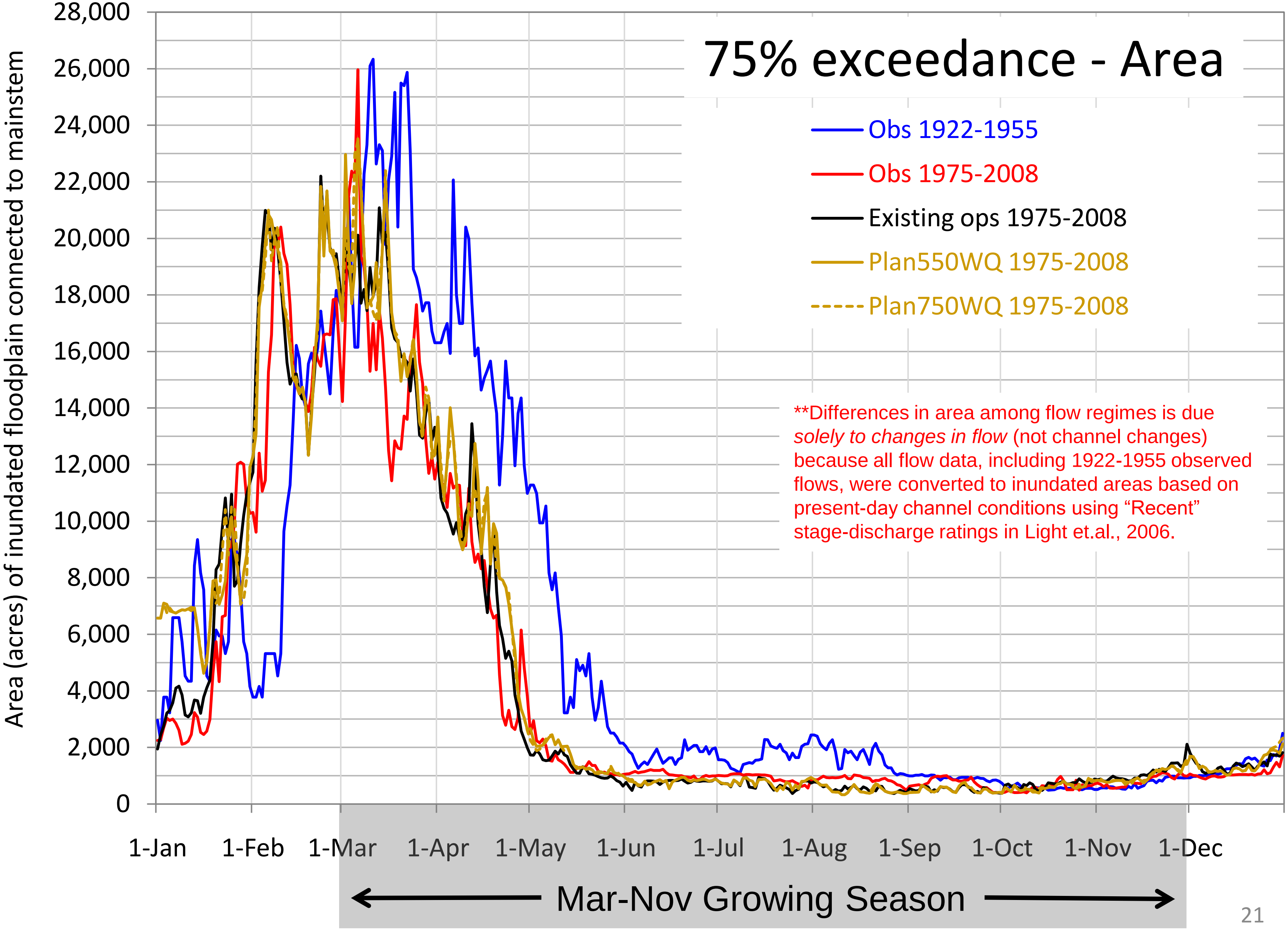
Area Exceedance Hydrographs

Daily exceedance for acres of inundated floodplain at selected frequencies:

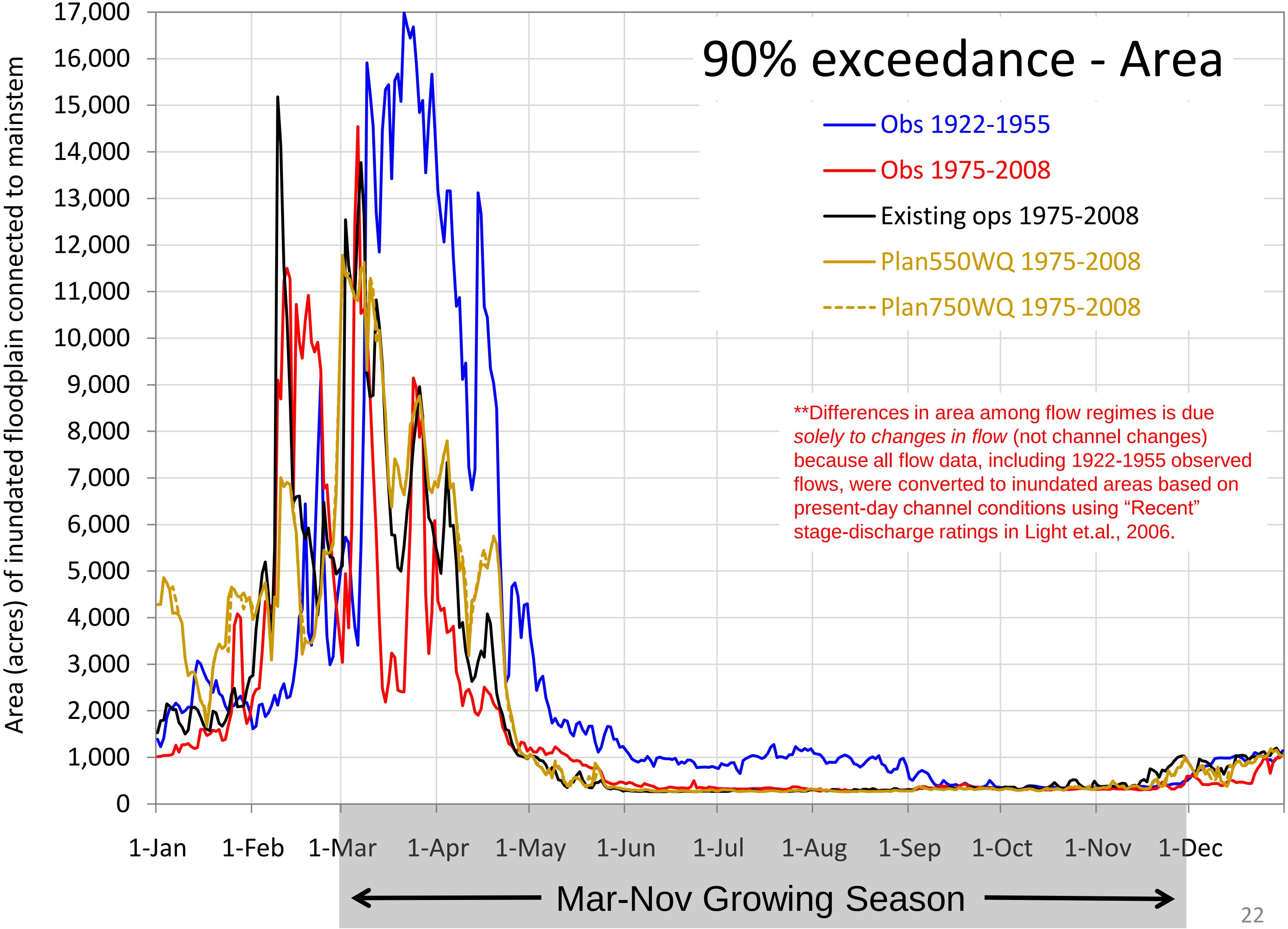
75 and 90%

Full year (Jan-Dec) included on all graphs, with growing season (Mar-Nov) indicated by shading on axis.



**Differences in area among flow regimes is due *solely to changes in flow* (not channel changes) because all flow data, including 1922-1955 observed flows, were converted to inundated areas based on present-day channel conditions using “Recent” stage-discharge ratings in Light et.al., 2006.

90% exceedance - Area



**Differences in area among flow regimes is due *solely to changes in flow* (not channel changes) because all flow data, including 1922-1955 observed flows, were converted to inundated areas based on present-day channel conditions using “Recent” stage-discharge ratings in Light et.al., 2006.

"Greene, Chris"
<Chris.Greene@dcnr.alabama.gov>
05/26/2011 10:51 AM

To "'Alice_Lawrence@fws.gov'" <Alice_Lawrence@fws.gov>
cc
bcc
Subject RE: Draft Fish and Widlife Coordination Act Report for the Corps' ACF Water Control Manual Update

History: This message has been forwarded.

Alice,

We have reviewed the Draft FWCA Report for the Corps' ACF Water Control Manual update and have no additional comments.

Thanks,

J. Chris Greene
Environmental Affairs Supervisor
Alabama Wildlife & Freshwater Fisheries Division
Fisheries Section
64 North Union Street, Suite 658
Montgomery, Alabama 36104
334-353-0210

From: Alice_Lawrence@fws.gov [mailto:Alice_Lawrence@fws.gov]
Sent: Monday, May 09, 2011 9:37 AM
To: matt_thomas@dnr.state.ga.us; Cook, Stan; ted.hoehn@myfwc.com; david.bernhart@noaa.gov; prescott.brownell@noaa.gov; miles.croom@noaa.gov
Cc: Sandy_Tucker@fws.gov; Donald_Imm@fws.gov; Jerry_Ziewitz@fws.gov; Will_Duncan@fws.gov; karen_herrington@fws.gov
Subject: Draft Fish and Widlife Coordination Act Report for the Corps' ACF Water Control Manual Update

Hello everyone- here is the Service's Draft FWCA Report for the Corps' ACF WCM update. Please review the report and provide us with official comments that represent your agency. This will enable us to reflect your comments in our Final Draft FWCA Report and include your letters as appendices.

You already have many of the appendices that are currently referenced in the report. However, if you would like one of the appendices that you don't already have, please let me know and I can get it to you. Also, it is our understanding that the Corps is updating some of the figures and text that was provided in their January 18, 2011, Response to the Service's PAL. However, we do not have that information and wanted to go ahead and get this draft report to you.

We would like to have your comments by COB May 23rd so that we may deliver a Final Draft FWCA Report to the Corps by June 1, 2011. We know it is a quick turnaround but really appreciate your review.
Thanks so much- Alice, Will, and Karen

Alice P. Lawrence
Fish and Wildlife Biologist
United States Fish and Wildlife Service
105 Westpark Drive, Suite D
Athens, Georgia 30606
Phone: 706.613.9493 X 222
Fax: 706.613.6059

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE

Southeast Regional Office
263 13th Avenue South
St. Petersburg, Florida 33701-5505
(727) 824-5317; FAX (727) 824-5300
http://sero.nmfs.noaa.gov/

June 10, 2011 F/SER47:PB/pw

(Sent via Electronic Mail)

Ms. Sandra F. Tucker
Field Supervisor
U.S. Fish and Wildlife Service
105 West Park Drive, Suite D
Athens, Georgia 30606

Dear Ms. Tucker:

NOAA's National Marine Fisheries Service (NMFS) reviewed your Draft Fish and Wildlife Coordination Act Report (DFWCAR) for the Mobile District Corps of Engineers' (COE) proposed Water Control Manual (WCM) update for the Apalachicola-Chattahoochee-Flint (ACF) River Basin. The update to the WCM proposed by the COE is described in their response dated January 18, 2011, to the Planning Aid Letter provided to the COE by the U.S. Fish and Wildlife Service on April 2, 2010. In consideration of potential impacts on estuarine, coastal, marine, and riverine fishery and aquatic resources, NMFS may provide additional comments directly to the COE under the authority of the Magnuson-Stevens Fishery Conservation and Management Act and the Endangered Species Act when the COE releases the updated WCM for public review.

The purpose of the update is to identify new operating criteria and guidelines the COE will use for operating five COE reservoirs within the ACF River Basin, which encompasses portions of the states of Georgia, Alabama, and Florida and historically has been a source of freshwater and ecological support for fish and wildlife, diadromous fish, Apalachicola Bay, and coastal marine ecosystems.

Major impacts to historic fishery and aquatic resources have taken place since the beginning of dam construction in the early 19th century. Federal dams and water resource operations by the COE have had substantial effects on the living resources of the ACF River Basin. The water storage capacity of Buford Dam and Lake Lanier is the largest of all the dams on the Chattahoochee River. The WCM update has the potential to positively influence water resource management in the ACF, but other dams and water withdrawals are significant and should also be considered in the WCM. For example, construction of non-federal dams and hydropower dams licensed by the Federal Energy Regulatory Commission are additional factors in alteration of aquatic resources and fish and wildlife habitats and are not managed by the COE but nonetheless influence COE operations. Significant impacts have resulted from fragmentation of riverine habitats by dams that block fish migrations, inundate habitat, and alter natural seasonal flow conditions.

Your DFWCAR reviews many important and complex environmental land and water resource management factors that should be considered by the COE in final development of the WCM update. NMFS supports the U.S. Fish and Wildlife Service's sections on "Evaluation of the Selected Plan," and "Fish and Wildlife Conservation Measures and Recommendations" with regard to fishery and aquatic resources under our authority.

We appreciate the opportunity to provide comments on the DFWCAR. Please direct related correspondence to the attention of Prescott Brownell at our Charleston Area Office. He may be reached at (843) 762-8609 or by e-mail at Prescott.Brownell@noaa.gov.

Sincerely,

Pace Wilber

/ for

Miles M. Croom
Assistant Regional Administrator
Habitat Conservation Division

cc:

FWS, Alice_Lawrence@fws.gov
F/SER47, Prescott.Brownell@noaa.gov

United States Department of the Interior
Fish and Wildlife Service
105 West Park Drive, Suite D
Athens, Georgia 30606
Phone: (706) 613-9493
Fax: (706) 613-6059

West Georgia Sub Office
P.O. Box 52560
Ft. Benning, Georgia 31995-2560
Phone: (706) 544-6428
Fax: (706) 544-6419

Coastal Sub Office
4980 Wildlife Drive
Townsend, Georgia 31331
Phone: (912) 832-8739
Fax: (912) 832-8744

April 2, 2010

Colonel Byron Jorns
US Army Corps of Engineers, Mobile District
P.O. Box 2288
Mobile, AL 36628-0001

Dear Colonel Jorns:

We are providing your agency with a Planning Aid Letter (PAL) for the proposed Water Control Manual (WCM) Updates for the Apalachicola-Chattahoochee-Flint (ACF) River Basin in Georgia, Alabama, and Florida. The purpose of the updates is to identify operating criteria and guidelines for managing water storage and release of water from Corps reservoirs. In the National Environmental Policy Act (NEPA) review, the Corps will address current operations, proposed changes in water management operations at the reservoir projects within the limits of the existing authorities, as well as potential impacts throughout the basin that would result from implementation of the updated manual.

The purpose of the PAL is to identify resource values and issues, identify endangered species issues, and propose preliminary changes, mitigation, or enhancement opportunities to facilitate your decision-making as it relates to equal consideration of fish and wildlife resources. We submit the following comments and recommendations under the ESA, the Migratory Bird Treaty Act (MBTA)(49 Stat. 755, as amended; 16 U.S.C. § 702 *et seq*.), and the FWCA (48 Stat. 401, as amended; 16 U.S.C. § 661 *et seq*.). These comments are based on previous studies and government documents as well as new datasets and information provided by State and Federal agencies. Although all of the comments from the Florida Fish and Wildlife Conservation Commission (FFWCC) have not been integrated, this final version of the PAL addresses many of the issues that FFWCC raised. We will continue to provide additional expertise and information in the form of another PAL and/or the draft Fish and Wildlife Coordination Act report. A separate consultation will occur regarding the potential impacts of the Corp's proposal on federally-listed threatened and endangered fish and wildlife species protected under the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. § 1531 *et seq*.).

1. Development of Corps Alternatives and Mitigation

We have identified data needs and assessment methods that can help you in developing alternatives that maximize fish and wildlife benefits, and avoid, minimize and compensate for impacts to fish and wildlife resources, where appropriate.

1.1 Flow Regime

The WCM update should include a thorough evaluation of project-related flow regime alterations and the potential to restore flow regime components that have ecological and geomorphic significance. We recommend the Corps develop alternatives that would maximize benefits to fish and wildlife resources in light of other project purposes. To support this effort, we have provided preliminary ecosystem flow guidelines for four river sections; below Buford, West Point, Walter F. George, and Jim Woodruff dams. These flow regime guidelines are guided by the principle that ecosystems evolved as a response to the natural flow regime. Thus, we analyzed river flows and developed flow guidelines based on United States Geological Survey (USGS) flow data that were collected prior to Buford Dam construction in the mid 1950's, a benchmark of the first major river regulation source in the upper Chattahoochee River. Reliance on pre-regulation datasets to derive ecosystem flows is particularly useful for locations where empirically derived ecology-flow relationships are scant (such as the upper Chattahoochee River).

We recognize that complete implementation of all guidelines presented herein is not feasible given the expansive flow alteration and consumptive demands in the ACF River Basin that have occurred since Buford Dam construction. However, restoration of some natural flow regime components presented in these guidelines can restore structural and functional ecosystem elements that were lost or reduced as a consequence of flow regulation. For example, provision of stable flow windows (*sensu* Freeman et al. 2001) in the spring may increase riverine fish recruitment, even though restoration of other naturally occurring flow regime components may not be attainable. Relatively small discharge changes can have substantial ecological effects. For example, the Tennessee Valley Authority's (TVA's) strategy to increase baseflows below Normandy Dam (Figure 1) during the spring and summer mussel recruitment months resulted in biologically and statistically significant increases in mussel diversity and density (Figure 2, Ahlstedt and Johnson 2004).

Development of environmental flow alternatives would include an evaluation of the operational feasibility, constraints, and tradeoffs to providing the different aspects of environmental flow measures that are captured in our guidelines. Explicit magnitude, frequency, duration, timing, and rate of change guidelines are provided to illustrate the types of flow modifications that are likely to benefit the ecosystem and to help inform the development of Corps flow alternatives. However, should the magnitude of a flow guideline be deemed unattainable, we request that the Corps identify a flow magnitude that is attainable or recommend an attainable frequency for the recommended flow magnitude. An explanation for the change also will be helpful. We recognize these guidelines do not define whether the basin is entering a dry, average, or wet month, which are the lines between the lower and upper limits on the flow prescription graphs. We recommend that you work with us to develop appropriate hydrological and meteorological criteria (e.g., basin inflow, precipitation, and reservoir levels) needed to classify the coming month as a dry, average, or wet month.

Successful implementation of ecosystem flows in the Chattahoochee River is challenged by water demand increases, reduced operational flexibility imposed by meeting minimum discharge requirements at downstream locations, and the importance of minimizing high discharge-related

damage to infrastructure. To address these challenges, we considered only the range of flows that were likely to be above minimum flow requirements and less than flows that could cause major infrastructure damage as identified by information provided by the National Weather Service (NWS) Advanced Hydrologic Prediction Service (NWS 2010; Table 1). The ecosystem flow guidelines are preliminary because in instances where water is diverted from the channel, or the channel is anthropogenically altered, natural flows may be insufficient to meet ecological needs.

Successful implementation of ecosystem flows in the Apalachicola River is challenged by the same types of limitations described for the Chattahoochee River. The degree of Apalachicola River channel entrenchment and widening, caused largely by Corps reservoir and dredging operations, varies spatially, but the discharge that is now required to reach bankfull elevation and cause floodplain inundation in the upper portion of the river is generally greater than the discharge that was historically required. However, datasets are available that quantify the amount of floodplain habitat inundated with the current level of entrenchment and over a range of discharges. These datasets, in combination with those that describe flow effects on sturgeon spawning and mussel habitats, will help to inform the development of future ecosystem flow guidelines and the evaluation of alternatives.

Thorough explanations of the physical, chemical, and ecological benefits from base flows, pulses, stable flow windows for spawning, and intra- and interannual flow variation are outside the scope of this letter; however, we refer the reader to Junk et al. 1989, Poff et al. 1997, Richter et al. 1998, Freeman et al. 2001, Postel and Richter 2003, and Mathews and Richter 2007 for fuller descriptions. The importance of baseflows, pulses, and flood flows are described within these resources, and they are quantitatively evaluated using the recently developed Environmental Flow Components (EFCs) in Indicators of Hydrologic Alteration (IHA)(Mathews and Richter 2007). General descriptions of the baseflow, pulse, and high pulse flow guidelines are provided below with general descriptions of the ecological significance of those flow guidelines.

Similar to the Instream Flow Guidelines provided to the ACF Compact's Federal Commissioner (USFWS 1999), the guidelines provided in this letter were developed using IHA, use the pre-dam period of record as a benchmark for comparison of flow alternatives, and rely on percentiles to define the frequency of high and low flow extremes. Using EFCs is recommended because the analysis separates ecologically-relevant hydrograph components (e.g., baseflows from pulses) allowing computation of magnitude, frequency, duration, timing, and rate of change statistics on individual hydrograph components rather than on the entire dataset. Consequently, these hydrograph summary statistics are easily developed, interpreted, and communicated, and have been used successfully to inform flow management downstream from hydropower dams.

1.1.1 Baseflow and small pulses

Baseflows determine the amount of habitat that is available for forage, reproduction, and rearing, which has a substantial influence on the abundance, diversity, and distribution of aquatic fauna. We have provided explicit base flow recommendations for every month in dry, average, and wet water years. Small pulses that do not exceed bankfull elevation provide influxes of upstream

trophic subsidies, and reprieves from low dissolved oxygen and high temperature that sometimes occur during summer months. Small pulses are included in the guidelines with explicit magnitude, frequency, duration, timing, and rate of change recommendations (Figures 3-6).

The flow guidelines were based on average daily flows (Figures 3-6). Average daily flows obscure the diel streamflow variation imposed by hydropower generation. Consequently, hydropower generation at Buford, West Point, Walter F. George, and to a lesser extent, Woodruff Dam, may change discharge two orders of magnitude, and change river stage significantly within a few hours. As a result, habitat availability is limited to periods that are too brief for the completion of essential life history requirements. To mitigate this impact, the provision of non-hydropower peaking "windows" should be evaluated during critical reproductive and rearing periods in order to reestablish native plant, fish, and invertebrate abundance and diversity in river reaches downstream from Corps-operated projects. Generally, this period corresponds to March – May when water temperatures increase. The timing, duration, and magnitude of this window should vary interannually in order to optimize the reproductive requirements of each species every few years. However, the duration of the non-peaking window requires additional research, but we expect that a minimum of 4-6 weeks between March and May are required.

The dry, average, and wet year baseflow guidelines are based on a retrospective analysis of the pre-dam hydrograph (Figures 3-6). It will be necessary to use appropriate hydrological and meteorological criteria to classify the coming month into dry, average, or wet categories. However, average daily baseflows should remain near the dry, average, and wet year flow guidelines depending on the category, and should not fall below the lower limit on any day of any year.

1.1.2 High flow pulses

High flow pulses that exceed bankfull elevation provide important ecological services. A large proportion of sport and non-game fishes rely on floodplain habitats to spawn, rear young, and forage. High flow pulses are also major forces that control nutrient and organic matter dynamics in large rivers, create new habitats, and ultimately affect riverine animal biomass (Junk et al. 1989). However, the spring reservoir refill period extends into the principal spawning season for a high proportion of fishes, meaning that spring flows and floodplain inundation are reduced. Thus, ensuring seasonal high flows and river-floodplain connectivity with the timing, frequency, duration, magnitude, and rate of change necessary to sustain ecological functions and wildlife populations are essential flow management objectives for dams on large rivers.

To provide flows that inundate the floodplain, the potential for reducing the magnitude of the autumn drawdown, changing the order of refill, and/or beginning the spring refill earlier in order to provide fish access to and inundation of the floodplain should be evaluated. Similarly, the Savannah District Corps has operated the Savannah River reservoir system in recent years with reduced winter drawdown to provide spring pulses that meet multiple downriver ecosystem objectives. This evaluation should separately consider flow conditions in wet, average, and dry climatic years. Additionally, it should be noted that relatively small changes in river stage can significantly increase the amount of river-floodplain connectivity. Consequently, minor changes

in dam operation could have large and positive effects on the river-floodplain ecosystem.

Recognizing that there are limits on operational flexibility due to the presence of infrastructure in some floodplains, methods should be evaluated to provide the operational flexibility necessary for floodplain inundation, which falls under the Corps' coequal project purpose of "Fish and Wildlife Resources." Such methods could include 1) protecting structures (e.g. moving to locations of higher elevations or elevating structures using stilts as is done in coastal communities) that may be impacted by 2, 10, 50, and 100-year recurrence interval pre-dam flows during periods of floodplain inundation; and/or 2) the purchase of structures built in the historic floodplain so that the Corps can intentionally provide flows that inundate the floodplain. These analyses should be simple to conduct, and would include acquisition of floodplain maps and identification of anthropogenic structures within the 2, 10, 50, and 100-year floodplains.

1.2 Floodplain inundation assessments

The relationships among the areal extent of Apalachicola River floodplain inundation, channel entrenchment effects, and water releases from Jim Woodruff Lock and Dam were previously assessed and related to discharge using the datasets and summaries provided by Light et al. 1998 and Light et al. 2006. These datasets have informed biologists and the Corps of the effects of flow releases on river-floodplain resources. Due to the difficulty of surveying all floodplain streams, lakes, and forests, Light et al. 1998 used intensive surveys at a subset of sites, general surveys at approximately 300 sites, and Geographic Information Systems (GIS) to assess the effects of hydrogeomorphic alteration on floodplain inundation areal extent. Light et al. 2006 compared pre-dam stage (prior to 1954) and recent stage (1995–2004) at five streamflow gaging stations in relation to discharge at the Chattahoochee gage (USGS gage number 02358000, Apalachicola River at Chattahoochee, FL). These stage-discharge relationships can also be used to calculate area (acres) of aquatic habitat connected to the main channel of the non-tidal Apalachicola River at different discharges for the pre-Lanier (1929-1955) and post-West Point (1975-2007) periods.

More recently, floodplain elevation maps have been generated using Light Detection and Ranging (LIDAR) remote sensing data with <1 ft accuracy and related to Apalachicola River stage-discharge relationships developed by Light et al. 2006 (Ron Bartel, Northwest Florida Water Management District [NWFWMD], 2010, pers. comm.). Stage-based LIDAR data may provide a more thorough and accurate evaluation of river flow effects on river-floodplain connectivity and habitat availability. We recommend that the Corps contact the NWFWMD to confirm that these datasets exist, request permission to access and use these new datasets, or invite collaboration between the Corps and the NWFWMD to evaluate effects of flow alternatives on floodplain resources. Operations in the environmental flow alternatives should be developed that will use reservoir storage at certain times to augment flow and increase Apalachicola floodplain inundation.

1.3 Water Quality

The effects of reservoir operations on water quality should be closely examined in the WCM update, including ongoing and potential future effects to dissolved oxygen (DO), temperature, nutrient and organic material dynamics, and capacity to assimilate industrial and municipal

discharges. We request that the Mobile District use the WCM update to make necessary modifications that will improve water quality downstream of Corps projects, as is being done by TVA and other Corps districts.

1.3.1 Dissolved Oxygen

The Service is most concerned about low DO in project tailwaters. We recommend that the Corps make a concerted effort to ensure that releases from all five ACF dams meet or exceed DO and other applicable water quality standards. An appropriate effort would include first monitoring DO upstream and downstream of Corps reservoirs, experimenting with operational and/or structural modifications to Corps projects to improve DO levels, and conducting post-modification DO monitoring to ensure that DO levels have been improved to State water quality standards. Examples of low DO releases from Buford, West Point, and Walter F. George dams are detailed below.

We urge the Corps to 1) monitor DO upstream and downstream of Lanier Reservoir, West Point Reservoir, Walter F. George Reservoir, and Jim Woodruff Reservoir and 2) experiment with operational and/or structural modifications to improve DO levels, and conduct post-modification DO monitoring to ensure that DO levels increase to state water quality standards. Simple weighted averages that formulate the amount of sluicing necessary to achieve the required downstream dissolved oxygen requirements may be particularly useful. The DO that results from the mixing of two water bodies (DO_{mx}) is a function of the dissolved oxygen (DO_1 and DO_2) and volumes (Q_1 and Q_2) of the two water bodies and is calculated using the following equation:

$$DO_{mx} = \frac{Q_1 * DO_1 + Q_2 * DO_2}{Q_1 + Q_2}$$

1.3.1.1. Buford Dam tailwaters

Low DO levels were recorded by the Georgia Department of Natural Resources-Wildlife Resources Division (GDNR-WRD) just below Buford Dam during 1996-2006. These DO levels affect angler success, GDNR-WRD's stocking rates, and the native aquatic community. Periodic measurements taken during this period resulted in monthly minimum instantaneous $\leq$ 1.0 mg/L in September through December. Monthly average values were < 5.0 mg/L from August through November (Figure 7; Chris Martin, GDNR-WRD, 2010, pers. comm.). Low DO levels persisted downriver, depending on operational and climatic factors. For example, based on GDNR-WRD measurements on November 5, 2005, DO increased to 5.0 mg/L three miles downriver, and increased to 6.0 mg/L 5.2 miles downriver when releases from Buford Dam were < 2.0 mg/L (Chris Martin, GDNR-WRD, 2010, pers. comm.).

The Corps upgraded the venting capabilities of the Buford Dam turbines over the past few years. However, the upgrades resulted in < 1.0 mg/L increase over previous conditions (Chris Martin, GDNR-WRD, 2010, pers. comm.). The Corps should thoroughly evaluate the effectiveness of these upgrades.

Useful tools to improve DO levels to State standards in Georgia trout waters (6.0 mg/L daily average, 5.0 mg/L instantaneous) include sluicing instead of running discharge through the

penstocks and units, or to use a combination of the two routing methods. For example, on September 15, 2000, GDNR-WRD recorded a DO level of 1.5 mg/L at Buford Dam during a minimum flow release through the house unit. In contrast, DO levels measured on the same date during sluicing indicate that DO remained above 6.0 mg/L (Chris Martin, GDNR-WRD, 2010, pers. comm.). Thus, the Corps has demonstrated that sluicing below Buford Dam is an effective tool to mitigate low DO effects associated with hypolimnetic releases.

1.3.1.2. West Point Dam tailwaters

Dissolved oxygen data collected by the Corps downstream from West Point Dam from 1999 through 2001 indicate that DO levels met or exceeded the Georgia instantaneous standard (4 mg/L) 35% of the monitoring period in 1999, (monitoring from 6/15-9/14), 30% of the monitoring period in 2000 (monitoring from 7/25-9/30), and 4% of the monitoring period in 2001 (monitoring from 6/8-10/5; Georgia Power Company 2002). GDNR-WRD has investigated multiple fish kills below West Point Dam and has concluded that these fish kills are attributable to low dissolved oxygen levels (GDNR-WRD letter to the Corps, November 20, 2008).

1.3.1.3 Walter F. George Dam tailwaters

Low DO levels were associated with minor fish and mussel kills downstream of Walter F. George Dam (Rob Weller, GDNR-WRD, 2008, pers. comm.).

1.3.2 Temperature

The water temperatures of hypolimnetic releases below large dams are lower than would naturally occur during spring and summer months. Low water temperatures negatively affect warmwater fishes that require warmer water temperatures necessary for spawning and growth of young-of-year fishes. Thermal alteration can be ameliorated by structural modification of penstock location in the water column. Another option to moderate thermal alteration is to release (via sluicing) warmer water from a higher elevation in the reservoir's water column. Once this water mixes with the cold hypolimnetic release, water temperatures more closely approximate natural water temperatures. A recent example of sluicing effects in the Mobile District comes from measurements taken during summer 2009 below Allatoona Dam. Sluicing in June caused water temperatures to increase approximately10ºC (Figure 8). Temperature increases were observed many miles downriver (USFWS 2009 unpublished data).

Similar to DO recommendations, we urge the Corps to monitor water temperature upstream and downstream of the five ACF Corps impoundments, and 1) experiment with operational and/or structural modifications to improve temperature levels, as needed, and 2) conduct post-modification monitoring to ensure that temperatures have been improved. Simple weighted averages that formulate the amount of sluicing necessary to achieve the required downstream temperature requirements may be useful. The seasonal timing of such releases exhibiting modified temperatures is of great importance. For example, the current summer thermal regime on the Etowah River, created by operations at Allatoona Dam, provides cool thermal refuge for striped bass in the upper Coosa River system. A thermal modification during the summer months below Allatoona Dam could be detrimental to fishes such as striped bass and lake sturgeon (Matt Thomas, GDNR-WRD, 2010, pers. comm.). Because the Service and GDNR-

WRD have responsibilities to protect native aquatic communities as well as recreational fisheries, we recommend the Corps explore methods for temperature modifications below their facilities, but coordinate closely with State and Federal agencies to determine the appropriate timing of such alterations.

In addition, it should be noted that the current thermal regime of Lanier Reservoir's tailwater is critical to the Chattahoochee River trout fishery and trout production at GDNR-WRD's Buford Hatchery. The tailwater trout fishery in the Chattahoochee, one of Georgia's premier fisheries, is dependent upon cold, well-oxygenated water releases for the survival of trout. The Buford Trout Hatchery produces 400,000 catchable trout annually and is dependent on Lanier Reservoir coldwater storage to maintain this production. Potential impacts to Chattahoochee River trout waters should be considered when making WCM decisions (Matt Thomas, GDNR-WRD, 2010, pers. comm.). The coldwater trout fishery below Buford Dam is of great importance to GDNR-WRD, and is also a responsibility for the Service as an important recreational fishery. Discussions between GDNR-WRD and the Corps should occur to determine if modifications are possible that avoid trout fishery impacts but also provide benefits to native warmwater fisheries below Buford Dam.

1.4 Fish Passage

Corps ACF dams impede the migration of diadromous and potadromous fishes including striped bass, Alabama shad, American eel, and Gulf sturgeon. Jim Woodruff Dam's impact on diadromous fish passage is large compared to dams on other southeastern rivers because it is located in the lower part of a large river basin. Consequently, there is significant interest in improving fish passage at this facility, as well as the two next upstream Corps facilities, George W. Andrews Lock and Dam and Walter F. George Lock and Dam. We appreciate the Corps' willingness and cooperation to modify operations thus far at Jim Woodruff to maximize fish passage for Alabama shad. Support and facilitation of fish passage research at Woodruff Dam, as well as other ACF Federal dams (notably George W. Andrews Lock and Dam and Walter F. George Lock and Dam) should continue with a goal of identifying and implementing operations and/or modifications that would allow riverine species to travel their historic migratory pathways. Provisions for fish passage should be incorporated in the WCM for Jim Woodruff Lock and Dam, George W. Andrews Lock and Dam, and Walter F. George Lock and Dam, while maintaining the need for operational flexibility.

1.5 Climate Change

The effects of climate change to ACF flow regimes and how to best adapt reservoir operations to the most likely foreseeable changes should be evaluated. It is our understanding that the Corps will be considering sea level rise when developing alternatives (Corps 2009). However, climate change will also affect river flows and the effects of a given set of operating rules will vary depending on whether the basin's climate becomes drier, wetter, more variable, or less variable. In particular, it is vitally important to adapt the level set as the top of conservation (TOC) pool to the long-term hydrology of the basin and the essential purposes the projects serve. In a scenario with greater variability between annual high flows and low flows, for example, it may not be feasible for these projects to simultaneously serve their existing levels of flood control protection and minimum flow support without adapting TOC pool levels to prevailing weather conditions.

The Corps already practices this concept with the multiple action zones and the occasional variances from the rule curves to store water above the TOC pool elevation during dry periods. Several models are developed that will be useful in this analysis and are briefly described in section *2.2 Evaluation of Alternative Models*. In addition to including multiple future climate scenarios into modeled discharge scenarios and Corps alternatives, flow provisions should be created for dry, average, and wet years in order to account for current climate variability.

1.6 Navigation

Navigation is an authorized project purpose for all five ACF Corps dams and the Corps has used reservoir storage in the past to support navigation. In recent years, however, lacking water quality certification to maintain the channel in Florida, we have seen only occasional flow management for the navigation purpose. Current physical channel dimensions dictate the flows that are necessary for navigability. Without providing flows to meet channel depth authorizations, dredging would be necessary to maintain channel navigability. Dredging has significant adverse effects to fish and wildlife. If flows for navigation are included in the WCM update, we recommend that dredging needs, dredging impacts on fish and wildlife, and a cost-benefit analysis be included in an evaluation of the effects of the channel maintenance activities required for navigation flow support. If flows for navigation are not included in the WCM update, improvement or simplification of the four-zone reservoir operational scheme that governs current operation should be considered.

1.7 Reservoir and Riverine Fisheries Management

The Corps follows a draft Standard Operating Procedure (SOP) for “Lake Regulations and Coordination for Fish Management Purposes.” The “fish spawn” SOP goal is to manage for generally stable or rising reservoir levels and for generally stable or gradually declining river levels for about 4 to 6 weeks in the spring months at Corps’ reservoirs. These draft SOPs are protective of reservoir fish spawning; however, stable or rising river levels are also beneficial for riverine sport fisheries. We understand it is not feasible to have stable and/or rising water levels in both the reservoirs and river during times of declining basin inflow. To address this issue, recent reservoir and riverine fisheries literature should be reviewed to evaluate whether a 4-6 week stable or rising reservoir window is supported for reservoir fish spawning and/or potentially detrimental to riverine fish spawning. We also recommend development of an alternative that includes modifying the draft SOPs to occasionally emphasize river spawning over reservoir spawning and define those circumstances where this would occur without unreasonably compromising other project purposes. Finally, we recommend that the Corps identify fish and wildlife recreation facilities that need infrastructure improvements to operate at a wider range of flows and/or reservoir elevations.

1.8 National Wildlife Refuges

The Service previously recommended to the Corps that a seasonal pattern of reservoir levels at W.F. George Reservoir would best accommodate the needs of Eufaula National Wildlife Refuge. Water levels that provide seasonal habitat for a large number of migratory bird species, control the spread of undesirable aquatic vegetation, and allow the manipulation of off-reservoir impoundments for waterfowl are principal concerns of the Refuge. These recommendations, which we included in the draft FWCA report for the Corps' 1998 Draft EIS on ACF water

allocation, were to manage the reservoir so that it behaves more like a river. Reservoir elevations that cycle between the highest levels (190 ft) in the late winter and early spring to the lowest levels (185 ft) in the late summer were recommended. These recommendations remain valid. How the benefits and impacts of such a scheme compare with the existing operating regime and other alternatives should be considered.

1.9 Apalachicola Bay

The predicted levels of freshwater inflow into Apalachicola Bay resulting from Corps alternatives will be of importance to the Service because they may affect salinity levels. Freshwater inflow reductions cause salinity increases and indirectly increase oyster mortality through increased colonization of marine oyster bed predators (Corps 1998). Additionally, juvenile Gulf sturgeons have optimal growth rates at relatively low salinity (9-10 ppt), and periods of extended higher salinities would likely limit feeding habitat availability.

As part of the Comprehensive Study for the Corps' DEIS (1998), the National Ocean Service (NOS) examined the freshwater inflow effects on the water circulation and salinity changes in Apalachicola Bay. Oysters were selected as a biological response variable because of their commercial fishery importance, habitat requirements, and expected response to salinity fluctuations (Corps 1998). A three-dimensional hydrodynamic model produced output that was used in an integrated biological model to assess the effects of potential freshwater inflow changes to Apalachicola Bay salinities and oysters. Predicted oyster mortality and oyster bed growth rates were compared for the various Corps' alternatives.

More recently, Livingston et al. (2000) developed a spatially-explicit hydrodynamic circulation model of the bay that predicts salinity, among other variables, as a function of freshwater inflow. This model has been used to model oyster mortality and growth in relation to freshwater inputs. The Service has used the results of this model to make inferences on the availability of low-salinity bay habitat for Gulf sturgeon. In addition, an alternative Apalachicola Bay salinity model was recently developed by Peter Sheng at the University of Florida (Sheng and Kim 2009). By using the Corps' daily average discharge output from the ResSim model for the Sumatra gage for the various alternatives, the model can compare the spatial extent and temporal duration of low- and high-salinity conditions among the alternative freshwater inflow scenarios. This information can be used to make inferences on the availability of bay habitat for Gulf sturgeon and to model oyster mortality and growth.

We recommend that the Corps or the Corps' consultants (Tetra Tech) contact the NWFWMD and/or the Florida Department of Environmental Protection (FDEP) to request permission to access and use the Livingston et al. models, or invite a collaboration between the Corps and NWFWMD/FDEP to evaluate effects of flow alternatives on Apalachicola Bay resources. The Sheng and Kim (2009) model should also be incorporated in the WCM update process to predict effects to Gulf sturgeon feeding habitat and potentially oyster mortality and growth. If all models are made available to the Corps and the Service, we recommend that the strengths and limitations of each model be evaluated to determine the model that will best suit the assessment requirements. In addition, coordination should occur with FFWCC's Fish and Wildlife Research

Institute to complete analyses of the relationship of freshwater inflow to the benthic communities of Apalachicola Bay and changes in fish and shellfish abundance.

1.10 Decision Support Model to Evaluate Changes to Corps' Operations

It is important to evaluate the effects of management strategies on the riverine ecosystem, recreation, navigation, hydropower, and other uses of Federal dams. Because of the numerous and sometimes competing demands for water, it is difficult to evaluate the effects of proposed management alternatives and to make the evaluation transparent. However, multiple free decision support tools (e.g., Netica) are available to facilitate the evaluation of alternatives. These tools are versatile in the sense that new information that results from monitoring the effects of management strategies is easily integrated into the analysis and decision process. Consequently, a better and more transparent understanding of how Corps operations affect the ecology and use of the ACF system can lead to improved future management. Therefore, a decision support model should be incorporated into the WCM update process.

1.11 Adaptive Management

An adaptive management program should be developed, consistent with the authorized purposes of the ACF reservoirs, for achieving specific ecological and social goals for the management of the ACF system including specific releases for Woodruff Dam. The program would formulate hypotheses about how such benefits might be achieved through dam operations, implement those operations, monitor ecosystem responses, and revise the operations based upon lessons learned.

2. Recommendations for Corps Hydrologic Modeling

2.1 Increasing Consumptive Demands

The impacts of increasing consumptive (municipal, industrial, and agricultural) water demands in the basin should be recognized and considered. This is a variable that an analysis of operational alternatives should incorporate along with climate-driven hydrologic variability. The relationship between increasing consumptive demands in the ACF Basin and effects on various project purposes should be quantified. For example, how is sustainable minimum flow release from Woodruff Dam affected if consumptive demands increase by 25, 50 or 100 percent by the years 2020, 2050, and 2080? We recognize the order made by Judge Magnuson limits operational alternatives for the express purposes of water supply. However, we also recognize that surface and groundwater withdrawals will continue to be made at various points in the system. The Corps alternative analysis must include metrics regarding water supply withdrawals including potential increases. The volume of storage that is being provided for water supply and has been proposed in each project and any limitations due to hydrologic conditions of meeting the water supply storage volume should be documented, as well as any potential changes in agricultural irrigation due to expanded irrigated acres or changes in crop composition.

2.2 Evaluation of Alternative Models

The Corps' unimpaired flows dataset that was used in the 1998 draft EIS was compared to 1) the unimpaired flows dataset that the Corps expects to use for the WCM update and 2) to the pre-Buford Dam USGS streamflow gage data. Aside from the addition of recent flow records, the most recent Corps-modeled unimpaired dataset is essentially unchanged from the 1998 version.

Compared to the USGS gage data, these datasets do not accurately represent the magnitude, duration, timing, and rate of change of flow extremes (i.e., minimum and maximum flows). Because flow extremes play important roles in reservoir operational decisions and in riverine, estuarine, and floodplain ecology, efforts should be made to develop unimpaired flow and alternative flow datasets that more accurately reflect flow extremes. We recommend that the use of alternative models be investigated to develop better unimpaired flow and alternative flow datasets.

Similarly, land cover has changed significantly since the early 20th century in the upper and middle portions of the ACF basin. Prior to both mainstem damming and discharge gaging, expansive agriculture, chestnut blight, fire suppression, and other factors affected land cover in the southern Appalachians, Piedmont, Fall-line Sandhills, and upper Coastal Plain regions. The hydrological consequences of land cover changes could have been manifested in the flow extremes observed during droughts and heavy rain. Nevertheless, the pre-dam hydrologic period of record is presently the best available hydrologic dataset to characterize pre-dam streamflows, develop ecosystem flow alternatives, and with which to compare flow alternatives. Models that predict hydrological alteration that occurs in response to land cover changes could be particularly useful in the development and assessment of flow alternatives.

The United States Geological Survey (USGS) is developing a Precipitation-Runoff Modeling System (PRMS, http://water.usgs.gov/software/PRMS) for the ACF. This watershed model will facilitate the inclusion of impacts of precipitation, climate, and land use changes on streamflow, sediment yields, and basin hydrology. If the PRMS is developed specifically for the ACF in a timeframe useful for the ACF WCM update process, it should be used as an additional evaluation tool. The PRMS output potentially could be used to 1) check the precision of the Corps' unimpaired flows datasets, and 2) supply an alternative unimpaired flow dataset to use based on informed climate and land use change predictions. Use of this model is based on the assumption that the PRMS model results reflect average flows and flow extremes better than existing datasets and other models. The latter analysis may be particularly useful to determine if reservoirs can maintain downstream flows through droughts.

National Oceanic and Atmospheric Administration (NOAA) funded the Georgia Water Resources Institute (GWRI) to complete a historical and future assessment of precipitation, evapotranspiration, soil moisture, and run-off trends in the ACF Basin to support ongoing water resources planning in the region. This method used both historical gage data and the Corps unimpaired flows dataset in a Joint Variable Spatial Downscaling model that incorporated climate change effects. Future stream flow, river flow, reservoir level, and power generation forecasts were made at the sub-basin level for the next 100 years. Coordination with USGS and GWRI should occur regarding these new models to explicitly address climate-based operational flexibility during the development and evaluation of flow alternatives, the WCM update, and the EIS analyses.

Lastly, the Corps' HEC-5Q water quality analyses rely on average daily flow to predict water quality parameters (e.g., temperature and dissolved oxygen) in six hour time steps and at 0.5 mile intervals. Although these model outputs can be used to compare among flow alternatives, they are not expected to accurately predict either the water quality values or the range of values that

are likely to occur in response to hourly discharge changes. Alternative water quality models exist and State resource agencies should be contacted to determine whether water quality models are developed for the ACF Basin. Additionally, regression models that accurately predict water quality parameters (e.g., water temperature and dissolved oxygen) can be developed using a combination of water quality datasets, hourly discharge, and other environmental parameters (e.g., weather and solar exposure). Alternative water quality assessment methods should be considered to accurately evaluate effects of flow alternatives on water quality.

3. Evaluation of Corps Alternatives for FWCA Report

3.1 ResSim Model Output Analyses

It is our understanding that ResSim will be used for the Corps' flow analyses. The flow statistics used by the Service in the past to analyze the resulting datasets were derived by using the Indicators of Hydrologic Alteration (IHA) and the Range of Variability Approach (RVA). Because flow is a master variable in fluvial systems, and because the ecology of fish and wildlife is closely linked to the flow regimes in which they evolved, the current evaluation should continue to rely on tools such as IHA, RVA, and Environmental Flow Components (EFCs) (Mathews and Richter 2007). Specific flow statistics and species-specific flow-ecology relationships (as available) that are important to natural resource sustainability, as well as the ACF Riverine Community Habitat Assessment and Restoration Concept (RCHARC) study (Freeman et al. 1997), should also be considered.

3.2 HEC-5Q Water Quality Model Output Analyses

It is our understanding that HEC-5Q will be used for the Corps' water quality analyses. We understand that this model predicts water quality parameters in six hour time intervals in river and reservoirs. Similar to the analyses contained in the Corps' 1998 draft EIS (Corps 1998), the analyzed data should be composed of summer values (May through October), separated by drought, dry, average, and wet year types for each alternative. The following information should be developed for each alternative to evaluate the effects on water quality and aquatic resources in the modeled tailrace and riverine locations:

- Total number of days with dissolved oxygen below a daily average of 6 milligrams per liter (mg/L) in locations within Georgia trout waters, and below a daily average of 5 mg/L in non-trout waters;
- Total number of instantaneous "measurements" less than 4 mg/L;
- Monthly exceedance figures and box plots with outliers for dissolved oxygen (mg/L);
- Monthly exceedance figures and box plots with outliers for water temperature; and
- Average stream percent wastewater.

For each alternative, the following information should be developed to evaluate the effects on water quality and aquatic resources for the modeled ACF reservoir locations:

- Average values of summer Chlorophyll a (*u*g/L);
- Average summer retention time (days); and

- Average summer phosphorus loading (pounds/acre/month).

3.3 Floodplain Connectivity Analyses

Assessing the extent of floodplain inundation will be a critical component of the alternatives analysis assessment. The Apalachicola River floodplain analysis should be decided following the Corps' attempt to access the river stage-based LIDAR data collected and housed by the NWFWMD. If the data are made available, the Corps should provide these data to the Service and an analysis of the area of aquatic habitat (separated by aquatic habitat type) connected to the Apalachicola River under the range of discharges for the period of record should be evaluated. If LIDAR data are not provided, the magnitude, duration, timing, frequency, and rate of change of Apalachicola River floodplain inundation should be evaluated using the relationships quantified by Light et al. 1998 and Light et al. 2006.

Although the areal extent of the Chattahoochee River floodplain is one-fifth that of the Apalachicola River floodplain (Davis 1997), it likely served multiple important ecological roles prior to flow alteration by multiple mainstem reservoirs. To our knowledge, the Tri-State Comprehensive Study Riparian Wetland Element (Davis 1997) houses the best available dataset for assessing the effects of flow alternatives on the Chattahoochee River floodplain. These data should be used to evaluate the probable extent of floodplain inundation for each flow alternative. However, data are only available for one riverine site in the Chattahoochee River Basin positioned between Jim Woodruff Lock and Dam and G.W. Andrews Lock and Dam. At unsurveyed locations, known river stages at which floodplain inundations occurs should be used to evaluate the frequency, duration, and timing of floodplain inundation for flow alternatives provided by the Corps (see Table 1 and associated information provided by NWS 2010). At sites without this information, the 2-year recurrence interval discharge to approximate the incipient point of flooding should be used to evaluate the frequency, duration, and timing of floodplain inundation. Because channel alteration (e.g., channel incision) can increase the recurrence interval at which flooding occurs and because we have little information on channel alteration, other data sources should be investigated to aid in the floodplain inundation assessment.

3.4 Reservoir Fisheries Analyses

Sport fisheries are important recreational and economic resources in all of the Federal ACF reservoirs. Important sport fishes in all five reservoirs include largemouth bass and crappie, but each reservoir supports a mix of several additional species, including walleye (Lanier Reservoir only), striped bass, bluegill, redear sunfish, and others. Based on interviews of fisheries managers and researchers in the basin, Ryder et al. (1995) identified the species considered critical in an evaluation of operating alternatives and the relative acceptability of reservoir levels for these species. A Delphi technique was used to obtain expert opinion for select reservoirs on reservoir fish guilds, important seasonal periods for those species, and acceptability ratings for various reservoir levels in the ACF and ACT (Ryder et al. 1995). The Service cooperated with the Corps for the 1998 draft EIS for ACF water allocation to develop a reservoir fisheries performance measure using the findings of Ryder et al. (1996). This information was used to create a reservoir fisheries performance measure by looking at the critical spawning and rearing periods, reservoir elevations during these times, and assigning a greater weight to stable or rising elevations during those time periods. The performance measures were then compared for the various alternatives.

The reservoir fisheries performance measure should be updated with additional information, literature, and/or relevant datasets that have been developed in the past ten years, and used to evaluate the relative impacts of the Corps' alternatives on reservoir sport fisheries. Potential new datasets to be included that have been indentified to date include largemouth bass young-of-year data in West Point Reservoir (Brent Hess, GDNR-WRD, 2010, pers. comm.), as well as black basses and crappie data in relation to reservoir retention times and year-class strength in Walter F. George, West Point, and Bartletts Ferry reservoirs (Mike Maceina, Auburn University, 2010, pers. comm.).

3.5 Riverine Fisheries Analyses

Sport fisheries are also important recreational and economic resources in the riverine portions of the ACF project, especially in the Apalachicola River. Reproduction of many fishes is intricately tied to the floodplain, and alteration of flow regimes can affect reproductive success, year-class strength, growth, condition, and other life-history attributes. Data identified to date will be provided by the FFWCC and the USGS and used to evaluate the relative impacts of the Corps' alternatives on riverine sport fisheries. Specific measures to be evaluated include year-class strength versus acres of inundated floodplain spawning habitat, changes in catch rates of sportfishes in various water years, and changes in relative weight (condition) of sportfishes in various water years.

3.6 Apalachicola Bay Salinity Analyses

If a salinity model is incorporated in the WCM update process, as described in Section 1.8 above, the model output should be incorporated in the FWCA evaluation. A list of data needs should be developed to be produced as a result of these analyses. These data should include the spatial extent and temporal duration of low- and high-salinity conditions among the alternative freshwater inflow scenarios and possibly the percent oyster mortality and oyster growth rates.

3.7 Federally-protected Species Analyses

It is our understanding that the Corps will be conducting certain analyses to evaluate the effects of the various alternatives on federally-protected species. These analyses will be contained in the Corps' Biological Assessment (BA) accompanying the draft EIS. The Service will include these analyses in our FWCA evaluation, assuming they are available for us to do so. The types of analyses that should be evaluated are contained in the "*Analyses for the Effects of the Action*" section of the Service's June 1, 2008, RIOP Biological Opinion (USFWS 2008) and are listed below:

Gulf sturgeon

- Frequency (% of days) of Gulf sturgeon spawning habitat availability (acres of potentially suitable spawning substrate inundated to depths of 8.5 to 17.8 feet) on each day March 1st through May 31st, at the two sites that support spawning;
- Frequency (% of years) of Gulf sturgeon spawning habitat availability (maximum acres of potentially suitable spawning substrate inundated to depths of 8.5 to 17.8 feet for at

least 30 consecutive days each year), March 1st through May 31st, at the two sites that support spawning;
- Daily fall rates with respect to exposure of Gulf sturgeon eggs and larvae;
- Maximum number of consecutive days per year less than 16,000 cfs; and
- Departures from average water temperatures between March 1st to May 31st.

Freshwater mussels
- Lowest daily flow for each year;
- Inter-annual frequency of flows less than 5,000-10,000 cfs;
- Maximum number of days per year with flows less than 5,000 – 10,000 cfs;
- Maximum number of consecutive days less than 5,000 – 10,000 cfs;
- Median number of days per year less than 5,000 – 10,000 cfs;
- Frequency (percent of days) of daily stage changes (ft/day); and
- Frequency (percent of days) of daily stage changes (ft/day) when releases at Woodruff Dam are less than 10,000 cfs.

Floodplain connectivity
- Frequency (% of days) of growing season (April-October) floodplain connectivity (acres) to the main channel using Light et al. (1998);
- Frequency (% of years) of growing season (April-October) floodplain connectivity (acres) to the main channel using Light et al. (1998).

4.0 Recommendations for Additional Coordination

This PAL includes comments from the State wildlife agencies in the basin. As is encouraged under the FWCA, we will continue to coordinate with these agencies, and will coordinate with NOAA Fisheries, as we move forward.

To assist in the development of alternatives and mitigation, we have suggested evaluations and analyses that address flow, water quality, fish passage, climate change, navigation, reservoir and riverine fisheries management, impacts to Eufaula National Wildlife Refuge, Apalachicola Bay resources, as well as the inclusion of a decision support model and adaptive management. Our recommendations for hydrologic modeling include addressing the impacts of increasing consumptive demands and evaluating alternative models to reflect flow extremes and climate change. We have identified analyses to evaluate Corps alternatives with respect to flow, water quality, floodplain connectivity, reservoir and riverine fisheries, Apalachicola Bay resources, and federally-protected species. We anticipate that the next step will be for the Corps and the Service to work together to update the interagency SOW to reflect Corps and Service responsibilities for the evaluations and analyses contained in this PAL. As you know, such a division of labor occurred to produce the prior DEIS and FWCA Report (Corps 1998).

We would like to be involved in the development of alternatives, including the development of environmental flows alternatives. The Service would like to assist in the development of such

alternatives to maximize benefits to ecological resources and to gain a better understanding of the consequences of implementing such alternatives on other authorized project purposes and operational constraints. Once all of the alternatives have been analyzed, we anticipate working with the Corps to identify opportunities for restoration, compensation, and enhancement.

We appreciate the opportunity to participate in the planning stages of your project. We would like to stress the Corps water management is not just about avoiding adverse affects, but also to look at opportunities to restore and improve habitat. If you have any questions, please contact Georgia Ecological Services staff biologists Alice Lawrence or Will Duncan at (706) 613-9493, or Panama City Ecological Services staff biologist Karen Herrington at (850) 769-0552 ext. 250.

Sincerely,

Sandra S. Tucker

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Field Supervisor

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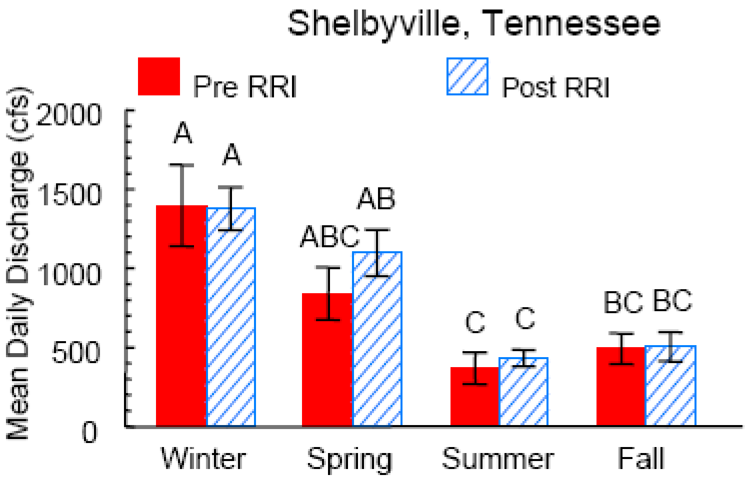
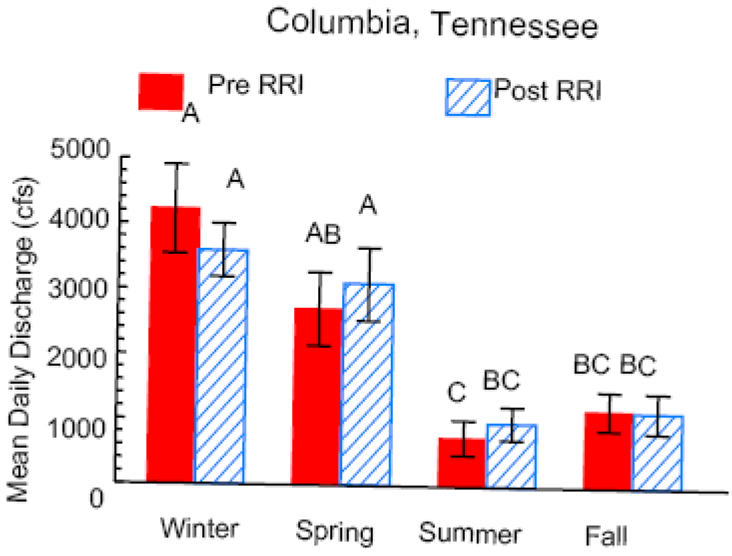
Table 1. Locations and river stages in the Chattahoochee River where the National Weather Service Advanced Hydrologic Prediction Service predicts damage to occur. Discharges were calculated using stage-discharge relationships at USGS streamflow gages. Only damage to manmade structures was considered as damage. Flooding of riverwalks, riverwalk structures, yards, and moving of equipment or livestock to avoid inundation was not considered to be damage.

Location (upstream to downstream order	Stage at which damage occurs	Discharge at which damage occurs
Chattahoochee at Norcross	16	20631
Chattahoochee at Roswell	14	29846
Chattahoochee at Atlanta	18	22023
Chattahoochee at Whitesburg	26	49379
Chattahoochee at West Point	21	62530
Chattahoochee at Columbus	41	261407

Figure 1. Histogram of mean + standard error daily discharge values reported in cubic feet per second (cfs) obtained from river gauges on the Duck River at Shelbyville (top) and Columbia (bottom), Tennessee by season. Means represent daily discharge values for each month for 10 years pre and 10 years post Reservoir Release Discharge Initiative (RRI) completed at Normandy Dam beginning in late 1991. Letters atop standard error bars indicate significantly different means as determined by Tukey's a-posteriori test. Results of analysis of variance (F values and p values) are indicated below each graph. Graphs and figure title taken directly from Alstedht and Johnson 2004, and used with permission from Dr. Paul Johnson.


Shelbyville, Tennessee

F = 8.9 *p* = 0.0001 *df* = 80


Columbia, Tennessee

F = 11.4 *p* = 0.0001 *df* = 80

Figure 2. Comparative mean + s.e. of mussel species (top) and mussel number (bottom) sampled from 17 sites in the Duck River in 1977, 1988, and 2002. Letters atop standard error bars indicate statistically different means determined by Tukey's HSD a-posteriori test. Results of analysis of variance (F values and p values) are indicated below each graph. Graphs and figure title taken directly from Alstedht and Johnson 2004, and used with permission from Dr. Paul Johnson.

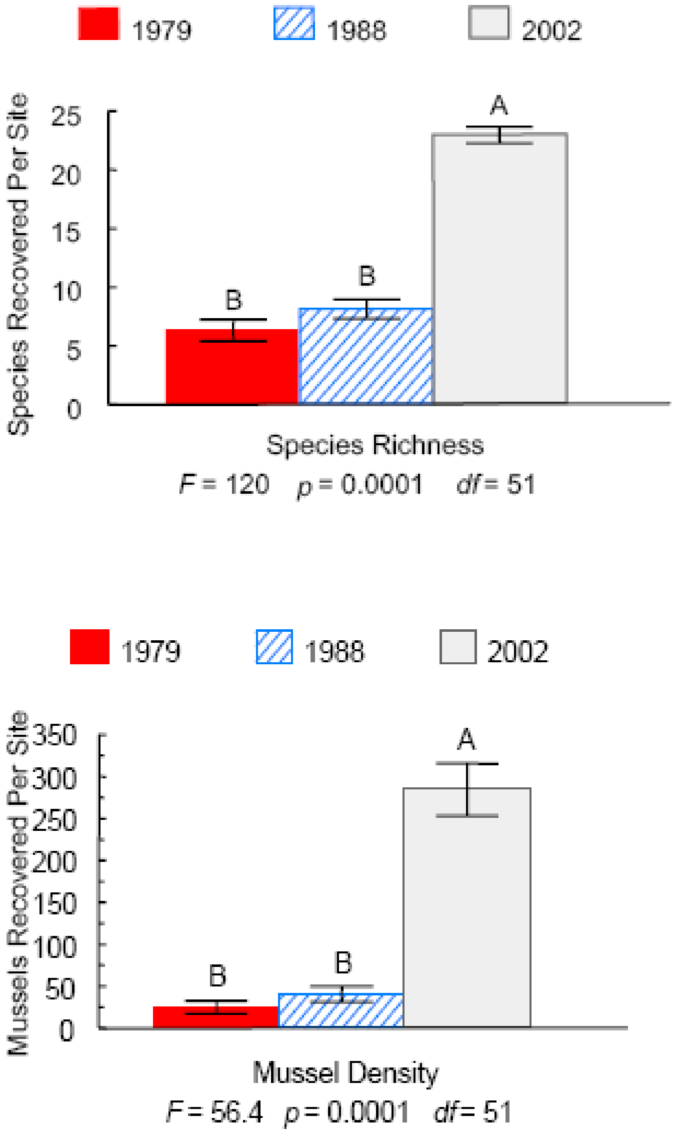
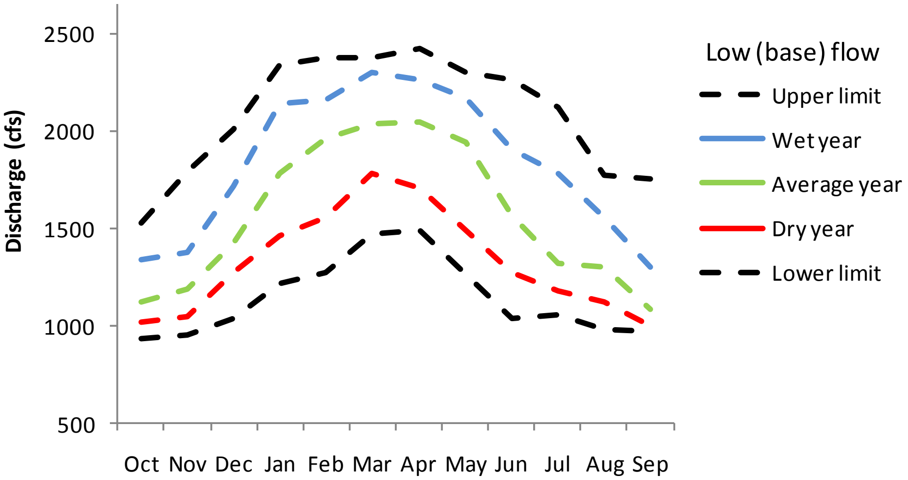


Figure 3. Preliminary a) low (base) flow and b) low and pulse flow guidelines and description for the Chattahoochee River USGS Norcross gage.

a)



b)

Data analyzed: The only pre-Buford dam data that were available for this analysis extended between 1903 and 1946 (44 years) at the Chattahoochee River gage (02335000) at Norcross.

Base flow description

Low (base) flows are defined as all flows that fall below the lower 25th percentile of flows for the pre-Buford dam period at the USGS Norcross gage. The 10th, 25th, 50th, 75th, and 90th percentiles for low flows for each month were then calculated to quantitatively describe the monthly lower and upper base flow limit, and dry, average, and wet year low flow recommendations. Most calculations were derived from Environmental Flow Components in Indicators of Hydrologic Alteration (Version 7-1).

Pulse flow description

High flows were defined as flows that exceeded 75% of the average daily flows for the period of record. Small pulses were defined as all high flows that were lower than the 2-year recurrence interval, and high pulses were defined as high flows that fall between the 2 and 10-year recurrence interval. The 2-year recurrence interval discharge was used as an indication of bankfull discharge because the discharge that corresponds to the incipient point of flooding was unknown. Consequently, small pulses are not expected to exceed bankfull elevation, but high pulses are expected to exceed bankfull elevation and cause floodplain inundation. The recommendations for small and high pulses correspond to the 25th and 75th percentiles of magnitude, frequency, duration, timing, and rise and fall rate values. High pulse recommendations were made only for wet years because more than half of pre-dam years did not contain pulses based on the parameters used to define high pulses in this analysis.

Small pulses

At the Chattahoochee River USGS Norcross gage, 9-18 flow pulses per year should be between 3,658 and 4,980 cfs, should last between 2-3 days, and should occur between mid-March and early June. Rise and fall rates can range between 1,260-2,054 cfs and 1,178-733 cfs, respectively.

High pulses

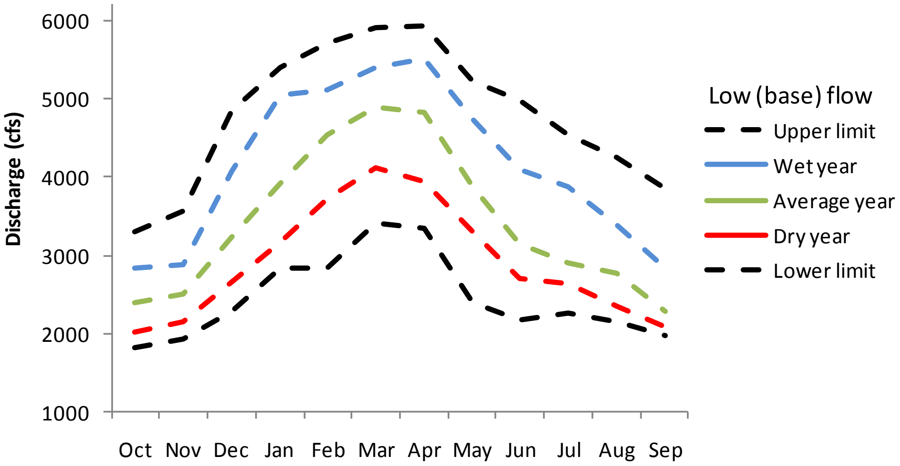
In wet years, a pulse of 17,650-28,080 cfs should last 9-80 days, should occur between early January and early May. Rise rates should range between 697-7518 cfs/day, and fall rates should range between 3376-460 cfs/day.

Non-hydropower peaking window

We recommend that the Corps evaluate the provision of non-hydropower peaking “windows" during critical reproductive and rearing periods for a minimum of 4-6 weeks from March – May.

Figure 4. Preliminary a) low (base) flow and b) low and pulse flow guidelines and description for the Chattahoochee River at the USGS gage below West Point Dam.

a)



b)

Data analyzed: The pre-Buford dam data that were available for this analysis extended between 1896 and 1955 (60 years) at the Chattahoochee River gage (02339500) below West Point Dam.

Base flow description

Low (base) flows are defined as all flows that fall below the lower 25th percentile of flows for the pre-Buford dam period at the USGS West Point gage. The 10th, 25th, 50th, 75th, and 90th percentiles for low flows for each month were then calculated to quantitatively describe the monthly lower and upper base flow limit, and dry, average, and wet year low flow recommendations. Most calculations were derived from Environmental Flow Components in Indicators of Hydrologic Alteration (Version 7-1).

Pulse flow description

High flows were defined as flows that exceeded 75% of the average daily flows for the period of record. Small pulses were defined as all high flows that were lower than the 2-year recurrence interval, and high pulses were defined as high flows that fall between the 2 and 10-year recurrence interval. The 2-year recurrence interval discharge was used as an indication of bankfull discharge because the discharge that corresponds to the incipient point of flooding was unknown. Consequently, small pulses are not expected to exceed bankfull elevation, but high pulses are expected to exceed bankfull elevation and cause floodplain inundation. The recommendations for small and high pulses correspond to the 25th and 75th percentiles of magnitude, frequency, duration, timing, and rise and fall rate values. High pulse recommendations were made only for wet years because more than half of pre-dam years did not contain pulses based on the parameters used to define high pulses in this analysis.

Small Pulses

At the Chattahoochee River gage below West Point, 9-16 flow pulses per year should peak between 8,853 and 11,580 cfs, should last between 3-4 days, and should occur between early March and mid-June. Rise and fall rates can range between 2,483-3,698 cfs/day and 2,256-1,536 cfs/day, respectively.

High Pulses

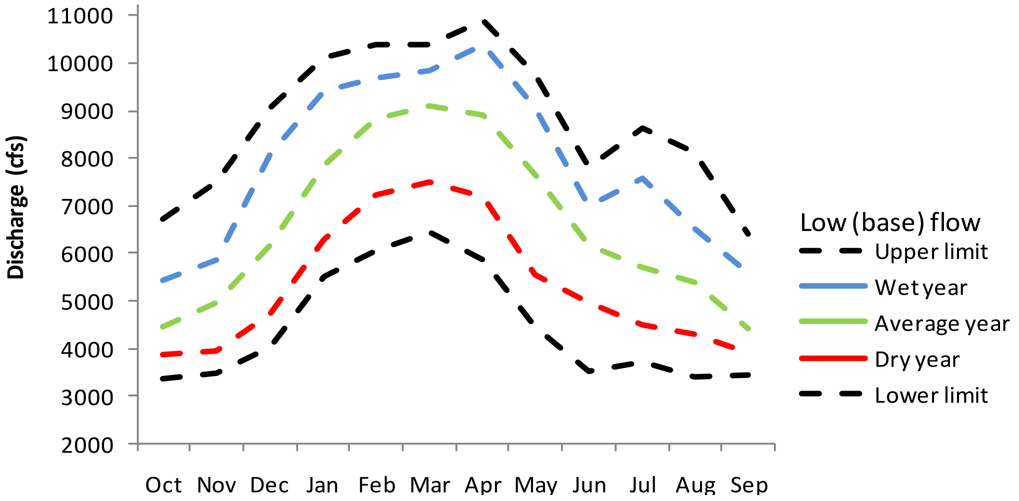
In wet years, a pulse that peaks between 48,830 - 58,950 cfs should last between 19-38 days, and should occur between mid-January and early April. Rise and fall rates can range between 5,563-13,170 cfs/day and 4,230-1787 cfs/day, respectively.

Non-hydropower peaking window

We recommend that the Corps evaluate the provision of non-hydropower peaking “windows" during critical reproductive and rearing periods for a minimum of 4-6 weeks from March – May.

Figure 5. Preliminary a) low (base) flow and b) low and pulse flow guidelines and description for the Chattahoochee River at the Walter F. George Corpsnode.

a)



b)

Data analyzed: ACOE unimpaired flows dataset at the Walter F. George node and inferences from West Point analysis results.

Base flow description

No USGS discharge data for the pre-Buford dam period are available at Walter F. George. However, comparisons between pre-Buford USGS gage data and Corps-modeled "unimpaired flows" data show similar median monthly flows. Thus, we used median monthly flows in the Corps-modeled unimpaired dataset (1936-2006) to calculate the predicted low (base) flows that should occur at the W.F. George node. We excluded 103 negative flow values from the Corps dataset in this analysis.

Low (base) flows are defined as all flows that fall below the lower 25th percentile of flows for the pre-Buford Dam period at the USGS West Point gage. The 10th, 25th, 50th, 75th, and 90th percentiles for low flows for each month were then calculated to quantitatively describe the monthly lower and upper base flow limit, and dry, average, and wet year low flow recommendations. Most calculations were derived from Environmental Flow Components in Indicators of Hydrologic Alteration (Version 7-1).

Pulse flow description

Again, no USGS discharge data for the pre-Buford dam period are available at Walter F. George. Corps-modeled unimpaired flows do not represent the flow extremes (minimum and maximum flow duration, magnitude, timing, frequency, and rate of change) that were observed at USGS gages during the pre-Buford Dam period. Consequently, using the Corps-modeled data to make high pulse recommendations cannot be justified.

Small pulses

We infer from the West Point analysis that used real pre-Buford Dam USGS data, that 9-16 flow pulses per year should peak between 1.8-2.4 times higher than the baseflow river stage (approximately 16,369-21,535 cfs) in March for an average flow year. Pulses should last between 3-4 days, and should occur between early March and mid-June. Rise and fall rates should not exceed rates from other site recommendations.

High pulses

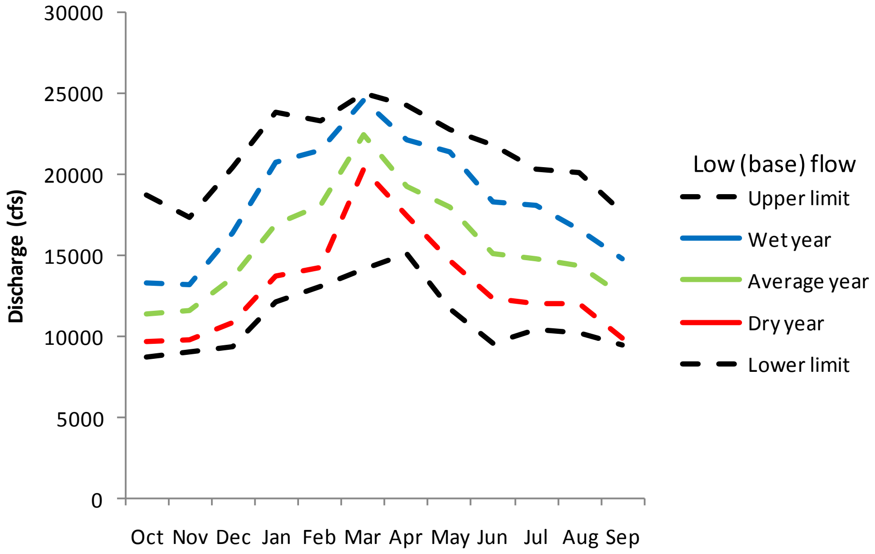
Development of a wet year flow guidelines is complicated by the fact that no stage-discharge relationships are presently known for the river segment between Walter F. George Dam and Woodruff Dam. However, the National Weather Service Advanced Hydrologic Prediction Service indicates that extensive floodplain inundation occurs at a river stage of 150 ft, although no significant damage is predicted to occur up to 160 ft. Consequently, we recommend that the ACOE evaluate wet year releases from Walter F. George that range between 150 and 160 ft. Duration, timing, and rates of change should be similar to the recommendations for West Point Dam.

Non-hydropower peaking window

We recommend that the Corps evaluate the provision of non-hydropower peaking "windows" during critical reproductive and rearing periods for a minimum of 4-6 weeks from March – May.

Figure 6. Preliminary a) low (base) flow and b) low and pulse flow guidelines and description for the Apalachicola River USGS gage at Chattahoochee, FL.

a)



b)

Data analyzed: The pre-Buford dam data that were available for this analysis extended between 1922 and 1955 (34 years) at the Apalachicola River gage (02358000) at Chattahoochee, FL.

Base flow description

Low (base) flows are defined as all flows that fall below the lower 25th percentile of flows for the pre-Buford dam period at the USGS West Point gage. The 10th, 25th, 50th, 75th, and 90th percentiles for low flows for each month were then calculated to quantitatively describe the monthly lower and upper base flow limit, and dry, average, and wet year low flow recommendations. Most calculations were derived from Environmental Flow Components in Indicators of Hydrologic Alteration (Version 7-1).

Pulse flow description

High flows were defined as flows that exceeded 75% of the average daily flows for the period of record. Small pulses were defined as all high flows that were lower than the 2-year recurrence interval, and high pulses were defined as high flows that fall between the 2 and 10-year recurrence interval. The 2-year recurrence interval discharge was used as an indication of bankfull discharge because the discharge that corresponds to the incipient point of flooding was unknown. Consequently, small pulses are not expected to exceed bankfull elevation, but high pulses are expected to exceed bankfull elevation and cause floodplain inundation. The recommendations for small and high pulses correspond to the 25th and 75th percentiles of magnitude, frequency, duration, timing, and rise and fall rate values. High pulse recommendations were made only for wet years because more than half of pre-dam years did not contain pulses based on the parameters used to define high pulses in this analysis.

Small Pulses

At the Apalachicola River gage at Chattahoochee, FL, 3-6 flow pulses per year should peak between 30,950 and 41,110 cfs, should last between 4-13 days, and should occur between mid-February and mid-May. Rise and fall rates can range between 2,493-5,356 cfs/day and 2,353-1,473 cfs/day, respectively.

High Pulses

In wet years, a pulse that peaks between 86,630-122,800 cfs should last between 28-68 days, and should occur between late-February and early April. Rise and fall rates can range between 2,544-8,108 cfs/day and 4,236-2,330 cfs/day, respectively.

Non-hydropower peaking window

We recommend that the Corps evaluate the provision of non-hydropower peaking “windows" during critical reproductive and rearing periods for a minimum of 4-6 weeks from March – May.

Figure 7. Monthly maximum, average, and minimum dissolved oxygen concentrations in the Chattahoochee River at Buford Dam. Data courtesy of Georgia Department of Natural Resources-Wildlife Resources Division.

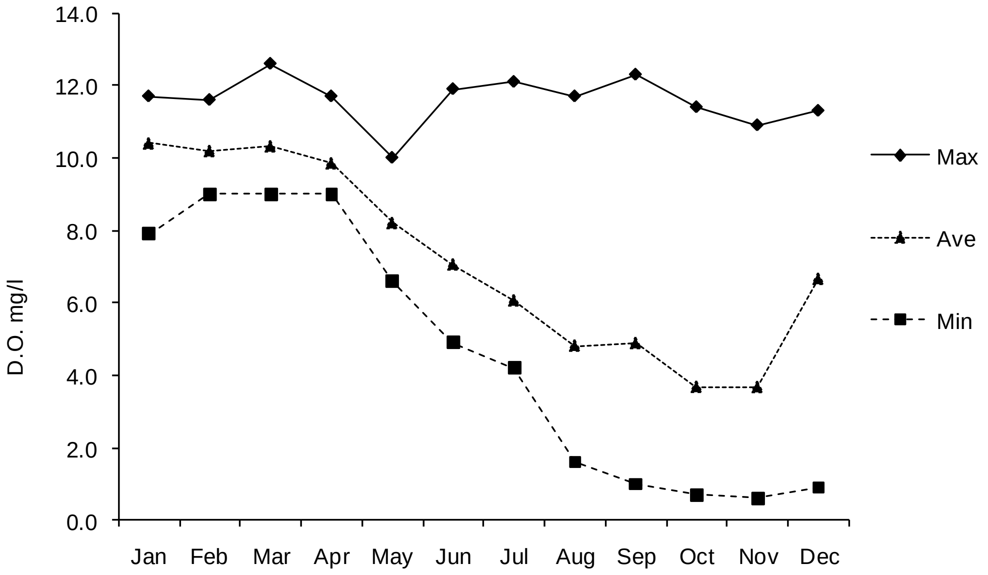
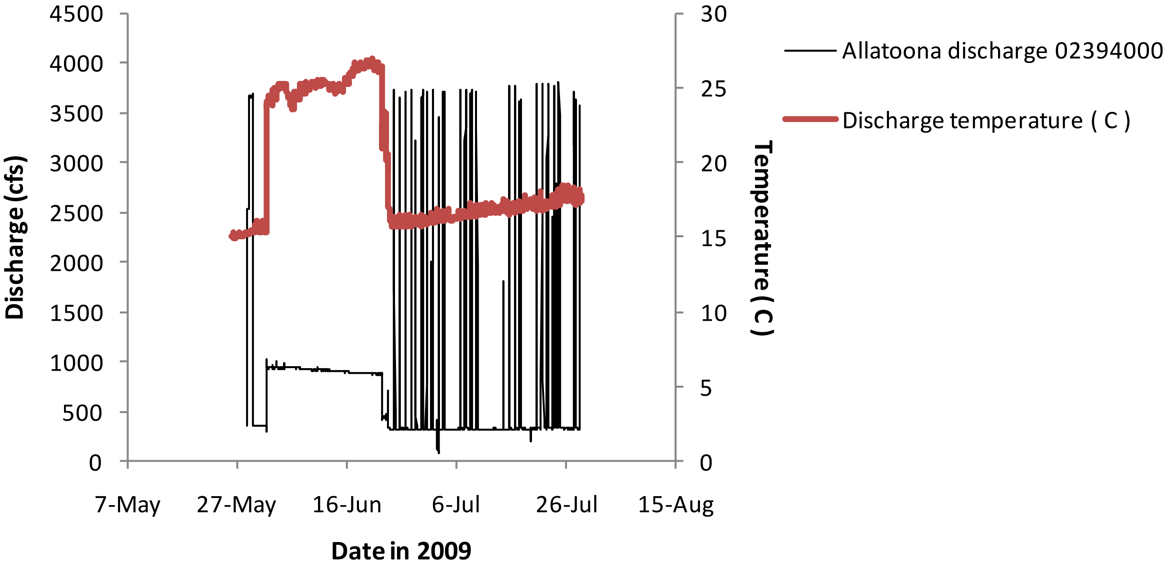


Figure 8. Discharge and water temperature measurements below Allatoona Dam on the Etowah River, Georgia. Sluicing from a location higher in the reservoir's water column occurred in June, causing the observed downriver temperature increases.



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March 1, 2011

Colonel Steven J. Roemhildt
US Army Corps of Engineers, Mobile District
P.O. Box 2288
Mobile, AL 36628-0001

Dear Colonel Roemhildt:

We are providing an Addendum to the U.S. Fish and Wildlife Service (Service)'s April 2, 2010, Planning Aid Letter (PAL) for the proposed Water Control Manual (WCM) Updates for the Apalachicola-Chattahoochee-Flint (ACF) River Basin in Georgia, Alabama, and Florida. The purpose of the WCM Updates is to identify operating criteria and guidelines for managing water storage and release of water from United States Army Corps of Engineers (Corps) reservoirs. In the National Environmental Policy Act (NEPA) review, the Corps will address current operations, proposed changes in water management operations at the reservoir projects within the limits of the existing authorities, as well as potential impacts throughout the basin that would result from implementation of the updated manual.

The purpose of the Service's 2010 PAL was to identify resource values and issues, identify endangered species issues, and propose preliminary changes, mitigation, or enhancement opportunities to facilitate your decision-making as it relates to equal consideration of fish and wildlife resources. Based on recent analyses conducted by the Service, we submit the following addendum under the Fish and Wildlife Coordination Act (FWCA) (48 Stat. 401, as amended; 16 U.S.C. § 661 *et seq*.). This addendum solely addresses ecosystem flow guidelines -- all other information and recommendations in the PAL are still applicable. In the future, we will provide additional information in the form of a draft Fish and Wildlife Coordination Act report. A separate consultation will occur regarding the potential impacts of the Corps' proposal on federally-listed fish and wildlife species protected under the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. § 1531 *et seq*.).

Rationale for revision of ecosystem flow guidelines

The ecosystem flow guidelines that were delivered in the PAL were developed with the aid of Indicators of Hydrologic Alteration (IHA; TNC 2007). Although the IHA methodology is scientifically defensible, subsequent examination of IHA methodology and output revealed several concerns that could affect possible incorporation of the guidelines in the Corps' operations. Therefore, the Service is providing revised low and high flow guidelines (Figures 1-4 and Tables 1-4).

We had two reasons for revising the flow guidelines. First, the default IHA parameters used for the PAL initially separated the flow data into high and low flows using a percentile of the pre-Buford period of record. This method resulted in representation of low-flow discharges in summer-fall months by many values, and representation of low flows in winter-spring months by fewer values. This means that some months in some years were not represented in subsequent analyses. For example, historic low flows in the Apalachicola River remained above the 75th percentile or above flood stage for prolonged time periods, meaning that those periods were not represented in the low flow analysis. Thus, if the historic flow regime is to be used to help guide low flow alternative development, evaluation, and implementation, the low flow analysis should examine the entire range of low flows that occurred in every month of every year before construction of Buford Dam.

Second, the low and high flow analyses in IHA calculate summary statistics using median values (for non-parametric analyses) to represent each year (TNC 2007). For example, IHA calculates the annual median high pulse magnitude, and uses the median values from every year to calculate summary statistics. While this is a statistically valid approach to summarizing large datasets, summarizing multiple intra-annual pulses by a single value results in a narrower range of magnitude, duration, timing, and rate of change values. Because the intent of the analysis is to quantify a range of discharge values that are likely to be beneficial to riverine habitat and fauna and to facilitate planning for high flows in the Corps' operations, we calculated the following high-flow guidelines by including each high flow event in summary statistic calculation (e.g., percentiles representing upper and lower limits, and dry, average, and wet years). With the exception of not using annual medians to calculate percentiles, the revised method for high flow guideline development is analogous to the "non-advanced" method for high flow analysis in IHA.

Low flow analysis methodology

1. In Microsoft Excel, the seven smallest values from each month in every year were extracted for analysis. We chose multiple values to represent each month so that the overall results are less likely to be influenced by an aberrant value (i.e., less likely to be skewed by one value), especially in future analyses that may examine and compare Corps' modeled flow alternatives which are likely to occasionally contain negative discharge values. A comparison of the effects of one, seven, and ten minimum flow values to represent low flows in each month showed little difference in overall low flow hydrograph shape, similar flow magnitudes throughout the year, and minor differences in winter 90th percentile flow magnitudes. These results also generally correspond to the Web-based Hydrograph Analysis Tool (WHAT Local Minimum Method; Lim et al. 2005) output for baseflow generation. Collectively, these results lend greater support for the decision to use the seven lowest values to characterize low flows.

2. The 10th, 25th, 50th, 75th, and 90th percentiles for each month were calculated on the extracted data to define the lower limit, dry year, average year, wet year, and upper limit, respectively.

3. The Walter F. George low flow guidelines were calculated slightly differently. A long-term period of pre-Buford Dam discharge data was not available below Walter F. George. As a proxy

for actual data, the Corps' unimpaired flows dataset was used. As referenced in the PAL, the unimpaired flows datasets do not accurately represent the magnitude, duration, timing, and rate of change of flow extremes (p. 14 in April 2, 2010 PAL). Thus, these low flow guidelines should be treated as estimates.

4. Note that in this low flow analysis, in cases where an entire month is above flood stage, the lowest values are flood-related values. A strength of the low flow analysis is that the user can characterize the entire range of the lower flows that occur in every month of the user's flow dataset.

High flow analysis methodology

1. In Microsoft Excel, the 75th percentile of all flows in the time series was used as the flow threshold to separate high flows from the remainder of the flow dataset. Because this is consistent with our understanding of the meteorological conditions that should cause pulses to occur, the 75th percentile is a valid threshold to separate low and high flows.

2. The following parameters were then calculated: The duration of each high flow event, the maximum discharge in each sequence of high flows, the date of the initial high flow value, the rise rate (calculated as the difference between the preceding low flow value to the maximum flow divided by the number of time steps (n-1)), and the fall rate (calculated as the difference between the maximum flow and the following low flow value, divided by the number of time steps (n-1)).

3. The 2-year and 10-year recurrence interval discharges were calculated using the following methodology: Maximum discharge was calculated for every year, and the 50th and 90th percentiles in Excel were used to calculate approximations of the 2- and 10-year recurrence intervals, respectively. This is a close approximation to the IHA method, but not as sophisticated as the USGS PeakFQ calculation (Flynn et al. 2006). Nevertheless, these percentiles provide close approximations of these recurrence interval discharges. Although bankfull discharge in the Coastal Plain physiographic province tends to occur more frequently than every two years, we used an approximate 2-year recurrence interval basinwide as a consistent guide.

4. The 2-year and 10-year recurrence interval discharges were used to further separate high flows into small pulses, high pulses, and floods (note: these are the default values used in IHA to separate high flow data). Maximum high flow values between the 75th percentile and the 2-year recurrence interval were classified as small pulses (analogous to High Pulses in IHA). Values between the 2- and 10-year recurrence interval were classified as high pulses (analogous to small floods in IHA), and values greater than the 10-year recurrence interval were classified as floods. With the exception of the Apalachicola River analysis, floods greater than the 10-year recurrence interval were excluded from this letter because they exceed the discharge stages that are predicted to cause damage according to the National Weather Service Advanced Hydrologic Prediction Service (Table 1 in April 2, 2010 PAL).

5. The range of discharge values that were used to define small and high pulses are presented in the tables. Similar to the PAL, we also provide the 25th and 75th percentiles of the magnitudes, frequencies, durations, rise rates, and fall rates which were calculated separately for small pulses,

high pulses, and floods. These values correspond to the high flow guidelines presented in Tables 1-4. Timing values were visually estimated from histograms of pulse or flood occurrence by month.

6. The Walter F. George high flow guidelines were calculated slightly differently. As referenced in the PAL, the unimpaired flows datasets do not accurately represent the magnitude, duration, timing, and rate of change of flow extremes (p. 14 in April 2, 2010 PAL). Consequently, using the Corps-modeled data to make high pulse recommendations cannot be justified. Thus, high pulse frequency, duration, timing, and rate of change calculations were used from the West Point analysis. To calculate magnitudes, however, the West Point analysis indicated that pulses should peak 1.6-3.5 times higher than the low flow river discharge in March [7,720-16,500 cubic feet per second (cfs)]. Assuming that pulses at Walter F. George should also peak 1.6-3.5 times higher than March low flow (derived from the Corps' unimpaired flows model output), small pulses below Walter F. George should peak between 14,161-30,978 cfs.

Figure 1. Low flow guidelines for the Chattahoochee River near Norcross, GA (USGS 02335000).

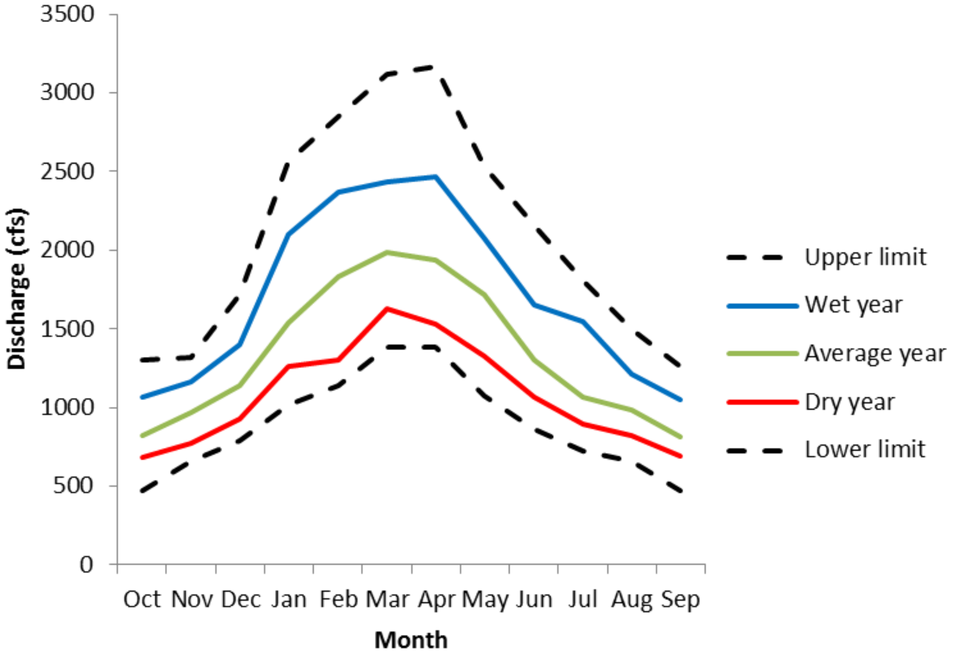

Figure 2. Low flow guidelines for the Chattahoochee River at West Point, GA (USGS 02339500).

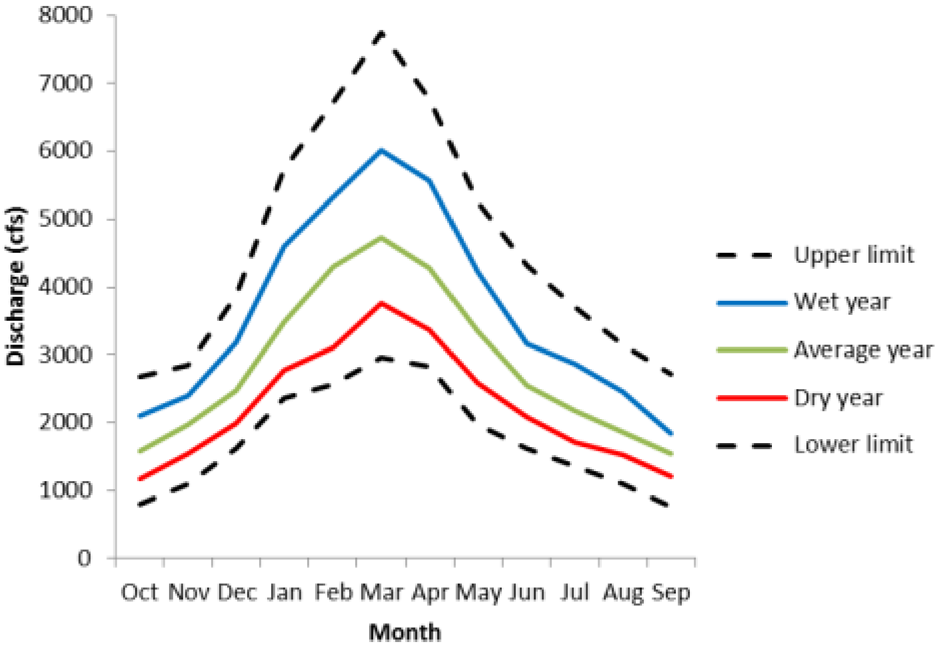

Figure 3. Low flow guidelines for the Chattahoochee River at Walter F. George using the Corps' unimpaired flows dataset.

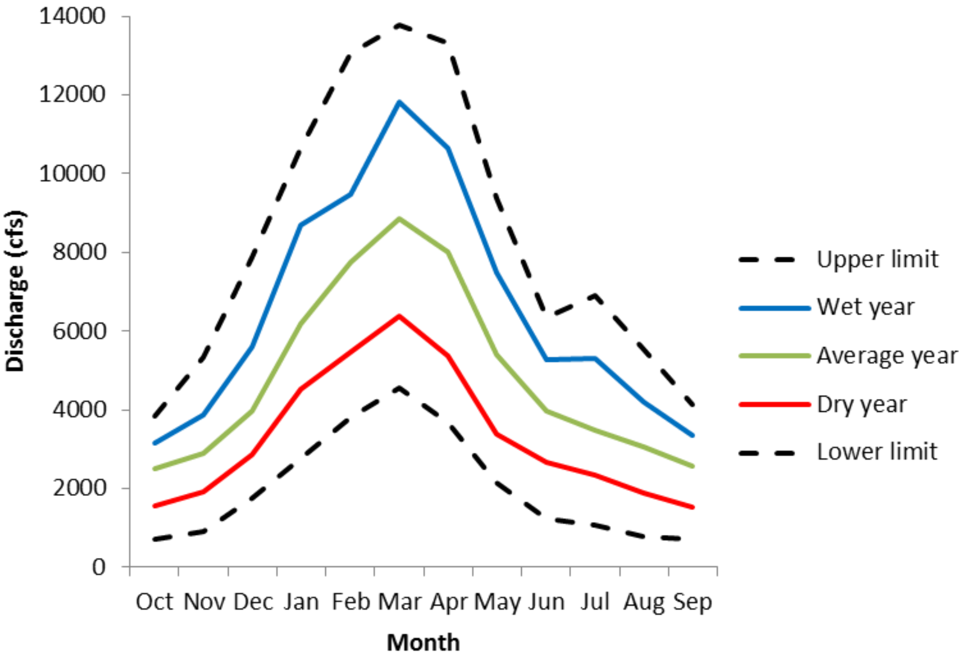

Figure 4. Low flow guidelines for the Apalachicola River at Chattahoochee, FL (USGS 02358000).

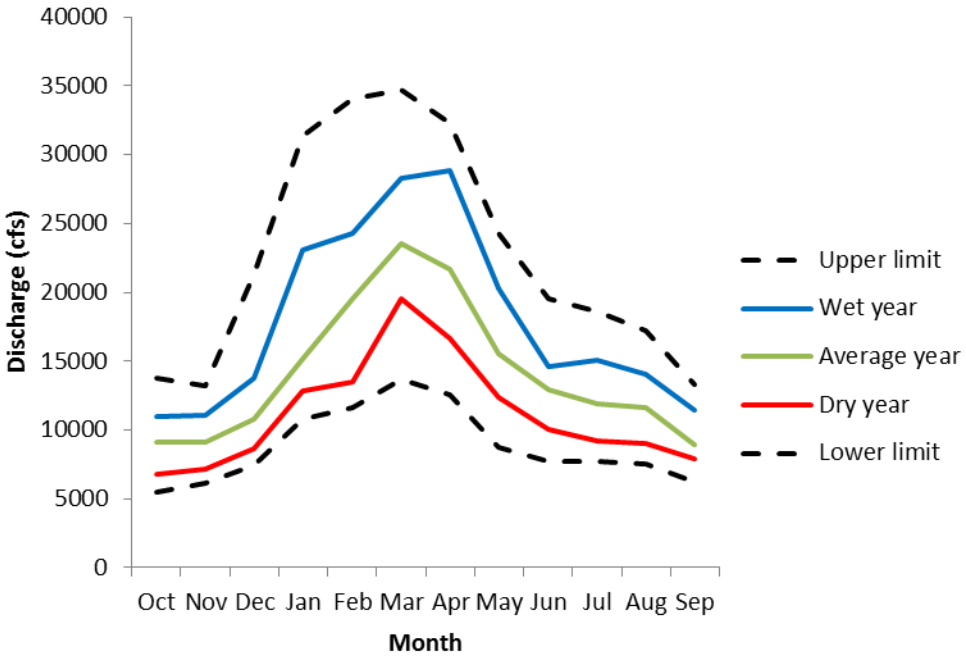

Table 1. High flow guidelines for the Chattahoochee River near Norcross, GA developed from USGS gage 02335000 for the pre-Buford Dam period from January 1, 1903 to September 30, 1946.

	Small pulse	High Pulse
Range used (cfs)	2550-17249	17250-33549
Magnitude (cfs)	3105-6787.5	19000-28900
Frequency (# events/year)	9-18	0-1
Duration (days)	1-5	11-72
Rise Rate (cfs/day)	770-2775	927-7830
Fall Rate (cfs/day)	507-1452	459-2193
Timing	Oct-Sep	Dec- Mar

Table 2. High flow guidelines for the Chattahoochee River near West Point Dam developed from USGS gage 02339500 for the pre-Buford Dam period from August 1, 1896 to December 31, 1955.

	Small pulse	High Pulse
Range used (cfs)	6250-45649	45650-71079
Magnitude (cfs)	7720-16500	51150-60825
Frequency (# events/year)	10-15	0-1
Duration (days)	2-6	17-39
Rise Rate (cfs/day)	1605-5118	5336-12509
Fall Rate (cfs/day)	1092-2850	1622-4472
Timing	Oct-Sep	Dec- Mar

Table 3. High flow guidelines for the Chattahoochee River at Walter F. George Dam developed from low flow analysis on the Corps' unimpaired flow dataset, and inferences from Chattahoochee River at West Point Dam high flow analysis. See text for additional details.

	Small pulse	High Pulse
Range used (cfs)	N/A	N/A
Magnitude (cfs)	14,161-30,978	95598-114187
Frequency (# events/year)	10-15	0-1
Duration (days)	2-6	17-39
Rise Rate (cfs/day)	1605-5118	5336-12509
Fall Rate (cfs/day)	1092-2850	1622-4472
Timing	Oct-Sep	Dec- Mar

*Upper range of high pulse values may need to be reevaluated to ensure that damage to structures is avoided. The stage discharge relationship (used to ensure that guidelines do not cause damage) was calculated using available data between 79 ft (6,510 cfs) and 110 ft (90,200 cfs; USGS gage 02343805), meaning that discharge calculations above this range of values are extrapolations and should be used cautiously.

Table 4. High flow guidelines for the Apalachicola River near Chattahoochee, FL developed from USGS gage 02358000 for the pre-Buford Dam period from July 1, 1922 to December 31, 1955.

	Small pulse	High Pulse	Flood
Range used (cfs)	25800-73799	73800-150499	≥ 150500
Magnitude (cfs)	28600-43475	85650-116500	201500-268500
Frequency (# events/year)	3-6	0-1	≥ 10 year RI
Duration (days)	3-15	32.5-68.5	49.5-89.5
Rise Rate (cfs/day)	2166-5606	2763-8056	7650-8761
Fall Rate (cfs/day)	1250-2615	1916-3811	4527-5795
Timing	Dec-Sep	Jan-Mar	Jan-Apr

Thank you for your January 18, 2011, response to the Service's PAL-requested analyses. We are currently reviewing the information that you provided, but recommend using ecosystem flow guidelines as calculated in the manner outlined above. As we continue to review the information you have produced, additional addendums or information requests may be supplied by the Service. We appreciate the opportunity to participate in the planning stages of your project and look forward to exploring opportunities to restore and improve habitat. If you have any questions, please contact Georgia Ecological Services staff biologists Will Duncan or Alice Lawrence at (706) 613-9493, or Panama City Ecological Services staff biologist Karen Herrington at (850) 769-0552 ext. 250.

Sincerely,

Sandra S. Tucker

Sandra S. Tucker
Field Supervisor

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May 23, 2011

Ms. Alice P. Lawrence
Fish and Wildlife Biologist
United States Fish and Wildlife Service
105 Westpark Drive, Suite D
Athens, Georgia 30606

RE: Florida Fish and Wildlife Conservation Commission's Comments on Draft Fish and Wildlife Coordination Act Report.

Dear Ms. Lawrence;

The State of Florida, through its Fish and Wildlife Conservation Commission ("Commission") submits the following comments on the *Draft Fish and Wildlife Coordination Act Report on the Water Control Manual Updates for the Apalachicola-Chattahoochee-Flint River Basin in Georgia, Alabama and Florida* ("Draft Report") shared with us on May 9, 2011. We previously provided comments on your April 2010 Planning Aid Letter ("PAL"), and supplied additional information relevant to the Draft Report in our paper entitled *The Impact of Reduced Flows on the Apalachicola River and Bay Ecosystem* (February 2011). We have since reviewed (but were not afforded an opportunity to comment on) your March 2011 PAL Addendum. Florida commends the Service for identifying a number of key concerns shared by the Commission and agrees with the Service's general assessment that the Corps of Engineers' proposed alternatives, as reflected in the Corps' January 2011 response to the PAL ("PAL Response"), are unacceptable.

We wish to underscore the importance of consistent, transparent communication among the Corps, the Service and the Commission. As you correctly note, the Fish and Wildlife Coordination Act ("FWCA"), 16 U.S.C. §§ 661 *et seq.*, requires the Corps to consult with the Service <u>and</u> the Commission, Draft Report at 35, but such coordination has not occurred. The Corps has, in fact, refused to coordinate directly with the Commission, instead directing us to funnel our input through the Service. This is not consistent with the Corps' obligations and hinders our ability to conduct our analyses. For instance, the Service apparently has had the PAL Response since January 2011, but was only authorized by the Corps to share it with the Commission in April 2011. We are now forced to comment on the Draft Report in less than three weeks. Better coordination is required.

Nevertheless, we offer the following comments on the Draft Report and, as appropriate, the PAL Response. We trust the Service will continue to convey Florida's concerns in its discussions with the Corps.

The No Action/Baseline alternative is not acceptable.

The No Action/Baseline Alternative is a continuation of existing operations dictated in large measure by the 1989 Draft Water Control Plan ("DWCP") as modified by a series of *ad hoc* operational protocols. As a preliminary matter, it is important to note that this set of operations has never been subjected to FWCA analysis and has similarly eluded consultation requirements imposed by Section 7 of the Endangered Species Act ("ESA"), 16 U.S.C. §§ 1531 *et seq.* It is imperative that the No Action/Baseline Alternative be scrutinized meaningfully and not accepted merely because it constitutes a continuation of the *status quo*.

To that end, threatened and endangered species conservation is compromised by the arbitrary storage thresholds described on pages 1-9 to 1-11 of the PAL Response. These "Actions Zones" reflect interim operational practices implemented through the Revised Interim Operating Plan. Continued adherence to the Action Zones precludes the Corps from using the full conservation storage capacity for all the purposes authorized by Congress when the lakes were constructed, and thereafter. That water should be made available to bring flows more in keeping with the Service's Environmental Flow Guidelines ("Guidelines") as identified in the PAL and PAL Addendum.

For example, year-2000 flow and lake storage hydrographs (Slides 2-7) show that when Apalachicola River flows were 2,000-3,000 cfs lower than the lower limit Guidelines and 5,000-6,000 cfs lower than the dry-year Guidelines, the lakes were still holding 800,000-1,200,000 acre feet of conservation storage plus an additional 1,856,000 acre feet of inactive storage. Existing operations model run (Baseline-0) shows that during the lowest lake levels reached in the entire period (2007), the lakes still held more than 500,000 acre feet of conservation storage plus the inactive storage.

The full storage capacity of these Federal projects is not being used as Congress intended. The balance being struck by the Corps is unreasonable, as threatened and endangered species conservation is being undermined to support, among other things, recreation and sport fishing under present Corps protocols.

For example, Florida has long expressed concerns with the Standard Operating Procedure ("SOP") governing reservoir fish spawning. The SOP deprives the Apalachicola River and its threatened and endangered species of water during the critical spawning period ostensibly for the protection of sport fish spawning in the reservoirs. Yet, there is no credible evidence that a one-foot drop in lake levels has a significant impact on year-class strength in reservoirs. In contrast, we have documented a direct correlation between year-class strength and river flow in the Apalachicola. The water withheld upstream to support sport fish spawning would make a tremendous difference in providing a longer duration of floodplain inundation in April and May to support spawning (including Gulf sturgeon and host fish for threatened and endangered mussel species) in the Apalachicola River.

Finally, analyzing the No Action/Baseline alternative (and all others), the Corps assumes that maximum upstream consumption will occur at all times. This assumption is incorrect, as consumptive use changes seasonally and in response to climatic variation. Some account should be made for this variation in all analyses.

The "Action" Alternatives are not acceptable.

The incremental differences among the No Action/Baseline alternative and the action alternatives is meaningless. These alternatives are so similar in nature, and their effects so indistinguishable, that they would not survive the most basic NEPA challenge. *See, e.g., Muckleshoot Indian Tribe v. U.S. Forest Service*, 177 F.3d 800 (9th Cir. 1999) (holding unlawful NEPA analysis that considered only no action and two virtually identical action alternatives). In fact, the proposed alternatives are little more than a gloss on the No Action/Baseline alternative.

The proposed action alternatives will actually be *worse* for threatened and endangered mussel species due to the increase in storage (and corresponding decrease in flow) caused by raising the Action Zones. While we understand that the final operating criteria chosen will be subject to ESA Section 7 consultation, we agree with the Service that the proposed changes in the reservoir Action Zones, drought protocols, and ramping rates would result in freshwater mussels being subjected to low flows for a greater duration than previously experienced. This is unacceptable, particularly given the repeated culling of mussel populations experienced over the last 5 years. For this reason, we suggest all efforts be made to maintain flows above 6,000 cfs at all times.

Moreover, the proposed action alternatives do not include a true conservation alternative designed to serve the needs of fish and wildlife and related habitats in the Apalachicola River Basin. Rather, all the alternatives are merely variations on a theme of perpetuating existing operations. As you correctly point out, fish and wildlife is a co-equal purpose under the FWCA. Draft Report at 1. The Corps does not acknowledge this, and each of the proposed action alternatives renders fish and wildlife subservient to all other uses.

In its PAL Response, the Corps completely dismisses the notion of developing an operating protocol based on replicating a more natural hydrograph that reflects the importance of the Guidelines. The Commission disagrees that such a protocol is too difficult to justify analysis. That said, the difficulty associated with developing an alternative that actually complies with the FWCA and ESA is irrelevant. The Corps is legally obligated to evaluate at least one alternative that recognizes the co-equal priority of fish and wildlife (and related habitat) maintenance.

The Guidelines (modified as per the Commission's suggestions herein) should be the foundatiou of all analyses of the Corps operations.

We generally support the Service's Guidelines and concur that these guidelines (as modified below) should be used as the yardstick against which to measure the relative "success" or "failure" of any alternative's ability to meet the needs of fish and wildlife in the Basin. Flow guidelines based on pre-dam flows need to be added to all graphs related to fish and wildlife resources, and incorporated into all levels of analysis and decision-making. To accomplish this, we have the following suggestions.

The Guidelines are calculated using only the lowest 7 days in each month, which makes it difficult to directly compare other flow data and constrains the applicable guideline to a single number for each month. To make "apples-to-apples" comparisons, one must convert all other flow data to the lowest 7 days per month before comparing them to the Guidelines, which is unnecessarily complex and prevents the Guidelines from being used in all analyses as intended. For hydrograph-type analyses, the Commission proposes a slightly modified flow guideline that is calculated from <u>all the data</u>, such as the 90% exceedance hydrograph shown on Slide 1. Other daily exceedance hydrographs, such as 75% (blue line, Slide 13), could also be used. An additional benefit of using daily exceedance hydrographs is that they better match conditions in April and May, which typically have much higher flows at the beginning of the month than at the end.

More importantly, however, none of the analyses in Section 2.7 of the PAL Response include pre-dam "guideline" data. Because the Corps did not use hydrographs, neither the Guidelines nor the Commission's exceedance hydrograph alternative can be adapted and added to the Corps' graphs. We recommend that daily pre-dam flow data be used directly to serve as an ecosystem flow guideline in every case regardless of the type of statistic or graphical display used in the evaluation. We provide an example of this in the frequency curves on Slides 9-11 and 17-19, which have a pre-dam "guideline" shown in blue on every graph. Similarly, pre-dam "guideline" flow data should be added to all of the graphs in Section 2.7 of the PAL Response, which display various frequency and "number of days per year" analyses. Calculating various statistics with the pre-dam flow data it is a much more flexible approach that allows an ecosystem guideline to be added to every graph.

Finally, the Corps continues to employ the misguided Run of River ("RoR") rubric in numerous graphs in the PAL Response. All RoR flow data should be removed because it is not an appropriate basis for analyses or decisions related to ecosystem protection. River-floodplain biota has never experienced natural conditions remotely resembling those of the RoR flow regime. Minimum flow in the RoR regime is 34 cfs. Furthermore, RoR flow in late summer and early fall of 2007 averaged 2,700 cfs for a continuous duration of 2.5 months, which represents conditions that riverine biota could not survive. In all graphs related to fish and wildlife resources or ecosystem protection, the RoR rubric should be removed and replaced with an ecosystem guideline based on pre-dam flows (as described in our suggestions above).

Floodplain Inundation Analyses are inappropriate.

Analysis of frequency in percent of years of the annual maximum of 30-day minimum acres of inundated floodplain is not useful and should be replaced with hydrographs similar to Slides 21 and 22. Hydrographs provide a more useful tool than frequency curves for assessing critical flows throughout the entire year, as the Service notes on pages 8-9 of the Draft Report. Because duration and timing of seasonal flow and habitat requirements vary for each species, hydrographs showing the full year are the preferred method for either describing long-term summaries of flow (Slides 13-14) or area data (Slides 21-22), or for focusing on selected individual dry years (Slides 3-5). Hydrographs allow analysis of sturgeon and other fish spawning conditions in the spring, mussel habitat conditions in the summer, and a variety of other biological requirements using the same graph.

In addition, the PAL Response (2-73) contains an erroneous assumption regarding floodplain connectivity. The Corps indicates floodplain inundation in the Apalachicola River does not occur until flows reach 100,000 cfs. However, the approximate flows at which significant floodplain inundation begins in each reach can be estimated from the breaks in the curves in Figure 27B of Light et al., 1998, as follows:

Upper Reach – 28,000-29,000 cfs
Middle Reach – 13,000-14,000 cfs
Nontidal Lower Reach – 13,000-14,000 cfs

It appears the Corps incorrectly assumed that the floodplain is not inundated until river levels exceed top of bank elevations in the upper reach. This assumption is incorrect for two reasons: First, the greatest proportion of floodplain area in the Apalachicola River is in the middle and lower reach where top of bank elevations are much lower (relative to river levels) than in the upper reach. Second, during rising river flow, movement of river water into the floodplain through numerous breaks in the levee at stream and slough mouths allows almost unimpeded connections between the river and floodplain in all reaches. Thus nearly all of the floodplain forest becomes inundated long before the top of bank elevations are overtopped.

Analyses of Bay species should be augmented.

Juvenile Gulf sturgeon analyses are scant. There should be additional analyses of the impact of proposed and existing operations on juvenile sturgeon in the Bay. While we agree generally with the conclusions contained in the Bay section of the Draft Report, we encourage the Service to provide additional details about potential impacts to estuarine sentinel species (e.g., Eastern oysters, *Crassostrea virginica* or White shrimp, *Litopenaeus setiferus*).

Floodplain Inundation Stage Discharge Analyses are inadequate

We disagree with the following statements on Page 25 of Draft Report: *"The Corps provided the Service with pertinent Apalachicola River floodplain inundation stage-discharge analyses in their response to the PAL. This has been adequately addressed and is no longer a conservation measure."* The analyses conducted were inadequate and should be revised to include comparisons to ecosystem guidelines in every graph, hydrographs showing seasonality and duration of flows and inundated area throughout the year, and expanded views of frequency curve data at the low-flow end. We have provided some examples of each in the attached slides.

In addition, for your information, LIDAR data are now available for the entire Apalachicola River and should be used for more accurate future analysis.

Adaptive Management only works if operations are modified as necessary.

The Draft Report contains a recommendation to implement Adaptive Management. Fundamentally, this concept is about taking action to improve progress toward desired outcomes. The key to successful adaptive management, therefore, is to modify operations that are shown, through monitoring, to be detrimental to species. While the Commission appreciates the Service's recommendation to incorporate adaptive management principles into the Water Control Planning process, the Corps has not shown a willingness to modify its behavior in response to monitoring data that show negative impacts on species.

For adaptive management to succeed, clear objectives (e.g., restoration of a viable reproductive mussel population in Swift Slough) must be identified. Sound monitoring techniques must be employed, and the data reviewed regularly to ascertain whether the goals are being met. Finally, specific response alternatives should be identified in the event the stated goals are not being met. Each of these three elements is a necessary component of any adaptive management program.

Climate Change Analysis

One of the impacts of climate change is an anticipated rise in sea levels. The Draft Report should address the minimum flows needed to mitigate the impacts of salt water incursion due to sea level rise.

Fish Passage

We agree that the Corps should look at fish passage operations for anadromous fish species, such as the Alabama shad, as part of the Water Control Manual update.

We thank you for the opportunity to comment and your attention to this matter. Again we hope for improved coordination in the future.

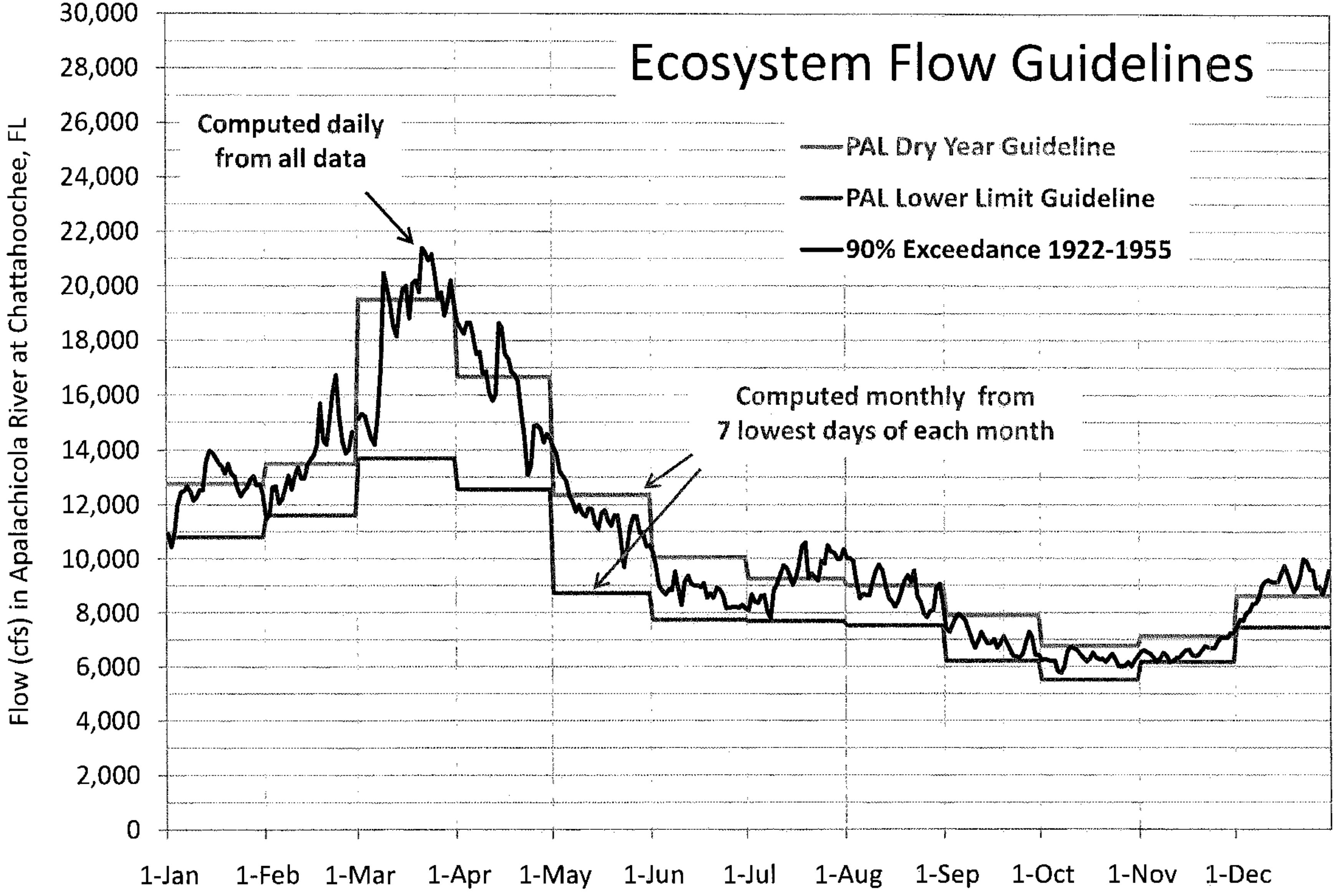
Respectfully,

Harold G. Vielhauer
General Counsel

cc: Mr. Don Imm
USFWS-Panama City Field Office

Ms. Sandy Tucker
US Fish and Wildlife Service

Encl.

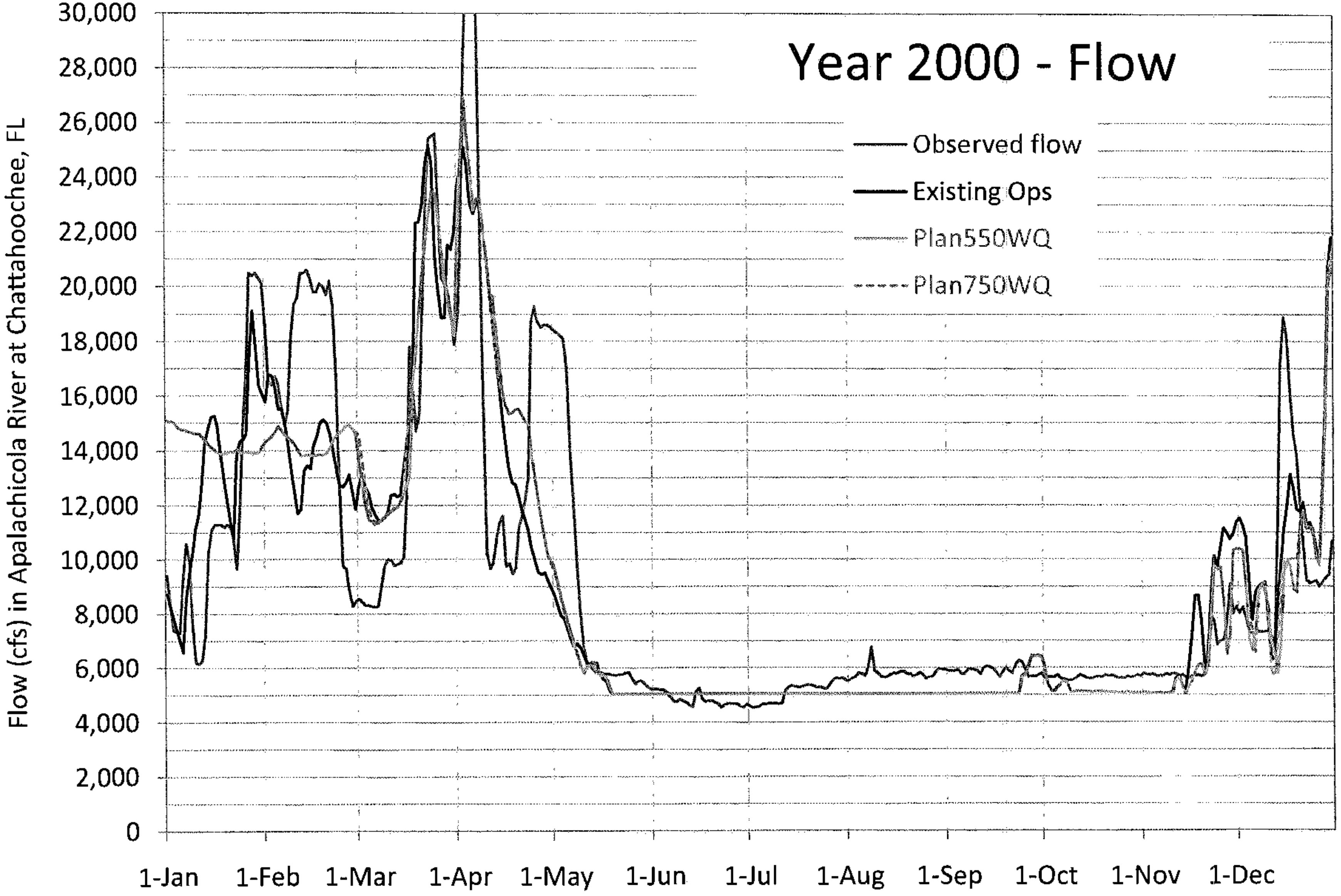

Ecosystem Flow Guidelines
Computed daily from all data
PAL Dry Year Guideline
PAL Lower Limit Guideline
90% Exceedance 1922-1955
Computed monthly from 7 lowest days of each month
Flow (cfs) in Apalachicola River at Chattahoochee, FL
30,000
28,000
26,000
24,000
22,000
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec

Flows Vs Lake Storage

At times when Ecosystem Flow Guidelines are ***not*** *met, what is the Total Composite Storage (TCS) in the Federal Reservoirs?*

Year 2000 is provided in the following example.

Data source: 8-20-2011 Corps model output


Year 2000 - Flow
Observed flow
Existing Ops
Plan550WQ
Plan750WQ
Flow (cfs) in Apalachicola River at Chattahoochee, FL
30,000
28,000
26,000
24,000
22,000
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1-Jan
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1-Apr
1-May
1-Jun
1-Jul
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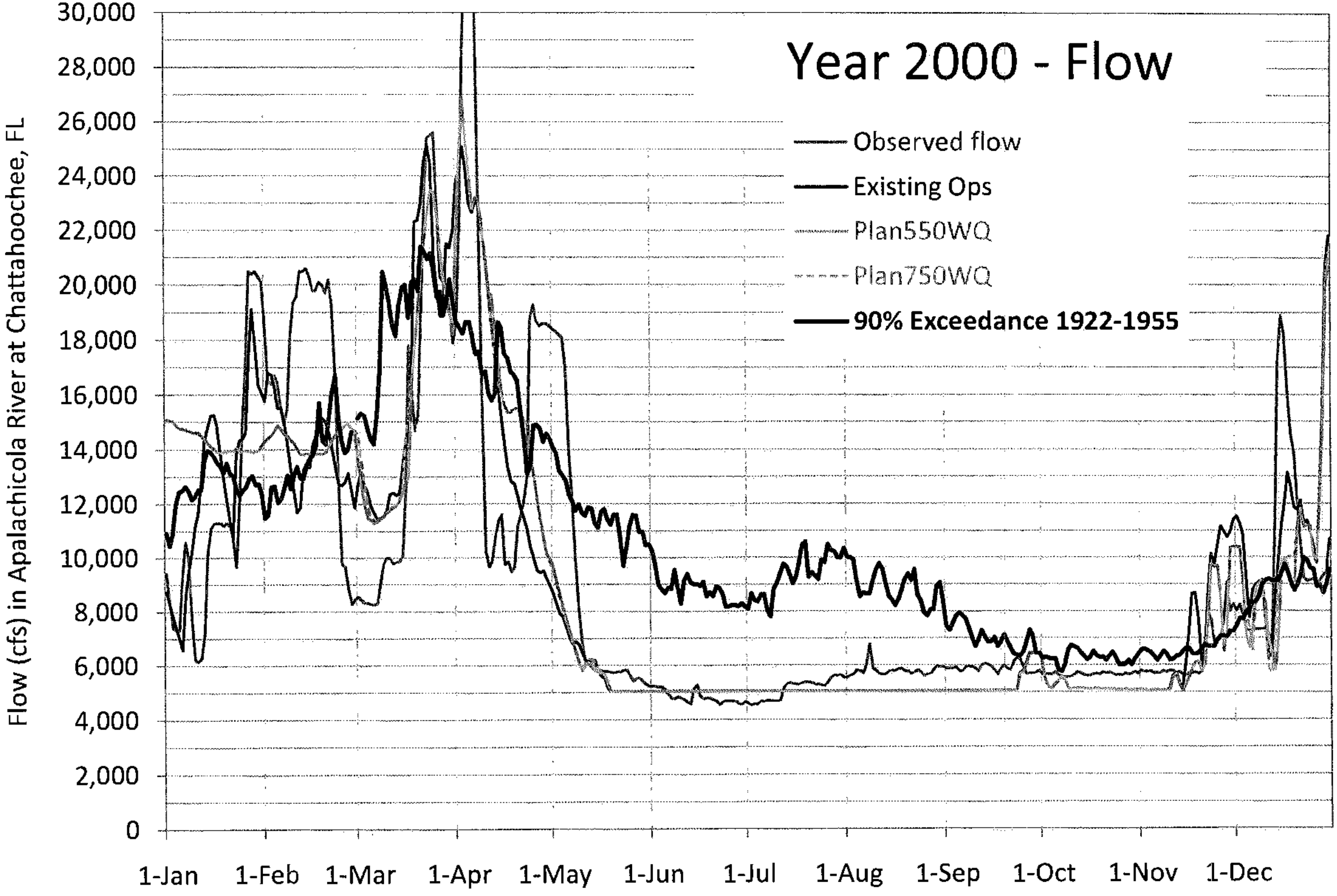
1-Nov
1-Dec


Year 2000 - Flow
Observed flow
Existing Ops
Plan550WQ
Plan750WQ
90% Exceedance 1922-1955
Flow (cfs) in Apalachicola River at Chattahoochee, FL
30,000
28,000
26,000
24,000
22,000
20,000
18,000
16,000
14,000
12,000
10,000
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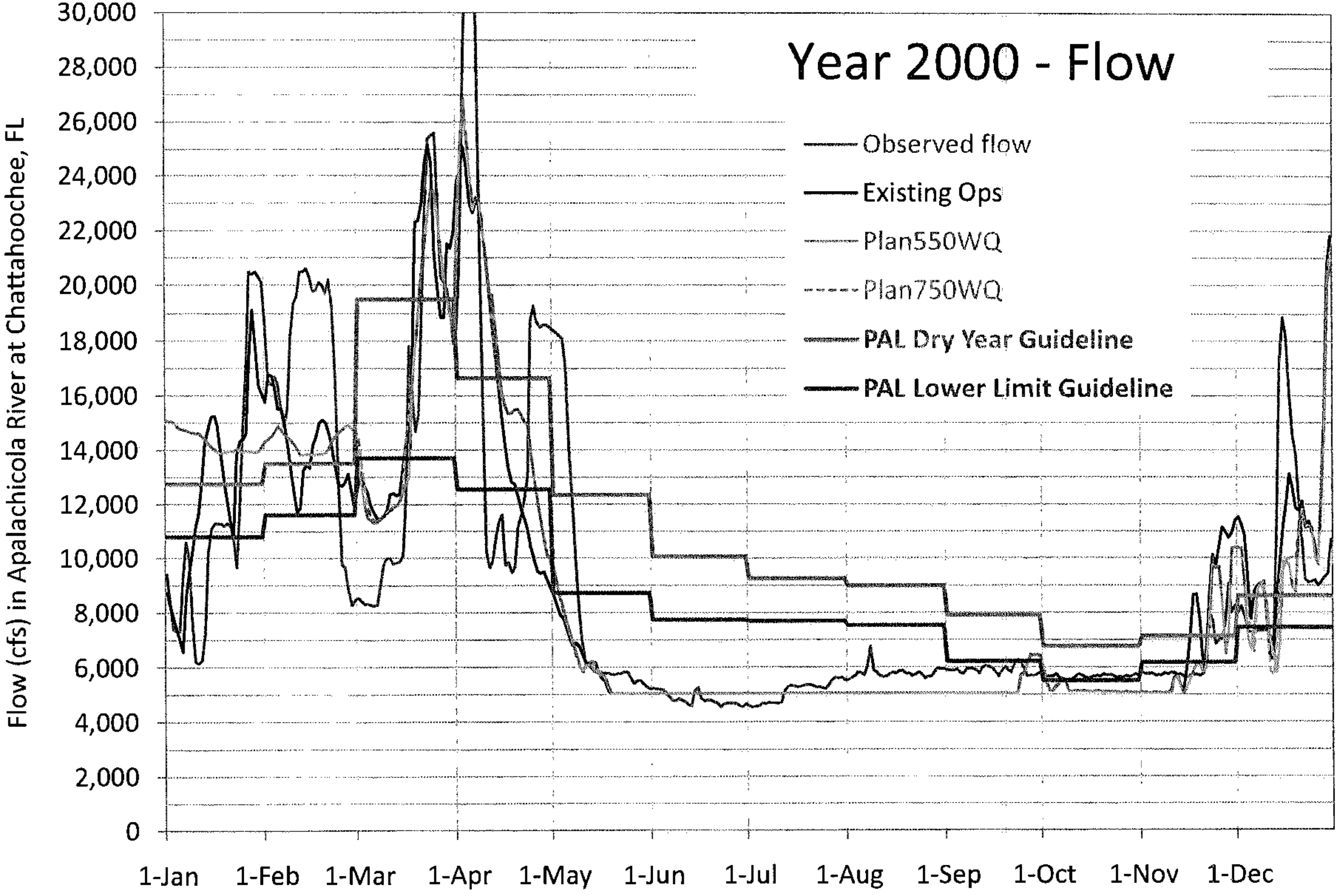
Year 2000 - Flow
Observed flow
Existing Ops
Plan550WQ
Plan750WQ
PAL Dry Year Guideline
PAL Lower Limit Guideline
Flow (cfs) in Apalachicola River at Chattahoochee, FL
30,000
28,000
26,000
24,000
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18,000
16,000
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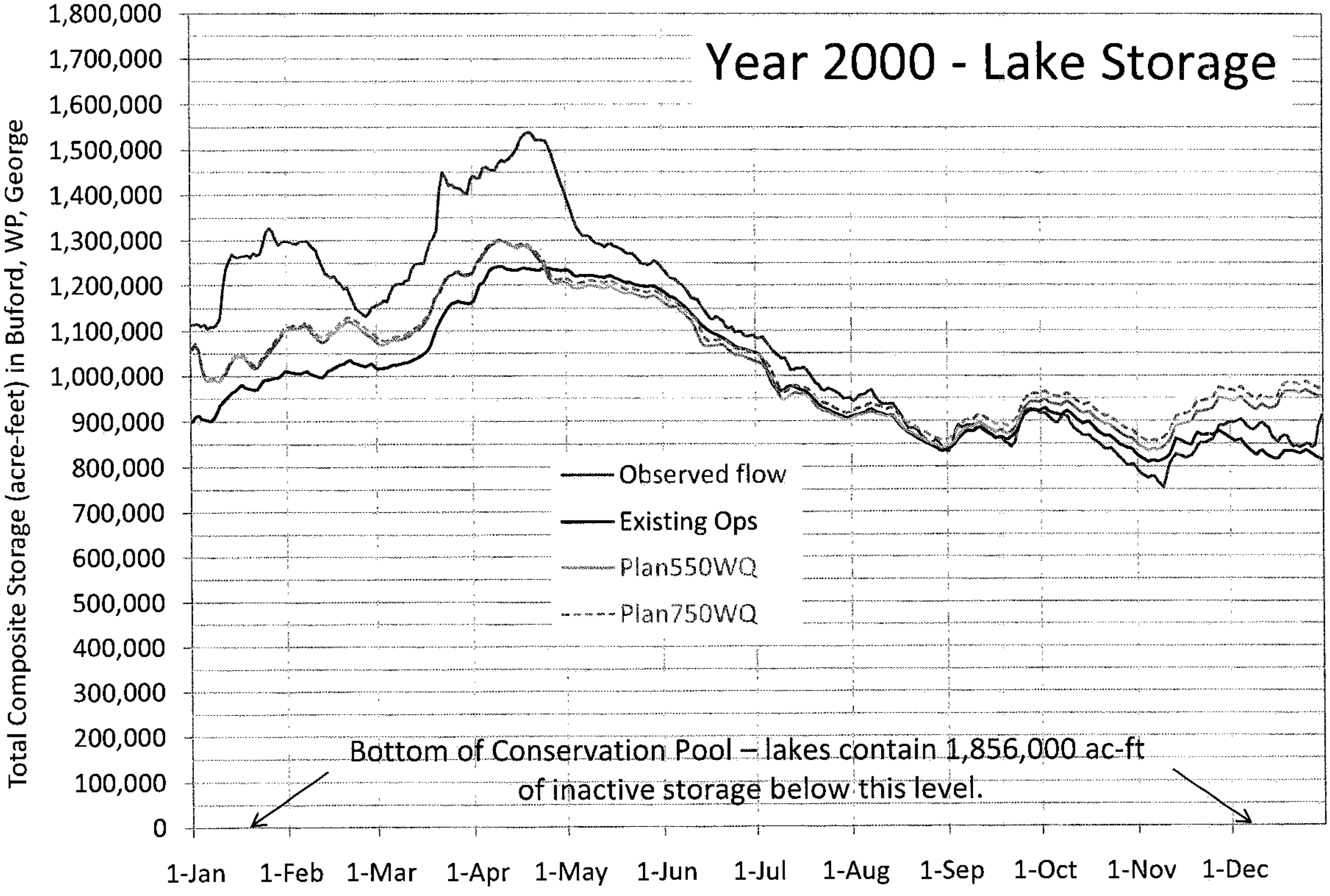
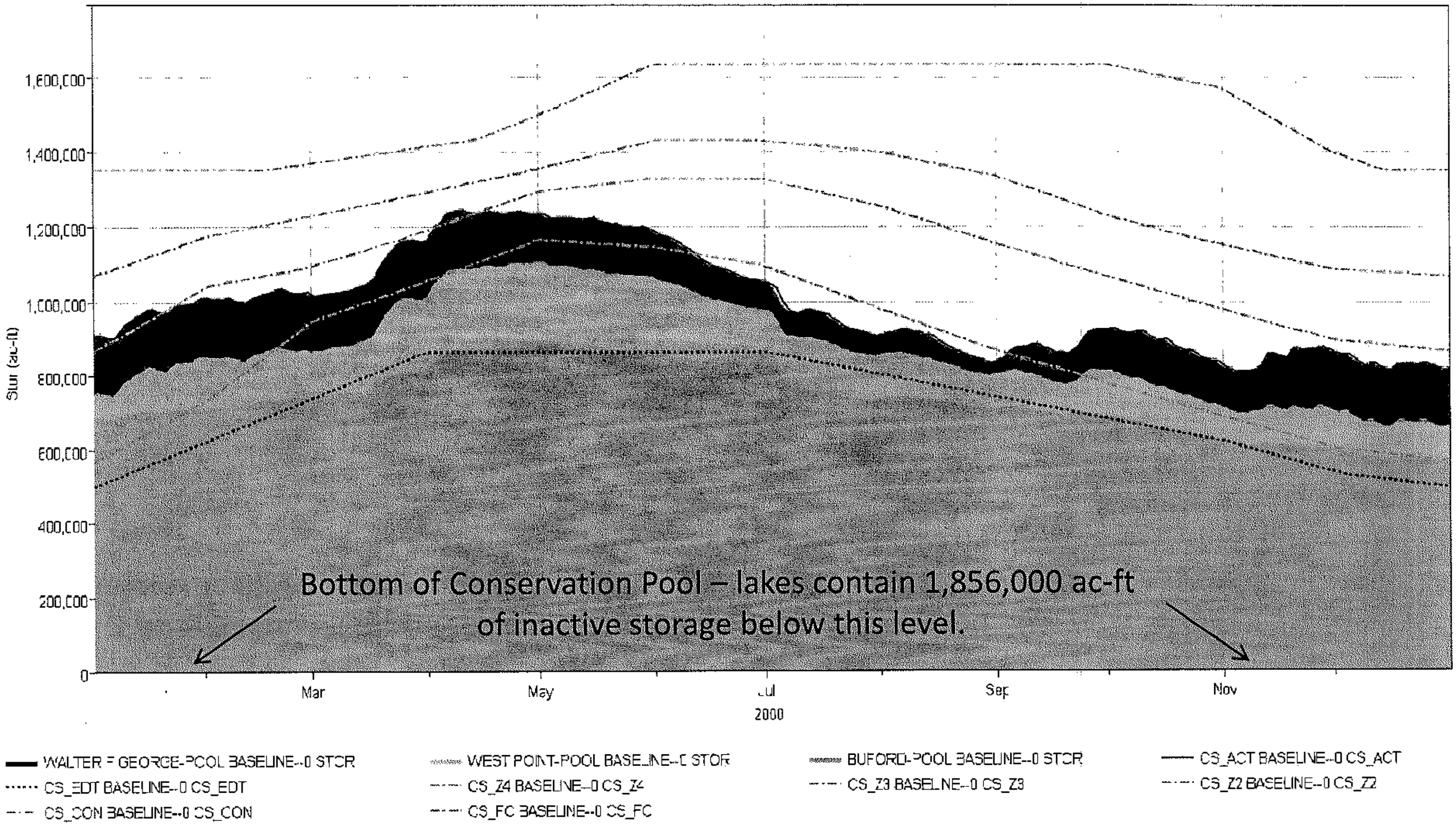
1-Dec


Year 2000 - Lake Storage
Total Composite Storage (acre-feet) in Buford, WP, George
1,800,000
1,700,000
1,600,000
1,500,000
1,400,000
1,300,000
1,200,000
1,100,000
1,000,000
900,000
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
Observed flow
Existing Ops
Plan550WQ
Plan750WQ
Bottom of Conservation Pool – lakes contain 1,856,000 ac-ft of inactive storage below this level.
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec

Year 2000 - Lake Storage (Existing Ops only)



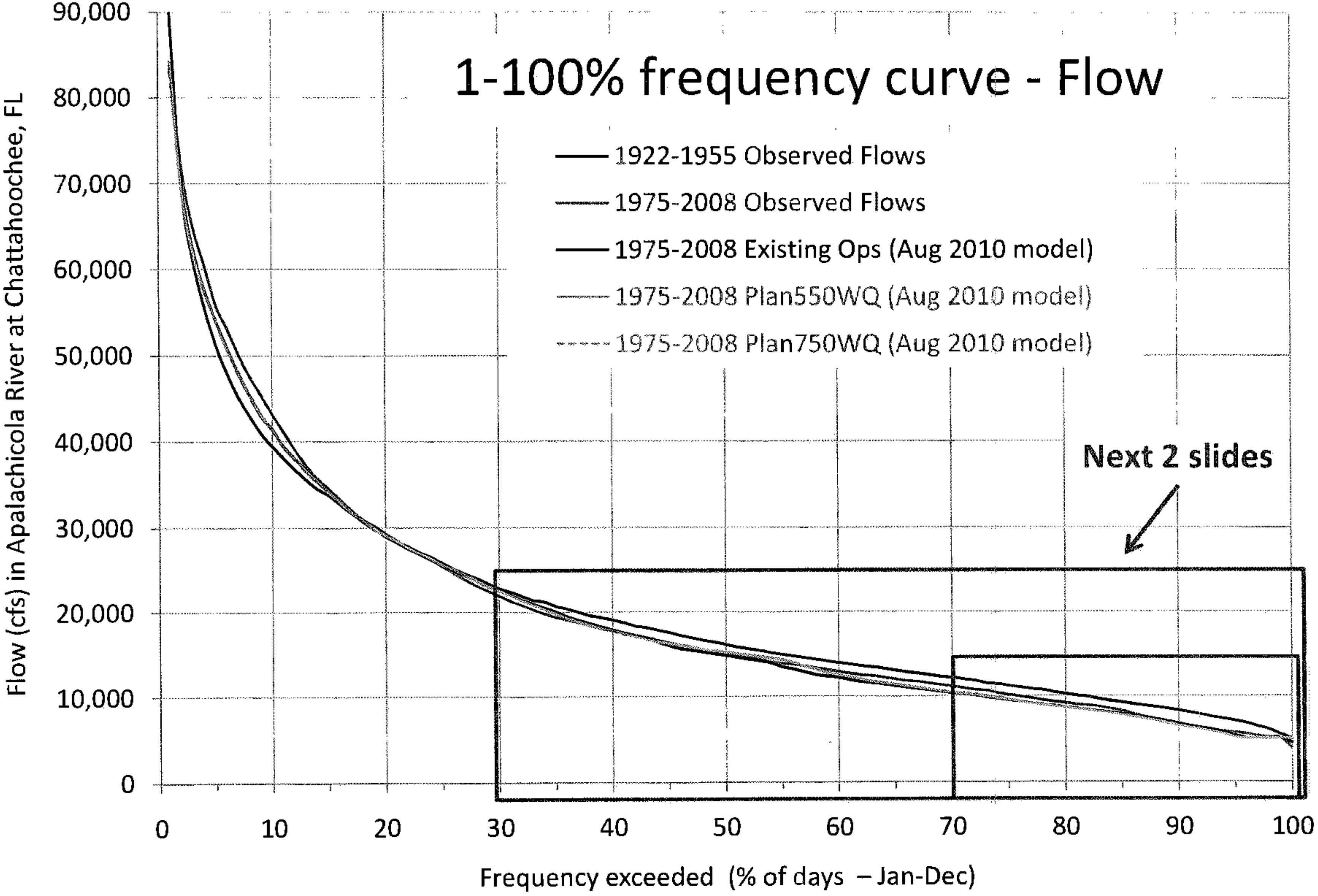
Bottom of Conservation Pool – lakes contain 1,856,000 ac-ft of inactive storage below this level.

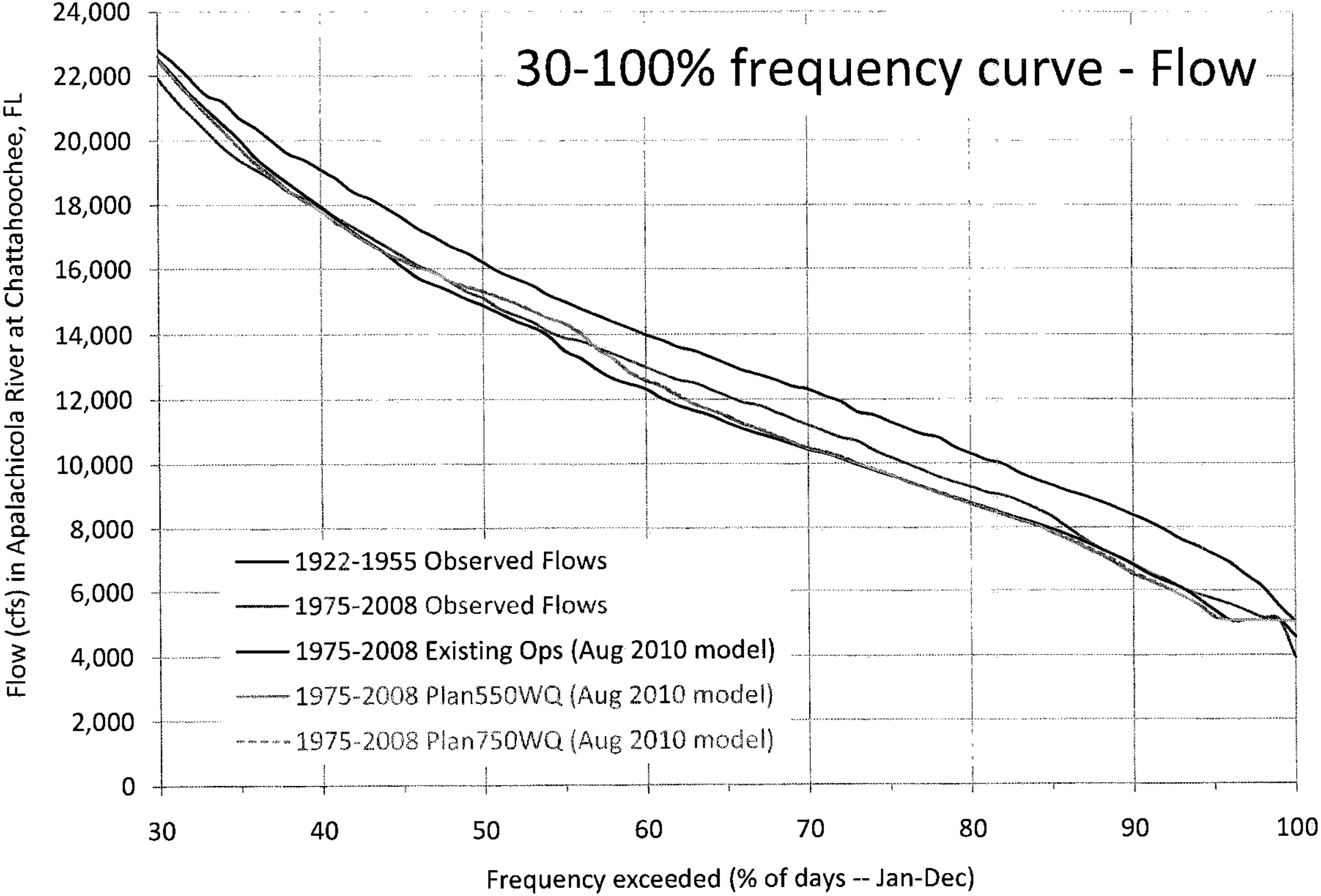
Flow Frequency Curves

Frequency that flows are exceeded
(% of days -- Jan-Dec)*

**To distinguish from growing season only (Mar-Nov)*

1-100% frequency curve - Flow




30-100% frequency curve - Flow
Flow (cfs) in Apalachicola River at Chattahoochee, FL
24,000
22,000
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
30
40
50
60
70
80
90
100
Frequency exceeded (% of days -- Jan-Dec)
1922-1955 Observed Flows
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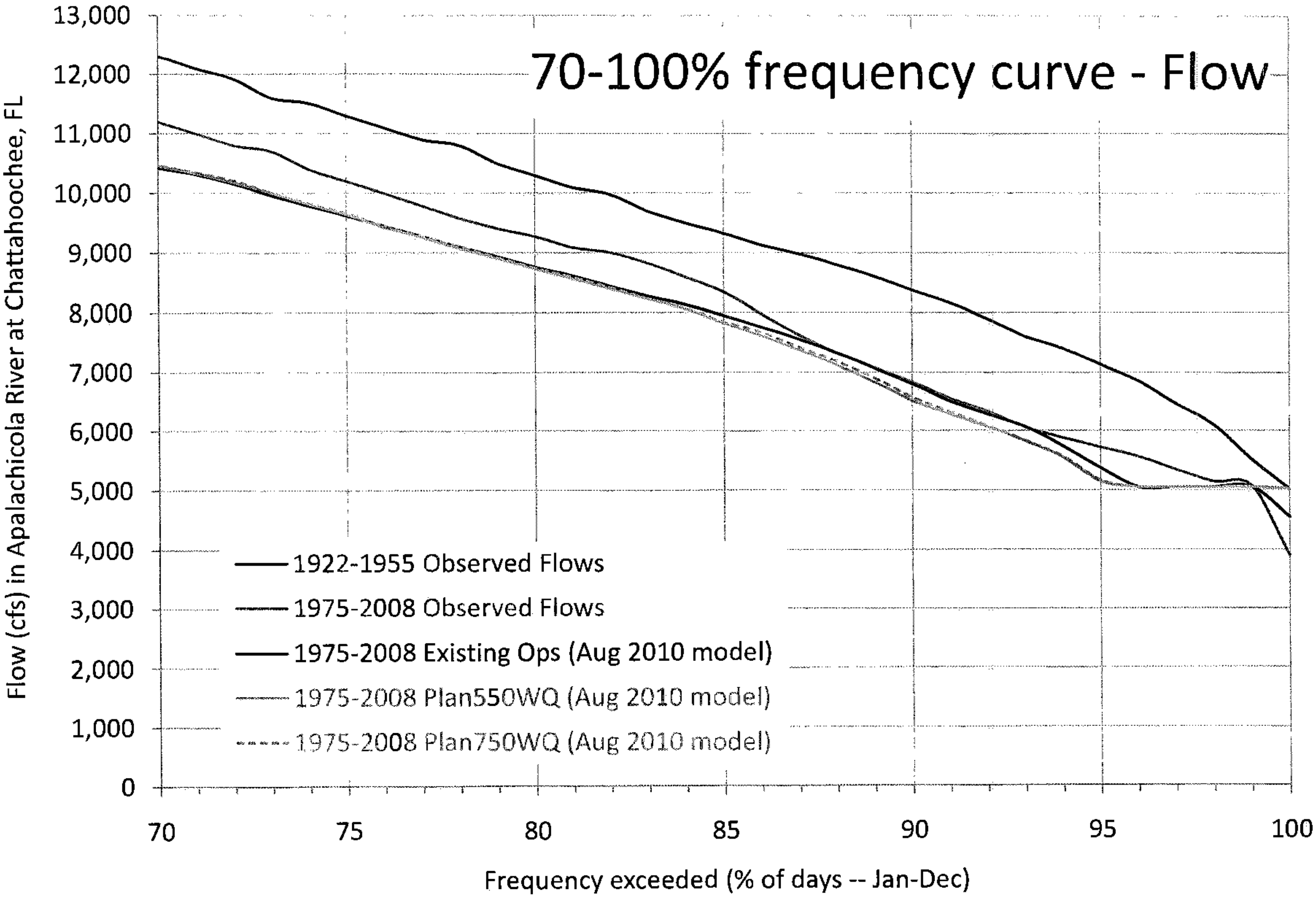
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Daily exceedance flows for
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75 and 90%

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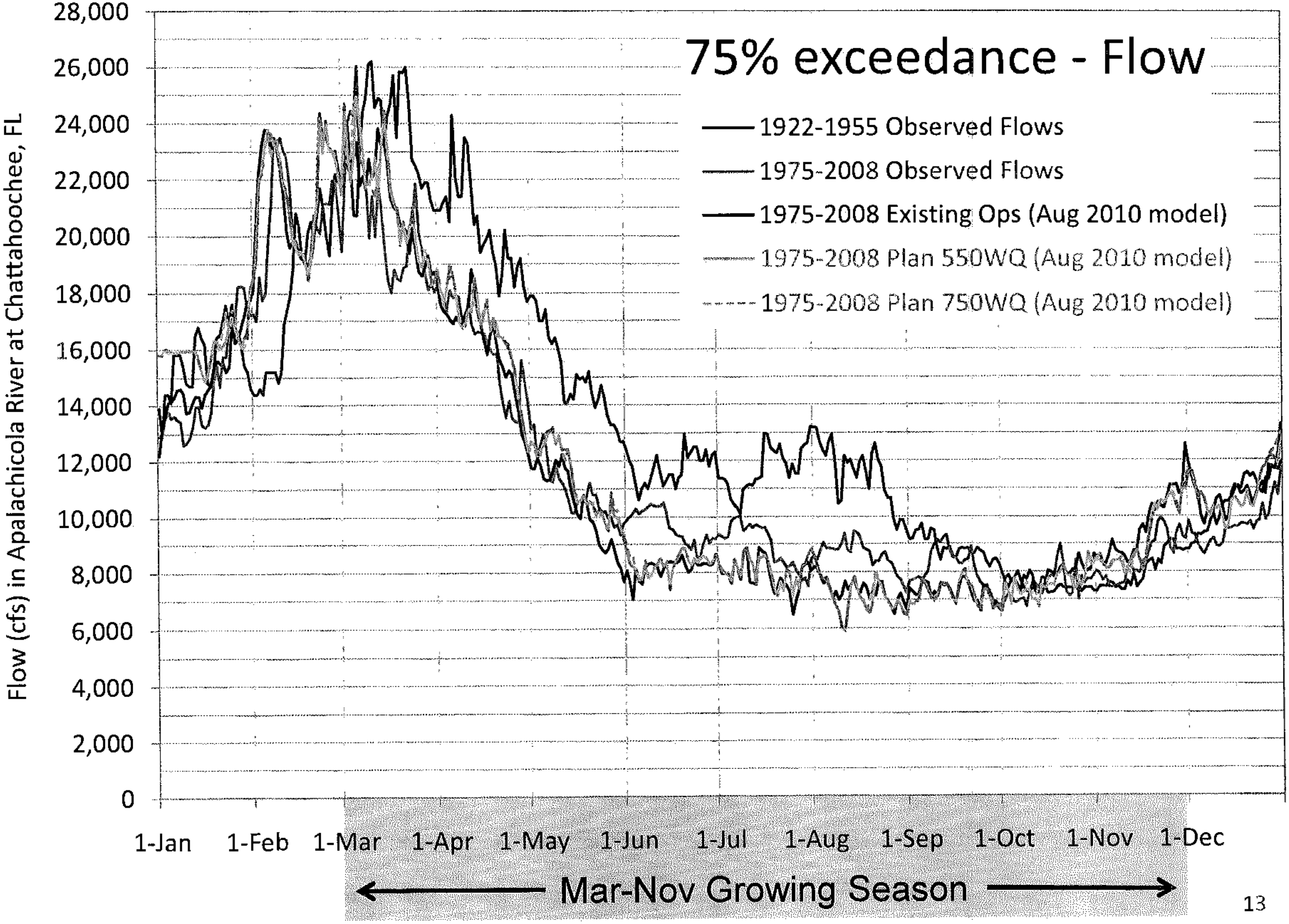
75% exceedance - Flow
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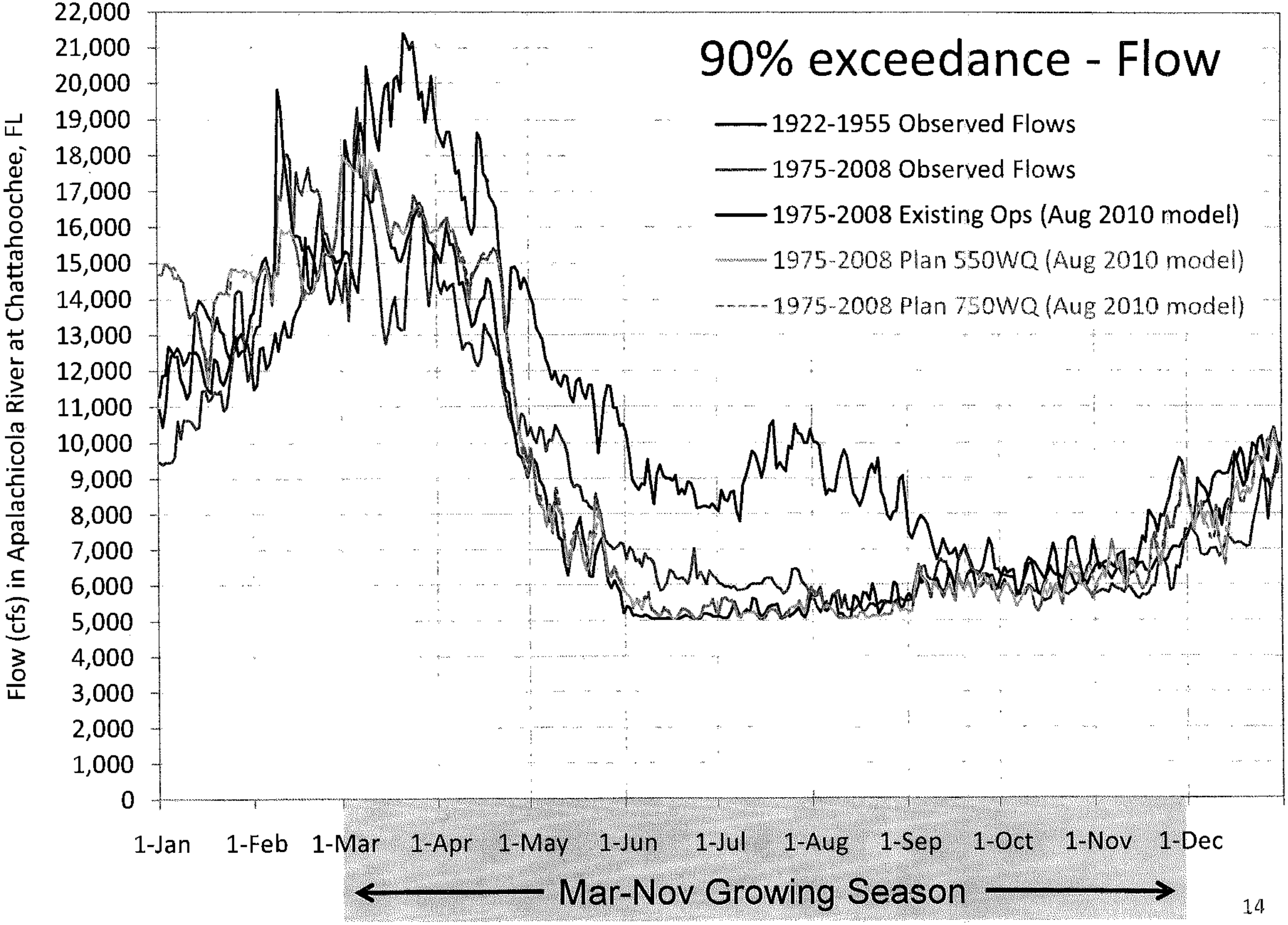
24,000
22,000
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
Mar-Nov Growing Season


90% exceedance - Flow
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12,000
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9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
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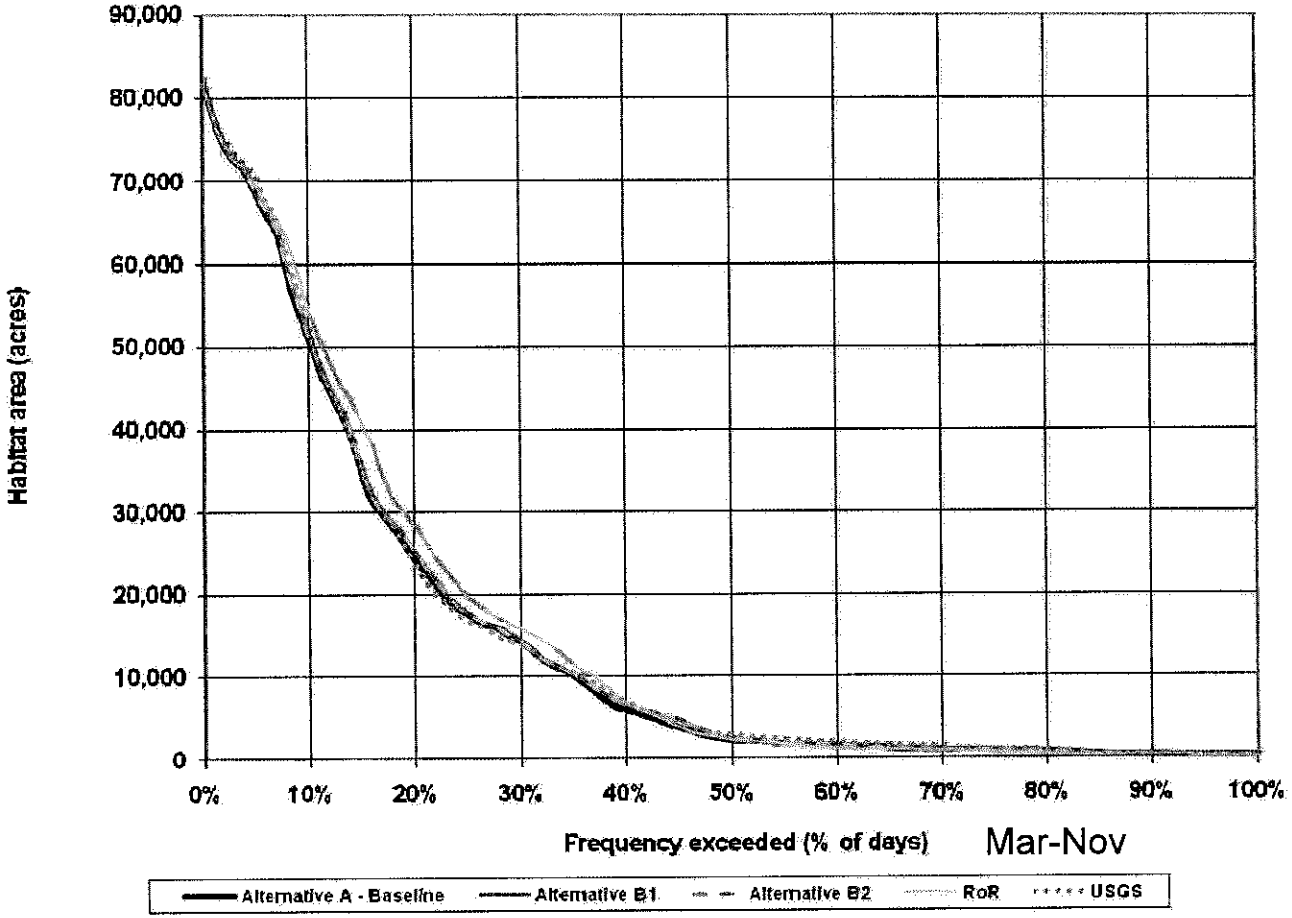
Frequency that acres of inundated floodplain
are exceeded in the growing season
(% of days – Mar-Nov)

Analysis provided by Corps

Graph from Corps 1/18/2011 Response to PAL, page 2-95:



This graph was created by the Corps in response to FFWCC request.

Suggested revisions:

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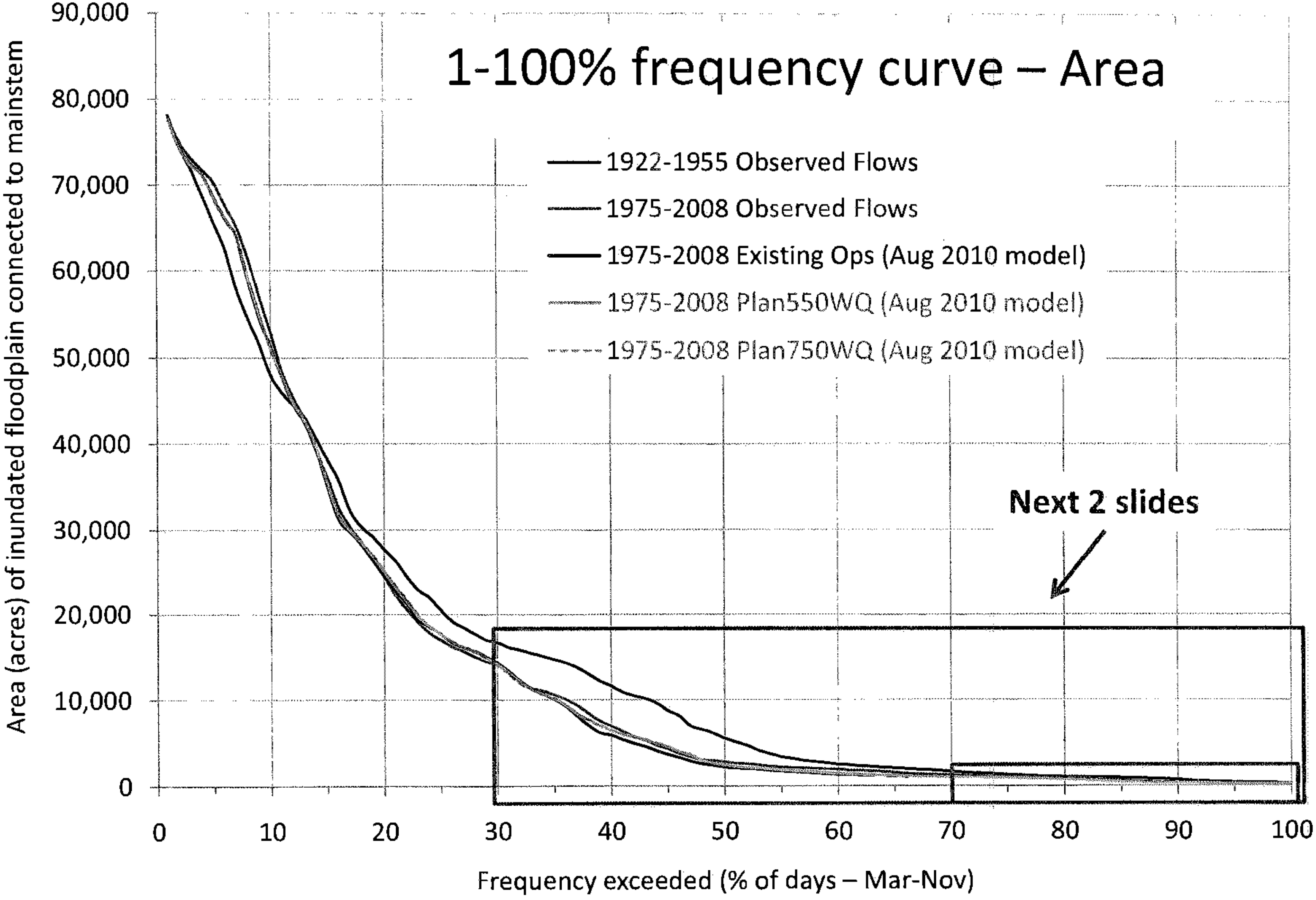
-- Expand data at low end

1-100% frequency curve – Area



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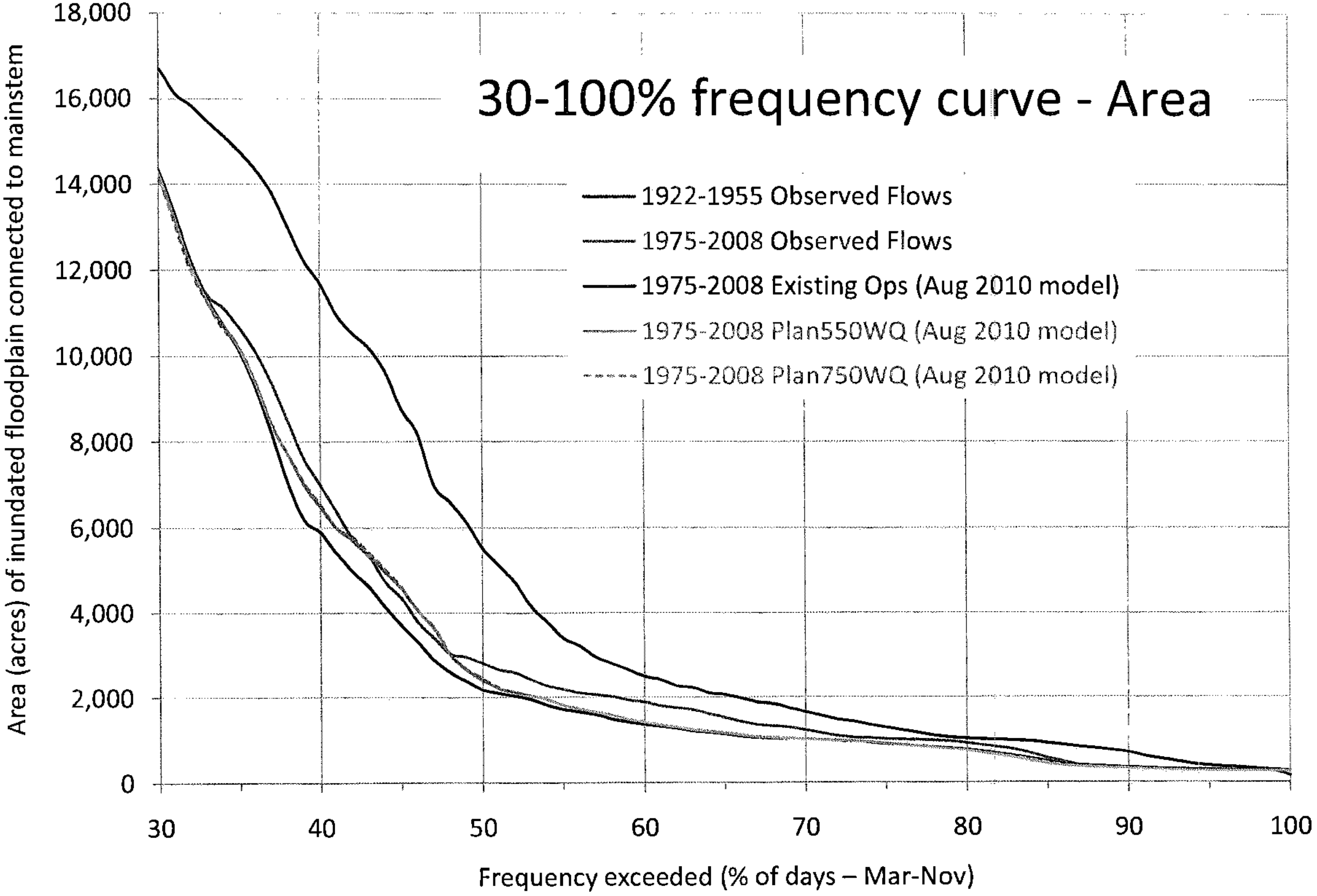

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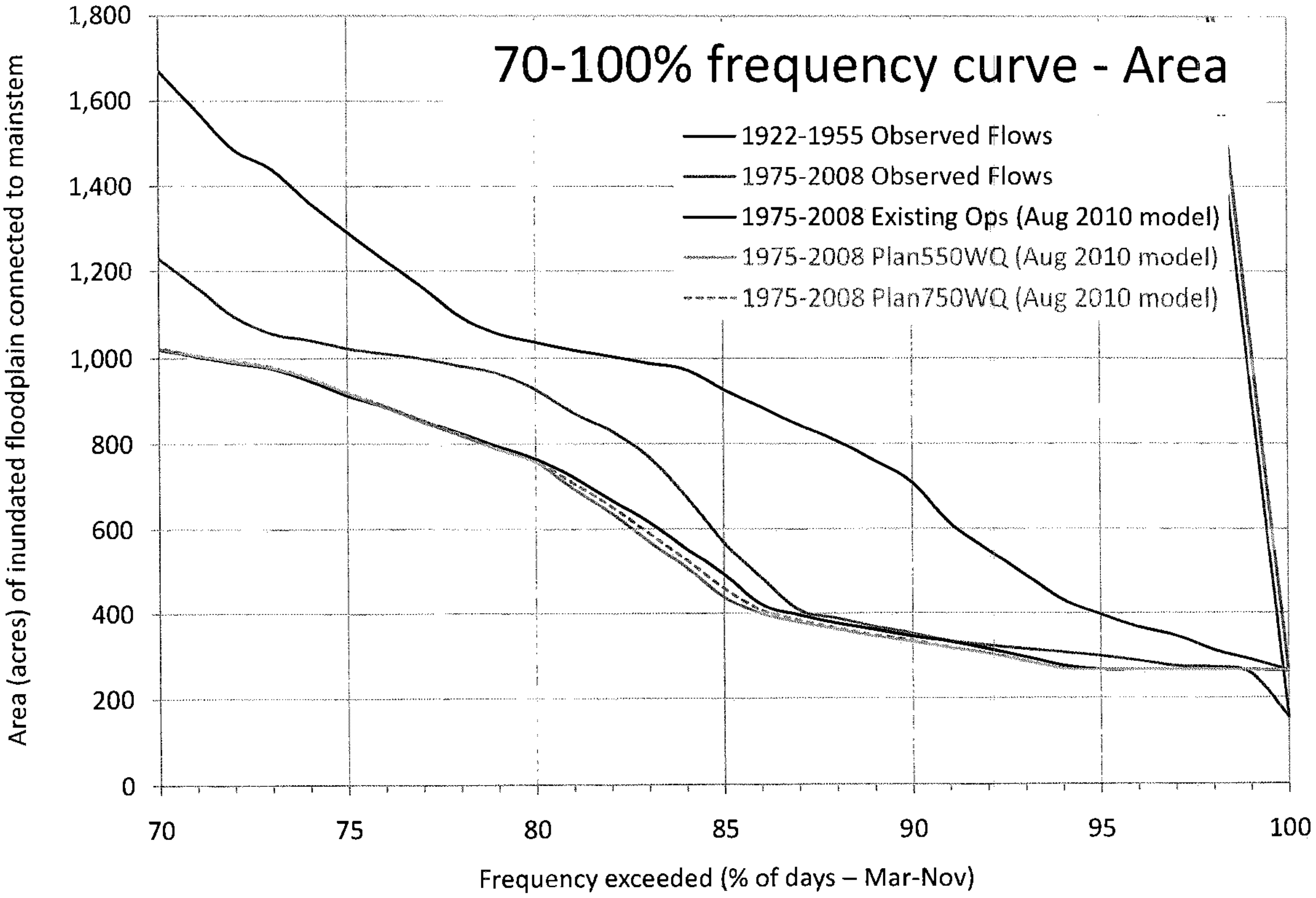

70-100% frequency curve - Area

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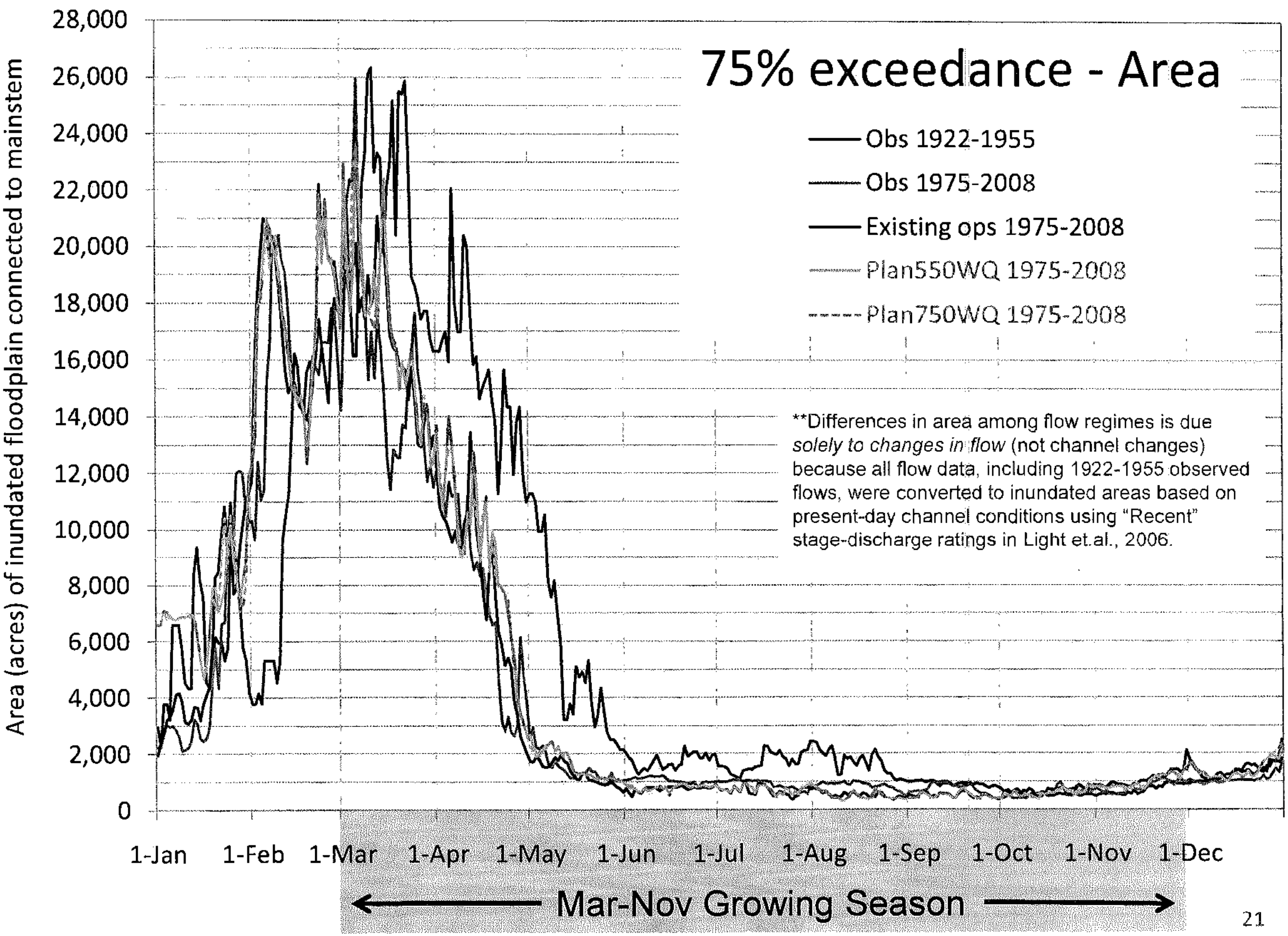

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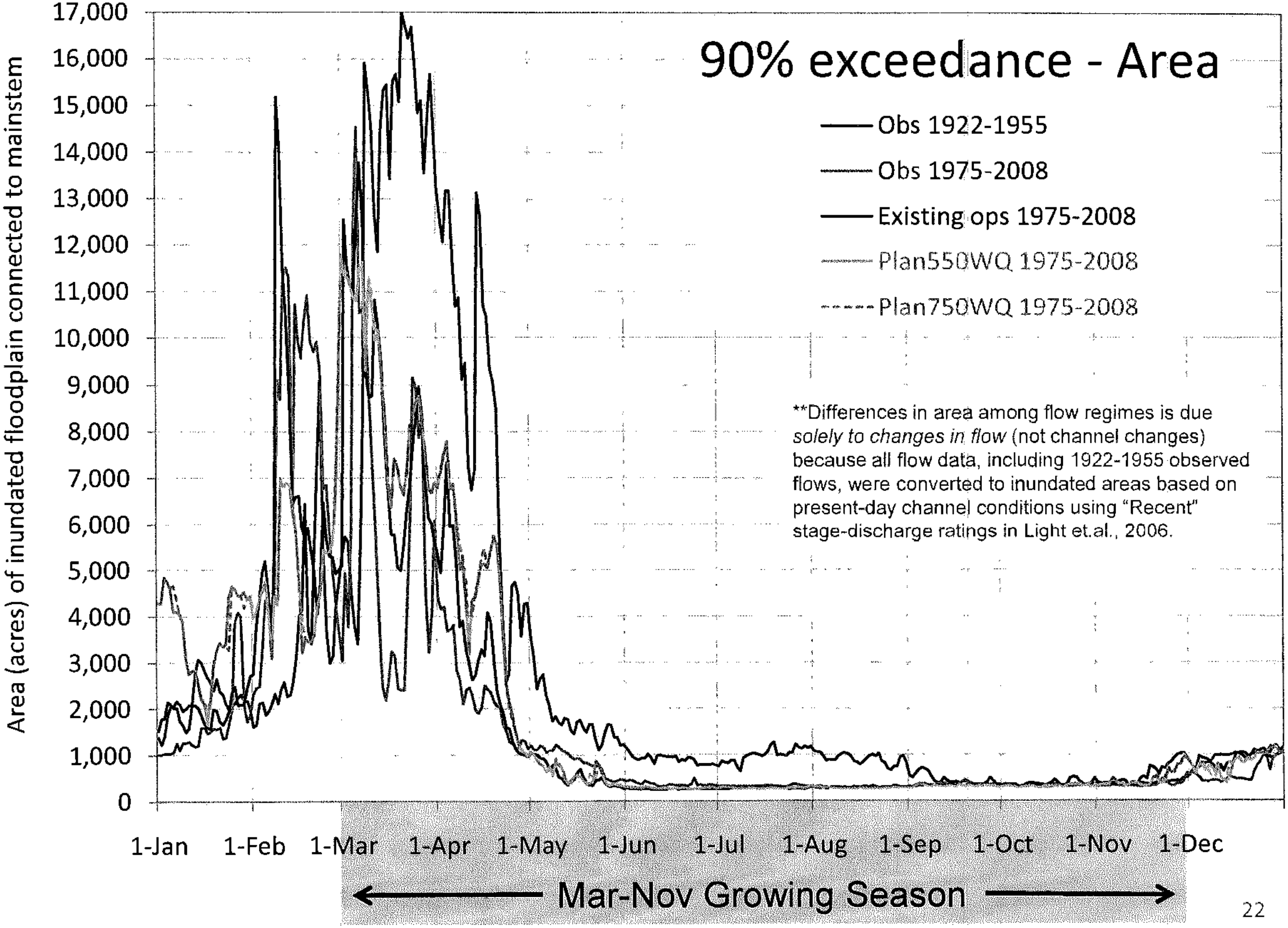
90% exceedance - Area



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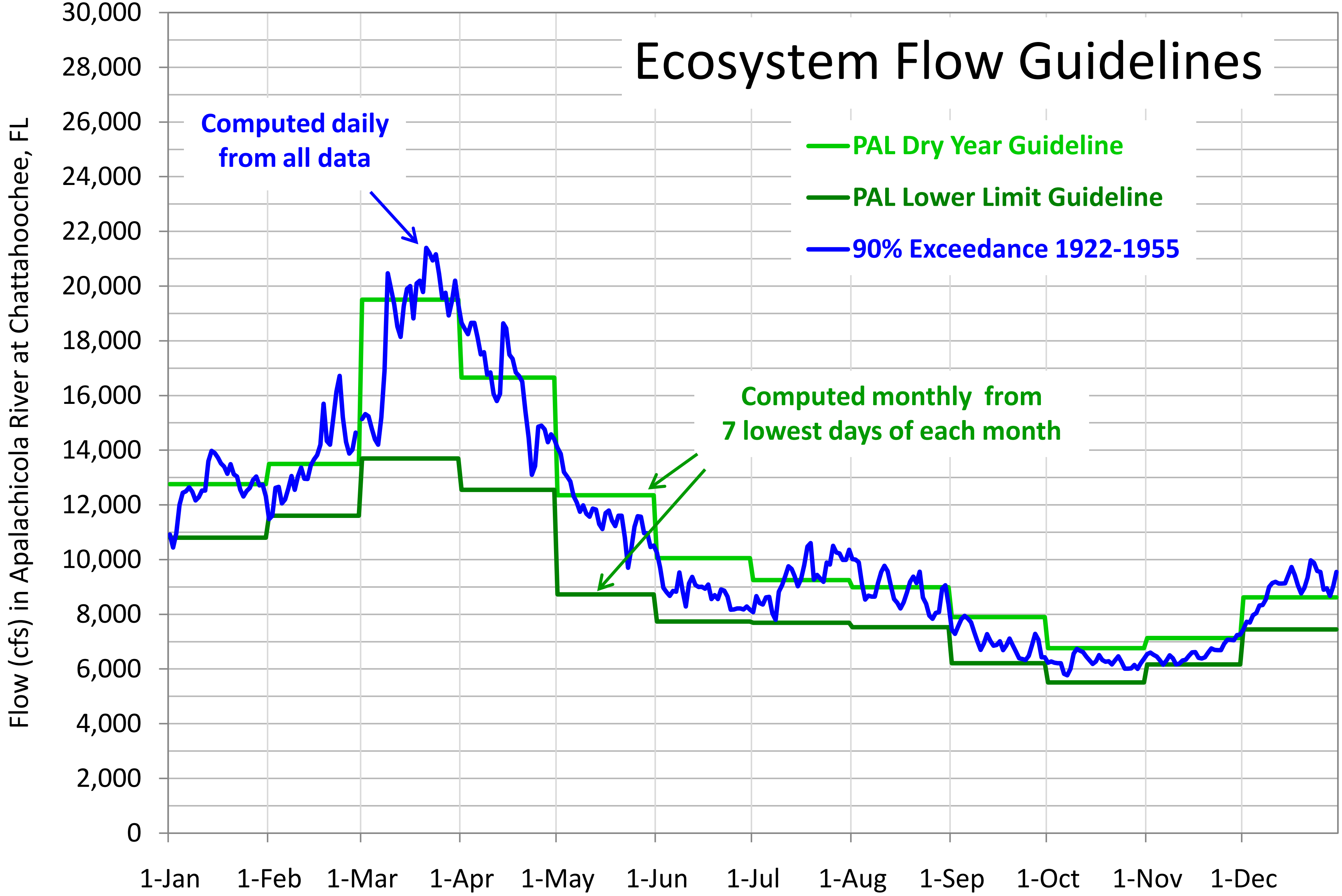


Ecosystem Flow Guidelines

Computed daily from all data

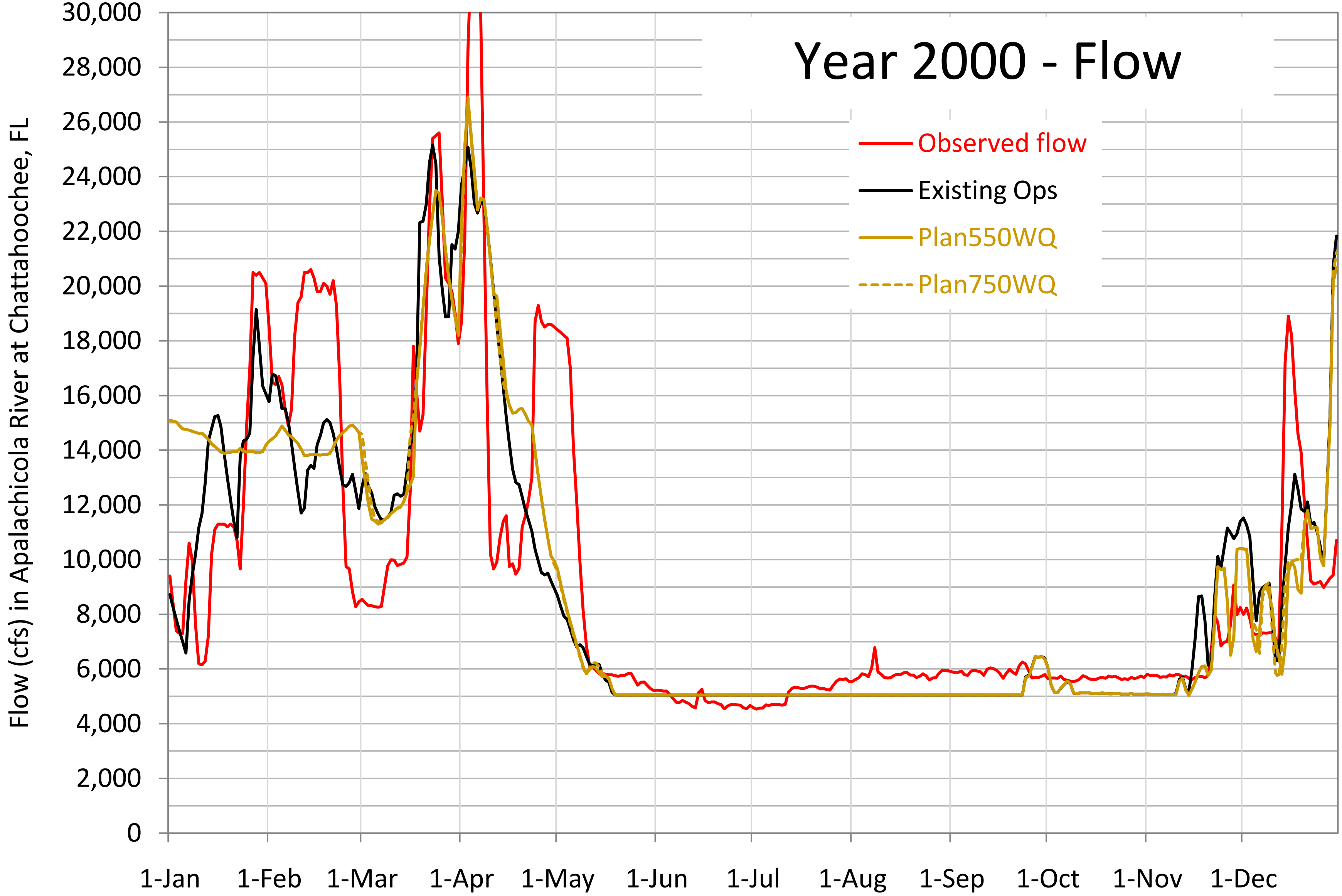
Computed monthly from 7 lowest days of each month

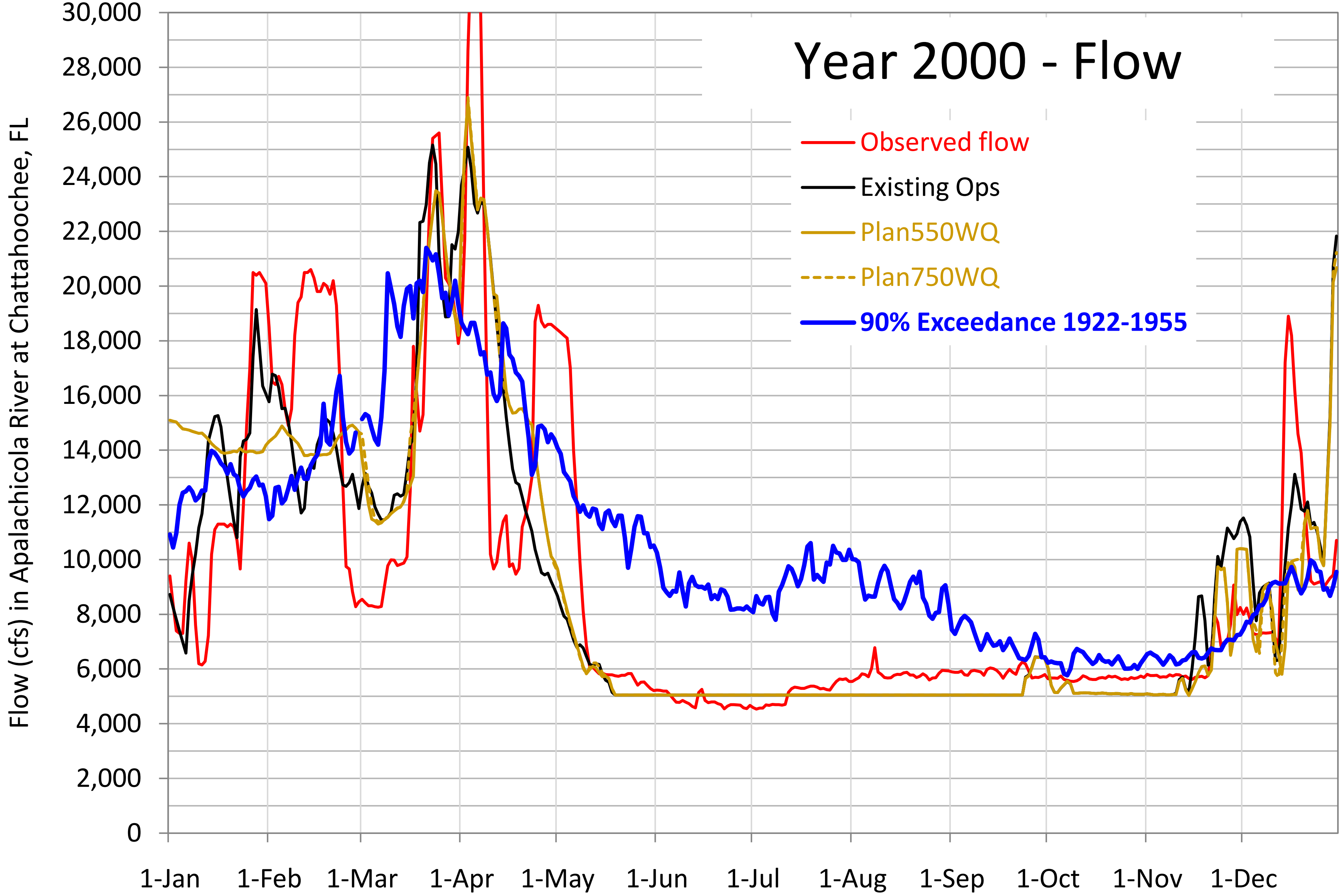
Flows Vs Lake Storage

*At times when Ecosystem Flow Guidelines are **not** met, what is the Total Composite Storage (TCS) in the Federal Reservoirs?*

Year 2000 is provided in the following example.

Data source: 8-20-2011 Corps model output


Year 2000 - Flow
Observed flow
Existing Ops
Plan550WQ
Plan750WQ
Flow (cfs) in Apalachicola River at Chattahoochee, FL
30,000
28,000
26,000
24,000
22,000
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec


Year 2000 - Flow
Observed flow
Existing Ops
Plan550WQ
Plan750WQ
90% Exceedance 1922-1955
Flow (cfs) in Apalachicola River at Chattahoochee, FL
30,000
28,000
26,000
24,000
22,000
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1-Jan
1-Feb
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1-Apr
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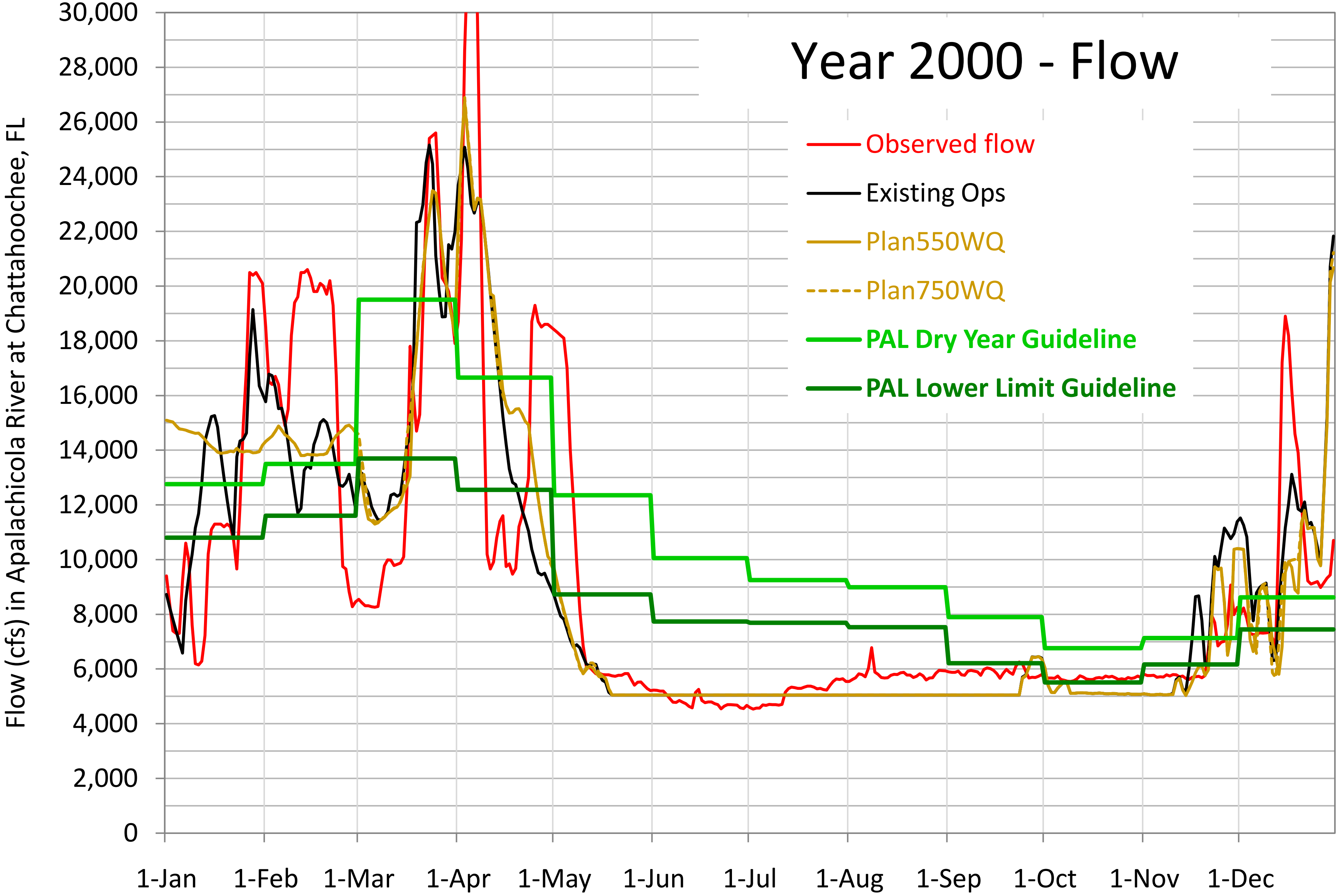
1-Sep
1-Oct
1-Nov
1-Dec


Year 2000 - Flow
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30,000
28,000
26,000
24,000
22,000
20,000
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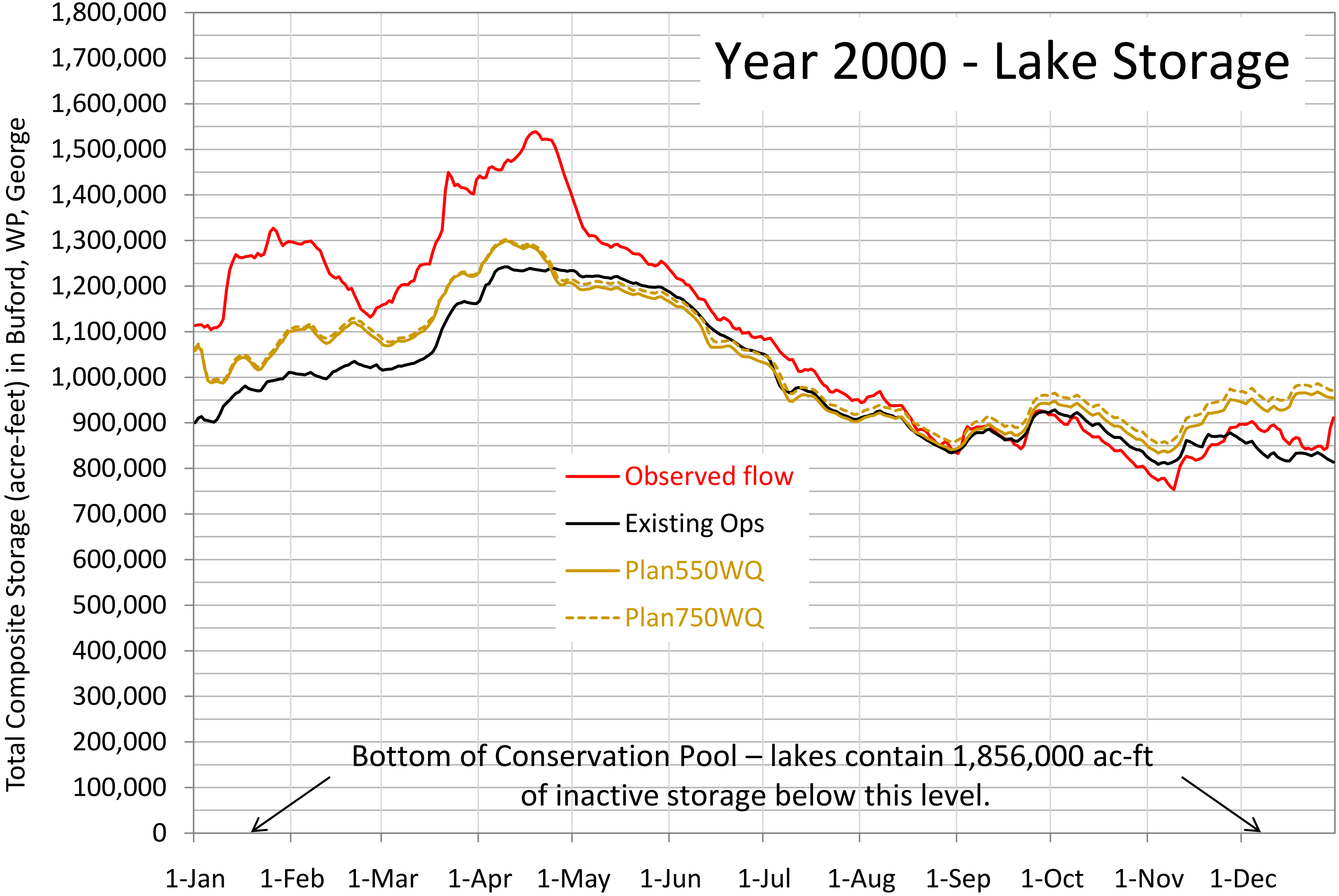
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
Observed flow
Existing Ops
Plan550WQ
Plan750WQ
PAL Dry Year Guideline
PAL Lower Limit Guideline



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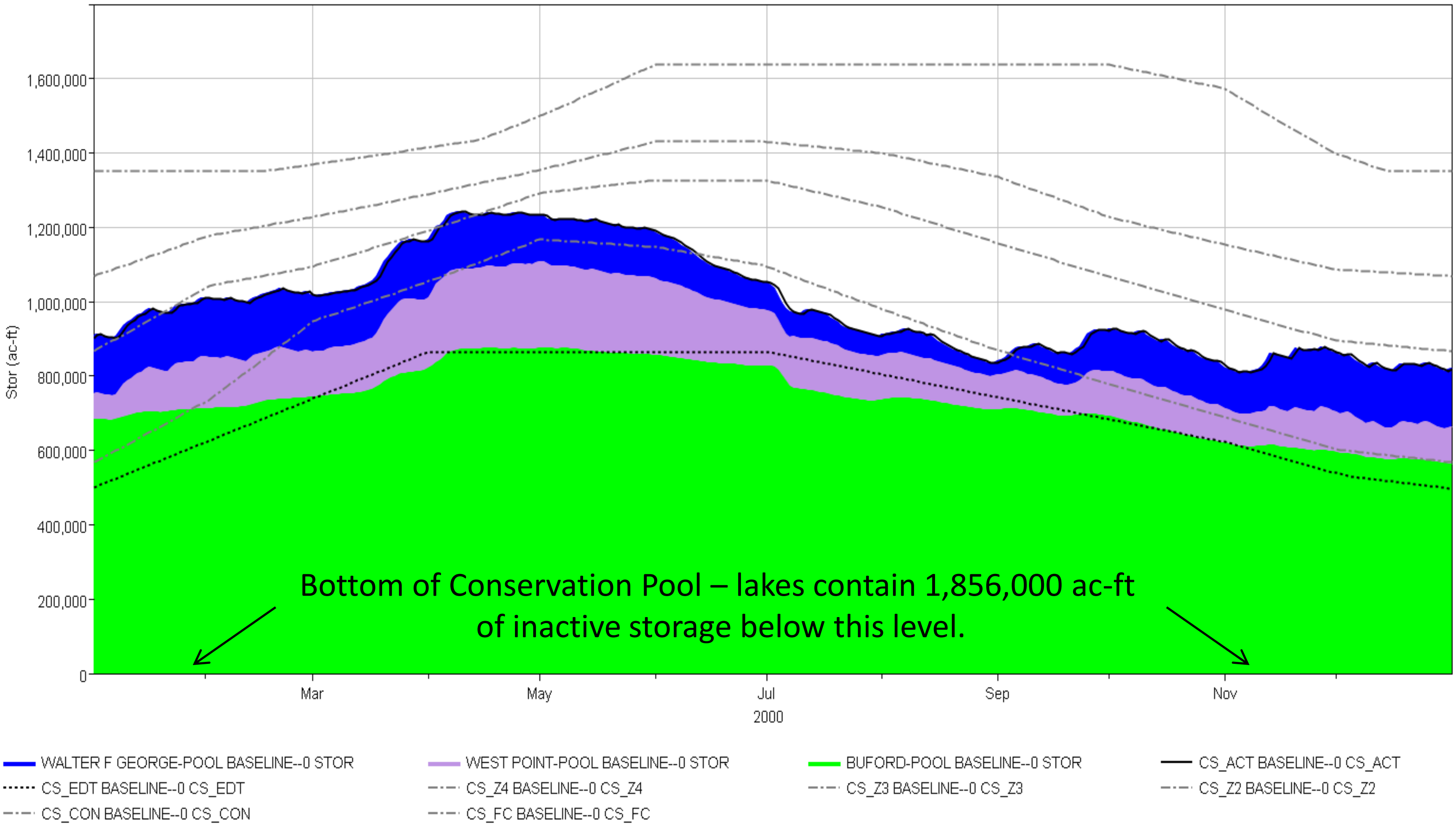

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Frequency that flows are exceeded
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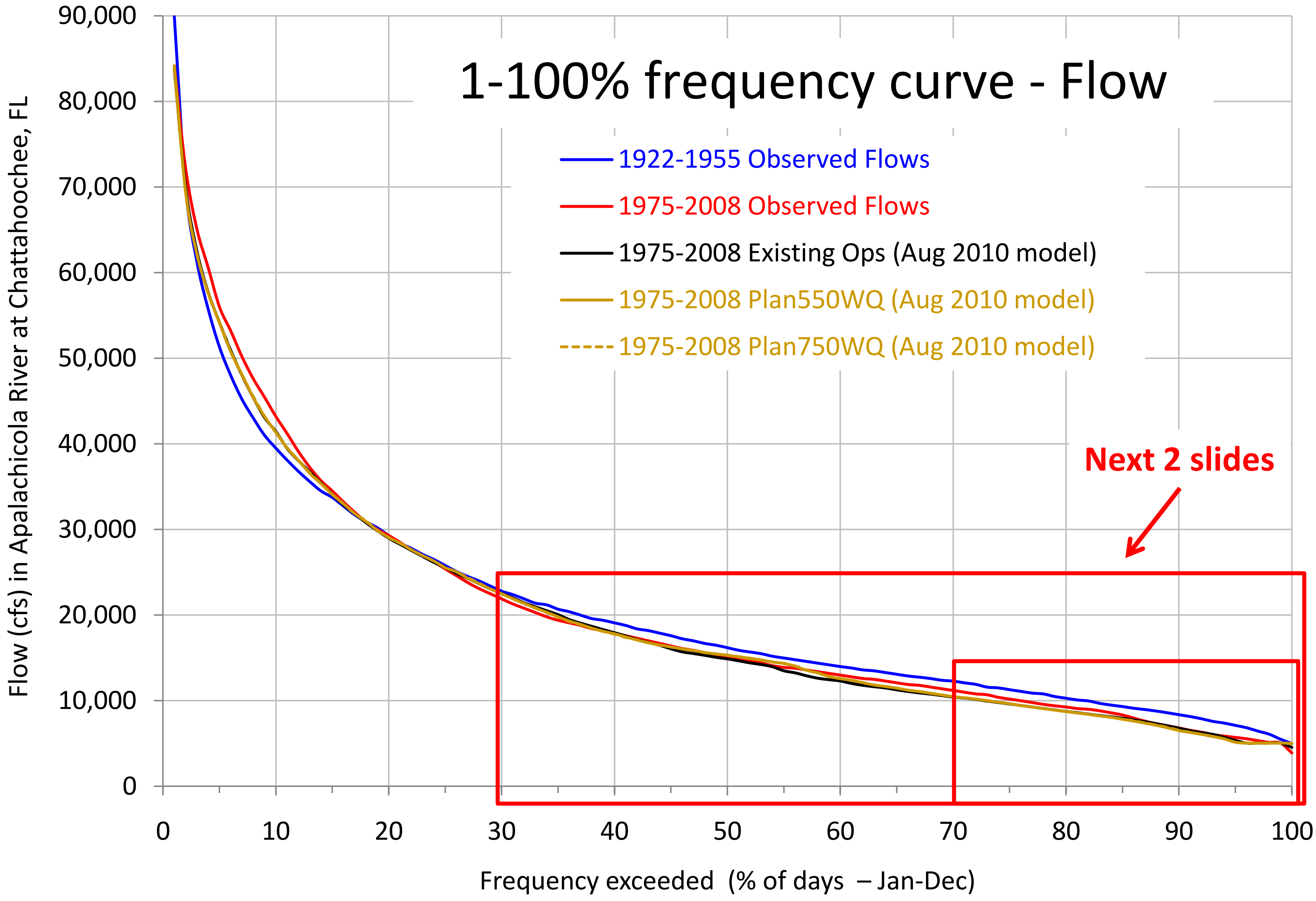
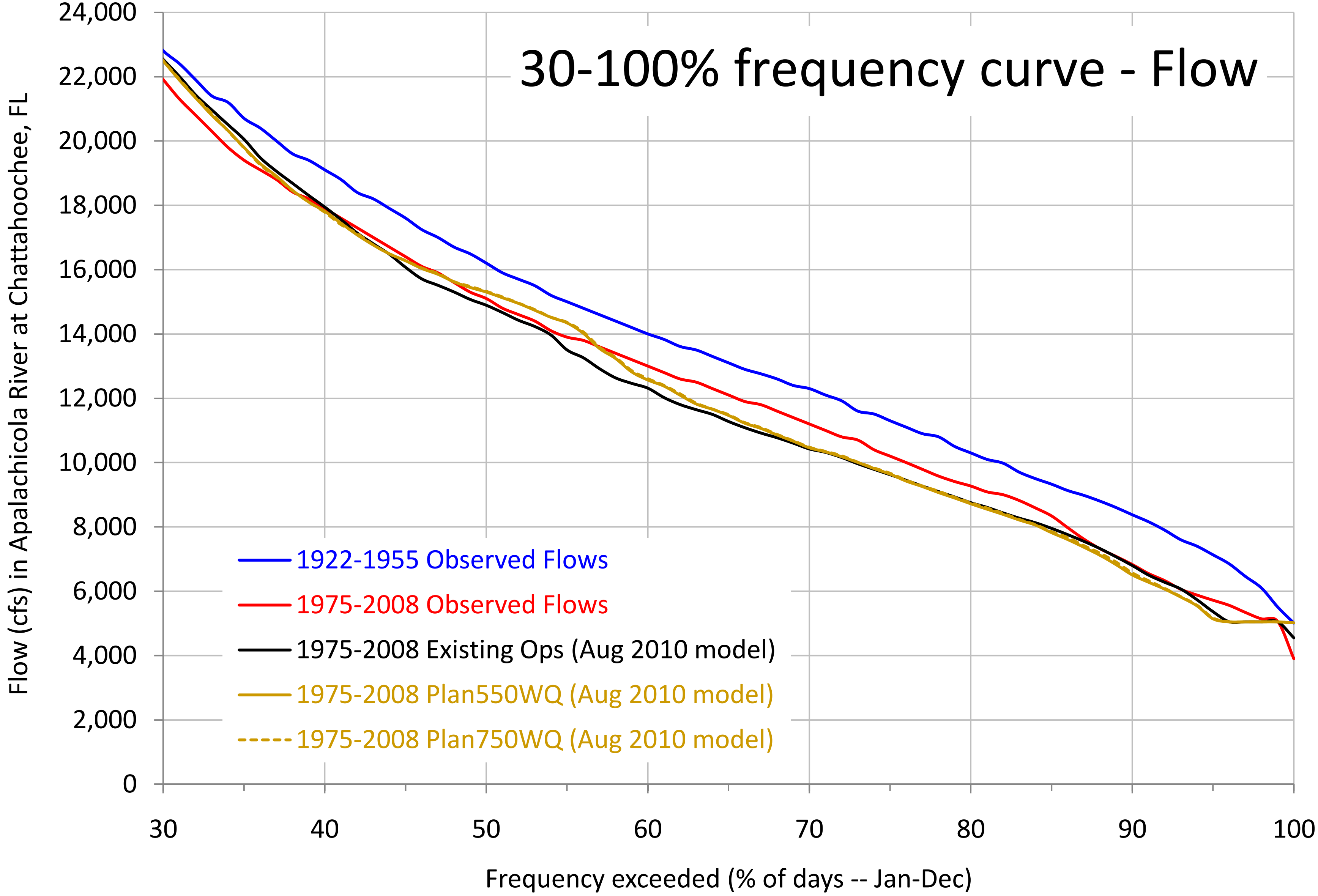


Next 2 slides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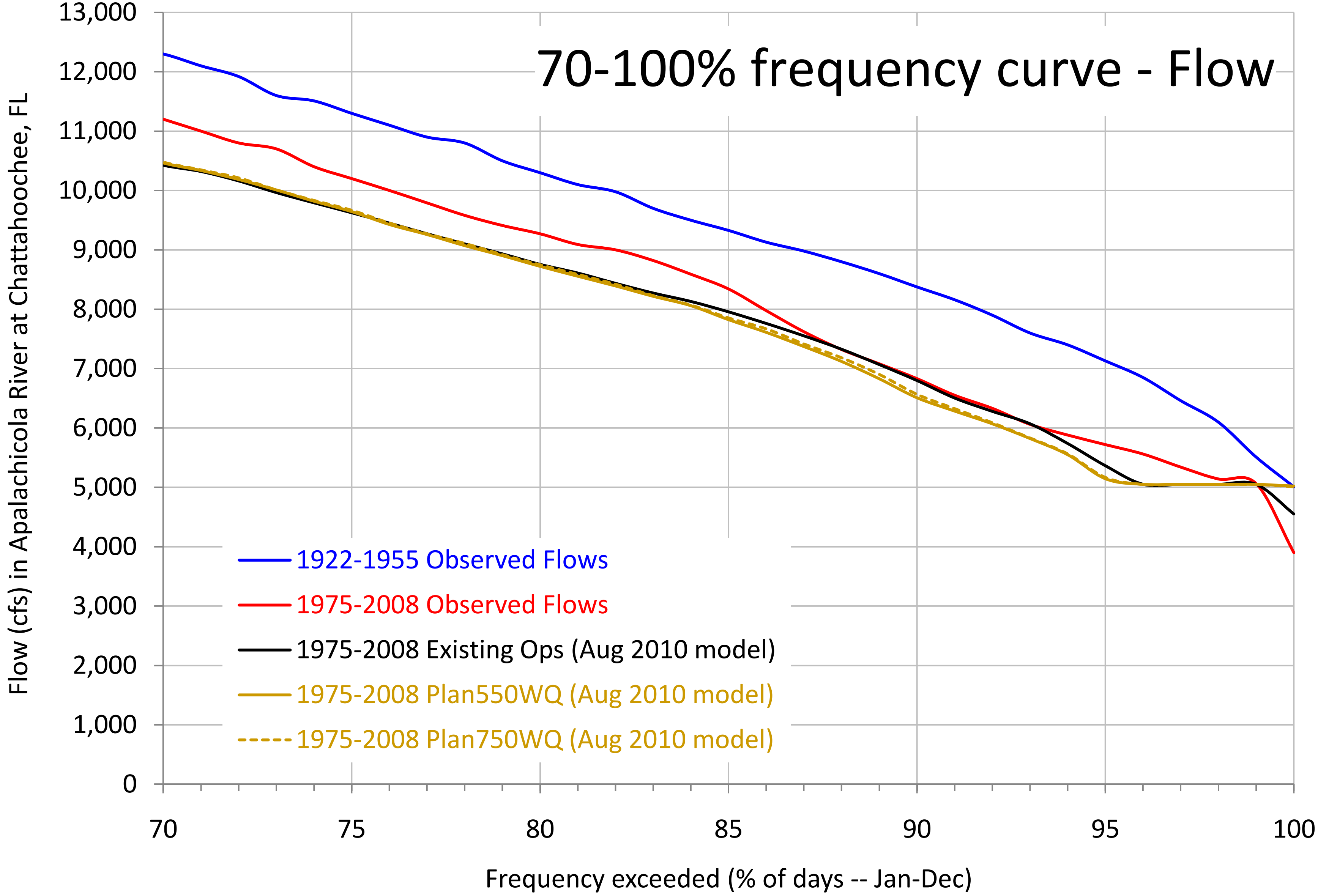
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5,000
4,000
3,000
2,000
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0
70
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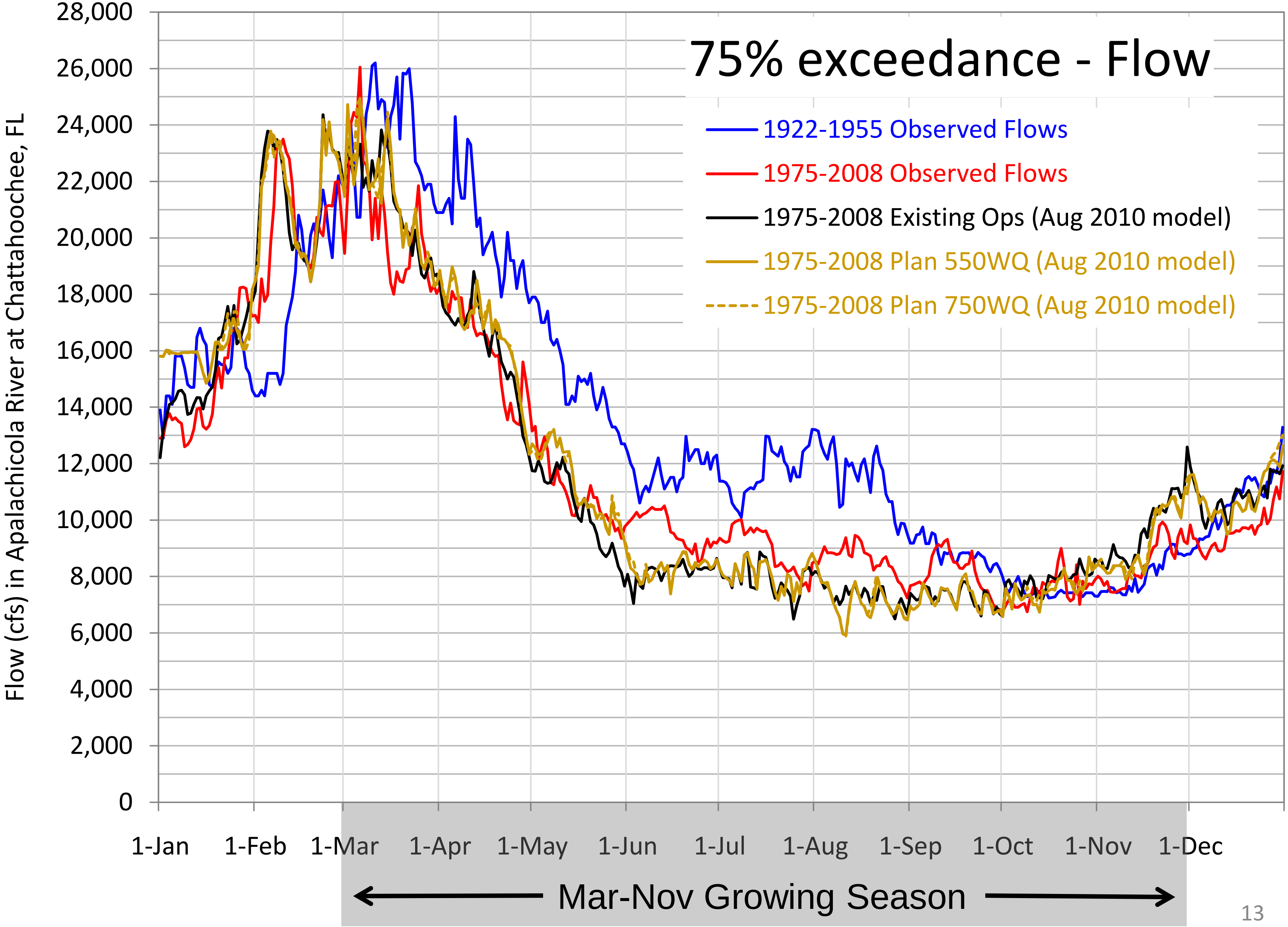

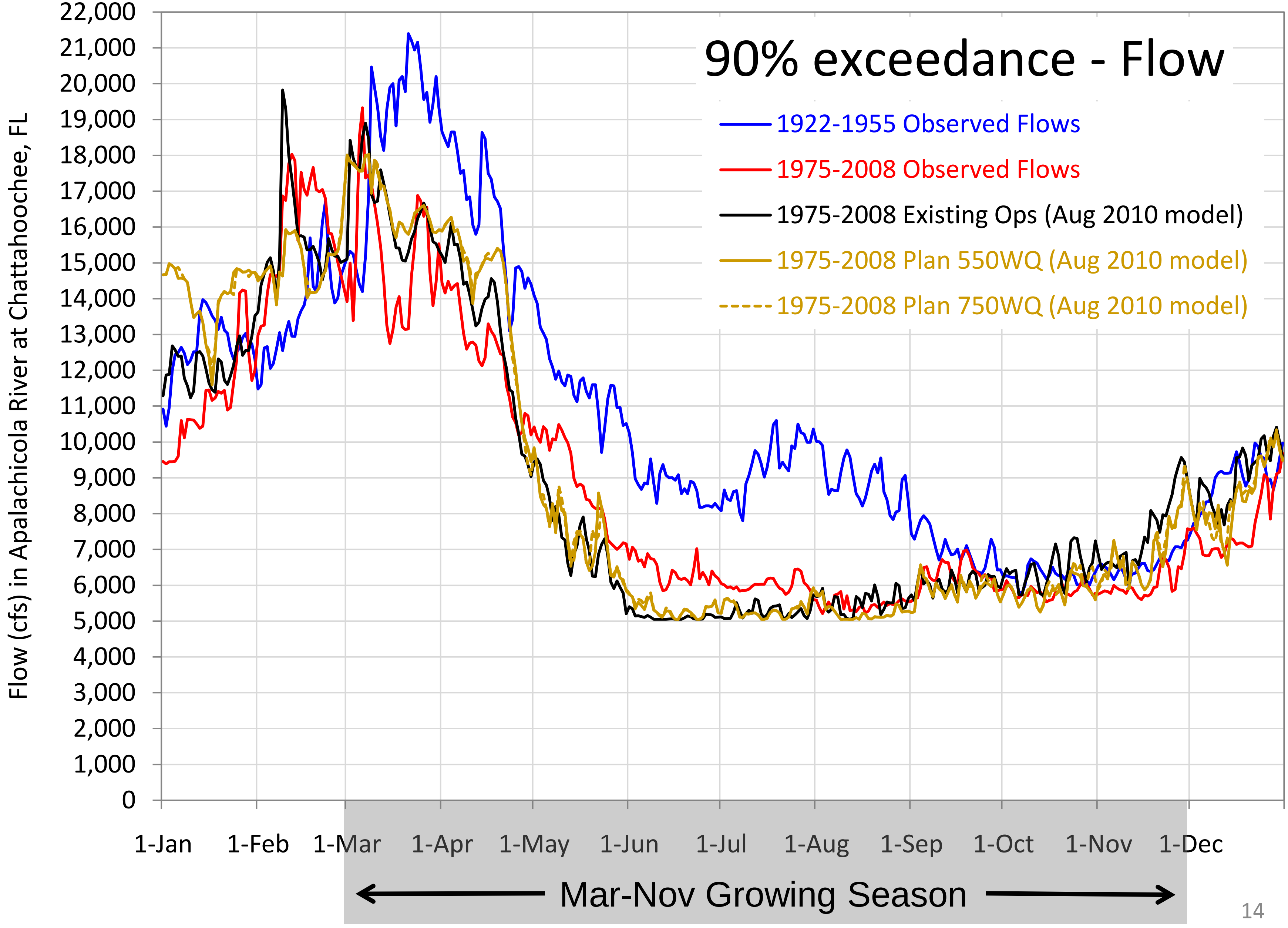
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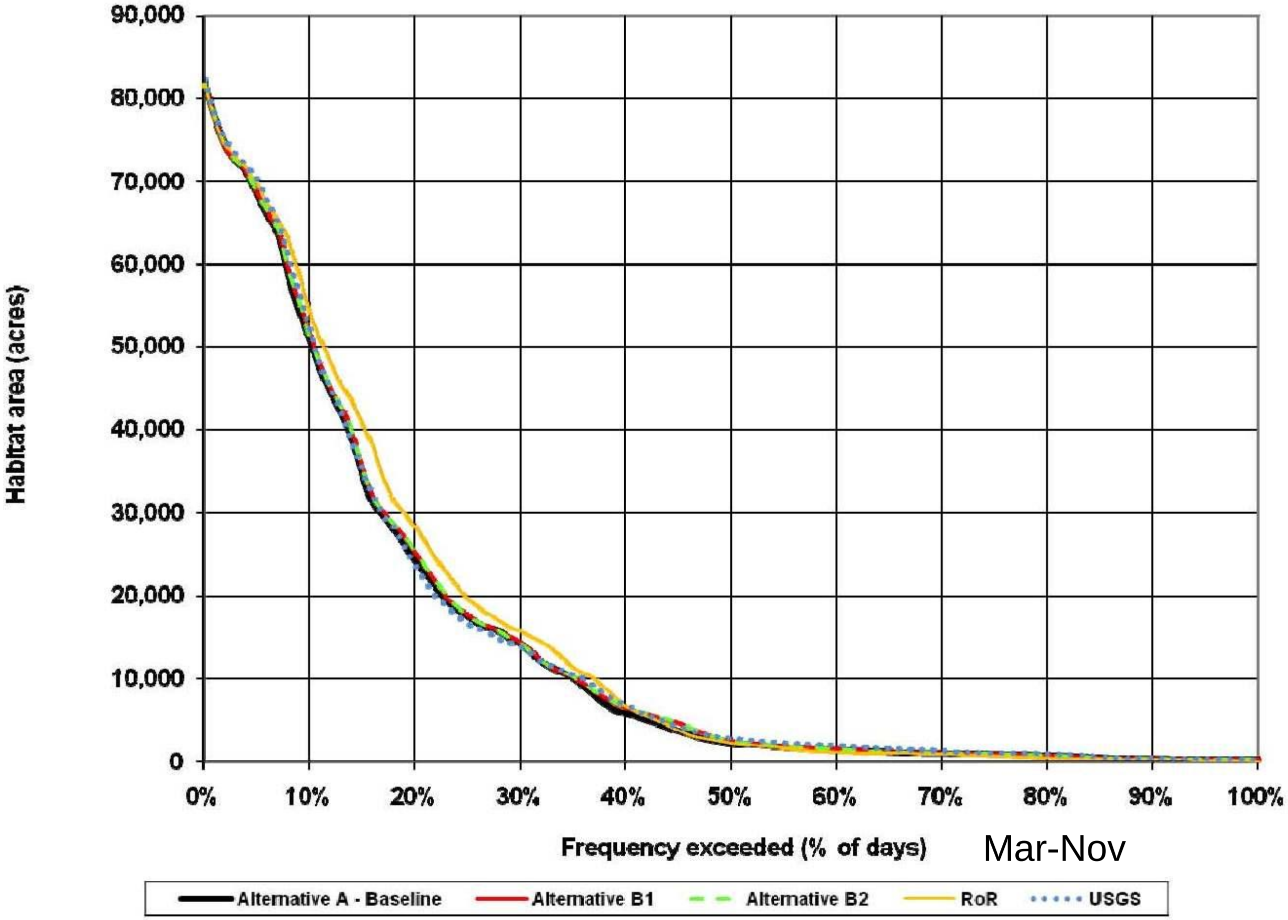

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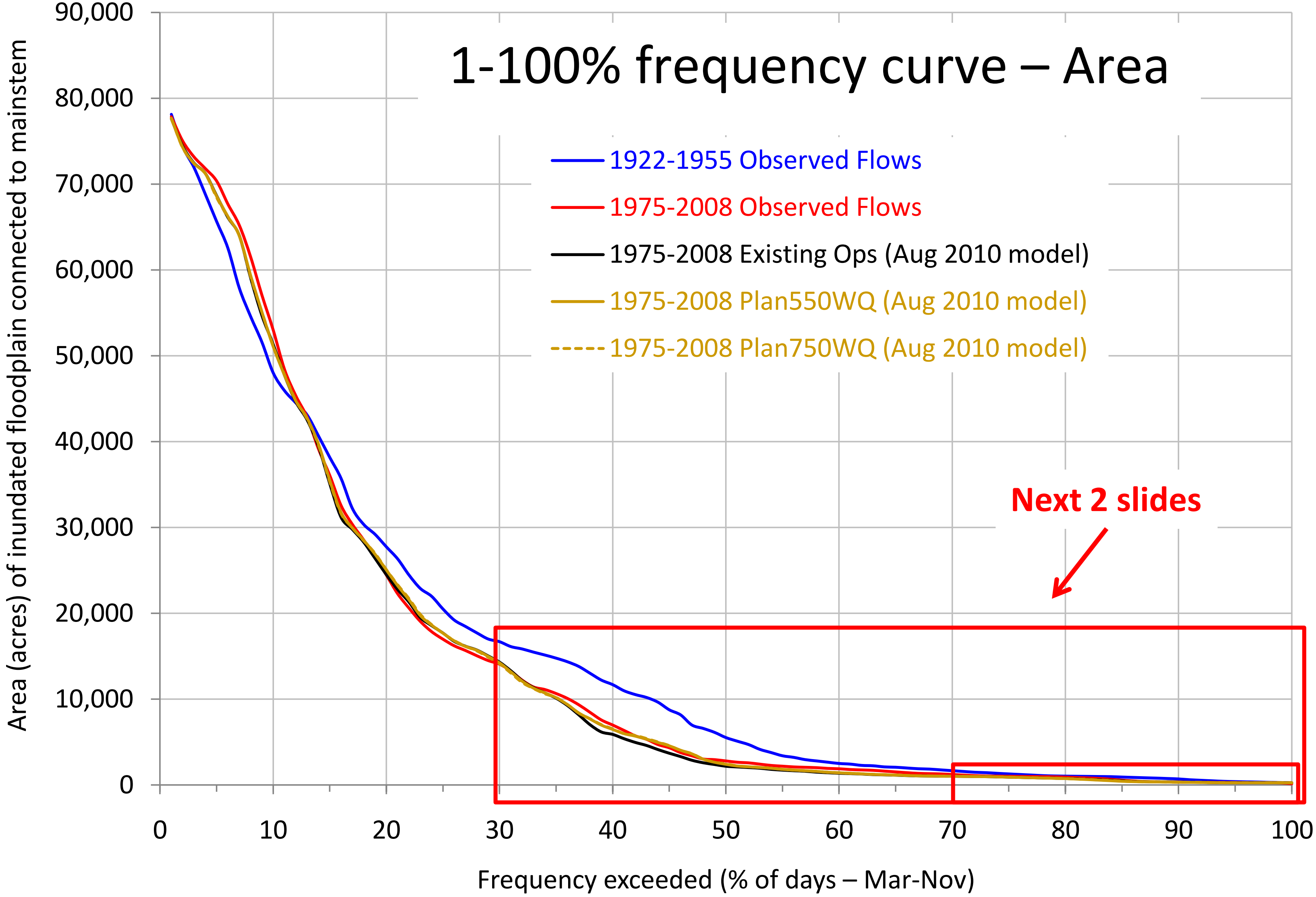

Next 2 slides

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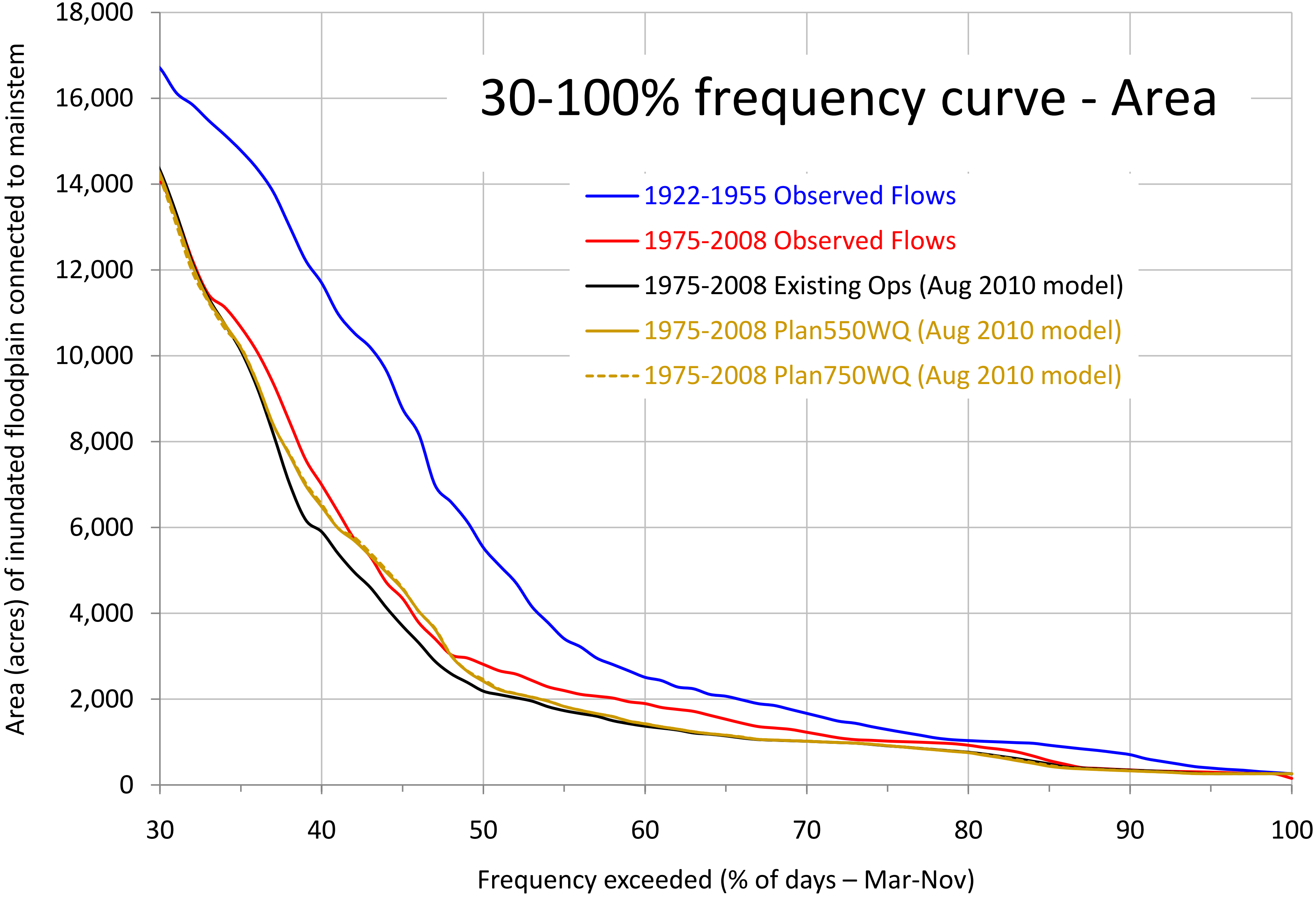

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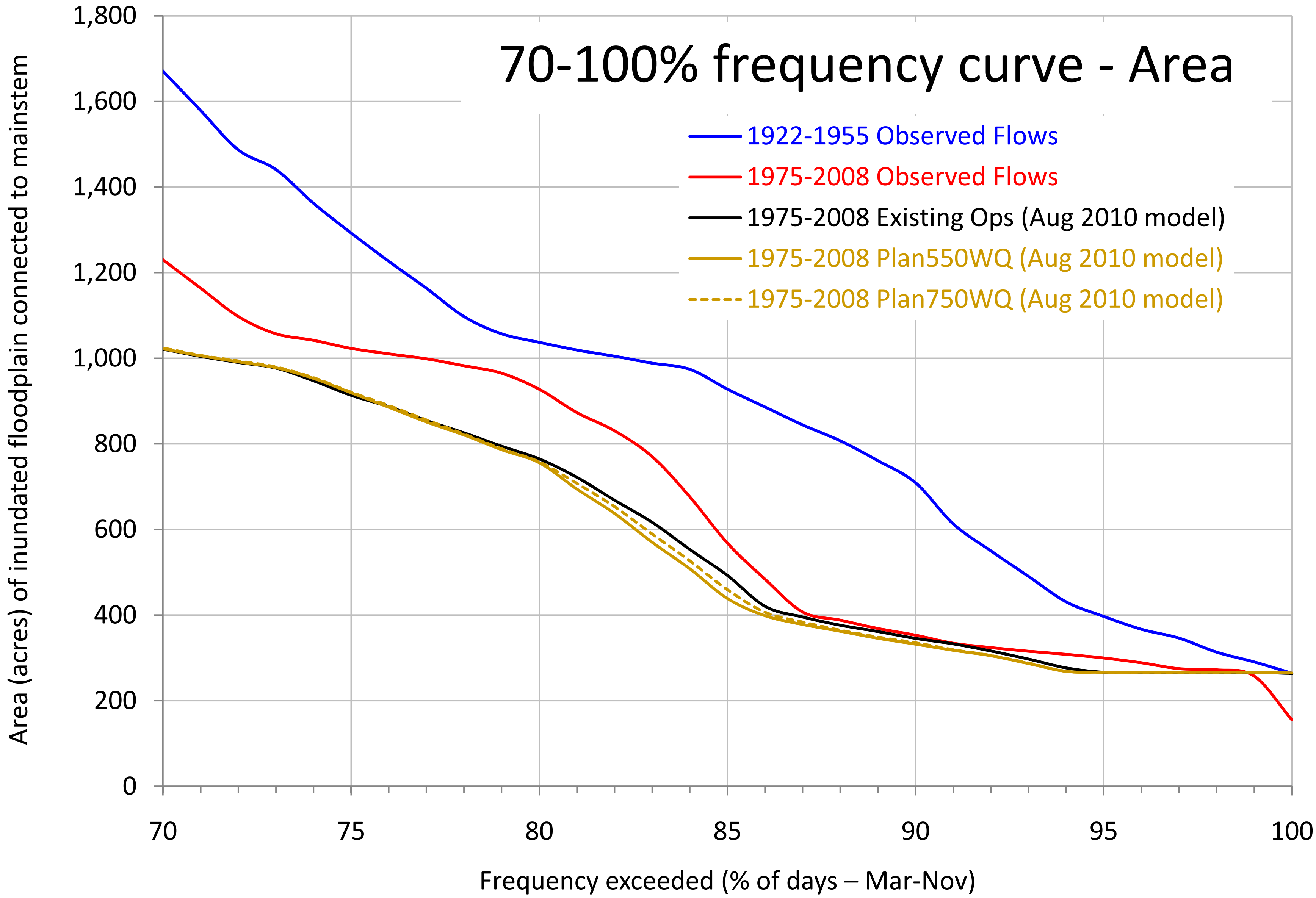

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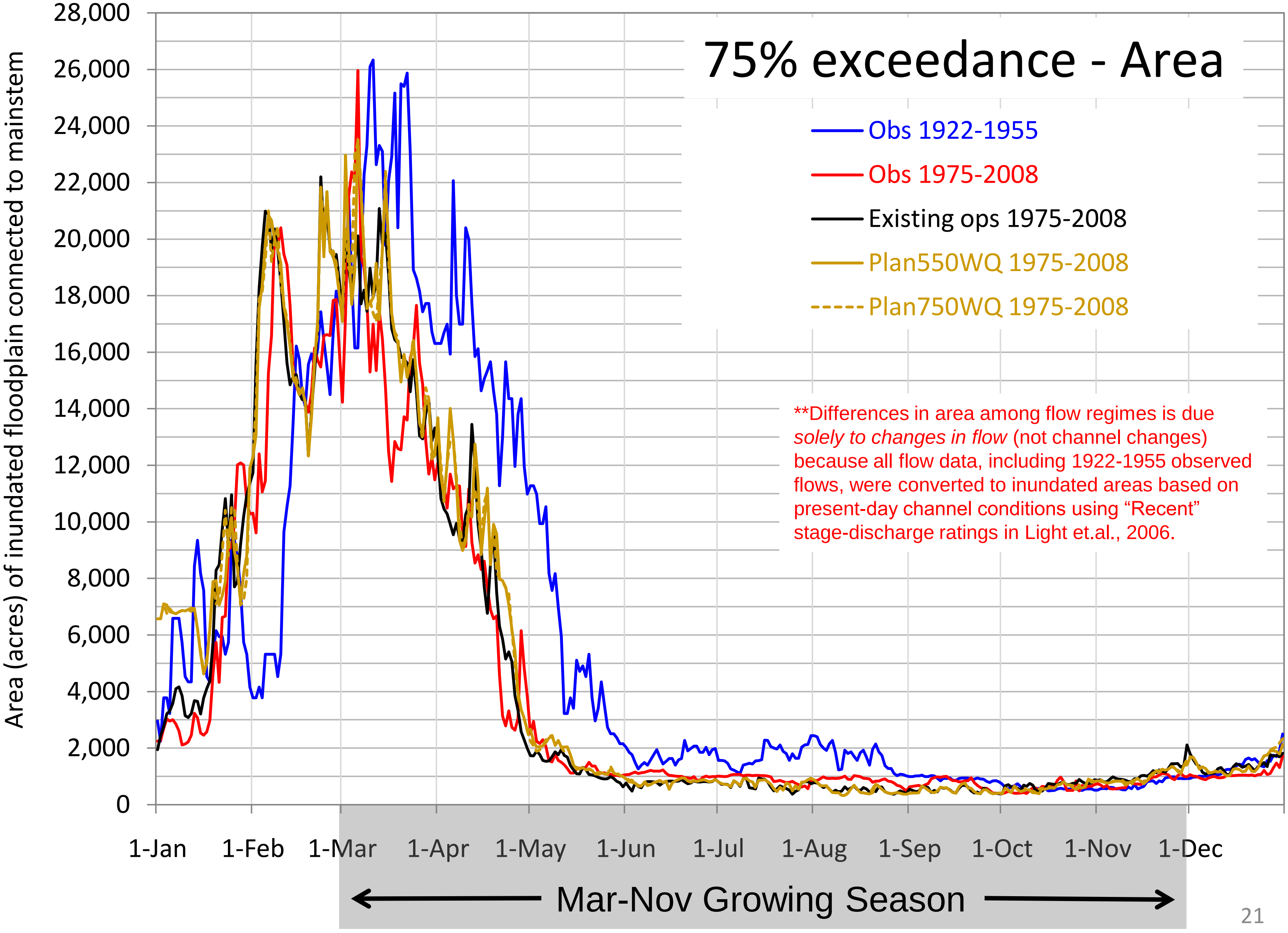

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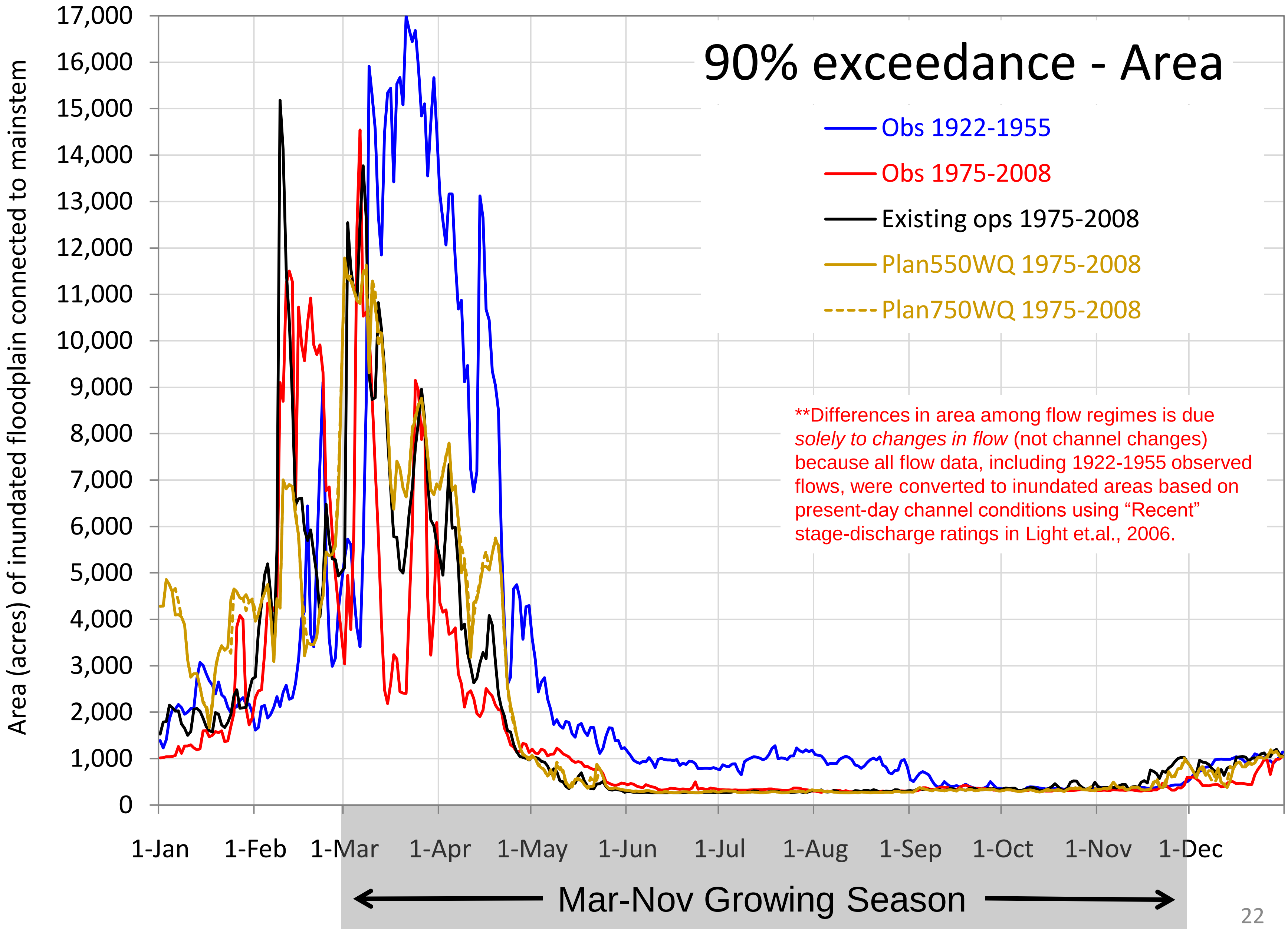

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Simulating the Impact of USACE Operating Alternatives on Salinity and Oyster Population in Apalachicola Bay, FL

Draft Interim Report

By

Y. Peter Sheng, Ph.D.,
Justin R. Davis, Ph.D., and
Vladimir A. Paramygin, Ph.D.

Civil and Coastal Engineering Department
University of Florida

Presented to the

Fish and Wildlife Service
U.S. Department of Interior

April 27, 2011

Table of Contents

Introduction

The Apalachicola-Chatahoochee-Flint (ACF) system is an important watershed-riverine-estuarine ecosystem which encompasses the tri-state area of Georgia, Alabama, and Florida. Freshwater originates in northeast Georgia and flows through Chattahoochee River, Flint River, and Apalachicola River before reaching the Apalachicola Bay in Florida. While the freshwater is used for drinking and agriculture, it is also vital to the shellfish in the Apalachicola Bay. Reduced freshwater flow in the ACF system will result in higher salinity in the Apalachicola Bay which could adversely impact the oysters. Low salinity, on the other hand, may endanger the federally threatened Gulf sturgeon in the Bay. Therefore, it is important to develop quantitative understanding on how freshwater flow in the ACF system impacts the salinity in the Apalachicola Bay, so that the amount of freshwater flow necessary to maintain fish and wildlife in Bay can be better understood.

As a first step towards the development of an integrated modeling system of the ACF system to enable assessment of the impact of freshwater withdrawal and climate change on the salinity and biological species inside the Apalachicola Bay, Sheng and Paramygin (2010a) developed a hydrodynamic model to simulate the flow and salinity distribution inside Apalachicola Bay. Their model is based on the 3D curvilinear-grid hydrodynamic model CH3D (Sheng 1987, Sheng et al. 2008, Sheng and Paramygin 2010a) and was successfully applied to simulate the salinity dynamics in the Bay during the summer of 2004 when 5 hurricanes passed the region. The simulation captured the significant variation in salinity that occurred during the 2004 hurricane season. The CH3D model used by Sheng and Paramygin (2010a) has several advantages over the model used by Huang (2010) for Apalachicola Bay:

- It uses a boundary-fitted grid to accurately resolve the complex shorelines of the Apalachicola Bay system;
- It uses very high spatial grid resolution (~20 m) in the horizontal directions;
- It can simulate circulation driven by wind, tide, and density gradients, while allowing flooding and drying of the shorelines during hurricanes and storms;
- It can be coupled to a large scale circulation model of the Gulf of Mexico;
- It allows incorporation of various wind and precipitation fields; and
- It has been integrated with ecosystem models, CH3D-IMS (Sheng and Kim 2009), and inundation models, CH3D-SSMS (Sheng et al. 2010; Sheng and Paramygin 2010b).

Therefore in this study we used the CH3D model for Apalachicola Bay to study the impact of freshwater alteration on the salinity, Gulf sturgeon, and oyster population in the Apalachicola Bay.

Results of the hydrodynamic and salinity simulations can be used to simulate the oyster population inside the Apalachicola Bay. Hofmann et al. (1992), Klinck et al. (1992), Powell et al. (2003) developed an oyster population dynamic model for oysters in Galveston Bay, Texas. Since Apalachicola Bay and Galveston Bay have similar-sized adult oyster populations, Wang et al. (2008) applied the post-settlement population dynamic model of Powell, Hofmann, and Klinck to Apalachicola Bay with necessary modifications to account for the specific conditions in Apalachicola Bay. Post-settlement adult oysters are divided into four size groups, while oyster filtration rate is assumed to be dependent on salinity, temperature, and turbidity, spawning patterns are dependent on the relationship between temperature and food supply during critical feeding periods, the same temperature-dependent reproduction efficiency equations from Galveston Bay holds true, and no specific relationship exists between salinity and oyster growth rate. Thus, low salinity results in low oyster reproduction due to lower filtration rate and higher respiration. Livingston et al. (2000) also studied the oyster population in Apalachicola Bay.

Wang et al. (2008) simulated the oyster population between March 2004 and June 2005 at two sites: Dry Bar, a site with strong river influence located to the southwest of the Apalachicola River, and Cat Point, a site with little river influence located to the southeast of the River. Model results agreed well with data except during July and September 2004 when hurricanes were affecting the Apalachicola Bay. Nevertheless, Wang et al. (2008) suggested that, anticipating increased freshwater use upstream of the Apalachicola River, Apalachicola Bay will become increasingly saltier, causing a substantial decrease in oyster growth rates, particularly in summer when oyster growth rates are normally high in the Bay.

During this study, we constructed and validated an oyster population dynamic model similar to the one described by Wang et al. (2008), and coupled it to the hydrodynamic-salinity model described above to assess the impact of freshwater alteration on oyster population in Apalachicola Bay.

Initial Model Setup and Verification

A CH3D model computational grid was developed for Apalachicola Bay and surrounding areas to simulate the salinity distribution in the bay, the grid, selected data sites, and bathymetry/topography values used in the model are shown in Figures 1 and 2. From hereon, this grid is referred to as the “fine” grid. A coarse grid has also been developed which has 4 times fewer grid cells. The “coarse” grid is obtained by merging 2 by 2 cell blocks of the fine grid into a single grid cell of the coarse grid and reapplying the bathymetry/topography interpolation.

CH3D is applied in a 3D mode with 8 vertical sigma-grid layers. The time step used for simulations is set to 1 minute which allows to 1 year to be simulated in approximately 1.2 days of wall clock time on a single CPU core (Intel Core i7 870 @ 2.93 Ghz).

The model has two open boundaries – at the west and south ends, tidal forcing (in a form of tidal constituents) is used at these boundaries to drive the tides inside the model domain. The tidal constituents are based on the data at the NOAA tidal gage (872-8690) located at the mouth of the Apalachicola River (Figure 1). Significant constituents (amplitudes > 1 cm) are K1, M2, O1, P1, S2, SA, and SSA.

A river flow boundary condition is introduced at the Apalachicola River (Sumatra gage) and the flows are based on the daily flow rates provided by the USACE. It is assumed that flow at the Sumatra gage is freshwater only, hence the river boundary value of salinity is set to 0 ppt.

Wind forcing over the domain is based on 6-hourly wind data from the NOGAPS model (https://www.fnmoc.navy.mil/public) and is linearly interpolated in time at the time step of the CH3D model.

The initial salinity field is based on interpolation of a HYCOM model snapshot of surface salinity; hence, the initial salinity profile is vertically uniform. Subsequently, all model simulations use a spin-up period of 3 months prior to starting the main simulation to ensure that there is time to establish a realistic (spatial and vertical) salinity distribution in the domain.

Apalachicola National Estuarine Research Reserve (ANERR) provides salinity data at several sites. Comparisons with observed data were done to verify the model, which showed satisfactory performance (Figure 3 and Figure 4) with the test year being simulated (2004).

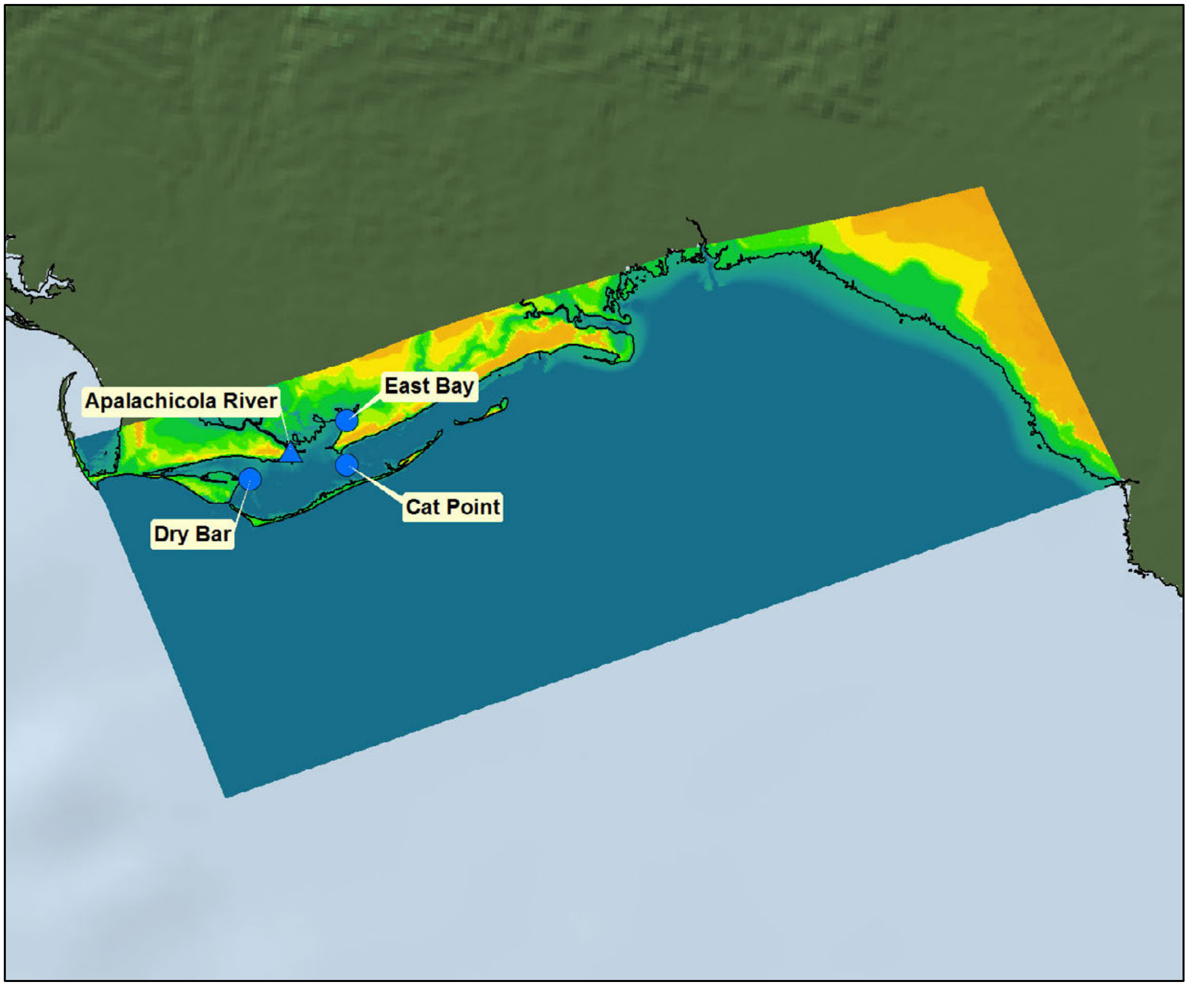


Figure 1. CH3D model grid and selected data sites

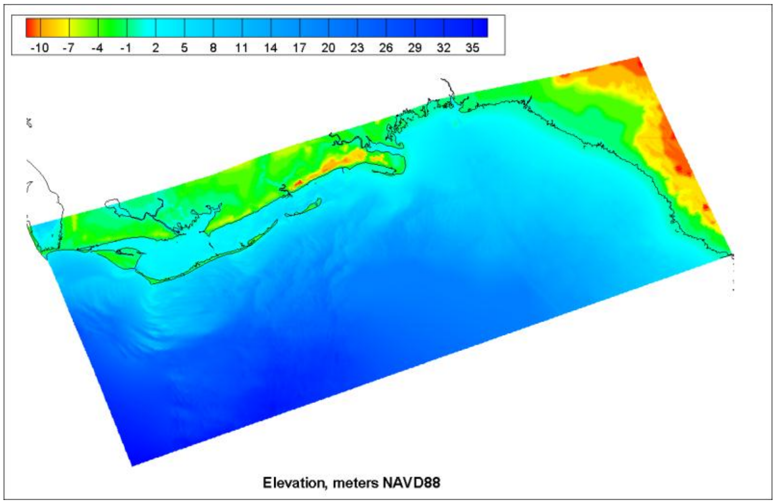


Figure 2. CH3D model grid bathymetry / topography

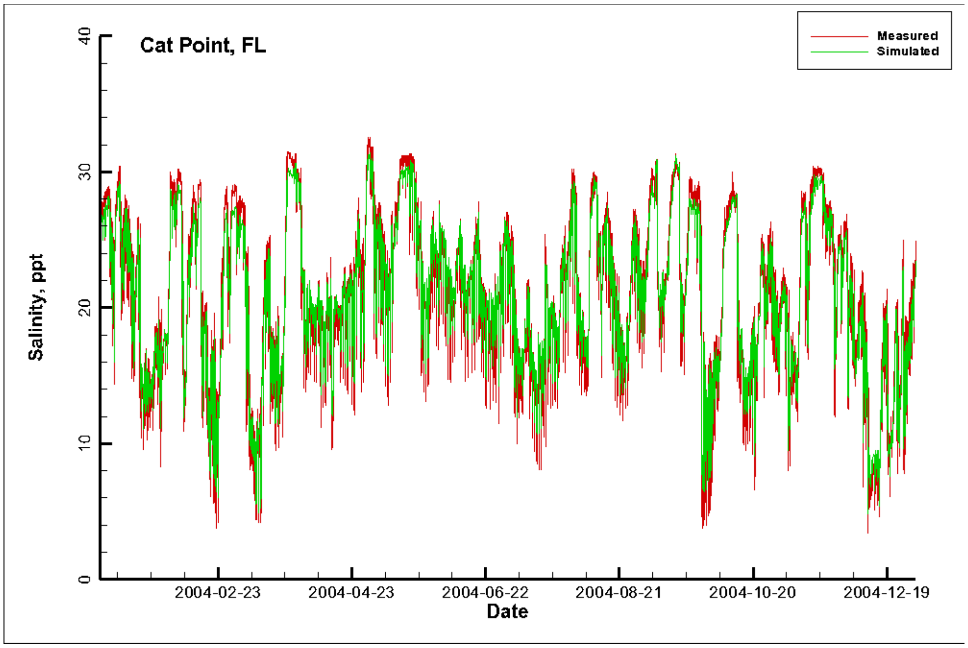


Figure 3. Simulated salinity at the Cat Point site during 2004

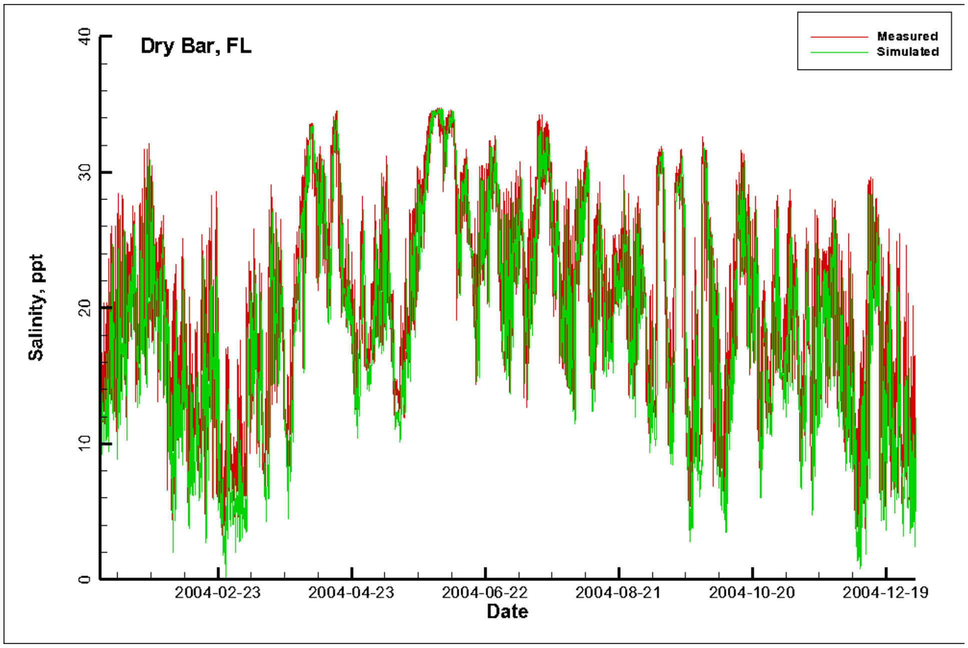


Figure 4. Simulated salinity at the Dry Bar site during 2004

10 Year Simulations

1999-2008. Fine grid

Four flow discharge scenarios were considered for the 10 year (1999-2008) simulations:

a) Observed

b) Current operations

c) Alternative #1

d) Alternative #2

Base scenario a) uses observed flow rates at the Sumatra gage provided by the USACE. Scenarios b), c) and d) use altered flows, statistics for the time series of flow rates are provided in Table 1.

With the exception of these flow rates all other model parameters and forcing remain the same for all scenarios.

Table 1. Statistics for the flow rates (m^3/s) at the Sumatra gage

	mean	**mean %**	**std dev**	**std dev %**	**min**	**max**
Observed	519.2		411.4		124.6	4700.6
Current	514.4	0.92	391.3	4.89	136.4	3965.7
Alt #1	515.9	0.64	391.4	4.86	136.4	3965.7
Alt #2	516.4	0.54	391.0	4.96	136.4	3965.7

Salinity for the observed scenario during 2004 is consistent with the results produced by the verification simulation displayed in Figure 3 and Figure 4. These results show that there is little difference in salinity inside Apalachicola Bay between the observed scenario and the current and alternate scenarios. However, due to reduced flow rates, simulated salinity in current and alternate scenarios results in slightly higher highs and lower lows as compared to the observed scenario.

1980-1989. Fine grid

Another 10 year time period was also considered (1980-1989). This period was chosen to correspond to the period used by Huang (2010). The same grid was used as in the previous simulations.

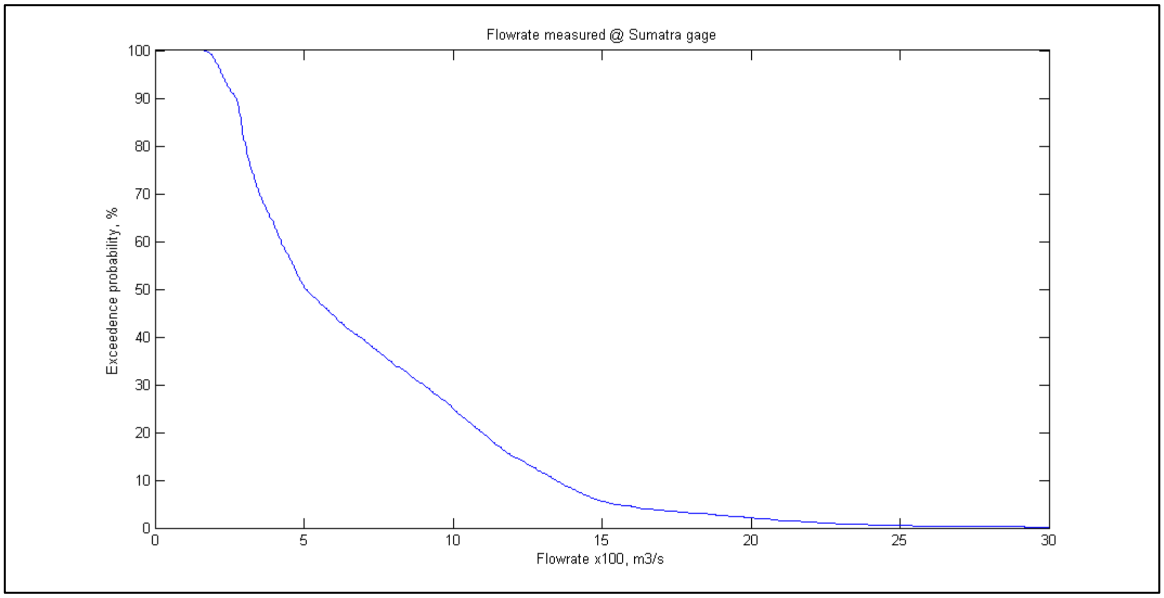


Figure 5. Obsereved flowrate probability of exceedence at the Sumatra gage

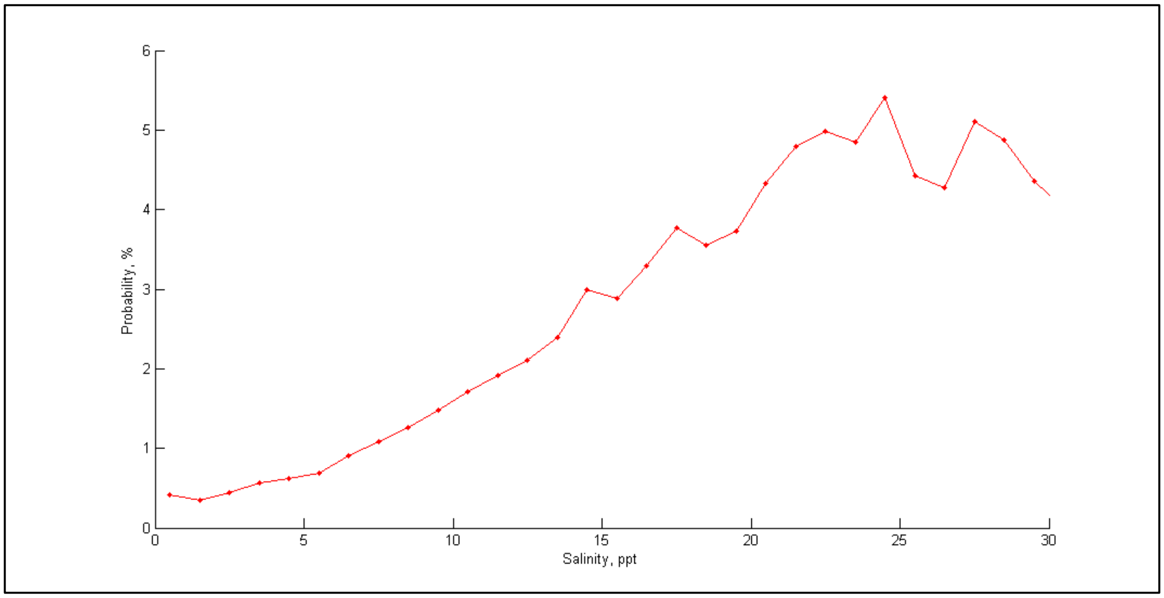


Figure 6. Probability density of simulated salinity at Cat Point

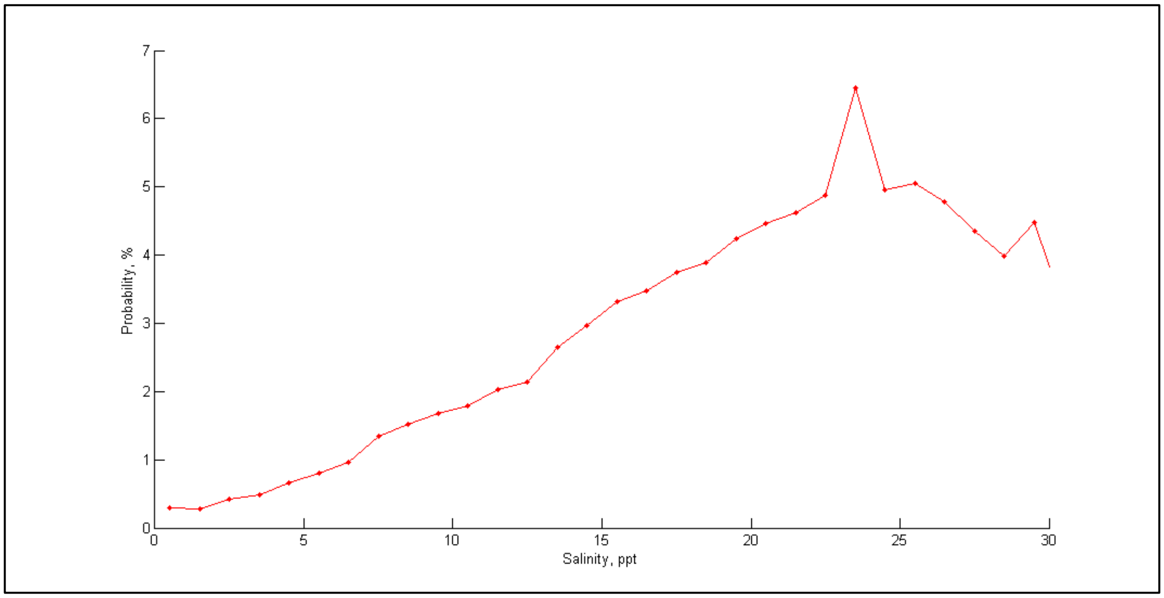


Figure 7. Probability density of simulated salinity at Dry Bar

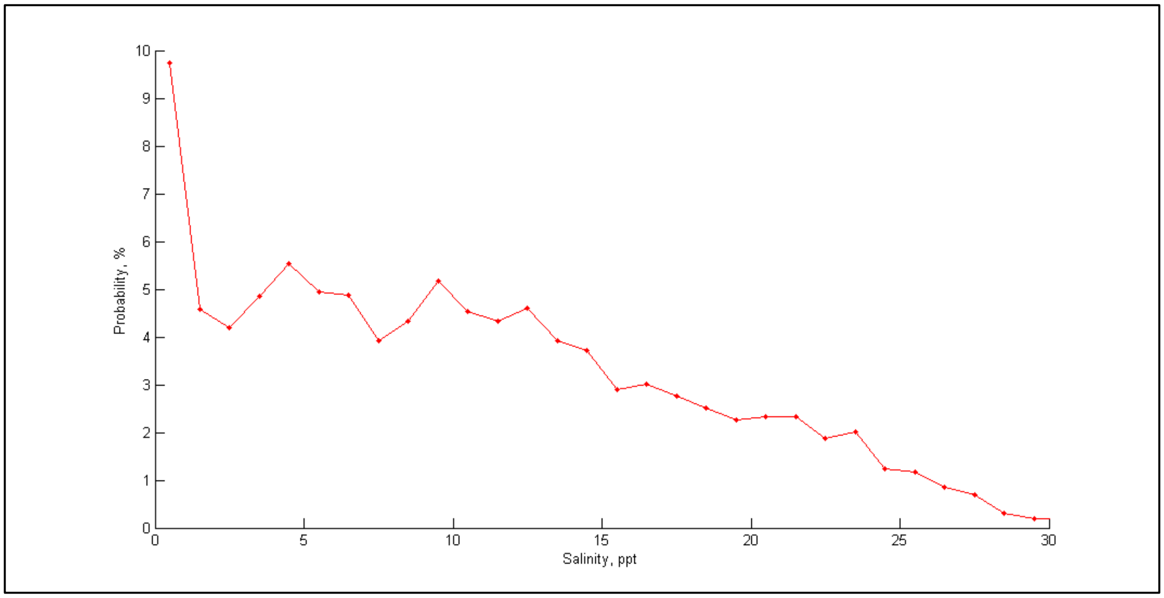


Figure 8. Probability density of simulated salinity at East Bay

1980-1989. Coarse grid

Due to the simulated salinity differing slightly from the results of Huang (2010) – a coarser grid was developed in an attempt to better reproduce Huang's two distinctive peaks in the probability of exceedance figures for salinity; however, results were similar to those produced by the finer grid model and aggregate functions (e.g. probability of exceedence, probability density, etc.) showed little difference compared to the fine grid model results.

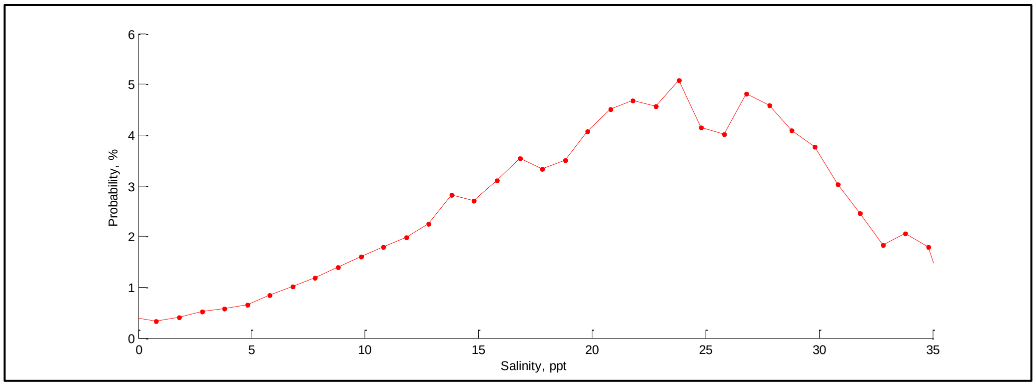


Figure 9. Probability density of simulated salinity at Cat Point

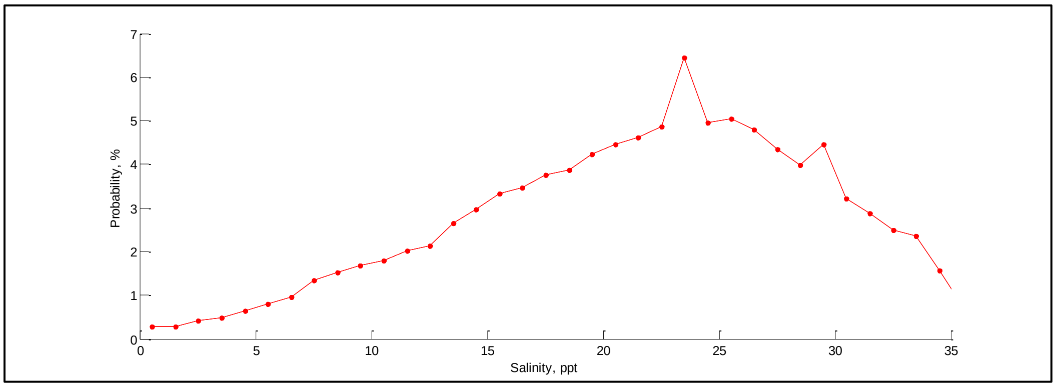


Figure 10. Probability density of simulated salinity at Dry Bar

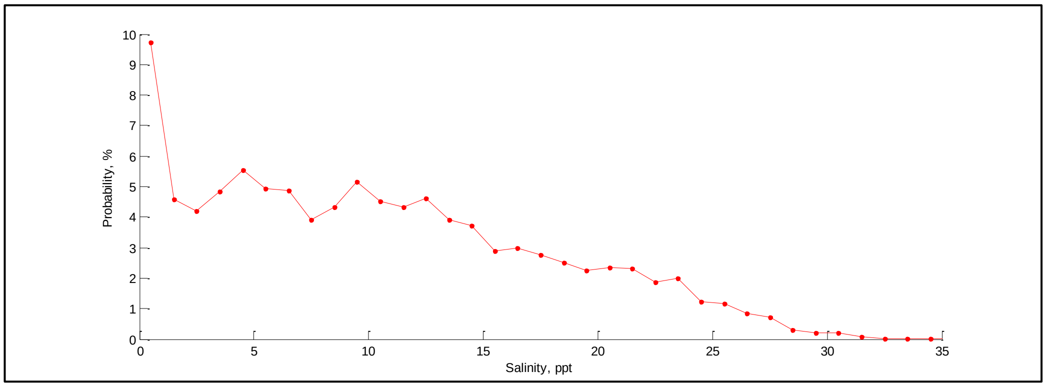


Figure 11. Probability density of simulated salinity at East Bay

Analysis Products

A number of model outputs were requested by the FWS – the complete list is available in Appendix B. This section comprises of the figures and tables that are dedicated to fulfilling the request and provide various information based on the results of simulations. All model results presented in this section are based on the 10 year simulation (1999-2008) fine grid using the four different flow scenarios. Given that the flow rate is the only parameter which changes – it is the only parameter that affects the differences in salinity and therefore results, generally, correlate well with the flow at Sumatra gage.

Figure 12 and Figure 13 show the exceedence probability at the Cat Point and Dry Bar sites, respectively, for the four scenarios. As it was mentioned previously – the observed scenario produces slightly higher highs and lower lows in salinity values and there is very little difference, however, between the Current, Alternative #1 and Alternative #2 scenarios.

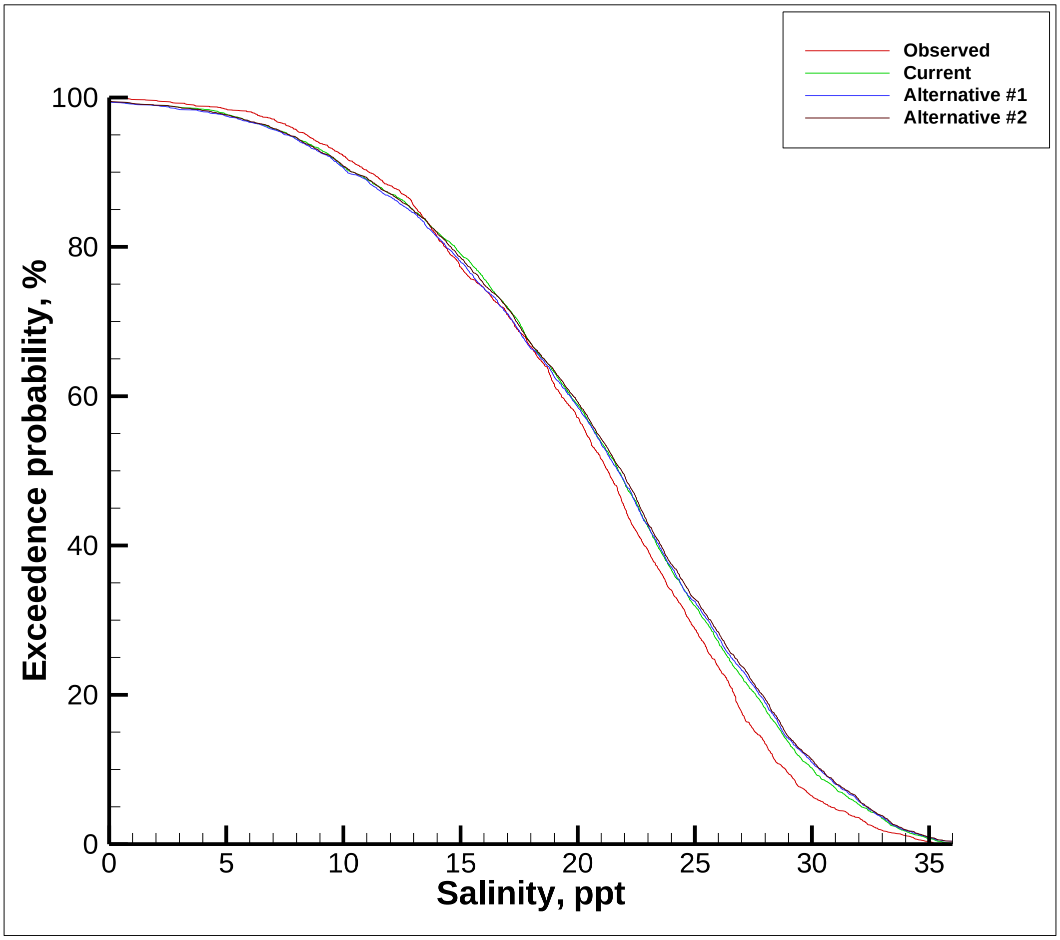


Figure 12. Probability of exceedence at the Cat Point site

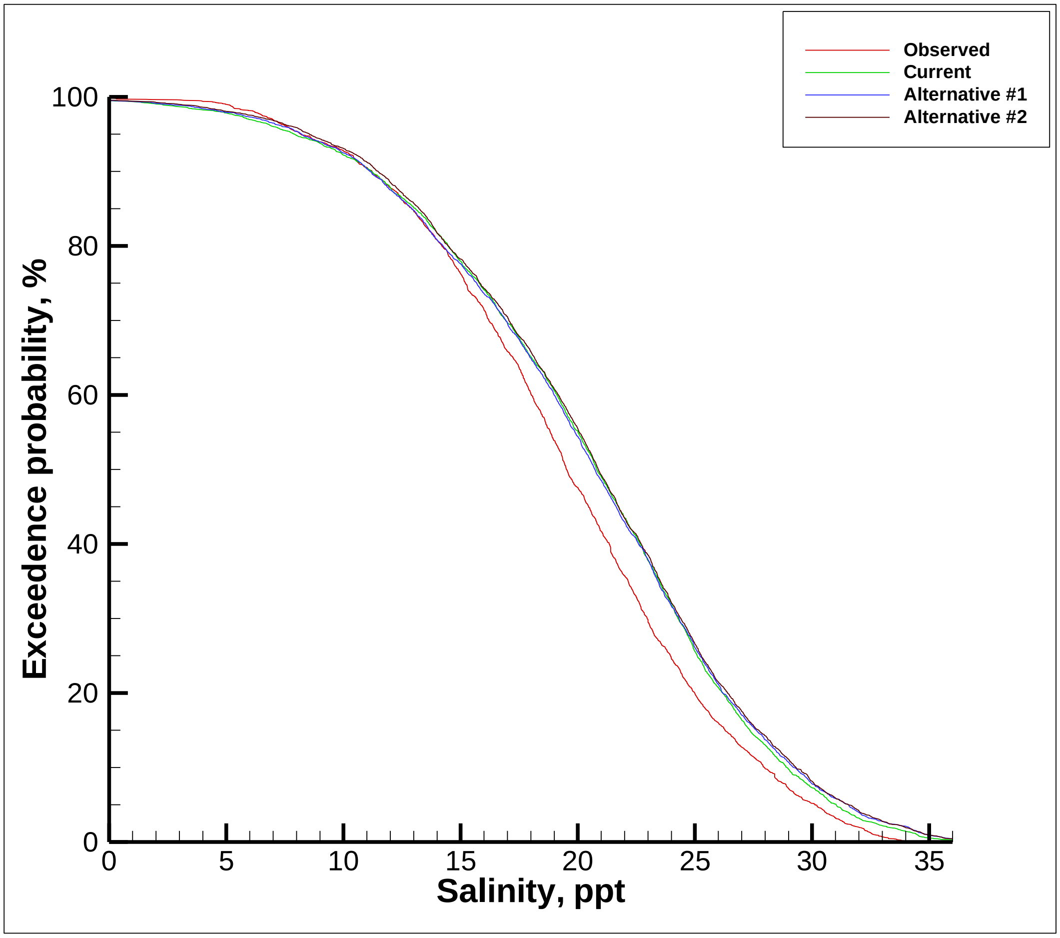


Figure 13. Probability of exceedence at the Dry Bar site

Summary statistics for growth rates of Class 4 (Marketable) oysters at the Cat Point and Dry Bar sites are presented in the tables and figures below. It can be clearly seen that the mean growth rate in August is significantly larger (3 to 4 times) as compared to the growth rate for the entire year at the Cat Point site and smaller for the Dry Bar site. Oyster population model results are based on the simulated bottom salinity at Cat Point and Dry Bar for the four flow scenarios.

Table 2. Growth rate (mg AFDW/oyster/day) statistics for Class 4 (marketable) oysters at Cat Point for the 10 year simulations.

Statistic	Scenario	All Months	August Months Only
Mean	Observed	1.78	5.79
	Current	1.41	4.66
	Alternate #1	1.30	4.31
	Alternate #2	1.31	4.35
Median	Observed	2.65	7.08
	Current	2.65	7.00
	Alternate #1	2.63	6.99
	Alternate #2	2.63	6.99
Standard Deviation	Observed	5.73	5.00
	Current	6.46	7.10
	Alternate #1	6.63	8.01
	Alternate #2	6.62	7.90
Interquartile Range	Observed	1.43	2.10
	Current	1.39	2.16
	Alternate #1	1.42	2.17
	Alternate #2	1.42	2.17

Table 3. Growth rate (mg AFDW/oyster/day) statistics for Class 4 (marketable) oysters at Dry Bar for the 10 year simulations.

Statistic	Scenario	All Months	August Months Only
Mean	Observed	2.92	2.19
	Current	2.42	0.81
	Alternate #1	2.39	0.69
	Alternate #2	2.44	0.78
Median	Observed	4.42	5.26
	Current	4.41	5.14
	Alternate #1	4.39	5.14
	Alternate #2	4.39	5.15
Standard Deviation	Observed	5.04	7.63
	Current	6.36	10.45
	Alternate #1	6.26	10.39
	Alternate #2	6.20	10.32
Interquartile Range	Observed	1.87	1.23
	Current	1.97	1.23
	Alternate #1	2.05	1.95
	Alternate #2	2.03	1.63

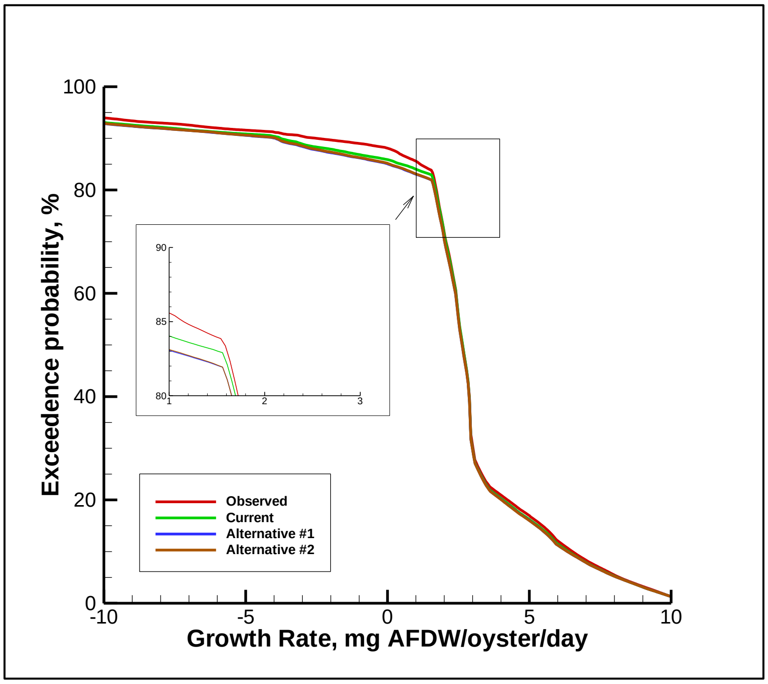


Figure 14. Exceedance probabilty at Cat Point as a function of growth rate for marketable oysters (Class 4) for the 10 year simulations during all months.

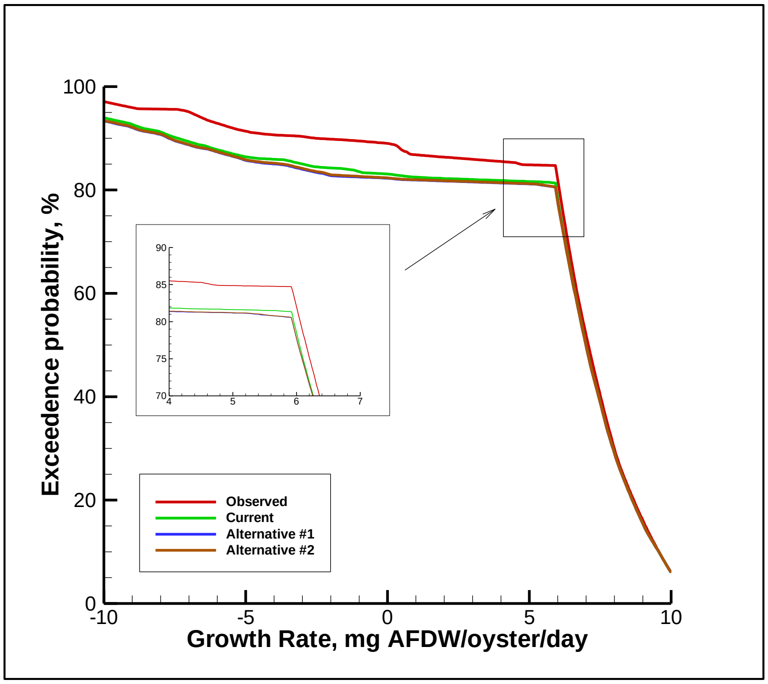


Figure 15. Exceedance probabilty at Cat Point as a function of growth rate for marketable oysters (Class 4) for the 10 year simulations during the August months only.

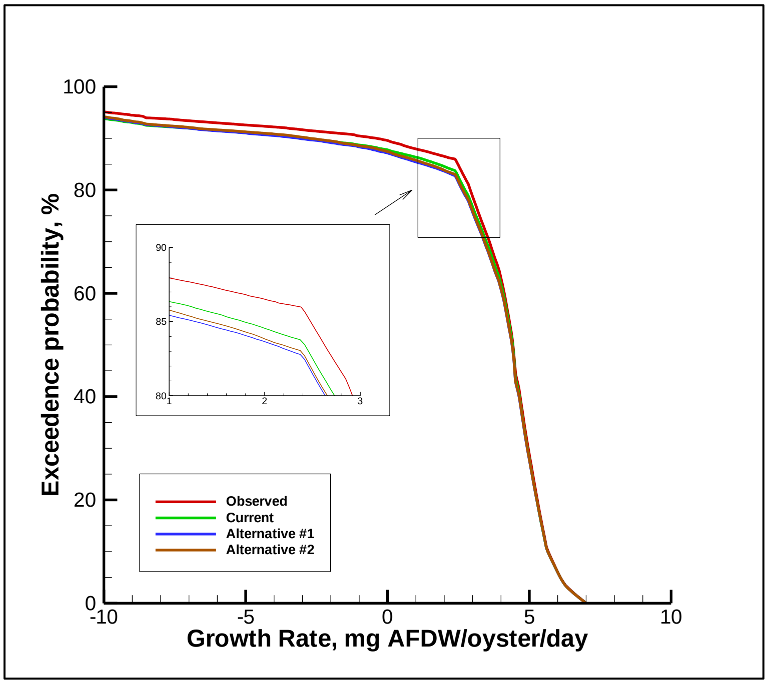


Figure 16. Exceedance probabilty at Dry Bar as a function of growth rate for marketable oysters (Class 4) for the 10 year simulations during all months.

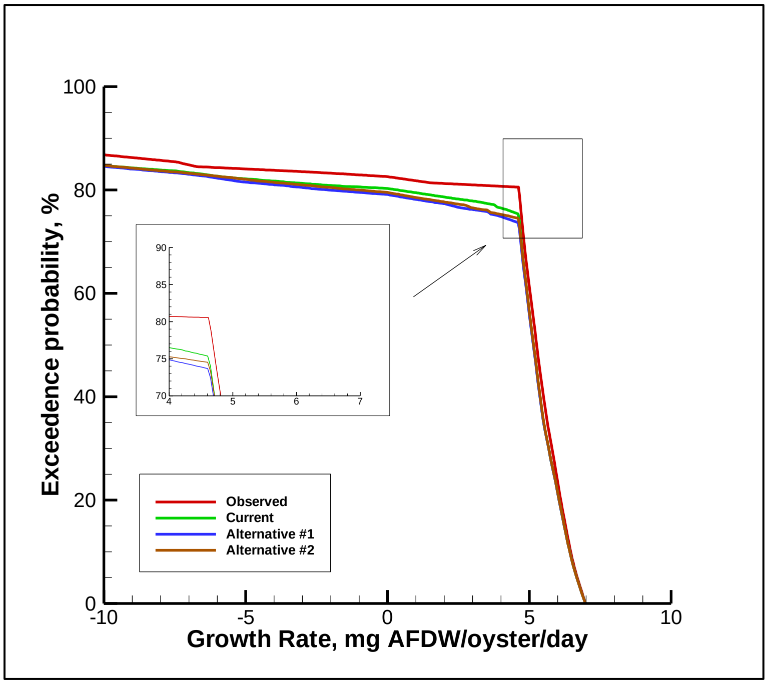
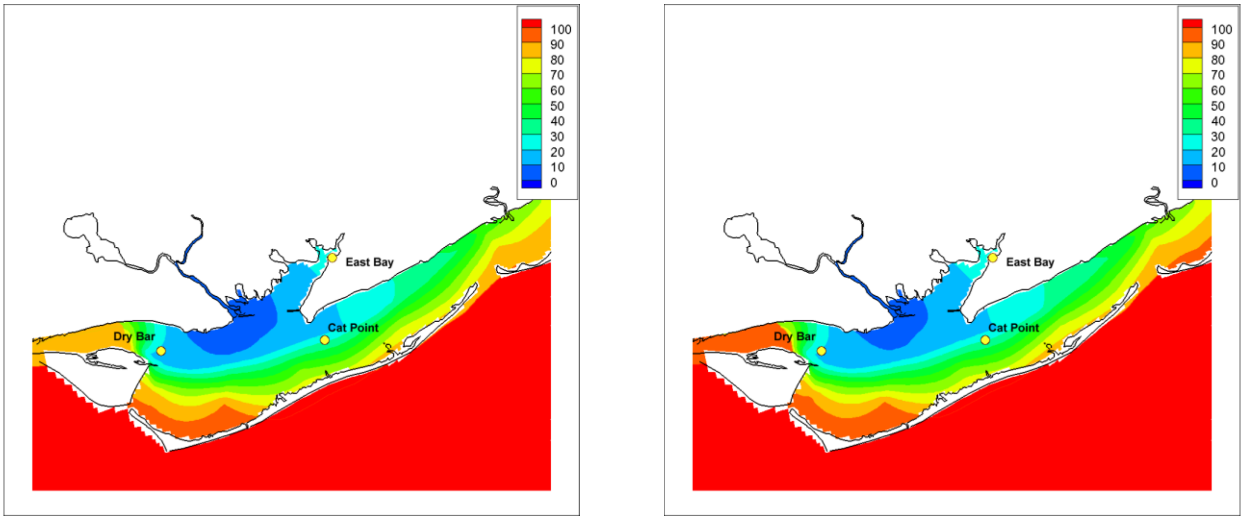
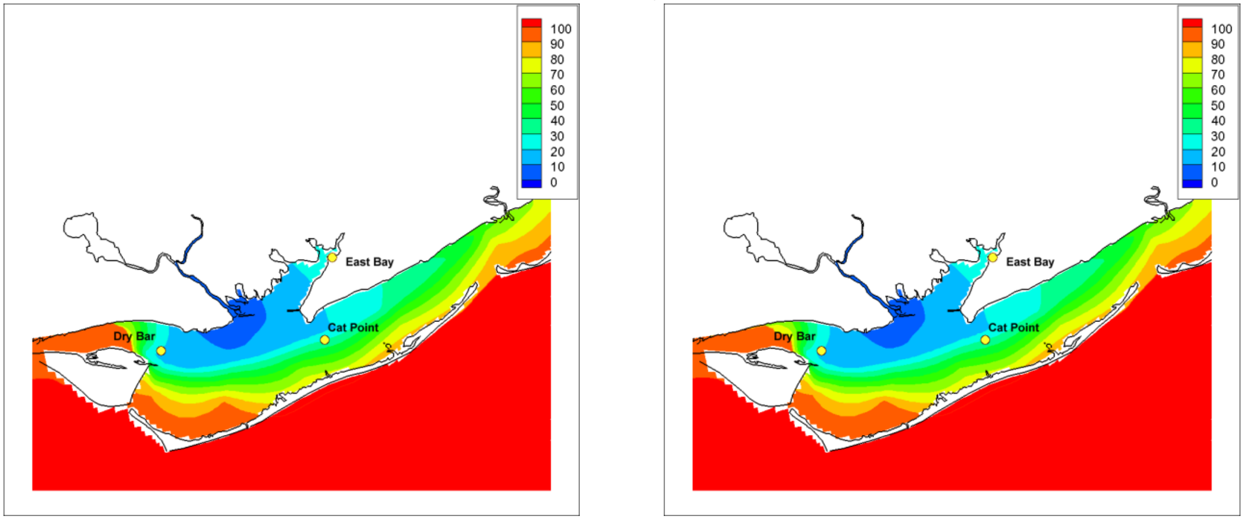


Figure 17. Exceedence probability at Dry Bar as a function of growth rate for marketable oysters (Class 4) for the 10 year simulations during the August months only.

The following figures and tables present the number of days when salinity exceeds 26 ppt (important for oysters) and when the salinity exceeds 10 ppt (important for sturgeon).



a) Observed b) Current

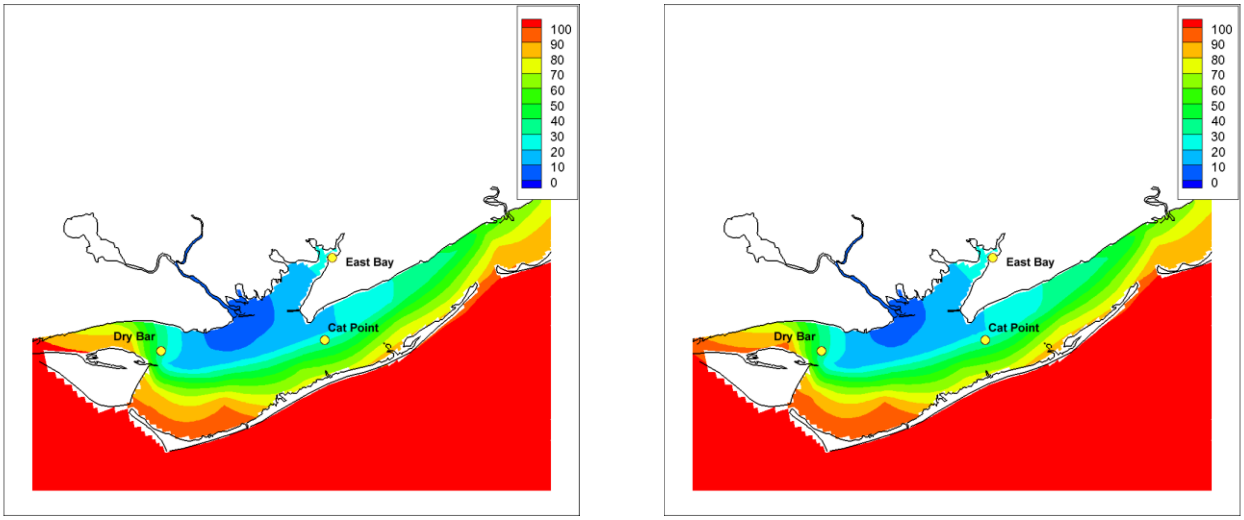


c) Alternative #1 d) Alternative #2

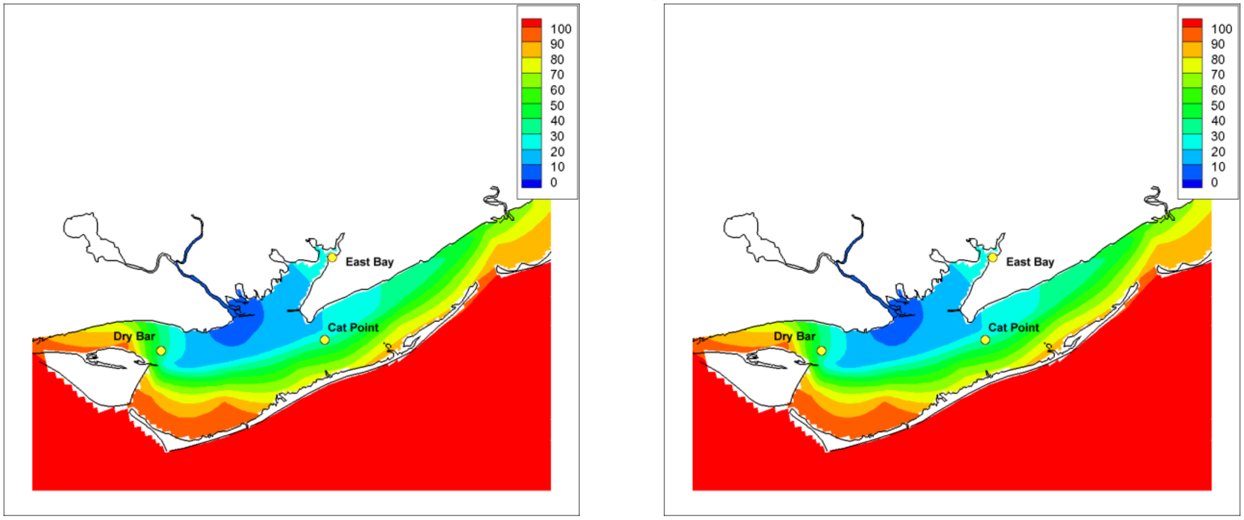
Figure 18. Percentage of days when salinity exceeds 26 ppt for four scenarios during a dry (annual discharge) year (2002)

Table 4 Acreages affected by the percentage of days when salinity exceeds 26 ppt for four scenarios during a dry (annual discharge) year (2002)

% of days	Observed	Current	Alternative #1	Alternative #2
0-10	8682.77	5804.57	5499.89	5079.00
10-20	17059.82	17788.53	17818.89	17741.41
20-30	10170.56	10540.15	10608.20	10777.82
30-40	9461.74	9566.44	9603.08	9618.79
40-50	9057.60	9050.27	9019.90	9077.49
50-60	9839.71	9555.97	9539.22	9509.90
60-70	12861.35	12208.02	12175.56	12048.88
70-80	12351.46	12982.80	12978.61	13360.77
80-90	18268.06	10956.86	10889.85	10521.30



a) Observed b) Current

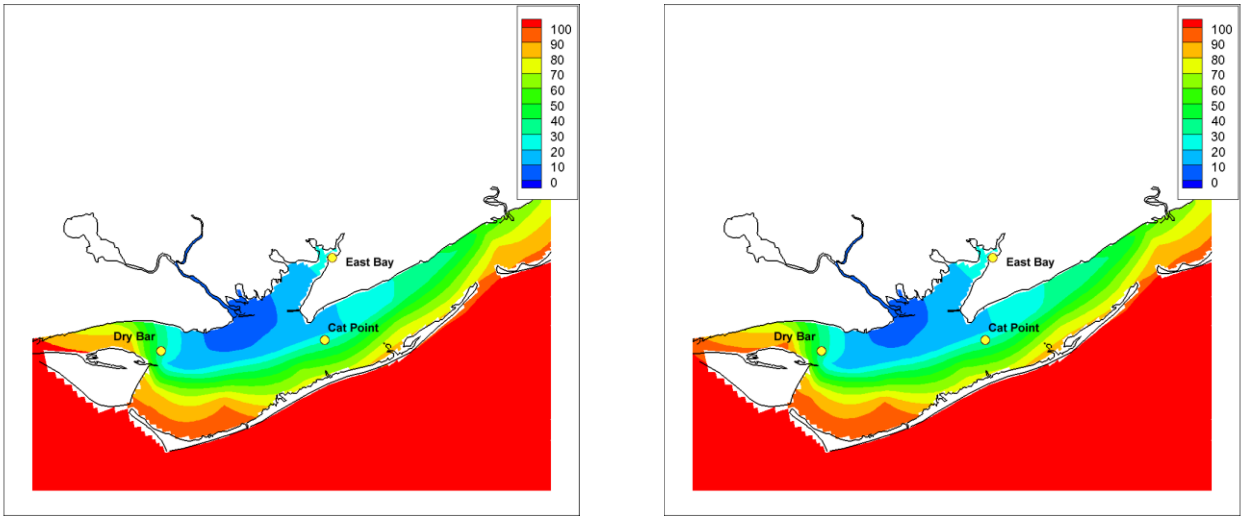


c) Alternative #1 d) Alternative #2

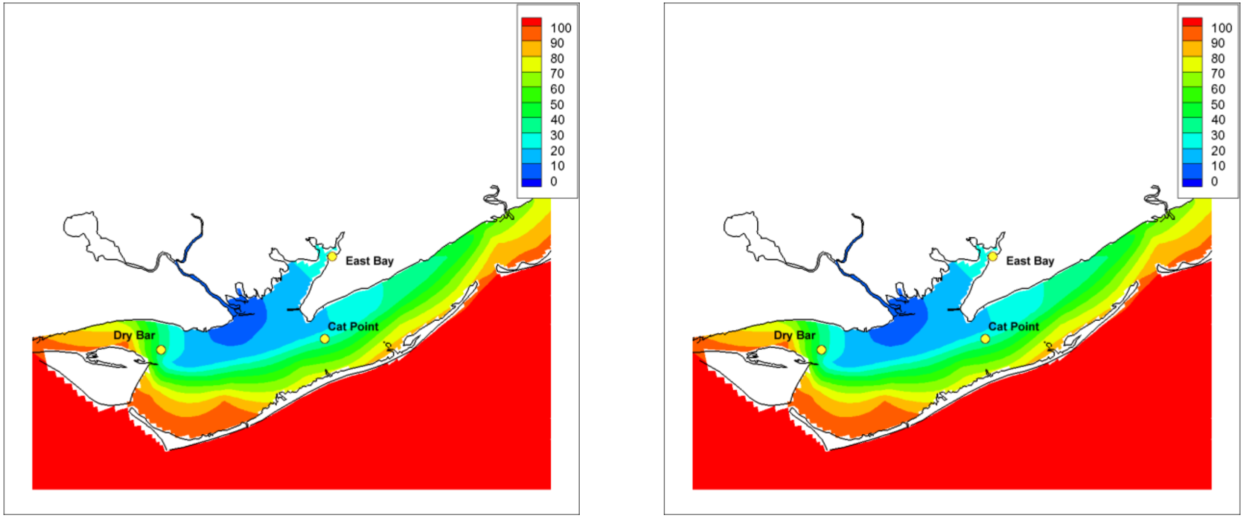
Figure 19. Percentage of days when salinity exceeds 26 ppt for four scenarios during a wet (annual discharge) year (2005)

Table 5. Acreages affected by the percentage of days when salinity exceeds 26 ppt for four scenarios during a wet (annual flow) year (2005)

% of days	Observed	Current	Alternative #1	Alternative #2
0-10	7032.70	4895.77	4640.30	4420.43
10-20	15968.84	15783.53	15684.06	15553.18
20-30	10609.25	11019.67	11166.25	11263.63
30-40	9845.99	10061.67	10050.15	10084.70
40-50	9505.71	9453.36	9484.77	9463.83
50-60	10223.96	10063.76	9995.71	9976.86
60-70	13348.20	12568.19	12504.32	12366.12
70-80	13862.28	14223.49	14231.87	14372.17
80-90	15062.14	14692.55	14662.19	14608.79



a) Observed b) Current

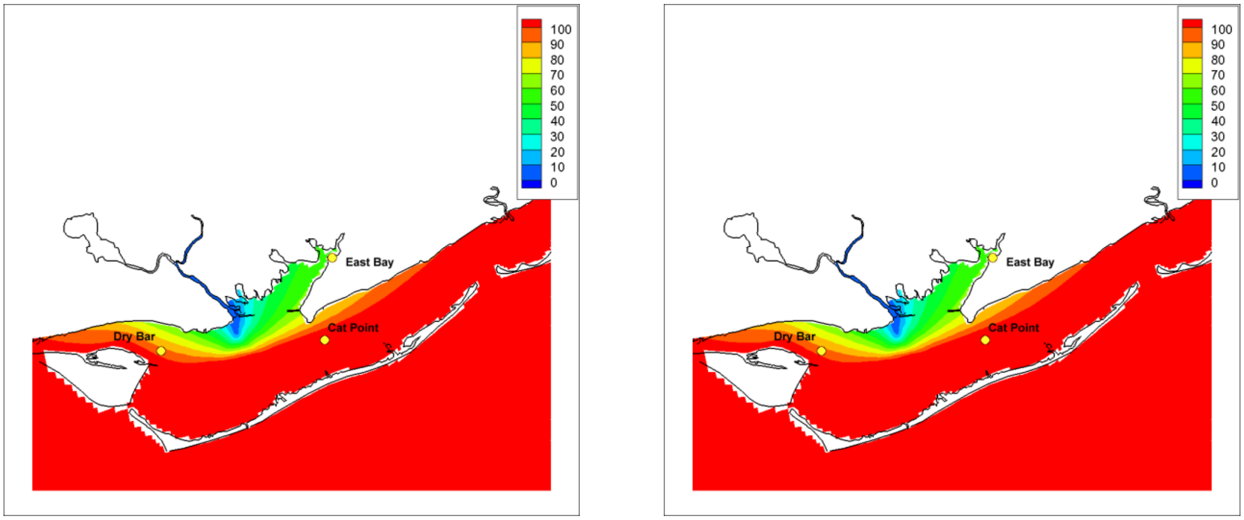


c) Alternative #1 d) Alternative #2

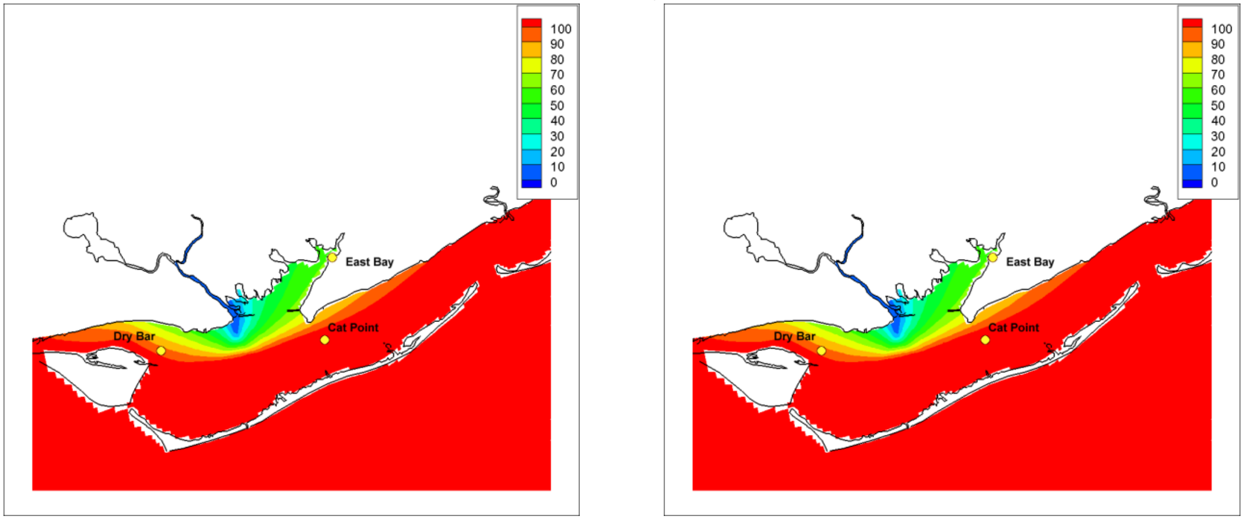
Figure 20. Percentage of days when salinity exceeds 26 ppt for four scenarios during an average (annual flow) year (2001)

Table 6. Acreages affected by the percentage of days when salinity exceeds 26 ppt for four scenarios during an average (annual flow) year (2001)

% of days	Observed	Current	Alternative #1	Alternative #2
0-10	7649.38	5406.71	5247.56	5290.49
10-20	16005.49	16189.76	16167.77	16163.59
20-30	10287.82	10636.47	10689.87	10681.49
30-40	9789.45	9850.18	9873.21	9867.97
40-50	9432.42	9459.64	9452.32	9468.02
50-60	10277.35	10073.19	10009.32	10011.41
60-70	13204.76	12466.63	12489.66	12479.19
70-80	13785.85	14188.94	14174.29	14171.14
80-90	14313.54	13396.37	13339.83	13367.05



a) Observed b) Current

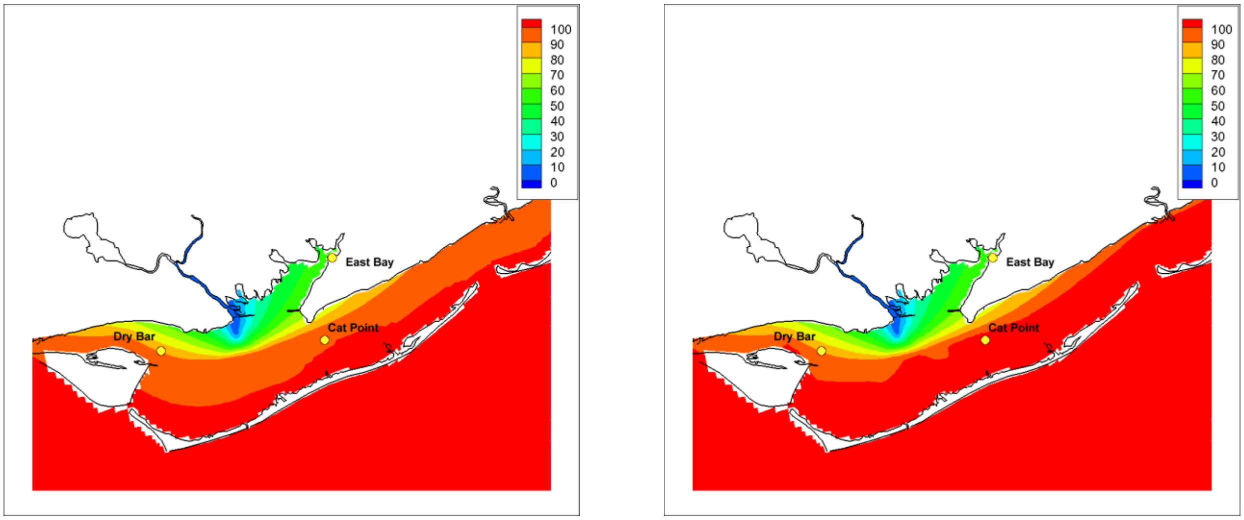


c) Alternative #1 d) Alternative #2

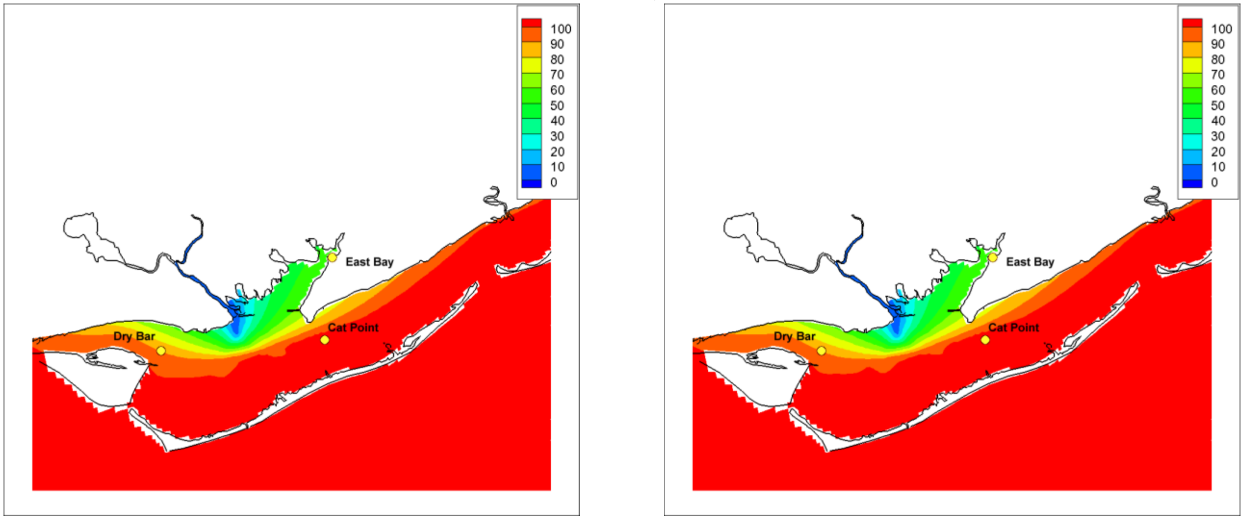
Figure 21. Percentage of days when salinity exceeds 10 ppt for four scenarios during Oct-Mar of a dry (Oct-Mar flow) year (2001)

Table 7. Acreages affected by the percentage of days when salinity exceeds 10 ppt for four scenarios during Oct-Mar of a dry (Oct-Mar flow) year (2001)

% of days	Observed	Current	Alternative #1	Alternative #2
0-10	526.64	493.14	463.82	468.01
10-20	794.67	785.25	770.59	775.83
20-30	1045.95	1031.29	1022.92	1019.78
30-40	1460.56	1420.78	1383.09	1387.27
40-50	3085.51	2980.81	2884.48	2911.71
50-60	4935.56	4982.67	4887.40	4918.81
60-70	3075.04	3082.37	3226.85	3204.87
70-80	3390.19	3340.98	3351.45	3348.31
80-90	5305.15	5225.58	5049.68	5062.24



a) Observed b) Current

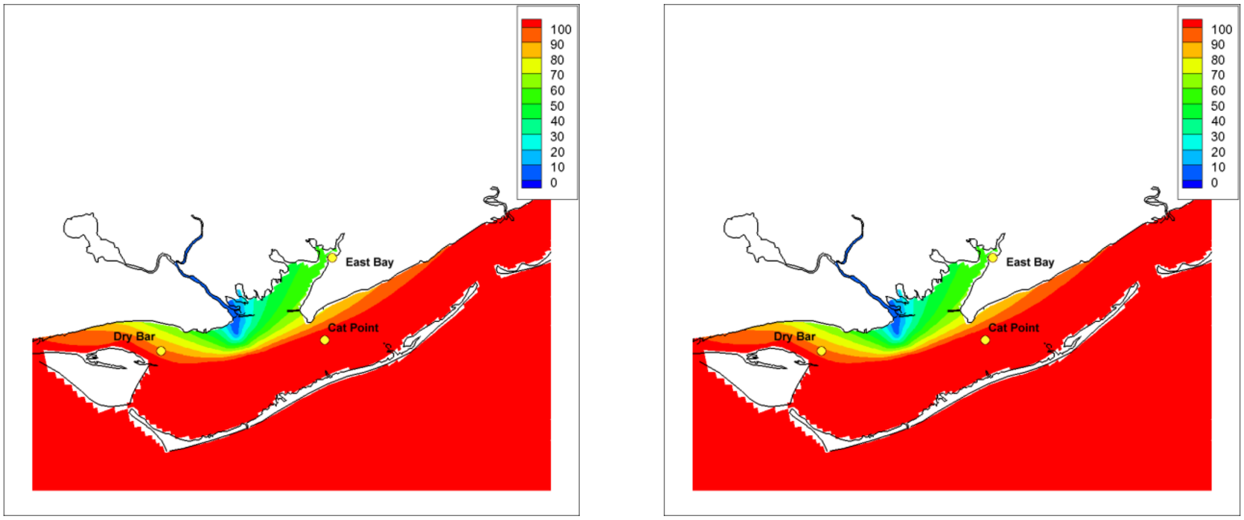


c) Alternative #1 d) Alternative #2

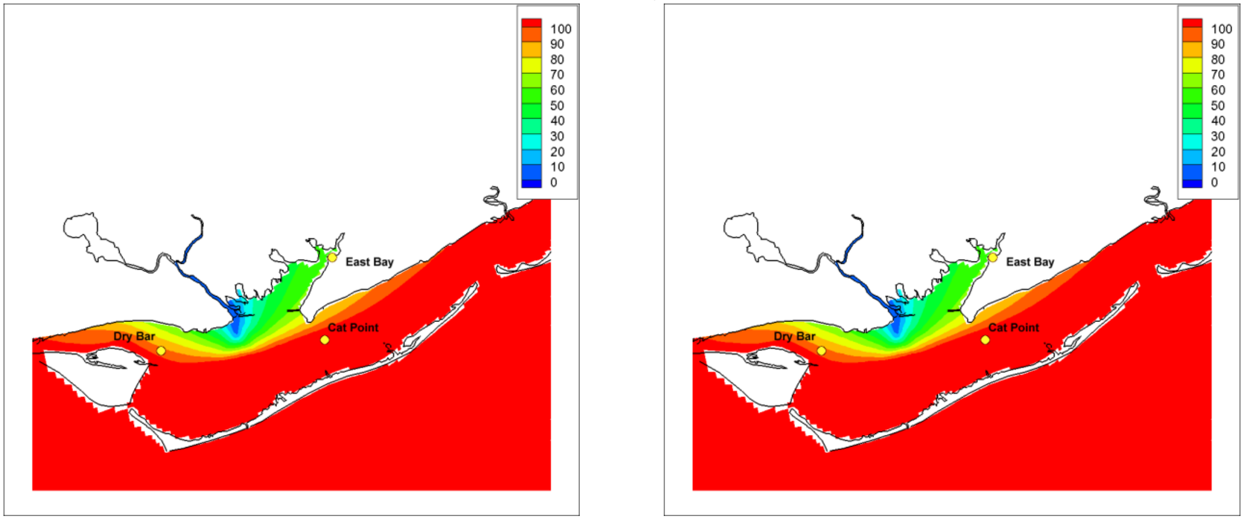
Figure 22. Percentage of days when salinity exceeds 10 ppt for four scenarios during Oct-Mar of a wet (Oct-Mar flow) year (2009)

Table 8. Acreages affected by the percentage of days when salinity exceeds 10 ppt for four scenarios during Oct-Mar of a wet (Oct-Mar flow) year (2009)

% of days	Observed	Current	Alternative #1	Alternative #2
0-10	571.66	506.75	505.70	488.95
10-20	899.37	885.76	854.35	855.40
20-30	1137.04	1105.63	1119.24	1109.82
30-40	1675.20	1614.47	1606.10	1570.50
40-50	3975.46	3800.61	3743.02	3727.32
50-60	4733.49	4844.47	4885.30	4913.57
60-70	3294.91	3284.44	3265.59	3269.78
70-80	4268.62	4090.63	4029.90	4010.01
80-90	7307.01	6996.05	6997.10	6869.37



a) Observed b) Current



c) Alternative #1 d) Alternative #2

Figure 23. Percentage of days when salinity exceeds 10 ppt for four scenarios during Oct-Mar of an average (Oct-Mar flow) year (2004)

Table 9. Acreages affected by the percentage of days when salinity exceeds 10 ppt for four scenarios during Oct-Mar of an average (Oct-Mar flow) year (2004)

% of days	Observed	Current	Alternative #1	Alternative #2
0-10	531.88	505.70	481.62	468.01
10-20	818.75	793.63	793.63	776.87
20-30	1052.23	1040.72	1040.72	1051.19
30-40	1464.75	1477.32	1454.28	1405.07
40-50	3229.99	3090.74	3046.77	3009.08
50-60	4983.72	4995.24	4995.24	5028.74
60-70	3073.99	3062.47	3107.50	3110.64
70-80	3455.10	3453.01	3418.45	3401.70
80-90	5599.36	5463.25	5407.75	5325.04

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Appendix A. Description of the Oyster Population Model

The time-dependent, post-settlement, oyster population model (e.g. Powell et al. 1992; Hofmann et al. 1992, 1994; Klinck et al. 1992, 2002) is based on the energy flow equation in which net production is calculated from the difference between assimilation and respiration and where the net production is the sum of somatic and reproductive tissue production.

Governing Equations

The governing equation is

$$NP_j = P_{gj} + P_{rj} = A_j - R_j$$

Where *j* is the size class, NP_j is the net production, P_{gj} is the somatic production, P_{rj} is the reproductive tissue production, A_j is the assimilation, and R_j is the respiration. The equation for each oyster class can be written as (Klinck et al. 2002)

$$\frac{dO_j}{dt} = -\alpha_j O_j + \beta_j O_{j+1} - \gamma_j O_j + \delta_j O_{j-1} - loss_j$$

where O_j is the somatic energy present in each class, j, of oysters in units of [cal/m^2]. Total energy is calculated by adding the reproductive portions to the amount calculated by the preceding equation.

Term	Representation
$\frac{dO_j}{dt}$	The time rate of change of O_j
$-\alpha_j O_j$	Loss from O_j to O_{j-1}
$\beta_j O_{j+1}$	Gain to O_j from O_{j+1}
$-\gamma_j O_j$	Loss from O_j to O_{j+1}
$\delta_j O_{j-1}$	Gain to O_j from O_{j-1}
$-loss_j$	Loss from O_j due to mortality, predation, etc.

This equation is then solved using a Crank-Nicholson approach. Assuming $\frac{dO_j}{dt} = F$, then

$$\frac{O_j^{n+1} - O_j^n}{\Delta t} = \frac{1}{2}[F^{n+1} + F^n]$$

where the equations for *F* are defined as

$$F^{n+1} = -\alpha_j O_j^{n+1} + \beta_j O_{j+1}^{n+1} - \gamma_j O_j^{n+1} + \delta_j O_{j-1}^{n+1} - loss_j^n$$

$$F^n = -\alpha_j O_j^n + \beta_j O_{j+1}^n - \gamma_j O_j^n + \delta_j O_{j-1}^n - loss_j^n$$

Substituting these two equations into the equation for $\frac{O_j^{n+1} - O_j^n}{\Delta t}$ and rearranging terms such that the *n+1* terms are on the left and the *n* terms are on the right and multiplying by Δt yields

$$O_j^{n+1} - \frac{\Delta t}{2}\left[-\alpha_j O_j^{n+1} + \beta_j O_{j+1}^{n+1} - \gamma_j O_j^{n+1} + \delta_j O_{j-1}^{n+1}\right] = O_j^n + \frac{\Delta t}{2}\left[-\alpha_j O_j^n + \beta_j O_{j+1}^n - \gamma_j O_j^n + \delta_j O_{j-1}^n\right] - \Delta t * loss_j^n$$

which then can be rewritten as

$$O_j^{n+1}\left[1 + \frac{\Delta t}{2}\alpha_j + \frac{\Delta t}{2}\gamma_j\right] + O_{j-1}^{n+1}\left[-\frac{\Delta t}{2}\delta_j\right] + O_{j+1}^{n+1}\left[-\frac{\Delta t}{2}\beta_j\right] = O_j^n\left[1 - \frac{\Delta t}{2}\alpha_j - \frac{\Delta t}{2}\gamma_j\right] + O_{j-1}^n\left[\frac{\Delta t}{2}\delta_j\right] + O_{j+1}^n\left[\frac{\Delta t}{2}\beta_j\right] - \Delta t * loss_j^n$$

where the transfer and loss rates are defined as

$$\alpha_j = \frac{w_j}{w_{j-1}}\frac{w_j}{w_j - w_{j-1}}\left|NP_j^{n+1}\right| \quad \text{for } NP_j^{n+1} < 0$$
$$\alpha_j = 0 \quad \text{for } NP_j^{n+1} \geq 0$$

$$\gamma_j = \frac{w_j}{w_{j+1}}\frac{w_j}{w_{j+1} - w_j}\left|NP_j^{n+1}\right| \quad \text{for } NP_j^{n+1} > 0$$
$$\gamma_j = 0 \quad \text{for } NP_j^{n+1} \leq 0$$

$$\beta_j = \frac{w_{j+1}}{w_j}\frac{w_j}{w_{j+1} - w_j}\left|NP_{j+1}^{n+1}\right| \quad \text{for } NP_{j+1}^{n+1} < 0$$
$$\beta_j = 0 \quad \text{for } NP_{j+1}^{n+1} \geq 0$$

$$\delta_j = \frac{w_{j-1}}{w_j}\frac{w_j}{w_j - w_{j-1}}\left|NP_{j-1}^{n+1}\right| \quad \text{for } NP_{j-1}^{n+1} > 0$$
$$\delta_j = 0 \quad \text{for } NP_{j-1}^{n+1} \leq 0$$

$$-\Delta t * loss_j^n = -\Delta t * MortalityRate * O_j^n$$

Assimilation Term

Size and Temperature

$$FR_j = \frac{L_j^{0.96} T^{0.95}}{2.95}$$

$$L_j = W_j^{0.317} 10^{0.669}$$

Where FR_j is the filtration rate (ml filtered per individual per min); L_j is the length in cm (Doering and Oviatt 1986), obtained from W_j, the ash-free dry weight (g); and T is the temperature in Celsius.

Salinity

$$FR_{sj} = \begin{cases} FR_j & \text{S} \geq 7.5 \text{ ppt} \\ \dfrac{FR_j(S - 3.5)}{4} \quad \text{when} & 3.5 \text{ ppt} < S < 7.5 \text{ ppt} \\ 0 & S \leq 3.5 \text{ ppt} \end{cases}$$

where S is the ambient salinity in ppt.

Turbidity

$$FR_{\tau j} = FR_{sj}(1 - 0.01x)$$

where x is the percent reduction in filtration rate. The equation for total particulate content, τ, (inorganic + organic) (g/L) can be written as

$$\tau = (4.17 * 10^{-4}) * 10^{0.0418x}$$

This equation was printed incorrectly in several papers, e.g. Hofmann et al. (1992) and Powell et al. (1992), but later corrected in Powell et al. (1995). This equation can then be rewritten in terms of filtration rate as

$$x = \frac{\log_{10}\tau + 3.38}{0.0418}$$

Finally, the equation for filtration rate can then be rewritten as

$$FR_{\tau j} = FR_{sj}\left[1 - 0.01\left(\frac{\log_{10}\tau + 3.38}{0.0418}\right)\right]$$

This equation was written incorrectly in several papers, e.g. Powell et al. (1992) and Powell et al. (1996), but correct in Powell et al. (1995).

Ingestion

$$I_j = f * FR_{\tau j}$$

where f is the measured food value (mg/L) and I_j is the ingestion.

Assimilation

$$A_j = I_j * A_{eff}$$

where the assimilation efficiency, A_{eff}, is defined as 0.75 (Powell et al. 1992).

Respiration Term

Temperature and Weight

Respiration as a function of temperature and weight was obtained from Powell et al. (1992) via Dame (1972) as

$$R_{TW} = (69.7 + 12.6 * T)W_j^{b-1} \quad \text{where } b = 0.75$$

where R is defined in units of µL O_2 consumed per hr per g dry weight (Powell et al. 1992). These units are converted to calories using the relation 1 mL O_2=4.75 cal used by Winter et al. (1984) via Thompson and Bayne (1974).

Salinity

Salinity's effect on oyster respiration were parameterized using the Powell et al. (1992) formulation which used data provided in Shumway and Koehn (1982) as

$$R_r = \begin{cases} 0.007 * T + 2.099 & \text{when } T < 20\ ^{\circ}C \\ 0.0915 * T + 1.324 & T \geq 20\ ^{\circ}C \end{cases}$$

where R_r is the ratio of respiration at 10 ppt to respiration at 20 ppt.

$$R_r = \frac{R_{10\text{ ppt}}}{R_{20\text{ ppt}}}$$

Respiration

$$R_j = \begin{cases} R_{TW} & \text{S} \geq 15\text{ ppt} \\ R_{TW}\left(1 + \left[\dfrac{(15 - S) * (R_r - 1)}{5}\right]\right) \quad \text{when} & 10\text{ ppt} < S < 15\text{ ppt} \\ R_{TW}R_r & S \leq 10\text{ ppt} \end{cases}$$

Per Powell et al. (1992), Shumway and Koehn (1982) identified salinity's effect on respiration at 20 ppt; however, a 15 ppt cutoff is used to conform to Chanley's (1958) growth observations.

Reproduction

For adult oysters (e.g. those considered adult or marketable but not those considered spat or juvenile), net production is apportioned into growth and reproduction by using the following formulation

$$P_{rj} = R_{eff} * NP_j$$

where P_{rj} is the portion of new production in reproduction, R_{eff} is the temperature dependent reproductive efficiency defined as (Hofmann et al. 2006)

$$R_{eff} = R_1 * T - R_0$$

where R_1 and R_0 are constants. This equation is written incorrectly (temperature dependence is missing) in Powell et al. (1992). In general, the maximum value of R_{eff} is limited to some value R_{max} such that this equation can be rewritten as

$$R_{eff} = \min(R_1 * T - R_0,\ R_{max})$$

and min() represents the minimum value function.

Based on observations by Soniat and Ray (1985), the R_1 and R_0 constants have a seasonal component such that (Hofmann et al. 1992)

$$\begin{array}{lll} R_1 = 0.054 \text{ and } R_0 = 0.729 & \text{for} & \text{January} - \text{June} \\ R_1 = 0.047 \text{ and } R_0 = 0.809 & & \text{July} - \text{December} \end{array}$$

These constants are defined correctly in Hofmann et al. (1992), Powell et al. (1992) and Powell et al. (1996) but incorrectly in Powell et al. (1995) and Wang et al. (2008) (R_1 was defined as 0.0047 instead of 0.047 for the July-December period).

Spawning

Following Wang et al. (2008), spawning occurs when the cumulative reproductive biomass (R_{total}) exceeds 20% of the total biomass and the temperature is greater than or equal to 25 degrees C (Ingle and Dawson 1952; Hayes and Menzel 1981). Once spawning occurs, reproductive biomass was divided into male (R_m) and female (R_f) biomass. The ratio of females to males (f_{ratio}) is calculated using

$$f_{ratio} = 0.021L_b - 0.62$$

where L_b is the shell length in mm. Then, the female portion of reproductive biomass can be calculated by combining the following two equations

$$f_{ratio} = \frac{R_f}{R_m}$$

$$R_{total} = R_f + R_m$$

to yield

$$R_f = \left(\frac{R_{total}}{1 + \frac{1}{f_{ratio}}} \right)$$

Then, the female portion of biomass can be converted into eggs spawned by

$$\text{Number of Eggs Spawned} = \left[R_f \left(\frac{6100 \text{ calories}}{\text{g dry weight}} \right)_{\text{oysters}} \right] \left(\frac{\text{g dry weight}}{6133 \text{ calories}} \right)_{\text{oyster eggs}} \left(\frac{1}{W_{\text{egg}}} \right)$$

where the term within the square brackets on the right hand side represents the female biomass converted to calories and the weight on an egg, W_{egg}, is 13 ng per egg (Powell et al. 1992 p. 393). Wang et al. (2008) and others (e.g. Powell et al. 1995, 1996) define the weight of an egg as

$$W_{\text{egg}} = 2.14 * 10^{-14} * V_{\text{egg}}$$

where V_{egg} is the oyster egg volume in (μm^3).

Larval Recruitment

Following Wang et al. (2008), larval life span was set to 15 days (Ingle and Dawson 1952), and larval to spat survival was set at $1/10^8$ (Powell et al. 1996)

$$\text{Number of New Spat per Spawn} = \frac{1}{10^8} * \text{Number of Larvae Recruited per Spawn}$$

It is not clear how larval life span is to be applied.

Mortality

Lavae

$$\text{Number of Larvae Recruited per Spawn} = \ s * \text{Number of Eggs Spawned}$$

where *s*, the survival rate per spawn is defined as (Davis and Calabrese 1964)

$$s = \begin{cases} 0.7 \quad for \quad 27.5\ ^\circ C \leq T \leq 32.5\ ^\circ C \text{ and } 10\, ppt \leq \ S \leq 27.5\, ppt \\ 0 \qquad\qquad\qquad\qquad\qquad \text{otherwise} \end{cases}$$

The variable, *s*, is defined incorrectly in Wang et al. (2008) as mortality rate.

Post-settlement Population

Mortality of the post-settlement population follows the formulation of Wang et al. (2008)

$$\text{Number dying per time} = k_d(\text{number of living})$$

$$k_d = \begin{cases} \quad 0 \qquad\quad \text{if} \qquad \text{Winter or Spring (Sep} - \text{Apr)} \\ \text{Constant} \quad \text{otherwise} \end{cases}$$

where k_d is the daily mortality rate. However, because low salinity is a major cause of catastrophic mortality, the equation of daily mortality rate is modified as follows

$$k_d = (\alpha_1 S + \beta_1)T + (\alpha_2 S + \beta_2) \quad \text{if} \quad S < 6 \text{ ppt}$$

where α_1=-0.000348, β_1=0.01764, α_2=0.00232, and β_2=-0.3089 (Powell et al. 1996). α_1 is defined incorrectly in Wang et al. (2008) as -0.00034.

Growth Rate Formulation

$$(\text{Oyster Growth Rate})_j = (NP_{somatic})_j * W_j * \frac{1000 \text{ mg}}{\text{g}} * \frac{86400 \text{ s}}{\text{day}} \qquad \left[\frac{\text{mg AFDW}}{\text{oyster} * \text{day}}\right]$$

where Net Production is provided in units of [1/s] and W is the average oyster weight in units of [g AFDW/oyster]

Specific Relations for Apalachicola Bay Model

Size Classes

Characteristics of the size classes were based on Wang et al. (2008). Average length was from field measurement, while average biomass was determined from the following length-weight relationships:

$$\ln(Biomass) = C_1 * \ln(Length) + C_2$$

which can be solved for biomass as

$$Biomass = (Length)^{C_1} * e^{C_2}$$

where

Site	C_1	C_2	R^2
Cat Point	2.505	-10.980	0.83
Dry Bar	2.202	-9.125	0.90

Site	1 (Spat)	2 (Juvenile)	3 (Adult)	4 (Marketable)
Cat Point				
Initial Count	0	26	22	21
Average Length (mm)	12	36	66	85
Average Biomass (g AFDW)	0.0086	0.1349	0.6157	1.1605
Dry Bar				
Initial Count	0	26	22	21
Average Length (mm)	12	39	66	96
Average Biomass (g AFDW)	0.0259	0.3472	1.1059	2.5236

Total Particulate Content<>Turbidity

Based on a water quality analysis of storm-water inputs into Apalachicola Bay, Wang et al. (2008) defined the relation between total particulate content and turbidity as

$$\tau = 1.4593 * \text{Turbidity} + 0.904$$

where total particulate content, τ, is in units of mg/L and Turbidity is in NTU.

Food<>Chlorophyll-a

Following Wang et al. (2008), Chlorophyll-a was used as an index of available food following the formulas presented in (Soniat et al. 1984, 1998)

$$\text{Food} = 1.4593 * \text{Chlorophyll} - \text{a} + 0.520$$

where Food, is in units of mg dry weight/L (Soniat et al. 1998) and Chlorophyll-a is in units of µg/L (Soniat et al. 1998). The units of food are converted into calories using the caloric conversion of 5168 cal per g dry weight (Wang et al. 2008).

Reproduction

The maximum reproductive efficiency, R_{max}, was set to 0.8 (Wang et al. 2008). Furthermore, following the assumptions of Wang et al. (2008), when $NP < 0$, reproduction was assumed to be zero or there was no resorption of gonadal tissue.

Post-Settlement Mortality

For periods when salinity is greater than 6 ppt, the daily mortality rate, k_d, was defined as (Wang et al. 2008)

Site	Reference Year	High-Salinity Year	Low-Salinity Year
Cat Point	0.00020	0.00061	0.00014
Dry Bar	0.00079	0.00122	0.00038

Average/Reference Year Simulations

Using the average year data shown in Figure 3 of Wang et al. (2008), the average year was simulated and then compared to the reference year lines for marketable oysters of Figure 6 of Wang et al. (2008).

Cat Point

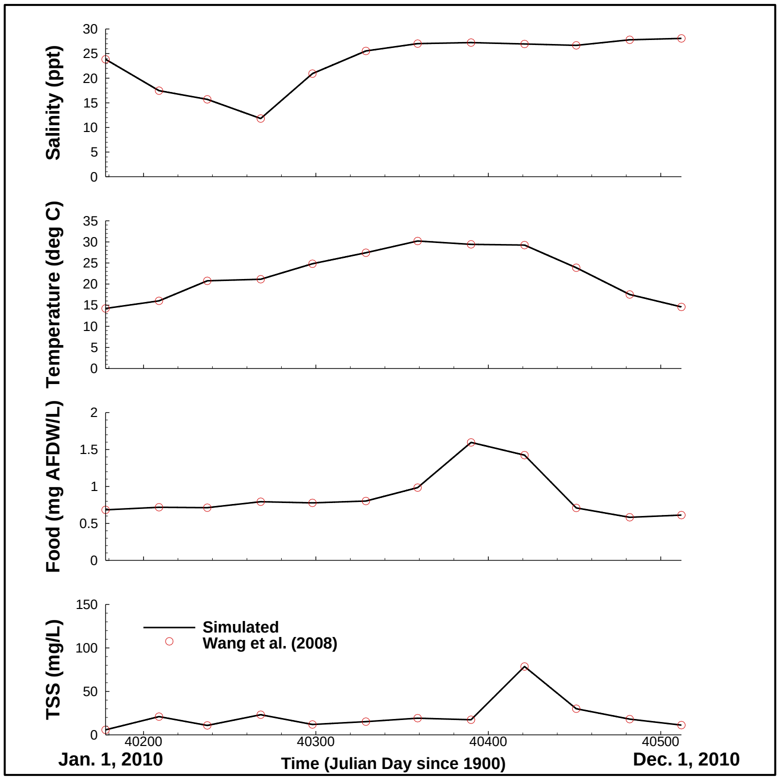


Figure 24. Forcing functions for the Cat Point reference year simulation

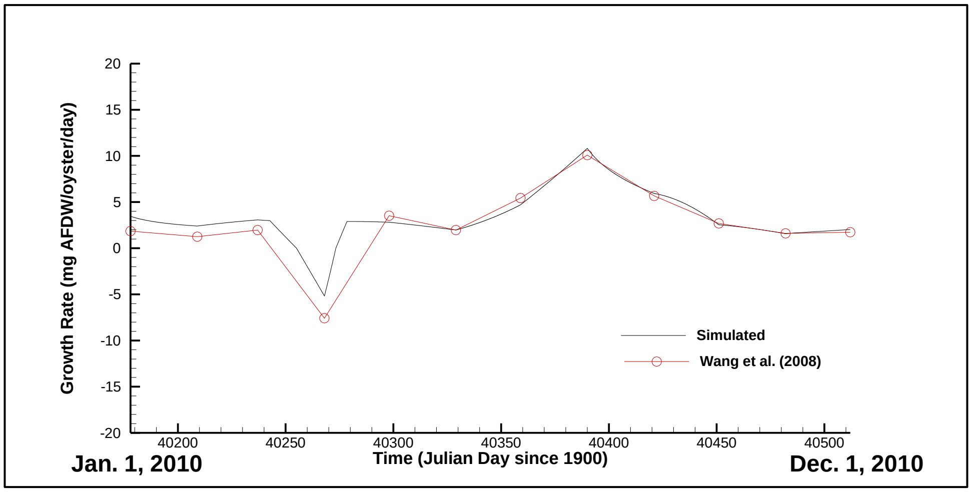


Figure 25. A comparison between the marketable oyster growth rate at Cat Point during the reference year simulated using the model presented herein and the results of Wang et al. (2008)

Dry Bar

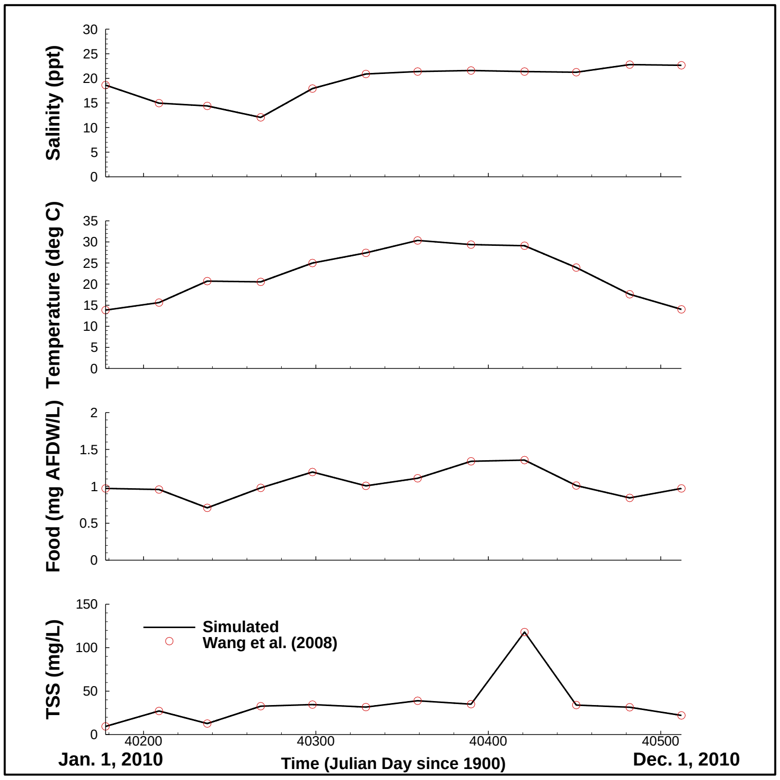


Figure 26. Forcing functions for the Dry Bar reference year simulation

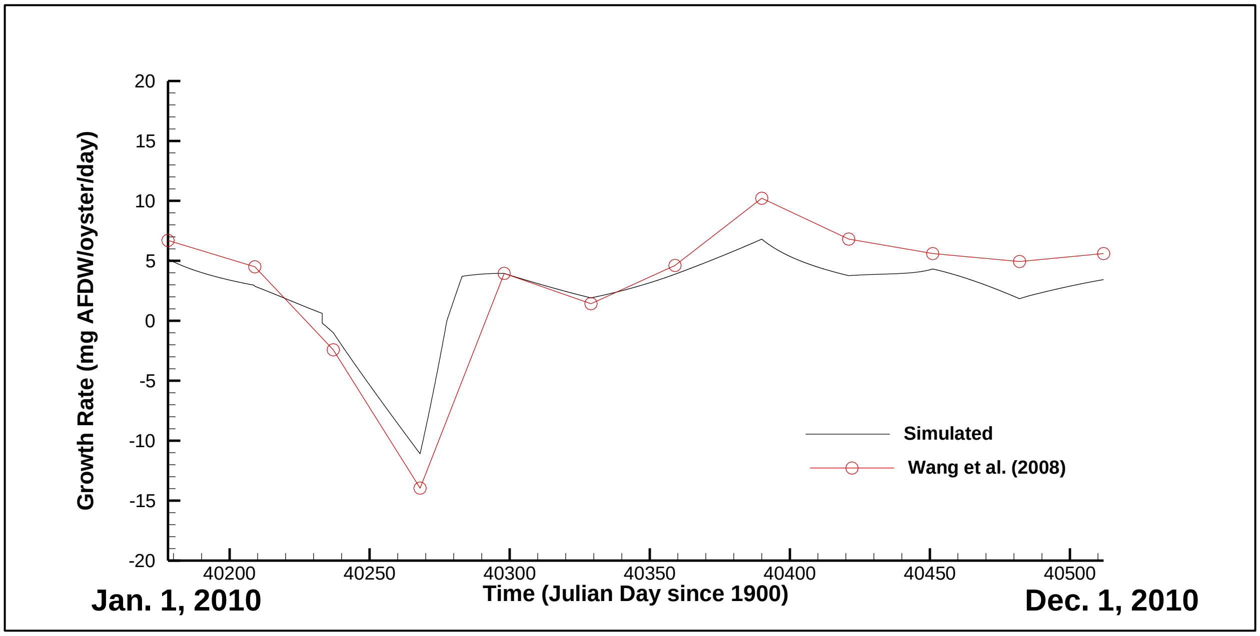


Figure 27. A comparison between the marketable oyster growth rate at Dry Bar during the reference year simulated using the model presented herein and the results of Wang et al. (2008)

Mar 2004 – June 2005 Cat Point Simulation

Using data obtained for the period of Mar. 2004 to June 2005, growth rate at Cat Point was simulated and compared to the total growth rate values shown in Figure 5a of Wang et al. (2008). Two sets of simulations were performed, one with the original observed salinity/temperature data and the second with daily averaged data.

Observed Salinity/Temperature

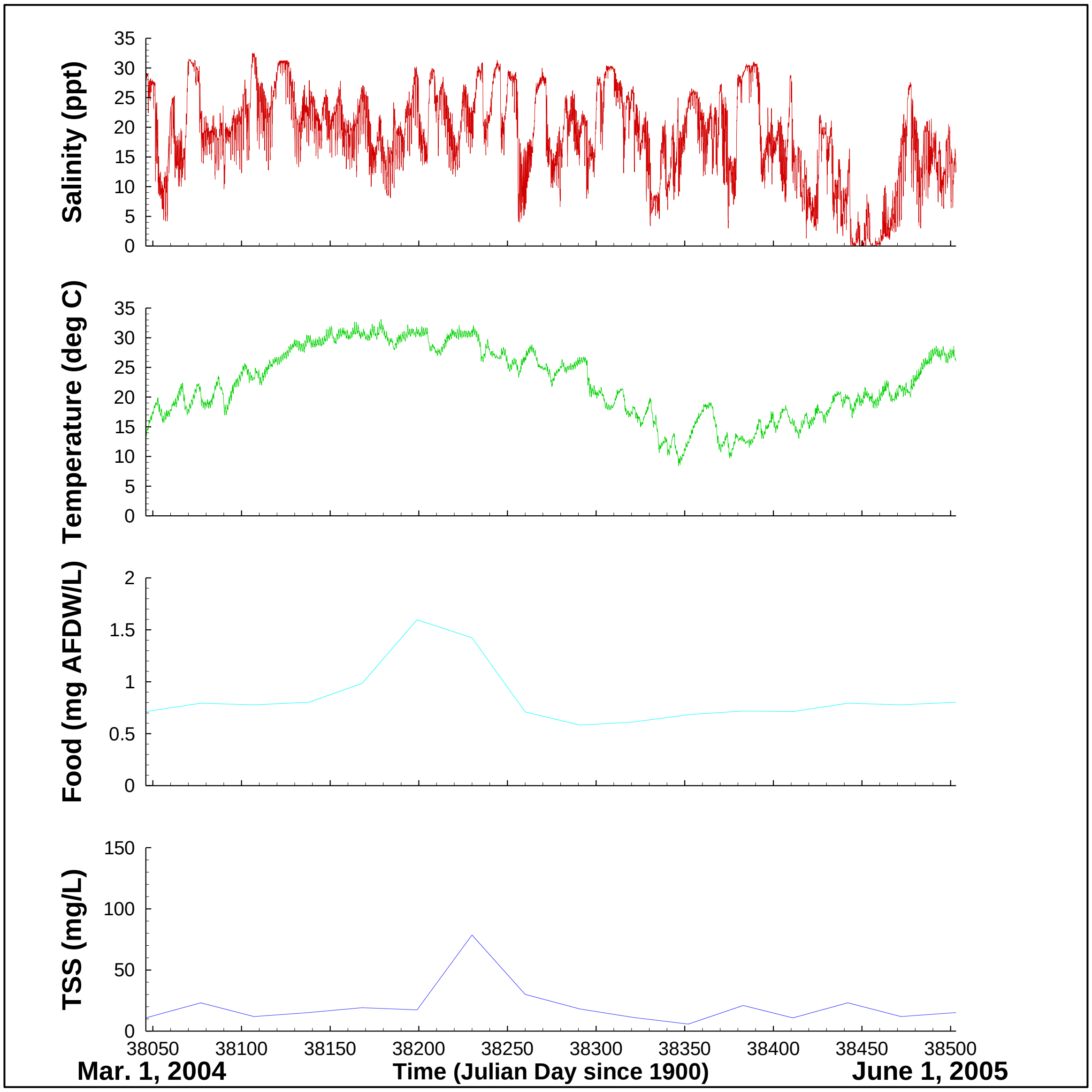


Figure 28. Forcing functions for the Cat Point Mar. 2004-June 2005 simulation using the observed salinity/temperature data

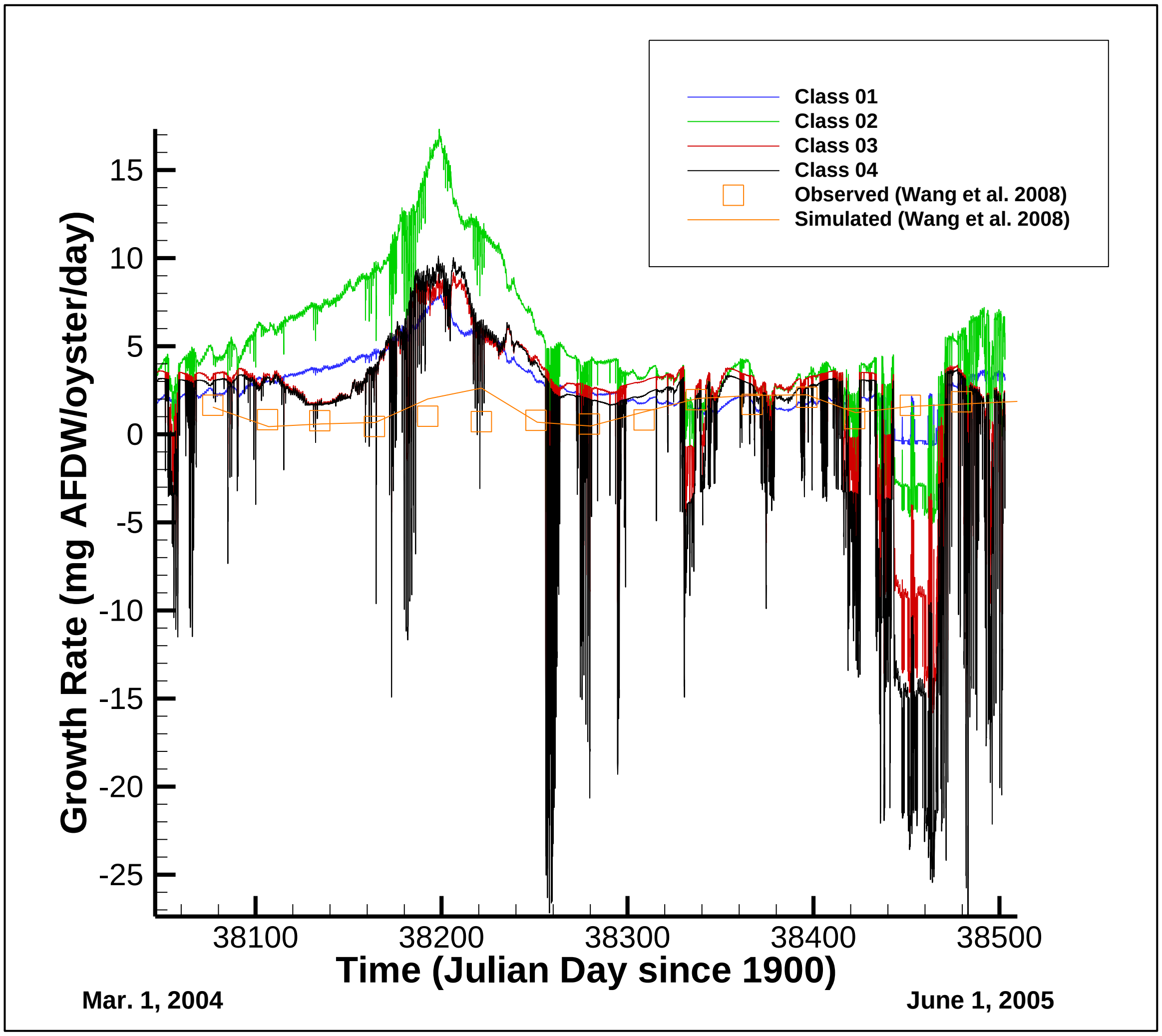


Figure 29. A comparison between the total oyster growth rate at Dry Bar during the reference year simulated using the model presented herein (each class plotted individually) and the results of Wang et al. (2008) (total growth rate) using the observed salinity/temperature data

Daily Averaged Salinity/Temperature Data

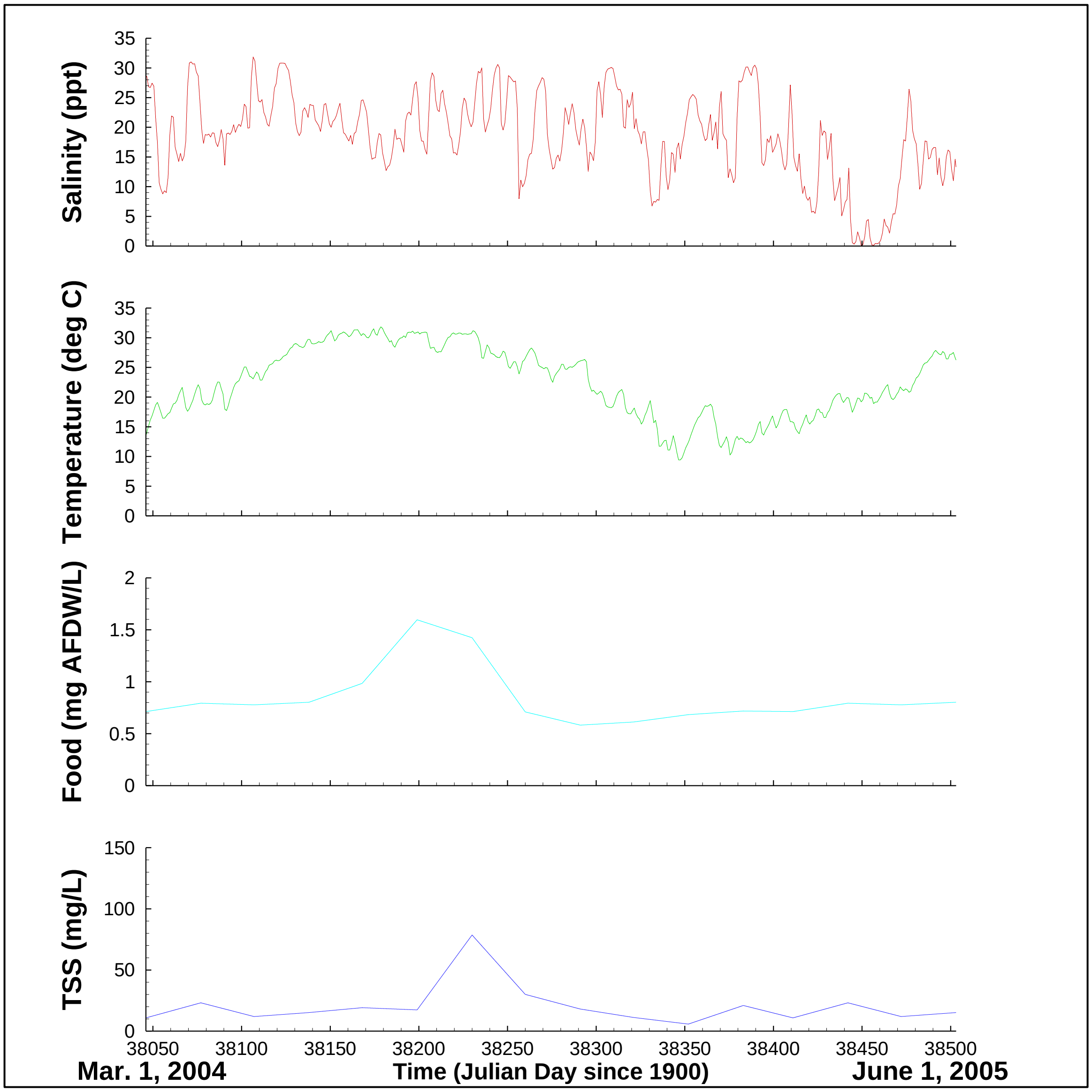


Figure 30. Forcing functions for the Cat Point Mar. 2004-June 2005 simulation using the daily averaged salinity/temperature data

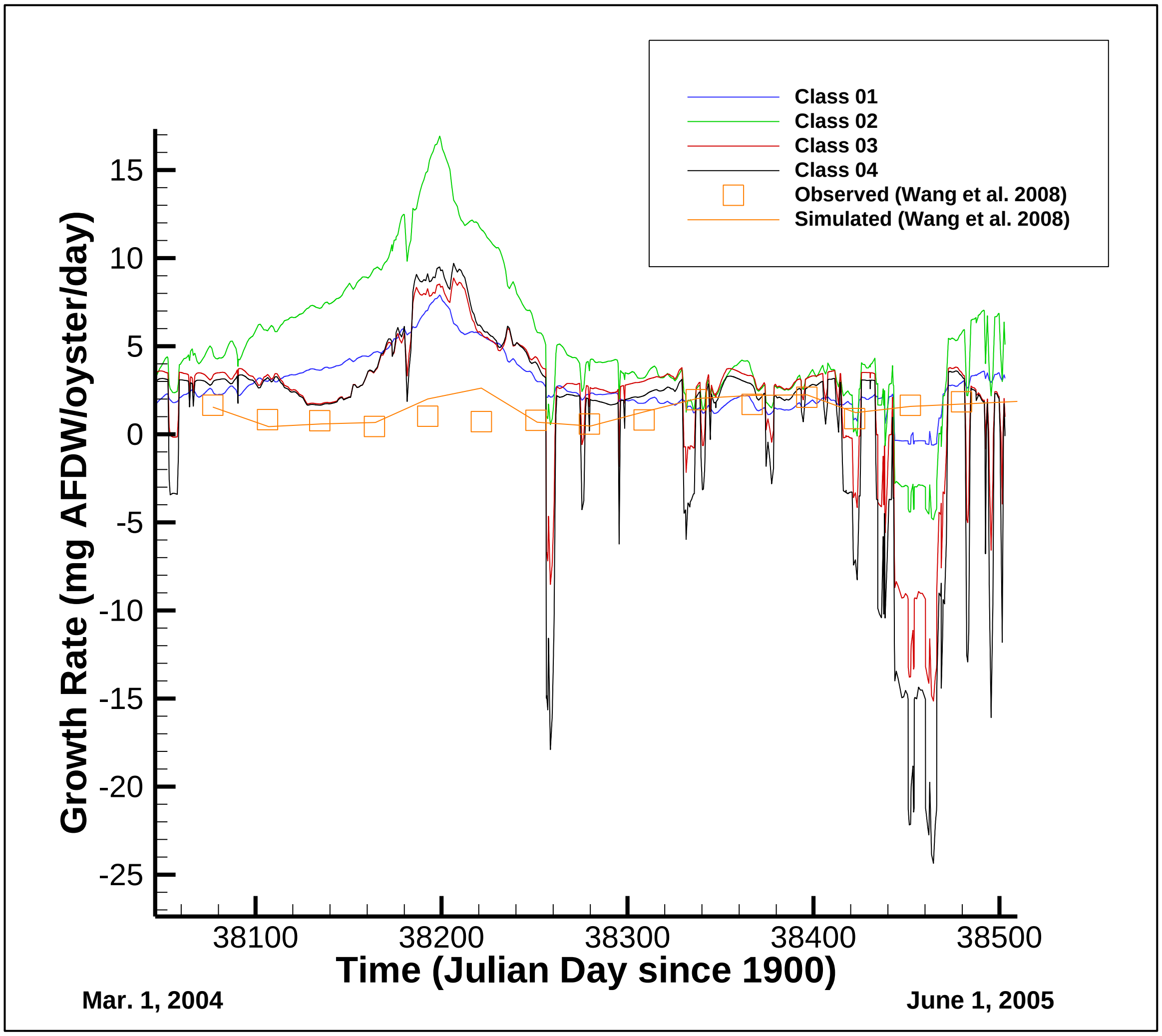


Figure 31. A comparison between the total oyster growth rate at Dry Bar during the reference year simulated using the model presented herein (each class plotted individually) and the results of Wang et al. (2008) (total growth rate) using the daily averaged salinity/temperature data

Appendix B. FWS Requested Results

The following revised list of requested results was email by Karen Herrington to Y. Peter Sheng on April 5, 2011. Items A1, B1, B2 and B4 were eliminated from an earlier larger list of requested results.

A. Oysters:

1.
2. Probability of exceedence at Cat Point and Dry Bar station for all 4 scenarios
3. Summary statistics for Class 4 (Marketable) growth rates at Dry Bar and Cat Point for all 4 scenarios
4. Exceedence probability at Cat Point and Dry Bar as a function of growth rate of marketable oysters (Class 4) for all 4 scenarios
5. August (generally peak growth rates) summary statistics for Class 4 (Marketable) growth rates at Dry Bar and Cat Point for all 4 scenarios
6. August Exceedence probability at Cat Point and Dry Bar as a function of growth rate of marketable oysters (Class 4) for all 4 scenarios
7. Salinity contour map for the total number of days salinity exceeds 26 ppt in the following years for all 4 scenarios. Please scale the colors to the percent of days (i.e., 10%, 20%, 30%, etc.) and give the acreages of each color for each scenario in a comparative table
    - Dry year = 2002 (based on ranked mean annual discharge)
    - Wet year = 2005
    - Average year = 2001

B. Sturgeon:

1.
2.
3. Salinity contour map for the total number of days salinity exceeds 10 ppt from 1 October- 31 March for the following years for all 4 scenarios. Please scale the colors to the percent of days (i.e., 10%, 20%, 30%, etc.) and give the acreages of each color for each scenario in a comparative table
    - Dry year = 2001 (based on ranked mean Oct-March discharge)
    - Wet year = 2009
    - Average year = 2004
4.

USFWS Questions regarding the ACOE January 18, 2011 Correspondence:

1. In our PAL and the May 27, 2010 email from Will Duncan, we requested that you use the environmental flow guidelines to develop an environmental flow alternative or use the guidelines to analyze your alternatives and to identify the constraining authorization (if present) that impairs the Corps ability to achieve the recommended flow targets. You have provided some of those analyses in this report, but have you completed these analyses and identified the constraints for the remaining flow recommendations for the four river sections (below Buford, West Point, Walter F. George, and Jim Woodruff dams)?
2. How was the RES-SIM model developed and how well does it (ie. the baseline) conditions represent actual operations? Has this type of assessment been completed, specifically for parameters that are biologically relevant? Could the model output be updated through 2010?
3. To gain a better understanding of the constraints that you have, and so we don't continue stating the same thing on every document, can we obtain a copy of your agreement(s) with SEPA in the ACF? For similar reasons, may we also view the original language that describes the "flood damage reduction" authorized purpose?
4. Page 1-7: Why don't the numbers on Table 5.2-1 correspond with the hours of operation in the text above the table? Do the numbers in the text correspond to longer periods (e.g. 11 hours total at Buford on weekends) within which Buford Dam will generate power for e.g. three hours?
5. Page 1-9: When the fish spawn SOP was developed, why did it not include river segments below the major dams? Would a similar SOP for riverine habitats be of interest to the ACOE in the Chattahoochee River?
6. Page 1-14: It is stated that W.F. George currently has no minimum flow requirement, but when low dissolved oxygen values are observed below the dam, spillway gates are opened until the DO readings return to an acceptable level. How often is DO actually measured at this location?
7. Page 1-16: What is your reasoning for assuming that current water supply operations for Buford and Peachtree Creek would remain constant with 2007 demand data for your 10 to 15-year WCM Planning Window?
8. Page 1-16 and 1-21: It appears that the preferred alternative includes increased hydropower generation at Buford. What is the purpose or impetus for this increase (e.g., request from SEPA? Atlanta water supply? etc.)
9. Page 1-17: You mention that increasing Zone 4 would result in more water available, but there is no discussion of how frequently the drought operations were triggered with and without this change. In general, we would like to see your thought process for alternative development (e.g., were you trying to minimize the number of times drought ops were triggered?, etc.) and the results of these analyses (e.g., how did this change affect the occurrence frequency of the drought trigger).
10. Page 1-19: You mention volumetric balancing accounting but state elsewhere in the document that there will be no volumetric balancing in your preferred alternative. Is this a typo?
11. Page 1-20, Figure 11.3-4: Can you please show us a direct comparison of composite storage zones (similar to figs 11.3-1 to 11.3-4) under the no action alternative and preferred alternative? Or possibly a table with values if this figure would be too busy? Specifically, a summary of the composite zone changes (whether each zone is larger or smaller, time of year, reason for change, etc.) would be helpful. It would also be helpful to understand how often your model results indicate that you will operate in the various zones.

12. Page 1-20: You state that the drought plan revisions will remain in place until composite conservation storage reaches Zone 1. As in question #4 above, what is the thought process here and what are the results of the analyses you ran to make this decision?
13. Page 1-21: With what frequency and duration have each of the projects operated in each zone historically, and for each modeling scenario (baseline, alternative 1, and alternative 2)? How often in zone 4 was there peaking (number of peaking events/day) below each project?
14. Page 1-23: It is stated that there will be no changes to fish spawn or fish passage operations under the Proposed Action Alternative. Regardless, new language for fish spawn operations at JWLD will be included in this WCM update though, correct?
15. Page 1-23: You state that RIOP modifications (especially the fall rate and drought zone changes) were based in part on reducing the likelihood of triggering releases less than 5,000 cfs. Again, as in questions 4 & 6, what analyses did you run here to test/justify these decisions and what were the results?
16. Page 2-28: How would results be different if hourly data were used? What are the minimum DO observations observed and how well do the model results stack up against observed DO? Is it appropriate to have all dry years represented by 2007 and normal years by 2004? Same issues apply to temperature analyses on page 2-55.
17. Page 2-49: What is meant by the term "occurrence **interval**?" Where is the interval? Also, page 2-25 mentions that "It was recommended that percent exceedence may assume violation of water quality standards and thus percent occurrence was utilized for the presentation of water quality." Exceedence is a statistical term adopted for use in water policy. Regardless, it is more appropriate in this case to use exceedence. Just be clear that you are not using the term "exceedence" in a policy sense.
18. Page 2-60: The term "rainfall conditions" is used to identify specific years for detailed analyses. Similarly, the terms dry year and average year are used throughout the document without clear explanation regarding what constitutes a dry and average year. This needs to be made very clear. How were they defined, and does the term "rainfall conditions" actually mean a discharge-related variable?
19. Page 2-65: Based on the model input, what are the major drivers of algae change over time? Y-axes should be chlorophyll-a, not algae.
20. Pages 2-72 to 2-76: We had many comments, questions, and concerns about this section. Most concerns centered on the ambiguity of the analysis and the derivation of reported numbers. Because of these problems, we are hard-pressed to provide meaningful review and feedback. However, related to the baseflow analysis, we recommend an alternative analysis for depicting low flows that are likely to occur for each alternative. That analysis and associated rationale is included in the PAL addendum. Such an analysis is more intuitive and should take no more than a day for multiple nodes alternatives. Thus, we strongly encourage the ACOE to complete this analysis in lieu of the results reported in these sections.
21. Page 2-73: "The channel capacity at this location was used as a constraint in the HEC ResSim modeling analysis to ensure that flows did not go higher than 11,000 cfs." Why are the modelers unwilling or unable to model flows greater than 11,000 cfs?
22. Page 2-73: How is channel capacity defined, and where did the number come from?
23. Page 2-76: Can you please fix the figure references throughout the document ie. "Error! Reference source not found?" Does "upstream of Atlanta" refer to Norcross? Please use gage numbers and gage names to identify sites. How were these values determined? Are they percentiles of minimum flows or some annualized metric? How is "Dry year" defined in the

subsequent page? Many of these concerns will be addressed once the revised analysis is implemented.

24. For much of the flow analyses performed, you compare model output from the pre-dam period, no action, scenario 1, and scenario 2. Please provide the range of years and specific datasets used for each scenario.
25. Figures 2.7-1 to 2.7-13 and Table 2.7-1: We understand that direct comparisons cannot be made due to channel bed degradation and removal of hard bottom habitat; however, is it possible to add the pre-dam scenario to these figures?
26. Page 2-80: This statement is inaccurate: "The flow magnitude for average years overall, however, is 500–1,000 cfs, reduced from the pre-dam flows." Baseflows in the summer and fall seasons (including a portion of spawning season) are elevated, not reduced. Graphs depict reported values as averages, but could they be medians based on the non-parametric RVA in IHA?
27. Page 2-83, Figure 2.7.1.1: Spawning Habitat Availability- Overall, there is very weak treatment regarding what data is being conveyed on the graphs. For example, our initial review indicated that the analysis had been cut and paste from the 2008 BO. On the graphs and in legends and text, can you please define ROR, the intent of using USGS data and ROR, and the period of record used. Remember, if we (agencies with previous involvement) are unable to correctly interpret the results, it is unlikely that others will. This needs to be crystal clear. There are also grammatical problems in this section.
28. Page 2-87, Table 2.7-1: Why were there no flows lower than 5,000 cfs? Does that mean the drought plan was never triggered in these scenarios? If not during the exceptionally severe 2007 drought, what hydrologic conditions would it take to trigger the drought zone?
29. Page 2-92: We expect that the fall rates associated with pulses will differ from the RIOP. The RIOP was intended to be protective of organisms at a lower range of flow, and the pulse flow recommendations consider a large range of flows that are relevant to other ecosystem attributes.
30. Page 2-99: Could you please clarify this? "This operation was considered but deemed to not represent a viable operating alternative (USFWS 2010)." Did USFWS request it and then deem it as not a viable option? This is difficult to interpret without having a references section. Please include a references section.
31. Page 2-99: It is stated that "Holding the reservoir at higher elevations during the winter wet season would increase induced surcharge and the frequency of damaging downstream flows..." Damaging to what? Can you please share the modeling output that demonstrates this?
32. Page 2-101: You discuss analyzing how providing a minimum flow of 15,400 cfs impacted the number of times the drought zone was triggered. As in questions 4, 6, & 7, it would be helpful for us to know what analyses you have completed on triggers and how results influenced your alternative development. For example, it seems unusual that a minimum flow of 15,400 cfs would trigger drought operations more often than a minimum flow of 16,200 cfs.
33. Page 2-101: We appreciate the evaluation of a longer navigation season and feel it would also benefit riverine fishes. Please tell us if this will be a guaranteed minimum flow to provide a 7 ft channel or if it will be only "as requested" by navigation interests. How will this "navigation season" be different from the old navigation windows that were 10 days to a two-week period? Will this be a continuous minimum flow for months? If so, we assume that you are anticipating that you will be able to balance the fish spawn SOP and this new navigation flow, in light of the fact that the prior navigation windows prompted complaints that the windows had adversely affected reservoir fish spawn activities.

34. Page 2-102: W.F. George is also a peaking plant (Page 1-7) but was not included in the discussion of why non-hydropower peaking windows cannot be implemented at ACOE hydropower peaking facilities. It also needs to be addressed.
35. Page 2-109: Where's the references section?

Other Important considerations:

36. The ACOE used HEC-5Q to model daily change in water quality parameters. Are we correct in that the model input used average daily discharge to calculate water quality parameters for each time step? If so, we think it would be wise for the ACOE to acknowledge that daily fluctuations in WQ may be obscured by this simplification, but that this model represents the best available information on water quality responses to instream flow changes.
37. Similarly, it would be wise for the ACOE to propose a coarse plan of action for addressing DO issues caused by ACOE projects (e.g., propose potential collaborations, funding sources, and general steps, and rough timeline needed to do so).
38. Page 1-5: "the river system would operate in a fairly normal manner." Please clarify this.
39. Page 1-6: "…enough electricity to supply approximately 110,000 households." This is important to consider, but is more useful when context is provided. For example, 110,000 households is 3.65% of Georgia households or X% of Florida households.
40. Page 1-15: "Reservoir operations are also influenced by agricultural water withdrawals…" This is an important component of this section, and it needs additional (minor) elaboration so that your point isn't lost. Is the point that water removed from the Flint is offset by reservoirs in the Chattahoochee to meet flow needs in the Apalachicola- especially during low flow periods? If so, that point is lost in this section.
41. Page 2-25: Repeatedly throughout the document, the ACOE uses different terms to describe the alternatives (e.g preferred vs proposed ; scenario 1 vs. alternative 550 vs Alternative B1 or B2); It would be beneficial if consistent terms are used to describe each modeling scenario.
42. Page 2-26: The term "baseline" is used for 24 pages before it is defined on page 2-50. Also, it had been indicated that the methods used to develop all output would be included in this document and they aren't.
43. Page 2-75: It would be appropriate to explain to readers that values closer to "1" are better.
44. Page 2-76: "2.4.2 Impacts of Critical Low Flow Periods" could use improvement. We'd all be better served with a table showing comparisons of the results.

Comparison of ACOE Baseline HEC Res-Sim output and observed data for a comparable period

Based on the Corps' response to the Planning Aid Letter, the baseline model output from HEC Res-Sim represents current operations following implementation of the RIOP (post September 2006). Therefore, there should be good general agreement between baseline conditions and observed conditions since September 2006. In instances where the modeled data are statistically different from observed data (ie. black boxes in table below), users of the Res-Sim output should be cautious regarding comparisons and recommendations based on that aspect of the data. In instances where statistical significance was not detected (white boxes in table), there is support for using that aspect of the data for comparison of flow alternatives to the baseline model output.

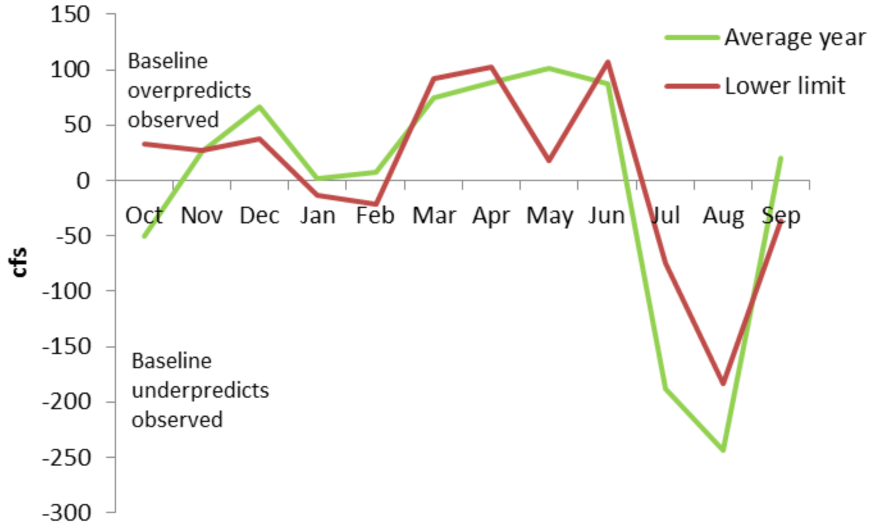
	Pulse Magnitude (cfs)	Pulse Duration (days)	Pulse Rise Rate (cfs/day)	Pulse Fall Rate (cfs/day)	Pulse Frequency (#/month)	Reversals (#/month)
Chattahoochee at Norcross	9*	2	-97	-108	-1.35	-2.6
Chattahoochee at West Point	-984*	2*	-483	-93	-0.18	-2.1
Apalachicola at Chattahoochee	-2791	7.7*	-1454*	-924*	-0.33	-4.7

Statistics and nuances of the table: Tests of statistical differences between the ACOE modeled baseline scenario and observed discharge in the Chattahoochee and Apalachicola rivers are provided in the table. Black boxes depict statistical differences. For the purposes of this analysis, we assumed that pulses were independent of one another. Two-tailed t-tests were used to test for statistical significance, except paired t-tests were used for monthly pulse frequency and reversals. P-values < 0.05 were used as thresholds for statistical significance. Pooled variances were used except in instances when the Satterthwaite method was used for unequal variances (*). Numbers in the table are the mean baseline value minus the mean observed value.

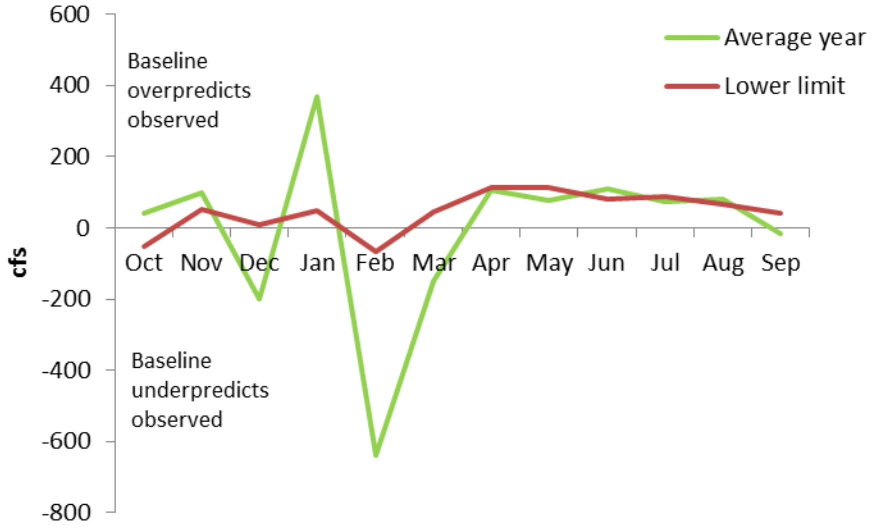
In this analysis (Table above), pulses were defined as any pulse or flood greater than the 75th percentile of the modeled baseline scenario. Analysis period included Sep 01, 2006 to Dec 31, 2008, the period for which the baseline scenario (presumably reflective of current operations) was implemented and for which observed data can be compared.

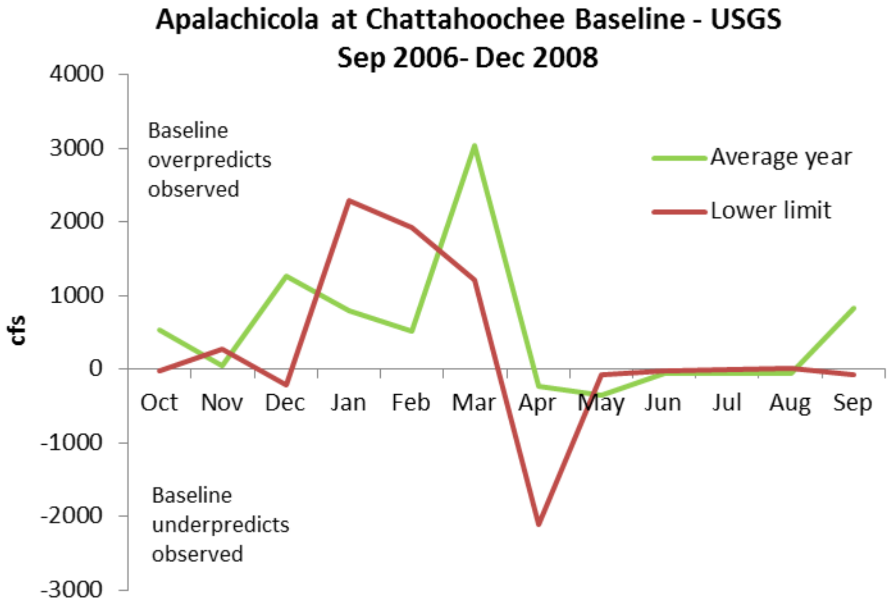
Figures: Using the same period of record for modeled baseline and observed discharge, the low flow analysis was conducted using the 7 lowest flows observed for every month of every year. The lines on the graph are the differences between the baseline and the observed USGS data for the 50th percentile (average year) and 10th percentile (lower limit). Values less than 0 indicate that the baseline modeled discharge underpredicted observed discharge, and values greater than 0 indicate the converse. Beyond the graphical comparison, no statistics were calculated for low flows.

Chattahoochee at Norcross
Sep 2006 to Dec 2008



Chattahoochee below West Point Dam
Sep 2006 to Dec 2008




Apalachicola at Chattahoochee Baseline - USGS
Sep 2006- Dec 2008
4000
3000
2000
1000
0
-1000
-2000
-3000
cfs
Baseline overpredicts observed
Baseline underpredicts observed
Average year
Lower limit
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep

USFWS Planning Aid Letter August 2013

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August 29, 2013

Mr. Curtis Flakes
Chief, Planning and Environmental Division
United States Army Corps of Engineers
P.O. Box 2288
Mobile, AL 36628-0001

Subject: Planning Aid Letter, Apalachicola-Chattahoochee-Flint Water Control Manual Updates

Dear Mr. Flakes:

The U.S. Army Corps of Engineers, Mobile District (Corps), currently is updating the Water Control Manual (WCM) for the Apalachicola-Chattahoochee-Flint (ACF) River Basin in Georgia, Alabama, and Florida. The WCM update identifies operating criteria and guidelines for managing water storage and release of water from Corps reservoirs and, therefore, will guide future water management operations in the basin. We previously provided Planning Aid Letters (PALs) for the proposed WCM update to the Corps April 2, 2010, and March 1, 2011; these PALS identify resource values and issues in the basin, including rare species, and propose preliminary changes, mitigation, or enhancement opportunities to minimize impacts and facilitate your National Environmental Policy Act analysis of the project. The comments in these PALs are still applicable.

The Service, in previous correspondence (July 19, 2013, Revised Alternative to the Corps), identified performance measures that the Corps should use, in simulated operations, to compare the relative effects of the no-action and action alternatives considered for the WCM update on various target species. We used these performance measures in the development of the Service's Revised Alternative. In this PAL, we fully describe these performance measures. We submit these comments and recommendations under the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. § 1531 *et seq.*), the Migratory Bird Treaty Act, (49 Stat. 755, as amended; 16 U.S.C. § 702 *et seq.*), and the Fish and Wildlife Coordination Act (FWCA) (48 Stat. 401, as amended; 16 U.S.C. § 661 *et seq.*). Our comments are based on previous studies and government documents, as well as new datasets and information provided by State and Federal agencies. We will provide additional expertise and information in our FWCA Report and during a separate section 7 consultation under the ESA.

Description of Performance Measures

Apalachicola River Floodplain Fish Spawning and Rearing

The Floodplain Spawning Habitat Performance Measure (FSHPM) calculates the maximum amount of floodplain spawning habitat available for at least 30 consecutive days during the months of April through October. It is based on data and methods described in Service biological opinions prepared for proposed interim rules governing the releases from Woodruff Dam (USFWS 2006, 2008, 2012).

Multiple studies establish the importance of floodplain habitats to the life history of many riverine fishes, including several specific to the Apalachicola River (Walsh et al. 2006, 2009; Pine et al. 2006; Dutterer et al. 2011). These studies provide evidence of spawning and rearing activity for at least 44 species representing 16 families (predominantly Centrarchidae and Cyprinidae) in floodplain habitats, when available, during the growing season. Fish use in floodplain habitats requires time for adult movement from the main channel into the floodplain, courtship and spawning behaviors, egg incubation, and juvenile growth to a size capable of moving to and surviving in the main channel when water levels recede. We consider 30 days of continuous inundation minimally sufficient to ensure successful completion of the reproductive process in the floodplain. A greater spatial extent of habitat availability provides greater benefits for fish reproduction. The spatial extent of non-tidal floodplain inundation as a function of discharge from Woodruff Dam was quantified (Figure 1; Light et al. 1998, 2006).

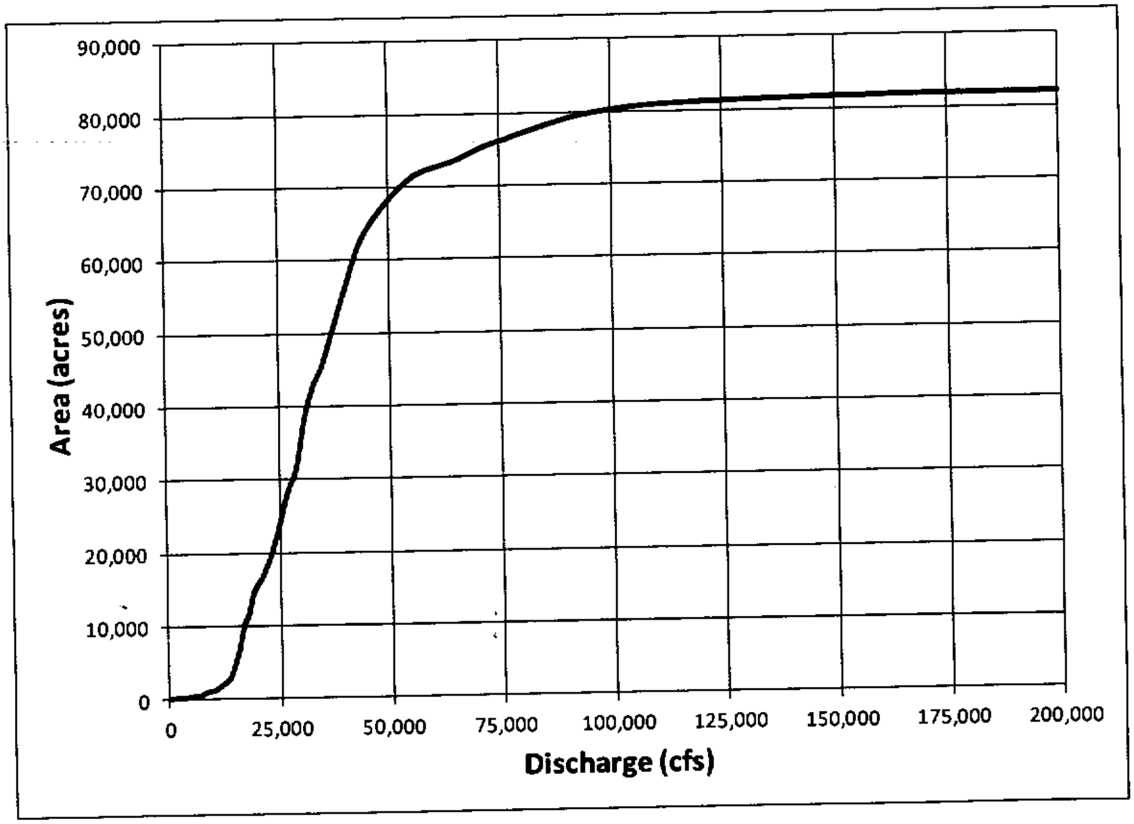


Figure 1. Area (acres) of aquatic non-tidal floodplain habitat connected to the main channel of the Apalachicola River as a function of discharge (cubic feet per second) from Woodruff Dam (data from Light et al. 1998).

The FSHPM computes a 30-day running minimum inundated floodplain acreage from observed or simulated daily releases from Woodruff Dam during April through October. The annual maximum of these values represents the amount of habitat that was continuously available for at least 30 days to support spawning behaviors and subsequent development of eggs and larvae. The FSHPM is an Excel workbook that requires multiple years of daily discharges as input. The primary output is a graphical frequency distribution ("box and whiskers" plot) of annual maximum 30-day continuous floodplain habitat availability. The Excel workbook is organized for comparing the discharge distributions of existing operations (the RIOP) as simulated by ResSim, and up to three additional simulated operations alternatives.

The inter-annual distribution of annual habitat availability estimated by this measure should serve as the basis for comparing the relative effects to floodplain-spawning fishes in simulated operations of the no-action and action alternatives considered for the WCM update. The Corps has stated that they will operate the system in a balanced manner in an attempt to meet all authorized project purposes. Given this objective, we recommend that the Corps prepare and choose alternatives that maximize the amount of inundated floodplain habitat while balancing other project purposes. While this metric is developed to analyze the April-October period, the April to May period is most important because it encompasses spawning and peak abundance of early life stages of floodplain fishes (Walsh et al. 2006). Peak inundation during the growing season generally occurs in April. However, given the protracted spawning period of many fishes, we included April through October in the Excel workbook.

Gulf Sturgeon Spawning

The Sturgeon Spawning Habitat Performance Measure (SSHPM) calculates the maximum amount of Gulf sturgeon (*Acipenser oxyrinchus desotoi*) spawning habitat available for at least 30 consecutive days from March through May. It is based on data and methods described in Service biological opinions prepared for proposed interim rules governing the releases from Woodruff Dam (USFWS 2006, 2008, 2012).

There are at least 10 potential Gulf sturgeon spawning sites on the Apalachicola River, based on the presence of a limestone, marl, or other hard substrate where sturgeon deposit their adhesive eggs. Egg collections have confirmed that three of these sites (river miles 105, 100, and 99) support spawning at a range of depths from 8.5 to 17.8 feet, a range that excludes the deepest 10 percent and shallowest 10 percent of collections. The SSHPM uses the discharge-habitat relationships for these three sites to predict spawning habitat availability based on these depths (Figure 2).

The SSHPM computes a 30-day running minimum habitat acreage from observed or simulated daily releases from Woodruff Dam during March through May. The annual maximum of these values represents the amount of habitat that was continuously available for at least 30 days to support spawning behaviors and subsequent development of sturgeon eggs and larvae. The SSHPM is an Excel workbook application that requires multiple years of daily discharges as input. The primary output is a graphical frequency distribution ("box and whiskers" plot) of annual maximum 30-day continuous habitat availability. The Excel workbook is organized for comparing the discharge distributions of existing operations (the RIOP) as simulated by ResSim, and up to three additional simulated operations alternatives.

The inter-annual distribution of annual habitat availability estimated by this measure should serve as the basis for comparing the relative effects to sturgeon spawning in simulated operations of the no-action and action alternatives considered for the WCM update. The Corps has stated that they will operate the system in a balanced manner in an attempt to meet all authorized project purposes. Given this objective, we recommend that the Corps prepare and choose alternatives that maximize the amount of inundated Gulf sturgeon spawning habitat while balancing other project purposes.

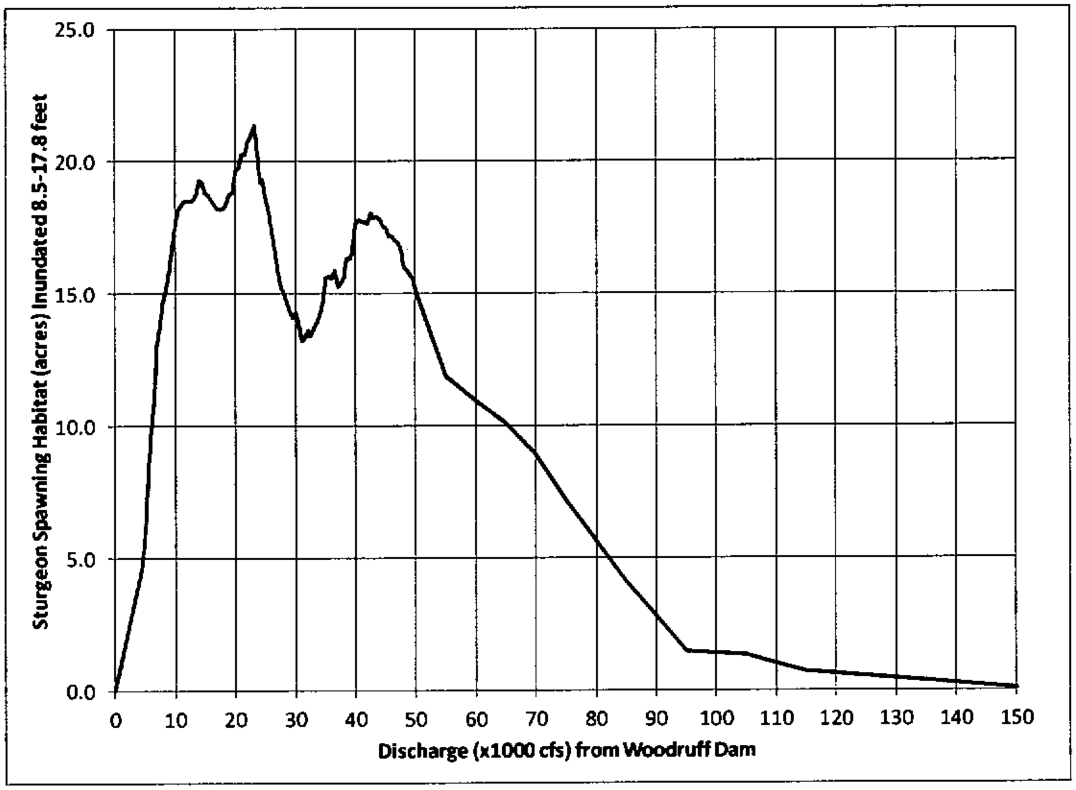


Figure 2. Area (acres) of hard substrate inundated to depths of 8.5 to 17.8 feet at the three known Gulf sturgeon spawning sites on the Apalachicola River at flows of 0 to 150,000 cfs (USFWS 2008).

Apalachicola River Mussels

The Service currently is working on a habitat-based performance measure for the federally-endangered fat threeridge (*Amblema neislerii*) in the Apalachicola River, but this metric will not be ready in time for use in the draft Environmental Impact Statement (EIS) and is not applicable to other mussel species. At this time, the best data available to evaluate the effects of operating alternatives on all three federally-listed mussels are the frequency, magnitude, and duration of low flows in the Apalachicola River.

The Apalachicola River Mussel Performance Measures (ARMPMs) are a suite of hydrologic measures related to mussel survival. Over the past eight years, we have described direct effects to mussels by exposure during low flow conditions. The ARMPMs are based on several of the low-flow and fall-rate metrics described in the biological opinions prepared for proposed interim rules governing the releases from Woodruff Dam (USFWS 2006, 2008, 2012). The ARMPMs include the following metrics: (1) the inter-annual frequency of flow rates less than 5,000 to 10,000 cfs; (2) the median number of days per year less than the thresholds of 5,000 to 10,000 cfs; (3) the median number of consecutive days per year of discharge less than 5,000 to 10,000 cfs; (4) the median fall rates when flows are less than 10,000 cfs; (5) and the maximum fall rates when flows are less than 10,000 cfs.

The ARMPMs are an Excel workbook that requires multiple years of daily discharges as input. The primary outputs are graphical frequency distributions (line charts) for ARMPMs 1-3 above and calculations of ARMPMs 4 and 5. The workbook is organized for comparing the distributions of existing operations (the RIOP) as simulated by ResSim, and up to three additional simulated operations alternatives.

The metrics should serve as the basis for comparing the relative effects to mussels in simulated operations of the no-action and action alternatives considered for the WCM update. The Corps has stated that they will operate the system in a balanced manner in an attempt to meet all authorized project purposes. Given this objective, we recommend that the Corps prepare and choose alternatives that reduce the occurrence and fall rates of low flows, while balancing other project purposes.

Reservoir Fisheries

Multiple game and non-game fishes use the littoral zone for spawning and rearing (e.g., Centrarchidae). The Reservoir Fisheries Performance Measure (RFPM) is an index of habitat conditions for these littoral-zone spawning fishes, computed from time-series of daily surface elevations for Lanier, West Point, and W.F. George reservoirs using the Corps' elevation vs. surface area relationships for each reservoir. We have not developed a RFPM for Andrews and Seminole reservoirs because operating alternatives for these relatively shallow and essentially run-of-river impoundments are unlikely to change their patterns of surface elevation variability.

Like the FSHPM, the RFPM computes a 30-day running minimum habitat acreage during the spawning season from observed or simulated daily reservoir elevations. The annual maximum of these values during the spawning season represents the amount of habitat continuously available for at least 30 days to support spawning behaviors and the growth and development of early life-history stages.

The depth of productive littoral-zone habitat varies with surface elevation, water quality, the extent and duration of reservoir draw-downs in previous years, and other factors. The Corps' fish management plans from the 1970's suggest that 20 feet below full summer pool elevation is the "approximate bottom of the productive zone" for each of the three large storage reservoirs (Corps 1974a, 1974b, 1975). However, fisheries managers and experts for these reservoirs described depths greater than 15, 7, and 10 feet below full summer pool as "totally unacceptable" for littoral spawning or rearing habitat in Lanier, West Point, and W.F. George, respectively (Ryder et al. 1995). The RFPM uses the elevations from Ryder et al. (1995) corresponding to the "unacceptable" depths below full pool as the "floor" of the littoral productive zone.

Ploskey and Reinert (1995) cited numerous studies of successful reproduction and development of strong year classes associated with years of high water inundating terrestrial vegetation in reservoirs. They found positive correlations in West Point and W.F. George reservoirs between spring-time perimeter area (depth less than 6 meters) and standing crop data for Centrarchids. Flooded terrestrial vegetation is especially important to fisheries in Lanier and West Point, where aquatic vegetation is relatively sparse in constantly inundated areas. Miranda et al. (1984) found positive correlations between young-of-year largemouth bass abundance and the extent and duration of flood-pool inundation (i.e., elevations exceeding the top of the conservation pool) at West Point reservoir.

Based on this information, the RFPM computes two subsets of the area of the productive zone inundated during the spawning season for 30 days or more: 1) the area, if any, exposed during the previous growing season for at least 45 consecutive days, where terrestrial vegetation could have colonized exposed shorelines during the previous year; and 2) the area, if any, above the normal full pool elevation that could support perennial terrestrial vegetation (Figure 3). The second subset is a subset of the first, and by adding these two areas to the full inundated area of the productive zone, the RFPM triple-counts inundated acres above normal full pool and double-counts inundated acres that were exposed during the previous year.

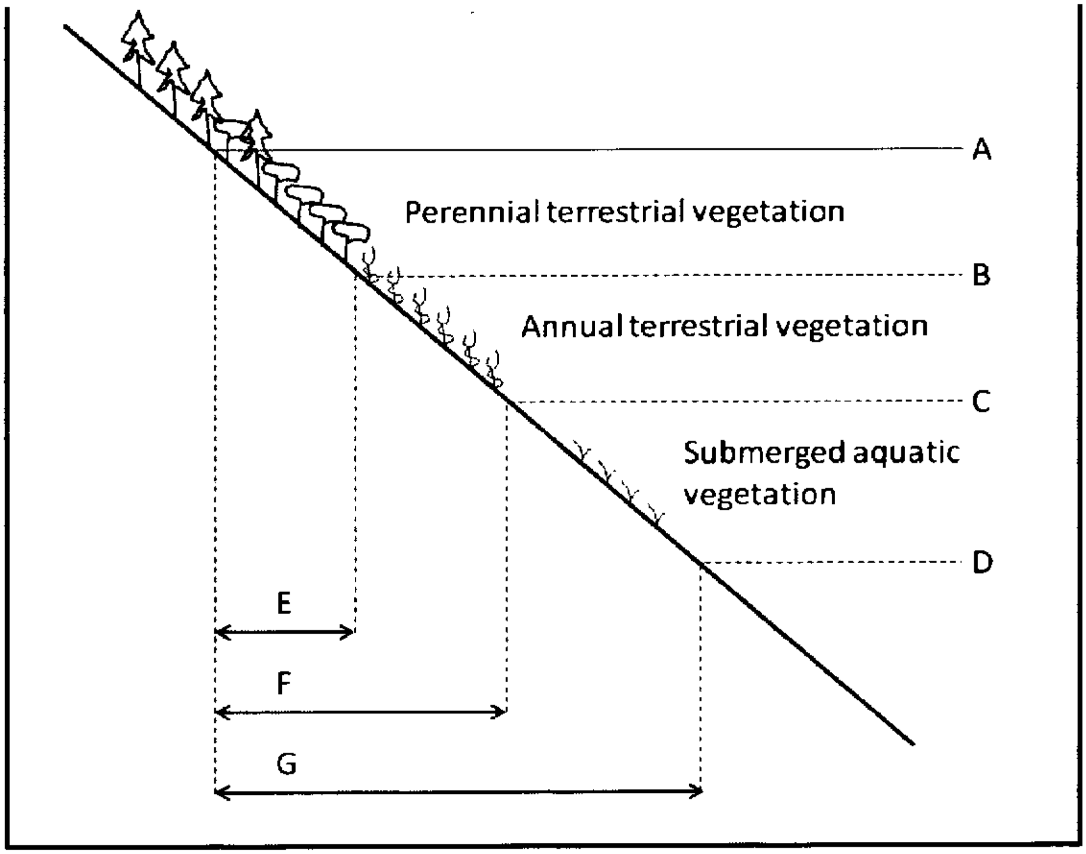


Figure 3. Conceptual drawing of a reservoir shoreline showing RFPM physical features, where
A = maximum surface water elevation sustained for at least 30 days during the spawning season;
B = full conservation pool elevation and lower extent of perennial terrestrial vegetation;
C = the minimum elevation exposed for at least 45 days during the growing season in the previous year;
D = the elevation of the lower extent of reservoir productive zone;
E = the inundated area between A and B;
F = the inundated area between A and C; and
G = the inundated area between A and D.

In this depiction, A exceeds both B and C, and the RFPM would report for the year the sum of E + F + G as the annual habitat acreage (E is triple counted, and F is double counted). In years when A does not exceed B, E is 0; when A does not exceed C, F is zero; and when A does not exceed D, G is zero.

The fish spawning seasons specific to each reservoir for the RFPM are identified in the Corps' Standard Operating Procedure (SOP) for fish spawning in the ACF system (Table 1). The intent of the SOP is to maintain stable or rising reservoir levels for 4 weeks during the 8-week window to promote successful fish spawning and rearing. The 30-day running minimum area calculated in the RFPM begins on the first day of the fish spawn window and concludes on the day that captures the last day of the spawn window in the 30-day minimum calculation. The other temporal and spatial parameters used in the RFPM (e.g., growing season length, elevation of the lower extent of the productive zone) for each reservoir are given in Table 1 along with the values we recommend for its use; however all are user-definable parameters.

Table 1. User-definable parameters for the RFPM with recommended values for its use.

Parameter	Lanier	West Point	W.F. George
Growing season[1] start	Mar. 30	Mar. 20	Mar. 10
Growing season[2] end	Oct. 30	Nov. 5	Nov. 15
Spawning season start	Apr. 1	Apr. 1	Mar. 15
Spawning season end	Jun. 1	Jun. 1	May 15
Elevation (ft) for lower extent of reservoir productive zone	1056	628	180
Exposure duration (days) for establishing terrestrial vegetation during the growing season	45	45	45
Inundation duration (days) for spawning/early rearing	30	30	30
Full conservation pool elevation (ft) and lower extent of perennial terrestrial vegetation	1071	635	190

1=Average dates of last spring freeze (National Weather Service 2013a).
2=Average dates of first fall freeze (National Weather Service 2013b).

Although many other factors besides reservoir elevations, such as flow-through volume, nutrient loading, etc., may influence the population dynamics of reservoir fishes, we believe the RFPM is a relatively simple and useful index for ranking the effects of operating alternatives on reservoir fisheries habitat. We considered using the performance measure that the Service developed for the Corps' 1998 ACF Water Allocation DEIS, which was based in part on the expert-opinion survey results described in Ryder et al. (1995). We prefer and now recommend the RFPM, because it relies solely on direct measures of reservoir area that are likely to contain the habitat features supporting successful fish reproduction. Further, the RFPM results are more easily computed and interpreted than those of the 1998 DEIS performance measure, and are consistent with the Corps' fish spawn SOP, which was adopted after the 1998 DEIS.

The RFPM is an Excel workbook that requires multiple years of daily reservoir elevations as input. The primary output is a graphical frequency distribution ("box and whiskers" plot) for each reservoir of annual maximum 30-day continuous habitat availability. The spreadsheet is organized for comparing the distributions of observed reservoir levels, existing operations (the RIOP) as simulated by ResSim, and up to 6 additional simulated operations alternatives. Displaying additional alternatives is possible by replicating the functions within the spreadsheet.

Chattahoochee River Shoal Bass Recruitment

The Chattahoochee River Shoal Bass Recruitment Performance Measure (CRSBPM) predicts shoal bass (*Micropterus cataractae*) recruitment using a combination of discharge and river water temperatures. Shoal bass are a recently-described black bass endemic to the ACF River Basin, are listed as a species of concern by American Fisheries Society, and are regionally vulnerable (Warren et al. 2000). They frequently occur in shoals over rocky sediments in water exceeding 0.66 feet per second (Sammons and Goclowski 2012). Shoal bass frequently co-occur with other shoal-dwelling native species and their population response to discharge and water quality may be an indicator of shoal fish community response. Because of their recreational fishery significance and the availability of potentially suitable shoal habitat, Georgia Department of Natural Resources and the National Park Service initiated a 5-year shoal bass stocking program in 2003 below Morgan Falls Dam on the Chattahoochee River.

A study was initiated to evaluate the success of the stocking program and to characterize variables affecting recruitment (Long and Porta 2011). The relative abundance (electrofishing catch-per-unit effort) of age-3 shoal bass was of specific interest because these individuals were the minimum age (size) susceptible to capture, had the potential to be stocked, and were present in the river for a duration of time acceptable for inferences regarding cohort recruitment. Mean spring water temperature was highly correlated with discharge, and spring water temperature and bass length at stocking were strong predictors of age-3 catch per unit effort ($F_{2,3}= 20.78$, $R^2 = 0.93$, $p < 0.10$). Because stocked and wild shoal bass had similar lengths, growth rates, and longevity, we expect that wild and stocked fish respond similarly to river water temperatures and that the multiple regression formula of Long and Porta (2011) can be used to make inferences regarding both wild and stocked shoal bass:

$$\log_{10}\text{age-3 abundance} = -6.262 + 0.055_{\text{LStock}} + 0.306_{\text{SpTemp}}$$

where LStock is length in millimeters at time of stocking, and SpTemp is Spring water temperature (from stock date to June 21) in degrees Celsius.

In order to use Long and Porta's (2011) multiple regression model to evaluate multiple alternatives for the WCM updates, we estimated the relationship between discharge and water temperature in the Chattahoochee River at two locations. We used United States Geological Survey (USGS) average daily discharge and temperature data from the Chattahoochee River below Morgan Falls Dam, Georgia gage (USGS #02335815 at river mile 312.5; temperature data available for 2004-2006) and the Chattahoochee River at Atlanta, Georgia gage (USGS #02336000 at river mile 303; temperature data available for 2002-2009, 2011-2012). Both locations were within the study area of Long and Porta (2011). Average temperature and discharge were used for May and June (combined), because averages were used to develop the multiple regression model, and May and June constitute a majority of the spring stocking events (Long and Porta 2011). Exponential relationships produced the best-fit lines (Atlanta $R^2 = 0.94$; Morgan Falls $R^2 = 0.88$; Figure 4).

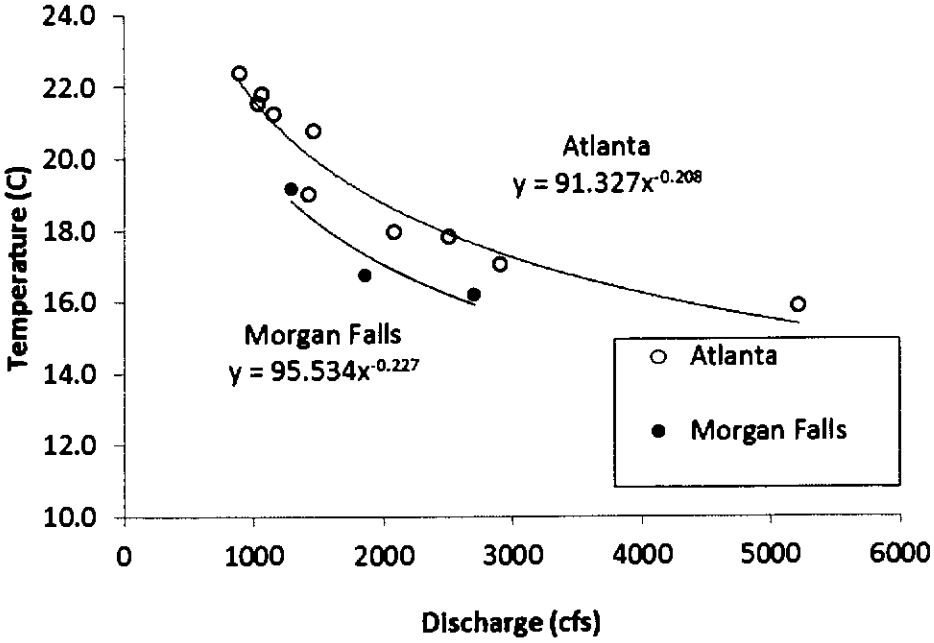


Figure 4. The relationship between spring temperature and average daily discharge for the USGS gage near the Chattahoochee River below Morgan Falls Dam, Georgia (USGS #02335815 at river mile 312.5; temperature data available for 2004-2006) and the USGS gage near the Chattahoochee River at Atlanta, Georgia (USGS #02336000 at river mile 303; temperature data available for 2002-2009, 2011-2012).

Based on these regressions, the CRSBPM is an Excel workbook that computes the average water temperature for May-June based on modeled discharge from the reservoir, then uses the Long and Porta (2011) regression formula to calculate recruitment as catch-per-unit effort of stocked age-3 shoal bass. The user can specify a bass length at stocking to examine recruitment effects. However, it is important that the user specify a length within the range measured in the study (23.7-68.0 mm), and that a consistent length is used to compare alternatives. We used 30 mm because smaller fish are likely to be more vulnerable to temperature changes, although trends are the same for any size selected. The primary output is a graphical frequency distribution ("box and whiskers" plot) that compares predicted age-3 catch-per-unit effort (not log-transformed) among multiple alternatives. The workbook is organized for comparing the distributions of existing operations (the RIOP) as simulated by ResSim, and up to three additional simulated operations alternatives.

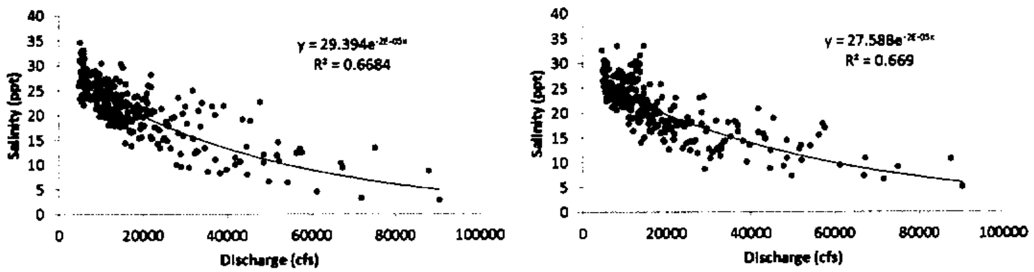
The metric should serve as the basis for comparing the relative effects to age-3 shoal bass in simulated operations of the no-action and action alternatives considered for the WCM update. The Corps has stated that they will operate the system in a balanced manner in an attempt to meet all authorized project purposes. Given this objective, we recommend that the Corps prepare and choose alternatives that improve shoal bass recruitment, while balancing other project purposes.

Apalachicola Bay Salinity

Because salinity in Apalachicola Bay is influenced by river flows, low salinities are prevalent during wet, high flow years and high salinities are prevalent during droughts. Optimal salinities for oysters are less than 26 parts per thousand (ppt) (Livingston et al. 2000; Huang 2010), and juvenile Gulf sturgeon require salinities less than 10 ppt (Altinok and Grizzle 2001; Randall and Sulak 2007;

Sulak et al. 2009). In our 2010 draft FWCA Report, the Service evaluated the effects of reservoir operation alternatives on salinity in Apalachicola Bay using output from a hydrodynamic salinity model developed by Sheng et al. (2011). This model provides detailed information about salinity throughout the bay over various freshwater inflows; however, it is time consuming and requires intensive data post-processing. While revising the alternative we submitted in July 2013, we sought a simpler, nimbler way to evaluate the effects of reservoir operations on salinity in Apalachicola Bay. Because we examined over 80 alternatives, hydrodynamic salinity modeling was not feasible.

The Apalachicola National Estuarine Research Reserve provided us their average daily salinity data for monitoring stations in the bay from 1992 to 2013. We focused on East Bay, which is important juvenile Gulf sturgeon habitat from October through March. We also focused on Cat Point and Dry Bar, which are commercially important oyster bars and where low salinities are most important from May through October. We developed regression relationships between the mean monthly salinity at each of these locations within Apalachicola Bay and the mean monthly discharge at the USGS gage in the Apalachicola River near Chattahoochee, FL (USGS gage 02358000; Figure 5). The Apalachicola Bay Salinity Performance Measure (ABSPM) uses these regressions to compute the mean monthly salinity for these three locations for each month of every year in the simulated discharge period of record. These values represent the average monthly salinities that are experienced at these locations to support Gulf sturgeon and oyster growth and survival.


A) Cat Point

B) Dry Bar

C) East Bay Bottom

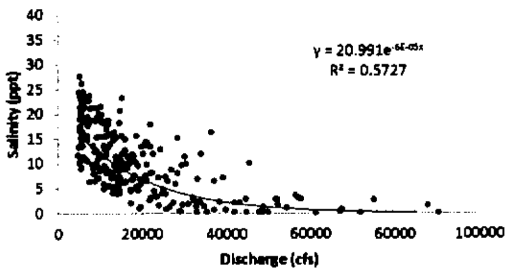


Figure 5. The relationship between Apalachicola River at Chattahoochee discharge (USGS #02358000) and Apalachicola Bay salinity at A) Cat Point, B) Dry Bar, and C) the bottom of East Bay.

The ABSPM is an Excel workbook that produces a graphical frequency distribution ("box and whiskers" plot) of mean monthly salinity for October through March for juvenile sturgeon in East Bay, and May through October for oysters at Cat Point and Dry Bar. The spreadsheet is organized for comparing the salinity distributions resulting from existing operations (the RIOP) as simulated in ResSim, and up to six additional simulated operations alternatives. The ABSPM should serve as the basis for comparing the relative effects of the no-action and action alternatives considered for the WCM update. The Corps has stated that they will operate the system in a balanced manner in an attempt to meet all authorized project purposes. Given this objective, we recommend that the Corps prepare and choose alternatives that improve oyster and sturgeon growth and survival as measured by these performance metrics, while balancing other project purposes.

The Corps should note that the ABSPM is a coarse metric, because it is based on mean monthly salinities. Differences among the alternatives that we have analyzed to date are relatively minor. This may be due to the coarse temporal scale of the metric or the possibility that substantial changes in the bay salinity metric require large amounts of water. Finer spatiotemporal-scale evaluation is necessary to discern whether changes in reservoir operations may improve salinity regimes for sturgeon, oysters, and other bay resources. The Service recommends that the Corps also consider hydrodynamic salinity modeling for comparing the relative effects on Apalachicola Bay salinity in simulated operations of the no-action and action alternatives considered for the WCM update.

Summary

This PAL describes six performance measures that we recommend the Corps use to evaluate impacts of the no-action and action alternatives considered for the WCM update on various target species. We request the opportunity to analyze the Corps' future alternatives using the Service's performance measures. Alternatively, we can provide technical assistance or Excel workbooks for the Corps' analyses, as needed.

Our revised alternative, provided to you July 19, 2013, exhibited improvements to all these performance measures, except the ABSPM, when compared to conditions under the Revised Interim Operating Plan. As discussed above, a lack of notable improvement to the ABSPM may be due to the coarseness of the metric or the requirement for substantial changes in reservoir operations to result in changes to the bay salinity metric. Because most performance measures improved in our revised alternative, we did not prioritize them during our alternative development process. We can develop tailored recommendations in the future if it appears a priority ranking for the six performance measures is needed during the Corps' alternative development process.

We appreciate the opportunity to participate in the planning stages of your project. We would like to stress that the Corps' water management is not just about avoiding adverse effects, but also about restoring and improving habitat. If you have any questions, please contact Georgia Ecological Services staff biologists Will Duncan or Alice Lawrence at (706) 613-9493, or Panama City Ecological Services staff biologist Karen Herrington at (850) 348-6495.

Sincerely,

Robin B. Goodloe
Acting Field Supervisor

cc: J. Ziewitz, USFWS, Tallahassee, FL
K. Herrington, USFWS, St. Charles, MO
S. Abbott, USFWS, Ft. Benning, GA
C. Sumner, Corps, Mobile, AL
D. Imm, USFWS, Panama City, FL
D. Everson, USFWS, Daphne, AL
B. Zettle, Corps, Mobile, AL

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USACE Request for Reinitiating of Consultation
July 2014

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DEPARTMENT OF DEFENSE
UNITED STATES OF AMERICA

DEPARTMENT OF THE ARMY
U.S. ARMY ENGINEER DISTRICT, MOBILE DISTRICT
CORPS OF ENGINEERS
P.O. BOX 2288
MOBILE, ALABAMA 36628-0001

REPLY TO
ATTENTION OF:

July 22, 2014

Inland Environment Team
Planning and Environmental Division

Dr. Catherine T. Phillips
Acting Project Leader
U.S. Fish and Wildlife Service
1601 Balboa Avenue
Panama City, Florida 32405

Dear Dr. Phillips:

This letter is to inform you that the U.S. Army Corps of Engineers (USACE) is requesting to reinitiate consultation of the Biological Opinion on the U.S. Army Corps of Engineers, Mobile District, Revised Interim Operating Plan for Jim Woodruff Dam and the Associated Releases to the Apalachicola River (BO) dated May 22, 2012. In the BO it was believed that the Chipola slabshell is less vulnerable to low-flow related mortality than the fat three ridge or purple bankclimber because of its thinner shell and likely higher mobility, as well as the generally steeper bank slopes in the Chipola River. Previous Chipola slabshell mortality had not been observed and based on limited survey data, it was assumed that flow reductions could affect less than 1% of the slabshell population estimated to be 2,650 individuals. Therefore, it was determined that a total of six Chipola slabshell may be exposed in the Chipola River downstream of the Chipola Cutoff.

Currently the USACE is approaching the incidental take limit as defined in the 2012 BO. The USACE has conducted incidental take monitoring during the summer and fall of 2013 and summer of 2014. We have observed a total of five Chipola slabshell mortalities at the monitoring sites as well as one additional mortality in similar habitat area near a monitoring site. During the 2013 incidental take monitoring period we observed a total of one Chipola slabshell and have observed four slabshell thus far in the 2014 incidental take monitoring period. All of these occurrences were observed at the same monitoring site within the Chipola Cutoff labeled as site C9. It was on July 16, 2014 that an additional mortality was observed after spot checking similar habitat downstream of site C9. Once the field data is extrapolated for the entire Chipola River downstream of the Chipola Cutoff, the incidental take for Chipola slabshell will most likely exceed the incidental take limit.

We believe the BO underestimated the level of incidental take for the Chipola slabshell and are reinitiating consultation in order to request additional take. Should you have any questions, comments, or recommendations, please contact Mr. Brian Zettle, (251) 690-2115, Email: brian.a.zettle@sam.usace.army.mil.

Sincerely,

Curtis M. Flakes
Chief, Planning and Environmental
Division

USFWS August 2014 Amendment to May 2012 Biological Opinion

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MARCH 3, 1849

IN REPLY REFER TO:

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Field Office
1601 Balboa Avenue
Panama City, FL 32405-3721
Tel: (850) 769-0552
Fax: (850) 763-2177

August 07, 2014

Mr. Curtis M. Flakes
Chief, Planning and Environmental Division
U.S. Army Corps of Engineers
P.O. Box 2288
Mobile, Alabama 36628-0001

Dear Mr. Flakes:

This document constitutes an amendment to the U. S. Fish and Wildlife Service's May 22, 2012 Biological Opinion (BO) and Incidental Take Statement (ITS) for the Revised Interim Operating Plan (RIOP) for Jim Woodruff Dam which addresses water management operations at Jim Woodruff Dam and the associated releases to the Apalachicola River. The U.S. Army Corps of Engineers (USACE) requested reinitiation of this Endangered Species Act (Act) section 7(a)(2) consultation by letter dated July 22, 2014 because the amount of take for the Chipola slabshell may exceed authorized levels during the 2014 monitoring period. This letter responds to your request.

The reinitiation request states that the USACE is approaching the incidental take limit for Chipola slabshell provided in the 2012 BO. The USACE has conducted incidental take monitoring during the summer and fall of 2013 and summer of 2014 and has observed a total of 6 Chipola slabshell exposures and mortalities. One live slabshell was found exposed during the 2013 monitoring period and 5 dead have been documented thus far in 2014. All were observed at or near site C9, the only monitoring site on the Chipola Cut. When extrapolated for the entire lower Chipola River and Cutoff, the incidental take of 6 Chipola slabshell is likely exceeded.

In the 2012 BO, we concluded that a total of 6 Chipola slabshell may be exposed in the Chipola River downstream of the Chipola Cutoff when the releases from Woodruff are reduced to 4,500 cfs. We believed the Chipola slabshell to be less vulnerable to low-flow related mortality because of the generally steeper bank slopes (>20%) in the Chipola River, and because its thinner shell made it more mobile than the fat threeridge or purple bankclimber. In the BO, we noted that no slabshell mortality was documented during the low flow conditions of 2006-2008 and 2010-2011. Although we did not observe slabshell mortality, we assumed that some low-flow mortality had occurred.

At the time of the BO, the Chipola slabshell's known range within the action area was limited to the Chipola River downstream of the Chipola Cutoff as the species was not known to occur in the Chipola Cutoff. Limited recent (1990 to 2012) surveys in the Cutoff have documented other mussels species including Fat threeridge and Purple bankclimber, but not Chipola slabshell. A survey conducted in the Cutoff at site C9 during October 2008 found 154 mussels of 9 species, but slabshells were not detected (Gangloff 2011 unpub. data). The first documented collection of slabshell in the Cutoff was in summer 2013 during take monitoring at the C9 site. During monitoring in summer 2014, four additional slabshells were found at the site, and one slabshell was found approximately 50 meters downstream of the monitoring site, in an area with similar habitat features. All 6 individuals were less than 60 mm in length. We do not have length-at-age data for Chipola slabshell from which to infer the age of these mussels, however, external shell annuli indicate they are young individuals–likely less than 3 years old when found. Therefore, recent recruitment to the site may partially explain why none were detected during the 2008 sampling.

The C9 site is one of the few areas in the Chipola Cutoff with a relatively shallow bankslope (mean slope of 0.20, Gangloff 2011 unpub. data), a feature known to cause mussel stranding and mortality (USFWS 2011). The C9 monitoring site is approximately 80 meters in length and the shallow bank habitat appears (in aerials) to extend at least another 80 meters downstream of the monitoring site. A spot-check in the downstream reach found one stranded slabshell, and additional, undetected strandings have likely occurred in this area. We conservatively estimate that at least10 individuals (5 observed in the upstream reach and 5 estimated in the downstream reach) were stranded in this area of the Cutoff. The exposures at the C9 site indicate that slabshells may be more prone to stranding than previously believed.

This amendment to the 2012 BO revises our original take estimate for Chipola slabshell, and adds the Chipola Cutoff as part of its known range within the action area. We have no qualitative survey data or habitat data to use as a basis to calculate the number of mussels that may become stranded in the Cutoff reach. We relied upon limited survey data, results of the 2013 and 2014 monitoring, and habitat conditions in the Chipola River and Cutoff to provide a basis for a conservative, not-likely-to-exceed, take estimate. In total, we anticipate that a maximum of 100 Chipola slabshells may be exposed in the Chipola Cutoff and Chipola River downstream of the Cutoff, during each of these events. We anticipate take of not more than 50 Chipola slabshell if flows are reduced to 4,500 cfs, and 50 if they recolonize areas above elevations associated with flows of 5,000 cfs and are exposed when flows are again reduced to >= 5,000 cfs

This number is considerably higher than anticipated in the 2012 BO, however, the majority of the species' range is in the Chipola River upstream of the action area, and take of 100 Chipola slabshells is still much less than 1% of the population. Therefore, this increase in the amount of incidental take does not change the conclusion of the original BO–we still conclude that water management operations at Jim Woodruff Dam due to the RIOP will not jeopardize the continued existence of the Chipola slabshell.

All other sections of the BO and ITS remain unchanged, and all terms and conditions apply. Thank you for you cooperation during this consultation. If you have any questions or concerns, please feel free to contact me or Ms. Sandra Pursifull of this office at 850-769-0552.

Sincerely,

Dr. Catherine T. Phillips
Acting Project Leader

USACE Response to Planning Aid Letter January 2015

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ACF Water Control Manual Update Response to Planning Aid Letter

U.S. Army Corps of Engineers
October 2014

Contents

1 Description of the Proposed Action and Alternatives

1.1 Introduction

The U.S. Army Corps of Engineers (USACE) proposes to prepare an updated Master Manual for the Apalachicola, Chattahoochee, and Flint River (ACF) Basin. A draft Master Manual was proposed in 1989 along with certain changes to the project manuals, as part of a post-authorization change report for Lake Lanier. The draft 1989 Master Water Control Plan described system operations at that time, but it was never finalized because of litigation filed by Alabama. USACE has been operating projects in the ACF Basin under the draft 1989 Master Water Control Plan on an interim basis pending update of the Master Manual and individual project water control manuals. The component parts of the updated Master Manual would include five project-level water control manuals, presented as appendices that would specify how the various reservoir projects will be operated as a balanced system:

- Appendix A: Jim Woodruff Reservoir
- Appendix B: Buford Dam
- Appendix C: Walter F. George Dam
- Appendix D: George W. Andrews Reservoir
- Appendix E: West Point Reservoir

Water control manuals (WCM) also contain drought operations plans and divide the amount of water in storage into action zones to assist federal water managers in knowing when to reduce or increase reservoir releases and conserve storage in the USACE reservoirs, and how to ensure the safety of dams during extreme conditions such as floods. The individual manuals typically outline the regulation schedules for each project, including operating criteria, guidelines, and guide curves, and specifications for storage and releases from the reservoirs. The water control manuals also outline the coordination protocol and data collection, management, and dissemination associated with routine and specific water management activities (such as flood-control operations or drought contingency operations). Operational flexibility and discretion are necessary to balance the water management needs for the numerous (and often competing) authorized project purposes at each individual project. In addition, there is a need to balance basin-wide water resource needs. Project operations also must be able to adapt to seasonal and yearly variations in flow and climatic conditions.

The updated manual would be prepared in compliance with Engineer Regulation (ER) 1110-2-240 and all other pertinent USACE regulations and policies. Accordingly, the updated Master Manual, including updated water control plans and manuals for the ACF system and each federal project within that system, will reflect operations under existing congressional authorizations, taking into account changes in basin hydrology and demands from years of growth and development, new/rehabilitated structural features, legal developments, and environmental issues.

On June 28, 2011, the U.S. Court of Appeals for the Eleventh Circuit issued an opinion that the authorizing documents for the Buford Dam project include water supply as an authorized purpose. Additionally, the 2011 decision ordered the USACE to reconsider whether it has the legal authority to operate the Buford Project to accommodate Georgia's request made in 2000 to adjust the operation of Lake Lanier, and to enter into agreements with the State, or water supply providers, to accommodate increases in water supply withdrawals from Lake Lanier and downstream at Atlanta. The USACE provided a legal opinion in 2012, concluding that it has sufficient authority under applicable law to accommodate that request, but noting that any decision to take action on Georgia's request would require a separate analysis. On January 11, 2013, the Governor of the State of Georgia provided updated demographic and water demand data to confirm the continued need for 705 million gallons per day (mgd) to meet Georgia's water needs from Lake Lanier and the Chattahoochee River to approximately the year 2040 rather than 2030 as specified in the 2000 request.

Because updating the water control plans and manuals requires making a decision on Georgia's water supply request, USACE will consider, along with operations for all authorized purposes, an expanded range of water supply alternatives associated with the Buford Dam/Lake Lanier project, including current levels of water supply withdrawals and additional amounts that Georgia in 2013 requested from Lake Lanier and downstream at Atlanta. The following sections present the No Action Alternative (NAA) and the Proposed Action Alternative (PAA). The PAA, presented in Section 1.4, is USACE's Preferred Alternative.

1.2 Alternative Formulation Process

1.2.1 Models Used

The alternatives formulation process relied extensively on modeling using the latest software application, HEC-ResSim Version 3.2, Build 3.2.1.19. The software incorporates characteristics of the basin and individual reservoirs including physical constraints (spillway capacities, area-discharge curves, flows associated with hydroelectric power generation, and such) and operational procedures (action zones, balancing, and the like). After ensuring that the corresponding HEC-ResSim models could effectively reproduce the HEC-5 (the predecessor model used for simulating ACF operations) results, Mobile District and HEC created another HEC-ResSim model that captured the most significant operations as of 2008, and the Revised Interim Operating Plan (RIOP)(See Section 1.3.4.4.3 for further RIOP discussion) rules and head limits constraints. That model was presented to stakeholders in October 2008 and generally accepted as a promising improvement to ACF reservoir system modeling. Mobile District and HEC have continued to refine the HEC-ResSim model, using it to evaluate alternatives in support of the 2012 Legal Opinion.

USACE HEC also developed HEC-5Q to provide an analytic tool for evaluating the water quality response. The model is linked with the HEC-ResSim model through an input of flows by reach. The enhanced HEC-5Q developed for the Columbia River Basin was generalized and improved to meet the requirements of the ACT Basin. Longitudinally segmented reservoirs were layered so that the vertical distribution of phytoplankton, dissolved oxygen (DO), and other parameters could be represented. A branching of longitudinally segmented reservoirs was added as an option; it included variable water surface elevations based on backwater computations. A graphical user interface was also added to facilitate displaying and interpreting model results.

1.2.2 Development of Alternatives

On the basis of the operational challenges and problems associated with existing basin operations, extensive stakeholder input during three rounds of scoping, and accounting for the Eleventh Circuit Court of Appeals' ruling, the USACE developed objectives for the WCM updated and identified numerous management measures for possible consideration in the updated WCM. A measure can be defined as a feature or activity that can be implemented at a specific geographic site to address one or more of the objectives. The measures considered in updating the WCM included variations for revising reservoir drawdown and refill periods, reshaping action zones, and balancing zone drawdown proportionally among projects; revising hydroelectric power generation; revising drought operations and environmental flows; and developing navigation-specific operations. The USACE used an iterative process to identify the various measures that would be further developed, analyzed, and refined toward the goal of developing an updated WCM. Each water management measure was considered individually and determined whether it passed the screening criteria established for the WCM update.

The approach to formulating plans employs two phases. In the first phase, water management measures were identified and screened to identify the set of measures that will be combined to form water management alternatives. The evaluation of water management alternatives in this phase assumed that the water supply withdrawals from Lake Lanier would be limited to the 20 mgd withdrawn under the relocation contracts; releases from Buford Dam would be made in accordance with the Chattahoochee River Management System (CRMS), the existing operation; and water supply withdrawals from the Chattahoochee River in the Atlanta metro area would be limited to the amounts withdrawn in 2007. These assumptions facilitate the comparison of the performance of the water management alternatives using a consistent baseline condition that is relatively independent of the influence of the water supply withdrawals from Lake Lanier under the expired contracts. In this phase the No Action Water Management Alternative and six other Water Management Alternatives were considered. The alternative suggested by U.S. Fish and Wildlife Service (USFWS) in a July 19, 2013, letter was among the alternatives considered. The results of ResSim modeling pertaining to the project purposes were used to rank the ability of the alternatives to meet the objectives established for the WCM update. The water management alternative finally chosen represented the best balance of all authorized project purposes. The result of this formulation phase was the identification of a Water Management Proposed Action Alternative.

In the second phase of alternatives formulation, measures for analyzing different levels of water supply use that might be accommodated, including the Georgia 2013 request for water supply from Lake Lanier and for downstream withdrawers were identified and screened to identify the set of measures that were then combined to form water supply alternatives. For this phase, the Water Management No Action Alternative and the Water Management Proposed Action Alternative were used to evaluate and compare the water supply options. The result of this formulation phase was the identification of a tentative PAA. Refinements to the Water Management Proposed Action Alternative and the PAA will be considered in the interest of improving efficiency or reducing adverse effects. The PAA resulting from this two-phased formulation process will consist of a Water Management Proposed Action Alternative together with a proposal for providing some amount of water supply for the Atlanta region.

As a result of the alternatives formulation process, USACE has to date developed a total of eight alternatives. These alternatives are comprised of either the existing water management plan (Water Management No Action Alternative) or the Water Management Proposed Action Alternative together with some quantity of water withdrawn from Lake Lanier and a release from Buford Dam to satisfy either existing or future (2040) water needs for metro Atlanta. For the purposes of the FWCAR, this discussion will focus on comparing the PAA to the NAA; however some graphical data of the other six alternatives will be presented for completeness. Full details of the iterative process used in the alternative selection methodology as well as all project impacts of each alternative will be provided in the Draft Environmental Impact Statement.

1.3 No Action Alternative

The CEQ regulations require analysis of the NAA 40 CFR.1502.14. In the ACF WCM EIS, no action represents no change from the current management direction or level of management intensity. This alternative would represent continuation of the current water control operations at each of the federal projects in the ACF Basin. The USACE's operations have changed incrementally since completion of the 1958 ACF Master Manual. The changes were documented in a draft water control plan in 1989. However, additional incremental changes in water control operations have occurred since 1989 and are reflected in the No Action Alternative operation and the RIOP. Except in very general terms, it is not possible to describe a single set of reservoir operations that apply to the entire period since completion of the 1958 ACF Master Manual. The NAA reflects operational practices on the ACF Basin as described in the following documents:

- Draft ACF Water Control Plan dated 1989
- Project Water Control Manuals for Buford (1991), West Point (1984), Walter F. George (1993), George Andrews (1996), and Jim Woodruff Lock and Dam (1985) (USACE, Mobile District, 2010b)
- RIOP and Environmental Assessment (EA) (June 2008), as modified by the updated RIOP/EA (May 2012)
- South Atlantic Division Regulation (DR) PDS-O-1, *Project Operations, Lake Regulation and Coordination for Fish Management Purposes* (May 31, 2010) and Draft *Reservoir Regulation and Coordination for Fish Spawn Management Purposes Standard Operating Procedure* (SOP), (USACE, Mobile District SOP 1130-2-9) February 2005
- Chattahoochee River Management System (CRMS) as described in the ACF Basin Master Reservoir Regulation Manual, Appendix B, Buford Dam (Lake Sidney Lanier) Chattahoochee River, GA, February 1991

Additionally, the NAA includes current water supply operations including withdrawals directly from Lake Lanier as well as releases from Buford Dam for downstream withdrawal. The following subsections describe key operational elements that apply to evaluating the NAA.

1.3.1 General System Operations

The USACE operates five dams in the ACF Basin (in upstream to downstream order)—Buford, West Point, Walter F. George, George W. Andrews (Andrews) on the mainstem of the Chattahoochee River, and Jim Woodruff (Woodruff), immediately below the confluence of the Chattahoochee and Flint rivers at the upstream extent of the Apalachicola River. Buford Dam, West Point Dam, and Walter F. George Lock and Dam are reservoirs (Lake Lanier, West Point Lake, and Walter F. George Lake, respectively) with a combined conservation storage capacity (relative to the top of each reservoir's full summer pool) of about 1.64 million acre-feet (ac-ft). Jim Woodruff Lock and Dam (Lake Seminole) is operated as a run-of-river project and only very limited pondage is available to support project purposes (USACE, Mobile District 1998a). Andrews is a lock and dam without any appreciable water storage behind it.

The last environmental impact statements evaluating the environmental consequences of the individual operating reservoirs in the ACF Basin were completed in the 1970's. Since then incremental changes in project operations have occurred due to changes in hydropower contracts and operating schedules, changes in navigation flow requirements, and other changes related to water quality, environment, or other uses of the system.

The reservoirs in the ACF Basin are managed and operated in accordance with authorized project purposes of flood risk management (formerly referred to as flood control or flood damage reduction), hydroelectric power generation, navigation, fish and wildlife conservation, recreation, water quality, and water supply and as an integrated system of water resource projects in which each reservoir has a role to play. ACF Basin water control operations consider all project functions and account for the full range of hydrologic conditions from flood to drought. Because actions taken at the upstream portion of the basin affect conditions downstream, the federal projects in the ACF Basin are operated as a system rather than as a series of individual, independent projects. The balancing of water control operations to meet each of these purposes varies between the individual projects and time of year. Operation of the projects is usually performed in a manner which represents a consideration of these at times competing purposes and, whenever possible, reservoir operations are managed to accommodate these purposes in a complementary fashion. For example, flood waters are evacuated to the greatest extent practicable through the powerhouse turbines to produce electricity. In addition to specific purposes for which these projects are operated, a variety of activities also benefit the operational patterns of these projects.

Many factors must be evaluated in determining project or system operation, including project requirements, time of year, weather conditions and trends, downstream needs, and the amount of water remaining in storage. The guidelines are not limited to a specific hydrologic condition, and therefore the Master Manual differs from a flood risk management or drought management plan; however, the plan is broad enough that it can fulfill requirements for a drought management plan.

Traditionally, the federal projects in the ACF Basin have been operated in such a manner that hydroelectric power generation requirements controlled during the summer months when energy demands are high, while navigation needs dominated during the fall, low-flow months. Whenever rainfall has caused water levels to rise excessively, flood risk management operations override other project functions. During extreme drought conditions, water supply and water quality requirements have been the major operating concerns. During the extreme drought period beginning in 2006, federally listed threatened and endangered species conservation also became a priority consideration in managing the system. This water management approach recognizes that extreme droughts may produce situations where trade-offs are required. For example, in extreme droughts project operations directed primarily at water supply, water quality, and/or endangered species conservation, may receive higher consideration than other purposes, such as hydroelectric power generation, navigation, or recreation.

1.3.2 Guide Curves

A guide curve is the seasonally variable desired pool elevation in a reservoir to fully meet project purposes. Existing guide curves are shown in the Water Control Manuals for Buford Dam (1991), West Point Dam (1984), Walter F. George Lock and Dam (1993), George W. Andrews Lock and Dam (1996), and Jim Woodruff Lock and Dam (1985) projects. The guide curves for Lanier, West Point, and Walter F. George lakes are shown in Figure 1.3-1, Figure 1.3-2, and Figure 1.3-3.

1.3.3 Action Zones

The *1989 draft ACF Water Control Plan* (USACE, Mobile District 1989a) defines action zones for each of the three major storage projects on the ACF Basin—Lake Lanier (Figure 1.3-1), West Point Lake (Figure 1.3-2), and Walter F. George Lake (Figure 1.3-3). Those zones are used to manage the reservoirs at the highest level possible while balancing the needs of all the authorized purposes. Zone 1, the highest in each reservoir, defines a reservoir condition where all authorized project purposes should be met. As lake levels decline, Zones 2 through 4 define increasingly critical system water shortages and guide the USACE in reducing flow releases resulting from drier-than-normal or drought conditions. The action zones also provide guidance on meeting minimum hydroelectric power generation needs at each project, and they determine the amount of storage available for downstream purposes such as flood risk management, hydroelectric power generation, navigation, fish and wildlife conservation, recreation, water quality, and water supply.

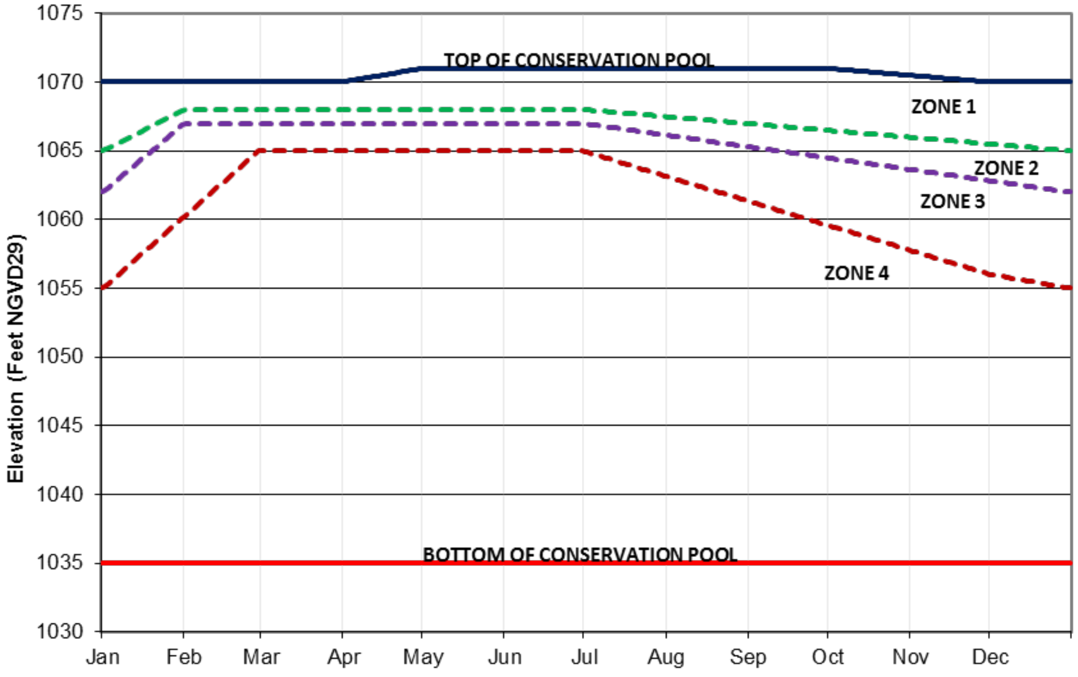

Figure 1.3-1. Lake Lanier water control action zones

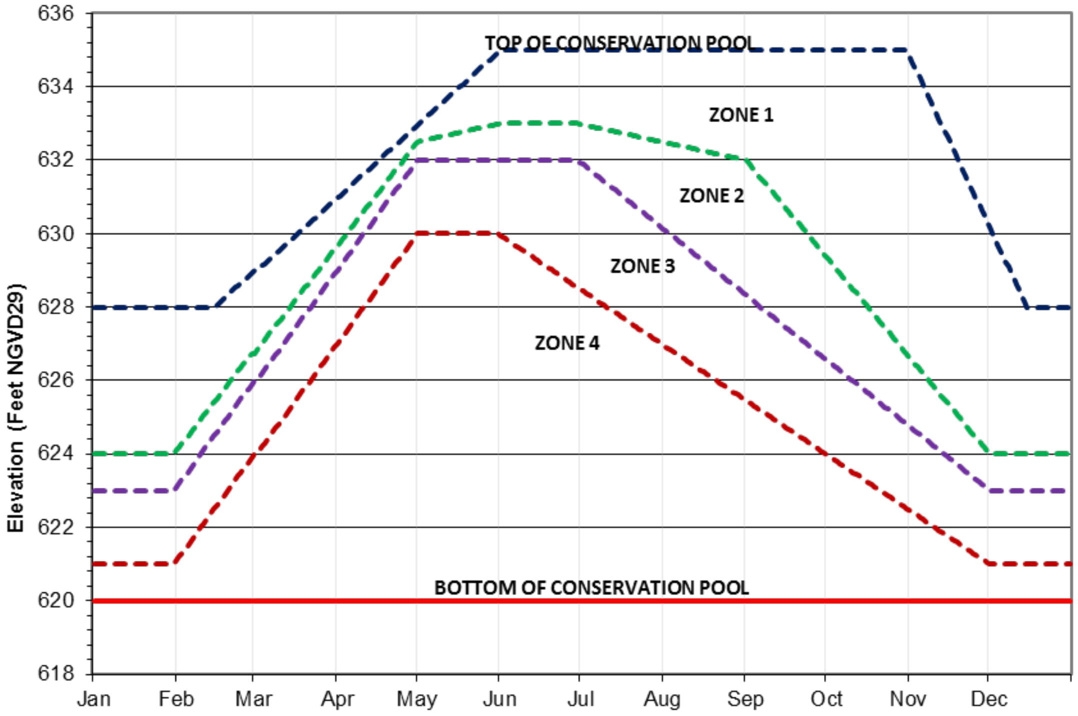

Figure 1.3-2. West Point Lake water control action zones

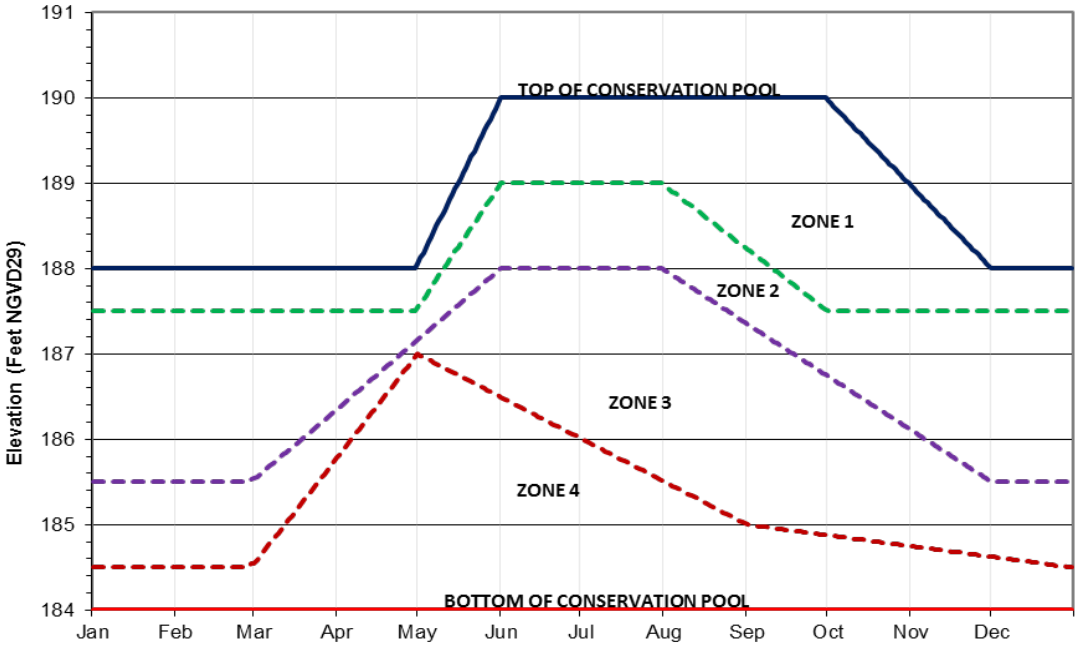

Figure 1.3-3. Walter F. George Lake water control action zones

At the time of their development in 1989, action zones were derived on the basis of past project operations, which considered time of year, historical pool level/release relationships, operational limits for conservation, and recreational resource impact levels. The action zones have provided a key management tool for more than 20 years providing the basic guidelines for operating the river system; however, other factors and activities might cause the USACE to operate the reservoirs differently than the zones shown on the charts. Examples of those factors or activities could include exceptional flood risk management measures, fish spawn operations, maintenance and repair of turbines, emergency situations such as a drowning and chemical spills, draw-downs because of shoreline maintenance, releases made to free grounded barges, and other circumstances.

The storage projects are operated to maintain their lake level in the same zones concurrently. However, because of the hydrologic and physical characteristics of the river system and factors mentioned above, there might be periods when one reservoir is in a higher or lower zone than another. When that occurs, the USACE makes an effort to bring the reservoirs back into balance with each other as soon as conditions allow. By doing so, effects on the river basin are shared equitably among the projects. The following definitions apply to the action zones:

- Zone 1: Indicates that releases can be made in support of seasonal navigation (when the channel has been adequately maintained) and hydroelectric power releases. If all reservoirs are in Zone 1 or above, the USACE would operate the river system normally.
- Zone 2: Indicates that water to support seasonal navigation might be limited. Hydroelectric power generation is supported at a reduced level. Minimum flow targets are met.
- Zone 3: Indicates that water to support seasonal navigation might be significantly limited. Hydroelectric power generation is supported at a reduced level. Minimum flow targets are met.
- Zone 4: Indicates that navigation is not supported. Hydroelectric power demands will be met at minimum levels and might occur only for concurrent uses. Minimum flow targets are met.

The action zones have provided a key management tool for more than 20 years. They play a substantial role in several aspects of operating the lakes and dams. Under the NAA, it is assumed that the action zones would remain in effect unchanged.

1.3.4 Authorized Project Purposes

The following subsections describe each of the operations in the NAA for the authorized project purposes in more detail.

1.3.4.1 Flood Risk Management

The objective of flood risk management operations (formerly referred to as flood control) is to impound excess flows, thereby reducing downstream river levels below flood stage. Whenever flood conditions occur, operation for flood risk management takes precedence over all other project functions. Only Buford and West Point Dams have storage allocated for flood risk management operations. During the principal flood season, December through April, the regulation plan at Walter F. George Lake provides for lower lake levels to ensure lower peak stages throughout the reservoir during major floods. George W. Andrews and Jim Woodruff dams operate to pass inflows.

The timing of flood peaks in the ACF Basin is of considerable importance in determining the effectiveness of reservoir operations for flood risk management and the degree to which such operations can be coordinated. During a flood event, excess water above the normal pool elevation or *guide curve* is evacuated (released) consistent with other project needs as soon as downstream waters have receded enough that releases from the reservoirs will not increase the natural maximum flood heights downstream. This timely evacuation is necessary so that consecutive flood events will not cause floodwaters to exceed allocated storage capacities and endanger the integrity of the dam. Both turbines and spillways are used, as necessary, to evacuate floodwaters.

Because flooding usually occurs in the winter and spring when rainfall and runoff are more plentiful and hydroelectric power generation demands are lower, the guide curve operation generally reflects this situation by specifying a lower elevation during this time period. Transitions between the seasonal levels are gradual to moderate increases or decreases in outflow. By drawing down the pool in late fall, either specifically for flood risk management (flood control) as at West Point or coincidentally for other purposes, additional storage is gained for containing floodwaters.

For flood risk management purposes, releases are reduced or terminated at Buford Dam, except for the small hydropower unit, as soon as it appears that downstream river stages will exceed flood stage. Key gaging stations in the vicinity are intensively monitored to determine when floodwaters have begun to recede so that flood storage in the reservoir can be expeditiously evacuated in a manner consistent with other project functions without exacerbating downstream flooding. Projects on the middle and lower river pass flood waters once the pool has reached the top of the conservation pool. West Point and Walter F. George operate according to specified flood risk management plans, as outlined in their Water Control Manuals. Spillway gates are opened if necessary to assist the turbines in passing these flows.

Even though the traditional flood season spans several months, discrete incidences of flooding should have insignificant long-duration effects if pool elevations are maintained close to guide curve elevations. No pool is allowed to remain above its guide curve for any appreciable length of time without prior approval of a temporary deviation or variance by the USACE South Atlantic Division.

1.3.4.2 Hydroelectric Power Generation

Hydroelectric power generation is a small but key feature in meeting the power demands of the region. Hydroelectric power generation plants provide a portion of the region's electric power peak demands. Peaking capability on short notice is greatly valued for power grid reliability. Hydroelectric power generation is instantaneously available to meet extreme increases in power demand or to replace unexpected interruptions in thermal generation. The power generated by the USACE projects in the ACF Basin is marketed by the Southeastern Power Administration (SEPA), an agency of the Department of Energy. SEPA markets power on the basis of a system that comprises a large geographical area to a number of cooperatives and municipal retail suppliers of power, referred to as *preference customers*. Projects within SEPA's Georgia-Alabama-South Carolina system include Buford, West Point, and Walter F. George on the Chattahoochee; four projects in the Alabama, Coosa, and Tallapoosa River Basin; and three projects on the Savannah River Basin. The 10 powerhouses in this system have been operated most of the time as *peaking plants* in an integrated fashion to produce an aggregate hydroelectric power generation supply for the system. As a result, power generation demands have been balanced among these projects weekly to enhance the long-term generating capability of the entire system. By integrating the operation of these projects, the total utility and marketability of power produced for the entire system is greatly increased and the adverse effects on the reservoirs are more balanced. When the system obligation cannot be met, the SEPA arranges for supplemental power or purchases from other sources, or both.

The storage projects (Lake Lanier, West Point Lake, and Walter F. George Lake) are operated as *peaking plants* and generally provide at least two hours of generation a day, five days a week at powerhouse capacity through the year, as long as sufficient conservation storage is available. The amount of generation per day is governed by a preset guide curve and action zones for each reservoir, with diminishing energy generation with declining storage. Minimum generation provides the release that would normally meet downstream water supply and water quality demands, as well as provides the capacity specified in SEPA's marketing arrangement. During the summer and early fall (July through October) typical operation provides minimum generation of four hours a day at a project if the pool level is above Zone 3, as identified on Figure 1.3-1 (Lake Lanier), Figure 1.3-2 (West Point Lake), and Figure 1.3-3 (Walter F. George Lake). This increase assists in meeting the high energy demands during that period. Minimum releases may also be increased if local inflows below the project are insufficient to meet water quality/water supply requirements. Additional generation solely to meet system hydroelectric power generation demands does not occur.

Because it does not have the ability to store appreciable amounts of flow, the Jim Woodruff (Lake Seminole) project is operated as a run-of-river plant and is dependent on releases from the upstream impoundments on the Chattahoochee River and from the Flint River. Unlike projects with appreciable conservation storage, run-of-river hydroelectric power generation facilities do not follow a guide curve, nor do they fluctuate or redistribute flows. The output of the plant varies with changes in the inflow entering Lake Seminole. The Jim Woodruff is a one-project system and power generated is marketed by SEPA to seven preference customers in the northern part of Florida to provide a specific minimum capacity and weekly energy. When that obligation cannot be met, the SEPA arranges for supplemental power or purchases from other sources, or both.

The current RIOP includes a limited hydroelectric power peaking operation at Jim Woodruff Dam when daily average releases are less than the combined capacity of the powerhouse turbines (about 16,000 cubic feet per second (cfs)) to deliver extra power during hours of peak demand for electricity. Those peaking releases are included in the daily average discharge computations for the RIOP minimum flow provisions. The peaks are also included in the stage computations for the RIOP maximum fall rate schedule; however, the maximum fall rate schedule addresses the difference between the average river stage on consecutive calendar days, not the shorter-term differences that result from peaking operations within a calendar day. The current RIOP includes a provision that discontinues peaking operations at the Jim Woodruff plant as average daily releases approach 6,700 cfs, to maintain instantaneous releases greater than or equal to the 5,000 cfs minimum flow requirement.

Droughts experienced over the basin in the past 35 years have revealed that, during extended low-flow seasons, operation of the federal projects in the ACF Basin for hydroelectric power generation production to meet the SEPA contract requests do not provide enough flexibility to adequately meet other authorized purposes. During these times, water taken from storage during the high-energy-demand months (June through September) would draw the pools down to such an extent that recreation would be affected in the lakes and less storage would be available late in the year to meet other release requirements, such as navigation or water quality. In such instances, hydroelectric power generation has been curtailed, as necessary, to balance the entire system operation. The typical hours of operation by action zone are presented in Table 1.3-1.

Table 1.3-1. Typical hours of peaking hydroelectric power generation by USACE project

Action zone	Buford Dam (hours of operation)	West Point Dam (hours of operation)	Walter F. George Dam (hours of operation)
Zone 1	3	4	4
Zone 2	2	2	2
Zone 3	2	2	2
Zone 4	0	0	0

In addition to hydroelectric power generation being governed by action zone, physical limitations also factor into the power generation decisions. The main hydroelectric power generation units and small house unit intakes at Buford Dam are at elevation 919 ft. However, severe cavitation occurs in the main hydroelectric power generation units when the water surface falls to 1,035 ft or below, at which time the units are taken out of service and generation ceases. The small house unit goes off-line when water elevations reach 1,020 ft or below. With this measure the current hydroelectric power generation schedule would be maintained.

Under the NAA, it is assumed that the current hydroelectric power generation operations would remain in effect unchanged.

1.3.4.3 Navigation

The existing authorized navigation project includes a 9-ft by 100-ft navigation channel from Apalachicola, Florida, to Columbus, Georgia, on the Chattahoochee River, and to Bainbridge, Georgia, on the Flint River. Hydraulic and sedimentation characteristics of the Apalachicola River have been such that, despite maintenance dredging, the controlling channel depth has typically been less than 9 ft during a large portion of the normal low-flow period of the summer and fall each year. Groundings have been frequent, and barge loadings have been reduced considerably at times in the past to avoid grounding delays. Because of deteriorating channel conditions and limited channel availability during the low-flow months, navigation windows were routinely scheduled during the low-flow months in the 1990s. Navigation windows were composed of storing water in the upstream reservoirs for several weeks and then making increased releases for a 10-day to 2-week period to allow commercial barge navigation to make a round trip up river for scheduled delivery of commodities. Concerns were raised regarding the fluctuations of both reservoir and river stages associated with navigation window releases, and the continued use of navigation windows became increasingly controversial, especially during sustained, low-flow periods when observed fluctuations were more extreme. As a result of fluctuating river stages during navigation windows, gradual ramping rates were developed in coordination with the USFWS and Florida Fish and Wildlife Conservation Commission, with the goal to provide for ramping down rates of not more than one-half ft/d during fish spawn activities, and no more than one ft/d during other times of the year, whenever flows were below 20,000 cfs.

Through most of the 1990s, the navigation channel on the ACF Basin was used consistently and frequently by commercial traffic. The authorized navigation channel downstream of Jim Woodruff Dam was maintained in reasonably reliable condition by way of maintenance dredging, snagging, and training works, combined with flows from upstream that were generally sufficient to meet navigation needs. During that period, annual tonnage ranged from 550,000 to 640,000, and annual traffic ranged from 900 to 1,200 trips. Navigational use of the ACF waterway declined precipitously during 1999 and has not recovered since. The last navigation window was provided in the spring of 2000, and it precipitated complaints that the navigation window was scheduled during the period of fish spawn and had adversely affected both reservoir and riverine fish spawn activities. No navigation windows have been scheduled since, and none are planned in the foreseeable future.

No dredging was conducted in 2000 or 2002 because of sustained drought conditions in the basin, and only very limited dredging was conducted in 2001 and then was shut down because of sustained, low flow conditions. The navigation project was not maintained in 2002–2005, principally due to the lack of navigation traffic, environmental conditions and constraints on dredging activities, and consequently, funding constraints. In March 2004 the USACE, Mobile District applied for a 5-year renewal of the Section 401 water quality certification for maintenance dredging of the authorized navigation channel in the Apalachicola River. After an extended period of coordination and negotiation regarding renewal of water quality certification, the Florida DEP formally denied the Mobile District's request on October 11, 2005 (USACE, Mobile District 2006). No maintenance dredging on the Apalachicola River, or appreciable navigation use of the ACF navigation system, has occurred since. In June 2012, the Mobile District applied to the Florida DEP for a permit to continue to conduct routine maintenance snagging to remove tree snags from the navigation channel in the Apalachicola River portion of the project. The request did not include any proposed dredging activity. The snagging permit was issued to USACE, Mobile District, on November 27, 2013 and is in effect for ten years from the issue date (FLDEP 2013a). Minimal navigation dredging occurred in 2010 on the Chattahoochee River upstream of Jim Woodruff Lock and Dam to facilitate navigation on that portion of the ACF waterway, but no dredging has been conducted since. No water management activities are routinely being undertaken in the ACF Basin specifically to support navigation.

Although navigation is an authorized purpose of the USACE projects in the ACF Basin, the basin is not set up to actively support navigation flow requirements which are currently estimated to require 20,600 cfs for a 9-ft channel This is principally due to a lack of commercial navigation use and the inability to secure the necessary water quality certification from the Florida DEP to perform the required maintenance dredging and other operational activities for the navigation channel downstream of Jim Woodruff Dam, as discussed above. Limited use of special releases to assist with critical navigation requirements (in the form of a brief navigation window) have been addressed on a case-by-case basis. Such special releases, when requested, are coordinated with Alabama, Florida, and Georgia; federal resource agencies; and key stakeholders.

1.3.4.4 Fish and Wildlife Conservation

West Point Dam is the only federal project in the ACF Basin with *fish and wildlife conservation* specifically included in its original authorization by Congress. Nonetheless, the ACF Basin USACE reservoirs (Lanier, West Point, Walter F. George, Andrews, and Seminole lakes) operate to support fish and wildlife conservation pursuant to the authority in either the Fish and Wildlife Coordination Act or the Endangered Species Act (ESA). Generally, reservoir operations for fish and wildlife conservation consist of either maintaining pool elevations during fish spawns or making special releases to minimize the possibility of fish kills. Special drawdowns for specific environmental purposes may be specified from time to time, but only after coordination with state and federal resource agencies and others, as appropriate. Although the possibility of requiring water control actions may extend throughout a season, the actual actions are usually of short duration. In addition to fishery management, these operations include aquatic plant control, waterfowl, and other terrestrial habitat management. The various projects in the basin have specific operations for fish and wildlife, which are described in the individual reservoir regulation manuals for these projects. Specific fish and wildlife conservation activities on the USACE ACF Basin projects are addressed in more detail in the following paragraphs.

1.3.4.4.1 Fish Spawning

In addition to providing for minimum flow and water quality releases, the USACE operates the system to provide favorable conditions for annual fish spawning, both in the reservoirs and the Apalachicola River. In most water years (October 1 - September 30) it is not possible to hold both lake levels and river stages at a steady or rising level for the entire spawning period, especially when upstream lakes or the Apalachicola River spawning periods overlap. During the fish spawning period for each waterbody (Table 1.3-2), the USACE's goal is to operate for a generally stable or rising lake level and a generally stable or gradually declining river stage on the Apalachicola River for approximately 4 to 6 weeks during the designated spawning period. When climatic conditions preclude a favorable operation for fish spawn, the USACE consults with the state fishery agencies and the USFWS on balancing needs in the system and minimizing the effects of fluctuating lake or river levels. USACE South Atlantic Division Regulation (DR) 1130-2-16 (March 30, 2001) and Mobile District Draft Standard Operating Procedure (SOP) 1130-2-9 (February 2005) were developed to address reservoir regulation and coordination for fish management purposes. South Atlantic DR 1130-2-16 has been updated and renumbered as South Atlantic DR PDS-O-1 (May 31, 2010), *Project Operations, Lake Regulation and Coordination for Fish Management Purposes*. It specifically applies to operations at Lake Lanier, West Point Lake, Walter F. George Lake, and Lake Seminole in the ACF Basin as well as other reservoirs in the USACE South Atlantic Division. Under the NAA, it is assumed that the fish spawn operations would remain in effect unchanged.

Table 1.3-2. Specific principal fish spawning period

	Fish spawn period
Lake Lanier	April 1–June 1
West Point Lake	April 1–June 1
Walter F. George Lake	March 15–May 15
Lake Seminole	March 1–May 1
Apalachicola River	April 1–June 1

1.3.4.4.2 Fish Passage

Most springs (since 2005) from March through May, the USACE has operated the lock at Jim Woodruff Dam to facilitate downstream to upstream passage of Alabama shad and other anadromous fishes (those that return from the sea to the rivers where they were born to breed). There are slight differences in the locking technique each year. However, in general two fish locking cycles are performed each day between 8 a.m. and 4 p.m.; one in the morning and one in the afternoon. The operation consists of opening the lower lock gates and getting fish into the lock in one of three ways—by transporting them into the lock by boat (2005), using attraction flows to entice the fish into the lock (2006–2007), by leaving the lower gate open for a period before a lockage and allowing the fish to move in without an attraction flow (2008), in 2009 no lockages were done, and attraction flows were used again in 2010 - 2012. Once the fish are in the lock (or assumed to be in the lock), the downstream doors are closed. The lock is filled to the reservoir elevation and the upper gates are opened. Studies are ongoing to determine the most appropriate technique and timing for the locks, but the number of lock cycles per day will not change. Under the NAA, it is assumed that the current fish passage operation would remain in effect unchanged.

1.3.4.4.3 Endangered Species Conservation - Revised Interim Operations Plan

In addition to fish spawn management and fish passage operations, the USACE manages releases from Jim Woodruff Dam to support the federally protected Gulf sturgeon and mussel species (fat threeridge, purple bankclimber, and Chipola slabshell) in the Apalachicola River. That operation is governed by a set of minimum flow and maximum fall rate provisions called the Revised Interim Operations Plan (RIOP) resulting from formal consultation concluded in May 2012 with USFWS issuance of a new Biological Opinion for Jim Woodruff Lock and Dam.

The May 2012 RIOP is governed by two basic parameters applicable to daily releases from Jim Woodruff Dam: a minimum discharge in relation to average basin inflows (measured as daily average in cfs) and a maximum fall rate (vertical drop in river stage [ft/day]). The 2012 RIOP places limitations on refill, but it does not require a net drawdown of composite conservation storage (discussed in more detail below) unless basin inflow is less than 5,000 cfs.

Minimum Discharge. The RIOP varies minimum discharges from Jim Woodruff Dam by basin inflow and by month, and the releases are measured as a daily average flow in cfs at the Chattahoochee gage. Table 1.3-3 shows minimum releases from Jim Woodruff Dam prescribed by the RIOP and shows when and how much basin inflow is available for increasing reservoir storage. Except when basin inflow is less than 5,000 cfs, the minimum releases are not required to exceed basin inflow. The RIOP defines additional basin inflow threshold levels that vary by three seasons: spawning season (March–May); non-spawning season (June–November); and winter (December–February). The RIOP incorporates composite conservation storage thresholds that factor into minimum release decisions. Composite conservation storage is calculated by combining the conservation storage of Lake Sidney Lanier, West Point Lake, and Walter F. George Lake. Conservation storage in each of the individual reservoirs consists of four zones, which are determined by the operational guide curve for each project. The composite conservation storage uses the four-zone concept as well (i.e., Zone 1 of the composite conservation storage represents the combined storage available in Zone 1 for each of the three storage reservoirs). Figure 1.3-4 illustrates the ac-ft of storage available for Composite Zones 1 through 4 throughout the year.

Table 1.3-3. May 2012 RIOP for Jim Woodruff Dam, Apalachicola River minimum discharge from Woodruff Dam by month and by basin inflow (BI) rates

Months	Composite conservation storage zone	Basin inflow (BI) (cfs)	Releases from Jim Woodruff Lock and Dam (cfs)	BI available for storage[a]
March–May	Zones 1 and 2	≥ 34,000	≥ 25,000	Up to 100% BI>25,000
		≥ 16,000 and < 34,000	≥ 16,000+50% BI > 16,000	Up to 50% BI>16,000
		≥ 5,000 and < 16,000	≥ BI	
		< 5,000	≥ 5,000	
	Zone 3	≥ 39,000	≥ 25,000	Up to 100% BI>25,000
		≥ 11,000 and < 39,000	≥ 11,000+50% BI > 11,000	Up to 50% BI>11,000
		≥ 5,000 and < 11,000	≥ BI	
		< 5,000	≥ 5,000	
June–November	Zones 1,2, and 3	≥ 22,000	≥ 16,000	Up to 100% BI>16,000
		≥ 10,000 and < 22,000	≥ 10,000+50% BI > 8,000	Up to 50% BI>10,000
		≥ 5,000 and < 10,000	≥ BI	
		< 5,000	≥ 5,000	
December–February	Zones 1,2, and 3	≥ 5,000	≥ 5,000 (Store all BI> 5,000)	Up to 100% BI > 5,000
		< 5,000	≥ 5,000	
At all times	Zone 4	NA	≥ 5,000	Up to 100% BI > 5,000
At all times	Drought Zone	NA	≥ 4,500[b]	Up to 100% BI > 4,500

Source: USACE, Mobile District 2012; USFWS 2012.

a. Consistent with safety requirements, flood risk management purposes, and equipment capabilities.

b. Once composite conservation storage falls below top of Drought Zone, ramp-down to 4,500 cfs will occur at a rate of 0.25 ft/day.

The 2012 RIOP operations and thresholds from March through May are intended to support Gulf sturgeon spawning activities. The 16,000 cfs minimum release is also based on evaluation of spawning and rearing needs for the host fish necessary for mussel reproduction. The RIOP operations from June through February are intended to support the federally protected mussels, host fish for mussels, and young sturgeon.

During spawning season, two sets of four basin-inflow thresholds and corresponding releases exist according to the composite conservation storage (Figure 1.3-4). When the composite conservation storage is in Zones 1 and 2, a less conservative operation is in place. When the composite conservation storage is in Zone 3, a more conservative operation is in place while still avoiding or minimizing impacts on federally listed species and designated critical habitat in the river. When the composite conservation storage falls below the bottom of Zone 3 into Zone 4, the drought contingency operations are *triggered*. Drought contingency operations are summarized below.

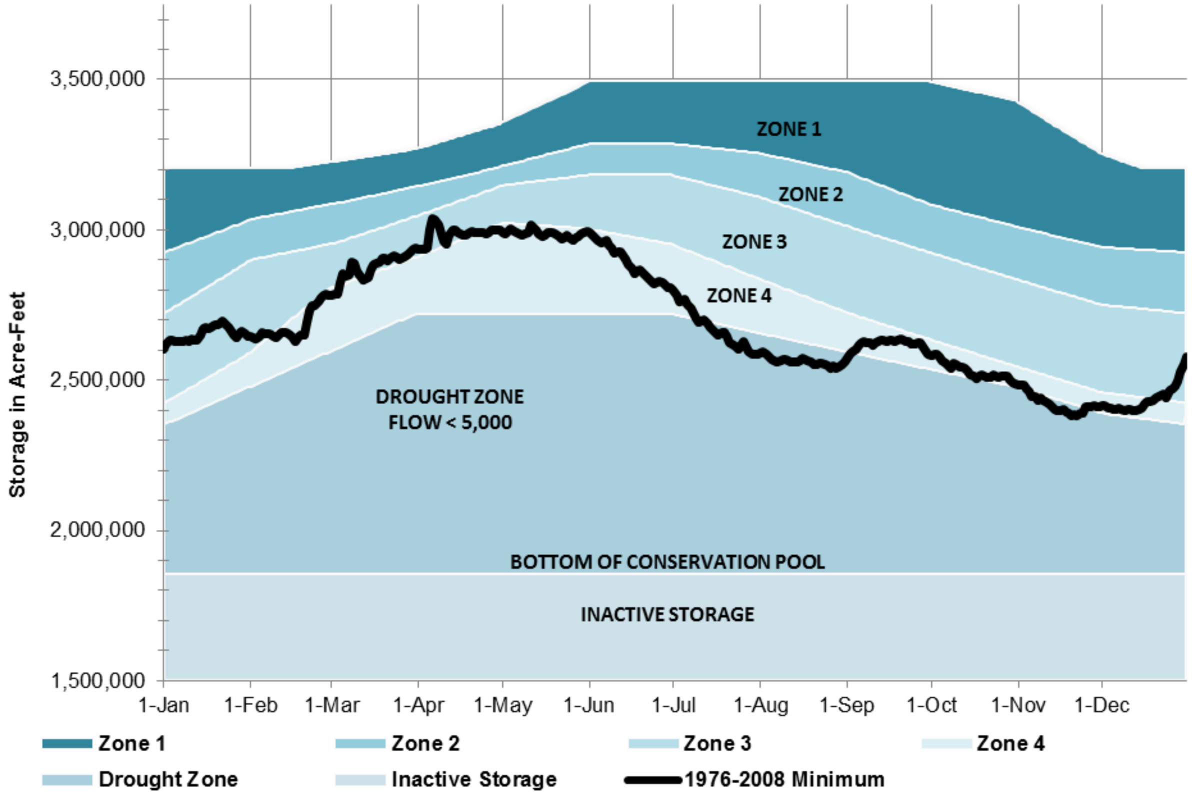

Figure 1.3-4. Basin composite conservation storage and associated action zones (in ac-ft).

During spawning season (March through May), the composite conservation storage is monitored daily to determine water management operations. Recently experienced climatic and hydrologic conditions and meteorological forecasts are used in addition to composite conservation storage values when determining the appropriate basin inflow thresholds in support of water management operations.

During non-spawning season (June through November), one set of four basin inflow thresholds and corresponding releases exists according to composite conservation storage in Zones 1 through 3. When composite conservation storage falls below the bottom of Zone 3 into Zone 4 the drought contingency operations are triggered.

During the winter season (December through February), there is only one basin inflow threshold and corresponding minimum release (5,000 cfs) while in composite conservation storage Zones 1 through 3. There are no basin inflow storage restrictions as long as this minimum flow is met under these conditions. When composite conservation storage falls below the bottom of Zone 3 into Zone 4, drought contingency operations are triggered.

The flow rates included in Table 1.3-3 prescribe minimum, not target, releases for Jim Woodruff Dam. During a given month and basin inflow rate, releases greater than the minimum releases in Table 1.3-3 may occur consistent with the maximum fall rate schedule, described below, or as needed to achieve other project purposes, such as hydroelectric power generation or flood risk management.

Maximum Fall Rate. The fall rate, also called the down-ramping rate, is the vertical drop in river stage (water surface elevation) that occurs over a given period. Fall rates are expressed in units of feet per day (ft/day), and they are measured at the Chattahoochee, Florida U.S. Geological Survey (USGS) gage as the difference between the daily average river stage for consecutive calendar days. Rise rates are not addressed. Table 1.3-4 lists the maximum fall rates. The maximum fall rate schedule is suspended when composite conservation storage is in Zone 4 and the drought contingency operation is implemented. Unless otherwise noted, fall rates under the drought contingency operation would be managed to match the fall rate of the basin inflow.

Table 1.3-4. May 2012 RIOP for Jim Woodruff Dam: Apalachicola River maximum fall rate for discharge from Woodruff Dam by release range for composite conservation storage Zones 1, 2, and 3 [a,b]

Approximate release range (cfs)	Maximum fall rate (ft/day)
> 30,000 [a]	Fall rate is not limited [c,d]
> 20,000 and ≤ 30,000 [b]	1.0 to 2.0 [d]
Exceeds Powerhouse Capacity (~ 16,000) and ≤ 20,000 [b]	0.5 to 1.0 [d]
Within Powerhouse Capacity and > 10,000 [b]	0.25 to 0.5
Within Powerhouse Capacity and ≤ 10,000 [b]	0.25 or less

Source: USACE, Mobile District 2012; USFWS 2012

a. Consistent with safety requirements, flood risk management purposes, and equipment capabilities.

b. The maximum fall rate schedule is suspended in Composite Zone 4.

c. For flows greater than 30,000 cfs, it is not reasonable and prudent to attempt to control the down-ramping rate, and no ramping rate is required.

d. Maximum fall rates must be less than 8 ft in a consecutive 14-day period when flows are less than 40,000 cfs in March, April, and May in order to avoid take of Gulf sturgeon eggs and larvae.

During the Gulf sturgeon spawning period (March - May), the USACE will make releases from Jim Woodruff Dam to ensure that river stage declines of 8 feet or more will not occur in less than 14 days when river flows are less than 40,000 cfs (under both normal and drought operations).

Drought Contingency Provisions in the RIOPs. The RIOP includes a drought contingency operation (referred to as a drought plan). The drought plan specifies a minimum release from Jim Woodruff Dam and temporarily suspends other minimum release and maximum fall rate provisions until composite conservation storage in the basin is replenished to a supported level. Under the drought plan, minimum discharge is determined in relation to the composite conservation storage and not average basin inflow. The drought plan is triggered when composite conservation storage falls below the bottom of Zone 3 into Zone 4. At that time, all the composite conservation storage Zone 1 through 3 provisions (seasonal storage limitations, maximum fall rate schedule, and minimum flow thresholds) are suspended, and management decisions are based on the provisions of the drought plan. The drought plan includes the option for a temporary waiver from the existing water control plan to allow temporary storage above the winter pool guide curve at the Walter F. George and West Point projects if the opportunity presents itself and/or begin spring refill operations at an earlier date in order to provide additional conservation storage for future needs as well as provide for a minimum releases less than 5,000 cfs from Jim Woodruff Dam.

The drought plan prescribes two minimum releases on the basis of composite conservation storage in Zone 4 and an additional zone referred to as the Drought Zone (Figure 1.3-4). The Drought Zone delineates a volume of water roughly equivalent to the inactive storage in lakes Lanier, West Point, and Walter F. George, plus Zone 4 storage in Lake Lanier. The Drought Zone line was adjusted to include a smaller volume of water at the beginning and end of the calendar year. When the composite conservation storage is within Zone 4 and above the Drought Zone, the minimum release from Jim Woodruff Dam is 5,000 cfs and all basin inflow above 5,000 cfs that is capable of being stored may be stored.

Once the composite conservation storage falls into the Drought Zone, the minimum release from Jim Woodruff Dam is 4,500 cfs and all basin inflow above 4,500 cfs that is capable of being stored may be stored. When transitioning from a minimum release of 5,000 to 4,500 cfs, fall rates are limited to a

0.25 ft/day drop. The 4,500 cfs minimum release is maintained until composite conservation storage returns to a level above the top of the Drought Zone, at which time the 5,000 cfs minimum release is reinstated. The drought plan provisions remain in place until conditions improve such that the composite conservation storage reaches a level above the top of Zone 2 (i.e., within Zone 1). At that time, the temporary drought plan provisions are suspended, and all the other provisions are reinstated. During drought contingency operations, a monthly monitoring plan that tracks composite conservation storage to determine water management operations (the first day of each month represents a decision point) is implemented to determine which operational triggers are applied. In addition, recent climatic and hydrological conditions experienced and meteorological forecasts are used when determining the set of operations in the upcoming month.

Although the drought plan provides for flows lower than 5,000 cfs in the river, provisions that allow for reduced flows during the refill period when system storage is lower and storage conservation measures when composite conservation storage is in Zone 4 should result in fewer occasions when these low flows are triggered or in occasions where storage shortages result in flows less than 5,000 cfs.

1.3.4.5 Recreation

All the USACE lakes have become important recreational resources on the ACF Basin. A wide variety of recreational opportunities are provided at the lakes including boating, fishing, picnicking, sightseeing, water skiing, and camping. Recreation impact levels have been identified for various lake elevations at each of the reservoir projects (Table 1.3-5).

Table 1.3-5. Water levels affecting USACE project recreation

USACE project	Initial impact level (IIL) (ft NGVD)	Recreation impact level (RIL) (ft NGVD)	Water Access Limited Level (WAL) (ft NGVD)
Lake Lanier	1,066	1,063	1060
West Pont Lake	632.5	629	627
Walter F. George Lake	187	185	184
Lake Seminole	76	NA	NA

To maximize the potential recreational use of all the projects, the USACE operates the reservoirs in the ACF Basin as a system, keeping the drawdown levels and rates balanced among the reservoirs. The USACE gives those considerations greater attention during the primary recreation season of May through early September. Reservoirs are managed to maintain a steady pool at as high a level as possible, consistent with other authorized purposes, particularly during the primary recreation season. To sustain reasonable access to the reservoir during periods of declining inflows to the reservoirs, drawdowns are performed at as steady a rate as possible. There may be times during drought conditions when water releases are reduced to levels that satisfy only downstream water supply/water quality requirements. This conservation of storage generally allows the pools to be maintained at a higher level throughout the prime recreation season.

As other ACF water management objectives are addressed, lake levels might decline during prime recreation periods. Large reservoir drawdowns impact recreational use: access to the water for boaters and swimmers is inhibited; submerged hazards (e.g., trees, shoals, boulders) become exposed or nearly exposed, posing safety issues; and exposed banks and reservoir bottoms become unsightly and diminish the recreation experience. Consequently, for Lake Lanier, West Point Lake, and Walter F. George Lake, certain levels were identified in each impoundment at which recreation activities would be affected (Table 1.3-5). The *Initial Impact level* (IIL) represents the level at which recreation impacts are first observed (i.e., some boat launching ramps are unusable, most beaches are unusable or minimally usable, and navigation hazards begin to surface). The *Recreation Impact level* (RIL) defines the level at which major impacts on concessionaires and recreation are observed (more ramps are not usable, all beaches are unusable, boats begin having problems maneuvering in and out of marina basin areas, loss of retail business occurs). The level at which severe impacts are observed in all aspects of recreational activities is called the *Water Access Limited level* (WAL). At this point, all or almost all boat ramps are out of service, all swimming beaches are unusable, major navigation hazards occur, channels to marinas are impassable and/or wet slips must be relocated, and a majority of private boat docks are unusable. The NAA assumed that recreation operations would remain in effect unchanged.

1.3.4.6 Water Quality

Buford Dam, West Point Dam, and Jim Woodruff Lock and Dam all provide continuous minimum releases which, in addition to meeting other project purposes and providing associated benefits, also benefits downstream water quality. Walter F. George Lock and Dam and George W. Andrews Lock and Dam have no specific minimum flow provisions.

At Buford Dam, the small turbine is operated continuously to provide a minimum flow from the dam of approximately 600 cfs. When it is necessary to have the unit out of service, the releases are made through the sluice. Under agreements with Georgia, discharges from Buford Dam, when considered in combination with the contribution of local drainage between the dam and the city of Atlanta and reregulation by GPC’s Morgan Falls Dam, are to be sufficient to provide a minimum flow rate of 750 cfs at Peachtree Creek. Reregulation of streamflows at Morgan Falls Dam to provide that required flow is often not possible without weekend releases at Buford Dam.

During periods of reservoir stratification and reservoir turnover (destratification) in the fall, releases from Buford Dam hydroelectric units or sluice gates can contain high concentrations of metals, such as iron and manganese, which can cause toxicity problems at the Buford Trout Hatchery, 2 mi downstream of the dam. The release water during summer and fall is also low in dissolved oxygen (DO) except during periods of peaking generation. Self-aspirating turbines were installed at Buford Dam in 2005 to improve DO levels downstream. However, minimal benefits to downstream DO have been recorded since installation. The hatchery has also installed a water treatment system, but there still may be an occasional need for emergency releases of water from Lake Lanier for water quality purposes.

At West Point Dam, a small generating unit provides a continuous release of about 675 cfs. This flow provides low flow augmentation to benefit water quality and public health. As with Buford Dam, the release waters during reservoir stratification are low in DO concentration during minimum release periods.

Even though there are no specific continuous minimum flow requirements below Walter F. George Lock and Dam, the USACE has an established SOP to address conditions when low DO values are observed below the dam (USACE, Mobile District 1993a).

Because of the shallowness of the reservoir and the relative amount of storage when compared to inflow, Lake Seminole and George W. Andrews Lake do not stratify and water quality downstream of the dam does not fluctuate to the same degree as at other reservoirs in the basin. However, minimum releases of at least 5,000 cfs are maintained from Jim Woodruff Dam (except under extreme drought conditions). Those minimum flows are needed to meet environmental flow requirements for endangered species conservation, but as a by-product they also meet the water supply and waste assimilation needs of downstream industrial users.

While operating to serve other federally authorized purposes, USACE reservoirs in the ACF Basin provide downstream flow conditions that collaterally support waste assimilation needs of numerous municipal and industrial (M&I) wastewater dischargers in the basin. That collateral benefit of project operations is particularly valuable during annual low flow (summer/fall) periods and extended drought periods. The NAA assumed that the current water quality operations would remain in effect unchanged.

1.3.4.7 Water Supply

Various M&I entities withdraw water directly from Lake Lanier, and others withdraw directly from the Chattahoochee River downstream of Lake Lanier. Reservoir operations are also influenced by agricultural water withdrawals on the Flint River. Agricultural demands vary depending on the climatic conditions but are generally 1.5 to 2 times the withdrawals for M&I (USFWS 2006). Water withdrawals in Georgia are made pursuant to water withdrawal permits issued by the Georgia Department of Natural Resources. Previous water supply contracts issued by the USACE for withdrawals from Lake Lanier expired in 1990 and have not been reissued. The Water Supply Act of 1958 provides authority for reallocation or addition of storage in USACE reservoirs for water supply, with the cost of storage and associated facilities to be reimbursed by a non-USACE entity via water storage agreements; no storage in projects in the ACF Basin is allocated to water supply.

Water management for the water supply/water quality function involves taking water from storage, either directly from the reservoir or through dam releases for downstream interests. Such operations ensure that sufficient drinking water is available for M&I needs and agreements to provide in-stream flow for water quality are not violated. Releases from projects in the system will be the minimum (capacity) release for hydroelectric power or releases needed for basin-wide water supply/water quality, whichever is greater. The water supply users withdrawing water directly from Lake Lanier and their 2007 withdrawal amounts total approximately 128 mgd, as follows:

- Gwinnett County—88.19 mgd
- City of Gainesville—18.75 mgd (Includes net withdrawal of 8.0 mgd authorized by their relocation contract[1].)
- City of Cumming—20.07 mgd (Includes water furnished to Forsyth County, GA.)
- City of Buford—1.47 mgd (2.0 mgd authorized by their relocation contract)

In general, Lake Lanier weekly water supply/quality release decisions are based on the Chattahoochee River Management System (as recorded in the *Apalachicola Basin Reservoir Regulation Manual*, Appendix B, February 1991 [USACE, Mobile District 1991]). Under the management system, in coordination with the Atlanta Regional Commission and Georgia Power Company, the USACE determines weekly the daily amounts of water to release from Buford Dam to accommodate the anticipated downstream river withdrawals for M&I water supply by DeKalb County, City of Atlanta, Cobb County/Marietta Water Authority, and Fulton County, and to assure water quality at the confluence of the Chattahoochee River and Peachtree Creek. Such a weekly schedule of Buford Dam water releases is to ensure that sufficient water is available for Chattahoochee River water supply withdrawals, water quality flows at Peachtree Creek, hydroelectric power generation and fish and wildlife conservation needs. During the winter and spring, releases from Lanier can be reduced because of sufficient downstream tributary flows to meet the GAEPD's target water quality flow at Peachtree Creek. To the extent possible, the releases are in conjunction with peaking power operations and minimize effects on hydroelectric power generation. In 2007, downstream withdrawals averaged 277 mgd.

The NAA assumed that releases from Buford Dam would continue to be made to provide for the current need of 277 mgd for downstream withdrawals by metro Atlanta water providers and current withdrawals

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[1] As part of the compensation for the municipal property acquired for the Buford Dam project and under the resulting relocation contracts terms, each city was granted the right to withdraw, free of charge, specified amounts of water from the reservoir. It was agreed that Buford could withdraw 2.0 mgd and Gainesville 8.0 mgd. Presently Gainesville withdraws approximately 18 mgd and returns approximately 10 mgd resulting in a net withdrawal of 8 mgd. The total gross withdrawal under relocation contracts is 20 mgd.

from Lake Lanier amounting to 128 mgd, including 20 mgd for the relocation contracts, would continue. Additionally, it is assumed that the withdrawals from West Point Lake for the relocation contract would continue.

1.4 Proposed Action Alternative

Under the PAA, the USACE would continue to operate projects in the ACF Basin in a balanced manner to achieve all authorized project purposes. In light of the July 2011 Eleventh Circuit Court of Appeals ruling, USACE is considering, along with operations for all authorized purposes, an expanded range of water supply alternatives associated with the Buford Dam/Lake Lanier project, including current levels of water supply withdrawals and additional amounts that Georgia in 2013 requested from Lake Lanier and downstream at Atlanta. The following sections identify key elements of the PAA that differ from the NAA.

1.4.1 Action Zones

Under the PAA, the USACE would modify the action zones for Lake Lanier, West Point Lake, and Walter F. George Lake. The proposed modifications are shown in Figure 1.4-1, Figure 1.4-2, and Figure 1.4-3. At Lake Lanier, Zones 1, 2 and 3 were expanded to reflect proportionality of contributing watershed size and historic operations to meet system demands. The action zones reflected by Figure 1.4-1 achieve a more equitable balance between action zone sizing based on the project's watershed size and because they provide a proportionately balanced drawdown among the projects when operating in Zone 1. In refining the action zones, generally they were revised upward in the winter months at Lake Lanier and at West Point Lake and downward in the summer months at Walter F. George Lake, as reflected in Figure 1.4-1, Figure 1.4-2, and Figure 1.4-3, respectively.

The following definitions apply to the revised action zones:

- Zone 1: Indicates that releases can be made in support of a navigation season (January–April or May), hydroelectric power releases, water supply, and water quality releases. If all the lakes are in Zone 1 or above, the river system would operate in a fairly normal manner.
- Zone 2: Indicates that releases can be made in support of a navigation season (January - April or May). Hydroelectric power generation is supported at the same or a reduced level. Water supply and water quality releases are met. Minimum flow targets are met.
- Zone 3: Navigation is not supported. Hydroelectric power generation is supported at a reduced level. Water supply and water quality releases are met. Minimum flow targets are met.
- Zone 4: Navigation is not supported. Hydroelectric power demands will be met at a minimum level and might occur only for concurrent uses. Water supply and water quality releases are met. Minimum flow targets are met.

The revised action zones were developed to better:

1. Facilitate refill of each reservoir.
2. Minimize low-water recreational impacts and hazard levels.
3. Balance system storage throughout the basin.
4. Enhance ability to balance refill relative to watershed and hydrology.
5. Achieve proportional drawdown in each reservoir.

Changes in the Lake Lanier action zones are proposed to facilitate refill and storage of water relative to the watershed size. By increasing Zone 4 to 1,060 ft in January, there will be more water in the reservoir when drought operations go in to effect. This operational change allows for more water storage to balance water management throughout the ACF Basin.

The zones were derived on the ability of the reservoirs to refill (considering hydrology, watershed size, and physical constraints of each reservoir), recreation effects and hazard levels, and the proportionality of zone drawdown between projects.

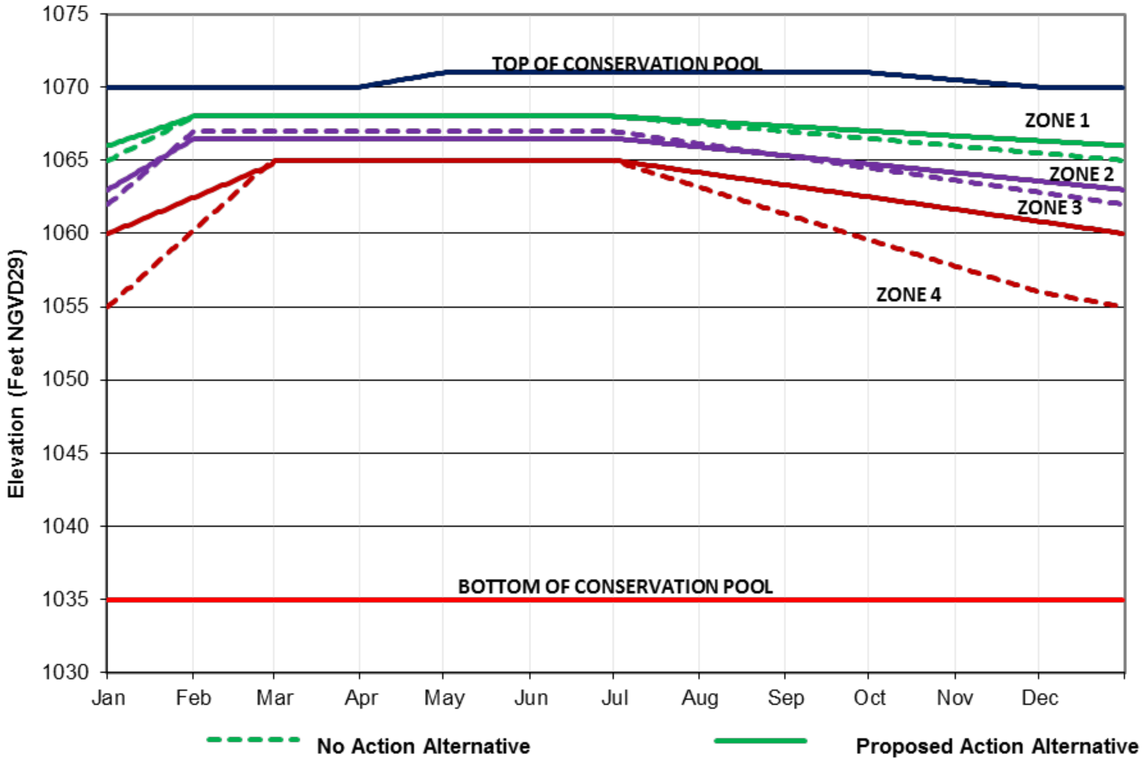

Figure 1.4-1. Lake Lanier water control action zones

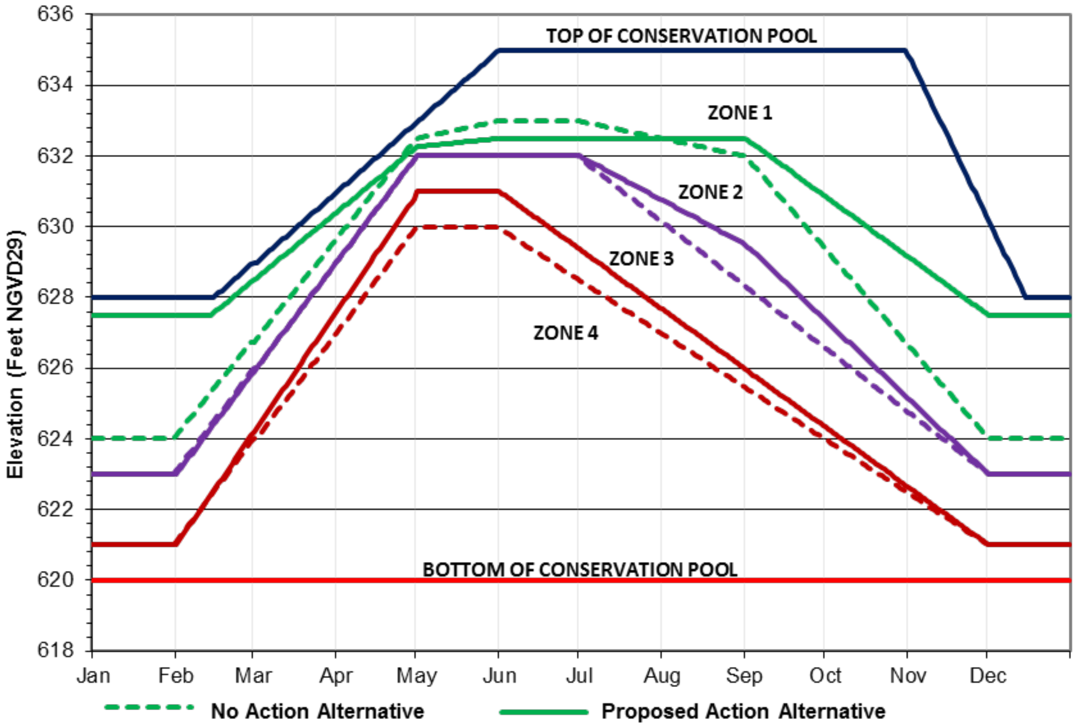

Figure 1.4-2. West Point Lake water control action zones

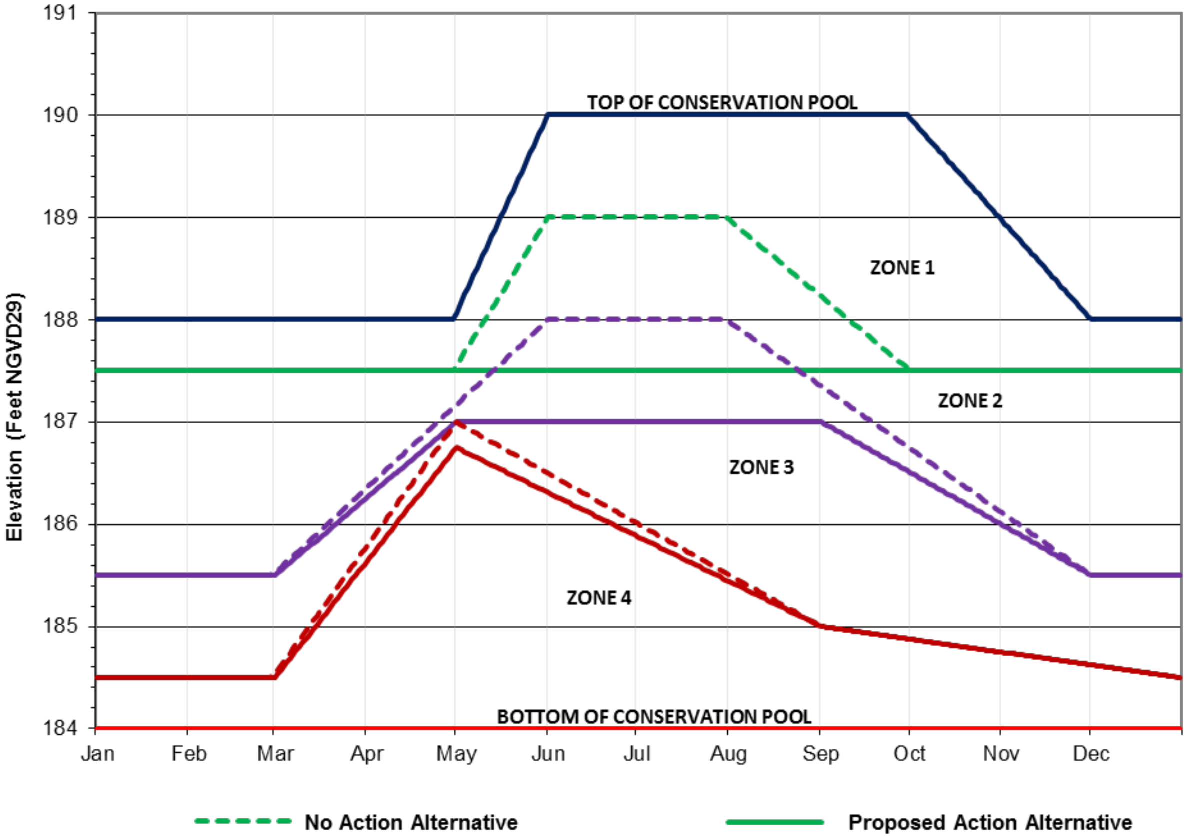

Figure 1.4-3. Walter F. George Lake water control action zones

Changes to action zones in the Walter F. George Lake allow use of more available storage in the reservoir to achieve proportional drawdown and balance system storage. Decreasing Zone 2 to 187.5 from May through October and Zone 3 from 188 ft to 187 ft from March through December allows for more storage water to be released downstream during critical low flow periods.

1.4.1.1 Drought Operations

The proposed drought plan is similar to the NAA drought plan and incorporates the drought provisions of the May 2012 RIOP which specifies a minimum release from Jim Woodruff Dam and temporarily suspends the other minimum release and maximum fall rate provisions until composite conservation storage (Table 1.4.1 and Figure 1.4-4) within the basin is replenished to a level that can support them. Under the drought plan the minimum discharge is determined in relation to composite conservation storage and not average basin inflow. Drought operations are “triggered” on the first day of the month when composite conservation storage of the ACF Basin falls below the bottom of Zone 2 into Zone 3 in the PAA (Figure 1.4-4). At that time all the composite conservation storage Zone 1-2 provisions (seasonal storage limitations, maximum fall rate schedule, and minimum flow thresholds) are suspended and management decisions are based on the provisions of the drought plan. Under the drought plan, the Jim Woodruff Dam minimum discharge is determined in relation to composite conservation storage only. The drought plan includes a temporary waiver from the existing water control plan to allow temporary storage above the winter pool guide curve at the Walter F. George and West Point projects if the opportunity presents itself and/or begin spring refill operations at an earlier date in order to provide additional conservation storage for future needs as well as provide for a minimum releases less than 5,000 cfs from Jim Woodruff Dam.

Table 1.4.1 Proposed Drought Operation for Jim Woodruff Dam, Apalachicola River minimum discharge from Woodruff Dam by month and by basin inflow (BI) rate. (No change from No Action)

Months	Composite conservation storage zone	Basin inflow (BI) (cfs)	Releases from Jim Woodruff Lock and Dam (cfs)	BI available for storage[a]
March–May	Zones 1 and 2	≥ 34,000	≥ 25,000	Up to 100% BI>25,000
		≥ 16,000 and < 34,000	≥ 16,000+50% BI > 16,000	Up to 50% BI>16,000
		≥ 5,000 and < 16,000	≥ BI	
		< 5,000	≥ 5,000	
	Zone 3	≥ 39,000	≥ 25,000	Up to 100% BI>25,000
		≥ 11,000 and < 39,000	≥ 11,000+50% BI > 11,000	Up to 50% BI>11,000
		≥ 5,000 and < 11,000	≥ BI	
		< 5,000	≥ 5,000	
June–November	Zones 1,2, and 3	≥ 22,000	≥ 16,000	Up to 100% BI>16,000
		≥ 10,000 and < 22,000	≥ 10,000+50% BI > 8,000	Up to 50% BI>10,000
		≥ 5,000 and < 10,000	≥ BI	
		< 5,000	≥ 5,000	
December–February	Zones 1,2, and 3	≥ 5,000	≥ 5,000 (Store all BI> 5,000)	Up to 100% BI > 5,000
		< 5,000	≥ 5,000	
At all times	Zone 4	NA	≥ 5,000	Up to 100% BI > 5,000
At all times	Drought Zone	NA	≥ 4,500[b]	Up to 100% BI > 4,500

The drought plan prescribes two minimum releases from Jim Woodruff Dam based on composite conservation storage in Zone 4 and an additional zone referred to as the Drought Zone, Figure 1.4-4. The Drought Zone delineates a volume of water roughly equivalent to the inactive storage in lakes Lanier, West Point and Walter F. George plus Zone 4 storage in Lake Lanier; however, the Drought Zone line has been adjusted to include a smaller volume of water at the beginning and end of the calendar year. When the composite conservation storage is within Zone 4 and above the Drought Zone, the minimum release from Jim Woodruff Dam is 5,000 cfs and all basin inflow above 5,000 cfs that is capable of being stored may be stored. Once the composite conservation storage falls below the Drought Zone, the minimum release from Jim Woodruff Dam is 4,500 cfs and all basin inflow above 4,500 cfs that is capable of being stored may be stored. When transitioning from a minimum release of 5,000 to 4,500 cfs, fall rates will be limited to a 0.25 ft/day drop. The 4,500 cfs minimum release is maintained until composite conservation storage returns to a level above the top of the Drought Zone, at which time the 5,000 cfs minimum release is re-instated. The drought plan provisions of the PAA remain in place until conditions improve such that the composite conservation storage reaches a level above the top of Zone 2 (i.e., within Zone 1). If recovery conditions are achieved in February, drought plan provisions will not be suspended until March, provided composite conservation storage remains above Zone 4. At that time, the temporary drought plan provisions are suspended, and all the other provisions are re-instated. During the drought contingency operations a monthly monitoring plan that tracks composite conservation storage in order to determine water management operations (the first day of each month will represent a decision point) will be implemented to determine which operational triggers are applied. In addition, recent climatic and hydrological conditions experienced and meteorological forecasts will be used when determining the set of operations to utilize in the upcoming month.

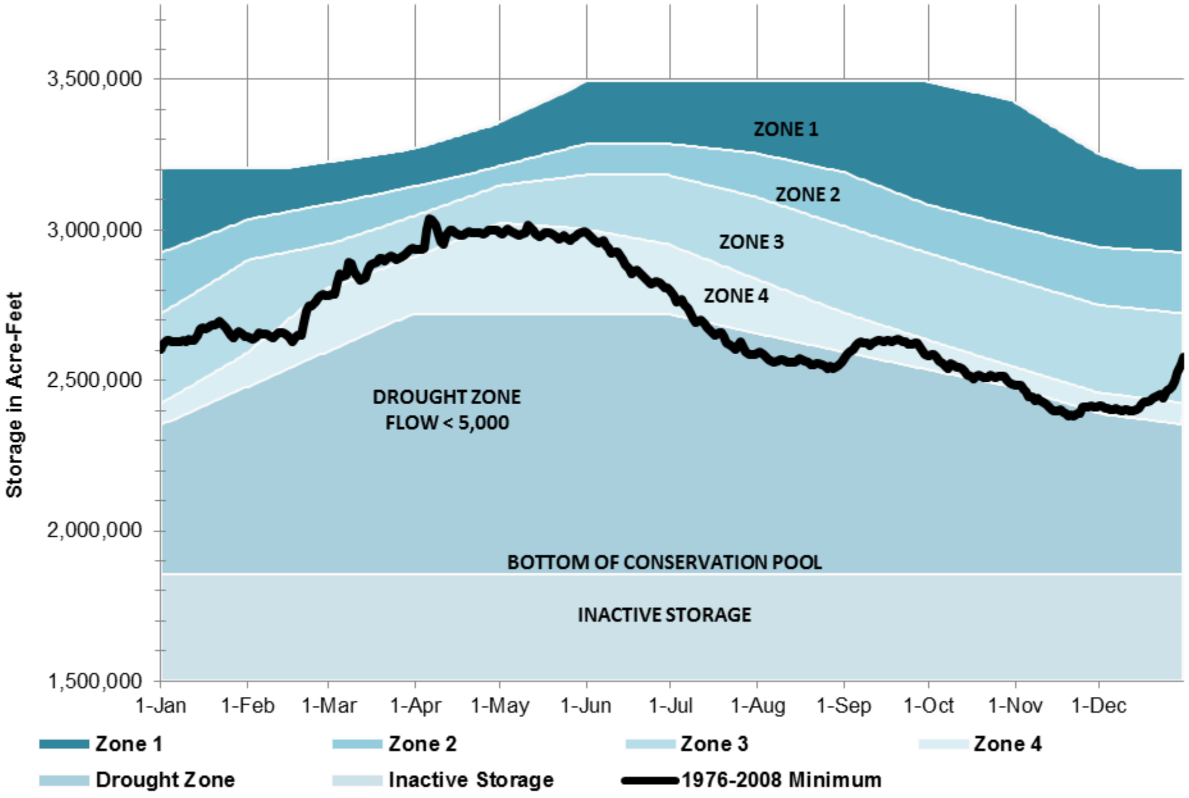

Figure 1.4-4. Basin composite conservation storage and associated action zones (in ac-ft).

1.4.1.2 Flood Risk Management

No changes to the flood risk management operations described in the NAA are proposed. When developing the PAA, flood risk management capabilities and capacities of reservoirs were not reduced.

1.4.1.3 Hydroelectric Power

Under the PAA, USACE would operate Buford Dam, West Point Dam, Walter F. George Dam, and Jim Woodruff Dam for hydroelectric power generation, but the amount of generation would vary by action zone. Conservation storage at Lake Lanier is much more sensitive to hydroelectric power generation operations because of the small drainage area above Buford Dam from which to refill the reservoir, particularly under drought conditions. The proposed generation schedule at Lake Lanier would provide greater operational flexibility to meet power demands in the system while conserving storage as variable climate conditions might dictate.

Under the PAA, when Lake Lanier is in Zone 1 or 2 during non-drought conditions, generation would typically be in the hourly ranges shown in the table below. Similarly, during drought operations as described above, generation would typically be reduced to that depicted in Table 1.4.2.

Table 1.4-2. Typical hours of peaking hydroelectric power generation by USACE project

Action zone	Buford Dam (hours of operation)	West Point Dam (hours of operation)	Walter F. George Dam (hours of operation)
Zone 1	0–4	0-4	0-4
Zone 2	0–4	0-2	0-2
Zone 3	0–2	0-2	0-2
Zone 4	0–2	0	0

1.4.1.4 Navigation

Under the PAA, when supported by ACF Basin hydrologic conditions, USACE will provide a reliable navigation season. The water management objective is to ensure a predictable minimum navigable channel in the Apalachicola River for a continuous period of time that is sufficient for navigation use.

Assuming basin hydrologic conditions allow, a typical navigation season would begin in January of each year and continue for 4 to 5 consecutive months (January through April or May). During the navigation season the flows at the Blountstown, Florida, USGS gage (USGS 02358700) should be adequate to provide at least a 7 ft channel. The most recent channel survey and discharge-stage rating was used to determine the flow required to sustain a minimum navigation depth during the navigation season. The USACE's capacity to support a navigation season will be dependent upon actual and projected system-wide conditions in the ACF Basin prior to and during the months of January, February, March, April and May (Figure 1.4-5). These conditions include, but are not limited to:

1. A navigation season can only be supported when ACF Basin composite conservation storage is in Zone 1 or Zone 2.
2. A navigation season will not be supported when the ACF Basin composite conservation storage is in Zone 3 and below. Provided drought operations have not been triggered, navigation support will resume when basin composite conservation storage level recovers to Zone 2 and is forecast to remain above Zone 3 for a practicable, continuous period of time.
3. A navigation season will not be supported when drought operations are in effect. Navigation will not be supported after drought operations have ceased until the ACF Basin composite conservation storage recovers to Zone 1.
4. The determination to extend the navigation season beyond April will depend on ACF Basin inflows, recent climatic and hydrological conditions, meteorological forecasts, and basin-wide model forecasts. Based on an analysis of these factors, the Corps will determine if the navigation season will continue through part or all of May.
5. Down ramping of flow releases (regardless of period in the navigation season) will adhere to the Jim Woodruff Dam fall rate schedule (Table 1.3-4) for federally listed species.
6. Releases that augment the flows to provide for the 7-ft navigation channel will also be dependent on navigation channel conditions that ensure safe navigation.

When it becomes apparent that, due to diminishing inflows, downstream flows and depths must be reduced, navigation bulletins will be issued to project users. These notices will be issued as expeditiously as possible in order to give barge owners, and other waterway user's, sufficient time to make arrangements to light load or remove their vessels before action is taken at Jim Woodruff Dam to reduce releases.

Though special releases will not be standard practice, they may occur for a short duration to assist navigation during the navigation season (Figure 1.4-5). For instance, releases may be requested to achieve up to a 9-ft channel. These shall be evaluated on a case by case basis, subject to applicable laws and regulations and the conditions above.

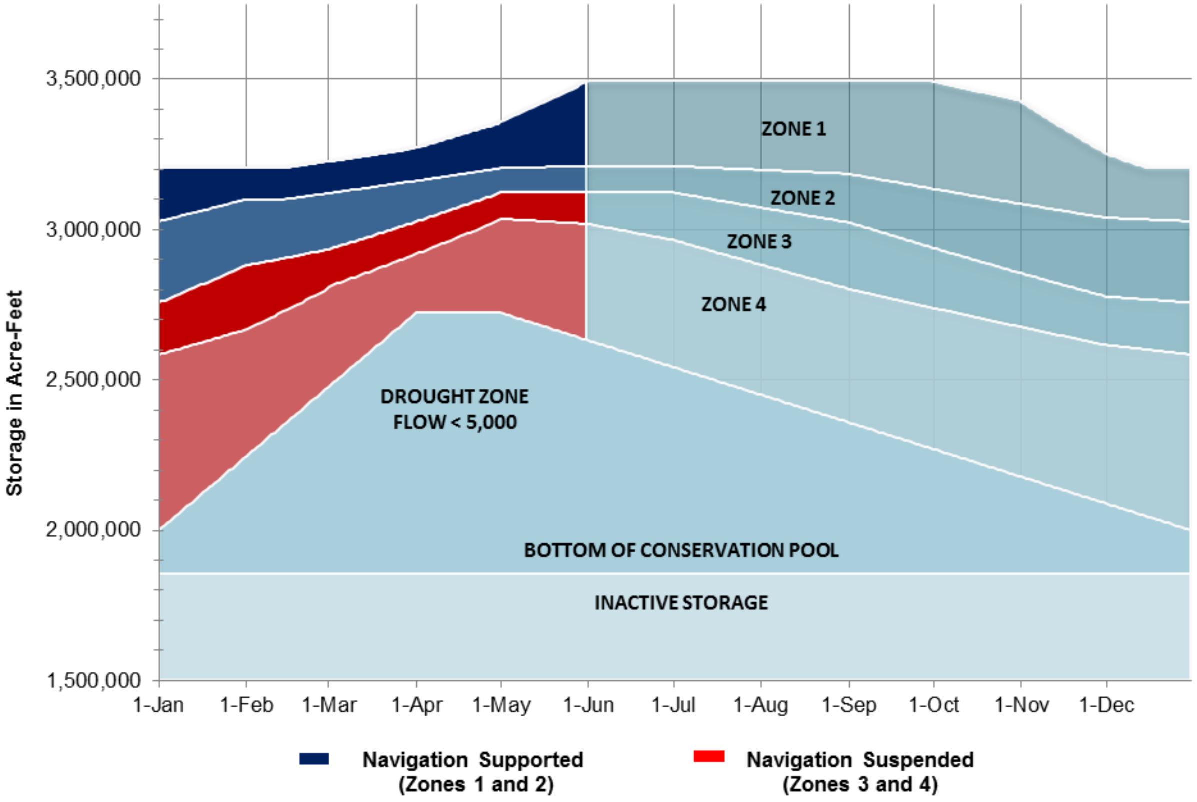

Figure 1.4-5. Composite conservation storage for navigation

1.4.1.5 Fish and Wildlife Conservation

Under the PAA, there are no changes to fish spawn or fish passage operations described in the NAA.

Federally Listed Species **-** Under the PAA, the USACE would continue to make releases for threatened and endangered species below Jim Woodruff Dam on the basis of seasonal requirements (spawning, non-spawning, and winter), composite conservation storage, and basin inflows in accordance with the May 2012 RIOP described previously under the NAA and the PAA for Drought Operations (Table 1.4.1), but with one modification, suspending the ramping rate during prolonged low flow. When Basin Inflow (BI) has been less than 7,000 cfs for 30 days the use of the ramping rate will be suspended and will be resumed when BI has been greater than 10,000 for 30 days. The PAA ramping rate is shown in Table 1.4.3. Release requirements dictated by composite conservation storage would be in accordance with the revised action zones discussed above.

Table 1.4.3 Proposed Apalachicola River maximum fall rate for discharge from Woodruff Dam by release range for composite conservation storage Zones 1, 2, and 3 [a,b]

Approximate release range (cfs)	Maximum fall rate (ft/day)
> 30,000 [a]	Fall rate is not limited [c,d]
> 20,000 and ≤ 30,000 [b]	1.0 to 2.0 [d]
Exceeds Powerhouse Capacity (~ 16,000) and ≤ 20,000 [b]	0.5 to 1.0 [d]
Within Powerhouse Capacity and > 10,000 [b]	0.25 to 0.5
Within Powerhouse Capacity and ≤ 10,000 [b]	0.25 or less[e]

Source: USACE, Mobile District 2012; USFWS 2012

a. Consistent with safety requirements, flood risk management purposes, and equipment capabilities.

b. The maximum fall rate schedule is suspended in Composite Zone 4.

c. For flows greater than 30,000 cfs, it is not reasonable and prudent to attempt to control the down-ramping rate, and no ramping rate is required.

d. Maximum fall rates must be less than 8 ft in a consecutive 14-day period when flows are less than 40,000 cfs in March, April, and May in order to avoid take of Gulf sturgeon eggs and larvae.

e. Fall rate suspended when basin inflow <7,000 cfs for 30 days and resumed when >10,000 cfs for 30 days.

1.4.1.6 Recreation

The PAA has no changes to operations in support of recreation from those described in the NAA.

1.4.1.7 Water Quality

Under the PAA, releases from Buford Dam would be made sufficient to provide a minimum flow rate of 750 cfs at Peachtree Creek from May through October and 650 cfs from November through April. Under agreements with Georgia, discharges from Buford Dam, when considered in combination with the contribution of local drainage between the dam and the city of Atlanta and reregulation by GPC's Morgan Falls Dam, are to be sufficient to provide a minimum flow rate at Peachtree Creek of 750 cfs (May through October) and 650 (November through April).

No changes are proposed for releases through the house unit at West Point Dam.

1.4.1.8 Water Supply

Under the PAA, the Corps would continue to accommodate net withdrawals of 8 mgd by the City of Gainesville, and withdrawals of 2 mgd by the City of Buford, from Lake Lanier under relocation agreements. In addition, under the authority of the Water Supply Act of 1958, the Corps would reallocate 189,500 acre-feet of storage in Lake Lanier to accommodate a portion (165) mgd of Georgia's 2040 water supply need. The PAA assumes that an additional 40 mgd would be withdrawn from the yet-to-be constructed Glades Reservoir to meet that future need. Finally, under the authority of the 1946 River and Harbor Act, the Corps would make releases from Buford Dam to provide for water supply withdrawals of up to 408 mgd from the Chattahoochee River downstream at Atlanta by 2040.All other water supply operations in the ACF Basin described in the NAA would remain the same.

2 RESPONSE TO PLANNING AID LETTERS

The USFWS provided Planning Aid Letters (PAL) dated April 1, 2010; March 1, 2011; and August 29, 2013. The 2010 PAL recommended analyses using Indicators of Hydrologic Alteration. This approach was superseded by recommendations in the 2011 PAL Addendum which provided revised high and low flow guidelines to be used instead of the IHA. The 2013 PAL provided additional performance metrics to be used to compare the relative effects of the NAA and PAA.

In response to the 2011 Eleventh Circuit Court ruling, USACE developed eight alternatives comprised of either the existing water management plan (Water Management No Action Alternative) or the Water Management Proposed Action Alternative together with some quantity of water withdrawn from Lake Lanier and a release from Buford Dam to satisfy either existing or future (2040) water needs for metro Atlanta. In figures shown in subsequent sections, the results of several alternatives are shown on the same figure. The NAA is identified as No Action or Alt1A and the PAA is identified as Proposed Action or Alt7H.

The responses below are keyed to specific performance metrics or issues raised in the 2010 PAL and later added, amended, or augmented by the 2011 and 2013 PALs.

2.1 ResSim Model Output Analyses

As requested, the revised ecosystem guidelines provided by the 2011 PAL Addendum were used in the development of the analysis of the environmental consequences of the PAA. This analysis was woven into various sections of water and biological resources analyses.

2.2 HEC-5Q Water Quality Model Output Analyses

The HEC-5Q modeled output was processed to illustrate variations between the PAA and NAA for the ACF Basin. The modeled results were compared longitudinally down the Chattahoochee River of the ACF Basin and as time series in select locations. Longitudinal plots, or system profiles, were initially examined to understand the most critical locations for water quality related to various parameters. Following an evaluation of the range of longitudinal modeled results, specific locations were selected where the range of modeled output was the greatest. The time series of modeled results were plotted at specific locations to illustrate the seasonal response of pollutants.

Model results were output in six-hour time intervals in the river and reservoirs. The results presented below were analyzed at various seasonal intervals; generally, May through October for dissolved oxygen (DO) and April through October for nutrients (total phosphorus, total nitrogen, and chlorophyll *a*). All model results were reviewed annually, seasonally, and based on dry, normal, and wet years for each alternative. Dry and wet years were defined by the driest 25th percentile (1 in 4 yr) and the wettest 25th percentile (1 in 4 yr). The following plots can be used to address questions presented in the 2010 PAL by parameter. Note that the longitudinal figures present the percent occurrence of modeled output; the opposite of the percent exceedance. It was recommended that percent exceedance may assume violation of water quality standards and thus percent occurrence was utilized for the presentation of water quality. In the following figures the PAA is labeled as Alt7H.

2.2.1 Dissolved Oxygen

a. Total number of days with DO below a daily average of 6 milligrams per liter (mg/L) in locations within Georgia trout waters, and below a daily average of 5 mg/L in non-trout waters.

Figure 2.2-1and Figure 2.2-2 present the variations of DO modeled along the Chattahoochee River. These results do not explicitly define the number of days when concentrations are less than state standards (6 mg/L for secondary trout waters and 5 mg/L) but they do provide insight to where low DO concentrations occur for the period from May through October. Figure 2.2-3 through Figure 2.2-6 present DO occurrence plots at Norcross, Georgia and Morgan Falls Dam. These locations are within the secondary trout waters.

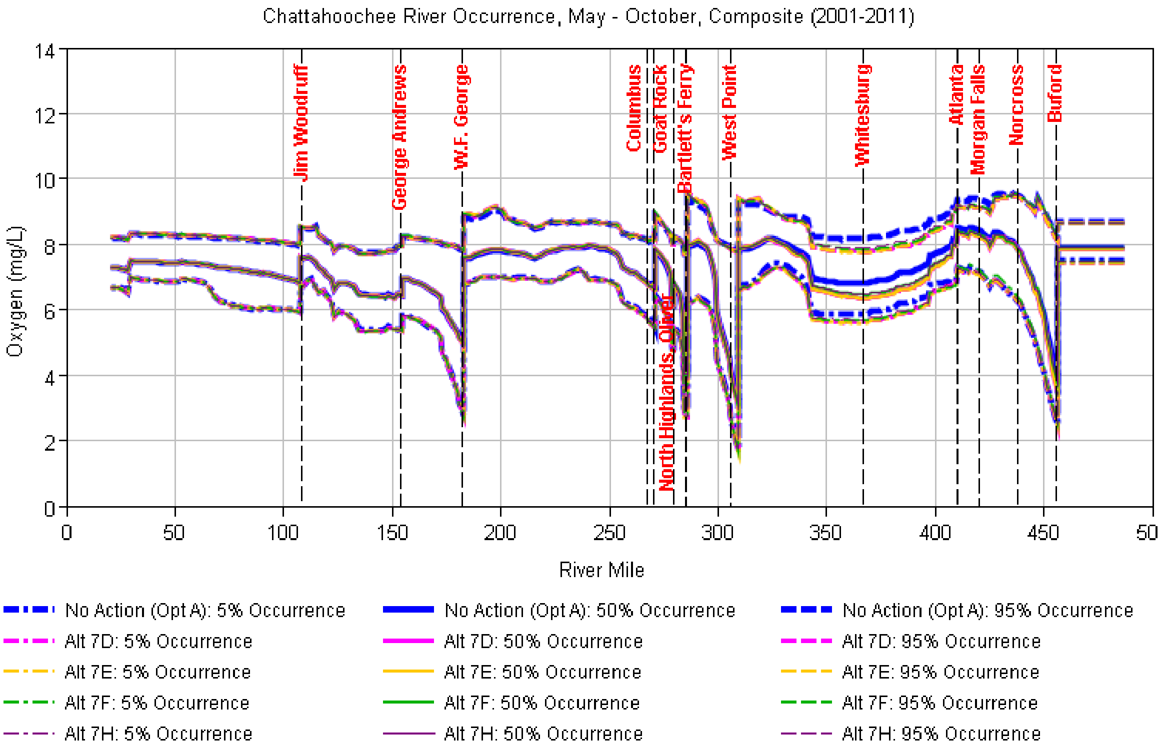

Figure 2.2-1. May through October DO for the modeled period from 2001 through 2011.

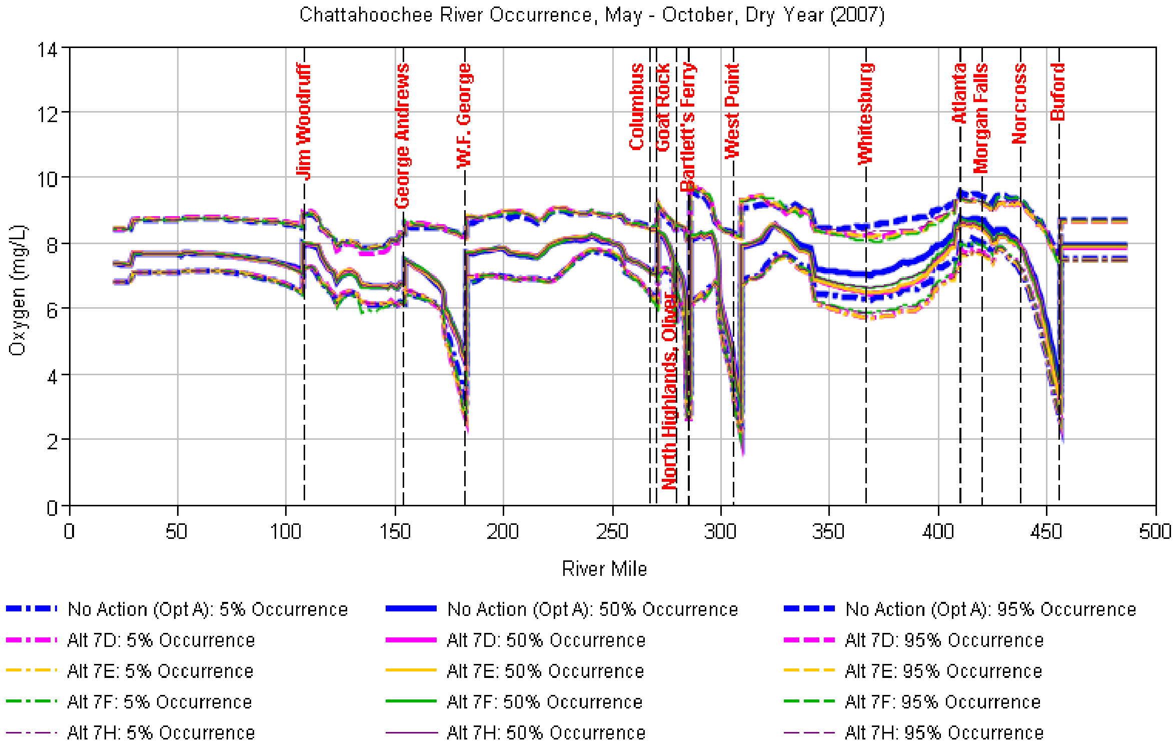

Figure 2.2-2. May through October DO modeled for a representative dry period (2007) when low concentrations would be expected.

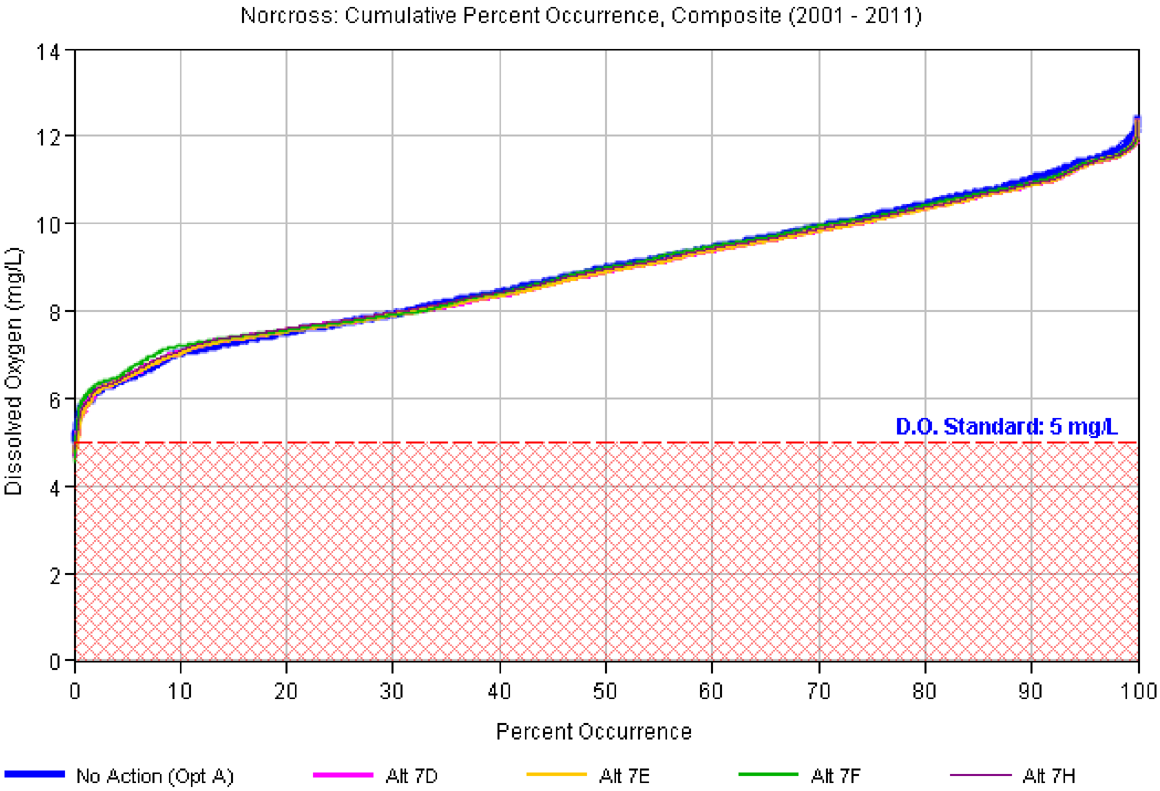

Figure 2.2-3. Occurrence of daily average DO in the Chattahoochee River at Norcross, Georgia, for the period from 2001 through 2011.

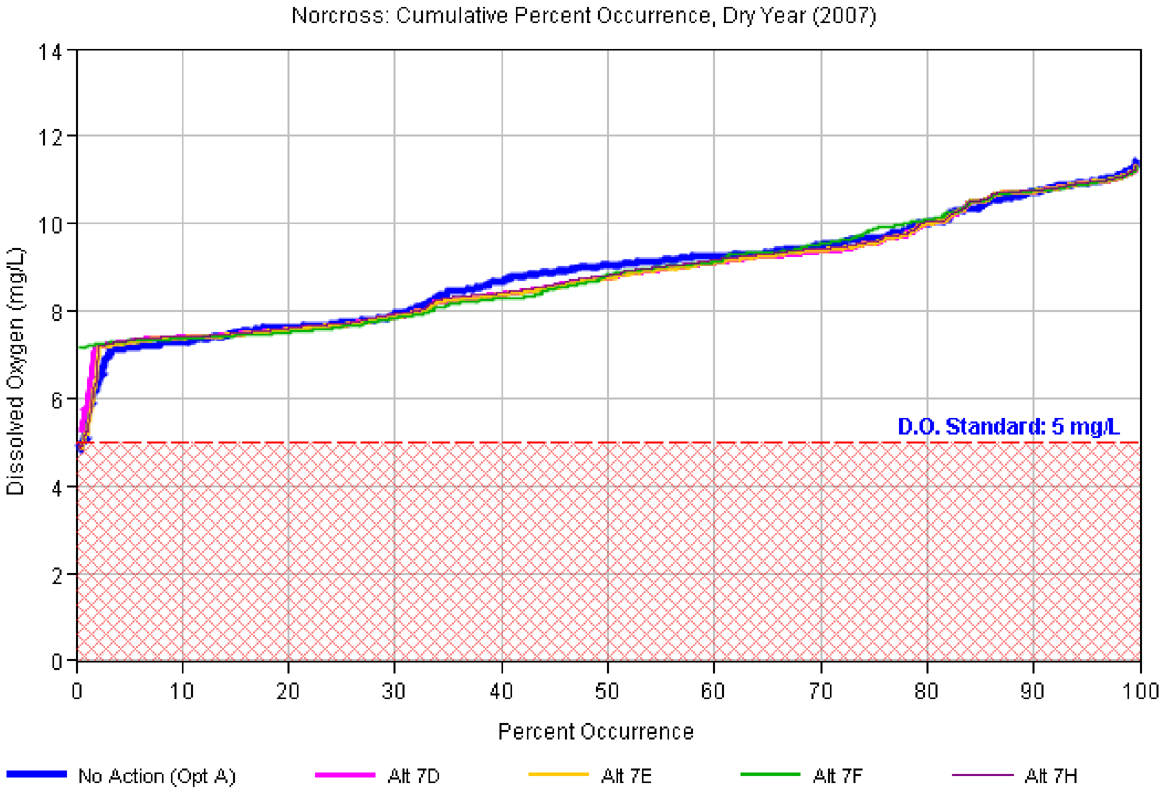

Figure 2.2-4. Occurrence of daily average DO in the Chattahoochee River at Norcross, Georgia, for a representative dry year (2007).

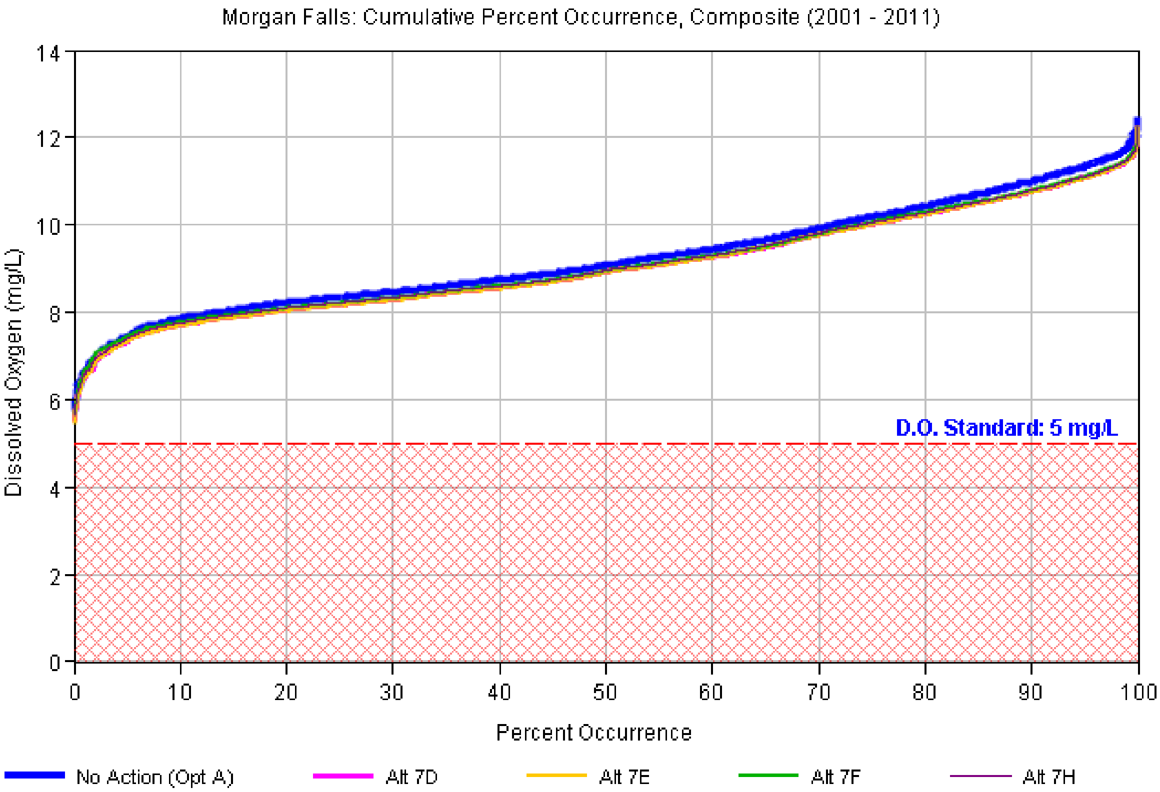

Figure 2.2-5. Occurrence of daily average DO in the Chattahoochee River at Morgan Falls Dam, near Atlanta, Georgia, for the period from 2001 through 2011.

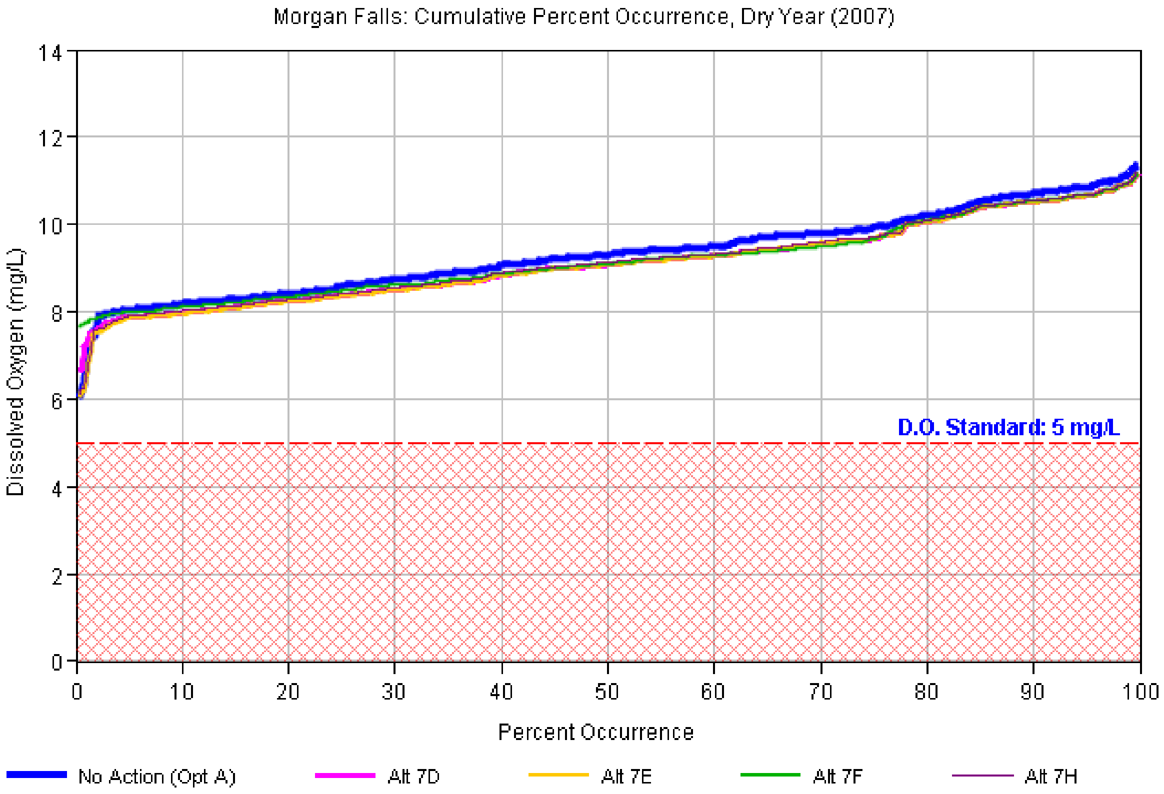

Figure 2.2-6. Occurrence of daily average DO in the Chattahoochee River at Morgan Falls Dam, near Atlanta, Georgia, for a representative dry year (2007).

The following occurrence plots (Figure 2.2-7 through Figure 2.2-14) illustrate occurrences of DO at locations where, based on Figure 2.2-1and Figure 2.2-2, median concentrations are less than state standards. These locations are downstream of Buford, West Point, Bartletts Ferry, and Walter F. George dams.

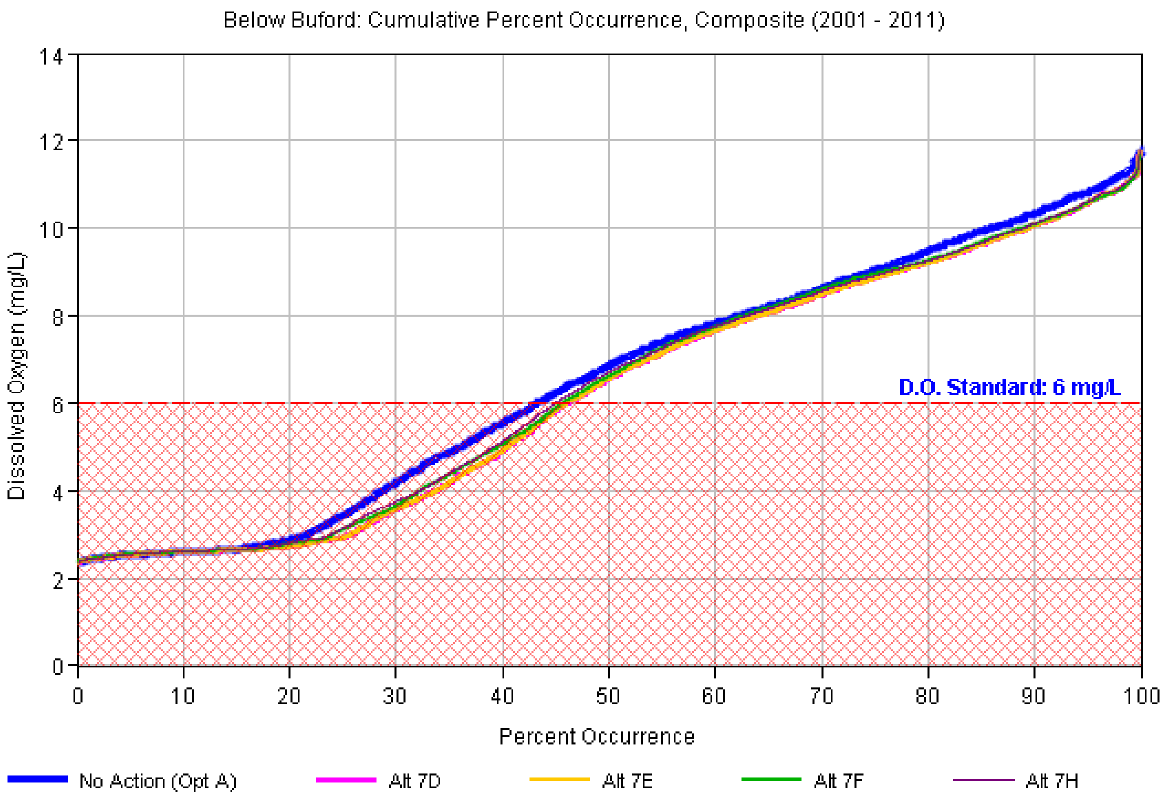

Figure 2.2-7. DO occurrence downstream of Buford Dam for the modeled period (2001 – 2011).

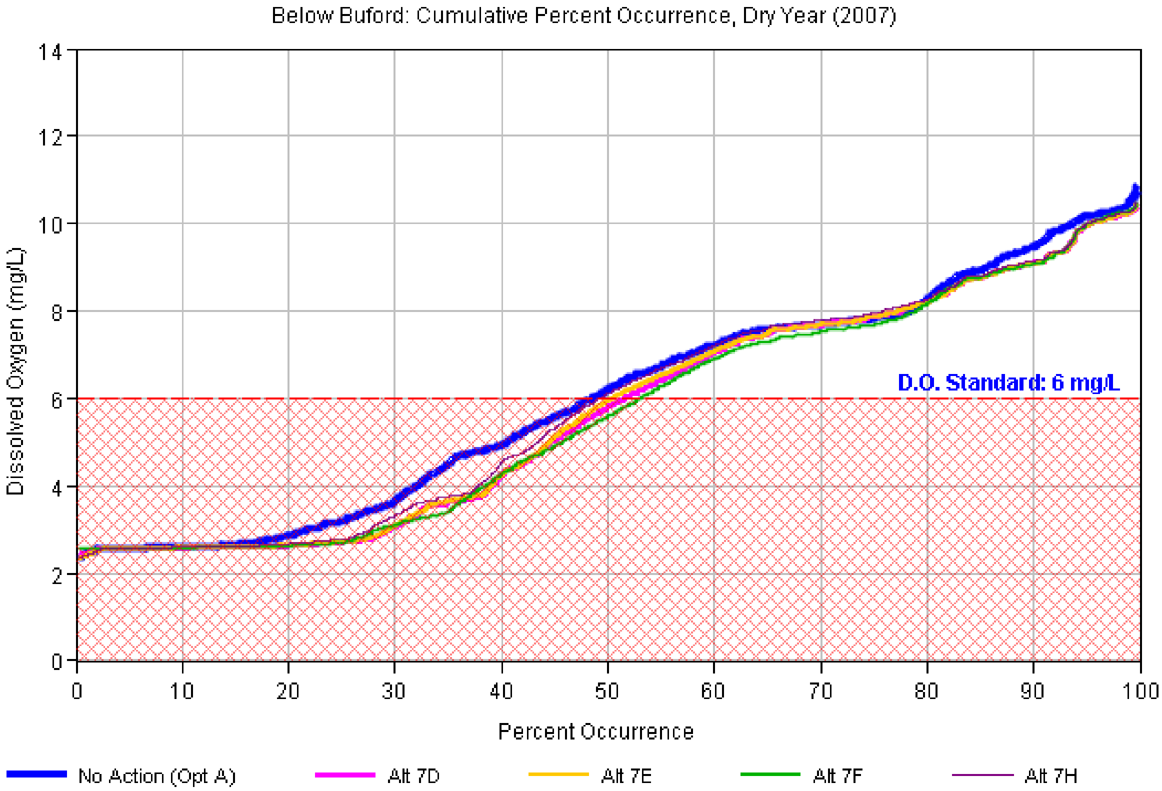

Figure 2.2-8. DO occurrence downstream of Buford Dam for a representative dry year (2007).

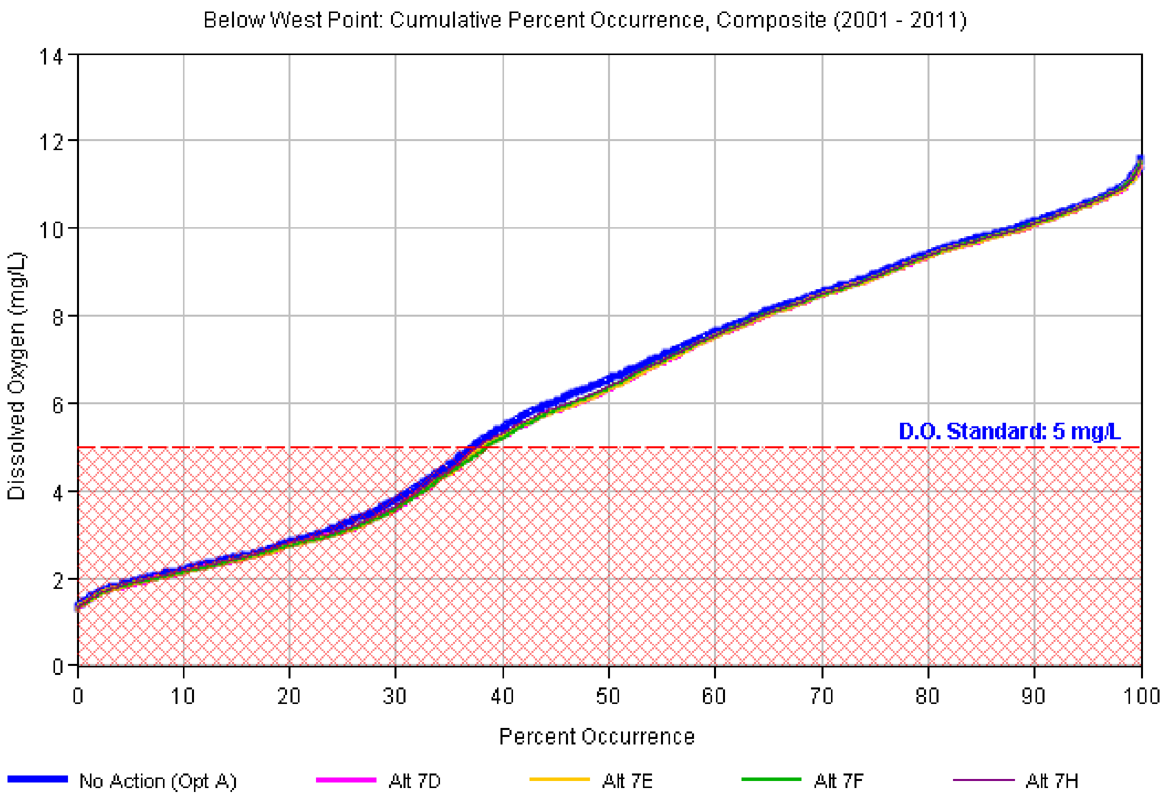

Figure 2.2-9. DO occurrence downstream of West Point Dam for the modeled period (2001 - 2011).

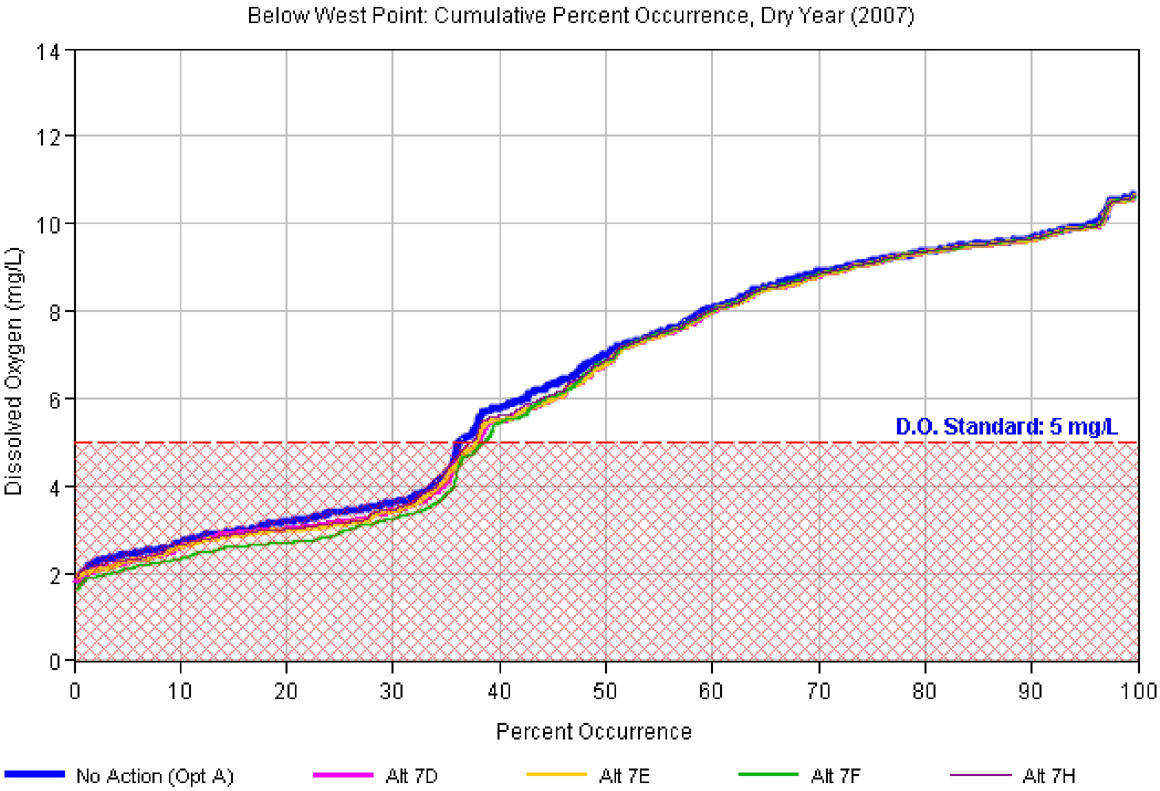

Figure 2.2-10. DO occurrence downstream of West Point Dam for a representative dry year (2007).

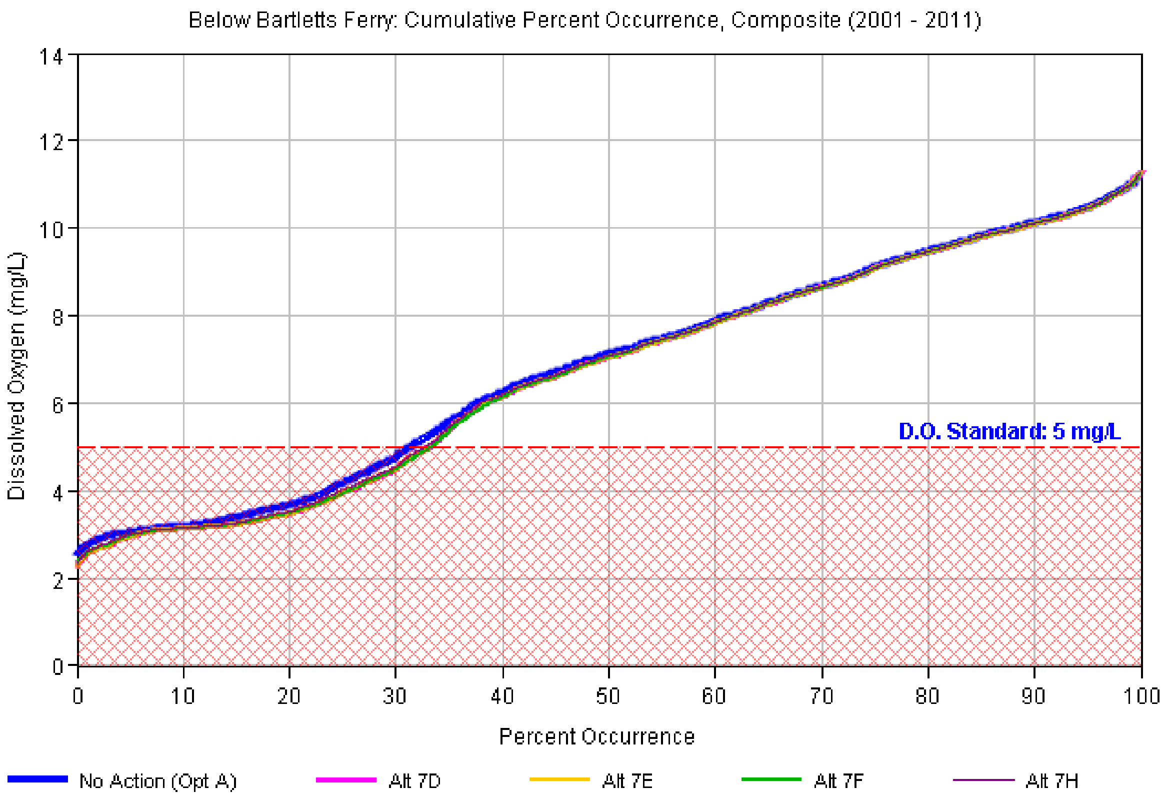

Figure 2.2-11. DO occurrence downstream of Bartletts Ferry Dam for the modeled period (2001 - 2011).

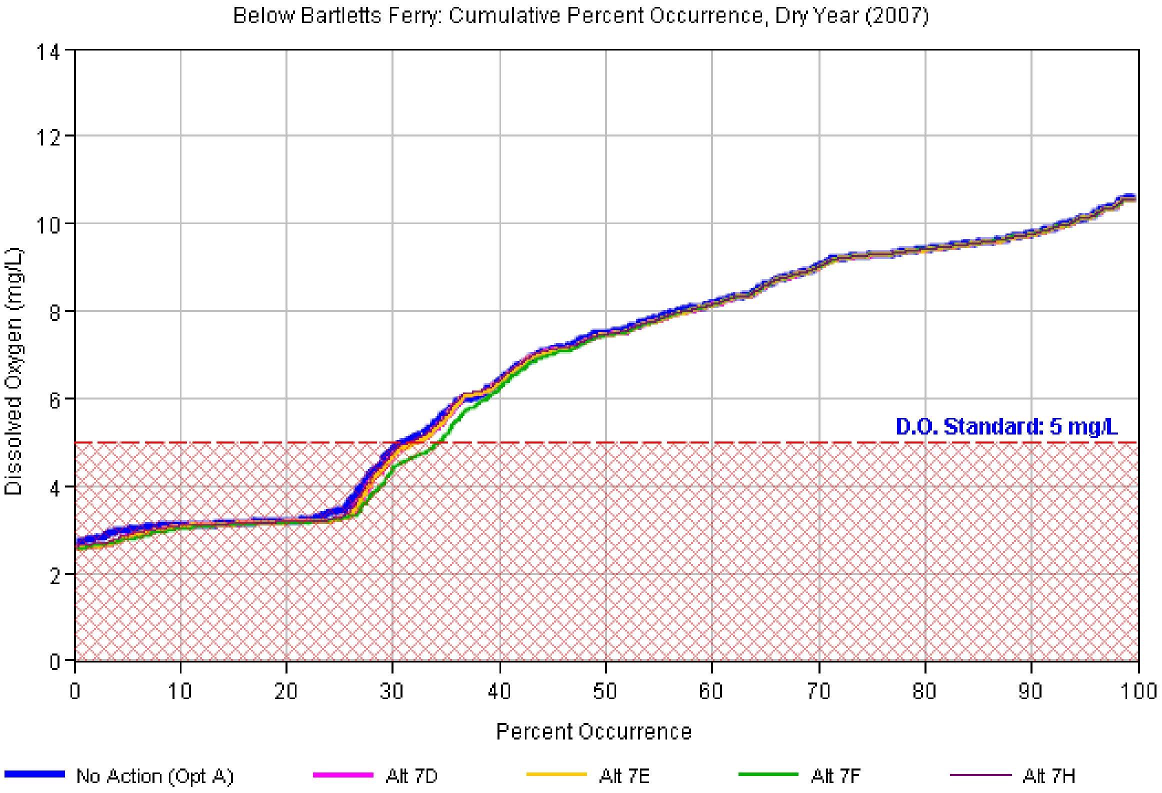

Figure 2.2-12. DO occurrence downstream of Bartletts Ferry Dam for a representative dry year (2007).

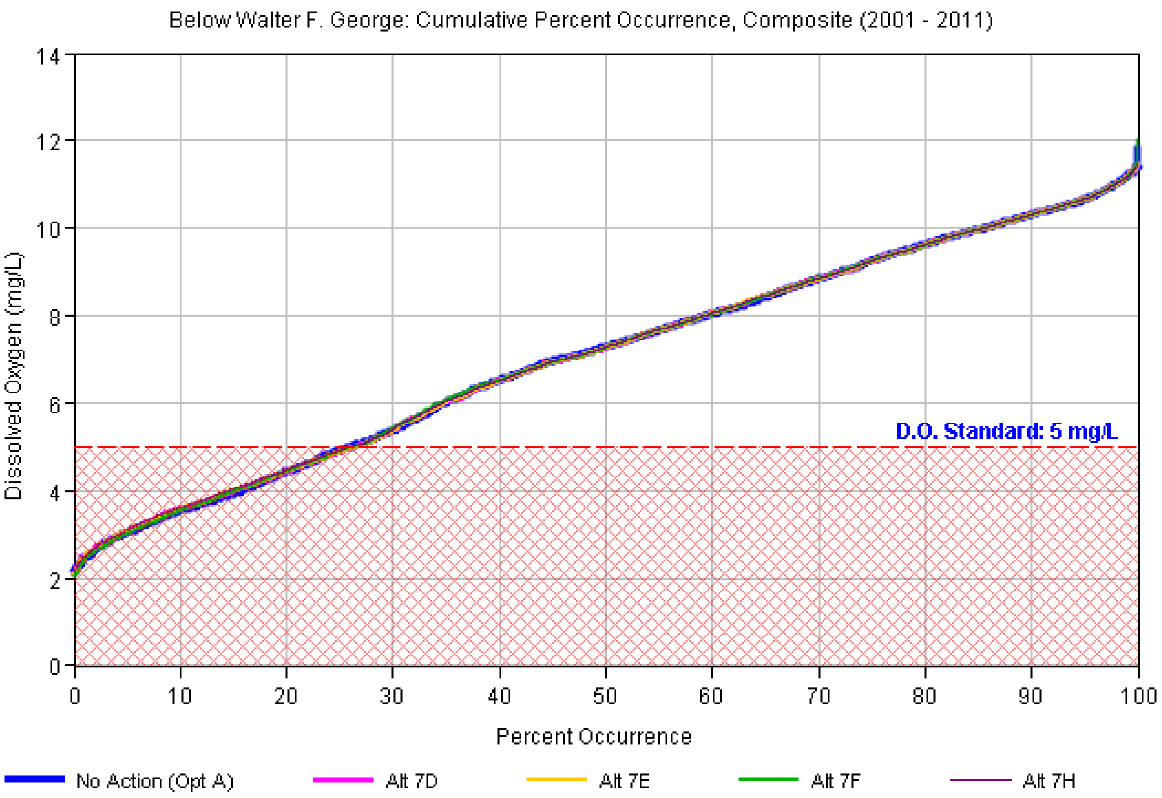

Figure 2.2-13. DO occurrence downstream of Walter F. George Dam for the modeled period (2001-2011).

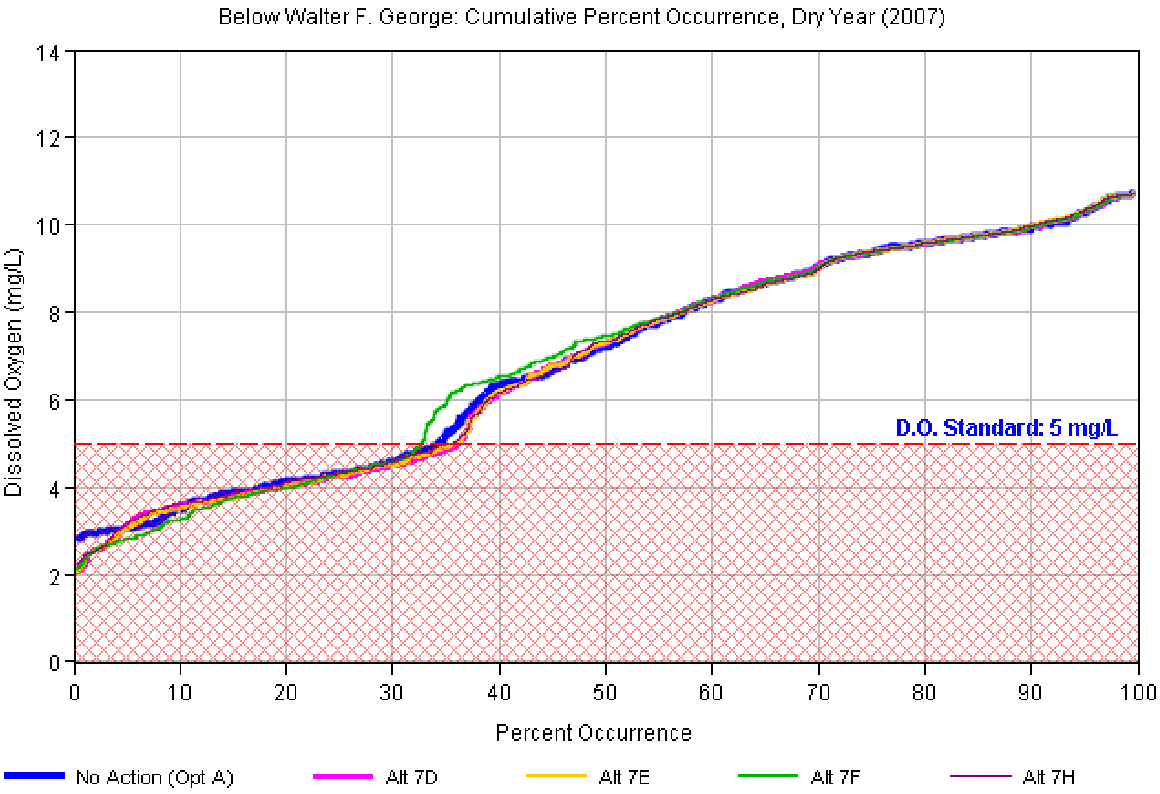

Figure 2.2-14. DO occurrence downstream of Walter F. George Dam for a representative dry year (2007).

b. Total number of instantaneous "measurements" less than 4 mg/L.

Instantaneous modeled results were not simulated. The river profile simulations suggest that DO values less than 4 mg/L are only expected at several tailrace locations (as illustrated in Figure 2.2-7 through Figure 2.2-14). Time series plots for these locations are also provided below in Figure 2.2-15 through Figure 2.2-18.

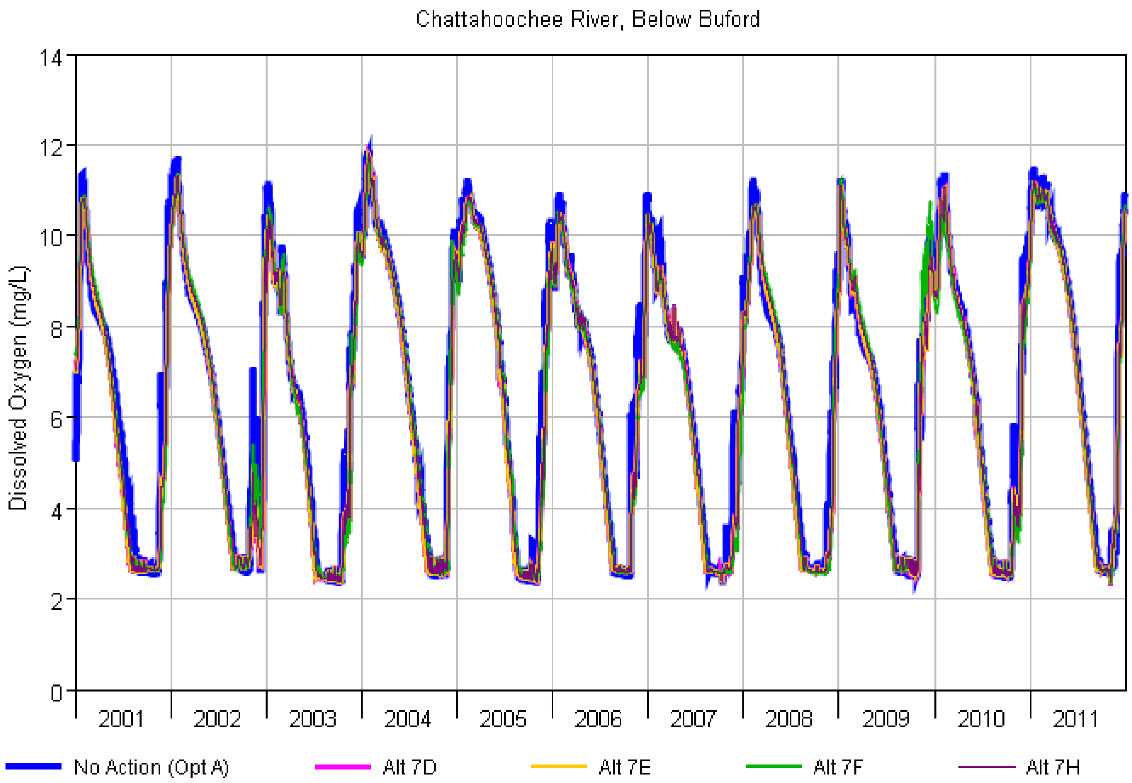

Figure 2.2-15. Time series DO from Buford Dam releases.

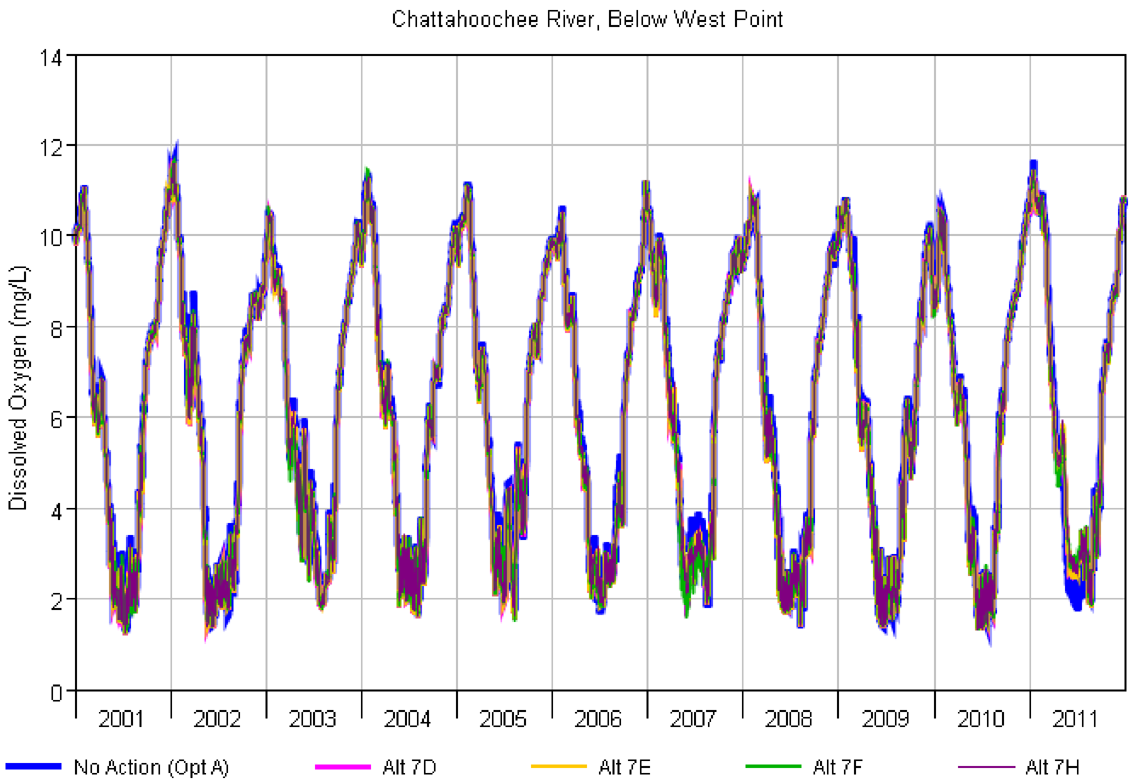

Figure 2.2-16. Time series DO from West Point Dam releases.

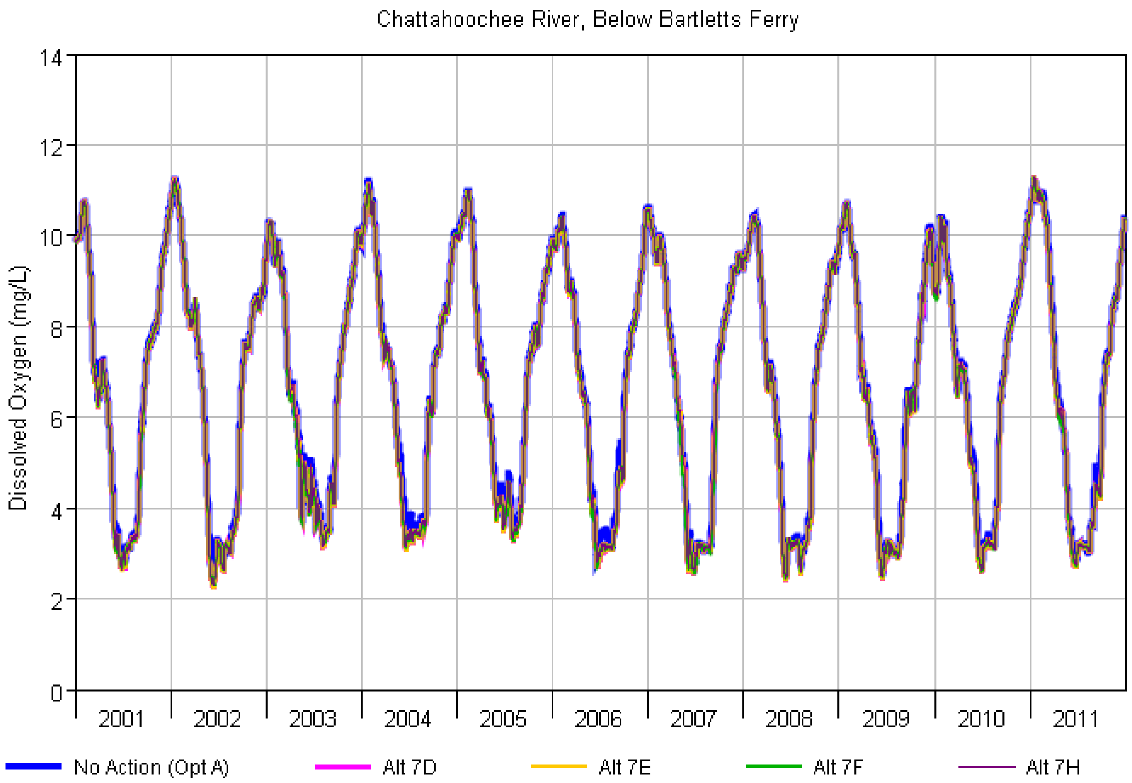

Figure 2.2-17. Time series DO from Bartletts Ferry Dam releases.

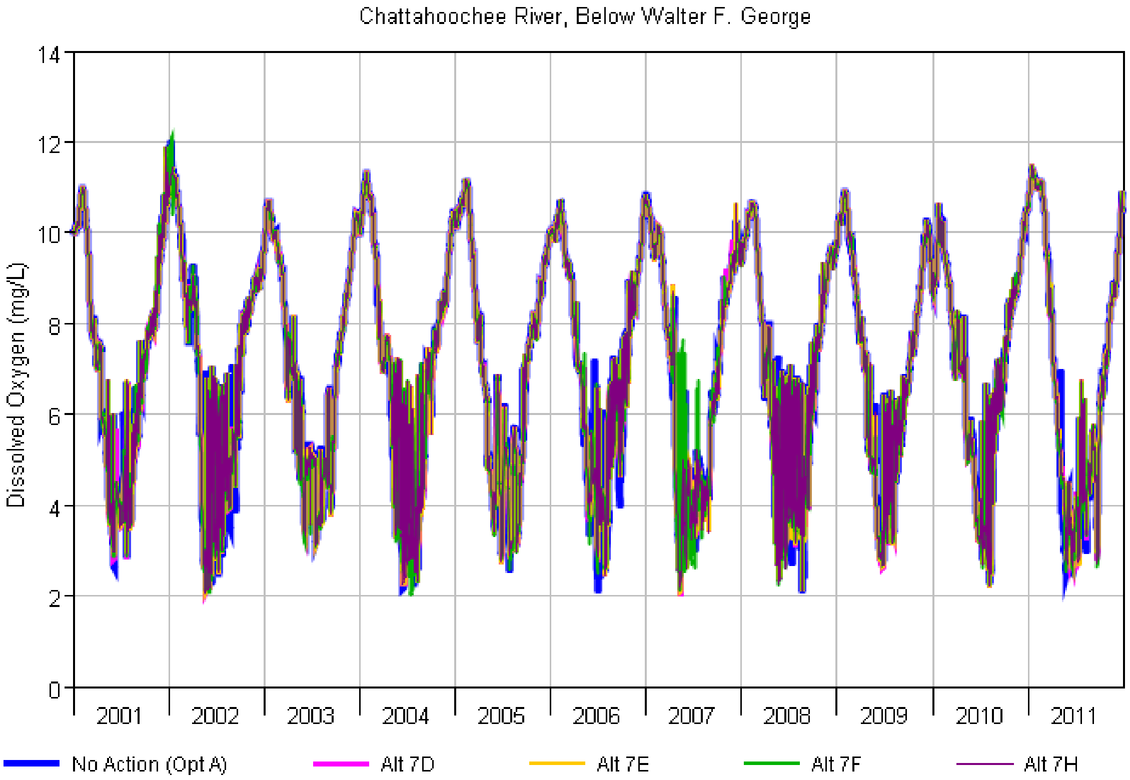

Figure 2.2-18. Time series DO from Walter F. George Dam releases.

c. Monthly exceedance figures and box plots with outliers for DO (mg/L).

Monthly exceedance figures for DO were not generated. However, the following figure generally provides the same information in a format we believe is easier to communicate. Figure 2.2-19 illustrates the change in DO values between the NAA and the PAA (PAA minus NAA is illustrated) at the 5, 50, and 95 percent occurrence intervals. For these DO plots, the 95 percent occurrence interval means that the values are this number or lower 95 percent of the simulation at this location (i.e., only 5 percent of the time the value is higher than this – a rare occurrence). Conversely, the 5 percent occurrence interval means that the values are this number or lower 5 percent of the simulation at this location (i.e., 95 percent of the time the value is higher than this – this too is a rare occurrence). The 50 percent occurrence represents the median occurrence.

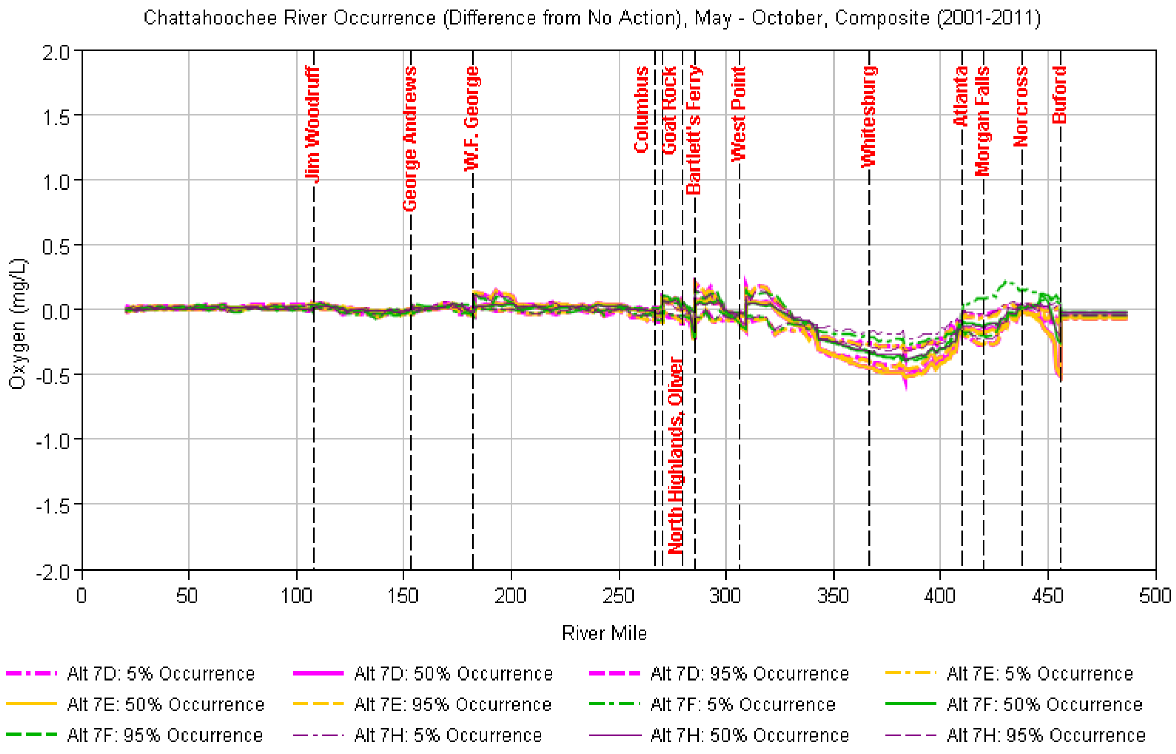

Figure 2.2-19. Changes in longitudinal DO in the Chattahoochee River for the May through October for the model period (2001 through 2011).

2.2.2 Water Temperature

a. Monthly exceedance figures and box plots with outliers for water temperature.

Monthly exceedance figures for temperature were not generated. Again, we believe that river profiles and occurrence plots illustrate this information more clearly than the box plots. The following figures first illustrate temperatures along the riverine profile and then illustrate the change in temperature from the NAA (PAA minus the NAA is illustrated). The delta profile plots clearly illustrate the magnitude of the change in water temperature of each of the alternatives as compared to the NAA.

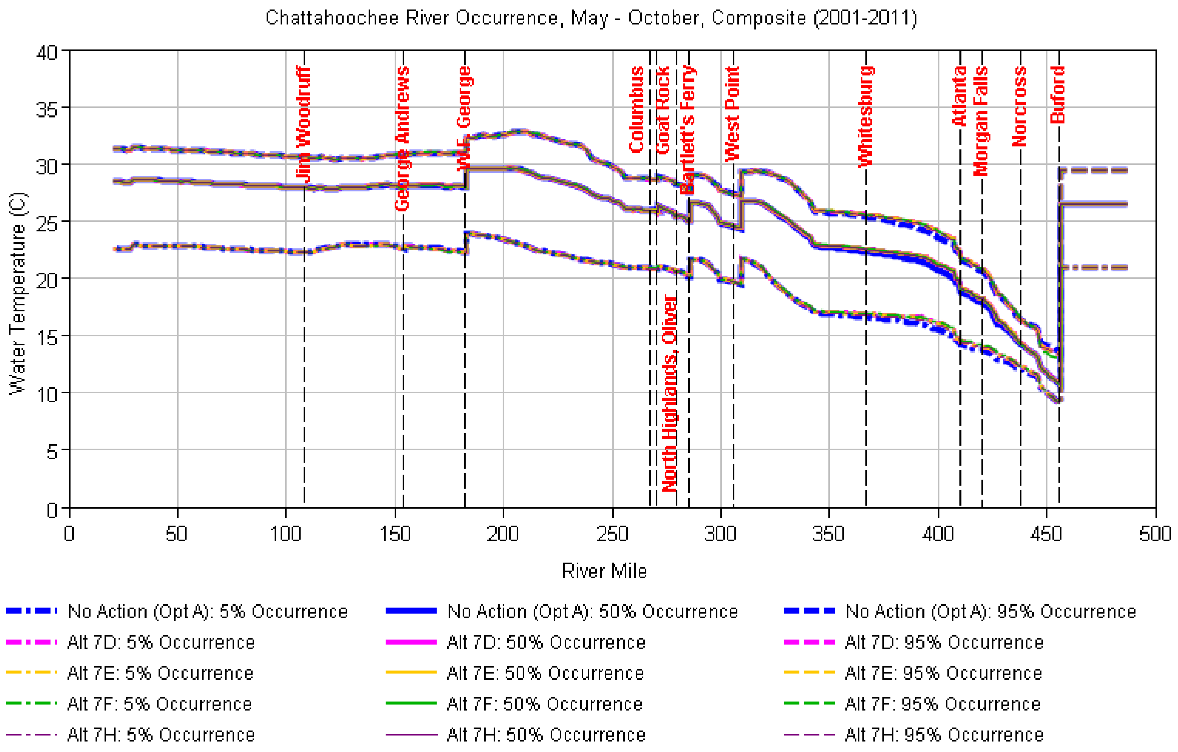

Figure 2.2-20. May through October water temperatures along the Chattahoochee River for the modeled period (2001-2011).

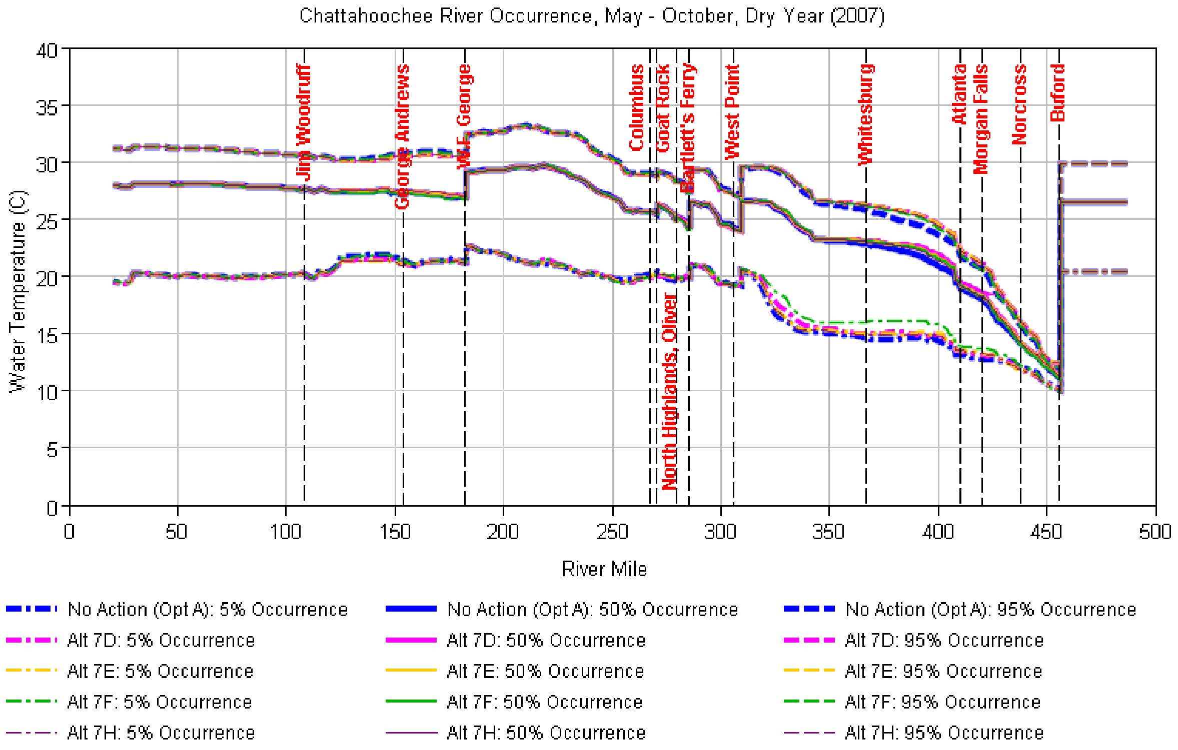

Figure 2.2-21. May through October water temperatures along the Chattahoochee River for a representative dry year (2007).

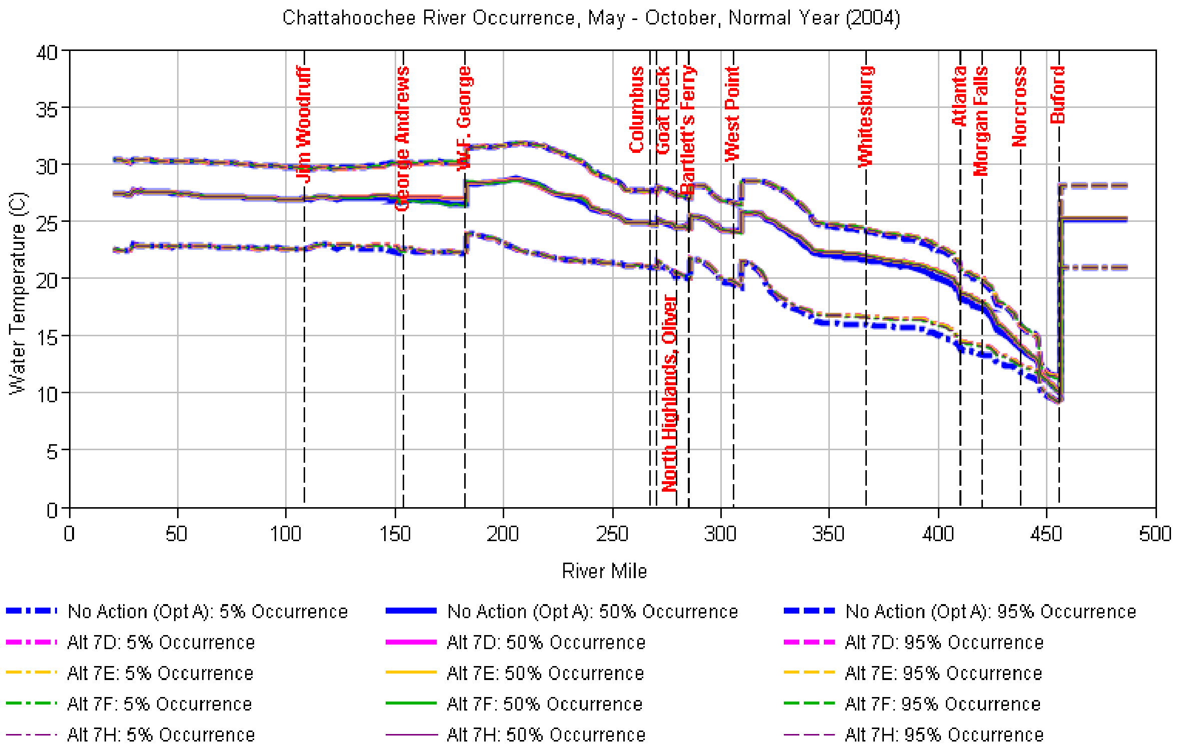

Figure 2.2-22. May through October water temperatures along the Chattahoochee River for a representative normal year (2004).

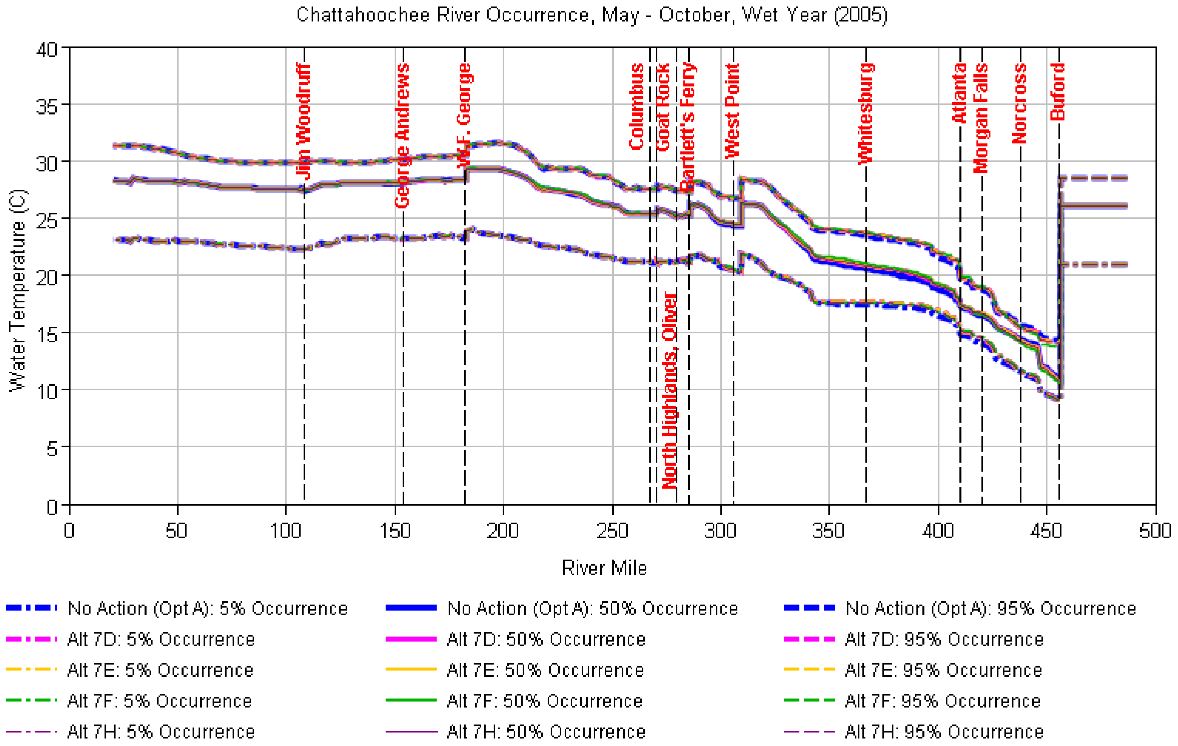

Figure 2.2-23. May through October water temperatures along the Chattahoochee River for a representative wet year (2005).

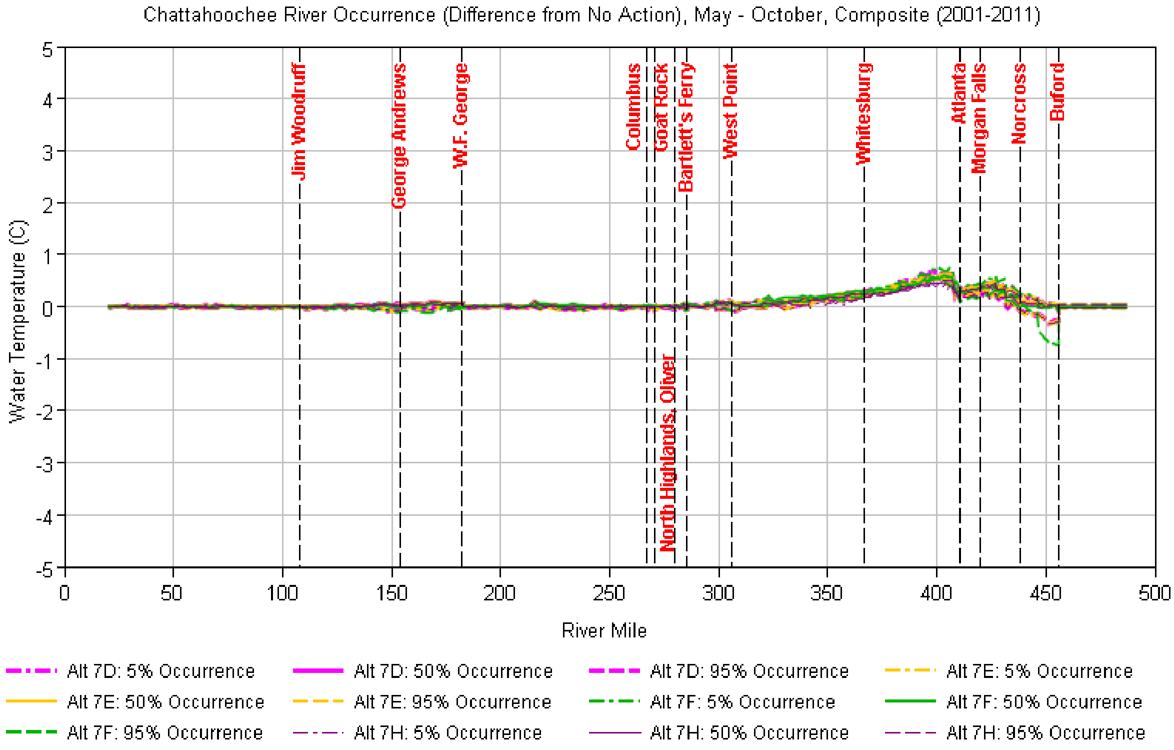

Figure 2.2-24. Changes in longitudinal water temperature in the Chattahoochee River for May through October for the modeled period from 2001 through 2011.

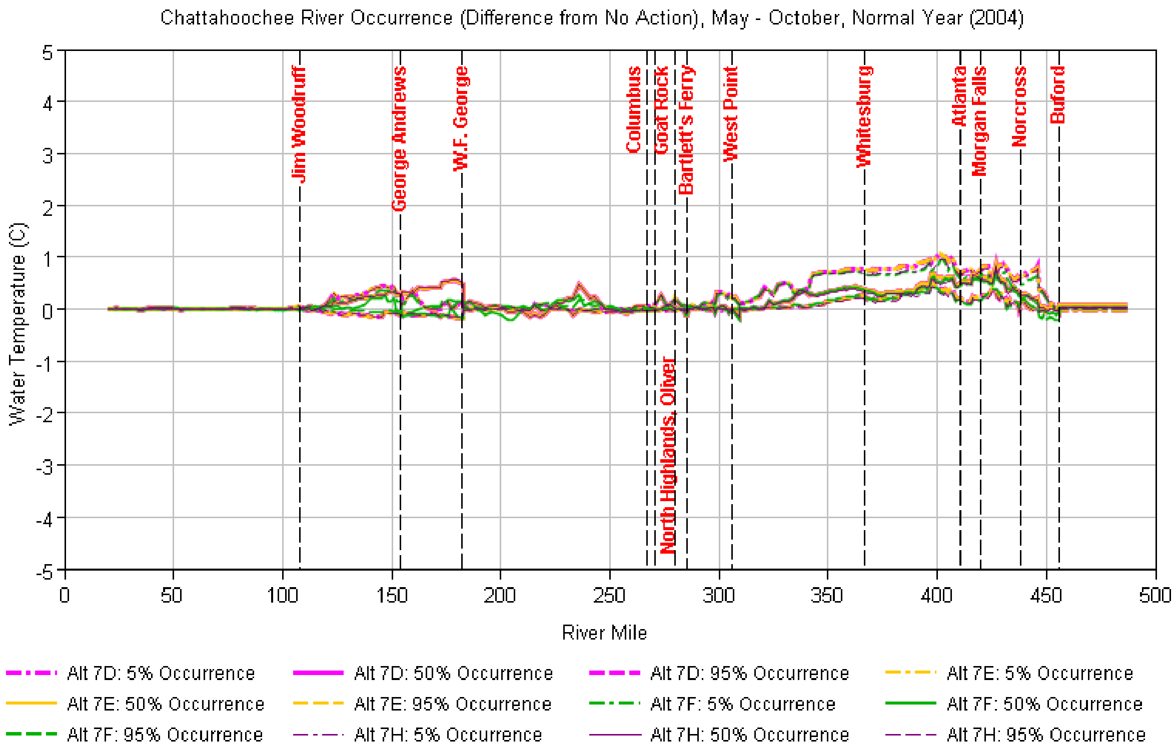

Figure 2.2-25. Changes in longitudinal water temperature in the Chattahoochee River for May through October representing hydrologic conditions in a normal year (2004).

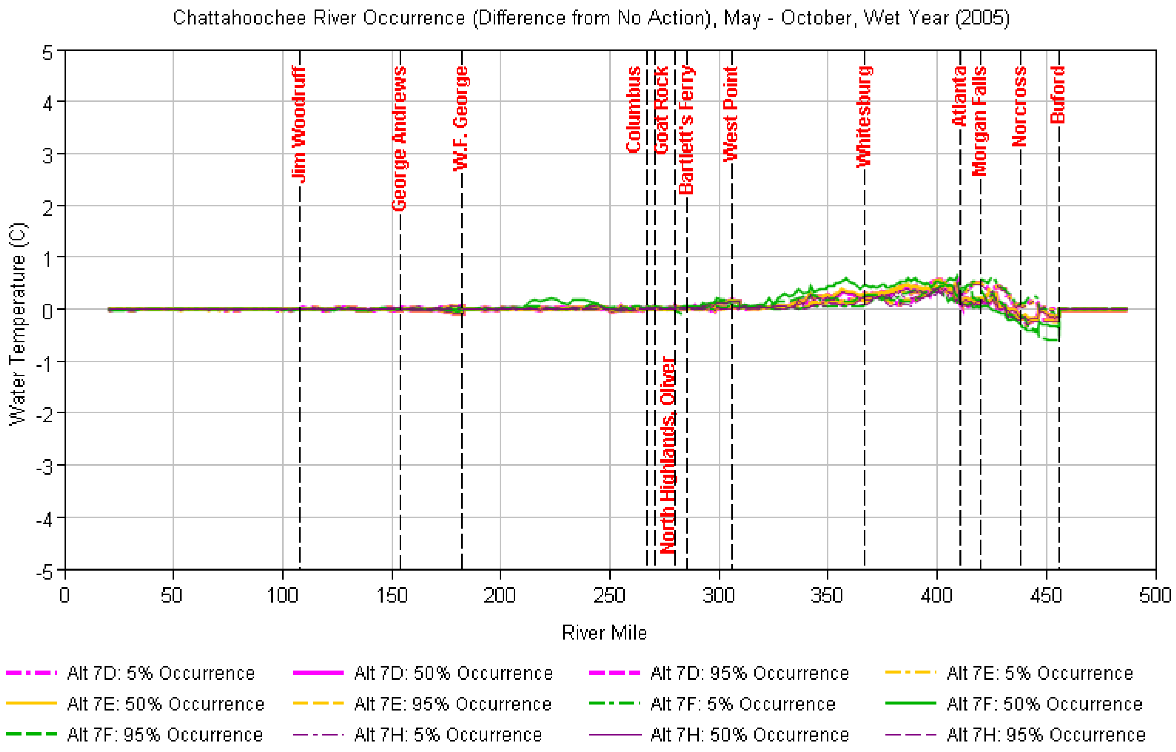

Figure 2.2-26. Changes in longitudinal water temperature in the Chattahoochee River for May through October representing hydrologic conditions in a wet year (2005).

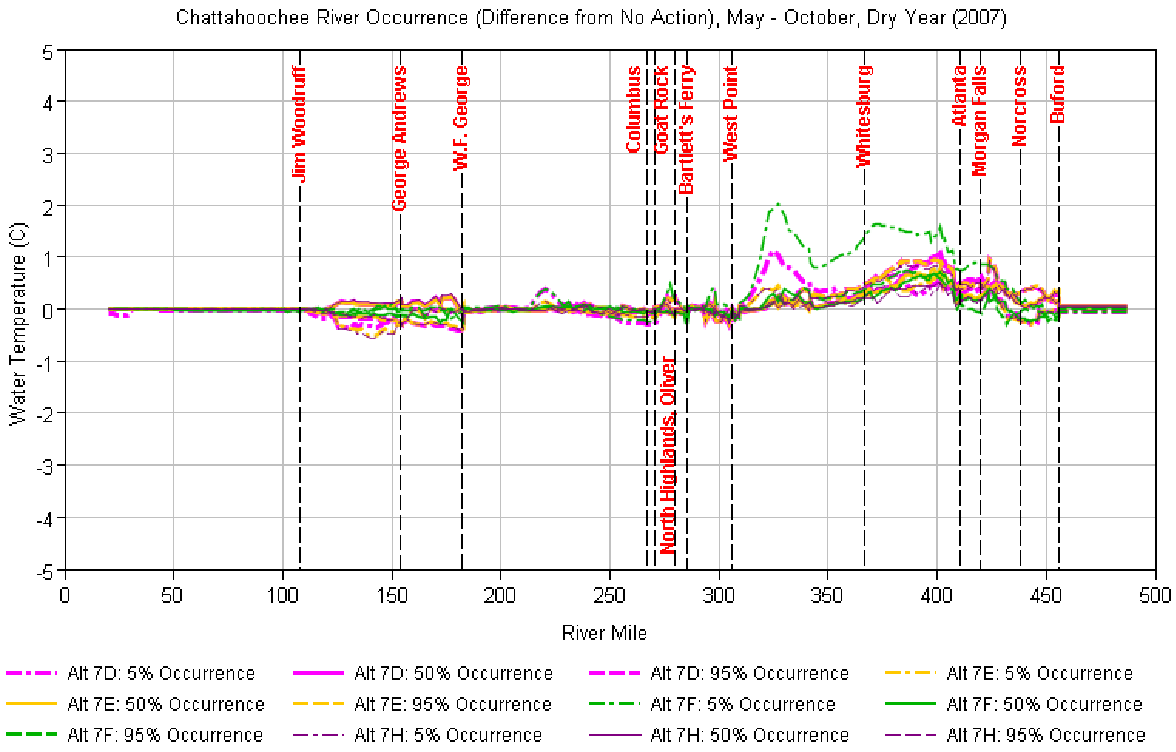

Figure 2.2-27. Changes in longitudinal water temperature in the Chattahoochee River for May through October representing hydrologic conditions in a dry year (2007).

2.2.3 Wastewater

a. Average stream percent wastewater.

Average stream flow percent that is wastewater is presented for May through October in the figures to follow; these figures also present the 5 percent and 95 percent occurrences.

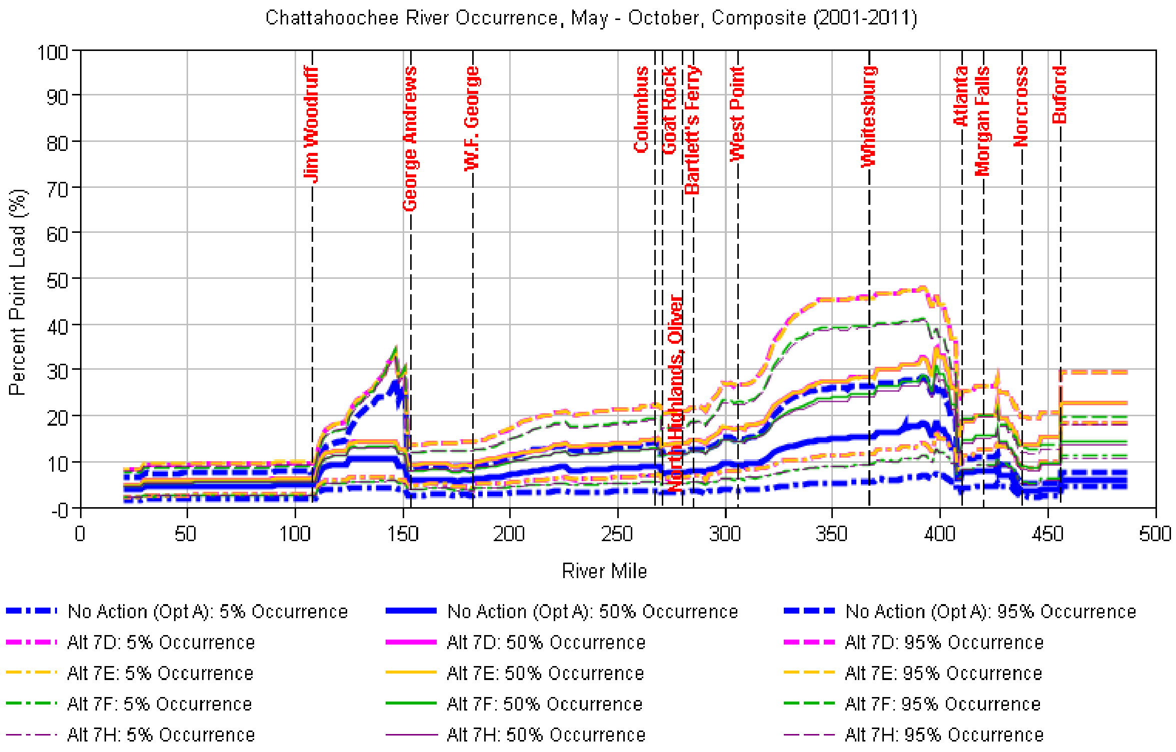

Figure 2.2-28. Percent of total flow that is wastewater along the Chattahoochee River for May through October of the modeled period (2001-2011).

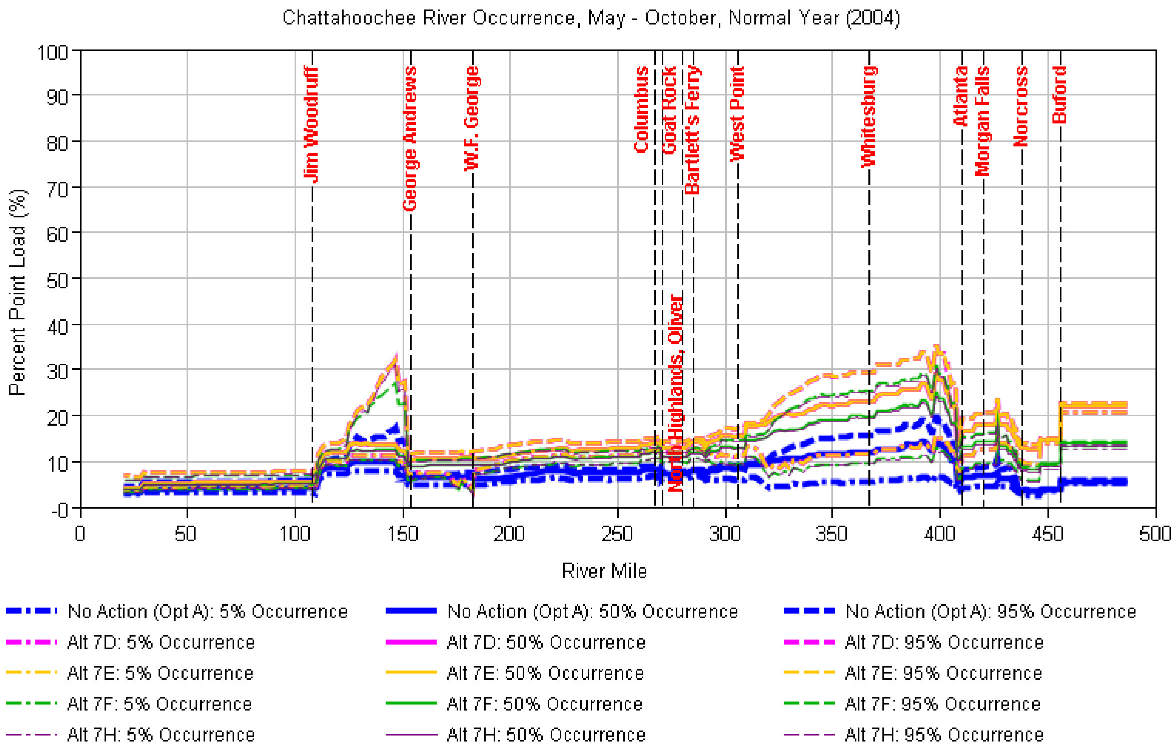

Figure 2.2-29. Percent of total flow that is wastewater along the Chattahoochee River for May through October in a representative normal year (2004).

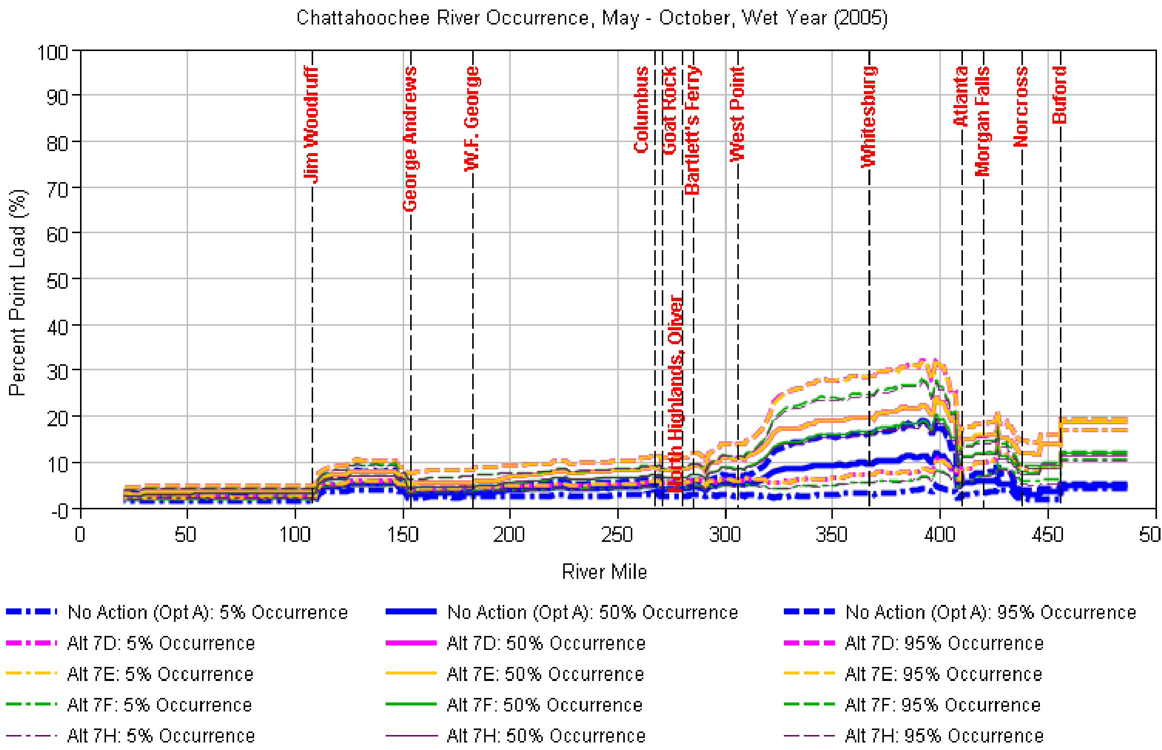

Figure 2.2-30. Percent of total flow that is wastewater along the Chattahoochee River for May through October in a representative wet year (2005).

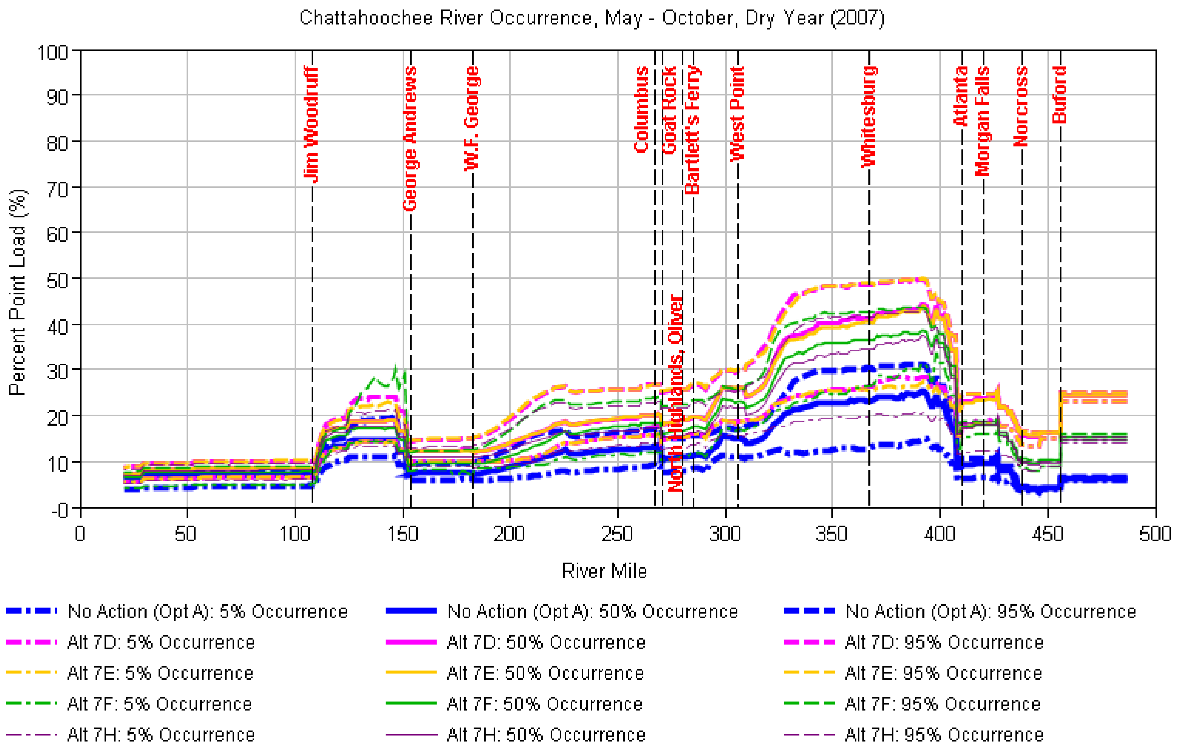

Figure 2.2-31. Percent of total flow that is wastewater along the Chattahoochee River for May through October in a representative dry year (2007).

2.2.4 Chlorophyll *a*

a. Average values of summer Chlorophyll *a* (*u*g/L)

Chlorophyll *a* in various rainfall conditions is presented for the system in the following figures. Figures are also provided that present areas in the system where the greatest changes would be expected. The greatest changes would be expected in West Point Lake, Bartletts Ferry Lake, and Walter F. George in extreme conditions. Table 2.2-1 presents the growing season (April through October) average and annual geometric mean of chlorophyll *a* in USACE reservoirs.

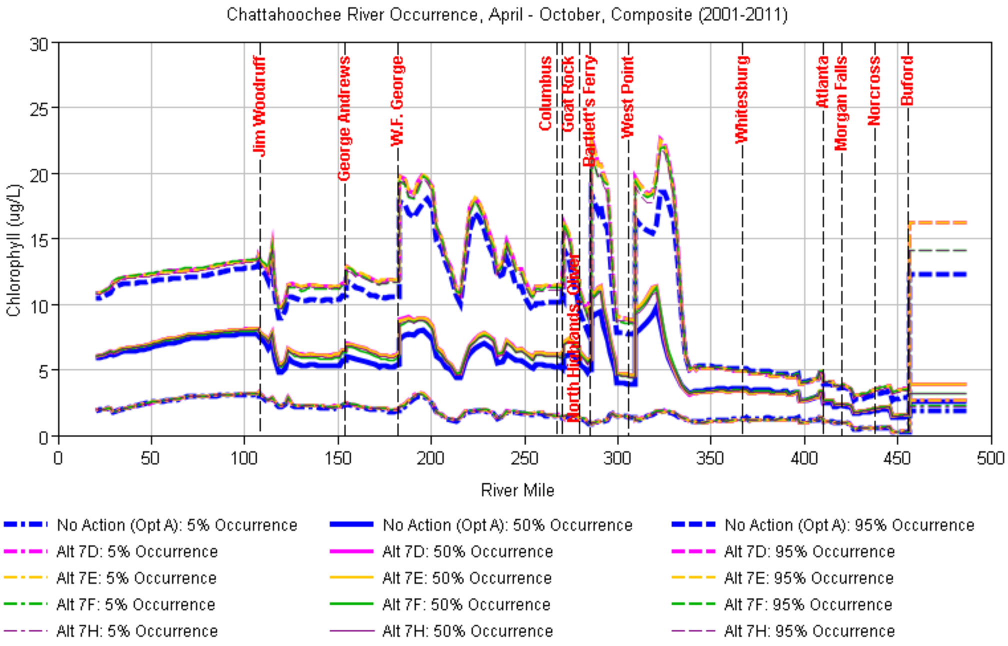

Figure 2.2-32. Chlorophyll *a* along the Chattahoochee River for April through October of the modeled period (2001-2011).

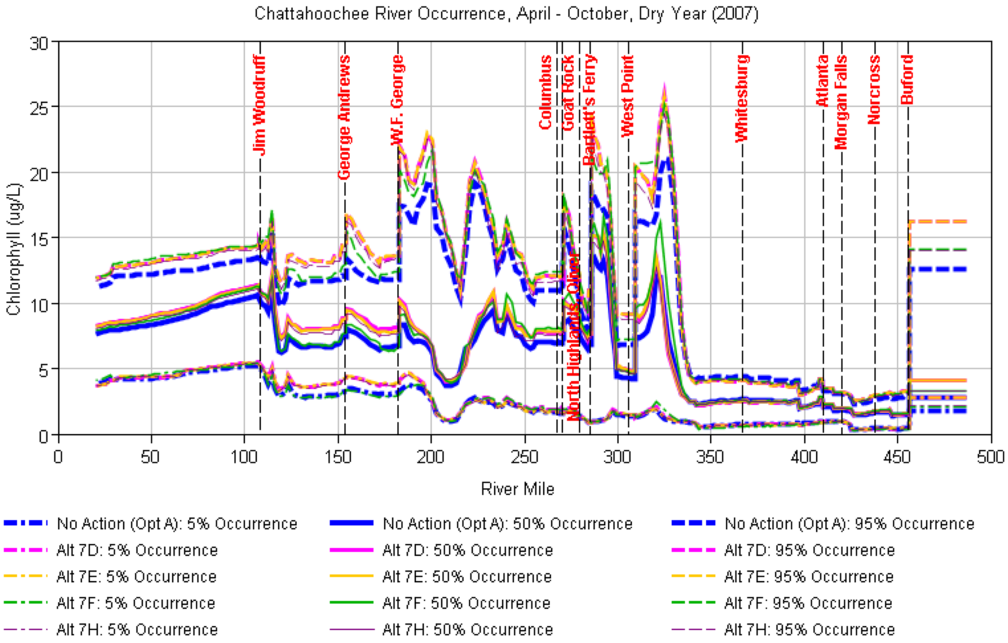

Figure 2.2-33. Chlorophyll *a* along the Chattahoochee River for April through October in a representative dry year (2007).

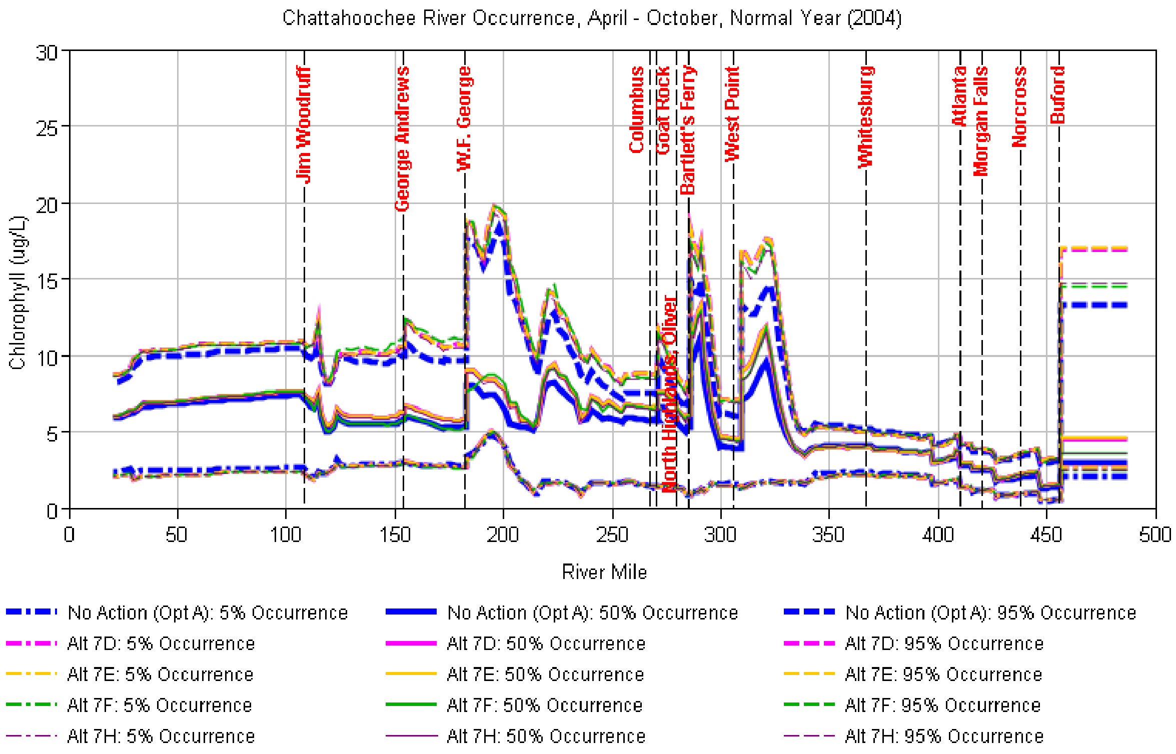

Figure 2.2-34. Chlorophyll *a* along the Chattahoochee River for April through October in a representative normal year (2004).

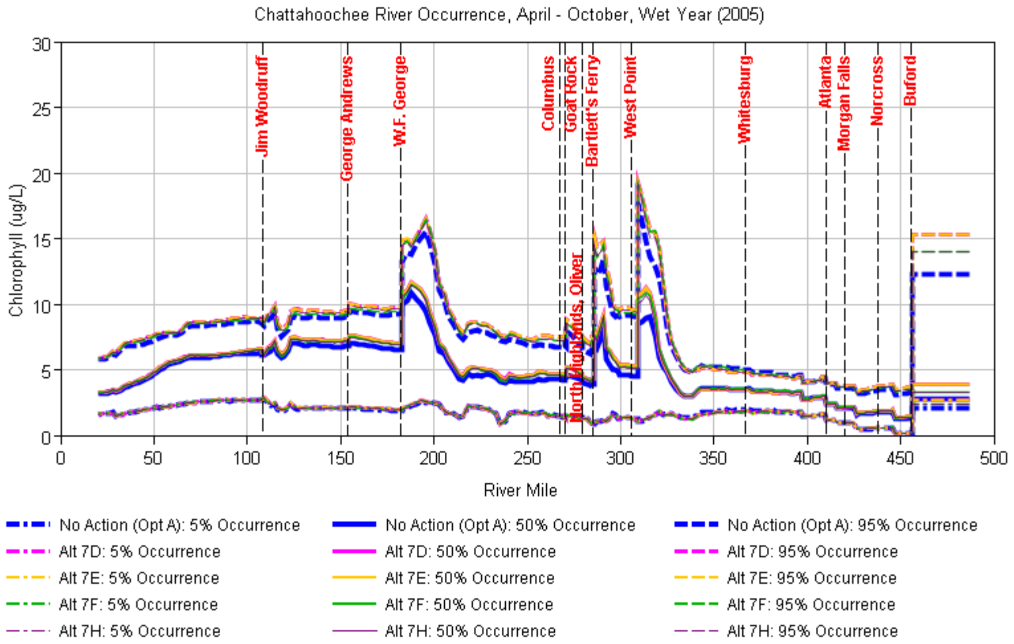

Figure 2.2-35. Chlorophyll *a* along the Chattahoochee River for April through October in a representative wet year (2005).

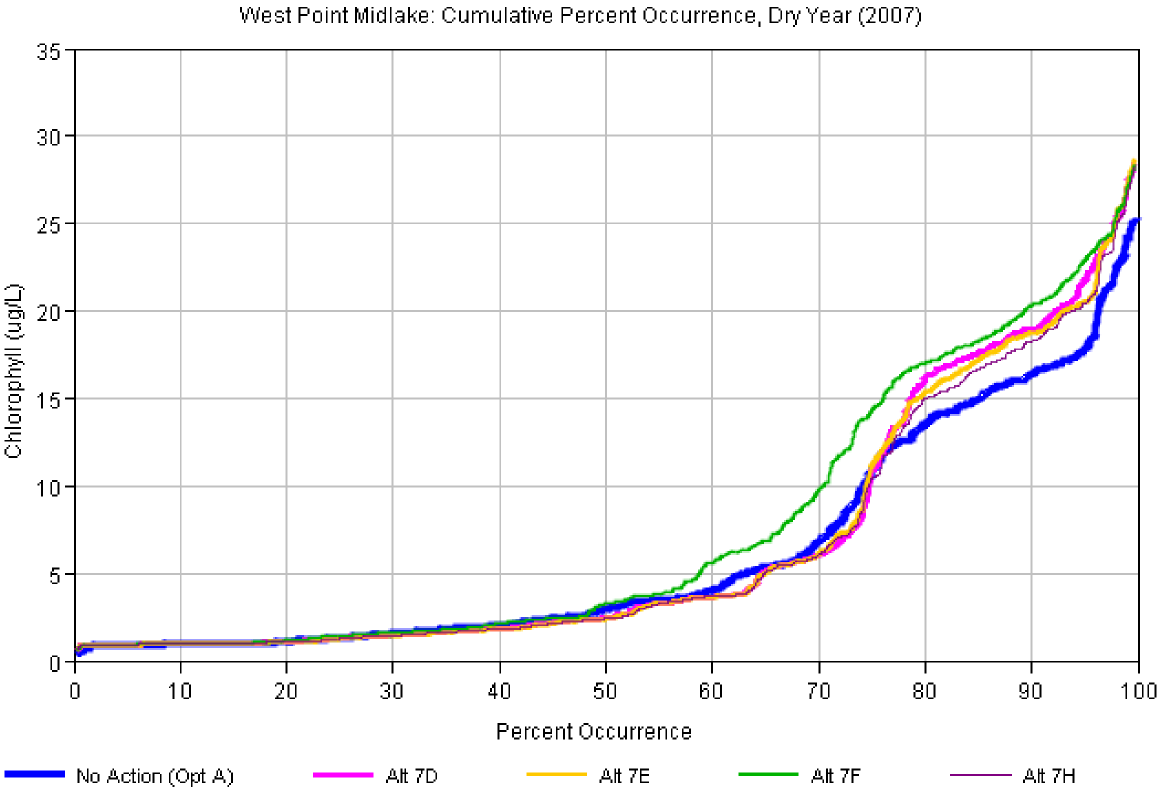

Figure 2.2-36. Occurrence of daily average chlorophyll *a* in a mid-reservoir location of West Point Lake for a representative dry year (2007).

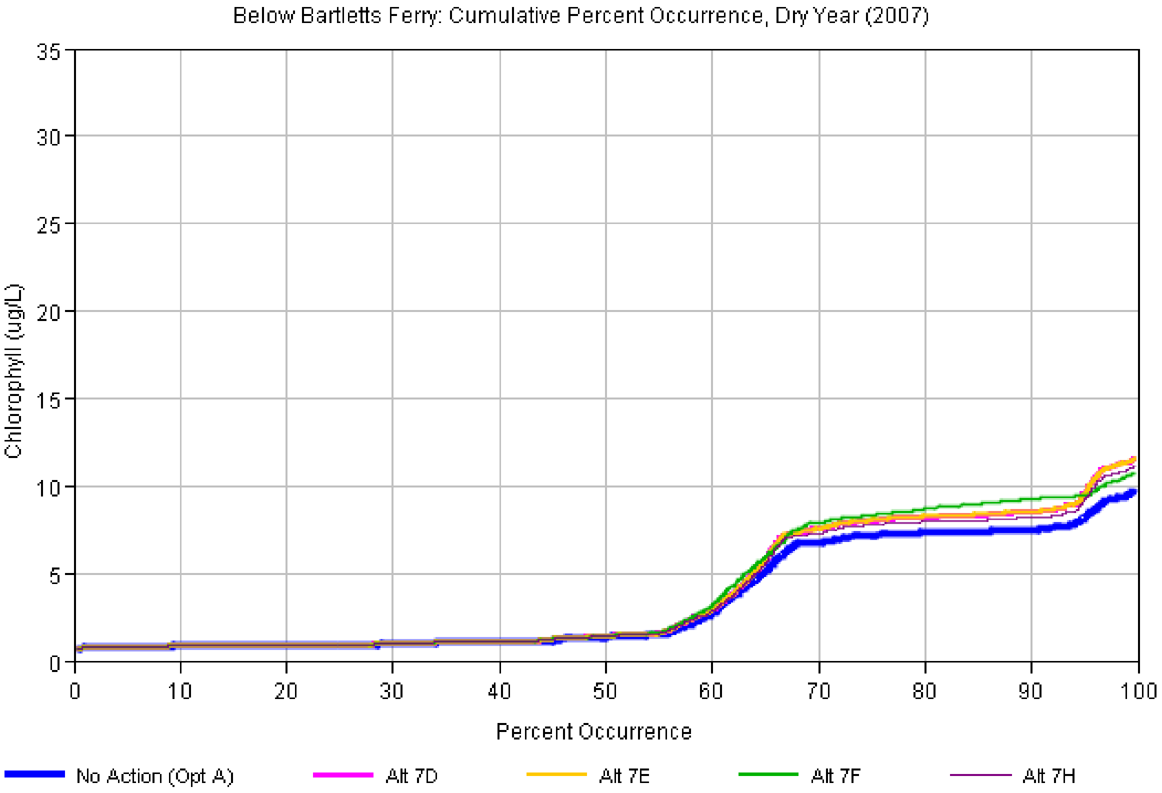

Figure 2.2-37. Occurrence of daily average chlorophyll *a* in a mid-reservoir location of Bartletts Ferry Lake for a representative dry year (2007).

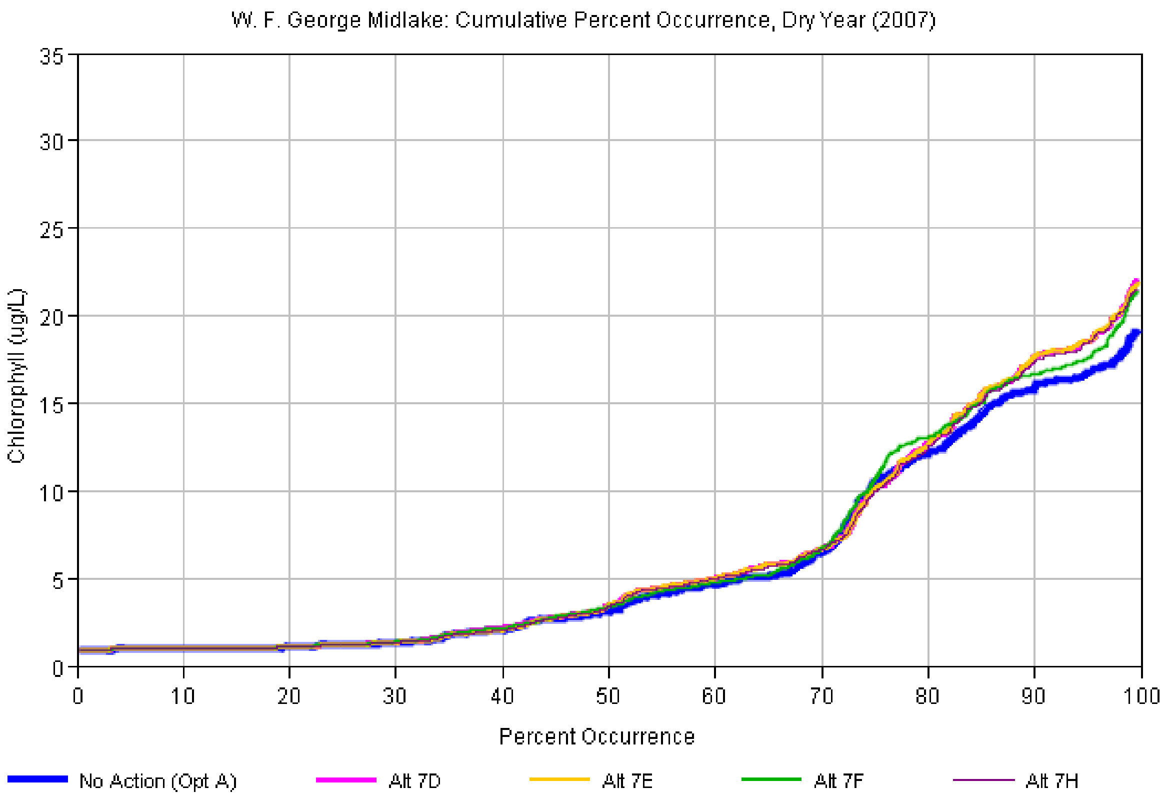

Figure 2.2-38. Occurrence of daily average chlorophyll *a* in a mid-reservoir location of Walter F. George Lake for a representative dry year (2007).

Table 2.2-1. Growing season (April-October) average and annual geometric mean of chlorophyll *a* at USACE reservoirs in the ACF Basin

Year	**Modeled (µg/L)**		**Change from No Action Alternative (µg/L)**
	No Action	**Proposed Action**	**PAA**
	Lake Sidney Lanier[a]		
2000	2.6	5.7	3.1
2001	3.2	4.2	0.9
2002	3.8	4.8	1
2003	3.7	4.3	0.6
2004	4.6	5.2	0.6
2005	4.2	4.8	0.5
2006	4.1	4.7	0.6

Year	Modeled (µg/L)		Change from No Action Alternative (µg/L)
	No Action	Proposed Action	PAA
2007	4.2	4.9	0.7
2008	4	4.7	0.7
2009	4.2	4.7	0.5
2010	4.1	4.6	0.5
2011	4.2	4.9	0.6
West Point Mid-Lake[a]			
2000	7.9	12.1	4.1
2001	8.1	8.4	0.4
2002	11.1	11.9	0.7
2003	4.4	4.5	0.1
2004	5.8	6.4	0.7
2005	4.1	4.3	0.1
2006	7.2	7.5	0.3
2007	9.4	9.8	0.4
2008	10.7	11.2	0.4
2009	7.8	9.2	1.3
2010	6.2	6.7	0.5
2011	8.1	9.8	1.7
Walter F. George Mid-Lake[a]			
2000	9.3	9.9	0.6
2001	7.7	8.1	0.5
2002	8.1	8.8	0.7
2003	4.9	5.1	0.3
2004	7	7.7	0.6
2005	4.9	5.2	0.3
2006	8.3	9.2	0.9
2007	9	9.5	0.5
2008	9.3	10.1	0.7
2009	6.9	7.4	0.5
2010	5.9	6.3	0.4
2011	8.1	8.5	0.4
Lake Seminole Mid-Lake[b]			
2000	3.3	3.4	0.1
2001	2.4	2.5	0.1

Year	Modeled (µg/L)		Change from No Action Alternative (µg/L)
	No Action	Proposed Action	PAA
2002	3	3.2	0.2
2003	3.2	3.3	0.1
2004	3.1	3.2	0.1
2005	3.1	3.2	0.1
2006	3	3.3	0.3
2007	3.3	3.6	0.4
2008	3.3	3.6	0.3
2009	2.7	2.8	0.1
2010	2.7	2.7	0.1
2011	2.9	3.1	0.3

[a]: Based on growing season average
[b]: Based on geometric mean for the modeled period

2.2.5 Retention

a. Average summer retention time (days).

Table 2.2-2 presents monthly retention times for the water quality model period (2001 through 2011).

Table 2.2-2. Monthly retention times (in days) for reservoirs on the Chattahoochee River for the period from 2001 through 2011

Year-Month	Retention time (days)																			
	Buford Dam		Morgan Falls Dam		West Point Dam		Bartletts Ferry Dam		Goat Rock Dam		Oliver Dam		North Highlands Dam		Walter F. George Dam		George W. Andrews Dam		Jim Woodruff Dam	
	NAA	PAA	NAA	PAA	NAA	PAA	NAA	PAA	NAA	PAA	NAA	PAA	NAA	PAA	NAA	PAA	NAA	PAA	NAA	PAA
01-Jan	1003	1241	1	1	74	74	24	24	1	1	4	4	0.2	0.2	72	72	1.4	1.4	14	14
01-Feb	1185	1292	1	1	68	67	20	20	1	1	3	3	0.2	0.2	70	70	1.4	1.4	15	15
01-Mar	1369	1319	1	1	29	28	7	7	0	0	1	1	0.1	0.0	15	15	0.3	0.3	3	3
01-Apr	1222	958	1	1	65	60	14	14	1	1	2	2	0.1	0.1	35	34	0.7	0.7	5	5
01-May	1109	905	1	1	147	133	37	34	2	2	6	6	0.3	0.3	162	134	2.8	2.4	20	19
01-Jun	1273	944	1	1	84	81	24	23	1	1	4	4	0.2	0.2	69	70	1.2	1.2	11	11
01-Jul	902	704	1	1	110	103	30	27	1	1	5	5	0.2	0.2	130	119	2.3	2.1	17	16
01-Aug	666	665	1	1	104	107	32	32	1	1	5	5	0.2	0.2	129	115	2.3	2.1	21	20
01-Sep	671	663	1	1	102	107	38	39	2	2	6	7	0.3	0.3	146	155	2.7	2.8	23	24
01-Oct	610	825	1	1	76	112	35	48	2	2	6	8	0.3	0.4	116	133	2.3	2.6	25	26
01-Nov	588	862	1	1	81	126	30	37	1	2	5	6	0.2	0.3	110	132	2.2	2.7	26	29
01-Dec	616	850	1	1	86	119	35	40	2	2	6	7	0.3	0.3	130	148	2.6	3.0	23	23
02-Jan	893	1210	1	1	78	52	28	21	1	1	5	3	0.2	0.2	92	68	1.8	1.4	20	16
02-Feb	1236	1311	1	1	64	91	23	29	1	1	4	5	0.2	0.2	64	77	1.2	1.5	14	16
02-Mar	1375	1439	1	1	112	97	25	22	1	1	4	4	0.2	0.2	65	63	1.3	1.2	13	13
02-Apr	1126	1020	1	1	106	104	31	30	1	1	5	5	0.2	0.2	75	73	1.5	1.5	13	12
02-May	1111	893	1	1	108	91	36	31	2	1	6	5	0.3	0.2	163	106	3.0	2.1	24	22
02-Jun	945	838	1	1	167	170	54	54	2	2	9	9	0.4	0.4	291	230	4.9	4.3	34	32
02-Jul	875	784	1	1	148	154	45	45	2	2	7	7	0.3	0.3	195	182	3.6	3.6	32	32
02-Aug	713	650	1	1	135	144	52	53	2	2	9	9	0.4	0.4	223	242	4.2	4.7	32	32
02-Sep	847	889	1	1	139	153	44	45	2	2	7	7	0.3	0.3	166	235	3.3	4.6	24	28
02-Oct	634	1005	1	1	91	103	23	25	1	1	4	4	0.2	0.2	145	150	2.9	3.0	21	21
02-Nov	693	959	1	1	57	57	14	14	1	1	2	2	0.1	0.1	63	65	1.2	1.3	11	11
02-Dec	695	926	1	1	34	35	10	11	0	0	2	2	0.1	0.1	42	43	0.8	0.8	10	10
03-Jan	669	628	1	1	68	60	19	18	1	1	3	3	0.1	0.1	77	67	1.5	1.4	12	10
03-Feb	746	659	1	1	47	47	12	12	1	1	2	2	0.1	0.1	38	39	0.7	0.8	8	9
03-Mar	330	281	0	0	32	30	8	7	0	0	1	1	0.1	0.1	25	24	0.5	0.5	4	4
03-Apr	459	478	0	0	53	53	10	10	0	0	2	2	0.1	0.1	34	33	0.7	0.7	6	6

Retention time (days)

Year-Month	Buford Dam		Morgan Falls Dam		West Point Dam		Bartletts Ferry Dam		Goat Rock Dam		Oliver Dam		North Highlands Dam		Walter F. George Dam		George W. Andrews Dam		Jim Woodruff Dam	
	NAA	PAA	NAA	PAA	NAA	PAA	NAA	PAA	NAA	PAA	NAA	PAA	NAA	PAA	NAA	PAA	NAA	PAA	NAA	PAA
03-May	294	297	0	0	20	21	5	5	0	0	1	1	0.0	0.0	25	25	0.4	0.4	5	5
03-Jun	293	303	0	0	24	24	6	6	0	0	1	1	0.0	0.0	25	25	0.4	0.4	5	5
03-Jul	303	311	0	0	35	35	9	9	0	0	1	1	0.1	0.1	30	30	0.5	0.5	6	6
03-Aug	482	495	0	0	68	69	16	16	1	1	3	3	0.1	0.1	53	53	0.9	0.9	8	8
03-Sep	622	611	1	1	106	104	26	26	1	1	4	4	0.2	0.2	111	110	1.9	1.9	14	14
03-Oct	609	599	1	1	106	104	31	30	1	1	5	5	0.2	0.2	89	88	1.7	1.6	16	16
03-Nov	503	581	0	1	37	38	12	12	1	1	2	2	0.1	0.1	51	52	1.0	1.0	13	14
03-Dec	539	544	1	1	36	36	15	15	1	1	2	2	0.1	0.1	57	57	1.1	1.1	12	12
04-Jan	635	293	1	0	50	36	17	13	1	1	3	2	0.1	0.1	48	40	0.9	0.8	12	11
04-Feb	391	678	0	1	33	39	10	11	0	0	2	2	0.1	0.1	28	30	0.6	0.6	6	7
04-Mar	464	424	0	0	69	64	19	18	1	1	3	3	0.1	0.1	65	56	1.3	1.2	11	9
04-Apr	521	353	1	0	89	62	22	17	1	1	4	3	0.2	0.1	83	65	1.6	1.4	16	13
04-May	560	953	1	1	83	136	23	33	1	2	4	6	0.2	0.3	96	140	1.9	2.8	15	20
04-Jun	756	971	1	1	127	126	28	28	1	1	5	5	0.2	0.2	149	149	2.7	2.8	18	20
04-Jul	756	723	1	1	100	115	22	23	1	1	4	4	0.2	0.2	120	140	2.1	2.4	17	17
04-Aug	755	718	1	1	114	113	23	22	1	1	4	4	0.2	0.2	122	119	2.1	2.1	20	20
04-Sep	587	695	0	0	54	54	12	12	1	1	2	2	0.1	0.1	45	45	0.8	0.8	8	8
04-Oct	560	634	1	1	91	100	22	24	1	1	4	4	0.2	0.2	75	79	1.4	1.5	11	12
04-Nov	440	637	0	0	29	31	9	9	0	0	1	2	0.1	0.1	33	34	0.7	0.7	9	10
04-Dec	291	292	0	0	27	27	9	9	0	0	2	2	0.1	0.1	35	35	0.7	0.7	8	8
05-Jan	575	586	1	1	52	51	16	16	1	1	3	3	0.1	0.1	51	51	1.0	1.0	10	10
05-Feb	343	361	0	0	31	31	9	9	0	0	2	2	0.1	0.1	31	32	0.6	0.6	8	8
05-Mar	304	310	0	0	26	26	6	6	0	0	1	1	0.0	0.0	23	23	0.8	0.8	5	5
05-Apr	396	401	0	0	34	34	8	8	0	0	1	1	0.1	0.1	18	18	0.3	0.3	3	3
05-May	392	443	0	0	65	69	16	17	1	1	3	3	0.1	0.1	70	69	1.3	1.3	9	9
05-Jun	422	409	0	0	69	67	15	14	1	1	2	2	0.1	0.1	50	51	0.9	0.9	8	8
05-Jul	298	305	0	0	22	22	6	6	0	0	1	1	0.0	0.0	22	22	0.4	0.4	4	4
05-Aug	296	303	0	0	43	44	11	11	0	0	2	2	0.1	0.1	37	37	0.6	0.6	7	7
05-Sep	508	521	1	1	96	98	26	27	1	1	4	4	0.2	0.2	117	119	2.0	2.0	14	14
05-Oct	637	625	1	1	121	119	32	32	1	1	5	5	0.2	0.2	89	88	1.7	1.7	16	16

	Retention time (days)																			
	Buford Dam		Morgan Falls Dam		West Point Dam		Bartletts Ferry Dam		Goat Rock Dam		Oliver Dam		North Highlands Dam		Walter F. George Dam		George W. Andrews Dam		Jim Woodruff Dam	
Year-Month	NAA	PAA	NAA	PAA	NAA	PAA	NAA	PAA	NAA	PAA	NAA	PAA	NAA	PAA	NAA	PAA	NAA	PAA	NAA	PAA
05-Nov	610	606	1	1	57	56	19	19	1	1	3	3	0.1	0.1	68	67	1.3	1.3	16	16
05-Dec	601	602	1	1	43	43	16	16	1	1	3	3	0.1	0.1	53	53	1.0	1.0	11	11
06-Jan	393	440	0	0	31	32	13	13	1	1	2	2	0.1	0.1	40	41	0.8	0.8	8	8
06-Feb	462	474	0	0	34	34	11	11	1	1	2	2	0.1	0.1	35	35	0.7	0.7	8	8
06-Mar	499	502	0	0	52	52	13	13	1	1	2	2	0.1	0.1	39	39	0.8	0.7	8	8
06-Apr	438	382	0	0	75	63	22	19	1	1	4	3	0.2	0.1	61	56	1.2	1.1	12	11
06-May	466	322	1	0	74	56	24	19	1	1	4	3	0.2	0.1	89	56	1.6	1.2	14	11
06-Jun	698	881	1	1	119	117	36	37	2	2	6	6	0.3	0.3	177	155	3.3	3.2	27	26
06-Jul	668	719	1	1	96	138	37	53	2	2	6	9	0.3	0.4	137	254	2.7	4.9	26	35
06-Aug	649	789	1	1	150	148	50	50	2	2	8	8	0.4	0.4	193	195	3.8	4.0	32	31
06-Sep	656	809	1	1	104	151	36	49	2	2	6	8	0.3	0.4	150	202	2.9	4.0	25	28
06-Oct	660	838	1	1	88	128	32	41	1	2	5	7	0.2	0.3	142	189	2.8	3.7	25	31
06-Nov	681	900	1	1	88	80	24	22	1	1	4	4	0.2	0.2	81	80	1.6	1.6	17	17
06-Dec	701	920	1	1	76	80	24	26	1	1	4	4	0.2	0.2	87	91	1.7	1.8	19	19
07-Jan	722	980	1	1	47	49	14	14	1	1	2	2	0.1	0.1	46	47	0.9	0.9	9	9
07-Feb	744	1013	1	1	71	80	19	20	1	1	3	3	0.1	0.2	59	62	1.2	1.2	10	11
07-Mar	708	576	1	1	81	84	20	20	1	1	3	3	0.2	0.2	52	54	1.0	1.1	9	10
07-Apr	528	302	1	0	141	75	34	22	2	1	6	4	0.3	0.2	78	56	1.6	1.2	13	10
07-May	526	456	1	1	99	91	33	31	2	1	6	5	0.3	0.2	157	125	3.2	2.7	24	22
07-Jun	819	665	1	1	141	144	49	49	2	2	8	8	0.4	0.4	191	182	3.9	3.9	33	33
07-Jul	770	819	1	1	136	137	54	53	2	2	9	9	0.4	0.4	195	200	4.0	4.3	32	33
07-Aug	600	639	1	1	111	107	53	51	2	2	9	8	0.4	0.4	157	154	3.4	3.4	33	33
07-Sep	612	591	1	1	104	100	51	50	2	2	8	8	0.4	0.4	175	171	3.9	3.9	33	33
07-Oct	444	390	1	1	84	85	45	45	2	2	7	7	0.3	0.3	186	184	4.2	4.2	33	33
07-Nov	567	675	1	1	90	99	48	53	2	2	8	8	0.4	0.4	167	200	3.7	4.4	34	38
07-Dec	814	812	1	1	120	118	47	47	2	2	8	8	0.4	0.4	249	256	5.0	5.1	32	33
08-Jan	1012	964	1	1	87	107	26	28	1	1	4	5	0.2	0.2	70	73	1.4	1.5	12	12
08-Feb	1198	1134	1	1	98	95	22	21	1	1	4	3	0.2	0.2	46	46	0.9	0.9	7	7
08-Mar	1311	1240	1	1	87	83	21	21	1	1	4	3	0.2	0.2	55	54	1.1	1.1	8	8
08-Apr	1098	1015	1	1	119	121	27	27	1	1	4	4	0.2	0.2	64	64	1.3	1.3	10	10

	Retention time (days)																			
	Buford Dam		Morgan Falls Dam		West Point Dam		Bartletts Ferry Dam		Goat Rock Dam		Oliver Dam		North Highlands Dam		Walter F. George Dam		George W. Andrews Dam		Jim Woodruff Dam	
Year-Month	NAA	PAA	NAA	PAA	NAA	PAA	NAA	PAA	NAA	PAA	NAA	PAA	NAA	PAA	NAA	PAA	NAA	PAA	NAA	PAA
08-May	975	798	1	1	166	131	39	33	2	2	6	6	0.3	0.3	249	146	4.4	2.9	23	21
08-Jun	747	622	1	1	162	161	49	49	2	2	8	8	0.4	0.4	273	207	5.1	4.2	32	30
08-Jul	811	665	1	1	149	151	46	46	2	2	8	8	0.4	0.4	217	202	4.1	4.1	30	30
08-Aug	818	681	1	1	162	167	35	35	2	2	6	6	0.3	0.3	109	143	1.9	2.4	16	17
08-Sep	665	547	1	1	141	149	45	45	2	2	8	8	0.4	0.4	146	146	2.8	2.8	18	18
08-Oct	770	627	1	1	97	128	37	42	2	2	6	7	0.3	0.3	135	141	2.6	2.7	23	24
08-Nov	745	666	1	1	108	134	47	50	2	2	8	8	0.3	0.4	93	99	1.8	1.9	19	20
08-Dec	696	912	1	1	76	67	26	22	1	1	4	4	0.2	0.2	45	43	0.9	0.8	7	7
09-Jan	677	957	1	1	61	69	21	22	1	1	3	4	0.2	0.2	58	61	1.1	1.2	11	11
09-Feb	984	916	1	1	95	99	28	28	1	1	5	5	0.2	0.2	79	82	1.6	1.7	15	16
09-Mar	1338	1237	1	1	43	41	9	9	0	0	2	1	0.1	0.1	25	24	0.6	0.6	6	6
09-Apr	1019	1254	1	1	63	63	13	13	1	1	2	2	0.1	0.1	23	23	0.4	0.4	3	3
09-May	743	1035	1	1	102	119	22	25	1	1	4	4	0.2	0.2	61	63	1.1	1.1	9	9
09-Jun	681	786	1	1	108	105	30	30	1	1	5	5	0.2	0.2	96	99	1.7	1.8	12	12
09-Jul	658	779	1	1	138	162	44	52	2	2	7	9	0.3	0.4	145	146	2.7	2.8	20	20
09-Aug	667	811	1	1	142	169	42	50	2	2	7	8	0.3	0.4	157	162	2.8	3.0	21	22
09-Sep	698	1003	0	0	30	31	9	10	0	0	2	2	0.1	0.1	38	41	0.7	0.7	10	11
09-Oct	651	670	0	0	40	41	10	10	0	0	2	2	0.1	0.1	33	33	0.6	0.6	9	9
09-Nov	272	381	0	0	20	22	6	6	0	0	1	1	0.0	0.0	19	20	0.4	0.4	5	6
09-Dec	202	204	0	0	15	15	5	5	0	0	1	1	0.0	0.0	11	11	0.2	0.2	3	3
10-Jan	247	250	0	0	24	24	7	7	0	0	1	1	0.1	0.1	20	20	0.4	0.4	4	4
10-Feb	216	219	0	0	22	22	7	7	0	0	1	1	0.1	0.1	19	19	0.4	0.4	3	3
10-Mar	300	305	0	0	27	27	7	7	0	0	1	1	0.1	0.1	22	22	0.4	0.4	5	5
10-Apr	480	494	0	0	65	66	17	17	1	1	3	3	0.1	0.1	54	54	1.1	1.1	10	10
10-May	339	369	0	0	46	47	12	12	1	1	2	2	0.1	0.1	41	40	0.7	0.7	7	7
10-Jun	620	610	1	1	98	98	27	27	1	1	4	4	0.2	0.2	96	101	1.7	1.8	13	13
10-Jul	617	601	1	1	113	117	34	34	2	2	6	6	0.3	0.3	137	137	2.5	2.5	18	18
10-Aug	598	583	1	1	112	115	36	37	2	2	6	6	0.3	0.3	145	147	2.6	2.7	22	22
10-Sep	571	646	1	1	97	98	35	36	2	2	6	6	0.3	0.3	152	152	2.8	2.8	28	28
10-Oct	602	687	1	1	93	113	35	41	2	2	6	7	0.3	0.3	125	133	2.3	2.5	25	24

	Retention time (days)																			
	Buford Dam		Morgan Falls Dam		West Point Dam		Bartletts Ferry Dam		Goat Rock Dam		Oliver Dam		North Highlands Dam		Walter F. George Dam		George W. Andrews Dam		Jim Woodruff Dam	
Year-Month	NAA	PAA	NAA	PAA	NAA	PAA	NAA	PAA	NAA	PAA	NAA	PAA	NAA	PAA	NAA	PAA	NAA	PAA	NAA	PAA
10-Nov	679	703	1	1	80	85	29	30	1	1	5	5	0.2	0.2	101	106	2.0	2.1	21	22
10-Dec	561	703	1	1	65	67	24	24	1	1	4	4	0.2	0.2	92	89	1.8	1.8	19	19
11-Jan	708	506	1	1	79	39	26	17	1	1	4	3	0.2	0.1	88	47	1.7	1.1	17	12
11-Feb	743	986	1	1	54	101	16	24	1	1	3	4	0.1	0.2	46	75	0.9	1.4	10	12
11-Mar	464	530	0	0	42	43	12	13	1	1	2	2	0.1	0.1	38	38	0.7	0.7	10	10
11-Apr	281	223	0	0	45	40	13	12	1	1	2	2	0.1	0.1	47	43	0.9	0.8	10	9
11-May	357	256	0	0	75	49	24	17	1	1	4	3	0.2	0.1	126	63	2.4	1.4	22	16
11-Jun	648	813	1	1	127	115	46	46	2	2	8	7	0.3	0.3	178	157	3.4	3.3	34	32
11-Jul	682	768	1	1	139	132	48	51	2	2	8	8	0.4	0.4	176	221	3.3	4.3	29	35
11-Aug	618	643	1	1	121	119	48	53	2	2	8	9	0.4	0.4	165	174	3.2	3.5	34	34
11-Sep	619	695	1	1	99	112	35	41	2	2	6	7	0.3	0.3	132	134	2.7	2.9	33	33
11-Oct	607	662	1	1	106	98	48	50	2	2	8	8	0.4	0.4	163	158	3.5	3.6	34	33
11-Nov	632	471	1	1	79	69	36	34	2	2	6	6	0.3	0.3	136	149	3.0	3.3	32	33
11-Dec	663	1126	1	1	91	109	28	33	1	1	5	5	0.2	0.3	142	198	2.9	3.9	32	35
Overall Median	643	665	1	1	82	85	24	24	1	1	4	4	0	0	79	72	2	1	14	14
Apr-Oct Median	637	665	1	1	102	105	32	31	1	1	5	5	0	0	125	125	2	2	18	18
Apr-Oct Average	654	660	1	1	98	101	30	31	1	1	5	5	0	0	118	117	2	2	19	19

2.2.6 Phosphorus

a. Average summer phosphorus loading (pounds/acre/month).

Alabama, Florida, and Georgia have established criteria for reservoirs and lakes in the ACF Basin for total phosphorus (TP) loads. The nutrient criteria for TP in major headwaters contributing to the lakes in Georgia and Alabama are based on annual loads in pounds. In accordance with the water quality standards set by Alabama and Georgia, the TP annual loading for West Point Lake headwaters at Chattahoochee River at U.S. Highway 27 should not exceed 1,400,000 lbs and for Walter F. George Lake headwaters, the annual TP loading at Chattahoochee River at U.S. Highway 39 should not exceed 2,000,000 lbs. The calculated TP loads for the NAA and the PAA are shown in Table 2.2-3. The loads were calculated using the HEC-5Q model outputs of TP concentrations (mg/L) and modeled flows (cfs) with proper conversion factors applied to derive annual loads in lbs. The numbers in the table are annual TP loads in lbs. Florida has nutrient criteria established for freshwater streams. As per Florida's standards, the final numeric nutrient criteria for freshwater streams in Florida Panhandle West for TP is 0.06 mg/L and 0.01 mg/L for clear lakes with a range of 0.01-0.03 mg/L.

Table 2.2-3. Total phosphorus loads at West Point Lake headwaters and Walter F. George Lake headwaters for the modeled period (2001–2011)

		Annual total phosphorus loads in lbs	
Year	**Location**	**No Action**	**Proposed Action**
2001	West Point Lake headwaters	712,042	819,239
	Walter F. George Lake headwaters	1,373,380	1,496,488
2002	West Point Lake headwaters	670,891	796,697
	Walter F. George Lake headwaters	1,079,952	1,202,749
2003	West Point Lake headwaters	1,270,703	1,408,768
	Walter F. George Lake headwaters	1,954,469	2,098,159

2004	West Point Lake headwaters	883,364	987,643
	Walter F. George Lake headwaters	1,451,393	1,562,383
2005	West Point Lake headwaters	1,116,965	1,232,542
	Walter F. George Lake headwaters	2,010,591	2,144,219
2006	West Point Lake headwaters	705,698	794,918
	Walter F. George Lake headwaters	1,198,458	1,286,756
2007	West Point Lake headwaters	469,004	564,871
	Walter F. George Lake headwaters	922,982	1,025,569
2008	West Point Lake headwaters	441,386	518,935
	Walter F. George Lake headwaters	1,159,097	1,258,390
2009	West Point Lake headwaters	1,245,841	1,352,346
	Walter F. George Lake headwaters	2,399,330	2,560,087

2010	West Point Lake headwaters	851,467	936,327
	Walter F. George Lake headwaters	1,555,310	1,643,827
2011	West Point Lake headwaters	628,419	735,635
	Walter F. George Lake headwaters	1,048,589	1,153,484

Longitudinal profiles were used as an initial indication of changes that would be expected between the NAA and the PAA. Figure 2.2-39 through Figure 2.2-41 illustrates the response of TP to changes between the NAA and the PAA. Figure 2.2-42 and Figure 2.2-43 illustrate the change in TP between the NAA and the PAA for the modeled period and a representative dry year when the greatest variation would be expected.

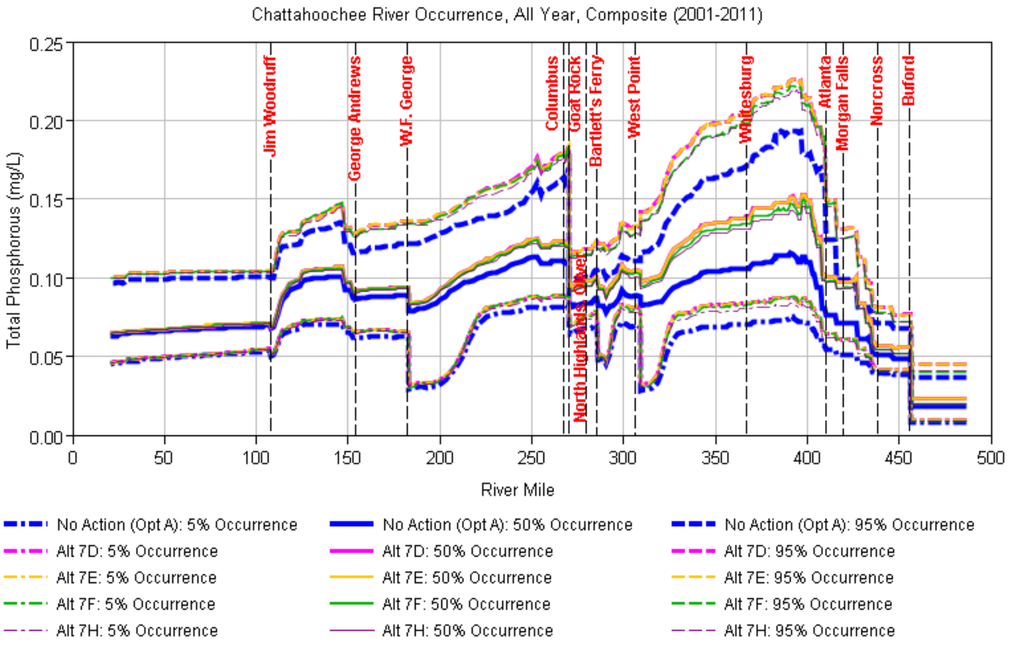

Figure 2.2-39. Longitudinal profile occurrence of daily total phosphorus in the ACF Basin for the period 2001-2011 for the NAA and the PAA

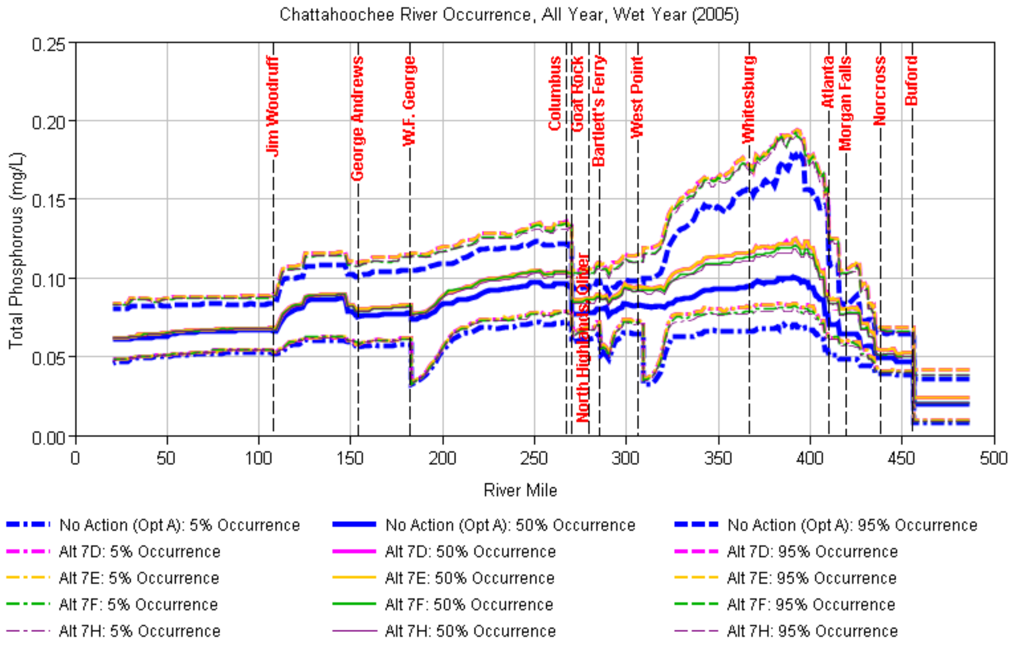

Figure 2.2-40. Longitudinal profile occurrence of daily total phosphorus in the ACF Basin for a wet year (2005) for the NAA and the PAA

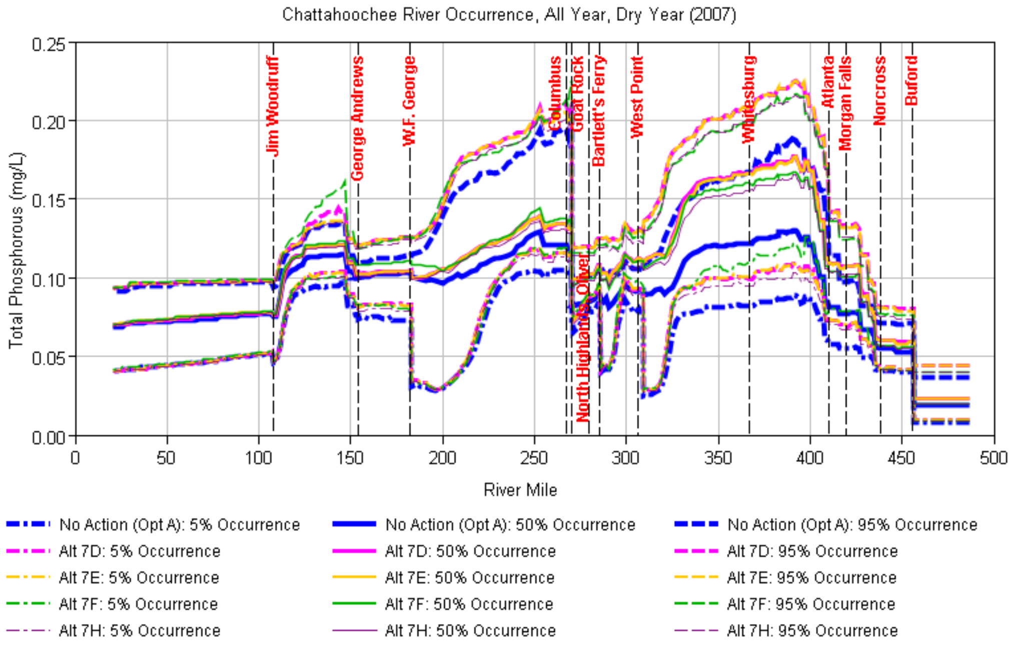

Figure 2.2-41. Longitudinal profile occurrence of daily total phosphorus in the ACF Basin for a dry year (2007) for the NAA and the PAA

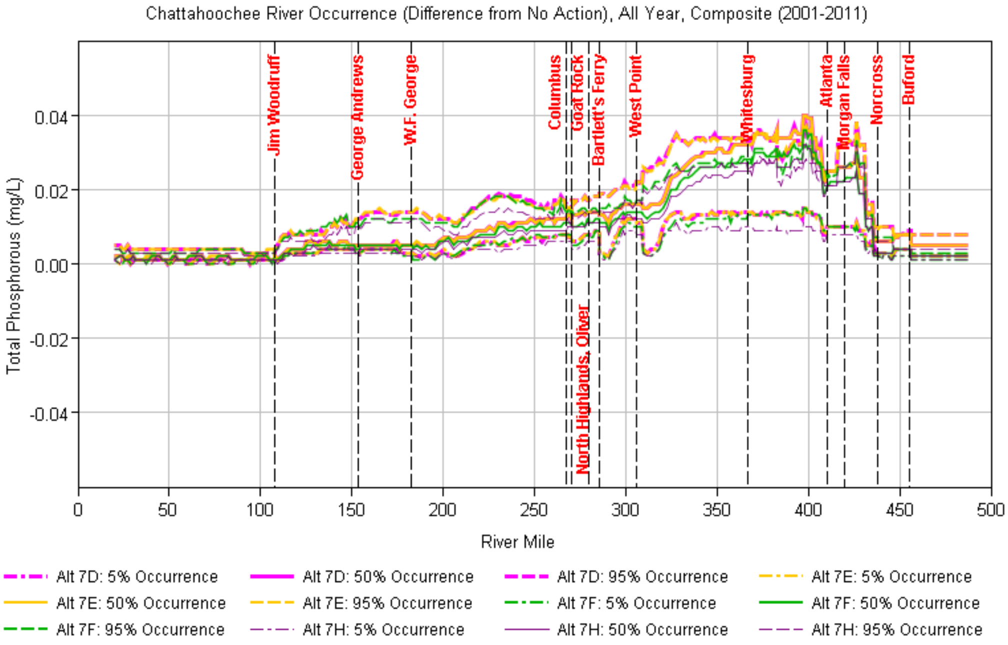

Figure 2.2-42. Longitudinal profile of change in daily total phosphorus in the ACF Basin from the NAA for the PAA for the model period (2001-2011)

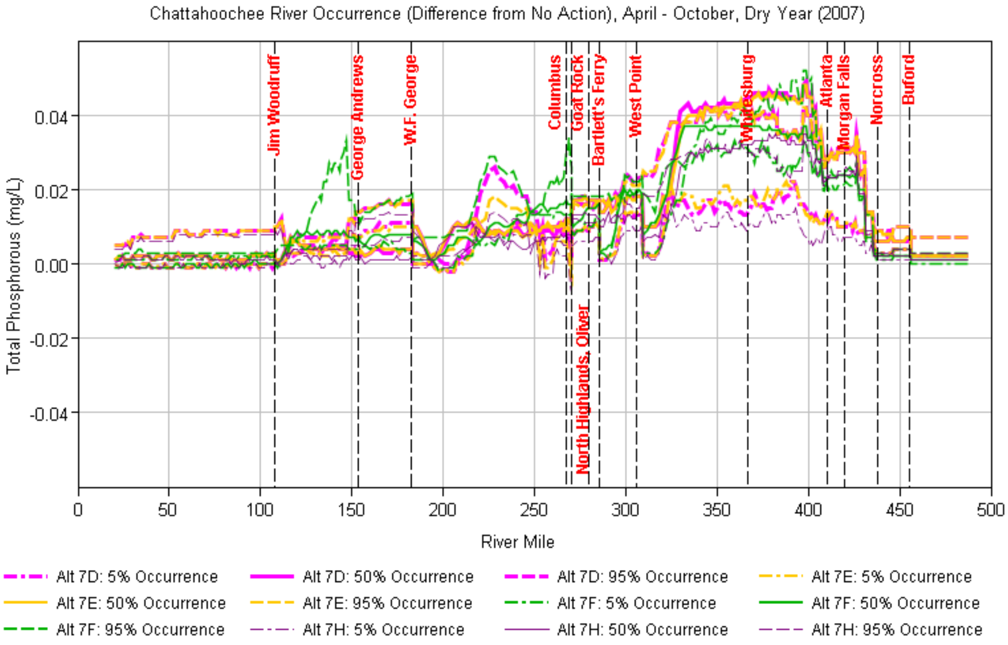

Figure 2.2-43. Longitudinal profile of change in daily total phosphorus from the NAA in the ACF Basin during growing season (April through October) of a dry year (2007) for the PAA

2.3 Floodplain Connectivity Analyses

A complete set of the Apalachicola River floodplain LIDAR data is not available and therefore this was not used in this analysis. However, available data was used to determine the annual maximum 30-day growing season floodplain connectivity as described in the 2013 PAL. These results are illustrated in Figure 2.3-1 and Figure 2.3-2. Given that conditions in the PAA are very similar to those for the 2012 RIOP, little change would be expected.

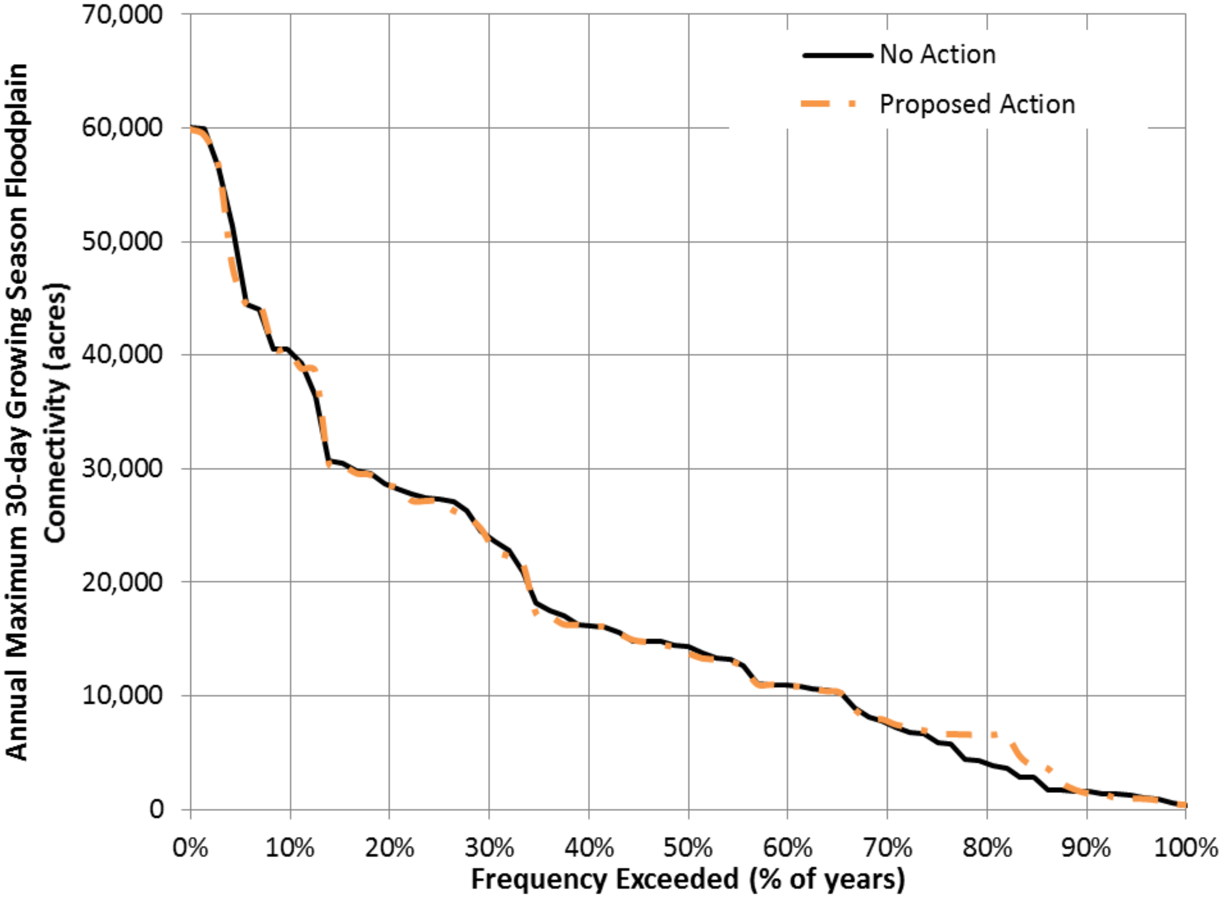

Figure 2.3-1. Frequency of annual maximum 30-day growing season (April through September) floodplain connectivity in acres for the NAA and PAA over the modeled period

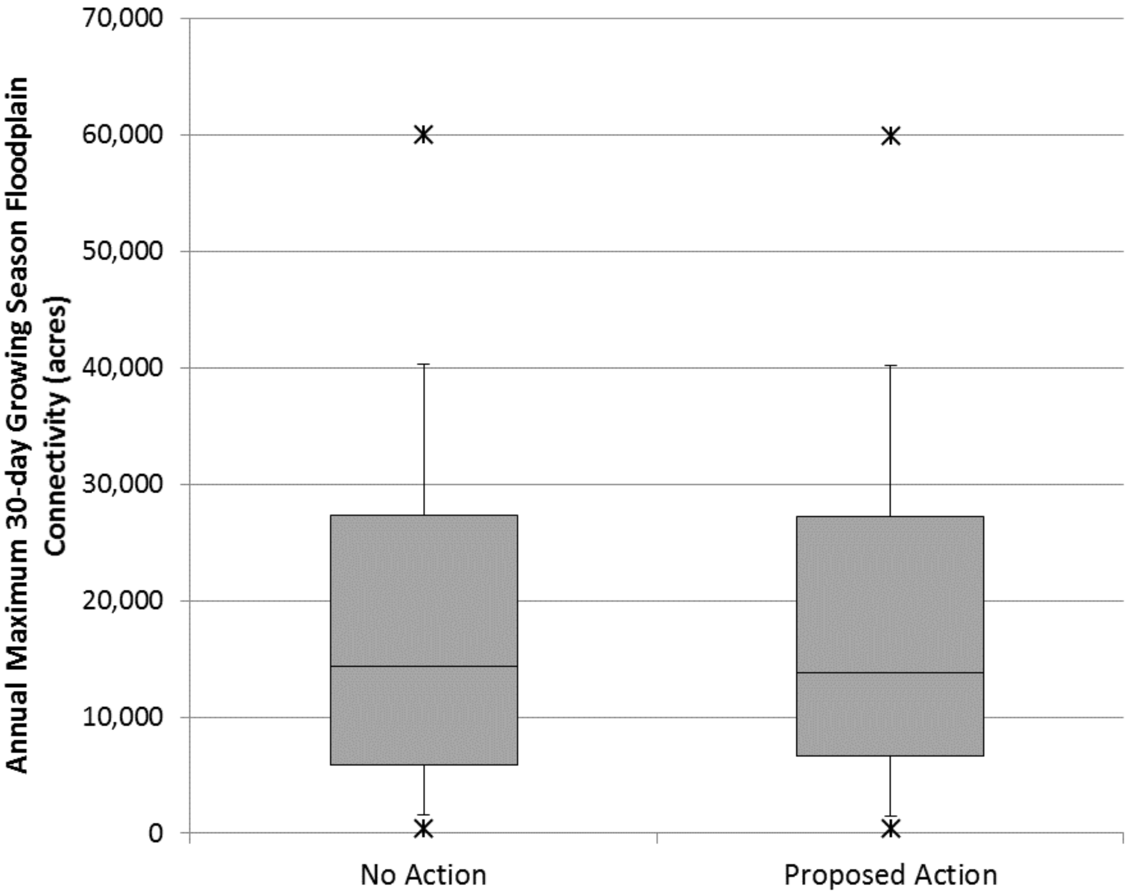

Figure 2.3-2. Statistics (minimum; 10th, 25th, 50th, 75th, and 90th percentiles; and maximum) for the annual maximum 30-day growing season (April through September) floodplain connectivity in acres for the NAA and PAA over the modeled period

Similar results would be expected along the Chattahoochee River; given that conditions in the PAA are very similar to the NAA, little change would be expected. The Chattahoochee River is essentially disconnected from its floodplain, so floodplain connectivity would not be influenced by the different alternatives. Changes in streamflow on the Chattahoochee River from Norcross to Columbus are minor and would not be expected to reach flows defined in Table 1 of the 2010 PAL. USACE manages operations to reduce flooding. Flood risk management operations would remain unchanged from those currently employed.

2.4 Reservoir Fisheries Analyses

Reservoir fisheries were evaluated using methods described in the 2013 PAL. Previous work based on Ryder et al. (1996) was not used for this analysis.

Operational flow changes would affect habitat for reservoir fisheries and other aquatic resources mainly through changes in water levels, reservoir flushing rates (retention times), and associated changes in water quality parameters, such as nutrient loading and DO concentrations. Seasonal water level fluctuations can substantially change the area of shallow-water habitats and inundated shoreline vegetation in reservoirs and, in turn, influence the reproductive success of resident fish populations.

Substantial daily or weekly fluctuations in reservoir levels associated with hydroelectric power generation peaking operations could adversely affect reservoir fisheries by dewatering spawning and nursery habitats for littoral species, exposing nests and eggs deposited in shallow-water habitats, and reducing the availability of shoreline cover and its associated invertebrate food supply. Performance measures developed by the USFWS were used in this evaluation, specifically to assess reservoir fisheries habitat, based on the assumption that a greater departure of reservoir levels from optimum (e.g., littoral spawning, rearing) results in a greater effect on habitats, including loss. The Reservoir Fisheries Performance Measure (RFPM) was recommended by the USFWS because it specifically characterizes the spatial extent of the reservoir most likely to support successful fish survival and reproduction as a direct function of containing suitable habitat features.

The effect of the alternatives on reservoir fisheries was determined using the area (in acres) of productive zone inundated for more than 30 days during the spawning season, as calculated using the RFPM. The inundated productive zone was defined for each reservoir and is presented in Figure 2.4-1, Figure 2.4-2, and Figure 2.4-3. These figures illustrate little difference between median values of the productive zone between the NAA and PAA.

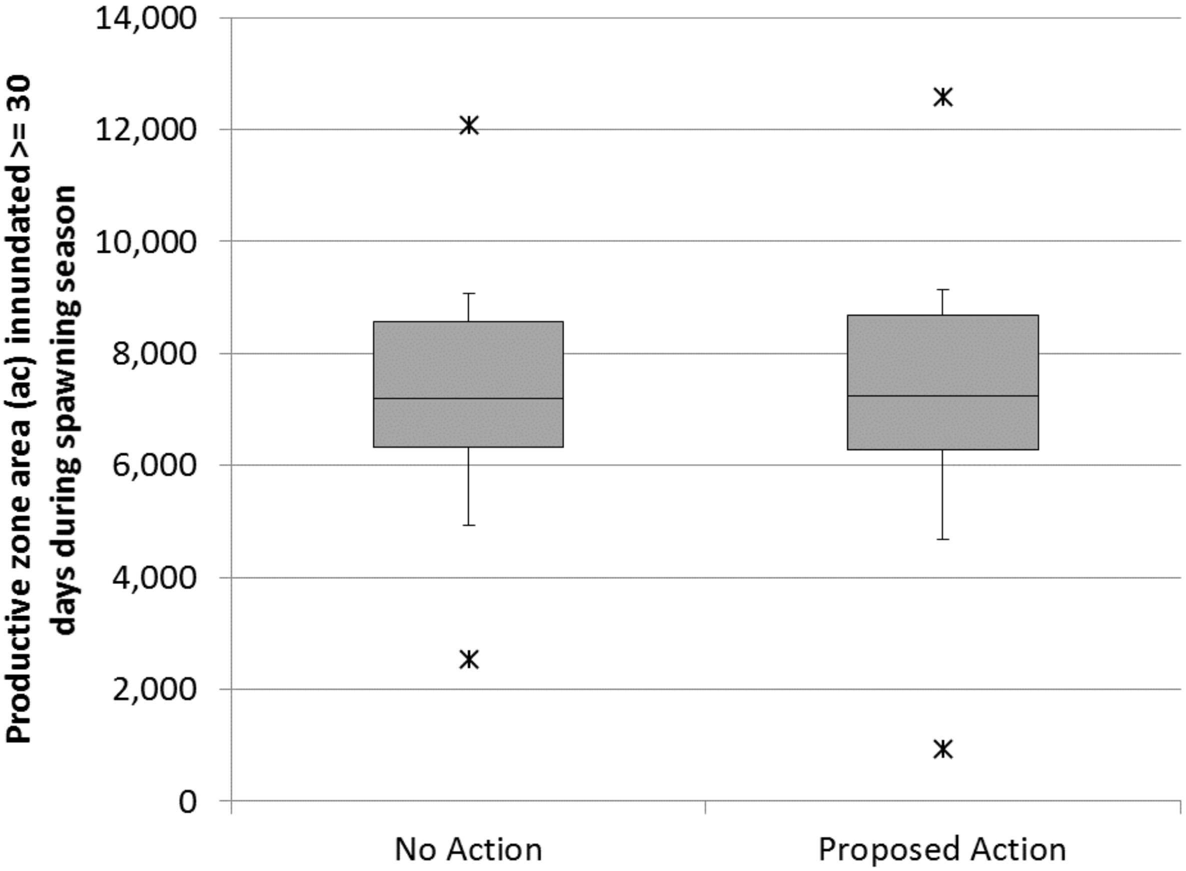

Figure 2.4-1. Reservoir fisheries performance measure results for the NAA and PAA at Lake Sidney Lanier

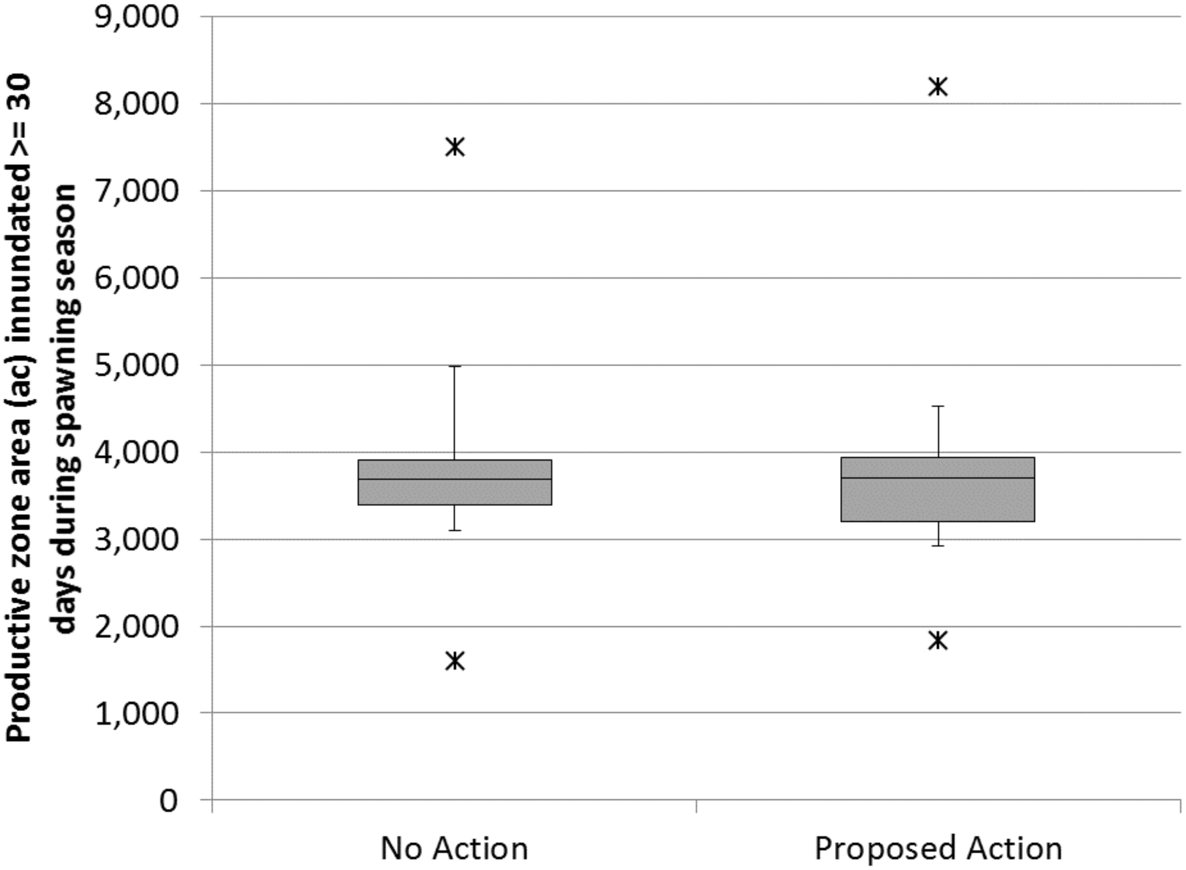

Figure 2.4-2. Reservoir fisheries performance measure results for the NAA and PAA at West Point Lake

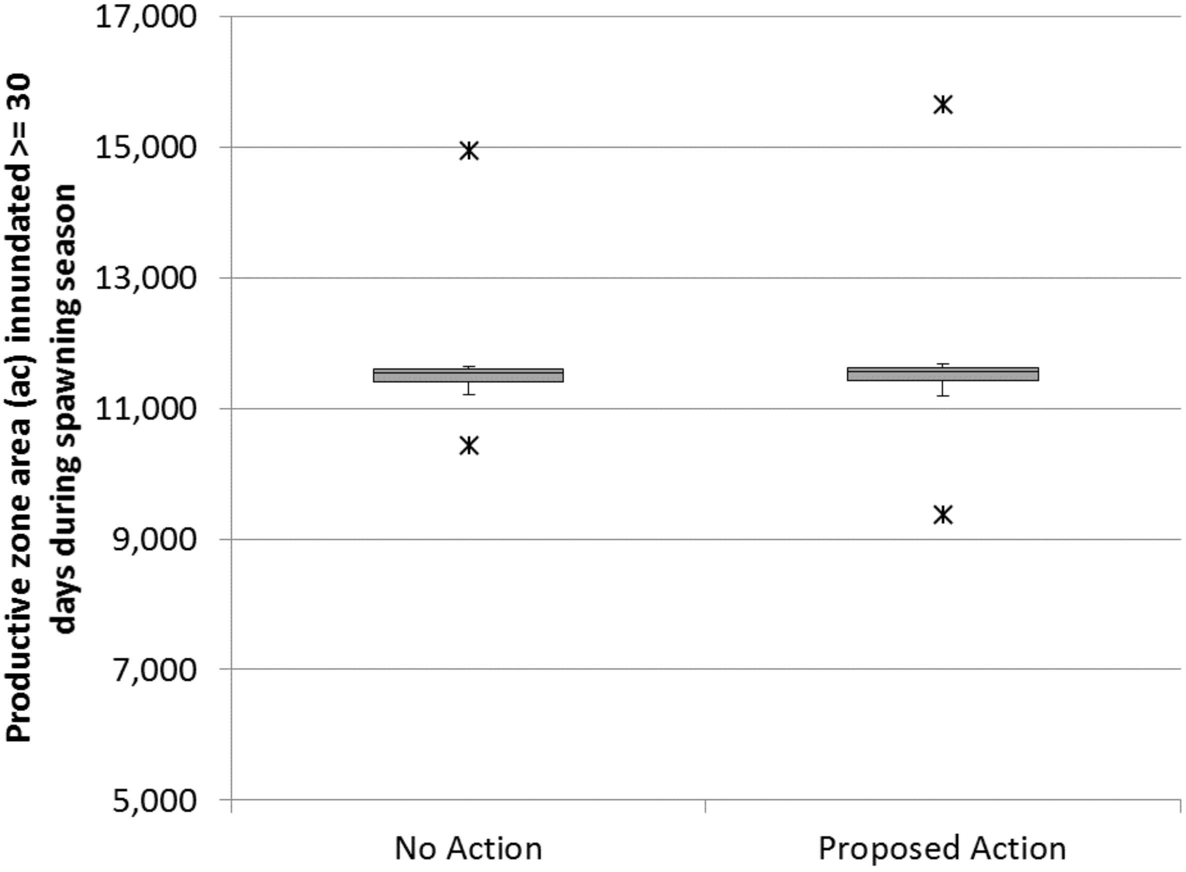

Figure 2.4-3. Reservoir fisheries performance measure results for the NAA and PAA at Walter F. George Lake

2.5 Riverine Fisheries Analyses

Sport fisheries are important recreational and economic resources in the riverine portions of the ACF project, especially in the Apalachicola River. The survival and reproduction of many fishes are intricately tied to the floodplain, and alteration of flow regimes can affect reproductive success, year-class strength, growth, condition, and other life-history attributes. There are existing effects of controlled flows in the ACF Basin on lateral connectivity and floodplain inundation. Before the Chattahoochee River became subjected to human controls, there were substantial flows with natural variability in magnitude and seasonal fluctuations. Because of the series of dams now present in the Chattahoochee River system, the Chattahoochee River is essentially disconnected from its floodplain. Fish and aquatic resources in the ACF Basin between Buford Dam and Apalachicola Bay will be affected differently due to differences in streamflow and water quality. Since water quality was described in response to specific requests by USFWS in Section 2.2, this section describe how streamflow may affect riverine fisheries.

The monthly flow range at the 10th, 25th, 50th, 75th and 90th percentile exceedance for the NAA and PAA were compared. These flows were calculated from HEC-ResSim results at various points in the Chattahoochee River to represent the monthly flow upper limit (10th percent exceeded), a wet year (25th percent exceeded), an average year (50th percent exceeded), a dry year (75th percent exceeded), and the lower limit (90th percent exceeded).

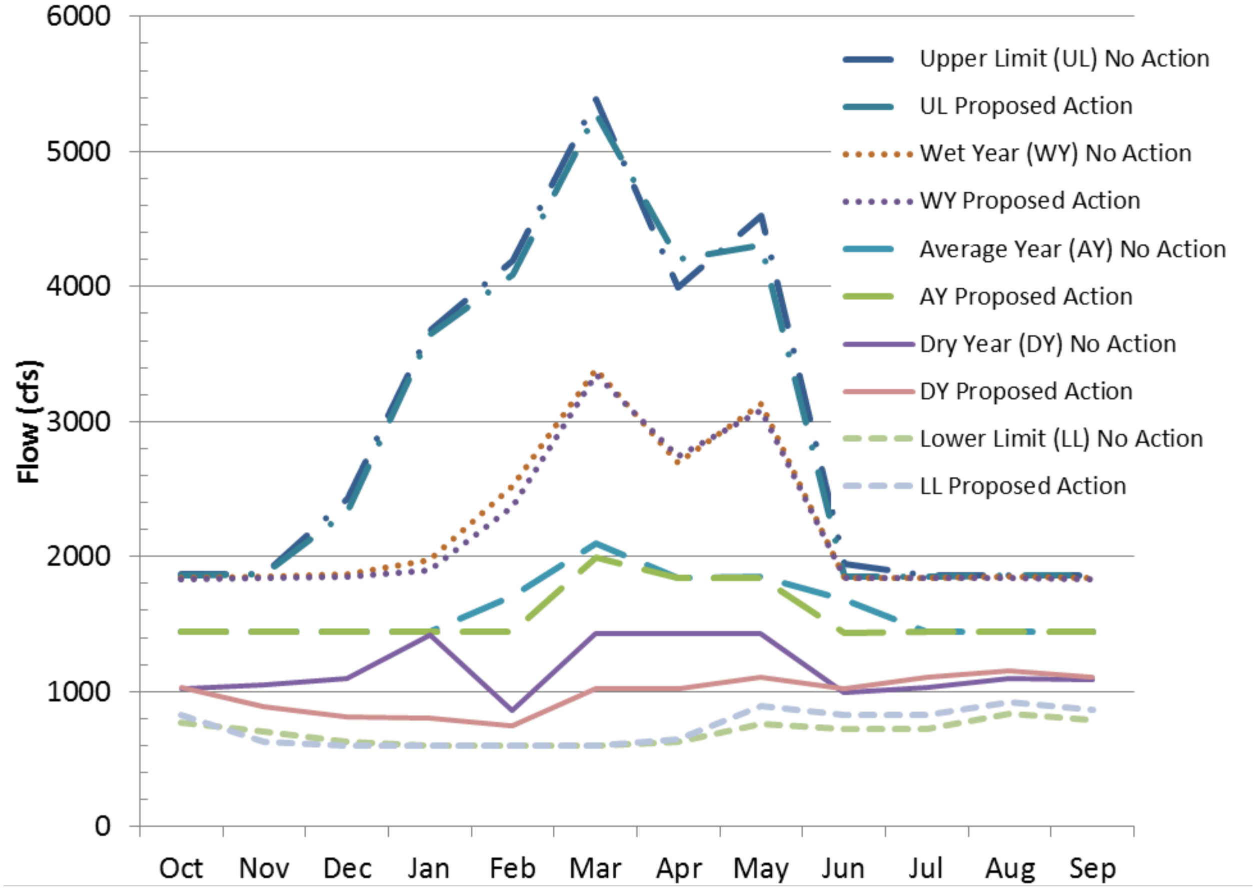

Figure 2.5-1. Buford Dam monthly discharge statistics for the NAA and PAA [monthly flow upper limit (10th percent exceeded), a wet year (25th percent exceeded), an average year (50th percent exceeded), a dry year (75th percent exceeded), and the lower limit (90th percent exceeded)].

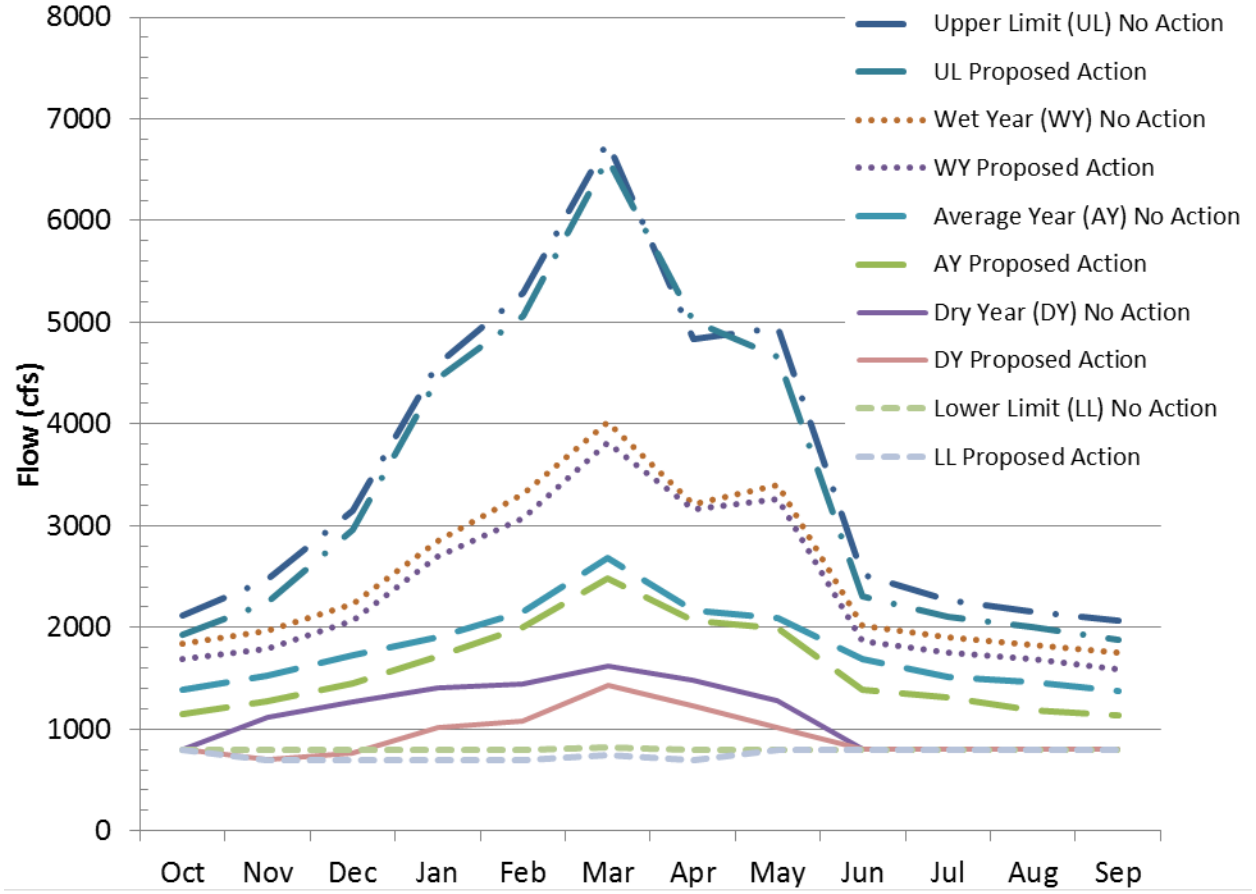

Figure 2.5-2. Atlanta, Georgia monthly flow statistics for the NAA and PAA [monthly flow upper limit (10th percent exceeded), a wet year (25th percent exceeded), an average year (50th percent exceeded), a dry year (75th percent exceeded), and the lower limit (90th percent exceeded)].

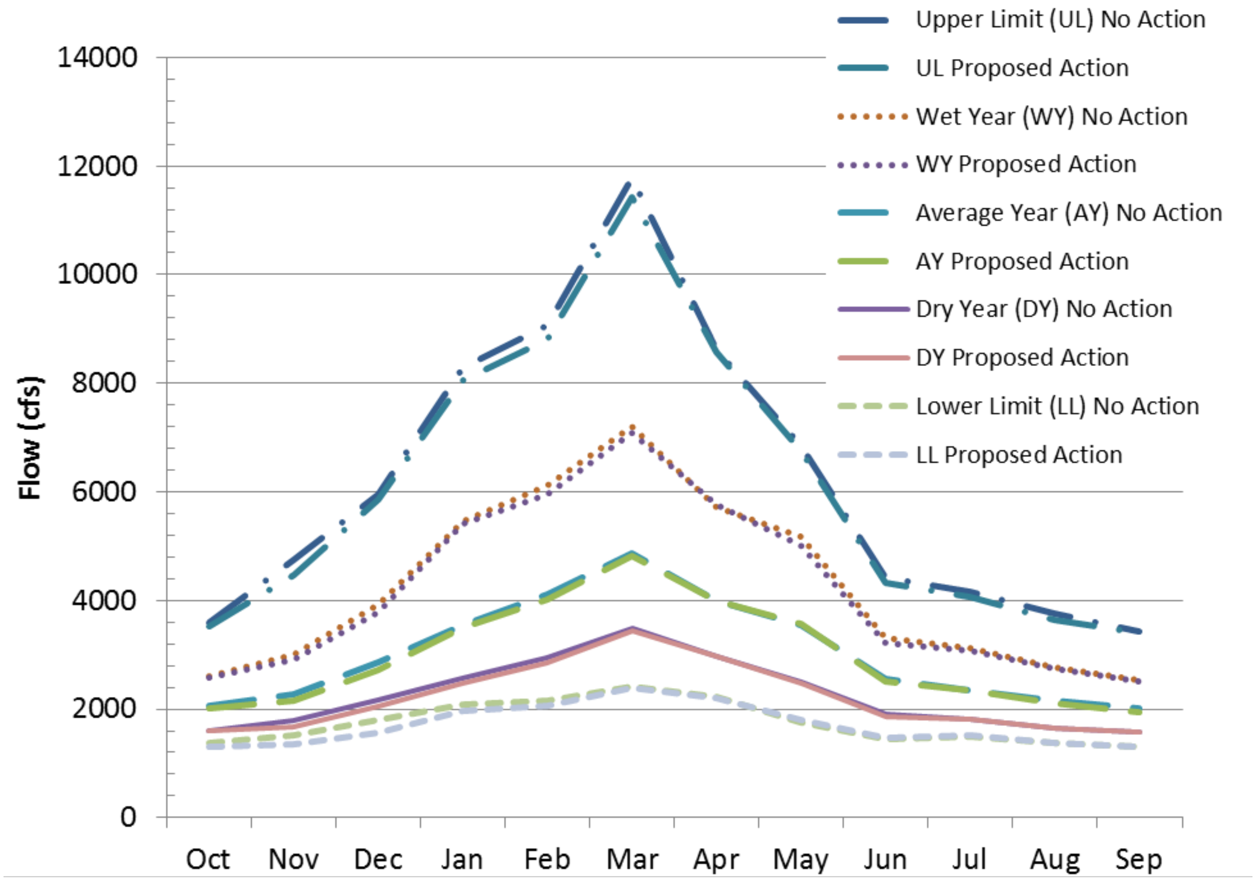

Figure 2.5-3. Whitesburg, Georgia monthly flow statistics for the NAA and PAA [monthly flow upper limit (10th percent exceeded), a wet year (25th percent exceeded), an average year (50th percent exceeded), a dry year (75th percent exceeded), and the lower limit (90th percent exceeded)].

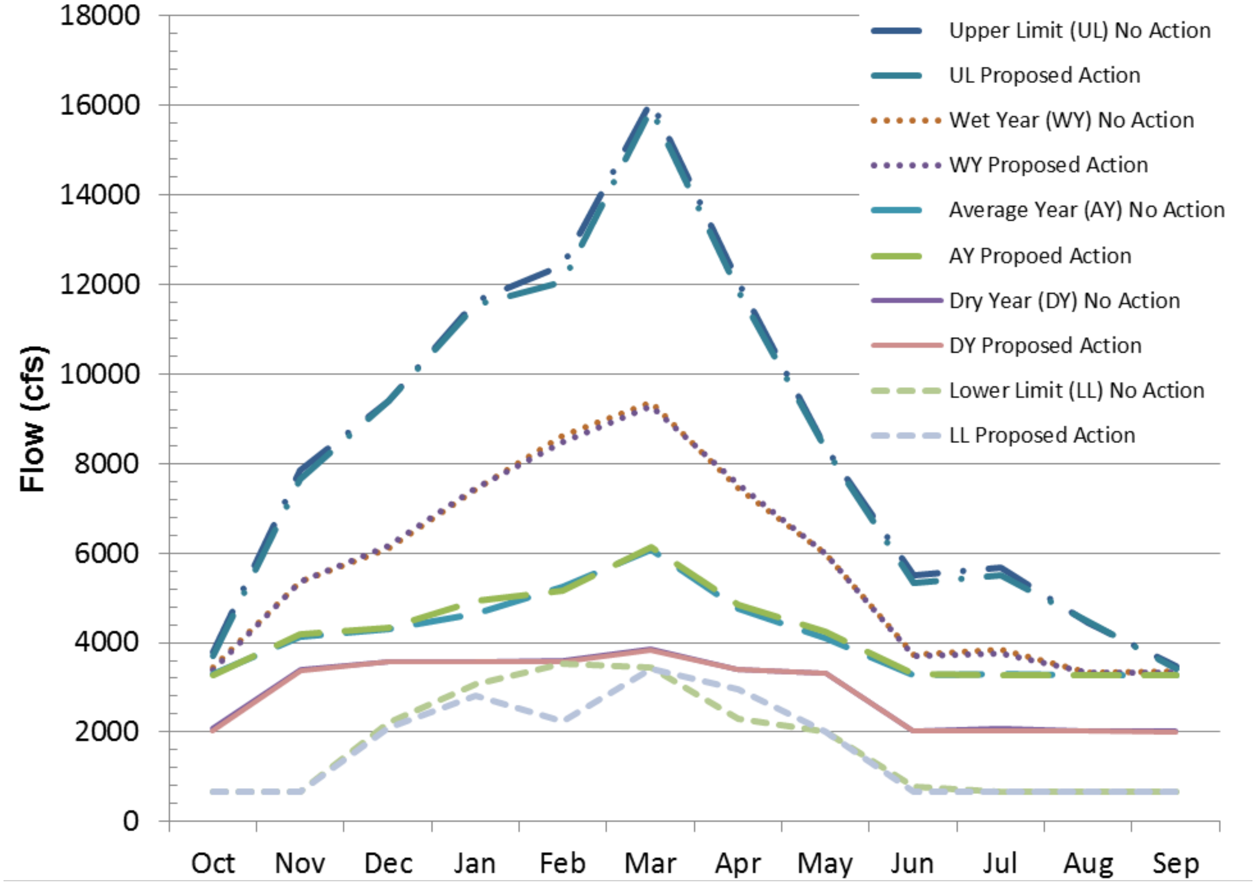

Figure 2.5-4. West Point Dam monthly discharge statistics for the NAA and PAA [monthly flow upper limit (10th percent exceeded), a wet year (25th percent exceeded), an average year (50th percent exceeded), a dry year (75th percent exceeded), and the lower limit (90th percent exceeded)].

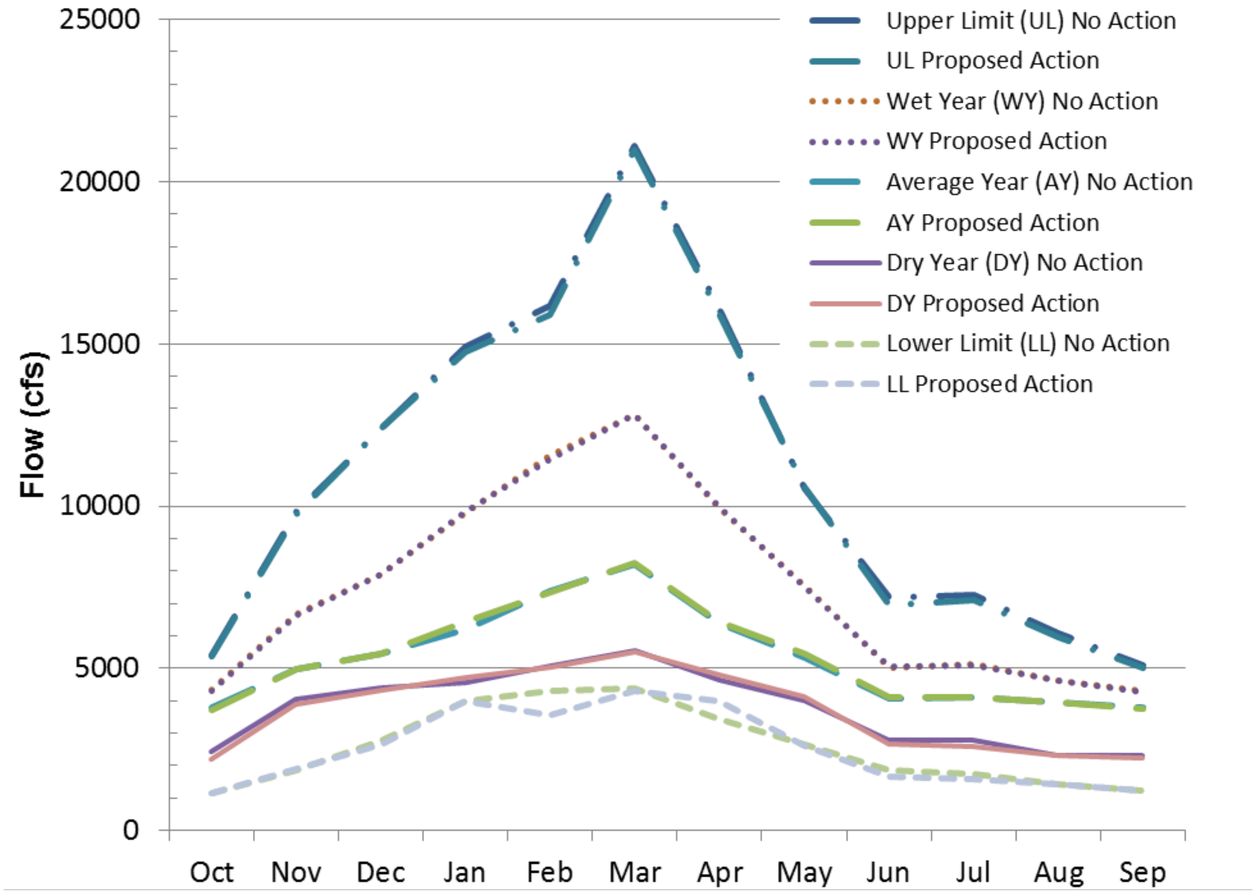

Figure 2.5-5. Columbus, Georgia monthly flow statistics for the NAA and PAA [monthly flow upper limit (10th percent exceeded), a wet year (25th percent exceeded), an average year (50th percent exceeded), a dry year (75th percent exceeded), and the lower limit (90th percent exceeded)].

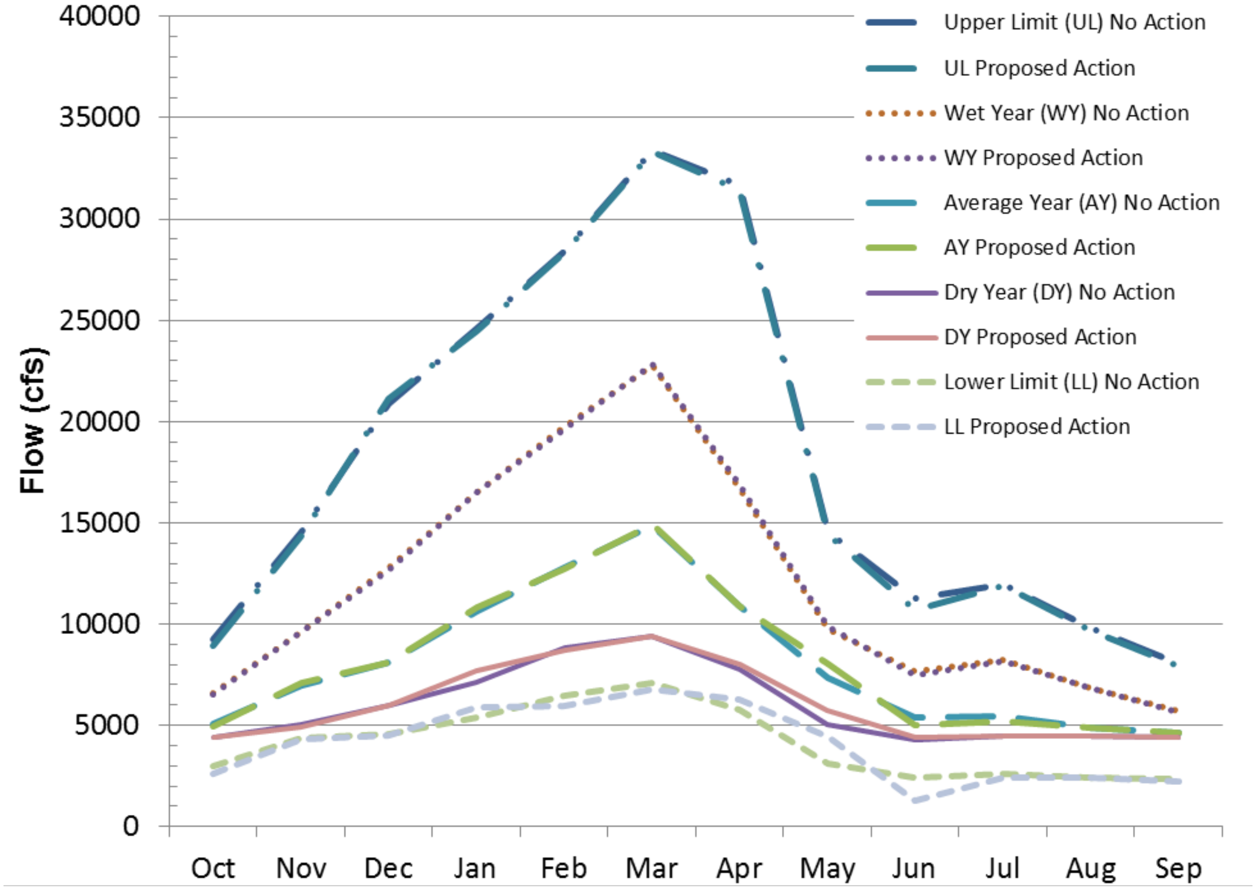

Figure 2.5-6. George Andrews Dam monthly discharge statistics for the NAA and PAA [monthly flow upper limit (10th percent exceeded), a wet year (25th percent exceeded), an average year (50th percent exceeded), a dry year (75th percent exceeded), and the lower limit (90th percent exceeded)].

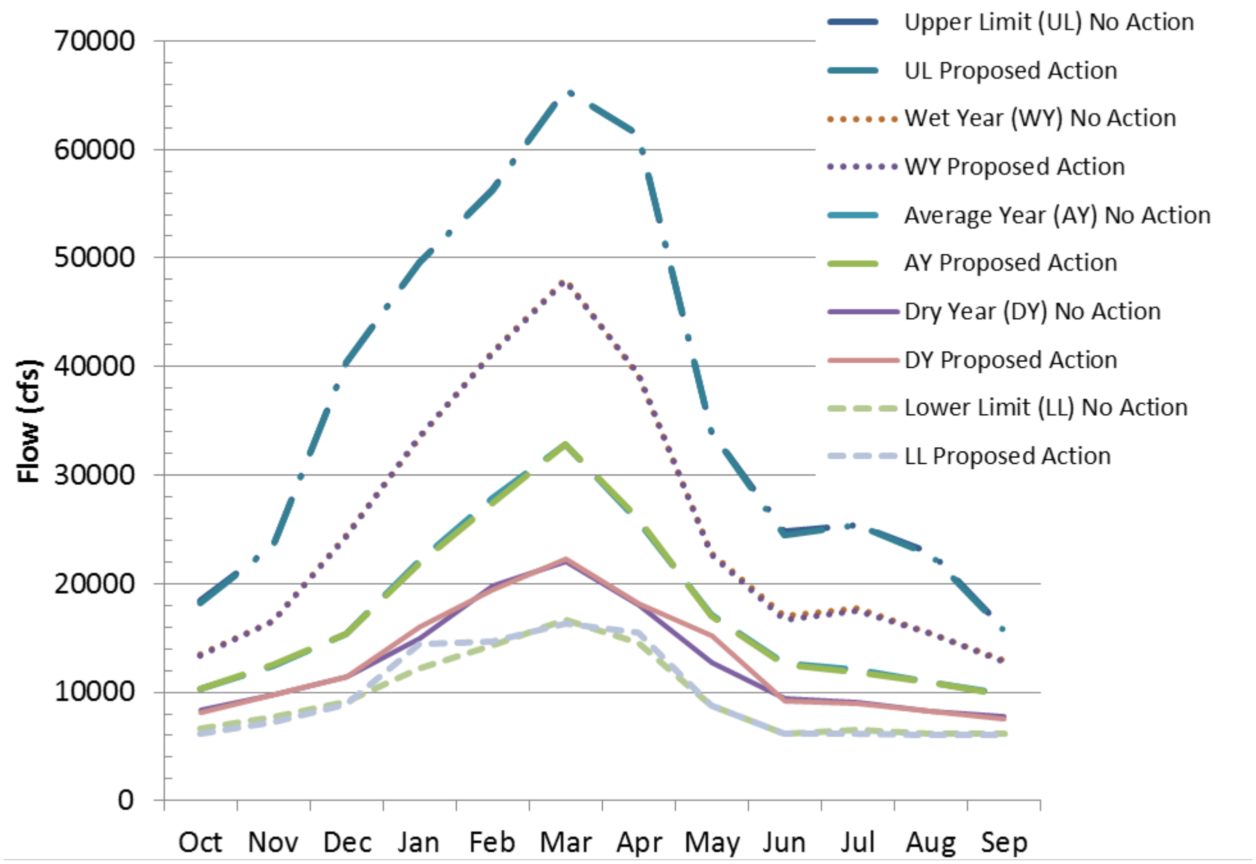

Figure 2.5-7. Chattahoochee, Florida monthly flow statistics for the NAA and PAA [monthly flow upper limit (10th percent exceeded), a wet year (25th percent exceeded), an average year (50th percent exceeded), a dry year (75th percent exceeded), and the lower limit (90th percent exceeded)].

2.5.1 Chattahoochee River Shoal Bass Recruitment

As requested in the 2013 PAL, results from both the HEC-5Q and HEC-ResSim modeling efforts were used to evaluate the Chattahoochee River Shoal Bass Recruitment Performance Measure (CRSBPM). Shoal bass (*Micropterus cataratae*) are a fairly recently described species (Williams and Burgess 1999) in the centrarchid (sunfish) family and is endemic to the ACF Basin. Shoal bass frequently occur in shoals (commonly co-occurring with other species) over rocky sediments in flows exceeding 0.66 ft per second. Recruitment of age-3 bass is of particular interest since this cohort has survived prevalent river conditions and has the potential to be stocked to support the recreational fishery. Recruitment success is largely dependent on surface water and spring temperature and is highly correlated with discharge.

The CRSBPM was evaluated in Atlanta, Georgia near river mile 410. The slightly higher median age-3 abundance from the PAA would be expected to be beneficial to shoal bass (Figure 2.5-8).

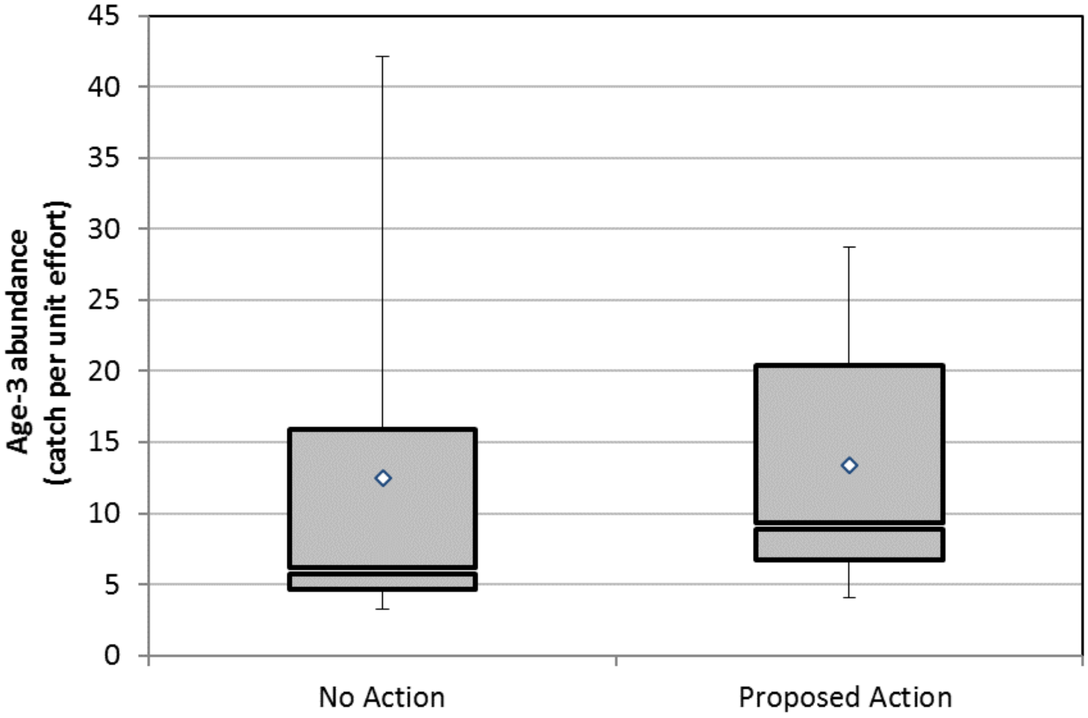

Figure 2.5-8. Shoal bass age-3 abundance at Atlanta, Georgia for the NAA and PAA (minimum; 25th, 50th, and 75th percentiles; maximum; and mean, where mean is represented by the diamond)

2.6 Apalachicola Bay Salinity Analyses

The USFWS conducted salinity modeling of the Apalachicola Bay. USACE reviewed USFWS model and concluded that, since there would be little change in the releases from Jim Woodruff Dam, little change in salinity in the Apalachicola Bay would be expected as a result of the PAA. Freshwater flows are also critical to the protection of the estuarine oyster fishery, which is sensitive to variations in salinity. The oyster fisheries in the estuarine portions of Apalachicola Bay experience impacts from drought and flooding as a result of both natural and unnatural flow variation. The PAA would present no anticipated change in the flows (wet, dry, or normal) to the estuary from the NAA, and therefore the PAA is not expected to change the current state of the oyster fishery.

Similarly, given the absence of appreciable changes in the flow dynamics from the NAA, additional impacts on other estuarine species and fisheries are not expected.

2.7 Federally-protected Species Analyses

As requested by the USFWS, the Federally-protected species analysis is consistent with the evaluations completed for the 2012 RIOP.

2.7.1 Gulf Sturgeon Analysis

Applying the Sturgeon Spawning Habitat Performance Measure described in the 2013 PAL, USACE found that no effects on Gulf sturgeon would be expected as a result of implementing the PAA compared to the NAA. Gulf sturgeon spawning habitat was quantified at three locations known to support the species. The maximum amount of habitat available during inundation at 8.5 to 17.8 ft depths from March through May, as well as the amount of habitat available during which conditions range from 8.5 to 17.8 ft over a 30-day period to support the timing of three life stages (spawning, egg incubation, and early larval development) of Gulf sturgeon were evaluated. Collectively, these three stages have been estimated to occur over approximately 30 days in the ACF Basin (USFWS 2008b; Pine et al. 2006; Sulak et al. 2004). The effects of the alternatives were based on the change in median annual Gulf sturgeon spawning habitat from that available under the NAA, which is 18.17 acres. The median spawning habitat under all the alternatives, including the PAA, would be expected to be equal to the NAA at 18.17 acres.

This approach to evaluating Gulf sturgeon habitat was used instead of those presented in the 2010 PAL. However, review of other information presented in this response would be expected to address points identified in the 2010 PAL. Daily fall rates were evaluated for protection of mussels (Section 2.7.2). The maximum number of days per year with flows less than 10,000 cfs is discussed in Section 2.7.2.3. Figure 2.2-24through Figure 2.2-27 illustrate the departure from average water temperature between May and October. Though this is not the USFWS requested period, those figures along with Figure 2.7-1 illustrate that little to no change in water temperature would be expected in the Apalachicola River.

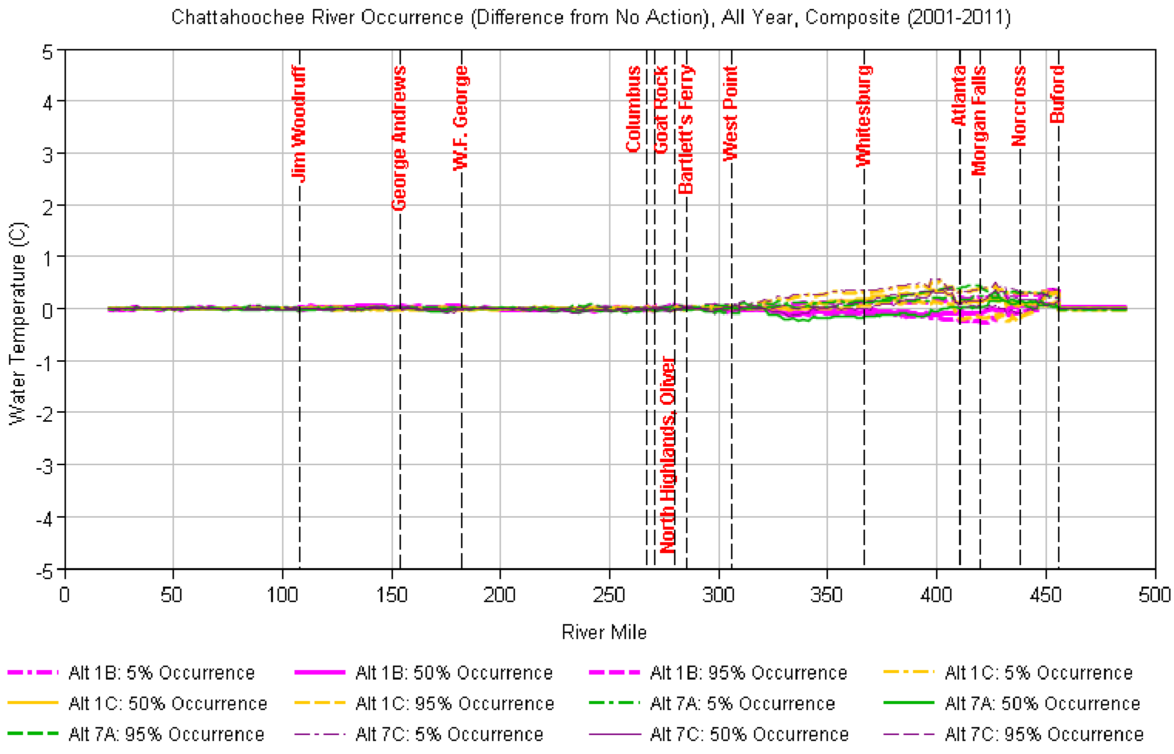

Figure 2.7-1. Change in water temperature for the modeled period 2001 through 2011

2.7.2 Freshwater Mussels Analysis

2.7.2.1 Lowest Daily Flow Rate for Each Year

The lowest annual flows at Chattahoochee, Florida for the modeled period from 1939 through 2011 are presented in Table 2.7-1. Both the PAA and the NAA do not include simulated flows less than 5,000 cfs.

Table 2.7-1.
Minimum modeled flow at Chattahoochee, Florida for the modeled period.

	Flow (cfs)	
Year	**No Action**	**Proposed Action**
1939	9443	9442
1940	7284	6196
1941	5040	5188
1942	9619	9619
1943	7833	7827
1944	9161	9163
1945	9119	9406
1946	10409	10317
1947	9881	9884
1948	11905	11905
1949	13462	13471
1950	7757	7701
1951	5576	5050
1952	7189	7115
1953	8852	8852
1954	5458	5050
1955	5019	5050
1956	5400	5050
1957	5537	5600
1958	8257	8254
1959	8451	8489
1960	8825	8775
1961	7872	7869
1962	7382	7374
1963	5716	5693
1964	12680	12673
1965	9392	9399
1966	8453	8453
1967	7555	7550
1968	5780	5278
1969	5976	5951
1970	6996	6996
1971	9831	9862
1972	6794	6787
1973	8634	8636
1974	8534	8490
1975	14286	14355
1976	8157	8262
1977	6345	6200

	Flow (cfs)	
Year	**No Action**	**Proposed Action**
1978	6918	6203
1979	6723	6675
1980	6447	6441
1981	5045	5049
1982	8363	8576
1983	8507	8504
1984	8292	8292
1985	5889	6183
1986	5049	5049
1987	6289	6087
1988	5050	5050
1989	8271	6311
1990	6106	5964
1991	9002	9005
1992	8435	7281
1993	5709	5543
1994	8880	10618
1995	7167	7006
1996	7644	7645
1997	5841	5781
1998	8296	7748
1999	5050	5050
2000	5050	5050
2001	5101	5296
2002	5050	5050
2003	8938	8977
2004	7035	5844
2005	9128	9123
2006	5050	5050
2007	5050	4550
2008	5050	5050
2009	7470	5859
2010	5721	5709
2011	5010	5050

2.7.2.2 Inter-annual Frequency of Flows less than 5,000–10,000 cfs

Mussels are susceptible to stranding at flows ranging from 5,000 to 10,000 cfs, particularly following high-flow events (> 100,000 cfs) that serve to move individuals into depositional areas (USFWS 2008b). Inter-annual flows, expressed as the frequency of occurrence of the percent of years, were evaluated to address the potential for stranding. The results are presented below.

Evaluation of the inter-annual frequency of flows less than 10,000 cfs indicates a close correspondence of the NAA and PAA (Figure 2.7-2).

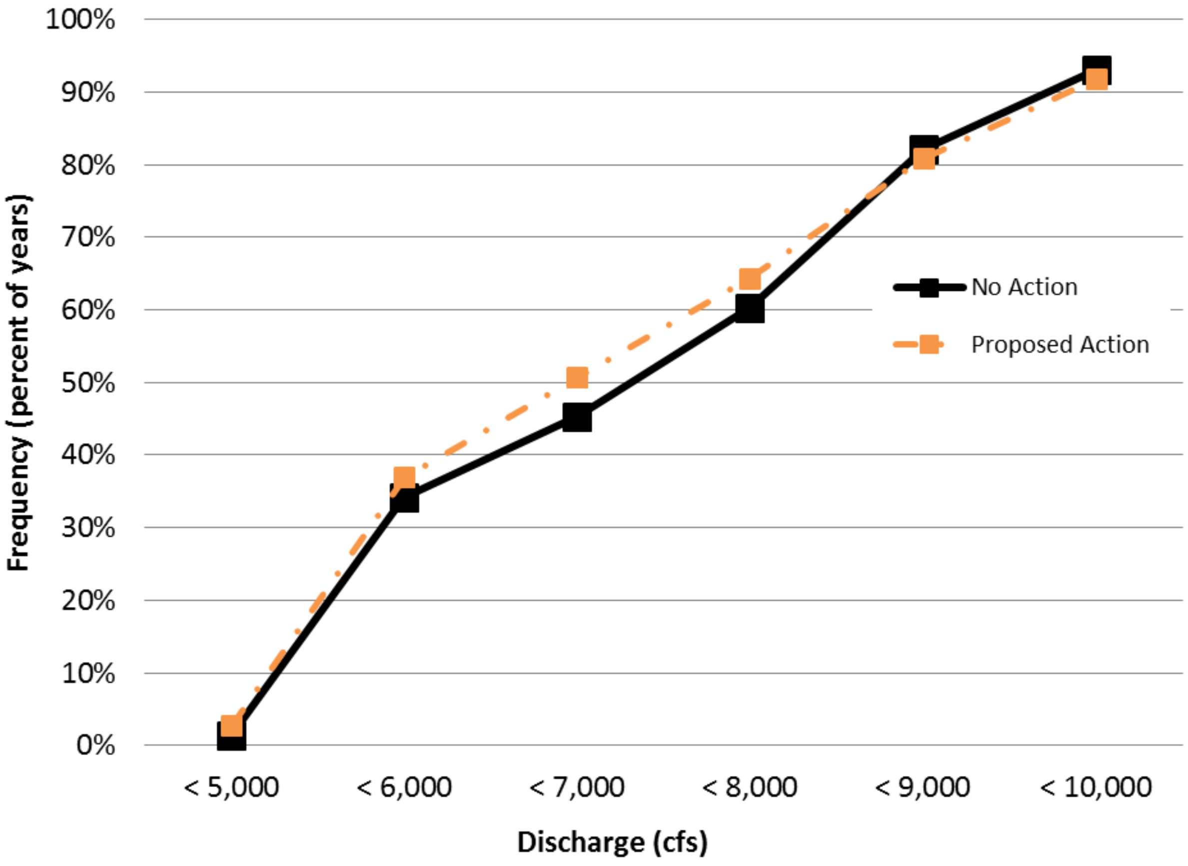

Figure 2.7-2. Inter-annual frequency of flows between 5,000-6,000; 6,000-7,000; and 8,000-10,000 cfs based on 1939 – 2011 (*Figure 4.2.5.A.* from the 2008 Biological Opinion [BO] and *Figure 4.2.3.A.* from the 2012 BO)

2.7.2.3 Maximum Number of Days per Year Flows less than 5,000–10,000 cfs

The maximum number of days per year with flows less than 5,000–10,000 cfs provides an estimation of the most severe conditions aquatic biota will experience under the proposed flow regimes. The modeled NAA tracks closely with the PAA in discharges greater than 6,000 cfs (Figure 2.7-3).

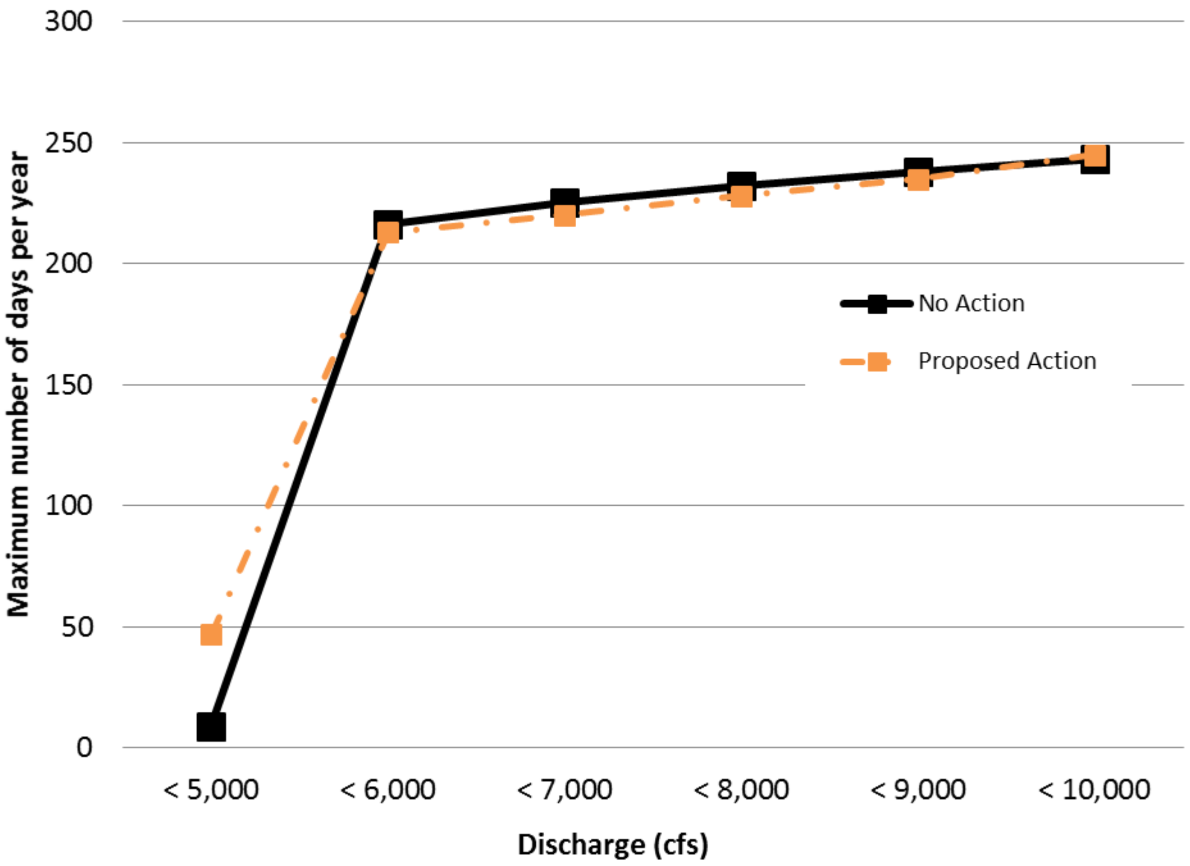

Figure 2.7-3. Maximum number of days per year with flows between 5,000-6,000; 6,000-7,000; and 8,000-10,000 cfs from 1939 – 2011 (*Figure 4.2.5.B.* from the 2008 BO and *Figure 4.2.3.B.* from the 2012 BO*)*

2.7.2.4 Maximum Number of Consecutive Days less than 5,000 - 10,000 cfs

Mussels can survive brief periods of stranding by closing their shells or burrowing in substrate. Thus, without extreme water temperatures, mussel survival from stranding is most likely a function of exposure duration (USFWS 2008b). To address that, the maximum number of consecutive days of flows between 5,000 and 10,000 cfs was evaluated. Figure 2.7-4 shows the maximum number of consecutive days of flows at less than 5,000–10,000 cfs is similar in the PAA to the NAA.

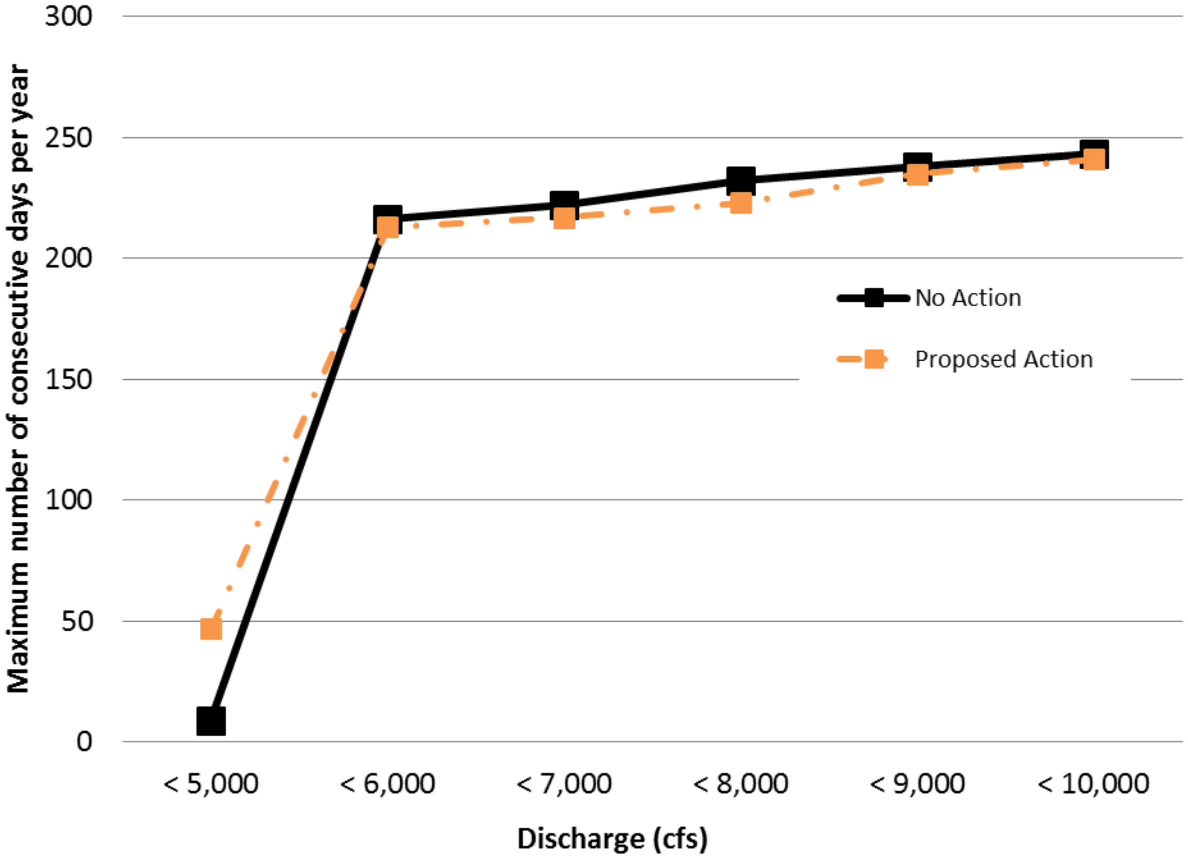

Figure 2.7-4. Maximum number of consecutive days with flows between 5,000-6,000; 6,000-7,000; and 8,000-10,000 cfs from 1939 – 2011 (*Figure 4.2.5.C.* from the 2008 BO and *Figure 4.2.3.C.* from the 2012 BO*)*

2.7.2.5 Median Number of Days per Year Flows less than 5,000–10,000 cfs

The duration of moderate low-flow periods are also an important consideration for the survival of mussels and other aquatic biota. Chronic low-flow events occur with greater frequency than extreme events and, despite the less severe conditions, serve to decrease habitat availability, increase physiological stress, and increase both exposure-related and predatory mortality. Median flows below 7,000 cfs would not be expected in the NAA and would only occur once in the PAA (Figure 2.7-5). The median number of consecutive days per year was also evaluated (Figure 2.7-6).

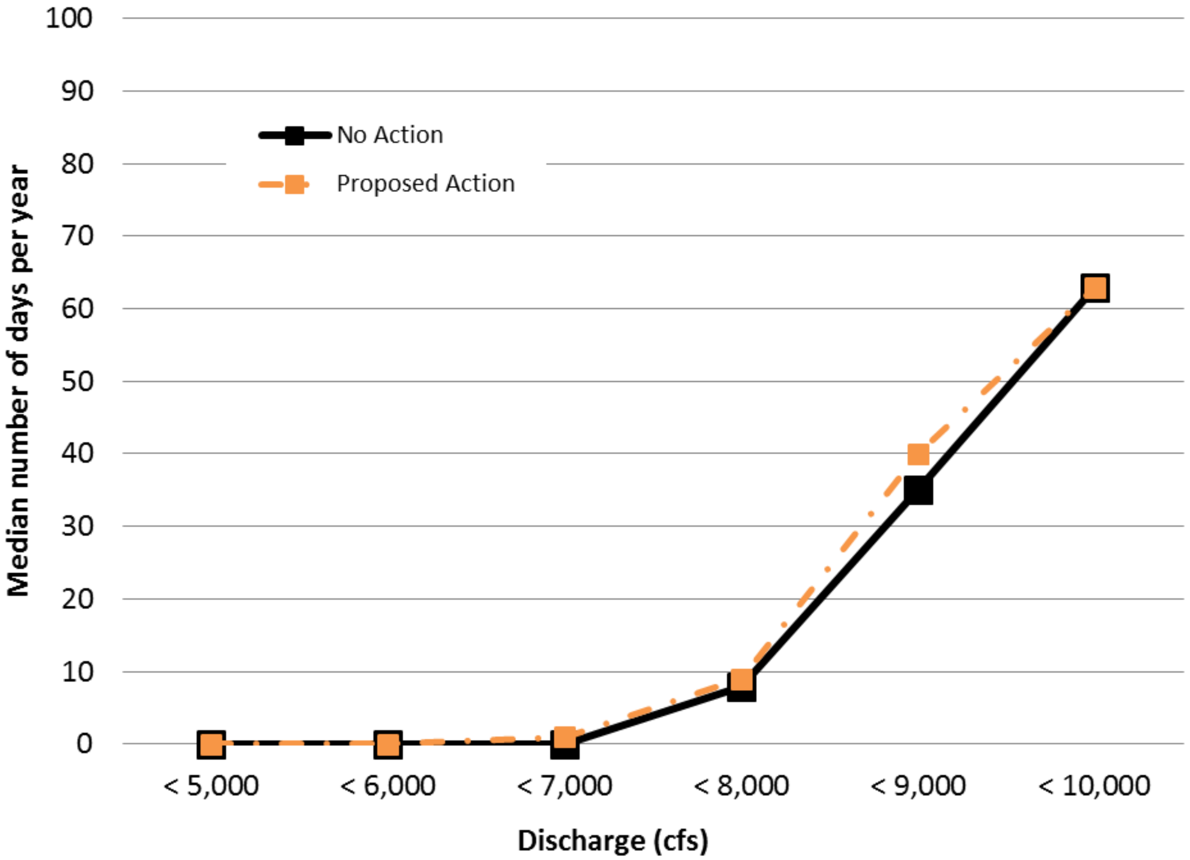

Figure 2.7-5. Median number of days per year with flows between 5,000-6,000; 6,000-7,000; and 8,000-10,000 cfs from 1939 – 2011 (*Figure 4.2.5.D.* from the 2008 BO and *Figure 4.2.3.D.* from the 2012 BO*)*

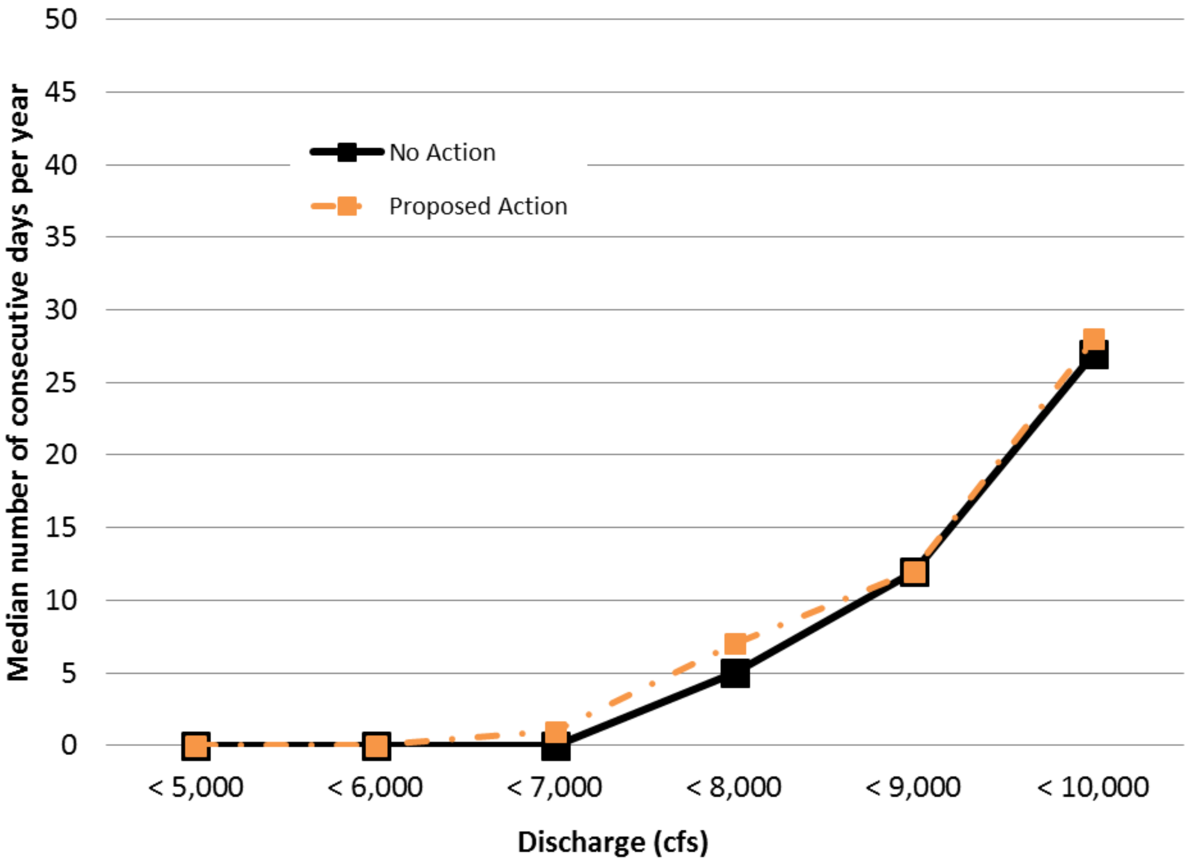

Figure 2.7-6. Median number of consecutive days per year with flows between 5,000-6,000; 6,000-7000; and 8,000-10,000 cfs from 1939 – 2011 (*Figure 4.2.3.E.* from the 2012 BO [Figure was not included in the 2008 BO]*)*

2.7.2.6 Frequency (Percent of Days) of Daily Stage Change Expressed as Ft/Day

The 2012 RIOP maximum fall rate schedule was established to avoid extreme declines in daily river stage levels and decrease the risk of exposure or stranding of aquatic biota. Declining river stages are moderated by operating schedules to provide an attenuation of flows that allow for more gradual fall rates as flows decline. Those rates are not presented but results presented in Section 0, for releases from Woodruff Dam less than 10,000 cfs would be expected to sufficiently illustrate differences between the NAA and PAA since the listed mussels generally do not occur at stages higher than those equivalent to 10,000 cfs.

2.7.2.7 Frequency (Percent of Days) of Daily Stage Change Expressed as Ft/Day when Releases at Woodruff Dam are less than 10,000 cfs

A fall rate analysis was performed to evaluate whether an increase in the percentage of days with rates greater than 0.25 ft/day would affect federally listed mussel species. The evaluation is restricted to periods when releases from Jim Woodruff Dam are less than 10,000 cfs. The results are illustrated in Figure 2.7-7.

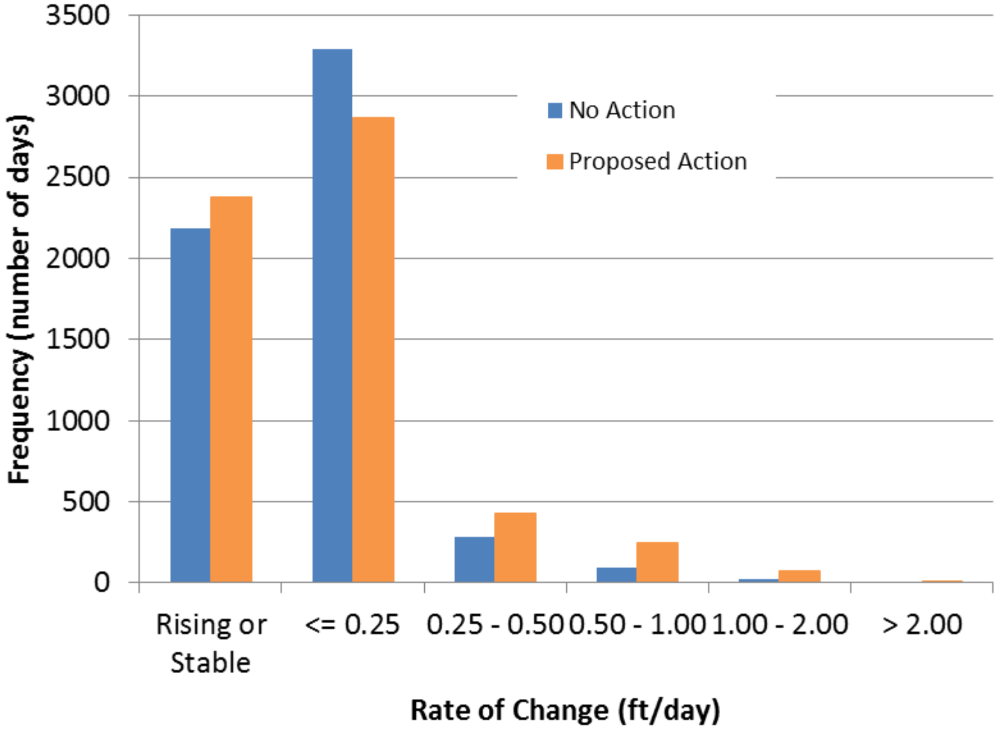

Figure 2.7-7. Frequency (number of days) of daily stage changes (ft/day) when releases at Woodruff Dam are less than 10,000 cfs from 1939-2011. (*Figure 4.2.5.F.* from the 2008 BO and *Figure 4.2.3.G.* from the 2012 BO*)*

2.8 Additional Analysis - Fish and Wildlife Management Facilities

2.8.1 Eufaula National Wildlife Refuge

The potential impacts on Eufaula National Wildlife Refuge (ENWR) are primarily related to reservoir level fluctuations at W.F. George Lake, influencing the refuge in three critical areas (USFWS 1998): (1) direct effects on habitat availability for wildlife; (2) effects on vegetation communities, particularly with respect to invasive species; and (3) the availability of water during October and November to off-reservoir impoundments that support waterfowl habitat management.

Reservoirs are generally associated with large watersheds and tributaries because of their engineered purpose of providing flood damage reduction, hydroelectric power, and navigation. As a result, they are characterized as receiving large organic and inorganic inputs, high nutrient loads, and contaminants (Miranda et al. 2010). Depositional filling effectively limits surface area and volume, thereby creating isolation of backwater areas, promoting habitat degradation, and decreasing overall depth (Patton and Lyday 2008).

Water-level fluctuation, common in reservoir settings, also limits the formation of persistent species associations and assemblage structure, especially in vegetation and open littoral zones. Drennen (1995) noted the importance of proper reservoir management strategies in the ACF Basin in support of wood duck (*Aix sponsa*) brooding and rearing habitat, heron rookeries, and foraging habitat for bald eagles, wood storks, and migratory species. Other species, including Florida softshell (*Apalone ferox*), common snapping turtle (*Chelydra serpentine)*, and common slider (*Trachemys scripta*) have been observed nesting in sandbars and mudflats when reservoir levels are below 186 feet (USACE, Mobile District 1998a).

Several factors influence the success of exotic introductions, including habitat connectivity and propagule pressure, disturbance and environmental variability, and species diversity and biotic interactions (Davis et al. 2000; Elton 1958). Davis and colleagues (2000) established the concept of fluctuating resources availability (FRA), which suggests that communities become more susceptible to invasions in response to the amount of unused resources. Disturbances may temporarily reduce the number of native species and thus provide an opportunity for invasive species. The FRA hypothesis specifically predicts that systems with fluctuating resources or elevated productivity will be more susceptible to invasive species. Within the ENWR, alligatorweed (*Alternanthera philoxeroides*) has become the most prolific invader of ephemeral wetlands in response to fluctuating water levels (USFWS 1998). Other undesirable species include black willow (*Salix nigra*), *Sesbania*, and cutgrass (*Leersia* spp.).

Reservoir levels lower than 186 feet provide important wading bird habitat during spring and fall and serve to concentrate waterfowl during the winter months. These habitats, not usually available at higher water levels, provide important forage and nesting areas. For example, Drennen (1995) observed ring-billed gulls feeding on mussels along flats that had become exposed during low-water conditions. However, in contrast, the ability to supply water to off-reservoir impoundments requires reservoir levels above 185 feet (Ziewitz and Luprek 1996). This also allows gravity-flow flooding, which provides a more precise and cost-effective means of adjusting water levels in the impoundments.

The USACE considered the USFWS request to cycle Walter F. George Lake between the highest levels (190 ft) in late winter/early spring to the lowest levels (185 ft) in late summer to accommodate Eufaula National Wildlife Refuge operations (Figure 2.8-1). As proposed, the option would require operation of the reservoir at its highest pool levels during winter-spring, when flood releases are typically the greatest. That would reduce the ability of the project to attenuate approximately 87,000 ac-ft of potential downstream flooding. By holding the reservoir higher during the winter wet season, induced surcharge and damaging downstream flows are increased, resulting in bank erosion and channel modifications below the project. Similarly, to operate the project at its lowest levels during the summer is contrary to what is required to meet the highest demands for recreation, hydroelectric power, and flow augmentation. Essentially, such an option would remove Walter F. George Lock and Dam from the system approach to operations across the basin and eliminate approximately 100,000 ac-ft of conservation storage that could be used to meet authorized project purposes in the summer. Given the demands of the system, including the minimum flow provisions of the RIOP, the proposed operation would have significant adverse effects on the authorized project purposes and the structural stability and safety of the dam. For these reasons, operations to manage Walter F. George Lake to benefit the Eufaula Wildlife Refuge operations were not considered further.

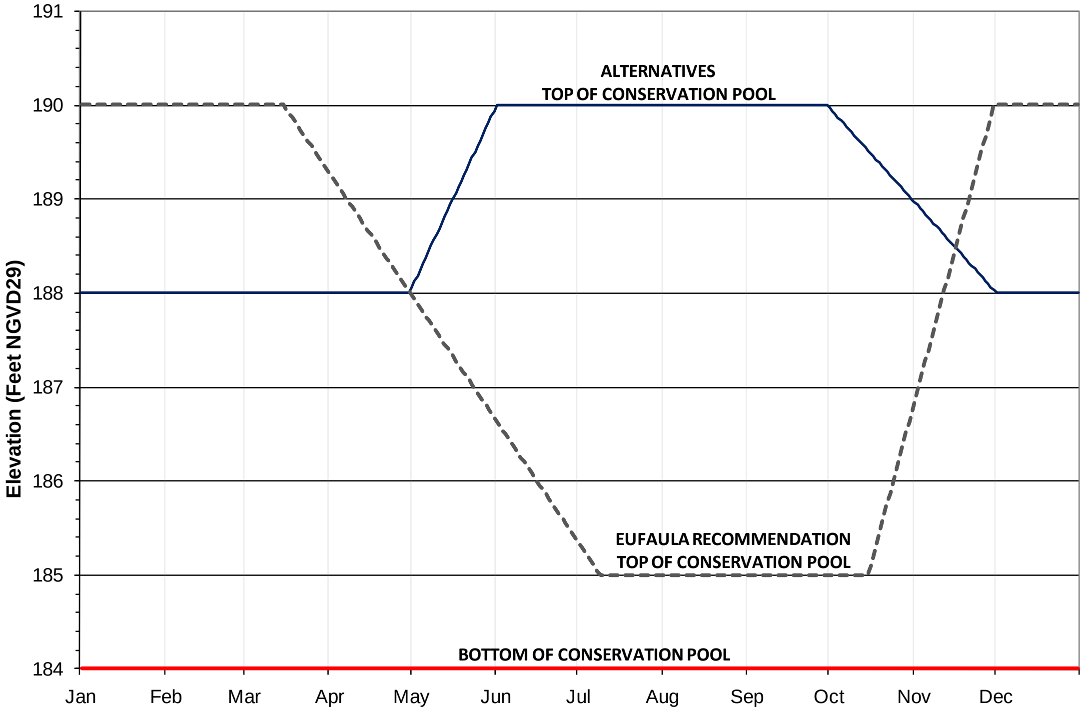

Figure 2.8-1. Eufaula National Wildlife Refuge recommended water surface elevation compared with the NAA and PAA top of conservation pool elevation.

The differences between the median daily water surface elevations at Walter F. George Lake are negligible between the NAA and PAA (Figure 2.8-2).

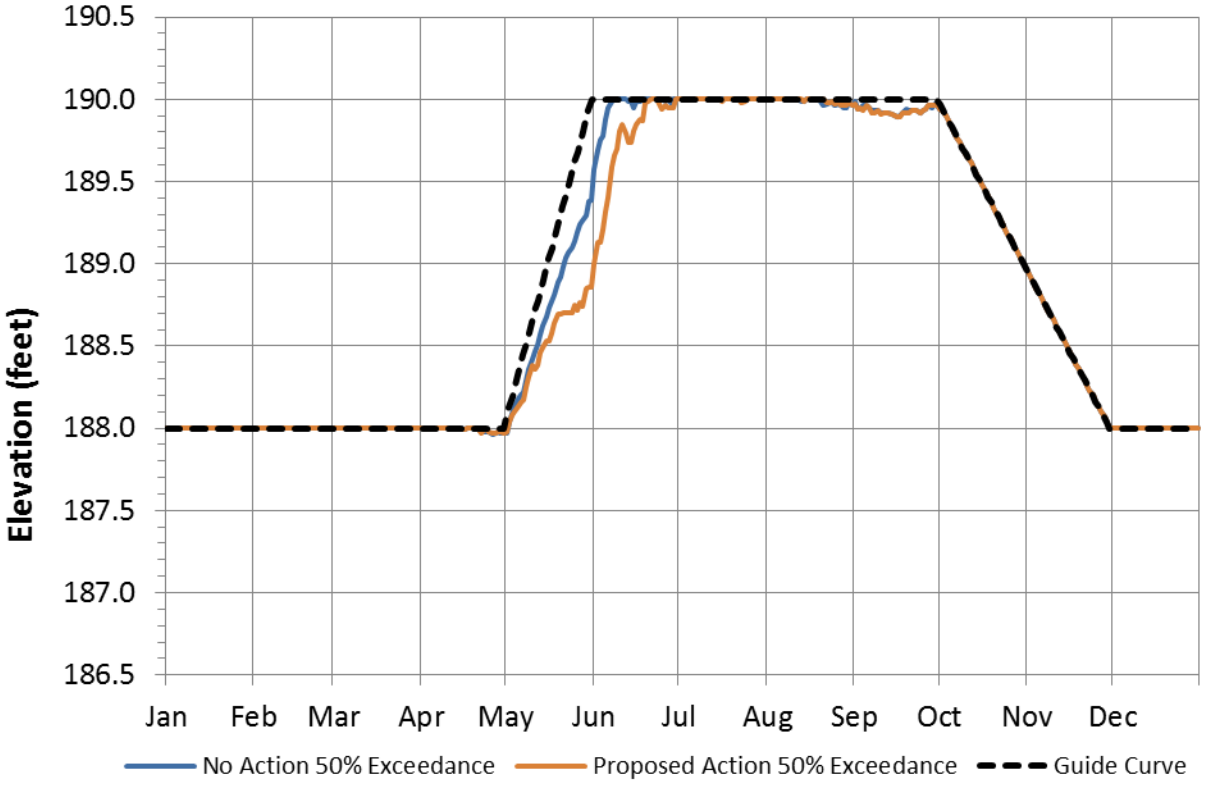

Figure 2.8-2. Walter F. George Lake, median daily water surface elevation over the modeled period of record (1939-2011) for the NAA and PAA

2.8.2 Fish hatcheries

Four major fish hatcheries are in the ACF Basin. Buford Trout Hatchery is the only fish hatchery in the ACF Basin that relies on surface flows for its operations, and it is the largest user of water. Changes in flow on the Chattahoochee River are negligible between alternatives, and would not be expected to affect operations at the Buford Trout Hatchery (Figure 2.8-3).

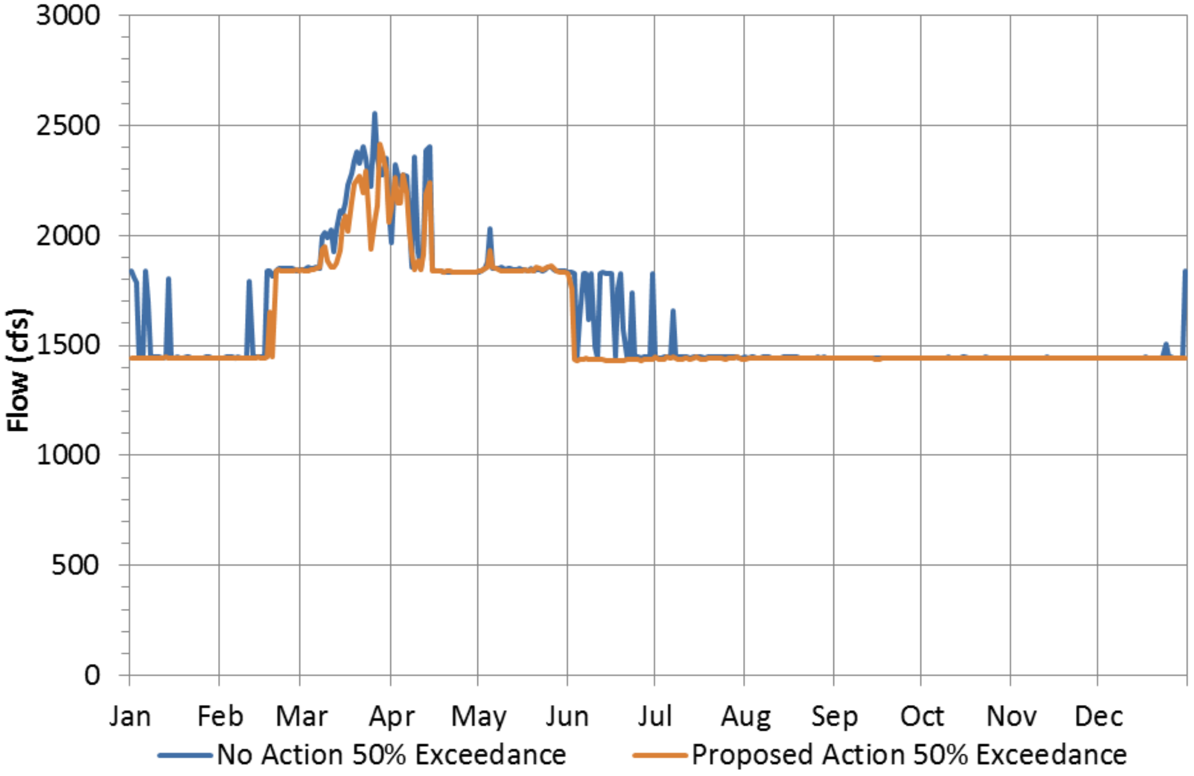

Figure 2.8-3. Chattahoochee River—median daily flows below Buford Dam, Georgia (RM 348.1) for the NAA and PAA

USFWS Request March 2015

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United States Department of the Interior

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Townsend, Georgia 31331

March 12, 2015

Dear Mr. Sumner,

Thank you for your response to our Planning Aid Letter (PAL). We have reviewed the information provided to us in the Apalachicola-Chattahoochee-Flint Water Control Manual (WCM) Update Response to Planning Aid Letter received on January 30, 2015. The review and exchange of information between the United States Army Corps of Engineers (Corps) and the United States Fish and Wildlife Service (USFWS) is a continuation of coordination under the Fish and Wildlife Coordination Act (FWCA) (48 Stat. 401, as amended; 16 U.S.C. § 661 *et seq.*). This coordination will facilitate your National Environmental Policy Act (NEPA) (42 U.S.C. § 4321 *et seq.*) analysis of the project.

Subsection 2(a) of the FWCA provides that the Federal agency constructing, permitting, or licensing a water resource development project "shall first consult" with the USFWS, with the principal procedural element to include the opportunity for continuing participation in planning that begins at the early stages such as at the reconnaissance stage. So that the Corps might give equal consideration to fish and wildlife, we recommended an alternative that would avoid and minimize adverse effects to fish and wildlife, and in some cases, enhance conditions for fish and wildlife affected by project operations. Your response indicated that you considered the alternative, but dismissed it in favor of the Proposed Action Alternative (PAA) that you will carry forward in your analysis to support a decision for a revised WCM.

The reasons for your dismissal of the PAL alternative and other alternatives are not clear; therefore, it is not evident whether the fish and wildlife benefits associated with our recommendations received the equal consideration mandated under Section 2 of the FWCA. Further, action agencies are required under NEPA regulations at 40 CFR 1502.14 to "rigorously explore and objectively evaluate all reasonable alternatives, and for alternatives which were eliminated from detailed study, briefly discuss the reasons for their having been eliminated." We are not aware of the process that the Corps has applied in dismissing or selecting alternatives, or will apply in making the final decision.

We request the following information to assist in our evaluation and report development, facilitate coordination with the States, and help ensure that the intent of the FWCA and NEPA is achieved:

1. Quantitative and operational measures (feature or activity) that defined each of the eight alternatives considered by the Corps, including reservoir drawdown and refill periods, action zone elevations, reservoir balancing methods, hydropower generation, drought operations, navigation, and environmental flow releases. The criteria used to compare and rank the alternatives will also assist our review.

2. Modeling parameters used to reproduce the USFWS alternative in Hydrologic Engineering Center-ResSim (ResSim), including a list of any changes made to the alternative since it was delivered to you and the rationale for such changes. Please also provide the water quality and hydrological model output for the USFWS alternative for all nodes in the Apalachicola, Chattahoochee, and Flint rivers.

3. DSS file(s) that includes the ResSim output for each node for each of the eight alternatives considered, including reservoir elevations, flows, and water quality.

4. Quantitative relationships among hydrology, temperature, and dissolved oxygen that were used to produce the dissolved oxygen and temperature graphs.

5. Modeled dissolved oxygen and temperature data for all Chattahoochee River nodes for all alternatives.

6. High flow guidelines for the PAA and No Action Alternative (NAA), or the data necessary for USFWS to produce them.

7. Clarification of the demands data that were used for Phase 1 and Phase 2 of your analysis. Please provide your analysis of demands scenarios that were considered.

8. Composite zones for the NAA and the other alternatives considered. Please confirm the method used to compute composite zones.

9. Estimates showing percent of days in Zones 1-4 and the drought zone for each alternative. Please include a table or graph showing the number of days required to transition from drought operations to Zone 1 for each alternative. Alternatively, you may provide USFWS with the requisite data and we will compute the statistics.

10. A description of how navigation was incorporated into ResSim. For example, was it a continuous navigation period for a period of 4-5 months, or several three-week periods

nested within the 4-5 month period? Please provide the discharge and duration values that were used, and clarify whether May was included in the modeling.

11. The analysis used to define action zone elevations.

We expect that many of the information needs that we identified are already available as DSS files, a format that should be efficient to transfer to us and that we are prepared to use. Additional information and data requests may be made in the future as part of the ongoing coordination with the States and the Corps. Please contact Will Duncan or Alice Lawrence at 706-613-9493, or Grant Webber at 850-769-0552 should you have questions regarding the requested information.

Sincerely,

Donald Imm

Draft Fish and Wildlife Coordination Act Report July 2015

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United States Department of the Interior

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Coastal Sub Office
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Townsend, Georgia 31331

July 31, 2015

Colonel Jon J. Chytka
US Army Corps of Engineers, Mobile District
P.O. Box 2288
Mobile, AL 36628-0001

Dear Colonel Chytka:

We are providing your agency with a Draft Fish and Wildlife Coordination Act Report (DFWCAR) for the proposed Water Control Manual (WCM) updates for the Apalachicola-Chattahoochee-Flint (ACF) River Basin in Georgia, Alabama, and Florida in fulfillment of Section 2(b) of the Fish and Wildlife Coordination Act (FWCA) (48 Stat. 401, as amended; 16 U.S.C. § 661 *et seq.*). The purpose of the WCM updates is to identify operating criteria and guidelines for managing water storage and release of water from U.S. Army Corps of Engineers (Corps) reservoirs. We submit the following comments and recommendations under the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. § 1531 *et seq.*), the Migratory Bird Treaty Act (MBTA) (49 Stat. 755, as amended; 16 U.S.C. § 702 *et seq.*), and the FWCA. A separate consultation will occur regarding the potential impacts of the Corps' proposal on federally-listed threatened and endangered fish and wildlife species protected under the ESA. We anticipate providing comments on the draft Environmental Impact Statement (DEIS) that the Corps is preparing to support its decision regarding the WCM update, and it is our understanding that the Corps intends to include this DFWCAR as an appendix to the DEIS. Delivery of the final version of this report will depend upon the Corps' schedule.

A draft version of the DFWCAR was distributed to the National Oceanic and Atmospheric Administration (NOAA), Georgia Department of Natural Resources- Wildlife Resources Division (GDNR-WRD), Alabama Department of Conservation and Natural Resources (ADCNR), and Florida Fish and Wildlife Conservation Commission (FFWCC). The Service subsequently received comments from FFWCC, ADCNR, NOAA, and GDNR-WRD. Since the Service received comments on the DFWCAR, and based on new information received from the Corps, the Service has recently developed an additional Appendix to the DFWCAR (Appendix XV) that has not yet been reviewed by the State wildlife agencies and NOAA. *If these agencies have comments on Appendix XV, which pertains to the Corps' alternatives selection process, we* *respectfully ask that they supply their comment letters regarding Appendix XV directly to the Corps and copy the Service on their correspondence.*

The problems with the methodology that the Corps used to select alternatives, detailed in Appendix XV, are considered to be significant by the Service. When several corrections were made by the Service, the ranking of alternatives changed. Regardless, the Service provides this DFWCAR in the event the Corps proceeds with the alternative that they have selected.

The DFWCAR outlines the fish and wildlife concerns and planning objectives that were provided in our April 2, 2010, Planning Aid Letter (PAL), March 1, 2011, PAL addendum, July 19, 2013, submission of the United States Fish and Wildlife Service's (Service) revised alternative, and August 29, 2013, PAL to you, along with our understanding of the Corps' responses to our concerns and objectives. The DFWCAR describes the alternatives and evaluates the anticipated impacts of the selected plan. Currently, the Service does not fully support the Corps' proposed alternative. However, our report provides the Corps with fish and wildlife conservation measures, recommendations, and methodologies that would address our concerns.

We urge the Corps, in cooperation with the Service and the State wildlife agencies, consider additional alternatives for analysis and analyses of potential impacts that would address our concerns about water quality in project tailraces, alterations of flow regimes that adversely affect fish and wildlife, etc., and that could lead to formulation of an environmentally preferable alternative in the Corps' decision-making process for the operations of the ACF Corps' reservoirs.

The Service recognizes the Corps' desire to complete this study in a timely manner but believes that a more informed alternative selection methodology and impact analysis should be utilized. The Service is willing to work with the Corps to expeditiously identify and implement such recommendations. If you have any questions, please contact Georgia Ecological Services staff biologists Alice Lawrence or Will Duncan at (706) 613-9493, Panama City Ecological Services staff biologist Grant Webber at (850) 769-0552, or Southeast Regional Office staff biologist David Walther at (337) 291-3122.

Sincerely,

Donald Imm
Field Supervisor

cc: G. Webber, USFWS, Panama City, FL
C. Phillips, USFWS, Panama City, FL
D. Walther, USFWS, Lafayette, LA
B. Pearson, USFWS, Daphne, AL
S. Abbott, USFWS, Ft. Benning, GA
M. Hubbard, USFWS, Eufaula, AL

B. Zettle, Corps, Mobile, AL
C. Sumner, Corps, Mobile, AL
T. Litts, GDNR-WRD, Social Circle, GA
S. Cook, ADCNR, Montgomery, AL
T. Hoehn, FFWCC, Tallahassee, FL
N. Kajumba, EPA, Atlanta, GA
B. Cox, NPS, Atlanta, GA
P. Wilber, NOAA, Charleston, SC

Draft Fish and Wildlife Coordination Act Report

On

Water Control Manual Updates for the Apalachicola-Chattahoochee-Flint River Basin in Georgia, Alabama, and Florida

Prepared by:

Georgia Ecological Services
Athens, Georgia

U.S. Fish and Wildlife Service
Southeast Region
Atlanta, Georgia
July 2015

United States Department of the Interior

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B. Cox, NPS, Atlanta, GA
P. Wilber, NOAA, Charleston, SC

EXECUTIVE SUMMARY

The United States Army Corps of Engineers (Corps) proposes to prepare an updated Master Manual for the Apalachicola-Chattahoochee-Flint (ACF) Basin. The purpose of the Water Control Manual (WCM) updates is to identify operating criteria and guidelines for managing water storage and release of water from Corps reservoirs. This Draft Fish and Wildlife Coordination Act Report (DFWCAR) outlines the United States Fish and Wildlife Service (Service)'s fish and wildlife concerns and planning objectives, describes the alternatives, and evaluates the anticipated project impacts of the selected plan.

The Corps' proposed action alternative (PAA) would modify the action zones for Lanier Reservoir, West Point Reservoir, and Walter F. George Reservoir. The Corps states in general, the action zones would be revised upward in the winter months at Lanier Reservoir and at West Point Reservoir and downward in the summer months at Walter F. George Reservoir.

The proposed drought plan would be similar to the No Action Alternative (NAA), except drought operations would be "triggered" when composite conservation storage of the ACF Basin falls below the bottom of Zone 2 into Zone 3 in the PAA. Under the NAA, drought operations are currently "triggered" when composite conservation storage falls below the bottom of Zone 3 into Zone 4.

The PAA proposes no changes to the NAA flood risk management operations. Under the PAA, the hours of hydropower generation would continue to vary by action zone, but a greater range of hourly production would be incorporated for operational flexibility in all action zones except for Zone 4 at West Point Reservoir and Walter F. George Reservoir.

Under the PAA, the Corps would provide a reliable navigation season if hydrologic conditions allow, typically extending from January through April or May. Providing a navigation season would only be supported when the ACF Basin composite storage is in Zones 1 or 2, not in Zone 3 or below. The navigation season would not be supported when drought operations are in effect and would not be supported after drought operations have ceased until the ACF Basin composite conservation storage recovers to Zone 1. The Corps' determination to extend the navigation season beyond April would depend on inflows, recent climatic and hydrological conditions, meteorological forecasts, and basin-wide model forecasts. Down ramping of flow releases would adhere to the Jim Woodruff fall rate schedule for federally-listed species, regardless of period in the navigation season. Augmenting flow releases to provide a 7-foot navigation channel would be dependent on channel conditions that ensure safe navigation. In addition, special releases may occur for a short duration to assist navigation during the navigation season.

Under the PAA, there would be no changes to the NAA for fish spawn, fish passage, or recreation operations. Releases for federally-listed species below Jim Woodruff would be modified in that the ramping rate would be suspended during prolonged low flow. The ramping rate would be suspended when basin inflow is less than 7,000 cubic feet per second (cfs) for 30 days and would be resumed when basin inflow is greater than 10,000 cfs for 30 days.

The PAA would include releases from Buford Dam, when considered in combination with contribution of local drainage between the dam and the city of Atlanta and reregulation of Georgia Power Company's Morgan Falls Dam, to be sufficient to provide a minimum flow at

Peachtree Creek of 750 cfs during May through October and 650 cfs during November through April. In contrast, the NAA includes releases from Buford Dam that provide a minimum flow at Peachtree Creek of 750 cfs year-round.

The PAA would continue to accommodate net withdrawals of 8 million gallons per day (mgd) by the City of Gainesville and withdrawals of 2 mgd by the City of Buford from Lanier Reservoir under relocation agreements. Additionally, 189,500 acre-feet of storage in Lanier Reservoir would be reallocated by the Corps to accommodate a portion (165 mgd) of Georgia's 2040 water supply need; this assumes that an additional 40 mgd would be withdrawn from the yet-to-be constructed Glades Reservoir to meet that future need. The Corps would also make releases from Buford Dam to provide for water supply withdrawals up to 408 mgd from the Chattahoochee River downstream at Atlanta by 2040. All other water supply operations would remain the same as the NAA.

The Service does not fully support the Corps' adoption of the PAA for the following reasons:

- the Corps' current alternatives selection process (Service 2015; Appendix XV),
- a failure to adequately address conservation measures identified in the Service's PAL (Service 2010; Appendix V), PAL addendum (Service 2011; Appendix VI), and the Service's 2011 DFWCAR (Service 2011) and subsequently included in this report,
- modeling developed from limited consumptive use scenarios without sufficiently considering climate change and future increase in consumptive demands,
- inadequately assessed effects to riverine ecosystems and federally-listed Gulf Sturgeon,
- increased frequency of low flows causing negative impacts to federally-listed mussels, and
- increased storage resulting in lower magnitude releases and possibly slightly higher salinities to the Apalachicola River and East Bay. Based on model results provided by the Corps, the negative effects of the PAA on fish and wildlife resources are a consequence of reservoir system operation changes and increases in consumptive demands that are part of the PAA.

We do, however, provide the Corps with recommendations intended to benefit fish and wildlife at the end of this document. The Service has suggested evaluations and analyses that address flow, water quality, fish passage, climate change, reservoir and riverine fisheries management, Apalachicola Bay resources, the inclusion of a decision support model and adaptive management, federally-petitioned species under the Endangered Species Act (ESA), impacts to the National Park Service (NPS)'s Chattahoochee River National Recreation Area, and ecosystem services. Our recommendations for hydrologic modeling include addressing the impacts of increasing consumptive demands and evaluating alternative models to reflect flow extremes and climate change. We also recommend that the Corps outline an approach to mitigation, which is one of the intents of coordination under the Fish and Wildlife Coordination Act (FWCA). The intent of these evaluations and analyses is to inform the development of alternatives and to address the impacts of the PAA.

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V. Service's April 2, 2010, Planning Aid Letter to Corps.

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XII. University of Florida's April 27, 2011, Draft interim report to the Service entitled, *Simulating the impact of USACE operating alternatives on salinity and oyster populations in Apalachicola Bay, FL.*

XIII. Service's March 12, 2015, Questions regarding the Corps' January 21, 2015, Response to Service's PAL.

XIV. Service's 2011 comparison of the Corps baseline model output and observed data for a comparable period.

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INTRODUCTION

Purpose, Scope, & Authority

The following is taken from the United States Army Corps of Engineers (Corps)' response to the United States Fish and Wildlife Service (Service)'s Planning Aid Letter (PAL) (Corps 2015a):

> "The Corps proposes to prepare an updated Master Manual for the ACF River Basin. A draft Master Manual was proposed in 1989 along with certain changes to the project manuals, as part of a post-authorization change report for Lake Lanier. The draft 1989 Master Water Control Plan described system operations at that time, but it was never finalized because of litigation filed by Alabama. The Corps has been operating projects in the ACF Basin under the draft 1989 Master Water Control Plan on an interim basis pending update of the Master Manual and individual project water control manuals. The component parts of the updated Master Manual would be five project-level water control manuals, presented as appendices that would specify how the various reservoir projects will be operated as a balanced system.
>
> …Water control manuals also contain drought operations plans and divide the amount of water in storage into action zones to assist federal water managers in knowing when to reduce or increase reservoir releases and conserve storage in the Corps reservoirs, and how to ensure the safety of dams during extreme conditions such as floods. The individual manuals typically outline the regulation schedules for each project, including operating criteria, guidelines, and guide curves, and specifications for storage and releases from the reservoirs. The water control manuals also outline the coordination protocol and data collection, management and dissemination associated with routine and specific water management activities (such as flood-control operations or drought contingency operations). Operational flexibility and discretion are necessary to balance the water management needs for the numerous (and often competing) authorized project purposes at each individual project. In addition, there is a need to balance basin-wide water resource needs. Project operations also must be able to adapt to seasonal and yearly variations in flow and climatic conditions.
>
> …the updated Master Manual, including updated water control plans and manuals for the ACF system and each federal project within that system, will reflect operations under existing congressional authorizations, taking into account changes in basin hydrology and demands from years of growth and development, new/rehabilitated structural features, legal developments, and environmental issues."

The Service's involvement in this project is authorized by the Fish and Wildlife Coordination Act (FWCA). The FWCA establishes fish and wildlife conservation as a co-equal purpose or objective of federally-funded or permitted water resource development proposals or projects.

This Draft Fish and Wildlife Coordination Act Report (DFWCAR) is presented in fulfillment of FWCA and constitutes the final report of the Secretary of the Interior as required by Section 2(b) of the FWCA.

FWCA Agency Coordination

The Service distributed a draft of the DFWCAR on May 19, 2015, to Georgia Department of Natural Resources- Wildlife Resources Division (GDNR-WRD), Alabama Department of Conservation and Natural Resources (ADCNR), Florida Fish and Wildlife Conservation Commission (FFWCC), and National Oceanographic and Atmospheric Administration (NOAA) for their review. We received comments from FFWCC on June 15, 2015, ADCNR on June 16, 2015, NOAA on June 18, 2015, and from GDNR on June 25, 2015. The Service also received comments from GDNR-Environmental Protection Division (GDNR-EPD) on June 5, 2015. However, because the FWCA requires that the Service coordinate with fish and wildlife agencies to ensure that fish and wildlife needs receive equal consideration, we have addressed GDNR-EPD's comments in a June 18, 2015, correspondence separate from the FWCA process.

We encourage the Corps to review these agency correspondences and consider them in their decision-making process. The agency responses to a draft of the DFWCAR are attached as Appendices I-IV; a summary of the correspondences is as follows:

<u>FFWCC</u>

FFWCC shares a number of key concerns with the Service's DFWCAR and agrees with the Service's general assessment that the PAA is unacceptable. FFWCC emphasizes the importance of consistent, transparent communication among the Corps, Service, and FFWCC. FFWCC notes that the Corps is required to consult with the Service *and* FFWCC, but this has not occurred; FFWCC requests the relevant datasets supporting the Corps' analyses. Until the relevant datasets are provided to FFWCC, they state that they cannot fully and effectively provide detailed comments as requested. After reviewing the Corps' datasets they will provide additional comments on these materials, as well as the DFWCAR, in accordance with FWCA. FFWCC notes that they, as well as the Service, earlier asked the Corps to address the impacts of current and projected consumptive water uses as part of the WCM Update process. The FFWCC states that the Corps has not offered any such analysis, and based on information being developed supporting litigation captioned *Florida vs. Georgia*, No 142 Orig., they "reject the Service's apparent interim conclusion that upstream consumptive uses are not having a significant effect on Florida's fish and wildlife resources."

Service Response: Per FFWCC's request, we have provided FFWCC with all relevant information that we have been provided by the Corps. The Service contacted FFWCC representatives/counsel to gain clarification regarding FFWCC's last sentence (cited above). FFWCC stated that this refers to the Service's statement in the DFWCAR that, "based on model results provided by the Corps, the negative effects of the PAA on fish and wildlife resources are, in part, a consequence of reservoir system operation changes. They are not solely the result of increases in consumptive demands that are part of the PAA." The Service does not consider this particular comment as necessarily addressing the issue of significance; rather that effects are jointly caused by both reservoir operations and increased consumptive demands. In this Final Draft version of the DFWCAR we have tried to clarify the meaning of our statement.

ADCNR

ADCNR encourages the Corps to fully develop and analyze alternatives or suites of alternatives that will maximize and benefit fish and wildlife resources of the State of Alabama. They also encourage decision support models, in an adaptive management framework, to evaluate these alternatives.

Specific concerns highlighted in ADCNR's correspondence include water quality, instream flow, increasing consumptive demand, State-protected aquatic species, and drought conditions and impacts. In terms of water quality, ADCNR agrees that releases from the Corps' ACF dams should meet or exceed State water quality standards and that water quality issues should be a priority for the protection of aquatic resources. Assessments for improvement should be fully considered in the suites of evaluated alternatives and the PAA. ADCNR agrees with the Service that alternative water quality assessment methods should be used to evaluate the effects of Corps' operations on water quality. ADCNR believes improvements to current Corps' facilities are within the scope of the WCM update process and recommend they be addressed while analyzing alternatives.

In terms of instream flow, ADCNR states that the responsibility of the Corps' water control operations must include a flow regime that maintains ecological integrity to protect the physical, chemical, and biological functions of waters flowing into the State of Alabama. Per their Instream Flow Policy implemented in 2012, ADCNR states that it is their policy to advocate for the protection of instream flow requirements in all water allocation decisions.

ADCNR requests the Corps a conduct comprehensive analysis of increasing consumptive demands in the ACF Basin and include those with the suite of considered alternatives. ADCNR states that increased demands including increased water supply withdrawals, increased volume storage, and changes in industrial, municipal, and agricultural practices could impact hydrologic conditions.

ADCNR states that potential impacts to State-protected species by Corps operations should be avoided and minimized. Impacts should be fully assessed and potential impacts from operating under the PAA should not be greater than operating under the NAA.

In terms of drought conditions and impacts, ADCNR is concerned that minimum flows during drought conditions under the PAA would have significant negative impacts on aquatic species. They recommend an analysis of alternative instream flow regimes be conducted such that minimum flows during drought conditions under the PAA are not lower than under the NAA.

ADCNR also recommends an anadromous fish passage plan be developed for George W. Andrews Lock & Dam (GWLD) and Walter F. George Lock & Dam (WFGLD).

GDNR

GDNR's comments pertain primarily to water temperature, fishery performance measures, fish passage, and water quality. In terms of water temperature, GDNR states that the thermal regime below Buford Dam is of importance to GDNR and to recreational anglers. An introduced trout fishery is supported from Buford Dam to Bull Sluice Reservoir and this section of the Chattahoochee River receives approximately 90,000 angler trips per year. GDNR suggests that downstream recreation should be considered as a coequal consideration in the WCM update process. They note that increased hydropeaking operations at Buford Dam would reduce available recreational opportunities in NPS' Chattahoochee River National Recreation Area, which are typically limited to times of minimum flows.

GDNR states that increased water temperatures would have different impacts on trout populations depending on the distance from Buford Dam. Water temperature is not expected by GDNR to be a concern at the Buford Trout Hatchery intake, with one possible exception being an increased frequency of 2-unit generations during the fall, when water drawn from the thermocline, pre-turnover, can lead to drastic temperature increases in a short time, leading to shock. South of the Norcross gage, GDNR states that small temperature increases may lead to localized stress and mortality if water temperatures exceed 22ºC for any considerable length of time; it is only currently a concern during summer months, which experience the most impact on water temperatures due to warmwater tributary inputs and solar radiation. Because research by GDNR indicates limited trout movement in the Chattahoochee River, a localized mortality event could lead to extended, severely reduced angler opportunities in a given section.

GDNR clarifies that summer habitat for striped bass in West Point Reservoir can be very marginal and the cool flows in the Morgan Falls tailrace mitigate for the lack of summer coolwater, high oxygen habitat. The Service had stated in the DFWCAR that spring coldwater releases may have a critical inhibiting impact on the West Point Reservoir striped bass reproduction, based on Hess and Jennings (1999). Hess and Jennings (1999) suggest temperature as possibly an inhibiting factor for reproduction, but also mention low flows as another potential inhibiting factor; therefore, GDNR states that it may not be appropriate to view higher flows/low temperatures as negative in an evaluation of riverine fish habitat.

In terms of fishery performance measures, GDNR reiterates the importance of individualizing the response of vegetation to water level management at Lanier Reservoir, West Point Reservoir, and Walter F. George Reservoir as part of the Reservoir Fishery Performance Measure (RFPM). They are concerned about using a single metric for three very different reservoirs. GDNR hopes to continue to work with the Service to refine the RFPM to more accurately model the fishery-related effects of water levels in each reservoir.

GDNR considers the continuation of the Corps' fish spawn management procedures as critically important for reservoir fisheries. As a Conservation Measure in the DFWCAR, the Service suggests investigate modifying the Fish Spawn Standard Operation Procedures (SOPs) to occassionally emphasize river spawning over reservoir spawning and define those circumstances where this would occur without unreasonably compromising other project purposes. GDNR would like to understand this Conservation Measure in more detail and state that conditions to meet this goal may be difficult in most years; in addition, the per-unit impacts in water management choices may not be uniform between rivers and reservoirs.

GDNR states that it is appropriate to use water temperature as the driving factor related to shoal bass abundance in the Chattahoochee River Shoal Bass Performance Measure (CRBPM) for the Morgan Falls tailwater. However, GDNR states that thermal impacts farther downstream, between Peachtree Creek and West Point Reservoir, are likely minimal relative to shoal bass reproduction and recruitment in normal years. Apparent limited shoal bass abundance in this reach could be due to other limiting factors that should be addressed and considered when using the CRBPM to inform flow regimes.

In terms of fish passage, GDNR agrees that improved fish passage would provide benefits to multiple species (e.g., increased habitat availability for Gulf Sturgeon and Striped Bass).

In terms of water quality, GDNR states that it is important to consider that there may be positive benefits to a reservoir fishery from increased residence time or nutrient loading. GDNR states that Lanier Reservoir and Walter F. George Reservoir have not historically had problems of algal mats and/or fish kills due to chlorophyll-*a* or phosphorous loading, and West Point Reservoir nutrient levels have drastically decreased following upstream wastewater infrastructure improvements in the past two decades. When classifying water quality changes as positive or negative, potential benefits from increases in residence time or nutrient loading that can lead to increases biomass and improved fishing should be considered.

GDNR agrees that increased dissolved oxygen levels below Corps' dams would have positive benefits to tailwater fisheries. The State water quality standard at Norcross and Morgan Falls both fall within State-listed trout waters, and as such, were incorrectly cited in the Corps' response to the Service's PAL (Corps 2015a) and subsequently the Service's DFWCAR as a daily average of 5.0 mg/L instead of 6.0 mg/L. An increase in dissolved oxygen at Buford Trout Hatchery in the late summer and fall pre-turnover period would alleviate stress on trout held in hatchery raceways. Increases in dissolved oxygen levels below West Point Dam should provide a benefit to shoal bass populations. Electrofishing surveys below WFGLD have indicated that low dissolved oxygen may severely impact recreational fishing opportunities for several miles downstream.

GDNR also clarifies that Buford Trout Hatchery's withdrawal, listed as 7 mgd, is a pass-through system and the net withdrawal is negligible on downstream flows (limited to evaporation).

NOAA

NOAA is supportive of the Service's comments addressing the current inadequacy of the evaluation of the PAA on Gulf Sturgeon and recommends the Corps provide a more thorough evaluation of the effects of implementing the PAA on Gulf Sturgeon. NOAA is supportive of the Service's comments that fish passage provisions, with operational flexibility, should be incorporated at not only Jim Woodruff Lock and Dam (JWLD), but also at the two Corps facilities upstream of JWLD, GWLD and WFGLD.

In addition, NOAA states that additional examinations are needed to determine how variations in freshwater inflow to Apalachicola Bay affect seagrass, fish, and shellfish abundances. NOAA recommends the Corps coordinate with FFWCC to complete analyses and include an updated Apalachicola Bay salinity model for predicting oyster mortality and growth in the WCM.

Prior Studies and Reports

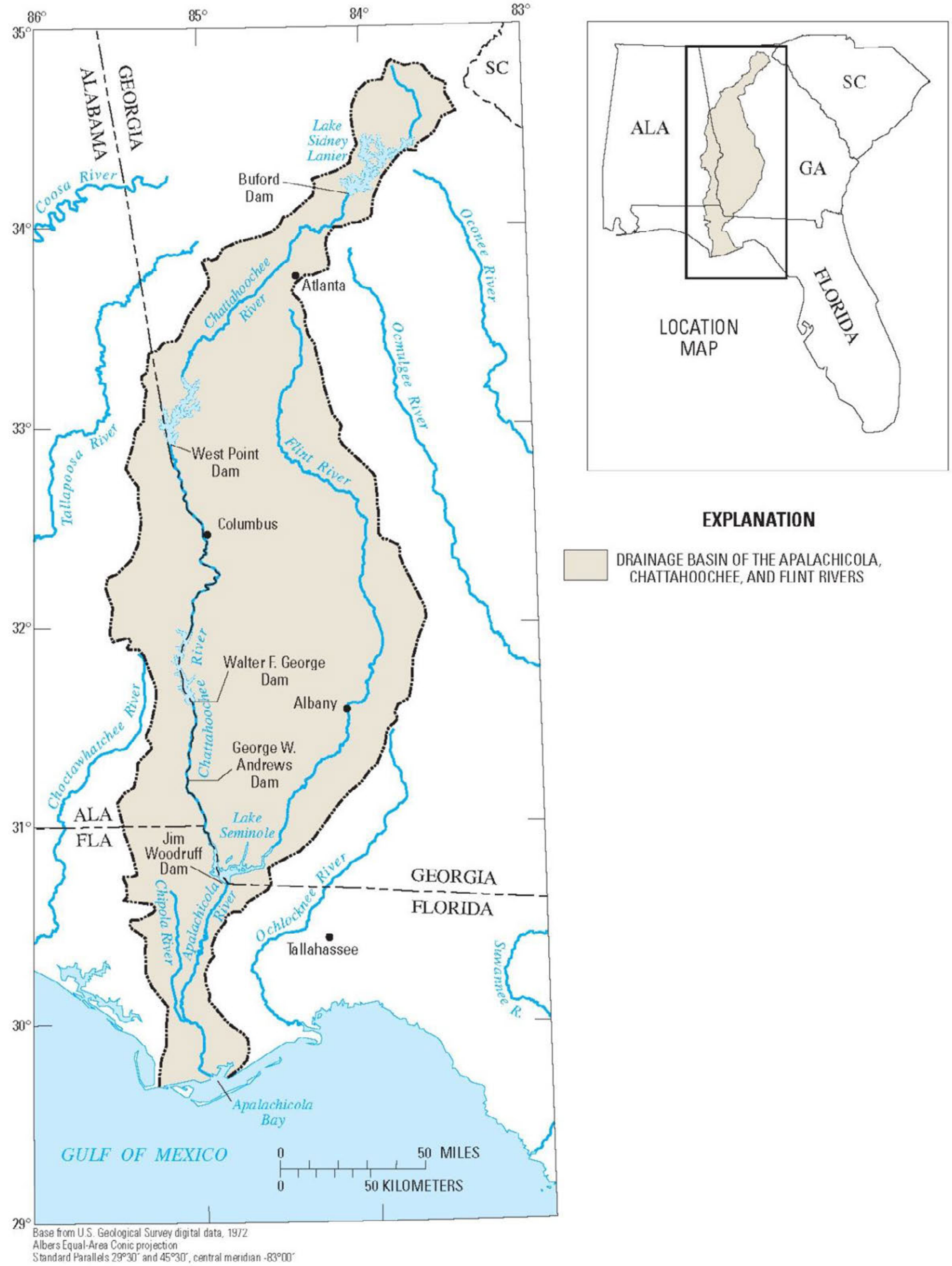
The following studies and/or reports are the most pertinent documents involved in producing this DFWCAR:

- Corps' April 15, 2008, description of proposed action modification to the Interim Operations Plan at Jim Woodruff Dam;
- Service's 2008 and 2012 biological opinions for the Corps' Revised Interim Operations Plan;
- Service's April 2, 2010, PAL to the Corps (Appendix V);
- Corps' January 18, 2011, response to the Service's PAL;
- FFWCC's February 22, 2011, correspondence to Donald Imm, Service Field Supervisor, and Major General Todd T. Semonite, Corps titled *The Impact of Reduced Flows on the Apalachicola River and Bay Ecosystems (*Appendix XI*);*
- Service's March 1, 2011, PAL addendum to the Corps (Appendix VI);
- University of Florida's April 27, 2011, draft interim report to the Service entitled, *Simulating the Impact of USACE Operating Alternatives on Salinity and Oyster Population in Apalachicola Bay, Florida* (Sheng et al. 2011; Appendix XII);
- Service's June 2011 DFWCAR to the Corps;
- Service's July 19, 2013, Revised alternative for consideration in the ACF River Basin WCM to the Corps (Appendix VIII);
- Service's August 29, 2013, PAL to the Corps (Appendix IX);
- Corps' February 6, 2014, HEC5Q and Service water temperature model comparisons; and
- Corps' January 21, 2015, response to the Service's PAL.

DESCRIPTION OF STUDY AREA

The 19,910 square mile (mi^2) ACF River basin stretches from north central Georgia to the eastern border of Alabama to the Gulf coast through the central Florida panhandle. The drainage principally comprises the Chattahoochee (8,770 mi^2) and Flint (8,460 mi^2) rivers, which meet to form the Apalachicola River (2,680 mi^2) near the border of Florida and Georgia. Water resources in the ACF River basin have been developed to meet various demands for municipal and industrial water supply, flood control, hydropower, navigation, fish and wildlife conservation, recreation, and agricultural water supply (Corps 1998).

There are currently 14 reservoirs impounding the mainstem ACF river system, of which five are federally-owned and 9 are privately-owned projects. Eleven reservoirs are located on the Chattahoochee River, two on the Flint River, and one, JWLD, is located near the confluence of the Chattahoochee and Flint rivers which forms the Apalachicola River. The federally-owned projects include JWLD, as well as four projects along the mainstem Chattahoochee River: GWALD, WFGLD, West Point Dam, and Buford Dam (Figure 1).



Base from U.S. Geological Survey digital data, 1972
Albers Equal-Area Conic projection
Standard Parallels 29°30′ and 45°30′, central meridian -83°00′

Figure 1. Map of the ACF Basin showing location of the Corps' dams (source: Light et al. 2006).

FISH AND WILDLIFE CONCERNS AND PLANNING OBJECTIVES

The Service's fish and wildlife concerns, planning objectives, recommendations and requested analyses have been previously described in detail to the Corps in our 2010 PAL (Service 2010; Appendix V) and 2011 PAL addendum (Service 2011; Appendix VI). Some of our concerns and planning objectives were represented in our scoping comments (Service 2013; Appendix VII), revised alternative (Service 2013; Appendix VIII), and 2013 PAL (Service 2013; Appendix IX). Our overarching planning objective is to identify negative impacts to aquatic ecosystems, and provide considerations for improving, protecting, and mitigating for losses to aquatic resources associated with the revision of the Corps' Water Control Manual.

In the Fish and Wildlife Conservation Measures and Recommendations Section we have included a summary of our current understanding of the Corps' position on each issue, as well as additional conservation measures and recommendations developed from the Corps' 2011 response to the Service's PAL and more recent conservation and mitigation measures. These more recent measures include recommendations for the Corps' to consider the effects of the PAA on species in the ACF Basin that have been petitioned for Federal listing under the ESA, impacts to NPS' Chattahoochee River National Recreation Area, and ecosystem services, as well as the development of appropriate mitigation.

DESCRIPTION OF CORPS' NO ACTION ALTERNATIVE AND SELECTED PLAN

No Action Alternative

The Corps' NAA represents continuation of the current water control operations at each of the Federal projects in the ACF Basin. There is not one comprehensive document that reflects the Corps' current operational practices; instead they are described in multiple Corps documents including:

- 1989 Draft ACF Water Control Plan;
- June 2008, Revised Interim Operations Plan (RIOP) and Environmental Assessment, as modified by the updated RIOP/EA (May 2012);
- May 2010, South Atlantic Division Regulation (DR) 1130-2-16, Project Operations, Lake Regulation and Coordination for Fish Management Purposes and February 2005, Draft Reservoir Regulation and Coordination for Fish Spawn Management Purposes Standard Operating Plan (SAM SOP 1130-2-9);
- February 1991, Chattahoochee River Management System as described in the Apalachicola Basin Reservoir Regulation Manual, Appendix B, Buford Dam (Lake Sidney Lanier) Chattahoochee River, GA; and
- Project WCM s for Buford (1991), West Point (1984), Walter F. George (1993), George Andrews (1996), and Jim Woodruff Lock and Dam (1985) projects.

The NAA as it dictates general system operations, action zones, and authorized project purposes is described in detail in the Corps' response to the Service's PAL (Corps 2015a). The NAA also includes current water supply operations including withdrawals directly from Lanier Reservoir and Buford Dam releases for downstream withdrawal.

Proposed Action Alternative

The PAA as it dictates general system operations, action zones, and authorized project purposes is also described in detail in the Corps' response to the Service's PAL (Corps 2015a). In light of the July 2011 Eleventh Circuit Court of Appeals ruling, the Corps is considering current levels of water supply withdrawals and a portion (165 mgd) of Georgia's 2040 water supply need within Lanier Reservoir, assuming an additional 40 mgd would be withdrawn from projected construction and use of Glades Reservoir. Releases from Buford Dam would provide for water supply withdrawals of up to 408 mgd from the Chattahoochee River at Atlanta. The PAA provides a minimum flow rate of 750 cfs at Peachtree Creek from May through October and 650 cfs from November through April.

Under the PAA, the Corps would modify the action zones for Lanier Reservoir, West Point Reservoir, and Walter F. George Reservoir. Specifically, the action zones in Lanier Reservoir and West Point Reservoir are shifted upward in the fall and winter months and the action zones are shifted downward in Walter F. George Reservoir, primarily during summer months.

The hours of hydropower generation under the PAA would continue to vary by action zone, but a greater range of hourly production would be incorporated in all action zones at Lanier Reservoir, West Point Reservoir, and Walter F. George Reservoir except for Zone 4 at West Point Reservoir and Walter F. George Reservoir. This operational flexibility appears that it would result in potentially more variability in hydropower production at Buford Dam and less hydropower production at West Point Dam and Walter F. George Dam.

Under the PAA, the Corps would provide a reliable navigation season. If hydrologic conditions allow, a typical navigation season would extend from January through April or May. During this navigation season the flows at the Blountstown, Florida USGS gage would provide at least a 7-foot channel, which corresponds to 16,200 cfs at Blountstown (Corps 2015b). Providing a navigation season would only be supported when the ACF Basin composite storage is in Zones 1 or 2, not in Zone 3 or below. The navigation season would not be supported when drought operations are in effect and would not be supported after drought operations have ceased until the ACF Basin composite conservation storage recovers to Zone 1. The determination to extend the navigation season beyond April would depend on inflows, climatic and hydrological conditions, and meteorological and basinwide forecasts. Downramping of flow releases would adhere to the JWLD fall rate schedule. Releases to provide for the 7-foot navigation channel would also be dependent on navigation channel conditions that ensure safe navigation.

Under the PAA, there would be no changes to flood damage reduction, fish spawn, fish passage, or recreational operations. Releases for federally-listed species below JWLD would be modified in that the ramping rate would be suspended during prolonged low flows. Use of ramping rate rules would be suspended when basin inflow has been less than 7,000 cfs for 30 days, and would be resumed when basin inflow is greater than 10,000 cfs for 30 days.

The PAA would include a drought plan that would be similar to the NAA, but drought operations would be "triggered" when composite conservation storage of the ACF Basin falls below the bottom of Zone 2 into Zone 3. Under the NAA, drought operations are currently "triggered" when composite conservation storage falls below the bottom of Zone 3 into Zone 4. Under both the NAA and PAA, drought plan provisions would remain in place until conditions improve such that composite conservation storage reaches a level above the top of Zone 2. Additionally, reshaping of the action zones, including the Drought Zone, will affect both the duration and magnitude of flow releases throughout the system of reservoirs.

FISH AND WILDLIFE RESOURCES WITHOUT THE PROJECT

A fundamental component of the FWCA Report is the evaluation of resources with and without the project, so that impacts to fish and wildlife habitats and populations, human uses of resources, and other habitat values lost or gained can be quantified, negative impacts avoided or minimized, and unavoidable impacts mitigated. It is standard practice for such analyses to include evaluations and comparisons of long- and short-term future resource conditions with and without the project and for mitigation to be based on projections of future resource conditions (Figure 2).

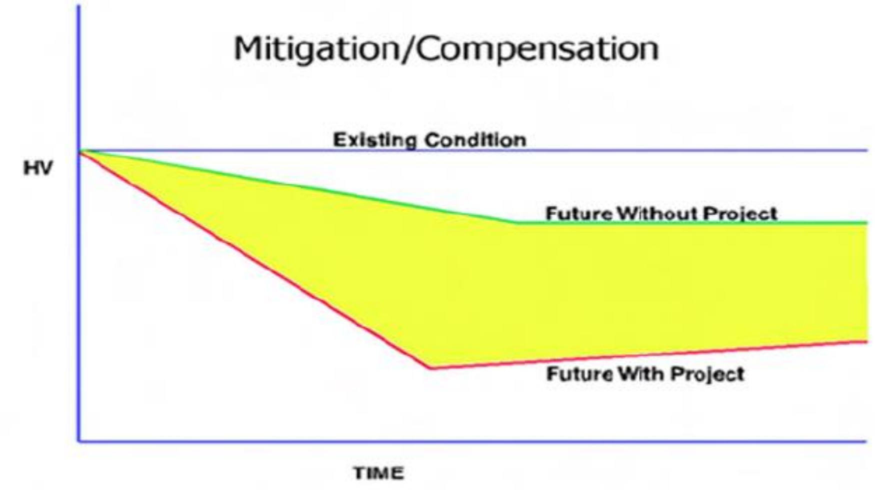


Figure 2. Mitigation and compensation of habitat values (HV) lost for a hypothetical water resource project. Yellow area projects future habitat values lost and mitigation/compensation needs.

The Corps combined multiple changes to operations at Corps projects with increased allocation of water for the Atlanta area in order to formulate the PAA. Although the PAA consists of multiple changes to the existing WCM, the PAA represents a single action (formulation of a new WCM) that describes “the project.” In order to discuss and evaluate mitigation measures, we defined the following terms based on our understanding of the Corps’ actions:

> *Existing condition* is defined as the condition of the system without the modification to existing operations or additional consumptive uses.
>
> *Future without the project* is defined as the condition of the system without changes to Corps projects or an increased allocation for the Atlanta area. The future without the project should include forecasts for climate change and increased municipal, industrial, and agricultural consumptive demands from elsewhere in the ACF Basin.

> *Future with the project* is defined as the condition of the system with changes to Corps projects and an increased allocation for the Atlanta area. The future with the project should include forecasts for climate change and increased municipal, industrial, and agricultural consumptive demands from elsewhere in the ACF Basin.

The *existing condition (blue line)* has been modeled by the Corps as the NAA, not including future consumptive demands and climate change. No *future without the Project* (green line) scenario was provided in the Corps' analyses. The *future without the Project* should include existing operations of Corps projects, with projected consumptive demands and climate change. Similarly, the *future with the project (red line)* is not fully represented. The PAA included proposed changes to operations and future consumptive demands through 2040 for the Atlanta area, but did not incorporate basinwide consumptive demand projections or climate change.

Changes in future resource conditions include changes related to water consumption, water quality, climate change, and associated effects on habitat and biota. For these reasons, we asked the Corps in the 2010 PAL (Service 2010; Appendix V) to include in their modeling efforts multiple future climate scenarios that could affect reservoir levels, river discharges, and estuary inflow. The Corps did not incorporate multiple climate scenarios into their modeling, thereby complicating comparisons between the future conditions with and without the PAA; they state that detailed climate change modeling and an impacts discussion have been incorporated in the DEIS when it becomes available. However, the Corps did incorporate increased consumptive water use in the Atlanta area in response to the ruling of the Eleventh Circuit Court, thereby incorporating, in part, a component that is necessary to evaluate the *Future with the Project*. Consequently, we have no option but to use the NAA to evaluate future fish and wildlife resources without the PAA, and to use the PAA as a proxy for future with the project.

A multitude of fish and wildlife resources are dependent upon discharge and have been affected by long-term discharge changes. FFWCC provided a summary and comparison of pre-Buford Dam and post-West Point Dam conditions that exhibit discharge and salinity changes in the Apalachicola River and Bay ecosystems (FFWCC 2011; Appendix XI). Although the interpretations of the analyses were made by FFWCC and not the Service, impacts identified (hypothesized, realized, or modeled) in FFWCC's correspondence are relevant because operational changes at Corps facilities have the potential to ameliorate, exacerbate, or have no effect on such project-induced impacts and impacts associated with other changes in future resource conditions. Apalachicola River and Bay impacts addressed in the FFWCC letter include:

- Long-term decreases in river flow, especially spring and summer low flows during dry conditions
- Decreases in floodplain inundation and associated changes in forest composition, ichthyofauna, and invertebrates
- Gulf sturgeon spawning and rearing habitat reductions, and population effects as a consequence of barrier construction (JWLD) and flow reductions
- Fish spawning habitat reductions as a consequence of reduced river flows
- Mussel habitat reductions and population effects
- Modeled estuary salinity changes as a response to Apalachicola River discharge changes and upstream flow depletions

- Influence of floodplain organic matter on oyster diet and estuary productivity
- Changes in oyster drill (*Dermocystidium marinum*) prevalence in oysters as a function of estuary inflow and salinity over multiple years.

Negative impacts of current operations on aquatic resources in other portions of the basin include:

- Loss of riverine habitat and fluvial species assemblages, including federally-listed mussel species and Gulf sturgeon that are now thought to be extirpated from the mainstem Chattahoochee River
- Loss of unimpeded passage for migratory fishes
- Fragmentation of aquatic populations in the mainstem and tributaries
- Significantly altered dissolved oxygen and temperature regimes
- Highly altered flow regimes that affect assemblages of riverine aquatic biota in the remaining flowing river segments below dams.

It is reasonable to expect that future conditions exhibiting the cumulative combination of increased population growth, consumptive demands, wastewater input, changes in climate, and continued operation of Federal projects will show increasing impacts to these natural resources. Based on correspondence with the Corps and with the States as part of the FWCA process, we have addressed or are currently addressing the types of impacts that could potentially occur as a consequence of changes in current project operations. The Corps has included projected increases in consumptive uses. However, because the Corps has not provided an evaluation of project impacts associated with a more accurate projection of future conditions, including climate change and sea level rise, direct comparisons of the future of the resource with and without the project are hampered. Consequently, we emphasize that the Corps should develop and quantify projected positive and negative impacts for ‘with the project’ and ‘without the project’ scenarios based on more accurate projections of future conditions so that appropriate mitigation measures can be developed and included in the Corps’ National Environmental Policy Act (NEPA) documents.

PROJECT IMPACTS & EVALUATION METHODOLOGY

Project impacts should be identified by comparing future resource conditions under the NAA to future conditions with the Corps’ PAA. Impacts can theoretically be beneficial, adverse, or have no appreciable differences, but are limited to fish and wildlife resources that could be affected by Corps project operation changes. Thus, the intent of this section is to describe effects of project operations on biologically relevant parameters. The overall biological interpretation of the results (e.g. descriptions of whether the PAA is beneficial, adverse, or no difference compared to the NAA) is reserved for the *Evaluation of the Selected Plan* section below.

Analyses Provided by the Corps

In response to the Service’s April 2, 2010, PAL, March 1, 2011, PAL addendum, and August 29, 2013, PAL, the Corps completed several requested analyses to support the comparison of the NAA and PAA (Corps 2015a). The Corps relied on HEC-ResSim to simulate management alternatives and evaluate the resulting effects to reservoir levels, river stages, and river discharge. Our understanding is that calculations of basin inflow from January 1939 through December

2008 were determined and anthropogenically-influenced variables (e.g. consumption levels, reservoir evaporation and release schedules) were used to create synthetic flow and discharge datasets that simulate expected conditions under the NAA and PAA. Datasets through 2008 were used for phase one of the Corps' alternatives formulation; datasets thorough 2011 were subsequently available and were used for phase two of the Corps' alternatives formulation. The phased approach to the Corps' formulation of alternatives is described in greater detail in the Corps' response to the Service's PAL (page 1-4, Corps 2015a).

As with any model, there are limitations and caveats associated with model development and use, all of which should be acknowledged by the Corps. As an example, we have provided the results of a statistical and qualitative analysis that evaluates congruency between actual operations as measured by discharge at USGS gages and model output of existing operations (i.e., the NAA) for the comparable post-RIOP period (Service 2011; Appendix XIV). The analysis shows a high degree of similarity for many components of the hydrograph at most locations, but also several exceptions. Statistical differences between measured discharge and modeled discharge for existing operations include:

> Chattahoochee at Norcross: pulse duration and frequency, and number of reversals;
>
> Chattahoochee at West Point: pulse magnitude, duration, and rise rate, and number of reversals;
>
> Apalachicola at Chattahoochee: number of reversals.

The intent of HEC-ResSim is not to perfectly replicate existing operations. HEC-ResSim results are particularly useful for comparing trends, not necessarily absolute magnitudes. Therefore, it is recommended to the reader and analyst that interpretation of the aforementioned parameters is focused on data trends, not absolute magnitudes, during comparisons of alternatives.

HEC-5Q was used to model water quality. Impacts assessed at multiple locations throughout the basin using HEC-5Q included effects on dissolved oxygen, water temperature, wastewater, chlorophyll-*a*, reservoir retention time, and phosphorus. For many of the analyses, the Corps evaluated a composite period from 2001-2011, but also extracted a subset of the data to represent dry (2007), normal (2004), and wet (2005) hydrologic year types. Data were further extracted to examine only the months of April or May (depending on the analysis) through October in order to examine effects during critical low flow and fish spawning periods. While these analyses are useful and statistically valid, we caution the reviewers regarding the following. When data are combined for multiple months into a single graph, and when percentiles are used to characterize multi-month datasets, the high and low extremes that occur in a *single* month may be obscured by the data associated with all other months. For example, daily values within a month for modeled chlorophyll-*a* could actually be higher than the values represented on graphs that combine multiple months. We emphasize that this is not a failing of the Corps' analysis, but it does identify an area of investigation for which additional model data are available. We recommend that time series plots also be used (similar to dissolved oxygen plots in Figures 2.2-15 to 2.2-18 of the Corps' 2015 response to PAL) to illustrate variation that is likely to occur.

Using the recommended performance measures included in the Service's PAL (Service 2013; Appendix IX), floodplain connectivity, reservoir fisheries, and Chattahoochee River shoal bass recruitment analyses were performed by the Corps. Federally-protected species analyses on the Apalachicola River included Gulf Sturgeon and freshwater mussels. Effects on shoreline vegetation and wildlife at Eufaula National Wildlife Refuge (NWR), as well as flows at Buford Fish Hatchery were also assessed.

Below, we assess impacts of the PAA relative to the NAA using the Corps analyses. General descriptions of the analyses are presented, but more thorough descriptions of the Corps methodologies and graphical depictions of output may be found in the Corps' response to the Service's PAL (Corps 2015a). Values presented below are approximations based on visual interpretations of graphs provided by the Corps.

Dissolved Oxygen

Suitable dissolved oxygen levels are critical for fish and invertebrates. The Corps' simulation of dissolved oxygen includes 4 measurements per day. The Corps then summarized these data as daily average occurrence plots. Daily average dissolved oxygen values varied along the longitudinal river profile, with May-October median dissolved oxygen values in both the NAA and PAA analyses falling below State standards below Corps projects at Buford Dam, West Point Dam, and Walter F. George Dam. Generally, dissolved oxygen levels were similar in the NAA and PAA. The largest differences between the NAA and PAA occurred in the dry year (2007) simulation, with the greatest differences below Buford Dam stretching from Atlanta to below Whitesburg on the Chattahoochee River. We emphasize that the results provided by the Corps represent modeled data. Results may differ from observed dissolved oxygen values that occur during similar weather and hydrological conditions.

> Buford Dam downstream: The PAA and NAA results were similar. Both were less than the State standard of 6 mg/L at 45% occurrence for the composite 2001-2011 period and 50% occurrence for a dry year (2007). The NAA produced 1.0 mg/L higher dissolved oxygen at the 35% occurrence for both the composite period and a dry year simulation. This represents the largest deviation between the NAA and PAA. Minimum dissolved oxygen at this location for both the NAA and PAA is approximately 2.5 mg/L.
>
> Norcross: The PAA and NAA results were similar and generally remained above the 6.0 mg/L State standard, except for approximately 2% of both the composite (2001-2011) and dry (2007) modeled period.
>
> Morgan Falls: The PAA and NAA results were similar and remained above the 6.0 mg/L State standard, except for <1% of the composite (2001-2011) modeled period.
>
> West Point Dam downstream: The PAA and NAA results were similar. Both were less than the State standard of 5 mg/L at ~38% occurrence for the composite (2001-2011) period and dry year (2007). Minimum dissolved oxygen at this location for both the NAA and PAA is approximately 1.7 mg/L.
>
> Bartletts Ferry: The PAA and NAA results were similar. Both were less than the State standard of 5 mg/L at ~32% occurrence for the composite (2001-2011) period and dry year (2007). Minimum dissolved oxygen at this location for both the NAA and PAA is approximately 2.5 mg/L. However, it should be noted that this modeled data will not

likely accurately reflect dissolved oxygen values in Bartletts Ferry tailrace. As a result of Georgia Power Company (GPC)'s recent Federal Energy Regulatory Commission (FERC) relicensing process, GPC has recently initiated installing stoplogs to improve dissolved oxygen levels in their tailrace during summer months each year (FERC 2014). GPC's monitoring results to date indicate dissolved oxygen levels in Bartletts Ferry tailrace meet State water quality standards as a result of this methodology.

Walter F. George downstream: The PAA and NAA results were similar. Both were less than the State standard of 5 mg/L at ~25% occurrence for the composite (2001-2011) period and 35% occurrence for the dry year (2007). Minimum dissolved oxygen at this location for both the NAA and PAA is approximately 2.5 mg/L.

Water Temperature

Alteration of water temperature can greatly affect the persistence and abundance of aquatic species in a given location. Most notably, suitable water temperatures are critical for reproduction. Simulated water temperature for the NAA and PAA varied along the longitudinal river profile, with the largest temperature drops below Buford Dam (17 °C) and West Point Dam (3 °C) for modeled period between 2001-2011 in May through October. The NAA and PAA model results were similar along the longitudinal river profile in wet, dry, and normal years and in the 2001-2011 composite from May through October, with modeled warmer water temperatures (less than 1°C) most spatially prevalent in normal and dry years.

Wastewater

In the absence of quantitative models that describe water quality changes in response to flow management alternatives, percent wastewater can serve as a proxy. As percent wastewater increases, wastewater-associated substances are expected to increase along with negative impacts to the aquatic environment. Simulated average stream percent wastewater from May through October varied along the longitudinal river profile, with the largest percent wastewater between Atlanta and West Point Dam (the maximum reported NAA value was 28% wastewater for the 95% occurrence value) and below George W. Andrews Dam (the maximum reported NAA value was 28% wastewater for the 95% occurrence value) for the 2001 - 2011 composite period. Similar trends were observed in representative wet, dry and normal years. Percent wastewater in the PAA was approximately 15% greater than the NAA in the river segment between Atlanta and West Point Dam, making average conditions under the PAA more similar to drought conditions under the NAA. These trends persist along the longitudinal river profile, but the magnitude of the differences between the NAA and PAA decline in a downriver direction.

Chlorophyll *a*

Chlorophyll-*a* is correlated with algal biomass. Because algal mats can cause nuisance conditions in lakes and river shoals, it is often considered to be undesirable. Chlorophyll-*a* is also an indicator of eutrophication, stemming from increases in organic matter or nutrients and potentially causing water quality problems. Simulated chlorophyll-*a* varied along the longitudinal river profile during the April through October modeled period, with peak concentrations in reservoirs. Similar trends were observed in the 2001-2011 composite and in the wet, dry, and normal years. Results were similar between the NAA and PAA, with any differences between the two resulting in higher chlorophyll-*a* values as a result of the PAA. However, in dry and normal years, as well as for the composite period, the PAA 95% occurrence had daily average algal concentrations 1-5 µg/L higher than the NAA in Walter F. George Reservoir, West Point Reservoir and Bartletts Ferry Reservoir. The 50% and 5% occurrences for the NAA and PAA in the composite period and all year types were similar.

In their comments on the Service's DFWCAR (GDNR 2015; Appendix III), GDNR states that it is important to consider that there may be positive benefits to a reservoir fishery from nutrient loading. They state that algal mats and fish kills related to chlorophyll-*a* have not historically been a problem at Lanier Reservoir or Walter F. George Reservoir, and that the nutrient levels at West Point Reservoir have drastically decreased following upstream wastewater infrastructure improvements in the past two decades. If not at critical levels, GDNR states that an increase could lead to increased biomass and improved fishing within these three reservoirs. GDNR states that when classifying water quality changes as positive or negative for the purpose of evaluation, these potential benefits should be considered.

Reservoir Retention Time

We requested average summer retention times at each Corps reservoir. Data were provided in hard copy, tabular format for each month. Reviewing a subset of the data, June through August retention times at West Point Reservoir were generally similar between the NAA and PAA between 2001 and 2011. However, qualitative evaluation of the PAA showed higher retention times in 2002 (max= 9 days higher in August), 2006 (max= 42 days higher in July), 2008 (max= 5 days higher in August), and 2009 (max= 27 days higher in August). We request the average summer retention time data be summarized by the Corps for each of the Corps reservoirs to facilitate quantitative comparisons.

Phosphorus

Algal growth is stimulated by increases in phosphorus. Total phosphorus loads over the modeled period (2001-2011) at both of the selected locations, the headwaters of West Point Reservoir and Walter F. George Reservoir, both increased in the PAA when compared to the NAA. Simulated total phosphorus varied along the longitudinal river profile, with peak concentrations downstream from Atlanta and Columbus. Similar trends were observed in the 2001-2011 composite and in the wet and dry year longitudinal profiles; a normal year longitudinal profile was not included. Results were similar between the NAA and PAA during the composite period and within each year type; however, any differences observed between the PAA and NAA resulted in higher total phosphorus levels in the PAA analysis. Model output frequently produced concentrations 0.01-0.03 mg/L greater in the PAA analysis than the NAA analysis in the composite period and up to 0.05 mg/L greater during a dry year.

In their comments on the Service's DFWCAR (GDNR 2015; Appendix III), GDNR states that it is important to consider that there may be positive benefits to a reservoir fishery from nutrient loading. They state that algal mats and fish kills related to phosphorus have not historically been a problem at Lanier Reservoir or Walter F. George Reservoir, and that the nutrient levels at West Point Reservoir have drastically decreased following upstream wastewater infrastructure improvements in the past two decades. If not at critical levels, GDNR states that an increase could lead to increased biomass and improved fishing within these three reservoirs. GDNR states that when classifying water quality changes as positive or negative for the purpose of evaluation, these potential benefits should be considered.

Floodplain Connectivity

The Apalachicola River and floodplain ecosystems depend on seasonal flooding and connectivity to maintain forest community structure, ensure availability of spawning and rearing habitats, export detritus and nutrients to fuel higher trophic levels in the river and estuary, and support biodiversity in the region. Floodplain connectivity can result in functions such as regulation of soil and water chemistry, flood storage and displacement of energy, and carbon sequestration. Consequently, effects of project operations on the frequency, magnitude and timing of floods were evaluated. The Service developed the Floodplain Spawning Habitat Performance Measure (FSHPM) to assist in this evaluation. The measure calculates the maximum amount of spawning habitat available for at least 30 consecutive days during the months of April through October. It is unclear whether the Corps used the FSHPM to develop the graphical comparison. As described by the Corps, it is unknown whether they calculated *consecutive* days. The Corps used the period from April through September, not April through October as specified by the FSHPM. We suspect that the results would be similar, but clarification and corrections should be made. The annual maximum 30-day growing season floodplain connectivity is the same for the NAA and PAA for the April through September period, with the exception of slightly higher connected acreage at the 80th percentile of years.

The State of Florida previously suggested that LIDAR (Light Detection and Ranging) data were available and should be used in this analysis. We agree that LIDAR data likely would be informative, especially regarding quantification of acreage connected at a range of discharges in the Apalachicola River. However, given that the NAA and PAA exceedance curves are nearly the same, we do not expect that using LIDAR data would lend additional insights.

Chattahoochee River floodplain connectivity would be expected to be nearly the same between the NAA and PAA. Conditions in the NAA would be very similar to the PAA as the Chattahoochee River is currently essentially disconnected from its floodplain. Therefore, we do not expect differences in floodplain inundation in the Chattahoochee River.

Reservoir Fisheries

The Reservoir Fisheries Performance Measure (RFPM) was used to quantify the effects of the NAA and PAA on reservoir fisheries for the entire period of record. The RFPM uses the acreage of productive zone inundated for more than 30 days during the spawning season, and gives weight to inundated habitats that have potentially been colonized by terrestrial vegetation. The RFPM is fully described in the Service's PAL (Service 2013; Appendix IX). Differences between the NAA and PAA are small at each Corps reservoir (Lanier Reservoir, West Point Reservoir, and Walter F. George Reservoir). Results from the reservoir retention time analysis (2001-2011) indicate that there may be an improvement in reservoir fisheries in some years, given that retention times may increase and reservoir fisheries may respond positively.

GDNR expressed concern to the Service regarding use of the RFPM. Concerns included a) additional analyses that rely on more current fisheries data could lend additional insights, b) the length of time necessary for terrestrial vegetation to colonize previously exposed shoreline may be longer than allowed for in the performance measure, representing a potential future refinement, and c) giving extra weight to re-inundated habitat could be construed as a recommendation to intentionally reduce reservoir levels.

We generally agreed with the first concern, if more current fisheries data were to be provided. However, in GDNR's comments on the Service's DFWCAR (GDNR 2015; Appendix III) they state that the currency of the data may not be the issue as the datasets span a 20+ year timeframe. Instead, the ability of currently-used sampling gears may be limited for this particular data need.

Based on GDNR's observations, we also agree that the length of time necessary for terrestrial vegetation to colonize previously exposed shoreline may be longer, especially for Lanier Reservoir. With regards to weighting re-inundated habitat, the process that was originally used to define optimal reservoir levels for fisheries (the Delphi process) included the following expert opinion from biologists in Georgia, Alabama, and Florida representing State wildlife agencies, power companies, universities, the Service, and the Corps:

> "The fisheries experts noted throughout the survey process that reservoir levels are only part of what affect reservoir fisheries. Spawning will take place at a number of reservoir levels and what matters most are fluctuations from that level, with avoidance of drawdowns during spawning (and rearing) being paramount. However, ideal reservoir levels for spawning (usually full-pool) ensure that the greatest spawning area is available for fish."

The 2013 RFPM takes drawdowns into account by calculating the "minimum" elevation and acreage continuously available for at least 30 days per year. Fluctuations above the minimum do not provide benefits, and 'dips' below the minimum count against the measure for that year. Thus, years with more continuously inundated acreage are considered better and are quantified as such in the performance measure. Finally, the Delphi approach emphasized maximizing "spawning area," but relied on expert opinion to derive water levels and effects of lower levels. The 2013 RFPM improved upon the Delphi approach by using a direct measure of acreage in the calculation.

Following a meeting requested by GDNR (January 15, 2015), we further investigated GDNR's concern regarding the inclusion of re-inundated acreage. We compared RFPM results from existing operations to the alternative submitted by the Service using both including and excluding re-inundated acreage. We found that both alternatives produce similar RFPM results. However, differences between averages and medians for including versus excluding re-inundated acreage techniques, although relatively small, can potentially lead to divergent conclusions regarding the effects to reservoir fisheries.

We requested that GDNR compile information and draft correspondence that can be used to refine the RFPM on January 15, 2015. In GDNR's comments on the Service's DFWCAR (GDNR 2015; Appendix III), they state that most of their concerns surround the use of a single metric for three very different reservoirs (Lanier, West Point, and Walter F. George Reservoirs). Most of the fish habitat at Walter F. George Reservoir is in the form of submerged and emergent aquatic vegetation, versus Lanier Reservoir, and similarly West Point Reservoir, in which the majority of the flooded vegetation is terrestrial. Therefore, reservoir operations may have differing responses to vegetative growth in each of the three reservoirs. We would like to work with GDNR to incorporate refinement to the RFPM. We continue to recommend use of the RFPM until new information is developed and incorporated as appropriate.

Riverine Fisheries

The riverine fisheries analysis includes comparisons to the Service's ecosystem flow guidelines (Service 2011; Appendix VI) and the Chattahoochee River Shoal Bass Recruitment Performance Measure (CRSBPM) (Service 2013; Appendix IX).

Instream Flow Guidelines:

The exceedance graphs supplied by the Corps are not calculated in a manner that is comparable to the Service's ecosystem flow guidelines. The Corps has indicated that they will not be providing additional analyses of the NAA and PAA in the manner requested by the Service. If we have the time to produce comparisons between the NAA and PAA using the ecosystem flow guidelines, they will be integrated in subsequent Service reports.

Chattahoochee River Shoal Bass Recruitment:

The status of Shoal Bass in the Chattahoochee River between West Point Reservoir and Atlanta is less studied than in Chattahoochee River tributaries and the river near Morgan Falls Dam, although habitat appears suitable. Shoal Bass are a warmwater species of black bass native to the ACF Basin; because water temperatures increase to a level that could support a warmwater fishery in river shoals of the mainstem Chattahoochee River from Morgan Falls Dam to West Point Reservoir, Shoal Bass are of interest to natural resource managers. Their co-occurrence with other warmwater species may make them a useful sentinel species for warmwater fish communities. The CRSBPM (Chattahoochee River Shoal Bass Performance Measure) relies on the relationship between Shoal Bass recruitment and water temperature in the spring (Service 2013; Appendix IX). Water temperature decreases as flow increases. The CRSBPM shows that the PAA results in higher abundance (catch per unit effort) of shoal bass than the NAA.

The CRSBPM is used to quantify effects of the NAA and PAA on shoal bass recruitment from Morgan Falls Dam to West Point Reservoir. In GDNR's comments on the Service's DFWCAR (GDNR 2015; Appendix III), they state that using water temperature as the driving factor related to shoal bass abundance is appropriate for the upper stretch of the Morgan Falls tailwater. They state that thermal impacts below Peachtree Creek are likely minimal to shoal bass reproduction and recruitment in normal years. Despite this, shoal bass abundance appears to be limited between Peachtree Creek and West Point Reservoir and it is possible that there are additional limiting factors that should be addressed and considered when using the CRSBPM to inform flow regimes. GDNR states that this measure should be updated as new information becomes available.

It should be noted that the CRSBPM results generated by the Corps use simulated water temperatures from the HEC-5Q model. HEC-5Q provides consistently lower values for seasonal mean temperatures (~2° Celsius at flows less than 1000 cfs) than observed data at Atlanta (Corps 2014); the CRSBPM developed by the Service used observed data. Although HEC-5Q produces lower temperatures as a function of discharge than the Service's methodology used to develop the CRSBPM, the Shoal Bass abundance trend should remain the same.

Federally-protected Species in the Apalachicola River

Gulf Sturgeon:

The following analyses were requested in the Service's 2010 PAL (Appendix V) and recommended in the Service's 2013 PAL (Appendix IX). In addition, the Service's 2013 PAL also recommended use of the Sturgeon Spawning Habitat Performance Measure (SSHPM). Following the analysis descriptions below (in italics), we provide a summary of available information and identify remaining information gaps.

Frequency (% of days) of Gulf Sturgeon spawning habitat availability (acres of potentially suitable spawning substrate inundated to depths of 8.5 to 17.8 feet) on each day March 1st through May 31st, at the two sites that support spawning. The Service's 2013 PAL provided the SSHPM as an addition to the analyses recommended in the Service's 2010 PAL. The Corps indicated that they used the SSHPM and concluded that there were no differences between the NAA and PAA based on the median annual spawning habitat availability. The SSHPM results were not provided to us, so we are unable to evaluate effects beyond the median at this time.

Frequency (% of years) of Gulf Sturgeon spawning habitat availability (maximum acres of potentially suitable spawning substrate inundated to depths of 8.5 to 17.8 feet for at least 30 consecutive days each year), March 1st through May 31st, at the two sites that support spawning. The SSHPM computes the annual spawning habitat available for 30 days, and plots the distribution of annual spawning habitat as boxplots. The distribution of data displayed by the SSHPM informs interpretation of annual spawning acreage frequency. Therefore, the SSHPM results should be prepared, shared, and incorporated to help inform an interannual analysis of sturgeon spawning habitat effects.

Daily fall rates with respect to exposure of Gulf Sturgeon eggs and larvae. Regarding daily fall rates, the Corps referenced the daily fall rate results provided for mussels. Mussel fall rate results are specific to flows less than 10,000 cfs all year for every year. Furthermore, as referenced in the Service's 2013 PAL, the maximum amount of sturgeon spawning habitat available occurs between 10,000 and 50,000 cfs, a range not encompassed by the fall rates computed for mussels. We recommend that the analysis be specific to the sturgeon spawning and early life stages that include the larger range of flows that encompass sturgeon spawning.

Maximum number of consecutive days per year less than 16,000 cfs. The Corps referenced the mussel analysis that evaluates the maximum number of days per year with flows less than 10,000 cfs. The maximum number of consecutive days <16,000 cfs was calculated because discharges <16,000 cfs cause estuary salinity levels to increase above 10 ppt at some locations, thereby creating suboptimal conditions for juvenile Gulf Sturgeon growth at those locations. This analysis was not provided and therefore, we cannot evaluate differences between the PAA and NAA for this metric.

Departures from average water temperatures between March 1st to May 31st. The Corps referenced the HEC-5Q water temperature differences from the NAA, for a year-round composite period (2001-2011). Other data referenced by the Corps include analyses during May-October for a composite period (2001-2011) and all year types. These analyses show no difference between the NAA and PAA below JWLD. Although the March 1st to May 31st period wasn't specifically evaluated, these results suggest that there are no temperature differences in average water temperature between March 1st and May 31st.

Freshwater Mussels:

Low flows in the Apalachicola River have the potential to reduce habitat, and expose and strand freshwater mussels. Lower flows may result in changes in flow energy, dissolved oxygen, water temperatures, and differences in availability of suitable substrate and food. Thus, we requested that the Corps provide several low flow analyses, similar to those provided in the 2008 and 2012 biological opinions (Service 2008, Service 2012). The following analyses were requested in the Service's 2010 PAL (Appendix V) and were recommended again in the Service's 2013 PAL (Appendix IX). The Service's 2013 PAL also recommended use of the Apalachicola River Mussel Performance Measure (ARMPM), which is included in the analyses below. Following the analysis descriptions below (in italics), we provide a summary of available information.

Lowest daily flow for each year. The effects to mussels are more extreme at the lower range of flows. In the Apalachicola River, federally-listed mussel species are generally known to occur from JWLD [located at approximately River Mile (RM) 106] down to lower reaches, with the highest densities currently located from approximately RM 50 to RM 34. When considering flows less than 6,000 cfs, PAA annual minimum flows were lower than the NAA by more than 50 cfs in 10 years, greater in 5 years, and similar in 11 years. When considering the entire period of record (1939-2011), the PAA resulted in lower annual minimum flows than the NAA in 38 years, identical annual minimum flows in 13 years, and greater annual minimum flows in 22 years. During the 2007 drought, PAA flows were projected to be lower (4,550 cfs) than the NAA (5,050 cfs). These results demonstrate that overall annual minimum flows under the PAA are lower, and in droughts they are likely to be more extreme.

Inter-annual frequency of flows less than 5,000-10,000 cfs;
Maximum number of days per year with flows less than 5,000 – 10,000 cfs; and
Maximum number of consecutive days less than 5,000 – 10,000 cfs. These three metrics showed similar trends. The percent of years when flows were below 5,000-6,000 cfs, 6,000-7,000 cfs, and 7,000-8,000 cfs is greater under the PAA. The maximum number of days/year and the maximum number of consecutive days per year that flows are less than 5,000 cfs is approximately 35 days greater under the PAA. These results demonstrate that the PAA results in more frequent lower flows that remain low for longer periods compared to the NAA, thereby creating conditions that could increase mortality of both common and federally-listed mussels.

Median number of days per year less than 5,000 – 10,000 cfs; and
Median number of consecutive days per year less than 5,000 – 10,000 cfs (added to the ARMPM). The PAA and NAA were similar, although at flows between 7,000-10,000 cfs the PAA had a slightly greater median number of days per year. Because the median is a measure of central tendency, these results demonstrate that the PAA and NAA perform similarly when considering a large range of hydrologic year types. However, the PAA's trend of slightly lower medians in relation to the NAA mirrors that of the previous set of metrics, thereby creating conditions that could increase mortality of both common and federally-listed mussels.

Frequency (percent of days) of daily stage changes (ft/day); and

Frequency (percent of days) of daily stage changes (ft/day) when releases at Woodruff Dam are less than 10,000 cfs. River stage fall rates were examined because rapidly declining river stages have the potential to increase the risk of mussel exposure and stranding. The Corps did not evaluate the former, which includes the entire range of flows, because federally-listed mussels generally do not occur at stages higher than those equivalent to 10,000 cfs. The Corps' histogram comparing fall rates for the NAA and PAA for the modeled period of record (1939-2011) below JWLD when releases are less than 10,000 cfs indicate a high degree of similarity, with the ≤ 0.25 ft/day category comprising the largest proportion of fall rates. The NAA had approximately 450 more days when fall rates were ≤ 0.25 ft/day. The PAA had approximately 400 more days in the higher fall rate categories compared to the NAA. Collectively, the fall rate results indicate that the PAA results in flows that have a higher potential to strand mussels. These results may reflect the Corps' fall rate modification as part of the PAA. When basin inflow has been less than 7,000 cfs for 30 days, the use of the 0.25 ft/day fall rate will be suspended and will be resumed when basin inflow has been greater than 10,000 cfs for 30 days. The slow rate of federally-listed mussel recolonization into re-inundated habitat means that few mussels occupy habitats that were exposed over the previous 30 days. Slow ramping rates for declining flows that would expose these recently re-inundated habitats may provide limited benefits to mussels, and may come at a cost to reservoir storage.

National Wildlife Refuges and Fish Hatcheries

The Service requested several analyses of impacts to Eufaula National Wildlife Refuge (NWR) and hatcheries (Service 2010; Appendix V), and an evaluation of potential management options that could benefit Eufaula NWR. In response to that request, the Corps provided the following (Corps 2015a):

> *Eufaula NWR:* "The USACE considered the USFWS request to cycle Walter F. George Lake between the highest levels (190 ft) in late winter/early spring to the lowest levels (185 ft) in late summer to accommodate Eufaula National Wildlife Refuge operations (Figure 2.8-1). As proposed, the option would require operation of the reservoir at its highest pool levels during winter-spring, when flood releases are typically the greatest. That would reduce the ability of the project to attenuate approximately 87,000 ac-ft of potential downstream flooding. By holding the reservoir higher during the winter wet season, induced surcharge and damaging downstream flows are increased, resulting in bank erosion and channel modifications below the project. Similarly, to operate the project at its lowest levels during the summer is contrary to what is required to meet the highest demands for recreation, hydroelectric power, and flow augmentation. Essentially, such an option would remove Walter F. George Lock and Dam from the system approach to operations across the basin and eliminate approximately 100,000 ac-ft of conservation storage that could be used to meet authorized project purposes in the summer. Given the demands of the system, including the minimum flow provisions of the RIOP, the proposed operation would have significant adverse effects on the authorized project purposes and the structural stability and safety of the dam. For these reasons, operations to manage Walter F. George Lake to benefit the Eufaula Wildlife Refuge operations were not considered further."

> *Fish Hatcheries:* "Four major fish hatcheries are in the ACF Basin. Buford Trout Hatchery is the only fish hatchery in the ACF Basin that relies on surface flows for its operations, and it is the largest user of water. Changes in flow on the Chattahoochee River are negligible between alternatives, and would not be expected to affect operations at the Buford Trout Hatchery (Figure 2.8-3)."

Buford Trout Hatchery withdraws about 7 mgd (11 cfs) of flow from the Chattahoochee River below Buford Dam year-round (Corps 2011). In their comments on the DFWCAR, GDNR has clarified that this is a pass-through system and the net withdrawal of water is limited to evaporation, thus is negligible on downstream flows (GDNR 2015; Appendix III). It appears from the Corps' analysis of median daily flows below Buford Dam that changes in flow are negligible between alternatives; however, the period of record is not specified but should be provided. We also suggest that flows below the median be analyzed, as they are more likely to impact the hatchery than median flows. The results of the HEC-5Q water quality modeling indicate only minor changes in water temperature and dissolved oxygen at this location as a result of the PAA in comparison to the NAA.

Analyses of Apalachicola Bay

We used a combination of sources to evaluate effects to Apalachicola Bay. The Corps provided the Apalachicola Bay salinity model results from HydroLogics (2012) that included a comparison between the RIOP and proposed changes to the RIOP described in the February 2012 Biological Assessment by the Corps of Engineers. HydroLogics found very limited differences between the two operational scenarios. The Service previously relied upon the University of Florida's 3D hydrodynamic salinity modeling for Apalachicola Bay to interpret effects to salinities, oysters, and juvenile sturgeon. Because of the length of time necessary to conclude the University of Florida 3D hydrodynamic salinity modeling in Apalachicola Bay, it was not possible to include those results in this report. However, if results become available, we will provide them in the future. In place of those results, however, we identify three lines of evidence that suggest differences between the NAA and PAA:

> 1) The Apalachicola Bay Salinity Performance Measure (ABSPM) shows no difference in salinities between the NAA and PAA at Cat Point and Dry Bar, but a 1.0 ppt increase in the median salinity at East Bay;
>
> 2) Low flows in the Apalachicola River at the Chattahoochee gage are lower in the PAA than in the NAA. Differences in low flows most likely manifest themselves in relatively minor salinity shifts, but may exceed salinity thresholds for juvenile Gulf Sturgeon and oysters; and
>
> 3) The range of flows used previously in the hydrodynamic salinity model [2011 Alternative 2 (Alt2)] are similar to the PAA, and the 2011 Alt2 resulted in slightly slower, but nearly identical, oyster growth rates at Cat Point compared to the 2011 NAA. It also resulted in lower acreage suitable for juvenile sturgeon compared to the 2011 NAA. Each of these lines of evidence is treated in the subsections below.

ABSPM. The ABSPM is described fully in the Service's 2013 PAL (Appendix IX). In that document we state, "Differences among the alternatives that we have analyzed to date are relatively minor. This may be due to the coarse temporal scale of the metric or the possibility that substantial changes in the bay salinity metric require large amounts of water...” We continue to view the ABSPM as a coarse metric and expect that additional statistical approaches currently unavailable to us may help the Corps and Service decipher whether different results are *statistically* different or meaningful. We also suggest that fine resolution models of bay salinities also show little salinity difference between alternatives previously considered (Sheng et al. 2011; Appendix XII). The Service calculated the ABSPM using the Corps’ 2015 data. Results show that there is no predicted salinity difference between the PAA and NAA at Cat Point or Dry Bar, and a 1.0 ppt increase in the median at East Bay (Figure 3). Although the East Bay salinity increase seems relatively minor, it resulted in a larger portion of modeled salinities exceeding the 10 ppt optimal salinity for juvenile sturgeon (see the greater 50th-75th percentiles for East Bay in Figure 3).

Estuary inflow analysis. Salinities in the estuary increase as Apalachicola River discharge decreases (Service 2013; Appendix IX). We evaluated changes in estuary inflows using results from the ARMPM which specifically evaluates differences between the NAA and PAA at a range of low flows. A description of the results is provided in the freshwater mussel section. In summary, the PAA results in higher percent of years when flows are < 5,000 cfs, < 6,000 cfs, < 7,000 cfs, and < 8,000 cfs, and a ~35 day increase in the maximum number of consecutive days per year when salinities are < 5,000 cfs. Discharge decreases are of concern for mussels and the bay. The salinity difference between inflows of 5000 cfs and 8000 cfs is 1.6 ppt at Cat Point, 1.5 ppt at Dry Bar, and 2.6 ppt at East Bay (Table 1). We stress that the trendlines upon which the salinity estimates are based account for a large proportion of the variance in the discharge salinity relationship. However, the University of Florida 3D modeling should provide a better spatial depiction and quantification of impacts to salinity throughout the estuary. That said, although it appears that changes in discharge at low flows manifest themselves in relatively minor salinity shifts in magnitude at these monitoring points, these shifts may exceed the salinity thresholds we identified in our 2013 PAL (Service 2013; Appendix IX).

Table 1. Apalachicola Bay salinities (ppt) predicted by the salinity-discharge relationships in the ABSPM.

Chattahoochee Gage Discharge (cfs)	Cat Point	Dry Bar	East Bay
5000	26.6	25.0	15.6
6000	26.1	24.5	14.6
7000	25.6	24.0	13.8
8000	25.0	23.5	13.0
9000	24.6	23.0	12.2
10,000	24.1	22.6	11.5

Hydrodynamic salinity model. During the evaluation of alternatives in 2011, we used a 3D curvilinear-grid hydrodynamic salinity model to simulate the flow and salinity dynamics inside Apalachicola Bay (Sheng et al. 2011; Appendix XII). The modeling effort (described below) that we anticipate including in this report is the same as the one developed in 2011, but with a revised inflow dataset. The 2011 salinity modeling considered years 1999-2008. The range of flows used previously in the hydrodynamic salinity model (2011 Alt2) are similar to the 2015 PAA. Using the inflow data from the 2011 modeling, we compared estuary salinities (from the ABSPM) to the 2015 PAA for the 1999-2008 period of record. We found that the 2015 PAA produced similar salinities to those generated from the 2011 Alternative 2 based on salinity responses at Cat Point, Dry Bar, and East Bay (Figure 4). Consequently, we expect that the 3D salinity model for the 2015 PAA may produce similar salinity and oyster growth rate results as the 2011 Alt2. The 2011 Alt2 3D salinity model resulted in slightly higher, but nearly identical, salinities at Cat Point and Dry Bar. Salinity changes resulted in a 0.10 mg ash free dry weight (AFDW)/oyster/day decreased growth rate (a 7.1% decrease) at Cat Point compared to the NAA, and a 0.02 mg AFDW/oyster/day increased growth rate (a 0.8% increase) at Dry Bar (based on a comparison of means for all months). It also resulted in less acreage considered suitable for juvenile sturgeon at Cat Point and Dry bar during dry, average, and wet years. Effects to juvenile Gulf Sturgeon in East Bay were not evaluated using the 3D hydrodynamic salinity model because the model overpredicts salinities in East Bay (Sheng et al. 2011; Appendix XII).

The following information was included in the Service's 2011 DFWCAR and is relevant to the interpretation of Apalachicola Bay salinity modeling and oyster and sturgeon responses:

> "The model showed satisfactory performance with observed salinity collected by the Apalachicola National Estuarine Research Reserve in 2004. Specific details on model development and performance are provided in the report. The authors also developed an oyster population dynamic model similar to the one described by Wang et al. (2008), and coupled it with the hydrodynamic-salinity model to assess the impact of freshwater alteration on oyster populations in Apalachicola Bay. Four discharge scenarios were considered in the 10 year (1999-2008) simulations: 1) observed data from the USGS gaging station 02359170 near Sumatra, Florida, 2) no action alternative (i.e., current operations), 3) proposed alternative minimum flow scenario 1 (550 cfs target at Peachtree Creek), and 4) proposed alternative minimum flow scenario 2 (750 cfs target at Peachtree Creek).
>
> The Service requested that the authors provide various analyses of model output specific to oysters and Gulf sturgeon with the assumption that optimal salinities for oysters are less than 26 ppt (Livingston et al. 2000; Huang 2010), and juvenile Gulf sturgeon require salinities less than 10 ppt (Altinok and Grizzle 2001; Sulak et al. 2009). To assess the impacts of the four discharge scenarios on oysters, we requested that comparisons be made at Dry Bar (an oyster bar with strong river influence) and Cat Point (an oyster bar with little river influence). These analyses included salinity exceedance probabilities, summary statistics and exceedance probabilities for oyster growth rates, and salinity contour maps with associated acreages for the total number of days when salinity exceeded 26 ppt in a wet, dry, and average year. For Gulf sturgeon, we requested salinity contour maps describing the total number of days salinity exceeded 10 ppt from 1 October- 31 March for the following years for all 4 scenarios in a dry, wet, and average year.
>
> Analyses indicate that there will be no appreciable difference in the magnitude or timing of estuary freshwater inflow between the no action and proposed action alternatives

> (Sheng et al. 2011). There is little difference in salinity or oyster growth rates in any of the various analyses.
>
> These effects on the bay relative to historic operations result from changes in the volume and timing of freshwater inflow due to the reservoir operations of the RIOP and the proposed WCM alternatives, and less so to apparent changes in consumptive water uses. Historic basin inflow rates (the Corps' reported daily project inflow data) from 1976 to 2008 are roughly equivalent with the basin inflow data used in the modeled scenarios (unimpaired flow minus consumptive water uses), and the modeled basin inflow data is actually slightly higher overall (period-of-record average daily basin inflow values are 34 to 103 cfs greater) than the historic data. Therefore, the differences in the bay salinity results do not appear related to any simulated increase in consumptive water demands. However, average annual releases (1976-2008) from Woodruff Dam are about 400 to 500 cfs less than historic under the no-action and proposed alternatives, and average monthly composite reservoir storage is about 35,000 to 111,000 acre feet greater than historic levels in the months of August through October. Although salinities and oyster growth rates are similar between the no action and proposed action alternatives, all model outputs indicate that flows will continue to be lower than what historically and even recently occurred (i.e., pre-IOP in 2006) and thereby continuing suboptimal conditions for oysters, Gulf sturgeon, and other fish and wildlife in Apalachicola Bay.
>
> In their May 23, 2011, correspondence to the Service, FFWCC states that there should be additional analyses of the impact of proposed and existing operations on juvenile Gulf sturgeon in Apalachicola Bay. They generally agree with the conclusions contained in the Apalachicola Bay section of the Service's DFWCAR, but would like to see additional details about potential impacts to estuarine sentinel species, such as eastern oysters or white shrimp. The Service agrees with FFWCC that additional datasets should be sought or generated to quantify impacts to juvenile Gulf sturgeon, eastern oysters, white shrimp, and other species. The Service searched for additional analyses and new datasets prior to drafting the PAL but located few. Thus, the Service welcomes additional information that FFWCC can provide to assess impacts of proposed and existing operations.
>
> FFWCC also states that the DFWCAR should address the minimum flows needed to mitigate the impacts of saltwater incursion due to sea level rise. Thus, we recommend that the Corps capitalize on existing datasets to evaluate the effects of sea level rise on estuary-riverine salinities, and to quantitatively evaluate the discharges required to minimize saltwater incursion. This modeling effort should include both short- and long-term planning horizons."

The Service agrees with FFWCC's 2011 comment that additional biological information should be sought to inform an assessment of impacts associated with proposed and existing operations. We requested additional information from FFWCC on November 13, 2013, and continue to welcome additional quantitative relationships between salinity and the biology of the Apalachicola Bay.

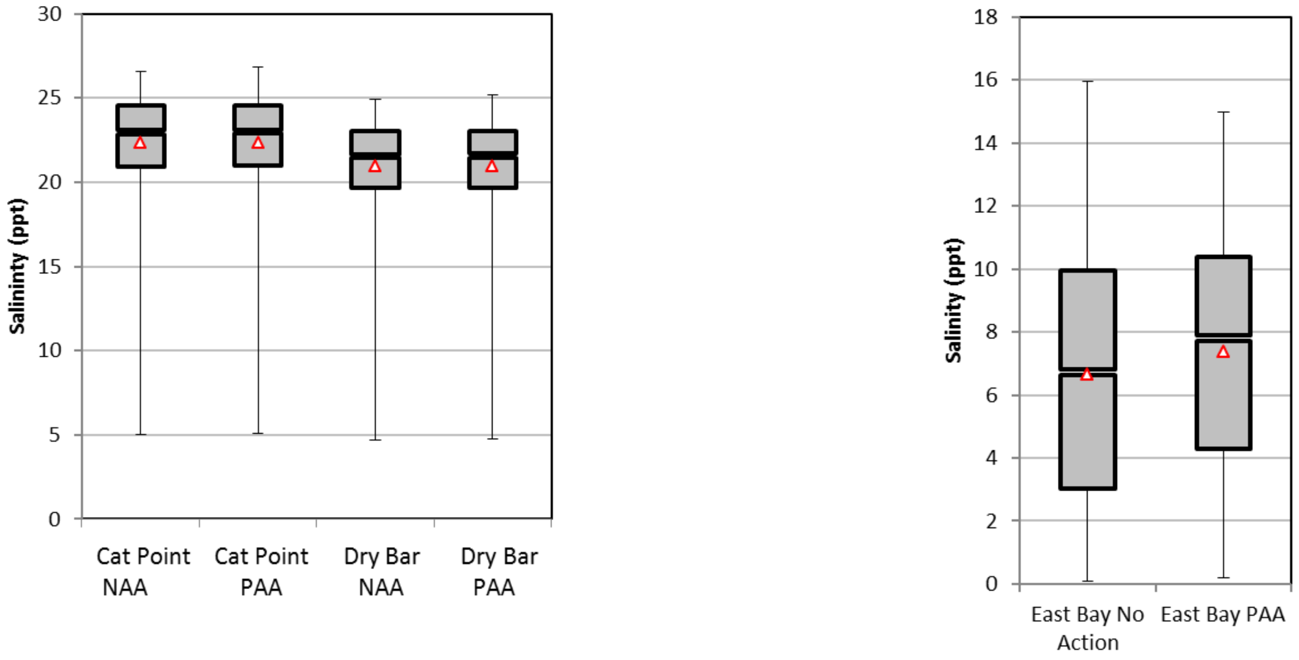


Figure 3. Salinity results for the Apalachicola Bay Salinity Performance Measure (ABSPM) for the NAA and PAA. These data include 1939-2008.

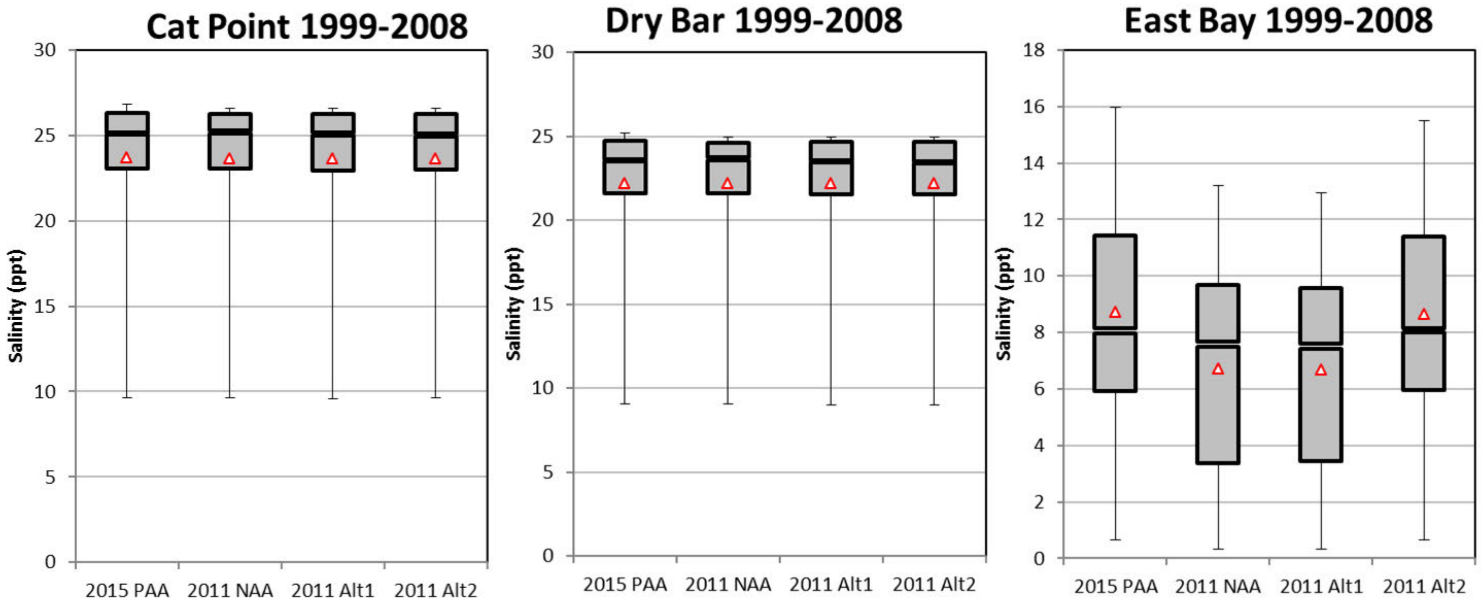


Figure 4. Salinities as predicted from the ABSPM for the PAA in 2015 and for comparison, the alternatives proposed in 2011. The period 1999-2008 represents the period used in the 2011 estuary modeling, which showed no difference between the NAA, 2011 Alt1, and 2011 Alt2.

EVALUATION OF THE SELECTED PLAN

The purpose of this section is to evaluate the relative merits of the NAA and PAA and ultimately determine their acceptability from the standpoint of the Service's responsibilities under the FWCA and our mission to conserve, protect, and enhance fish and wildlife resources. To that end, we succinctly describe the impacts of the PAA relative to the NAA in terms of each biological and/or habitat parameter considered. Each parameter is described as an improvement (+), a negative impact (-), or no change (0) over the NAA, regardless of the magnitude of the difference between the NAA and PAA. We emphasize that this approach is one method to evaluate the PAA, and it is not meant to be the sole deciding factor in the Service's evaluation. Rationales for the individual assignment of signs are provided in the text below Table 2. The Corps provided the Service limited interpretation of their analyses in their 2015 response to the Service's PAL (Corps 2015a); the evaluation below is solely based on the Service's interpretation.

Table 2. Scoring of impacts to fish and wildlife resources resulting from the Corps' PAA relative to the NAA. The PAA is better (+), worse (-), or the same (0) as the NAA for fish, wildlife or habitat. NAE indicates that the Corps has not adequately evaluated the parameter or the analysis is ongoing, and N/A indicates that the analysis is not applicable. All symbols are applicable to the reach below the dam, except variables shaded in grey are applicable to the reservoir upstream from the dam.

	Buford	West Point	W.F. George	J. Woodruff
Dissolved Oxygen	-	0	0	0
Temperature		0	0	0
Coldwater fishery	-	N/A	N/A	N/A
Warmwater fish community	+	0	0	0
Wastewater	-	-	-	-
Chlorophyll-*a*	-	-	-	-
Reservoir Retention Time	NAE	NAE	NAE	NAE
Phosphorus	-	-	-	-
Floodplain connectivity:				
Chattahoochee	0	0	0	N/A
Apalachicola	N/A	N/A	N/A	0
Reservoir Fisheries	0	0	0	N/A
Riverine Fisheries				
Shoal bass	+	N/A	N/A	N/A
Flow guidelines	NAE	NAE	NAE	NAE
Salinity	N/A	N/A	N/A	-
Gulf sturgeon	N/A	N/A	N/A	NAE
Freshwater mussels	N/A	N/A	N/A	-
Eufaula NWR	N/A	N/A	0	N/A
Buford Fish Hatchery	0	N/A	N/A	N/A

Dissolved Oxygen

Higher dissolved oxygen levels are considered to be better for fish and invertebrates, but frequently fell below State standards for both the NAA and PAA below Buford Dam, West Point Dam, and WFGLD. For the composite period, compared to the NAA, the PAA exhibited lower dissolved oxygen levels immediately below Buford Dam and then transitioned to similar dissolved oxygen levels below Atlanta. However, the differences between the alternatives were small and occurred at low occurrence levels, meaning that both the NAA and PAA frequently provide poor conditions for fish and wildlife.

Water Temperature

Temperatures were expected to be similar throughout the ACF Basin, with differences between the NAA and PAA fluctuating between -0.25 and 0.5°C for the composite period. However, when normal, wet, and dry years are separated, the PAA shows the most drastic deviation from the NAA from Norcross to West Point Reservoir. In this reach, temperatures under the PAA were expected to warm up to ~0.5°C from the NAA with the greatest temperature difference exhibited between Atlanta and West Point Reservoir. The following fisheries information is taken largely from Georgia Power Company (2006):

Historically a warmwater river, the mainstem Chattahoochee River tailrace became an artificially created coldwater river following the construction of Buford Dam. Bottom releases from Buford Dam create coldwater releases suitable for a non-native brown (*Salmo trutta*) and rainbow trout (*Oncorhynchus mykiss*) fishery in a 48-mile section of river extending downstream to Peachtree Creek.

GDNR has historically stocked this section of river with rainbow and brown trout and manages the trout fishery in two distinct segments: the Buford Dam tailwater extending 30 river miles downstream to Georgia Highway 400; and the Morgan Falls Dam tailwater extending 12 miles downstream to Peachtree Creek. The first segment is colder with greater flow fluctuations and the second segment is warmer with less fluctuations.

Water temperature is of great concern to GDNR in this section of the Chattahoochee River. They are very interested in maintaining the cold temperature regime for the trout fishery, the most popular sport fishery in this section of the Chattahoochee River. They report that high summer water temperatures potentially detrimental to trout have been occurring more frequently in recent years in the Morgan Falls Dam tailwater, and that nonpoint stormwater runoff from impervious surfaces in tributary watersheds appears to contribute to these conditions. In GDNR’s comments on the Service’s DFWCAR (GDNR 2015; Appendix III), they note that increased water temperatures will have different impacts on the trout population depending on the distance from Buford Dam. As an example, GDNR states that temperature is not expected to be of concern at Buford Trout Hatchery, located approximately two miles downstream of Buford Dam, except for possibly an increased frequency of 2-unit generations during the fall pre-turnover period, when water drawn from the thermocline of Lanier Reservoir can lead to drastic temperature increases in a short time, leading to shock. Currently a concern during summer months, south of the Norcross gage small temperature increases may lead to localized stress and mortality if water temperature exceeds 22ºC for any considerable length of time.

As summer maximum water temperatures have become more marginally suitable for trout, GDNR has diversified its management objectives downstream of Morgan Falls Dam to include restoration of native shoal bass (*Micropterus cataractae*), a warmwater bass species endemic to the ACF River basin. Under the NAA, GDNR considers the reach to be a transition zone capable of supporting both coldwater and warmwater fisheries and initiated a stocking program for shoal bass in the reach of the Chattahoochee River below Morgan Falls Dam. GDNR, along with other State and Federal agencies including ADCNR, the Service, and the National Park Service (NPS) have been involved with restoration and research activities to improve the status of the species.

GDNR has also reintroduced striped bass (*Morone saxatilis*) into what is now West Point Reservoir. Striped bass restoration in the ACF Basin is a collaborative effort between the conservation agencies in Georgia, Alabama, Florida, and the Service, with the goal of restoring a self-sustaining population to the maximum extent possible. The group meets on an annual basis to set goals and discuss ongoing management and research for striped bass in the ACF system. West Point Reservoir is currently designated as a potential broodfish repository and is one of the highest priority reservoirs to receive stocked striped bass.

Because striped bass exhibit upstream migrations to spawn in riverine conditions, a striped bass fishery has developed in the Chattahoochee River downstream of Morgan Falls Dam, the first upstream barrier to striped bass migrating upstream from West Point Reservoir. Persistence of a small population in West Point Reservoir suggests that striped bass in the river are capable of limited natural reproduction. However, coldwater releases from Buford Dam during the spring spawning period of striped bass, and abrupt decreases in water temperature that occur with Buford Dam peaking operations, have been identified as critical factors inhibiting striped bass spawning and adversely affecting survival of eggs and larvae in the upper Chattahoochee River near Morgan Falls Dam (Hess and Jennings 1999). GDNR clarified in their comments on the Service's DFWCAR that Hess and Jennings (1999) also mentioned low flows as another potential inhibiting factor to reproduction (GDNR 2015; Appendix III). Striped bass movement upstream to Morgan Falls increases as summer progresses, indicating that the water temperatures in the summer serve as a coolwater refuge. GDNR-WRD considers this "coolwater refuge" effect to be of significant importance to the survivability of adult striped bass.

Because the PAA exhibits slightly warmer water temperatures below Buford Dam to Norcross, the PAA is less favorable than the NAA for the coldwater fishery. Water temperatures are warmer between Whitesburg and West Point, which is an improvement for the warmwater fish community including shoal bass. The Service proposes that elements of both a cold-cool water and warmwater fishery potentially could be supported if water quality and flows are improved. The PAA has the potential to benefit the warmwater fishery without compromising the coldwater fishery strictly from a temperature aspect.

Wastewater

The NAA and PAA model results were similar along the longitudinal river profile within each scenario, with the average stream percent wastewater in the PAA model output typically greater than the NAA. These modeled results suggest that the PAA would be slightly less favorable than the NAA.

Chlorophyll-*a*

Chlorophyll-*a* is correlated with algal biomass, which may cause nuisance conditions in aquatic ecosystems. Chlorophyll-*a* was higher in the PAA than the NAA throughout the river system, but differences were relatively small. This indicates that the PAA is slightly less favorable when compared to the NAA.

Reservoir Retention Time

Higher retention rates may result in decreased reservoir water quality. We requested average summer retention times at each Corps reservoir. Data were provided in hard copy, tabular format for each month. At West Point Reservoir, June through August retention times were generally similar between the NAA and PAA between 2001 and 2011. However, qualitative evaluation of the PAA showed higher retention times in 2002 (max= 9 days higher in August), 2006 (max= 42 days higher in July), 2008 (max= 5 days higher in August), and 2009 (max= 27 days higher in August). We request the average summer retention time data be summarized by the Corps for each of the Corps reservoirs to facilitate quantitative comparisons; therefore, we are not currently able to evaluate the PAA in comparison to the NAA.

Phosphorus

Algal growth is stimulated by increases in phosphorus. Thus, phosphorus levels were modeled and compared between the NAA and PAA. Total phosphorus loads at both of the selected locations, the headwaters of West Point Reservoir and Walter F. George Reservoir, both increased in the PAA when compared to the NAA. Any differences observed between the PAA and NAA in the longitudinal profiles resulted in higher total phosphorus levels in the PAA.

Floodplain Connectivity- Chattahoochee and Apalachicola Rivers

The Service developed the Floodplain Spawning Habitat Performance Measure (FSHPM) to assist in this evaluation. The measure calculates the maximum amount of spawning habitat available for at least 30 consecutive days during the months of April through October. It is unclear whether the Corps used the FSHPM to develop the graphical comparison. As described by the Corps, it is unknown whether they calculated *consecutive* days. The Corps used the period from April through September, not April through October as specified by the FSHPM.

Apalachicola River floodplain connectivity, evaluated using the annual maximum 30-day acreage during the April through September growing season, is nearly identical between the NAA and PAA. Chattahoochee River floodplain connectivity would be expected to be nearly identical between the NAA and PAA; conditions in the NAA would be very similar to the PAA as the Chattahoochee River is currently essentially disconnected from its floodplain.

Indicated previously, the Corps has not yet provided output from the ecosystem flow guidelines for the comparison of the NAA, PAA, and pre-Buford period. The Corps should provide output from the ecosystem flow guidelines for the comparison of the NAA, PAA, and pre-Buford period.

Reservoir Fisheries

RFPM differences between the NAA and PAA were generally small, suggesting low potential for realized fisheries differences between the two alternatives.

Riverine Fisheries

It appears the riverine fisheries analysis provided by the Corps relied on percentiles that do not separate low and high flows. Output from the revised ecosystem flow guideline methodology recommended in the Service's PAL addendum (Service 2011; Appendix VI) has not yet been provided by the Corps for the comparison of the NAA, PAA, and pre-Buford Dam period. Therefore, the Corps should provide output from the revised ecosystem flow guidelines for the comparison of the NAA, PAA, and pre-Buford Dam period.

The CRSBPM shows that the PAA results in higher abundance of Shoal Bass than the NAA. This may indicate that for the river section upstream from West Point Reservoir, conditions are more favorable for the native warmwater fish community. Based on modeled water temperatures, there are small anticipated effects to the coldwater fish community below Buford Dam.

In addition, we requested daily fall rates with respect to exposure of Gulf Sturgeon eggs and larvae. Although daily fall rates are applicable to Gulf Sturgeon, they are also relevant to riverine and floodplain fishes in the Apalachicola River. We did not receive an analysis of daily fall rates for Gulf Sturgeon. This analysis should be completed in order to provide a more thorough evaluation of effects to the Apalachicola River and floodplain fishes. Should fall rates be higher under the PAA, the PAA would be less preferable because they may result in less floodplain connectivity, resulting in more floodplain stranded fishes of all ages and smaller year classes. Effects to fishes are also implicated in the FSHPM above.

Federally-protected Species in the Apalachicola River

Gulf Sturgeon

Effects to Gulf Sturgeon were not adequately assessed, as described in the *Project Impacts & Evaluation Methodology* section above. For the Service to adequately assess the Corps' future determination of the proposed action under the ESA, we will need to review suitable analyses of the effects of the proposed action.

Freshwater mussels

The only freshwater mussel analysis was for the river segment below JWLD. The PAA results in lower flows that remain low for longer periods compared to the NAA, thereby creating conditions that are less hospitable for mussel communities, including federally-listed mussels.

Mussel population viability is intricately tied to host fish density (Watters 1997; Haag and Warren 1998). Because many of the fish species dependent on the floodplain serve as host fish to freshwater mussels in the Apalachicola River, freshwater mussels may also be impacted by fall rates that occur at higher flow magnitudes. Although high flow fall rates were not evaluated, other mussel indicators show negative impacts to freshwater mussels, making the PAA less preferable for mussels.

National Wildlife Refuges and Fish Hatcheries

Eufaula NWR

The Service had requested the examination of alternate Walter F. George Reservoir management strategies to accommodate the request and freshwater needs of Eufaula NWR. The Corps indicated that they are unable to meet that request, meaning that there is no change in reservoir levels and therefore, no change to Eufaula NWR.

Fish Hatcheries

Buford Fish Hatchery relies on a freshwater intake below Buford Dam to support fish rearing. There is similar water availability for Buford Fish Hatchery for both alternatives. Dissolved oxygen levels and temperatures were nearly identical. Therefore, effects of the PAA on Buford Fish Hatchery are the same as the NAA.

Analyses of Apalachicola Bay

Several lines of evidence suggest that the PAA may result in greater Apalachicola Bay salinities when compared to the NAA. The ABSPM shows no difference in salinities between the NAA and PAA at Cat Point and Dry Bar, but a 1.0 ppt increase in the median salinity at East Bay. Additionally, low flows in the Apalachicola River at Chattahoochee are lower in the PAA than in the NAA. Differences in low flows most likely manifest themselves in relatively minor salinity shifts, but may exceed salinity thresholds for juvenile Gulf Sturgeon and oysters. In addition, the range of flows used previously in the University of Florida's hydrodynamic salinity model [2011 Alternative 2 (Alt2)] are similar to the PAA, and the 2011 Alt2 resulted in slower oyster growth rates at Cat Point compared to the 2011 NAA, and lower juvenile sturgeon acreage compared to the 2011 NAA.

FISH AND WILDLIFE CONSERVATION MEASURES AND RECOMMENDATIONS

The intent of this section is to identify measures that should be taken to prevent the loss of or damage to fish and wildlife resources and to provide for the improvement of such resources. In the Service's 2010 PAL and 2011 PAL addendum, we identified resources and analyses that would be necessary in order to address planning objectives. Although some planning objectives were addressed by Corps analyses as described in prior sections, several were not adequately addressed. We review our current understanding of the Corps' position on each issue (italicized text) and note whether the planning objectives were adequately addressed. Those planning objectives that were not adequately addressed are conveyed here as conservation measures, or recommendations, that should be taken to reduce impacts and benefit fish and wildlife (Table 3).

The conservation measures provided in the Service's 2011 DFWCAR included the development of an alternative or a suite of alternatives that would maximize benefits to fish and wildlife resources in light of other project purposes. The Corps indicated that it is difficult and labor intensive to try alternative management scenarios, and as such, we encouraged the Corps to investigate alternative models that enable greater flexibility in model use and alternative development, while retaining the utility of HEC-ResSim (Service 2011).

We investigated a suite of operational alternatives that could provide benefits to fish and wildlife resources; a Service-developed alternative was provided to the Corps as part of our scoping comments (Service 2013; Appendix VII). We provide a discussion of our alternative in this section because its formulation stems from our previously recommended conservation measures, including, "Develop an alternative or suite of alternatives that would maximize benefits to fish and wildlife resources in light of other project purposes" and "Incorporate a decision support model into the WCM update process to evaluate the effects of management strategies on the riverine ecosystem, recreation, navigation, hydropower, and other uses of Federal dams."

Table 4. Fish and wildlife conservation measures and recommendations.

Fish and Wildlife Service Alternative Evaluation:		
	ALT1	Clarify the criteria required for an alternative to warrant full consideration
Conservation Measures Included from the Service's 2010 PAL & 2011 PAL Addendum:		
Flow Regime		
	FR1	Develop a suite of flow alternatives
	FR2	Conduct ecosystem flow analyses using guidelines
	FR3	Provide fish access to and inundation of the floodplain
	FR4	Evaluate methods to provide the operational flexibility necessary for floodplain inundation
	FR5	Evaluate the operational feasibly of implementing environmental flow measures
	FR6	Develop appropriate predictive hydrological and meteorological criteria
Floodplain Inundation Assessment		
	FP 1	Utilize LIDAR to evaluate floodplain inundation
Water Quality		
	WQ1	Improve and monitor dissolved oxygen
	WQ2	Evaluate/upgrade venting capabilities at Buford turbines
	WQ3	Improve and monitor water temperatures
Fish Passage		
	FM1	Improve fish passage
Climate Change		
	CC1	Include multiple future climate scenarios into modeling

Navigation		
	NV1	Evaluate the effects of channel maintenance activities
Reservoir and Riverine Fishes/Fisheries Management		
	FM2	Review recent fisheries literature
	FM3	Modify Fish Spawn SOPs to occasionally emphasize river spawning over reservoir spawning
	FM4	Implement fish and wildlife recreation facility improvements
Apalachicola Bay		
	AB1	Incorporate an updated Apalachicola Bay salinity model
	AB2	Determine freshwater inflow effects on benthic communities of Apalachicola Bay
Decision Support Model to Evaluate Changes to Corps' Operations		
	DS1	Incorporate a decision support model into the WCM update process
Adaptive Management		
	AMP1	Develop an adaptive management program
Increasing Consumptive Demands		
	CD1	Consider the impacts of increasing consumptive water demands
Evaluation of Alternative Models		
	AM1	Use alternative models to better represent flow
	AM2	Precipitation-Runoff Modeling System as an evaluation system
	AM3	New models to explicitly address climate-based operational flexibility
	AM4	Alternative water quality assessment methods
Conservation Measures Developed from the Corps' 2011 PAL Response:		
	FR7	Minimum flow provisions downstream of WFGLD
	FR8	Drought zone trigger changes
Additional Conservation Measures:		
	FM5	Evaluate effects to Gulf Sturgeon
	FM6	Evaluate effects to petitioned species
	NPS1	Evaluate effects to NPS' Chattahoochee River National Recreation Area
	ES1	Ecosystem services impacts should be described and quantified
Mitigation Measures:		
	MIT1	Identify a mitigation approach
	MIT2	Habitat-based evaluation techniques
	MIT3	Mitigate estuary impacts

Fish and Wildlife Service Alternative Evaluation

Subsequent discussions with the Corps (as cited in Service 2013; Appendix VIII) indicated that to warrant full consideration, an alternative would need to: 1) accommodate a navigation season, and 2) retain the storage action zones to ensure a balanced system operation. Consequently, we addressed both criteria in subsequent modeling and submitted a revised alternative to the Corps.

Although the Corps stated that action zone changes would eliminate the Service's alternative from consideration at the time, the Corps subsequently adopted changes to the storage action zones in the PAA. Action zone changes affect the reservoir system's ability to meet multiple project objectives in a variety of hydrological conditions. Had changes to action zones not been removed from consideration, the alternative that the Service submitted would have more comprehensively considered the range of options that could result in better system performance while providing benefits to fish and wildlife. We ask that the Corps clarify the criteria required for an alternative to warrant full consideration.

We reviewed the rationale for eliminating the Service's alternative from consideration. We provide the list of criteria that the Corps used to rank alternatives, and a comparison of the Service's alternative relative to the PAA based on their summary. We stress that our review is ongoing, and that additional information pertaining to our evaluation will be included in subsequent Service reports.

Table 4. Summary of conclusions drawn by the Corps' evaluation criteria and rankings used to select the PAA and a qualitative comparison of the Service's alternative to the PAA.

Evaluation Criteria by project purpose	Difference relative to PAA
Water Quality/Peachtree Creek Q >750	Better
Hydropower (System)	Worse
Navigation (System)	Better
Recreation (Buford, WP, WFG)	Worse
Fish and Wildlife (Apalachicola)	Worse

Additionally, the Service has recently reviewed new information from the Corps regarding their current alternatives selection process and we are greatly concerned with the methodology used by the Corps. Our concerns are described in detail in Appendix XV; due to the fact that Appendix XV has been recently developed, these concerns have not yet been reviewed as part of the DFWCAR by the State wildlife agencies and NOAA in relation to their responsibilities under FWCA.

Conservation Measures Included from the Service's 2010 PAL & 2011 PAL Addendum

Flow Regime

FR1) Develop an alternative or suite of alternatives that would maximize benefits to fish and wildlife resources in light of other project purposes.

> *This has not been completed and should be developed. Iterative development should consider a range of operational changes, including changes to action zones, flow triggers, target and minimum flows, and flows identified for navigation, conservation, hydropower, and recreation purposes. Additionally, the Service provided the Corps sets of low and pulse flow guidelines to aid in flow alternative development and evaluation (Service 2011; Appendix VI). Flow guidelines were not used to develop or evaluate*

> *alternatives. Since providing the flow guidelines, we developed the CRSBPM to assist with the evaluation of flow alternatives in the Chattahoochee River. We continue to recommend use of both the flow guidelines and the CRSBPM. As additional performance metrics become available for the Chattahoochee River, we can reconsider the use of flow guidelines in the Chattahoochee River.*
>
> *Although the Service's 2011 PAL addendum provided sets of low and pulse flow guidelines from which alternatives could be developed and compared, and the Service's 2010 PAL included requests for modeling non-hydropower peaking windows, the Corps did not develop alternatives based on those guidelines because of management limitations cited in their response to the Service's PAL (Corps 2011). However, within the Service's 2010 PAL, we stated:*
>
> *"We recognize that complete implementation of all guidelines presented herein is not feasible given the expansive flow alteration and consumptive demands in the ACF River Basin that have occurred since Buford Dam construction. However, restoration of some natural flow regime components presented in these guidelines can restore structural and functional ecosystem elements that were lost or reduced as a consequence of flow regulation."*
>
> *We reiterate to the Corps that achieving a natural hydrograph in its entirety is not the goal, but providing for some components of the natural hydrograph could be beneficial. To date, none of the natural flow regime components have been incorporated into the flow alternative development…"*

FR2) Conduct ecosystem flow analyses using the methodology cited in the Service's 2011 PAL addendum, composed of analyses at four nodes (below Buford, West Point, WFGLD, and JWLD) for the NAA and PAA. Subsequently, compare the results with the Service's ecosystem flow guidelines. We also recommend the Corps evaluate the provision of non-hydropower peaking "windows" during critical reproductive and rearing periods for a minimum of 4-6 weeks from March-May.

> *In the Service's 2011 PAL addendum, we provided updated ecosystem flow guidelines representing natural conditions, as well as updated methodology for the Corps to analyze their low and high flow releases under the NAA and PAA. Such analyses have not been provided to the Service.*
>
> *FFWCC generally supports the Service's guidelines, but also recommends a modified approach to the development of low flow guidelines (FFWCC 2011). The Service used the seven lowest values from every month in every year to characterize low flows in dry, average, and wet months for the pre-Buford period. FFWCC proposed that daily exceedance values based on all the pre-Buford hydrology, including baseflows, pulses, and floods, be used to develop guidelines. Subsequent analyses by the Service show that the 90% exceedance roughly corresponds to the lower limit and dry month flow guidelines, and the 50% exceedance values track the wet year flow guidelines, with the exception of the wetter months, lending some support to this alternative approach. We*

agree with FFWCC that this type of analysis has merit for comparing flow alternatives and characterization of flow data. However, the Service views this method as complementary but not substitutive for flow guideline development, because:

1. *Exceedance plots include all flows including pulses and floods. Therefore, low flow guidelines that could come from exceedance plots are potentially influenced by high flows, thereby inflating low flow guideline values. This is particularly evident with exceedance probabilities less than 75%, and in wetter months. One intent of the Service's flow guideline development was to separate multiple flow components (low flows, pulses, and floods) and illustrate the inter- and intra-annual variation in flows. Exceedance plots blur the distinction between low flows, and pulses and floods which is one reason why exceedance plots were not used initially.*

2. *Daily exceedance plots show a large amount of daily variation. Similar to the Service's flow guidelines, this variation illustrates that a range of low flow values may be beneficial for fish and wildlife resources. However, one intention of the Service's guidelines was to provide managers and modelers real values to evaluate and/or incorporate into a flow alternative. Although selecting the seven lowest values for every month of every year to characterize dry, average, and wet months is a simplification of the pre-Buford hydrology, the Service expects that there is a higher likelihood of successful incorporation of the Service's 60 low flow guideline values (represented by the lower and upper limit, and dry, average, and wet conditions for each of 12 months), than the 365 values required for one year type using the exceedance probability method.*

The Corps addressed the feasibility of providing non-hydropower peaking windows from March to May (4-6 weeks) at Buford Dam and West Point Dam in their response to the Service's PAL (Corps 2011). The Corps states that a loss of hydropower production, as well as physical, safety, and logistical limitations would prohibit the implementation of non-hydropower peaking windows at these facilities. We note that fish and wildlife and hydropower production are coequal purposes at these facilities and under both the no action alternative and the proposed action alternative; benefits to riverine fauna are sacrificed at the expense of hydropower production. While the Corps has repeatedly stated that revised water control operations shall reflect existing structural and physical constraints (e.g., no consideration of structural improvements), there is no funding for structural improvements, and such improvements are outside the WCM update process, the Service continues to recommend that the Corps explore options to alter downstream flow releases to minimize impacts to or benefit riverine aquatic resources below their projects in the ACF Basin. Such changes in operation do not necessarily come at the cost of reduced hydropower production.

FR3) Evaluate the potential for reducing the magnitude of the autumn drawdown, changing the order of refill, and/or beginning the spring refill earlier in order to provide fish access to and inundation of the floodplain.

> *The PAA proposes zone changes in Lanier Reservoir, West Point Reservoir, and Walter F. George Reservoir, but incorporates no changes to the top of the conservation pool guide curves. We continue to recommend the Corps address and evaluate all of these options listed above.*

FR4) Evaluate methods to provide the operational flexibility necessary for floodplain inundation, which could include 1) protecting structures (e.g. moving to locations of higher elevations or elevating structures using stilts as is done in coastal communities) that may be impacted by 2, 10, 50, and 100-year recurrence interval pre-dam flows during periods of floodplain inundation, and/or 2) the purchase of structures built in the historic floodplain so that the Corps could intentionally provide flows that inundate the floodplain.

> *This has not been completed. In the past the Corps has stated that one of their guiding principles for the WCM update process is that the flood control capabilities and capacities of the reservoirs will not be reduced (see Decision Support Model to Evaluate Changes to Corps' Operations below). Corps projects are managed in part for flood damage reduction, the objective of which is "storage of excess flows thereby reducing downstream river levels below flood stage and producing no higher stages than would otherwise occur naturally." The methods suggested by the Service would not reduce the flood control capabilities and capacities of the reservoirs. First identifying and then protecting or purchasing structures that may be impacted by floods at naturally-occurring discharges could actually reduce potential flood damage, increase operational flexibility, as well as benefit aquatic resources. Thus, we encourage the Corps to continue investigating those methods listed above.*

FR5) Evaluate the operational feasibility, constraints, and tradeoffs to providing different component(s) of environmental flow measures that are captured in our guidelines.

> *These analyses have not been conducted by the Corps. The Corps stated in their 2011 PAL Response that "Defining a real life operation that meets the authorized project purposes and better meets the "natural" hydrograph and then translating that operation into code for the reservoir simulation is a large undertaking. To the extent that FWS feels more needs to be done, we request additional guidance and support."*
>
> *As stated in the 2010 PAL, we stress to the Corps that achieving a natural hydrograph in its entirety is not the goal, but providing for some components of the natural hydrograph could be beneficial. The specific components of the ecosystem flow guidelines were meant to be reviewed and considered for implementation on an individual basis by the Corps rather than collectively considered as a whole.*
>
> *Updated ecosystem flow guidelines for four locations in the ACF Basin were provided to the Corps in our 2011 PAL addendum. We agree that it is a potentially large undertaking to include flow guidelines, but we emphasize that the WCM update is itself a large*

> *undertaking that is worthy of a critical evaluation of the feasibility, constraints, and tradeoffs to providing environmental flow measures.*

FR6) Work with the Service and others to develop appropriate hydrological and meteorological criteria (e.g., basin inflow, precipitation, and reservoir levels) needed to classify the coming month as a dry, average, or wet month.

> *In the past, the Corps has stated that they have been engaged in conversations with entities such as the National Weather Service, but indicated that they do not have the reliable science to accurately make these predictions for operation of the ACF Basin system. We have recommended that the Corps work with the Service so that we may collectively develop reasonable methods for defining hydrological conditions useful for reservoir and ecosystem management. To date, these conversations have not occurred.*

Floodplain inundation assessments

FP1) Use LIDAR and stage-discharge relationships to calculate area (acres) of aquatic habitat connected to the main channel of the non-tidal Apalachicola River to compare the magnitude, duration, timing, frequency, and rate of change of Apalachicola River floodplain inundation in the NAA, PAA, and pre- Buford period.

> *The Corps provided the Service with pertinent Apalachicola River floodplain inundation stage-discharge analyses in their response to the PAL. When the data are available, the Corps should use LIDAR, if applicable, to supplement existing analyses of floodplain inundation in the Apalachicola River.*

Dissolved Oxygen

WQ1) Ensure that releases from all five ACF dams meet or exceed water quality standards, including monitoring water quality upstream and downstream of Corps reservoirs, experimenting with operational and/or structural modifications to Corps projects to improve water quality, and conducting post-modification water quality monitoring to ensure that levels have been improved to State water quality standards.

> *The Corps has stated that they currently monitor water temperature, pH, conductivity, and DO below Buford Dam and West Point Dam, and DO seasonally below WFGLD. They have stated that one of their guiding principles for the WCM update process is that revised water control operations shall reflect existing structural and physical constraints [e.g., no consideration of structural improvements, there is no funding for structural improvements, and such improvements are outside the WCM update process (see* Decision Support Model to Evaluate Changes to Corps' Operations below*)]. Subsequently, because the NAA and PAA significantly affect water quality, do not comply with State standards, and do not meet the designated project purpose of fish and wildlife, we continue to request that as part of the WCM update the Corps outline the steps that would be necessary on part of the Federal government and other entities to improve*

> *water quality below Federal projects in the ACF Basin.*
>
> *The Corps should make it a priority to ensure that releases from all five ACF dams meet or exceed DO, temperature, and other applicable water quality standards. In GDNR's 2011 comments on the Service's DFWCAR (Service 2011), GDNR-WRD agrees that improvement of DO downstream of Corps reservoirs is important and would be beneficial to aquatic resources. We are available to assist the Corps in exploring alternate funding opportunities, including Corps restoration authorities (e.g., Section 1135 or 216) to address these impacts.*

WQ2) Evaluate the effectiveness of the upgraded venting capabilities at Buford turbines.

> *The Corps has stated that research is outside the scope of the WCM update process. As stated above, we continue to recommend that the Corps needs to make a concerted effort to ensure that releases from all five ACF dams meet or exceed DO and other applicable water quality standards. We are available to assist the Corps in exploring alternate funding opportunities, including Corps restoration authorities (e.g., Section 1135 or 216) to address these impacts.*

Temperature

WQ3) Monitor water temperature upstream and downstream of the five ACF Corps impoundments, and 1) experiment with operational and/or structural modifications to improve temperature levels, as needed, and 2) conduct post-modification monitoring to ensure that temperatures have been improved.

> *As noted above, the Corps has stated that the revised water control operations shall reflect existing structural and physical constraints, that there is no funding for structural improvements, and such improvements are outside the WCM update process. The Corps needs to make it a priority to manage temperature levels to benefit aquatic life in accordance with resource agency management objectives. We are available to assist the Corps in exploring alternate funding opportunities.*

Fish Passage

FM1) Provisions for fish passage should be incorporated in the WCM for JWLD, GWALD, and WFGLD, while maintaining the need for operational flexibility.

> *Although the Corps has included formal language in the WCM update for fish locking at JWLD, they have not included similar language for GWALD or WFGLD. They have stated that 1) just because it is not explicitly stated in the updated version of the manuals does not mean that operations cannot change in the future, and 2) not including language in the manual does not preclude lockings at GWALD or WFGLD. However, we continue to recommend formal language be included in the WCM update. There is ample evidence that fish passage operations at the lock at JWLD are passing Alabama shad upstream, and the species may benefit from passage at these other Corps lock and dam facilities. In*

> *FFWCC's 2011 comments on the Service's 2011 DFWCAR (Service 2011), FFWCC also agrees that the Corps should explore fish passage operations for anadromous fish species, such as the Alabama shad as part of the WCM update.*

Climate Change

CC1) In addition to considering sea level rise, include multiple future climate scenarios into modeled discharge scenarios and Corps alternatives and create flow provisions for dry, average, and wet years in order to account for current climate variability.

> *The Corps states that they have considered climate change to some extent in the form of sea level rise. Their evaluations have determined that sea level rise is not projected to affect JWLD, the lowermost Corps' project in the ACF Basin. No consideration has been given to the impact of climate change on hydrology. However, because climate change will potentially affect river flows and Corps operations, the Corps should include future climate scenarios over short and long terms, and flow provisions for dry, average, and wet years. Available sources that have been brought to our attention and may be of use are the National Climate Change Viewer (http://www.usgs.gov/climate_landuse/clu_rd/nex-dcp30.asp) and the National Climate Assessment (http://nca2014.globalchange.gov/downloads).*

Navigation

NV1) If navigation is included in the WCM update, evaluate the effects of channel maintenance activities required for navigation support by including an analysis of dredging needs, dredging impacts on fish and wildlife, and a cost-benefit analysis.

> *A navigation season has been included in the Corps' PAA to achieve a 7-foot channel at Blountstown, Florida from January through April or May. The Corps states that though special releases will not be standard practice, they may occur as a result of case-by-case requests to the Corps for a short duration to assist navigation during the navigation season (e.g., to achieve a 9-foot channel). Dredging needs, dredging impacts on fish and wildlife, and a cost-benefit analysis have not been included by the Corps in an evaluation of the effects of the PAA. Therefore, we assume there are no plans for dredging in the Apalachicola or Chattahoochee Rivers related to the PAA. If the Corps anticipates that maintenance dredging will need to occur in the future, we recommend that dredging needs, dredging impacts on fish and wildlife, and a cost-benefit analysis be included in an evaluation of the effects of the channel maintenance activities required for navigation flow support as indirect or cumulative impacts within the NEPA documentation.*

Reservoir and Riverine Fisheries Management

FM2) Review recent fisheries literature for additional information regarding detrimental impacts to riverine fish spawning due to a 4-6 week stable or rising reservoir window, per the Corps' draft Standard Operating Procedure (SOP) for "Lake Regulations and Coordination For Fish Management Purposes."

> *The purpose of this literature search is to critically evaluate the relative merits and costs of operating projects for the benefit of reservoir and riverine fisheries so that the best available science can be integrated into an informed management approach.*
>
> *In past ResSim model simulations that were run by the Corps using the entire period of record at the time, the fish spawn SOP governed less than 1% of releases at Corps reservoirs in the ACF Basin. The Corps states this is because fish spawn operations are largely the same as operations that are already conducted for higher priority purposes at their reservoirs.*
>
> *The Corps states that the fish spawn SOP has been in operation since the 1970's and the operating windows were based on water temperatures. The Corps states that the window is determined by dates because it is labor intensive to base the window on water temperatures. A reservoir fisheries literature search was recently conducted for the Corps by TetraTech but no pertinent research was found. In the past, GDNR-WRD has stated that the fish spawn SOP is important and should continue. However, given potential changes to the system and news insights since the 1970's, we recommend that additional data should be collected and analyses conducted to ensure that no modifications or improvements to this management strategy are needed concurrent with SOP implementation.*
>
> *A literature search has not been conducted regarding downstream flows during the fish spawn SOP period and the resulting impacts to riverine fish spawning. However, FFWCC recently provided the Corps and the Service with riverine spawning information specifically for the Apalachicola River (FFWCC 2011; Appendix XI). The report details how decreased spring flows have resulted in less aquatic floodplain habitats in the Apalachicola River floodplain system during critical spawning and nursery periods.*
>
> *We continue to recommend a literature search be conducted for additional supporting information, especially applicable to areas upstream of the Apalachicola River.*

FM3) Investigate modifying the Fish Spawn SOPs to occasionally emphasize river spawning over reservoir spawning and define those circumstances where this would occur without unreasonably compromising other project purposes.

> *The Corps states that the existing fish spawn SOP language already indicates they can or will emphasize benefits to river spawning over reservoir spawning if riverine fishes have experienced unfavorable conditions for several years. The existing language in the fish spawn SOP is as follows:*
>
> *"An imbalance of prey and forage fish could occur following the second or third year of poor or unsuccessful spawning and recruitment, leading to poor sport fishing. Areas where the spawns were recently unsuccessful should be given higher priority for fish management operations under low water conditions." It is unclear in the documentation provided by the Corps how determinations will be made to ensure that river spawning*

> *takes precedence over reservoir spawning, and how operations will be modified to facilitate river spawning. To the Service, the existing language does not seem to pertain to riverine habitats and instead appears to remain focused on reservoir fisheries. Per our recommendation in the PAL, periodic emphasis of riverine spawning should be included in the fish spawn SOP. We are available to work with the Corps to develop specific SOP revisions that recognize both reservoir and riverine habitat management.*

FM4) Identify fish and wildlife recreation facilities that need infrastructure improvements to operate at a wider range of flows and/or reservoir elevations.

> *The Corps has stated that one of their guiding principles for the WCM update process is that revised operations shall reflect existing structural and physical constraints. They have also stated that there is no funding for structural improvements and such improvements are outside the WCM update process. However, this recommendation could lead to increased operational flexibility for the Corps in the future. We are available to assist the Corps in exploring alternate funding opportunities.*

Apalachicola Bay

AB1) Incorporate an updated Apalachicola Bay salinity model (Sheng et al. 2011; Appendix XII) in the WCM update process to predict effects to oyster mortality and growth.

> *Previous modeling results (Sheng et al. 2011; Appendix XII) are incorporated into this DFWCAR (above). If updated results are produced in an allowable timeframe, we recommend that the Corps incorporate Sheng's modeling results not only to evaluate effects of their project operations, but also to inform their development of a PAA.*

AB2) Coordinate with FFWCC's Fish and Wildlife Research Institute to complete analyses of the relationship of freshwater inflow to the benthic communities of Apalachicola Bay and changes in fish and shellfish abundance.

> *FFWCC provided pertinent analyses to the Service and to the Corps comparing the pre-dam and post-West Point periods of record, but did not include analyses for future actions, such as the WCM proposed alternatives or other future Corps' proposed actions. In that correspondence FFWCC provides updated research that raises "significant hydrologic and biological concerns applicable to any alternative [Corps] operation departing from the historic flow regime of the Apalachicola River" (FFWCC 2011; Appendix XI). We recommend the Corps move forward by coordinating with FFWCC and the Service's Panama City Field Office to complete similar analyses on the WCM proposed alternatives and other future Corps' proposed actions.*

Decision Support Model to Evaluate Changes to Corps' Operations

DS1) Incorporate a decision support model into the WCM update process to evaluate the effects of management strategies on the riverine ecosystem, recreation, navigation, hydropower, and other uses of Federal dams.

> *The Corps has stated that they have used a decision support approach on a coarse scale; they subsequently shared a synopsis of their decision-making process with the Service in 2010. This synopsis from the Corps indicated that at the time, their Modeling Team and Project Delivery Team had developed internal guiding principles for the revised WCM and an iterative process for the development of their alternative(s), which relied heavily on ResSim outputs. The Corps' guiding principles at that time were as follows:*
>
> 1. *Flood control capabilities and capacities of the reservoirs will not be reduced (e.g. no measure is acceptable if it raises the likelihood, frequency, or severity of flooding).*
> 2. *The ACF will continue to be operated as a system. The balancing of water control operations to achieve each of the project purposes will continue to vary between the individual projects and the time of year. Operation of the projects will continue to usually be performed in a manner which represents a consideration of these oftentimes competing purposes and, whenever possible, reservoir operations are scoped to accommodate these purposes in a complimentary fashion (balancing).*
> 3. *The revised water control operations shall be within existing project purposes and authorities.*
> 4. *The revised water control operations shall reflect existing structural and physical constraints (e.g. no consideration of structural improvements).*
> 5. *The revised water control operations shall meet the existing Endangered Species Act requirements.*
> 6. *The fish spawn SOP will continue to be implemented within the reservoirs.*
> 7. *Reallocation of storage to meet current water supply demands [where current equaled the highest levels of consumption experienced to date] at Lake Sidney Lanier for municipal and industrial (M&I) water supply shall be evaluated in conjunction with revised water control operations. (This guiding principle was subsequently revised to account for a district court ruling in Phase 1 of the consolidated ACF litigation, 17 July 2010 ("Phase I Ruling").*
> 8. *The revised water control operations will not adversely alter the water quality in Corps reservoirs.*
>
> *We request that the Corps provide updated guiding principles if they have changed.*

Adaptive Management

AMP1) Develop an adaptive management program, consistent with the authorized purposes of the ACF reservoirs, for achieving specific ecological and social goals for the management of the ACF system including specific releases for Woodruff Dam.

> *The Corps states that the periodic updating of the WCM is a form of adaptive management and should be practiced. We urge the Corps to consider a management approach that fosters implementation of an operational strategy with clearly defined goals or hypotheses, an evaluation to assess outcomes of the operation, and integration of the knowledge gained from that operation into management. The adaptive management program should be interdisciplinary and include multiple agencies and organizations representing stakeholders within the ACF Basin.*

Increasing Consumptive Demands

CD1) Recognize and consider the impacts of increasing consumptive (municipal, industrial, and agricultural) water demands in the basin and incorporate it into analysis of operational alternatives along with climate-driven hydrologic variability. Quantify the relationship between increasing consumptive demands in the ACF Basin and effects on various project purposes. Include metrics regarding water supply withdrawals, including potential increases, in the alternatives analysis. The volume of storage that is being provided for water supply and has been proposed in each project and any limitations due to hydrologic conditions of meeting the water supply storage volume should be documented, as well as any potential changes in agricultural irrigation due to expanded irrigated acres or changes in crop composition.

> *In the PAA the Corps included future M&I water withdrawals to accommodate a projected 2040 water supply need in the Atlanta area. However, this does not include future consumptive use projections for the same time period at other locations in the basin (e.g., municipal, industrial, and agricultural increases in the Chattahoochee below the Atlanta area, increases in the Flint Basin). Therefore, projected future increases including all categories of withdrawals across the ACF, as well as predictions for climate-driven hydrologic variability, should be included in the Corps' analyses. In addition, a "Future without project" that incorporated such future consumptive water demands was not evaluated in the Corps response to the Service's PAL (Corps 2015a; Appendix X), making comparisons between a more accurate representation of an "Existing condition", "Future without project", and the "Future with Project" not possible.*

Evaluation of Alternative Models

AM1) Investigate the use of alternative models to develop better unimpaired flow and alternative flow datasets. Compared to the USGS gage data, the unimpaired flow dataset does not accurately represent the magnitude, duration, timing, and rate of change of flow extremes (i.e., minimum and maximum flows). Because flow extremes play important roles in reservoir operational decisions and in riverine, estuarine, and floodplain ecology, efforts should be made to develop unimpaired flow and alternative flow datasets that more accurately reflect flow extremes.

> *Fundamental differences in output between the USGS gage data and the NAA (e.g., current operations) are described in Appendix XIV. In the past, the Corps has stated that*

> *at this point in the process they are locked into using ResSim and HEC-5Q. The Corps has indicated that it is difficult and labor intensive to try alternative management scenarios. We encourage the Corps to investigate alternative models that enable greater flexibility in model use and alternative development, while retaining the utility of HEC-ResSim. We recommend the use of alternative models be investigated as soon as possible, to inform the Corps not only for the WCM update process but also for future Corps' proposed actions.*

AM2) If the United States Geological Survey's (USGS) Precipitation-Runoff Modeling System (PRMS, http://water.usgs.gov/software/PRMS) is developed specifically for the ACF in a timeframe useful for the ACF WCM update process, use it as an additional evaluation tool to 1) check the precision of the Corps' unimpaired flows datasets, and 2) supply an alternative unimpaired flow dataset to use based on informed climate and land use change predictions.

> *It is our understanding that the PRMS model is not ready for use at this time. However, if and when it is developed specifically for the ACF it should be used by the Corps as an additional evaluation tool for the WCM update process and future Corps' proposed actions.*

AM3) Coordinate with USGS and Georgia Water Resources Institute (GWRI) regarding new models to explicitly address climate-based operational flexibility during the development and evaluation of flow alternatives, the WCM update, and the EIS analyses.

> *We continue to recommend that the Corps coordinate directly with GWRI to address climate-based operational flexibility as soon as possible, to inform the Corps not only for the WCM update process but also for future Corps' proposed actions.*

AM4) Consider alternative water quality assessment methods to accurately evaluate effects of flow alternatives on water quality. Because the HEC-5Q water quality model outputs are not expected to accurately predict either the water quality values or the range of values that are likely to occur in response to hourly discharge changes, consider using existing alternative water quality models or develop regression models to accurately predict water quality parameters using a combination of water quality datasets, hourly discharge, and other environmental parameters (e.g., weather and solar exposure).

> *The Corps states that HEC-5Q is advantageous because it considers the system holistically and also cite similar results between their simulated output to their observed tailrace data. Because HEC-5Q relies on daily average flow it does not accurately reflect water quality values that are likely to occur in response to hourly discharge changes. We continue to recommend alternative water quality assessment methods to accurately evaluate the effects of Corps operations on water quality.*

Conservation Measures Developed from the Corps' 2011 PAL Response

FR7) There are no minimum flow provisions downstream of WFGLD. When low dissolved oxygen values are observed below the dam, the Corps states that spillway gates are opened until the dissolved oxygen readings return to an acceptable level. The Service has not seen actual data that exhibit an improvement in dissolved oxygen levels using this methodology. However, if this methodology is in fact effective, the Corps should evaluate modifying WFGLD's operations to provide a continuous minimum flow release instead of operating in a "reactive response" mode. Continuous minimum flow releases are already implemented at the other four other Corps' ACF Basin projects.

FR8) Consider other options for operational flexibility that do not include changing the drought zone trigger from Zone 3 to Zone 2, and postponing the reinstatement of normal operations until Zone 1 is reached. While these changes enable the Corps to operate the reservoir system in a more conservative manner, they likely result in an increased frequency and duration of low flows in the Apalachicola River.

Additional Conservation Measures

FM5) Evaluation of effects to Gulf Sturgeon was specified in our PAL's. The Service developed the SSHPM to facilitate the Corps' analysis, but this information was not included in the information provided to the Service. Effects to Gulf Sturgeon should be included in the development and evaluation of alternatives.

FM6) The impacts of the PAA to species in the ACF Basin currently petitioned for Federal listing under the ESA should also be described and quantified. Updated surveys and quantitative relationships between Corps operations and population or habitat effects for many of these species are lacking; effort should be expended to update surveys and quantify effects of proposed future actions to these species. This information will improve our understanding and future evaluation of project impacts on a larger variety of species that inhabit a broader set of ecosystems and river segments.

NPS1) The impacts of the PAA to NPS' Chattahoochee River National Recreation Area should be described and quantified. NPS' January 14, 2013 scoping comments to the Corps include information and recommendations associated with the Corps' flow releases from Lanier reservoir that should be considered.

ES1) The impacts of the PAA to ecosystem services should be described and quantified. Ecosystem services are the benefits that humans derive from ecosystems. These services provided by riverine ecosystems are diverse, such as water filtration provided by aquatic invertebrates and carbon sequestration provided by floodplain connectivity. In addition, riverine habitats can provide excellent recreational opportunities. These are among the ecosystem services that are, to some extent, affected by flow management.

Mitigation Measures

MIT1) In the Corps' NEPA documentation, the impacts of the PAA on fish and wildlife resources should not only be described and quantified, but the Corps should also outline an approach to mitigation. Mitigation measures should be based upon more accurate projections of future projected resource conditions with and without the project.

MIT2) Development of mitigation measures should be scientifically formulated, and based on the future with and future without the project scenarios, and a determination of the net change between the two. The Service's Mitigation Policy (FR 46(15):7644-7663; January 23, 1981) calls for evaluation using habitat-based evaluation techniques wherever possible. The Habitat Evaluation Procedures (HEP) developed by the Service are specified for use as a basic tool for evaluating project impacts and as a basis for formulating subsequent recommendations for mitigation. It can yield data that can be used effectively in comparing alternatives and conditions. Other available "standard" techniques that may be applicable include the Habitat Evaluation System (HES) and Wetland Evaluation Technique (WET) developed by the Corps of Engineers, and the Hydromorphologic Methodology (HGM). Where instream flows are involved, the Service's Instream Flow Incremental Methodology (IFIM) may be able to provide information in making mitigation recommendations. Other updated evaluation systems may be used, provided they conform to the policies contained in the Mitigation Policy.

MIT3) Impacts to the estuary that result from lower inflow and higher salinities have been quantified using empirical relationships and models. Mitigation for these impacts should be determined and implemented, and we recommend that the Corps consult with the State of Florida and the Service's Panama City Field Office.

The Service is available to work with the Corps to identify suitable mitigation measures.

SUMMARY AND FWS POSITION

The Service does not fully support the Corps' adoption of the PAA for the following reasons:

- the Corps' alternatives selection process (Service 2015; Appendix XV),
- a failure to adequately address conservation measures identified in the Service's PAL (Service 2010; Appendix V), PAL addendum (Service 2011; Appendix VI), and the Service's 2011 DFWCAR (Service 2011) and subsequently included in this report,
- modeling developed from limited consumptive use scenarios without sufficiently considering climate change and future increase in consumptive demands,
- inadequately assessed effects to riverine ecosystems and federally-listed Gulf Sturgeon,
- increased frequency of low flows causing negative impacts to federally-listed mussels, and

- increased storage resulting in lower magnitude releases and most likely higher salinities to the Apalachicola River and Bay. Based on model results provided by the Corps, the negative effects of the PAA on fish and wildlife resources are a consequence of reservoir system operation changes and increases in consumptive demands that are part of the PAA.

In accordance with the FWCA and Service mitigation policy (FR 46(15):7644-7663; January 23, 1981), we identified steps that should be taken to ensure that fish and wildlife resources are protected or improved. We identified additional conservation measures and steps that should be taken as part of an update to the WCM. We emphasize again that the WCM update is a large undertaking that is worthy of a critical evaluation of the feasibility, constraints, and tradeoffs to providing environmental measures.

The Corps has not provided an evaluation of project impacts associated with a more accurate projection of future conditions, and therefore direct comparisons of the future of the resource with and without the project are hampered. Consequently, we emphasize that the Corps should develop and quantify projected positive and negative impacts for ‘with the project’ and ‘without the project’ scenarios based on more accurate projections of future conditions so that appropriate mitigation measures can be developed and included in the Corps’ NEPA documents and our report.

We also emphasize that the Corps’ impact to water quality, primarily dissolved oxygen, below several projects in the ACF Basin is unacceptable. The Corps needs to seek authorization and appropriations to ensure that water quality standards are met below these projects.

To date, all analyses provided by the Corps consist of evaluations of the effects of a PAA developed by the Corps, which excluding actions already taken by the Corps at JWLD, includes no project operation improvement to benefit fish and wildlife. To ensure sustainability for these resources, and especially those that are imperiled, the Service will continue to work cooperatively with the Corps and all stakeholders. In particular, the Service needs to be an integral member of the Corps’ team when formulating and evaluating operational alternatives. We encourage the Corps to follow the recommendations and conservation measures included in this document and are ready to assist in the development of a WCM that balances protection of fish and wildlife resources in the ACF River Basin with other project purposes.

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June 15, 2015

Ms. Alice P. Lawrence
Fish and Wildlife Biologist
United States Fish and Wildlife Service
105 Westpark Drive, Suite D
Athens, Georgia 30606

RE: Florida Fish and Wildlife Conservation Commission's Comments on June 2015 Draft Fish and Wildlife Coordination Act Report.

Dear Ms. Lawrence:

The State of Florida, through its Fish and Wildlife Conservation Commission ("Commission"), submits the following comments on the *Draft Fish and Wildlife Coordination Act Report on the Water Control Manual Updates for the Apalachicola-Chattahoochee-Flint River Basin in Georgia, Alabama and Florida* ("Draft Report").[1] Florida commends the Service for identifying a number of key concerns shared by the Commission and agrees with the Service's general assessment that the Corps' Proposed Action Alternative ("PAA"), as reflected in the Corps' October 2014 response to the Service's planning aid letters ("PAL Response"), is unacceptable.

As indicated in our May 2011 letter, we wish to underscore the importance of consistent, transparent communication among the Corps, the Service and the Commission. As you correctly note, the Fish and Wildlife Coordination Act ("FWCA"), 16 U.S.C. §§ 661 *et seq.*, requires the Corps to consult with the Service and the Commission, Draft Report at 45, but such coordination has not occurred. Florida first received the Draft Report and corresponding Corps materials on May 19, 2015. We have been asked to respond to the Draft Report, the PAL Response, and the PAA, all by June 16, 2015. However, the Corps has not provided to the Service or the Commission any of the relevant datasets supporting the Corps' analyses. At this point, the absence of substantive data precludes us from fully assessing the validity of the agencies' conclusions. Until all relevant datasets have been provided to the Commission, we cannot fully and effectively provide detailed comments as requested. Based on the limited information that has been provided, we concur with the Service that "all analyses provided by the Corps consist of evaluations of the effects of a PAA developed by the Corps that includes no consideration of project operation enhancement to benefit fish and wildlife."

We hereby request copies of the complete datasets the Corps is using to develop the PAA (and any other alternatives for the Water Control Manual Update), as well as in preparing the PAL Response. Upon receipt of the datasets and any additional analysis completed in

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[1] Florida previously provided comments on your April 2010 Planning Aid Letter, and supplied additional information relevant to the Draft Report in our paper entitled *The Impact of Reduced Flows on the Apalachicola River and Bay Ecosystem* (February 2011) and an addendum in May 2011. Florida also provided additional comments to the U.S Army Corps of Engineers ("Corps") during its re-initiation of scoping pursuant to the National Environmental Policy Act (January 2013). Those comments are incorporated fully herein by this reference.

response to the Service, we will provide additional comments on these materials, as well as the Draft Report, in accordance to the FWCA.

In the meantime, we note the Commission and the Service earlier asked the Corps to address the impacts of current and projected consumptive water uses as part of the Water Control Manual Update process. The Corps has not offered any such analysis. Based on information being developed in support of the litigation captioned *Florida v. Georgia*, No 142 Orig., we reject the Service's apparent interim conclusion that upstream consumptive uses are not having a significant effect on Florida's fish and wildlife resources.

We thank you for the opportunity to comment and your continued attention to this matter. We hope for improved coordination in the future.

Sincerely,

Bud Vielhauer,
General Counsel

Cc: Mr. Donald Imm, U.S. Fish and Wildlife Service
Donald_Imm@fws.gov
Ms. Catherine Phillips, U.S. Fish and Wildlife Service- Panama City
Catherine_Phillips@fws.gov
Mr. Curtis Flakes, U.S. Army Corp of Engineers-Mobile District
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The mission of the Wildlife and Freshwater Fisheries Division is to manage, protect, conserve, and enhance the wildlife and aquatic resources of Alabama for the sustainable benefit of the people of Alabama.

CHARLES F. "CHUCK" SYKES
DIRECTOR

FRED R. HARDERS
ASSISTANT DIRECTOR

June 16, 2015

Mr. Donald Imm
U. S. Fish and Wildlife Service
105 West Park Drive, Suite D
Athens, Georgia 30606

RE: Draft Fish and Wildlife Coordination Act Report (DFWCAR) for the proposed Water Control Manual (WCM) updates for the Apalachicola-Chattahoochee-Flint (ACF) River Basin in Georgia, Alabama, and Florida

Dear Mr. Imm:

The Alabama Department of Conservation and Natural Resources (ADCNR), Division of Wildlife and Freshwater Fisheries has reviewed the Draft Fish and Wildlife Coordination Act Report (DFWCAR) prepared by the U. S. Fish and Wildlife Service (USFWS) for the proposed Water Control Manual (WCM) updates for the Apalachicola-Chattahoochee-Flint (ACF) River Basin in Georgia, Alabama, and Florida and provides the following comments. We encourage the U. S. Army Corps of Engineers (the Corps) to fully develop and analyze alternatives or suites of alternatives that will maximize and benefit fish and wildlife resources of the State of Alabama. We also encourage continued incorporation of decision support models, in an adaptive management framework, to evaluate these alternatives. Consideration of additional alternatives for analysis will address specific concerns highlighted in this letter and include: water quality, instream flow, increasing consumptive demand, state-protected aquatic species, and drought conditions and impacts. These specific areas are priorities for ADCNR for the protection and management of state-trust resources.

- *Water Quality* Water releases from the five ACF dams should meet or exceed State water quality standards. We agree with USFWS recommendations that water quality issues should be a priority for the protection of aquatic resources. State standards for dissolved oxygen should consistently be met, and assessments for improvement should be fully considered in the suites of evaluated alternatives and the Proposed Action Alternative (PAA). Water temperature should also be a priority in the manual update process, with a suite of alternatives analyzed for appropriate management. We also agree with the recommendation that alternative water quality assessment methods be used to evaluate the effects of Corps operations on water quality. Additionally, ADCNR believes that structural and physical improvements to current facilities are within the scope of the WCM update process and recommend they be addressed when analyzing alternatives for water quality management.

- *Instream Flow* The Corps' operations do not require approval of or the licensing process of the Federal Energy Regulatory Commission. However, the responsibility of the Corps' water control operations must include a flow regime that maintains ecological integrity to protect the physical, chemical, and biological functions of waters flowing into the State of Alabama through the

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Apalachicola River. Natural flow regimes in a stream or river channel adequately support the full suite of ecological functions (biodiversity, channel maintenance, floodplain operation) through factors such as timing (seasonal), frequency (how often), magnitude (size of water events), rate of change (how quickly water is delivered), and duration (how long do the events last) to ensure complete ecosystem functions. Deviations from the natural flow regime of rivers and streams affect their physical, chemical, and biological functions. Whether there is a significant impact on ecological integrity depends on the magnitude of deviation. ADCNR implemented an Instream Flow Policy in 2012 which explains our position on flow standards. The following are excerpts from that policy:

Instream flows are incorrectly thought of as minimum flows by many. Minimum flows are just that, minimal, and do not fully protect stream functions. The whole concept of a minimum flow had led to many rivers and streams becoming depleted and damaged with respect to their hydrological and ecosystem function. Minimum flows actually become maximum flows in highly used and altered systems since managed flows are rarely allowed to exceed this "minimum" limit. "Conservation Flow" is defined as the minimum continuous water flow requirement as determined by ADCNR that is necessary to maintain the biological, physical, and chemical integrity of a waterway using generally accepted scientific methodologies. Conservation flow for regulated waterways shall be as follows: 1) for waterways regulated for hydropower production the requirement shall be determined through the Federal Energy Regulatory Commission licensing process; 2) for waterways regulated for other purposes (such as drinking water impoundments) the recommended seasonal requirement is 30% of Mean Annual Flow (MAF) for July through November, 60% MAF for January through April, and 40% MAF for May, June, and December or will be based on accepted instream flow methodology such as the Instream Flow Incremental Methodology (IFIM).

"Subsistence Flow" is the minimum water flow requirement as determined by ADCNR that must remain in a waterway in order to avoid serious or long-term adverse effects on the biological integrity of the waterway. Subsistence flow shall be determined as follows: 1) for waterways regulated for hydropower production the requirement shall be determined through the Federal Energy Regulatory Commission licensing process; 2) for waterways regulated for other purposes (such as drinking water impoundments) and for unregulated waterways the requirement is 10% of Mean Annual Flow (MAF) or will be based on an accepted instream flow methodology such as the Instream Flow Incremental Methodology (IFIM).

It is the policy of ADCNR to advocate for the protection of instream flow requirements in all water allocation decisions.

- <u>Increasing Consumptive Demands</u> ADCNR requests the Corps conduct comprehensive analysis of increasing consumptive demands in the ACF Basin, and include those with the suite of considered alternatives. Increased consumptive demands in the basin could have negative impacts on the aquatic resources of the State of Alabama. Increased demands including: increased water supply withdrawals, increased volume storage, and changes in industrial, municipal, and agricultures practices could change and impact hydrologic conditions throughout the basin. Hydrologic conditions below Corps' dams are the responsibility of the Corps, and as such instream flow regimes should be designed to restore and/or maintain the ecological integrity of the system.

- <u>State-protected species</u> Potential impacts to state-protected species by Corps operations should be avoided and minimized. Impacts should be fully assessed in the suite of alternatives presented in the manual updates. Potential impacts resulting from operating under the PAA should not be greater than operating under the no action alternative (NAA).

- *Drought conditions and impacts* We are concerned that minimum flows during drought conditions, under the PAA, would have significant negative impacts on aquatic species. State-protected mussels in particular would suffer extreme negative impacts. An analysis of alternative instream flow regimes should be conducted such that minimum flows during drought conditions under the PAA are not lower than minimum flows under the NAA. Sufficient instream flows should provide water quality that meets state standards, and allows for the management and protection of and state-trust resources.

- *Fish Passage* A fish passage plan for anadromous fish species should be developed and included for George W. Andrews Lock & Dam and Walter F. George Lock & Dam in the final WCM updates.

In conclusion, we appreciate the opportunity to comment on the Draft Fish and Wildlife Coordination Act Report. ADCNR stands ready to work with the Corps to develop Water Control Manuals that protect and conserve the fish and wildlife resources of the State of Alabama. We encourage the Corps to work alongside State and Federal agencies, and with stakeholders to provide comprehensive analysis of all alternatives for the ACF Basin.

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Sincerely,

Taconya D. Goar

Taconya D. Goar
Environmental Affairs Coordinator

GEORGIA
DEPARTMENT OF NATURAL RESOURCES
MARK WILLIAMS, COMMISSIONER

June 25, 2015

Donald Imm, Project Leader
U.S. Fish and Wildlife Service
Georgia Ecological Services
105 West Park Drive, Suite D
Athens, Georgia 30606

Dear Mr. Imm:

Thank you for the opportunity to once again review the Fish and Wildlife Service's (FWS) Draft Fish and Wildlife Coordination Act Report (DFWCAR) to the Corps of Engineers regarding the Water Control Manual update for the Apalachicola-Chattahoochee-Flint (ACF) basin. We are following up on our comments dated May 23, 2011 to address additional issues related to fisheries management that the Georgia Wildlife Resources Division (GAWRD) deems important.

Water Temperature

The thermal regime below Lake Lanier remains of importance to GAWRD and to Georgia anglers. The Lanier Tailwater (Buford Dam to Bull Sluice Reservoir) hosts a year-round fishery for wild brown trout and stocked rainbow trout. This fishery has existed for more than 50 years and produced a new state record brown trout in 2014. This section of the Chattahoochee River alone accounts for approximately 90,000 angler trips per year. On page 33, the DFWCAR suggests that hydropower and fish and wildlife should be coequal considerations in the water control manual. In addition, GAWRD suggests that downstream recreation should be a consideration as well. Increased hydropeaking operations would reduce the available recreational opportunities in the Chattahoochee River National Recreation Area as these are typically limited to times of minimum flows.

In any evaluation of water temperatures in this section of river, it is important to note that increased water temperatures will have different impacts on the trout population depending on the distance from Buford Dam. For instance, temperature is not expected to be a concern under any feasible operation regime at the Buford Trout Hatchery intake, which is located approximately two miles downstream of Buford Dam. Water temperatures in this part of the river never exceed critical species tolerance. One possible exception for this could be an increased frequency of 2-unit generations during the fall pre-turnover period, when water drawn from the thermocline of Lake Lanier can lead to drastic temperature increases in a short time, leading to shock. However, south of the Norcross gauge referenced in the DFWCAR, small temperature increases may lead to localized stress and mortality if water temperature exceeds 22°C for any considerable length of time. It is also important to note that this is only currently a concern during summer months when warmwater tributary inputs and solar radiation have the most impact on water temperatures in this section. Research by GAWRD indicates very little movement by trout in the Chattahoochee River, therefore a localized mortality event could lead to extended, severely limited recreational fishing opportunities in the affected section.

The DFWCAR addresses the West Point Reservoir gulf-strain striped bass population as requested in GAWRD's 2011 letter; however the impacts of temperature on striped bass above West Point reservoir need to be clarified. Summer habitat in West Point can be very marginal, and the cool flows from Morgan Falls dam (resulting from Buford Dam releases) mitigate for that lack of summer coolwater, high oxygen habitat. Page 25 of the DFWCAR states that spring coldwater releases may have a critical inhibiting impact on striped bass reproduction in the West Point population, citing Hess and Jennings (1999). The authors of this report suggested temperature was possibly an inhibiting factor to reproduction, but mentioned low flows as another potential inhibiting factor. Therefore, it may not be appropriate to view higher flows/low temperatures as negative in an evaluation of riverine fish habitat in the Corps' proposal. The striped bass management strategy for GAWRD at West Point Reservoir is similar to many other reservoirs in the state; while the potential for natural reproduction exists under ideal conditions; stocking is likely to be necessary to maintain a fishable population size and genetic repository of gulf-strain striped bass given the possibility of year-class failures due to multiple environmental factors.

Fishery Performance Measures

As mentioned in the DFWCAR, GAWRD requested a meeting with FWS to discuss details of the Reservoir Fishery Performance Measure (RFPM). Much of GAWRD's concerns center around the use of a single metric for three very different reservoirs. Most fish habitat at Walter F. George Reservoir is realized in the form of submerged and emergent aquatic vegetation. Fluctuations in water levels help promote the growth of this aquatic vegetation, and we believe the RFPM should better reflect this potential at Walter F. George. Conversely, Lanier Reservoir has very limited potential for aquatic vegetation due to its steeper banks and hard clay substrate. The majority of flooded vegetation is terrestrial and establishes during extended drawdowns (droughts). While these extended drawdowns can lead to future habitat benefits, we believe it is important that any evaluation tool does not encourage drought-like drawdowns at Corps reservoirs during normal years. West Point Reservoir is relatively similar to Lanier in that its potential for aquatic vegetation is limited; however it still deserves an individualized approach in the RFPM. More current data is requested by FWS in the DFWCAR, however GADNR does not believe that currency of the data is an issue given the 20+ year standardized sampling data sets at these reservoirs; however, the abilities of currently-used sampling gears may be limited for certain data needs, e.g. assessment of young-of-year sportfish. The GADNR hopes to continue to work with FWS to refine the RFPM to more accurately model the fishery-related effects of water levels in each reservoir.

Aside from the RFPM, the continuation of the Corps' fish spawn management procedures is critically important for reservoir fisheries. A rapid reservoir elevation decrease immediately following spawning activity could lead to a year-class failure for multiple species in a reservoir. On page 38 of the DFWCAR, FWS suggests "modifying the Fish Spawn SOPs to occasionally emphasize river spawning over reservoir spawning". We (GAWRD) would like to understand the mechanism for this decision process in more detail. Conditions to meet this goal without "unreasonably compromising other project purposes" may be difficult in most years, and the per-unit impacts in water management choices may not be uniform between rivers and reservoirs. Given our experience managing reservoirs and rivers in this system, GAWRD should be able to offer suggestions relative to this effort.

The Chattahoochee River Shoal Bass Performance Measure (CRSBPM) is used in the DFWCAR to attempt to quantify effects of the No Action Alternative (NAA) and Preferred Action Alternative (PAA) on shoal bass recruitment from Morgan Falls Dam to West Point Reservoir. This model is based on research conducted within listed trout waters in an approximately eight-mile stretch below Morgan Falls Dam. This is the area which is most thermally impacted during high-flow years, and GAWRD annually stocks shoal bass in this section to mitigate for poor recruitment during these high-flow years. This poor recruitment appears to be a result of depressed spring/summer water temperatures that inhibit gonad development in adult shoal bass. The model uses water temperature as the driving factor related to shoal bass abundance, which is appropriate in this upper stretch of the Morgan Falls Tailwater. However, thermal impacts to the Chattahoochee River below Peachtree Creek are likely minimal relative to shoal bass reproduction and recruitment in normal years, yet recent samples conducted by GADNR and Auburn University indicate that shoal bass abundance appears to be limited between Peachtree Creek and West Point Reservoir. It is possible that there are other limiting factors beyond water temperature (e.g. habitat or water quality) that should be addressed and considered when using the CRSBPM to inform flow regimes. The shoal bass is a recently-described (1999) species and research into its life history characteristics is ongoing. If appropriate, the CRSBPM should be updated as new information on this species becomes available.

Fish Passage

On page 7 and 8 of the DFWCAR, comments from the Florida Fish and Wildlife Conservation Commission suggest negative consequences to fish populations from fish passage impediments. The GAWRD agrees that improved fish passage would provide benefits to multiple species. As outlined in a March 24, 2014 MOU between GAWRD, GAEPD, and USFWS, allowing passage through Jim Woodruff Lock and Dam may greatly increase the amount of available gulf sturgeon habitat. Given the incised nature of the channel in the lower Chattahoochee River due to dredging operations, the ability to accommodate river-floodplain interactions (FWS recommendation FR3) may be limited, and added fish passage may have a greater impact on habitat availability. Striped bass have been found to reproduce below West Point Dam based on samples in Walter F. George Reservoir. Passage through Walter F. George Lock and Dam may provide positive benefits to the gulf striped bass population in the ACF.

Water Quality

In the evaluation of the selected plan, it is important to consider that there may be positive benefits to a reservoir fishery from increased residence time or nutrient loading. Algal mats and fish kills due to chlorophyll-*a* or phosphorous loading have not historically been a problem at Lanier or Walter F. George, and the nutrient levels at West Point have drastically decreased following upstream waste water infrastructure improvements in the past two decades. If chlorophyll-*a* and phosphorous are not at critical levels, an increase can actually lead to increased biomass and improved fishing in all three reservoirs. When classifying water quality changes as positive or negative for the purpose of evaluation, these potential benefits should be considered.

The GAWRD agrees with FWS that increased dissolved oxygen levels below Corps dams would have positive benefits to tailwater fisheries. On page 10 of the DFWCAR (and in the October 2014 Corps Response to the previous Planning Aid Letters), the standards for the Norcross and Morgan Falls stations are incorrect. As these stations both fall within state-listed trout waters, the state standard for dissolved oxygen is actually 6.0 mg/L, the same as the Buford Dam station. While differences in temperature between the NAA and the PAA are not generally a concern at Buford Trout Hatchery, depressed dissolved oxygen concentrations below the state standard and suspended metals such as iron and manganese in the late summer and fall can be problematic. An increase in dissolved oxygen during the critical pre-turnover period would alleviate much of this stress on fish being held in hatchery raceways. Below West Point Dam, increases in dissolved oxygen concentrations should provide a benefit to middle Chattahoochee shoal bass populations, particularly when combined with efforts by Georgia Power to increase dissolved oxygen levels below their hydropower projects in the area. Below Walter F. George Lock and Dam, electrofishing surveys have indicated that low dissolved oxygen may severely impact recreational fishing opportunities for several miles.

On page 18, the withdrawal for Buford Trout Hatchery is listed as 7 mgd. However, it is important to note that this is a pass-through system and the net withdrawal of river water is negligible on downstream flows (limited to evaporation while passing through the hatchery). As written, it appears that GAWRD is a net user of 7 mgd of ACF flows.

If you have any questions, please contact Thom Litts at (770) 918-6406.

Sincerely,

Mark Williams

Mark Williams

cc: Gail Cowie, EPD
Thom Litts, WRD

Re: ACF Water Control Manual Update ACOE Draft Fish and Wildlife Coordination Act Report for review

1 message

Pace Wilber - NOAA Federal <pace.wilber@noaa.gov> Thu, Jun 18, 2015 at 9:07 AM
To: "Lawrence, Alice" <alice_lawrence@fws.gov>
Cc: Fritz Rohde <Fritz.Rohde@noaa.gov>, Will Duncan <Will_Duncan@fws.gov>

Hello Alice.

Thank you for providing the NMFS an opportunity to review the Draft Fish and Wildlife Coordination Act Report for the proposed U.S. Army Corps of Engineers Water Control Manual updates for the Apalachicola-Chattahoochee-Flint River Basin Georgia, Alabama, and Florida. The NMFS greatly appreciates the care the U.S. Fish and Wildlife Service (FWS) has taken in preparing the report.

1). The NMFS agrees with comments by FWS pointing out multiple times the inadequacy of the effects evaluation on Gulf Sturgeon, which does not support the Proposed Action Alternative because the Corps "inadequately assessed effects to riverine ecosystems and the federally-listed Gulf Sturgeon (page 44 of FWS report)." Discussion of dissolved oxygen (DO) concentrations (page 10 of the FWS report) indicate releases actually decrease DO concentrations, which makes sense if releases are from the bottom of a reservoir. The NMFS recommends the Corps provide a more thorough evaluation of the effects of implementing the water control plan on Gulf Sturgeon.

2). The NMFS agrees with FWS (page 36) that provisions for fish passage, with operational flexibility, should be incorporated into all the dams, not just Jim Woodruff Dam. Conservation locking at Jim Woodruff Lock and Dam is passing Alabama Shad upstream. Fish passage at George W. Andrews Dam and Walter F. George Dam would aid Alabama Shad in the ACF Basin.

3). Additional examinations are needed of how variations in freshwater inflow to Apalachicola Bay affect seagrass, fish, and shellfish abundances. The NMFS recommends the Corps coordinate with Florida Fish and Wildlife Conservation Commission to complete the analyses and include in the water control manual an updated Apalachicola Bay salinity model for predicting oyster mortality and growth (page 39).

On Mon, Apr 27, 2015 at 10:11 AM, Lawrence, Alice <alice_lawrence@fws.gov> wrote:

> Hello- I hope everyone is doing well. If you remember, you reviewed our agency's last round of the Draft Fish and Wildlife Coordination Act Report (DFWCAR) back in 2011 regarding ACOE's ACF Water Control Manual Update before it was submitted to the Mobile District ACOE. At that time, we incorporated and attached the comments we received from the State wildlife agencies and NOAA Fisheries to the DFWCAR before it was submitted to ACOE. Under the Fish and Wildlife Coordination Act, ACOE is required to consult with the Service and the State wildlife agencies, "to provide that wildlife conservation shall receive equal consideration and be coordinated with other features of water-resource development programs through effectual and harmonious planning, development, maintenance, and coordination of wildlife conservation and rehabilitation..."
>
> We are currently preparing an updated DFWCAR for the Mobile District to include in their upcoming DEIS and I am 1) notifying you as the State wildlife agencies and NOAA Fisheries of our projected timeline, and 2) forwarding you background material from ACOE to assist in your review of the DFWCAR. We are planning on having a DFWCAR for you to review no later than early May, with the hopes that we may receive any comments you may have within 20 days after receiving the DFWCAR. I know this is a short turnaround time and we apologize- we have a short turnaround time as well. ACOE would like our completed DFWCAR in early June.
>
> I am attaching the Corps' Response to the Service's PAL as background material for you to better understand

> the DFWCAR when we send it along to you for your review. Our office received this document at the end of January, but I was out of the office until mid-March so I did not receive it until then.
>
> Thanks everyone! Please let Will or I know if you have questions (I will be in and out the rest of the day but should be in the office the rest of the week). Alice
>
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April 2, 2010

Colonel Byron Jorns
US Army Corps of Engineers, Mobile District
P.O. Box 2288
Mobile, AL 36628-0001

Dear Colonel Jorns:

We are providing your agency with a Planning Aid Letter (PAL) for the proposed Water Control Manual (WCM) Updates for the Apalachicola-Chattahoochee-Flint (ACF) River Basin in Georgia, Alabama, and Florida. The purpose of the updates is to identify operating criteria and guidelines for managing water storage and release of water from Corps reservoirs. In the National Environmental Policy Act (NEPA) review, the Corps will address current operations, proposed changes in water management operations at the reservoir projects within the limits of the existing authorities, as well as potential impacts throughout the basin that would result from implementation of the updated manual.

The purpose of the PAL is to identify resource values and issues, identify endangered species issues, and propose preliminary changes, mitigation, or enhancement opportunities to facilitate your decision-making as it relates to equal consideration of fish and wildlife resources. We submit the following comments and recommendations under the ESA, the Migratory Bird Treaty Act (MBTA)(49 Stat. 755, as amended; 16 U.S.C. § 702 *et seq*.), and the FWCA (48 Stat. 401, as amended; 16 U.S.C. § 661 *et seq*.). These comments are based on previous studies and government documents as well as new datasets and information provided by State and Federal agencies. Although all of the comments from the Florida Fish and Wildlife Conservation Commission (FFWCC) have not been integrated, this final version of the PAL addresses many of the issues that FFWCC raised. We will continue to provide additional expertise and information in the form of another PAL and/or the draft Fish and Wildlife Coordination Act report. A separate consultation will occur regarding the potential impacts of the Corp's proposal on federally-listed threatened and endangered fish and wildlife species protected under the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. § 1531 *et seq*.).

1. Development of Corps Alternatives and Mitigation

We have identified data needs and assessment methods that can help you in developing alternatives that maximize fish and wildlife benefits, and avoid, minimize and compensate for impacts to fish and wildlife resources, where appropriate.

1.1 Flow Regime

The WCM update should include a thorough evaluation of project-related flow regime alterations and the potential to restore flow regime components that have ecological and geomorphic significance. We recommend the Corps develop alternatives that would maximize benefits to fish and wildlife resources in light of other project purposes. To support this effort, we have provided preliminary ecosystem flow guidelines for four river sections; below Buford, West Point, Walter F. George, and Jim Woodruff dams. These flow regime guidelines are guided by the principle that ecosystems evolved as a response to the natural flow regime. Thus, we analyzed river flows and developed flow guidelines based on United States Geological Survey (USGS) flow data that were collected prior to Buford Dam construction in the mid 1950's, a benchmark of the first major river regulation source in the upper Chattahoochee River. Reliance on pre-regulation datasets to derive ecosystem flows is particularly useful for locations where empirically derived ecology-flow relationships are scant (such as the upper Chattahoochee River).

We recognize that complete implementation of all guidelines presented herein is not feasible given the expansive flow alteration and consumptive demands in the ACF River Basin that have occurred since Buford Dam construction. However, restoration of some natural flow regime components presented in these guidelines can restore structural and functional ecosystem elements that were lost or reduced as a consequence of flow regulation. For example, provision of stable flow windows (*sensu* Freeman et al. 2001) in the spring may increase riverine fish recruitment, even though restoration of other naturally occurring flow regime components may not be attainable. Relatively small discharge changes can have substantial ecological effects. For example, the Tennessee Valley Authority's (TVA's) strategy to increase baseflows below Normandy Dam (Figure 1) during the spring and summer mussel recruitment months resulted in biologically and statistically significant increases in mussel diversity and density (Figure 2, Ahlstedt and Johnson 2004).

Development of environmental flow alternatives would include an evaluation of the operational feasibility, constraints, and tradeoffs to providing the different aspects of environmental flow measures that are captured in our guidelines. Explicit magnitude, frequency, duration, timing, and rate of change guidelines are provided to illustrate the types of flow modifications that are likely to benefit the ecosystem and to help inform the development of Corps flow alternatives. However, should the magnitude of a flow guideline be deemed unattainable, we request that the Corps identify a flow magnitude that is attainable or recommend an attainable frequency for the recommended flow magnitude. An explanation for the change also will be helpful. We recognize these guidelines do not define whether the basin is entering a dry, average, or wet month, which are the lines between the lower and upper limits on the flow prescription graphs. We recommend that you work with us to develop appropriate hydrological and meteorological criteria (e.g., basin inflow, precipitation, and reservoir levels) needed to classify the coming month as a dry, average, or wet month.

Successful implementation of ecosystem flows in the Chattahoochee River is challenged by water demand increases, reduced operational flexibility imposed by meeting minimum discharge requirements at downstream locations, and the importance of minimizing high discharge-related

damage to infrastructure. To address these challenges, we considered only the range of flows that were likely to be above minimum flow requirements and less than flows that could cause major infrastructure damage as identified by information provided by the National Weather Service (NWS) Advanced Hydrologic Prediction Service (NWS 2010; Table 1). The ecosystem flow guidelines are preliminary because in instances where water is diverted from the channel, or the channel is anthropogenically altered, natural flows may be insufficient to meet ecological needs.

Successful implementation of ecosystem flows in the Apalachicola River is challenged by the same types of limitations described for the Chattahoochee River. The degree of Apalachicola River channel entrenchment and widening, caused largely by Corps reservoir and dredging operations, varies spatially, but the discharge that is now required to reach bankfull elevation and cause floodplain inundation in the upper portion of the river is generally greater than the discharge that was historically required. However, datasets are available that quantify the amount of floodplain habitat inundated with the current level of entrenchment and over a range of discharges. These datasets, in combination with those that describe flow effects on sturgeon spawning and mussel habitats, will help to inform the development of future ecosystem flow guidelines and the evaluation of alternatives.

Thorough explanations of the physical, chemical, and ecological benefits from base flows, pulses, stable flow windows for spawning, and intra- and interannual flow variation are outside the scope of this letter; however, we refer the reader to Junk et al. 1989, Poff et al. 1997, Richter et al. 1998, Freeman et al. 2001, Postel and Richter 2003, and Mathews and Richter 2007 for fuller descriptions. The importance of baseflows, pulses, and flood flows are described within these resources, and they are quantitatively evaluated using the recently developed Environmental Flow Components (EFCs) in Indicators of Hydrologic Alteration (IHA)(Mathews and Richter 2007). General descriptions of the baseflow, pulse, and high pulse flow guidelines are provided below with general descriptions of the ecological significance of those flow guidelines.

Similar to the Instream Flow Guidelines provided to the ACF Compact's Federal Commissioner (USFWS 1999), the guidelines provided in this letter were developed using IHA, use the pre-dam period of record as a benchmark for comparison of flow alternatives, and rely on percentiles to define the frequency of high and low flow extremes. Using EFCs is recommended because the analysis separates ecologically-relevant hydrograph components (e.g., baseflows from pulses) allowing computation of magnitude, frequency, duration, timing, and rate of change statistics on individual hydrograph components rather than on the entire dataset. Consequently, these hydrograph summary statistics are easily developed, interpreted, and communicated, and have been used successfully to inform flow management downstream from hydropower dams.

1.1.1 Baseflow and small pulses

Baseflows determine the amount of habitat that is available for forage, reproduction, and rearing, which has a substantial influence on the abundance, diversity, and distribution of aquatic fauna. We have provided explicit base flow recommendations for every month in dry, average, and wet water years. Small pulses that do not exceed bankfull elevation provide influxes of upstream

trophic subsidies, and reprieves from low dissolved oxygen and high temperature that sometimes occur during summer months. Small pulses are included in the guidelines with explicit magnitude, frequency, duration, timing, and rate of change recommendations (Figures 3-6).

The flow guidelines were based on average daily flows (Figures 3-6). Average daily flows obscure the diel streamflow variation imposed by hydropower generation. Consequently, hydropower generation at Buford, West Point, Walter F. George, and to a lesser extent, Woodruff Dam, may change discharge two orders of magnitude, and change river stage significantly within a few hours. As a result, habitat availability is limited to periods that are too brief for the completion of essential life history requirements. To mitigate this impact, the provision of non-hydropower peaking “windows” should be evaluated during critical reproductive and rearing periods in order to reestablish native plant, fish, and invertebrate abundance and diversity in river reaches downstream from Corps-operated projects. Generally, this period corresponds to March – May when water temperatures increase. The timing, duration, and magnitude of this window should vary interannually in order to optimize the reproductive requirements of each species every few years. However, the duration of the non-peaking window requires additional research, but we expect that a minimum of 4-6 weeks between March and May are required.

The dry, average, and wet year baseflow guidelines are based on a retrospective analysis of the pre-dam hydrograph (Figures 3-6). It will be necessary to use appropriate hydrological and meteorological criteria to classify the coming month into dry, average, or wet categories. However, average daily baseflows should remain near the dry, average, and wet year flow guidelines depending on the category, and should not fall below the lower limit on any day of any year.

1.1.2 High flow pulses

High flow pulses that exceed bankfull elevation provide important ecological services. A large proportion of sport and non-game fishes rely on floodplain habitats to spawn, rear young, and forage. High flow pulses are also major forces that control nutrient and organic matter dynamics in large rivers, create new habitats, and ultimately affect riverine animal biomass (Junk et al. 1989). However, the spring reservoir refill period extends into the principal spawning season for a high proportion of fishes, meaning that spring flows and floodplain inundation are reduced. Thus, ensuring seasonal high flows and river-floodplain connectivity with the timing, frequency, duration, magnitude, and rate of change necessary to sustain ecological functions and wildlife populations are essential flow management objectives for dams on large rivers.

To provide flows that inundate the floodplain, the potential for reducing the magnitude of the autumn drawdown, changing the order of refill, and/or beginning the spring refill earlier in order to provide fish access to and inundation of the floodplain should be evaluated. Similarly, the Savannah District Corps has operated the Savannah River reservoir system in recent years with reduced winter drawdown to provide spring pulses that meet multiple downriver ecosystem objectives. This evaluation should separately consider flow conditions in wet, average, and dry climatic years. Additionally, it should be noted that relatively small changes in river stage can significantly increase the amount of river-floodplain connectivity. Consequently, minor changes

in dam operation could have large and positive effects on the river-floodplain ecosystem.

Recognizing that there are limits on operational flexibility due to the presence of infrastructure in some floodplains, methods should be evaluated to provide the operational flexibility necessary for floodplain inundation, which falls under the Corps' coequal project purpose of "Fish and Wildlife Resources." Such methods could include 1) protecting structures (e.g. moving to locations of higher elevations or elevating structures using stilts as is done in coastal communities) that may be impacted by 2, 10, 50, and 100-year recurrence interval pre-dam flows during periods of floodplain inundation; and/or 2) the purchase of structures built in the historic floodplain so that the Corps can intentionally provide flows that inundate the floodplain. These analyses should be simple to conduct, and would include acquisition of floodplain maps and identification of anthropogenic structures within the 2, 10, 50, and 100-year floodplains.

1.2 Floodplain inundation assessments

The relationships among the areal extent of Apalachicola River floodplain inundation, channel entrenchment effects, and water releases from Jim Woodruff Lock and Dam were previously assessed and related to discharge using the datasets and summaries provided by Light et al. 1998 and Light et al. 2006. These datasets have informed biologists and the Corps of the effects of flow releases on river-floodplain resources. Due to the difficulty of surveying all floodplain streams, lakes, and forests, Light et al. 1998 used intensive surveys at a subset of sites, general surveys at approximately 300 sites, and Geographic Information Systems (GIS) to assess the effects of hydrogeomorphic alteration on floodplain inundation areal extent. Light et al. 2006 compared pre-dam stage (prior to 1954) and recent stage (1995–2004) at five streamflow gaging stations in relation to discharge at the Chattahoochee gage (USGS gage number 02358000, Apalachicola River at Chattahoochee, FL). These stage-discharge relationships can also be used to calculate area (acres) of aquatic habitat connected to the main channel of the non-tidal Apalachicola River at different discharges for the pre-Lanier (1929-1955) and post-West Point (1975-2007) periods.

More recently, floodplain elevation maps have been generated using Light Detection and Ranging (LIDAR) remote sensing data with <1 ft accuracy and related to Apalachicola River stage-discharge relationships developed by Light et al. 2006 (Ron Bartel, Northwest Florida Water Management District [NWFWMD], 2010, pers. comm.). Stage-based LIDAR data may provide a more thorough and accurate evaluation of river flow effects on river-floodplain connectivity and habitat availability. We recommend that the Corps contact the NWFWMD to confirm that these datasets exist, request permission to access and use these new datasets, or invite collaboration between the Corps and the NWFWMD to evaluate effects of flow alternatives on floodplain resources. Operations in the environmental flow alternatives should be developed that will use reservoir storage at certain times to augment flow and increase Apalachicola floodplain inundation.

1.3 Water Quality

The effects of reservoir operations on water quality should be closely examined in the WCM update, including ongoing and potential future effects to dissolved oxygen (DO), temperature, nutrient and organic material dynamics, and capacity to assimilate industrial and municipal

discharges. We request that the Mobile District use the WCM update to make necessary modifications that will improve water quality downstream of Corps projects, as is being done by TVA and other Corps districts.

1.3.1 Dissolved Oxygen

The Service is most concerned about low DO in project tailwaters. We recommend that the Corps make a concerted effort to ensure that releases from all five ACF dams meet or exceed DO and other applicable water quality standards. An appropriate effort would include first monitoring DO upstream and downstream of Corps reservoirs, experimenting with operational and/or structural modifications to Corps projects to improve DO levels, and conducting post-modification DO monitoring to ensure that DO levels have been improved to State water quality standards. Examples of low DO releases from Buford, West Point, and Walter F. George dams are detailed below.

We urge the Corps to 1) monitor DO upstream and downstream of Lanier Reservoir, West Point Reservoir, Walter F. George Reservoir, and Jim Woodruff Reservoir and 2) experiment with operational and/or structural modifications to improve DO levels, and conduct post-modification DO monitoring to ensure that DO levels increase to state water quality standards. Simple weighted averages that formulate the amount of sluicing necessary to achieve the required downstream dissolved oxygen requirements may be particularly useful. The DO that results from the mixing of two water bodies (DO_{mx}) is a function of the dissolved oxygen (DO_1 and DO_2) and volumes (Q_1 and Q_2) of the two water bodies and is calculated using the following equation:

$$DO_{mx} = \frac{Q_1 * DO_1 + Q_2 * DO_2}{Q_1 + Q_2}$$

1.3.1.1. Buford Dam tailwaters

Low DO levels were recorded by the Georgia Department of Natural Resources-Wildlife Resources Division (GDNR-WRD) just below Buford Dam during 1996-2006. These DO levels affect angler success, GDNR-WRD’s stocking rates, and the native aquatic community. Periodic measurements taken during this period resulted in monthly minimum instantaneous $\leq$ 1.0 mg/L in September through December. Monthly average values were < 5.0 mg/L from August through November (Figure 7; Chris Martin, GDNR-WRD, 2010, pers. comm.). Low DO levels persisted downriver, depending on operational and climatic factors. For example, based on GDNR-WRD measurements on November 5, 2005, DO increased to 5.0 mg/L three miles downriver, and increased to 6.0 mg/L 5.2 miles downriver when releases from Buford Dam were < 2.0 mg/L (Chris Martin, GDNR-WRD, 2010, pers. comm.).

The Corps upgraded the venting capabilities of the Buford Dam turbines over the past few years. However, the upgrades resulted in < 1.0 mg/L increase over previous conditions (Chris Martin, GDNR-WRD, 2010, pers. comm.). The Corps should thoroughly evaluate the effectiveness of these upgrades.

Useful tools to improve DO levels to State standards in Georgia trout waters (6.0 mg/L daily average, 5.0 mg/L instantaneous) include sluicing instead of running discharge through the

penstocks and units, or to use a combination of the two routing methods. For example, on September 15, 2000, GDNR-WRD recorded a DO level of 1.5 mg/L at Buford Dam during a minimum flow release through the house unit. In contrast, DO levels measured on the same date during sluicing indicate that DO remained above 6.0 mg/L (Chris Martin, GDNR-WRD, 2010, pers. comm.). Thus, the Corps has demonstrated that sluicing below Buford Dam is an effective tool to mitigate low DO effects associated with hypolimnetic releases.

1.3.1.2. West Point Dam tailwaters

Dissolved oxygen data collected by the Corps downstream from West Point Dam from 1999 through 2001 indicate that DO levels met or exceeded the Georgia instantaneous standard (4 mg/L) 35% of the monitoring period in 1999, (monitoring from 6/15-9/14), 30% of the monitoring period in 2000 (monitoring from 7/25-9/30), and 4% of the monitoring period in 2001 (monitoring from 6/8-10/5; Georgia Power Company 2002). GDNR-WRD has investigated multiple fish kills below West Point Dam and has concluded that these fish kills are attributable to low dissolved oxygen levels (GDNR-WRD letter to the Corps, November 20, 2008).

1.3.1.3 Walter F. George Dam tailwaters

Low DO levels were associated with minor fish and mussel kills downstream of Walter F. George Dam (Rob Weller, GDNR-WRD, 2008, pers. comm.).

1.3.2 Temperature

The water temperatures of hypolimnetic releases below large dams are lower than would naturally occur during spring and summer months. Low water temperatures negatively affect warmwater fishes that require warmer water temperatures necessary for spawning and growth of young-of-year fishes. Thermal alteration can be ameliorated by structural modification of penstock location in the water column. Another option to moderate thermal alteration is to release (via sluicing) warmer water from a higher elevation in the reservoir’s water column. Once this water mixes with the cold hypolimnetic release, water temperatures more closely approximate natural water temperatures. A recent example of sluicing effects in the Mobile District comes from measurements taken during summer 2009 below Allatoona Dam. Sluicing in June caused water temperatures to increase approximately10ºC (Figure 8). Temperature increases were observed many miles downriver (USFWS 2009 unpublished data).

Similar to DO recommendations, we urge the Corps to monitor water temperature upstream and downstream of the five ACF Corps impoundments, and 1) experiment with operational and/or structural modifications to improve temperature levels, as needed, and 2) conduct post-modification monitoring to ensure that temperatures have been improved. Simple weighted averages that formulate the amount of sluicing necessary to achieve the required downstream temperature requirements may be useful. The seasonal timing of such releases exhibiting modified temperatures is of great importance. For example, the current summer thermal regime on the Etowah River, created by operations at Allatoona Dam, provides cool thermal refuge for striped bass in the upper Coosa River system. A thermal modification during the summer months below Allatoona Dam could be detrimental to fishes such as striped bass and lake sturgeon (Matt Thomas, GDNR-WRD, 2010, pers. comm.). Because the Service and GDNR-

WRD have responsibilities to protect native aquatic communities as well as recreational fisheries, we recommend the Corps explore methods for temperature modifications below their facilities, but coordinate closely with State and Federal agencies to determine the appropriate timing of such alterations.

In addition, it should be noted that the current thermal regime of Lanier Reservoir's tailwater is critical to the Chattahoochee River trout fishery and trout production at GDNR-WRD's Buford Hatchery. The tailwater trout fishery in the Chattahoochee, one of Georgia's premier fisheries, is dependent upon cold, well-oxygenated water releases for the survival of trout. The Buford Trout Hatchery produces 400,000 catchable trout annually and is dependent on Lanier Reservoir coldwater storage to maintain this production. Potential impacts to Chattahoochee River trout waters should be considered when making WCM decisions (Matt Thomas, GDNR-WRD, 2010, pers. comm.). The coldwater trout fishery below Buford Dam is of great importance to GDNR-WRD, and is also a responsibility for the Service as an important recreational fishery. Discussions between GDNR-WRD and the Corps should occur to determine if modifications are possible that avoid trout fishery impacts but also provide benefits to native warmwater fisheries below Buford Dam.

1.4 Fish Passage

Corps ACF dams impede the migration of diadromous and potadromous fishes including striped bass, Alabama shad, American eel, and Gulf sturgeon. Jim Woodruff Dam's impact on diadromous fish passage is large compared to dams on other southeastern rivers because it is located in the lower part of a large river basin. Consequently, there is significant interest in improving fish passage at this facility, as well as the two next upstream Corps facilities, George W. Andrews Lock and Dam and Walter F. George Lock and Dam. We appreciate the Corps' willingness and cooperation to modify operations thus far at Jim Woodruff to maximize fish passage for Alabama shad. Support and facilitation of fish passage research at Woodruff Dam, as well as other ACF Federal dams (notably George W. Andrews Lock and Dam and Walter F. George Lock and Dam) should continue with a goal of identifying and implementing operations and/or modifications that would allow riverine species to travel their historic migratory pathways. Provisions for fish passage should be incorporated in the WCM for Jim Woodruff Lock and Dam, George W. Andrews Lock and Dam, and Walter F. George Lock and Dam, while maintaining the need for operational flexibility.

1.5 Climate Change

The effects of climate change to ACF flow regimes and how to best adapt reservoir operations to the most likely foreseeable changes should be evaluated. It is our understanding that the Corps will be considering sea level rise when developing alternatives (Corps 2009). However, climate change will also affect river flows and the effects of a given set of operating rules will vary depending on whether the basin's climate becomes drier, wetter, more variable, or less variable. In particular, it is vitally important to adapt the level set as the top of conservation (TOC) pool to the long-term hydrology of the basin and the essential purposes the projects serve. In a scenario with greater variability between annual high flows and low flows, for example, it may not be feasible for these projects to simultaneously serve their existing levels of flood control protection and minimum flow support without adapting TOC pool levels to prevailing weather conditions.

The Corps already practices this concept with the multiple action zones and the occasional variances from the rule curves to store water above the TOC pool elevation during dry periods. Several models are developed that will be useful in this analysis and are briefly described in section *2.2 Evaluation of Alternative Models*. In addition to including multiple future climate scenarios into modeled discharge scenarios and Corps alternatives, flow provisions should be created for dry, average, and wet years in order to account for current climate variability.

1.6 Navigation

Navigation is an authorized project purpose for all five ACF Corps dams and the Corps has used reservoir storage in the past to support navigation. In recent years, however, lacking water quality certification to maintain the channel in Florida, we have seen only occasional flow management for the navigation purpose. Current physical channel dimensions dictate the flows that are necessary for navigability. Without providing flows to meet channel depth authorizations, dredging would be necessary to maintain channel navigability. Dredging has significant adverse effects to fish and wildlife. If flows for navigation are included in the WCM update, we recommend that dredging needs, dredging impacts on fish and wildlife, and a cost-benefit analysis be included in an evaluation of the effects of the channel maintenance activities required for navigation flow support. If flows for navigation are not included in the WCM update, improvement or simplification of the four-zone reservoir operational scheme that governs current operation should be considered.

1.7 Reservoir and Riverine Fisheries Management

The Corps follows a draft Standard Operating Procedure (SOP) for “Lake Regulations and Coordination for Fish Management Purposes.” The “fish spawn” SOP goal is to manage for generally stable or rising reservoir levels and for generally stable or gradually declining river levels for about 4 to 6 weeks in the spring months at Corps’ reservoirs. These draft SOPs are protective of reservoir fish spawning; however, stable or rising river levels are also beneficial for riverine sport fisheries. We understand it is not feasible to have stable and/or rising water levels in both the reservoirs and river during times of declining basin inflow. To address this issue, recent reservoir and riverine fisheries literature should be reviewed to evaluate whether a 4-6 week stable or rising reservoir window is supported for reservoir fish spawning and/or potentially detrimental to riverine fish spawning. We also recommend development of an alternative that includes modifying the draft SOPs to occasionally emphasize river spawning over reservoir spawning and define those circumstances where this would occur without unreasonably compromising other project purposes. Finally, we recommend that the Corps identify fish and wildlife recreation facilities that need infrastructure improvements to operate at a wider range of flows and/or reservoir elevations.

1.8 National Wildlife Refuges

The Service previously recommended to the Corps that a seasonal pattern of reservoir levels at W.F. George Reservoir would best accommodate the needs of Eufaula National Wildlife Refuge. Water levels that provide seasonal habitat for a large number of migratory bird species, control the spread of undesirable aquatic vegetation, and allow the manipulation of off-reservoir impoundments for waterfowl are principal concerns of the Refuge. These recommendations, which we included in the draft FWCA report for the Corps' 1998 Draft EIS on ACF water

allocation, were to manage the reservoir so that it behaves more like a river. Reservoir elevations that cycle between the highest levels (190 ft) in the late winter and early spring to the lowest levels (185 ft) in the late summer were recommended. These recommendations remain valid. How the benefits and impacts of such a scheme compare with the existing operating regime and other alternatives should be considered.

1.9 Apalachicola Bay

The predicted levels of freshwater inflow into Apalachicola Bay resulting from Corps alternatives will be of importance to the Service because they may affect salinity levels. Freshwater inflow reductions cause salinity increases and indirectly increase oyster mortality through increased colonization of marine oyster bed predators (Corps 1998). Additionally, juvenile Gulf sturgeons have optimal growth rates at relatively low salinity (9-10 ppt), and periods of extended higher salinities would likely limit feeding habitat availability.

As part of the Comprehensive Study for the Corps' DEIS (1998), the National Ocean Service (NOS) examined the freshwater inflow effects on the water circulation and salinity changes in Apalachicola Bay. Oysters were selected as a biological response variable because of their commercial fishery importance, habitat requirements, and expected response to salinity fluctuations (Corps 1998). A three-dimensional hydrodynamic model produced output that was used in an integrated biological model to assess the effects of potential freshwater inflow changes to Apalachicola Bay salinities and oysters. Predicted oyster mortality and oyster bed growth rates were compared for the various Corps' alternatives.

More recently, Livingston et al. (2000) developed a spatially-explicit hydrodynamic circulation model of the bay that predicts salinity, among other variables, as a function of freshwater inflow. This model has been used to model oyster mortality and growth in relation to freshwater inputs. The Service has used the results of this model to make inferences on the availability of low-salinity bay habitat for Gulf sturgeon. In addition, an alternative Apalachicola Bay salinity model was recently developed by Peter Sheng at the University of Florida (Sheng and Kim 2009). By using the Corps' daily average discharge output from the ResSim model for the Sumatra gage for the various alternatives, the model can compare the spatial extent and temporal duration of low- and high-salinity conditions among the alternative freshwater inflow scenarios. This information can be used to make inferences on the availability of bay habitat for Gulf sturgeon and to model oyster mortality and growth.

We recommend that the Corps or the Corps' consultants (Tetra Tech) contact the NWFWMD and/or the Florida Department of Environmental Protection (FDEP) to request permission to access and use the Livingston et al. models, or invite a collaboration between the Corps and NWFWMD/FDEP to evaluate effects of flow alternatives on Apalachicola Bay resources. The Sheng and Kim (2009) model should also be incorporated in the WCM update process to predict effects to Gulf sturgeon feeding habitat and potentially oyster mortality and growth. If all models are made available to the Corps and the Service, we recommend that the strengths and limitations of each model be evaluated to determine the model that will best suit the assessment requirements. In addition, coordination should occur with FFWCC's Fish and Wildlife Research

Institute to complete analyses of the relationship of freshwater inflow to the benthic communities of Apalachicola Bay and changes in fish and shellfish abundance.

1.10 Decision Support Model to Evaluate Changes to Corps' Operations

It is important to evaluate the effects of management strategies on the riverine ecosystem, recreation, navigation, hydropower, and other uses of Federal dams. Because of the numerous and sometimes competing demands for water, it is difficult to evaluate the effects of proposed management alternatives and to make the evaluation transparent. However, multiple free decision support tools (e.g., Netica) are available to facilitate the evaluation of alternatives. These tools are versatile in the sense that new information that results from monitoring the effects of management strategies is easily integrated into the analysis and decision process. Consequently, a better and more transparent understanding of how Corps operations affect the ecology and use of the ACF system can lead to improved future management. Therefore, a decision support model should be incorporated into the WCM update process.

1.11 Adaptive Management

An adaptive management program should be developed, consistent with the authorized purposes of the ACF reservoirs, for achieving specific ecological and social goals for the management of the ACF system including specific releases for Woodruff Dam. The program would formulate hypotheses about how such benefits might be achieved through dam operations, implement those operations, monitor ecosystem responses, and revise the operations based upon lessons learned.

2. Recommendations for Corps Hydrologic Modeling

2.1 Increasing Consumptive Demands

The impacts of increasing consumptive (municipal, industrial, and agricultural) water demands in the basin should be recognized and considered. This is a variable that an analysis of operational alternatives should incorporate along with climate-driven hydrologic variability. The relationship between increasing consumptive demands in the ACF Basin and effects on various project purposes should be quantified. For example, how is sustainable minimum flow release from Woodruff Dam affected if consumptive demands increase by 25, 50 or 100 percent by the years 2020, 2050, and 2080? We recognize the order made by Judge Magnuson limits operational alternatives for the express purposes of water supply. However, we also recognize that surface and groundwater withdrawals will continue to be made at various points in the system. The Corps alternative analysis must include metrics regarding water supply withdrawals including potential increases. The volume of storage that is being provided for water supply and has been proposed in each project and any limitations due to hydrologic conditions of meeting the water supply storage volume should be documented, as well as any potential changes in agricultural irrigation due to expanded irrigated acres or changes in crop composition.

2.2 Evaluation of Alternative Models

The Corps' unimpaired flows dataset that was used in the 1998 draft EIS was compared to 1) the unimpaired flows dataset that the Corps expects to use for the WCM update and 2) to the pre-Buford Dam USGS streamflow gage data. Aside from the addition of recent flow records, the most recent Corps-modeled unimpaired dataset is essentially unchanged from the 1998 version.

Compared to the USGS gage data, these datasets do not accurately represent the magnitude, duration, timing, and rate of change of flow extremes (i.e., minimum and maximum flows). Because flow extremes play important roles in reservoir operational decisions and in riverine, estuarine, and floodplain ecology, efforts should be made to develop unimpaired flow and alternative flow datasets that more accurately reflect flow extremes. We recommend that the use of alternative models be investigated to develop better unimpaired flow and alternative flow datasets.

Similarly, land cover has changed significantly since the early 20th century in the upper and middle portions of the ACF basin. Prior to both mainstem damming and discharge gaging, expansive agriculture, chestnut blight, fire suppression, and other factors affected land cover in the southern Appalachians, Piedmont, Fall-line Sandhills, and upper Coastal Plain regions. The hydrological consequences of land cover changes could have been manifested in the flow extremes observed during droughts and heavy rain. Nevertheless, the pre-dam hydrologic period of record is presently the best available hydrologic dataset to characterize pre-dam streamflows, develop ecosystem flow alternatives, and with which to compare flow alternatives. Models that predict hydrological alteration that occurs in response to land cover changes could be particularly useful in the development and assessment of flow alternatives.

The United States Geological Survey (USGS) is developing a Precipitation-Runoff Modeling System (PRMS, http://water.usgs.gov/software/PRMS) for the ACF. This watershed model will facilitate the inclusion of impacts of precipitation, climate, and land use changes on streamflow, sediment yields, and basin hydrology. If the PRMS is developed specifically for the ACF in a timeframe useful for the ACF WCM update process, it should be used as an additional evaluation tool. The PRMS output potentially could be used to 1) check the precision of the Corps' unimpaired flows datasets, and 2) supply an alternative unimpaired flow dataset to use based on informed climate and land use change predictions. Use of this model is based on the assumption that the PRMS model results reflect average flows and flow extremes better than existing datasets and other models. The latter analysis may be particularly useful to determine if reservoirs can maintain downstream flows through droughts.

National Oceanic and Atmospheric Administration (NOAA) funded the Georgia Water Resources Institute (GWRI) to complete a historical and future assessment of precipitation, evapotranspiration, soil moisture, and run-off trends in the ACF Basin to support ongoing water resources planning in the region. This method used both historical gage data and the Corps unimpaired flows dataset in a Joint Variable Spatial Downscaling model that incorporated climate change effects. Future stream flow, river flow, reservoir level, and power generation forecasts were made at the sub-basin level for the next 100 years. Coordination with USGS and GWRI should occur regarding these new models to explicitly address climate-based operational flexibility during the development and evaluation of flow alternatives, the WCM update, and the EIS analyses.

Lastly, the Corps' HEC-5Q water quality analyses rely on average daily flow to predict water quality parameters (e.g., temperature and dissolved oxygen) in six hour time steps and at 0.5 mile intervals. Although these model outputs can be used to compare among flow alternatives, they are not expected to accurately predict either the water quality values or the range of values that

are likely to occur in response to hourly discharge changes. Alternative water quality models exist and State resource agencies should be contacted to determine whether water quality models are developed for the ACF Basin. Additionally, regression models that accurately predict water quality parameters (e.g., water temperature and dissolved oxygen) can be developed using a combination of water quality datasets, hourly discharge, and other environmental parameters (e.g., weather and solar exposure). Alternative water quality assessment methods should be considered to accurately evaluate effects of flow alternatives on water quality.

3. Evaluation of Corps Alternatives for FWCA Report

3.1 ResSim Model Output Analyses

It is our understanding that ResSim will be used for the Corps' flow analyses. The flow statistics used by the Service in the past to analyze the resulting datasets were derived by using the Indicators of Hydrologic Alteration (IHA) and the Range of Variability Approach (RVA). Because flow is a master variable in fluvial systems, and because the ecology of fish and wildlife is closely linked to the flow regimes in which they evolved, the current evaluation should continue to rely on tools such as IHA, RVA, and Environmental Flow Components (EFCs) (Mathews and Richter 2007). Specific flow statistics and species-specific flow-ecology relationships (as available) that are important to natural resource sustainability, as well as the ACF Riverine Community Habitat Assessment and Restoration Concept (RCHARC) study (Freeman et al. 1997), should also be considered.

3.2 HEC-5Q Water Quality Model Output Analyses

It is our understanding that HEC-5Q will be used for the Corps' water quality analyses. We understand that this model predicts water quality parameters in six hour time intervals in river and reservoirs. Similar to the analyses contained in the Corps' 1998 draft EIS (Corps 1998), the analyzed data should be composed of summer values (May through October), separated by drought, dry, average, and wet year types for each alternative. The following information should be developed for each alternative to evaluate the effects on water quality and aquatic resources in the modeled tailrace and riverine locations:

- Total number of days with dissolved oxygen below a daily average of 6 milligrams per liter (mg/L) in locations within Georgia trout waters, and below a daily average of 5 mg/L in non-trout waters;
- Total number of instantaneous "measurements" less than 4 mg/L;
- Monthly exceedance figures and box plots with outliers for dissolved oxygen (mg/L);
- Monthly exceedance figures and box plots with outliers for water temperature; and
- Average stream percent wastewater.

For each alternative, the following information should be developed to evaluate the effects on water quality and aquatic resources for the modeled ACF reservoir locations:

- Average values of summer Chlorophyll a (*u*g/L);
- Average summer retention time (days); and

- Average summer phosphorus loading (pounds/acre/month).

3.3 Floodplain Connectivity Analyses

Assessing the extent of floodplain inundation will be a critical component of the alternatives analysis assessment. The Apalachicola River floodplain analysis should be decided following the Corps' attempt to access the river stage-based LIDAR data collected and housed by the NWFWMD. If the data are made available, the Corps should provide these data to the Service and an analysis of the area of aquatic habitat (separated by aquatic habitat type) connected to the Apalachicola River under the range of discharges for the period of record should be evaluated. If LIDAR data are not provided, the magnitude, duration, timing, frequency, and rate of change of Apalachicola River floodplain inundation should be evaluated using the relationships quantified by Light et al. 1998 and Light et al. 2006.

Although the areal extent of the Chattahoochee River floodplain is one-fifth that of the Apalachicola River floodplain (Davis 1997), it likely served multiple important ecological roles prior to flow alteration by multiple mainstem reservoirs. To our knowledge, the Tri-State Comprehensive Study Riparian Wetland Element (Davis 1997) houses the best available dataset for assessing the effects of flow alternatives on the Chattahoochee River floodplain. These data should be used to evaluate the probable extent of floodplain inundation for each flow alternative. However, data are only available for one riverine site in the Chattahoochee River Basin positioned between Jim Woodruff Lock and Dam and G.W. Andrews Lock and Dam. At unsurveyed locations, known river stages at which floodplain inundations occurs should be used to evaluate the frequency, duration, and timing of floodplain inundation for flow alternatives provided by the Corps (see Table 1 and associated information provided by NWS 2010). At sites without this information, the 2-year recurrence interval discharge to approximate the incipient point of flooding should be used to evaluate the frequency, duration, and timing of floodplain inundation. Because channel alteration (e.g., channel incision) can increase the recurrence interval at which flooding occurs and because we have little information on channel alteration, other data sources should be investigated to aid in the floodplain inundation assessment.

3.4 Reservoir Fisheries Analyses

Sport fisheries are important recreational and economic resources in all of the Federal ACF reservoirs. Important sport fishes in all five reservoirs include largemouth bass and crappie, but each reservoir supports a mix of several additional species, including walleye (Lanier Reservoir only), striped bass, bluegill, redear sunfish, and others. Based on interviews of fisheries managers and researchers in the basin, Ryder et al. (1995) identified the species considered critical in an evaluation of operating alternatives and the relative acceptability of reservoir levels for these species. A Delphi technique was used to obtain expert opinion for select reservoirs on reservoir fish guilds, important seasonal periods for those species, and acceptability ratings for various reservoir levels in the ACF and ACT (Ryder et al. 1995). The Service cooperated with the Corps for the 1998 draft EIS for ACF water allocation to develop a reservoir fisheries performance measure using the findings of Ryder et al. (1996). This information was used to create a reservoir fisheries performance measure by looking at the critical spawning and rearing periods, reservoir elevations during these times, and assigning a greater weight to stable or rising elevations during those time periods. The performance measures were then compared for the various alternatives.

The reservoir fisheries performance measure should be updated with additional information, literature, and/or relevant datasets that have been developed in the past ten years, and used to evaluate the relative impacts of the Corps' alternatives on reservoir sport fisheries. Potential new datasets to be included that have been indentified to date include largemouth bass young-of-year data in West Point Reservoir (Brent Hess, GDNR-WRD, 2010, pers. comm.), as well as black basses and crappie data in relation to reservoir retention times and year-class strength in Walter F. George, West Point, and Bartletts Ferry reservoirs (Mike Maceina, Auburn University, 2010, pers. comm.).

3.5 Riverine Fisheries Analyses

Sport fisheries are also important recreational and economic resources in the riverine portions of the ACF project, especially in the Apalachicola River. Reproduction of many fishes is intricately tied to the floodplain, and alteration of flow regimes can affect reproductive success, year-class strength, growth, condition, and other life-history attributes. Data identified to date will be provided by the FFWCC and the USGS and used to evaluate the relative impacts of the Corps' alternatives on riverine sport fisheries. Specific measures to be evaluated include year-class strength versus acres of inundated floodplain spawning habitat, changes in catch rates of sportfishes in various water years, and changes in relative weight (condition) of sportfishes in various water years.

3.6 Apalachicola Bay Salinity Analyses

If a salinity model is incorporated in the WCM update process, as described in Section 1.8 above, the model output should be incorporated in the FWCA evaluation. A list of data needs should be developed to be produced as a result of these analyses. These data should include the spatial extent and temporal duration of low- and high-salinity conditions among the alternative freshwater inflow scenarios and possibly the percent oyster mortality and oyster growth rates.

3.7 Federally-protected Species Analyses

It is our understanding that the Corps will be conducting certain analyses to evaluate the effects of the various alternatives on federally-protected species. These analyses will be contained in the Corps' Biological Assessment (BA) accompanying the draft EIS. The Service will include these analyses in our FWCA evaluation, assuming they are available for us to do so. The types of analyses that should be evaluated are contained in the "*Analyses for the Effects of the Action*" section of the Service's June 1, 2008, RIOP Biological Opinion (USFWS 2008) and are listed below:

Gulf sturgeon

- Frequency (% of days) of Gulf sturgeon spawning habitat availability (acres of potentially suitable spawning substrate inundated to depths of 8.5 to 17.8 feet) on each day March 1st through May 31st, at the two sites that support spawning;
- Frequency (% of years) of Gulf sturgeon spawning habitat availability (maximum acres of potentially suitable spawning substrate inundated to depths of 8.5 to 17.8 feet for at

least 30 consecutive days each year), March 1st through May 31st, at the two sites that support spawning;

- Daily fall rates with respect to exposure of Gulf sturgeon eggs and larvae;
- Maximum number of consecutive days per year less than 16,000 cfs; and
- Departures from average water temperatures between March 1st to May 31st.

Freshwater mussels

- Lowest daily flow for each year;
- Inter-annual frequency of flows less than 5,000-10,000 cfs;
- Maximum number of days per year with flows less than 5,000 – 10,000 cfs;
- Maximum number of consecutive days less than 5,000 – 10,000 cfs;
- Median number of days per year less than 5,000 – 10,000 cfs;
- Frequency (percent of days) of daily stage changes (ft/day); and
- Frequency (percent of days) of daily stage changes (ft/day) when releases at Woodruff Dam are less than 10,000 cfs.

Floodplain connectivity

- Frequency (% of days) of growing season (April-October) floodplain connectivity (acres) to the main channel using Light et al. (1998);
- Frequency (% of years) of growing season (April-October) floodplain connectivity (acres) to the main channel using Light et al. (1998).

4.0 Recommendations for Additional Coordination

This PAL includes comments from the State wildlife agencies in the basin. As is encouraged under the FWCA, we will continue to coordinate with these agencies, and will coordinate with NOAA Fisheries, as we move forward.

To assist in the development of alternatives and mitigation, we have suggested evaluations and analyses that address flow, water quality, fish passage, climate change, navigation, reservoir and riverine fisheries management, impacts to Eufaula National Wildlife Refuge, Apalachicola Bay resources, as well as the inclusion of a decision support model and adaptive management. Our recommendations for hydrologic modeling include addressing the impacts of increasing consumptive demands and evaluating alternative models to reflect flow extremes and climate change. We have identified analyses to evaluate Corps alternatives with respect to flow, water quality, floodplain connectivity, reservoir and riverine fisheries, Apalachicola Bay resources, and federally-protected species. We anticipate that the next step will be for the Corps and the Service to work together to update the interagency SOW to reflect Corps and Service responsibilities for the evaluations and analyses contained in this PAL. As you know, such a division of labor occurred to produce the prior DEIS and FWCA Report (Corps 1998).

We would like to be involved in the development of alternatives, including the development of environmental flows alternatives. The Service would like to assist in the development of such

alternatives to maximize benefits to ecological resources and to gain a better understanding of the consequences of implementing such alternatives on other authorized project purposes and operational constraints. Once all of the alternatives have been analyzed, we anticipate working with the Corps to identify opportunities for restoration, compensation, and enhancement.

We appreciate the opportunity to participate in the planning stages of your project. We would like to stress the Corps water management is not just about avoiding adverse affects, but also to look at opportunities to restore and improve habitat. If you have any questions, please contact Georgia Ecological Services staff biologists Alice Lawrence or Will Duncan at (706) 613-9493, or Panama City Ecological Services staff biologist Karen Herrington at (850) 769-0552 ext. 250.

Sincerely,

Sandra S. Tucker

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Table 1. Locations and river stages in the Chattahoochee River where the National Weather Service Advanced Hydrologic Prediction Service predicts damage to occur. Discharges were calculated using stage-discharge relationships at USGS streamflow gages. Only damage to manmade structures was considered as damage. Flooding of riverwalks, riverwalk structures, yards, and moving of equipment or livestock to avoid inundation was not considered to be damage.

Location (upstream to downstream order	Stage at which damage occurs	Discharge at which damage occurs
Chattahoochee at Norcross	16	20631
Chattahoochee at Roswell	14	29846
Chattahoochee at Atlanta	18	22023
Chattahoochee at Whitesburg	26	49379
Chattahoochee at West Point	21	62530
Chattahoochee at Columbus	41	261407

Figure 1. Histogram of mean + standard error daily discharge values reported in cubic feet per second (cfs) obtained from river gauges on the Duck River at Shelbyville (top) and Columbia (bottom), Tennessee by season. Means represent daily discharge values for each month for 10 years pre and 10 years post Reservoir Release Discharge Initiative (RRI) completed at Normandy Dam beginning in late 1991. Letters atop standard error bars indicate significantly different means as determined by Tukey's a-posteriori test. Results of analysis of variance (F values and p values) are indicated below each graph. Graphs and figure title taken directly from Alstedht and Johnson 2004, and used with permission from Dr. Paul Johnson.

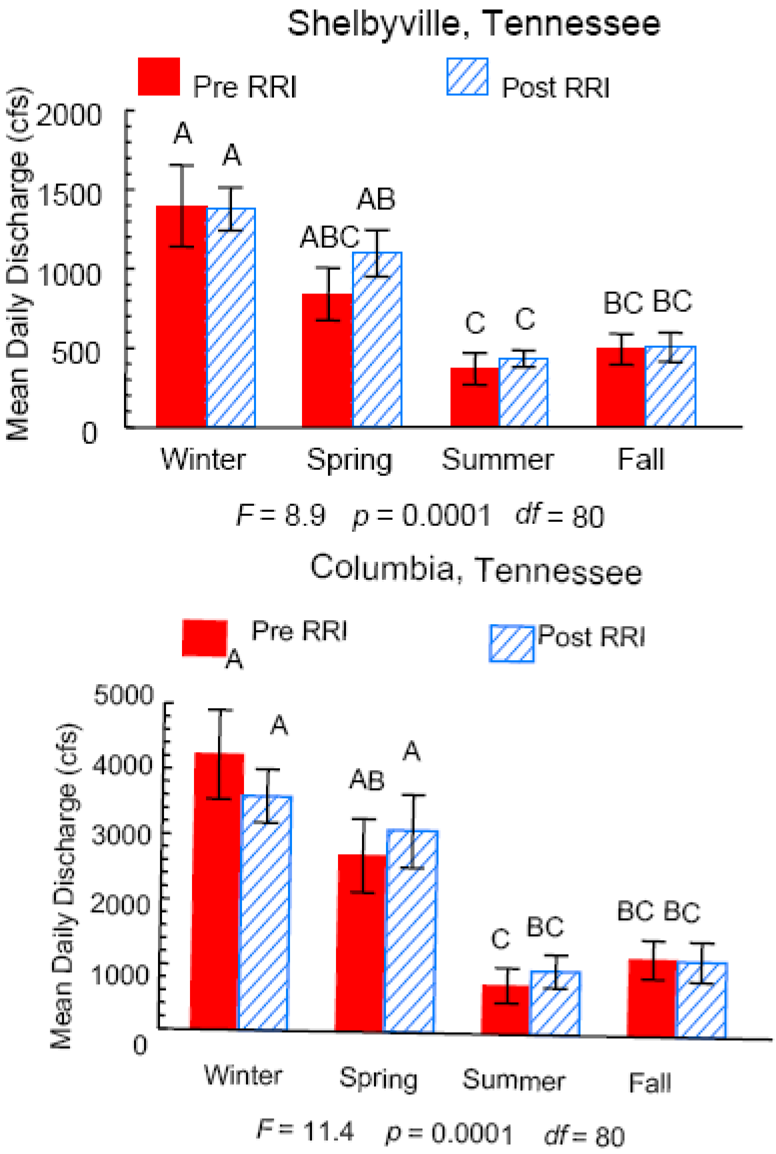


Figure 2. Comparative mean + s.e. of mussel species (top) and mussel number (bottom) sampled from 17 sites in the Duck River in 1977, 1988, and 2002. Letters atop standard error bars indicate statistically different means determined by Tukey's HSD a-posteriori test. Results of analysis of variance (F values and p values) are indicated below each graph. Graphs and figure title taken directly from Alstedht and Johnson 2004, and used with permission from Dr. Paul Johnson.

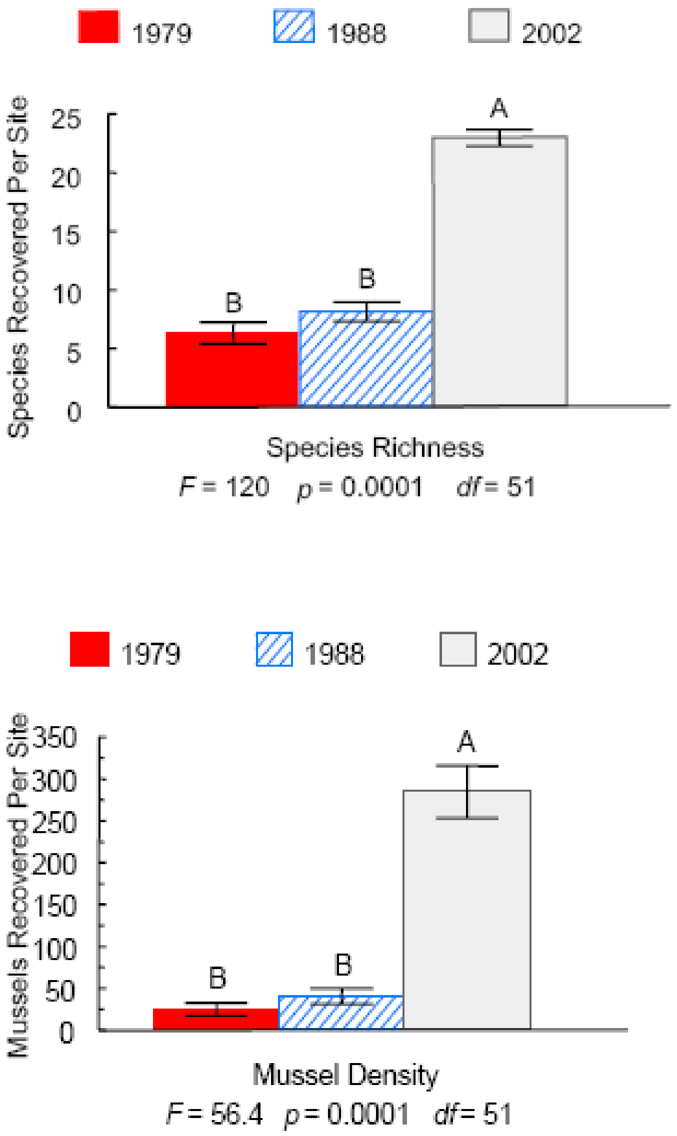
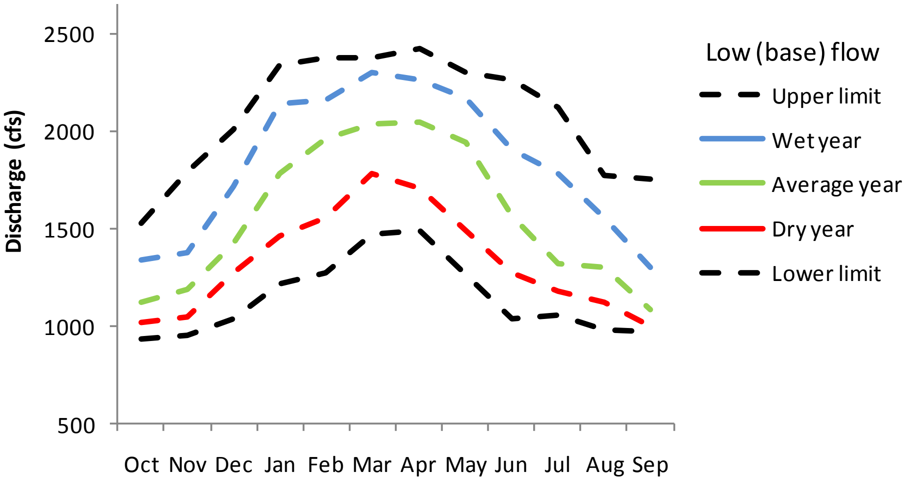


Figure 3. Preliminary a) low (base) flow and b) low and pulse flow guidelines and description for the Chattahoochee River USGS Norcross gage.

a)



b)

Data analyzed: The only pre-Buford dam data that were available for this analysis extended between 1903 and 1946 (44 years) at the Chattahoochee River gage (02335000) at Norcross.

Base flow description

Low (base) flows are defined as all flows that fall below the lower 25th percentile of flows for the pre-Buford dam period at the USGS Norcross gage. The 10th, 25th, 50th, 75th, and 90th percentiles for low flows for each month were then calculated to quantitatively describe the monthly lower and upper base flow limit, and dry, average, and wet year low flow recommendations. Most calculations were derived from Environmental Flow Components in Indicators of Hydrologic Alteration (Version 7-1).

Pulse flow description

High flows were defined as flows that exceeded 75% of the average daily flows for the period of record. Small pulses were defined as all high flows that were lower than the 2-year recurrence interval, and high pulses were defined as high flows that fall between the 2 and 10-year recurrence interval. The 2-year recurrence interval discharge was used as an indication of bankfull discharge because the discharge that corresponds to the incipient point of flooding was unknown. Consequently, small pulses are not expected to exceed bankfull elevation, but high pulses are expected to exceed bankfull elevation and cause floodplain inundation. The recommendations for small and high pulses correspond to the 25th and 75th percentiles of magnitude, frequency, duration, timing, and rise and fall rate values. High pulse recommendations were made only for wet years because more than half of pre-dam years did not contain pulses based on the parameters used to define high pulses in this analysis.

Small pulses

At the Chattahoochee River USGS Norcross gage, 9-18 flow pulses per year should be between 3,658 and 4,980 cfs, should last between 2-3 days, and should occur between mid-March and early June. Rise and fall rates can range between 1,260-2,054 cfs and 1,178-733 cfs, respectively.

High pulses

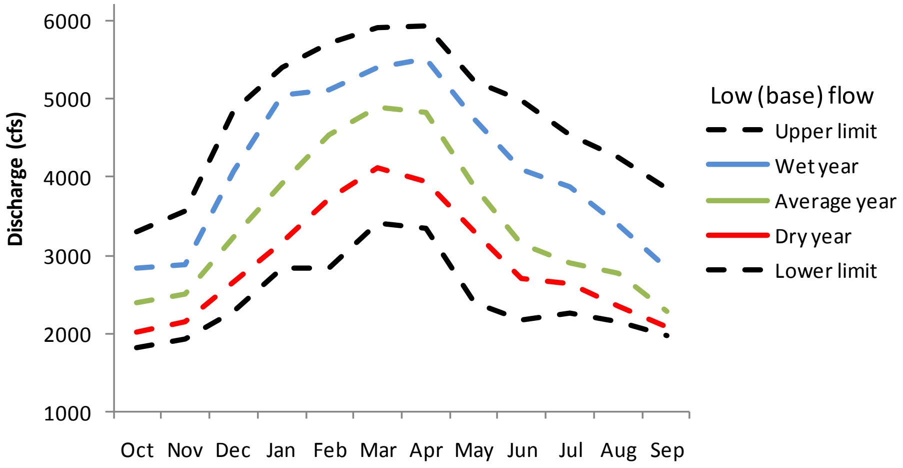
In wet years, a pulse of 17,650-28,080 cfs should last 9-80 days, should occur between early January and early May. Rise rates should range between 697-7518 cfs/day, and fall rates should range between 3376-460 cfs/day.

Non-hydropower peaking window

We recommend that the Corps evaluate the provision of non-hydropower peaking “windows" during critical reproductive and rearing periods for a minimum of 4-6 weeks from March – May.

Figure 4. Preliminary a) low (base) flow and b) low and pulse flow guidelines and description for the Chattahoochee River at the USGS gage below West Point Dam.

a)



b)

Data analyzed: The pre-Buford dam data that were available for this analysis extended between 1896 and 1955 (60 years) at the Chattahoochee River gage (02339500) below West Point Dam.

Base flow description

Low (base) flows are defined as all flows that fall below the lower 25th percentile of flows for the pre-Buford dam period at the USGS West Point gage. The 10th, 25th, 50th, 75th, and 90th percentiles for low flows for each month were then calculated to quantitatively describe the monthly lower and upper base flow limit, and dry, average, and wet year low flow recommendations. Most calculations were derived from Environmental Flow Components in Indicators of Hydrologic Alteration (Version 7-1).

Pulse flow description

High flows were defined as flows that exceeded 75% of the average daily flows for the period of record. Small pulses were defined as all high flows that were lower than the 2-year recurrence interval, and high pulses were defined as high flows that fall between the 2 and 10-year recurrence interval. The 2-year recurrence interval discharge was used as an indication of bankfull discharge because the discharge that corresponds to the incipient point of flooding was unknown. Consequently, small pulses are not expected to exceed bankfull elevation, but high pulses are expected to exceed bankfull elevation and cause floodplain inundation. The recommendations for small and high pulses correspond to the 25th and 75th percentiles of magnitude, frequency, duration, timing, and rise and fall rate values. High pulse recommendations were made only for wet years because more than half of pre-dam years did not contain pulses based on the parameters used to define high pulses in this analysis.

Small Pulses

At the Chattahoochee River gage below West Point, 9-16 flow pulses per year should peak between 8,853 and 11,580 cfs, should last between 3-4 days, and should occur between early March and mid-June. Rise and fall rates can range between 2,483-3,698 cfs/day and 2,256-1,536 cfs/day, respectively.

High Pulses

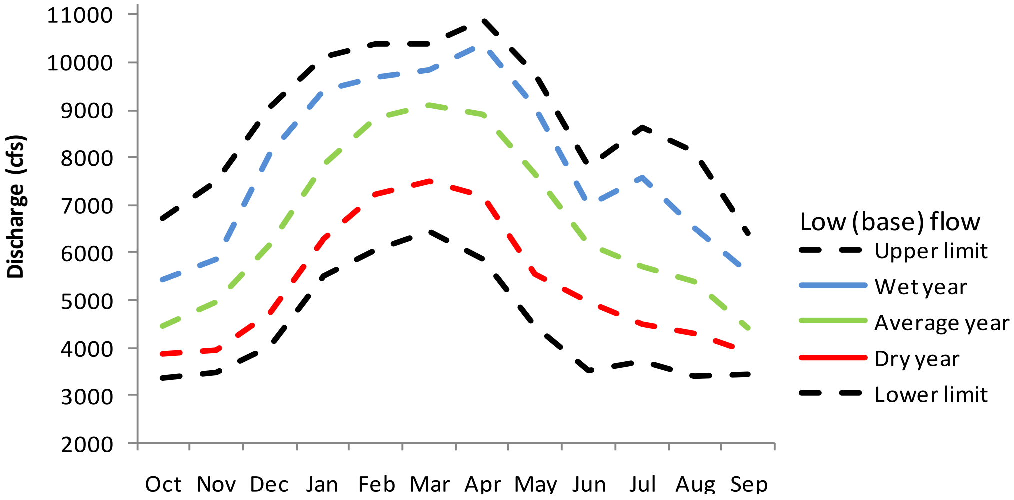
In wet years, a pulse that peaks between 48,830 - 58,950 cfs should last between 19-38 days, and should occur between mid-January and early April. Rise and fall rates can range between 5,563-13,170 cfs/day and 4,230-1787 cfs/day, respectively.

Non-hydropower peaking window

We recommend that the Corps evaluate the provision of non-hydropower peaking “windows" during critical reproductive and rearing periods for a minimum of 4-6 weeks from March – May.

Figure 5. Preliminary a) low (base) flow and b) low and pulse flow guidelines and description for the Chattahoochee River at the Walter F. George Corpsnode.

a)



b)

Data analyzed: ACOE unimpaired flows dataset at the Walter F. George node and inferences from West Point analysis results.

Base flow description

No USGS discharge data for the pre-Buford dam period are available at Walter F. George. However, comparisons between pre-Buford USGS gage data and Corps-modeled “unimpaired flows” data show similar median monthly flows. Thus, we used median monthly flows in the Corps-modeled unimpaired dataset (1936-2006) to calculate the predicted low (base) flows that should occur at the W.F. George node. We excluded 103 negative flow values from the Corps dataset in this analysis.

Low (base) flows are defined as all flows that fall below the lower 25th percentile of flows for the pre-Buford Dam period at the USGS West Point gage. The 10th, 25th, 50th, 75th, and 90th percentiles for low flows for each month were then calculated to quantitatively describe the monthly lower and upper base flow limit, and dry, average, and wet year low flow recommendations. Most calculations were derived from Environmental Flow Components in Indicators of Hydrologic Alteration (Version 7-1).

Pulse flow description

Again, no USGS discharge data for the pre-Buford dam period are available at Walter F. George. Corps-modeled unimpaired flows do not represent the flow extremes (minimum and maximum flow duration, magnitude, timing, frequency, and rate of change) that were observed at USGS gages during the pre-Buford Dam period. Consequently, using the Corps-modeled data to make high pulse recommendations cannot be justified.

Small pulses

We infer from the West Point analysis that used real pre-Buford Dam USGS data, that 9-16 flow pulses per year should peak between 1.8-2.4 times higher than the baseflow river stage (approximately 16,369-21,535 cfs) in March for an average flow year. Pulses should last between 3-4 days, and should occur between early March and mid-June. Rise and fall rates should not exceed rates from other site recommendations.

High pulses

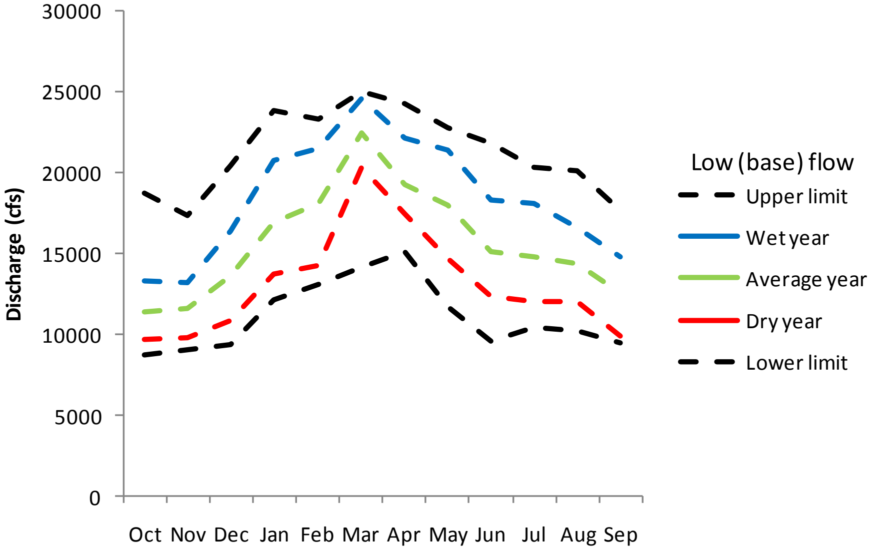
Development of a wet year flow guidelines is complicated by the fact that no stage-discharge relationships are presently known for the river segment between Walter F. George Dam and Woodruff Dam. However, the National Weather Service Advanced Hydrologic Prediction Service indicates that extensive floodplain inundation occurs at a river stage of 150 ft, although no significant damage is predicted to occur up to 160 ft. Consequently, we recommend that the ACOE evaluate wet year releases from Walter F. George that range between 150 and 160 ft. Duration, timing, and rates of change should be similar to the recommendations for West Point Dam.

Non-hydropower peaking window

We recommend that the Corps evaluate the provision of non-hydropower peaking “windows" during critical reproductive and rearing periods for a minimum of 4-6 weeks from March – May.

Figure 6. Preliminary a) low (base) flow and b) low and pulse flow guidelines and description for the Apalachicola River USGS gage at Chattahoochee, FL.

a)



b)

Data analyzed: The pre-Buford dam data that were available for this analysis extended between 1922 and 1955 (34 years) at the Apalachicola River gage (02358000) at Chattahoochee, FL.

Base flow description

Low (base) flows are defined as all flows that fall below the lower 25th percentile of flows for the pre-Buford dam period at the USGS West Point gage. The 10th, 25th, 50th, 75th, and 90th percentiles for low flows for each month were then calculated to quantitatively describe the monthly lower and upper base flow limit, and dry, average, and wet year low flow recommendations. Most calculations were derived from Environmental Flow Components in Indicators of Hydrologic Alteration (Version 7-1).

Pulse flow description

High flows were defined as flows that exceeded 75% of the average daily flows for the period of record. Small pulses were defined as all high flows that were lower than the 2-year recurrence interval, and high pulses were defined as high flows that fall between the 2 and 10-year recurrence interval. The 2-year recurrence interval discharge was used as an indication of bankfull discharge because the discharge that corresponds to the incipient point of flooding was unknown. Consequently, small pulses are not expected to exceed bankfull elevation, but high pulses are expected to exceed bankfull elevation and cause floodplain inundation. The recommendations for small and high pulses correspond to the 25th and 75th percentiles of magnitude, frequency, duration, timing, and rise and fall rate values. High pulse recommendations were made only for wet years because more than half of pre-dam years did not contain pulses based on the parameters used to define high pulses in this analysis.

Small Pulses

At the Apalachicola River gage at Chattahoochee, FL, 3-6 flow pulses per year should peak between 30,950 and 41,110 cfs, should last between 4-13 days, and should occur between mid-February and mid-May. Rise and fall rates can range between 2,493-5,356 cfs/day and 2,353-1,473 cfs/day, respectively.

High Pulses

In wet years, a pulse that peaks between 86,630-122,800 cfs should last between 28-68 days, and should occur between late-February and early April. Rise and fall rates can range between 2,544-8,108 cfs/day and 4,236-2,330 cfs/day, respectively.

Non-hydropower peaking window

We recommend that the Corps evaluate the provision of non-hydropower peaking “windows" during critical reproductive and rearing periods for a minimum of 4-6 weeks from March – May.

Figure 7. Monthly maximum, average, and minimum dissolved oxygen concentrations in the Chattahoochee River at Buford Dam. Data courtesy of Georgia Department of Natural Resources-Wildlife Resources Division.

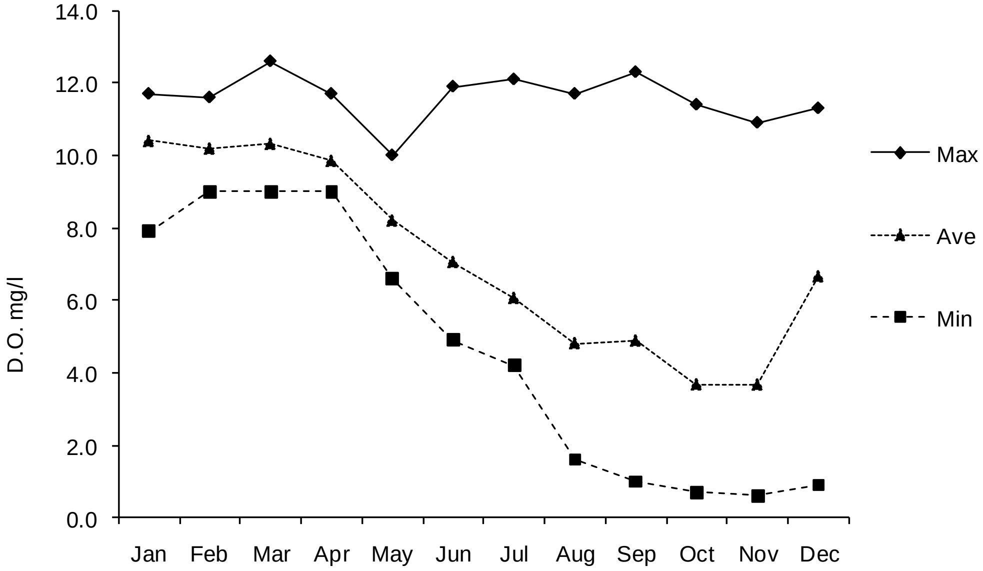
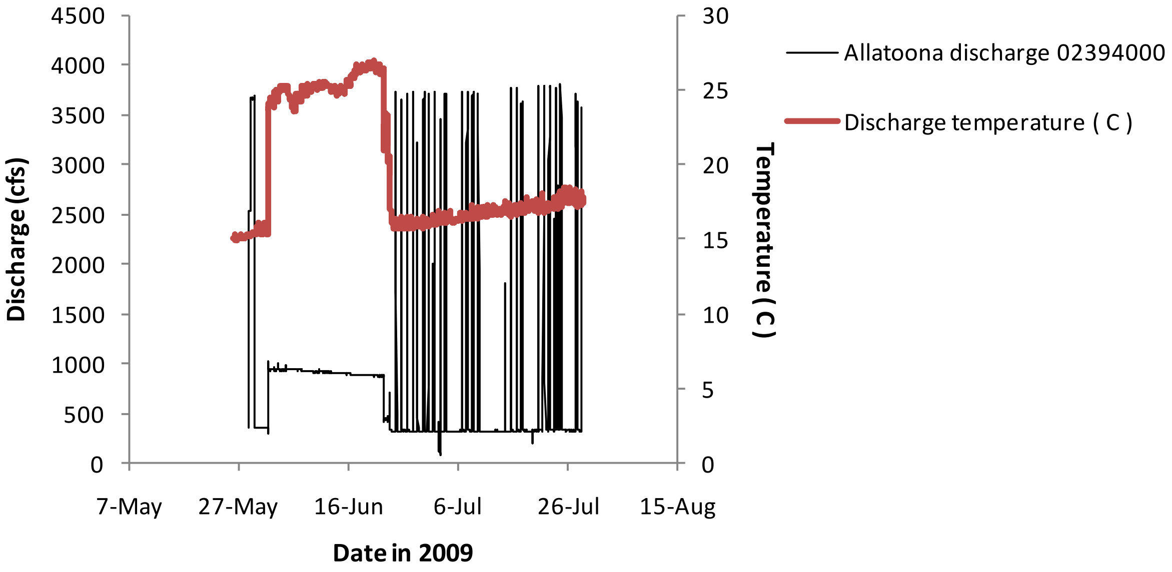


Figure 8. Discharge and water temperature measurements below Allatoona Dam on the Etowah River, Georgia. Sluicing from a location higher in the reservoir's water column occurred in June, causing the observed downriver temperature increases.



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March 1, 2011

Colonel Steven J. Roemhildt
US Army Corps of Engineers, Mobile District
P.O. Box 2288
Mobile, AL 36628-0001

Dear Colonel Roemhildt:

We are providing an Addendum to the U.S. Fish and Wildlife Service (Service)'s April 2, 2010, Planning Aid Letter (PAL) for the proposed Water Control Manual (WCM) Updates for the Apalachicola-Chattahoochee-Flint (ACF) River Basin in Georgia, Alabama, and Florida. The purpose of the WCM Updates is to identify operating criteria and guidelines for managing water storage and release of water from United States Army Corps of Engineers (Corps) reservoirs. In the National Environmental Policy Act (NEPA) review, the Corps will address current operations, proposed changes in water management operations at the reservoir projects within the limits of the existing authorities, as well as potential impacts throughout the basin that would result from implementation of the updated manual.

The purpose of the Service's 2010 PAL was to identify resource values and issues, identify endangered species issues, and propose preliminary changes, mitigation, or enhancement opportunities to facilitate your decision-making as it relates to equal consideration of fish and wildlife resources. Based on recent analyses conducted by the Service, we submit the following addendum under the Fish and Wildlife Coordination Act (FWCA) (48 Stat. 401, as amended; 16 U.S.C. § 661 *et seq*.). This addendum solely addresses ecosystem flow guidelines -- all other information and recommendations in the PAL are still applicable. In the future, we will provide additional information in the form of a draft Fish and Wildlife Coordination Act report. A separate consultation will occur regarding the potential impacts of the Corps' proposal on federally-listed fish and wildlife species protected under the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. § 1531 *et seq*.).

Rationale for revision of ecosystem flow guidelines

The ecosystem flow guidelines that were delivered in the PAL were developed with the aid of Indicators of Hydrologic Alteration (IHA; TNC 2007). Although the IHA methodology is scientifically defensible, subsequent examination of IHA methodology and output revealed several concerns that could affect possible incorporation of the guidelines in the Corps' operations. Therefore, the Service is providing revised low and high flow guidelines (Figures 1-4 and Tables 1-4).

We had two reasons for revising the flow guidelines. First, the default IHA parameters used for the PAL initially separated the flow data into high and low flows using a percentile of the pre-Buford period of record. This method resulted in representation of low-flow discharges in summer-fall months by many values, and representation of low flows in winter-spring months by fewer values. This means that some months in some years were not represented in subsequent analyses. For example, historic low flows in the Apalachicola River remained above the 75th percentile or above flood stage for prolonged time periods, meaning that those periods were not represented in the low flow analysis. Thus, if the historic flow regime is to be used to help guide low flow alternative development, evaluation, and implementation, the low flow analysis should examine the entire range of low flows that occurred in every month of every year before construction of Buford Dam.

Second, the low and high flow analyses in IHA calculate summary statistics using median values (for non-parametric analyses) to represent each year (TNC 2007). For example, IHA calculates the annual median high pulse magnitude, and uses the median values from every year to calculate summary statistics. While this is a statistically valid approach to summarizing large datasets, summarizing multiple intra-annual pulses by a single value results in a narrower range of magnitude, duration, timing, and rate of change values. Because the intent of the analysis is to quantify a range of discharge values that are likely to be beneficial to riverine habitat and fauna and to facilitate planning for high flows in the Corps' operations, we calculated the following high-flow guidelines by including each high flow event in summary statistic calculation (e.g., percentiles representing upper and lower limits, and dry, average, and wet years). With the exception of not using annual medians to calculate percentiles, the revised method for high flow guideline development is analogous to the "non-advanced" method for high flow analysis in IHA.

Low flow analysis methodology

1. In Microsoft Excel, the seven smallest values from each month in every year were extracted for analysis. We chose multiple values to represent each month so that the overall results are less likely to be influenced by an aberrant value (i.e., less likely to be skewed by one value), especially in future analyses that may examine and compare Corps' modeled flow alternatives which are likely to occasionally contain negative discharge values. A comparison of the effects of one, seven, and ten minimum flow values to represent low flows in each month showed little difference in overall low flow hydrograph shape, similar flow magnitudes throughout the year, and minor differences in winter 90th percentile flow magnitudes. These results also generally correspond to the Web-based Hydrograph Analysis Tool (WHAT Local Minimum Method; Lim et al. 2005) output for baseflow generation. Collectively, these results lend greater support for the decision to use the seven lowest values to characterize low flows.

2. The 10th, 25th, 50th, 75th, and 90th percentiles for each month were calculated on the extracted data to define the lower limit, dry year, average year, wet year, and upper limit, respectively.

3. The Walter F. George low flow guidelines were calculated slightly differently. A long-term period of pre-Buford Dam discharge data was not available below Walter F. George. As a proxy

for actual data, the Corps' unimpaired flows dataset was used. As referenced in the PAL, the unimpaired flows datasets do not accurately represent the magnitude, duration, timing, and rate of change of flow extremes (p. 14 in April 2, 2010 PAL). Thus, these low flow guidelines should be treated as estimates.

4. Note that in this low flow analysis, in cases where an entire month is above flood stage, the lowest values are flood-related values. A strength of the low flow analysis is that the user can characterize the entire range of the lower flows that occur in every month of the user's flow dataset.

High flow analysis methodology

1. In Microsoft Excel, the 75th percentile of all flows in the time series was used as the flow threshold to separate high flows from the remainder of the flow dataset. Because this is consistent with our understanding of the meteorological conditions that should cause pulses to occur, the 75th percentile is a valid threshold to separate low and high flows.

2. The following parameters were then calculated: The duration of each high flow event, the maximum discharge in each sequence of high flows, the date of the initial high flow value, the rise rate (calculated as the difference between the preceding low flow value to the maximum flow divided by the number of time steps (n-1)), and the fall rate (calculated as the difference between the maximum flow and the following low flow value, divided by the number of time steps (n-1)).

3. The 2-year and 10-year recurrence interval discharges were calculated using the following methodology: Maximum discharge was calculated for every year, and the 50th and 90th percentiles in Excel were used to calculate approximations of the 2- and 10-year recurrence intervals, respectively. This is a close approximation to the IHA method, but not as sophisticated as the USGS PeakFQ calculation (Flynn et al. 2006). Nevertheless, these percentiles provide close approximations of these recurrence interval discharges. Although bankfull discharge in the Coastal Plain physiographic province tends to occur more frequently than every two years, we used an approximate 2-year recurrence interval basinwide as a consistent guide.

4. The 2-year and 10-year recurrence interval discharges were used to further separate high flows into small pulses, high pulses, and floods (note: these are the default values used in IHA to separate high flow data). Maximum high flow values between the 75th percentile and the 2-year recurrence interval were classified as small pulses (analogous to High Pulses in IHA). Values between the 2- and 10-year recurrence interval were classified as high pulses (analogous to small floods in IHA), and values greater than the 10-year recurrence interval were classified as floods. With the exception of the Apalachicola River analysis, floods greater than the 10-year recurrence interval were excluded from this letter because they exceed the discharge stages that are predicted to cause damage according to the National Weather Service Advanced Hydrologic Prediction Service (Table 1 in April 2, 2010 PAL).

5. The range of discharge values that were used to define small and high pulses are presented in the tables. Similar to the PAL, we also provide the 25th and 75th percentiles of the magnitudes, frequencies, durations, rise rates, and fall rates which were calculated separately for small pulses,

high pulses, and floods. These values correspond to the high flow guidelines presented in Tables 1-4. Timing values were visually estimated from histograms of pulse or flood occurrence by month.

6. The Walter F. George high flow guidelines were calculated slightly differently.   As referenced in the PAL, the unimpaired flows datasets do not accurately represent the magnitude, duration, timing, and rate of change of flow extremes (p. 14 in April 2, 2010 PAL). Consequently, using the Corps-modeled data to make high pulse recommendations cannot be justified. Thus, high pulse frequency, duration, timing, and rate of change calculations were used from the West Point analysis. To calculate magnitudes, however, the West Point analysis indicated that pulses should peak 1.6-3.5 times higher than the low flow river discharge in March [7,720-16,500 cubic feet per second (cfs)]. Assuming that pulses at Walter F. George should also peak 1.6-3.5 times higher than March low flow (derived from the Corps' unimpaired flows model output), small pulses below Walter F. George should peak between 14,161-30,978 cfs.

Figure 1. Low flow guidelines for the Chattahoochee River near Norcross, GA (USGS 02335000).

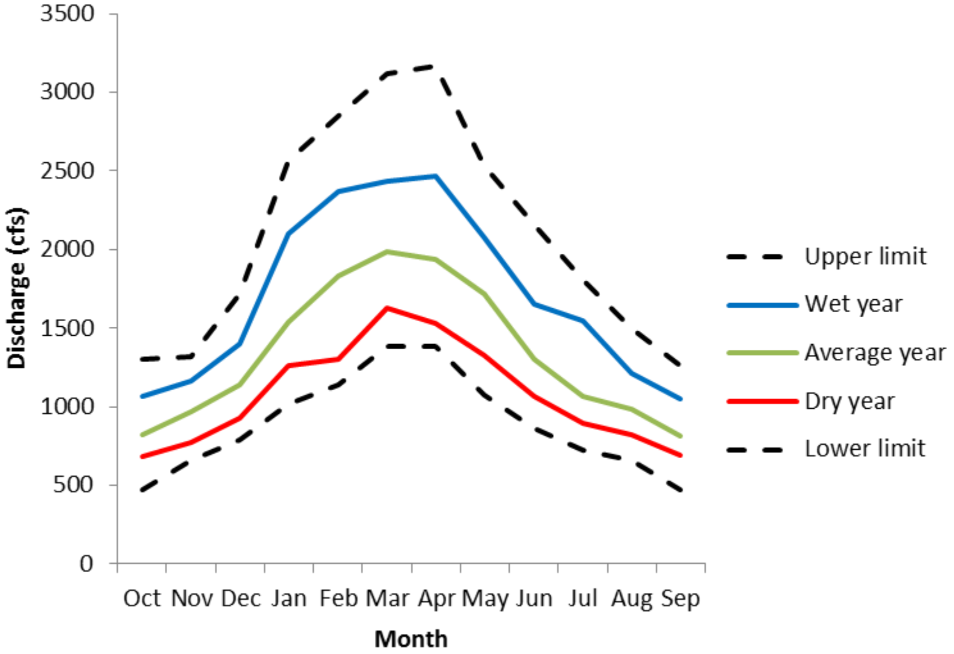

Figure 2. Low flow guidelines for the Chattahoochee River at West Point, GA (USGS 02339500).

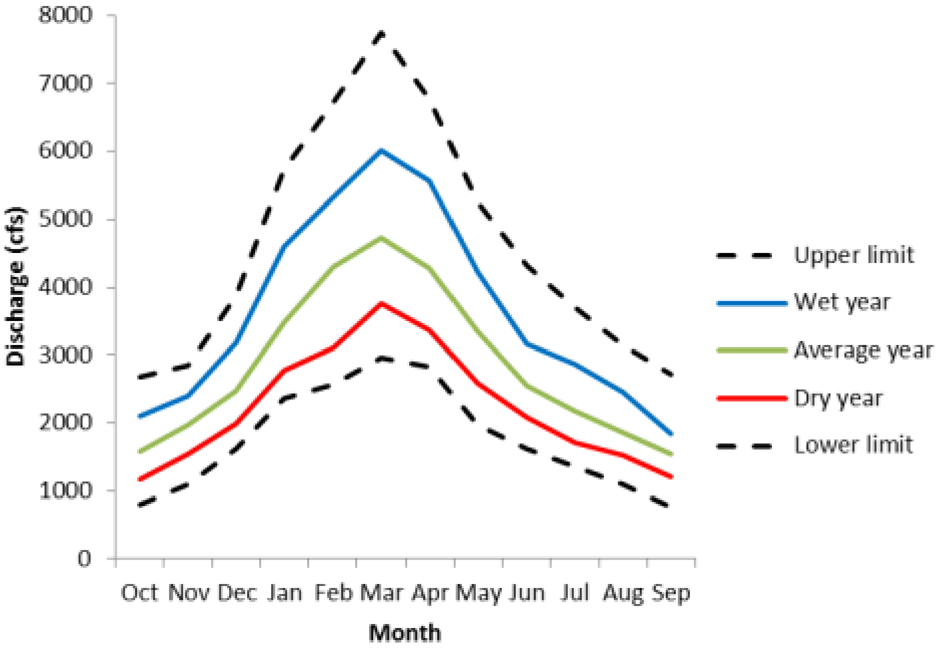

Figure 3. Low flow guidelines for the Chattahoochee River at Walter F. George using the Corps' unimpaired flows dataset.

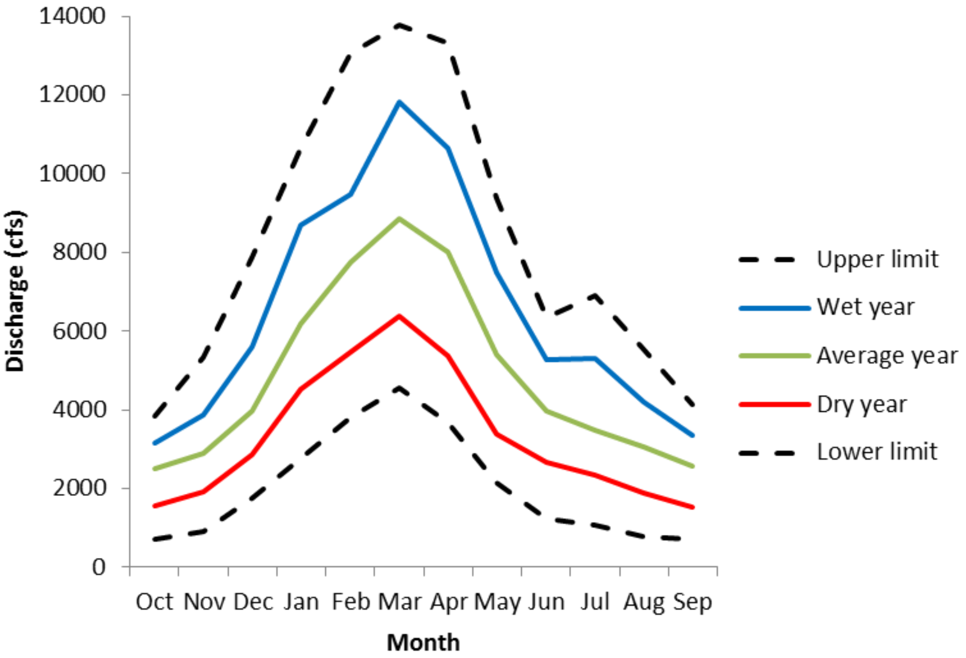

Figure 4. Low flow guidelines for the Apalachicola River at Chattahoochee, FL (USGS 02358000).

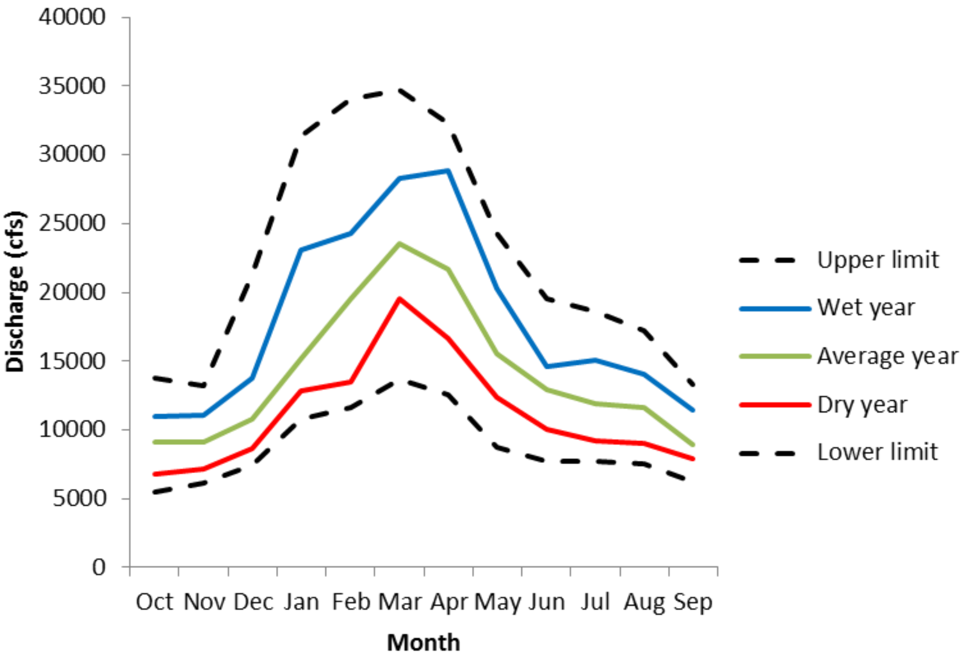

Table 1. High flow guidelines for the Chattahoochee River near Norcross, GA developed from USGS gage 02335000 for the pre-Buford Dam period from January 1, 1903 to September 30, 1946.

	Small pulse	High Pulse
Range used (cfs)	2550-17249	17250-33549
Magnitude (cfs)	3105-6787.5	19000-28900
Frequency (# events/year)	9-18	0-1
Duration (days)	1-5	11-72
Rise Rate (cfs/day)	770-2775	927-7830
Fall Rate (cfs/day)	507-1452	459-2193
Timing	Oct-Sep	Dec- Mar

Table 2. High flow guidelines for the Chattahoochee River near West Point Dam developed from USGS gage 02339500 for the pre-Buford Dam period from August 1, 1896 to December 31, 1955.

	Small pulse	High Pulse
Range used (cfs)	6250-45649	45650-71079
Magnitude (cfs)	7720-16500	51150-60825
Frequency (# events/year)	10-15	0-1
Duration (days)	2-6	17-39
Rise Rate (cfs/day)	1605-5118	5336-12509
Fall Rate (cfs/day)	1092-2850	1622-4472
Timing	Oct-Sep	Dec- Mar

Table 3. High flow guidelines for the Chattahoochee River at Walter F. George Dam developed from low flow analysis on the Corps' unimpaired flow dataset, and inferences from Chattahoochee River at West Point Dam high flow analysis. See text for additional details.

	Small pulse	High Pulse
Range used (cfs)	N/A	N/A
Magnitude (cfs)	14,161-30,978	95598-114187
Frequency (# events/year)	10-15	0-1
Duration (days)	2-6	17-39
Rise Rate (cfs/day)	1605-5118	5336-12509
Fall Rate (cfs/day)	1092-2850	1622-4472
Timing	Oct-Sep	Dec- Mar

*Upper range of high pulse values may need to be reevaluated to ensure that damage to structures is avoided. The stage discharge relationship (used to ensure that guidelines do not cause damage) was calculated using available data between 79 ft (6,510 cfs) and 110 ft (90,200 cfs; USGS gage 02343805), meaning that discharge calculations above this range of values are extrapolations and should be used cautiously.

Table 4. High flow guidelines for the Apalachicola River near Chattahoochee, FL developed from USGS gage 02358000 for the pre-Buford Dam period from July 1, 1922 to December 31, 1955.

	Small pulse	High Pulse	Flood
Range used (cfs)	25800-73799	73800-150499	≥ 150500
Magnitude (cfs)	28600-43475	85650-116500	201500-268500
Frequency (# events/year)	3-6	0-1	≥ 10 year RI
Duration (days)	3-15	32.5-68.5	49.5-89.5
Rise Rate (cfs/day)	2166-5606	2763-8056	7650-8761
Fall Rate (cfs/day)	1250-2615	1916-3811	4527-5795
Timing	Dec-Sep	Jan-Mar	Jan-Apr

Thank you for your January 18, 2011, response to the Service's PAL-requested analyses. We are currently reviewing the information that you provided, but recommend using ecosystem flow guidelines as calculated in the manner outlined above. As we continue to review the information you have produced, additional addendums or information requests may be supplied by the Service. We appreciate the opportunity to participate in the planning stages of your project and look forward to exploring opportunities to restore and improve habitat. If you have any questions, please contact Georgia Ecological Services staff biologists Will Duncan or Alice Lawrence at (706) 613-9493, or Panama City Ecological Services staff biologist Karen Herrington at (850) 769-0552 ext. 250.

Sincerely,

Sandra S. Tucker

Sandra S. Tucker
Field Supervisor

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January 11, 2013

Col. Steven J. Roemhildt, District Engineer
United States Army Corps of Engineers, Mobile
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Dear Col. Roemhildt:

The U.S. Fish and Wildlife Service (Service) has reviewed the United States Army Corps of Engineers' (Corps) October 12, 2012, Notice of Intent (NOI). The NOI announces the Corps' plans to revise the scope of the Draft Environmental Impact Statement (DEIS) for updating the Water Control Manual (WCM) for the Apalachicola-Chattahoochee-Flint (ACF) River Basin. The new scoping is necessary to accommodate a June 2011 decision of the U.S. Court of Appeals for the Eleventh Circuit, and a June 2012 legal opinion of the Corps' Chief Counsel regarding authority to accommodate municipal and industrial water supply from the Buford Dam/Lake Lanier Project. Our comments at this time represent input from our Alabama, Florida, and Georgia Ecological Services Field Offices, as well as our Southeast Regional Office pursuant to the Service's authorities under the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531 *et seq*.) and the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 *et seq*.).

The recommendations we provided in our June 2011 Draft Fish and Wildlife Coordination Act Report are still relevant and should continue to inform the scope of the DEIS. In addition to our previous input to the process, we wish to submit a concept for an alternative, described in the paragraphs below, to receive full consideration in the DEIS. This alternative would support flows in the Apalachicola and Chattahoochee rivers for the fish and wildlife purpose of the ACF projects. Apalachicola River flows are supported at levels greater than 5,000 cubic feet per second (cfs) as an environmentally-preferable substitute for the loss of flow support via the navigation purpose that occurred prior to the year 2000. Limited use of the ACF reservoirs when storage is available to support flows greater than the current minimum release of 5,000 cfs could reduce the occurrence of short-term declines in flows that either directly harm fish and wildlife or otherwise limit their populations. In addition, flow support in the Chattahoochee River would restore some natural flow regime components resulting in improvements in ecosystem elements that were lost or reduced as a consequence of flow regulation.

The focus of this alternative includes the regulated portion of the basin: Apalachicola River, Apalachicola Bay and the Chattahoochee River. The alternative we recommend supports monthly target and minimum releases from the system in a manner that is balanced with other project purposes and that avoids or minimizes some adverse effects of the current Revised Interim Operating Plan (RIOP), which uses system storage primarily to support the 5,000 cfs minimum release. We provide the following outline of such an alternative, but we believe that with more time and effort, this alternative can be improved upon to avoid or minimize adverse effects to fish and wildlife in the Apalachicola and Chattahoochee rivers. We fully expect the Corps to modify it as necessary to improve upon its potential to "avoid or minimize adverse effects" and to "restore and enhance the quality of the human environment," consistent with 40 CFR §1500.2(e) and §1500.2(f), respectively. We would like to work with you to further improve this alternative.

Reservoir Operations Alternative for Monthly Target and Minimum Flow Support

The governing features of the alternative we recommend are as follows:

1. Operate the system for target and minimum releases from Buford and Woodruff dams, consistent with current project-specific rules for flood-control, hydropower generation by storage zone, head limits, and maximum fall rates.
2. The targets and minimum releases are month- and zone-specific (Table 1 and 2).
3. Target releases are subject to zone-specific augmentation limits (Table 3).
4. Storage zones (1-4) are redefined for Lanier, West Point, and George, relative to the authorized top and bottom of the conservation pool.
5. Each storage zone contains a consistent year-round percentage of the total conservation storage at a project, but these percentages vary among the projects (Table 4).
6. Release decisions for Buford and Woodruff dams are based on the current composite storage zone (sum of storage in Lanier, West Point, and George), month, and the previous 7-day basin inflow.
7. If basin inflow exceeds the month/zone target, release the target flow from Buford and Woodruff dams. Basin inflow exceeding the target is available for storage.
8. If basin inflow does not exceed the month/zone target minus the zone augmentation limit, the release from Buford and Woodruff dams are the greater of: a) the month/zone minimum, or b) basin inflow plus the zone augmentation limit.
9. Each project makes daily releases to support its local operating requirements or to replenish storage in the project downstream, whichever is greater, so that all projects remain in the same operating zone.
10. Maximum fall rates and flow support for Woodruff Dam releases greater than 5,000 cfs are suspended when storage declines to Zone 4, and resumed when storage returns to a specified zone ("drought relief end zone").
11. When flows at Woodruff Dam have been less than 7,000 cfs for more than 30 days, maximum fall rates are suspended and resumed when flows have been greater than 10,000 cfs for 30 days.

We have tested this alternative with a hydrologic model of the basin that is comparable to the Corps' ACF ResSim model (the daily time step ACF Stella model developed during the ACF Comprehensive Study) using the Corps' 1939-2008 unimpaired flows and existing consumptive water demands. We believe our preliminary results demonstrate for this type of alternative both: a) its feasibility, because simulated reservoir elevations are comparable to historic patterns; and b) its potential for reducing environmental impacts, because simulated flows represent modest to significant improvements relative to the RIOP for several biologically relevant, flow-based, performance measures in the Chattahoochee and Apalachicola rivers. Although we programmed the model to suspend support of Woodruff Dam releases greater than 5,000 cfs when storage enters Zone 4 and resume such support upon refill to a user-specified zone (feature 10 listed above), reservoir levels in simulations of the settings in Tables 1-4 resuming support in Zone 1 versus Zone 3 were not appreciably different. Therefore, it appears unnecessary under this alternative to delay the resumption of normal operations until a complete refill of reservoir storage, probably due to its zone-graduated flows and augmentation limits. However, we recommend testing the utility of this feature in any evaluation of alternative flows, augmentation limits, and zone definitions.

On November 29-30, 2012, the Service hosted a Technical Workshop for Alternatives to Reservoir Operations in the ACF. Over 50 people attended including stakeholders representing all three States, multiple interest groups, and two members of your staff. We presented an earlier version of this alternative and preliminary model results. We have since further refined our alternative by adding specific flow targets for Buford Dam to improve flows in the Chattahoochee River. We are willing and able to share the model with the Corps and others, and would welcome further discussions with your staff about modeling this concept in ResSim as an alternative for the DEIS. We view the values given in Tables 1-4 as flexible parameters, and we encourage the Corps to test different sets of values as necessary to achieve the best balance of results for project purposes that are dependent on river flows and reservoir levels. Our primary interest is in improving flows and levels for fish and wildlife resources, for which this alternative appears promising, but we acknowledge the need to examine significant effects on all environmental resources affected by the operations of the ACF reservoirs, including the National Park Service's Chattahoochee River National Recreation Area. We would like to work with you on potential improvements to this alternative, and we can quickly evaluate changes in model parameters in the ACF Stella model in conjunction with your work in ResSim. In addition, the States of Florida and Georgia also presented alternatives at the workshop in Eufaula, and some of their concepts could be incorporated to improve this alternative.

We have not yet examined how this alternative performs under scenarios of potential climate change, increasing consumptive demands, or its response to HEC-5Q water quality analyses, but we recognize the importance and necessity of doing so. Significant changes to the long-term patterns of basin inflow to the Corps' projects will affect flow regimes and reservoir levels. The minimum releases built into the alternative concept we propose, and to a lesser extent the targets and augmentation limits, would insulate to some degree flow-dependent resources from the adverse effects of continuing increases in consumptive demands and from some changes in precipitation/runoff patterns in the basin. However, this insulation is limited by the storage and refill capacity of the reservoirs, and we recommend that the Corps evaluate how its proposed action and all reasonable alternatives would distribute the impacts of potential declines in basin inflow between reservoir- and river-dependent resources.

During our workshop, the alternative presented by State of Georgia and the Atlanta Regional Commission included flow targets for mussels that were based on bathymetric modeling in ArcGIS. Essentially, the Georgia Environmental Protection Division (GEPD) used the Corps' bathymetric data from 2009-2010 to delineate all the areas in the channel with a slope of 0.1 to 0.4, assuming that this is the preferred channel slope for the fat threeridge. They then linked the flow to stage and delineated the habitat that was less than 3-ft of inundation, assuming that fat threeridge prefer these shallow areas. These areas of slope and depth were then combined and modeled under various flow values to determine how much habitat (acres) was available at various flows from 10,000 cfs to 2,000 cfs. They concluded that more mussel habitat was available when flows were lower, so they recommended flows of 5,000 cfs with some pulses depending on basin inflows. There are several issues with this approach:

1) This method identifies a large amount of low slope-habitat in the actively migrating center of the channel. These habitats are comprised of coarse, shifting, sandy substrate. Mussel sampling last summer confirms that listed mussels do not occupy these habitats.
2) Our 2012 biological opinion on the RIOP discusses how the moderately depositional fat threeridge habitat is generally characterized by slopes of 10-40%, and that mussels in this habitat are generally found at a depth of about1-m regardless of flow. However, we also reported that fat threeridge are present in deeper, stable habitats in addition to the moderately depositional habitat. Additional sampling this summer indicates that fat threeridge can be abundant in these deep-water habitats associated with large woody material, along outside bends of the river, and in areas upstream of point bars. Slope may not play an important role in distribution, and it is likely that fat threeridge occur in areas with stable substrate that provide refuge from high flows, regardless of slope and depth.

We are currently undertaking a large-scale mussel distribution study using side-scan sonar and bathymetric data coupled with mussel sampling to determine mussel distribution in the river. We are willing to cooperate with GEPD to use our information to refine their approach in the future, but we do not support the performance measure for mussel habitat that GEPD described at the workshop.

We appreciate the opportunity to comment and look forward to continued participation as the WCM update moves forward. If you have any questions about these comments, please contact me at 706-613-9493 ext. 230, or Don Imm at 850-769-0552 ext. 247. I have assigned staff biologists Alice Lawrence (706-613-9493 ext. 222) and Will Duncan (ext. 227) to this project, and Dr. Imm has assigned staff biologist Karen Herrington (850-769-0552 ext. 250).

Sincerely,

Sandra S. Tucker

Sandra S. Tucker
Field Supervisor

cc: Jerry Ziewitz, FWS, Tallahassee, FL
Don Imm, FWS, Panama City, FL
Karen Herrington, St. Charles, MO
Bill Pearson, FWS, Daphne, AL
Dan Everson, FWS, Daphne, AL
Jennifer Pritchett, FWS, Daphne, AL
Stephanie Nash, FWS, Washington, D.C.
Joyce Stanley, OEPC, Atlanta, GA
Loretta Sutton, OEPC, Washington, D.C.

Table 1. Target and minimum releases (cfs) from Woodruff Dam.

	Zone1		Zone2		Zone3		Zone4
Month	Target*	Minimum	Target**	Minimum	Target***	Minimum	Minimum
JAN	21,000	10,000	15,000	10,000	10,000	5,000	5,000
FEB	28,000	10,000	20,000	10,000	10,000	5,000	5,000
MAR	33,000	16,000	22,000	16,000	16,000	5,000	5,000
APR	26,000	16,000	18,000	16,000	16,000	5,000	5,000
MAY	18,000	16,000	13,000	10,000	10,000	5,000	5,000
JUN	15,000	12,000	11,000	8,000	8,000	5,000	5,000
JUL	14,000	10,000	10,000	7,000	7,000	5,000	5,000
AUG	13,000	10,000	10,000	7,000	7,000	5,000	5,000
SEP	11,000	10,000	9,000	6,000	6,000	5,000	5,000
OCT	11,000	10,000	8,000	5,000	5,000	5,000	5,000
NOV	11,000	10,000	9,000	6,000	6,000	5,000	5,000
DEC	15,000	10,000	11,000	8,000	8,000	5,000	5,000

* Median observed flows, 1939-2008 (rounded to nearest 1,000).
** Observed flows exceeded 75% of the time, 1939-2008 (rounded to nearest 1,000).
*** The minimum releases of Zone2 are the target releases of Zone3.

Table 2. Target flows (cfs) for the Chattahoochee River at Peachtree Creek

Month	Zone 1*	Zones 2 and 3*	Zone 4
JAN	1,908	1,561	750
FEB	2,267	1,611	750
MAR	2,466	2,020	750
APR	2,404	1,896	750
MAY	2,131	1,648	750
JUN	1,611	1,326	750
JUL	1,326	1,109	750
AUG	1,220	1,022	750
SEP	1,009	857	750
OCT	1,016	843	750
NOV	1,202	954	750
DEC	1,412	1,152	750

*Discharge values derived from the low flow guidelines estimated for median and dry hydrological conditions at the Peachtree Creek node.

Table 3. Target augmentation limits (cfs) by zone.

Zone1	3,000
Zone2	2,000
Zone3	1,000
Zone4	n/a

Table 4. Allocation (percent) of conservation storage by zone.

	Lanier	West Point	WF George	Composite
Zone1	10%	20%	25%	13%
Zone2	20%	20%	25%	21%
Zone3	20%	20%	25%	21%
Zone4	50%	40%	25%	46%

United States Department of the Interior

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July 19, 2013

Mr. Curtis Flakes
Chief, Planning and Environmental Division
U.S. Army Corps of Engineers
P.O. Box 2288
Mobile, Alabama 36628-0001

RE: Revised alternative for consideration in the Apalachicola-Chattahoochee-Flint (ACF) River Basin Water Control Manual (WCM)

Dear Mr. Flakes :

The U.S. Fish and Wildlife Service (Service) is pleased to provide you with the first deliverable in our current scope of work for a Fish and Wildlife Coordination Act (FWCA) Report on the Corps' update of the Water Control Manual (WCM) for the Apalachicola-Chattahoochee-Flint (ACF) River Basin. The reservoir operations alternative that we describe in this letter is a refinement of the alternative that we outlined in our response dated January 11, 2013, to the Corps' October 12, 2012, Notice of Intent to reopen public scoping for the WCM update. Results suggest that our revised alternative would address the Corps' purpose and need for action in a manner consistent with the ACF projects' authorized purposes while protecting and enhancing habitat conditions for a broad suite of fish and wildlife resources.

The Service recommend that the Corps give this alternative full consideration in preparation of the Draft Environmental Impact Statement (DEIS) for the WCM to satisfy both the "equal consideration" provision of the FWCA and regulations to evaluate all reasonable alternatives under the National Environmental Policy Act (40 CFR 1502.14). We summarize in this letter the components of the alternative that your staff will require for hydrologic simulations of the proposed action and alternatives in the DEIS. We also provide summaries of how our alternative performs on several measures of habitat conditions relative to current operations (Enclosure 1). However, in advance of including the alternative in the DEIS, we strongly recommend that the Corps work with us to represent and evaluate the alternative in HEC-ResSim. Our hydrologic model is programmed in the STELLA dynamic modeling and simulation software. It is a nimble tool that enables rapid testing of multiple operating scenarios, but coordinating with you to model our alternative in ResSim will help ensure that: 1) the fish and wildlife benefits we see in our STELLA model results are replicated in ResSim; and 2) our STELLA model is properly representing the Corps' operations, especially how you balance system-wide storage. Our next scheduled FWCA deliverable is a Planning Aid Letter that will fully explain the development and application of performance measures that we used to evaluate a range of choices for operating the reservoirs, which we recommend to the Corps for evaluating all alternatives you may consider for the WCM update.

During April and May this year, we discussed with your staff the Corps' criteria for alternatives to evaluate in the DEIS. Our January, 2013, alternative already satisfied most of these criteria (e.g., no change to flood storage, releases from Lanier to support Atlanta water supply needs, etc.). Our discussions identified two primary modifications necessary for the Service's alternative to warrant full consideration in the Corps' analysis:

1) accommodate a navigation season; and
2) retain the storage action zones to ensure a balanced system operation.

Our revised alternative for enhancing the fish and wildlife benefits of project operations addresses both of these criteria. It specifies target and minimum flows that would provide a 9 to 7-feet deep navigation channel during January to May of most years. It relies on the Corps' "Option A" definition of the storage action zones in Lanier, West Point, and George. As before, our recommended alternative manages system releases according to a set of storage-zone-specific monthly minimum and target releases, where the use of storage to achieve the targets is subject to flow augmentation limits.

Upon request, we provided the Georgia Environmental Protection Division (GAEPD) a copy of our hydrologic STELLA-based model of the alternative that we proposed in our January scoping comments. GAEPD's review of this model discovered an error in the evaporative loss calculations and in the unimpaired flows data that we were using, which we subsequently corrected. GAEPD's letter to the Corps dated June 28, 2013, addressed these same errors, but did not acknowledge our corrections. The Service appreciates the GAEPD review, which has increased our confidence in the STELLA model as a means of representing alternative reservoir operations in the ACF system. In response to the GAEPD letter, we requested that your staff provide the latest set of demand data used by the Corps, but we have not received those data to date.

One issue we encountered while modeling various alternatives was head-limit restrictions at Woodruff Dam. Because release decisions are based on 7-day basin inflow and the adjustment of Lake Seminole's rule curve to account for head limit restrictions, variations in daily inflow in combination with head-limit restrictions would sometimes lead to insufficient storage in Lake Seminole to achieve the intended release. We saw two options for dealing with this issue: 1) allow the system to draw upon storage in Lake Seminole below 76.0 feet elevation, or 2) make supplemental releases from W.F. George to avoid a Seminole drawdown. Since the Corps seldom draws Seminole below 76.0 feet in actual practice, we chose option 2. In our STELLA model, supplemental releases from W.F. George are triggered when the elevation at Lake Seminole drops below 76.5 feet and are increased when the elevation drops below 76.25 feet. We requested information from James Hathorn of your staff to determine how the Corps represents Woodruff Dam head limits and any associated supplemental releases from W. F. George in ResSim in order to configure the STELLA model similarly. Because we are currently working with James to ensure consistency between ResSim and STELLA, we would like the opportunity to modify our approach to represent system operations and river flows in a manner acceptable to the Corps, which may result in minor modifications to our recommended alternative. Our present configuration of the STELLA model to represent our recommended alternative achieves 99.5% compliance with the daily minimum releases, and 96.2% compliance with the daily target releases as conditioned by the augmentation limits in the full 70-year simulation. The small fraction of days we do not achieve complete compliance is due to the head-limits and storage balancing issues described above.

We used the following approach for developing our alternative using the STELLA model.

1) We adopted existing, or developed new, performance measures for fish and wildlife resources dependent on ACF river flows or reservoir levels, including:
    - Apalachicola River floodplain fish spawning and rearing
    - Gulf sturgeon spawning
    - Apalachicola River mussels (several hydrologic metrics related to mussel survival)
    - Reservoir fisheries (Lanier, West Point, and W.F. George)
    - Chattahoochee River shoal bass recruitment
    - Apalachicola Bay salinity
2) We used the performance measures to compare period-of-record simulated flows and levels under current operations (the Revised Interim Operations Plan [RIOP]), the alternative recommended in our January, 2013, scoping comments (FWS1), and one or more test alternatives.
3) We tested the sensitivity of the model to changes in target flows, minimum flows, augmentation limits, and action zones independently to determine the effect of these operating parameters on simulated flows and levels and the performance measures.

4) Based on what we learned about single-parameter changes on model performance, we then explored the effects of multiple-parameter changes on model output, steering the tests to improve overall performance on the suite of performance measures.
5) We eliminated alternatives from further consideration that resulted in excessive impacts to flows and levels (e.g., alternatives that simulated a complete depletion of composite conservation storage).

We tested over 80 combinations of storage-zone-specific monthly minimum releases, target releases, and augmentation limits. The best-performing alternative relative to the fish and wildlife performance measures listed above, which we label FWS2 is described below. FWS2 represents a significant improvement on these measures compared to the RIOP and to the alternative concept that we provided in our January, 2013, scoping comments (labeled as "Scoping" in the charts of the Enclosure).

FWS2 Alternative Description

The governing features of the alternative we recommend are as follows:

1. Operate the system for minimum releases from Buford Dam, and target and minimum releases from Woodruff Dam, consistent with current project-specific rules for flood-control, hydropower generation by storage zone, head limits, and maximum fall rates.
2. The targets and minimum releases are month- and zone-specific (Tables 1, 2, and 3).
3. Target releases are subject to monthly composite zone-specific augmentation limits (Table 4).
4. Storage action zones (1-4) are as defined under the Corps' "Option A" zones, which the Corps provided to us.
5. If 7-day basin inflow exceeds the month/zone target, release the target flow from Woodruff Dams. All basin inflow exceeding the target is available for storage, subject to flood control rules.
6. If basin inflow does not exceed the month/zone target minus the zone augmentation limit, the release from Woodruff Dam is the greater of: a) the month/zone minimum, or b) basin inflow plus the zone augmentation limit.
7. Each project makes daily releases to support its local operating requirements or to replenish storage in the project downstream, whichever is greater, so that all projects remain in the same operating zone. The system is operated in such a manner that releases for the Apalachicola River are supplied from Lake Seminole, Lake Seminole is then supported by releases from W.F. George, releases are then made from West Point to balance West Point with George and finally releases are made from Lanier to balance Lanier and West Point.

8. Maximum fall rates and flow support for Woodruff Dam releases greater than 5,000 cfs are suspended when storage declines to Zone 4, and resumed when storage returns to Zone 3.
9. When releases from Woodruff Dam are less than 7,000 cfs for more than 30 days, maximum fall rates are suspended and resumed when releases exceed 10,000 cfs for 30 days.

We have not yet examined how this alternative performs under scenarios of potential climate change or increasing consumptive demands, or analyzed its effects on water quality, but we recognize the importance and necessity of doing so. Significant changes to the long-term patterns of basin inflow to the Corps' projects will affect flow regimes and reservoir levels.

Although we now submit this alternative for the Corps' full consideration in the DEIS for the WCM update, we are prepared to work with you to answer any questions that you may have and to revise it as necessary to ensure that it remains a viable option for the Corps. As you can see in the Enclosure, the improvements to fish and wildlife performance measures are in many instances substantial.

We appreciate the opportunity to coordinate with the Corps as the WCM update moves forward. If you have any questions about this alternative, please contact me at ext. 247, or Sandy Tucker at 706-613-9493 ext. 230.

Sincerely,

Donald W

Dr. Donald W. Imm
Project Leader

Enclosure:
Performance Measures Comparing RIOP simulations in STELLA to the FWS Scoping alternative (Scoping) and the current FWS recommended alternative (FWS 2)

cc: Jerry Ziewitz, FWS, Tallahassee, FL
Sandra Tucker, FWS, Athens, GA
Karen Herrington, St. Charles, MO
Bill Pearson, FWS, Daphne, AL
Dan Everson, FWS, Daphne, AL
Jennifer Pritchett, FWS, Daphne, AL

Table 1. FWS2 Target flows (cfs) for the Apalachicola River at Woodruff Dam.

Month	Zone 1	Zone 2	Zone 3	Zone 4
Jan	19,000	17,000	10,000	5,000
Feb	21,000	19,000	10,000	5,000
Mar	21,000	19,000	14,000	5,000
Apr	21,000	19,000	14,000	5,000
May	19,000	17,000	10,000	5,000
Jun	14,000	14,000	10,000	5,000
Jul	12,000	10,000	10,000	5,000
Aug	12,000	10,000	10,000	5,000
Sep	10,000	10,000	10,000	5,000
Oct	10,000	10,000	10,000	5,000
Nov	10,000	10,000	10,000	5,000
Dec	10,000	10,000	10,000	5,000

Table 2. FWS2 Minimum flows (cfs) for the Apalachicola River at Woodruff Dam.

Month	Zone 1	Zone 2	Zone 3	Zone 4
Jan	17,000	17,000	5,000	5,000
Feb	17,000	17,000	5,000	5,000
Mar	17,000	17,000	8,000	5,000
Apr	17,000	17,000	8,000	5,000
May	17,000	10,000	8,000	5,000
Jun	12,000	8,000	5,000	5,000
Jul	10,000	7,000	5,000	5,000
Aug	10,000	7,000	5,000	5,000
Sep	10,000	6,000	5,000	5,000
Oct	10,000	5,000	5,000	5,000
Nov	10,000	6,000	5,000	5,000
Dec	10,000	8,000	5,000	5,000

Table 3. FWS2 Minimum flows (cfs) for the Chattahoochee River at the Peachtree Creek USGS gage.

Month	Zone 1	Zone 2	Zone 3	Zone 4
Jan	1,910	750	650	650
Feb	2,270	1,170	650	650
Mar	2,470	1,390	750	650
Apr	2,400	1,470	750	650
May	2,130	750	750	650
Jun	1,610	750	750	650
Jul	1,330	750	750	650
Aug	1,220	750	750	650
Sep	1,010	750	650	650
Oct	1,020	750	650	650
Nov	1,200	750	650	650
Dec	1,410	750	650	650

Table 4. Augmentation Limits (cfs) for FWS2.

Month	Zone 1	Zone 2	Zone 3	Zone 4
Jan	2,000	0	1,000	0
Feb	4,000	2,000	2,000	0
Mar	4,000	2,000	3,000	0
Apr	4,000	2,000	3,000	0
May	2,000	4,000	2,000	0
Jun	2,000	2,000	1,000	0
Jul	2,000	2,000	1,000	0
Aug	2,000	2,000	1,000	0
Sep	0	1,500	1,000	0
Oct	0	1,500	1,000	0
Nov	0	1,500	1,000	0
Dec	0	1,500	1,000	0

Enclosure: Performance Measures Comparing RIOP simulations in STELLA to the FWS Scoping alternative (Scoping) and the current FWS recommended alternative (FWS 2)

Figure 1. Inter-annual frequency (percent of years) of discharge events less than 5,000 to 10,000 cfs under the RIOP (which was simulated in STELLA), the FWS Scoping alternative (Scoping), and the recommended alternative (FWS 2).

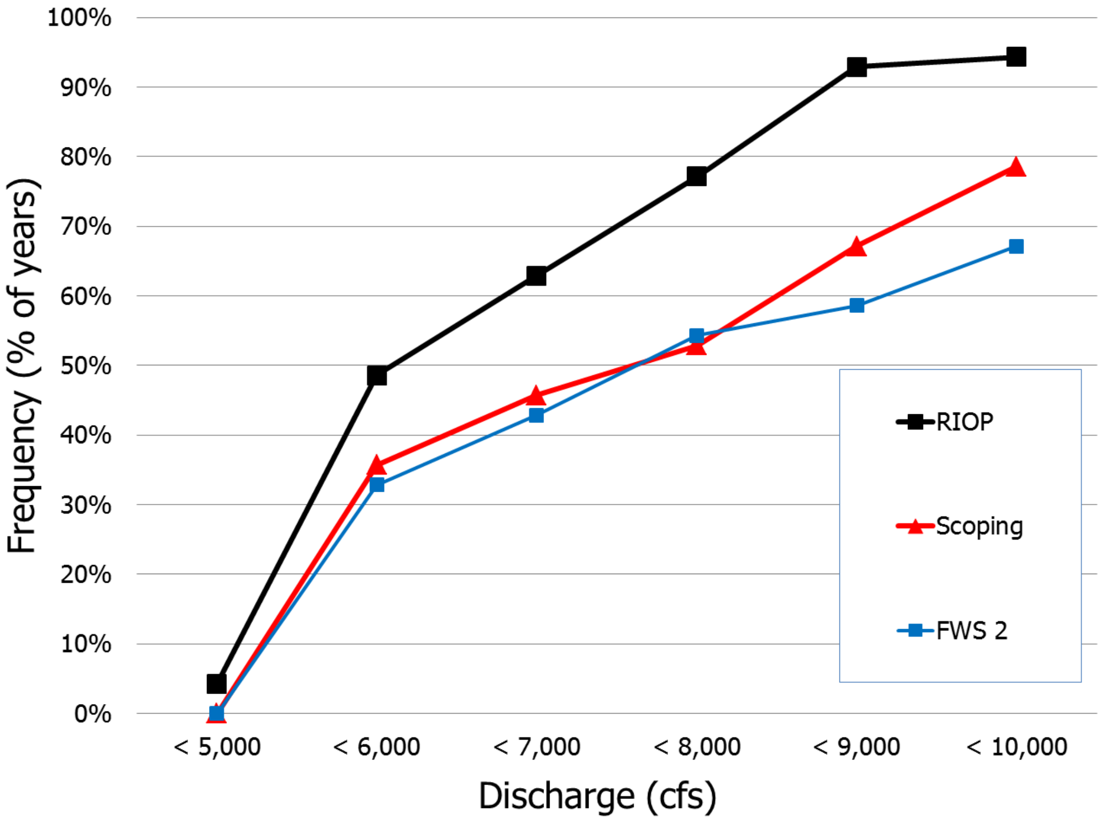


Figure 2. Median number of days per year of discharge less than 5,000 to 10,000 cfs under the RIOP (which was simulated in STELLA), the FWS Scoping alternative (Scoping), and the recommended alternative (FWS 2).

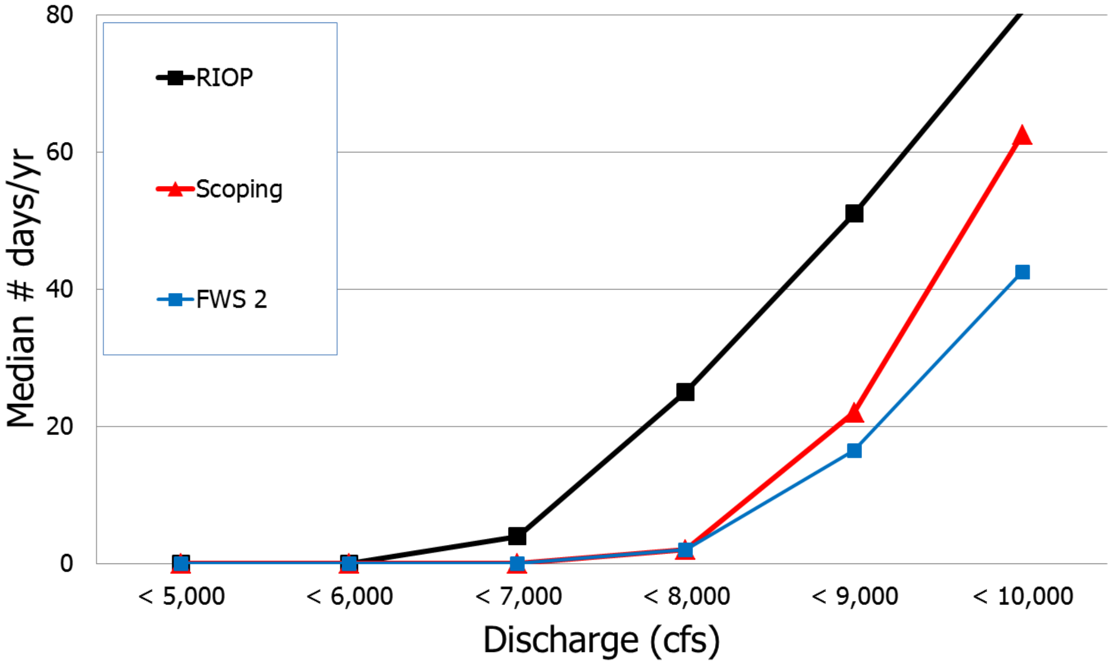


Figure 3. Median number of consecutive days per year of discharge less than 5,000 to 10,000 cfs under the RIOP (which was simulated in STELLA), the FWS Scoping alternative (Scoping), and the recommended alternative (FWS 2).

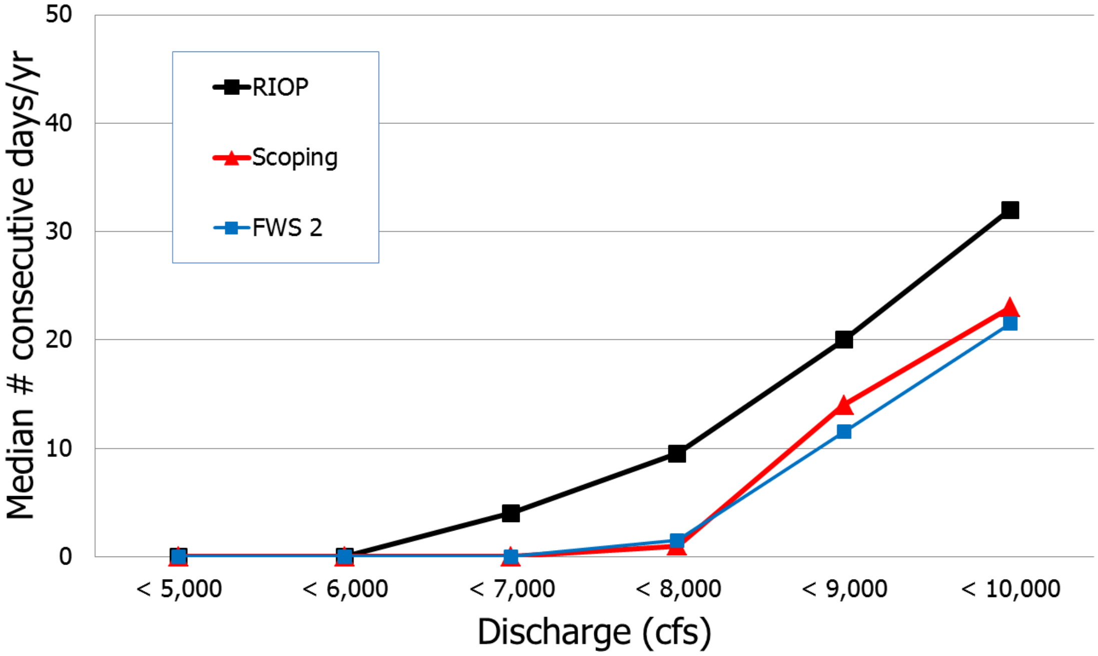


Figure 4. Annual maximum of growing-season (April-October) floodplain connectivity (acres) to the main channel for 30 consecutive days under the RIOP (which was simulated in STELLA), the FWS Scoping alternative (Scoping), and the recommended alternative (FWS 2). Note: Performance of this measure is likely actually better than appears here as a result of the modeling issue with head limits described in the attached letter.

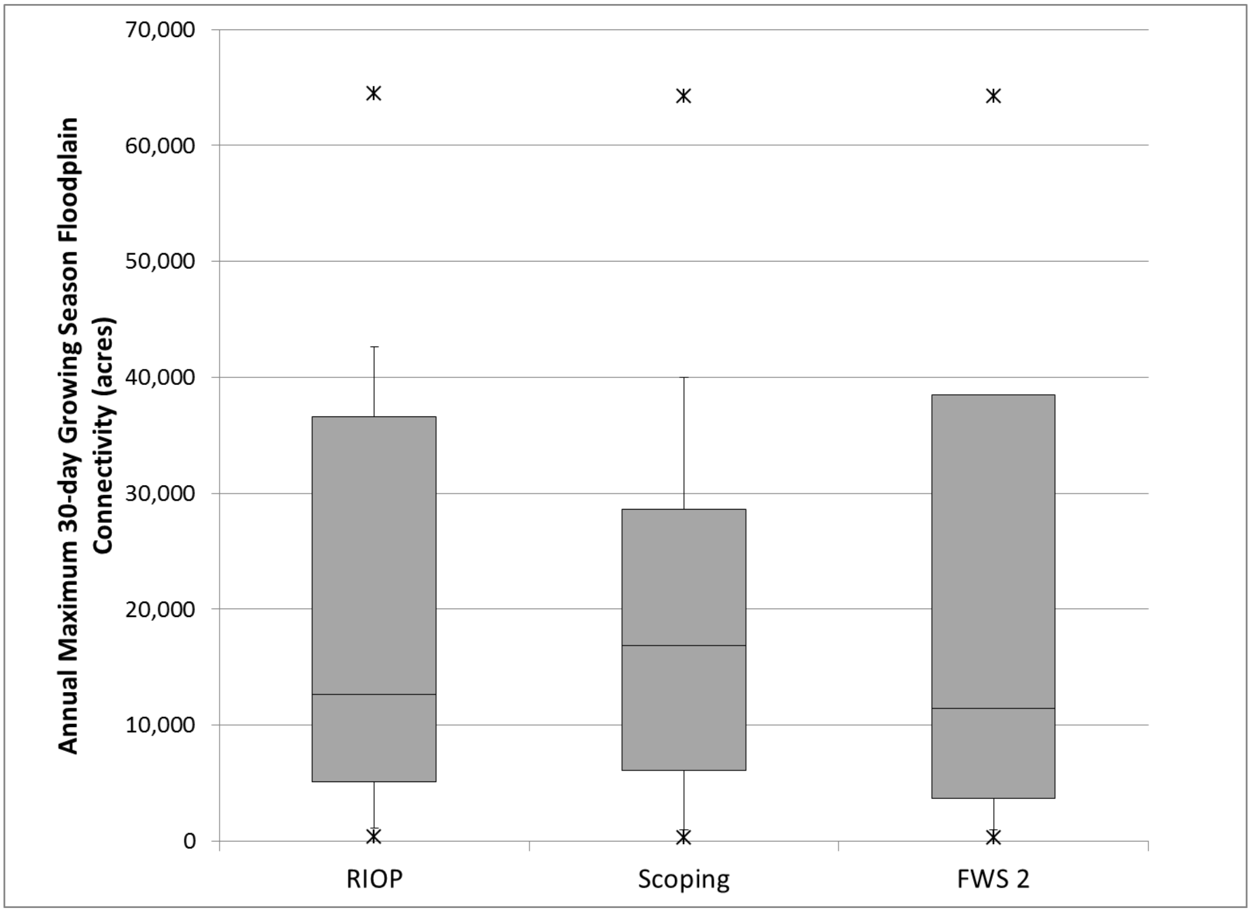


Figure 5. Annual Gulf sturgeon spawning habitat availability (maximum acres of potentially suitable spawning substrate inundated to depths of 8.5 to 17.8 feet for at least 30 consecutive days each year), March 1 through May 31, at the two known spawning sites, under the RIOP (which was simulated in STELLA), the FWS Scoping alternative (Scoping), and the recommended alternative (FWS 2).

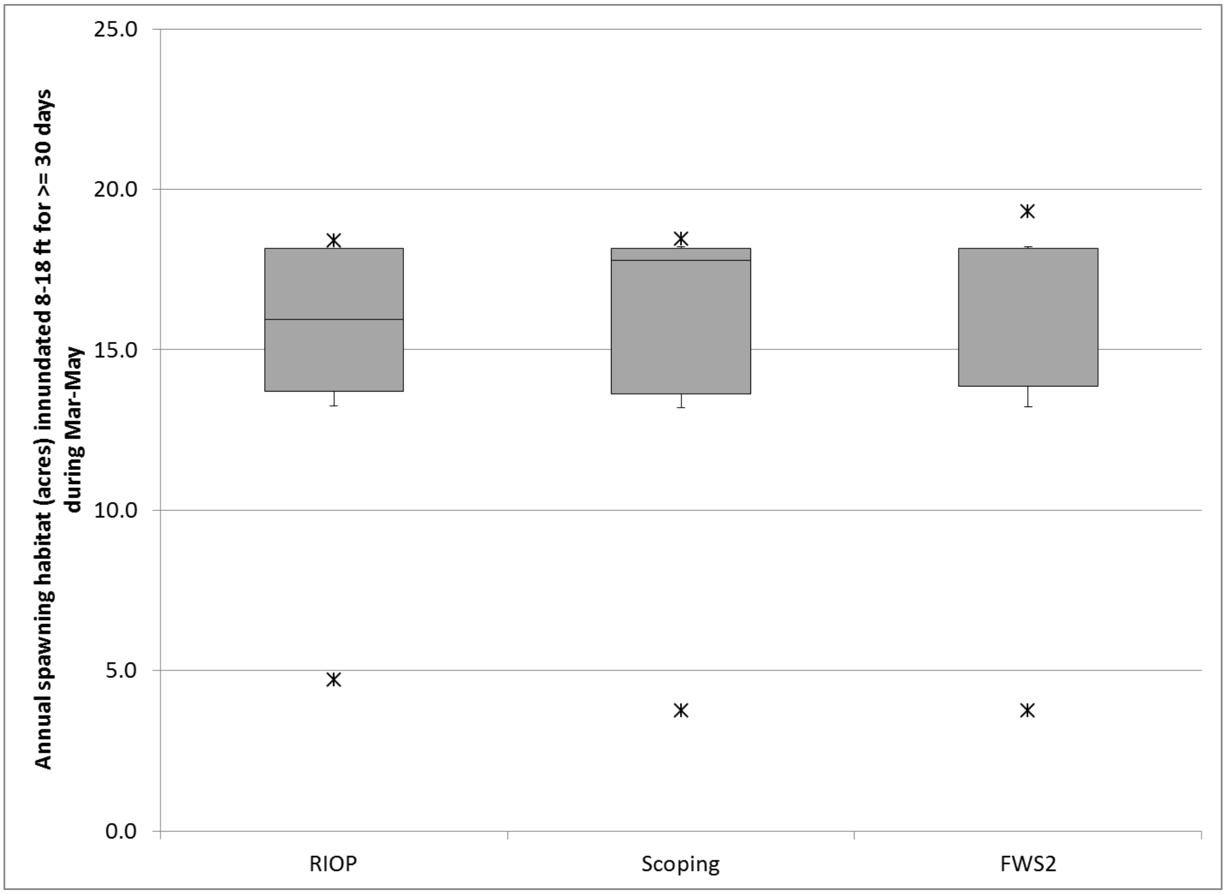


Figure 6. The amount of productive zone (acres) inundated during the reservoir fishery spawning season in Lake Lanier for 30 consecutive days under the RIOP (which was simulated in STELLA), the FWS Scoping alternative (Scoping), and the recommended alternative (FWS 2).

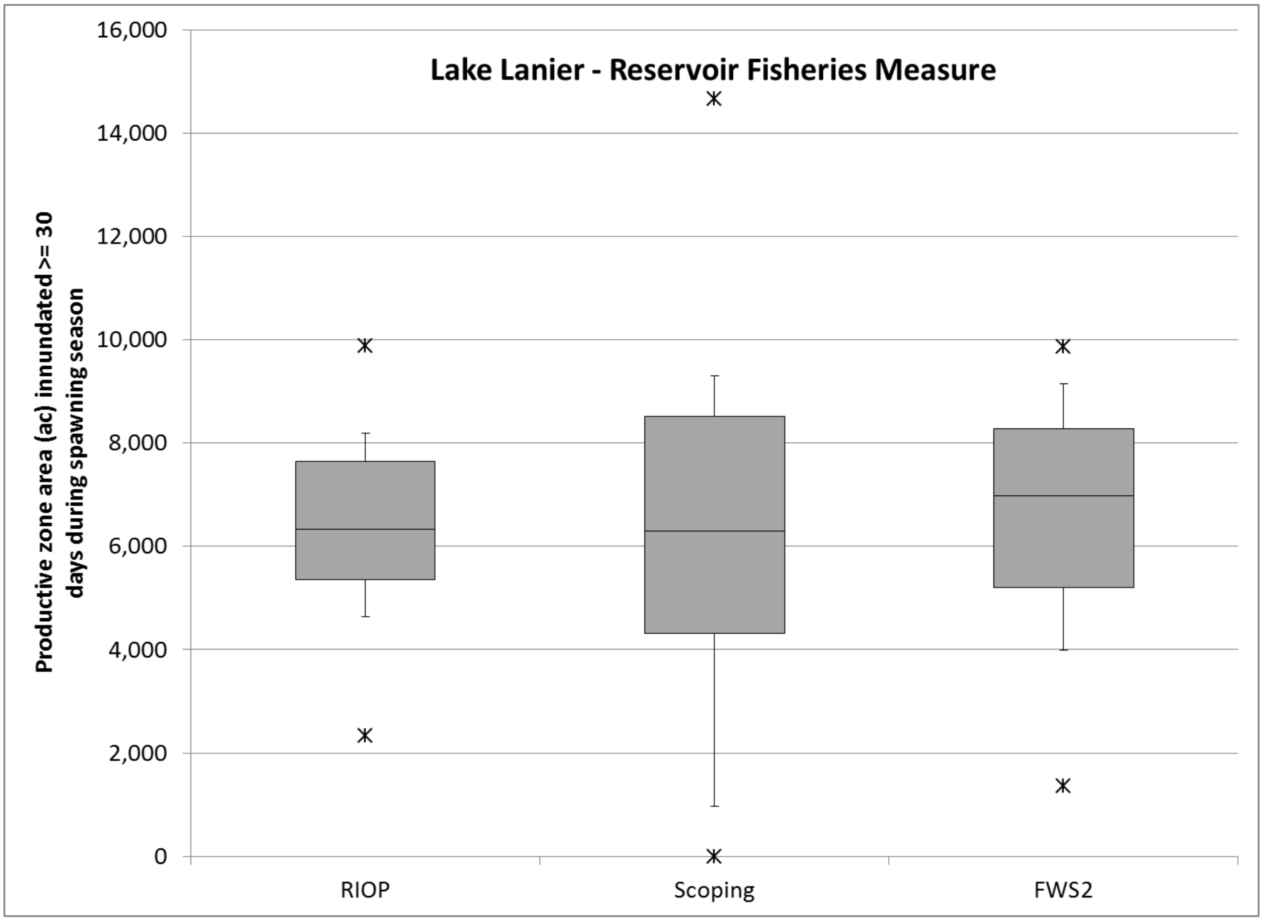


Figure 7. The amount of productive zone (acres) inundated during the reservoir fishery spawning season in West Point Lake for 30 consecutive days under the RIOP (which was simulated in STELLA), the FWS Scoping alternative (Scoping), and the recommended alternative (FWS 2).

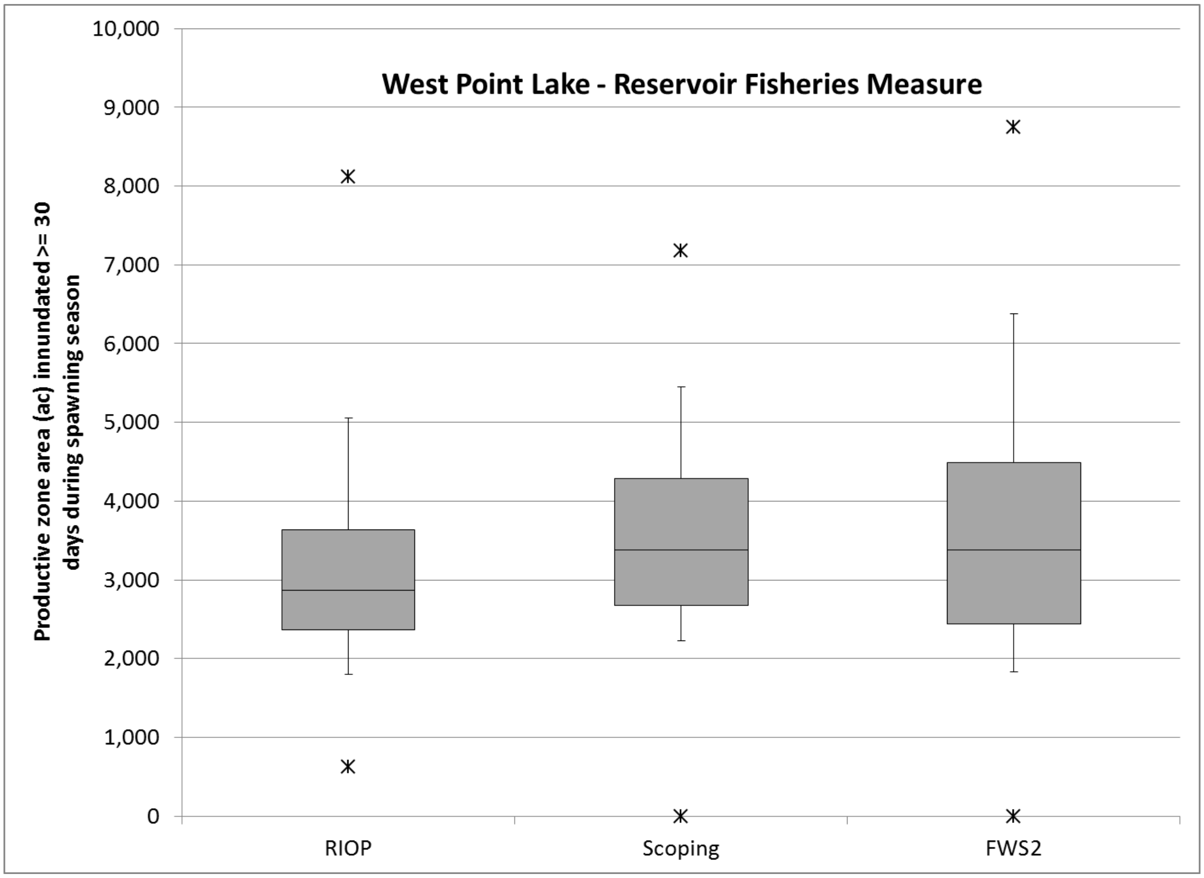


Figure 8. The amount of productive zone (acres) inundated during the reservoir fishery spawning season in W.F. George Reservoir for 30 consecutive days under the RIOP (which was simulated in STELLA), the FWS Scoping alternative (Scoping), and the recommended alternative (FWS 2).

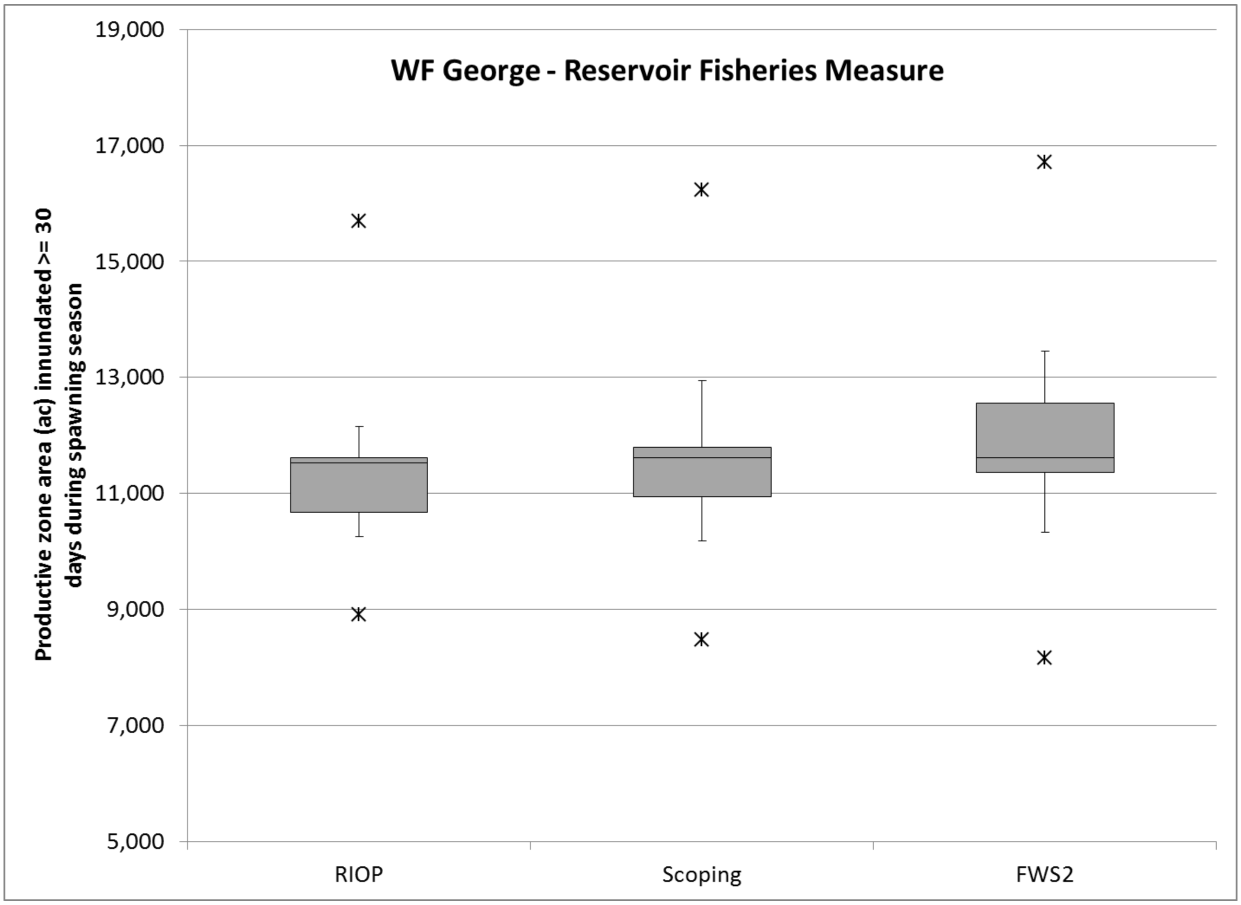
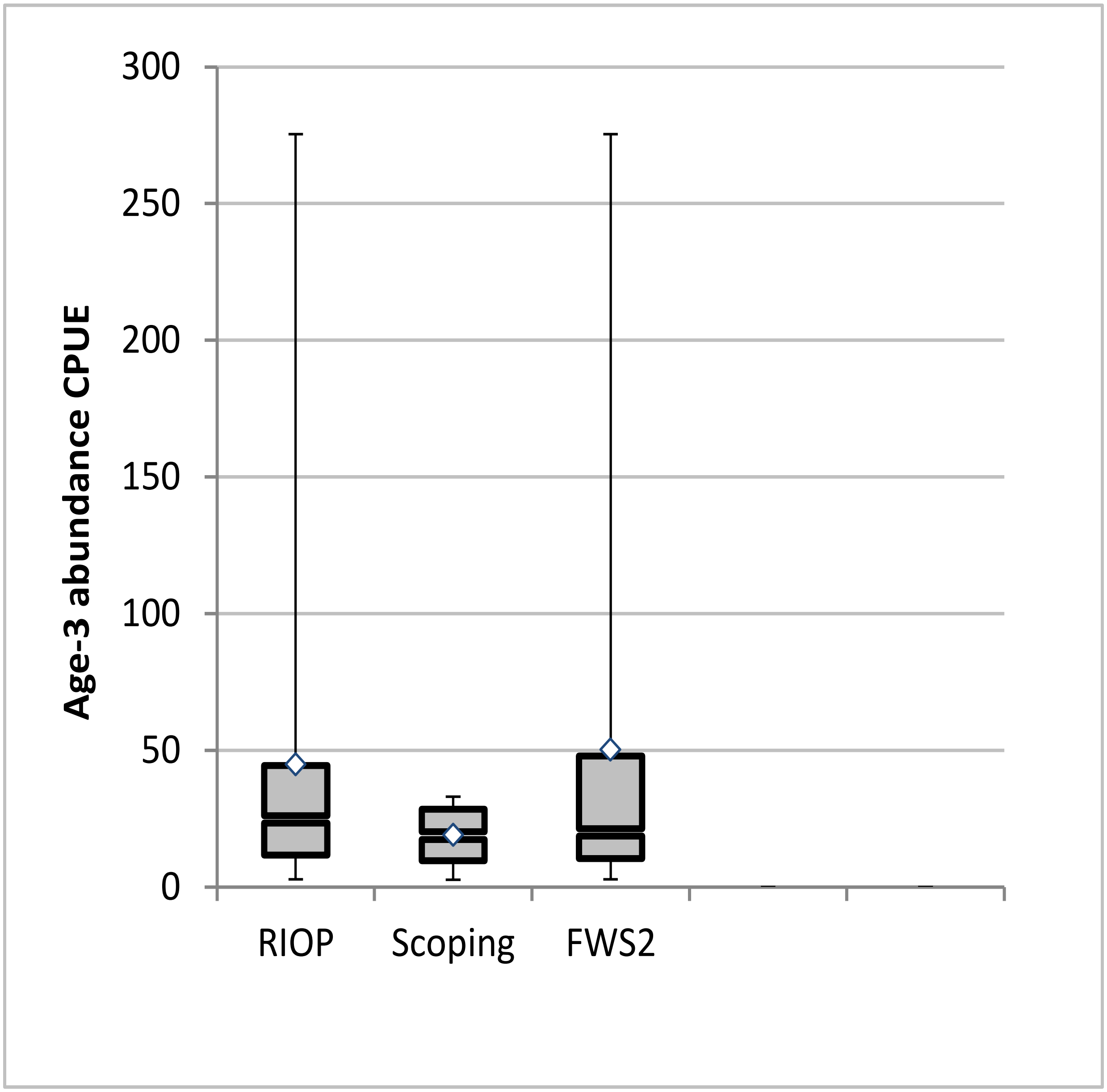


Figure 9. Catch per unit effort (CPUE) of age-3 shoal bass, an indicator of recruitment, under the RIOP (which was simulated in STELLA), the FWS Scoping alternative (Scoping), and the recommended alternative (FWS 2). Annual CPUE estimates are for the Chattahoochee River at the Atlanta gage for 30 mm shoal bass as predicted from empirical results from Porta 2011[1].



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[1] Porta, M.J. 2011. Effects of environmental variation on stocking success of an endemic black bass species in the Chattahoochee River, Georgia. Masters thesis, Oklahoma State University, Stillwater.

Figure 10. Median daily reservoir elevations for Lake Lanier for the simulated period of record (1939-2008) under the RIOP (which was simulated in STELLA), the FWS Scoping alternative (Scoping), and the recommended alternative (FWS 2)..

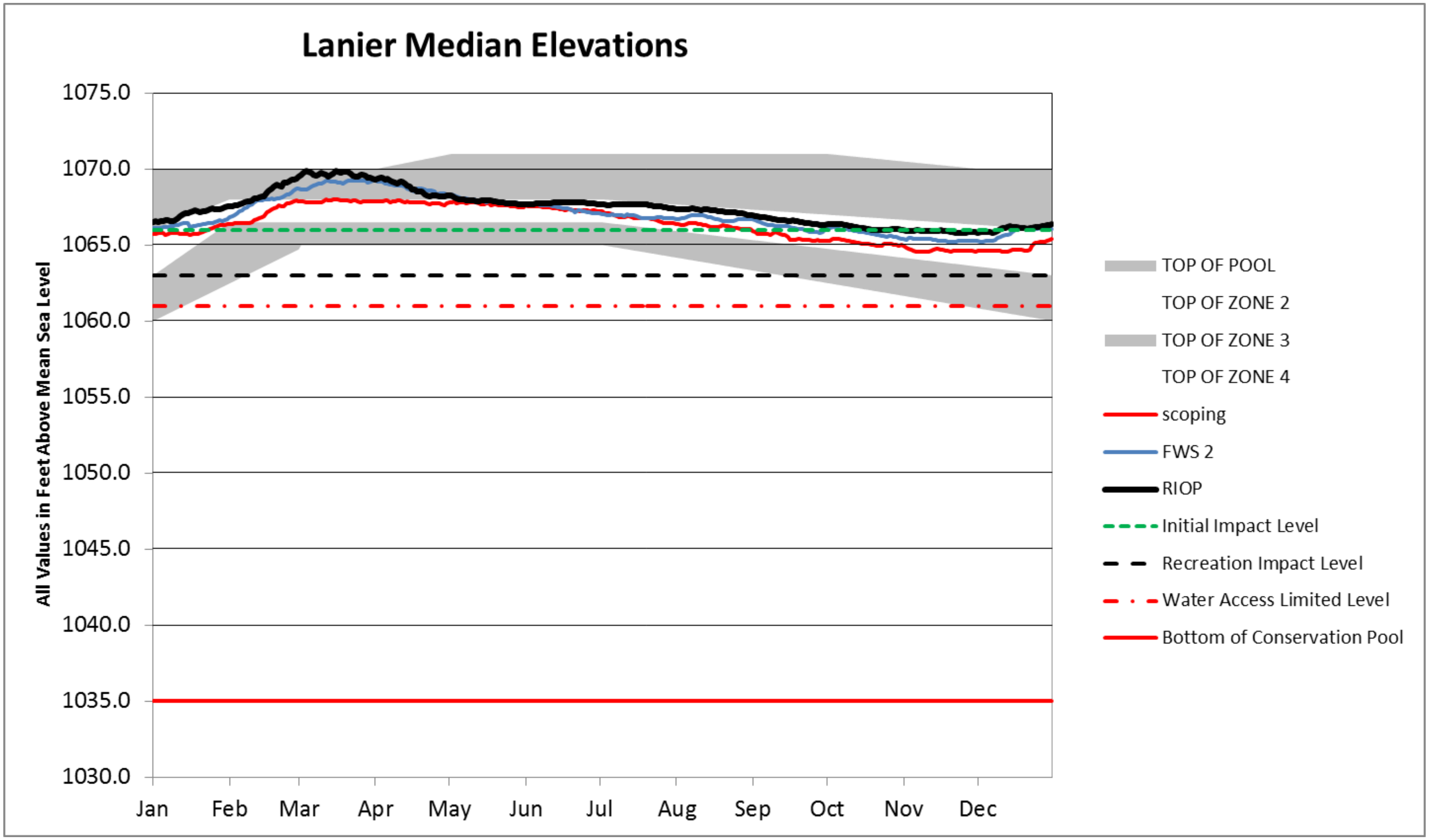


Figure 11. Lake Lanier reservoir elevations that are exceeded 75 % of the time in the simulated period of record (1939-2008) under the RIOP (which was simulated in STELLA), the FWS Scoping alternative (Scoping), and the recommended alternative (FWS 2)..

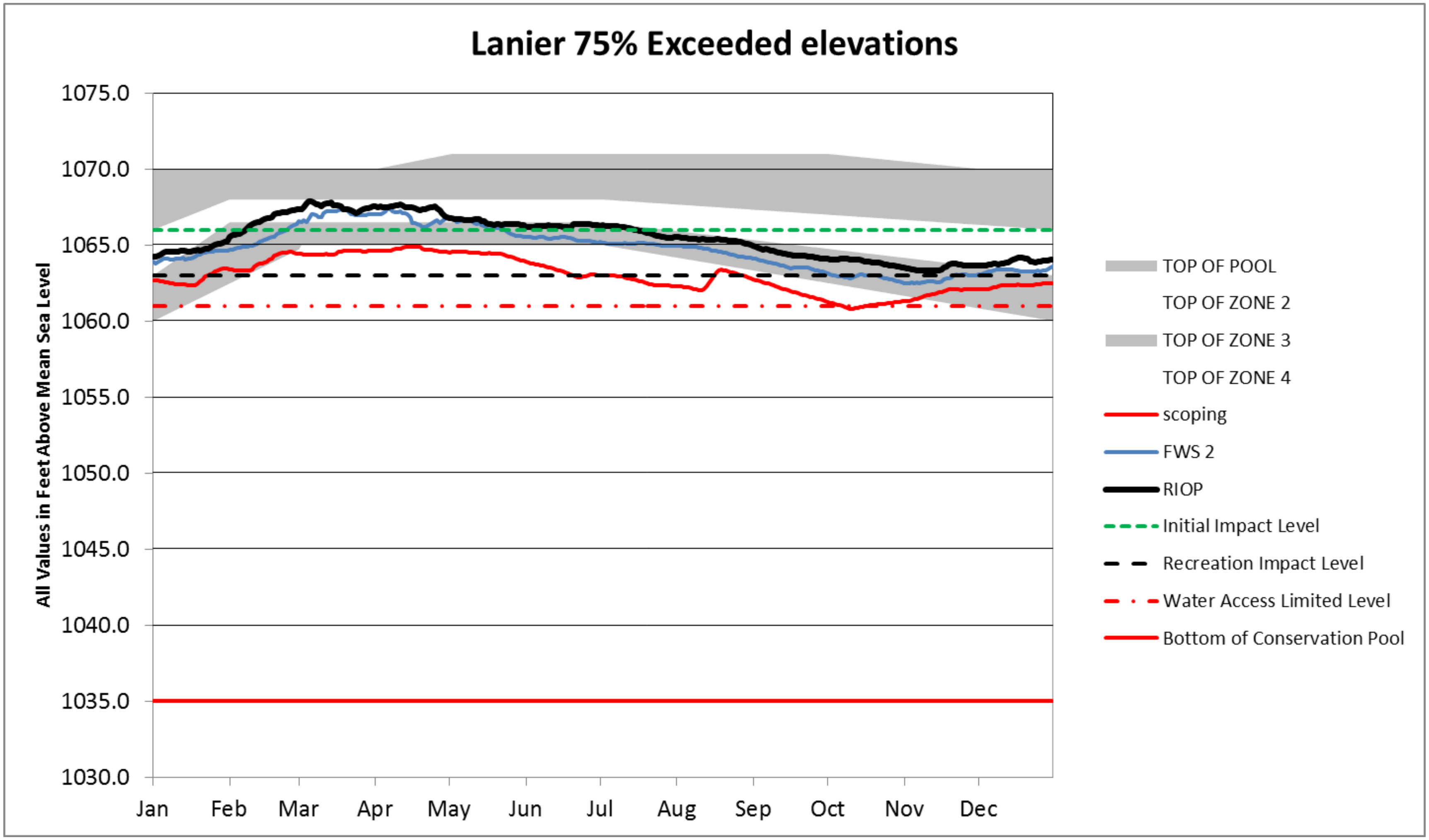


Figure 12. Lake Lanier reservoir elevations that are exceeded 90 % of the time in the simulated period of record (1939-2008) under the RIOP (which was simulated in STELLA), the FWS Scoping alternative (Scoping), and the recommended alternative (FWS 2)..

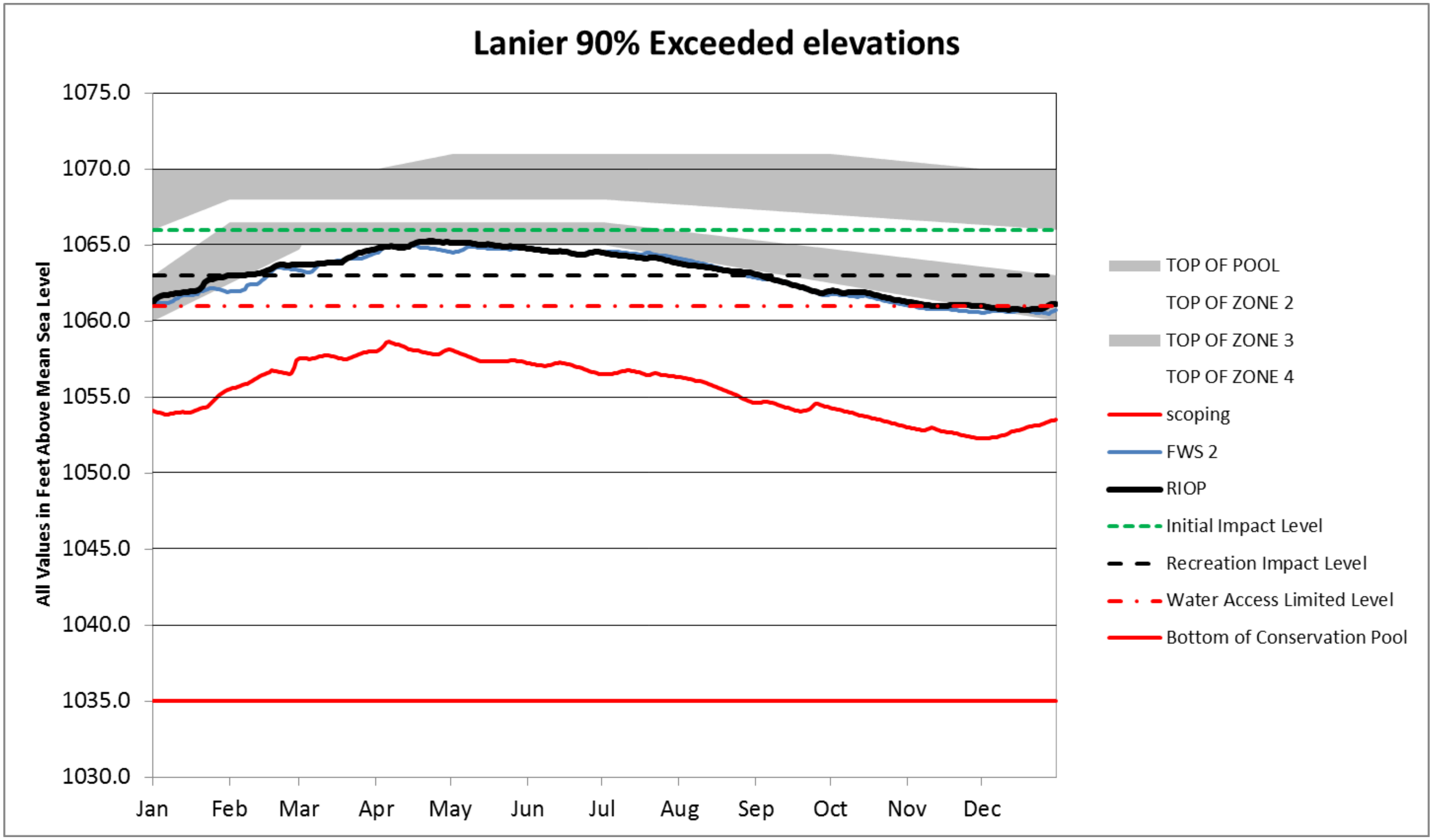


Figure 13. The minimum daily Lake Lanier reservoir elevations for the simulated period of record (1939-2008) under the RIOP (which was simulated in STELLA), the FWS Scoping alternative (Scoping), and the recommended alternative (FWS 2)..

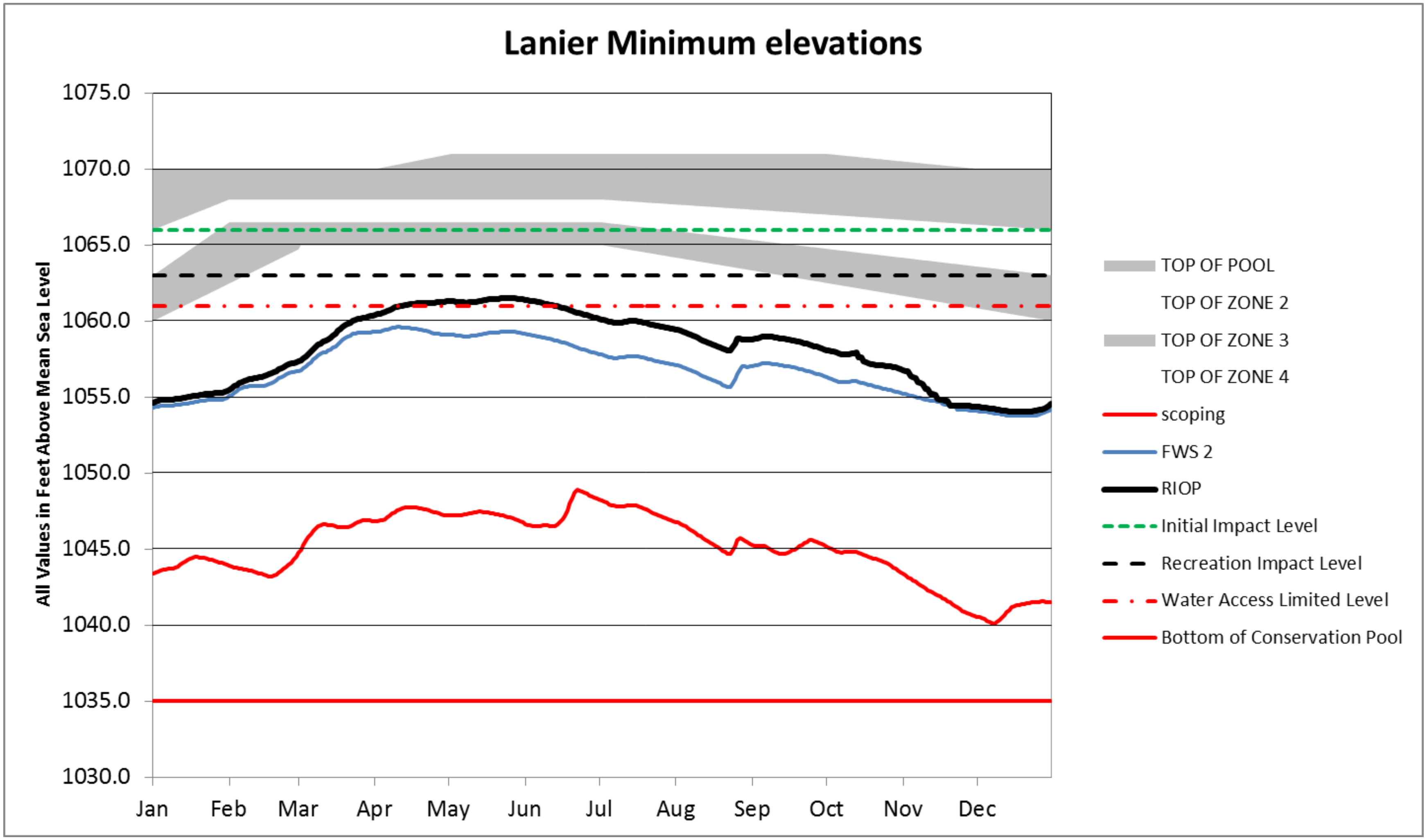


Figure 14. Median daily reservoir elevations for West Point Lake for the simulated period of record (1939-2008) under the RIOP (which was simulated in STELLA), the FWS Scoping alternative (Scoping), and the recommended alternative (FWS 2)..

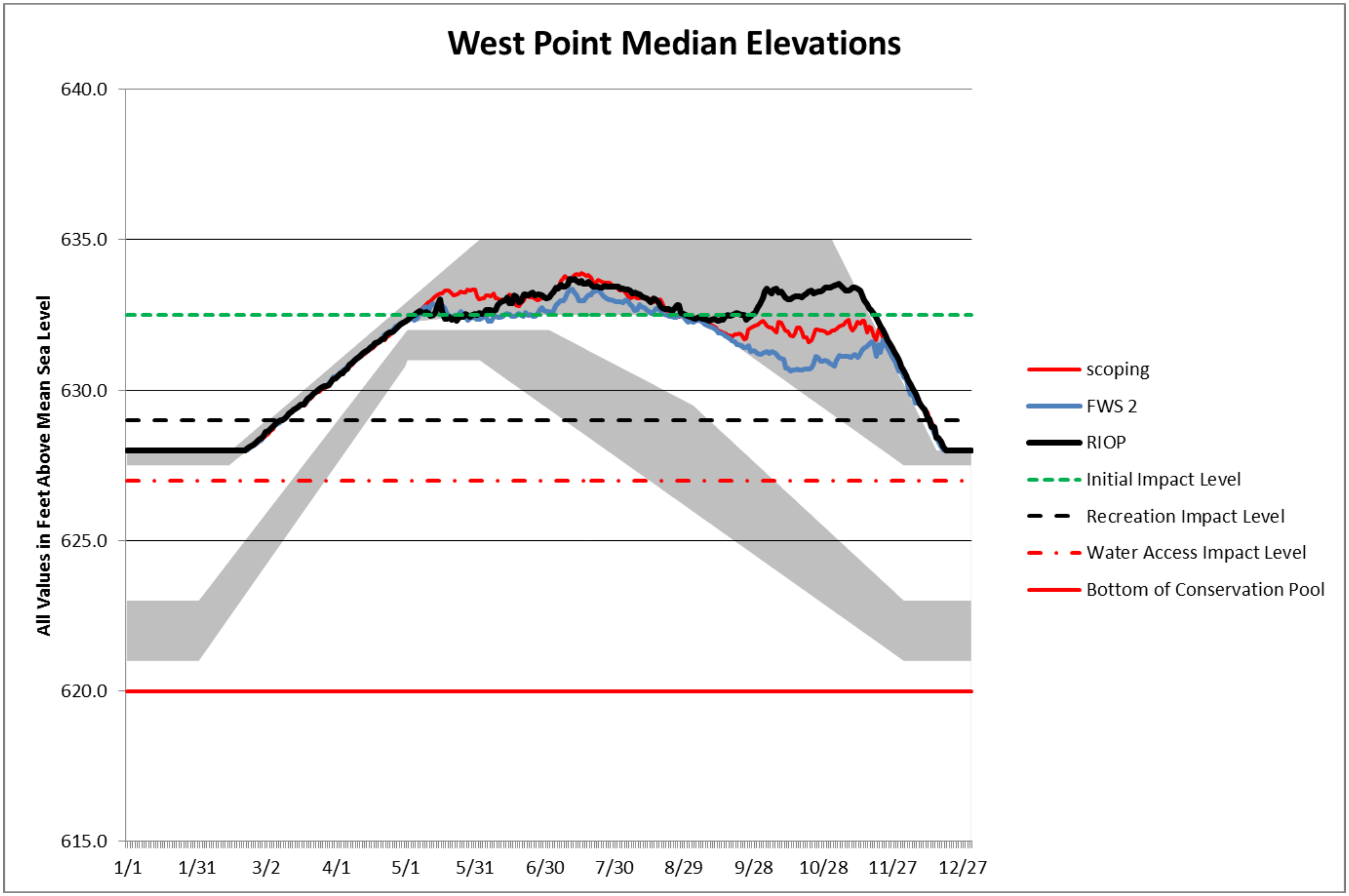


Figure 15. West Point Lake reservoir elevations that are exceeded 75 % of the time in the simulated period of record (1939-2008) under the RIOP (which was simulated in STELLA), the FWS Scoping alternative (Scoping), and the recommended alternative (FWS 2)..

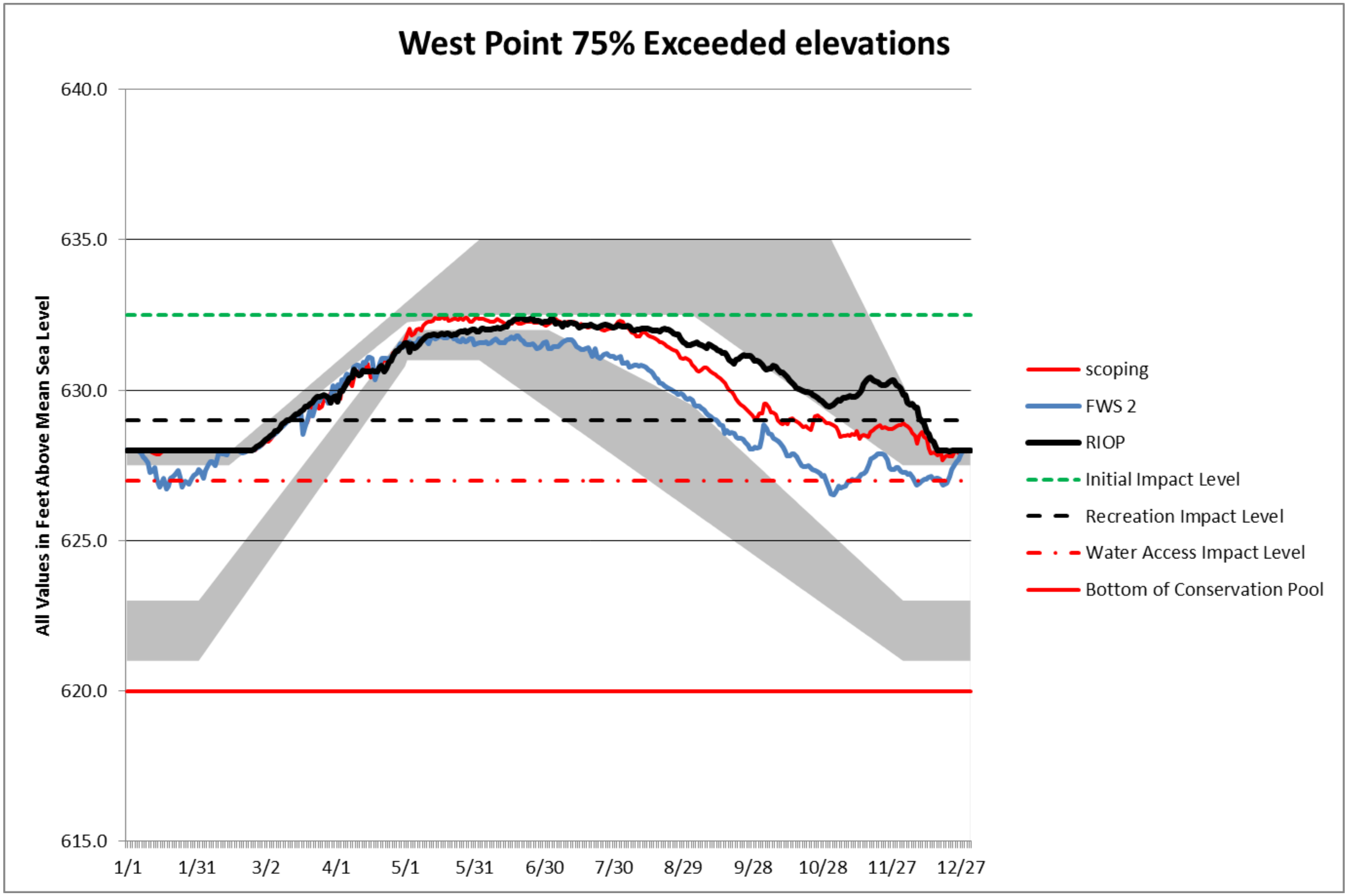


Figure 16. West Point Lake reservoir elevations that are exceeded 90 % of the time in the simulated period of record (1939-2008) under the RIOP (which was simulated in STELLA), the FWS Scoping alternative (Scoping), and the recommended alternative (FWS 2)..

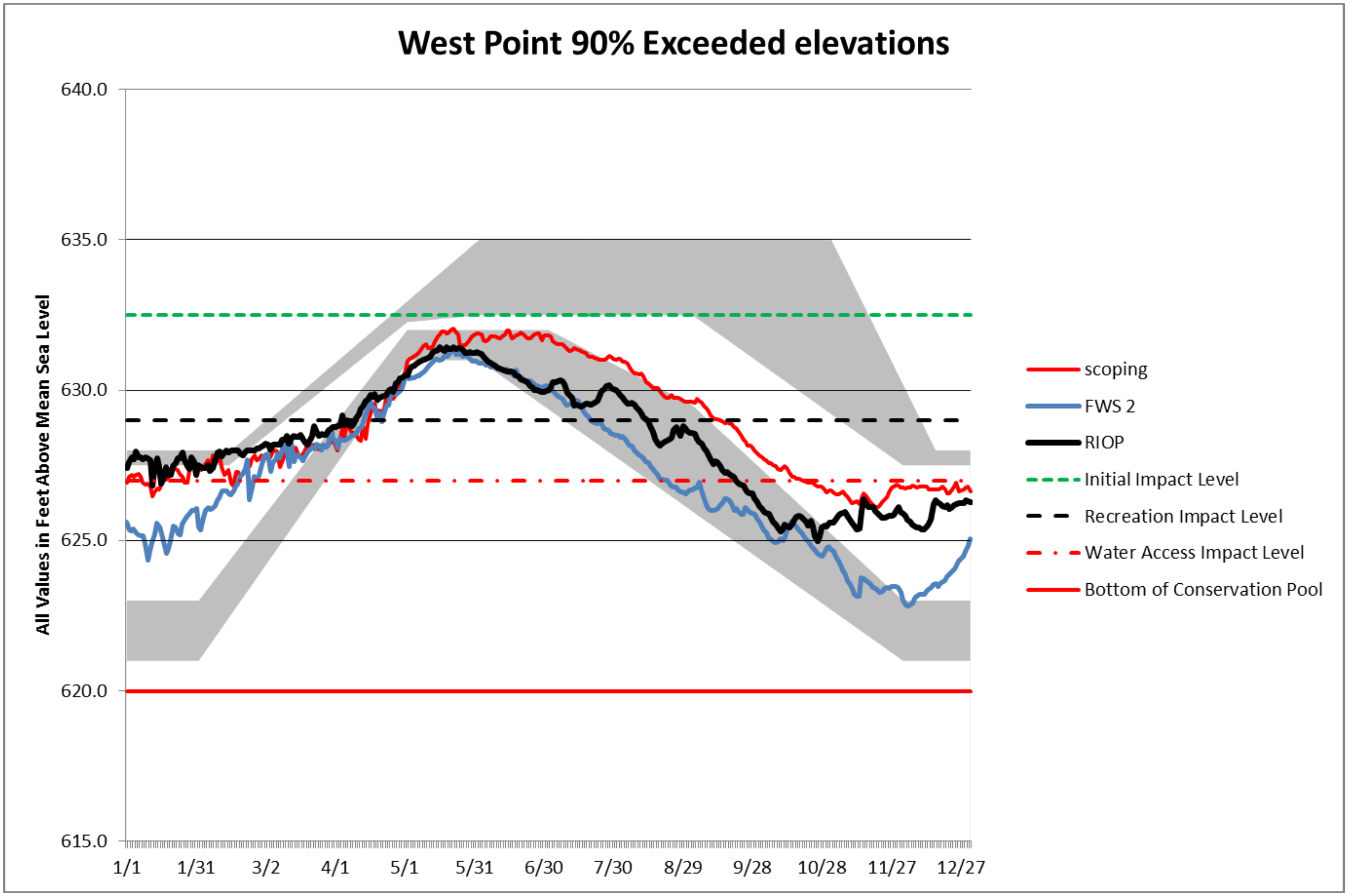


Figure 17. The minimum daily West Point Lake reservoir elevations for the simulated period of record (1939-2008) under the RIOP (which was simulated in STELLA), the FWS Scoping alternative (Scoping), and the recommended alternative (FWS 2)..

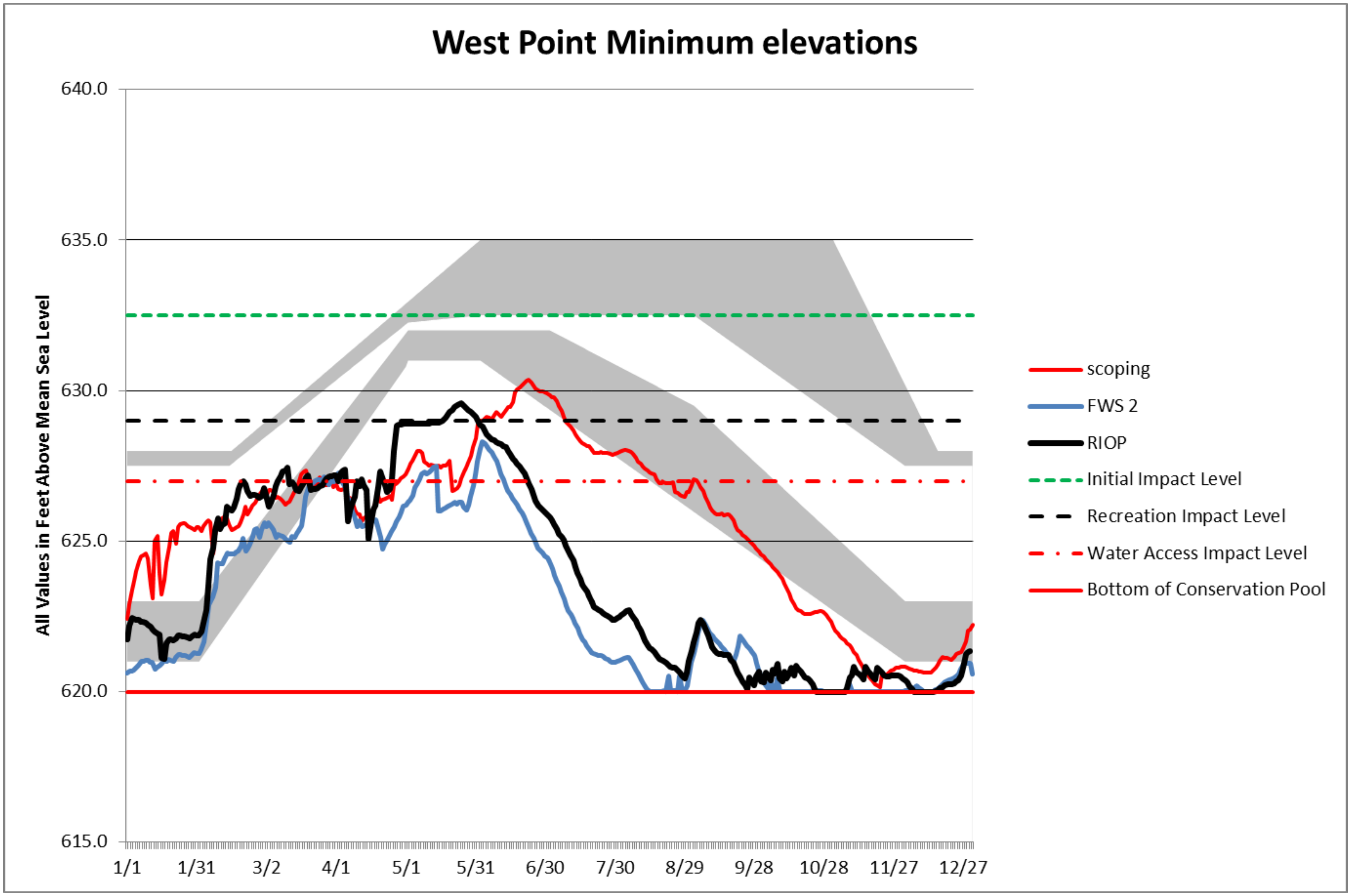


Figure 18. Median daily reservoir elevations for W.F. George for the simulated period of record (1939-2008) under the RIOP (which was simulated in STELLA), the FWS Scoping alternative (Scoping), and the recommended alternative (FWS 2)..

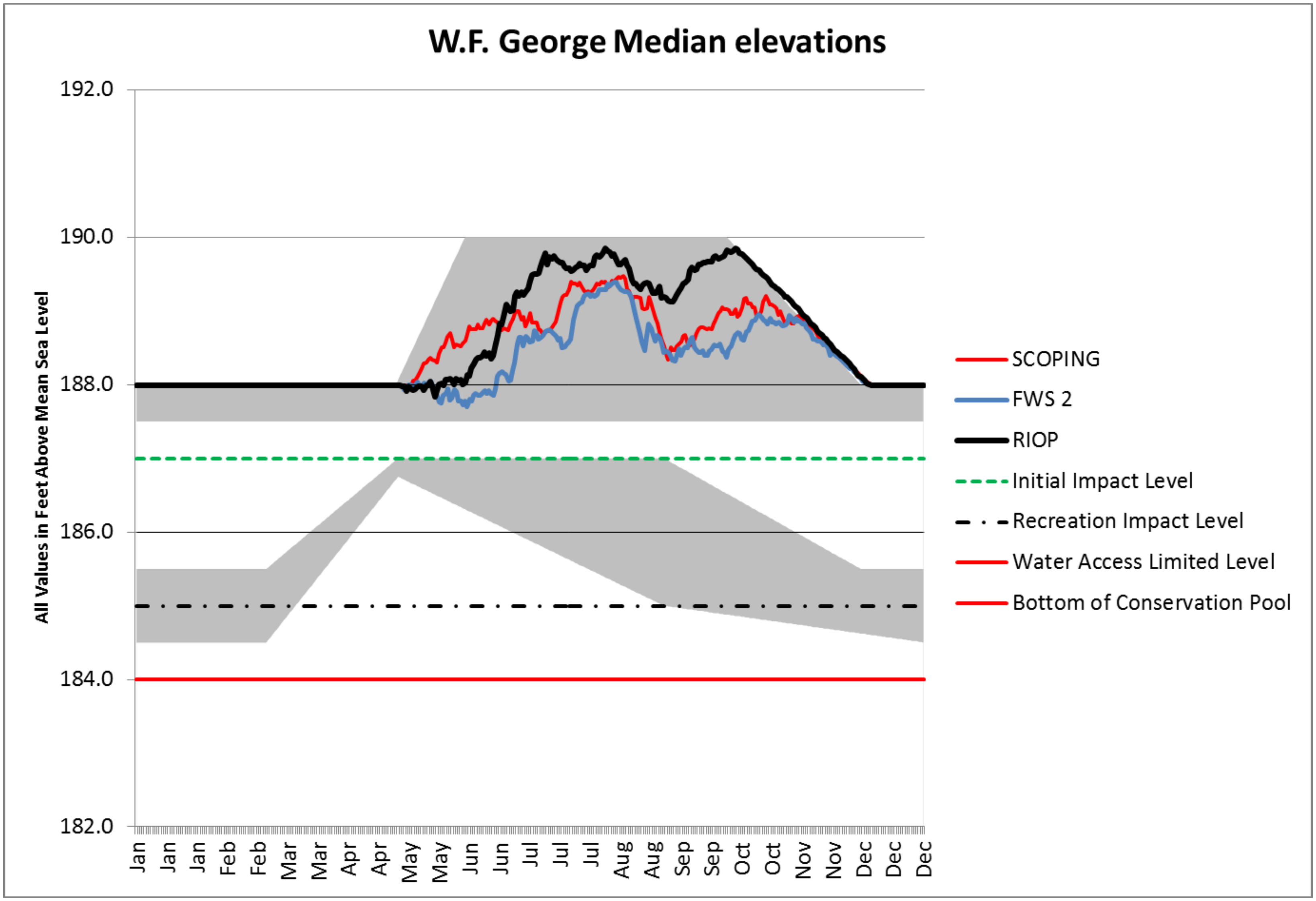


Figure 19. W.F. George reservoir elevations that are exceeded 75 % of the time in the simulated period of record (1939-2008) under the RIOP (which was simulated in STELLA), the FWS Scoping alternative (Scoping), and the recommended alternative (FWS 2)..

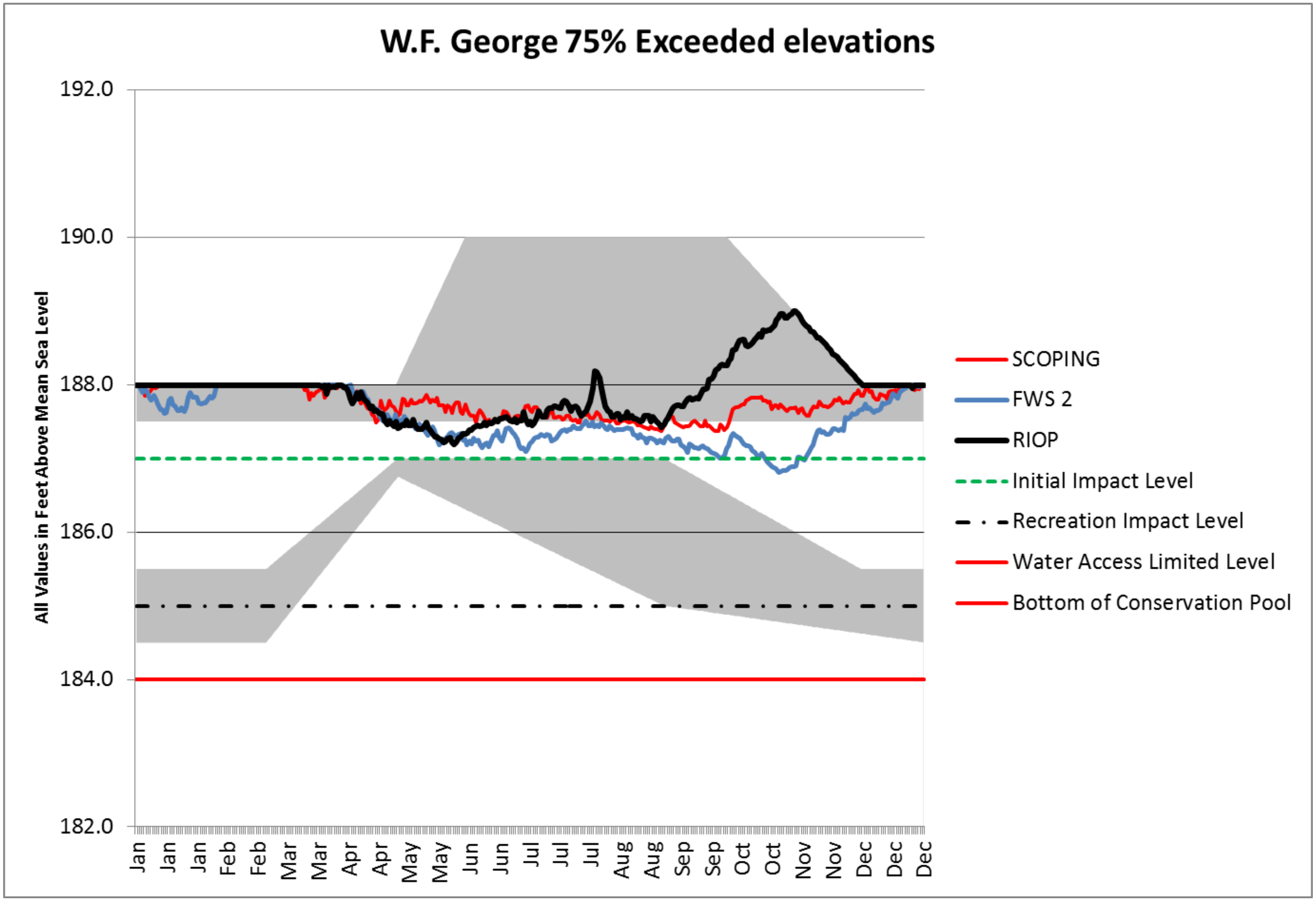


Figure 20. W.F. George reservoir elevations that are exceeded 90 % of the time in the simulated period of record (1939-2008) under the RIOP (which was simulated in STELLA), the FWS Scoping alternative (Scoping), and the recommended alternative (FWS 2)..

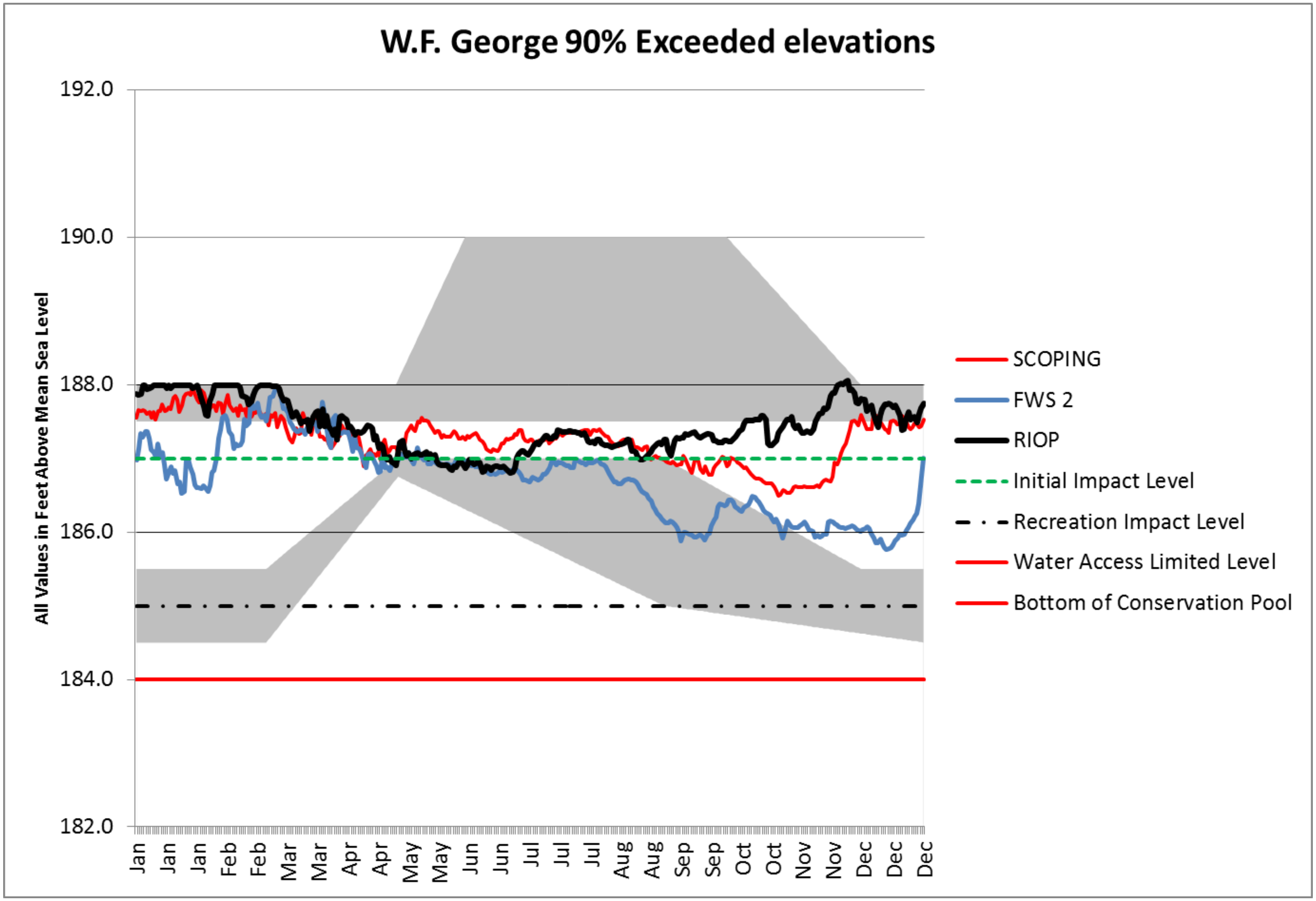
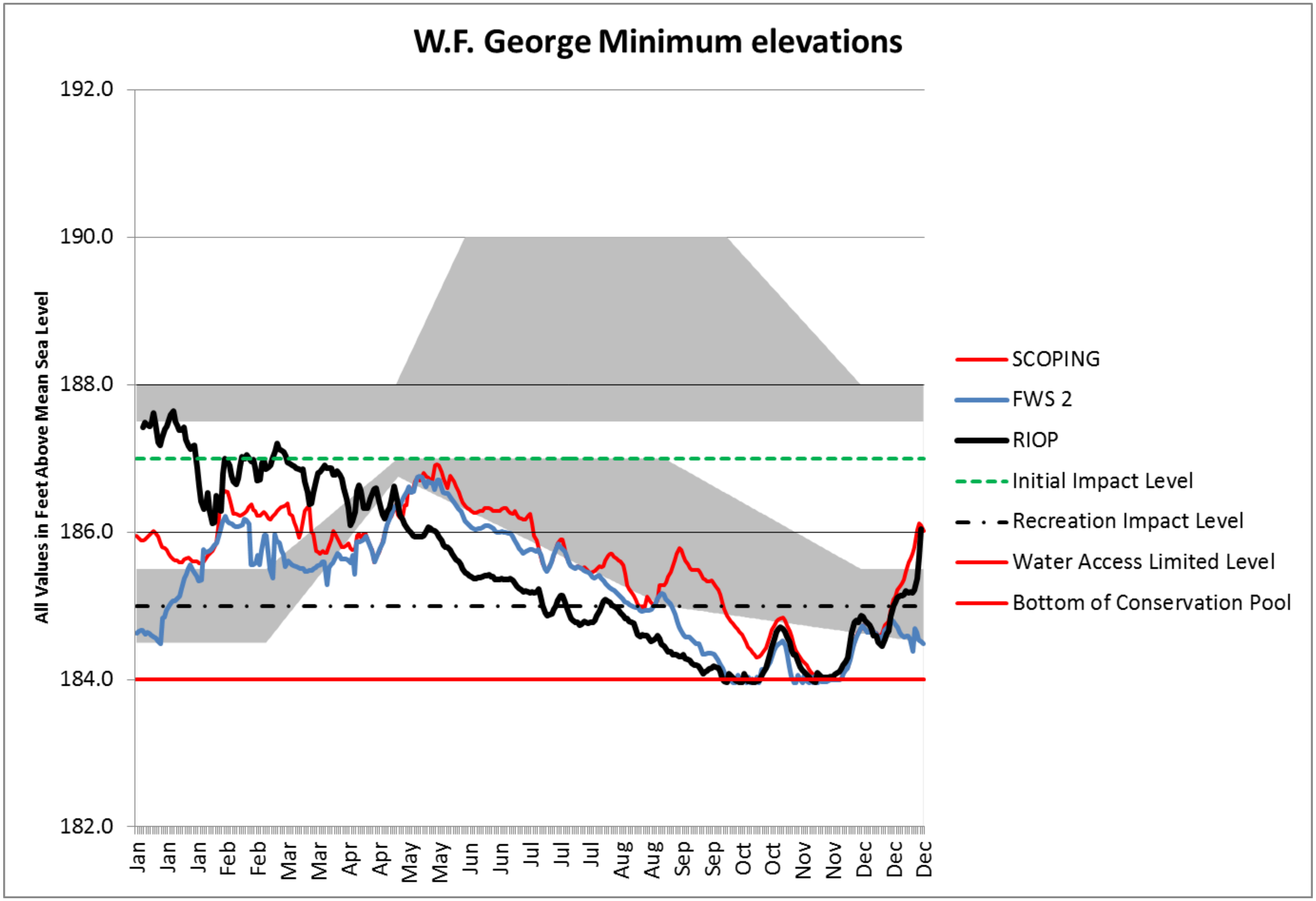


Figure 21. The minimum daily W.F. George reservoir elevations for the simulated period of record (1939-2008) under the RIOP (which was simulated in STELLA), the FWS Scoping alternative (Scoping), and the recommended alternative (FWS 2)..



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August 29, 2013

Mr. Curtis Flakes
Chief, Planning and Environmental Division
United States Army Corps of Engineers
P.O. Box 2288
Mobile, AL 36628-0001

Subject: Planning Aid Letter, Apalachicola-Chattahoochee-Flint Water Control Manual Updates

Dear Mr. Flakes:

The U.S. Army Corps of Engineers, Mobile District (Corps), currently is updating the Water Control Manual (WCM) for the Apalachicola-Chattahoochee-Flint (ACF) River Basin in Georgia, Alabama, and Florida. The WCM update identifies operating criteria and guidelines for managing water storage and release of water from Corps reservoirs and, therefore, will guide future water management operations in the basin. We previously provided Planning Aid Letters (PALs) for the proposed WCM update to the Corps April 2, 2010, and March 1, 2011; these PALS identify resource values and issues in the basin, including rare species, and propose preliminary changes, mitigation, or enhancement opportunities to minimize impacts and facilitate your National Environmental Policy Act analysis of the project. The comments in these PALs are still applicable.

The Service, in previous correspondence (July 19, 2013, Revised Alternative to the Corps), identified performance measures that the Corps should use, in simulated operations, to compare the relative effects of the no-action and action alternatives considered for the WCM update on various target species. We used these performance measures in the development of the Service's Revised Alternative. In this PAL, we fully describe these performance measures. We submit these comments and recommendations under the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. § 1531 *et seq.*), the Migratory Bird Treaty Act, (49 Stat. 755, as amended; 16 U.S.C. § 702 *et seq.*), and the Fish and Wildlife Coordination Act (FWCA) (48 Stat. 401, as amended; 16 U.S.C. § 661 *et seq.*). Our comments are based on previous studies and government documents, as well as new datasets and information provided by State and Federal agencies. We will provide additional expertise and information in our FWCA Report and during a separate section 7 consultation under the ESA.

Description of Performance Measures

Apalachicola River Floodplain Fish Spawning and Rearing

The Floodplain Spawning Habitat Performance Measure (FSHPM) calculates the maximum amount of floodplain spawning habitat available for at least 30 consecutive days during the months of April through October. It is based on data and methods described in Service biological opinions prepared for proposed interim rules governing the releases from Woodruff Dam (USFWS 2006, 2008, 2012).

Multiple studies establish the importance of floodplain habitats to the life history of many riverine fishes, including several specific to the Apalachicola River (Walsh et al. 2006, 2009; Pine et al. 2006; Dutterer et al. 2011). These studies provide evidence of spawning and rearing activity for at least 44 species representing 16 families (predominantly Centrarchidae and Cyprinidae) in floodplain habitats, when available, during the growing season. Fish use in floodplain habitats requires time for adult movement from the main channel into the floodplain, courtship and spawning behaviors, egg incubation, and juvenile growth to a size capable of moving to and surviving in the main channel when water levels recede. We consider 30 days of continuous inundation minimally sufficient to ensure successful completion of the reproductive process in the floodplain. A greater spatial extent of habitat availability provides greater benefits for fish reproduction. The spatial extent of non-tidal floodplain inundation as a function of discharge from Woodruff Dam was quantified (Figure 1; Light et al. 1998, 2006).

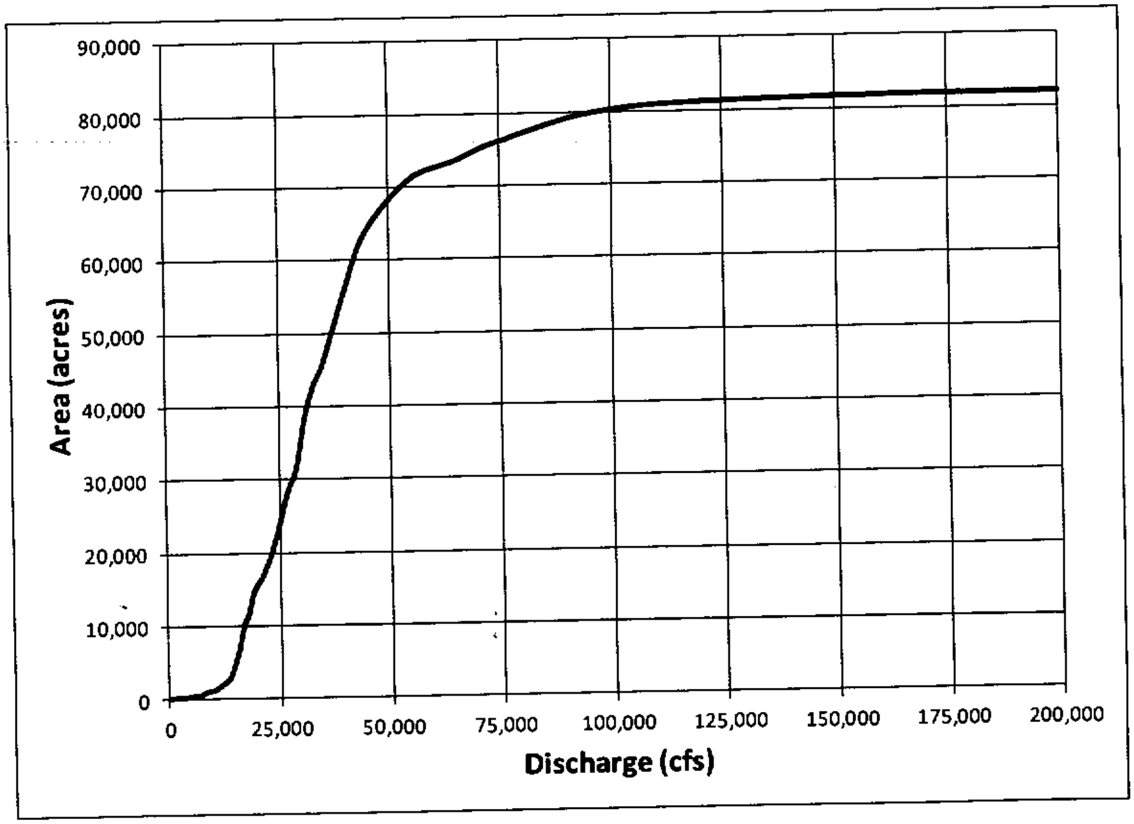

Figure 1. Area (acres) of aquatic non-tidal floodplain habitat connected to the main channel of the Apalachicola River as a function of discharge (cubic feet per second) from Woodruff Dam (data from Light et al. 1998).

The FSHPM computes a 30-day running minimum inundated floodplain acreage from observed or simulated daily releases from Woodruff Dam during April through October. The annual maximum of these values represents the amount of habitat that was continuously available for at least 30 days to support spawning behaviors and subsequent development of eggs and larvae. The FSHPM is an Excel workbook that requires multiple years of daily discharges as input. The primary output is a graphical frequency distribution ("box and whiskers" plot) of annual maximum 30-day continuous floodplain habitat availability. The Excel workbook is organized for comparing the discharge distributions of existing operations (the RIOP) as simulated by ResSim, and up to three additional simulated operations alternatives.

The inter-annual distribution of annual habitat availability estimated by this measure should serve as the basis for comparing the relative effects to floodplain-spawning fishes in simulated operations of the no-action and action alternatives considered for the WCM update. The Corps has stated that they will operate the system in a balanced manner in an attempt to meet all authorized project purposes. Given this objective, we recommend that the Corps prepare and choose alternatives that maximize the amount of inundated floodplain habitat while balancing other project purposes. While this metric is developed to analyze the April-October period, the April to May period is most important because it encompasses spawning and peak abundance of early life stages of floodplain fishes (Walsh et al. 2006). Peak inundation during the growing season generally occurs in April. However, given the protracted spawning period of many fishes, we included April through October in the Excel workbook.

Gulf Sturgeon Spawning

The Sturgeon Spawning Habitat Performance Measure (SSHPM) calculates the maximum amount of Gulf sturgeon (*Acipenser oxyrinchus desotoi*) spawning habitat available for at least 30 consecutive days from March through May. It is based on data and methods described in Service biological opinions prepared for proposed interim rules governing the releases from Woodruff Dam (USFWS 2006, 2008, 2012).

There are at least 10 potential Gulf sturgeon spawning sites on the Apalachicola River, based on the presence of a limestone, marl, or other hard substrate where sturgeon deposit their adhesive eggs. Egg collections have confirmed that three of these sites (river miles 105, 100, and 99) support spawning at a range of depths from 8.5 to 17.8 feet, a range that excludes the deepest 10 percent and shallowest 10 percent of collections. The SSHPM uses the discharge-habitat relationships for these three sites to predict spawning habitat availability based on these depths (Figure 2).

The SSHPM computes a 30-day running minimum habitat acreage from observed or simulated daily releases from Woodruff Dam during March through May. The annual maximum of these values represents the amount of habitat that was continuously available for at least 30 days to support spawning behaviors and subsequent development of sturgeon eggs and larvae. The SSHPM is an Excel workbook application that requires multiple years of daily discharges as input. The primary output is a graphical frequency distribution ("box and whiskers" plot) of annual maximum 30-day continuous habitat availability. The Excel workbook is organized for comparing the discharge distributions of existing operations (the RIOP) as simulated by ResSim, and up to three additional simulated operations alternatives.

The inter-annual distribution of annual habitat availability estimated by this measure should serve as the basis for comparing the relative effects to sturgeon spawning in simulated operations of the no-action and action alternatives considered for the WCM update. The Corps has stated that they will operate the system in a balanced manner in an attempt to meet all authorized project purposes. Given this objective, we recommend that the Corps prepare and choose alternatives that maximize the amount of inundated Gulf sturgeon spawning habitat while balancing other project purposes.

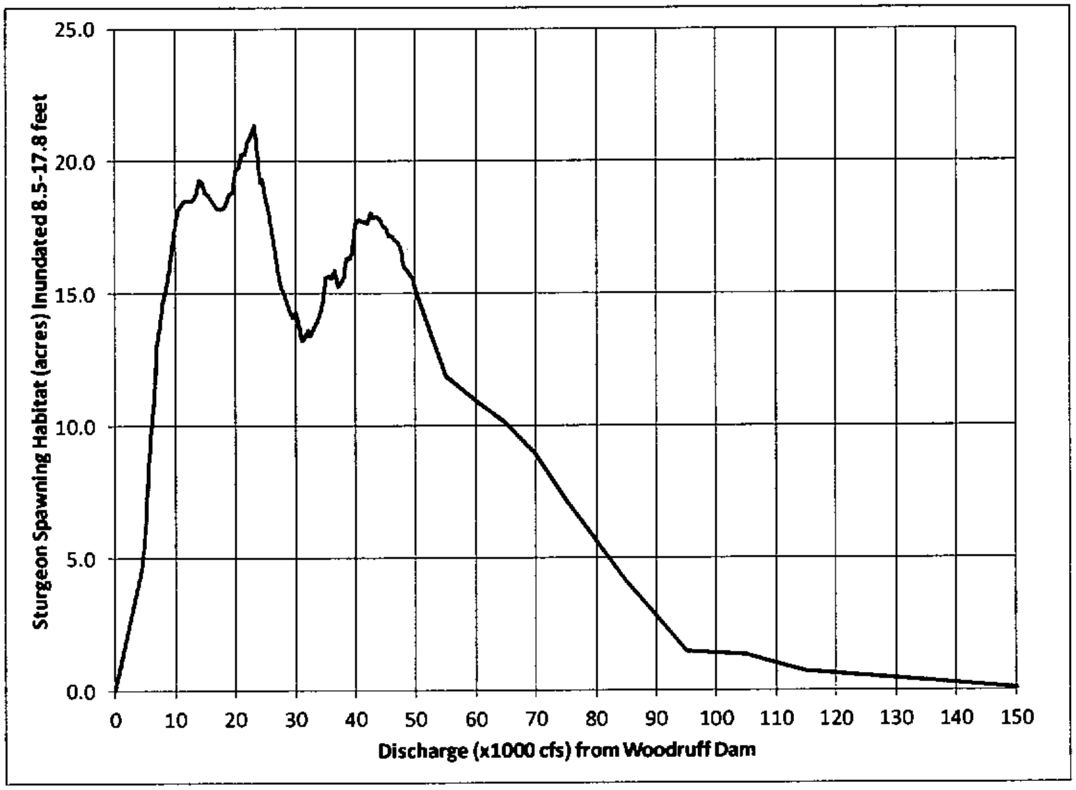

Figure 2. Area (acres) of hard substrate inundated to depths of 8.5 to 17.8 feet at the three known Gulf sturgeon spawning sites on the Apalachicola River at flows of 0 to 150,000 cfs (USFWS 2008).

Apalachicola River Mussels

The Service currently is working on a habitat-based performance measure for the federally-endangered fat threeridge (*Amblema neislerii*) in the Apalachicola River, but this metric will not be ready in time for use in the draft Environmental Impact Statement (EIS) and is not applicable to other mussel species. At this time, the best data available to evaluate the effects of operating alternatives on all three federally-listed mussels are the frequency, magnitude, and duration of low flows in the Apalachicola River.

The Apalachicola River Mussel Performance Measures (ARMPMs) are a suite of hydrologic measures related to mussel survival. Over the past eight years, we have described direct effects to mussels by exposure during low flow conditions. The ARMPMs are based on several of the low-flow and fall-rate metrics described in the biological opinions prepared for proposed interim rules governing the releases from Woodruff Dam (USFWS 2006, 2008, 2012). The ARMPMs include the following metrics: (1) the inter-annual frequency of flow rates less than 5,000 to 10,000 cfs; (2) the median number of days per year less than the thresholds of 5,000 to 10,000 cfs; (3) the median number of consecutive days per year of discharge less than 5,000 to 10,000 cfs; (4) the median fall rates when flows are less than 10,000 cfs; (5) and the maximum fall rates when flows are less than 10,000 cfs.

The ARMPMs are an Excel workbook that requires multiple years of daily discharges as input. The primary outputs are graphical frequency distributions (line charts) for ARMPMs 1-3 above and calculations of ARMPMs 4 and 5. The workbook is organized for comparing the distributions of existing operations (the RIOP) as simulated by ResSim, and up to three additional simulated operations alternatives.

The metrics should serve as the basis for comparing the relative effects to mussels in simulated operations of the no-action and action alternatives considered for the WCM update. The Corps has stated that they will operate the system in a balanced manner in an attempt to meet all authorized project purposes. Given this objective, we recommend that the Corps prepare and choose alternatives that reduce the occurrence and fall rates of low flows, while balancing other project purposes.

Reservoir Fisheries

Multiple game and non-game fishes use the littoral zone for spawning and rearing (e.g., Centrarchidae). The Reservoir Fisheries Performance Measure (RFPM) is an index of habitat conditions for these littoral-zone spawning fishes, computed from time-series of daily surface elevations for Lanier, West Point, and W.F. George reservoirs using the Corps' elevation vs. surface area relationships for each reservoir. We have not developed a RFPM for Andrews and Seminole reservoirs because operating alternatives for these relatively shallow and essentially run-of-river impoundments are unlikely to change their patterns of surface elevation variability.

Like the FSHPM, the RFPM computes a 30-day running minimum habitat acreage during the spawning season from observed or simulated daily reservoir elevations. The annual maximum of these values during the spawning season represents the amount of habitat continuously available for at least 30 days to support spawning behaviors and the growth and development of early life-history stages.

The depth of productive littoral-zone habitat varies with surface elevation, water quality, the extent and duration of reservoir draw-downs in previous years, and other factors. The Corps' fish management plans from the 1970's suggest that 20 feet below full summer pool elevation is the "approximate bottom of the productive zone" for each of the three large storage reservoirs (Corps 1974a, 1974b, 1975). However, fisheries managers and experts for these reservoirs described depths greater than 15, 7, and 10 feet below full summer pool as "totally unacceptable" for littoral spawning or rearing habitat in Lanier, West Point, and W.F. George, respectively (Ryder et al. 1995). The RFPM uses the elevations from Ryder et al. (1995) corresponding to the "unacceptable" depths below full pool as the "floor" of the littoral productive zone.

Ploskey and Reinert (1995) cited numerous studies of successful reproduction and development of strong year classes associated with years of high water inundating terrestrial vegetation in reservoirs. They found positive correlations in West Point and W.F. George reservoirs between spring-time perimeter area (depth less than 6 meters) and standing crop data for Centrarchids. Flooded terrestrial vegetation is especially important to fisheries in Lanier and West Point, where aquatic vegetation is relatively sparse in constantly inundated areas. Miranda et al. (1984) found positive correlations between young-of-year largemouth bass abundance and the extent and duration of flood-pool inundation (i.e., elevations exceeding the top of the conservation pool) at West Point reservoir.

Based on this information, the RFPM computes two subsets of the area of the productive zone inundated during the spawning season for 30 days or more: 1) the area, if any, exposed during the previous growing season for at least 45 consecutive days, where terrestrial vegetation could have colonized exposed shorelines during the previous year; and 2) the area, if any, above the normal full pool elevation that could support perennial terrestrial vegetation (Figure 3). The second subset is a subset of the first, and by adding these two areas to the full inundated area of the productive zone, the RFPM triple-counts inundated acres above normal full pool and double-counts inundated acres that were exposed during the previous year.

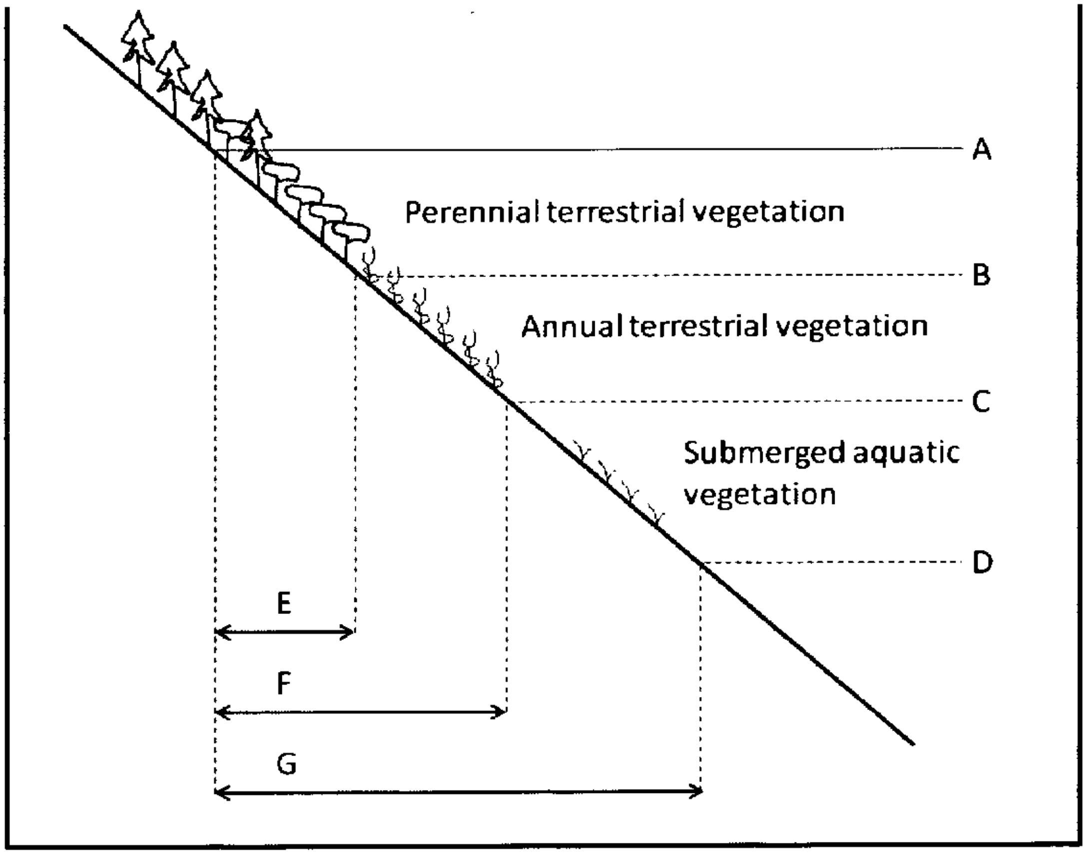

Figure 3. Conceptual drawing of a reservoir shoreline showing RFPM physical features, where
A = maximum surface water elevation sustained for at least 30 days during the spawning season;
B = full conservation pool elevation and lower extent of perennial terrestrial vegetation;
C = the minimum elevation exposed for at least 45 days during the growing season in the previous year;
D = the elevation of the lower extent of reservoir productive zone;
E = the inundated area between A and B;
F = the inundated area between A and C; and
G = the inundated area between A and D.

In this depiction, A exceeds both B and C, and the RFPM would report for the year the sum of E + F + G as the annual habitat acreage (E is triple counted, and F is double counted). In years when A does not exceed B, E is 0; when A does not exceed C, F is zero; and when A does not exceed D, G is zero.

The fish spawning seasons specific to each reservoir for the RFPM are identified in the Corps' Standard Operating Procedure (SOP) for fish spawning in the ACF system (Table 1). The intent of the SOP is to maintain stable or rising reservoir levels for 4 weeks during the 8-week window to promote successful fish spawning and rearing. The 30-day running minimum area calculated in the RFPM begins on the first day of the fish spawn window and concludes on the day that captures the last day of the spawn window in the 30-day minimum calculation. The other temporal and spatial parameters used in the RFPM (e.g., growing season length, elevation of the lower extent of the productive zone) for each reservoir are given in Table 1 along with the values we recommend for its use; however all are user-definable parameters.

Table 1. User-definable parameters for the RFPM with recommended values for its use.

Parameter	**Lanier**	**West Point**	**W.F. George**
Growing season[1] start	Mar. 30	Mar. 20	Mar. 10
Growing season[2] end	Oct. 30	Nov. 5	Nov. 15
Spawning season start	Apr. 1	Apr. 1	Mar. 15
Spawning season end	Jun. 1	Jun. 1	May 15
Elevation (ft) for lower extent of reservoir productive zone	1056	628	180
Exposure duration (days) for establishing terrestrial vegetation during the growing season	45	45	45
Inundation duration (days) for spawning/early rearing	30	30	30
Full conservation pool elevation (ft) and lower extent of perennial terrestrial vegetation	1071	635	190

1=Average dates of last spring freeze (National Weather Service 2013a).
2=Average dates of first fall freeze (National Weather Service 2013b).

Although many other factors besides reservoir elevations, such as flow-through volume, nutrient loading, etc., may influence the population dynamics of reservoir fishes, we believe the RFPM is a relatively simple and useful index for ranking the effects of operating alternatives on reservoir fisheries habitat. We considered using the performance measure that the Service developed for the Corps' 1998 ACF Water Allocation DEIS, which was based in part on the expert-opinion survey results described in Ryder et al. (1995). We prefer and now recommend the RFPM, because it relies solely on direct measures of reservoir area that are likely to contain the habitat features supporting successful fish reproduction. Further, the RFPM results are more easily computed and interpreted than those of the 1998 DEIS performance measure, and are consistent with the Corps' fish spawn SOP, which was adopted after the 1998 DEIS.

The RFPM is an Excel workbook that requires multiple years of daily reservoir elevations as input. The primary output is a graphical frequency distribution ("box and whiskers" plot) for each reservoir of annual maximum 30-day continuous habitat availability. The spreadsheet is organized for comparing the distributions of observed reservoir levels, existing operations (the RIOP) as simulated by ResSim, and up to 6 additional simulated operations alternatives. Displaying additional alternatives is possible by replicating the functions within the spreadsheet.

Chattahoochee River Shoal Bass Recruitment

The Chattahoochee River Shoal Bass Recruitment Performance Measure (CRSBPM) predicts shoal bass (*Micropterus cataractae*) recruitment using a combination of discharge and river water temperatures. Shoal bass are a recently-described black bass endemic to the ACF River Basin, are listed as a species of concern by American Fisheries Society, and are regionally vulnerable (Warren et al. 2000). They frequently occur in shoals over rocky sediments in water exceeding 0.66 feet per second (Sammons and Goclowski 2012). Shoal bass frequently co-occur with other shoal-dwelling native species and their population response to discharge and water quality may be an indicator of shoal fish community response. Because of their recreational fishery significance and the availability of potentially suitable shoal habitat, Georgia Department of Natural Resources and the National Park Service initiated a 5-year shoal bass stocking program in 2003 below Morgan Falls Dam on the Chattahoochee River.

A study was initiated to evaluate the success of the stocking program and to characterize variables affecting recruitment (Long and Porta 2011). The relative abundance (electrofishing catch-per-unit effort) of age-3 shoal bass was of specific interest because these individuals were the minimum age (size) susceptible to capture, had the potential to be stocked, and were present in the river for a duration of time acceptable for inferences regarding cohort recruitment. Mean spring water temperature was highly correlated with discharge, and spring water temperature and bass length at stocking were strong predictors of age-3 catch per unit effort ($F_{2,3}= 20.78$, $R^2 = 0.93$, $p < 0.10$). Because stocked and wild shoal bass had similar lengths, growth rates, and longevity, we expect that wild and stocked fish respond similarly to river water temperatures and that the multiple regression formula of Long and Porta (2011) can be used to make inferences regarding both wild and stocked shoal bass:

$$\log_{10}\text{age-3 abundance} = -6.262 + 0.055_{\text{LStock}} + 0.306_{\text{SpTemp}}$$

where LStock is length in millimeters at time of stocking, and SpTemp is Spring water temperature (from stock date to June 21) in degrees Celsius.

In order to use Long and Porta's (2011) multiple regression model to evaluate multiple alternatives for the WCM updates, we estimated the relationship between discharge and water temperature in the Chattahoochee River at two locations. We used United States Geological Survey (USGS) average daily discharge and temperature data from the Chattahoochee River below Morgan Falls Dam, Georgia gage (USGS #02335815 at river mile 312.5; temperature data available for 2004-2006) and the Chattahoochee River at Atlanta, Georgia gage (USGS #02336000 at river mile 303; temperature data available for 2002-2009, 2011-2012). Both locations were within the study area of Long and Porta (2011). Average temperature and discharge were used for May and June (combined), because averages were used to develop the multiple regression model, and May and June constitute a majority of the spring stocking events (Long and Porta 2011). Exponential relationships produced the best-fit lines (Atlanta $R^2 = 0.94$; Morgan Falls $R^2 = 0.88$; Figure 4).

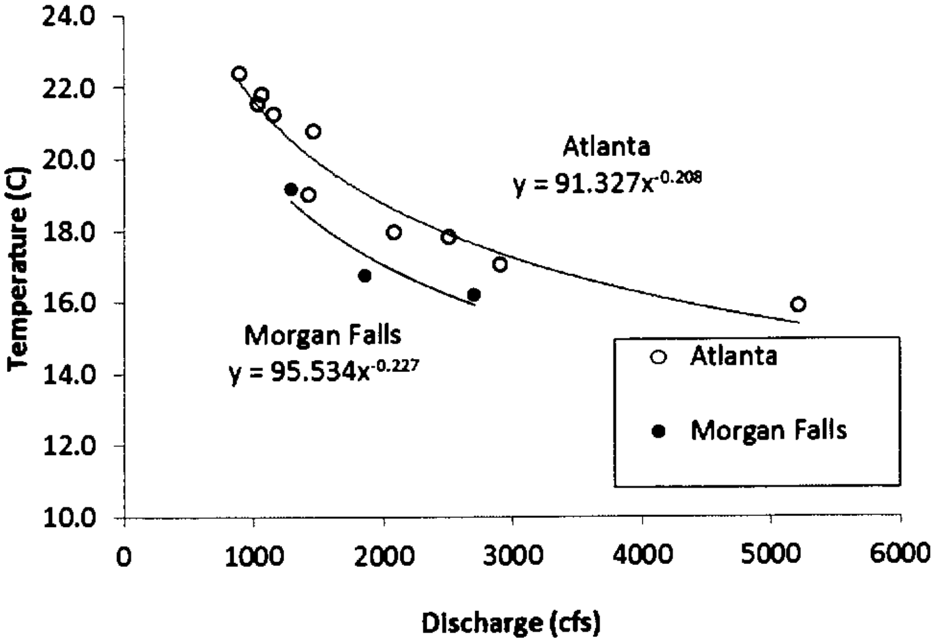

Figure 4. The relationship between spring temperature and average daily discharge for the USGS gage near the Chattahoochee River below Morgan Falls Dam, Georgia (USGS #02335815 at river mile 312.5; temperature data available for 2004-2006) and the USGS gage near the Chattahoochee River at Atlanta, Georgia (USGS #02336000 at river mile 303; temperature data available for 2002-2009, 2011-2012).

Based on these regressions, the CRSBPM is an Excel workbook that computes the average water temperature for May-June based on modeled discharge from the reservoir, then uses the Long and Porta (2011) regression formula to calculate recruitment as catch-per-unit effort of stocked age-3 shoal bass. The user can specify a bass length at stocking to examine recruitment effects. However, it is important that the user specify a length within the range measured in the study (23.7-68.0 mm), and that a consistent length is used to compare alternatives. We used 30 mm because smaller fish are likely to be more vulnerable to temperature changes, although trends are the same for any size selected. The primary output is a graphical frequency distribution ("box and whiskers" plot) that compares predicted age-3 catch-per-unit effort (not log-transformed) among multiple alternatives. The workbook is organized for comparing the distributions of existing operations (the RIOP) as simulated by ResSim, and up to three additional simulated operations alternatives.

The metric should serve as the basis for comparing the relative effects to age-3 shoal bass in simulated operations of the no-action and action alternatives considered for the WCM update. The Corps has stated that they will operate the system in a balanced manner in an attempt to meet all authorized project purposes. Given this objective, we recommend that the Corps prepare and choose alternatives that improve shoal bass recruitment, while balancing other project purposes.

Apalachicola Bay Salinity

Because salinity in Apalachicola Bay is influenced by river flows, low salinities are prevalent during wet, high flow years and high salinities are prevalent during droughts. Optimal salinities for oysters are less than 26 parts per thousand (ppt) (Livingston et al. 2000; Huang 2010), and juvenile Gulf sturgeon require salinities less than 10 ppt (Altinok and Grizzle 2001; Randall and Sulak 2007;

Sulak et al. 2009). In our 2010 draft FWCA Report, the Service evaluated the effects of reservoir operation alternatives on salinity in Apalachicola Bay using output from a hydrodynamic salinity model developed by Sheng et al. (2011). This model provides detailed information about salinity throughout the bay over various freshwater inflows; however, it is time consuming and requires intensive data post-processing. While revising the alternative we submitted in July 2013, we sought a simpler, nimbler way to evaluate the effects of reservoir operations on salinity in Apalachicola Bay. Because we examined over 80 alternatives, hydrodynamic salinity modeling was not feasible.

The Apalachicola National Estuarine Research Reserve provided us their average daily salinity data for monitoring stations in the bay from 1992 to 2013. We focused on East Bay, which is important juvenile Gulf sturgeon habitat from October through March. We also focused on Cat Point and Dry Bar, which are commercially important oyster bars and where low salinities are most important from May through October. We developed regression relationships between the mean monthly salinity at each of these locations within Apalachicola Bay and the mean monthly discharge at the USGS gage in the Apalachicola River near Chattahoochee, FL (USGS gage 02358000; Figure 5). The Apalachicola Bay Salinity Performance Measure (ABSPM) uses these regressions to compute the mean monthly salinity for these three locations for each month of every year in the simulated discharge period of record. These values represent the average monthly salinities that are experienced at these locations to support Gulf sturgeon and oyster growth and survival.

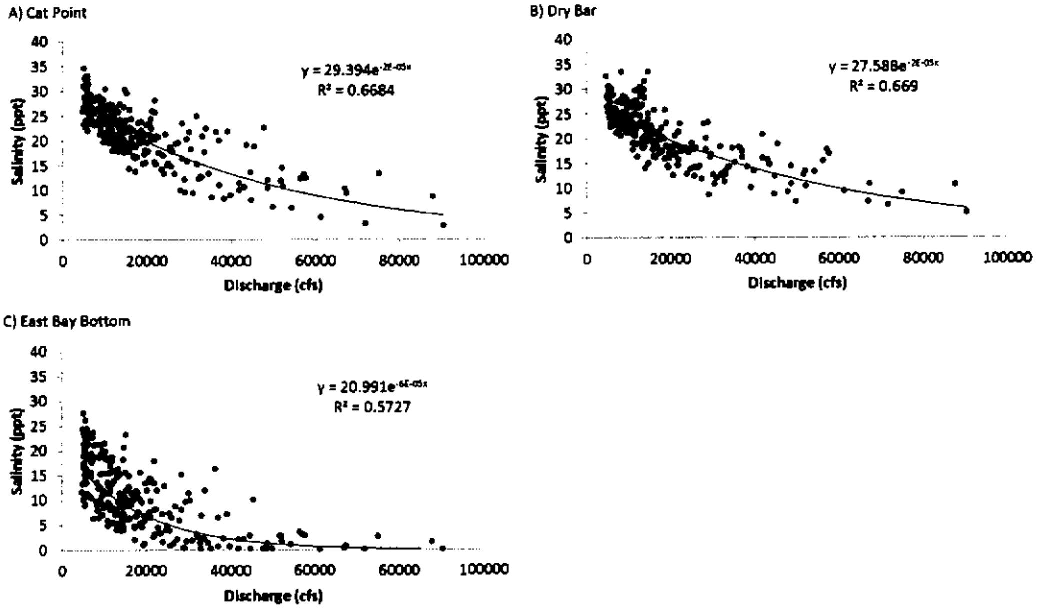

Figure 5. The relationship between Apalachicola River at Chattahoochee discharge (USGS #02358000) and Apalachicola Bay salinity at A) Cat Point, B) Dry Bar, and C) the bottom of East Bay.

The ABSPM is an Excel workbook that produces a graphical frequency distribution ("box and whiskers" plot) of mean monthly salinity for October through March for juvenile sturgeon in East Bay, and May through October for oysters at Cat Point and Dry Bar. The spreadsheet is organized for comparing the salinity distributions resulting from existing operations (the RIOP) as simulated in ResSim, and up to six additional simulated operations alternatives. The ABSPM should serve as the basis for comparing the relative effects of the no-action and action alternatives considered for the WCM update. The Corps has stated that they will operate the system in a balanced manner in an attempt to meet all authorized project purposes. Given this objective, we recommend that the Corps prepare and choose alternatives that improve oyster and sturgeon growth and survival as measured by these performance metrics, while balancing other project purposes.

The Corps should note that the ABSPM is a coarse metric, because it is based on mean monthly salinities. Differences among the alternatives that we have analyzed to date are relatively minor. This may be due to the coarse temporal scale of the metric or the possibility that substantial changes in the bay salinity metric require large amounts of water. Finer spatiotemporal-scale evaluation is necessary to discern whether changes in reservoir operations may improve salinity regimes for sturgeon, oysters, and other bay resources. The Service recommends that the Corps also consider hydrodynamic salinity modeling for comparing the relative effects on Apalachicola Bay salinity in simulated operations of the no-action and action alternatives considered for the WCM update.

Summary

This PAL describes six performance measures that we recommend the Corps use to evaluate impacts of the no-action and action alternatives considered for the WCM update on various target species. We request the opportunity to analyze the Corps' future alternatives using the Service's performance measures. Alternatively, we can provide technical assistance or Excel workbooks for the Corps' analyses, as needed.

Our revised alternative, provided to you July 19, 2013, exhibited improvements to all these performance measures, except the ABSPM, when compared to conditions under the Revised Interim Operating Plan. As discussed above, a lack of notable improvement to the ABSPM may be due to the coarseness of the metric or the requirement for substantial changes in reservoir operations to result in changes to the bay salinity metric. Because most performance measures improved in our revised alternative, we did not prioritize them during our alternative development process. We can develop tailored recommendations in the future if it appears a priority ranking for the six performance measures is needed during the Corps' alternative development process.

We appreciate the opportunity to participate in the planning stages of your project. We would like to stress that the Corps' water management is not just about avoiding adverse effects, but also about restoring and improving habitat. If you have any questions, please contact Georgia Ecological Services staff biologists Will Duncan or Alice Lawrence at (706) 613-9493, or Panama City Ecological Services staff biologist Karen Herrington at (850) 348-6495.

Sincerely,

Ron B. Goodloe

Robin B. Goodloe
Acting Field Supervisor

cc: J. Ziewitz, USFWS, Tallahassee, FL
K. Herrington, USFWS, St. Charles, MO
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November 13, 2013

Mr. Stan Cook
Chief Fisheries Section
Alabama Department of Conservation and Natural Resources
PO Box 301456
Montgomery, AL 36130

Subject: ACF Water Control Manual Updates – Request for Information

Dear Mr. Cook:

The U.S. Army Corps of Engineers, Mobile District (Corps), has resumed the Water Control Manual (WCM) updates for the Apalachicola-Chattahoochee-Flint (ACF) River Basin in Georgia, Alabama, and Florida. The WCM identifies operating criteria and guidelines for managing water storage and release of water from Corps' reservoirs. The proposed update will guide future water management operations at Corps projects in the basin. The Corps has resumed consultation with the U.S. Fish and Wildlife Service (Service) for this action under the Fish and Wildlife Coordination Act (FWCA) (48 Stat. 401, as amended; 16 U.S.C. § 661 *et seq.*).

The FWCA provides the basic authority for the Service's involvement in evaluating impacts of proposed water resource development projects, including construction and operation of dams, on fish and wildlife resources. The statute requires the Federal action agency for a water resource development project to (1) provide equal consideration to fish and wildlife resource issues as is given to other project purposes in project planning, (2) consult with the Service and State fish and wildlife agency (and the National Marine Fisheries Service in some instances) about these impacts, and (3) work with the Service and State to develop measures to protect, develop, and improve wildlife and their habitat. Where possible, the Federal action agency must incorporate these recommendations in project plans.

The previous Planning Aid Letters (PALs; dated April 2, 2010, and March 1, 2011) and the draft FWCAR (dated June 17, 2011) identified resource values and issues in the basin, including rare species, and proposed changes, mitigation, or enhancement opportunities to minimize impacts and facilitate the Corps' National Environmental Policy Act (NEPA) analysis of the project. The comments in these documents still are applicable. We now are advising the Corps on the current WCM update. In our July 19, 2013, letter (enclosed), we (1) identified a revised reservoir operation alternative that would not result in excessive impacts to river flows or reservoir levels and (2) recommended that the Corps give it full consideration in their NEPA analyses. We

followed up with a PAL that identified performance measures the Corps should use in NEPA evaluations of project effects on fish and wildlife resources and their habitats (August 29, 2013, enclosed). We used performance measures for fish and wildlife resources to develop the Service's Revised Alternative. We have continued to refine the Stella model used to develop the revised alternative, and although the revised alternative has not changed, the performance measure results included in the enclosure of the July 2013 letter have changed accordingly.

We will provide the Corps additional expertise and information in a future FWCAR and during section 7 consultation under the Endangered Species Act. We anticipate coordination with your agency during this process. At this stage in the process, we would appreciate if your agency would share with us any new information or datasets, relevant to the Corps' WCM update since our 2011 draft FWCA report, so that we may be best informed in developing comments and recommendations to the Corps. Over the course of the next year, we plan to share information from the Corps and the draft FWCA report with you, and will attach your comments to the final report to the Corps (unless you choose to provide the Corps with a separate FWCA report).

We appreciate your input in the planning stages of this project. If you have questions, please contact Georgia Ecological Services staff biologists Will Duncan or Alice Lawrence at (706) 613-9493, or Panama City Ecological Services staff biologist Karen Herrington at (850) 348-6495.

Sincerely,

Robin B. Goodloe
Acting Field Supervisor

Attachments:
July 19, 2013, USFWS letter to Mr. Curtis Flakes, Chief, Planning and Environmental Division, U.S. Army Corps of Engineers, Mobile District

August 29, 2013, USFWS Planning Aid Letter to Mr. Curtis Flakes, Chief, Planning and Environmental Division, U.S. Army Corps of Engineers, Mobile District

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K. Herrington, USFWS, St. Charles, MO
B. Pearson, USFWS, Daphne, AL
J. Earle, USFWS, Eufaula, AL
M. Thomas, GADNR, Social Circle, GA
H. Vielhauer, FFWCC, Tallahassee, FL
T. Hoehn, FFWCC, Tallahassee, FL
D. Bernhart, NOAA, St. Petersburg, FL
P. Gagliano, EPA, Atlanta, GA
C. Jackson, Chattahoochee River NRA, GA
B. Turner, ACF Stakeholders, Albany, GA

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November 13, 2013

Mr. Harold G. Vielhauer
General Council
Florida Fish and Wildlife Conservation Commission
620 South Meridian Street
Tallahassee, Florida 32399-1600

Subject: ACF Water Control Manual Updates – Request for Information

Dear Mr. Vielhauer:

The U.S. Army Corps of Engineers, Mobile District (Corps), has resumed the Water Control Manual (WCM) updates for the Apalachicola-Chattahoochee-Flint (ACF) River Basin in Georgia, Alabama, and Florida. The WCM identifies operating criteria and guidelines for managing water storage and release of water from Corps' reservoirs. The proposed update will guide future water management operations at Corps projects in the basin. The Corps has resumed consultation with the U.S. Fish and Wildlife Service (Service) for this action under the Fish and Wildlife Coordination Act (FWCA) (48 Stat. 401, as amended; 16 U.S.C. § 661 *et seq.*).

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P. Gagliano, EPA, Atlanta, GA
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November 13, 2013

Mr. Matt Thomas
Assistant Chief of Fisheries
Georgia Department of Natural Resources-Wildlife Resources Division
2070 U.S. Highway 278, SE
Social Circle, Georgia 30025-4711

Subject: ACF Water Control Manual Updates – Request for Information

Dear Mr. Thomas:

The U.S. Army Corps of Engineers, Mobile District (Corps), has resumed the Water Control Manual (WCM) updates for the Apalachicola-Chattahoochee-Flint (ACF) River Basin in Georgia, Alabama, and Florida. The WCM identifies operating criteria and guidelines for managing water storage and release of water from Corps' reservoirs. The proposed update will guide future water management operations at Corps projects in the basin. The Corps has resumed consultation with the U.S. Fish and Wildlife Service (Service) for this action under the Fish and Wildlife Coordination Act (FWCA) (48 Stat. 401, as amended; 16 U.S.C. § 661 *et seq.*).

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February 22, 2011

Mr. Donald Imm
Field Supervisor
U.S. Fish and Wildlife Service
1601 Balboa Avenue
Panama City, Florida 32405-3721

Major General Todd T. Semonite
South Atlantic Division
U.S. Army Corps of Engineers
Room 10M15
60 Forsyth Street, S.W.
Atlanta, GA 30303-8801

RE: ACF Master Water Control Manual Update; Fish and Wildlife Coordination Act Comments

Dear Mr. Imm and Major General Semonite:

Pursuant to its consultative role under the Fish and Wildlife Coordination Act, 16 U.S.C. §§ 661 *et seq.*, the Florida Fish and Wildlife Conservation Commission hereby provides initial comments on the ACF Master Water Control Manual update. These comments identify relevant fish and wildlife concerns that should be considered in development and analysis of alternative operating regimes (including baseline operations) as the Manual update proceeds. While the Corps has declined to consult directly with Florida, asking instead that we direct our concerns to the Fish and Wildlife Service, we trust these issues will be given appropriate consideration throughout the Manual update process.

We cannot yet comment on the specific alternatives under review because we still have not received any modeling information from the Corps. Rather, we have relied only on limited information made available by the Service. This represents a breakdown in the intergovernmental consultation process, which compromises our ability to provide effective comments. Nevertheless, the enclosed document includes updated research, raising significant hydrologic and biological concerns applicable to any alternative operation that departs from the historic flow regime of the Apalachicola River.

In closing, we reiterate our request that the federal agencies share with Florida all available modeling information relating to the alternatives presently under consideration. Only a fully transparent process can effectively incorporate all relevant scientific and commercial information bearing on the selection of alternatives to be pursued in the Corps' forthcoming draft environmental impact statement.

Sincerely,

Harold G. Vielhauer

Harold G. Vielhauer
General Counsel

Encl.
cc: Thomas M. Beason, Florida DEP

The Impact of Reduced Flows on the Apalachicola River and Bay Ecosystems

(February 2011)

1. Introduction to River and Floodplain Impacts

The Apalachicola River-floodplain system harbors an extensive array of natural habitats of great value to the State of Florida. This system includes wetland forests and aquatic habitats that undergo seasonal inundation from the mainstem of the Apalachicola River. Major components of the floodplain ecosystem include 124 miles of major channels, over 400 miles of floodplain channels, 118,000 acres of wetland forests, and 9,000 acres of tidal marshes (Appendix A). More than 60% of the floodplain wetlands in this system are state-owned conservation lands that were acquired primarily to preserve and protect the Apalachicola River and Bay.

The floodplain and its biological resources are degrading as a result of reduced flows from upstream. Most pointedly, there has been a 20-30% decline in spring and summer flows during dry conditions, resulting in less aquatic habitat, based on a comparison of the baseline period (pre-Lanier 1923-1955) to the recent period (post-West Point 1975-2008). The associated harm to biological resources has been most severe during years with low flows, and is expected to worsen if upstream demands increase and Apalachicola River flows continue to decline.

a. Long-Term Decrease in River Flow

Long-term changes in flow in the Apalachicola River have been measured at the Chattahoochee gage (station 02358000; USGS, 2010)[1]. Since 1981, low flows have been lower in magnitude and have occurred more frequently and for longer durations than at any time in the previous 60 years. The problem has been most acute in the last 10 years, with annual average flows in 2000, 2002, and 2007 being lower than any previous year in the entire 86-year period of record. Daily mean flows less than 6,000 cfs occurred almost 4 times more frequently in the recent period (820 days) than in the baseline period (223 days). Daily mean flows less than 5,000 cfs occurred 106 days in the recent period, but never occurred at any time during the baseline period.

Under low-flow conditions, April-August flows have declined an average of 3,200 cfs from baseline to recent periods; this represents a proportional decrease in flows of 23% and 29% for the 75% and 90% exceedance flows, respectively (Figure 1).[2] Flow declines are evident at

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[1] All river flow values presented in this report refer to discharge measured at the Chattahoochee gage.

[2] The 90% exceedance flows are ideal for assessing biological impacts because they represent very stressful conditions that occur frequently enough to prevent full biological recovery before the next event occurs. Moreover, in the late spring, summer, and fall of recent drought years, there were several consecutive months during which 90% exceedance flows represented actual flows relatively well (gray bars, Figure 3). This is partly because the summer pulses that were common in the lowest-flow years of the earliest period (Figure 2) have all but disappeared in the latest period (Figure 3). In the hot summer months of June-August, pulses of 11,000 cfs or higher occurred in every year of the baseline period, even during the worst drought years, providing riverine organisms temporary relief from the extreme

higher flows as well; proportional decreases in April-August flows were 12% and 16% for the 25% and 50% exceedance flows, respectively. A shift in the timing of the flood season was apparent to some extent in all five graphs in Figure 1. For example, in the 75% and 90% exceedance hydrographs, the highest flow values in the baseline period occurred during a 2-3 week period from early to late March, whereas the highest values in the recent period occurred several weeks earlier between early February and early March.

An alternative analysis averaging the daily flows for groups of relatively homogeneous years further shows the long-term flow change. Individual years in the baseline and recent periods can be sorted by mean annual flow and then grouped into three nearly equal groups: 1) high-flow years, 2) normal-flow years, and 3) low-flow years (Figure 4; Appendix B). The results show a significant decline in spring and summer flows from the 11 lowest-flow years in the baseline period to the 11 lowest-flow years in the recent period. In April through August of low-flow years, recent discharge averaged about 4,600 cfs less than baseline discharge, which represents a 31% decline in flows. Again, a shift in timing of the flood season was evident in low-flow years in Figure 4; the recent flood season began about 2 weeks earlier in February and ended about 2 weeks earlier in April than the baseline flood season.

Low-flow years were relatively well distributed throughout the baseline period, but 7 of the 11 lowest-flow years in the recent period occurred in the last decade (1999, 2000, 2001, 2002, 2006, 2007, and 2008). Although the timing of droughts is dictated by climatic conditions, there has been an increase in the frequency and duration of very low flows that cannot be explained by changes in climate. Low-flow years in the recent period (1975-2008) had less annual flow but no decline in annual rainfall compared to the baseline period (1923-1955) (Figure 5). This observation was confirmed in a related analysis in Appendix C, which found a significant decrease in the proportion of annual rainfall reaching the Apalachicola River as annual streamflow in low-flow years, from 26% in the baseline period to 22% in the recent period. These results indicate that human activities are increasing the severity of hydrologic droughts on the ACF.

b. General Biological Impacts

Primary functions of the floodplain system include seasonal flood pulsing to which biota are dependent and adapted, connectivity between the channel and floodplain so they behave as an integrated, interdependent unit, and the export of fresh water, detritus, and nutrient/sediment inputs to the Apalachicola Bay. Ecosystem services generated by this system include: (a) habitat for several threatened and endangered species, (b) vast floodplain forests that support high biological diversity and productivity, (c) wetland services such as water quality improvement, flood mitigation, and detritus production for downstream food webs, (d) recreational use and hunting that generate tourism dollars and license fees, (e) a key refuge area for the Atlantic flyway, and (f) support of the Bay as the second most productive fishery on the East and Gulf Coasts of the United States.

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conditions. However, in the recent period there were 6 years during which June-August flows never exceeded 11,000 cfs; in 2 of those years, 2000 and 2007, flows were less than 7,000 cfs continuously throughout the entire summer and most of the fall.

Flow declines during spring and summer have a greater impact on Apalachicola riverine biota than declines at other times of the year. Reproductive activity, early life stages, and growth of most floodplain organisms are concentrated in the spring and summer months. Flow declines during the spring of low-flow years occurred in the 10,000-30,000 cfs flow range (Figure 4), reducing inundation throughout very large areas of cypress-tupelo swamps (48,000 acres; Table 1). Spring is the primary season for fish spawning. When water levels and flows are too low to inundate floodplain swamps, riverine fishes lose access to food supplies as well as spawning and nursery habitat critical for reproductive activities.

Lack of water in floodplain swamps during spring months inhibits growth and survival of tupelo trees and other plant species that depend on wet conditions. Documented harm to riverine swamps has been extensive, including an estimated loss of over 3 million swamp trees from 1976-2004 (Darst and Light 2008). In addition, four plant species listed by the State of Florida as endangered, threatened, or commercially exploited (Coile and Garland 2003) grow in swamps and low bottomland hardwood forests of the Apalachicola River floodplain at elevations affected by flows of 10,000 to 30,000 cfs (endangered Thorne's buckthorn, *Sideroxylon thornei*; threatened cardinal flower, *Lobelia cardinalis*; threatened corkwood, *Leitneria floridana*; and commercially exploited royal fern, *Osmunda regalis*)[3]. Preservation of these state-listed species is dependent on sufficient flows in the Apalachicola River, particularly during the first 2-3 months of the growing season in the spring.

Flow declines during the summer occurred in the 5,000-15,000 cfs flow range (Figure 4), reducing connectivity of aquatic habitats in the floodplain of the riverine reach (Figure 6) and increasing salinity in the river and distributaries of the lower tidal reach (Figures 7 and 8). In the riverine reach, decreased flows cause loss of aquatic habitats as floodplain sloughs, streams, and lakes become disconnected from the main channel, exposing stream beds and creating isolated pools that become anoxic in hot weather. Decreased flows also expose woody debris along stream banks in the riverine reach, and expose other habitats that were historically covered with water during the summer. Fish access to these important habitats is critical for food and shelter for juveniles during the summer-fall nursery season, and mussels need flowing-water habitat for survival year-round. Many estuarine organisms, including juvenile Gulf sturgeon, require adequate flows in summer and fall to maintain tolerable salinities in feeding grounds in the river and distributaries of the lower tidal reach.

Decreased inundation of floodplain forests in the spring has greatly reduced available aquatic habitats for fishes during their peak spawning season. Of the approximately 230 miles of floodplain sloughs, streams, and lakes in the riverine reach (upper 86 miles of the river), less than one-quarter remain connected at the very low flows which have become much more prevalent in summer. As very low flow periods become more frequent and last longer, aquatic

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[3] These four species have been found at low elevations in Apalachicola River floodplain forests by Angus Gholson (Gholson 1985), Melanie Darst (unpublished field notes in files of USGS, Tallahassee), and Loran Anderson and others (FSU herbarium labels). Corkwood and royal fern are classified as obligate wetland species in the National wetland plant list (Reed 1997). Cardinal flower is an obligate wetland species according to the Florida wetland plant manual (Tobe et al. 1998). Thorne's buckthorn is so rare that it is not listed in either source, but appears to be an obligate wetland species based on the consistently low and wet habitat conditions described on FSU herbarium labels for this species. (An "obligate wetland species" almost always occurs in wetlands under natural conditions.)

habitats will be progressively reduced in extent and degraded in quality due to lack of water flow from the Apalachicola River mainstem. Effects extend to the Lower Chipola River, which receives about 75% of its flow directly from the Apalachicola River, and in the river and distributaries of the lower tidal reach, which become more saline when flows are very low.

Table 1. Selected species and habitats of the Apalachicola River and floodplain that have been adversely affected by decreased flow in spring and summer of low-flow years. [up, upper; mid, middle; lo, lower; mi, mile; ac, acre]

Season	Effects of decreased flow on selected species and habitats (fish/mussel impacts described in more detail later in report)	Amount and type of affected habitat	Location of affected habitat					
			Riverine			Tidal		
			Up	Mid	Lo	Up	Mid	Lo
April May	Spawning activities of the threatened Gulf sturgeon[1] are reduced when limestone shoals are exposed during spawing season.	3 confirmed and several potential sites (upper 6 mi)	●					
	Fish feeding and spawning activities are severely restricted when floodplain forests are not inundated during spawning season.	48,000 ac of swamp forests[4]	●	●	●	●	●	
	Reduced inundation of tupelo-cypress swamps in the spring inhibits tree regeneration, causing long-term declines in the number of trees and a shift in forest composition toward a drier mix of species.							
	State-listed plants in swamp forests[2] are affected by reduced flood inundation in the spring.							
June July August	Striped bass mortality occurs when cool-water floodplain streams are not accessible for thermal refuge. Adults of this species need an escape from high temperatures in main channel during summer.	11 cool-water refuge streams[5]	●	●				
	Fish spawning and juvenile survival is reduced when floodplain sloughs are disconnected from main channel during summer. Fishes and invertebrates die when trapped in disconnected pools.	200 mi of floodplain sloughs, streams, lakes[6]	●	●	●			
	Fish and invertebrate productivity declines when woody debris along sloping banks of main channel and floodplain sloughs are exposed.	750 mi of bank habitat[7]	●	●	●	●		
	Dessication and mortality of endangered fat three-ridge[1] and threatened purple bank climber[1] occurs where limestone shoals, bars along channel margins, or other critical habitats are exposed.	Sites along 90 mi of main channel and 2 mi of Swift Slough[8]	●	●	●	●		
	Salinity in lower tidal reach increases during extended periods of low flow, affecting fishes, aquatic invertebrates, submerged aquatic plants, and wetland plants[3] that are intolerant of high salinity .	6 mi of main channel, 90 mi of sloughs, 7,400 ac of swamp forests, 9,000 ac of tidal marshes[9]						●

Footnotes on next page

Table1. [Continued – Footnotes]

[1] Federally listed.

[2] Endangered Thorne's buckthorn (*Sideroxylon thornei*), threatened cardinal flower (*Lobelia cardinalis*) and commercially exploited royal fern (*Osmunda regalis*).

[3] Including State-listed species: threatened corkwood (*Leitneria floridana*), threatened cardinal flower (*Lobelia cardinalis*) and commercially exploited royal fern (*Osmunda regalis*).

[4] Appendix A Part 3. Riverine swamps (22,270 acres) plus upper and middle tidal swamps (26,100) equals 48,370 acres; rounded to 48,000 acres.

[5] Ten streams located throughout the upper riverine reach and one stream in the upper part of the middle riverine reach.

[6] Slough disconnection occurs in riverine reach but not tidal reach. Of the 230.5 miles of sloughs in the riverine reach, 18.7 miles are permanently connected (Light et al. 1998). [230.5 – 18.7 = 211.8; rounded to 200 miles]

[7] Appendix A Part 2. Includes banks along both sides of 85.8 miles of Apalachicola River, 16.5 miles of Lower Chipola River, and 230.5 miles of floodplain channels in riverine reach. Also includes 6.6 miles of major channels and 38.9 miles of floodplain channels in upper tidal reach. [85.8 + 16.5 + 230.5 + 6.6 + 38.9 = 378.3; doubled for banks on both sides is 756.6; rounded to 750 miles]

[8] Both species have been found throughout the upper 90 mile of the river. Primary site for purple bankclimber is at Race Shoal less than a mile downstream of Woodruff Dam, and primary sites for fat three-ridge are at multiple locations between river miles 30 and 55.

[9] Appendix A Part 2 and 3. Rounded numbers for all tidal floodplain channel lengths and wetland areas that are affected by salinity according to Figure 7. Nearly all are located in the lower tidal reach. [Figure 7 shows that not all lower tidal sloughs are affected by salinity, but several miles in the extreme lowest part of the middle tidal reach are affected by salinity. When the affected middle tidal reach sloughs were added, and the unaffected lower tidal reach sloughs subtracted, the total length was 90.5 miles, which was rounded to 90 miles.]

Of the myriad biological consequences of reduced flow in the Apalachicola River and floodplain we focus primarily on the following three impacts:

- loss of spawning and rearing habitats for an array of fish species leading to bottlenecks in fish reproduction, survival, and growth, especially when flows needed for strong year classes do not occur
- exposure of known spawning habitat of the federally protected Gulf sturgeon leading to failed reproductive success, and increases in salinity of delta distributaries leading to degraded conditions not suited for Gulf sturgeon juveniles
- high mortality of federally protected mussel species due to stranding, habitat loss, and isolation along banks of the mainstem and in floodplain sloughs.

2. Fishery resources

The Apalachicola River-floodplain system has one of the largest assemblages of freshwater fishes in Florida (Bailey et al.1954; Bass 1983). A total of 142 fresh water and estuarine fish species have been found in the riverine and tidal reaches of this river system. Approximately 99 species of fish are known to occur in the riverine reach and 79 of these species (80%) have utilized or are known to occur in floodplain habitats during their life history (Appendix E). At least 45 species are known to utilize the Apalachicola River floodplain for spawning and nursery habitats based on larval fish light trap collections from 2002-2007 (Walsh et al. 2006, 2008; Stephen J. Walsh, USGS, personal communication, 2010).

There are eight diadromous species, four endemic species, and twelve introduced species found in the system. Among these species are the anadromous Gulf sturgeon, catadromous American eel, endemic blue-striped shiner, and endemic shoal bass (Yerger 1977). The system also supports some of the largest extant populations remaining in the U.S. of two anadromous species, Alabama shad (Mettee et al. 1996) and Gulf striped bass (Wooley and Crateau 1983).

The sport fishery consists primarily of Centrachids (sunfishes, basses, and black crappie), Ictalurids (mainly channel catfish, flathead catfish, and blue catfish), and to a much lesser extent striped mullet near the rock shoals in the upper riverine reach and southern flounder in the lower riverine reach. Centrarchids were one of the dominant families in larval fish collections in the Apalachicola River and floodplain (Walsh et al. 2006, 2008). Sunfishes, largemouth bass, striped bass, white bass, black crappie, and catfish provide favorite recreational fisheries below Jim Woodruff Lock and Dam (JWLD).

During a 12-year period (1990-2002) the recreational fresh water fishery within the first 6 miles below JWLD and the lower 10 miles above the mouth has been estimated to generate a combined $1,353,000 to $2,032,000 annually from fishing effort during a 14-week peak creel survey period conducted from mid-February through May (DEP 2004). There are no estimates for the recreational fresh water fishing in the remaining 90 miles of main river channel or the more than 400 miles of floodplain sloughs, streams, and lakes in the riverine and tidal reaches of the system. However, field observations indicate there are significant bream, bass, black crappie, and freshwater catfish recreational fisheries in the remaining sections of the main river and backwaters that have not been surveyed for angler catches.

Decreased spring and summer flows have resulted in less aquatic floodplain habitats in the Apalachicola River-floodplain system during critical spawning and nursery periods. Walsh et al. (2008) identified early March to mid-June as the prime spawning and nursery periods for most of the fresh water species (including Centrachids) within the system. Some species continue to spawn in the summer months, and adequate flows throughout the summer are important for juvenile growth as well. During typical dry and drought conditions, availability of inundated floodplain aquatic habitat in April-May has declined 50-80% since 1975 compared to the baseline period of 1923-1955 (Figure 9a). About one-third of the sloughs in the middle riverine reach, which were connected to the main channel nearly all summer in the baseline period, have been completely disconnected during drought conditions in the summer since 1975 (Figure 9b).

That said, flows can be highly variable (<5,000 to >200,000 cfs). In the following paragraphs, fish life cycle processes in the Apalachicola River and floodplain are described in terms of the three major flow categories (high, medium, and low; measured at Chattahoochee, Florida).

High flows (>30,000 cfs) occur in most years from January through April inundating large areas of the 82,000-acre forested floodplain in the riverine reach (Figure 10). During flows of 32,000 cfs approximately one-half of the nontidal floodplain (40,700 acres) is connected to the main channel, while at 50,000 cfs, approximately 82% of the floodplain (67,400 acres) is inundated (Light et al. 1998). When these backwater areas are flooded, they serve as a refuge from the high velocities within the main channel and an opportunity for fish to migrate into the inundated floodplain to feed on aquatic and terrestrial organisms.

From March to June, adult largemouth bass and other species migrate into floodplain habitats during high flows for feeding and spawning. Pine et al. (2008) reported a strong seasonal movement of adult sonic tagged fish (largemouth bass, redear sunfish and spotted suckers) from the mainstem channel of the Apalachicola River to floodplain habitats during the spawning season from March to June. Over a 45-60 day period following these movements to the floodplain, larval fish catches in light traps increased substantially. Light traps collected 45 species of larval fish in the floodplain from 2002-2007 (Walsh et al. 2006, 2008; Stephen J. Walsh, personal communication, 2010), demonstrating the importance of floodplain aquatic habitats for reproduction. Maintaining high flows and inundation of the floodplain from March through June provides much needed aquatic habitats for newly hatched larval fish during this prime spawning and nursery period.

Medium flows (10,000-30,000 cfs) maintain main channel connections with tupelo-cypress swamps and floodplain sloughs and backwaters. All of the 230 miles of nontidal sloughs are connected at flows of about 19,000 cfs, and about half of them are connected at 10,000 cfs (Light et al. 1998). Thermal cool-water refuges for Gulf striped bass in the upper riverine reach are connected to the main channel during medium flows and provide critical summer habitats. Area of inundated floodplain forest, which is used for spawning and nursery habitats, is greatly reduced as flows decline below 14,000 cfs (Figure 11). As flows dropped below this level during a recent study, many adult fish returned to the main channel or major sloughs and larval fish collections in light traps declined (Pine et al. 2008).

Ongoing FWC fishery studies show that strong year-classes of largemouth bass were produced during years with extended periods of flows exceeding 13,000 cfs during spring and summer months (2003 and 2005) (Figure 12). Year-classes of largemouth bass were weak during years when flows were much lower than normal through most of the spring and summer (2004, 2006, 2007, and 2008). These data show a strong positive correlation ($r^2=0.88$; $p<0.05$) between March-September flows and fish abundance (Allen et al. 2009). March-September flows exceeded typical historic drought conditions 100% of the time in 2003 and 2005, but less than 50% of the time in 2004, 2006, 2007, and 2008. Three years of size distribution data for four sportfish species (Figure 13) also show markedly higher numbers of age-0 fish in a wet year (2005), as compared with dry years (2006 and 2007).

Strong age-0 largemouth bass year-class estimates from electrofishing catch rates were confirmed at age-1 and age-2 as these cohorts recruited to the adult populations and contributed significantly to the fishery (Figure 14). Maintaining floodplain forest inundation for extended periods during prime spawning and nursery periods in the spring is critical for producing stronger year-classes of many fish species within the Apalachicola River-floodplain system. Slough connectivity in the summer is also needed for subsequent juvenile growth and survival.

Low flows (<10,000 cfs) typically occurred during September, October, and November prior to 1955; however, it has become more common in recent years for low flows to occur throughout both summer and fall (Figures 1 and 4). When flows drop below 10,000 cfs during spring, floodplain forests are almost completely drained of standing water (Light et al. 1998). Adult fish that were using inundated forest areas for spawning must abandon their nests as they return to sloughs and the main channel where nursery habitats, cover, and food are much more limited. Adult and larval fish can become stranded in isolated pools if rates of decline are >1-2 feet/day.

There are only an estimated 740 acres of aquatic floodplain habitat (mostly in large backwater sloughs) at 8,000 cfs (Light et al. 1998). Many smaller sloughs are disconnected from the main channel, and water becomes stagnant as dissolved oxygen values decline through summer into fall. Adult fish become concentrated in deep areas of major sloughs and the main channel, while young age-0 fish are concentrated in connected sloughs and backwaters presumably for shelter and food. Comparisons of size distributions from electrofishing samples of 4 different species in 2005 revealed age-0 sportfish collected in September were substantially more abundant in sloughs compared to main channel habitats (Figure 15).

During **very low flows** (<6,000 cfs) much of the woody structure and natural bank root systems in main channel and side channel habitats is exposed. Valuable habitat complexity becomes unavailable for spawning, nursery, and predator avoidance functions (Light et al. 1998), and also limits the amount of aquatic habitat with macro-invertebrate populations that can be utilized as food by fish (Ager et al. 1986). As flows drop below 6,000 cfs, extensive side pools and low flow aquatic habitats that would otherwise be used as spawning and nursery areas become disconnected and often completely dry. Only a limited number of backwater sloughs in the middle and lower riverine reaches remain connected to the main channel at very low flows. Spawning and nursery habitats are extremely limited and shallow if very low flows exist during the March-June prime spawning season, which occurred in late spring of 2000 and 2007.

In addition, many cool-water spring runs in the upper riverine reach are too shallow to provide thermal refuge for adult Gulf striped bass survival during summer (Long et al. 2009). Rock shoals in the upper riverine reach are exposed and much of the river bottom has limited submersed woody debris useful for fish habitat. Dissolved oxygen levels in disconnected sloughs and backwater lakes are lower than the main channel during very low flows in summer and fall. Very low dissolved oxygen levels (<2.0 ppm) have been observed in the upper reaches of several connected major sloughs (Florida River, River Styx, and Kennedy Creek) during very low flows.

Persistent low flows negatively impact the year-classes of many freshwater species that rely on floodplain aquatic habitats for spawning and nursery functions. Crayfish (*Procambarus* spp.) are an important food item found in stomachs of sportfish such as largemouth bass that inhabit the Apalachicola River main channel and floodplains (Ager et al. 1986). In floodplain habitats of the Escambia River, Florida, crayfish constituted the bulk of the animal biomass (Bass 2002). Most riverine crayfish populations are directly controlled by annual water level fluctuations, and reduced crayfish populations during drought conditions have been observed in other rivers (Huner 1978 and 1997). Pollard et al. (1983) suggested that reductions in the extent and duration of flooding in Louisiana swamp habitats would likely diminish biological production in the Atchafalaya basin, thus resulting in less food for freshwater fishes with potential impacts on survival, growth, and condition. Similarly, lower flows and decreased inundation of crayfish habitats in the Apalachicola River-floodplain system have likely caused large reductions in this important food supply for fishes, resulting in slower growth, poor body condition, and potentially poor survival of fish.

Studies of fish length and weight in the Apalachicola River over multiple years support this assumption. Age-0 largemouth bass collected in electrofishing samples in September (2003 - 2007) revealed significantly higher ($p < 0.05$) mean total lengths and relative weight (Wr) values[4] during years with high spring-summer flows (2003 and 2005) compared to years with low spring-summer flows (2004, 2006, and 2007) (Figures 16 and 17). These results suggest that better feeding conditions existed in years with greater floodplain inundation of nursery habitats (Cailteux et al. 2007).

In summary if very low flows persist during critical spawning and nursery periods in spring and summer, weak year-classes and a decline in fish populations can be expected for many species. Consecutive and multiple years of very low flows can reduce survival and growth of young-of-the-year fish species that typically utilize floodplain habitats during critical production and development periods. Extended periods of low and very low flows are a bottleneck to the vitality of fish populations in the system and these low flows are a key factor limiting fish productivity and survival. Further reductions in flow will continue to reduce the capacity of both the channel and floodplain aquatic habitats for fish production and survival.

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[4] Relative weight (Wr) is the ratio of the actual weight of a fish to what a rapidly growing healthy fish of the same length should weigh, which is called “standard weight” (Anderson and Neumann 1996). These Wr values can be calculated and compared statistically.

a. Gulf sturgeon

Estimates of the population of Gulf Sturgeon in the Apalachicola River system range widely depending on the collection type and analytical treatment of the data. One thing is clear; the population is quite low. Because the species exhibits a high degree of fidelity for specific rivers within panhandle Florida, it is unlikely that further declines can be repopulated from other sources such as the Suwannee River (USFWS and GSMFC 1995). Consequently, the future status of the Gulf sturgeon population in the Apalachicola River-floodplain system is dependent upon the maintenance of spawning and rearing habitats within the river.

Because the original habitats have been severely diminished through truncation by the JWLD, spawning and rearing of the population are now dependent only on the Apalachicola River-floodplain system itself. Within this constraint, two regions are known to be particularly vulnerable to low flows: hard bottom sites as exemplified by the Race Shoal outcrop and the distributaries of the Apalachicola River delta. While other sturgeon habitats undoubtedly are vulnerable to effects from low flows, the critical role of these two habitats has been documented.

Gulf sturgeons are long-lived, with some individuals reaching at least 42 years in age. The age at sexual maturity for females ranges from 8 to 17 years, and for males from 7 to 21 years. Research on spawning periodicity of Gulf sturgeon indicate that males may be capable of annual spawning, but females require more than one year between spawning events (Huff 1975; Fox et al. 2000).

Increasing water temperature and flow during spring usually initiate spawning movements of adult Gulf sturgeon (Huff 1975). Spawning normally occurs between mid-March and early June, corresponding to typical historic high flow conditions. The peak spawning period occurs in the April-May timeframe pending appropriate water temperatures (16-20°C / 64-71°F), flows, and possibly lunar phases. River flow may also serve as an environmental cue that initiates both sturgeon migration and spawning.

Habitat at spawning sites where egg collection has occurred is well documented (Sulak and Clugston 1999; Fox et al. 2000; USFWS 2008). Fertilized eggs hatch in approximately 2 - 4 days and the larval fish inhabit cracks and crevices at the spawning site and in nearby areas to further develop. After 14 days, the larval fish are free-swimming. Flow and velocity requirements for Young-of-Year (YOY) sturgeon may vary depending on suitable substrate type. Chan et al. (1997) reported that YOY Gulf sturgeon under laboratory conditions exposed to water velocities over 12 cm/s (0.4 ft/s) preferred a cobble substrate, but at water velocities under 12 cm/s (0.4 ft/s) they used a variety of substrates (sand, gravel, and cobble). If spring flows and water velocities are too high or too low, several life-history stages of Gulf sturgeon may be adversely affected.

Within the system, seven locations have been identified as potential spawning areas, with documentation of sturgeon eggs at three sites below JWLD. These documented spawning sites ranged in length from 390 ft to 10,000 ft, and consisted of limestone outcropping habitats, shelves, walls, and high sand bluffs with hard substrates. Where limestone outcropping occurs, it is a shelf along one or both banks, generally in the vertical range of stages inundated by flows of 6,000 to 11,000 cfs.

The primary known spawning area, Race Shoal, is located at RM 105 near the town of Chattahoochee, Florida.[5] Detailed Army Corp of Engineers (COE) bathymetric surveys of Race Shoal in 2005 were used to develop a flow/stage to depth of rock relationship (USFWS 2008). This relationship has been used to predict and estimate the area of submersed rock habitat that may be available for spawning given a specific flow range and water level. From this an accurate estimate of flow necessary to cover Race Shoal can be derived. A depth of 4 feet is considered to be the minimum depth for Gulf sturgeon spawning. Approximately 21,600 cfs flow is needed to cover the entire shoal to a depth of 4 ft. Spawning depths can be maintained with a flow of 15,000 cfs in the more steeply sloping habitat closer to the channel thalweg. However, this habitat is considered to be suboptimal because of less texture in the rock surface, steeper slopes, and higher velocities. Since the construction of JWLD in 1954 and prior to the recent droughts beginning in 1999, flows exceeded 15,000 cfs for at least two consecutive weeks[6] at some time during peak spawning season (April-May) in 41 out of 44 years (93% of the years from 1955-1998). This has not been the case since 1999. Flows exceeded 15,000 cfs for two consecutive weeks in April-May in only 6 out of 12 years from 1999-2010 (50% of the years). In one of those years, 2006, the minimum flow during the highest 2-week period of the peak spawning season was only 15,200 cfs. As a consequence, sturgeon eggs were collected in 2006 only at the lower, less favorable portions of the shoal because most of the shoal was exposed.

Gulf Sturgeon were observed in the spring of 2008 to spawn over at least a 41-day period (Scollan and Parauka 2008). The upper egg sample site at Race Shoal accounted for the most spawning activity with 72% of the total eggs recorded during the 2008 study. Water temperatures ranged from 19.12 to 24.41°C during the period when eggs were collected (April 4 to May 14, 2008), which was consistent with previous studies conducted on the Apalachicola River. When egg collections from 2005, 2006, and selected 2008 collections are combined, the middle 80% of the data ranges from water depths of 7.2 to 17.1 ft, with a median elevation of 37 ft above mean sea level. Multiple females likely contributed to the spawning based on multiple spikes in egg collections and evidence of three groups of radio tagged adult sturgeon moving upriver during the study.

The relationship between egg collection and river stage is illustrated by differences between spring 2005 and 2006 (Figures 18 and 19). Lower flows and stages in 2006 appear to restrict collections to a narrower width of the limestone outcrop. Under normal flows the preferred spawning substrate appears to be located on the "flatter slope" portion of the hard-bottom shoal near the left descending shore based on the cross-section. These limestone areas are extremely rough and irregular. This irregularity and roughness provides a refuge for newly

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[5] However, the collection of three very small 1- 4" (25-100 mm TL) YOY sturgeon in June 2009 at the mouth of the Brothers River suggests another possible spawning area in the lower Apalachicola River or Brothers River (FWC unpublished data).

[6] Two weeks is the approximate time required for eggs to hatch and larvae to become free-swimming.

hatched fry from high velocities due to the many cracks and crevices in the rock. USFWS (2008) provides further support of this by stating that "at one location where sturgeon eggs were collected from a depth of 14.1 ft on May 2, 2005, the water velocity 1 ft below the water surface was 3.8 ft/sec and was 0.4 ft/sec 1 ft above the river bed." The shallow depths and exposed rock during low flows associated with flow regulation during drought condition severely restrict spawning activities and egg survival to levels approaching zero (Flowers et al. 2009)

The Gulf sturgeon spawning season is of course a critical period for the life cycle of the species. Figure 20 compares the number of days with flows during dry (75% exceedance) and drought (90% exceedance) conditions in the baseline (1923-1955) and recent years (1975-2008) above 15,000 cfs (considered to be the threshold of suboptimal conditions for spawning at Race Shoal). For the 90% exceedance flow (bottom graph), the estimated number of days during drought conditions was 49 days during the baseline but only 15 days during the recent period. A similar but less severe trend is shown for 75% exceedance flows (top graph). These estimates indicate that lower flow conditions now severely reduce the availability of suitable Gulf sturgeon spawning habitat at Race Shoal.

As noted above, there has been a temporal shift in the timing of high flows, along with the typical falling stage to summer levels, to earlier in the year. The shift is occurring when water temperatures are too low for sturgeon to spawn and at a time when spawning runs typically would not occur. This shift in flow regime is an additional factor in the inhibition or failure of successful spawning of this T&E species within this river system.

After spring spawning, adults appear to stay in the main river system until October or November (6 to 8 months). During the spring and summer, adult Gulf sturgeon in general do not appear to actively feed while inhabiting freshwater rivers and as a result lose weight (Mason and Clugston 1993; USFWS 2008; Wooley et al. 1985). However, adult sturgeon are believed to actively forage as soon as they enter the estuarine and marine environments after the fall migration from the rivers. During this time, they regain not only all of the mass they lost, but also grow significantly more. Furthermore, when females are becoming spawn-ready, even greater volumes of food must be consumed to generate the mass of eggs and sustain the upstream migration to the spawning site. With a limited timeframe for winter-feeding opportunities (~October through ~April), active foraging must be initiated as rapidly as possible as a survival strategy.

Protecting YOY and sub-adult Gulf sturgeon is also critical. These usually stay within the distributaries and estuary during their first six years. Kynard and Parker's (2004) experimental observations indicate that movement and migration of the larvae and juveniles are primarily conducted at night resulting in a stop-and-start downstream movement. The downstream migration of the YOY juveniles is stopped upstream of the freshwater/saltwater zone. YOY have been reported to be limited to freshwater environment due to an inability to osmoregulate. Sulak and Clugston (1999) estimated that, in the Suwannee River, larval/juvenile fish needed to spend approximately 5 months in fresh water between the spawning grounds and the mouth of the river where salinities increase. Limited collections of larval/juveniles have been acquired from plankton tows (Race Shoal) or trawls in the lower Apalachicola River near the mouth of Brothers River (Wooley et al. 1982; Foster et al. 1988; FWC unpublished data).

Recent statements to USFWS from USGS staff speculate that “Successful year-classes may be infrequent, may depend on mid-summer water conditions for YOY, rather than on spawning success” (Sulak pers. comm. 2009). Flowers et al. (2009) further states that “it is important to keep in mind that a strong year-class appearing in the length-frequency distribution is the product of, first, good spawning conditions, and then several ‘‘good’’ years for sturgeon survival over a variety of life stages.” It remains undetermined which factors (spawning success, mid-summer water conditions, and prey abundance, or others) play the dominant role in YOY survival and sturgeon population growth.

Juveniles to sub-adult sturgeon generally undergo increased salinity tolerance with age. As they mature the salinity tolerance is up to 5 parts per thousand (ppt), but salinities greater than 10 ppt may limit access to feeding habitat (Parauka et al. 2001) or result in death (Kynard and Parker 2004). As the sturgeon matures, the salinity tolerance increases due to physiological changes. Usually once they exceed 170 grams, they are capable of more rapid osmoregulation (Altinok et al. 1998).

Once fish reach age-1, they most likely feed near the mouth of the river and in low salinity regions of Apalachicola Bay. This behavior would be consistent with information from the Suwannee River estuary (Sulak et al. 2004; Parkyn et al. 2006). The Bay is shallow, averaging 1.8 to 2.7 m in depth. Soft muddy substrates comprise an estimated 78% of the open water zone with the remainder divided between oyster reefs and sandy sediments with submerged aquatic vegetation (Livingston 1984). Livingston (1983) reported that polychaete worms were the most abundant infaunal species found in the sediments of the Apalachicola Bay during the winter months. Further efforts in 1999 by The Florida Department of Environmental Protection (DEP) demonstrated that polychaetes, bivalves, gastropods, and amphipods dominated the benthos of Apalachicola Bay (Iocco et al. 2002). All of these organisms have been reported as food items for Gulf sturgeon (Huff 1975; Mason and Clugston 1993). The highest infaunal abundance in the Apalachicola Bay region occurred in the sediments of the lower river and distributaries (dominated by amphipods), and the second highest abundance occurred in East Bay (dominated by polychaetes). The DEP study also noted that salinity was negatively correlated with average abundance and biomass of infaunal organisms, but positively correlated with average species richness of infaunal organisms.

Juvenile sturgeon remain in low salinity and fresh water regions of the system to reduce early mortality (Flowers et al. 2009; Kynard and Parker 2004; Altinok et al. 1998). Higher salinity levels during low flows in the nearshore and estuarine areas may affect osmoregulation and thus reduce foraging areas. Figure 21 shows that during the months of June through November at low flow conditions an estimated 7,000 cfs is needed to provide low salinity (<10 ppt) conditions in the distributaries of the Apalachicola delta. This condition is reduced from an estimated 140 days during the baseline to an estimated 29 days during the recent period. In the brackish-water zone of the lower tidal reach, elevated salinities in lower river and distributary streams occur during low flows (Figure 8). Salinities gradually increase with decreasing flow, but are highest when flows drop below 7,000 cfs. Total number of days when daily mean flows were less than or equal to 7,000 cfs was much higher in the recent period (1,336 days) than in the baseline period (555 days). Flows were less than 7,000 cfs for more than 200 days per year in two of the last ten years. In the preceding 75 years (1923-1998), the duration of time with flows less than 7,000 cfs never exceeded 100 days per year.

Some direct observations now corroborate the restriction of juvenile sturgeon to delta and nearshore areas of Apalachicola Bay. The US Geological Survey conducted a limited winter study during 2006-2007 to monitor the movements of juvenile sturgeon within the East Bay-Apalachicola Bay area (Sulak et al. 2009). An array of 14 passive receivers was deployed that tracked the movements of four juvenile sturgeon (age 1-2 fish) ranging from 350-750 mm total length (TL). Of the radio tagged sturgeon, three (429-680 mm TL) were located several times although no locations were obtained for a fourth fish. These preliminary observations indicate that juvenile sturgeon remained close to shore (within 1-3 km), and mostly in the East Bay area (Figure 22). After October 2006, no encounters were detected by receivers within the main Apalachicola River proper or East River proper until late March 2007 when the fish began moving into that area. During the monitoring period, no data were obtained from the three receivers deployed further offshore in the bay. These preliminary observations suggest that early juvenile sturgeon may be using very shallow, nearshore areas and distributaries as winter feeding grounds.

b. Endangered mussels

The Apalachicola River basin historically contained a diverse mussel fauna of 34 species including 7 endemics. At least 3 of these endemics are believed to be extinct and 5 species are protected under the Endangered Species Act. The Apalachicola River-floodplain system in Florida including the Lower Chipola River downstream of Dead Lakes is presently known to contain extant populations of at least 3 federally protected mussels; the federally endangered *Amblema neislerii* (fat threeridge), federally threatened *Elliptoideus sloatianus* (purple bankclimber), and federally threatened *Elliptio chipolaensis* (Chipola slabshell). The status of threatened and endangered (T&E) mussel species in the Apalachicola River-floodplain can be generally characterized as declining. The USFWS (2008) concluded that both the fat threeridge and purple bankclimber were in various states of decline and that purple bankclimber populations may be experiencing “widespread reproductive failure” in both the Apalachicola and Flint Rivers.

Mussels are often considered a “keystone” species within rivers and perform critical ecological functions that positively influence diversity of other macroinvertebrate and fish communities (Vaughn and Hakenkamp 2001; Vaughn et al. 2001; Zimmerman 2004). Shell producing mollusks such as unionids have been postulated as ecosystem engineers; like oyster beds, the production of abundant, persistent shells (both live and dead) creates habitat resources that are otherwise unavailable to aquatic organisms such as invertebrates, periphyton, and small fishes (Gutierrez et aI. 2003). Similarly, communities of mussels may be able to stabilize substrates (Zimmerman 2007), thus creating important permanent habitats. The combination of mussel shell shapes and sizes within a mussel “bed” has been shown to contribute to substrate stability within the laboratory (Zimmerman and de Szaly 2007). In the Apalachicola River system and other Gulf drainage streams where relatively large stable substrates such as gravel and cobble are rare, live mussel communities themselves may represent key habitats for other biota (Johnson and Brown 2000; Zimmerman 2004).

Comparisons between historical and recent records indicate that dramatic declines in mussel abundance, distribution, and diversity of the Apalachicola and Chipola Rivers have occurred in the past 100 years. Brim-Box and Williams (2000) found historical records for 27 species in the mainstem Apalachicola River but found only 8 species during recent surveys. Unionid species richness in the Chipola River declined from 27 species historically to 19 species (Brim-Box and Williams 2000). Additionally, dramatic changes in the distribution of many ACF unionids have also occurred suggesting that habitat degradation is not limited to mainstem reaches.

Apalachicola mussels, including T&E species, generally live in rivers with flowing water all or most of the year and are relatively sedentary for their adult lives. Most adult mussel species are relatively sessile but can move underwater both vertically (Watters et al. 2001) and horizontally for short distances in response to water-level fluctuations or temperature changes. However, stranding also is common and movement can be limited. If the mussel becomes exposed, horizontal movement becomes an even greater effort and the animal may bury itself as a last resort if submergence is not achieved. Substrates such as sand and firm mud are easier for mussels to navigate than heavier substrates such as gravel and cobble. Mussels living on some types of bedrock, such as that at Race Shoal, are probably unable to move at all.

The three T&E mussel species in the Apalachicola River system require one or more specific fish hosts in order to reproduce (Table 2). These species must be in proximity to their host fish when water temperatures are at the correct temperature. Other conditions, such as water turbidity (fish hosts visually identify conglutinates as food items), water velocity, and connectivity between river and floodplain can have far-reaching implications to mussel reproductive success.

Table 2. Summary of reproductive variables of the fat threeridge, purple bankclimber, and Chipola slabshell. Table summarized from O'Brien and Williams (2002), Johnson (2007) pers. comm., Keller and Ruessler (1997), Priester (2007, unpublished data), and G. Zimmerman (pers. obs., June 2006).

Species	Brooding	Gravid temperature	Glochidia mechanism	Potential fish hosts
Fat threeridge	Short-term summer	75.2°F	Sticky, web-like mass; conglutinate	Weed shiner; bluegill; redear sunfish; largemouth bass; blackbanded darter
Purple bankclimber	Long-term / short term winter / spring	46.4 to 59.0°F	Thin conglutinates	eastern mosquitofish; blackbanded darter; guppy; greater jumprock
Chipola slabshell	Possibly short-term in the summer	Not known	Conglutinate is likely	bluegill; possibly other sunfish species

It is believed that the upper age is approximately 27 years for the fat threeridge and 15 years for the purple bankclimber. No growth data are known from the Chipola slabshell. Between 2006 and 2007 the USFWS thin-sectioned 31 dead shells of the fat threeridge. Thin-sectioning is a process by which a shell is cut into thin slices cross-grain and the number of observed annuli is counted as years under a microscope, similar to reading the annual rings of a tree (Neves and Moyer 1988; McCuaig and Green 1983). The USFWS found fat threeridge ages ranged from 2 years old (36 mm total length) to 27 years old (85 mm total length). They also found that there was a statistically significant relationship between the length of fat threeridge and age (USFWS 2008).

EnviroScience similarly conducted age and growth analyses on 11 purple bankclimber shells collected in 2005 (EnviroScience, unpub. data). Estimated assigned ages ranged from 3 years old (80 mm total length) to 15 years old (184 mm total length). Subsequent USFWS analysis of the length-age data (USFWS 2008) identified a pattern of fast initial growth, followed by slower and slower growth as age increased.

The fat threeridge generally inhabits Chipola and Apalachicola River main channel margins and floodplain sloughs in slow to moderate current and along moderate to steep banks (EnviroScience 2006a). This species is highly vulnerable to decreased flows because it prefers habitats of relatively shallow depth (<3 ft) that become exposed at very low flows. The fat threeridge has a thick heavy shell but it is still moderately mobile underwater because of the folds in its shell that allow it to move in mud (Watters 1994). The bank slopes along where the fat threeridge is normally found allow it to adjust its preferred depth by traveling relatively short distances unless impeded as water levels fluctuate. Under very low flow conditions, however, the fat threeridge can easily become stranded due to its heavy shell once the base of the slope becomes dewatered because the mussel must travel greater and greater distances to reach water. In addition, habitat on moderately steep banks under tree canopy is cooler than open flats, because of the shade from overhanging vegetation and the cool groundwater discharge from bank drainage. During very low flows, soil temperatures are much higher on the open flats than along the steeper, vegetated slopes at the edge of the channel.

The purple bankclimber inhabits river channels in moderate to fast current over sand or sand mixed with mud, cobble, gravel, trees, or bedrock (Williams and Butler 1994; EnviroScience 2006a). Most purple bankclimbers that have been recently collected have been found associated with the bedrock outcrop at Race Shoal near the dam and deeper habitats with larger, stable substrates such as bedrock, tree stumps, and gravel / cobble mixes in relatively fast currents (EnviroScience 2006a and unpublished data; FFWCC unpublished data; USFWS 2008). The purple bankclimber is intolerant of being stranded above the water based on field observations and observed mortality among tagged individuals from Swift Slough and Race Shoal during very low flow years (EnviroScience 2006b and unpublished data from Race Shoal monitoring efforts, Table 3).

The purple bankclimber develops a large, thick, heavy and sculptured shell that allows it to withstand high shear stress areas where many other mussel shell types would be dislodged (Watters 1994). In the ACF it is commonly found lying on its side rather than buried in the substrate. However, these characteristics make the species relatively immobile once stranded above water and it appears very intolerant of high temperatures and slow or stagnant water compared to other Apalachicola River unionids.

Almost all recent records of the purple bankclimber within the Apalachicola River system have been from deep habitats, as previously suitable habitat at higher elevations has been regularly exposed in the very low flows prevalent in recent droughts. For example, relatively fresh dead and live purple bankclimber were collected from Swift Slough in 2005 and 2006; however, all live individuals were later found dead and the species has since probably been extirpated from Swift Slough and other vulnerable shallow suitable habitats due to the effects of long periods of very low flows since 2006. The Chipola Cutoff and the Lower Chipola

River support some purple bankclimbers among stump and tree root habitats in moderate to high flow in some parts of the main channel and channel margins at greater depths (>8 ft), as does the Apalachicola River main channel in the lower riverine reach near RM 26 (see Figures 6 and 12 in EnviroScience 2006a). Because these areas have been under-sampled and many habitats require diving during normal flows, the size and extent of purple bankclimber populations within the Lower Chipola River and Chipola Cutoff remain relatively unknown.

Table 3. Recent timeline of mussel surveys and observations of mortality in the Apalachicola River-floodplain system. Chatt = Chattahoochee gage; Wewa = Wewahitchka gage; Mi35 = Mile 35 gage; AR = Apalachicola River; RM = River Mile; FTR = fat threeridge, PBC = purple bankclimber.

Date	River stage (ft)[7]	River flow (cfs)[8]	Site	Observation
2005 (10/23 to 11/10)	Wewa 14.2-15.1	8,800-10,200	AR (RM 40-48) Lower Chipola River Chipola Cutoff Swift Slough	Large and previously unknown populations of FTR observed in shallow habitats, with some minor mortality along AR channel margins. Swift Slough represented one of the largest known populations of FTR of any site.
	Chatt 41.3-43.0	8,700-12,100	AR (RM 105)	Most (90%) of PBC were observed at Race Shoals (EnviroScience 2006a).
2006 (6/14)	Wewa12.5	6,400	AR (RM 43.5)	Mussels observed stranded in AR channel margins. Translocated 800 FTR from marginal to deeper habitats as flows dropped below 6,500. These later died as the relocation site was exposed.
			AR (RM 44.3)	Established monitoring sites of tagged FTR at 3 different elevations
2006 (7/14)	Mi35 5.0	5,700	AR (RM 44.3)	>80% of tagged FTR were dead or not found due to exposure after 4 weeks, including the control site at the lowest elevation.

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[7] Feet above NGVD at gage closest to the indicated site. Mile 35 gage data was used if Wewa gage data was missing.

[8] Estimated flows at Chattahoochee gage associated with stage at the closest gage, calculated using stage-discharge relations in Light et al (2006). (Travel time is accounted for.)

Date	River stage (ft)[7]	River flow (cfs)[8]	Site	Observation
2006 (8/3)	Wewa 11.6	5,400	Swift Slough	Swift Slough was temporarily disconnected; FTR population estimated for Swift Slough was 18,000 individuals that had already experienced approximately 25% mortality.
2006 (8/7)	Wewa 12.1	6,000	AR (RM 46.8)	A long term monitoring site using ~500 tagged FTR was established.
2007 (5/29 to 12/20)	Wewa 10.8-11.7	4,700-5,500	Swift Slough	Beginning late May 2007, Swift Slough was disconnected continuously for almost 7 months and >90% of mussels died including almost all those at established tagging sites.
	Chatt 38.9-39.6[9]	4,800-5,800[23]	AR (RM 105)	Over 80 PBC at Race Shoals were nearly exposed (<1 ft) for almost 7 months. (Few PBC were found in 2009 searches).
2007 (6/14)	Mi35 4.7	5,400	AR (RM 46.8 and other nearby sites)	Approx. 47% of FTR were recaptured alive after 10 months; observed mortality was low. It is uncertain if loss of 53% was due to death, non-detection, or exodus from site. Persistence of mainstem FTR sites following high flows is uncertain.
2007 (11/14)	Wewa 11.2	5,000	AR (RM 40-48)	Six small sites with tagged FTR individuals (n = 50) were established to monitor acute effects of continued low flow.
2009 (Aug.)	--	--	AR (RM 105)	Few PBC found by FFWCC staff in qualitative searches.

In June 2008 there were an estimated 233,500 fat threeridge individuals within Florida's Apalachicola and Lower Chipola River basin that were affected by low flows (USFWS 2008). This estimate only included data from animals inundated at or above 5,000 cfs (Chattahoochee

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[9] Stages and flows were within this range at the Chattahoochee gage for this entire period except for a 4-day pulse from 9/4 to 9/7 when stages were 39.7-40.2 and flows were 6,000-6,900.

gage). It is the remnant of an earlier population that included many tens of thousands of mussels that had died when extended periods of very low flow occurred in 2006-2007 following three years of higher sustained flows (Figure 23). In Swift Slough alone, an estimated 10,600 to 33,879 individuals died since 2006 (EnviroScience 2006b).

T&E mussel populations in the Apalachicola River-floodplain system are directly affected by low flows. Mussels were stranded during very low flow in 2006-2007 on channel margin habitats in the mainstem and in the loop stream they occupied (Swift Slough) when it was cut off at its connection with the mainstem. During a tag and recapture study performed on the Apalachicola River at river mile 44.3 by EnviroScience in 2006, approximately 25% of mussels tagged during the first two weeks of exposure died, and 70% after four weeks of exposure (Figure 24). Ultimately, over 90% of the mussels at the site died at three bank elevations from exposure including the lowest elevation that was originally intended as a control (an elevation that was not expected to be exposed). This type of mortality was likely widespread in 2007 because antecedent flows had not been below 9,000 cfs for an extended period since late 2002 (Figure 23). During that time, fat threeridge and other mussels moved higher in elevation along the river banks to their preferred depths. Based on this information it is likely that mussels are most at risk during an initial and relatively rapid drawdown to very low flow conditions following multiple years of normal and high flows.

Mussel habitat is also directly reduced as slough connections to the mainstem river are severed or greatly reduced during very low flow periods. Such disconnections from the main channel can limit mussels’ access to fish hosts, a condition that ultimately has a large affect on mussel reproduction and distribution (Watters 1996). For example, rare and endangered mussel species (e.g. fat threeridge, northern riffleshell) typically experience many years of poor or no reproduction and population decline with an occasional successful year of reproduction and surviving cohort. If a successful reproduction year happens to occur during a very low flow year, then new mussel distribution will be limited by the availability of suitable habitat. While potential habitat exists in many of the sloughs and tributaries of the upper and middle riverine reaches, very few of these localities are able to support mussels (EnviroScience 2006a) because they have become increasingly disconnected. In the upper riverine reach, much of the water-level decline was due to channel incision. In contrast, reduced connections with the mainstem in the lower riverine reach of the Apalachicola, and in the Chipola Cutoff and Lower Chipola River, are mainly and increasingly due to decreased flows from upstream.

Mussel habitats also can become unavailable when extended periods of very low flows result in rapid colonization of depositional bars along channel margins by willow trees, grasses, and other vegetation (e.g. Apalachicola River NM 44.3). Mussels may not be able to return to these areas for some time, or, their ability to move with changes in water levels may be compromised due to the physical presence of the thick vegetation biomass. Movement may be particularly difficult in areas with minimal slopes where mussels must travel farther to track water level changes (e.g. NM 44.3). In steeper-sloped habitats such as Swift Slough and the Lower Chipola River, most mussel species, including the fat threeridge, can utilize the root complexes of established bank vegetation for refuge from high flows. However, for mussels to become established in complex root masses these areas must remain inundated continuously.

Conversely, if beneficial vegetation on steeper banks is harmed by extended periods of very low flows, this may decrease the amount of habitat available to mussels.

The highest mussel concentrations were commonly associated with areas of minor groundwater upwelling (G. Zimmerman, pers. obs. 6-26-06, 6-13-07). These areas act as refugia and are able to sustain mussels longer during periods of extended low flow. The amount of groundwater discharge is likely related to the extent and duration of moderate and high inundating flows that recharge surficial groundwater in the floodplain. It is reasonable to assume that groundwater-fed refugia for mussels are steadily reduced during extended droughts unless the floodplain is recharged by occasional inundation.

At Race Shoal (RM 105) near the dam, purple bankclimbers can be damaged by the synergistic effects of low flows. Race Shoal is a limestone outcrop with a very irregular surface consisting of gravel-filled depressions and well-defined pools. Mussels that exist there have very limited, if any, ability to migrate with receding flows. Very low flows have been observed to strand purple bankclimbers in shallow pools that also contain large populations of the invasive Asian clam (*Corbicula fluminea*) and algae. Most of the pools are spring fed which keeps them cool. But the spring water likely contains little oxygen or food, and when it is not mixed with Apalachicola River water the mussels will die. A compounding problem at Race Shoal, Swift Slough, and other channel margin habitats is that the Asian clam is the first to die under very low flow conditions. Once the Asian clams die, sometimes thousands in a single pool, the fouled water and poor water quality kills the remaining endangered native mussels, even those in deeper pools that would have otherwise survived (G. Zimmerman, pers. obs. 7-12-06).

Mussel populations within the shallow channel margins of the mainstem (e.g. RM 44.3) and in floodplain sloughs have been the most affected by low flows. Table 3 shows the results of recent survey efforts in these areas.

It is extremely difficult to estimate mussel mortality that results from extreme temperatures and exposure due to flow fluctuations. Mussels can die in a matter of hours once exposed without water in the sun at high temperatures in the open, or may persist for months in damp shaded sandy substrates, buried and kept cool by groundwater inputs (e.g. Swift Slough and RM 46.8 in areas along the channel margin). It also is difficult to determine whether the primary mechanism for mortality exposure for the fat threeridge is desiccation or high temperatures. Fat threeridge are apparently relatively tolerant of short term impacts compared to other mussel species in the Apalachicola River system, and have been tagged and persisted for days living in pools with surface temperatures in excess of 105^{o}F, although the bulk of the mussels themselves were buried in the much cooler groundwater-infused substrate along the bank margin. However, approximately 70 percent of tagged fat threeridge from the Apalachicola River main channel at RM 44.3 died after four weeks of exposure (Figure 24).

An analysis of Apalachicola River flows from the baseline period (1923 – 1955) compared to the recent period (1975 – 2008) shows a marked decrease in the availability of flowing water during the recent period (Figure 25). During the baseline period, an analysis of flows during drought conditions (90% exceedance flows) found only 81 days where the flow dropped below 6,200 cfs – the flow needed to maintain flowing water to a depth of 0.5 ft in Swift

Slough. By contrast, the recent period shows a nearly 250% increase in the frequency of flows below 6,200 cfs (201 days). Again, because mussel populations are long-lived and relatively sessile, under many conditions exposed mussels can only survive for a few days once exposed to high surface temperatures and without water. As low and very low flows have increased in the recent period, the ability of mussel populations to survive and persist in many Apalachicola River and floodplain habitats has decreased.

The effect of extremely high flows on mussel populations in the Apalachicola River system is relatively unknown. In other river systems, high river flows have been linked to patterns of mussel distribution (Layzer and Madison 1995). While the fat threeridge is known to exist in large numbers in moderately depositional areas along the borders of specific reaches of the main channel of the Apalachicola, it is unclear if these populations could persist in one area or if they would be regularly "blown out" downstream by high flows. Florida and the USFWS have established a number of tag-recapture sites on the main channel of the Apalachicola River near RM 40-50 and within Swift Slough to determine mussel movement and mortality and if mussels commonly dislodge under high flows. To date, these populations have persisted in the same locations for at least two years including conditions of relatively high flows in 2008 and 2009 (Figure 23).

The potential for populations to remain in place under high flows leads one to question the assumption made by the USFWS that the origin of high numbers (~18,000) of fat threeridge estimated to exist in the upper reaches of Swift Slough in 2006 were a result of mussels being blown in from a larger population upstream (USFWS 2008). Based on this assumption, USFWS concluded that the Swift Slough fat threeridge population was not self-sustaining (i.e., it was likely a "sink" population), and Swift Slough was discounted from the overall population estimate regarding the effects of low flows on the species. The USFWS based its opinion on the presumed ages of the fat threeridge collected there as well as that high numbers of fat threeridge had not been observed in Swift Slough during the 2000 drought. However, a relatively normal distribution of sizes and presumably ages of fat threeridge was known to exist in Swift Slough in 2006 at the time of the die-off (EnviroScience 2006a).

It is unlikely that a full range of sizes were "blown in" together by flooding because fast-moving water sorts sediment and other objects by size, and thus would have carried small and large mussels to different locations. In addition, there was no obvious source for the suspected blown-in mussels. The dredge spoil disposal site extending for approximately a mile immediately upstream of the head of Swift Slough had been used for spoil disposal as recently as 2000, and no mussels were found there prior to the 2006-2007 drought. Furthermore, if large numbers of mussels had been moved by high floods in this reach, a few mussels should also have been found in downstream sloughs such as Hog or Moccasin Slough, but none were found there.

A more likely explanation for the large numbers of mussels in Swift Slough in 2006 is that either the population was overlooked or buried in 2000 or growth rates are much faster than estimated from length-age curves. The length histogram generated for the fat threeridge collected from Swift Slough in 2005 (EnviroScience 2006a) showed that the population consisted of juveniles and adults of various size ranges (i.e., a normally reproducing population). Recent surveys of Swift Slough in 2010 have again shown that now that it is reconnected to the main stem of the Apalachicola River, recruitment is again occurring (T. Hoehn, personal communication, 2010).

There is recent evidence indicating that fat threeridge populations on the main river channel are vulnerable to rapid water level fluctuations down to very low flows, particularly after extended periods of relatively normal flows. Related to this point, a long term monitoring site of over 500 fat threeridge mussels was established on the main stem of the Apalachicola River in 2006, upstream of Wewahitchka at NM 46.8 (EnviroScience, unpub. data). In September, 2010 the FFWCC visited the site and marked the locations of recaptured mussels that had been tagged, and noted their condition (live, fresh dead, or dead). A total of 78 tagged fat threeridge were recaptured in the upper 1.5 ft of water depth. Of those recaptured, 35% were found dead (8 fresh dead, 20 dead). All mussels found were found by wading, and all were categorized as either high risk (49%) or moderate risk (51%) from exposure / stranding (FFWCC unpub. 9-13-2010 data). All mussels found had been marked with an “O”, indicating that they had originally been found and replaced below 1.5 ft of depth in prior years (2006 and 2008). Mussels with an “X” were those that had been placed in less than 1.5 ft of water in prior years. None of those mussels were found, despite extensive surveys of the surrounding areas. This suggests that most mussels tagged in the shallowest areas had died.

Monitoring of the 46.8 site was conducted again in November 2010 to detect mussels in deeper water. Additional mortality of fat threeridge was detected from mussel stranding, and the data are currently being processed. Initial results indicated that fat threeridge populations did not tend to migrate laterally (i.e., upstream or downstream) but generally only perpendicular to flow (up and down the river bank), as most mussels were recaptured within a few feet laterally of where they had been last placed. It is not yet certain if recruitment of mussels at the site (influx of mussels into the site and reproduction) offsets mortality rates.

These new data indicate that the PVA used to model fat threeridge populations in the Biological Opinion model (USFWS 2008) may be flawed. The model did not take into account large mortality events that have been observed as a result of a series of normal years followed by a sudden drop in river elevation as a result of very low flows (2006). Recent conversations with the USFWS (K. Herrington, 12-15-2010) indicated that the USFWS has observed significant mortality associated with two years of normal flows followed by a very low flow event in 2010, and confirms observations by EnviroScience and FFWCC staff. As fat threeridge move up the bank slope during normal flows to their preferred habitat, morality occurs when the mussels become stranded as water levels drop rapidly. Because the PVA did not take into account these mortality events, it is likely that the BiOp model underestimates extinction probabilities.

3. Introduction to Bay Impacts

Apalachicola Bay (Figure 26) is located in the panhandle of Florida at the terminus of the Apalachicola-Chattahoochee-Flint (ACF) River system and is one of the least contaminated, most productive estuarine areas in the US (Livingston 1984). Primary freshwater inflow to the bay is derived from the Apalachicola River, Florida’s largest river in terms of volume. A complex and unique interaction of river flow, bay bathymetry, winds, and tides combine to make this such a productive estuary (Livingston et al. 1997) and home to a variety of ecologically and commercially important species. The large input of fresh water from the Apalachicola River to the bay has long been documented to be one of the primary reasons behind the high productivity in the system. Among the variety of functions provided by the river to the bay, two of the most important are the provision of a continuous supply of nutrients that fuel the bay's primary and secondary production and the setup of a favorable salinity regime for growth and reproduction of numerous organisms, including the eastern oyster.

The importance of maintaining the natural flow regime of fresh water inputs to estuaries and thus supporting the ecosystem services that estuaries provide has become a well-established principle of coastal ecology and management. Freshwater inflows to the bay are primarily derived from the Apalachicola River with discharge divided between the main opening adjacent to the City of Apalachicola and the delta distributary system entering the western side of East Bay. Discharge through the distributary systems varies seasonally but estimates suggest that up to 20% of the total river flow may be diverted through this system into East Bay directly. In addition to the river, freshwater enters East Bay from the Tates Hell Swamp via Whiskey George and Cash Creeks.

4. Salinity/Flow Relationships

Estuaries function as transition zones between the salt environment of the sea and the freshwater of a river. Salinity fluctuation in these dynamic environments has been shown to be a dominant feature of estuaries and to a great extent helps to determine the type and distribution of organisms found in these systems. Horizontal gradients in salinity can form physiological barriers affecting the distribution of organisms, both fresh- and salt- water species, as well as screening out potential predators that might impact their population. Alterations of these patterns, especially increases in salinity, could eliminate these barriers and cause significant changes in resident species' assemblages in estuaries. Discharge from the Apalachicola River (the principal source of freshwater to the system) is the primary factor influencing salinity in the bay.

Salinity generally increases in the bay from north to south as distance from the mouth of the river increases and from west to east as one approaches the major openings to the Gulf to the east (Figure 27). Because of the geometric configuration (i.e., a relatively short distance between the river and the sea side) and dynamic nature of the bay, salinity values may range from 0 to near 35 psu (practical salinity units) over relatively short distances thus making considerable contributions to spatial and temporal variability. Lowest salinity is usually found around the mouth of the river and in East Bay with highest salinity observed in St. George Sound.

Vertical salinity stratification is often observed throughout the bay with higher salinity noted in bottom waters (Figure 28). This is particularly noticeable in deeper portions of the bay (e.g., navigation channel) but can be observed in shallow areas like East Bay as well where differences between surface and bottom salinity can exceed 10 psu (Edmiston 2008). Temporal changes in salinity are great and can be observed on a variety of scales. Short-term (tidal) variability can exceed 15 psu particularly in areas relatively close to the river mouth (Figure 29); weekly to monthly variability is primarily wind induced (Figure 30); seasonal variability is related to river flow and horizontal density gradients (Figure 31).

Low bay salinities generally coincide with high river discharge during winter and spring while highest salinities occur during fall low-flows. Secondary salinity reductions may be observed during late summer-early fall and are most pronounced in association with tropical storms. Long-term salinity trends typically follow river flow fluctuations (Livingston 1984) with low salinities predominant during wet, high-flow years and high salinities prevalent during droughts (Figure 32). River flows were high during 2003 and 2005 while 2007 was a drought year; salinities during 2003 and 2005 were correspondingly low while highest values were seen in 2007.

As part of a long-term monitoring program, the Apalachicola National Estuarine Research Reserve (ANERR) has been continuously recording salinity and other variables at three locations (four data loggers) within the bay since 1993 (Figure 33). These sites are located in areas with both ecological and commercial importance. Long-term daily average salinity data collected at these sites from 1993 to 2001 show the effects of low river flow, related to drought conditions during 1999 through 2001, on salinity in the bay. Two mid-bay stations (Cat Point to the east and Dry Bar to the west) as well as an East Bay site in the upper reaches of the bay, illustrate salinity differences between wet (1993-1998) and dry (1999-2001) conditions (Figures 34-37). Over all sites, salinity averaged about 4.5 psu greater during the drought relative to pre-drought years. Similar figures could be developed for other drought time periods (e.g., 2007) yet the overall salinity relationships remain unchanged; bay salinities decrease with higher river flow and increase under lower flow conditions.

Nui et al. (1998) showed that salinity at the Cat Point and Dry Bar sites reacts to changes in river flow (based on readings from the Sumatra gage) with a one-day lag, but the response differs by site. Fluctuations in river flow during a normal year explain as much as 10 psu of the salinity variability at either site with a slightly greater effect noted at Dry Bar. Water level fluctuation, caused by tides and meteorological conditions, is the dominant factor influencing bottom salinity at Cat Point in the eastern part of Apalachicola Bay. However, while water level is positively correlated with salinity at Cat Point it is negatively correlated with salinity at Dry Bar, suggesting the importance of river flow on the western side of the bay.

Morey and Dukhovskoy (2007) analyzed the long-term ANERR data logger records (Jan 1993-Dec 2005) to examine salinity variability within the bay, physical mechanisms affecting this variability, and the linkage between this variability and fluctuations in Apalachicola River discharge. Their analysis confirmed the importance of river discharge on salinity variability at the three ANERR sites.

A variety of models, like those developed by Niu et al. (1998) and Morey and Dubhovskoy (2007), can be used to estimate or predict salinity at specific locations in the bay but are dependent on having sufficient data on all environmental variables included in the models. Development of simple regression models relating salinity at certain bay sites with river flow is desirable provided these new models do not suffer from significant loss in explained variability. In an attempt to examine alternative models, we regressed mean monthly river flows measured at both the USGS Chattahoochee and Sumatra gages against mean monthly salinity values at the three ANERR data logger sites (Cat Point, Dry Bar and East Bay) for the period from January 2000 to December 2009. Best fit models were exponential regressions; these models are shown in Figures 38 (Chattahoochee flow) and 39 (Sumatra flow). As expected because of its location in the basin, discharge at Sumatra explained more of the variation in salinity than Chattahoochee flows and was used for all further comparisons. Also as expected, salinity at Dry Bar and Cat Point were more closely related to discharge than in upper East Bay regardless of location of discharge.

To further examine the relationship between discharge and salinity at these bay locations, we made two sets of estimates using the regressions developed with Sumatra discharge: (1) salinity at each site relative to specific incremental flows and (2) salinity at each site resulting from specific flow depletions at various discharge levels. Predicted salinities for various incremental flows are shown in Table 4.

Table 4. Salinity (psu) at three ANERR data logger sites in Apalachicola Bay estimated for specific incremental flows based on discharge (cfs) at the USGS Sumatra gage. Regression equations used to estimate these salinities are shown in Figure 39.

	Estimated Salinity		
Flow	Cat Point	Dry Bar	East Bay
5000	27.8	26.2	20.0
7500	26.5	24.9	17.2
10000	25.2	23.7	14.8
15000	22.8	21.5	11.0
20000	20.6	19.4	8.1
25000	18.7	17.6	6.0
30000	16.9	15.9	4.5
40000	13.8	13.0	2.5
50000	11.3	10.7	1.3
60000	9.3	8.7	0.7
75000	6.9	6.5	0.3

Generally, predicted salinities underestimated values observed during the relatively severe 2007 drought when bay salinities reached high levels. Observed mean salinity at Cat Point, for example, never fell below 31 psu between September and December 2007, reaching a maximum monthly mean of 34.6 psu in October. Mean river flow during this period (Sept-Dec) was about 6,400 cfs yielding an estimated mean salinity of 27.1 psu using the regression. Thus, while these regressions may describe the general salinity-flow relationship, predictions should be used with caution. Regressions that factor in winds and tides (Niu et al. 1998) may provide more accurate predictions, especially at the low-flow end of the discharge hydrograph; however, these models are more difficult to set up and require significantly more data to run.

In an attempt to refine predictions at the low-flow end of the hydrograph, regression models were developed after separating drought years from “normal”; the years 2000 and 2007 were considered drought years while all others were classified as normal. Regressions were recalculated with only slight improvement in predictions during low-flow conditions; revised regressions still underestimated salinity at Cat Point and Dry Bar under drought (Figure 40). As can be seen in the plots, this underestimation is caused by considerable variability in monthly salinity at low flows; least squared, best-fit regression models tend to average these conditions, thus underestimating the extremes observed.

While absolute salinity may be underestimated (particularly at low flows), these regressions may be useful in comparisons of flow scenarios where salinity differences among alternatives are sought and the data required to support the more complex multivariate models are not readily available. To this end we generated a series of salinity estimates from the original regressions (Figure 40) for increasing flow depletions; depletions were made from the lowest, middle, and highest mean monthly flows observed in 2007 and 2008. This time period contained a severe drought extending throughout most of 2007; proposals had been made to drop flows to even lower levels than were observed through upstream reservoir operations. Incremental depletions were taken from a base monthly flow and salinities were estimated for the three ANERR data logger sites (Table 5).

Table 5. Salinity at three ANERR data logger sites in Apalachicola Bay estimated for various flow depletions. Estimates are given for three levels of river discharge: low, mid, and high-flow conditions based on observed flows during 2007-2008. Regressions used to estimate these salinities are based on discharge at the USGS Sumatra gage (equations in Figure 39); all flow rates are given in cfs.

		Estimated Salinity		
	Flow	Cat Point	Dry Bar	East Bay
Low flow	5789	27.4	25.8	19.1
depletions				
500	5289	27.7	26.1	19.7
750	5039	27.8	26.2	20.0
1000	4789	28.0	26.3	20.3
1500	4289	28.2	26.6	20.9
Mid flow	10544	24.9	23.5	14.4
depletions				
1000	9544	25.4	23.9	15.3
2500	8044	26.2	24.7	16.7
5000	5544	27.5	25.9	19.4
High flow	30552	16.7	15.7	4.3
depletions				
1000	29552	17.0	16.0	4.6
2500	28052	17.6	16.5	5.0
5000	25552	18.5	17.4	5.8

Results indicate that, as expected, salinity increases with increasing amounts of depletion; salinity increases were greater under low-flow rates than at mid- to high-flow conditions for the same amount of depletion. For example, salinity increased by 0.5-1.2 psu at the three sites for a depletion of 1,000 cfs for the low-flow condition, but only by 0.3 psu for the same depletion at high flow. As with the previous use, caution is suggested in interpreting these salinity differences; further refinements of the models are warranted.

5. Nutrient Input and Primary Production.

The river delivers nutrients to the bay in two forms – as particulate and dissolved organic matter and as dissolved inorganic nitrogen (DIN) and phosphorus (DIP). The organic matter comes primarily as detrital material that the river collects from the 450 km^2 bottomland hardwood flood plain and lower wetlands that produce some 360,000 tons of litter per year (Livingston 1984). This addition of flood plain and wetland organic matter provides an organic subsidy of about 100 g carbon (C) m^{-2} y^{-1} to Apalachicola Bay, with most delivered during the high flow period (Mattraw and Elder 1982). Analyses of stable isotopes in the particulate detritus and oysters have suggested that this subsidy might provide up to 40% of oyster diets in the bay (Chanton and Lewis 2002).

But most of the growth of oysters and other animals in the bay occurs during the warmer lower flow months when the primary productivity of the phytoplankton in the bay is greatest and the supply of inorganic DIN and DIP is most critical. About 75% of the annual phytoplankton production of some 255 g C m^{-2} y^{-1} occurs during May through September (Mortazavi et al. 2000a, Putland and Iverson 2007). During this period the Apalachicola River provides about 8 times more DIN (the nutrient most limiting to primary production during this period) than the near shore Gulf of Mexico tidal inputs (Mortazavi et al. 2000b). The delivery of DIN by the river is directly proportional to the discharge of water from the river (Figure 41; Mortazavi et al. 2000b, Putland 2006), so the primary production and growth of the phytoplankton and all of the animals (including oysters) that graze on them are clearly coupled with and dependent upon the flow of river water into the bay during these warm lower flow months. This linkage is well illustrated by a recent comparison of phytoplankton growth and productivity throughout the bay during a wet (2003) and dry (2004) summer (Figure 42; Putland 2005) where greatest growth and production occur at a mid-range of salinities. As salinity increases above this range, productivity/growth decline. The base of the food web throughout the bay was markedly richer with higher river flows and greater fertilization. And, as discussed below, the availability of food for oysters is a critical factor in their ability to survive disease.

6. Apalachicola Bay Oysters.

One of the most characteristic organisms in the estuary for which Apalachicola Bay is well known is the eastern oyster (*Crassostrea virginica*); Apalachicola Bay supplies nearly 90% of Florida’s commercial landings and 10% of the national total. As such, oysters have become a major focus in the ongoing allocation of fresh water in the ACF drainage.

Freshwater inflow provides a continuing supply of nutrients that fuel the phytoplankton base for rapid oyster growth. In addition the low and variable salinity regime resulting from river input repels predators and disease that thrive in higher salinity conditions. River flow has been linked directly with commercial landings in the bay (Wilber 1992) with decreased mortality coincident with lowered salinities (Livingston et al. 2000).

Oyster mortality results from a combination of predation and disease. Stone crabs, blue crabs, and gastropod mollusks are primary predators. Disease mortality is produced by the protozoan parasite *Perkinsus marinus*, which is the causative agent of Dermo disease (derived from the earlier name *Dermocystidium marinum*). *P. marinsus* is common and widespread in oysters from the Gulf of Mexico (Craig et al. 1989) with prevalence greater than 50% at 48 of 49 sites examined around the Gulf; no site was parasite free. The parasite tends to be most prevalent during warm months in high salinity areas (Soniat 1996). Oyster mortality from Dermo decreases as salinity decreases with a threshold of pathogenicity reported between 9 and 12 ppt (Ragone and Burreson 1993). While Dermo survived in salinity less than 9 ppt, oyster mortality was minimal.

A monitoring program was initiated in 2007 to measure and document the incidence and prevalence of Dermo disease in oysters in Apalachicola Bay. The monitoring program provided monthly measurements of Dermo disease prevalence and intensity which were used for calibration and evaluation of a coupled oyster-parasite model (Hofmann et al. 1995; Powell et al. 1996) that was implemented for Apalachicola Bay.

a. Dermo prevalence.

Prevalence of Dermo infection, expressed as total, advanced, or weighted prevalence, varied seasonally with maximum values during summer months and minimum values in winter. High prevalence was generally coincident with high temperature and high salinity as has been observed in other areas of the Gulf (Soniat 1996) although overlap with cooler months was observed. Dermo was always prevalent in Apalachicola Bay oyster collections with infection rates similar at the two sites (Cat Pt. and Dry Bar). While individual oysters were often found to be disease free, total prevalence (proportion of infected oysters per site) at a site never dropped below 37% (Dry Bar Feb 2008) and was commonly observed to exceed 80%. Highest prevalence during the study was noted at Dry Bar in October 2008 with near 100% infection.

Despite similar total prevalence at the two sites, highest infection intensities (i.e., advanced prevalence) were measured in oysters from Cat Point. Advanced prevalence (proportion of infected oysters in Mackin scale classes 3-5) was higher at Cat Point during both 2007 and 2008 with values often exceeding 40%. The prevalence of advanced infection was somewhat lower (< 40%) at both sites during 2009 with highest infection shifting to Dry Bar.

Weighted prevalence (average infection intensity of all oysters per site) generally followed the pattern noted for advanced prevalence at the two sites. Highest values were observed at Cat Point during 2007 and 2008 while relatively similar intensities occurred during 2009. Average weighted prevalence over the sampling period was slightly higher at Cat Point (1.48) than Dry Bar (1.23) reflecting the greater proportion of advanced cases at Cat Point.

Weighted prevalence remained above 1.0 at both sites for the majority of the months measured in 2007 and 2008. Weighted prevalence is expressed on a scale that goes from 0 to 5, the Mackin scale. The Mackin scale is based on the doubling time of the disease organism, so a one unit increase on this scale represents a substantial increase in disease burden for the oyster host. Values above 2.5 indicate high disease burden, which is a precursor of a disease epizootic.

Both advanced (Figure 43) and weighted (Figure 44) prevalence showed coincident patterns with mean salinity although considerable variation was observed. For example, highest advanced and weighted prevalence was noted in July 2008 at a time when only moderately high salinity was recorded; highest salinities were noted in June and October 2008 and in July 2009 when prevalence was highly variable (low, high and moderate, respectively).

Linear regressions were used to determine relationships between salinity and disease prevalence at individual sites and at all sites combined. Based on these regressions, a significant portion of the variation in disease prevalence at all sites combined could be attributed to salinity alone and the higher the salinity, the greater the disease (Figure 45). Advanced prevalence was significantly related to salinity either by individual sites or sites combined (Figure 46). Variation was slightly greater at Cat Point than at Dry Bar when sites were assessed separately; salinity explained 32% of the variation in advanced prevalence when the sites were combined. Similarly, weighted prevalence was also significantly related to salinity either by individual sites or sites combined (Figure 47). As before, salinity explained a greater proportion of the variation in weighted prevalence at Dry Bar than at Cat Point. When sites were combined, the relationship explained about 37% of the variation in average disease intensity.

Multiple regressions were also run with salinity and temperature as the independent variables against each of the three dependent Dermo variables (i.e., total, advanced, and weighted prevalence). Adding temperature to salinity in a multiple regression analysis increased the amount of variation explained but only moderately. For all cases except Cat Point total prevalence, the addition of temperature significantly increased the variance explained in Dermo prevalence. This increase was noted for both sites tested separately or combined. Adjusted correlation coefficients (R^2) increased from 10-15%. The significant incorporation of salinity and temperature into the multiple regression models of disease prevalence indicates that both variables play a role in the incidence and prevalence of Dermo and that increased disease will occur at increased salinities and temperatures.

7. Dermo and oyster density

The relationship between Dermo disease and oyster abundance was examined by plotting estimated oyster density (quadrat collections taken by the Florida Department of Agriculture and Consumer Services, Division of Aquaculture) relative to Dermo advanced prevalence (Figure 48). Total and weighted prevalence could be examined as well but are not plotted here.

At Cat Point, initial densities of 500-600/m^2 declined to <250/m^2 coincident with increasing advanced Dermo prevalence during the first 2 years of the survey (Figure 49A). During the third year densities were not observed to increase significantly despite a decrease in disease. As a caveat it should be pointed out that density data were limited during 2009 precluding definitive conclusions concerning oyster abundance. Pearson correlation between density and advanced Dermo was marginally significant ($r=-0.443$; $n=21$, $p<0.05$; cutoff $r=-0.433$) suggesting a declining trend of density with increasing advanced disease levels. At Dry Bar, densities declined steadily throughout the survey period from initial levels >800/m^2 to about 500/m^2 during the second year to lows of about 300/m^2 during 2009 (Figure 49B). Advanced Dermo prevalence increased during 2007 and 2008 with peaks in 2009 slightly lower than 2008. As noted for Cat Point, limited data from 2009 preclude definitive conclusions concerning oyster abundance. No significant correlation was noted at Dry Bar between density and advanced Dermo ($r=-0.086$; $n=20$, $p>0.05$). Oyster densities in 2010 increased somewhat at Dry Bar yet remained low at Cat Point; no Dermo information was available coincident with recent density estimates.

In 2007 Dermo weighted prevalence at Cat Point remained high throughout the fall and into the early part of 2008. The typical reduction in Dermo that occurs in the fall did not occur until January of 2008 and was confined to two months rather than the typical 4-5 months. Dermo weighted prevalence in January 2008 at Cat Point was above 2.0; whereas, it was just above 1.0 in January 2007 and just below 1.0 in January 2009. The high salinity in 2007 resulted in increased Dermo prevalence which carried over into 2008. As a result, the oysters started the growing season in 2008 with a higher than normal disease burden. This allowed the weighted prevalence of Dermo to be higher in April, May, June and July than was observed in the equivalent months in 2007 and 2009. The pattern of disease prevalence at Dry Bay is similar, but with lower measured weighted disease prevalence values.

The rapid decline in disease prevalence at Cat Point in September 2008 was likely the result of a disease epizootic – the sick animals die which results in a decline in disease prevalence. Similarly, the reduction in weighted disease prevalence in late fall of 2007 at Cat Point is likely associated with an epizootic. The disease levels still remained high following this event which indicates that Dermo disease was well established at this time. Supporting evidence for epizootics is provided by the oyster density measurements which show significant reductions in oyster density at Cat Point and Dry Bay, relative to early in 2007, beginning in fall 2007 and continuing through 2008. The reduced oyster density has continued through 2009 and 2010 at both sites, indicating no recovery from the disease epizootic in 2007/08.

The measurements of Dermo disease show (1) increased disease prevalence associated with the sustained high salinity in 2007 that persisted throughout the fall, (2) carryover of the disease into the next year, (3) a disease epizootic in fall of 2008, and (4) a possible disease epizootic in late fall-early winter of 2007.

a. Apalachicola Bay oyster population simulations using 2007-2008 conditions.

The time evolution of oysters at Cat Point was simulated using the observed salinity and temperature conditions from 2007 and 2008. The simulated market-sized oysters declined over time, decreasing to about 150 oysters m^{-2} (Figure 49), which is similar to the oyster density values actually measured in 2007 and 2008 at Cat Point (Figure 48A). The total oyster population also declined over time but the decrease is less than obtained for the market-sized portion of the population (Figure 49A). The long-term decline in the simulated population indicates that the conditions that existed in 2007-2008 were not conducive to maintenance and/or expansion of the Apalachicola Bay oyster population.

Simulated Dermo disease intensity at Cat Point ranged between 0.5 and 2.5 (Figure 49B), which is similar to the range measured at Cat Point (Figure 44). This agreement indicates that the Dermo disease processes were correctly simulated by the oyster-disease model.

An increase in salinity in Apalachicola Bay by itself has consequences for the oyster population by increasing Dermo disease prevalence and intensity. However, associated with salinity changes are coincident changes in food supply and larval recruitment. Should either of these decline, coincident with an increase in salinity, then oyster populations in Apalachicola Bay will be seriously impacted.

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Figures

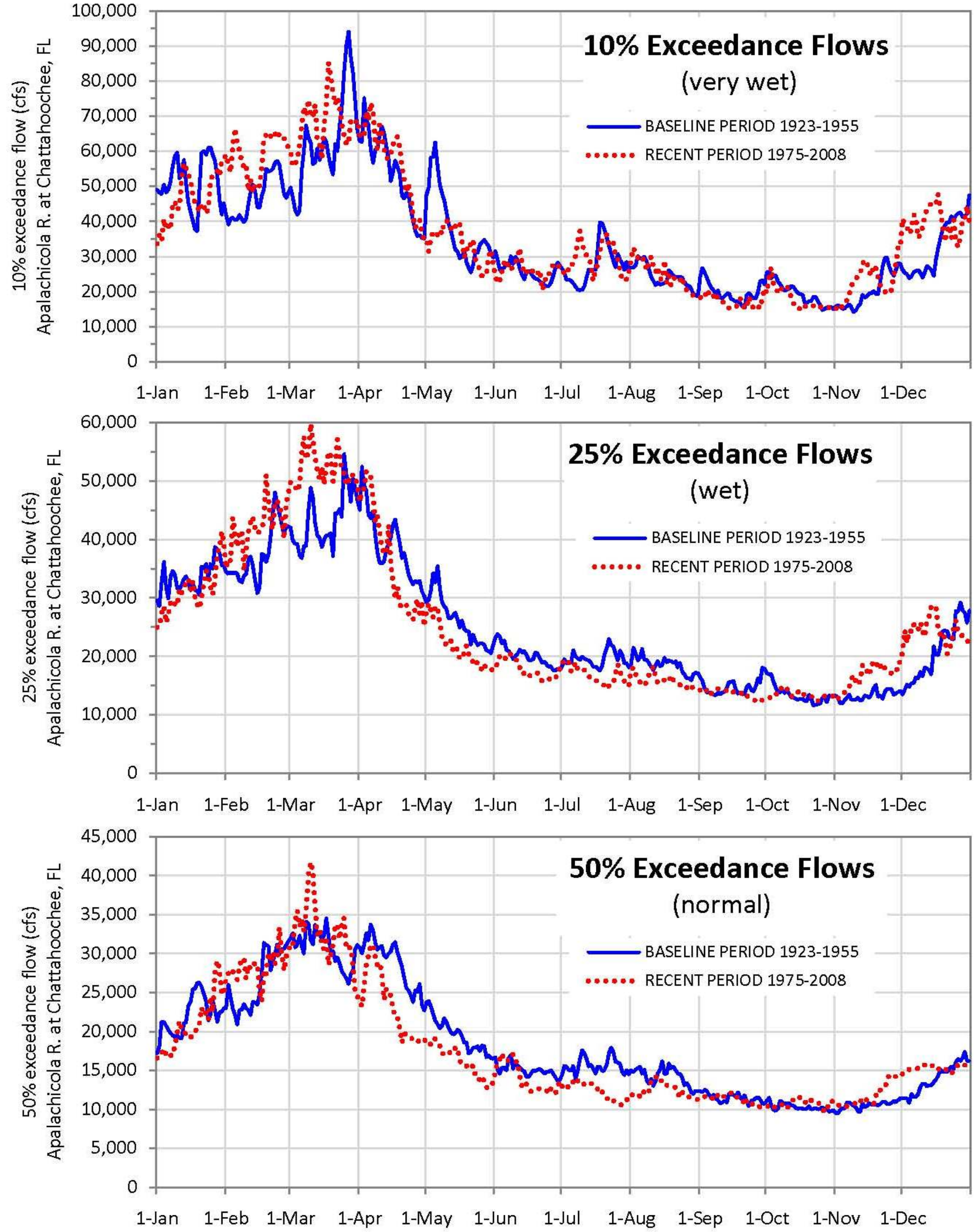
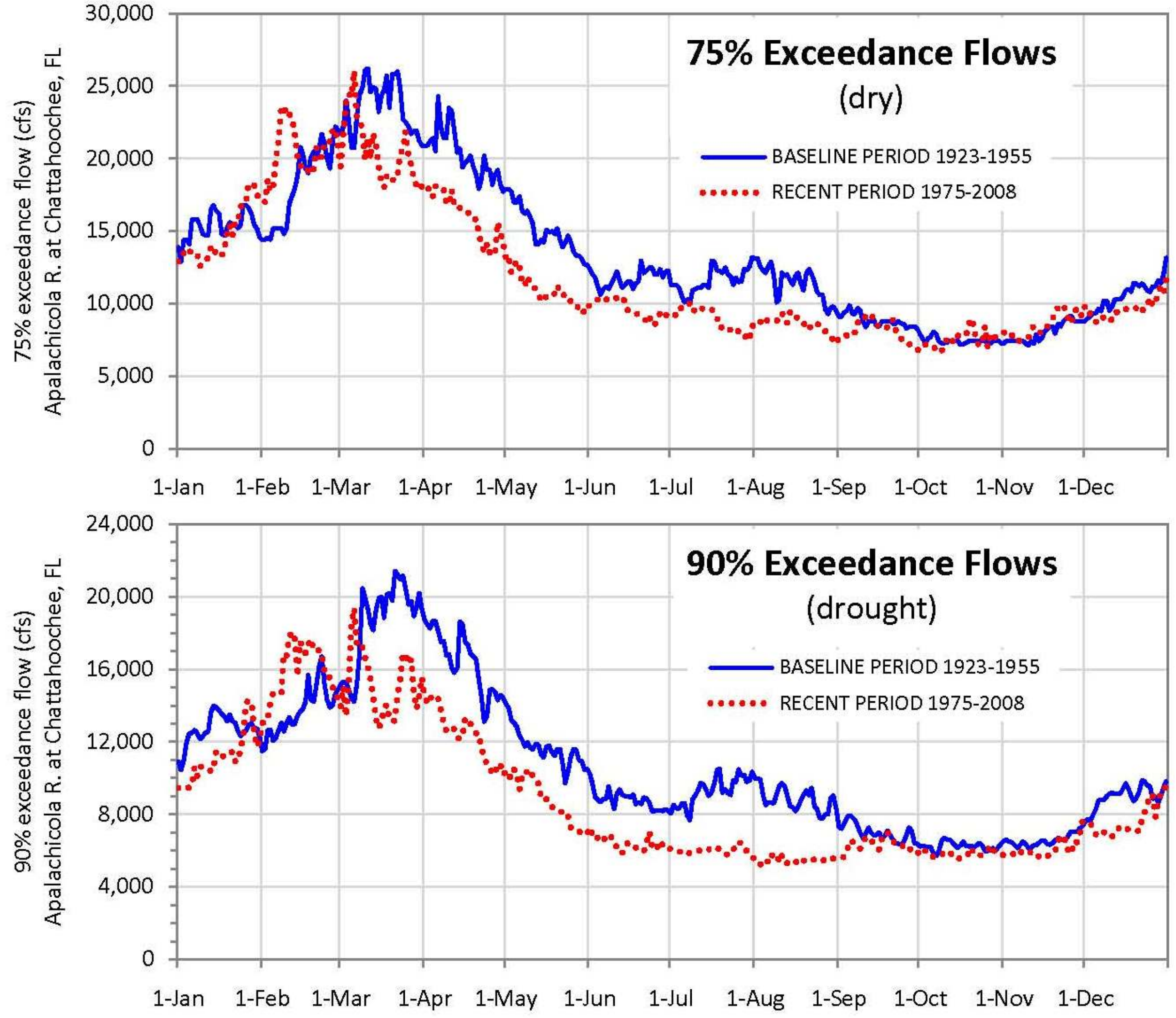


Figure 1. Flow in the Apalachicola River during two time periods (baseline and recent) under conditions ranging from very wet (10% exceedance) to drought (90% exceedance) (USGS 2010).



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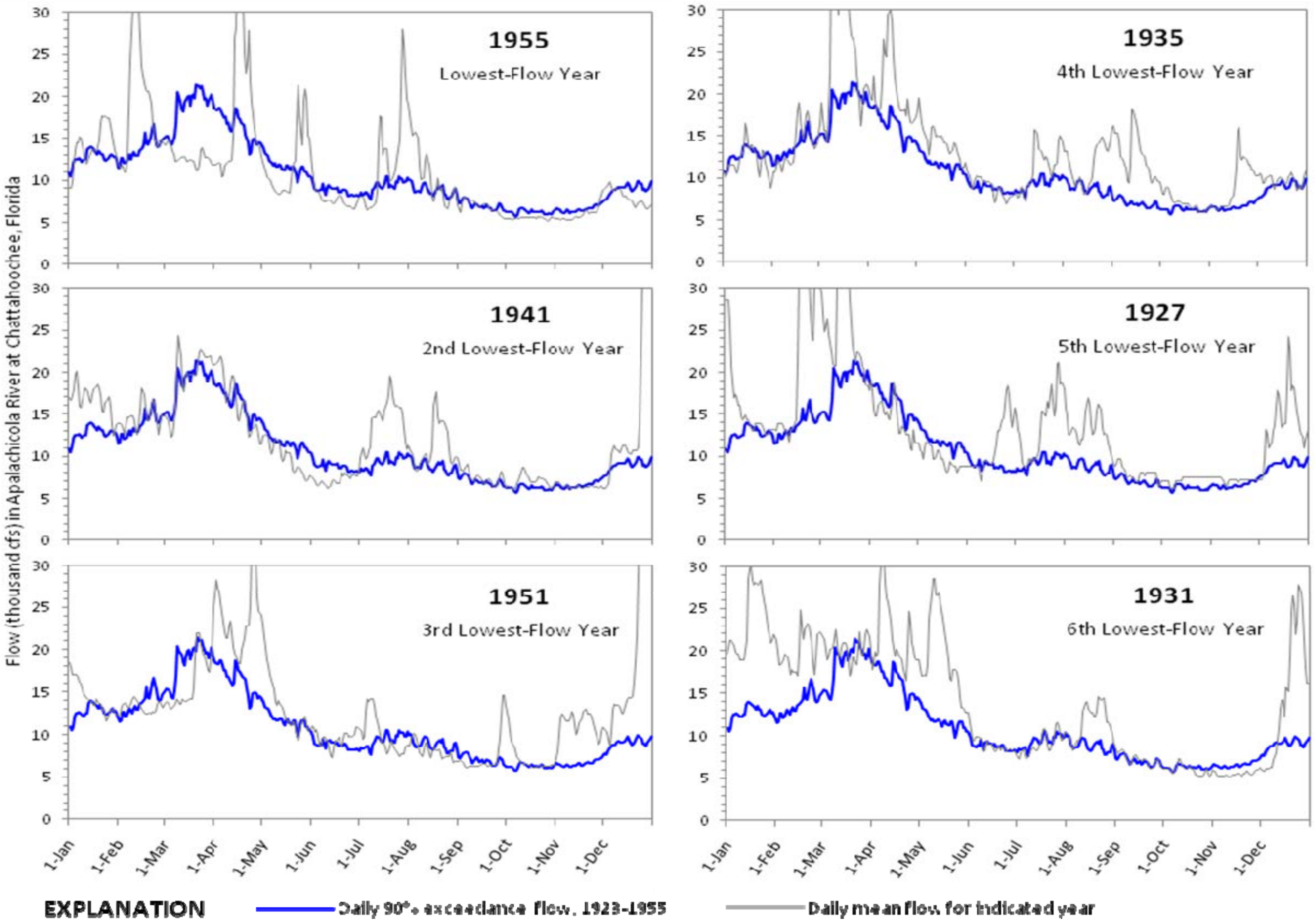


Figure 2. Daily 90% exceedance flow compared to daily mean flow in the lowest-flow years for the period 1923-1955. Six lowest-flow years were selected on the basis of mean annual flow. Flows >30,000 cfs are not shown (USGS 2010).

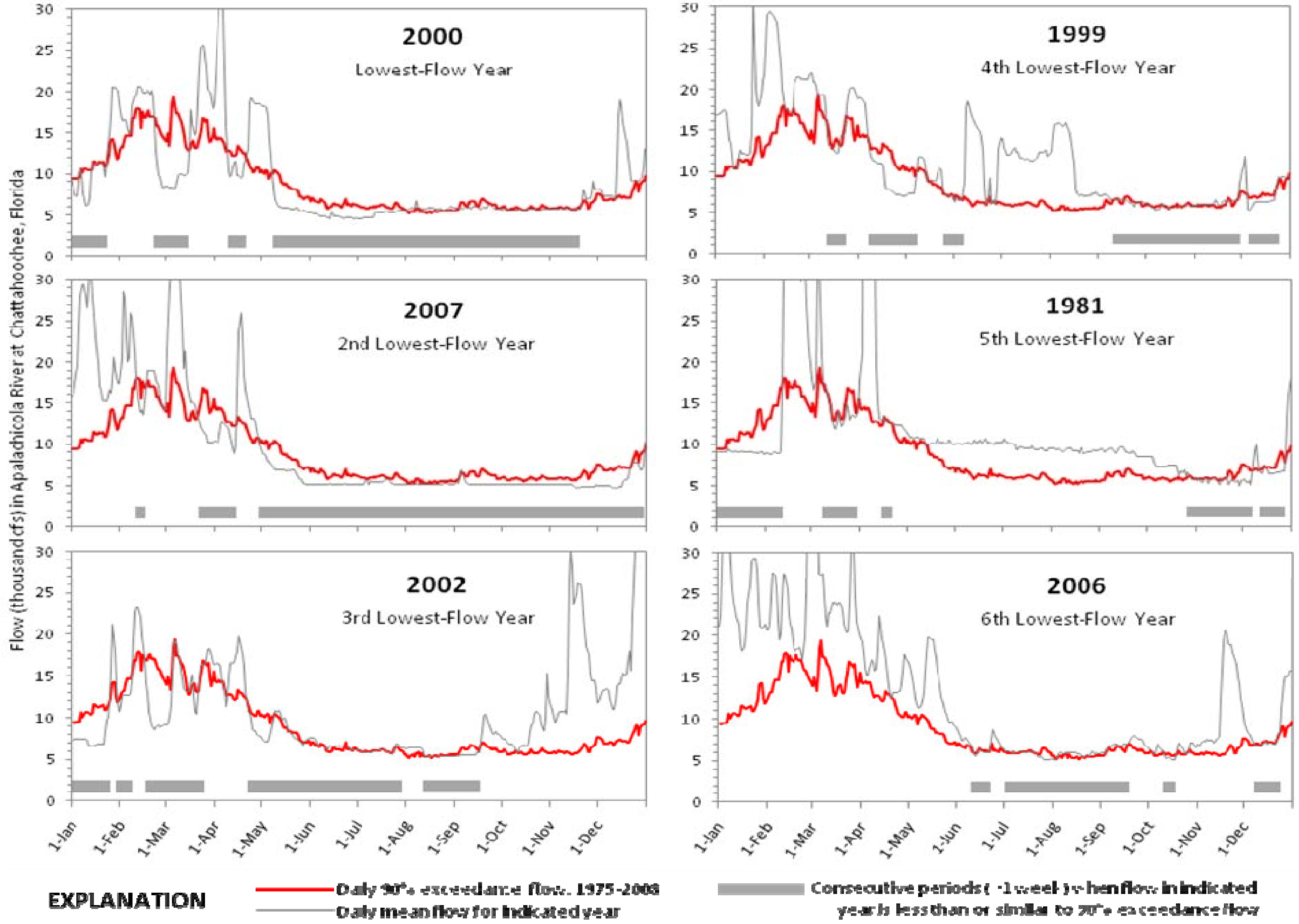


Figure 3. Daily 90% exceedance flow compared to daily mean flow in the lowest-flow years for the period 1975-2008. Six lowest-flow years were selected on the basis of mean annual flow. Flows >30,000 cfs are not shown (USGS 2010).

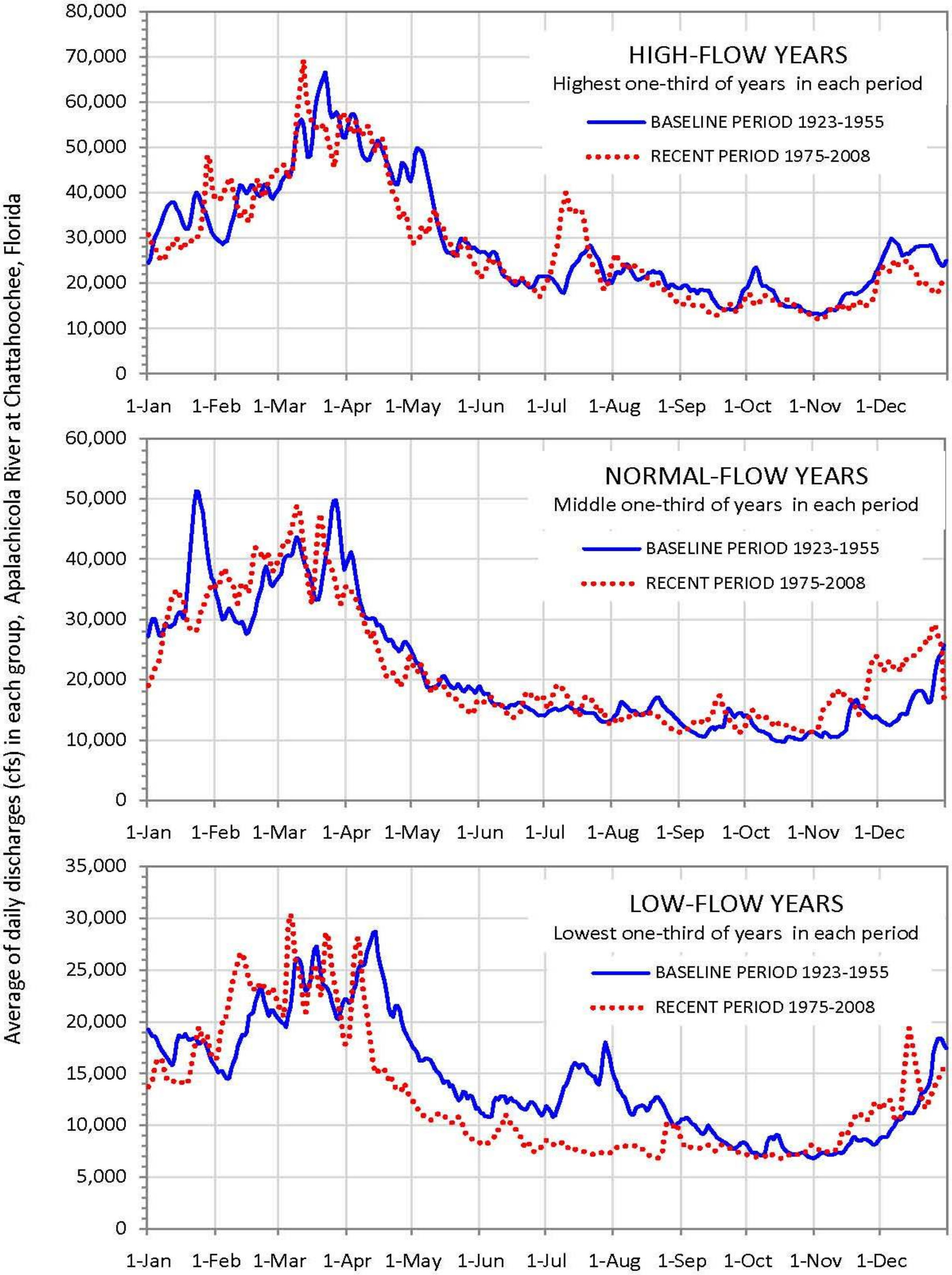


Figure 4. Average of the daily discharges in the Apalachicola River in three groups (high-flow, normal-flow, and low-flow years) within two time periods (baseline and recent). Years were sorted into three nearly equal groups on the basis of mean annual discharge (see list in Appendix B).

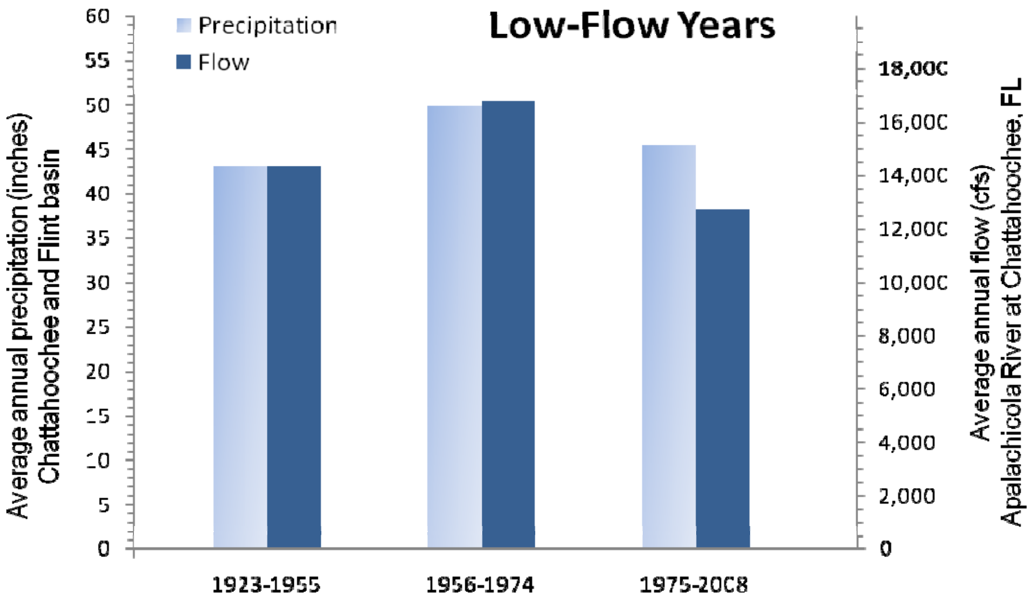


Figure 5. Annual precipitation in the Chattahoochee and Flint River basins compared to annual streamflow in the Apalachicola River in low-flow years during three time periods. Low-flow years are the lowest one-third of years in each time period, ranked in terms of mean annual flow. Data for each year are listed in Appendix C. The right axis was adjusted to make precipitation and flow bars the same height in the baseline period (1923-1955), so that rainfall-flow relations in later periods could be visually compared to the baseline condition (US Dept of Commerce 2009; USGS 2010).

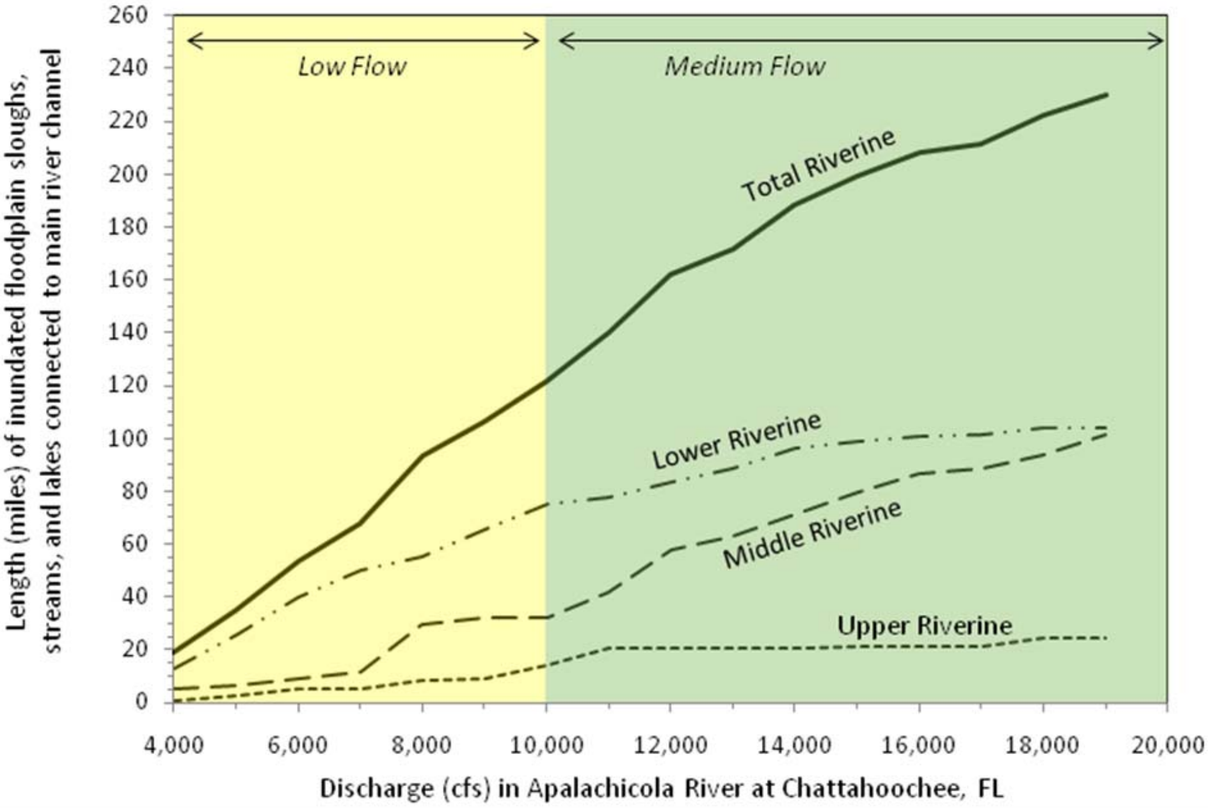


Figure 6. Length of floodplain sloughs, streams, and lakes in relation to flow in the riverine (nontidal) reach of the Apalachicola River. Length represents the linear distance along inundated reaches of floodplain sloughs, streams, and lakes that are connected to the main river channel under present channel conditions. Data from Table 7 in Light et al. (1998).

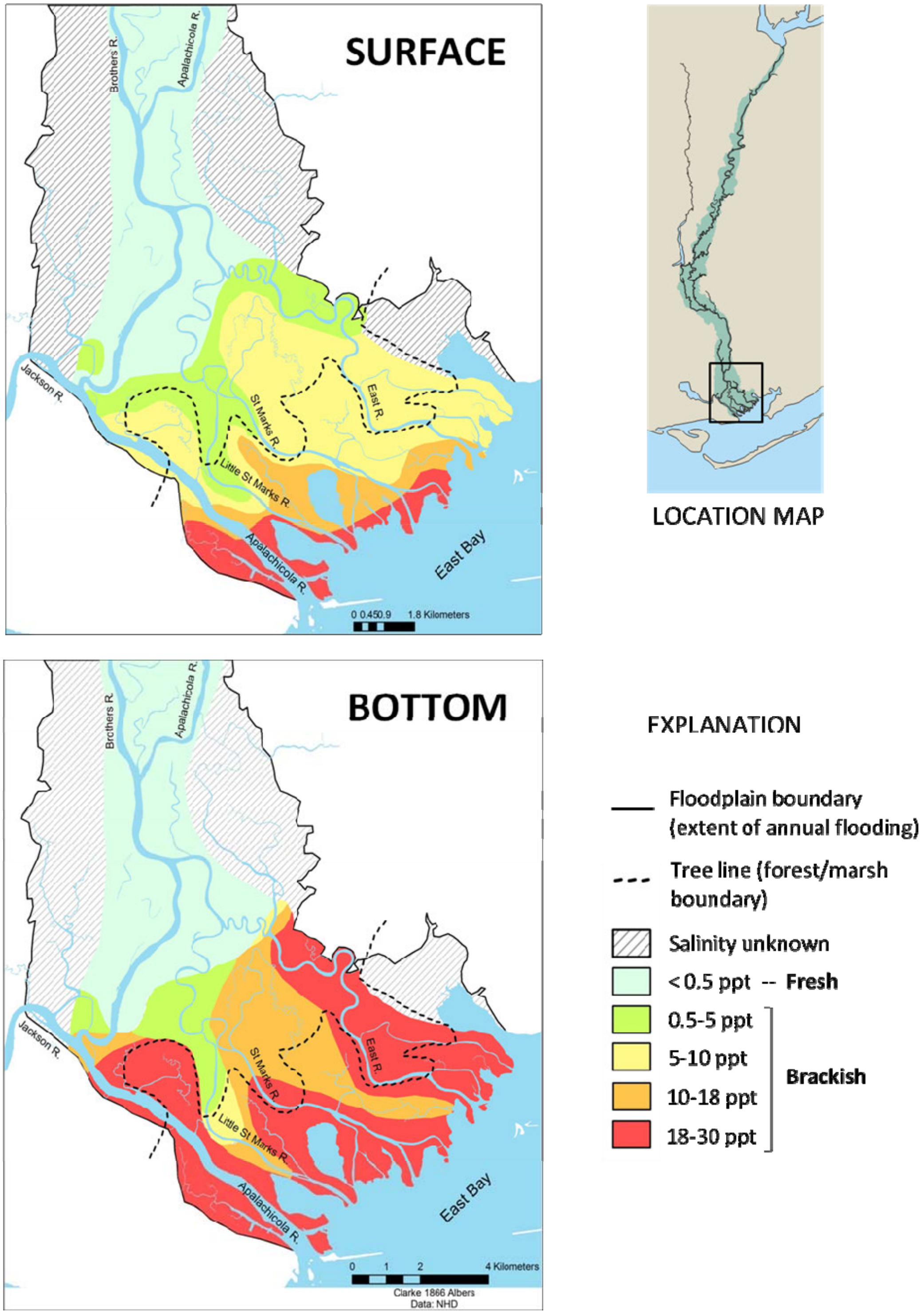
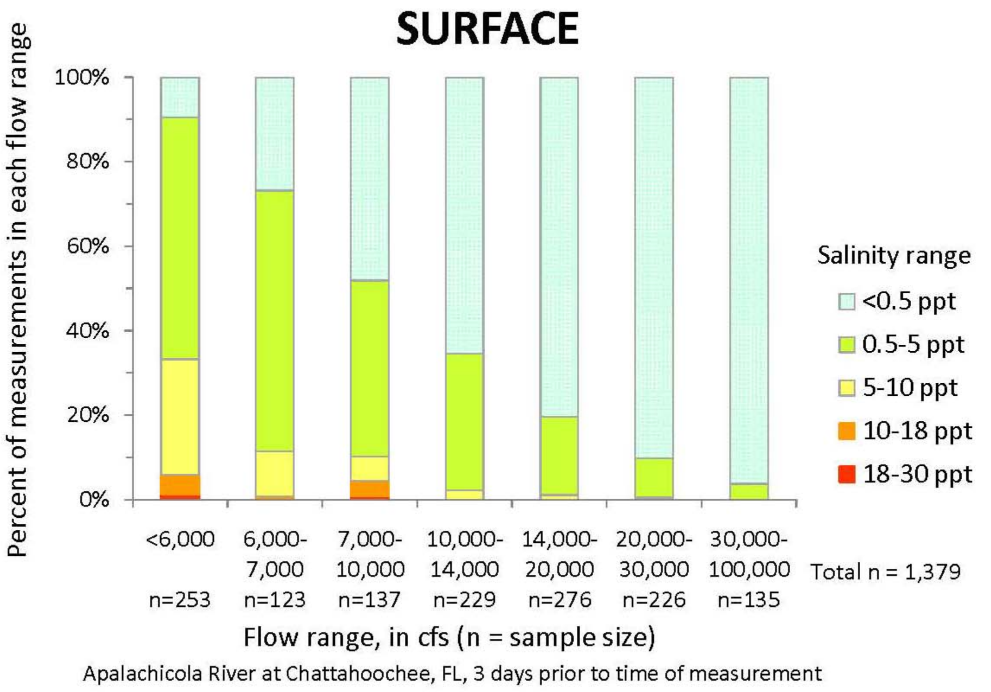


Figure 7. Zones indicating maximum upstream extent of brackish salinities (surface and bottom) in the lower Apalachicola River and distributaries. Zones were determined from data described in Appendix D.



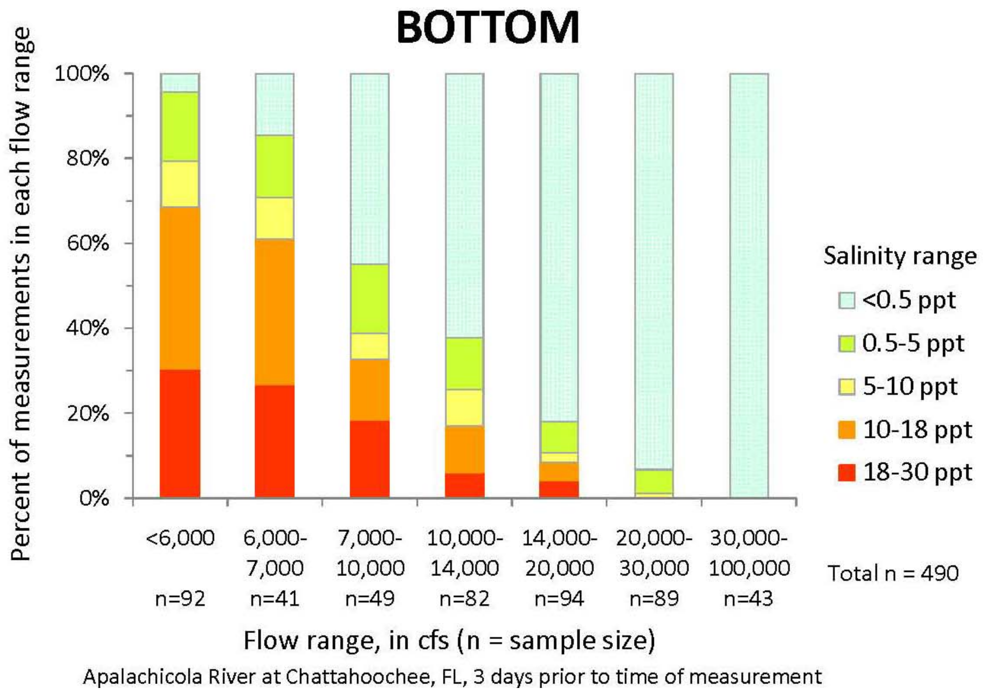


Figure 8. Surface and bottom salinity in brackish-water reaches of the lower Apalachicola River and distributaries in relation to river flow. This analysis is based on measurements from brackish-water zones only (see Figure 7). Source data are described in Appendix D. A time lag of 3 days (to account for travel time from the streamgage at Chattahoochee, Florida) was used to determine river flow associated with each salinity measurement.

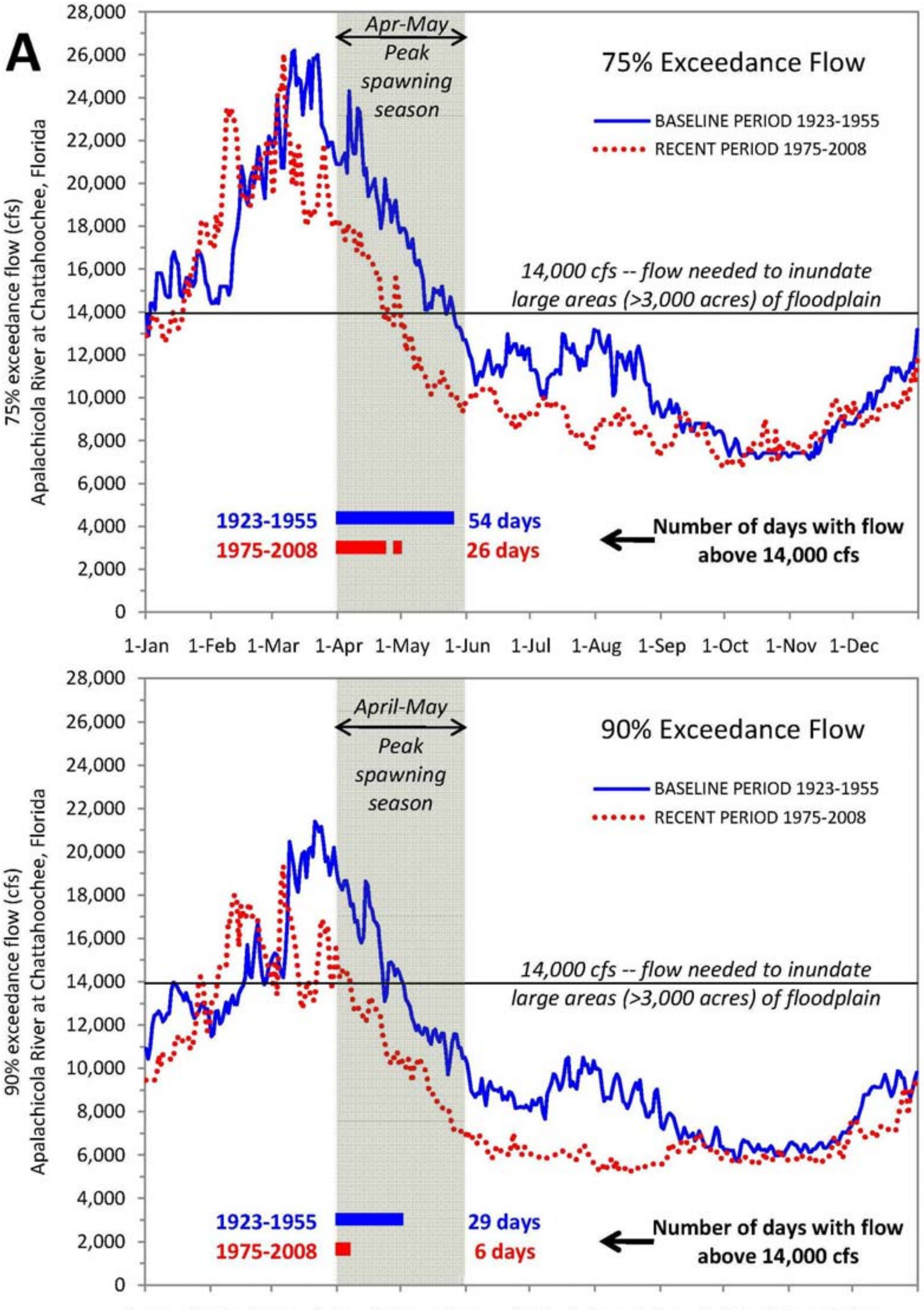


Figure 9. Decrease in availability of fish spawning and nursery habitat as a result of lower flows since 1975. (A) Floodplain forest inundation in spring. (B) Slough connectivity in summer. Baseline and recent flows are compared during dry (75% exceedance) and drought (90% exceedance) conditions.

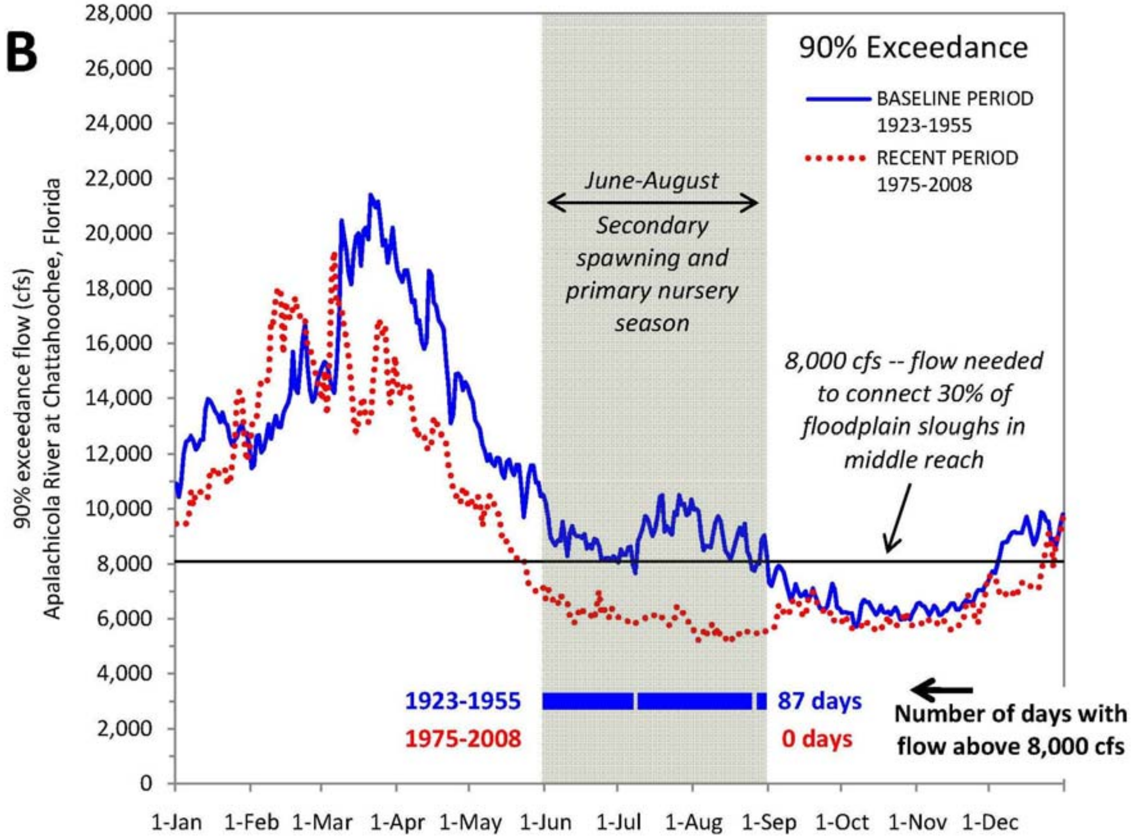


Figure 9. Continued -- (B) Slough connectivity in summer.

High Flows (> 30,000 cfs)

Figure 10. Forested floodplains inundated during high flows provide refuge from the main channel as well as feeding, spawning and nursery habitats for fish. Of the 99 species of fish known to occur in the Apalachicola River-floodplain system, 80% utilize aquatic floodplain habitats at some time during their life cycle. Photograph from Light et al. (1998).

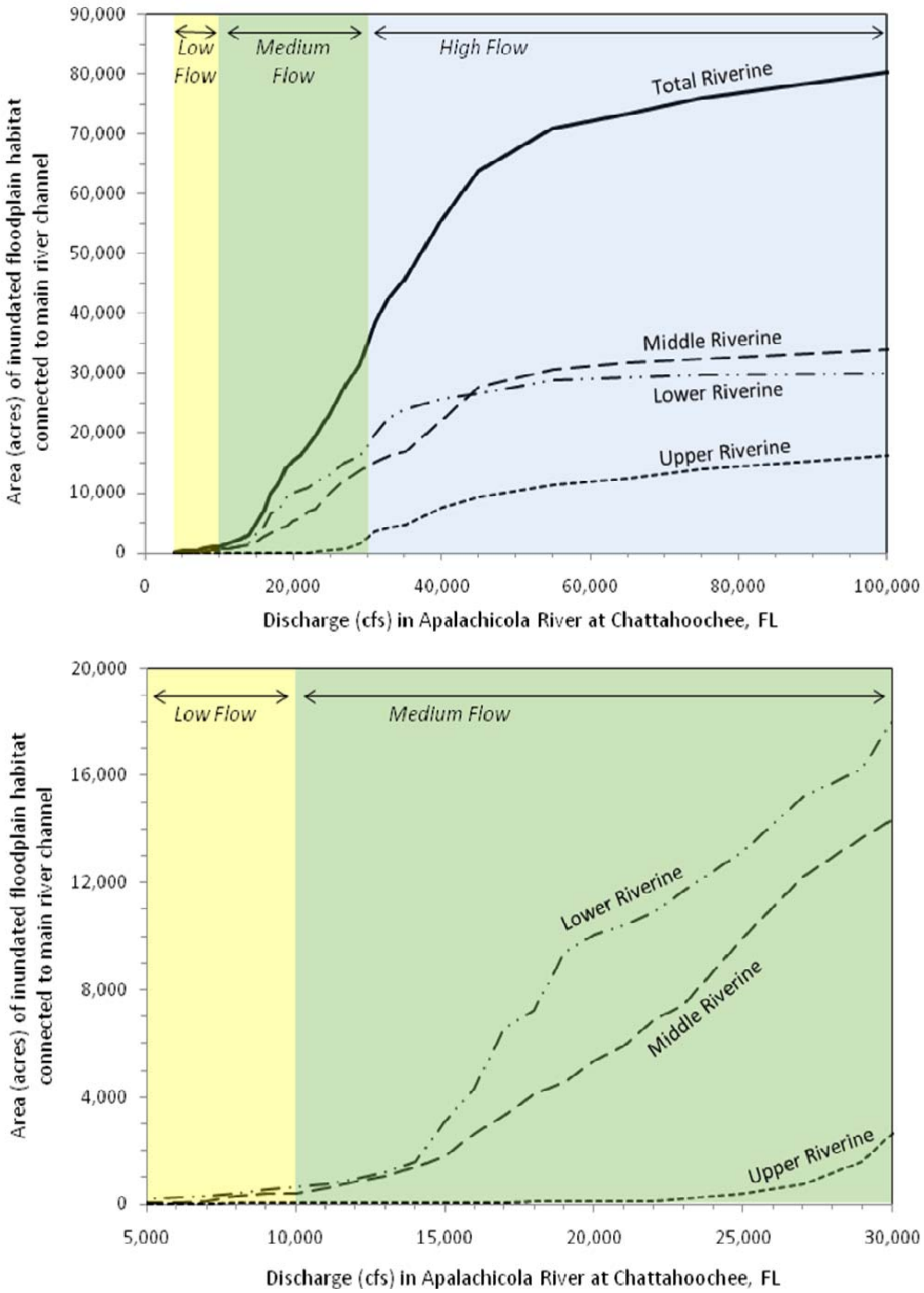


Figure 11. Area of inundated floodplain habitat in relation to flow in the riverine (nontidal) reach of the Apalachicola River. Area represents inundated floodplain habitat that is connected to the main river channel under present channel conditions. Modified from Figure 27 in Light et al. (1998).

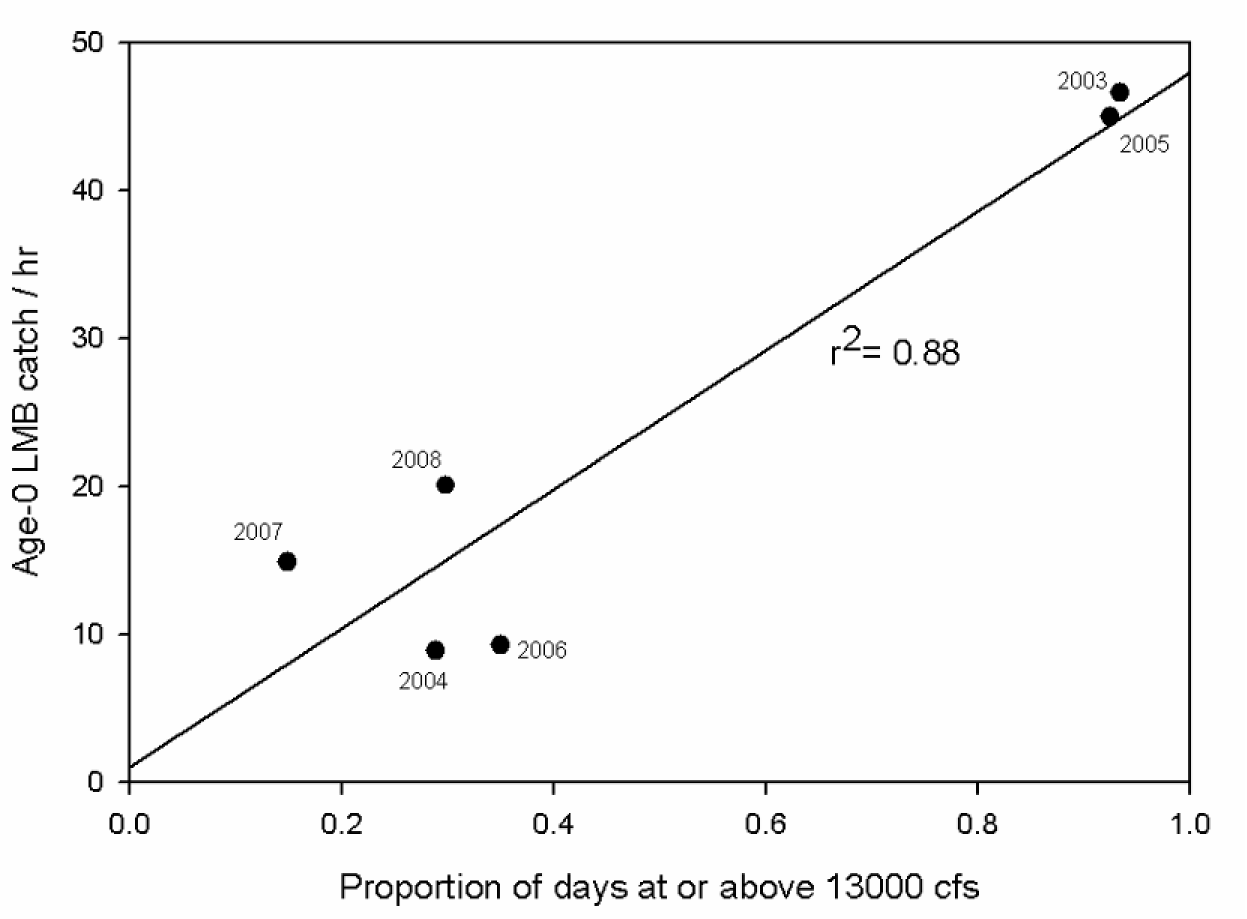


Figure 12. Relationship of mean catch per hour of age-0 largemouth bass (LMB) to the proportion of days during March 1 – September 30 that met or exceeded the 13,000 cfs threshold at USGS gage 02358000 near Chattahoochee, FL. From Allen et al. (2009).

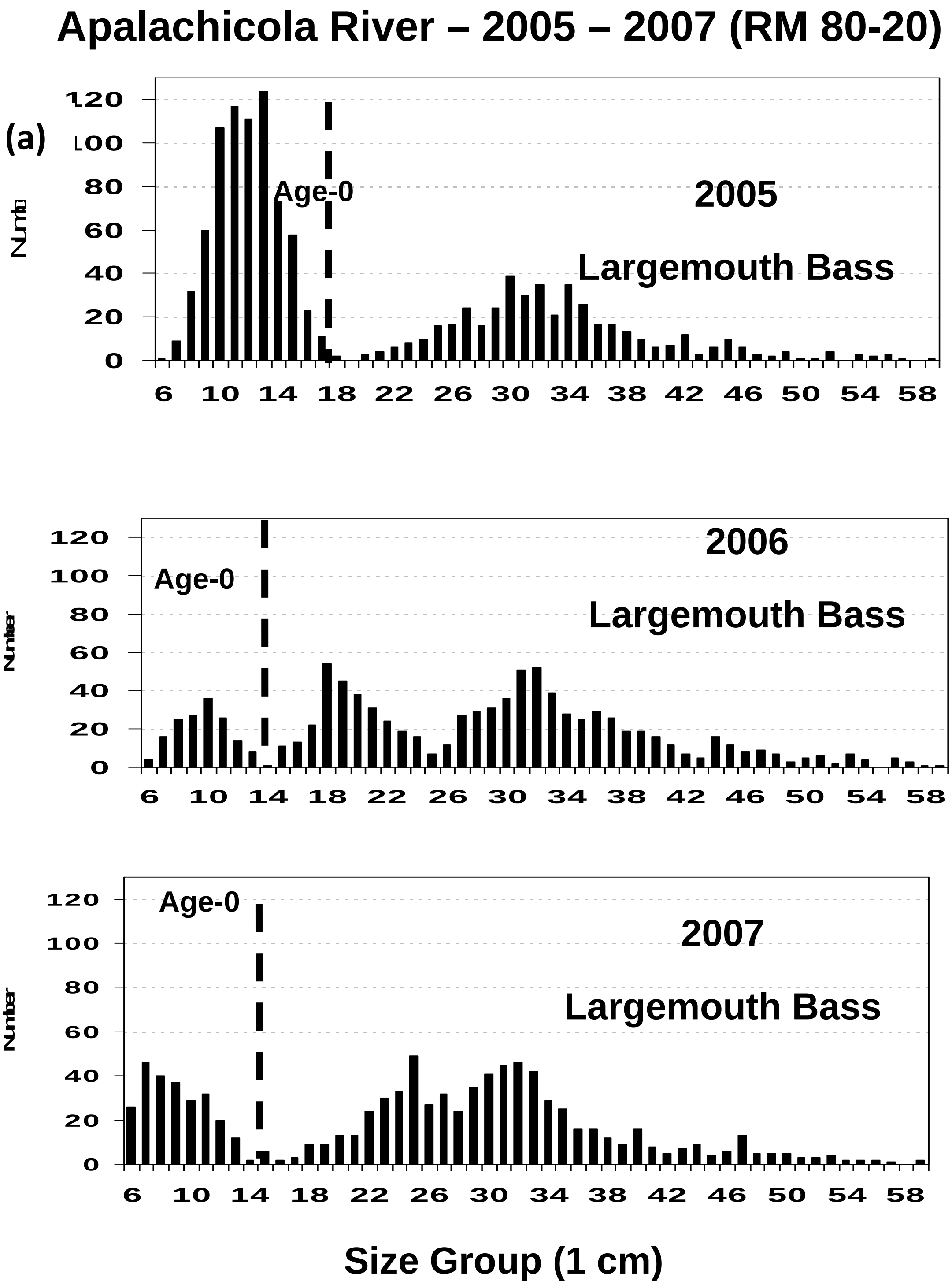
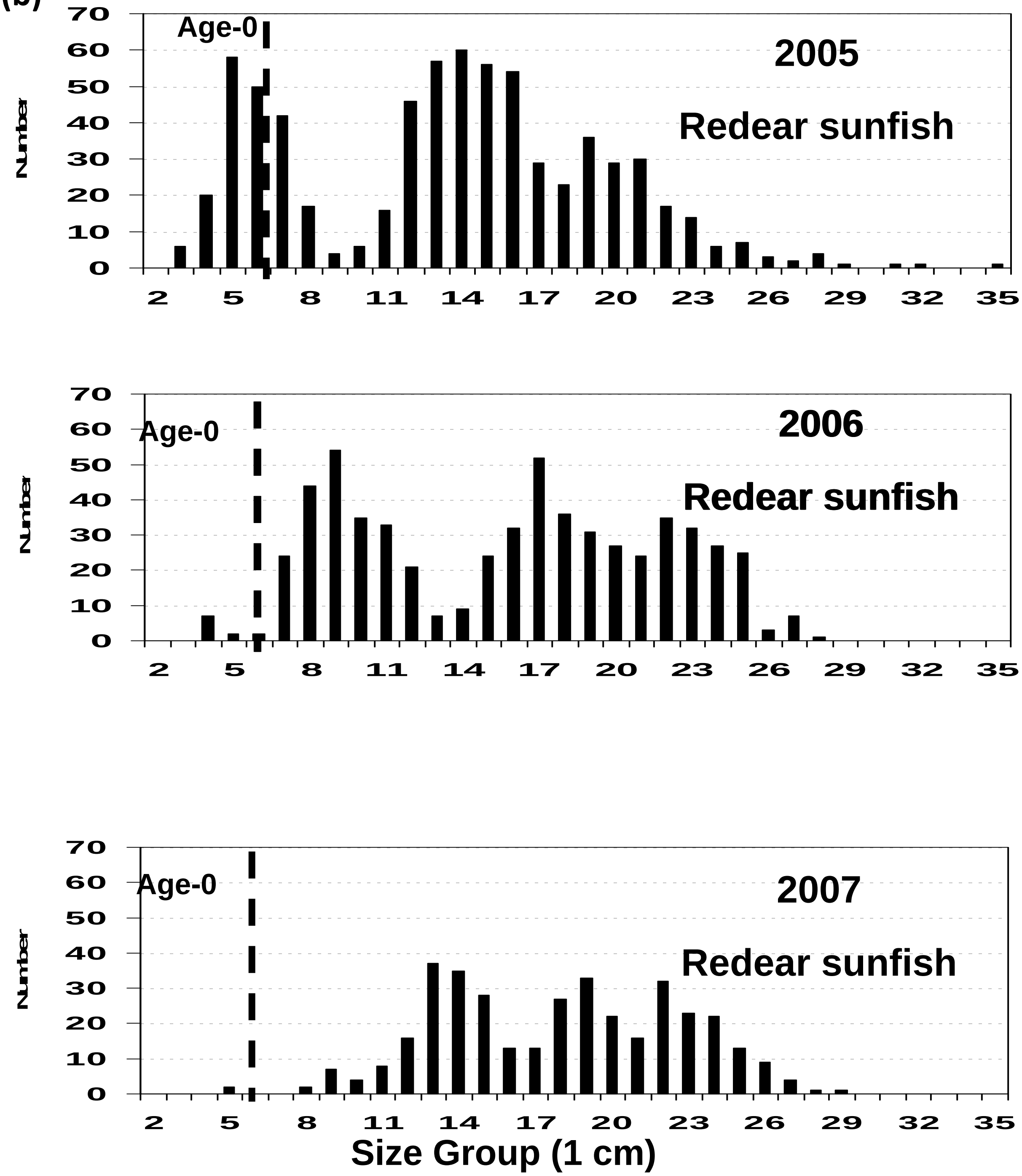


Figure 13. Size distribution of fish collected by electrofishing in the Apalachicola River main channel and sloughs in September 2005-2007 (a) largemouth bass (b) redear sunfish, (c) spotted sunfish, and (d) warmouth sunfish. Electrofishing effort among years was equal, with a total of 100 samples (10 minutes/sample) collected in each year (50 samples in the main channel plus 50 samples in the sloughs).

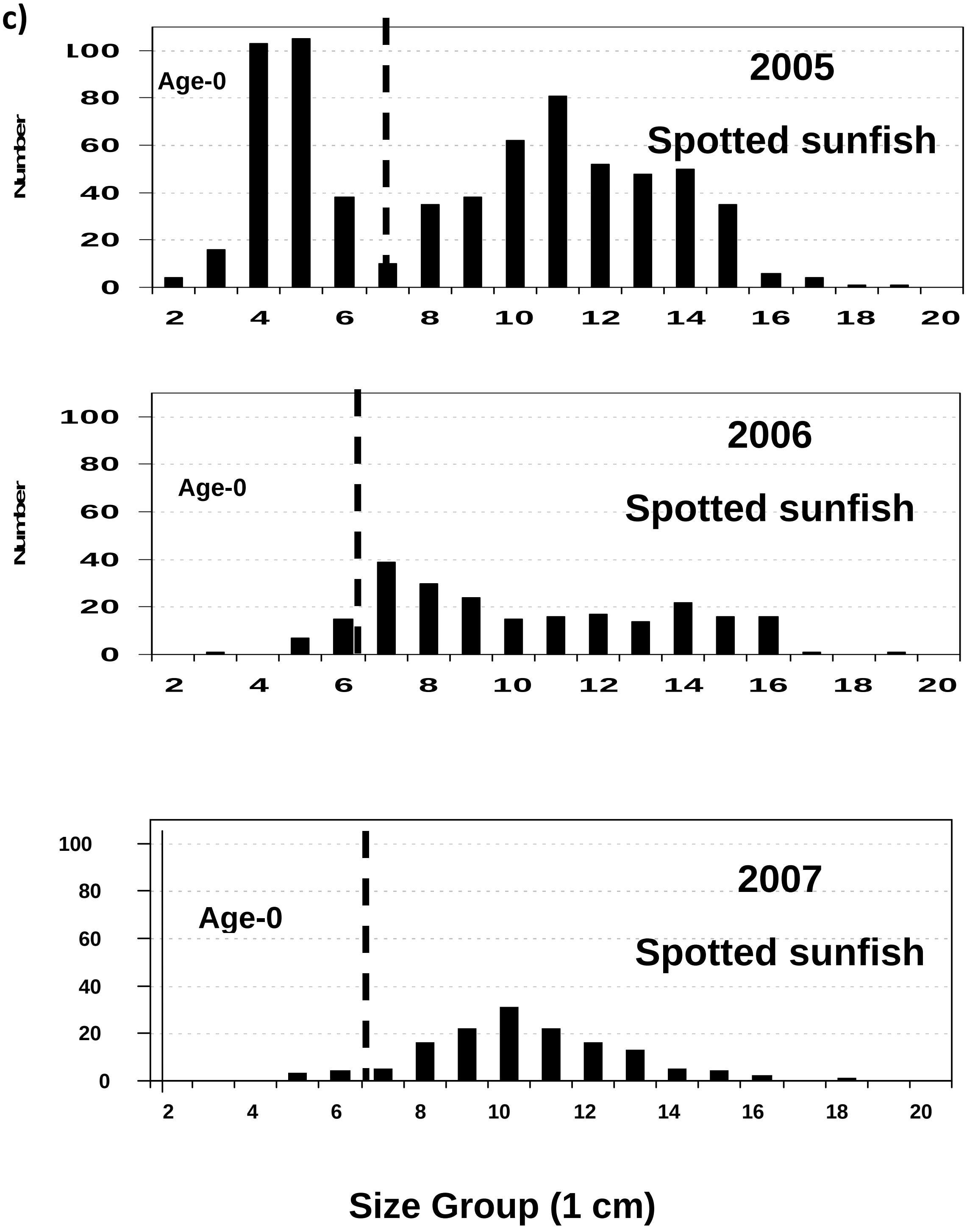
Apalachicola River – 2005 - 2007 (RM 80-20)

(b)

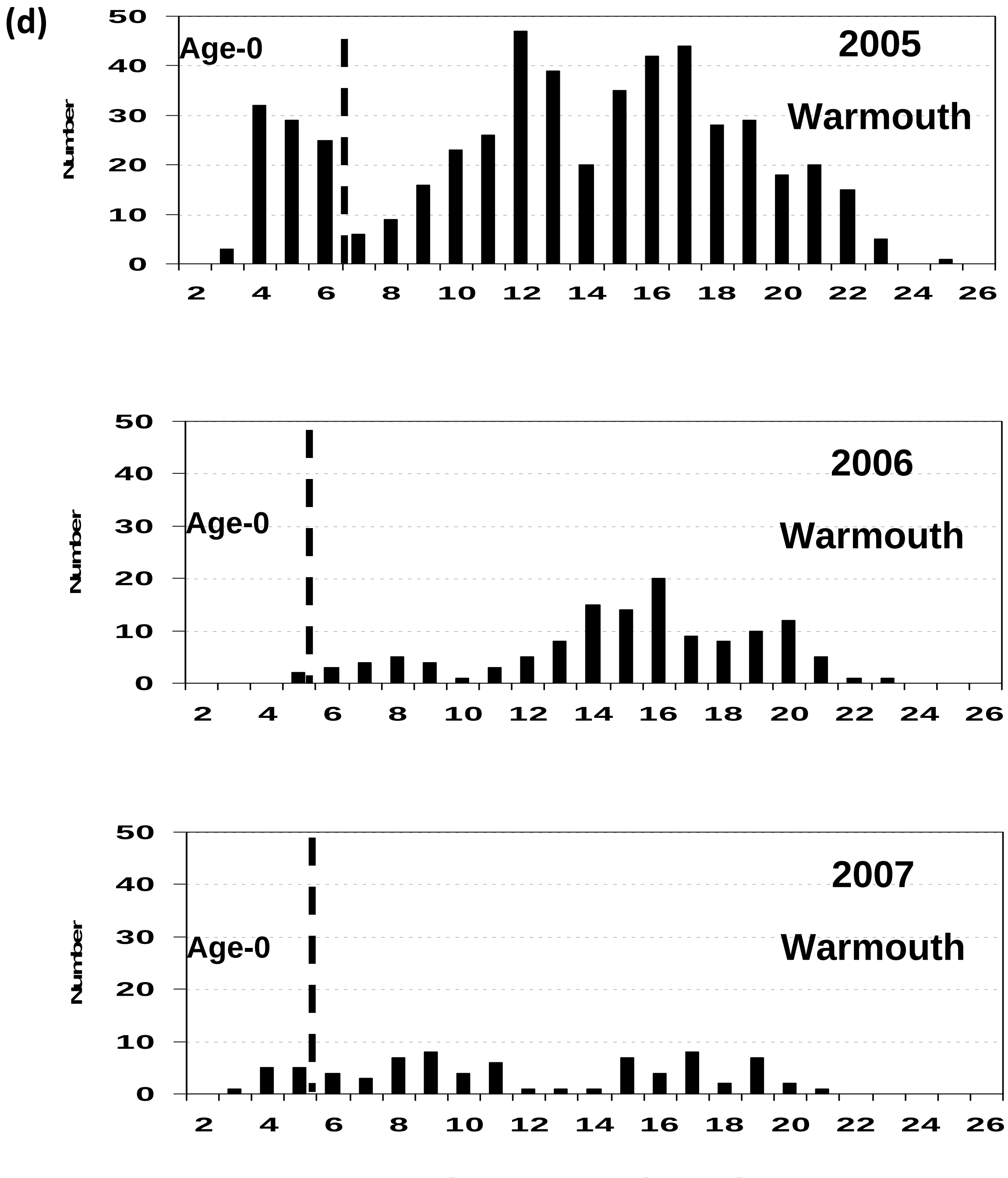


Apalachicola River – 2005-2007 (RM 80-20)

(c)



Apalachicola River – 2005 - 2007(RM 80-20)



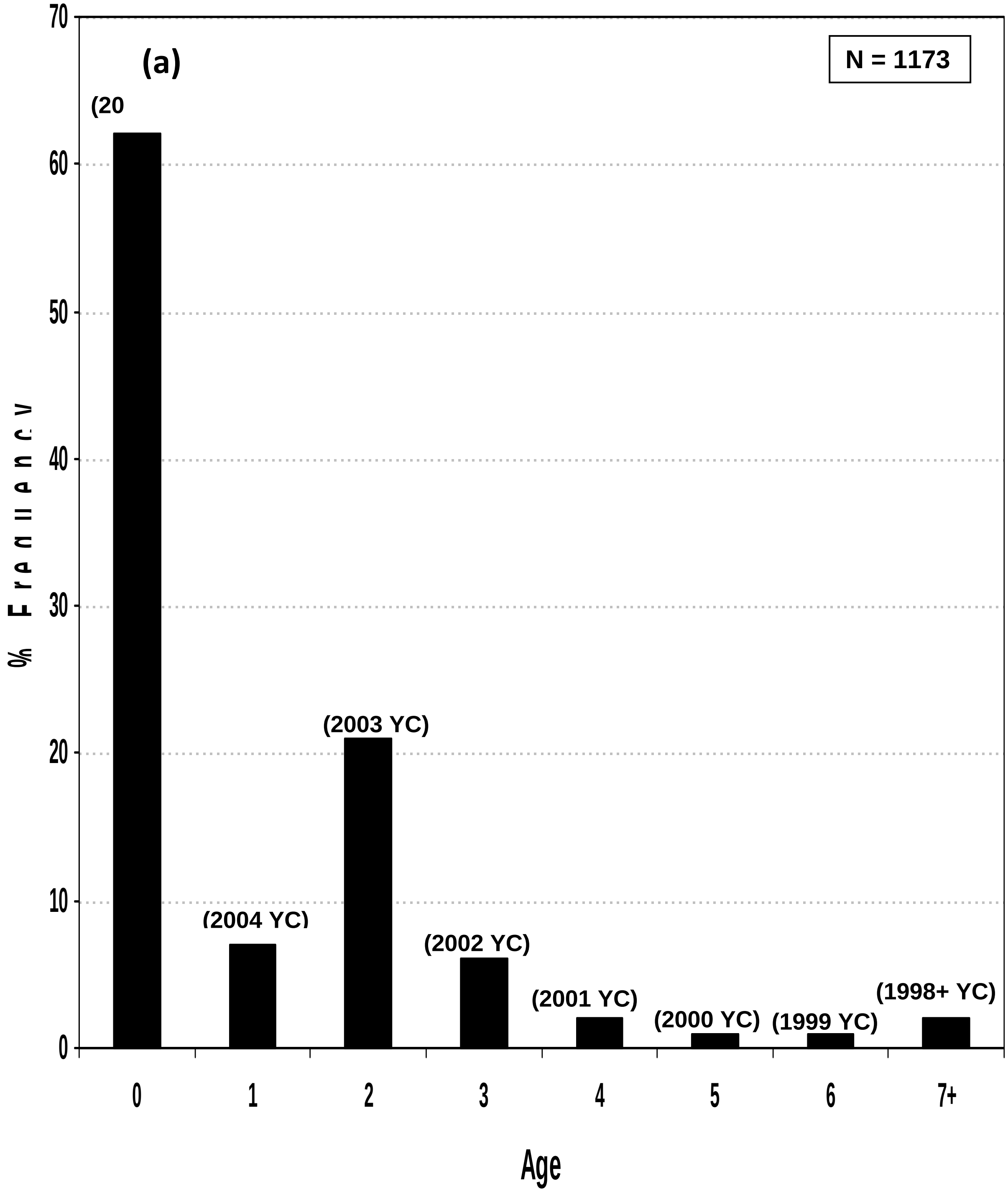
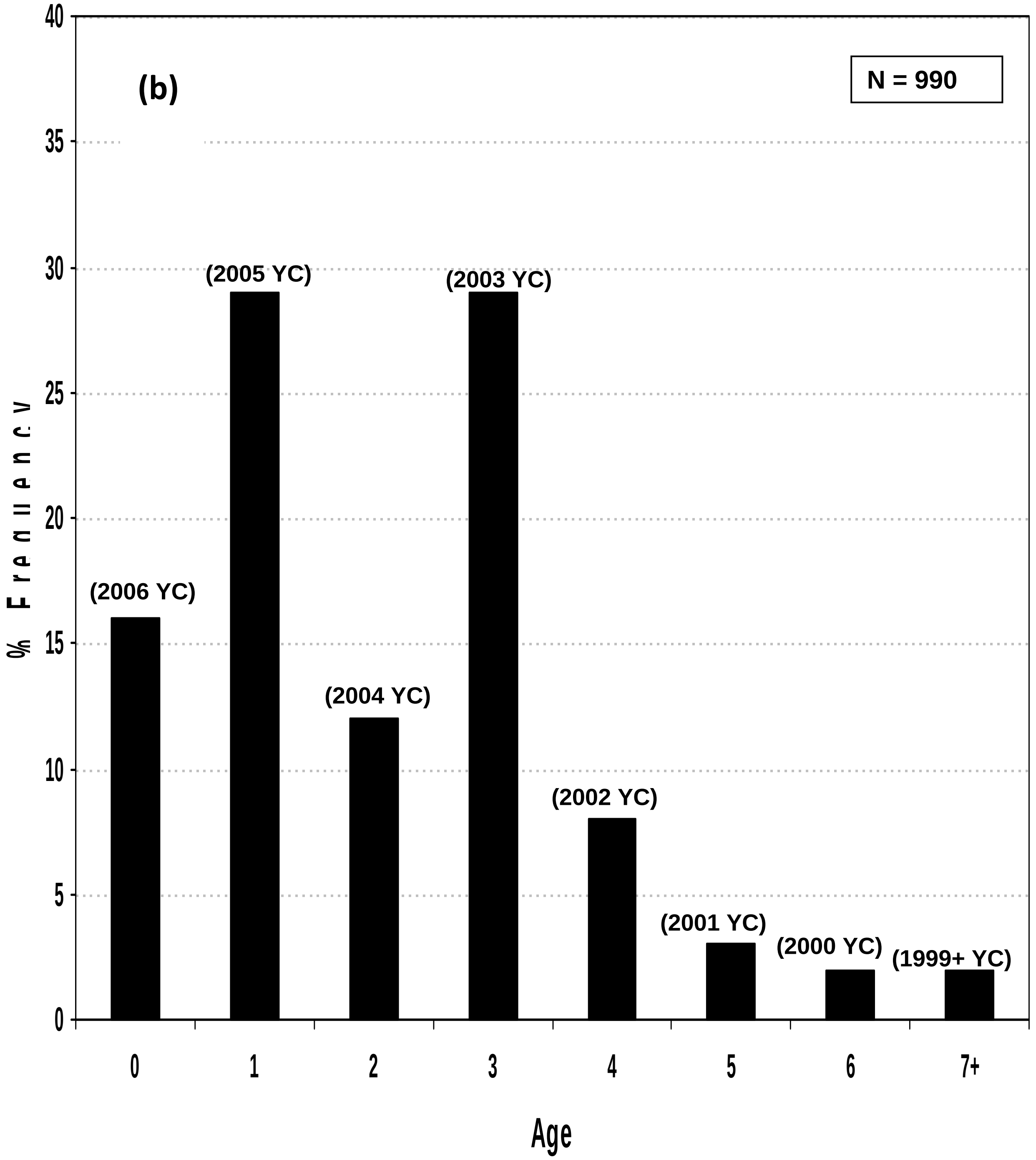
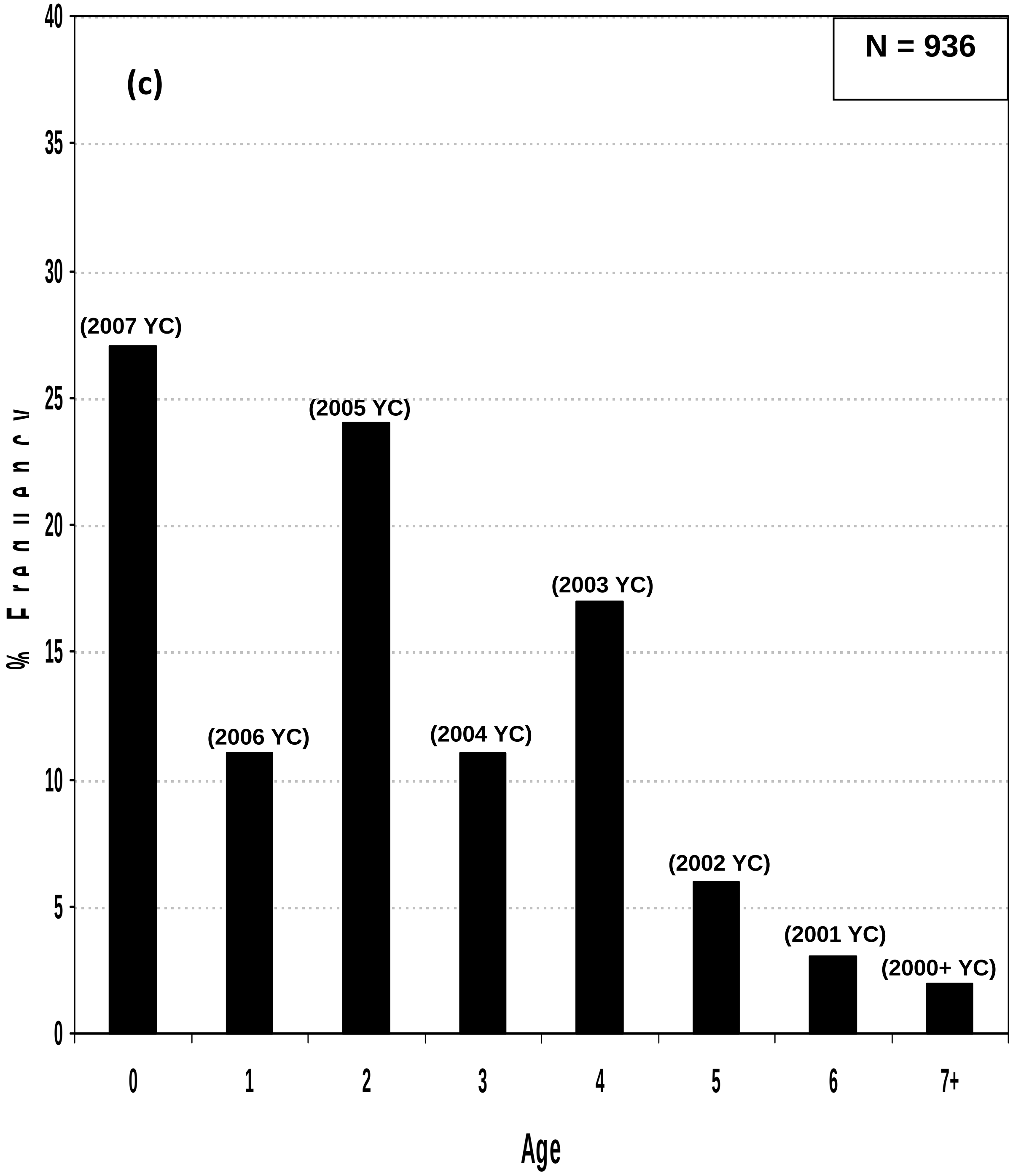


Figure 14. Age distribution of largemouth bass collected by electrofishing in the Apalachicola River-floodplain system (a) in September 2005, (b) in September 2006, and (c) in September 2007. YC=year class.


(b)
N = 990
% Frequency
0
5
10
15
20
25
30
35
40
(2006 YC)
(2005 YC)
(2004 YC)
(2003 YC)
(2002 YC)
(2001 YC)
(2000 YC)
(1999+ YC)
0
1
2
3
4
5
6
7+
Age


(c)
N = 936
% Frequency
0
5
10
15
20
25
30
35
40
(2007 YC)
(2006 YC)
(2005 YC)
(2004 YC)
(2003 YC)
(2002 YC)
(2001 YC)
(2000+ YC)
0
1
2
3
4
5
6
7+
Age

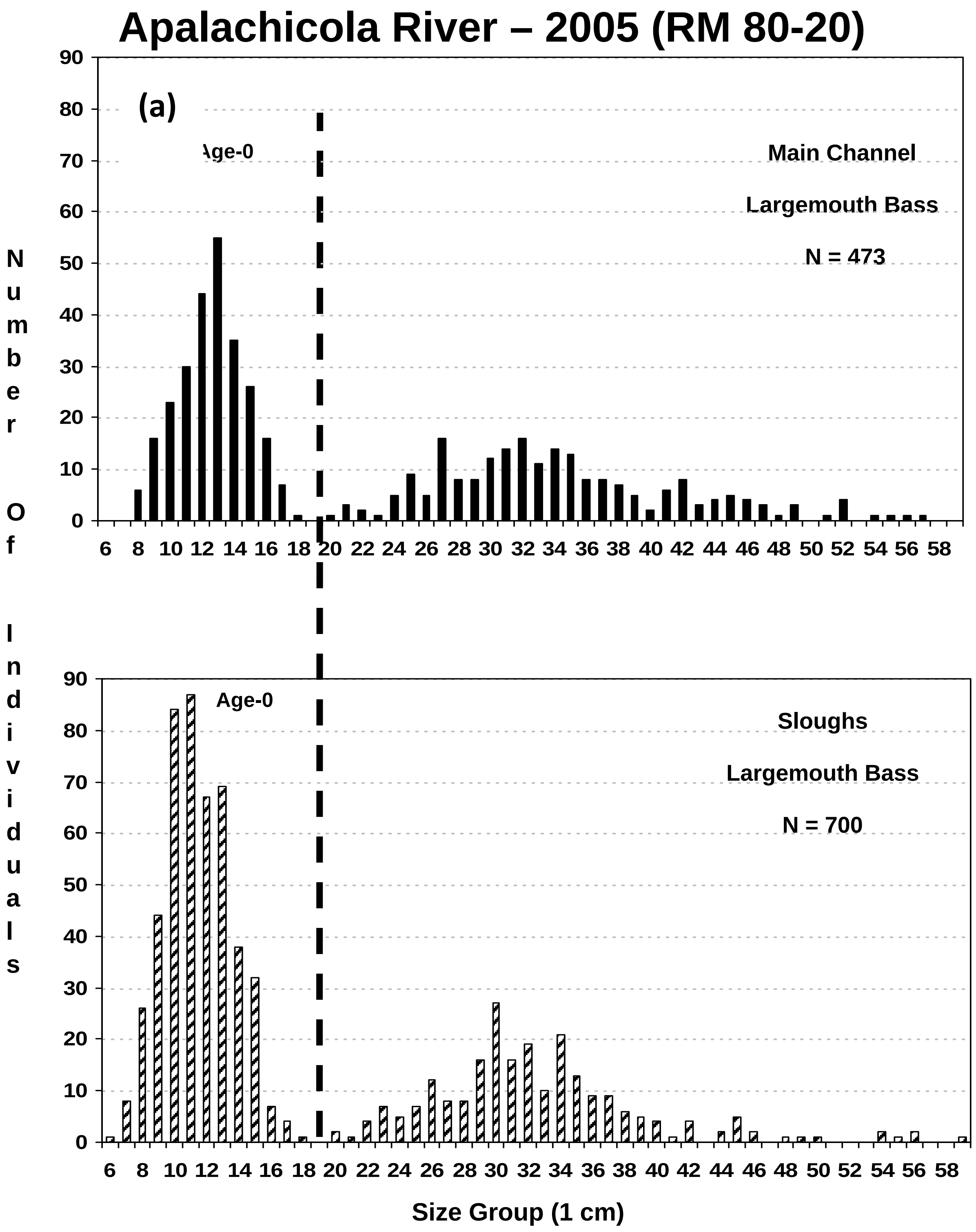
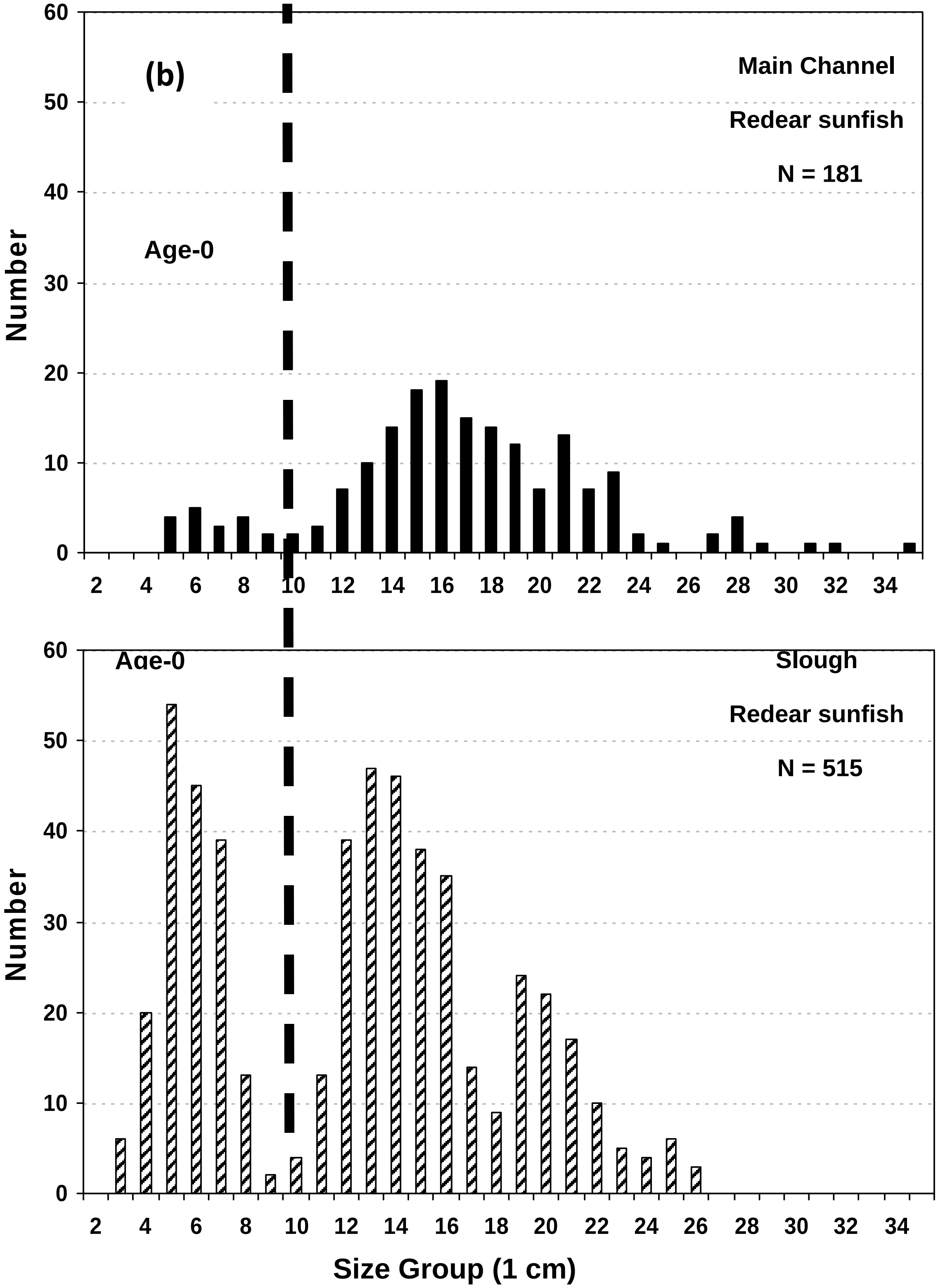
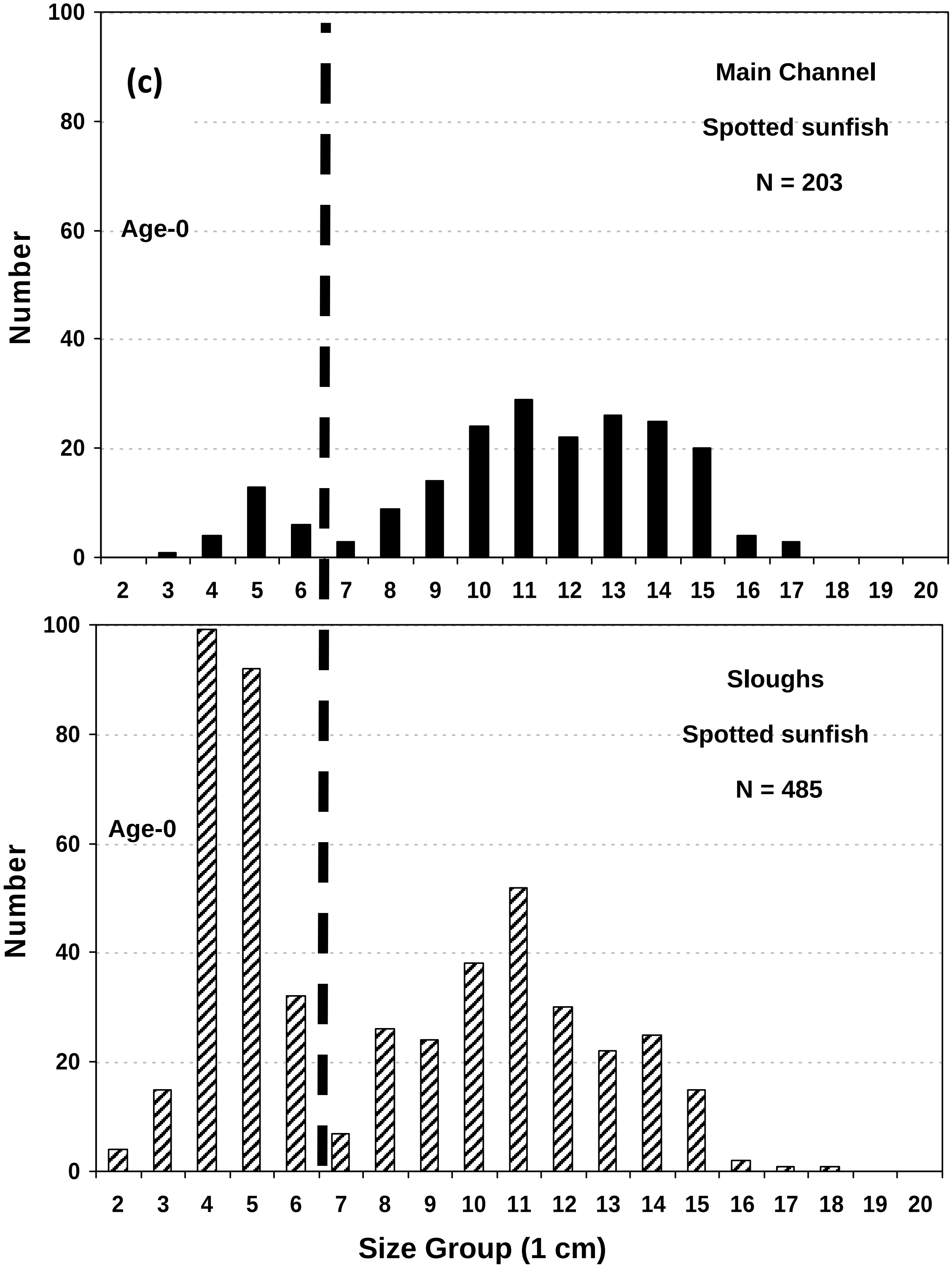
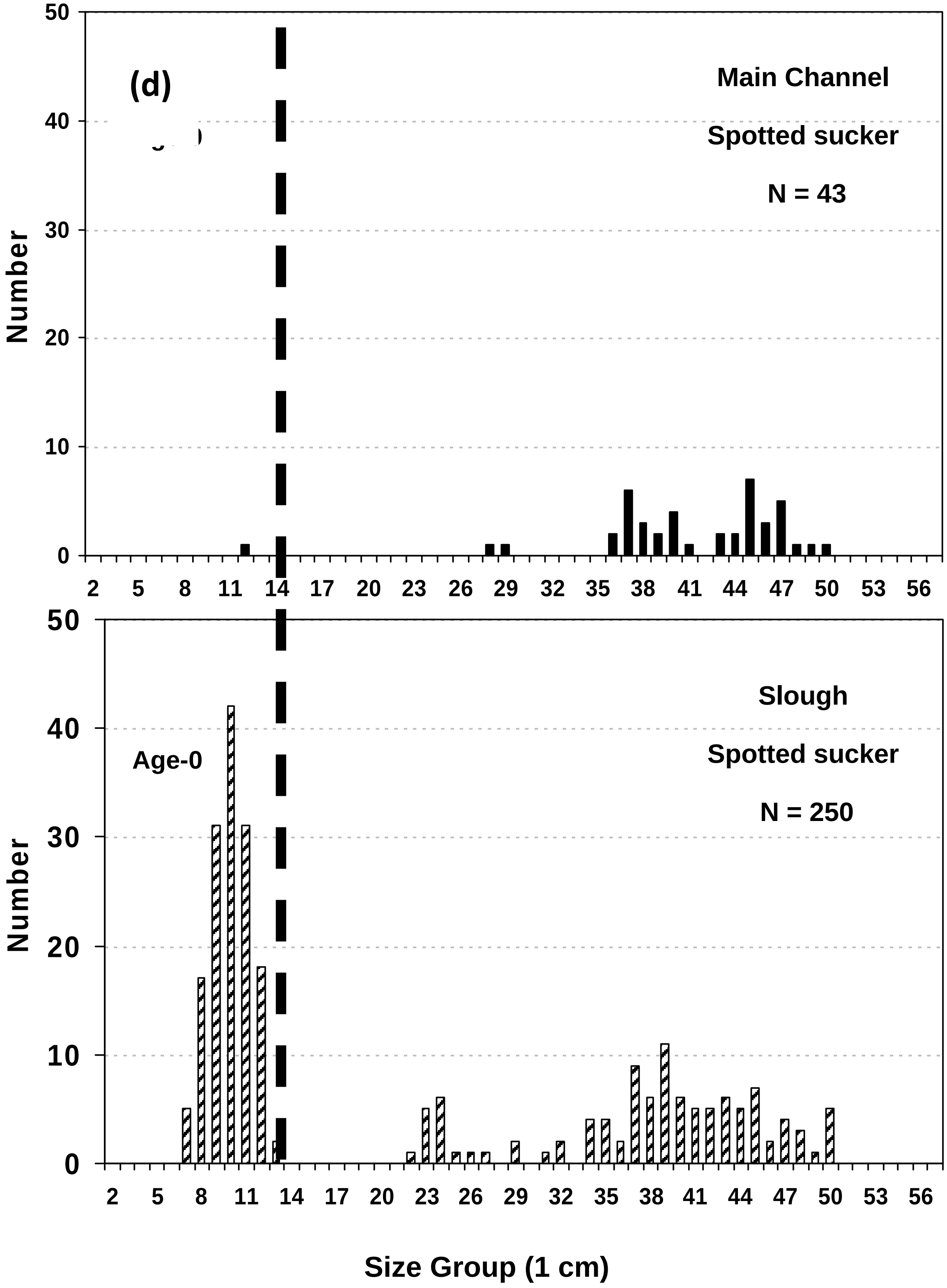


Figure 15. Size distribution of fish collected by electrofishing in the Apalachicola River main channel and sloughs in September 2005 (a) largemouth bass, (b) redear sunfish, (c) spotted sunfish, and (d) spotted suckers. Electrofishing effort was equal in main channel and sloughs. A total of 100 samples (10 minutes/sample) were collected, with 50 samples in the main channel and 50 samples in the sloughs.


(b)
Main Channel
Redear sunfish
N = 181
Age-0
Number
60
50
40
30
20
10
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
Age-0
Slough
Redear sunfish
N = 515
Number
Size Group (1 cm)


(c)
Main Channel
Spotted sunfish
N = 203
Age-0
Number
100
80
60
40
20
0
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
Sloughs
Spotted sunfish
N = 485
Age-0
Number
Size Group (1 cm)


(d)
Main Channel
Spotted sucker
N = 43
Number
0
10
20
30
40
50
2 5 8 11 14 17 20 23 26 29 32 35 38 41 44 47 50 53 56
Slough
Spotted sucker
N = 250
Age-0
Number
0
10
20
30
40
50
2 5 8 11 14 17 20 23 26 29 32 35 38 41 44 47 50 53 56
Size Group (1 cm)

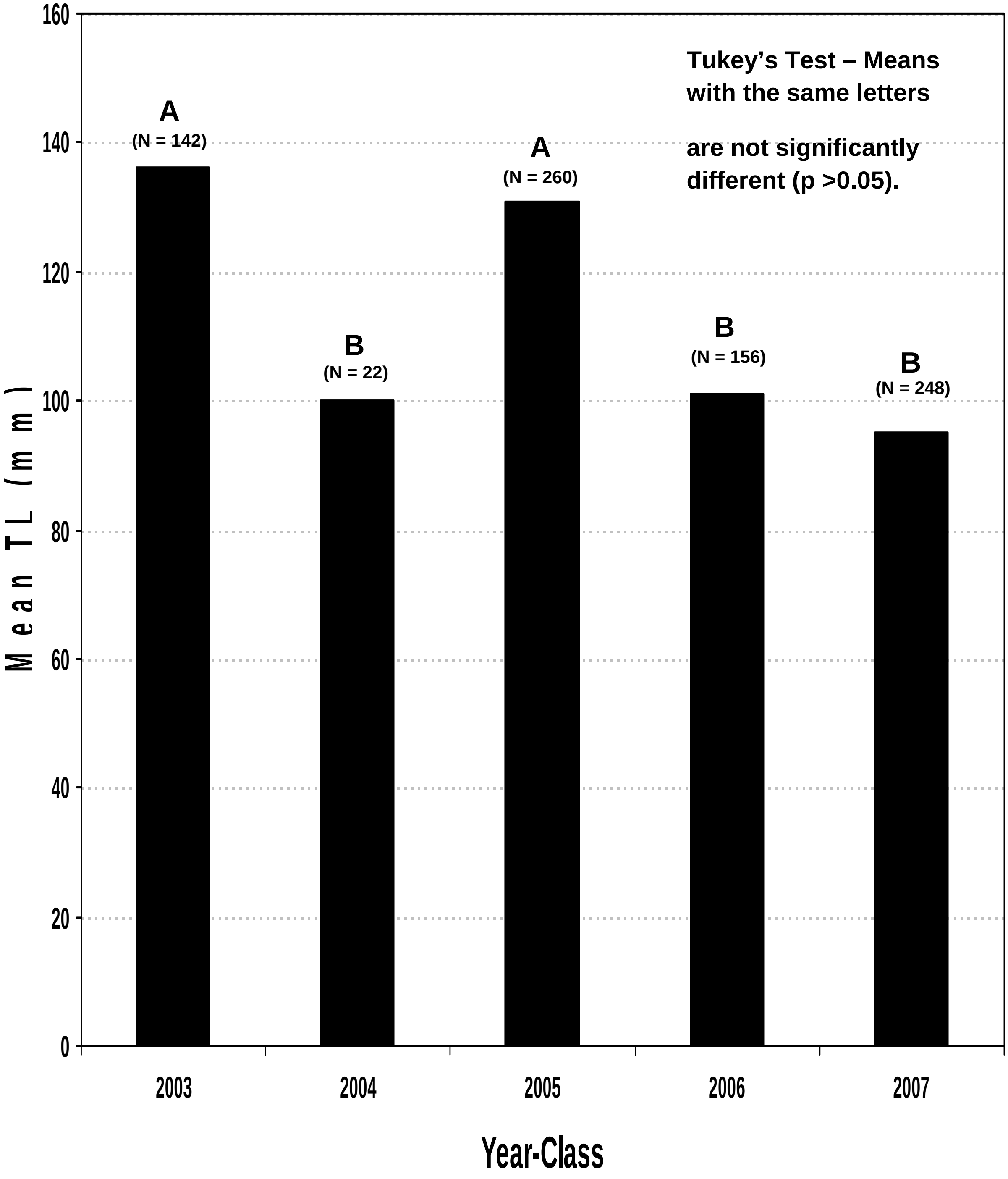


Figure 16. Mean total length (mm) of age-0 largemouth bass collected by electrofishing in the Apalachicola River sloughs and main channel in September. (High spring-summer flows in 2003 and 2005; low spring-summer flows in 2004, 2006, and 2007). Means with the same letters are not significantly different (p>0.05, Tukey's Test). Unpublished data, Charles Mesing, FWC, 2008.

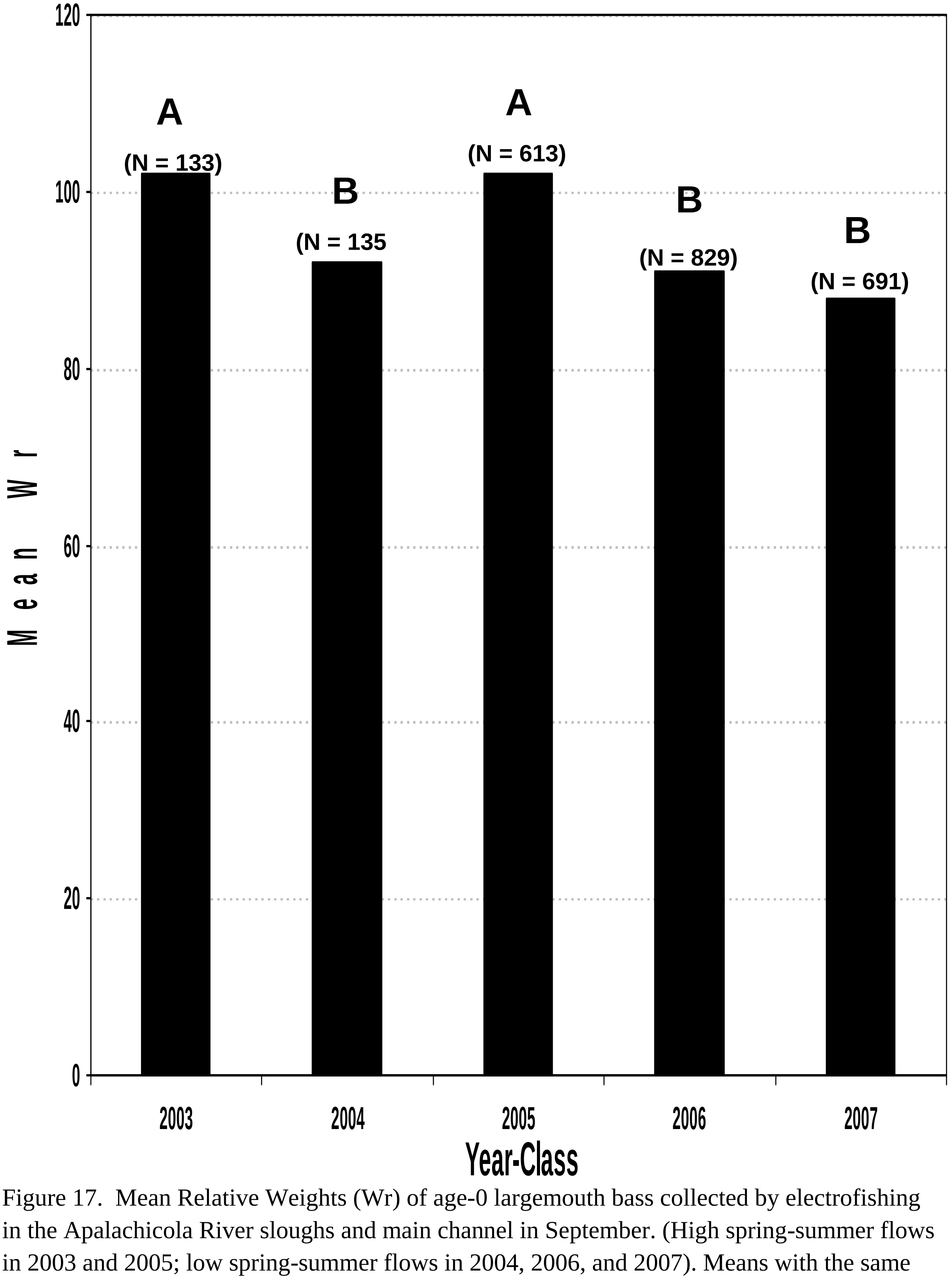


Figure 17. Mean Relative Weights (Wr) of age-0 largemouth bass collected by electrofishing in the Apalachicola River sloughs and main channel in September. (High spring-summer flows in 2003 and 2005; low spring-summer flows in 2004, 2006, and 2007). Means with the same letters are not significantly different (p>0.05, Tukey's Test).

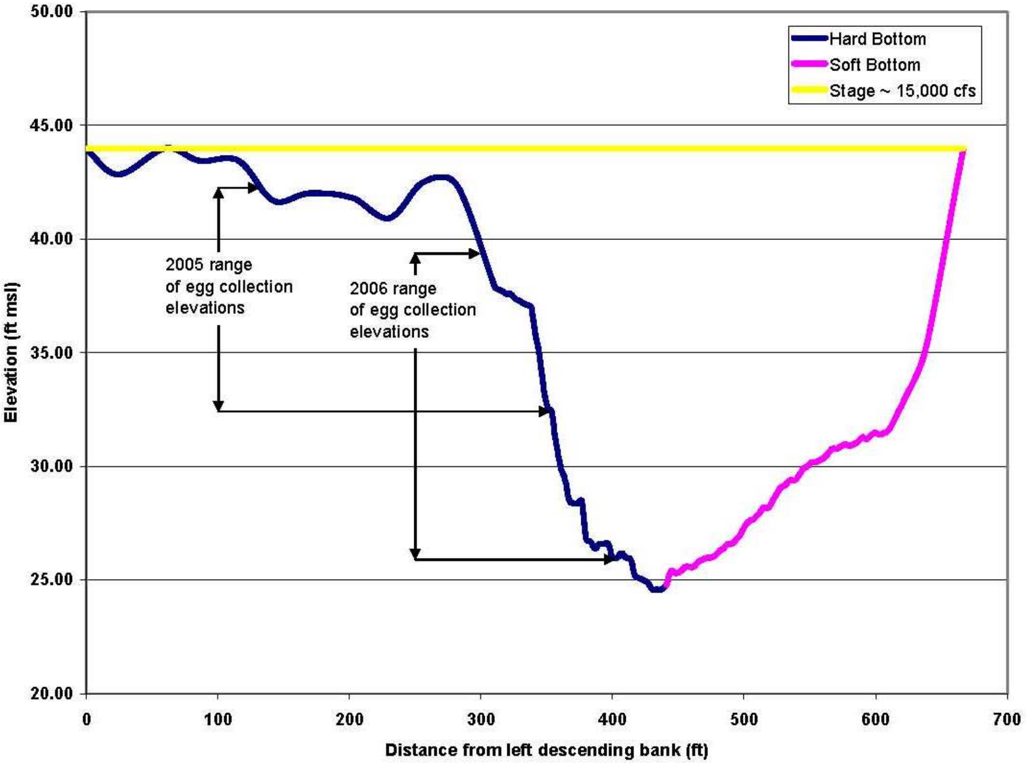
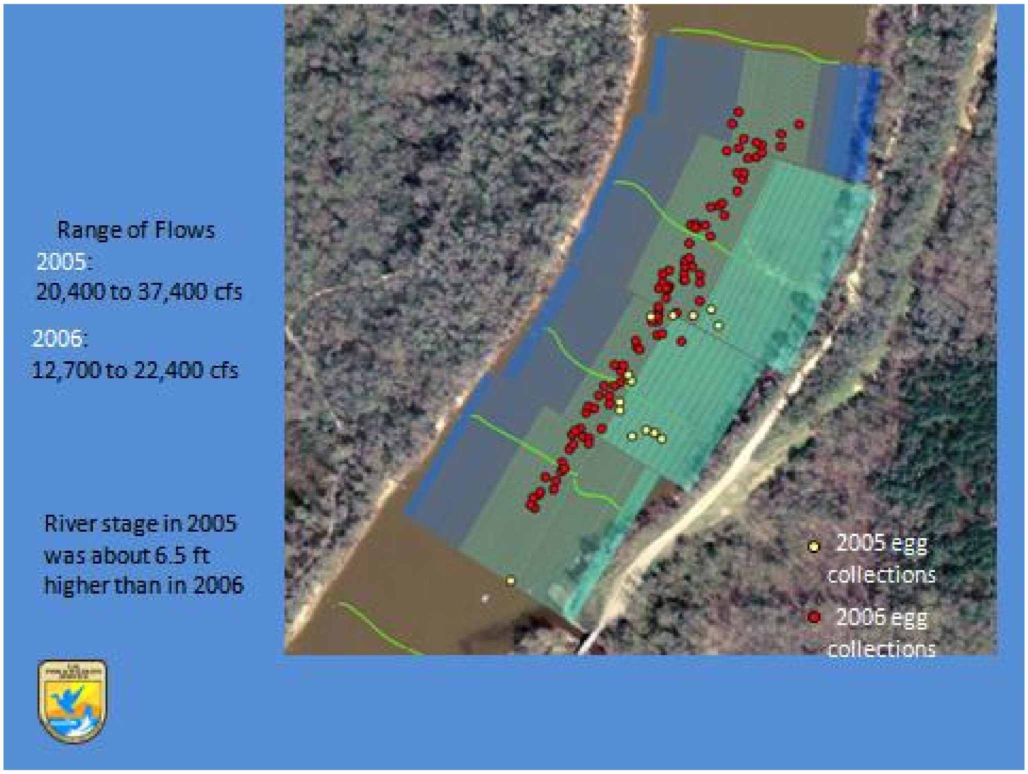


Figure 3.6.1.4.B. Cross section of the river at RM 105, which spans the limestone shoal where sturgeon eggs were collected in both 2005 and 2006.

Figure 18. Cross section of the river at RM 105, which spans the limestone shoal where sturgeon eggs were collected in both 2005 and 2006. From Biological Opinion (USFWS, 2008).



Range of Flows
2005:
20,400 to 37,400 cfs

2006:
12,700 to 22,400 cfs

River stage in 2005 was about 6.5 ft higher than in 2006

Figure 19. Gulf sturgeon egg collections during the 2005 and 2006 spawning season superimposed on the Race Shoal site depth grid. Lower flows and stages in 2006 appear to restrict collections to a narrower range of depth of the limestone outcrop. From Scollan and Parauka (2008).

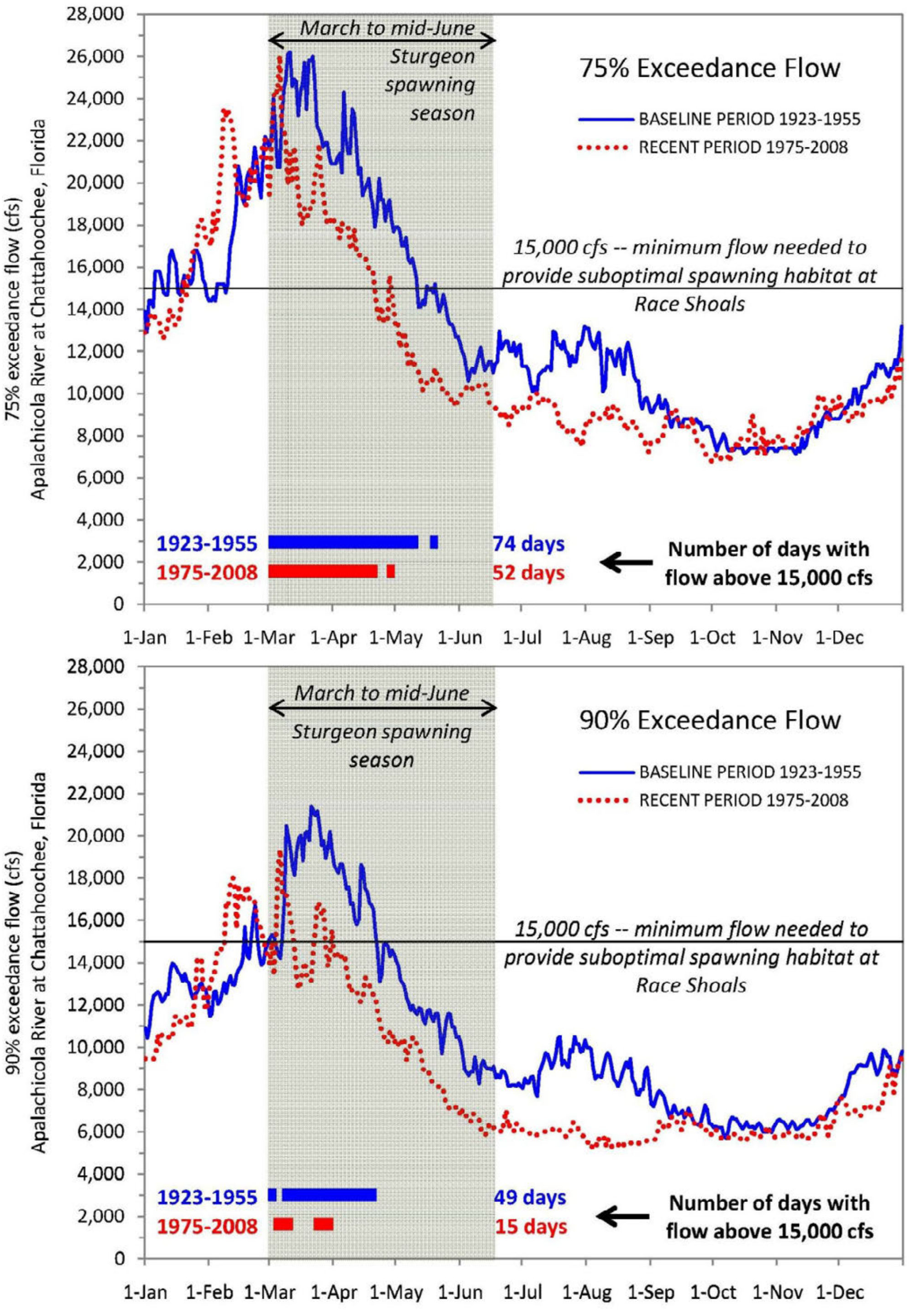


Figure 20. Decrease in availability of sturgeon spawning habitat at Race Shoal in March through May during dry (75% exceedance) and drought (90% exceedance) conditions. Hydrographs show 90% exceedance flows in the earliest 33 years (1923-1955) and the latest 34 years (1975-2008) of the period of record for Apalachicola River at Chattahoochee, Florida. [Flow data from USGS, 2010; see text for discussion of sturgeon spawning habitat and hydrology section for explanation of flow hydrographs.]

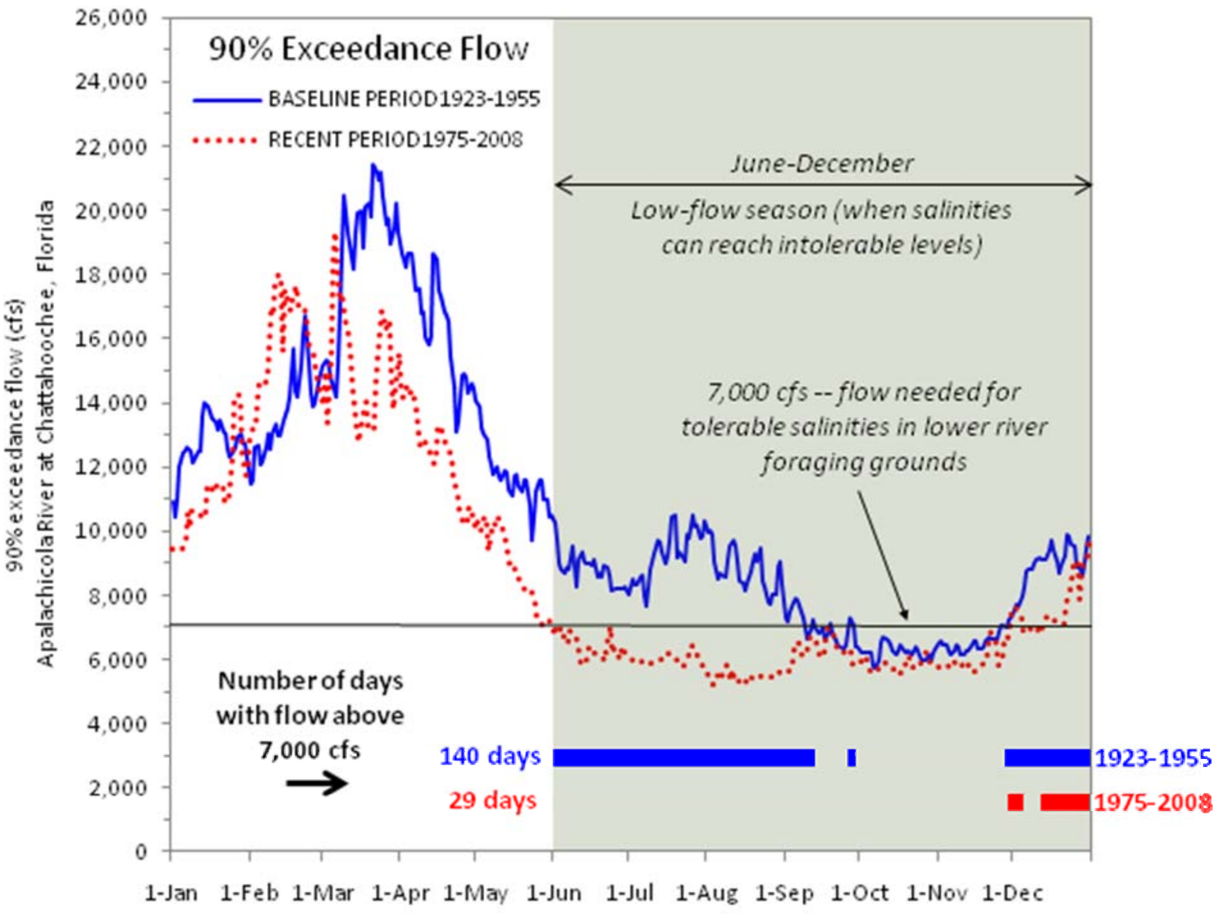


Figure 21. Decrease in availability of lower river foraging grounds with tolerable salinities for juvenile sturgeon in June through December during drought conditions. Hydrographs show 90% exceedance flows in the earliest 33 years (1923-1955) and the latest 34 years (1975-2008) of the period of record for Apalachicola River at Chattahoochee, Florida. [Flow data from USGS, 2010; see text for discussion of juvenile sturgeon foraging habitat requirements.]

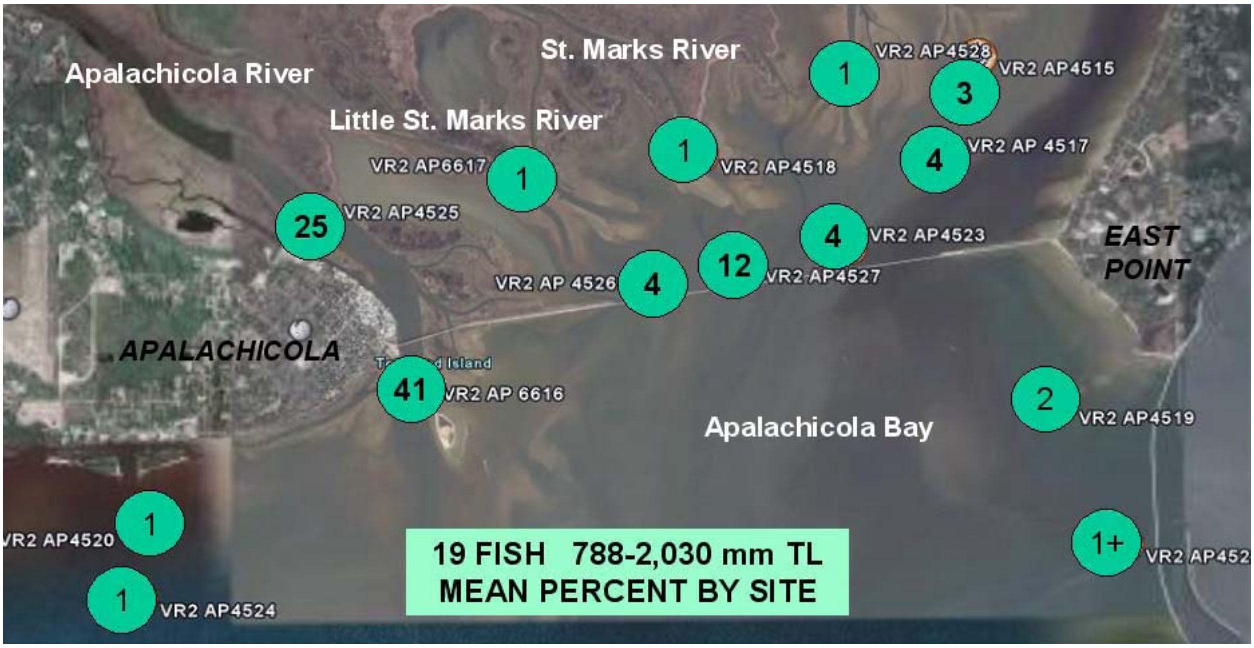
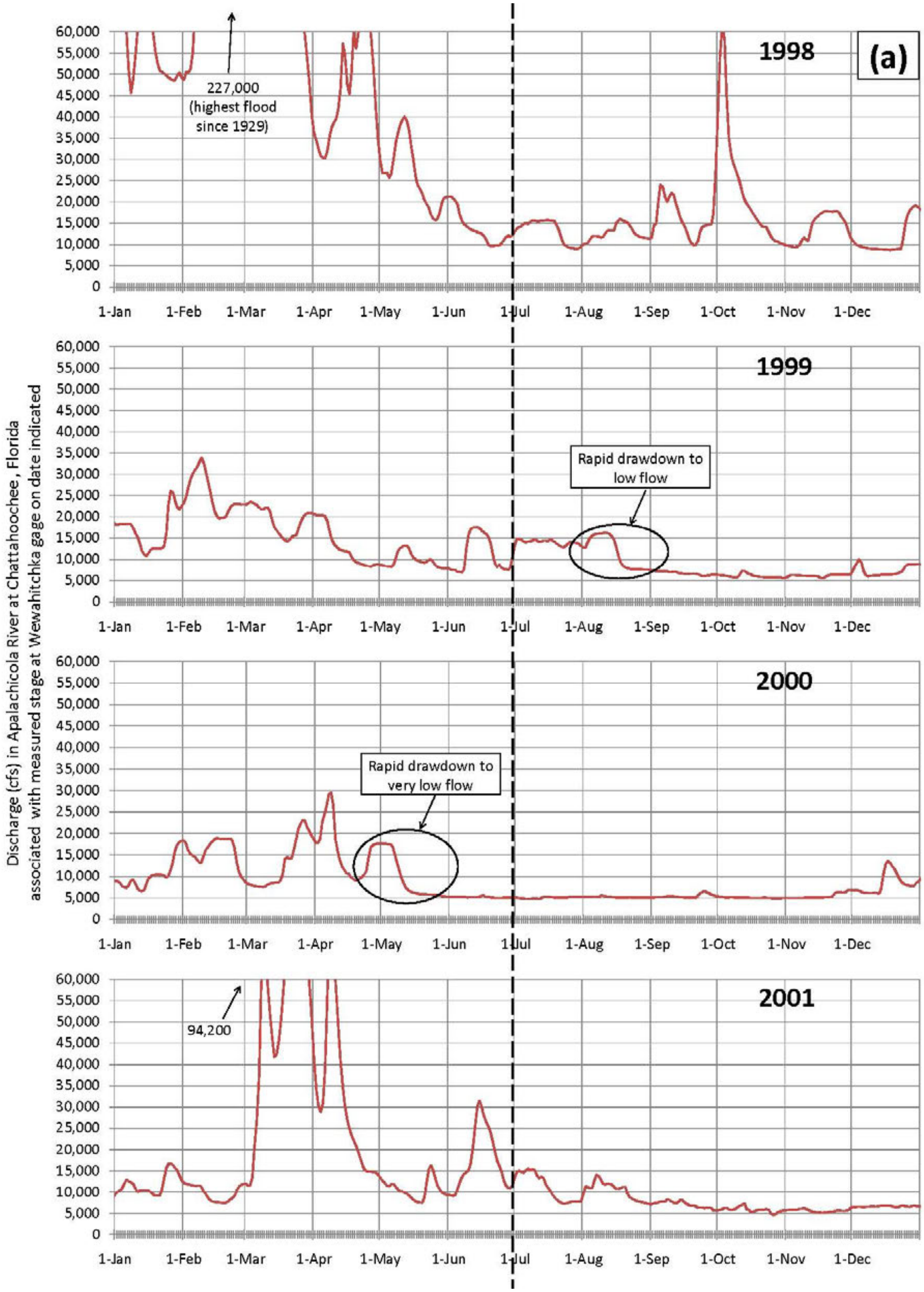
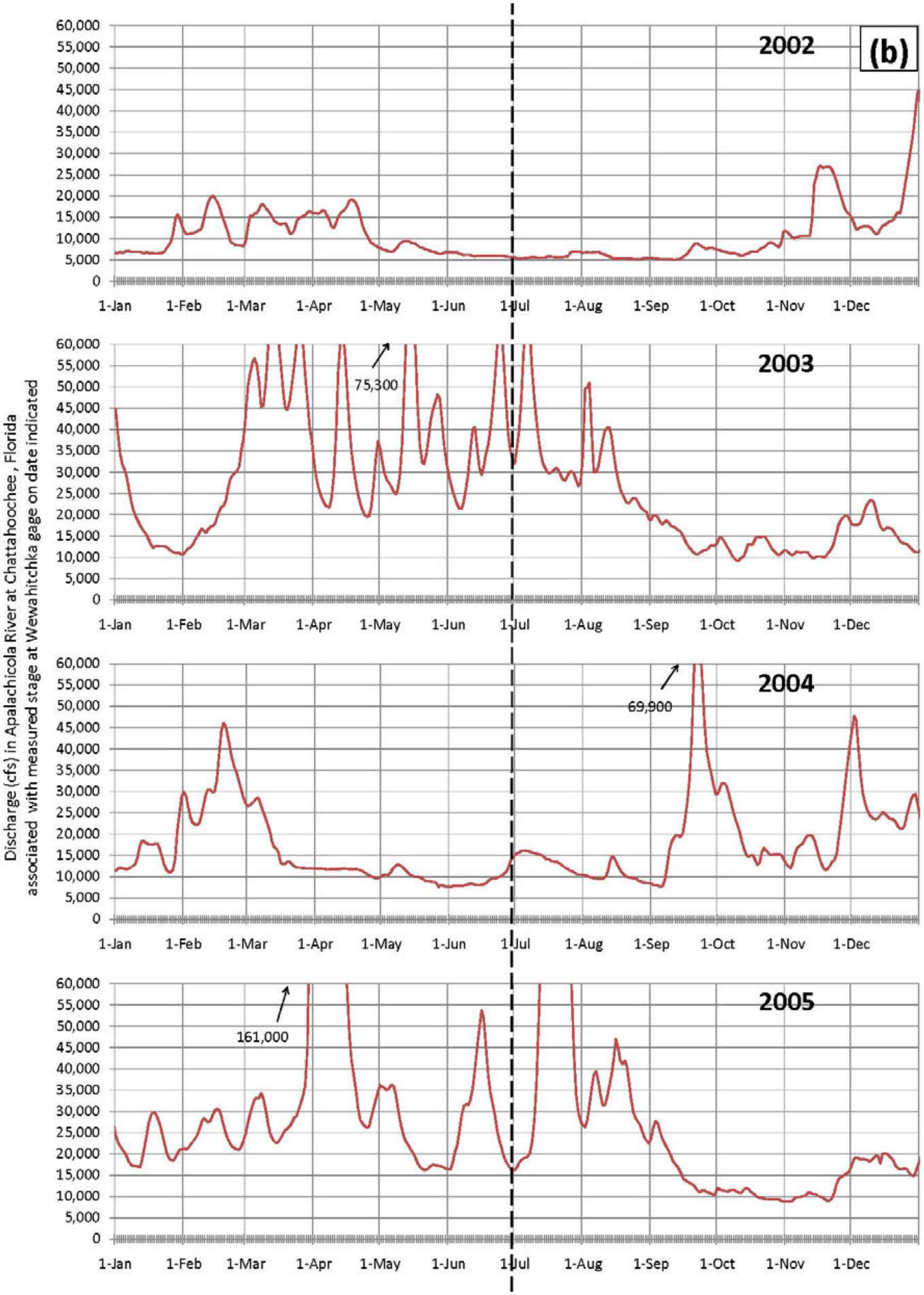


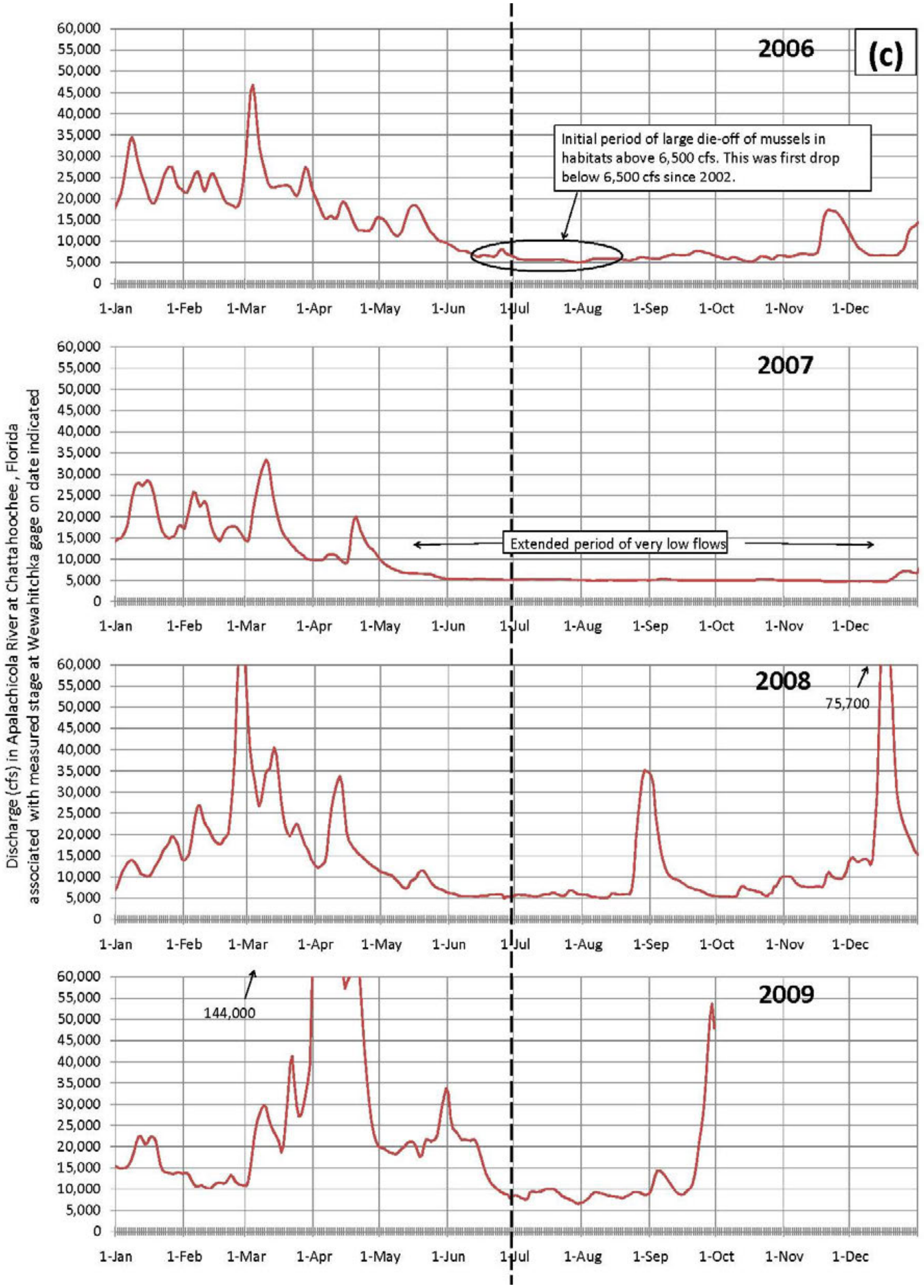
Figure 22. Distribution of Gulf sturgeon encounters during October 2006 through March 2007 while salinities were low in the distributaries of the delta and Bay margin. Of the 19 fish tagged, only 3 were detected after release. Numbers in the green dots represent frequency of encounters. From Sulak et al. (2009).

Figure 23. (on the following 3 pages). Annual flow hydrographs for the Apalachicola River (a) 1998 – 2001, (b) 2002 – 2005, (c) 2006 – 2009. The dashed line extending vertically through all the graphs at July 1 was added as a guide to facilitate year-to-year comparisons of summer flows. Flows above 60,000 cfs are not shown except for annotations on annual peaks. These hydrographs are based on river stage at the Wewahitchka gage (Wewa) because the largest populations of listed mussels are located in that reach of the river. Average discharge at the Chattahoochee gage associated with Wewa stage observed on the indicated dates was estimated using Wewa-Chattahoochee gage ratings modified from Light et al. (2006). Travel time from the Chattahoochee to Wewa gages has been accounted for in these graphs.


(a)
1998
227,000
(highest flood
since 1929)
1999
Rapid drawdown to
low flow
2000
Rapid drawdown to
very low flow
2001
94,200
Discharge (cfs) in Apalachicola River at Chattahoochee, Florida
associated with measured stage at Wewahitchka gage on date indicated
60,000
55,000
50,000
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec

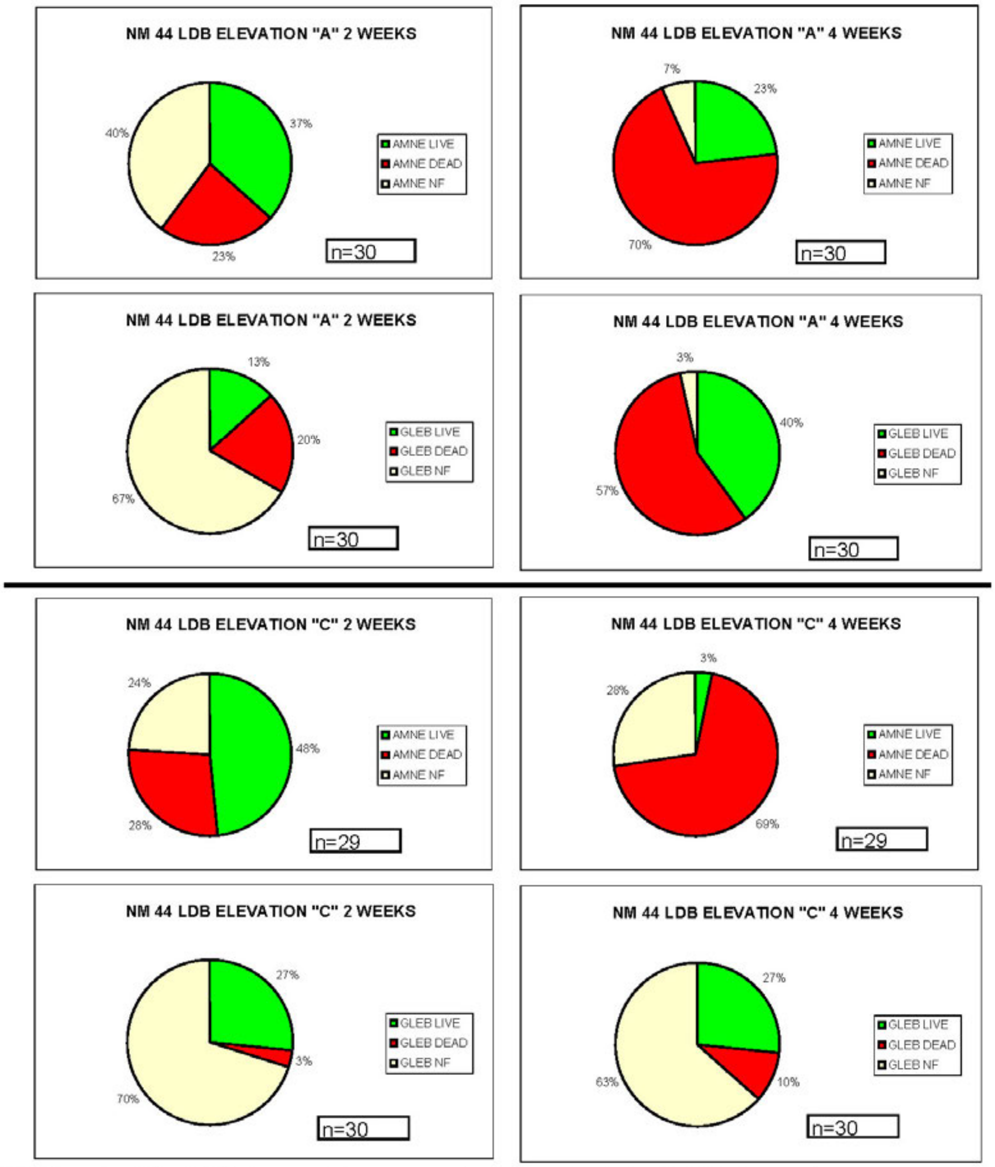


(b)
2002
2003
2004
2005
75,300
69,900
161,000
Discharge (cfs) in Apalachicola River at Chattahoochee, Florida associated with measured stage at Wewahitchka gage on date indicated
60,000
55,000
50,000
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec



Initial period of large die-off of mussels in habitats above 6,500 cfs. This was first drop below 6,500 cfs since 2002.

Extended period of very low flows



High Elevation "A" = (1.6ft above pool) Low Elevation "C" = (0.08ft below pool)
Pool elevation calc. = 94.01at 11:39 AM Central 6-14-06 Chatta. Gage ~5840 at dam

AMNE = *Amblema neslerii* (endangered fat threeridge)
GLEB = *Glebula rotundata* (non-listed round pearshell)
NF = not found

Figure 24. Results of mark and recapture at two elevations, Apalachicola River NM (RM) ~44.3 on 6/13/2006, 6/28/2006, and 7/12/2006. Mark and recapture studies of the fat threeridge on a channel margin area of the main stem at two elevations on the Apalachicola River found approximately 25% mortality after two weeks of exposure, and approximately 70% mortality after four weeks of exposure. The non-listed round pearlshell was found to have a greater tolerance to exposure. Almost all mussels (>90%) at this site perished including those at elevation “C” (which was initially established as a control site, but all its mussels died when flows were reduced more than anticipated).

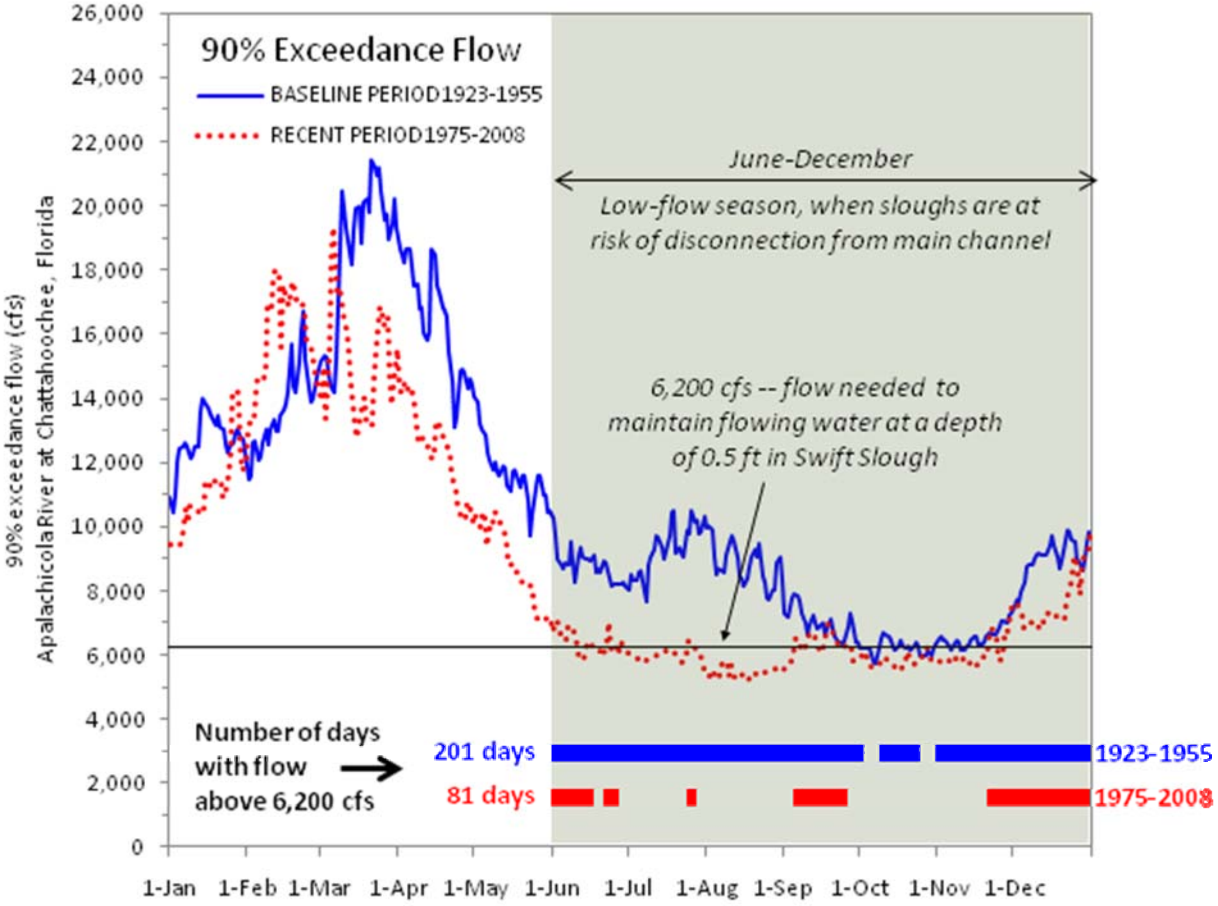


Figure 25. Decrease in availability of flowing-water for mussels in Swift Slough in June through December during drought (90% exceedance) conditions.

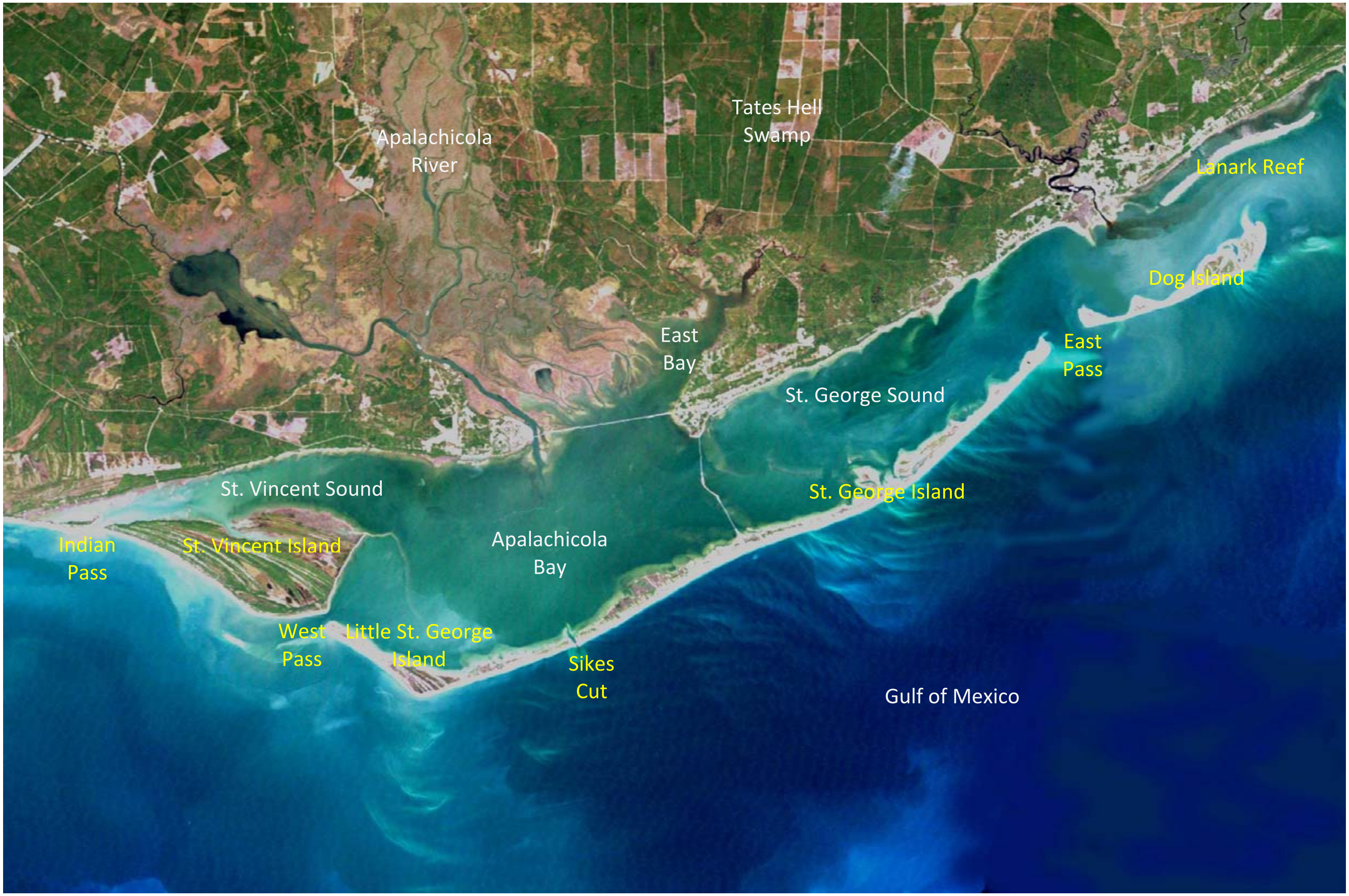


Figure 26. General location map of Apalachicola Bay showing prominent bay features including the four main sections of the bay, surrounding barrier islands and inlets/openings to the Gulf of Mexico.

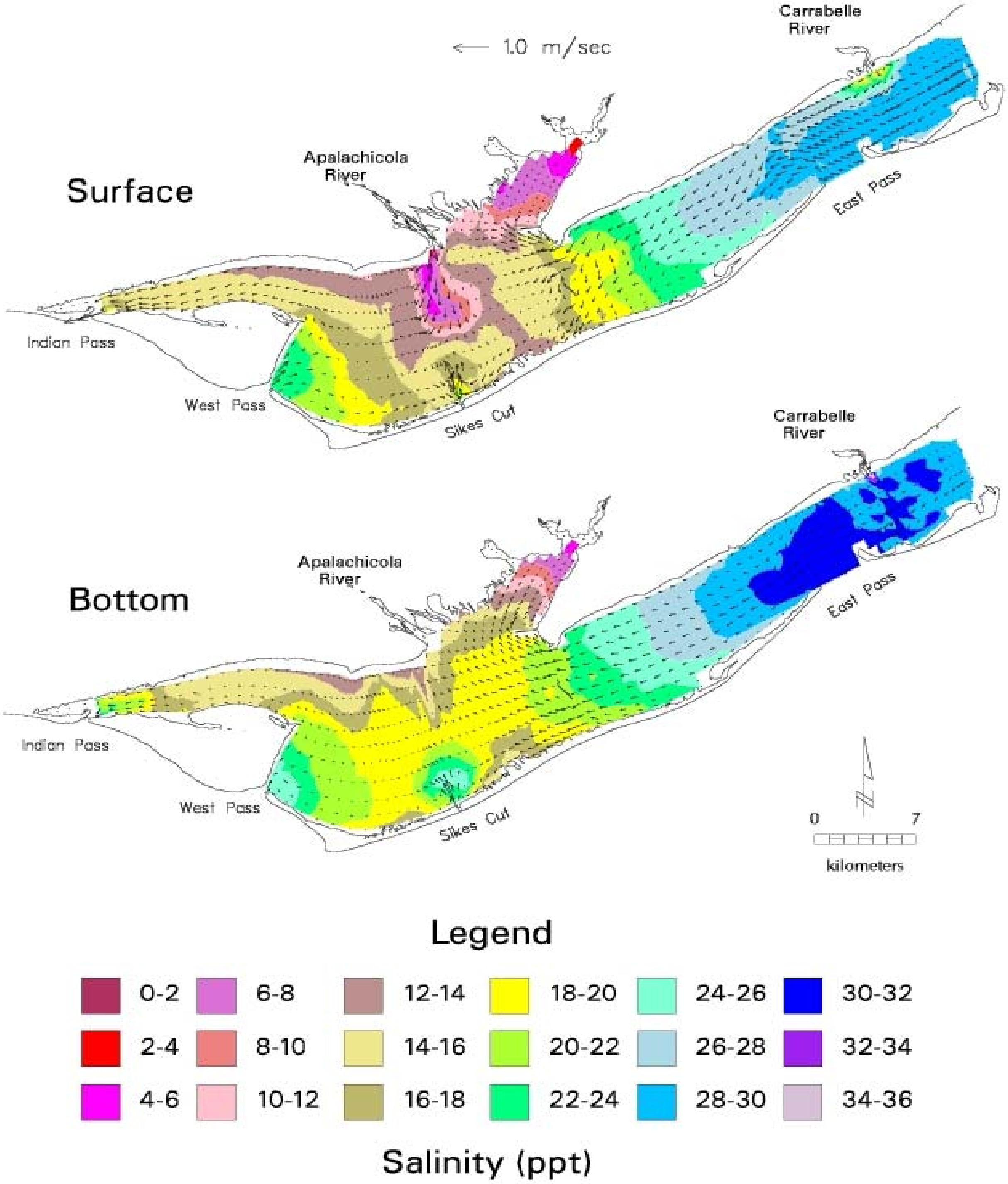


Figure 27. Horizontal salinity distribution in Apalachicola Bay showing hourly-averaged salinity. Surface (upper image) and bottom (lower image) salinity contours were generated using a 3-dimensional hydrodynamic model (Huang and Jones 1997). Ppt and psu are used interchangeable in this report to describe salinity units.

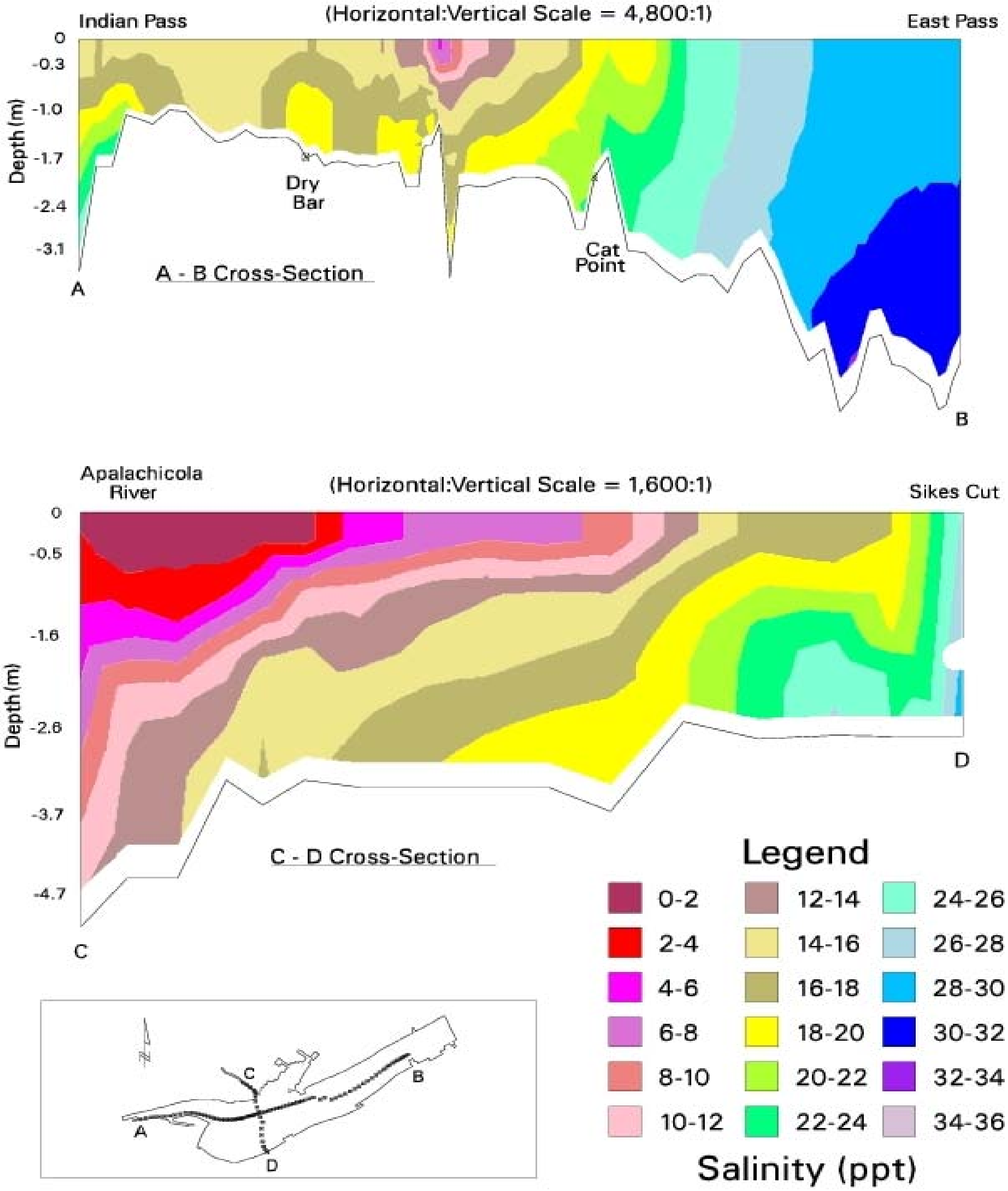


Figure 28. Vertical cross sections of Apalachicola Bay showing hourly-averaged salinity. Cross sections run east to west (A-B: upper image) and north to south (C-D: lower image). Salinity contours were generated using a 3-dimensional hydrodynamic model (Huang and Jones 1997).

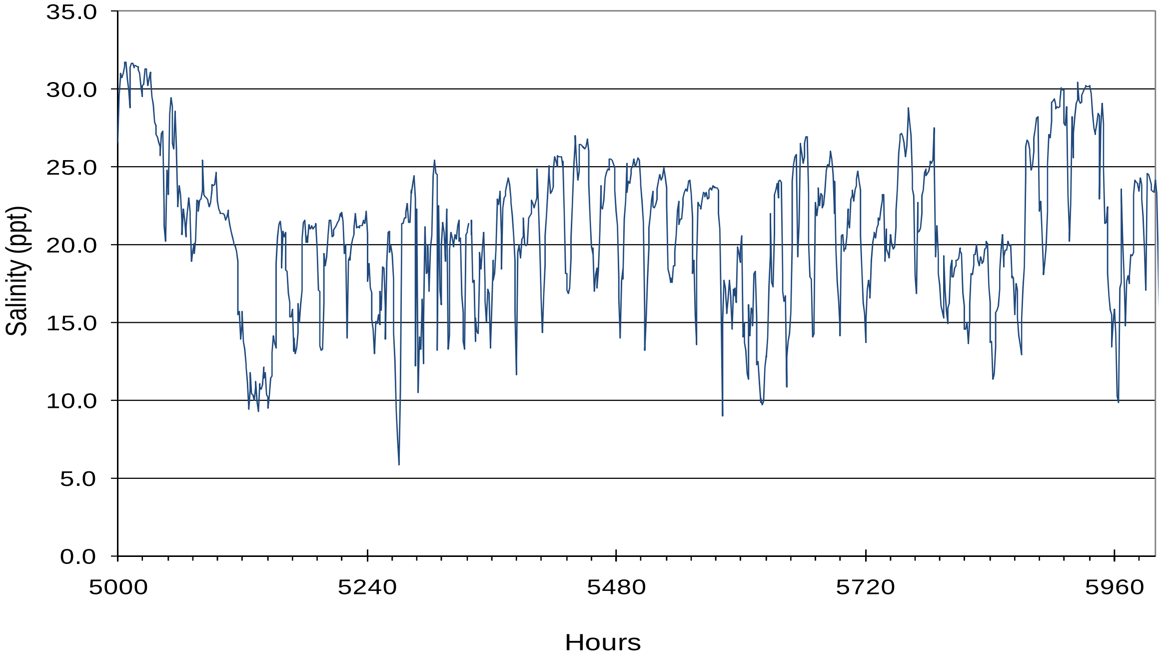


Figure 29. Short-term tidal salinity variation observed near Gorrie Bridge in lower East Bay. Hourly measurements are shown with figure intervals every 24 hours. Data were collected between 9/26-11/6/93. Data source: NWFWMD.

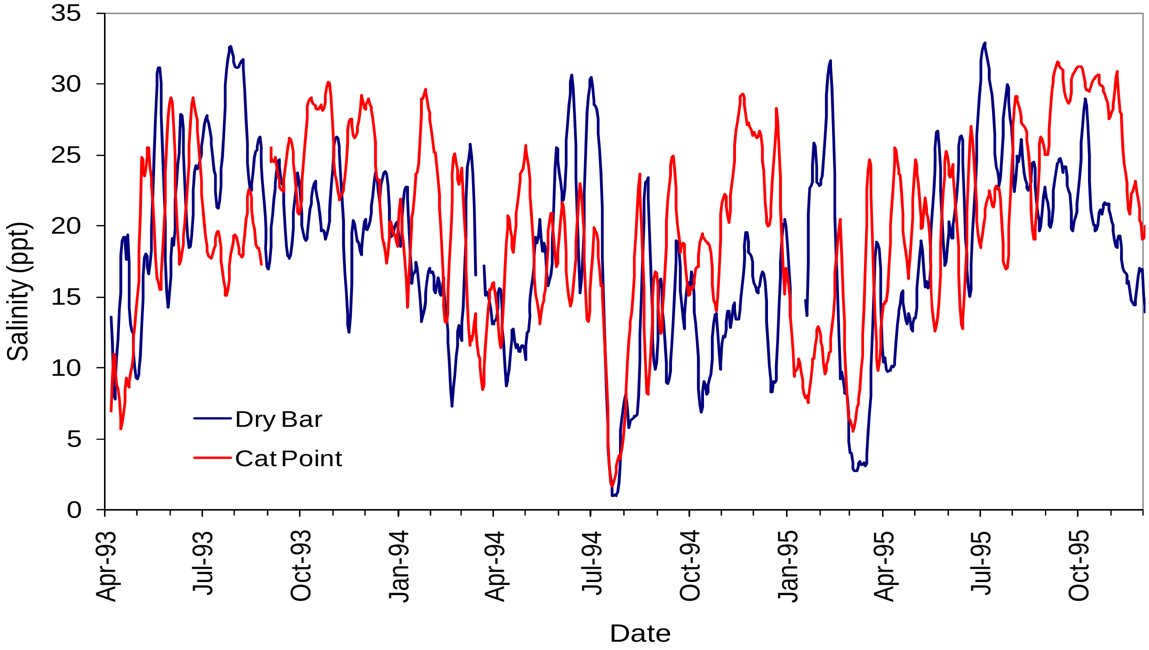


Figure 30. Weekly to monthly salinity variability observed at two sites in Apalachicola Bay. Data are shown as 7-day moving averages collected between 4/1/93-12/21/95. Data source: ANERR.

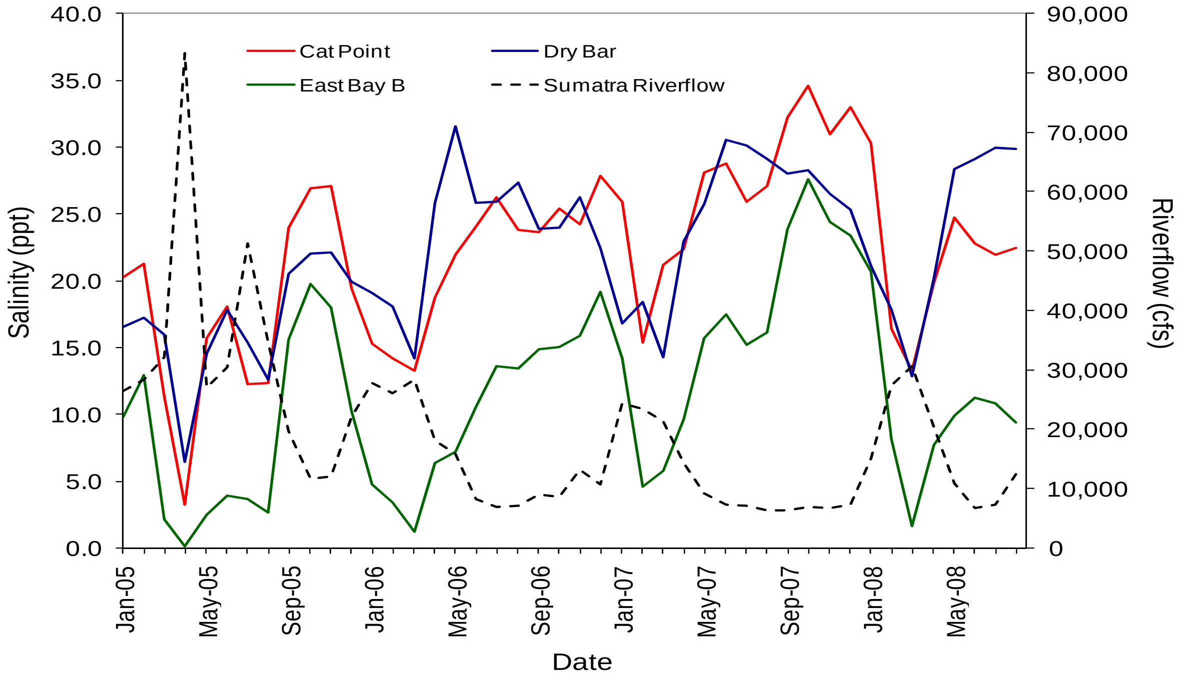


Figure 31. Seasonal salinity variation observed at three sites in Apalachicola Bay. Salinity values shown are monthly averages collected between 1/05-8/08. Mean monthly river flow is taken from the Sumatra gage. Data source: ANERR (salinity) and USGS (river flow).

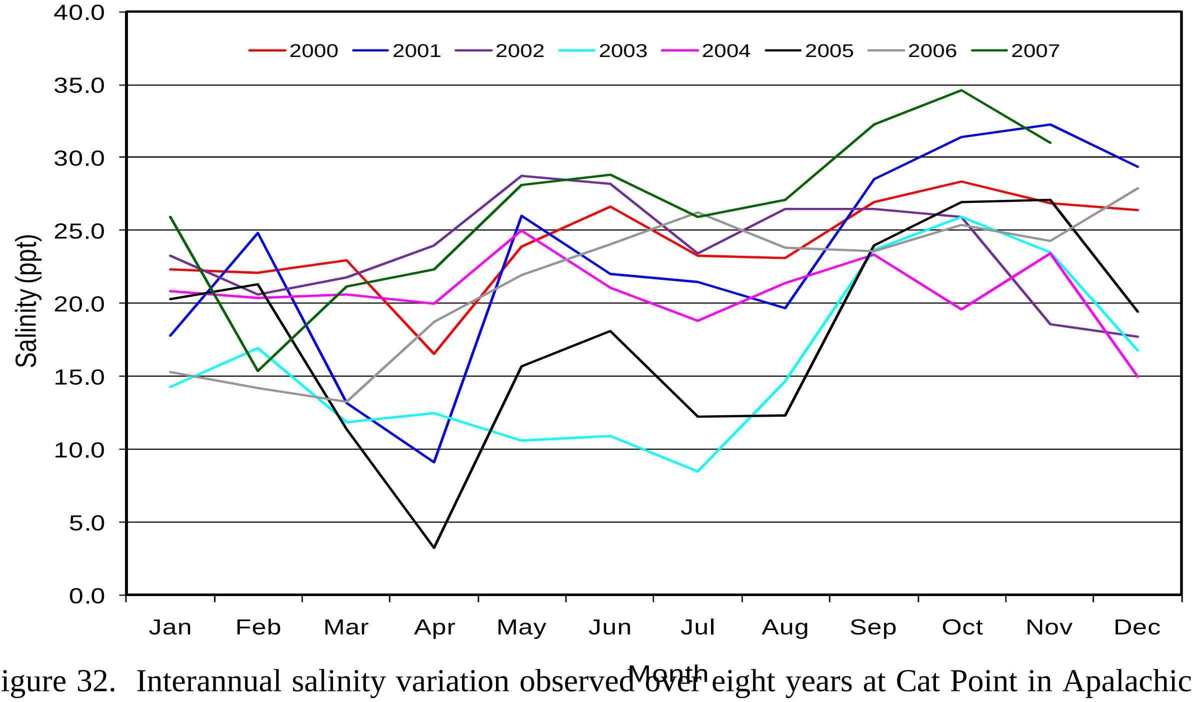


Figure 32. Interannual salinity variation observed over eight years at Cat Point in Apalachicola Bay. Salinity values are monthly averages shown by year collected between 2000 and 2007. Data source: ANERR.

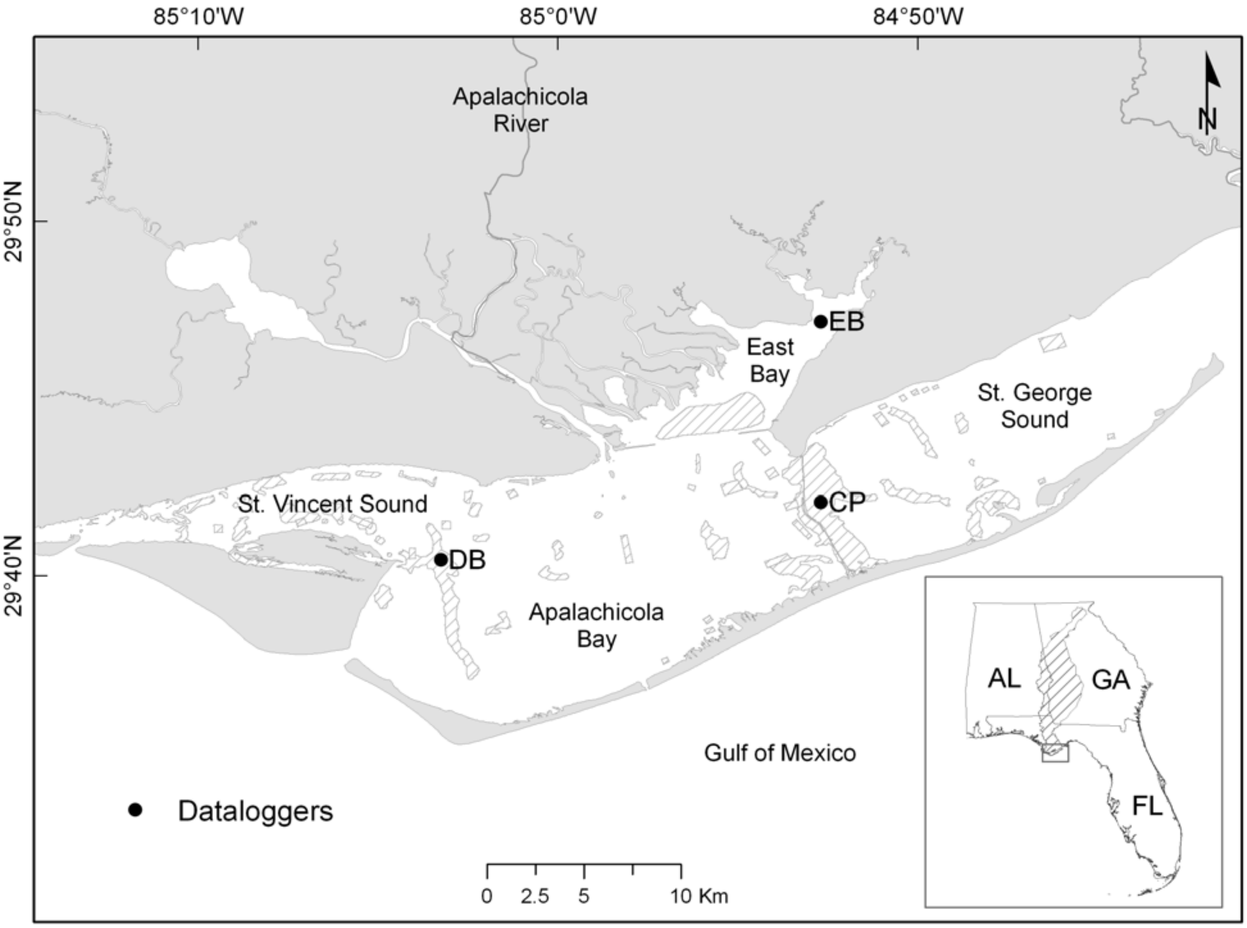
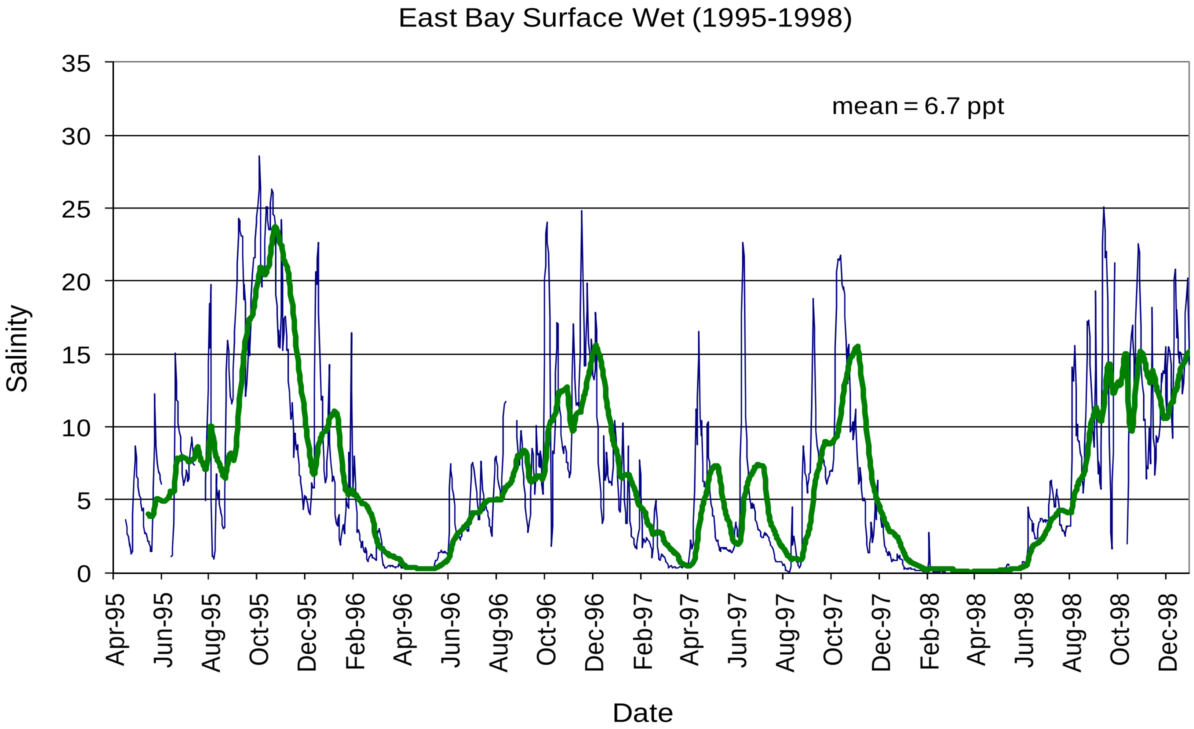


Figure 33. Location of ANERR dataloggers for collection of continuously recorded salinity measurements (15-30 min intervals; 1993 to present). Stations are: EB (upper East Bay), DB (Dry Bar) and CP (Cat Point). Cross-hatched areas in the bay indicate sites of major oyster reefs.



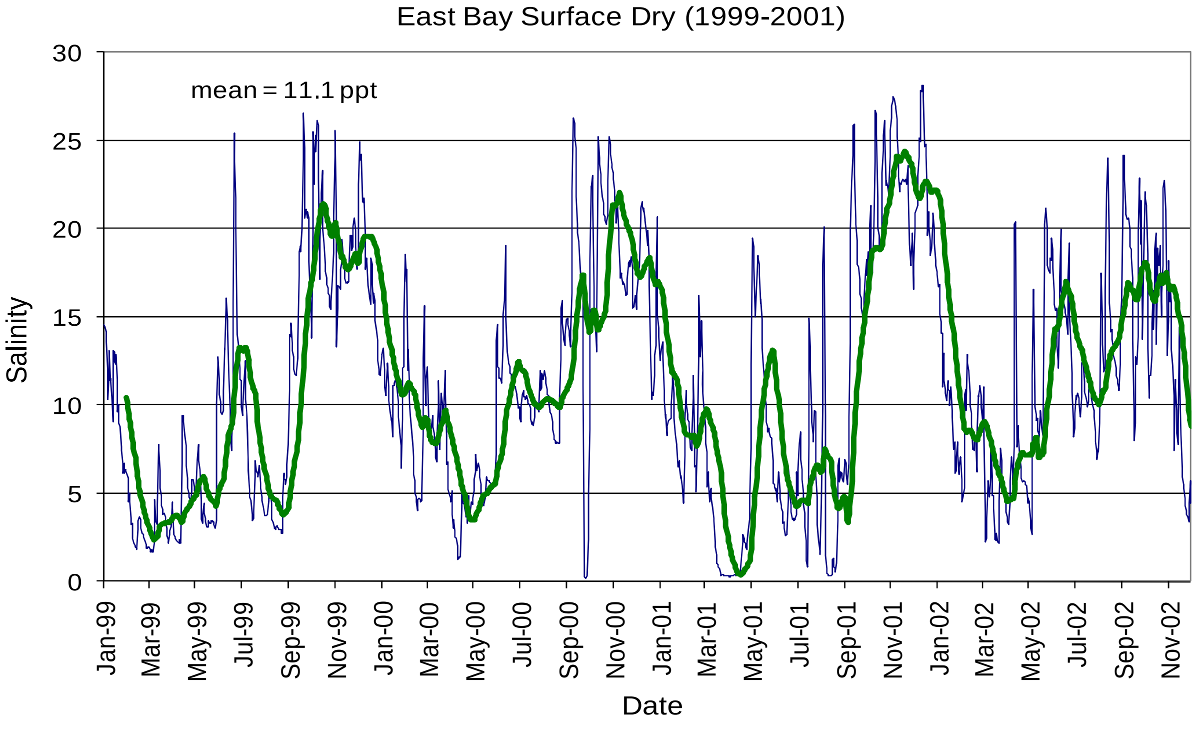
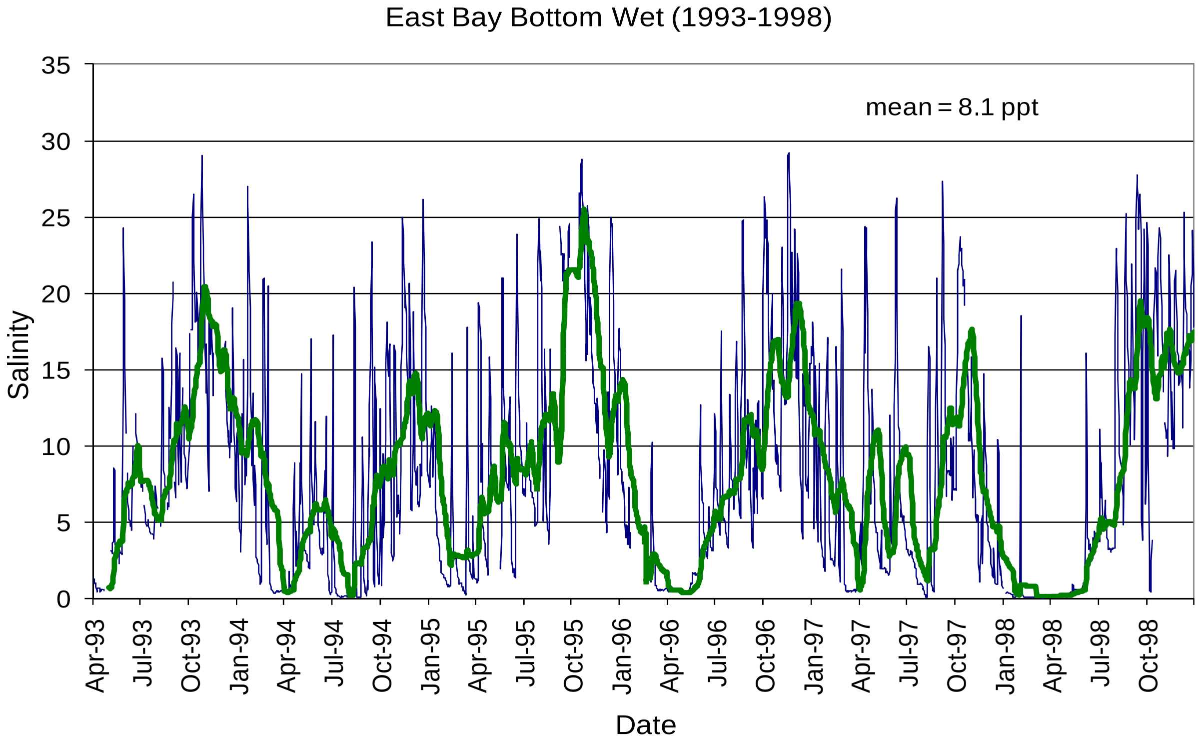


Figure 34. Mean daily surface salinity and a 30-day moving average at the East Bay site during wet (upper panel) and dry (lower panel) years. Data source: ANERR.



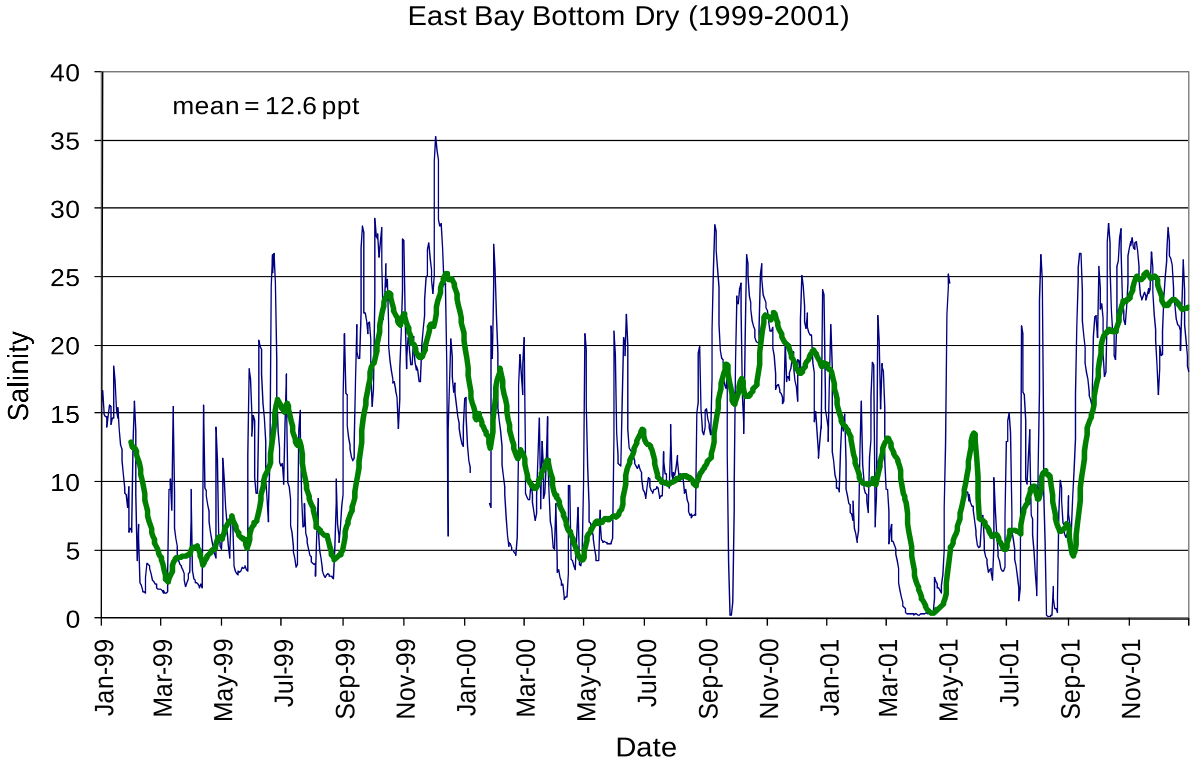


Figure 35. Mean daily bottom salinity and a 30-day moving average at the East Bay site during wet (upper panel) and dry (lower panel) years. Data source: ANERR.

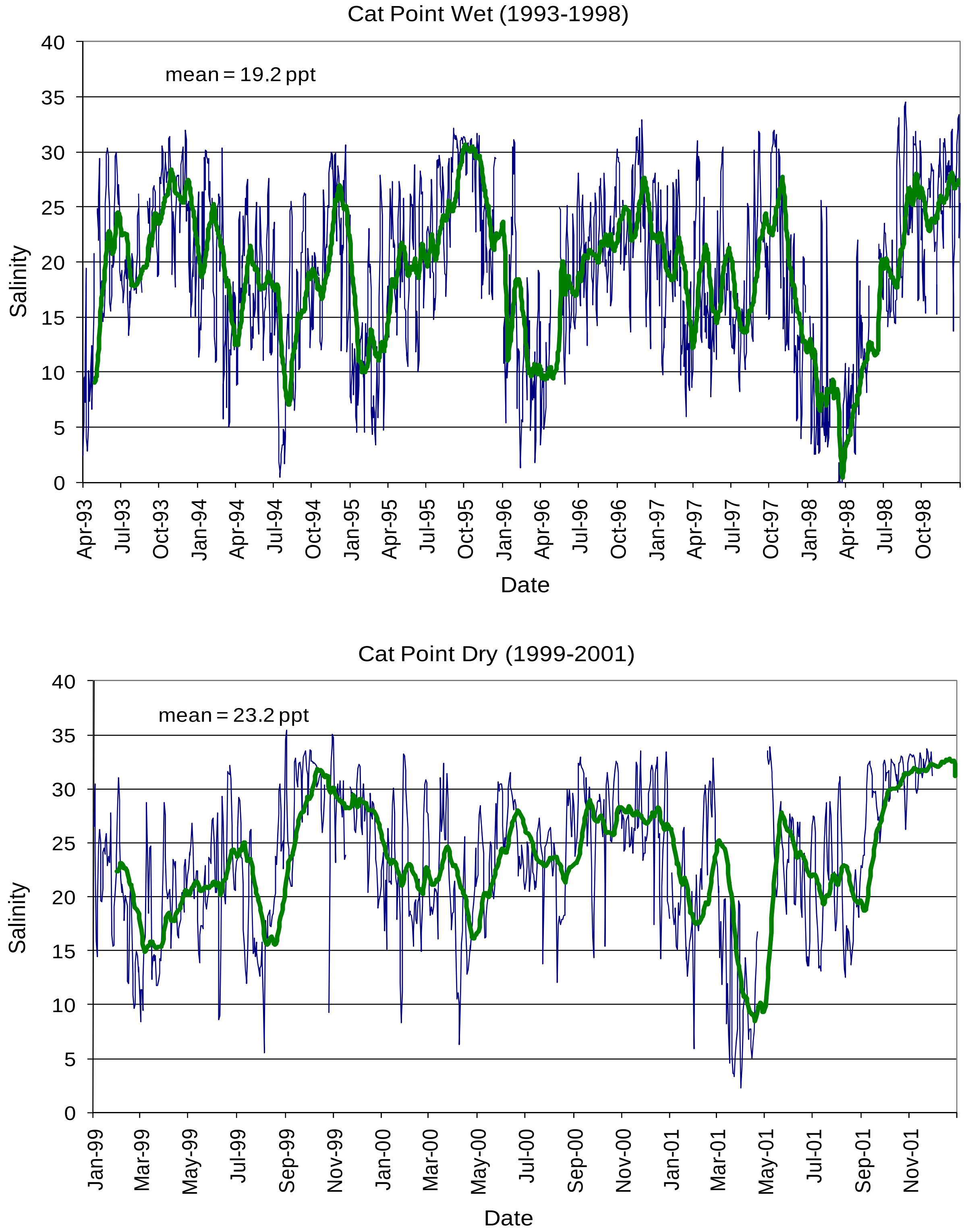
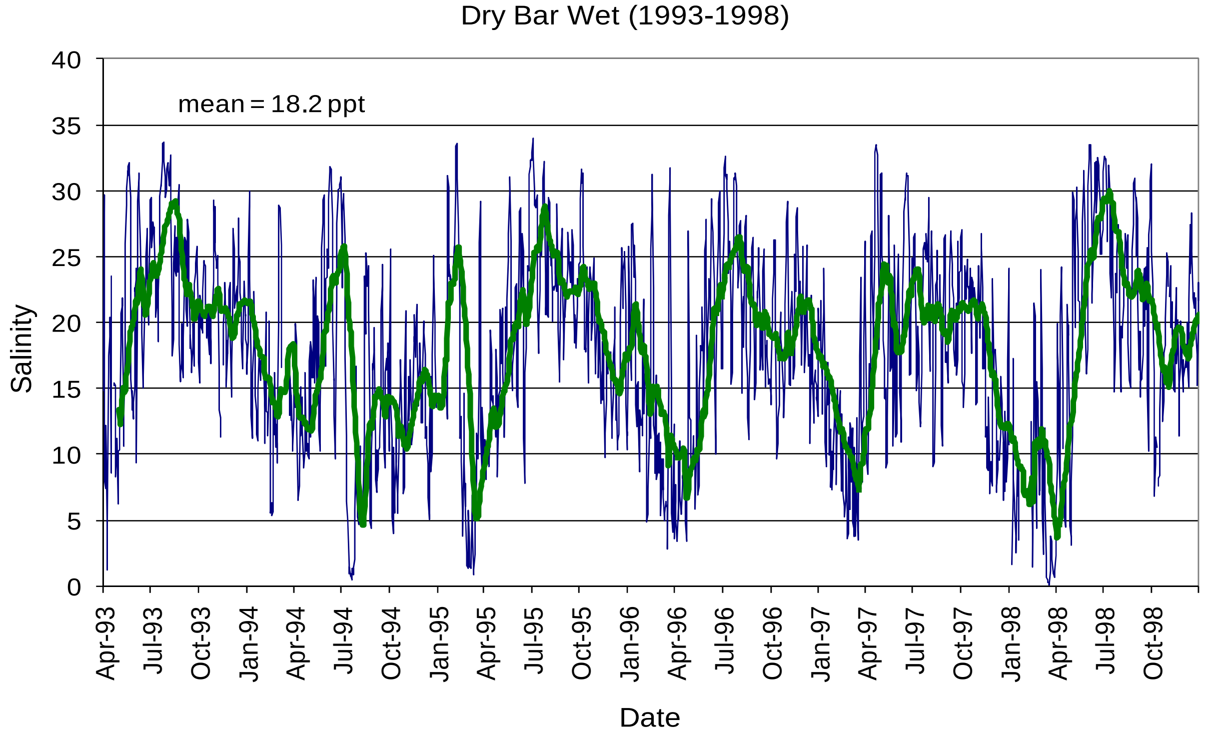


Figure 36. Mean daily mid-depth salinity and a 30-day moving average at the Cat Point site during wet (upper panel) and dry (lower panel) years. Data source: ANERR.



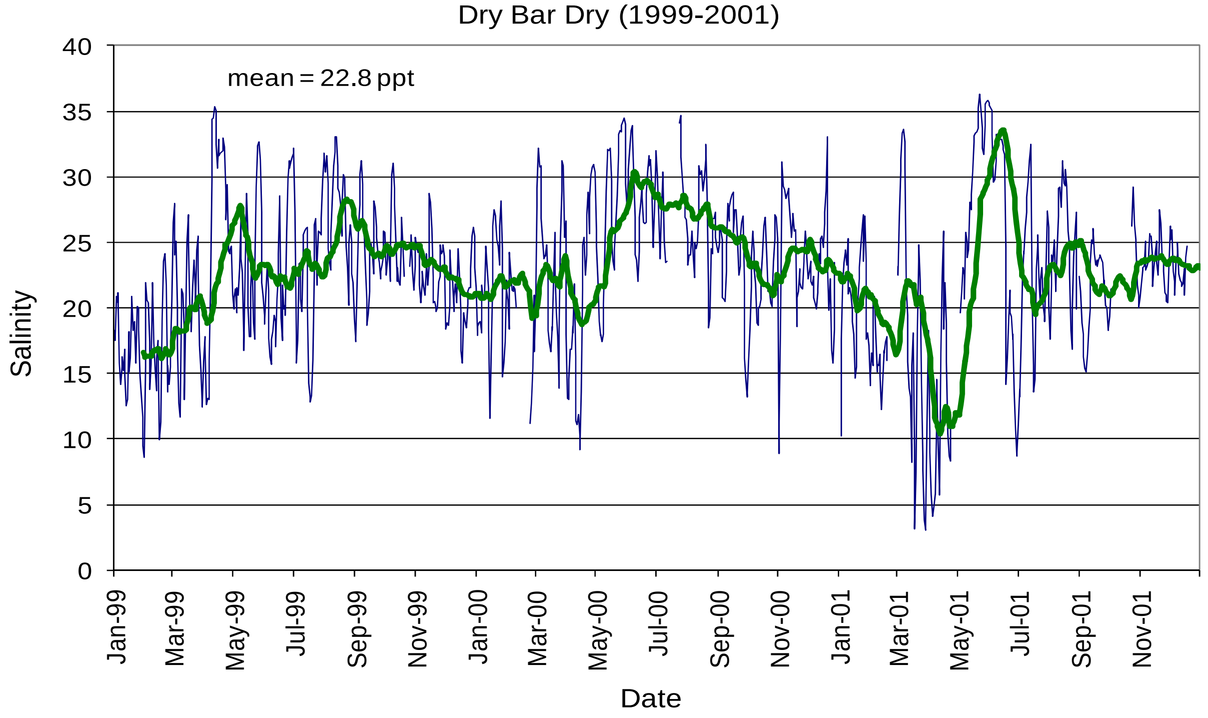
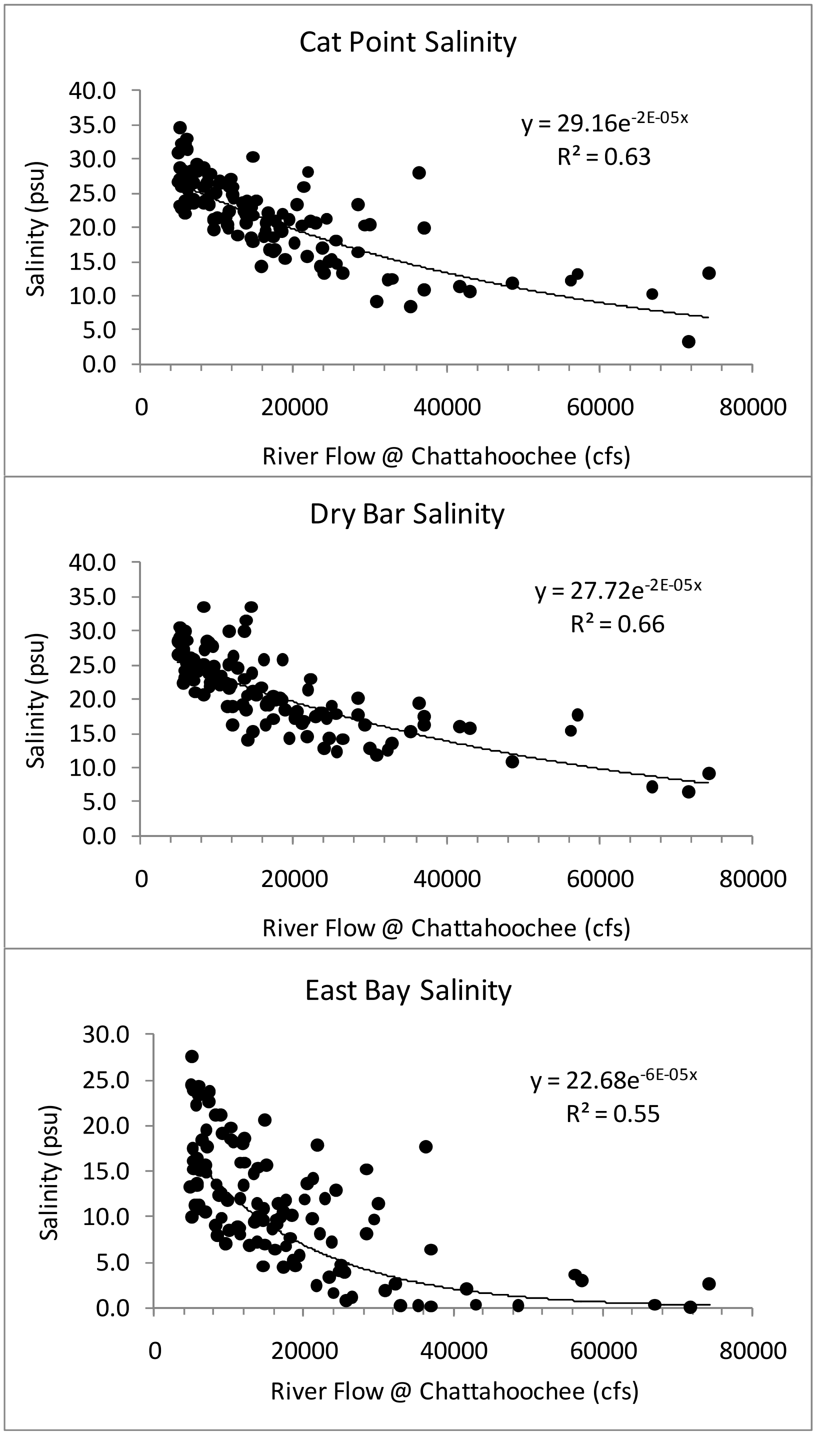


Figure 37. Mean daily mid-depth salinity and a 30-day moving average at the Dry Bar site during wet (upper panel) and dry (lower panel) years. Data source: ANERR.

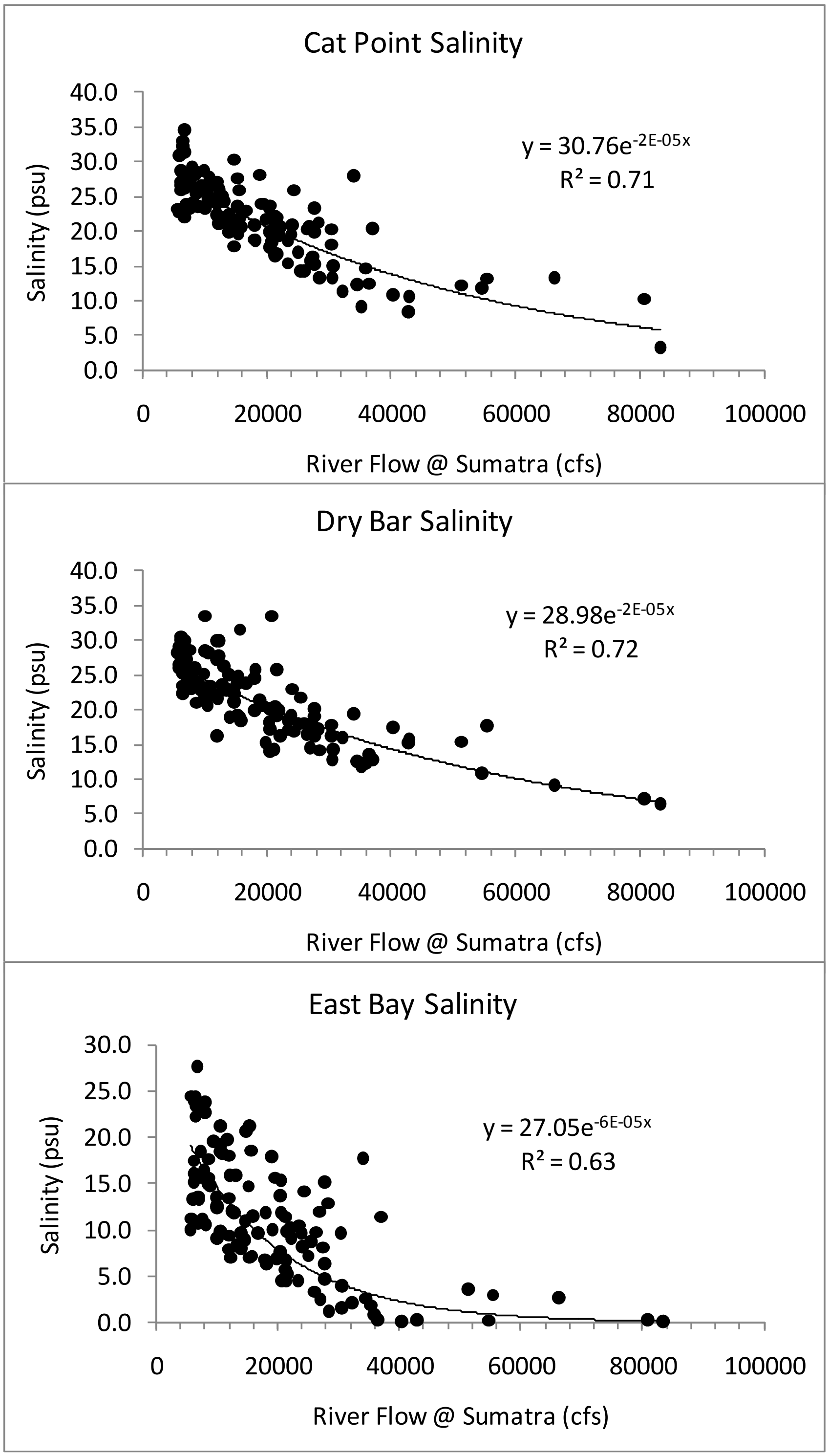


Cat Point Salinity

Dry Bar Salinity

East Bay Salinity

Figure 38. Simple exponential regressions between river flow at the Chattahoochee gage and salinity at three ANERR data logger sites: Cat Point (upper panel), Dry Bar (middle panel) and East Bay (lower panel). Regressions are based on monthly averaged flow and salinity measurements.


Cat Point Salinity

Dry Bar Salinity

East Bay Salinity

Figure 39. Simple exponential regressions between river flow at the Sumatra gage and salinity at three ANERR data logger sites: Cat Point (upper panel), Dry Bar (middle panel) and East Bay (lower panel). Regressions are based on monthly averaged flow and salinity measurements.

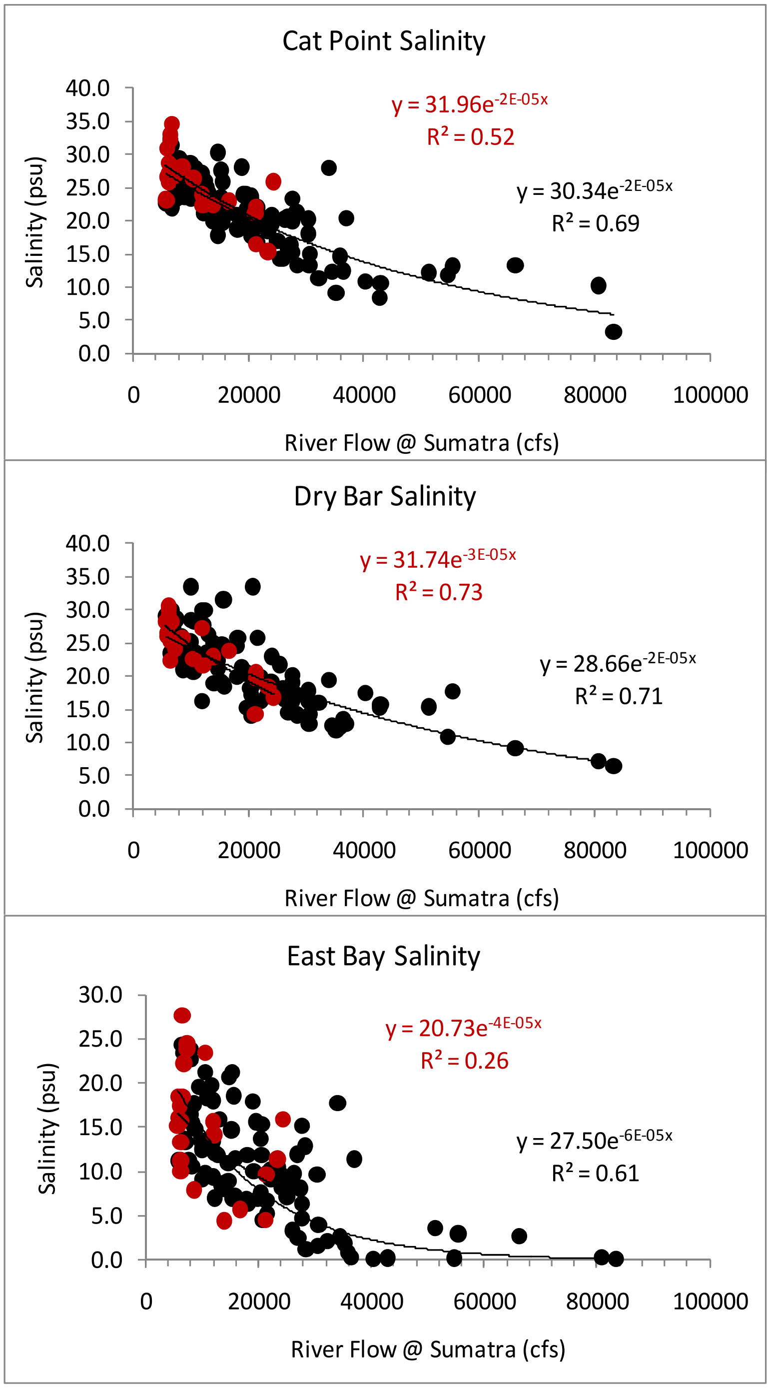


Figure 40. Simple exponential regressions between river flow at the Sumatra gage and salinity at three ANERR data logger sites: Cat Point (upper panel), Dry Bar (middle panel) and East Bay (lower panel). Regressions are based on monthly averaged flow and salinity measurements with drought years (2000, 2007 shown in red) separated from all other years (black).

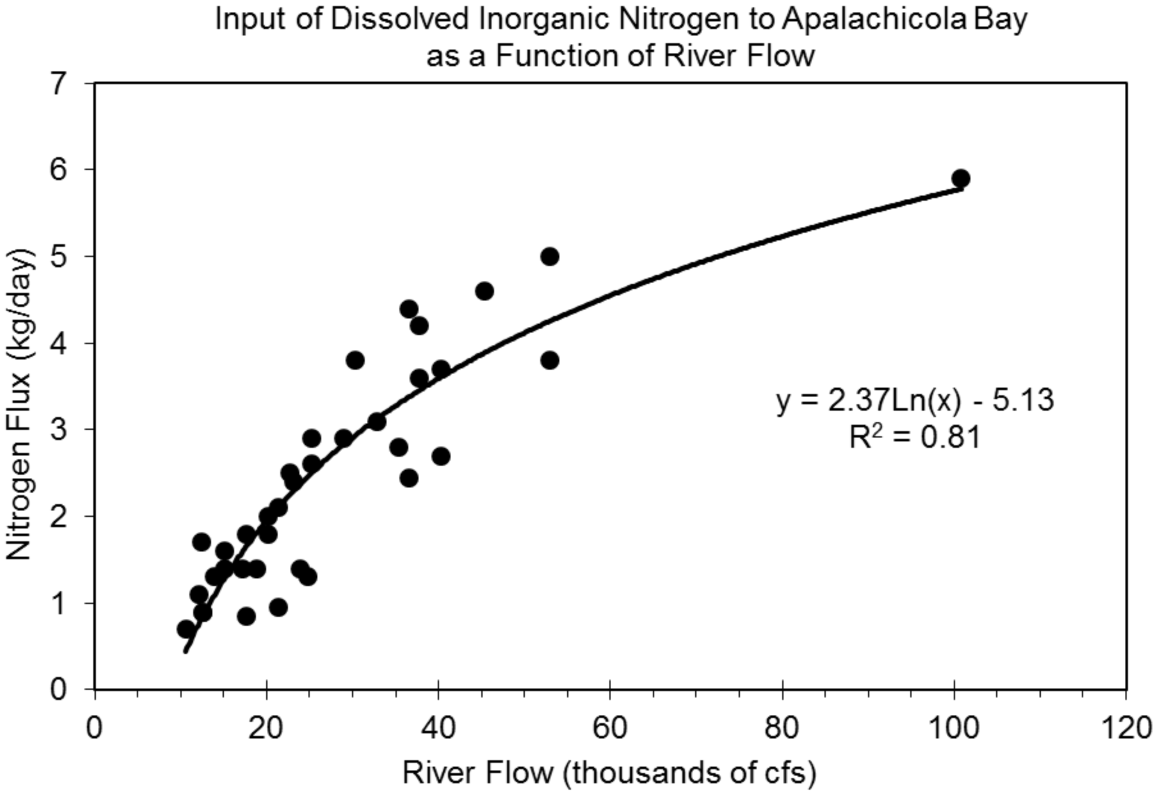


Figure 41. Relationship between dissolved inorganic nitrogen (DIN) and river flow in the Apalachicola River; data were taken from Mortazavi et al. (2000b).

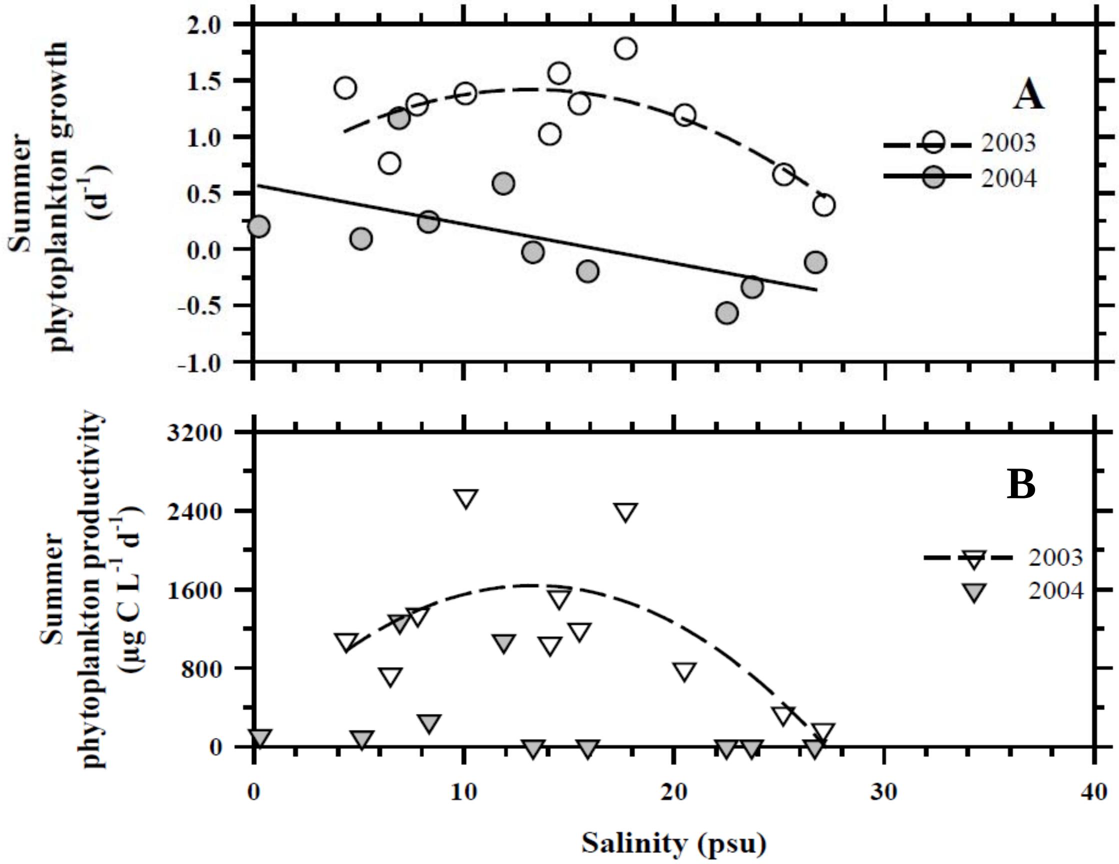


Figure 42. Phytoplankton (A) growth and (B) productivity during summer 2003 and 2004 relative to sea surface salinity (Putland 2005).

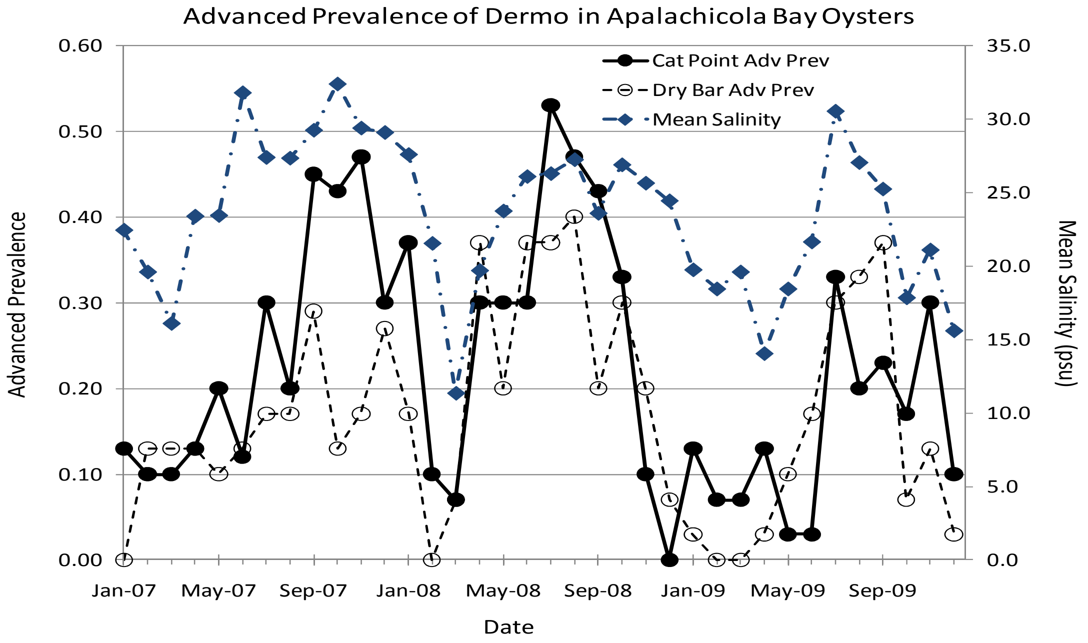


Figure 43. Dermo advanced prevalence in oysters from Cat Point and Dry Bar (2007-2009) relative to mean salinity at the two sites.

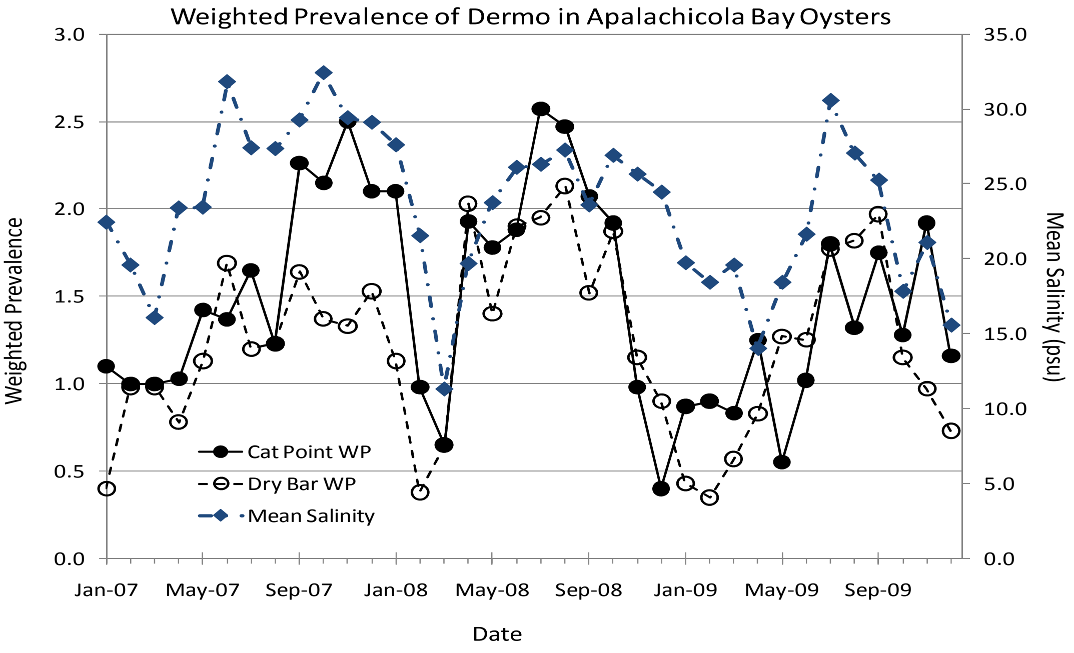


Figure 44. Dermo weighted prevalence in oysters from Cat Point and Dry Bar (2007-2009) relative to mean salinity at the two sites.

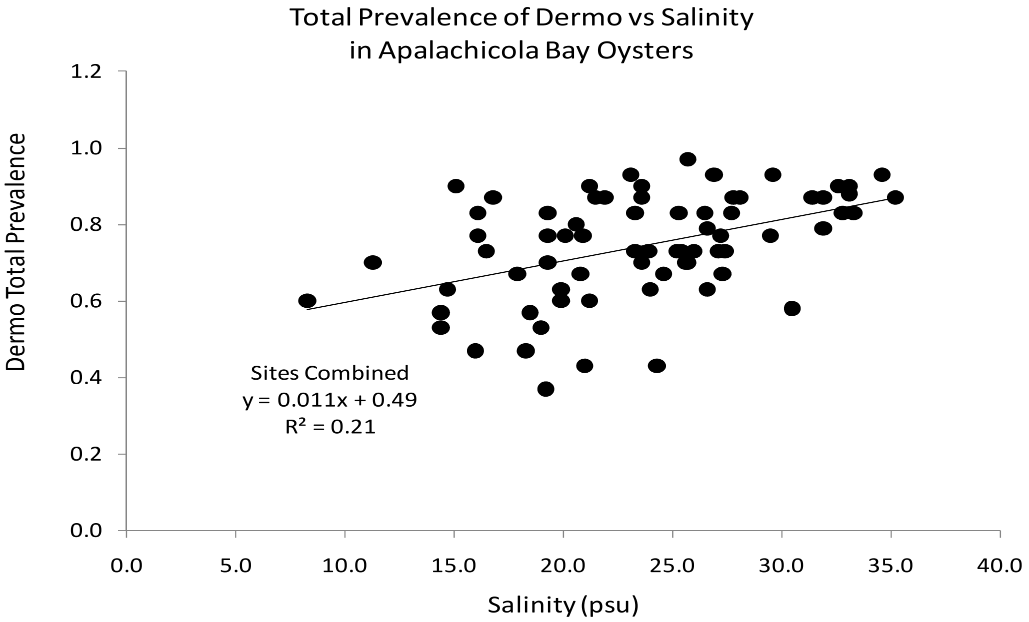


Figure 45. Dermo total prevalence in oysters from Cat Point and Dry Bar (2007-2009) relative to salinity at the two sites. A regression line is shown for the two sites combined; significance value $p < 0.05$.

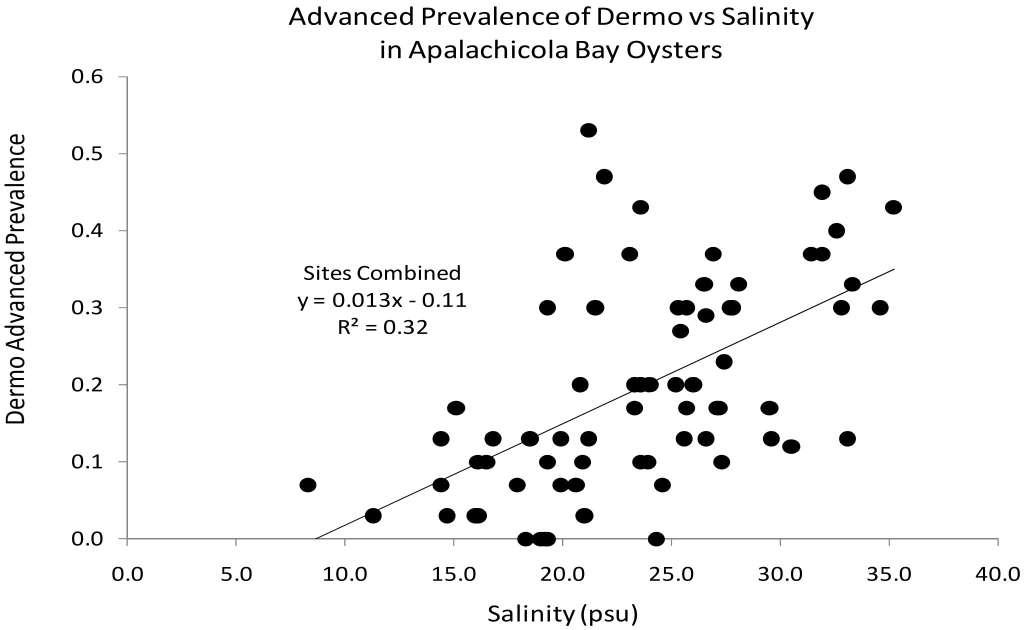


Figure 46. Dermo advanced prevalence in oysters from Cat Point and Dry Bar (2007-2009) relative to salinity at the two sites. A regression line is shown for the two sites combined; significance value $p < 0.05$.

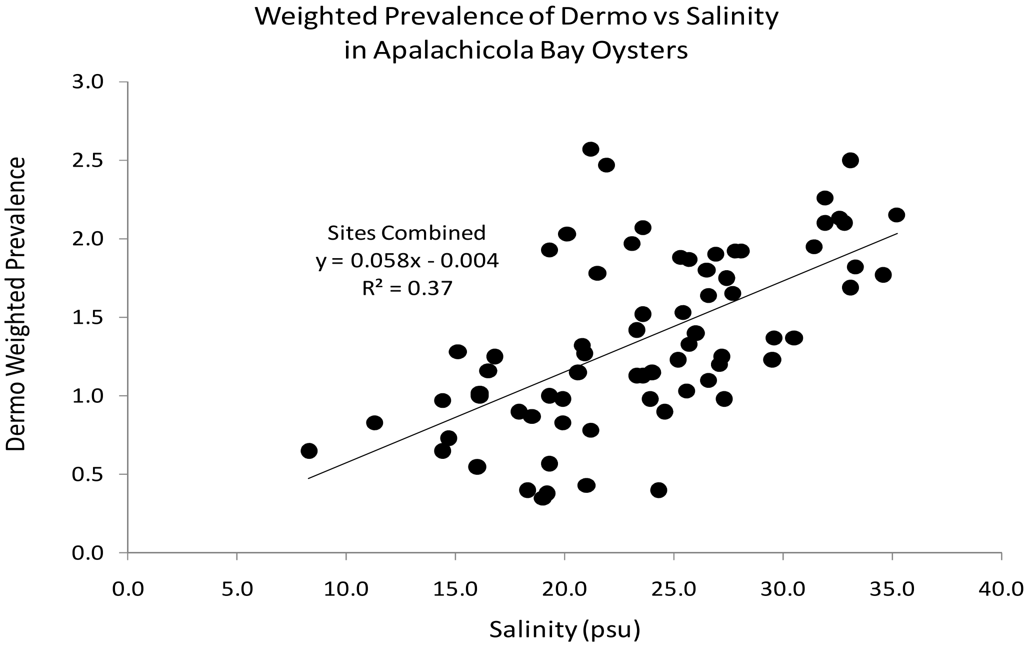
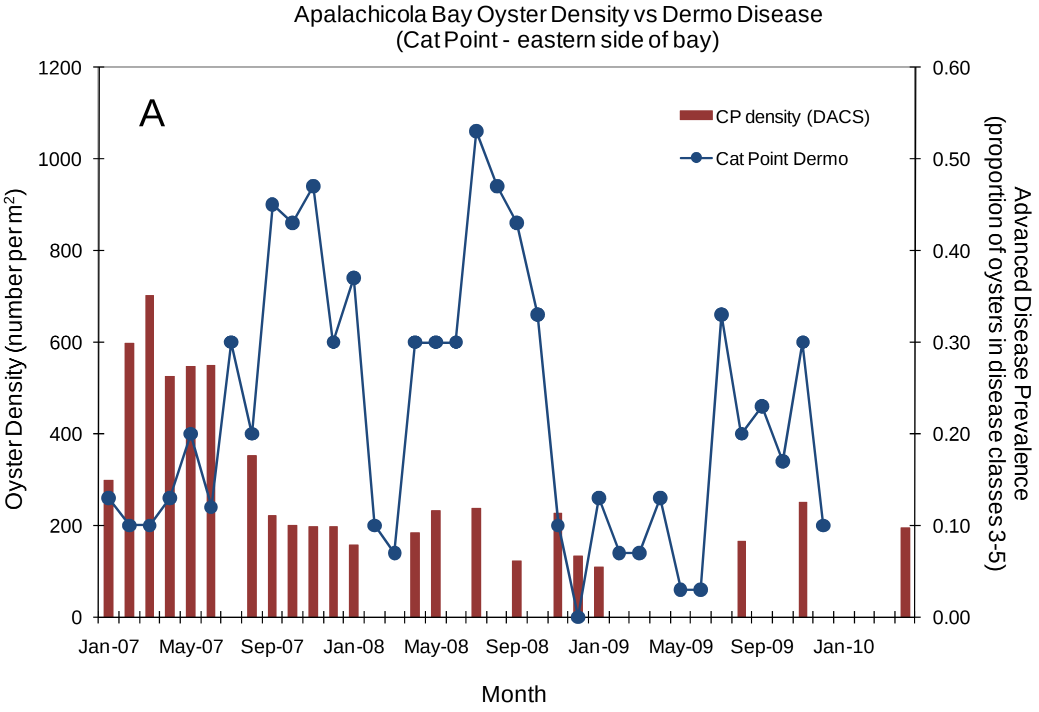


Figure 47. Dermo weighted prevalence in oysters from Cat Point and Dry Bar (2007-2009) relative to salinity at the two sites. A regression line is shown for the two sites combined; significance value $p < 0.05$.



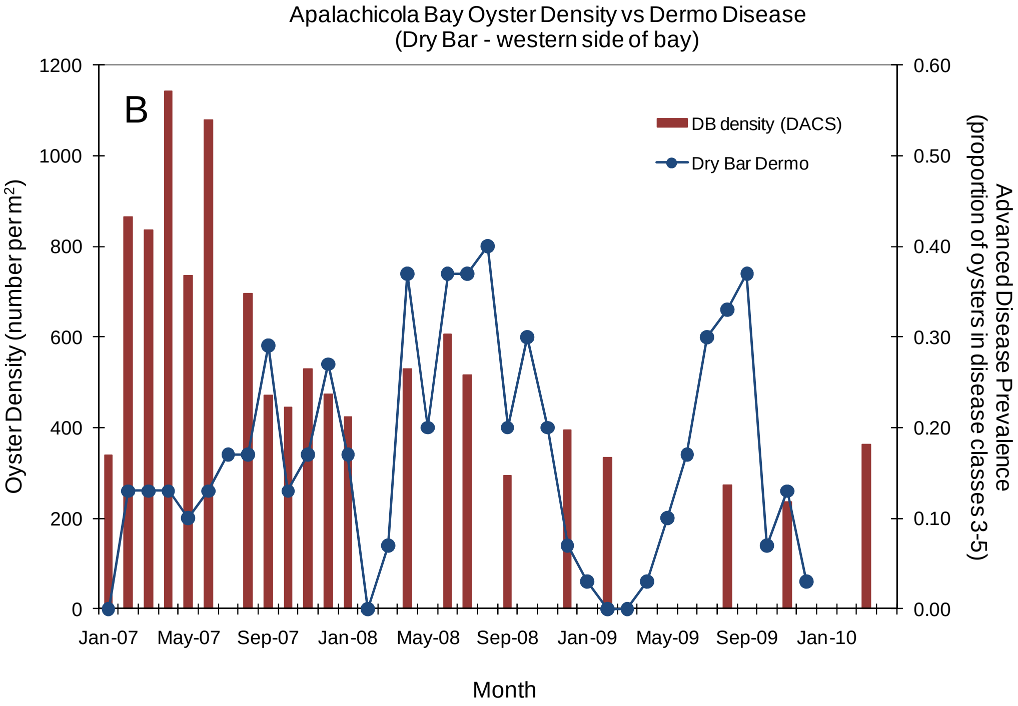
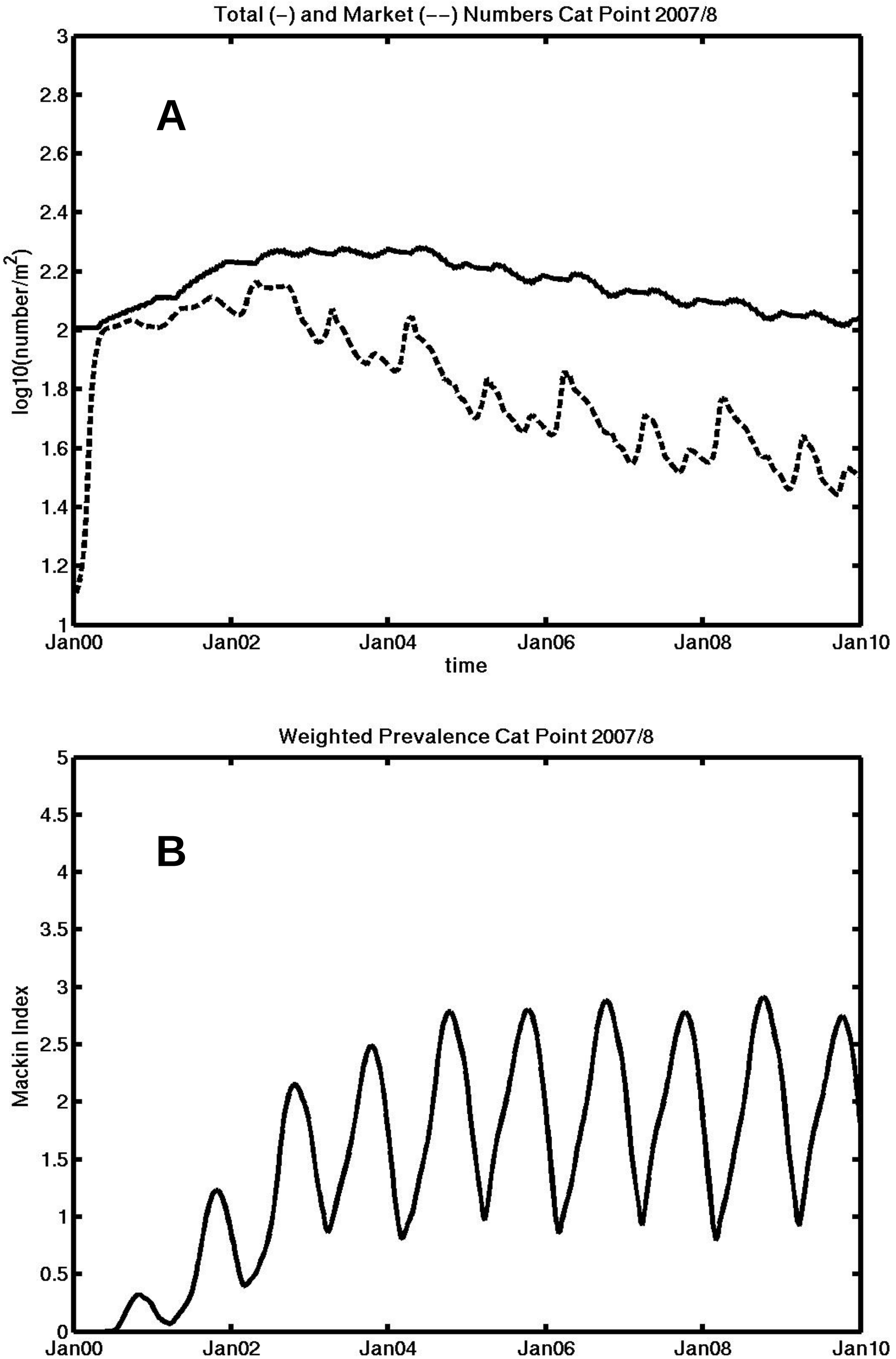


Figure 48. Oyster density and advanced Dermo prevalence at (A) Cat Point and (B) Dry Bar. Oyster density is given as number of oysters ≥25mm per m^2; oyster density source: DACS, Division of Aquaculture (2009).


Total (–) and Market (––) Numbers Cat Point 2007/8

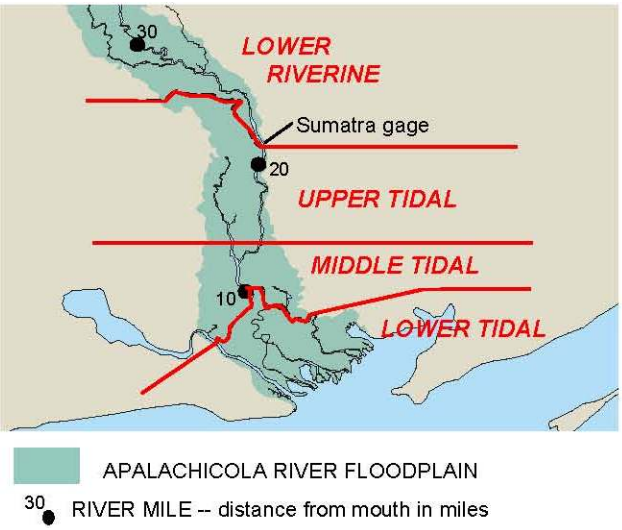
Weighted Prevalence Cat Point 2007/8

Figure 49. Time series of simulated (A) total and market-sized oysters, and (B) Dermo weighted prevalence at Cat Point.

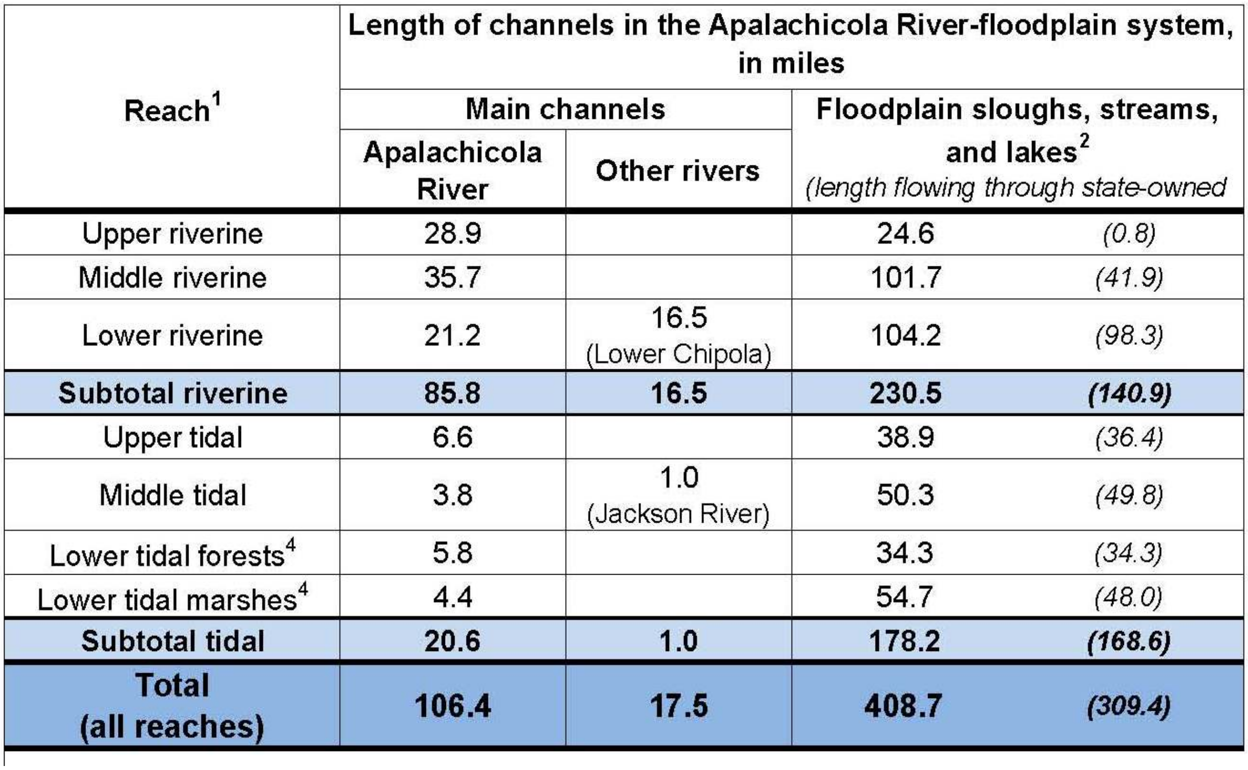
Appendices

Appendix A. Channel lengths and wetland areas in riverine and tidal reaches of the Apalachicola River and floodplain.

Part 1. Tidal reach boundaries



Part 2. Channel lengths

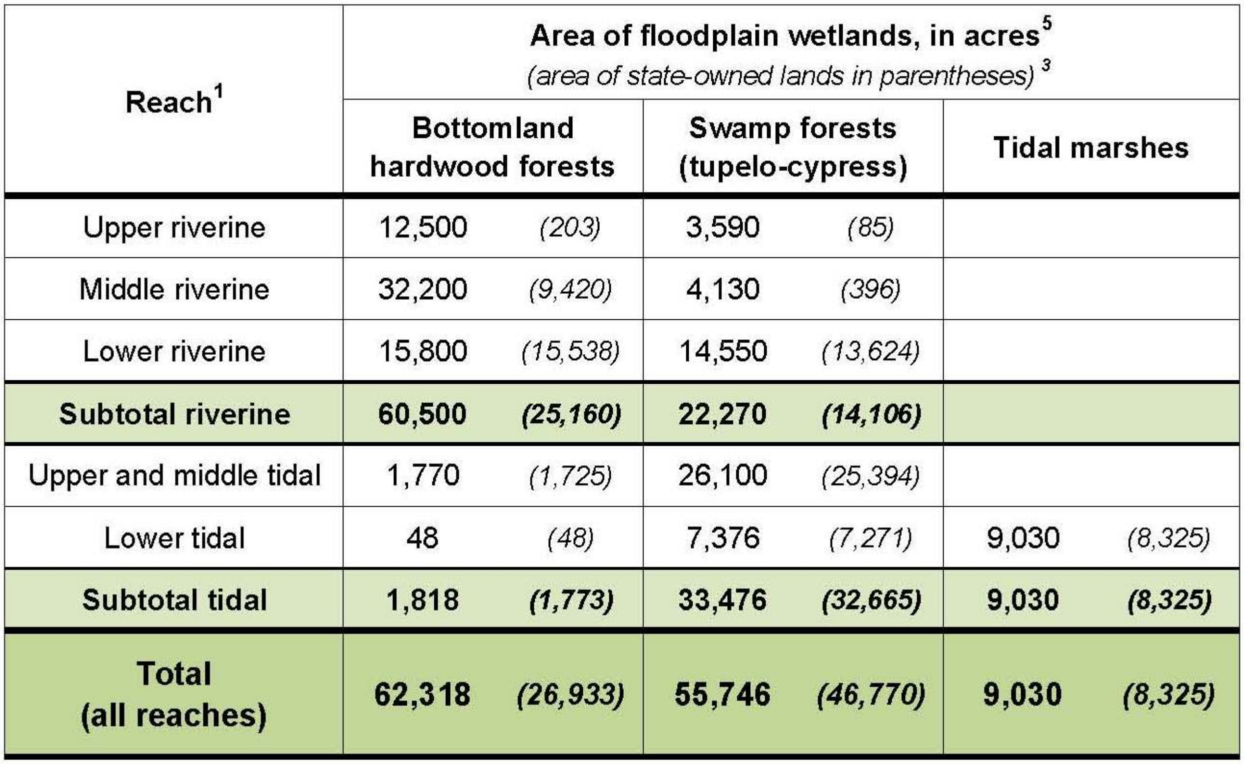


Reach[1]	Length of channels in the Apalachicola River-floodplain system, in miles			
	Main channels		Floodplain sloughs, streams, and lakes[2] *(length flowing through state-owned*	
	Apalachicola River	Other rivers		
Upper riverine	28.9		24.6	*(0.8)*
Middle riverine	35.7		101.7	*(41.9)*
Lower riverine	21.2	16.5 (Lower Chipola)	104.2	*(98.3)*
Subtotal riverine	**85.8**	**16.5**	**230.5**	***(140.9)***
Upper tidal	6.6		38.9	*(36.4)*
Middle tidal	3.8	1.0 (Jackson River)	50.3	*(49.8)*
Lower tidal forests[4]	5.8		34.3	*(34.3)*
Lower tidal marshes[4]	4.4		54.7	*(48.0)*
Subtotal tidal	**20.6**	**1.0**	**178.2**	***(168.6)***
Total (all reaches)	**106.4**	**17.5**	**408.7**	***(309.4)***

Footnotes on next page.

Appendix A. Continued.

Part 3. Wetland areas



Reach[1]	Area of floodplain wetlands, in acres[5] *(area of state-owned lands in parentheses)* [3]					
	Bottomland hardwood forests		Swamp forests (tupelo-cypress)		Tidal marshes	
Upper riverine	12,500	*(203)*	3,590	*(85)*		
Middle riverine	32,200	*(9,420)*	4,130	*(396)*		
Lower riverine	15,800	*(15,538)*	14,550	*(13,624)*		
Subtotal riverine	**60,500**	***(25,160)***	**22,270**	***(14,106)***		
Upper and middle tidal	1,770	*(1,725)*	26,100	*(25,394)*		
Lower tidal	48	*(48)*	7,376	*(7,271)*	9,030	*(8,325)*
Subtotal tidal	**1,818**	***(1,773)***	**33,476**	***(32,665)***	**9,030**	***(8,325)***
Total (all reaches)	**62,318**	***(26,933)***	**55,746**	***(46,770)***	**9,030**	***(8,325)***

[1] Riverine and tidal reach boundaries shown in Part 1. Source of reach boundaries is forest map by Leitman (1984) except for river mile 14 boundary between upper and middle tidal reaches, which was developed specifically for channel length inventory in Part 2.

[2] Floodplain channel lengths in the riverine reach are from Light et al. (1998). Floodplain channel lengths in the tidal reach are from measurements of all mapped streams on USGS 7.5-minute quadrangle maps, compiled by Helen Light and Michael Nesius, 2008.

[3] State land ownership was determined from a map prepared in November 2008 by Bryan Shoaf, Division of State Lands, Florida DEP. Most of the state lands in the Apalachicola River and floodplain were acquired for conservation purposes.

[4] Boundary between forests and marshes in lower tidal reach is called the "tree line", and its location is shown with a dashed line in Appendix D.

[5] Wetland areas are from forest map by Leitman (1984).

Appendix B. List of high-flow, normal-flow, and low-flow years in two time periods based on ranking by mean annual discharge. Mean annual discharge was calculated from calendar-year (Jan 1-Dec 31) streamflow data in Apalachicola River at Chattahoochee, Florida (USGS 2010).

BASELINE PERIOD (1923-55)				RECENT PERIOD (1975-2008)		
Year	Mean annual discharge (cfs)	Rank (1 is lowest)		Year	Mean annual discharge (cfs)	Rank (1 is lowest)
1929	39,580	33		1975	35,344	34
1948	36,830	32		1998	31,505	33
1936	30,973	31		1994	31,333	32
1949	29,250	30	***HIGH-FLOW YEARS***	1983	30,286	31
1946	28,130	29	*Highest one-third of years*	2005	29,240	30
1928	27,424	28	*based on mean annual discharge*	1976	26,695	29
1947	27,197	27		2003	26,600	28
1944	26,672	26	← *11 years in each period* →	1984	26,108	27
1937	25,995	25		1979	23,971	26
1923	25,600	24		1978	23,868	25
1953	24,706	23		1980	23,802	24
1943	24,062	22		1990	23,652	23
1926	23,161	21		1991	23,616	22
1942	22,585	20		1997	23,566	21
1930	22,152	19	***NORMAL-FLOW YEARS***	1993	23,114	20
1925	21,860	18	*Middle one-third of years*	1992	22,875	19
1933	21,295	17	*based on mean annual discharge*	1995	22,283	18
1939	21,062	16		1977	22,233	17
1924	20,645	15	← *11 years in baseline period*	1982	22,117	16
1952	19,198	14	*12 years in recent period* →	1996	21,964	15
1945	19,122	13		1987	20,592	14
1932	19,038	12		1989	20,416	13
				2004	17,236	12
1940	18,987	11		2001	16,058	11
1938	17,004	10		1985	15,115	10
1934	15,130	9		2008	14,607	9
1950	15,102	8	***LOW-FLOW YEARS***	1986	13,995	8
1954	14,381	7	*Lowest one-third of years*	1988	13,745	7
1931	13,996	6	*based on mean annual discharge*	2006	13,093	6
1927	13,525	5		1981	12,082	5
1935	13,237	4	← *11 years in each period* →	1999	11,233	4
1951	12,949	3		2002	10,874	3
1941	12,417	2		2007	9,722	2
1955	11,223	1		2000	9,341	1

Appendix C. Apalachicola River flow and Chattahoochee-Flint basin precipitation during low-flow years in three time periods. Low-flow years are the lowest one-third of years in each time period based mean annual discharge in the Apalachicola River at Chattahoochee, Florida. Precipitation is from NCDC climate division data which has been area-weighted to represent the Chattahoochee and Flint River basins. (USGS 2010; US Dept of Commerce-NCDC 2009).

Time period	Year	Rank within period (1 is lowest)	Annual mean discharge (cfs)	Annual flow volume (acre-ft)	Annual precipitation (inches)	Annual precipitation volume (acre-ft)[1]	Flow/ precipitation ratio[2]	
Baseline Period 1923-1955 (33 years)	1927	5	13,525	9,791,722	39.86	36,952,602	0.2650	Variable 1[3]
	1931	6	13,996	10,132,582	39.14	36,292,387	0.2792	
	1934	9	15,130	10,953,878	49.28	45,691,114	0.2397	
	1935	4	13,237	9,582,843	46.50	43,110,671	0.2223	
	1938	10	17,004	12,310,235	42.09	39,024,677	0.3154	
	1940	11	18,987	13,783,934	49.16	45,581,961	0.3024	
	1941	2	12,417	8,989,805	44.11	40,897,478	0.2198	
	1950	8	15,102	10,933,408	43.79	40,599,458	0.2693	
	1951	3	12,949	9,374,340	46.43	43,046,554	0.2178	
	1954	7	14,381	10,411,716	31.20	28,927,825	0.3599	
	1955	1	11,223	8,125,210	42.70	39,584,809	0.2053	
	Average		**14,359**	**10,399,061**	**43.11**	**39,973,594**	**0.2601**	
Intervening Period 1956-1974 (19 years)	1956	1	13,785	10,007,524	50.82	47,112,896	0.2124	
	1957	4	17,540	12,698,658	55.24	51,219,292	0.2479	
	1963	5	18,108	13,109,296	51.16	47,429,838	0.2764	
	1968	2	15,194	11,030,420	42.65	39,545,105	0.2789	
	1969	3	16,553	11,983,676	47.82	44,335,163	0.2703	
	1970	6	19,467	14,093,197	51.55	47,797,347	0.2949	
	Average		**16,775**	**12,153,795**	**49.87**	**46,239,940**	**0.2628**	
Recent Period 1975-2008 (34 years)	1981	5	12,082	8,747,028	44.39	41,157,923	0.2125	Variable 2[3]
	1985	10	15,115	10,942,830	49.49	45,884,723	0.2385	
	1986	8	13,995	10,131,769	43.32	40,163,073	0.2523	
	1988	7	13,745	9,978,089	45.03	41,748,334	0.2390	
	1999	4	11,233	8,132,668	41.24	38,238,313	0.2127	
	2000	1	9,341	6,781,131	42.03	38,965,646	0.1740	
	2001	11	16,058	11,625,164	46.28	42,909,353	0.2709	
	2002	3	10,874	7,872,595	53.18	49,301,748	0.1597	
	2006	6	13,093	9,478,949	43.72	40,533,299	0.2339	
	2007	2	9,722	7,038,526	39.19	36,338,006	0.1937	
	2008	9	14,607	10,603,855	51.96	48,177,211	0.2201	
	Average		**12,715**	**9,212,055**	**45.44**	**42,128,875**	**0.2187**	

See footnotes on next page.

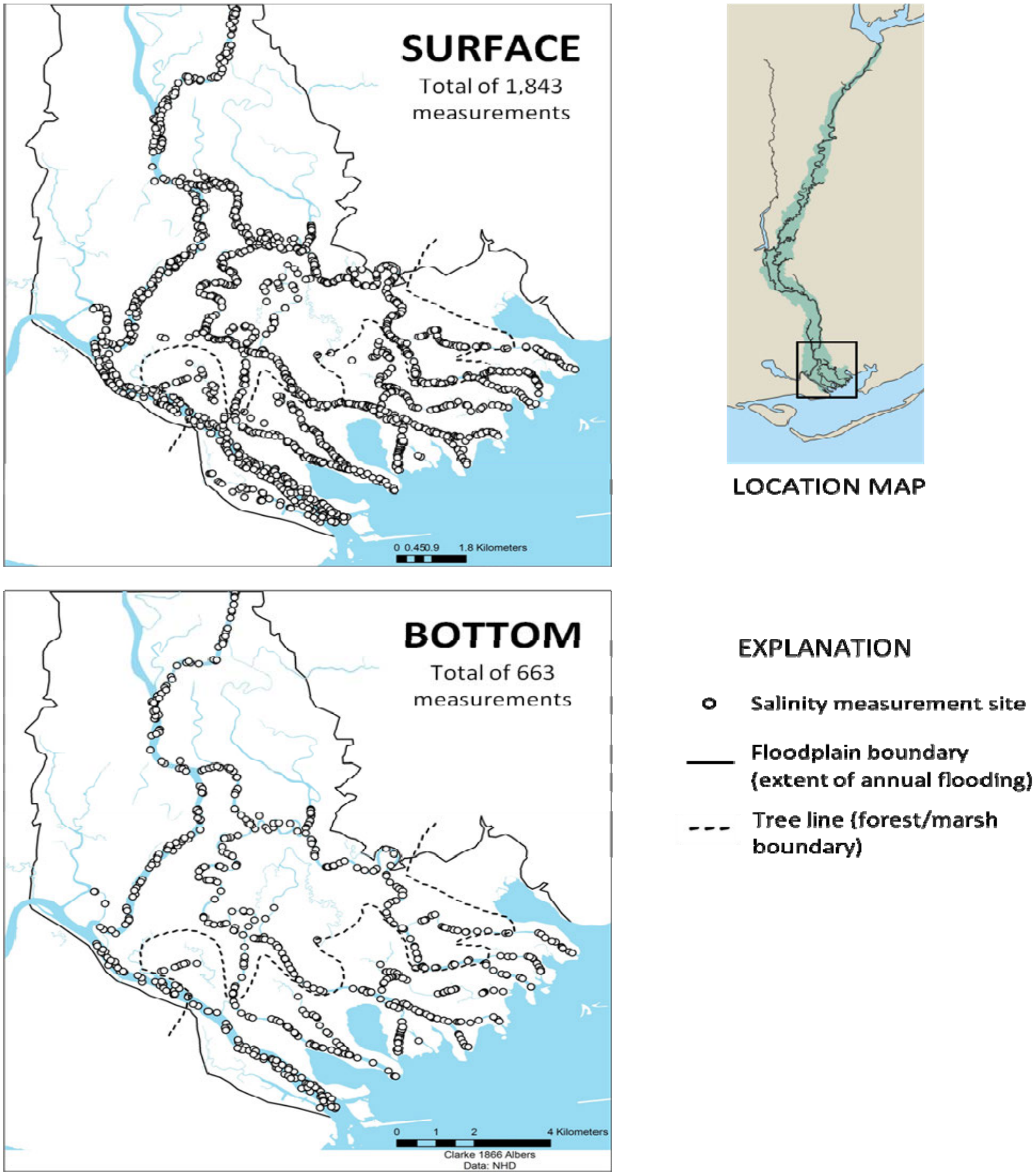
Appendix 2.C. Continued. (Footnotes)

[1] Precipitation volume for the basin upstream of Jim Woodruff Dam was calculated using an area of 11,125,739 acres.

[2] Flow/precipitation ratio is the annual flow volume (acre-ft) divided by the annual precipitation volume (acre-ft). It represents the approximate proportion of basin rainfall reaching the Apalachicola River as streamflow.

[3] **Variable 1** (baseline period) and **Variable 2** (recent period) are significantly different based on a two-sample t-Test with equal variance (p=0.0104). A one-tail t-Test was used because it was reasonable to expect that the flow/precipitation ratio in low-flow years has declined in the recent period (amount of anthropogenic consumption and evaporation has been large relative to the volume of flow). Variances were equal based on results of two-sample F-Test for variances.

Appendix D. Location of salinity measurements in the lower Apalachicola River and distributaries. Monthly measurements (randomly located within a network of grids) were made July 2000-Dec 2008 in association with fish monitoring collections by the Fish and Wildlife Research Institute of the Florida Fish and Wildlife Conservation Commission. Surface measurements were made during shoreline seine and trawl sampling at depths <= 0.5 m (mostly 0.2 m). Bottom measurements were made during trawl sampling only.



Appendix E. Species of fish known to occur in the Apalachicola River-floodplain system. Part 1. Species known to occur in the riverine reach (including species found in both riverine and tidal reaches). Part 2. Species known to occur in the tidal reach only.

Abbreviations:

TSN, Taxonomic Serial Number as listed in the Integrated Taxonomic Information System (ITIS) database. Numbers for additional species may be found using the ITIS online at www.itis.gov.

Type: A, anadromous; C, catadromous; F, freshwater; I, introduced; M, marine

Source (an attempt was made to list the earliest known source if multiple sources were available):

A85, Ager et al. 1985
B83, Bass 1983
B95, Bass 1995
B10, Bass and Hoehn 2010 (in prep)
H90, Hill et al 1990
L77, Livingston et al. 1977
P06, Pera et al. 2006
S09, Snelson et al. 2009
W06, Walsh et al. 2006
Y77, Yerger 1977
Other sources footnoted as needed

Floodplain collections:

AR, collected in Apalachicola River floodplain (based on summaries by Light et al. 1998 and Walsh et al. 2006)
E. US, collected in floodplains of other rivers of eastern United States (based on literature review by Light et al. 1995); presence in Apalachicola River floodplain is probable

tax. rev., taxonomic revision

Appendix E. -- Part 1. Species of fish known to occur in the riverine reach (including species found in both riverine and tidal reaches).

Family (scientific name)	**Family (common name)**	**Species (scientific name)**	**Species (common name)**	**TSN**	**Type**	**Source**	**Floodplain collections**
Petromyzontidae	Lampreys	Ichthyomyzon gagei	southern brook lamprey	159727	F	Y77	---
Acipenseridae	Sturgeon	Acipenser oxyrhynchus desotoi	Gulf of Mexico sturgeon	201894	A	Y77	---
Polyodontidae	Paddlefishes	Polyodon spathula	paddlefish	161088	F, I	[1]	---
Lepisosteidae	Gars	Lepisosteus oculatus	spotted gar	161095	F	Y77	AR
Lepisosteidae	Gars	Lepisosteus osseus	longnose gar	161094	F	Y77	AR
Amiidae	Bowfins	Amia calva	bowfin	161104	F	Y77	AR
Anguillidae	Freshwater eels	Anguilla rostrata	American eel	161127	C	Y77	AR
Clupeidae	Herrings	Alosa alabamae	Alabama shad	161705	A	Y77	---
Clupeidae	Herrings	Alosa chrysochloris	skipjack herring	161707	A	Y77	AR
Clupeidae	Herrings	Dorosoma cepedianum	gizzard shad	161737	F	Y77	AR
Clupeidae	Herrings	Dorosoma petenense	threadfin shad	161738	F	Y77	AR
Cyprinidae	Carps, minnows	Ctenopharyngodon idella	grass carp	163537	F, I	W06	AR
Cyprinidae	Carps, minnows	Cyprinella callitaenia	bluestripe shiner	163774	F	Y77	AR
Cyprinidae	Carps, minnows	Cyprinella leedsi	bannerfin shiner	163788	F	B83	E. US
Cyprinidae	Carps, minnows	Cyprinella venusta	blacktail shiner	163809	F	Y77	AR
Cyprinidae	Carps, minnows	Cyprinus carpio	common carp	163344	F, I	Y77	AR
Cyprinidae	Carps, minnows	Hybopsis sp. cf. H. winchelli	clear chub	163495	F	Y77	AR
Cyprinidae	Carps, minnows	Luxilus zonistius	bandfin shiner	163843	F	Y77	AR
Cyprinidae	Carps, minnows	Notemigonus crysoleucas	golden shiner	163368	F	Y77	AR
Cyprinidae	Carps, minnows	Notropis amplamala (tax. rev. N. buccata)	longjaw minnow (formerly silverjaw minnow)	No TSN (formerly 163479)	F	Y77 (tax.rev. P06)	E. US
Cyprinidae	Carps, minnows	Notropis baileyi	rough shiner	163427	F	B95	---
Cyprinidae	Carps, minnows	Notropis chalybaeus	ironcolor shiner	163403	F	Y77	AR
Cyprinidae	Carps, minnows	Notropis cummingsae	dusky shiner	163438	F	Y77	---
Cyprinidae	Carps, minnows	Notropis harperi	redeye chub	163444	F	Y77	AR
Cyprinidae	Carps, minnows	Notropis longirostris	longnose shiner	163452	F	Y77	---
Cyprinidae	Carps, minnows	Notropis maculatus	taillight shiner	163454	F	Y77	AR
Cyprinidae	Carps, minnows	Notropis petersoni	coastal shiner	163460	F	Y77	AR
Cyprinidae	Carps, minnows	Notropis texanus	weed shiner	163420	F	Y77	AR

[1] FWC, 2007, unpublished, E.A. Long

Appendix E. -- Part 1. Riverine reach -- Continued

Family (scientific name)	**Family (common name)**	**Species (scientific name)**	**Species (common name)**	**TSN**	**Type**	**Source**	**Floodplain collections**
Cyprinidae	Carps, minnows	Opsopoeodus emiliae	pugnose minnow	163876	F	Y77	AR
Cyprinidae	Carps, minnows	Pteronotropis grandipinnis	Apalachee shiner	689763	F	W06	AR
Cyprinidae	Carps, minnows	Pteronotropis signipinnus	flagfin shiner	201942	F	Y77	---
Cyprinidae	Carps, minnows	Pteronotropis welaka	bluenose shiner	201943	F	Y77	E. US
Cyprinidae	Carps, minnows	Semotilus thoreauianus (tax. rev. Semotilus atromaculatus)	Dixie chub (formerly creek chub)	163379	F	Y77	---
Catostomidae	Suckers	Carpiodes cyprinus	quillback	163917	F	Y77	AR
Catostomidae	Suckers	Carpoides velifer	highfin carpsucker	163920	F	[2]	---
Catostomidae	Suckers	Erimyzon sucetta	lake chubsucker	163922	F	Y77	AR
Catostomidae	Suckers	Minytrema melanops	spotted sucker	163959	F	Y77	AR
Catostomidae	Suckers	Moxostoma sp. cf. M. poecilurum	Apalachicola (grayfin) redhorse sucker	163927	F	Y77	AR
Ictaluridae	Bullhead catfishes	Ameiurus brunneus	snail bullhead	164035	F	Y77	AR
Ictaluridae	Bullhead catfishes	Ameiurus catus	white catfish	164037	F	Y77	E. US
Ictaluridae	Bullhead catfishes	Ameiurus natalis	yellow bullhead	164041	F	Y77	AR
Ictaluridae	Bullhead catfishes	Ameiurus nebulosus	brown bullhead	164043	F	Y77	AR
Ictaluridae	Bullhead catfishes	Ameiurus serracanthus	spotted bullhead	164047	F	Y77	AR
Ictaluridae	Bullhead catfishes	Ictalurus furcatus	blue catfish	163997	F, I	[3]	---
Ictaluridae	Bullhead catfishes	Ictalurus punctatus	channel catfish	163998	F	Y77	AR
Ictaluridae	Bullhead catfishes	Noturus funebris	black madtom	164014	F	Y77	E. US
Ictaluridae	Bullhead catfishes	Noturus gyrinus	tadpole madtom	164003	F	Y77	AR
Ictaluridae	Bullhead catfishes	Noturus leptacanthus	speckled madtom	164019	F	Y77	AR
Ictaluridae	Bullhead catfishes	Pylodictis olivaris	flathead catfish	164029	F, I	A85	AR
Esocidae	Pikes	Esox americanus americanus	redfin pickerel	162141	F	Y77	AR
Esocidae	Pikes	Esox niger	chain pickerel	162143	F	Y77	AR
Aphredoderidae	Pirate perches	Aphredoderus sayanus	pirate perch	164405	F	Y77	AR
Mugilidae	Mullets	Agonostomus monticola	mountain mullet	170355	C	Y77	---
Mugilidae	Mullets	Mugil cephalus	striped mullet	170335	M	Y77	AR
Atherinopsidae	Silversides	Labidesthes sicculus	brook silverside	166016	F	Y77	AR

[2] Clemson University, 2005, unpublished, J. Isely, S. Young

[3] FWC, 1997, unpublished, R. Cailteux

Appendix E. -- Part 1. Riverine reach -- Continued

Family (scientific name)	**Family (common name)**	**Species (scientific name)**	**Species (common name)**	**TSN**	**Type**	**Source**	**Floodplain collections**
Belonidae	Needlefishes	Strongylura marina	Atlantic needlefish	165551	A	Y77	AR
Fundulidae	Killifishes	Fundulus chrysotus	golden topminnow	165652	F	Y77	E. US
Fundulidae	Killifishes	Fundulus cingulatus	banded topminnow	165661	F	Y77	---
Fundulidae	Killifishes	Fundulus escambiae	russetfin topminnow (formerly eastern starhead topminnow)	165675	F	[4]	AR
Fundulidae	Killifishes	Fundulus notti	bayou/starhead topminnow	647286	F	Y77	---
Fundulidae	Killifishes	Fundulus olivaceus	blackspotted topminnow	165655	F	A85	AR
Fundulidae	Killifishes	Leptolucania ommata	pygmy killifish	165696	F	Y77	E. US
Fundulidae	Killifishes	Lucania goodei	bluefin killifish	165680	F	Y77	AR
Poeciliidae	Livebearers	Gambusia holbrooki	eastern mosquitofish	165896	F	Y77	AR
Poeciliidae	Livebearers	Heterandria formosa	least killifish	165915	F	Y77	AR
Moronidae	Temperate basses	Morone chrysops	white bass	167682	F, I	Y77	E. US
Moronidae	Temperate basses	Morone chrysops x M. saxatilis	sunshine bass	[hybrid]	F	A85	AR
Moronidae	Temperate basses	Morone saxatilis	striped bass	167680	A	Y77	E. US
Centrarchidae	Sunfishes	Ambloplites ariommus	shadow bass	168099	F	A85	---
Centrarchidae	Sunfishes	Centrarchus macropterus	flier	168102	F	Y77	AR
Centrarchidae	Sunfishes	Lepomis gulosus (syn. Chaenobryttus gulosus)	warmouth	168138 (168139)	F	Y77	AR
Centrarchidae	Sunfishes	Enneacanthus gloriosus	bluespotted sunfish	168113	F	Y77	AR
Centrarchidae	Sunfishes	Enneacanthus obesus	banded sunfish	168117	F	Y77	AR
Centrarchidae	Sunfishes	Lepomis auritus	redbreast sunfish	168131	F	Y77	AR
Centrarchidae	Sunfishes	Lepomis cyanellus	green sunfish	168132	F, I	Y77	AR
Centrarchidae	Sunfishes	Lepomis humilis	orangespotted sunfish	168151	F, I	Y77	AR
Centrarchidae	Sunfishes	Lepomis macrochirus	bluegill	168141	F	Y77	AR
Centrarchidae	Sunfishes	Lepomis marginatus	dollar sunfish	168152	F	Y77	AR
Centrarchidae	Sunfishes	Lepomis microlophus	redear sunfish	168154	F	Y77	AR
Centrarchidae	Sunfishes	Lepomis punctatus	spotted sunfish	168155	F	Y77	AR

[4] FWC, 1983, unpublished

Appendix E. -- Part 1. Riverine reach -- Continued

Family (scientific name)	**Family (common name)**	**Species (scientific name)**	**Species (common name)**	**TSN**	**Type**	**Source**	**Floodplain collections**
Centrarchidae	Sunfishes	Micropterus cataractae	shoal bass	564610	F	Y77	---
Centrarchidae	Sunfishes	Micropterus punctulatus	spotted bass	168161	F, I	Y77	AR
Centrarchidae	Sunfishes	Micropterus salmoides	largemouth bass	168160	F	Y77	AR
Centrarchidae	Sunfishes	Pomoxis annularis	white crappie	168166	F, I	W06	AR
Centrarchidae	Sunfishes	Pomoxis nigromaculatus	black crappie	168167	F	Y77	AR
Percidae	Perches	Ammocrypta bifascia	Florida sand darter	168514	F	A85	---
Percidae	Perches	Etheostoma edwini	brown darter	168390	F	Y77	E. US
Percidae	Perches	Etheostoma fusiforme	swamp darter	168358	F	Y77	AR
Percidae	Perches	Etheostoma parvipinne	goldstripe darter	168421	F	Y77	---
Percidae	Perches	Etheostoma swaini	Gulf darter	168439	F	Y77	AR
Percidae	Perches	Perca flavescens	yellow perch	168469	F, I	Y77	AR
Percidae	Perches	Percina nigrofasciata	blackbanded darter	168490	F	Y77	AR
Gerreidae	Mojarras	Eucinostomus harengulus (tax. rev. E. argenteus)	tidewater mojarra (formerly spotfin mojarra)	169025 (formerly 169015)	M	W06	AR
Elassomatidae	Pygmy sunfishes	Elassoma evergladei	Everglades pygmy sunfish	168169	F	Y77	AR
Elassomatidae	Pygmy sunfishes	Elassoma gilberti (tax. rev. E. okefenokee)	new species (formerly Okefenokee pygmy sunfish)	No TSN (formerly 168170)	F	Y77 (tax. rev. S09)	AR
Elassomatidae	Pygmy sunfishes	Elassoma zonatum	banded pygmy sunfish	168171	F	Y77	AR
Cichlidae	Cichlids	Oreochromis niloticus	Nile tilapia	553310	F, I	[5]	---
Paralichthyidae	Lefteye flounders	Paralichthys lethostigma	southern flounder	172738	M	Y77	---
Achiridae	Scrawed soles	Trinectes maculatus	hogchoker	172982	C	Y77	AR

[5] FWC, 2009, unpublished

Appendix E. -- Part 2. Species of fish known to occur in the tidal reach only.

Family (scientific name)	**Family (common name)**	**Species (scientific name)**	**Species (common name)**	**TSN**	**Type**	**Source**
Carcharhinidae	Requiem sharks	Carcharhinus leucas	bull shark	160275	M	B83
Dasyatidae	Stingrays	Dasyatis sabina	Atlantic stingray	160953	M	B83
Elopidae	Tarpons	Elops saurus	ladyfish	161111	M	B83
Megalopidae	Tarpons	Megalops atlanticus	tarpon	161116	M	[6]
Ophichthidae	Snake eels	Myrophis punctatus	speckled worm eel	161453	M	B83
Engraulidae	Anchovies	Anchoa mitchilli	bay anchovy	161839	M	L77
Clupeidae	Herrings	Brevoortia patronus	Gulf menhaden	161734	M	L77
Ariidae	Sea catfishes	Ariopsis felis	hardhead catfish	164165	M	B83
Ariidae	Sea catfishes	Bagre marinus	gafftopsail catfish	164159	M	B83
Mugilidae	Mullets	Mugil curema	white mullet	170336	M	L77
Atherinopsidae	Silversides	Membras martinica	rough silverside	165989	M	H90
Atherinopsidae	Silversides	Menidia beryllina	inland silverside (alternate name: tidewater silverside)	165993	M	L77
Fundulidae	Killifishes	Adinia xenica	diamond killifish	165682	M	L77
Fundulidae	Killifishes	Fundulus confluentus	marsh killifish	165645	M	L77
Fundulidae	Killifishes	Fundulus grandis	Gulf killifish	165651	M	L77
Fundulidae	Killifishes	Fundulus seminolis	Seminole killifish	165667	F	B10
Fundulidae	Killifishes	Fundulus similis	longnose killifish	165657	M	L77
Fundulidae	Killifishes	Lucania parva	rainwater killifish	165679	F	L77
Poeciliidae	Livebearers	Poecilia latipinna	sailfin molly	165898	M	L77
Cyprinodontidae	Killifishes	Cyprinodon variegatus	sheepshead minnow	165631	F	L77
Syngnathidae	Pipefishes, seahorses	Syngnathus floridae	dusky pipefish	166446	M	B83
Syngnathidae	Pipefishes, seahorses	Syngnathus scovelli	Gulf pipefish	166458	M	B83
Carangidae	Jacks	Hemicaranx amblyrhynchus	bluntnose jack	168740	M	[7]
Carangidae	Jacks	Oligoplites saurus	leatherjacket	168673	M	A85
Carangidae	Jacks	Trachinotus falcatus	permit	168709	M	B95
Lutjanidae	Snappers	Lutjanus griseus	gray snapper (mangrove)	168848	M	L77
Gerreidae	Mojarras	Eucinostomus gula	silver jenny	169016	M	L77

[6] FWC, unpublished

[7] FWC, 1989, Statewide Stream Monitoring Data

Appendix E. -- Part 2. Tidal reach -- Continued

Family (scientific name)	**Family (common name)**	**Species (scientific name)**	**Species (common name)**	**TSN**	**Type**	**Source**
Haemulidae	Grunts	Orthopristis chrysoptera	pigfish	169077	M	B83
Sparidae	Porgies	Archosargus probatocephalus	sheepshead	169189	M	L77
Sparidae	Porgies	Lagodon rhomboides	pinfish	169187	M	B83
Sciaenidae	Drums	Bairdiella chrysoura	silver perch	169259	M	L77
Sciaenidae	Drums	Cynoscion arenarius	sand seatrout	169243	M	L77
Sciaenidae	Drums	Cynoscion nebulosus	spotted seatrout	169239	M	B83
Sciaenidae	Drums	Leiostomus xanthurus	spot	169267	M	B83
Sciaenidae	Drums	Micropogonias undulatus	Atlantic croaker	169283	M	L77
Sciaenidae	Drums	Sciaenops ocellatus	red drum	169290	M	B83
Eleotridae	Sleepers	Eleotris amblyopsis (tax. rev. E. pisonis)	largescaled spinycheek sleeper (formerly spinycheek sleeper)	636827 (formerly 171932)	M	B95
Gobiidae	Gobies	Bathygobius soporator	frillfin goby	171820	M	B83
Gobiidae	Gobies	Ctenogobius boleosoma	darter goby	636799	M	B83
Gobiidae	Gobies	Ctenogobius shufeldti	freshwater goby	636837	M	H90
Gobiidae	Gobies	Gobiosoma bosc	naked goby	171789	M	L77
Gobiidae	Gobies	Gobiosoma robustum	code goby	171791	M	B83
Gobiidae	Gobies	Microgobius gulosus	clown goby	171808	M	L77

Simulating the Impact of USACE Operating Alternatives on Salinity and Oyster Population in Apalachicola Bay, FL

Draft Interim Report

By

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Presented to the

Fish and Wildlife Service
U.S. Department of Interior

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Introduction

The Apalachicola-Chatahoochee-Flint (ACF) system is an important watershed-riverine-estuarine ecosystem which encompasses the tri-state area of Georgia, Alabama, and Florida. Freshwater originates in northeast Georgia and flows through Chattahoochee River, Flint River, and Apalachicola River before reaching the Apalachicola Bay in Florida. While the freshwater is used for drinking and agriculture, it is also vital to the shellfish in the Apalachicola Bay. Reduced freshwater flow in the ACF system will result in higher salinity in the Apalachicola Bay which could adversely impact the oysters. Low salinity, on the other hand, may endanger the federally threatened Gulf sturgeon in the Bay. Therefore, it is important to develop quantitative understanding on how freshwater flow in the ACF system impacts the salinity in the Apalachicola Bay, so that the amount of freshwater flow necessary to maintain fish and wildlife in Bay can be better understood.

As a first step towards the development of an integrated modeling system of the ACF system to enable assessment of the impact of freshwater withdrawal and climate change on the salinity and biological species inside the Apalachicola Bay, Sheng and Paramygin (2010a) developed a hydrodynamic model to simulate the flow and salinity distribution inside Apalachicola Bay. Their model is based on the 3D curvilinear-grid hydrodynamic model CH3D (Sheng 1987, Sheng et al. 2008, Sheng and Paramygin 2010a) and was successfully applied to simulate the salinity dynamics in the Bay during the summer of 2004 when 5 hurricanes passed the region. The simulation captured the significant variation in salinity that occurred during the 2004 hurricane season. The CH3D model used by Sheng and Paramygin (2010a) has several advantages over the model used by Huang (2010) for Apalachicola Bay:

- It uses a boundary-fitted grid to accurately resolve the complex shorelines of the Apalachicola Bay system;
- It uses very high spatial grid resolution (~20 m) in the horizontal directions;
- It can simulate circulation driven by wind, tide, and density gradients, while allowing flooding and drying of the shorelines during hurricanes and storms;
- It can be coupled to a large scale circulation model of the Gulf of Mexico;
- It allows incorporation of various wind and precipitation fields; and
- It has been integrated with ecosystem models, CH3D-IMS (Sheng and Kim 2009), and inundation models, CH3D-SSMS (Sheng et al. 2010; Sheng and Paramygin 2010b).

Therefore in this study we used the CH3D model for Apalachicola Bay to study the impact of freshwater alteration on the salinity, Gulf sturgeon, and oyster population in the Apalachicola Bay.

Results of the hydrodynamic and salinity simulations can be used to simulate the oyster population inside the Apalachicola Bay. Hofmann et al. (1992), Klinck et al. (1992), Powell et al. (2003) developed an oyster population dynamic model for oysters in Galveston Bay, Texas. Since Apalachicola Bay and Galveston Bay have similar-sized adult oyster populations, Wang et al. (2008) applied the post-settlement population dynamic model of Powell, Hofmann, and Klinck to Apalachicola Bay with necessary modifications to account for the specific conditions in Apalachicola Bay. Post-settlement adult oysters are divided into four size groups, while oyster filtration rate is assumed to be dependent on salinity, temperature, and turbidity, spawning patterns are dependent on the relationship between temperature and food supply during critical feeding periods, the same temperature-dependent reproduction efficiency equations from Galveston Bay holds true, and no specific relationship exists between salinity and oyster growth rate. Thus, low salinity results in low oyster reproduction due to lower filtration rate and higher respiration. Livingston et al. (2000) also studied the oyster population in Apalachicola Bay.

Wang et al. (2008) simulated the oyster population between March 2004 and June 2005 at two sites: Dry Bar, a site with strong river influence located to the southwest of the Apalachicola River, and Cat Point, a site with little river influence located to the southeast of the River. Model results agreed well with data except during July and September 2004 when hurricanes were affecting the Apalachicola Bay. Nevertheless, Wang et al. (2008) suggested that, anticipating increased freshwater use upstream of the Apalachicola River, Apalachicola Bay will become increasingly saltier, causing a substantial decrease in oyster growth rates, particularly in summer when oyster growth rates are normally high in the Bay.

During this study, we constructed and validated an oyster population dynamic model similar to the one described by Wang et al. (2008), and coupled it to the hydrodynamic-salinity model described above to assess the impact of freshwater alteration on oyster population in Apalachicola Bay.

Initial Model Setup and Verification

A CH3D model computational grid was developed for Apalachicola Bay and surrounding areas to simulate the salinity distribution in the bay, the grid, selected data sites, and bathymetry/topography values used in the model are shown in Figures 1 and 2. From hereon, this grid is referred to as the “fine” grid. A coarse grid has also been developed which has 4 times fewer grid cells. The “coarse” grid is obtained by merging 2 by 2 cell blocks of the fine grid into a single grid cell of the coarse grid and reapplying the bathymetry/topography interpolation.

CH3D is applied in a 3D mode with 8 vertical sigma-grid layers. The time step used for simulations is set to 1 minute which allows to 1 year to be simulated in approximately 1.2 days of wall clock time on a single CPU core (Intel Core i7 870 @ 2.93 Ghz).

The model has two open boundaries – at the west and south ends, tidal forcing (in a form of tidal constituents) is used at these boundaries to drive the tides inside the model domain. The tidal constituents are based on the data at the NOAA tidal gage (872-8690) located at the mouth of the Apalachicola River (Figure 1). Significant constituents (amplitudes > 1 cm) are K1, M2, O1, P1, S2, SA, and SSA.

A river flow boundary condition is introduced at the Apalachicola River (Sumatra gage) and the flows are based on the daily flow rates provided by the USACE. It is assumed that flow at the Sumatra gage is freshwater only, hence the river boundary value of salinity is set to 0 ppt.

Wind forcing over the domain is based on 6-hourly wind data from the NOGAPS model (https://www.fnmoc.navy.mil/public) and is linearly interpolated in time at the time step of the CH3D model.

The initial salinity field is based on interpolation of a HYCOM model snapshot of surface salinity; hence, the initial salinity profile is vertically uniform. Subsequently, all model simulations use a spin-up period of 3 months prior to starting the main simulation to ensure that there is time to establish a realistic (spatial and vertical) salinity distribution in the domain.

Apalachicola National Estuarine Research Reserve (ANERR) provides salinity data at several sites. Comparisons with observed data were done to verify the model, which showed satisfactory performance (Figure 3 and Figure 4) with the test year being simulated (2004).

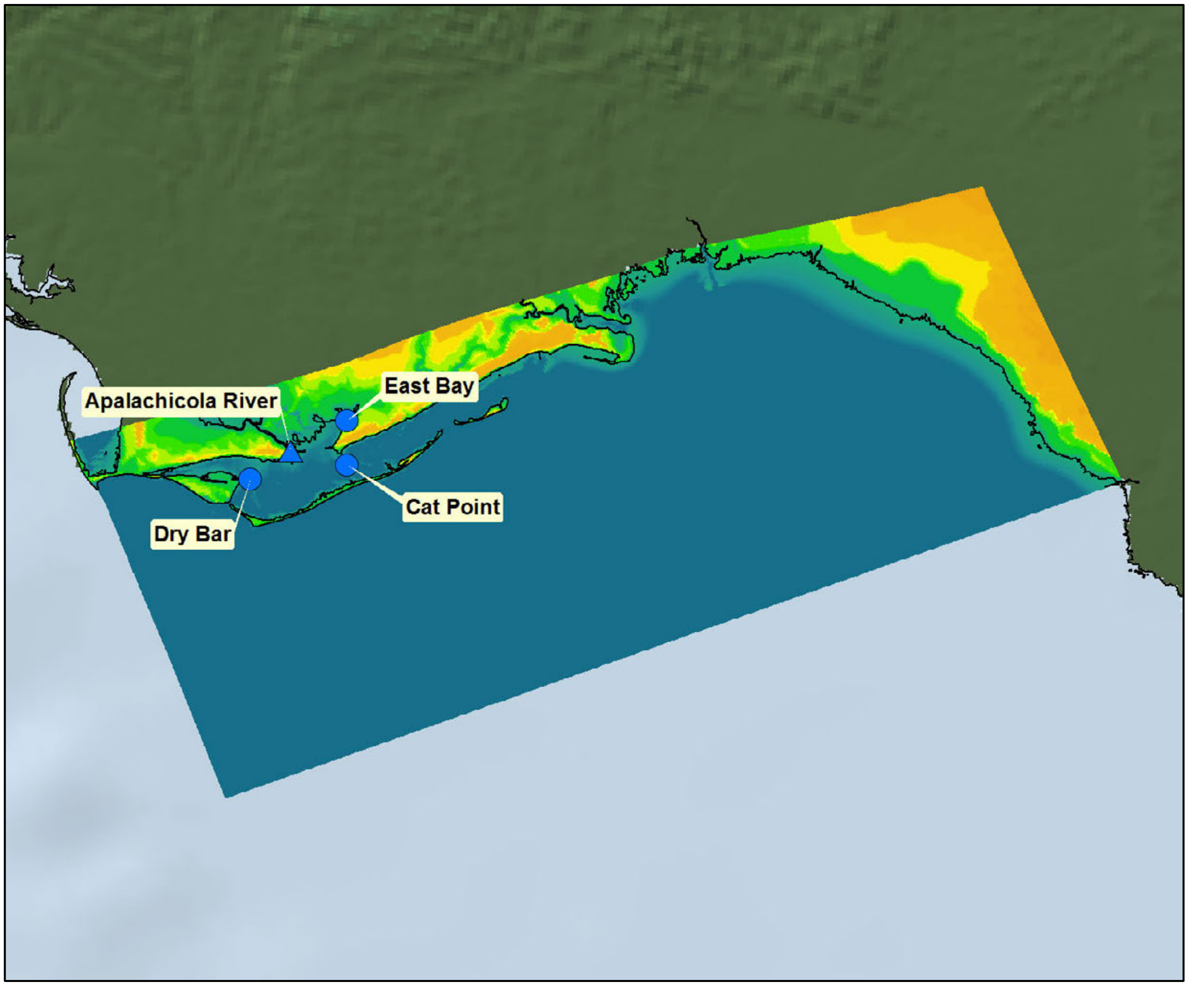


Figure 1. CH3D model grid and selected data sites

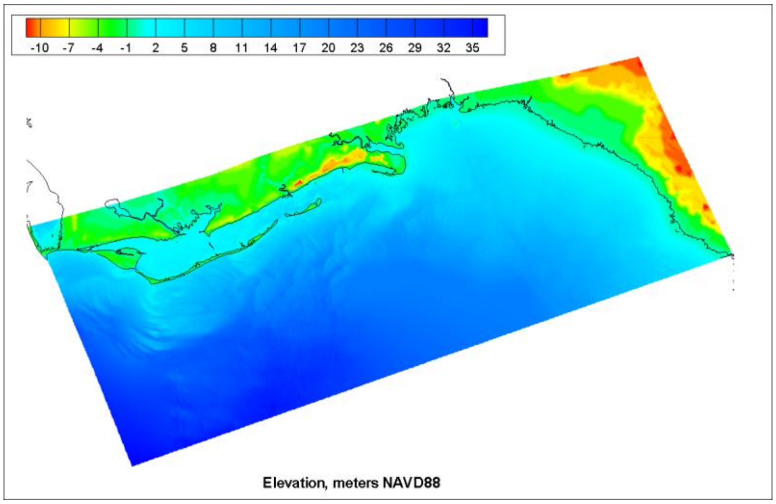


Figure 2. CH3D model grid bathymetry / topography

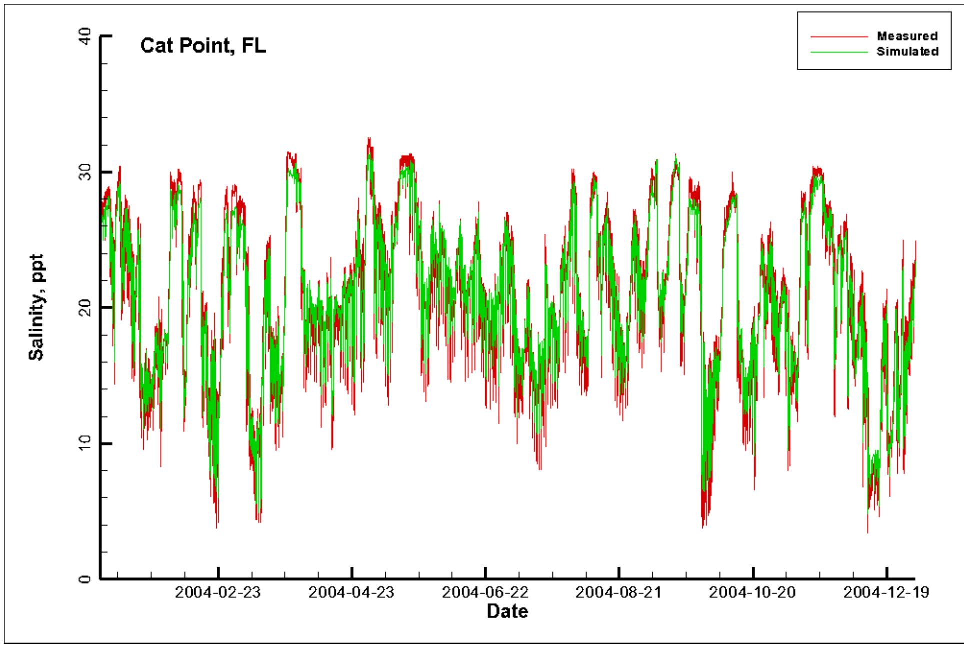


Figure 3. Simulated salinity at the Cat Point site during 2004

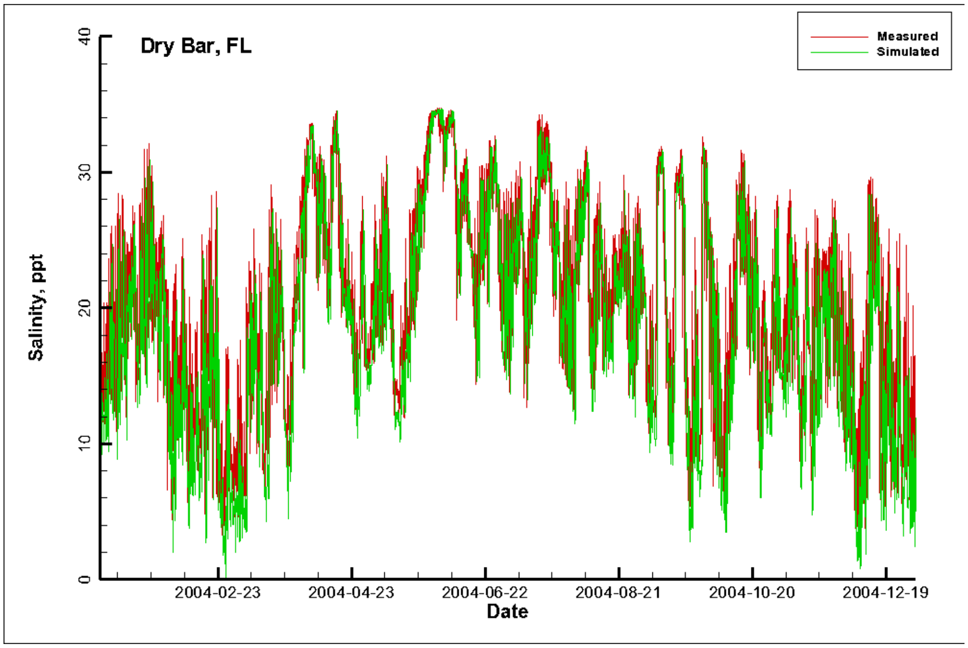


Figure 4. Simulated salinity at the Dry Bar site during 2004

10 Year Simulations

1999-2008. Fine grid

Four flow discharge scenarios were considered for the 10 year (1999-2008) simulations:

a) Observed

b) Current operations

c) Alternative #1

d) Alternative #2

Base scenario a) uses observed flow rates at the Sumatra gage provided by the USACE. Scenarios b), c) and d) use altered flows, statistics for the time series of flow rates are provided in Table 1.

With the exception of these flow rates all other model parameters and forcing remain the same for all scenarios.

Table 1. Statistics for the flow rates (m^3/s) at the Sumatra gage

	mean	**mean %**	**std dev**	**std dev %**	**min**	**max**
Observed	519.2		411.4		124.6	4700.6
Current	514.4	0.92	391.3	4.89	136.4	3965.7
Alt #1	515.9	0.64	391.4	4.86	136.4	3965.7
Alt #2	516.4	0.54	391.0	4.96	136.4	3965.7

Salinity for the observed scenario during 2004 is consistent with the results produced by the verification simulation displayed in Figure 3 and Figure 4. These results show that there is little difference in salinity inside Apalachicola Bay between the observed scenario and the current and alternate scenarios. However, due to reduced flow rates, simulated salinity in current and alternate scenarios results in slightly higher highs and lower lows as compared to the observed scenario.

1980-1989. Fine grid

Another 10 year time period was also considered (1980-1989). This period was chosen to correspond to the period used by Huang (2010). The same grid was used as in the previous simulations.

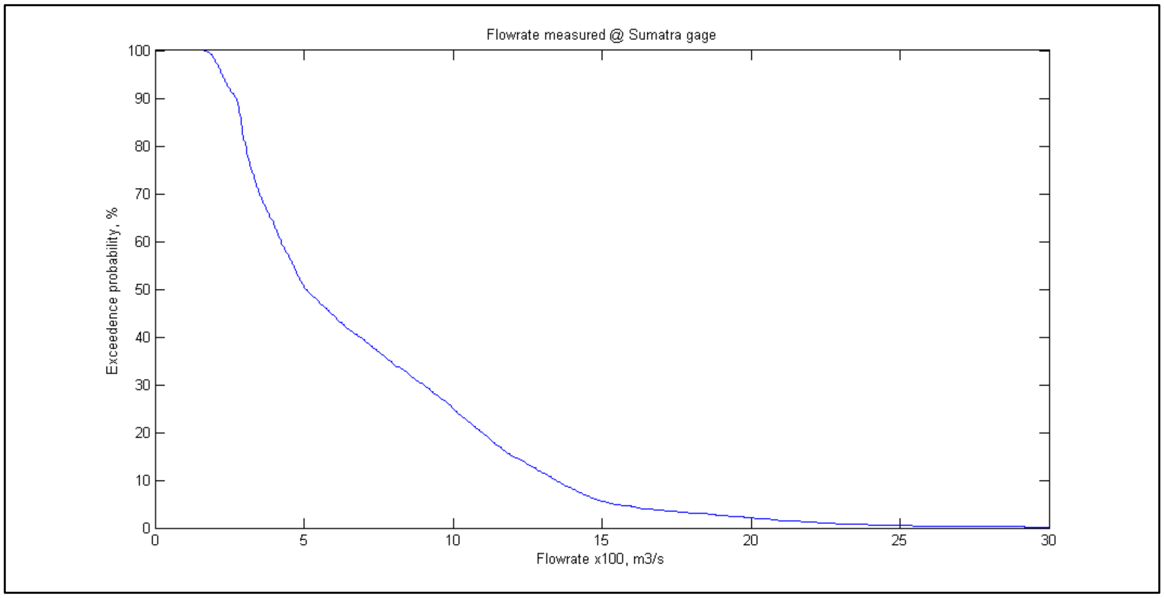


Figure 5. Obsereved flowrate probability of exceedence at the Sumatra gage

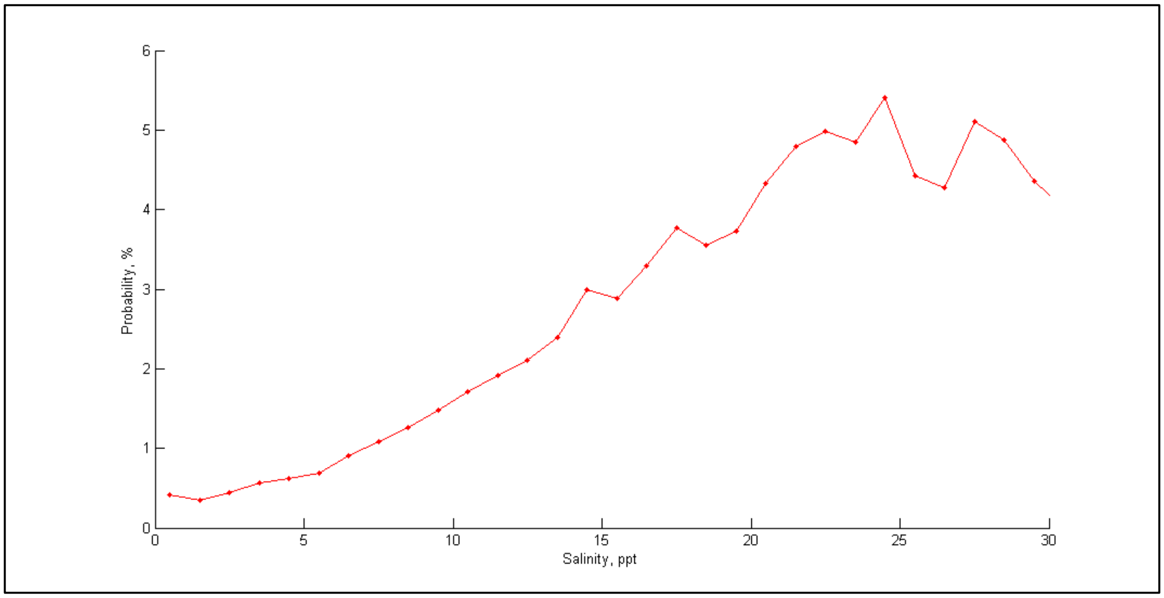


Figure 6. Probability density of simulated salinity at Cat Point

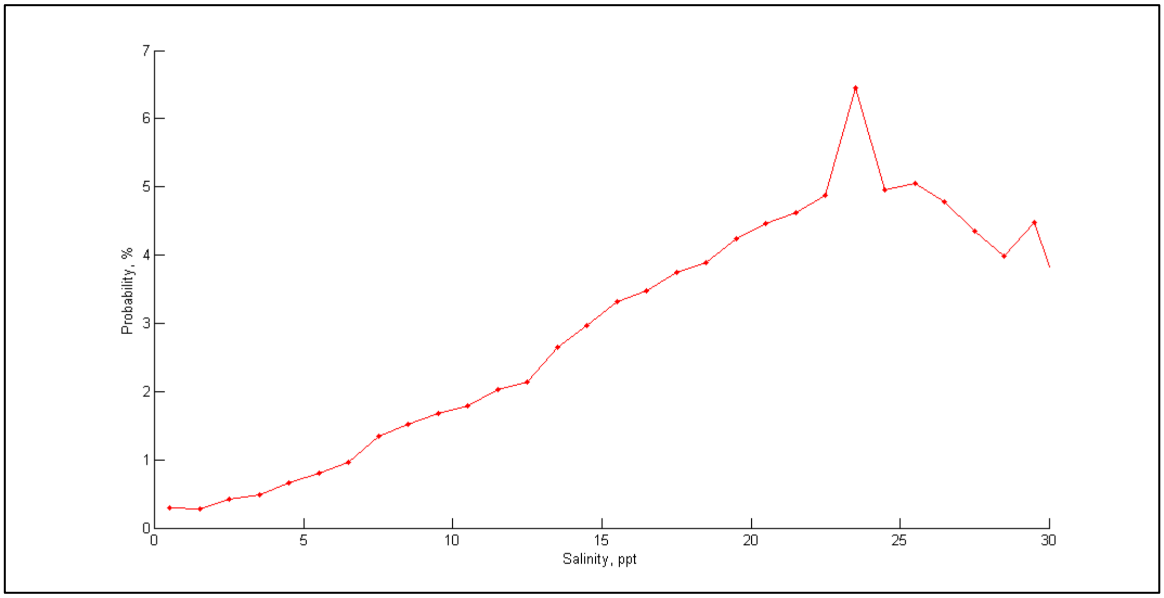


Figure 7. Probability density of simulated salinity at Dry Bar

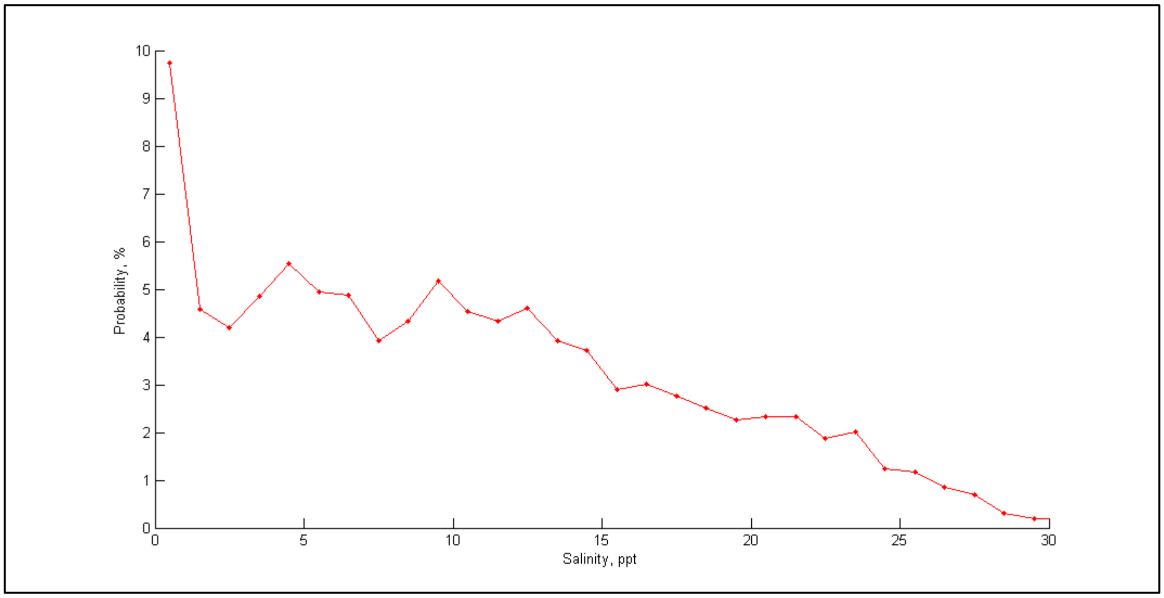


Figure 8. Probability density of simulated salinity at East Bay

1980-1989. Coarse grid

Due to the simulated salinity differing slightly from the results of Huang (2010) – a coarser grid was developed in an attempt to better reproduce Huang's two distinctive peaks in the probability of exceedance figures for salinity; however, results were similar to those produced by the finer grid model and aggregate functions (e.g. probability of exceedence, probability density, etc.) showed little difference compared to the fine grid model results.

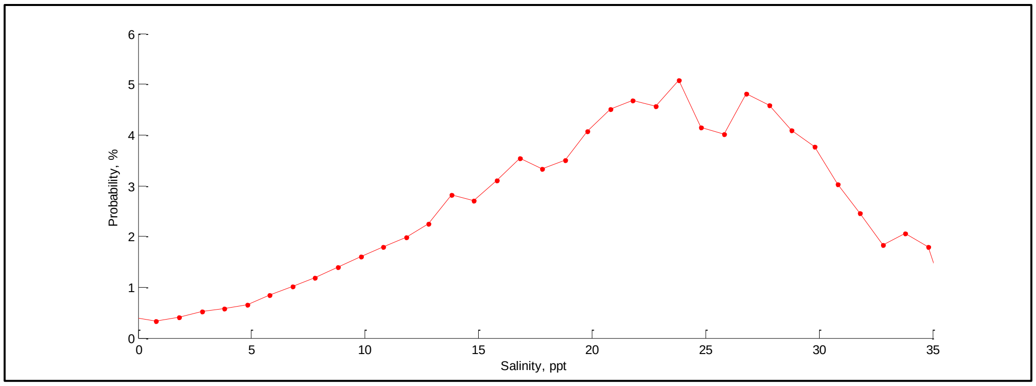


Figure 9. Probability density of simulated salinity at Cat Point

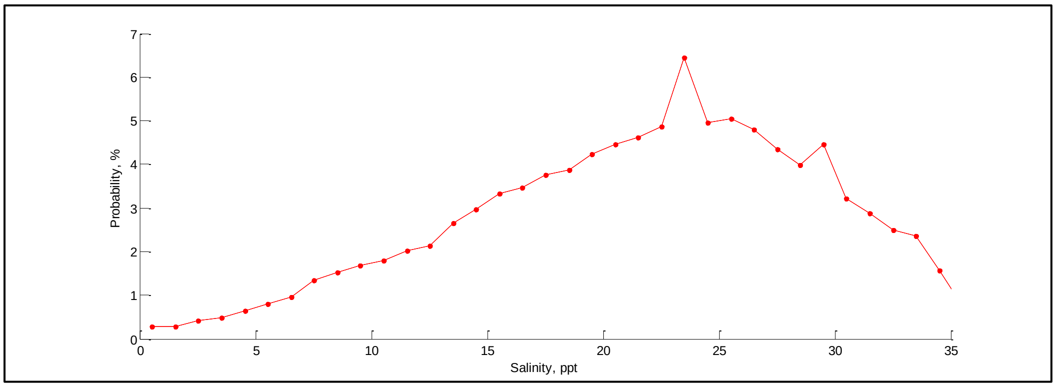


Figure 10. Probability density of simulated salinity at Dry Bar

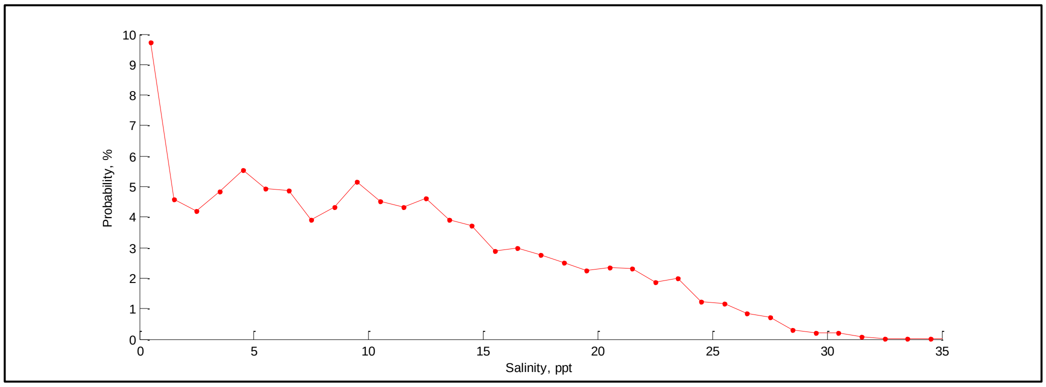


Figure 11. Probability density of simulated salinity at East Bay

Analysis Products

A number of model outputs were requested by the FWS – the complete list is available in Appendix B. This section comprises of the figures and tables that are dedicated to fulfilling the request and provide various information based on the results of simulations. All model results presented in this section are based on the 10 year simulation (1999-2008) fine grid using the four different flow scenarios. Given that the flow rate is the only parameter which changes – it is the only parameter that affects the differences in salinity and therefore results, generally, correlate well with the flow at Sumatra gage.

Figure 12 and Figure 13 show the exceedence probability at the Cat Point and Dry Bar sites, respectively, for the four scenarios. As it was mentioned previously – the observed scenario produces slightly higher highs and lower lows in salinity values and there is very little difference, however, between the Current, Alternative #1 and Alternative #2 scenarios.

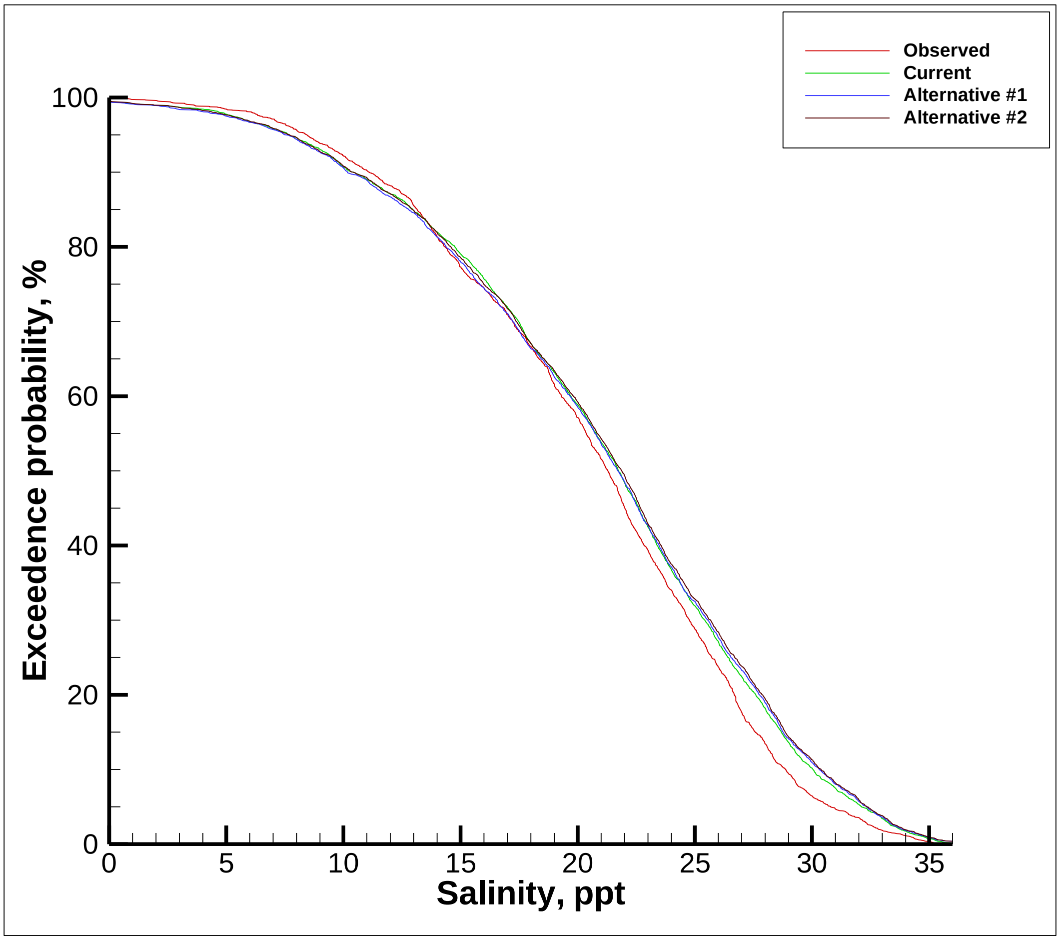


Figure 12. Probability of exceedence at the Cat Point site

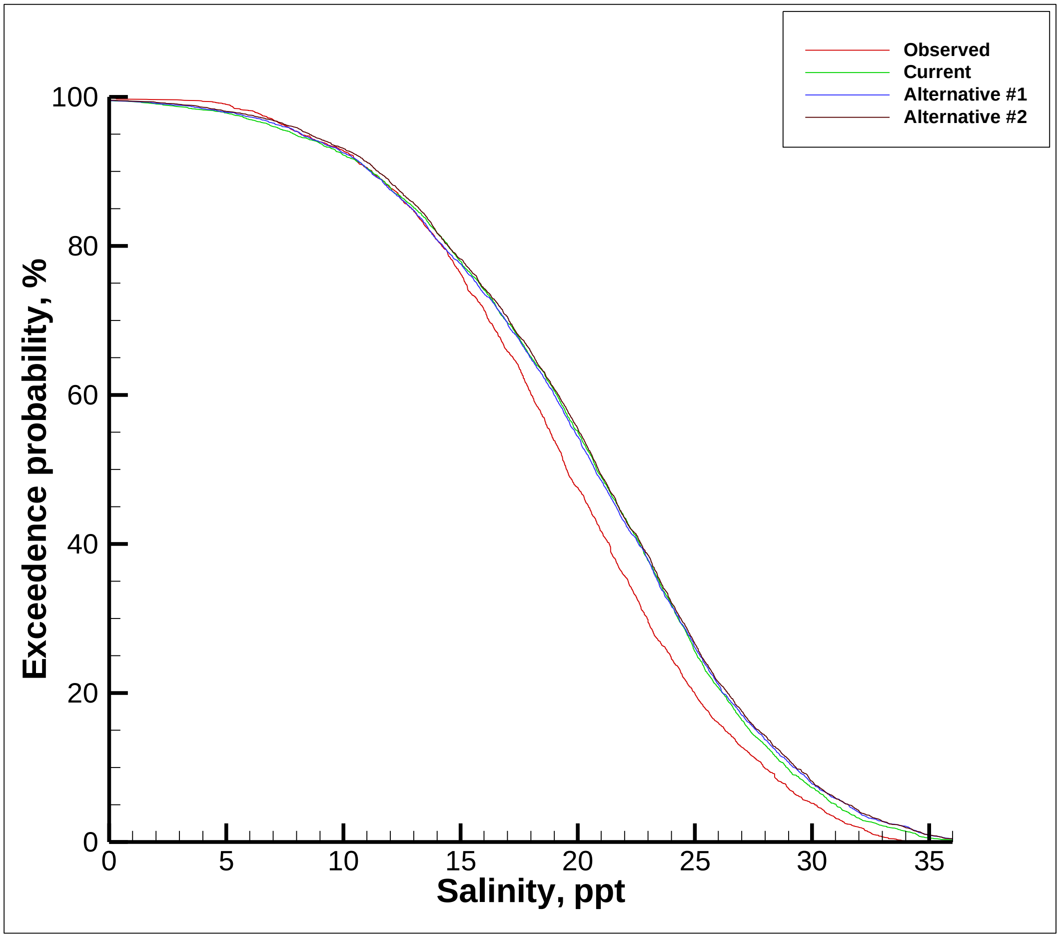


Figure 13. Probability of exceedence at the Dry Bar site

Summary statistics for growth rates of Class 4 (Marketable) oysters at the Cat Point and Dry Bar sites are presented in the tables and figures below. It can be clearly seen that the mean growth rate in August is significantly larger (3 to 4 times) as compared to the growth rate for the entire year at the Cat Point site and smaller for the Dry Bar site. Oyster population model results are based on the simulated bottom salinity at Cat Point and Dry Bar for the four flow scenarios.

Table 2. Growth rate (mg AFDW/oyster/day) statistics for Class 4 (marketable) oysters at Cat Point for the 10 year simulations.

Statistic	Scenario	All Months	August Months Only
Mean	Observed	1.78	5.79
	Current	1.41	4.66
	Alternate #1	1.30	4.31
	Alternate #2	1.31	4.35
Median	Observed	2.65	7.08
	Current	2.65	7.00
	Alternate #1	2.63	6.99
	Alternate #2	2.63	6.99
Standard Deviation	Observed	5.73	5.00
	Current	6.46	7.10
	Alternate #1	6.63	8.01
	Alternate #2	6.62	7.90
Interquartile Range	Observed	1.43	2.10
	Current	1.39	2.16
	Alternate #1	1.42	2.17
	Alternate #2	1.42	2.17

Table 3. Growth rate (mg AFDW/oyster/day) statistics for Class 4 (marketable) oysters at Dry Bar for the 10 year simulations.

Statistic	Scenario	All Months	August Months Only
Mean	Observed	2.92	2.19
	Current	2.42	0.81
	Alternate #1	2.39	0.69
	Alternate #2	2.44	0.78
Median	Observed	4.42	5.26
	Current	4.41	5.14
	Alternate #1	4.39	5.14
	Alternate #2	4.39	5.15
Standard Deviation	Observed	5.04	7.63
	Current	6.36	10.45
	Alternate #1	6.26	10.39
	Alternate #2	6.20	10.32
Interquartile Range	Observed	1.87	1.23
	Current	1.97	1.23
	Alternate #1	2.05	1.95
	Alternate #2	2.03	1.63

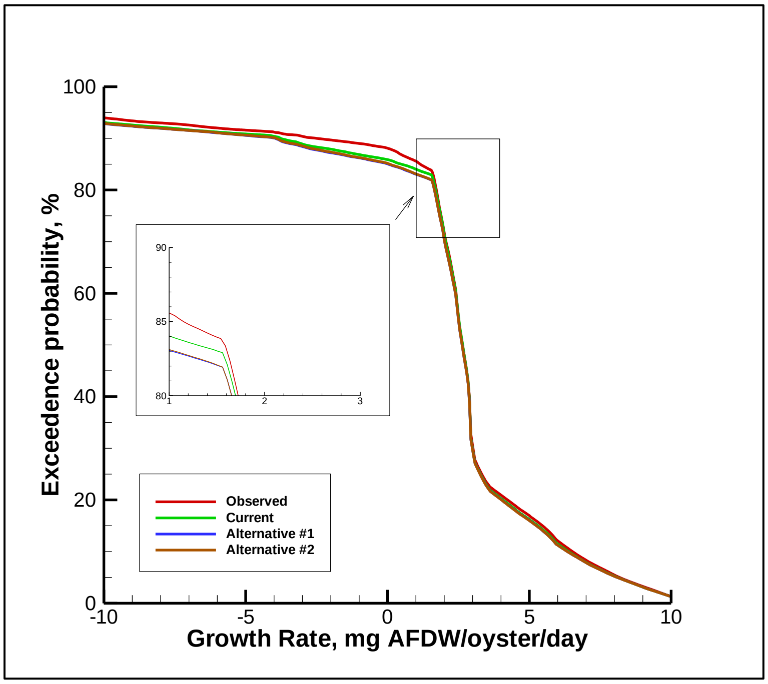


Figure 14. Exceedance probabilty at Cat Point as a function of growth rate for marketable oysters (Class 4) for the 10 year simulations during all months.

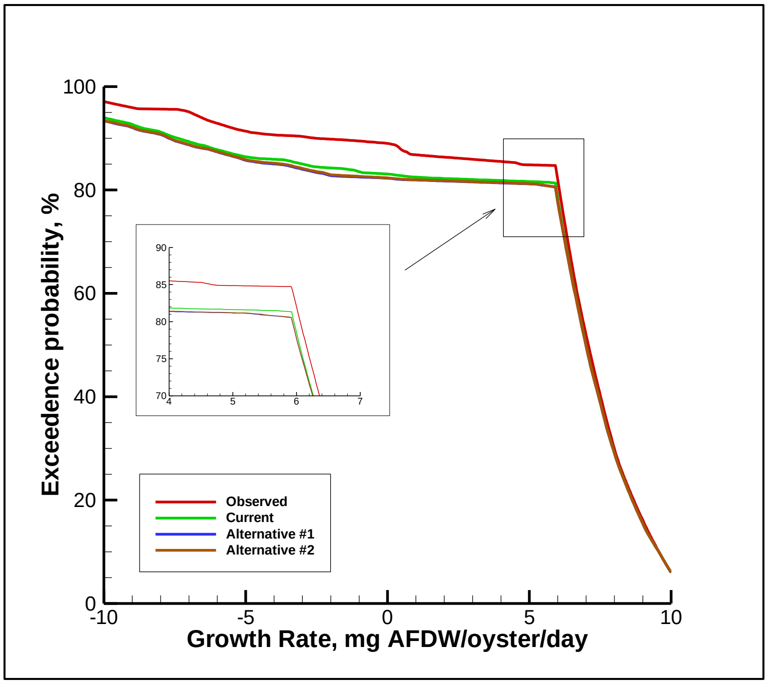


Figure 15. Exceedance probabilty at Cat Point as a function of growth rate for marketable oysters (Class 4) for the 10 year simulations during the August months only.

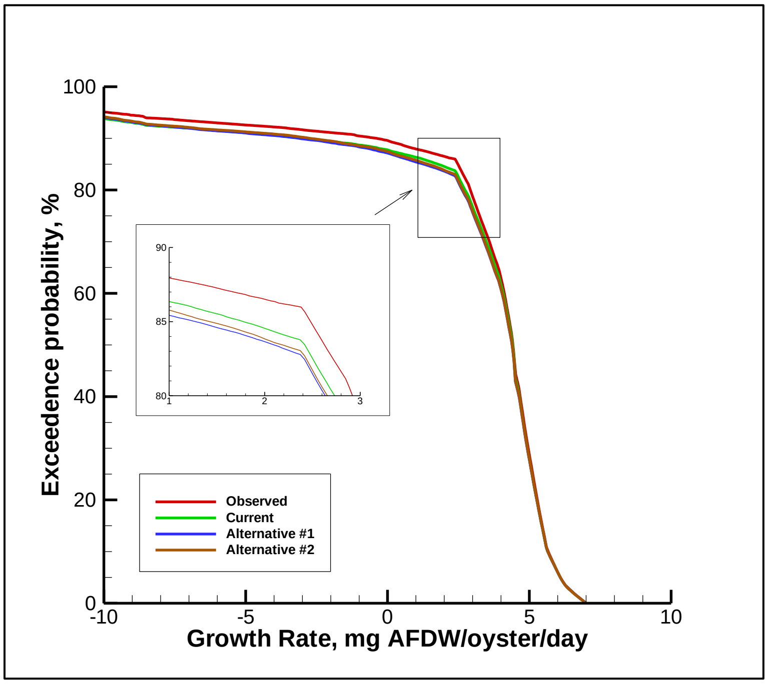


Figure 16. Exceedance probabilty at Dry Bar as a function of growth rate for marketable oysters (Class 4) for the 10 year simulations during all months.

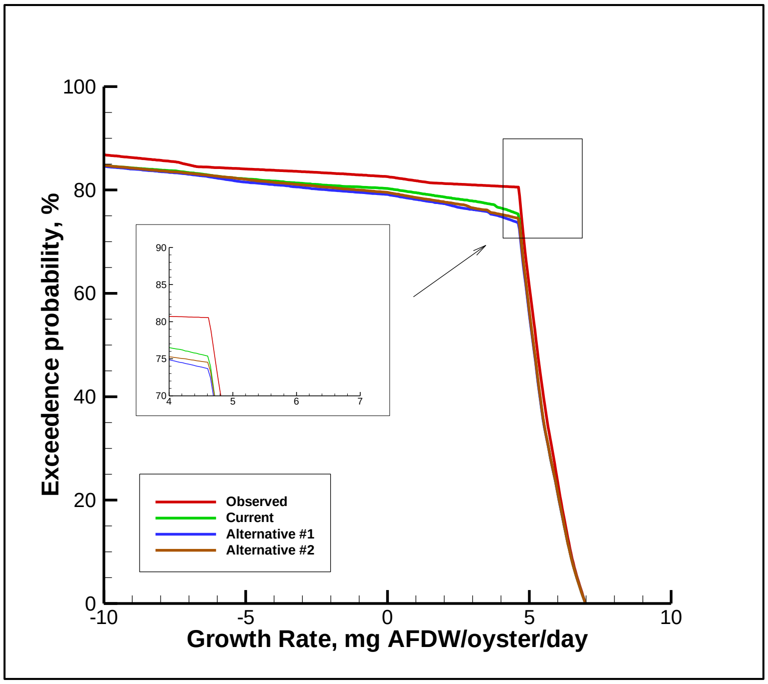
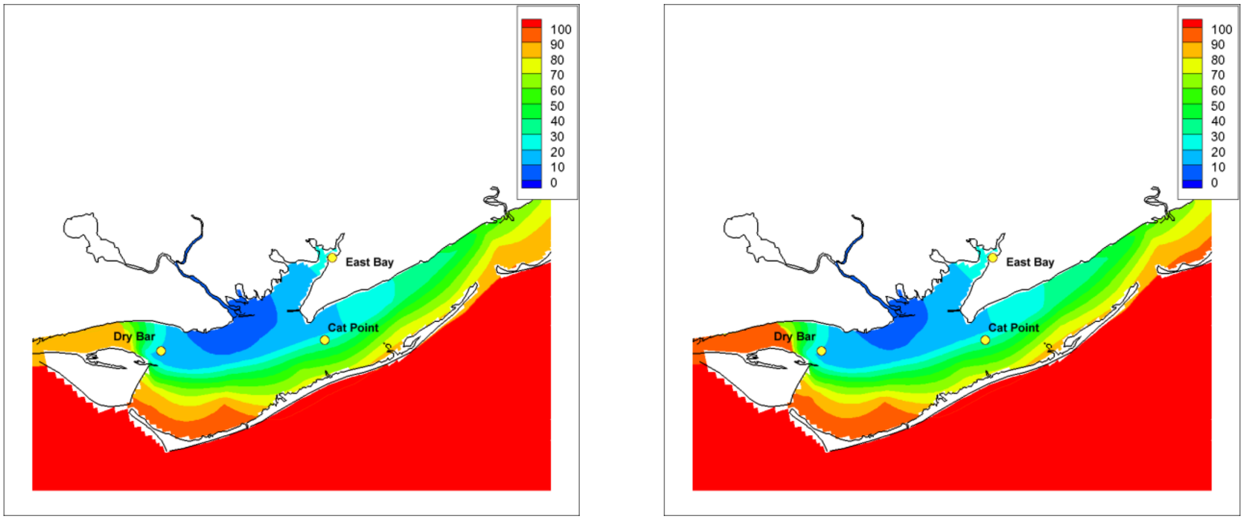
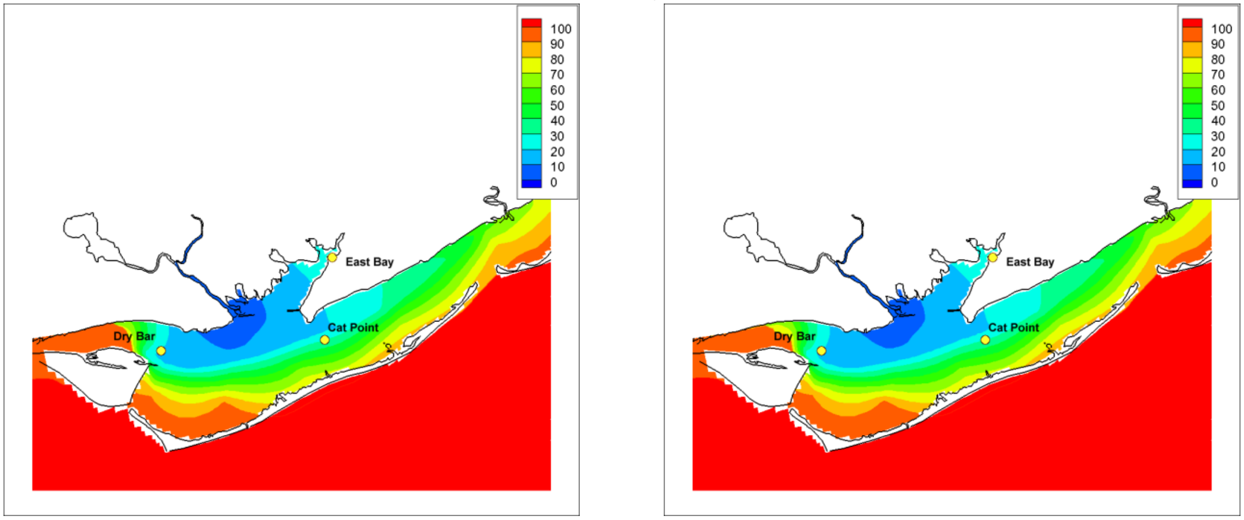


Figure 17. Exceedence probability at Dry Bar as a function of growth rate for marketable oysters (Class 4) for the 10 year simulations during the August months only.

The following figures and tables present the number of days when salinity exceeds 26 ppt (important for oysters) and when the salinity exceeds 10 ppt (important for sturgeon).



a) Observed b) Current

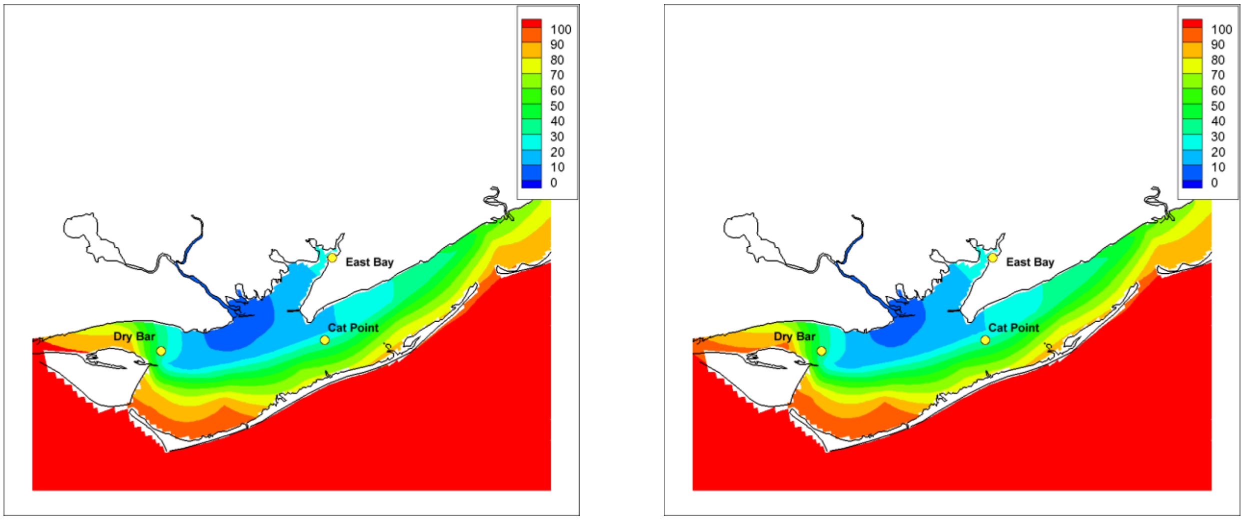


c) Alternative #1 d) Alternative #2

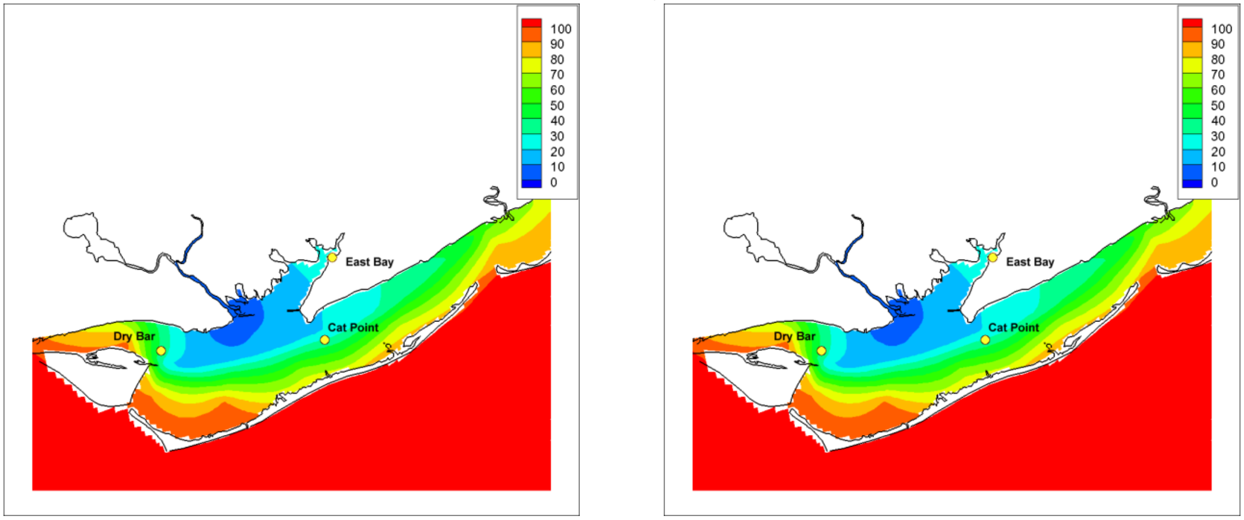
Figure 18. Percentage of days when salinity exceeds 26 ppt for four scenarios during a dry (annual discharge) year (2002)

Table 4 Acreages affected by the percentage of days when salinity exceeds 26 ppt for four scenarios during a dry (annual discharge) year (2002)

% of days	Observed	Current	Alternative #1	Alternative #2
0-10	8682.77	5804.57	5499.89	5079.00
10-20	17059.82	17788.53	17818.89	17741.41
20-30	10170.56	10540.15	10608.20	10777.82
30-40	9461.74	9566.44	9603.08	9618.79
40-50	9057.60	9050.27	9019.90	9077.49
50-60	9839.71	9555.97	9539.22	9509.90
60-70	12861.35	12208.02	12175.56	12048.88
70-80	12351.46	12982.80	12978.61	13360.77
80-90	18268.06	10956.86	10889.85	10521.30



a) Observed b) Current

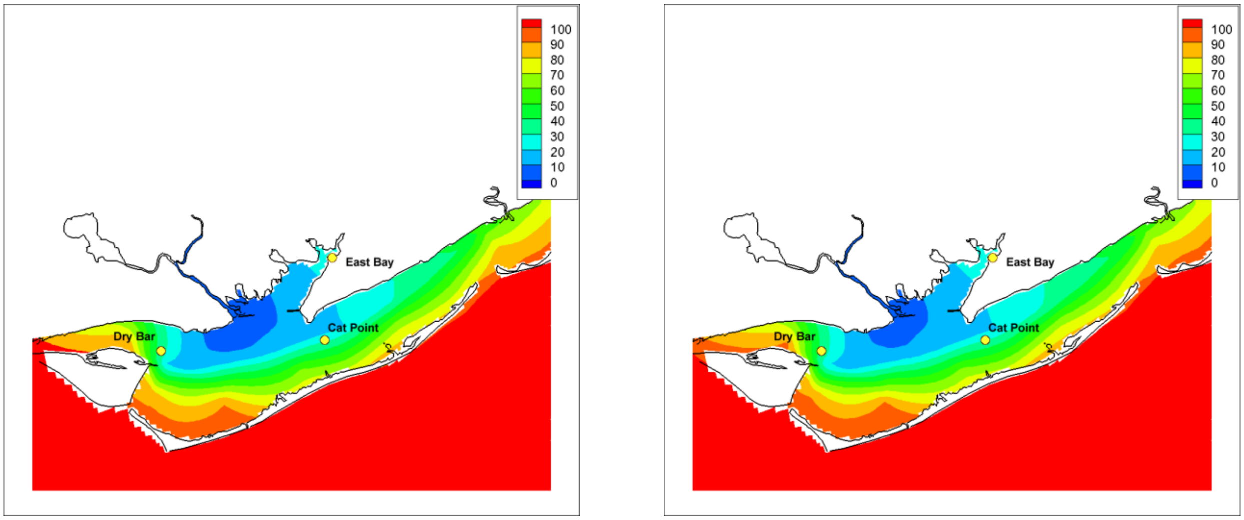


c) Alternative #1 d) Alternative #2

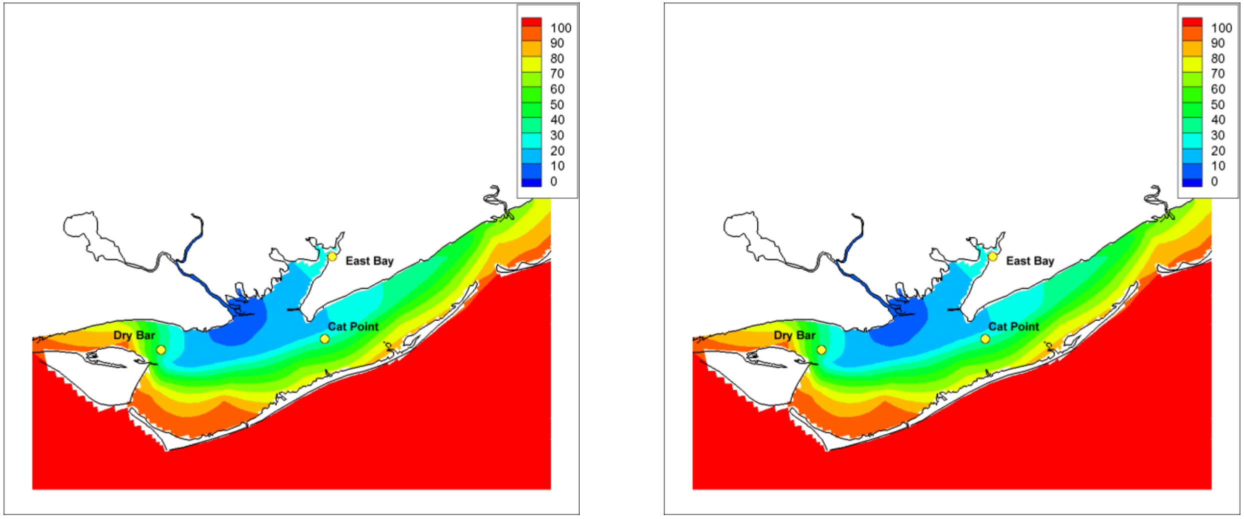
Figure 19. Percentage of days when salinity exceeds 26 ppt for four scenarios during a wet (annual discharge) year (2005)

Table 5. Acreages affected by the percentage of days when salinity exceeds 26 ppt for four scenarios during a wet (annual flow) year (2005)

% of days	Observed	Current	Alternative #1	Alternative #2
0-10	7032.70	4895.77	4640.30	4420.43
10-20	15968.84	15783.53	15684.06	15553.18
20-30	10609.25	11019.67	11166.25	11263.63
30-40	9845.99	10061.67	10050.15	10084.70
40-50	9505.71	9453.36	9484.77	9463.83
50-60	10223.96	10063.76	9995.71	9976.86
60-70	13348.20	12568.19	12504.32	12366.12
70-80	13862.28	14223.49	14231.87	14372.17
80-90	15062.14	14692.55	14662.19	14608.79



a) Observed b) Current

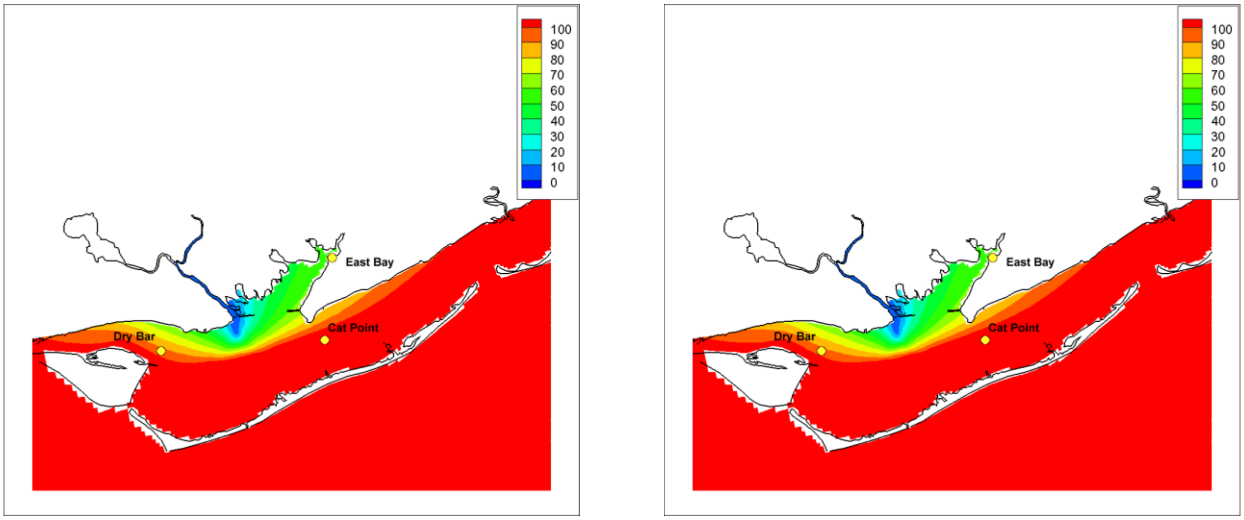


c) Alternative #1 d) Alternative #2

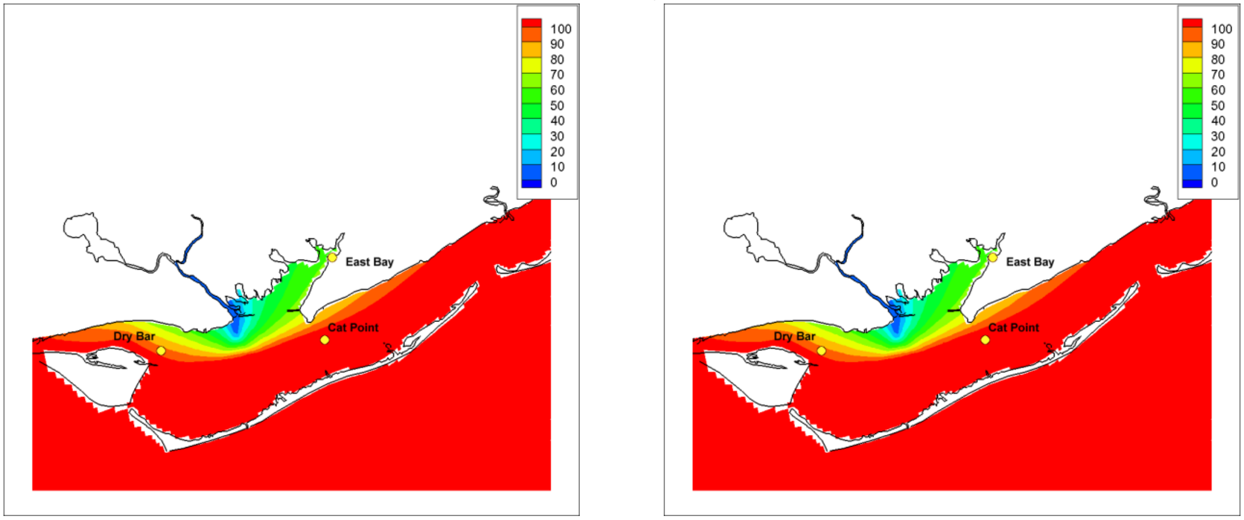
Figure 20. Percentage of days when salinity exceeds 26 ppt for four scenarios during an average (annual flow) year (2001)

Table 6. Acreages affected by the percentage of days when salinity exceeds 26 ppt for four scenarios during an average (annual flow) year (2001)

% of days	Observed	Current	Alternative #1	Alternative #2
0-10	7649.38	5406.71	5247.56	5290.49
10-20	16005.49	16189.76	16167.77	16163.59
20-30	10287.82	10636.47	10689.87	10681.49
30-40	9789.45	9850.18	9873.21	9867.97
40-50	9432.42	9459.64	9452.32	9468.02
50-60	10277.35	10073.19	10009.32	10011.41
60-70	13204.76	12466.63	12489.66	12479.19
70-80	13785.85	14188.94	14174.29	14171.14
80-90	14313.54	13396.37	13339.83	13367.05



a) Observed b) Current

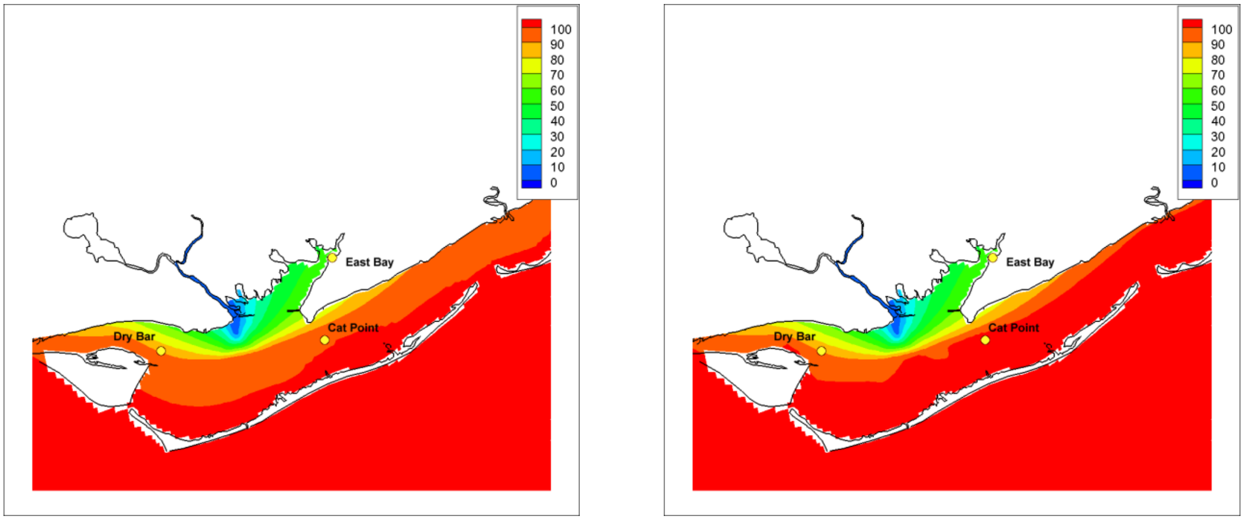


c) Alternative #1 d) Alternative #2

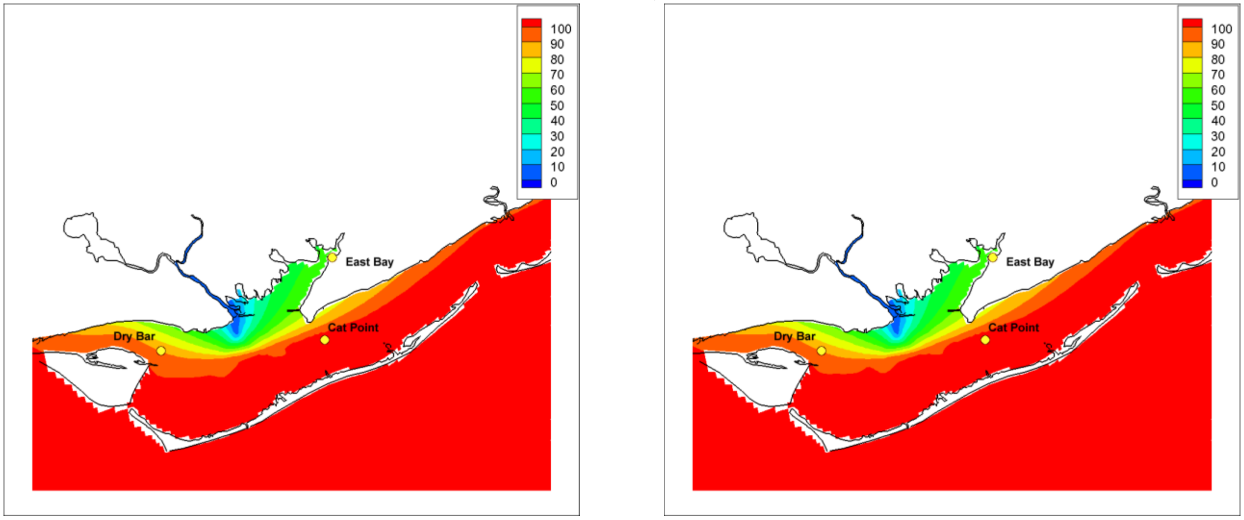
Figure 21. Percentage of days when salinity exceeds 10 ppt for four scenarios during Oct-Mar of a dry (Oct-Mar flow) year (2001)

Table 7. Acreages affected by the percentage of days when salinity exceeds 10 ppt for four scenarios during Oct-Mar of a dry (Oct-Mar flow) year (2001)

% of days	Observed	Current	Alternative #1	Alternative #2
0-10	526.64	493.14	463.82	468.01
10-20	794.67	785.25	770.59	775.83
20-30	1045.95	1031.29	1022.92	1019.78
30-40	1460.56	1420.78	1383.09	1387.27
40-50	3085.51	2980.81	2884.48	2911.71
50-60	4935.56	4982.67	4887.40	4918.81
60-70	3075.04	3082.37	3226.85	3204.87
70-80	3390.19	3340.98	3351.45	3348.31
80-90	5305.15	5225.58	5049.68	5062.24



a) Observed b) Current

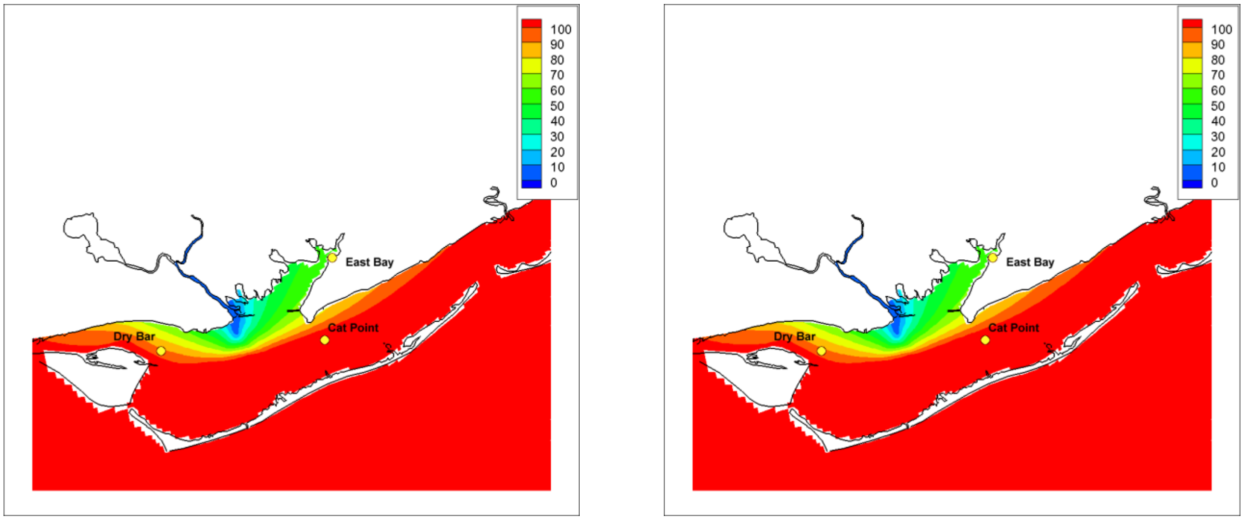


c) Alternative #1 d) Alternative #2

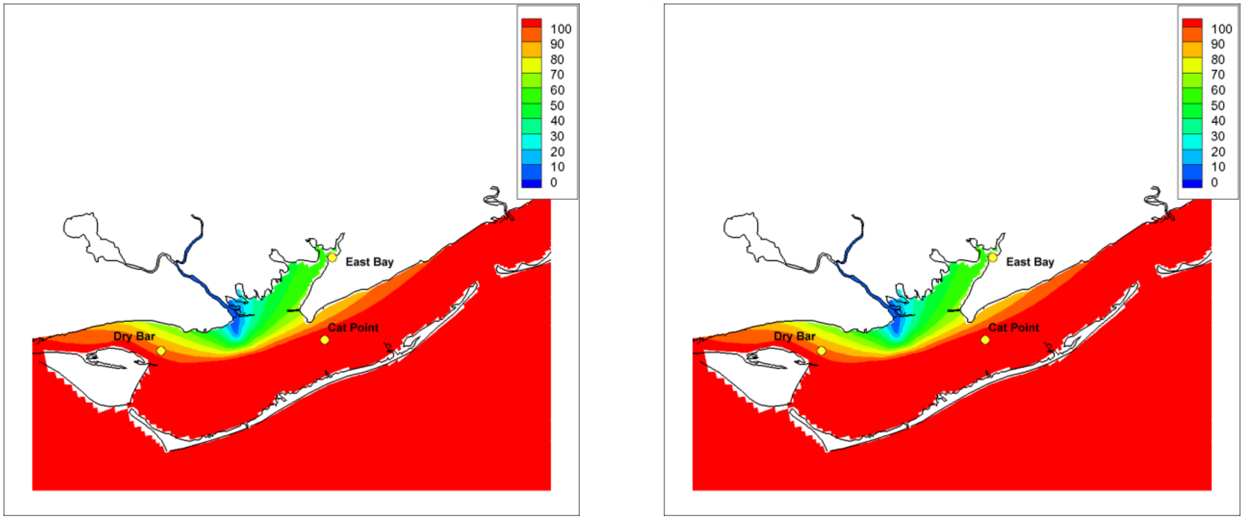
Figure 22. Percentage of days when salinity exceeds 10 ppt for four scenarios during Oct-Mar of a wet (Oct-Mar flow) year (2009)

Table 8. Acreages affected by the percentage of days when salinity exceeds 10 ppt for four scenarios during Oct-Mar of a wet (Oct-Mar flow) year (2009)

% of days	Observed	Current	Alternative #1	Alternative #2
0-10	571.66	506.75	505.70	488.95
10-20	899.37	885.76	854.35	855.40
20-30	1137.04	1105.63	1119.24	1109.82
30-40	1675.20	1614.47	1606.10	1570.50
40-50	3975.46	3800.61	3743.02	3727.32
50-60	4733.49	4844.47	4885.30	4913.57
60-70	3294.91	3284.44	3265.59	3269.78
70-80	4268.62	4090.63	4029.90	4010.01
80-90	7307.01	6996.05	6997.10	6869.37



a) Observed b) Current



c) Alternative #1 d) Alternative #2

Figure 23. Percentage of days when salinity exceeds 10 ppt for four scenarios during Oct-Mar of an average (Oct-Mar flow) year (2004)

Table 9. Acreages affected by the percentage of days when salinity exceeds 10 ppt for four scenarios during Oct-Mar of an average (Oct-Mar flow) year (2004)

% of days	Observed	Current	Alternative #1	Alternative #2
0-10	531.88	505.70	481.62	468.01
10-20	818.75	793.63	793.63	776.87
20-30	1052.23	1040.72	1040.72	1051.19
30-40	1464.75	1477.32	1454.28	1405.07
40-50	3229.99	3090.74	3046.77	3009.08
50-60	4983.72	4995.24	4995.24	5028.74
60-70	3073.99	3062.47	3107.50	3110.64
70-80	3455.10	3453.01	3418.45	3401.70
80-90	5599.36	5463.25	5407.75	5325.04

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Appendix A. Description of the Oyster Population Model

The time-dependent, post-settlement, oyster population model (e.g. Powell et al. 1992; Hofmann et al. 1992, 1994; Klinck et al. 1992, 2002) is based on the energy flow equation in which net production is calculated from the difference between assimilation and respiration and where the net production is the sum of somatic and reproductive tissue production.

Governing Equations

The governing equation is

$$NP_j = P_{gj} + P_{rj} = A_j - R_j$$

Where *j* is the size class, NP_j is the net production, P_{gj} is the somatic production, P_{rj} is the reproductive tissue production, A_j is the assimilation, and R_j is the respiration. The equation for each oyster class can be written as (Klinck et al. 2002)

$$\frac{dO_j}{dt} = -\alpha_j O_j + \beta_j O_{j+1} - \gamma_j O_j + \delta_j O_{j-1} - loss_j$$

where O_j is the somatic energy present in each class, j, of oysters in units of [cal/m^2]. Total energy is calculated by adding the reproductive portions to the amount calculated by the preceding equation.

Term	Representation
$\frac{dO_j}{dt}$	The time rate of change of O_j
$-\alpha_j O_j$	Loss from O_j to O_{j-1}
$\beta_j O_{j+1}$	Gain to O_j from O_{j+1}
$-\gamma_j O_j$	Loss from O_j to O_{j+1}
$\delta_j O_{j-1}$	Gain to O_j from O_{j-1}
$-loss_j$	Loss from O_j due to mortality, predation, etc.

This equation is then solved using a Crank-Nicholson approach. Assuming $\frac{dO_j}{dt} = F$, then

$$\frac{O_j^{n+1} - O_j^n}{\Delta t} = \frac{1}{2}[F^{n+1} + F^n]$$

where the equations for *F* are defined as

$$F^{n+1} = -\alpha_j O_j^{n+1} + \beta_j O_{j+1}^{n+1} - \gamma_j O_j^{n+1} + \delta_j O_{j-1}^{n+1} - loss_j^n$$

$$F^n = -\alpha_j O_j^n + \beta_j O_{j+1}^n - \gamma_j O_j^n + \delta_j O_{j-1}^n - loss_j^n$$

Substituting these two equations into the equation for $\frac{O_j^{n+1} - O_j^n}{\Delta t}$ and rearranging terms such that the *n+1* terms are on the left and the *n* terms are on the right and multiplying by Δt yields

$$O_j^{n+1} - \frac{\Delta t}{2}\left[-\alpha_j O_j^{n+1} + \beta_j O_{j+1}^{n+1} - \gamma_j O_j^{n+1} + \delta_j O_{j-1}^{n+1}\right]$$
$$= O_j^n + \frac{\Delta t}{2}\left[-\alpha_j O_j^n + \beta_j O_{j+1}^n - \gamma_j O_j^n + \delta_j O_{j-1}^n\right] - \Delta t * loss_j^n$$

which then can be rewritten as

$$O_j^{n+1}\left[1 + \frac{\Delta t}{2}\alpha_j + \frac{\Delta t}{2}\gamma_j\right] + O_{j-1}^{n+1}\left[-\frac{\Delta t}{2}\delta_j\right] + O_{j+1}^{n+1}\left[-\frac{\Delta t}{2}\beta_j\right]$$
$$= O_j^n\left[1 - \frac{\Delta t}{2}\alpha_j - \frac{\Delta t}{2}\gamma_j\right] + O_{j-1}^n\left[\frac{\Delta t}{2}\delta_j\right] + O_{j+1}^n\left[\frac{\Delta t}{2}\beta_j\right] - \Delta t * loss_j^n$$

where the transfer and loss rates are defined as

$$\alpha_j = \frac{w_j}{w_{j-1}}\frac{w_j}{w_j - w_{j-1}}\left|NP_j^{n+1}\right| \quad \text{for } NP_j^{n+1} < 0$$
$$\alpha_j = 0 \quad \text{for } NP_j^{n+1} \geq 0$$

$$\gamma_j = \frac{w_j}{w_{j+1}}\frac{w_j}{w_{j+1} - w_j}\left|NP_j^{n+1}\right| \quad \text{for } NP_j^{n+1} > 0$$
$$\gamma_j = 0 \quad \text{for } NP_j^{n+1} \leq 0$$

$$\beta_j = \frac{w_{j+1}}{w_j}\frac{w_j}{w_{j+1} - w_j}\left|NP_{j+1}^{n+1}\right| \quad \text{for } NP_{j+1}^{n+1} < 0$$
$$\beta_j = 0 \quad \text{for } NP_{j+1}^{n+1} \geq 0$$

$$\delta_j = \frac{w_{j-1}}{w_j}\frac{w_j}{w_j - w_{j-1}}\left|NP_{j-1}^{n+1}\right| \quad \text{for } NP_{j-1}^{n+1} > 0$$
$$\delta_j = 0 \quad \text{for } NP_{j-1}^{n+1} \leq 0$$

$$-\Delta t * loss_j^n = -\Delta t * MortalityRate * O_j^n$$

Assimilation Term

Size and Temperature

$$FR_j = \frac{L_j^{0.96} T^{0.95}}{2.95}$$

$$L_j = W_j^{0.317} 10^{0.669}$$

Where *FR*$_j$ is the filtration rate (ml filtered per individual per min); *L*$_j$ is the length in cm (Doering and Oviatt 1986), obtained from *W*$_j$, the ash-free dry weight (g); and *T* is the temperature in Celsius.

Salinity

$$FR_{sj} = \begin{cases} FR_j & \text{S} \geq 7.5 \text{ ppt} \\ \dfrac{FR_j(S - 3.5)}{4} \quad \text{when} & 3.5 \text{ ppt} < S < 7.5 \text{ ppt} \\ 0 & S \leq 3.5 \text{ ppt} \end{cases}$$

where *S* is the ambient salinity in ppt.

Turbidity

$$FR_{\tau j} = FR_{sj}(1 - 0.01x)$$

where *x* is the percent reduction in filtration rate. The equation for total particulate content, *τ*, (inorganic + organic) (g/L) can be written as

$$\tau = (4.17 * 10^{-4}) * 10^{0.0418x}$$

This equation was printed incorrectly in several papers, e.g. Hofmann et al. (1992) and Powell et al. (1992), but later corrected in Powell et al. (1995). This equation can then be rewritten in terms of filtration rate as

$$x = \frac{\log_{10}\tau + 3.38}{0.0418}$$

Finally, the equation for filtration rate can then be rewritten as

$$FR_{\tau j} = FR_{sj}\left[1 - 0.01\left(\frac{\log_{10}\tau + 3.38}{0.0418}\right)\right]$$

This equation was written incorrectly in several papers, e.g. Powell et al. (1992) and Powell et al. (1996), but correct in Powell et al. (1995).

Ingestion

$$I_j = f * FR_{\tau j}$$

where *f* is the measured food value (mg/L) and *I*$_j$ is the ingestion.

Assimilation

$$A_j = I_j * A_{eff}$$

where the assimilation efficiency, *A*$_{eff}$, is defined as 0.75 (Powell et al. 1992).

Respiration Term

Temperature and Weight

Respiration as a function of temperature and weight was obtained from Powell et al. (1992) via Dame (1972) as

$$R_{TW} = (69.7 + 12.6 * T)W_j^{b-1} \quad \text{where } b = 0.75$$

where R is defined in units of µL O_2 consumed per hr per g dry weight (Powell et al. 1992). These units are converted to calories using the relation 1 mL O_2=4.75 cal used by Winter et al. (1984) via Thompson and Bayne (1974).

Salinity

Salinity's effect on oyster respiration were parameterized using the Powell et al. (1992) formulation which used data provided in Shumway and Koehn (1982) as

$$R_r = \begin{cases} 0.007 * T + 2.099 & \text{when } T < 20\ ^{\circ}C \\ 0.0915 * T + 1.324 & T \geq 20\ ^{\circ}C \end{cases}$$

where R_r is the ratio of respiration at 10 ppt to respiration at 20 ppt.

$$R_r = \frac{R_{10\ \text{ppt}}}{R_{20\ \text{ppt}}}$$

Respiration

$$R_j = \begin{cases} R_{TW} & \text{S} \geq 15\ \text{ppt} \\ R_{TW}\left(1 + \left[\dfrac{(15 - S) * (R_r - 1)}{5}\right]\right) & \text{when} \quad 10\ \text{ppt} < S < 15\ \text{ppt} \\ R_{TW}R_r & S \leq 10\ \text{ppt} \end{cases}$$

Per Powell et al. (1992), Shumway and Koehn (1982) identified salinity's effect on respiration at 20 ppt; however, a 15 ppt cutoff is used to conform to Chanley's (1958) growth observations.

Reproduction

For adult oysters (e.g. those considered adult or marketable but not those considered spat or juvenile), net production is apportioned into growth and reproduction by using the following formulation

$$P_{rj} = R_{eff} * NP_j$$

where P_{rj} is the portion of new production in reproduction, R_{eff} is the temperature dependent reproductive efficiency defined as (Hofmann et al. 2006)

$$R_{eff} = R_1 * T - R_0$$

where R_1 and R_0 are constants. This equation is written incorrectly (temperature dependence is missing) in Powell et al. (1992). In general, the maximum value of R_{eff} is limited to some value R_{max} such that this equation can be rewritten as

$$R_{eff} = \min(R_1 * T - R_0,\ R_{max})$$

and min() represents the minimum value function.

Based on observations by Soniat and Ray (1985), the R_1 and R_0 constants have a seasonal component such that (Hofmann et al. 1992)

$$\begin{array}{llll} R_1 = 0.054 \text{ and } R_0 = 0.729 & \text{for} & \text{January} - \text{June} \\ R_1 = 0.047 \text{ and } R_0 = 0.809 & & \text{July} - \text{December} \end{array}$$

These constants are defined correctly in Hofmann et al. (1992), Powell et al. (1992) and Powell et al. (1996) but incorrectly in Powell et al. (1995) and Wang et al. (2008) (R_1 was defined as 0.0047 instead of 0.047 for the July-December period).

Spawning

Following Wang et al. (2008), spawning occurs when the cumulative reproductive biomass (R_{total}) exceeds 20% of the total biomass and the temperature is greater than or equal to 25 degrees C (Ingle and Dawson 1952; Hayes and Menzel 1981). Once spawning occurs, reproductive biomass was divided into male (R_m) and female (R_f) biomass. The ratio of females to males (f_{ratio}) is calculated using

$$f_{ratio} = 0.021L_b - 0.62$$

where L_b is the shell length in mm. Then, the female portion of reproductive biomass can be calculated by combining the following two equations

$$f_{ratio} = \frac{R_f}{R_m}$$

$$R_{total} = R_f + R_m$$

to yield

$$R_f = \left(\frac{R_{total}}{1 + \frac{1}{f_{ratio}}} \right)$$

Then, the female portion of biomass can be converted into eggs spawned by

$$\text{Number of Eggs Spawned} = \left[R_f \left(\frac{6100 \text{ calories}}{\text{g dry weight}} \right)_{\text{oysters}} \right] \left(\frac{\text{g dry weight}}{6133 \text{ calories}} \right)_{\text{oyster eggs}} \left(\frac{1}{W_{\text{egg}}} \right)$$

where the term within the square brackets on the right hand side represents the female biomass converted to calories and the weight on an egg, W_{egg}, is 13 ng per egg (Powell et al. 1992 p. 393). Wang et al. (2008) and others (e.g. Powell et al. 1995, 1996) define the weight of an egg as

$$W_{\text{egg}} = 2.14 * 10^{-14} * V_{\text{egg}}$$

where V_{egg} is the oyster egg volume in (μm^3).

Larval Recruitment

Following Wang et al. (2008), larval life span was set to 15 days (Ingle and Dawson 1952), and larval to spat survival was set at $1/10^8$ (Powell et al. 1996)

$$\text{Number of New Spat per Spawn} = \frac{1}{10^8} * \text{Number of Larvae Recruited per Spawn}$$

It is not clear how larval life span is to be applied.

Mortality

Lavae

$$\text{Number of Larvae Recruited per Spawn} = \ s * \text{Number of Eggs Spawned}$$

where *s*, the survival rate per spawn is defined as (Davis and Calabrese 1964)

$$s = \begin{cases} 0.7 \quad for \quad 27.5\ {}^{\circ}C \leq T \leq 32.5\ {}^{\circ}C \text{ and } 10\ ppt \leq\ S \leq 27.5\ ppt \\ 0 \qquad\qquad\qquad\qquad\qquad \text{otherwise} \end{cases}$$

The variable, *s*, is defined incorrectly in Wang et al. (2008) as mortality rate.

Post-settlement Population

Mortality of the post-settlement population follows the formulation of Wang et al. (2008)

$$\text{Number dying per time} = k_d(\text{number of living})$$

$$k_d = \begin{cases} 0 & \text{if} \quad \text{Winter or Spring (Sep} - \text{Apr)} \\ \text{Constant} & \text{otherwise} \end{cases}$$

where k_d is the daily mortality rate. However, because low salinity is a major cause of catastrophic mortality, the equation of daily mortality rate is modified as follows

$$k_d = (\alpha_1 S + \beta_1)T + (\alpha_2 S + \beta_2) \quad \text{if} \quad S < 6 \text{ ppt}$$

where α_1=-0.000348, β_1=0.01764, α_2=0.00232, and β_2=-0.3089 (Powell et al. 1996). α_1 is defined incorrectly in Wang et al. (2008) as -0.00034.

Growth Rate Formulation

$$(\text{Oyster Growth Rate})_j = (NP_{somatic})_j * W_j * \frac{1000\text{ mg}}{\text{g}} * \frac{86400\text{ s}}{\text{day}} \qquad \left[\frac{\text{mg AFDW}}{\text{oyster} * \text{day}}\right]$$

where Net Production is provided in units of [1/s] and W is the average oyster weight in units of [g AFDW/oyster]

Specific Relations for Apalachicola Bay Model

Size Classes

Characteristics of the size classes were based on Wang et al. (2008). Average length was from field measurement, while average biomass was determined from the following length-weight relationships:

$$\ln(Biomass) = C_1 * \ln(Length) + C_2$$

which can be solved for biomass as

$$Biomass = (Length)^{C_1} * e^{C_2}$$

where

Site	C_1	C_2	R^2
Cat Point	2.505	-10.980	0.83
Dry Bar	2.202	-9.125	0.90

Site	1 (Spat)	2 (Juvenile)	3 (Adult)	4 (Marketable)
Cat Point				
Initial Count	0	26	22	21
Average Length (mm)	12	36	66	85
Average Biomass (g AFDW)	0.0086	0.1349	0.6157	1.1605
Dry Bar				
Initial Count	0	26	22	21
Average Length (mm)	12	39	66	96
Average Biomass (g AFDW)	0.0259	0.3472	1.1059	2.5236

Total Particulate Content<>Turbidity

Based on a water quality analysis of storm-water inputs into Apalachicola Bay, Wang et al. (2008) defined the relation between total particulate content and turbidity as

$$\tau = 1.4593 * \text{Turbidity} + 0.904$$

where total particulate content, τ, is in units of mg/L and Turbidity is in NTU.

Food<>Chlorophyll-a

Following Wang et al. (2008), Chlorophyll-a was used as an index of available food following the formulas presented in (Soniat et al. 1984, 1998)

$$\text{Food} = 1.4593 * \text{Chlorophyll} - \text{a} + 0.520$$

where Food, is in units of mg dry weight/L (Soniat et al. 1998) and Chlorophyll-a is in units of µg/L (Soniat et al. 1998). The units of food are converted into calories using the caloric conversion of 5168 cal per g dry weight (Wang et al. 2008).

Reproduction

The maximum reproductive efficiency, R_{max}, was set to 0.8 (Wang et al. 2008). Furthermore, following the assumptions of Wang et al. (2008), when $NP < 0$, reproduction was assumed to be zero or there was no resorption of gonadal tissue.

Post-Settlement Mortality

For periods when salinity is greater than 6 ppt, the daily mortality rate, k_d, was defined as (Wang et al. 2008)

Site	Reference Year	High-Salinity Year	Low-Salinity Year
Cat Point	0.00020	0.00061	0.00014
Dry Bar	0.00079	0.00122	0.00038

Average/Reference Year Simulations

Using the average year data shown in Figure 3 of Wang et al. (2008), the average year was simulated and then compared to the reference year lines for marketable oysters of Figure 6 of Wang et al. (2008).

Cat Point

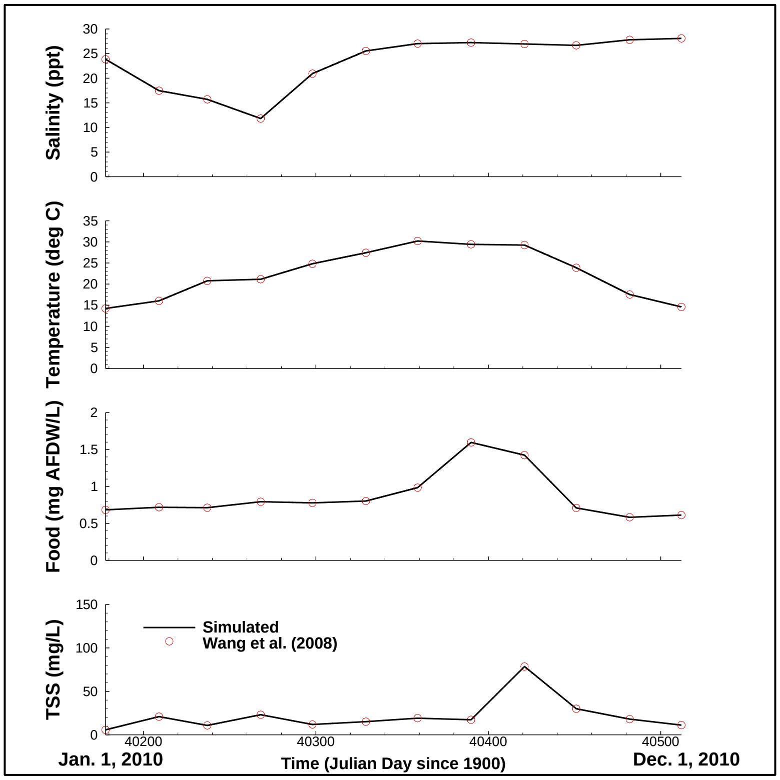


Figure 24. Forcing functions for the Cat Point reference year simulation

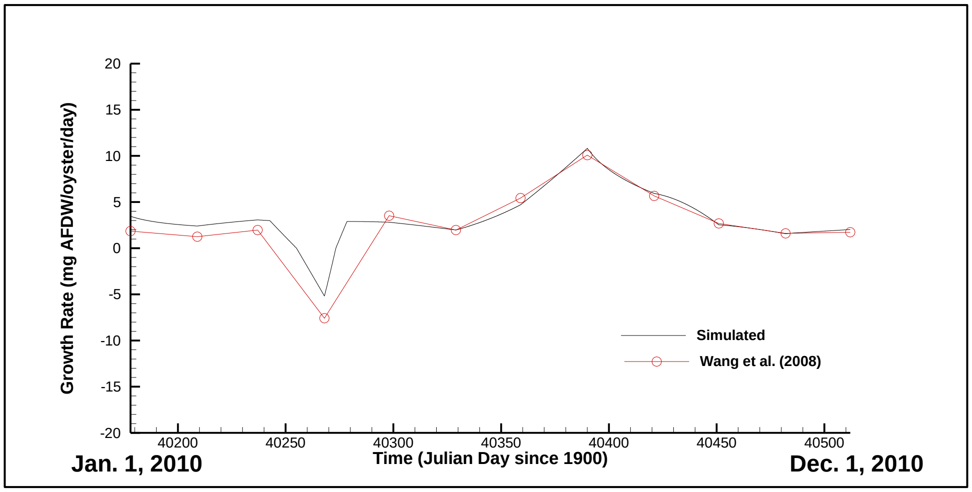


Figure 25. A comparison between the marketable oyster growth rate at Cat Point during the reference year simulated using the model presented herein and the results of Wang et al. (2008)

Dry Bar

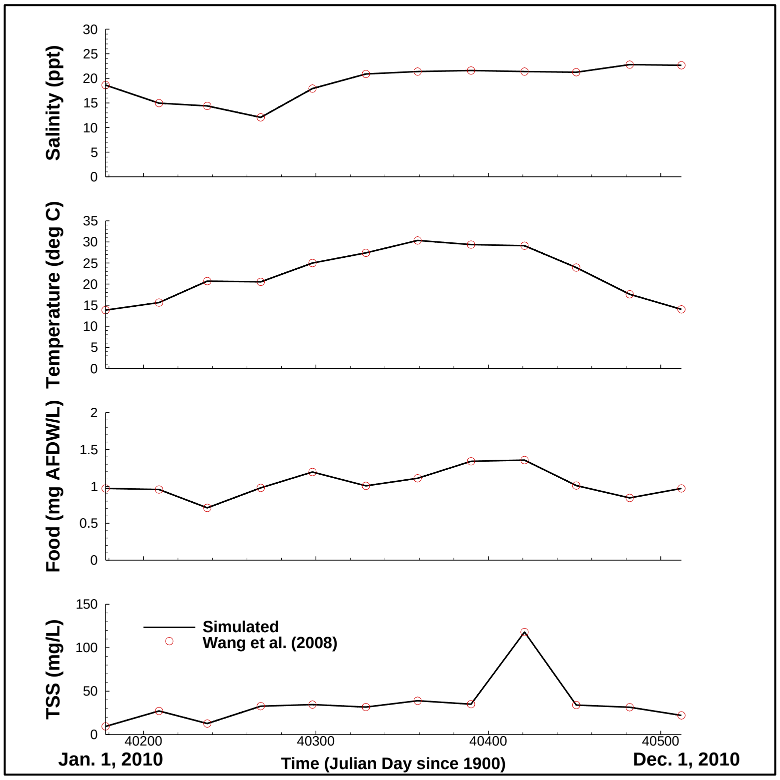


Figure 26. Forcing functions for the Dry Bar reference year simulation

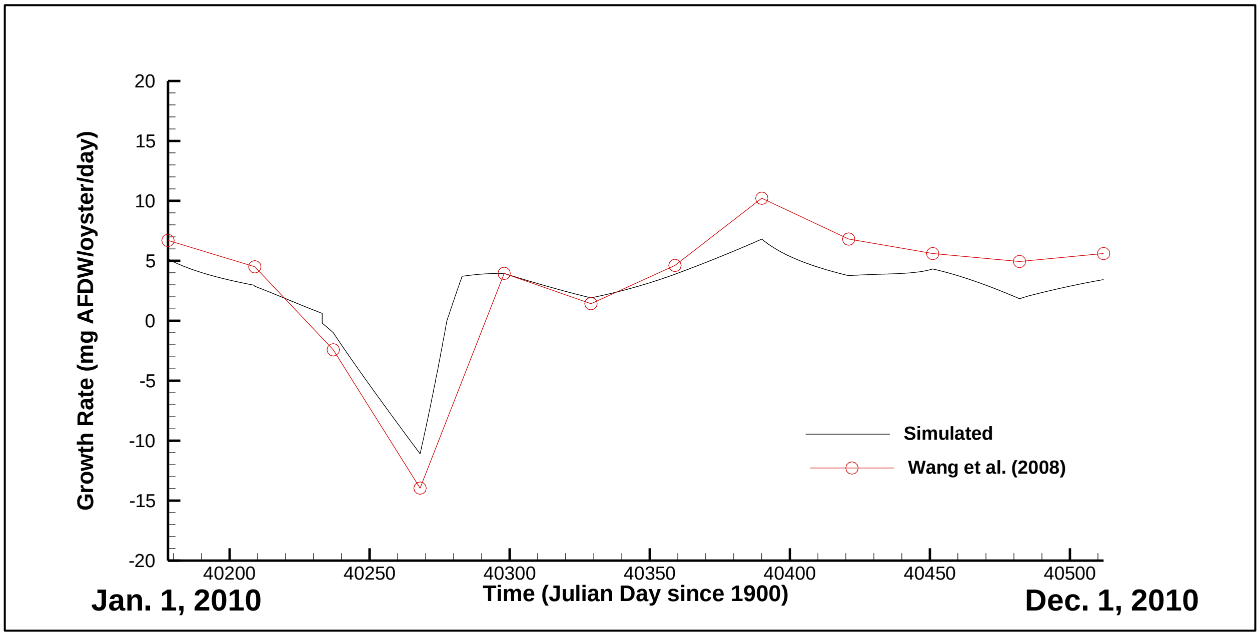


Figure 27. A comparison between the marketable oyster growth rate at Dry Bar during the reference year simulated using the model presented herein and the results of Wang et al. (2008)

Mar 2004 – June 2005 Cat Point Simulation

Using data obtained for the period of Mar. 2004 to June 2005, growth rate at Cat Point was simulated and compared to the total growth rate values shown in Figure 5a of Wang et al. (2008). Two sets of simulations were performed, one with the original observed salinity/temperature data and the second with daily averaged data.

Observed Salinity/Temperature

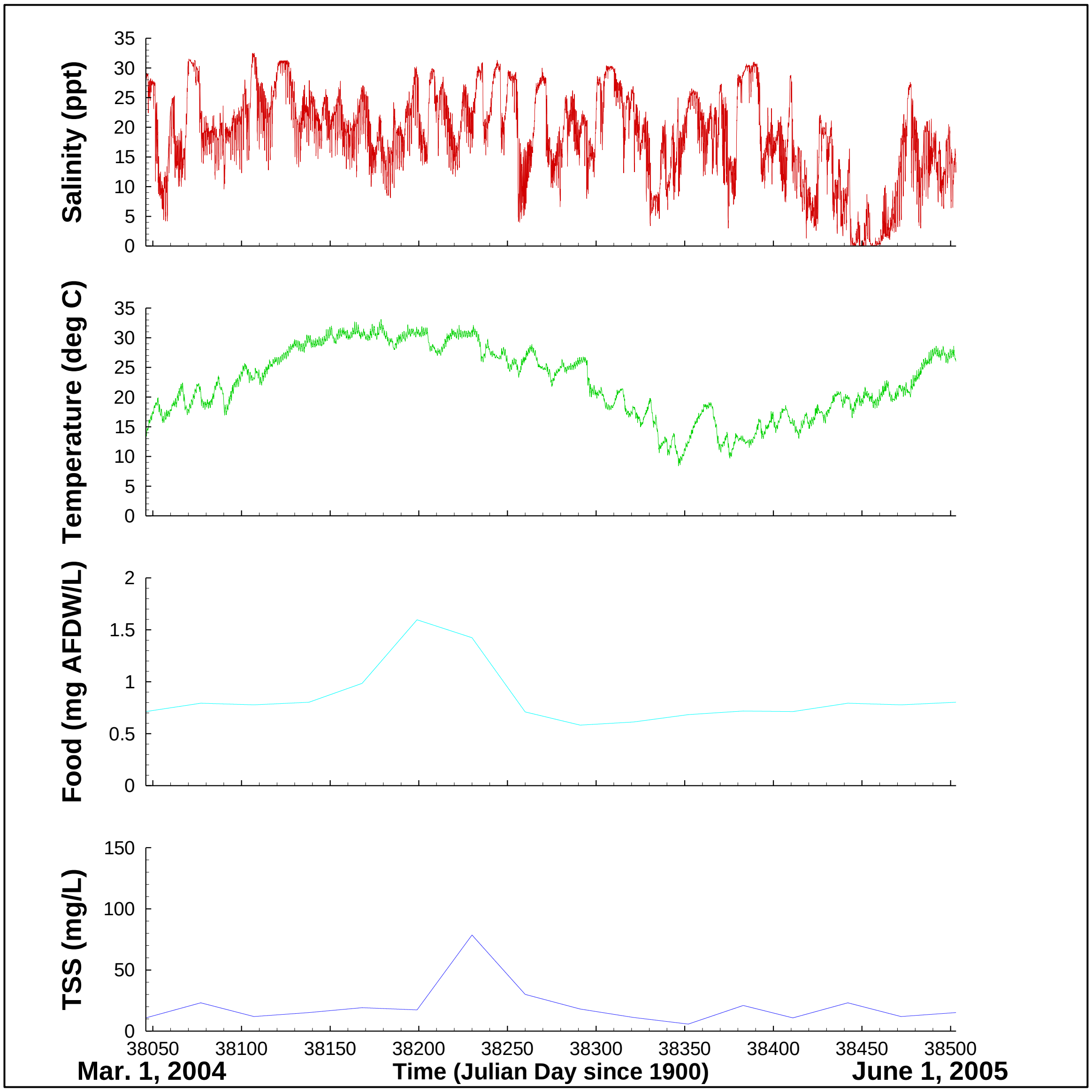


Figure 28. Forcing functions for the Cat Point Mar. 2004-June 2005 simulation using the observed salinity/temperature data

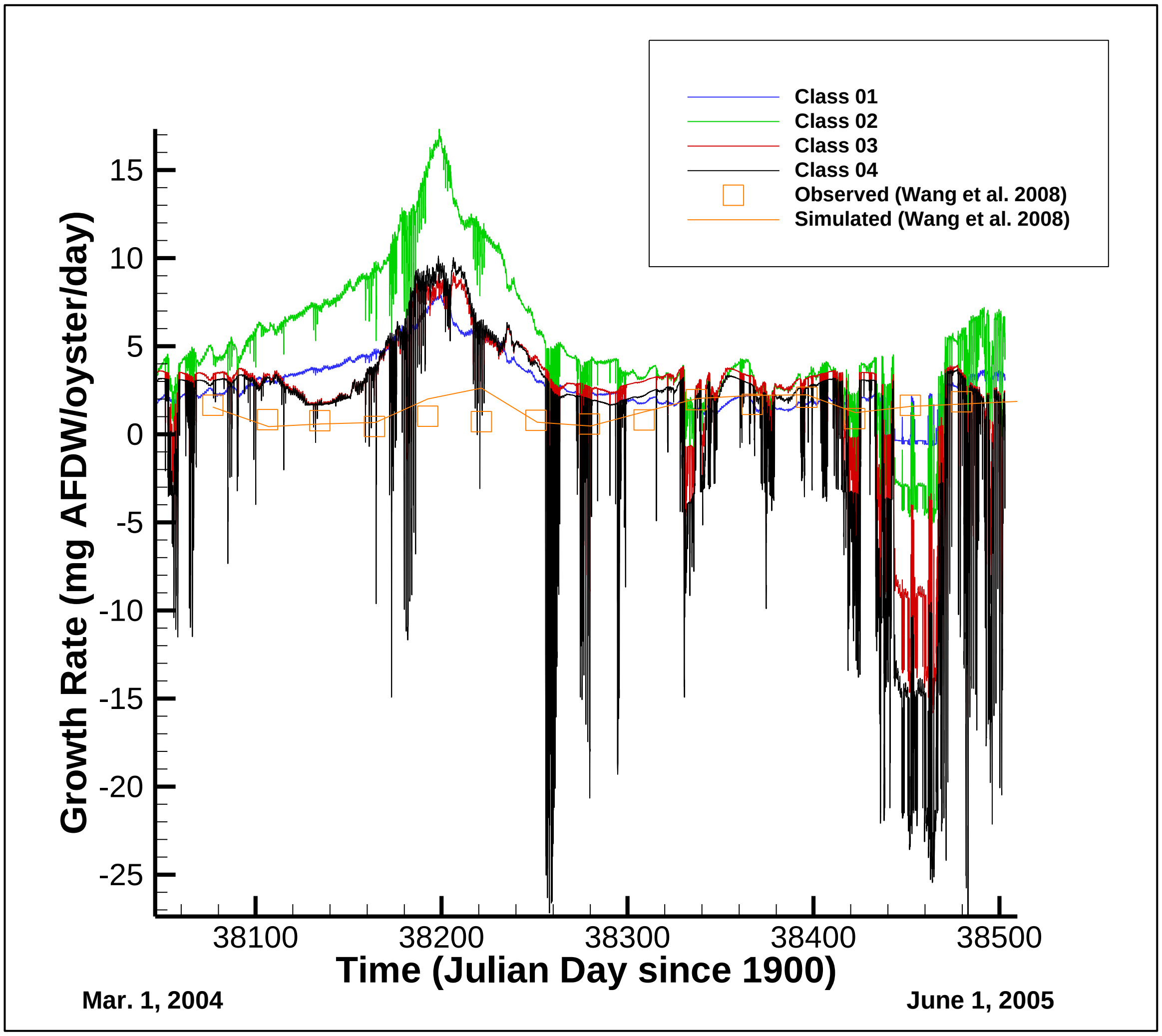


Figure 29. A comparison between the total oyster growth rate at Dry Bar during the reference year simulated using the model presented herein (each class plotted individually) and the results of Wang et al. (2008) (total growth rate) using the observed salinity/temperature data

Daily Averaged Salinity/Temperature Data

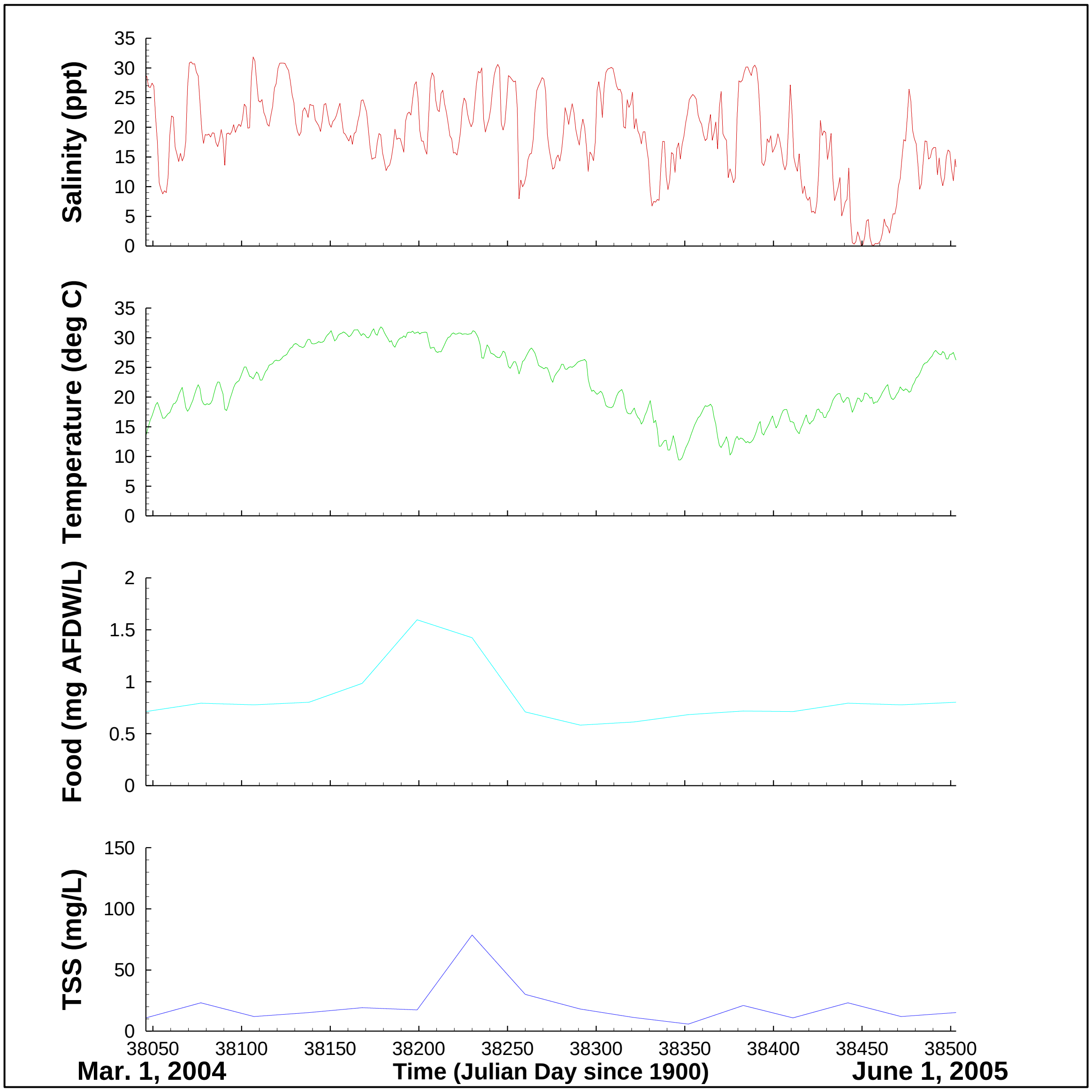


Figure 30. Forcing functions for the Cat Point Mar. 2004-June 2005 simulation using the daily averaged salinity/temperature data

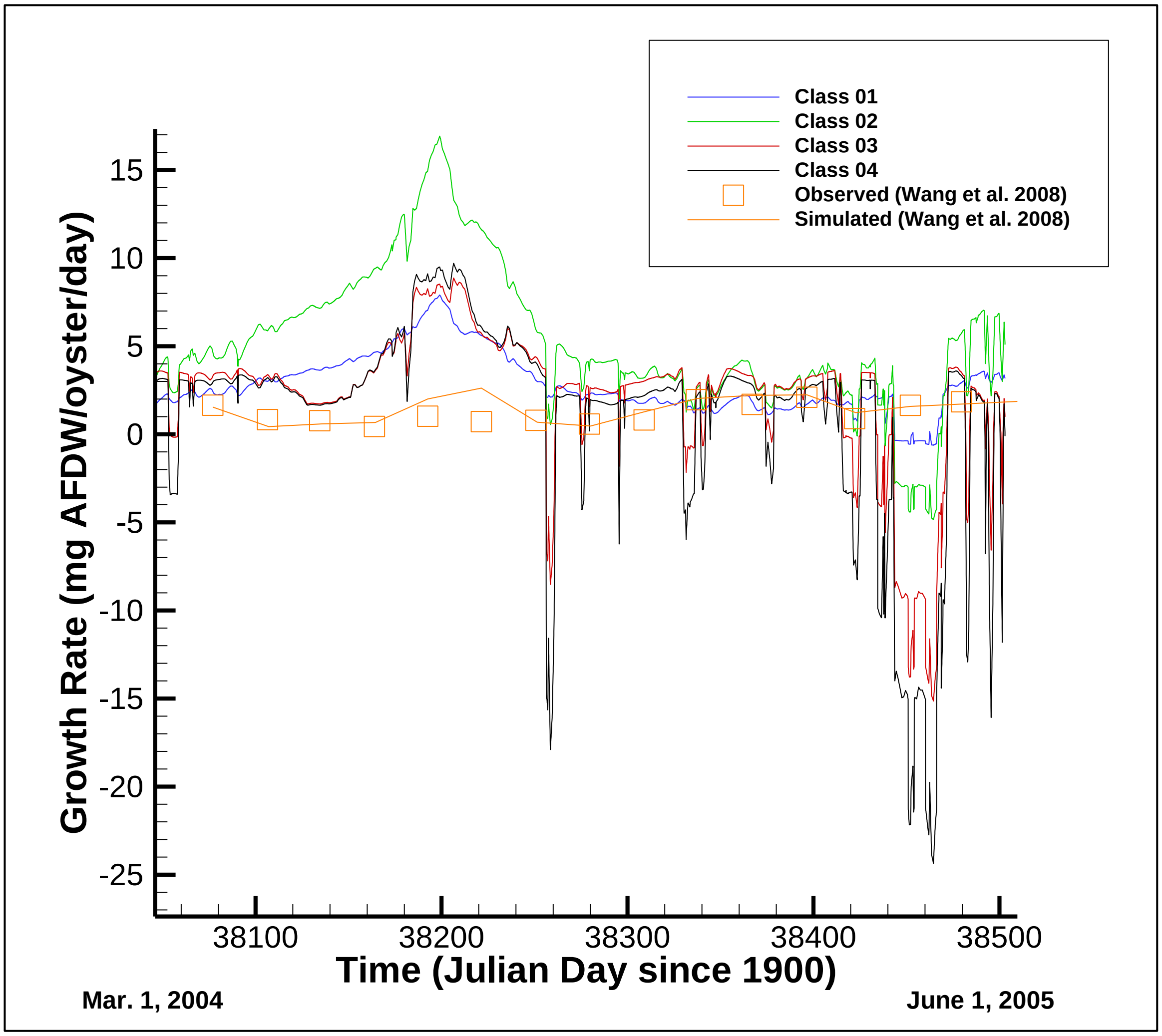


Figure 31. A comparison between the total oyster growth rate at Dry Bar during the reference year simulated using the model presented herein (each class plotted individually) and the results of Wang et al. (2008) (total growth rate) using the daily averaged salinity/temperature data

Appendix B. FWS Requested Results

The following revised list of requested results was email by Karen Herrington to Y. Peter Sheng on April 5, 2011. Items A1, B1, B2 and B4 were eliminated from an earlier larger list of requested results.

A. Oysters:

1.
2. Probability of exceedence at Cat Point and Dry Bar station for all 4 scenarios
3. Summary statistics for Class 4 (Marketable) growth rates at Dry Bar and Cat Point for all 4 scenarios
4. Exceedence probability at Cat Point and Dry Bar as a function of growth rate of marketable oysters (Class 4) for all 4 scenarios
5. August (generally peak growth rates) summary statistics for Class 4 (Marketable) growth rates at Dry Bar and Cat Point for all 4 scenarios
6. August Exceedence probability at Cat Point and Dry Bar as a function of growth rate of marketable oysters (Class 4) for all 4 scenarios
7. Salinity contour map for the total number of days salinity exceeds 26 ppt in the following years for all 4 scenarios. Please scale the colors to the percent of days (i.e., 10%, 20%, 30%, etc.) and give the acreages of each color for each scenario in a comparative table
    - Dry year = 2002 (based on ranked mean annual discharge)
    - Wet year = 2005
    - Average year = 2001

B. Sturgeon:

1.
2.
3. Salinity contour map for the total number of days salinity exceeds 10 ppt from 1 October- 31 March for the following years for all 4 scenarios. Please scale the colors to the percent of days (i.e., 10%, 20%, 30%, etc.) and give the acreages of each color for each scenario in a comparative table
    - Dry year = 2001 (based on ranked mean Oct-March discharge)
    - Wet year = 2009
    - Average year = 2004
4.

United States Department of the Interior

Fish and Wildlife Service
105 West Park Drive, Suite D
Athens, Georgia 30606

West Georgia Sub Office
P.O. Box 52560
Ft. Benning, Georgia 31995-2560

Coastal Sub Office
4980 Wildlife Dr.
Townsend, Georgia 31331

March 12, 2015

Dear Mr. Sumner,

Thank you for your response to our Planning Aid Letter (PAL). We have reviewed the information provided to us in the Apalachicola-Chattahoochee-Flint Water Control Manual (WCM) Update Response to Planning Aid Letter received on January 30, 2015. The review and exchange of information between the United States Army Corps of Engineers (Corps) and the United States Fish and Wildlife Service (USFWS) is a continuation of coordination under the Fish and Wildlife Coordination Act (FWCA) (48 Stat. 401, as amended; 16 U.S.C. § 661 *et seq.*). This coordination will facilitate your National Environmental Policy Act (NEPA) (42 U.S.C. § 4321 *et seq.*) analysis of the project.

Subsection 2(a) of the FWCA provides that the Federal agency constructing, permitting, or licensing a water resource development project "shall first consult" with the USFWS, with the principal procedural element to include the opportunity for continuing participation in planning that begins at the early stages such as at the reconnaissance stage. So that the Corps might give equal consideration to fish and wildlife, we recommended an alternative that would avoid and minimize adverse effects to fish and wildlife, and in some cases, enhance conditions for fish and wildlife affected by project operations. Your response indicated that you considered the alternative, but dismissed it in favor of the Proposed Action Alternative (PAA) that you will carry forward in your analysis to support a decision for a revised WCM.

The reasons for your dismissal of the PAL alternative and other alternatives are not clear; therefore, it is not evident whether the fish and wildlife benefits associated with our recommendations received the equal consideration mandated under Section 2 of the FWCA. Further, action agencies are required under NEPA regulations at 40 CFR 1502.14 to "rigorously explore and objectively evaluate all reasonable alternatives, and for alternatives which were eliminated from detailed study, briefly discuss the reasons for their having been eliminated." We are not aware of the process that the Corps has applied in dismissing or selecting alternatives, or will apply in making the final decision.

We request the following information to assist in our evaluation and report development, facilitate coordination with the States, and help ensure that the intent of the FWCA and NEPA is achieved:

1. Quantitative and operational measures (feature or activity) that defined each of the eight alternatives considered by the Corps, including reservoir drawdown and refill periods, action zone elevations, reservoir balancing methods, hydropower generation, drought operations, navigation, and environmental flow releases. The criteria used to compare and rank the alternatives will also assist our review.

2. Modeling parameters used to reproduce the USFWS alternative in Hydrologic Engineering Center-ResSim (ResSim), including a list of any changes made to the alternative since it was delivered to you and the rationale for such changes. Please also provide the water quality and hydrological model output for the USFWS alternative for all nodes in the Apalachicola, Chattahoochee, and Flint rivers.

3. DSS file(s) that includes the ResSim output for each node for each of the eight alternatives considered, including reservoir elevations, flows, and water quality.

4. Quantitative relationships among hydrology, temperature, and dissolved oxygen that were used to produce the dissolved oxygen and temperature graphs.

5. Modeled dissolved oxygen and temperature data for all Chattahoochee River nodes for all alternatives.

6. High flow guidelines for the PAA and No Action Alternative (NAA), or the data necessary for USFWS to produce them.

7. Clarification of the demands data that were used for Phase 1 and Phase 2 of your analysis. Please provide your analysis of demands scenarios that were considered.

8. Composite zones for the NAA and the other alternatives considered. Please confirm the method used to compute composite zones.

9. Estimates showing percent of days in Zones 1-4 and the drought zone for each alternative. Please include a table or graph showing the number of days required to transition from drought operations to Zone 1 for each alternative. Alternatively, you may provide USFWS with the requisite data and we will compute the statistics.

10. A description of how navigation was incorporated into ResSim. For example, was it a continuous navigation period for a period of 4-5 months, or several three-week periods

nested within the 4-5 month period? Please provide the discharge and duration values that were used, and clarify whether May was included in the modeling.

11. The analysis used to define action zone elevations.

We expect that many of the information needs that we identified are already available as DSS files, a format that should be efficient to transfer to us and that we are prepared to use. Additional information and data requests may be made in the future as part of the ongoing coordination with the States and the Corps. Please contact Will Duncan or Alice Lawrence at 706-613-9493, or Grant Webber at 850-769-0552 should you have questions regarding the requested information.

Sincerely,

Donald Imm

Comparison of ACOE Baseline HEC Res-Sim output and observed data for a comparable period

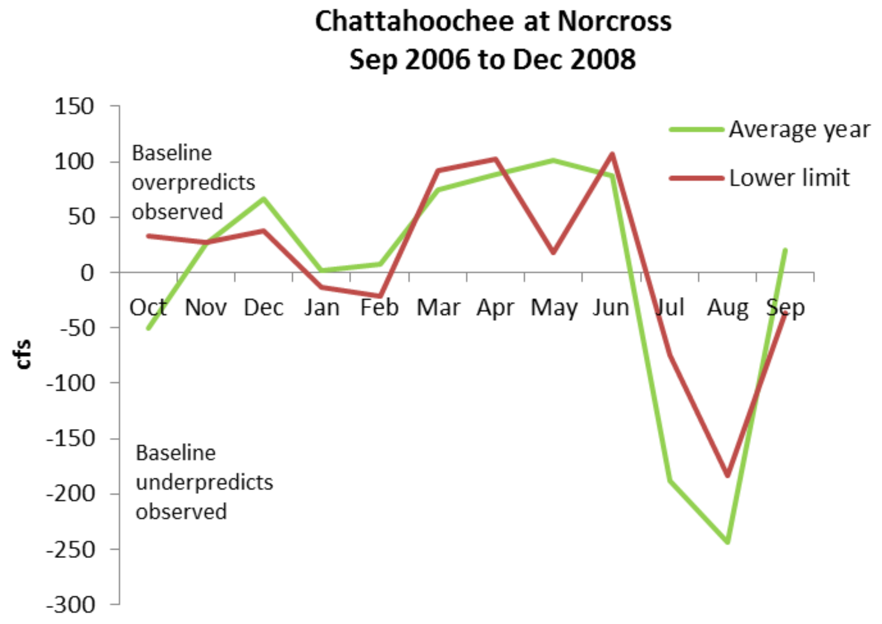
Based on the Corps' response to the Planning Aid Letter, the baseline model output from HEC Res-Sim represents current operations following implementation of the RIOP (post September 2006). Therefore, there should be good general agreement between baseline conditions and observed conditions since September 2006. In instances where the modeled data are statistically different from observed data (ie. black boxes in table below), users of the Res-Sim output should be cautious regarding comparisons and recommendations based on that aspect of the data. In instances where statistical significance was not detected (white boxes in table), there is support for using that aspect of the data for comparison of flow alternatives to the baseline model output.

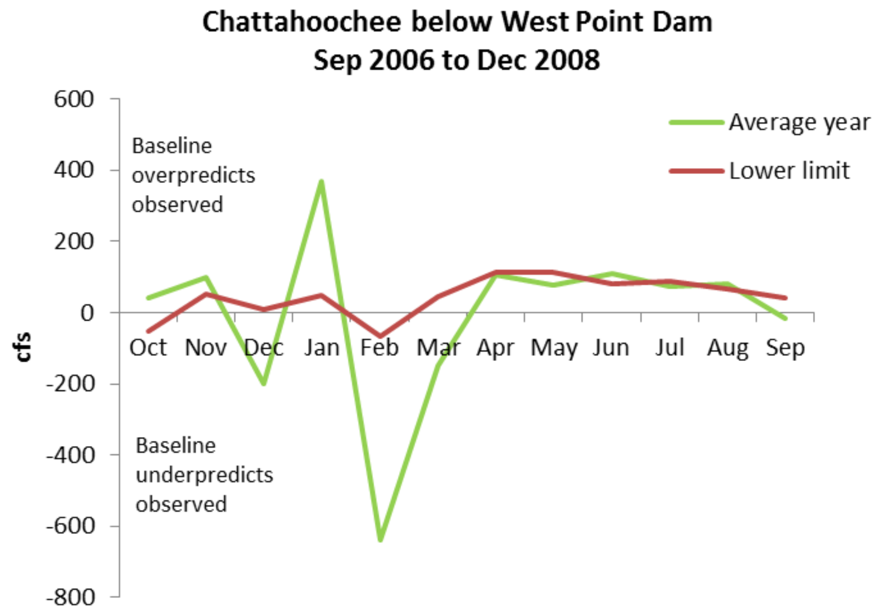
	Pulse Magnitude (cfs)	Pulse Duration (days)	Pulse Rise Rate (cfs/day)	Pulse Fall Rate (cfs/day)	Pulse Frequency (#/month)	Reversals (#/month)
Chattahoochee at Norcross	9*	2	-97	-108	-1.35	-2.6
Chattahoochee at West Point	-984*	2*	-483	-93	-0.18	-2.1
Apalachicola at Chattahoochee	-2791	7.7*	-1454*	-924*	-0.33	-4.7

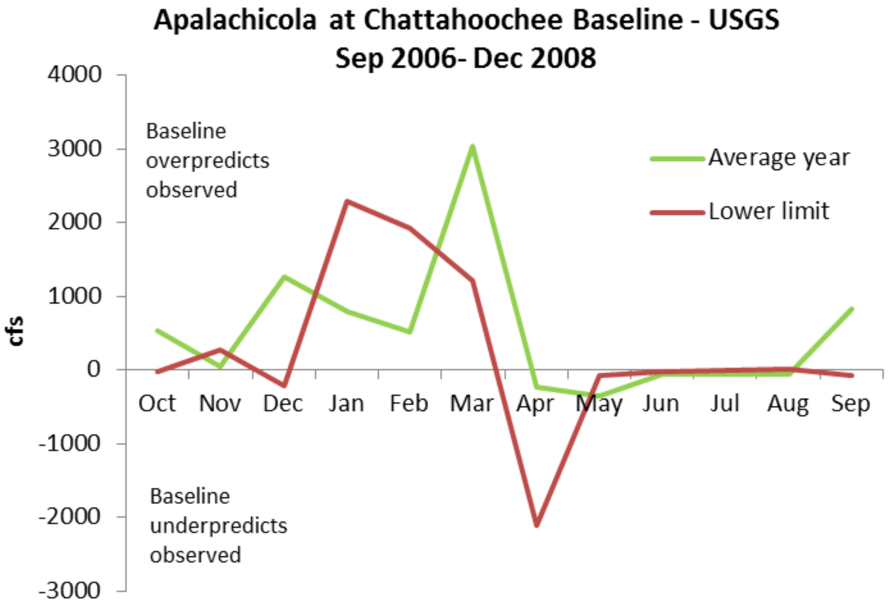
Statistics and nuances of the table: Tests of statistical differences between the ACOE modeled baseline scenario and observed discharge in the Chattahoochee and Apalachicola rivers are provided in the table. Black boxes depict statistical differences. For the purposes of this analysis, we assumed that pulses were independent of one another. Two-tailed t-tests were used to test for statistical significance, except paired t-tests were used for monthly pulse frequency and reversals. P-values < 0.05 were used as thresholds for statistical significance. Pooled variances were used except in instances when the Satterthwaite method was used for unequal variances (*). Numbers in the table are the mean baseline value minus the mean observed value.

In this analysis (Table above), pulses were defined as any pulse or flood greater than the 75th percentile of the modeled baseline scenario. Analysis period included Sep 01, 2006 to Dec 31, 2008, the period for which the baseline scenario (presumably reflective of current operations) was implemented and for which observed data can be compared.

Figures: Using the same period of record for modeled baseline and observed discharge, the low flow analysis was conducted using the 7 lowest flows observed for every month of every year. The lines on the graph are the differences between the baseline and the observed USGS data for the 50th percentile (average year) and 10th percentile (lower limit). Values less than 0 indicate that the baseline modeled discharge underpredicted observed discharge, and values greater than 0 indicate the converse. Beyond the graphical comparison, no statistics were calculated for low flows.


Chattahoochee at Norcross
Sep 2006 to Dec 2008
150
100
50
0
-50
-100
-150
-200
-250
-300
cfs
Baseline overpredicts observed
Baseline underpredicts observed
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Average year
Lower limit


Chattahoochee below West Point Dam
Sep 2006 to Dec 2008
600
400
200
0
-200
-400
-600
-800
cfs
Baseline overpredicts observed
Baseline underpredicts observed
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Average year
Lower limit


Apalachicola at Chattahoochee Baseline - USGS
Sep 2006- Dec 2008
4000
3000
2000
1000
0
-1000
-2000
-3000
cfs
Baseline overpredicts observed
Baseline underpredicts observed
Average year
Lower limit
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep

Problems regarding United States Army Corps of Engineers (Corps) alternatives selection process for the Apalachicola-Chattahoochee-Flint (ACF) Water Control Manual (WCM) update

July 31, 2015

The United States Fish and Wildlife Service (Service) has reviewed the methodology that the United States Army Corps of Engineers (Corps) used to select an alternative during Phase 1 of their analysis for the Apalachicola-Chattahoochee-Flint (ACF) Water Control Manual (WCM) update process. We support the Corps in their efforts to devise a transparent methodology, and their attempt to objectively select alternatives for analysis. Furthermore, the Service considers the Corps' effort to further refine their quantitative and transparent means of decision making a substantial improvement upon previous WCM updates. In our opinion, we have identified several problems with the Corps' methodology that render conclusions concerning the selection of an alternative for the Draft Environmental Impact Statement (DEIS) under this methodology questionable. Using the selection methodology provided to the Service means that the alternative selected by the Corps for consideration in the DEIS does not appear to accurately represent multiple project purposes, and does not appear to give fish and wildlife equal consideration because of the computational issues described below.[1]

The Service collaboratively discussed these findings and our conclusions during a conference call with the Corps on June 1, 2015 and our staff expressed an interest in "working with the Corps to identify errors and develop appropriate and transparent strategies for alternative selection" (Appendix A). The Service raised our concerns again on June 30, 2015. The Service's interpretation from the June 30, 2015, call is that the Corps is unable to make the necessary changes to the alternative selection methodology in advance of the forthcoming DEIS because:

1) The Corps acknowledged the Service's concerns, but stated that their ranking and evaluation methodology was chosen for its simplistic and transparent properties that they consider to be adequate for their selection process.
2) The time needed to make such changes would be much greater than the Service anticipates and would delay the process for adopting the ACF WCM;
3) The proposed action alternative (PAA) had been sent up the chain for review and approval; and

During our conference calls with the Corps, Service staff were told that the approach to selecting alternatives could not be changed at this time because this would result in considerable additional work if the selected alternative changes. While study schedule constraints have precluded completion of the many known planning and impact evaluation deficiencies; some of those errors and issues are likely of a lesser magnitude than those resulting from the potentially significant problems associated with plan selection methodology.

The FWCA is one of the major pieces of legislation aimed at ensuring that fish and wildlife resource issues, concerns, and opportunities are brought to the attention of decision makers and given *equal consideration in project planning*. The Service delivered scoping comments that included a management alternative for consideration, a revised alternative, and a Planning Aid Letter (PAL) to facilitate the Corps' development and evaluation of alternatives, collectively demonstrating the Service's involvement at multiple stages of the WCM update. However, had the Service had a greater role in the alternative formulation and evaluation process, including designing the criteria for selecting alternatives, our concerns with the process may have been resolved. Under the current timeline, the Corps is scheduled to release the DEIS based on a methodology that ultimately may have led to the possible incorrect selection of a PAA. The following summary of problems is not comprehensive, but serves to illustrate the severity of our concerns.

We recommend that the Corps work with the Service under the authorities of the FWCA to revise and improve the alternative selection methodology. It is the Service's understanding that this cannot be accomplished in advance of the forthcoming DEIS release. Therefore, we recommend that the Service and Corps work to improve the alternative selection methodology in advance of and future updates to the WCM. It is vital that the approach used in selecting alternatives be able to withstand inevitable scrutiny, given the long-term disputes over the management of the ACF basins' water resources. We strongly believe that it is important to undertake plan selection based on sound science and plan formulation principles.

Corps' ranking approach

The Service has three major concerns with the Corps' approach used in ranking and selecting alternatives:

- The current ranking approach obscures the actual range of differences between alternatives. Small differences within project purposes are treated the same as large differences when comparing alternatives.
- An incomplete set of fish and wildlife performance measures was used to score and then rank alternatives for the Fish and Wildlife project purpose. Based on the information provided to us, the set of fish and wildlife performance measures used by the Corps in the ranking do not fully capture the relationship between water management alternatives and their effect on fish and wildlife resources.
- There is no consideration regarding the uncertainty or precision of model output in the Corps' ranking process. When uncertainty and precision are considered, managers can robustly evaluate similarities and differences between alternatives.[2]

The details of these concerns are discussed below:

1) The Corps' approach to alternative selection involved the following basic steps. Modeled flow data from the Corps' HEC-ResSim model runs were used to calculate metrics related to each project purpose (i.e. water supply, recreation, hydropower, navigation, and fish and wildlife). Because metrics for each of these had different units of measurement [e.g., days versus megawatt hours (MWh)], the Corps then ranked each of the metrics on a scale of 1 to 7, with 7 being the worst. In statistical terms, the Corps converted the information-rich *ratio* data (e.g., days and MWh) to information-poor *ordinal* data (a 1-7 ranking). Rankings for each project purpose were summed, and the alternative with the smallest sum was selected as the best alternative. Ranking the data without regard to the numerical differences between alternatives fundamentally means that a) small differences within a project purpose are the same as large differences, b) a great amount of weight may be placed on inconsequential differences, and c) project purposes do not appear accurately represented when equal weight is given toward inconsequential and consequential differences among alternatives within a project purpose.

We illustrate this problem using two examples. Annual weekday hydropower and annual hydropower totals were used by the Corps to rank the seven alternatives for the hydropower project purpose (Table 1). For all alternatives considered, annual hydropower generation differs from the No Action Alternative (NAA) by less than 0.25%, and weekday hydropower by less than 1.30%. This illustrates that hydropower production for most of the alternatives is essentially the same, yet a < 1% difference results in Alternative 4 receiving a 7 and the NAA a 1. The Service questions whether the underlying data used to estimate hydropower production is so precise that these small differences in hydropower production are meaningful. If the differences in results are within the precision range of the empirical model, the alternatives could have simply been given the same ranking and the conclusion would have been that hydropower production under the different options was essentially the same. Under the ranking scheme used by the Corps, ranking the alternatives 1-7 when there is essentially no difference has a direct bearing on the final ranking of alternatives in that it accounts for 20% of the final score for each alternative, and therefore the alternative that is selected for the DEIS.

Table 1. Hydropower values used by the Corps to rank alternatives.

	Annual Hydropower Generation (MWh)	Annual Weekday Hydropower Generation (MWh)	Annual Hydropower Percent Change from NAA	Annual Weekday Hydropower Percent Change from NAA	Rank- Annual Hydropower Generation	Rank- Annual Weekday Hydropower Generation	Sum	Final rank
Alt 1/NAA	1,049,030	777,458			1	1	2	1
Alt 2	1,048,136	775,656	-0.09%	-0.23%	4	5	9	3
Alt 3	1,046,455	776,888	-0.25%	-0.07%	7	2	9	3
Alt 4	1,046,647	769,835	-0.23%	-0.98%	6	6	12	7
Alt 5	1,048,094	776,197	-0.09%	-0.16%	5	4	9	3
Alt 6	1,048,851	767,363	-0.02%	-1.30%	2	7	9	3
Alt 7	1,048,230	776,704	-0.08%	-0.10%	3	3	6	2

A second example of our concern is that inconsequential differences are also observed in other metrics such as the percent of years with Days < Flow, one metric intended to quantify the effects of Apalachicola River low flows on mussels. There is a 0.00% difference between the NAA and Alternative 4, yet they are ranked 2 and 3, respectively (Table 2). However, there is a 24.8% difference between the NAA and Alternative 6, yet they are ranked 1 and 2, respectively. In both comparisons, there is a 1 point difference in the ranking, meaning that a 24.8% improvement is equivalent to essentially no improvement.

The differences in hydropower among alternatives are minor compared to larger differences among alternatives for the mussel performance measure. Because of the ranking system used, the differences are treated the same. In our opinion, this does not represent a sensible approach to managing multiple project purposes.

Table 2. Values and rankings used by the Corps to represent one metric from the Apalachicola River Mussel Performance Measure (ARMPM).

	Percent of Years with Days < Flow	Percent Change from NAA	Ranking
Alt 1/NAA	3096		2
Alt 2	3178	2.65%	4
Alt 3	3534	14.16%	7
Alt 4	3096	0.00%	3
Alt 5	3274	5.75%	6
Alt 6	2329	-24.78%	1
Alt 7	3178	2.65%	4

2) The Service's 2013 PAL provided the Corps with performance measures that the Service recommended for use in the evaluation and selection of flow management alternatives. The performance measures included the Apalachicola River Mussel Performance Measures (ARMPMs), Fish Spawning Habitat Performance Measure (FSHPM), Sturgeon Spawning Habitat Performance Measure (SSHPM), Chattahoochee River Shoal Bass Performance Measure (CRSBPM), and Reservoir Fisheries Performance Measure (RFPM). Based on

discussions with the Corps (July 15, 2015), it is our understanding that the Corps used all of these during the earliest phases of alternative formulation, which led to the development of the seven water management alternatives that were later ranked at the end of Phase 1. Details regarding the earliest phases of alternative formulation were not available to the Service, and the scoring and ranking of alternatives at the end of Phase 1 only included the ARMPMs and FSHPM for the Fish and Wildlife project purpose. Although the results from the SSHPM, CRSBPM, and RFPM were either included or discussed in the supporting material provided by the Corps (ACOE 2015), they did not explicitly factor into the ranking and selection of alternatives, giving the appearance that the selection of alternatives is based on a fraction of the fish and wildlife metrics provided to the Corps.

3) There is no consideration regarding the uncertainty associated with model output in the Corps' current methodology. Quantitative models are useful in that they provide discrete numbers that can be used to compare alternatives. These numbers are generated based on empirically-derived mathematical relationships. There is standard error (uncertainty around the mean) associated with empirical relationships, meaning that numbers that appear different may actually be the same. As a solution, confidence intervals are an objective means of ascertaining whether two results are the same or different. In the hydropower example, taking standard error into consideration would likely show that most of the alternatives are the same and should not be ranked differently. When uncertainty is considered, managers can appropriately, robustly, and objectively evaluate similarities and differences between alternatives; not taking uncertainty into consideration could lead to erroneous conclusions.

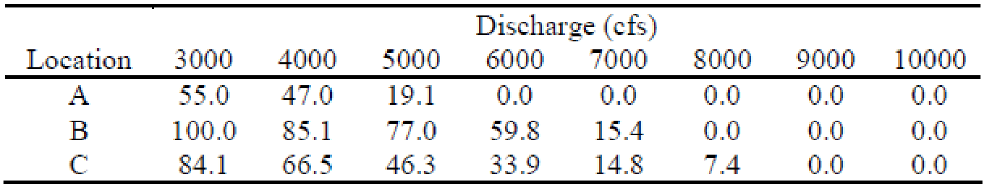
Corps' use of the ARMPM

The Service developed the ARMPMs to enable the Corps to visually and quantitatively evaluate the effects on shallow water mussel habitats in the Apalachicola River.[3] The Excel workbooks produce multiple graphical outputs that show the interannual frequency of flow rates less than 5,000 cubic feet per second (cfs) to 10,000 cfs, median number of days per year less than 5,000 cfs to 10,000 cfs, median number of consecutive days per year less than 5,000 cfs to 10,000 cfs, and two others based on fall rates. The results are graphically displayed in 1,000 cfs intervals so that the user may readily evaluate a range of low flows for a suite of alternatives (Figure 1).

The Corps condensed each ARMPM into a single number that is used to represent effects on each of the three federally-listed mussels. The Corps did this by summing, for example, the percent of years in each of the flow intervals. The alternative with the smallest sum ranks better than an alternative with a higher sum. The summation technique used by the Corps is transparent and quantitative, but may unintentionally result in an inappropriate ranking of alternatives.

Mussel exposure and mortality increase as flows decrease below 10,000 cfs (Table 3), meaning that reducing the frequency and duration of flows < 5,000 cfs and < 6,000 cfs has a bigger effect than reducing flows < 9,000 cfs and < 10,000 cfs. However, because the <10,000 cfs interval always has a significantly higher value, its inclusion may obscure potential benefits from reducing the frequency or duration of flows < 5,000 cfs and < 6,000 cfs. There are solutions to the summation problem, including weighting the intervals based on the potential exposure of mussels at corresponding discharges (see Table 1), or potentially eliminating the 9,000 -10,000 cfs interval from the calculations. We tested one of these solutions and found that it has a substantial impact on the overall ranking of alternatives for the Fish and Wildlife project purpose, which accounts for 20% of the score in the Corps' final ranking of alternatives.[4]

Table 3. An estimate of the percentage of fat threeridge mussels that would be exposed to the atmosphere at various discharges in the Apalachicola River. Sites were grouped by location in the river where group A included RM 30.0, group B included RM 41.5, 46.8, 48.4, and 49.0, and group C included RM 73.3. Table taken from Table 3.5.2.2.D in the Service's 2008 Biological Opinion (Service 2008).



	Discharge (cfs)							
Location	3000	4000	5000	6000	7000	8000	9000	10000
A	55.0	47.0	19.1	0.0	0.0	0.0	0.0	0.0
B	100.0	85.1	77.0	59.8	15.4	0.0	0.0	0.0
C	84.1	66.5	46.3	33.9	14.8	7.4	0.0	0.0

Corps' use of FSHPM

The Service developed the FSHPM to enable the Corps to visually and quantitatively evaluate effects to fish spawning habitat in the Apalachicola River floodplain. The Excel workbooks produce graphical outputs that show the distribution of the annual maximum 30-day growing season floodplain connectivity for the modeled period of record. The Corps condensed the FSHPM into a single number that is used to represent effects to fish spawning and then to compare alternatives. This was done by summing the maximum 30-day acreages for all modeled years and multiplying by 0.01389. The summed acreages were then ranked.

The method that the Corps chose to represent and rank metrics for the Fish and Wildlife project purpose is biased toward the protection of mussels. Five metrics were chosen to represent mussels (interannual frequency of flow rates less than 5,000 cfs to 10,000 cfs, median number of days per year less than 5,000 cfs to 10,000 cfs, median number of consecutive days per year less than 5,000 cfs to 10,000 cfs, and two others based on fall rates) and only one was used to represent FSHPM. Because each metric received equal weight in the ranking, mussels account for 83.3% of the ranking, and FSHPM 16.6%. The math used by the Corps means that mussels are five times more important than floodplain inundation and fishes. This is inconsistent with the intent of our PALs and performance measures. We tested one solution (giving equal weight to the floodplain metric) and found that it changed the overall ranking of alternatives for the Fish and Wildlife component of the evaluation.[5]

Corps' initial modeling using 20 million gallons per day (MGD) at Lanier Reservoir

In the Corps' modeling, they used a phased approach in which the first phase consisted of the selection of a water management alternative. The best performing alternative selected from the first phase was then used in the second phase as a foundation upon which a suite of water supply scenarios were tested. The first phase included a 20 MGD withdrawal from Lanier Reservoir and no Glades Reservoir withdrawals as a standard across all alternatives considered. Based on our discussions with the Corps (July 15, 2015), we understand that there was a legal rationale for using 20 MGD in the initial modeling even though consumptive use in the model is about an order of magnitude less than current use.

We are concerned that some alternatives considered in Phase 1 may have performed differently than the one selected to proceed to Phase 2 if higher consumptive uses are incorporated into the modeling; using the unrealistic volume of consumptive withdrawals could insert some bias into the alternative selection process. Several of the metrics used to rank project purposes are contingent upon reservoir levels, refill time, and flow targets at various river locations, each of which are affected by the individual set of parameters used to model alternatives. Depending on how an alternative is parameterized in HEC-ResSim, some alternatives may be more resilient than others when consumptive uses are increased.[6]

Corps' Water Supply Measure

The seven alternatives considered during Phase 1 of the Corps' analysis evaluated the system's *ability* to meet the water supply project purpose. The evaluation consisted of seven metrics that are based on the modeled period of record:

1) Buford minimum pool elevation (ft);
2) Minimum conservation pool elevation (1035 ft) reached (Y/N);
3) Buford percent time storage >/= Zone 1 (%);
4) Buford years in or below Zone 3 by Dec 1st;
5) Percent time refill from Zone 3 to Zone 1 by May 1st the next year;
6) Buford percent time at full pool by May 1st (1071 ft); and
7) Percent time pool elevation > 1066 ft during period of record.

Based on our discussions with the Corps on July 15, 2015, it is our understanding that the Corps views these metrics as indicators of the system's *ability* to meet the water supply project purpose, not the system's *performance* from a water supply perspective. We are concerned about the use of these metrics, but encourage the Corps to continue to discuss the intent, use, and potential reconsideration of these metrics. An example of our concern is that water supply in Lanier Reservoir is not contingent upon the percent of time water levels are in Zone 1, at full pool, or greater than 1066 ft. Water intake locations for Cumming Utilities (1020 ft) and Gwinnett County (two at 1025 ft) are 10-15 ft below the bottom of the conservation pool (1035 ft, Figure 2). The lowest Lanier Reservoir level on record occurred in 2007 when water levels were as low as 1,050.75 ft (NOAA 2015), and municipal water supply was maintained. The Service recognizes the importance of testing multiple climate/drought scenarios on the system's ability to meet multiple project purposes, and the importance of defining an objective method for selecting an alternative. However, it is the Service's present view that to base the water supply evaluation and alternative selection upon multiple metrics that do not evaluate whether water supply was or was not maintained in HEC-ResSim modeling is concerning.

Water supply accounts for 20% of the score used to select an alternative after water supply metrics are combined and ranked. A ranking approach that acknowledges the performance of the system to meet the water supply project purpose is necessary, and a revision of the metrics would undoubtedly have an effect on the ranking of alternatives in Phase 1. The metrics selected and used by the Corps currently serve only to favor alternatives that keep reservoir water levels high, possibly at the cost of other project purposes.

Figure 2. Action zones for Lanier Reservoir for the NAA and PAA. Figure source: Corps 2015.

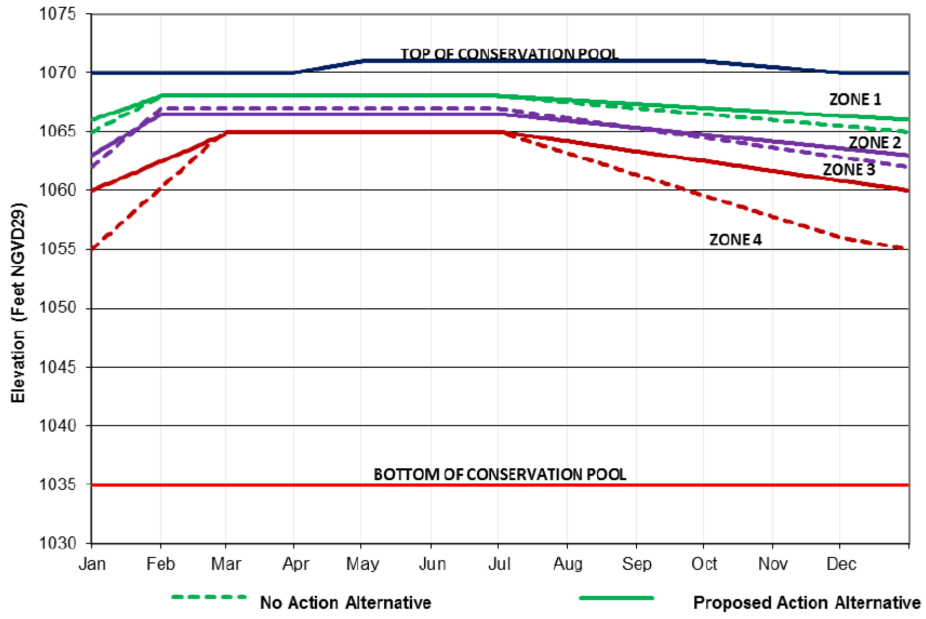


Figure 1.4-1. Lake Lanier water control action zones

Summary

As evidenced above, the alternative screening criteria used to select the PAA were based upon evaluations that do not reflect actual differences between alternatives, thus leading to our concern regarding the use of this method and the selection of the PAA. The Service recognizes the Corps' commitment to release the DEIS later this year. We support and recognize the importance of using a transparent methodology that is readily understandable by the public, and we acknowledge that the revised approach to alternative selection is probably an improvement upon previous attempts to update the WCM. However, we also expect that a more defensible methodology that is also transparent and understandable can be achieved. The Service is willing to work with the Corps to expeditiously identify and implement such methodology.

Citations

National Oceanic and Atmospheric Administration (NOAA). 2015. National Weather Service Advanced Hydrologic Prediction Service. Chattahoochee River at Lake Lanier. http://water.weather.gov/ahps2/hydrograph.php?wfo=ffc&gage=CMMG1

United States Army Corps of Engineers (Corps). 2015. ACF Water Control Manual Update Response to PAL. January 21, 2015.

United States Fish and Wildlife Service (Service). 2008. Biological opinion on the U.S. Army Corps of Engineers, Mobile District, Revised Interim Operating Plan for Jim Woodruff Dam and the Associated Releases to the Apalachicola River. Prepared by the U.S. Fish and Wildlife Service, Panama City Field Office, Florida. June 1, 2008. 225 p.

Footnotes

1. The Corps' perspective is that they have attempted to represent multiple project purposes. Much of this was done prior to the development of the ranking and scoring process.
2. The Corps acknowledges that some of the alternatives are similar and these alternatives were ranked differently. They also point out that the same ranking methodology was uniformly applied to all project purposes.
3. Recent USFWS mussel surveys show that the fat threeridge (*Amblema neislerii*) occurs at greater numbers and at a greater range of depths than previously known. Therefore, the ARMPM is presently treated as an indicator of effects to shallow water mussel habitats.
4. Discussions with the Corps on July 15, 2015 indicated that the Corps reviewed the alternatives and determined that there were not major differences between the alternatives and that the ranking methodology that converts to an "area under the curve" was sufficient and had the benefit of being transparent.
5. The Corps was consistent in their ranking approach across project purposes.
6. The Corps expects that the final ranking of alternatives would be the same between 20 MGD and current withdrawals, and based on that expectation, the decision was made to not invest in additional modeling to investigate this aspect of alternative formulation. Furthermore, the Corps indicated on July 15, 2015 that had any of the project purposes not been met at the end of Phase 2, they would have reconsidered the alternatives developed during Phase 1.

Appendix A. Excerpt from the Service's presentation to the Corps on June 1, 2015 regarding concerns with the Corps' ranking system used to select alternatives.

Concerns with Corp’s ranking system used to select alternatives

June 1, 2015

Will Duncan

Steve Leitman

2. PAL identified priorities/performance metrics

Included

- ARMPM
- FSHPM (sort of)

Not included

- SSHPM
- CRSBPM
- RFPM

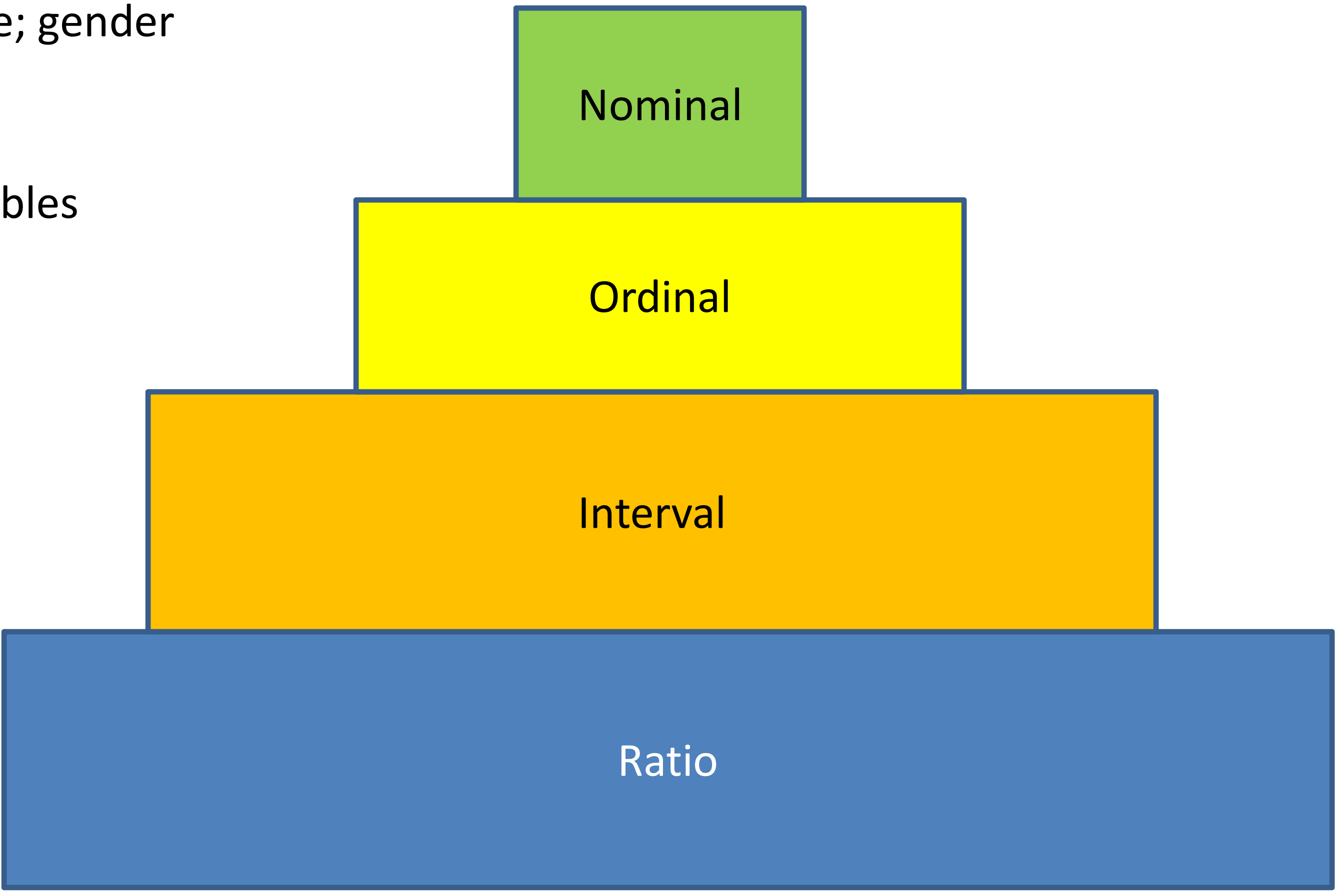
3. Conversion of ratio data to ordinal

Categorical data: no ordering; e.g. dark and light roast coffee; gender

Similar to categorical. Spacing between variables non-uniform; intervals unequal; e.g. ranking

Equally spaced intervals. $10,000, $15,000 and $20,000.

Has a true “0”
Real values
Numbers can be compared
e.g. Weight



Nominal

Ordinal

Interval

Ratio

4. No consideration of standard error/model confidence

- Standard error- uncertainty around the estimate of the mean measurement
- Confidence intervals
- Two results that fall within the same confidence interval are essentially the same

Summary of concerns

- We are concerned about the errors. More are lurking.
- We are very concerned about the approach. We can help improve it.
  - Small differences within project purpose are the same as large differences
  - A great amount of weight placed on inconsequential differences
  - Leads to a problem with public perception of “balancing” project purposes AND the FWS Evaluation
  - Even within a project purpose, there may be weighting problems
- We would like to work with you to identify errors and develop appropriate and transparent strategies for alternative selection.

USACE August 2015 Response to Draft Fish and Wildlife Coordination Act Report July 2015

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Response to U.S. Fish and Wildlife Service Draft Fish and Wildlife Coordination Act Report on Water Control Manual Updates for the Apalachicola-Chattahoochee-Flint River Basin in Georgia, Alabama, and Florida

Prepared by:

U.S. Army Corps of Engineers
MOBILE DISTRICT

August 2015

INTRODUCTION

The U.S. Army Corps of Engineers (Corps), Mobile District is updating the Water Control Manuals (WCMs) for the Apalachicola-Chattahoochee-Flint River Basin (ACF Basin). The WCM update process is to determine how the federal projects in the ACF Basin should be operated to meet all authorized purposes and to implement these operations through the means of the updated water control plans and manuals. Fish and wildlife conservation is an authorized purpose of the federal ACF system, and as good stewards of the environment and wanting to assure that the fish and wildlife interests were adequately considered, the Corps sought comment and analysis by the U.S. Fish and Wildlife Service (FWS) and state agencies of the Proposed Action Alternative (PAA) prior to release of the Draft EIS to the public. Although the PAA does not include any construction or structural modifications to the ACF project, nor is a report or a recommendation to Congress part of this effort, the Corps utilized the general framework of the Fish and Wildlife Coordination Act (FWCA) to solicit input from FWS and state agencies and to organize the information provided. On July 31, 2015, the FWS, Georgia Ecological Services Office, Athens, Georgia submitted the Draft *Fish and Wildlife Coordination Act Report on Water Control Manual Updates for the Apalachicola-Chattahoochee-Flint River Basin in Georgia, Alabama, and Florida* (DFWCAR) to the Corps, Mobile District. This report provides the Corps' detailed response to the questions and comments outlined in the DFWCAR.

The following comments regarding the WCM update purpose and scope are required to establish the appropriate context for the Corps' response to the DFWCAR. After that, the document is organized by first addressing the FWS's fish and wildlife conservation measures and recommendations; followed by discussion of the FWCA agency coordination, project impacts and evaluation methodology, the FWS's evaluation of the selected plan, and the FWS's position. Page numbers referencing the relevant information in the DFWCAR are provided.

The proposed action is to update the water control plans and manuals for the ACF Basin as directed by Secretary of the Army Pete Geren on January 30, 2008. Specifically, the purpose and need for the federal action is to determine how the federal projects in the ACF Basin should be operated for their authorized purposes, in light of current conditions and applicable law, and to implement those operations through updated water control plans and manuals. Conditions in the basin (e.g., population, socioeconomic, land use, infrastructure, and demand for water resources) have changed substantially since the federal reservoirs were authorized and constructed, and a variety of applicable federal and state environmental laws have been passed and implemented. Operation of the federal reservoir projects in the basin both affect, and are affected by, current conditions in the basin and must comply with current laws and regulations. This action will result in an updated Master Manual, including updated water control plans and manuals for the ACF system and each federal project within that system, that reflect operations under existing congressional authorizations, taking into account changes in basin hydrology and demands from years of growth and development, new/rehabilitated structural features, legal developments, and environmental issues.

On June 28, 2011, the U.S. Court of Appeals for the Eleventh Circuit issued an opinion that the authorizing documents for the Buford Dam project include water supply as an authorized purpose. Additionally, the 2011 decision ordered the Corps to reconsider whether it has the legal authority to operate the Buford Project to accommodate Georgia's request made in 2000 to adjust the operation of Lake Lanier, and to enter into agreements with the State, or water supply providers, to accommodate increases in water supply withdrawals from Lake Lanier and downstream at Atlanta. The Corps provided a legal opinion in 2012, concluding that it has sufficient authority under applicable law to accommodate that request, but noting that any decision to take action on Georgia's request would require a separate analysis. On January 11, 2013, the Governor of the State of Georgia provided updated demographic and water demand data to confirm the continued need for 705 million gallons per day (mgd) to meet Georgia's water needs from Lake Lanier and the Chattahoochee River to approximately the year 2040 rather than 2030 as specified in the 2000 request.

Because updating the water control plans and manuals requires making a decision on Georgia's water supply request, the Corps will consider, along with operations for all authorized purposes, an expanded range of water supply alternatives associated with the Buford Dam/Lake Lanier project, including current levels of water supply withdrawals and additional amounts that Georgia in 2013 requested from Lake Lanier and downstream at Atlanta.

During the WCM update process the Corps identified, documented, and evaluated the environmental effects of operating the federal projects in the ACF Basin under alternative management regimes that could reasonably be expected to accomplish the purpose and need of the proposed federal action. The range of actions, alternatives, and effects considered during the WCM update process are driven by the requirements set forth by Congress and Corps policies for project operation. Accordingly, the Corps considered operational changes within existing congressional authorities, as determined by recent court rulings, and delegated, discretionary authorities, and did not consider operational changes that would be expected to require additional congressional authority.

The analysis provided by the Corps to the FWS for the DFWCAR is consistent with the FWS guidance provided in the FWS's Planning Aid Letters (PAL) for the proposed WCM updates for the ACF River Basin in Georgia, Alabama, and Florida dated April 2, 2010, March 1, 2011, and August 29, 2013. The Corps submittal to the FWS on January 21, 2015 was based on the latest PAL guidance (August 29, 2013). The Corps' January 21, 2015, response to PAL provided the available information and was followed by multiple discussions with FWS, the submittal of the HEC-ResSim model results from both phases of the Corps' alternative formulation, and numerous Excel workbooks used by the Corps to evaluate the impacts of the alternatives. The Corps believes the information provided and the numerous discussions with the FWS regarding alternative formulation demonstrate that fish and wildlife were given equal consideration along with the other authorized project purposes.

FISH AND WILDLIFE CONSERVATION MEASURES AND RECOMMENDATIONS

Fish and Wildlife Service Alternative Evaluation

Pg 36-37 - The FWS's revised WCM alternative dated July 19, 2013 (Appendix VIII of the DFWCAR) includes the same revised action zones as the PAA. The response to PAL the Corps provided to the FWS in January 2015 briefly described the alternative formulation process and noted that Phase I of the alternative formulation process evaluated the No Action Alternative (NAA) and six other Water Management Alternatives. One of those other Water Management Alternatives was the FWS's alternative as described in the July 19, 2013, letter. The Corps utilized a subset of performance metrics to evaluate the various alternatives' ability to meet the authorized project purposes and rank the ability of the alternatives to meet the objectives established for the WCM update. The water management alternative finally chosen represented the best balance of all authorized project purposes. The result of this formulation phase was the identification of the Water Management plan represented in the PAA. The Corps appreciates the FWS's extensive efforts to identify a system-wide operational plan for consideration during the WCM update process and fully evaluated the FWS's alternative during Phase I of the alternative formulation process. The FWS's concerns with the alternative selection process methodology are addressed in the SUMMARY AND FWS POSITION section at the end of this document.

Flow Regime

Pg 37-38 (FR1) – The FWS recommends that the Corps develop an alternative that maximizes benefits to fish and wildlife resources in light of other project purposes. The Corps maintains that the alternative formulation process accomplishes this request. Full details of the iterative process used in the alternative selection methodology as well as all project impacts of each alternative are provided in the DEIS (Sections 4 and 6 respectively).

The FWS reiterates their requests for the Corps to consider flow guidelines, pulse flow guidelines, and non-hydropower peaking windows in order to provide for some components of the natural hydrograph and states "To date, none of the natural flow regime components have been incorporated into the flow alternative development". In the 2011 response to PAL the Corps provided detailed discussion regarding the physical, safety, and logistical limitations to making operational changes that mimic a natural flow regime. This discussion is still valid and is incorporated here by reference (USACE 2011). The Corps maintains that operating to match the natural flow regime is not possible at the multipurpose Federal projects since they were designed and built to alter the natural flow regime. Operating in a manner that seriously impacts the congressionally authorized purposes of hydropower production and flood risk management would require additional study authorization that is outside the scope of a WCM update. The PAA includes seasonally varying minimum flow provisions and fall rate provisions at Jim Woodruff Lock and Dam designed to mimic a more natural flow regime in the Apalachicola River. The construction of the series of Federal and non-federal reservoir projects in the heavily regulated Chattahoochee arm of the river basin has resulted in an altered flow regime that significantly limits the Corps' ability to provide for some components of the natural hydrograph.

Pg 38-39 (FR2) – The FWS recommends that ecosystem flow analyses using the methodology cited in the FWS's PAL addendum be conducted at four nodes (below Buford Dam, West Point Dam, Walter F. George Lock and Dam, and Jim Woodruff Lock and Dam) for the NAA and PAA and compared with the FWS's ecosystem flow guidelines. The FWS' PAL addendum provided revised low and high flow guidelines based on the pre-dam gage data or simulated pre-dam conditions where gage data were not available. In developing the revised low flow guidelines the FWS used flow magnitude percentiles for each month to define the lower limit, dry year, average year, wet year, and upper limit, (10th, 25th, 50th, 75th, and 90th) respectively. The Corps agrees with this approach and notes that the 2015 response to PAL provides a monthly flow statistics analysis of the simulated NAA and PAA depicting this information at numerous locations throughout the basin. The Corps response to PAL did not include a comparison of these simulations to the revised FWS's low flow guidelines based on the monthly seven lowest values. To the extent this analysis is still desired the Corps will provide it during the DEIS public review period.

The FWS also continues to recommend that the Corps evaluate the provision of non-hydropower peaking "windows" during critical reproductive and rearing periods for a minimum of 4-6 weeks from March – May. As described in the Corps' January 2011 response to PAL, non-hydropower peaking "windows" were considered and determined to not be prudent based on equipment limitations, safety concerns, and serious impacts to other authorized project purposes. The Corps maintains that all of the previously described reasons for not including non-hydropower peaking "windows" are still valid and incorporates them here by reference (USACE 2011).

The FWS states "fish and wildlife and hydropower production are coequal purposes at these facilities and under both the no action alternative and the proposed action alternative; benefits to riverine fauna are sacrificed at the expense of hydropower production." The Corps believes that the needs of both project purposes can be managed cooperatively to achieve benefits to both resources. The Corps operations, including hydropower production, result in a mix of beneficial and adverse effects to aquatic fauna. The Corps notes previously discussed benefits to the striped bass and shoal bass fisheries in the reach below Buford Dam to West Point Dam which are met in conjunction with hydropower production at upstream projects. To the extent that restoration of some of the natural flow regime components can be accomplished to the benefit of fish and wildlife resources in light of other project purposes, the Corps believes the PAA adequately strikes this balance. It is the responsibility of the Corps to best determine water management operations that meet all of the congressionally authorized project purposes. As described in the purpose and need section of the DEIS, the purpose and need for the federal action is to determine how the federal projects in the ACF Basin should be operated for their authorized purposes, in light of current conditions and applicable law, and to implement those operations through updated water control plans and manuals. The proposed action is not intended to maximize benefits to fish and wildlife resources or any other authorized project purposes, but to equably manage the federal projects for the benefit of all authorized project purposes. Accordingly, the alternatives considered in the DEIS do not address any proposed changes to water management practices that exceed existing congressional authority.

Pg 39-40 (FR3) – The FWS recommends evaluating the potential for reducing the magnitude of fall drawdowns and/or starting the spring refill earlier to provide inundation of the floodplain.

These actions would have serious implications for flood risk management. Considering the purpose and need for the proposed action, the Corps developed eight screening criteria to guide information gathering, to help identify solutions, and to formulate alternatives. One of these criteria requires maintaining at least the current level of flood risk management. The Corps operates projects in the ACF Basin to provide flood risk management, as Congress intended when authorizing the system and projects. Continued growth and development in the ACF Basin has resulted in the construction of homes and businesses in the floodplain. Any proposed action should not significantly alter the level of flood risk management intended by the Congress in its authorizing language or increase the current levels, frequency, and duration of flood damage. Accordingly, the alternatives considered in the DEIS do not address any proposed changes to water management practices that exceed existing congressional authority.

Pg 40 (FR4) – The FWS recommends that the Corps evaluate methods to provide the operational flexibility necessary for floodplain inundation including evaluating compensatory measures, such as elevating, moving, or purchase of structures, that would allow floodplain inundation. The Corps agrees that compensation actions could provide more flexibility regarding floodplain inundation, but maintains that they are not authorized or appropriate as part of a WCM update. These types of actions require separate study authority.

Pg 40 (FR5) – The FWS requests that the Corps evaluate the operational feasibility, constraints, and tradeoffs to providing different component(s) of environmental flow measures that are captured in our guidelines. The FWS reiterates that that achieving a natural hydrograph in its entirety is not the goal, but providing for some components of the natural hydrograph could be beneficial. In the 2011 response to PAL the Corps provided detailed discussion regarding the physical, safety, and logistical limitations to making operational changes that mimic a natural flow regime. This discussion specifically addresses the FWS's guidelines and it is still valid. That discussion is incorporated here by reference (USACE 2011). The Corps maintains that operating to match the natural flow regime is not possible at the multipurpose Federal projects since they were designed and built to alter the natural flow regime. Operating in a manner that seriously impacts the congressionally authorized purposes of hydropower production and flood risk management would require additional study authorization that is outside the scope of a WCM update.

Pg 41(FR6) – The FWS requests that the Corps participate in the development of appropriate hydrological and meteorological criteria needed to forecast future conditions as either dry, average, or wet. The Corps currently utilizes the NIDIS Low Flow Information System to alert other water management operators and basin stakeholders of low flow conditions. The Corps will continue to evaluate forecasting tools and is willing to meet with FWS to further discuss this issue.

Floodplain inundation assessments

Pg 41 (FP1) – The FWS requests that the Corps use LIDAR and stage-discharge relationships to compare floodplain inundation metrics. A full set of LIDAR data for the entire Apalachicola River may be available but has not been provided to the Corps during the numerous scoping periods. Further, the Corps is unaware that models or software that correlate the LIDAR data to specific discharges from Jim Woodruff Dam currently exist. It is our understanding that Florida Fish and Wildlife Conservation Commission (FFWCC) was contemplating or had begun to develop such tools, but that they are not available yet. Accordingly, the Corps utilized the best available information consistent with the guidance provided in the FWS's PAL. The FWS previously stated in the DFWCAR (Pg 17, Floodplain connectivity) that "given that the NAA and PAA exceedance curves are nearly the same, we do not expect that using LIDAR data would lend additional insights. Chattahoochee River floodplain connectivity would be expected to be nearly the same between the NAA and PAA. Conditions in the NAA would be very similar to the PAA as the Chattahoochee River is currently essentially disconnected from its floodplain. Therefore, we do not expect differences in floodplain inundation in the Chattahoochee River."

Dissolved Oxygen

Pg 41-42 (WQ1) – The FWS requests that the Corps ensure that releases from all five ACF dams meet or exceed water quality standards. Releases from the Corps' ACF dams are not subject to specific Clean Water Act effluent limitations. The Corps is not responsible for enforcing State water quality standards and cannot ensure that water quality standards are met. However, the Corps has given careful consideration to water quality standards and has evaluated the effects of each alternative on water quality. The Corps acknowledges the simulated DO results described by the FWS on pages 14-15 of the DFWCAR. These results are not surprising. Lower DO concentrations would be expected to occur below the major reservoirs under the NAA and PAA due to the low-oxygenated water being discharged from reservoirs. The DO concentrations found in the deeper portions of the reservoir may stay low because of stratification. As the water warms through the summer, the amount of DO in the water column would decrease in the deeper areas. Water released from the dams is from the deeper waters, where DO is depleted over time. Downstream from the immediate dam release, the large volume of water would result in greater velocities and reaeration, increasing oxygenation. These increased oxygen levels support fisheries downstream of the dams. The Corps has improved DO in the project tailraces through past efforts that included upgrading the venting capabilities of hydroelectric turbines, installation of siphons that release water with relatively higher DO levels from the top of the reservoir, and implementation of SOPs regarding monitoring DO levels and making special releases to temporarily improve tailrace DO. Not only was fish and wildlife conservation equally considered in the alternatives evaluation for the WCM, but as shown by these actions, the Corps has and continues to perform actions to benefit fish and wildlife in this system.

Pg 42 (WQ2) – The FWS recommends that the Corps evaluate the effectiveness of the upgraded venting capabilities at Buford turbines. This type of study requires separate study authority and is beyond the scope of this effort. The Corps agrees that alternative authorization and appropriation, such as Corps restoration authorities, would be necessary to fulfill this conservation recommendation and is willing to explore these opportunities with FWS.

Temperature

Pg 42 (WQ3) – With regards to the FWS request of the Corps to experiment with operational and/or structural modifications and follow up monitoring that improve temperature levels downstream of Corps reservoirs, such a study would require separate study authority and is beyond the scope of this effort.

Fish Passage

Pg 43 (FM1) – The FWS states that provisions for fish passage should be incorporated in the WCM for Jim Woodruff Lock and Dam, George W. Andrews Lock and Dam, and Walter F. George Lock and Dam. As stated previously, the Corps has adopted fish passage operations at Jim Woodruff Lock and Dam into the project's WCP. With regards to the other two projects, ongoing fish passage studies at Jim Woodruff Lock and Dam have demonstrated that very few fish that pass upstream travel up the Chattahoochee arm of the basin (recent genetic studies demonstrate that approximately 98% of the Alabama shad's natal waters were the Flint River). It appears that fish passage operations at George W. Andrews Lock and Dam and Walter F. George Lock and Dam would have limited success. However, the Corps maintains that 1) just because it is not explicitly stated in the updated version of the manuals does not mean that operations cannot change in the future, and 2) not including language in the project water control manuals does not preclude routine lock operations at George W. Andrews Lock and Dam or Walter F. George Lock and Dam which may benefit anadramous fish species.

Climate Change

Pg 43 (CC1) – As discussed during the coordination of the DFWCAR, the DEIS includes climate change and sea level rise analyses consistent with Corps' regulations. The Corps, in response to relevant guidance and public interest and input, engaged the Institute for Water Resources (IWR) to develop a numerical model to evaluate the resilience and limitations of proposed ACF Basin water management scenarios in response to potential climate change conditions. The ACF numerical model was developed to correlate with the HEC-ResSim and HEC-5Q models for the ACF system. Simulating the IWR climate change projections in HEC-ResSim and HEC-5Q provided an indication of the effects of prospective climate change on hydrology and water quality in the ACF Basin. The objective of this effort was a quantitative analysis of potential climate change in ACF Basin hydrology and, by extension, ACF Basin management. The details of this analysis are provided in the DEIS (Section 6.8).

Navigation

Pg 43 (NV1) Navigation is an authorized project purpose and as such is included in the WCM update. The Corps' proposed action includes operations for a navigation season. The navigation season operations assume no channel maintenance activities will occur on the Apalachicola River as these activities have been indefinitely deferred due to denial of a Section 401 water quality certificate from the State of Florida and recent congressional language that limits funding for dredging operations in the ACF Basin. If channel maintenance activities are re-instated for the Apalachicola River portion of the navigation project, the Corps would address the evaluations requested by the FWS during the water quality certification process.

Reservoir and Riverine Fisheries Management

Pg 43-44 (FM2, FM3) – FWS recommends reviewing recent fisheries literature for additional information regarding impacts to riverine fish spawning during a 4-6 week stable or rising reservoir window to benefit reservoir fish spawning. Also recommended was to modify Fish Spawn SOPs to occasionally emphasize river spawning over reservoir spawning. Lake regulation and coordination for fish management purposes is required by South Atlantic Division Regulation PDS-O-1 (31 May 2010). The Mobile District draft fish spawn SOP (2005) defines Corps operations for implementing this Division Regulation and includes requirements for an annual meeting with the various State and Federal fish and wildlife resource agencies. The purpose of the meeting is to evaluate the success or failures of executing the fish spawn operations during the previous year; share data including recent scientific investigations that support, modify, or reject the fish spawn operations; and identify potential refinements. The Corps believes this process can accomplish the goals identified by the FWS. The Corps welcomes the FWS's facilitation capabilities to better accomplish these goals as part of that process.

With regards to the FWS's request to investigate modifications to the fish spawn SOP to occasionally emphasize river spawning over reservoir spawning the Corps maintains that the existing language provides for this flexibility and specifically provides for "operational adjustments recommended by the interagency team to minimize impacts and/or enhance system-wide benefits". As described in the paragraph above, modifications to the SOP can be proposed and mutually agreed upon or rejected as part of the annual coordination meeting.

Pg 45 (FM4) The FWS recommends identifying fish and wildlife recreation facilities that need infrastructure improvement. As noted previously, infrastructure improvements and other construction activities require additional study authority and are outside the scope of the WCM update.

Apalachicola Bay

Pg 45 (AB1) - The Corps understands that the FWS is currently contracting with Dr. Peter Sheng to update the previously conducted hydrodynamic bay salinity modeling with simulated flow data from the HEC-ResSim modeling conducted for the WCM update. The Corps looks forward to reviewing this information if it is available prior to the release of the Final EIS. The Corps hopes this information will be available during the Section 7 consultation and completion of the National Environmental Policy Act (NEPA) process.

Pg 45 (AB2) – As described in the FISH AND WILDLIFE RESOURCES WITHOUT THE PROJECT section, the Corps disagrees with the relevancy of the impacts identified by the FFWCC in their analysis of the pre-dam and post-West Point periods of record. As previously discussed the appropriate without project condition for the purpose of this analysis is current operations, not a pre-dam condition. Congress previously authorized the construction and operation of the federal reservoirs to serve as a multi-purpose projects and they were built to achieve the congressionally authorized purposes.

Decision Support Model to Evaluate Changes to Corps' Operations

Pg 45/46 (DS1) – The DEIS includes a detailed description of the alternative development process for the WCM update. Considering the purpose and need for the EIS, the Corps developed eight screening criteria to guide information gathering, to help identify solutions, and to formulate alternatives. These screening criteria are described below:

Any proposed measure (or alternative) considered in the update process for the Master Manual should:

1. Meet the purpose and need of the proposed federal action
2. Address one or more of the congressionally authorized project purposes
3. Maintain at least the current level of flood risk management
4. Be consistent with the contemporary water resources needs of the basin to the extent practicable
5. Support the operation of the projects in the ACF Basin as a system
6. Not increase the risk to public safety in the facility or downstream of the project
7. Not exceed the physical limitations of or pose risks to the structural integrity of the projects
8. Not violate USACE responsibilities under the Endangered Species Act (ESA)

The 2010 guiding principles described in the DFWCAR were constraints identified early in the WCM update process. Considerable changes to the scope of the project have occurred since 2010 as a result of litigation. The screening criteria listed above are consistent with and evolved from the 2010 guiding principles listed in the DFWCAR. Although not specifically described in the screening criteria listed above, the fish spawn SOP (guiding principle 6) was included in all water management alternatives considered. Guiding principle 7 regarding reallocation of storage for water supply is not one of the screening criteria listed above; however, water supply needs were evaluated in conjunction with the water control manual update. Guiding principle 8 regarding water quality in Corps reservoirs is inherent within screening criteria 1 and 2.

Adaptive Management

Pg 46 (AMP1) – The Corps believes that the WCM guidance, fish spawn SOP, ESA compliance annual reports, and monthly coordination with the FWS regarding Apalachicola River flows achieve the goal of the formal adaptive management program the FWS recommends. The WCM guidance provides for operational flexibility to balance all project purposes over a wide variety of conditions.

Increasing Consumptive Demands

Pg 47 (CD1) As described above, the HEC-ResSim model includes standardized assumptions regarding consumptive demands (outside of the Atlanta area) that include the highest demand year (2007). These levels of consumptive demand were selected by the Corps because they represented the most severe consumptive demands experienced to date. The Corps has no authority to limit water use in the basin, a responsibility of the States, and thus applied the highest level of demands to each year of the simulation in order to evaluate the water management alternatives ability to perform with increased consumptive demands.

Evaluation of Alternative Models

Pg 47-48 (AM1) – The Corps will continue working with the states to improve the unimpaired flow development methodology and update the dataset accordingly. This Corps' analysis used "HEC-ResSim Version 3.2, Build 3.2.1.19". HEC-ResSim is a generalized reservoir operations modeling package. Per ECB 2007-6 (USACE, 2007) and EC 1105-2-407 (USACE, 2005b), HEC-ResSim falls under the category of "engineering models used in planning studies", leaving certification to the Science & Engineering Technology (SET) initiative associated with the Corps' Technical Excellence Network (TEN). The Corps' Hydrologic Engineering Center developed this software which is now the standard for Corps reservoir operations modeling. As of January 2010, the TEN guidance listed HEC-ResSim as "Community of Practice Preferred" for the purpose of reservoir system analysis.

The Water Control Manual Update team selected HEC-ResSim as the tool most capable of faithfully representing District water management practices as the culmination of a three-year model development and verification process. In 2006 Mobile District began working with HEC to create HEC-ResSim models based on established HEC-5 models simulating 1977, 1995, and 2006 physical and operational conditions. The three HEC-5 models hold significance as the tools "of record" used for analyses concerning the previous Environmental Impact Statement, the 1990's Comprehensive Study, and the Revised Interim Operating Plan (RIOP). After ensuring that the corresponding HEC-ResSim models could effectively reproduce the HEC-5 results, Mobile District and HEC created another HEC-ResSim model that captured the most significant operations as of 2008, including the RIOP rules and head limits constraints. This model was presented to stakeholders in October 2008 and generally accepted as a promising improvement to ACF reservoir system modeling. Other considerations factoring into Mobile District's selection of HEC-ResSim include ease of adaptation to other studies or operational use, availability of training, access to software developers for program enhancements, opportunity for linkage with water quality models, and ability to share with partners and stakeholders without licensing cost or restriction.

Since the Water Control Manual Update study was heavily accelerated but subject to unpredictable changes in scope, the long-standing relationship between Mobile District and HEC also afforded an important element of organizational trust that provided continuity.
The Mobile District's decision to use HEC-ResSim for modeling the ACF watershed represents a long term investment that continues to pay dividends. Completion of the ACF HEC-ResSim model for the initial water control manual update study in 2010 yielded a set of alternatives and associated results that satisfied the Corps' internal and external review processes. The model results continue to serve as a basis of debate among the stakeholders yet the Corps maintains that HEC-ResSim is the best available tool for evaluating alternative system wide operations and that it accurately reflects the resultant high and low flow conditions of these alternative operations. With regards to the FWS validation analysis, please reference the discussion in the PROJECT IMPACTS & EVALUATION METHODOLOGY section below.

Pg 48 (AM2) – The Precipitation-Runoff Modeling System (PRMS) is not available for use at this time.

Pg 48 (AM3) – The Corps is familiar with the Georgia Water Resources Institute (GWRI) models and maintains that HEC-ResSim is the best available tool for evaluating alternative system wide operations.

Pg 48 (AM4) – The Corps maintains that the HEC-5Q water quality model is appropriate for the WCM update. The HEC-5Q Water Quality Modeling Report included in the DEIS (Appendix K) provides a detailed description of the "Demonstration of Model Performance" conducted by the water quality modeling team. The demonstration included extensive comparison of modeled and observed time series (streams) and profiles (reservoirs) as well as a model sensitivity analysis.

Additional Conservation Measures Developed from the Corps' PAL Response

Pg 49 (FR7) - The FWS notes there are no minimum flow provisions downstream of Walter F. George Lock and Dam and the Corps should evaluate implementing a minimum flow provision at this project. The Walter F. George Lock and Dam project is a hydropower facility designed to meet peak demand that typically occurs during the weekday. During periods of normal flow Walter F. George Lock and Dam may not release water on the weekends if the Jim Woodruff flow provisions can be met without support from upstream reservoirs. Currently there is no authorized minimum flow requirement from Walter F. George Lock and Dam. Upstream projects (Buford and West Point) have small hydropower house units designed to provide a continuous minimum flow. Walter F. George Lock and Dam does not have a small hydropower house unit. To provide a continuous minimum flow, the project would have to spill water through the spillway. However, installation of siphons and occasional spillway releases assist with raising the dissolved oxygen level downstream of the project. The FWS mistakenly notes that minimum flow releases are already implemented at the other four ACF projects. This is not true for George W. Andrews Lock and Dam as it is a run of river project with no storage to support an at site minimum flow requirement. The discharge from George W. Andrews Lock and Dam matches the volume of inflow with some reregulation of the upstream Walter F. George Lock and Dam hydropower releases.

Pg 49 (FR8) –Drought operations under the PAA are triggered when the composite conservation storage drops into Zone 3 (not Zone 2 as indicated in the DFWCAR). The Corps notes that the Phase I alternative formulation process included alternative drought operation triggers to the one represented in the PAA.

Pg 49 (FM5) – The Corps utilized the Sturgeon Spawning Habitat Performance Measure (SSHPM) Excel workbook developed by the FWS and the Corps' response to PAL noted that there were no differences between the NAA and PAA (Section 2.7.1). The Corps provided the FWS with the workbook supporting this determination in March 2015.

Pg 49 (FM6) – The Corps will work closely with the FWS during the Section 7 consultation to ensure that the appropriate species are addressed. The Corps will utilize existing information for the species currently petitioned for listing and will work with FWS to identify opportunities to improve the understanding and future evaluation of project impacts on these species.

Pg 49 (NPS1) – The DEIS does address the impacts of the PAA to the NPS's Chattahoochee River National Recreation Area (Section 6).

Pg 49-50 (ES1) – The DEIS generally addresses ecosystem services in the numerous impact assessments conducted. The Corps currently does not have guidance on ecosystem services but is evaluating how to include consideration of ecosystem goods and services in Corps projects.

Mitigation Measures

Pg 50 (MIT1 and MIT2) - Mitigation includes measures to avoid, reduce, minimize, or compensate for adverse impacts that could result from a selected course of action. As potential water management measures were identified and alternatives were developed, potential actions to offset any adverse effects also were identified, analyzed and considered in the planning process. For example, increased water withdrawals from the Chattahoochee River to meet the needs of metropolitan Atlanta communities would result in a corresponding increase in treated wastewater returns to the river between Atlanta and West Point Lake. The impact analysis showed that the PAA would result in increased loadings of total phosphorus that would have a substantially adverse effect on water quality. The substantially adverse effects would also be expected downstream of West Point Lake to the headwaters of Walter F. George Lake. The adverse water quality effects in these portions of the Chattahoochee River would principally be associated with increased treated wastewater discharges to the river rather USACE project operations. The Georgia Environmental Protection Division may require changes to discharge permits for some facilities. After a thorough analysis of the impacts from the PAA and other alternatives, it was determined that specific compensatory mitigation measures for the Corps of Engineers were not required or necessary.

Water management inherently involves adapting to unforeseen conditions. Because adverse effects of the water control plan might occur in the future due to unforeseen conditions, actions would be taken within applicable authority and policies, and in coordination with other interests, to address such conditions when they occur through the implementation of temporary deviations to the water control plan, such as interim operation plans.

Pg50 (MIT3) – As described in the *Analyses of Apalachicola Bay* section below, the Corps believes that the PAA results in negligible impacts to the estuary. Therefore mitigation is not appropriate.

FWCA Agency Coordination

This section addresses comments provided to FWS from the Florida Fish and Wildlife Conservation Commission (FFWCC), Alabama Department of Conservation and Natural Resources (ADCNR), Georgia Department of Natural Resources, Wildlife Resources Division (GDNR-WRD) and National Oceanic and Atmospheric Administration (NOAA) regarding the DFWCAR. Please reference pages 1-3 of the DFWCAR.

FFWCC

The Corps believes that the PAA is the alternative that best balances authorized project purposes with the least environmental impact. Regarding coordination with FFWCC, in 2008 the Corps published a Notice of Intent to prepare an EIS in the Federal Register. That was followed by additional notices announcing additional information and meetings for the public scoping process. In 2009 scoping was reopened. The latest round of scoping occurred in 2012. During each of these scoping periods, FFWCC has had opportunity to participate. The FFWCC has also participated in both DFWCA report efforts related to the WCM update process. Additional opportunity to provide input to the Corps will be provided during the comment period upon public release of the DEIS. Fish and wildlife resources received equal consideration as other authorized purposes. The Corps believes its analysis includes impacts of current and projected consumptive water uses; the NAA compares current water demands to that of the PAA which includes an increase in consumptive water use.

ADCNR

The Corps analyzed a set of alternatives with an objective to balance all authorized project purposes. In accordance with the purpose and need of the proposed action, the Corps did not attempt to develop an alternative that would maximize and benefit the fish and wildlife resources of the State of Alabama. The proposed action is not intended to maximize benefits to fish and wildlife resources in any state, or any other authorized project purposes, but to equably manage the federal projects for the benefit of all authorized project purposes. Regarding water quality, the Corps will comply with all relevant laws and regulations. In regards to in-stream flow, the Corps believes that the PAA adequately balances all authorized project purposes. The FWS included discussion of consumptive demands, protected species minimum flows and fish passage at George W. Andrews Lock and Dam and Walter F. George Lock and Dam in the DFWCAR and those comments are addressed in the appropriate sections below.

GDNR-WRD

It is not clear from the GDNR-WRD comments whether or not the current or proposed operations result in water temperature conditions in the river segment between Buford Dam and West Point Lake incapable of supporting the trout and striped bass fisheries. They appear to favor a coldwater fishery in the upper portions of this reach, which currently exists and note the importance of cool water refugia to the survivability of adult striped bass. The impact analysis conducted by the Corps suggests that the proposed action will at worst maintain the current water temperature regime and may in fact improve water temperature for trout, striped bass, and shoal bass at critical transition zone locations below Morgan Falls Dam. The Corps acknowledges that the construction of dams impacts dissolved oxygen (DO) levels in the river that are important to aquatic resources. However, the Corps maintains that operational changes at the federal projects cannot substantially improve DO levels below Corps projects using existing infrastructure. At the request of the FWS the Corps previously evaluated the feasibility of operating the federal projects in a non-hydropower peaking manner to facilitate riverine fish spawn and replicate a seasonally varying baseflow hydrograph that more closely approximates natural conditions. The results of that evaluation were provided in the Corps' January 2011 response to PAL document and are further discussed below. As described in the description of the proposed action, the Corps will continue to implement the Draft Reservoir Regulation and Coordination for Fish Management Purposes Standard Operating Procedure (SOP) (SAM SOP 1130-2-9).

NOAA

NOAA states their support for the FWS comments on the evaluation of the PAA on Gulf Sturgeon, fish passage, and effects of freshwater inflow on Apalachicola Bay seagrass, fish and shellfish. The Corps addresses these comments in the appropriate sections below.

FISH AND WILDLIFE RESOURCES WITHOUT THE PROJECT

Pg 10/11 - The FWS describes the “fundamental component” of a FWCA report as the “evaluation of resources with and without the project, so that impacts to fish and wildlife habitats and populations, human uses of resources, and other habitat values lost or gained can be quantified, negative impacts avoided or minimized, and unavoidable impacts mitigated”. Since the proposed action is not a construction project and is instead a change in operation for an existing system of projects, “without project” is more appropriately defined under the NEPA interpretation of No Action and the type of evaluation is different. However, the Corps believes the NAA accurately reflects the “existing condition” and the PAA accurately reflects “the future with the project” condition. The NEPA requires a comparison of the existing condition (No Action) to potential alternatives including the proposed action. The existing condition as described by the Corps (NAA) complies with The Council on Environmental Quality (CEQ) Regulations for Implementing NEPA which requires the inclusion of the “alternative of no action” in an EIS. The CEQ further defines what is meant by the “alternative of no action” in a document titled *NEPAs Forty Most Asked Questions* (Forty Questions). In that document they state, with regards to federal actions such as updates to existing plans where ongoing programs initiated under existing legislation and regulations will continue, even as new plans are developed the “no action" is "no change" from current management direction or level of management intensity. Therefore, the "no action" alternative may be thought of in terms of continuing with the present course of action until that action is changed. Consequently, projected impacts of alternative management schemes would be compared to those impacts projected for the existing plan. In light of this guidance the Corps has selected a NAA that is both appropriate and in accordance with applicable law.

For the PAA the Corps maintains that we have adequately represented conditions that are likely to exist during the life of the project relevant to the management of the Corps’ projects. The 73-year period of historic hydrology upon which the simulated PAA is based represents the range of dry/normal/wet conditions that would be expected to occur during the life of the project. The FWS states that the PAA is not fully represented because it did not incorporate basinwide consumptive demand projections or climate change. The Corps does not agree with this conclusion. The PAA HEC-ResSim model includes standardized assumptions regarding consumptive demands (outside of the Atlanta area) that include the highest demand year (2007). These levels of consumptive demand were selected by the Corps because they represented the most severe consumptive demands experienced to date. The Corps has no authority to limit water use in the basin, a responsibility of the States, and thus applied the highest level of demands to each year of the simulation in order to evaluate the water management alternatives ability to perform with increased consumptive demands. The DEIS includes climate change and sea level rise analyses consistent with Corps' regulations. The Corps, in response to relevant guidance and public interest and input, engaged the Institute for Water Resources (IWR) to develop a numerical model to evaluate the resilience and limitations of proposed ACF Basin water management scenarios in response to potential climate change conditions. The ACF numerical model was developed to correlate with the HEC-ResSim and HEC-5Q models for the ACF system. Simulating the IWR climate change projections in HEC-ResSim and HEC-5Q provides an indication of the effects of prospective climate change on hydrology and water quality in the ACF Basin. The objective of this effort was a quantitative analysis of potential climate change in ACF Basin hydrology and, by extension, ACF Basin management. The details of this analysis are provided in the DEIS. To the extent the PAA simulations and analysis provide in the Corps' response to PAL does not satisfy the FWS's needs; the Corps believes the analysis provided in the Climate Change Analysis section of the DEIS will.

Page 11/12 – Despite acknowledging that the interpretation provided by the FFWCC that past and current federal reservoir operations have affected a multitude of fish and wildlife resources is the opinion of the FFWCC and not the FWS, the FWS states that the "impacts identified (hypothesized, realized, or modeled) in FFWCCs correspondence are relevant because operational changes at Corps facilities have the potential to ameliorate, exacerbate, or have no effect on such project-induced impacts and impacts associated with other changes in future resource conditions". The Corps disagrees with the relevancy of these impacts identified by the FFWCC. The analyses and subsequent interpretation provided by FFWCC are in large part a reiteration of extra record material submitted on behalf of the Florida parties in the Middle District of Florida "Phase II" case that the Federal Defendants and other parties have refuted on both the technical merit of the analyses and the faulty conclusions drawn from them. A detailed accounting of the Federal Defendants comments on these analyses is available in the court record and need not be restated here. However, in general the interpretations regarding the impacts of federal reservoir operations on fish and wildlife resources consistently ignore annual changes in hydrology that have a real bearing on project releases. In particular, they ignore generally accepted realized changes in the seasonal pattern of rainfall between the pre-dam condition and the post-dam condition. These changes inherently impact the hydrology of the Apalachicola River regardless of the influence of Corps operations and therefore must also be considered when evaluating those impacts which are a result of Corps discretionary operations. This failure raises serious questions as to the relevancy of the FFWCC analyses and interpretation. Presumably, the FWS understood these inadequacies and thus did not adopt the FFWCC's interpretations. The Corps requests that FWS also re-visit their decision regarding their relevancy. Accordingly, we believe the impact analyses we provided, in accordance with the PAL guidance, are appropriate for evaluating the impacts of implementing the PAA.

PROJECT IMPACTS & EVALUATION METHODOLOGY

Pg 13 – The FWS states that all models have limitations and caveats associated with model development and use, all of which should be acknowledged by the Corps. The FWS also provides again a statistical and qualitative analysis they conducted on the 2011 model data comparing observed and simulated data. The FWS cautions that interpretation of modeled hydrology focus on data trends, not on absolute magnitudes in comparisons of alternatives. These limitations are acknowledged by the Corps and are fully discussed in the DEIS.
With regards to the water quality analyses provided by the Corps, the FWS states "While these analyses are useful and statistically valid, we caution the reviewers regarding the following. When data are lumped for multiple months into a single graph, and when percentiles are used to characterize multi-month datasets, the high and low extremes that occur in a *single* month may be obscured by the data associated with all other months". The Corps recognizes that a thorough understanding of the methodology used for the impact analysis is required to make interpretations or draw conclusions and again points out that the impact analyses were provided in accordance with the guidance provided in the FWS's PAL. Time series plots for the various water quality parameters are available and some are provided in the HEC-5Q modeling report included as an appendix to the DEIS.

The Corps acknowledges there are limitations and caveats associated with model development and use but do not agree that a misunderstanding of these demonstrates inadequacies of the model or its intended use. The HEC-ResSim and HEC-5Q models were evaluated to ensure that they exhibited the tendencies seen in the observed data and that they were sufficient to provide reasonable long-term estimates of water quantity and quality through the ACF system. The central focus of this modeling effort was to enable the EIS team to evaluate the differences in water quantity and quality between a continuation of the no action alternative and implementation of the proposed action. The Corps' internal model review process has conducted similar analyses to the one provided by FWS and agrees that the models produce a high degree of similarity for many of the water quantity and quality parameters at most locations. However, as the Corps has explained to the FWS on numerous occasions interpreting these differences as a deficiency on the part of the models is inappropriate. The HEC-ResSim and HEC-5Q models were not developed or ever intended to produce outputs that matched exactly the observed data. Given the multitude of operational variations that have occurred over the period of record when responding to real life situations (equipment malfunctions, gage errors, and approved variances to operating rules) it is not possible to produce such outputs in the HEC-ResSim model. In so much as the HEC-ResSim model provides flow data to the HEC-5Q model as an input it is also unreasonable to expect perfect correlation between the water-quality simulated data and the observed data. In addition, since daily discharge data and non-point source loading data are not available, the HEC-5Q model includes assumptions regarding these parameters and these assumptions were coordinated with the appropriate water supply providers and resource agencies to ensure they are reasonable. The benefit of using these models for these impact analyses is that they can simulate flow and water quality data with shared assumptions so that the only modeled difference between the alternatives can be accurately interpreted as impacts associated with a change in operations (i.e., implementation of the proposed action). Given that this is what our respective agencies are trying to evaluate, the Corps believes the models are uniquely qualified and appropriate.

Dissolved Oxygen

Pgs 14/15 and Pg 30 – The Corps acknowledges the stated DO impacts. However, it should be emphasized, as noted by FWS, simulated DO results between the PAA and NAA were similar with small differences between the alternatives being realized at low occurrence levels. For reasons discussed previously, modelled results should be broadly compared between alternatives and were not intended to provide absolute results for specific locations and conditions such as those noted downstream of Buford Dam. We note that the PAA and NAA results were generally similar, albeit where low DO currently exists that condition would likely continue in the PAA. While dissolved oxygen levels downstream of Buford Dam and West Point Dam are depressed at times as a result of hydroelectric power generation when the lakes are stratified, there have been no recurring instances of fish distress or mortality in the dam tailrace areas as a result of low dissolved oxygen conditions. In the past, the Corps has made efforts to improve DO levels below the Federal projects with varying degrees of success. For example, during a major rehabilitation of all three hydropower generation units at Buford Dam during 2003 and 2004, self-aspirating turbines were installed to improve dissolved oxygen levels immediately downstream. The Walter F. George Lock and Dam project has experienced recurring instances of stress in the tailrace fishery and occasional fish kills due to low dissolved oxygen. Accordingly, USACE has implemented a SOP, established in 1988 and updated in 1993, to address conditions at the Walter F. George project when low dissolved oxygen values are observed in the tailrace. The SOP calls for spillway gates to be opened in accordance with a specific protocol until dissolved oxygen readings return to an acceptable level. Spillage siphons have also been constructed on the dam that can be used in lieu of spillway gate discharges.

As previously discussed with the FWS, studies to consider structural modifications to the Federal projects in order to improve DO and/or operational changes that result in serious impacts to one or more of the other authorized project purposes (such as significantly reducing or eliminating hydropower operations) are outside the scope of the WCM update. Furthermore these actions would require additional study authority and appropriation.

Water Temperature

Pg 15 and Pgs 30/31- The Corps agrees with the statements regarding the importance of water temperatures and with the conclusion that slight differences exist between the NAA and PAA. However, the Corps questions whether a 0.25-0.5^{o}C increase in water temperature between Buford Dam and Norcross is biologically significant to the coldwater fishery in this reach. It is not clear from the GDNR or FWS comments whether or not the NAA or PAA result in water temperature conditions in the river segment between Buford Dam and West Point Lake incapable of supporting the trout and striped bass, and shoal bass fisheries. Both agencies appear to favor a coldwater fishery to support non-native trout in the reach between Buford Dam and Morgan Falls, which currently exists and note the importance of cool water refugia to the survivability of adult striped bass. Both agencies also appear to support warmer water temperatures downstream of Morgan Falls for the native shoal bass. The impact analysis conducted by the Corps, acknowledges that minor temperature deviations may occur, but suggests that the proposed action will at worst maintain the current water temperature regime at critical transition zone locations below Morgan Falls Dam and may result in slightly warmer water temperature in this reach. The FWS notes that cold water conditions during the spring have been identified as a limiting factor to striped bass spawning and egg/larvae survival near Morgan Falls Dam. Based on the current analysis, it would appear that the Corps' NAA and PAA do support both a coldwater fishery above Morgan Falls Dam and a warmwater fishery below it despite the many variables impacting water quality in this reach that the Corps has no control over, such as, nonpoint stormwater runoff from impervious surfaces in tributary watersheds. From the DFWCAR comments, it is not clear what the recommendation is for the Corps to better manage water temperature in the reach.

Wastewater

Pg 15 and 32 – The Corps believes, that the HEC-5Q water quality model is a quantitative model that describes water quality changes in response to flow management alternatives and has provided the water quality analyses prescribed in the FWS's PAL accordingly. The Corps agrees that evaluating percent wastewater can provide additional insight for interpreting the water quality data and has provided it in accordance with the FWS's PAL guidance. The higher percent wastewater observed between Atlanta and West Point Dam under the PAA simulation is not surprising since more water is being utilized for water supply and more is being returned as wastewater. Improved treatment and conservation measures in the future could alleviate some of the negative impacts to the aquatic environment associated with the percent wastewater evaluation. This is supported by statements from GDNR in the Chlorophyll- α section where they note that "nutrient levels at West Point Reservoir have drastically decreased following upstream wastewater infrastructure improvements over the past two decades".

Chlorophyll-α

Pg 15 and 32– As described in the wastewater section above, increased water withdrawals from the Chattahoochee River to meet the needs of metropolitan Atlanta communities would result in a corresponding increase in treated wastewater returns to the river between Atlanta and West Point Lake. The impact analysis showed that the PAA would result in increased loadings of total phosphorus that would have a substantially adverse effect on water quality. The substantially adverse effects would also be expected downstream of West Point Lake to the headwaters of Walter F. George Lake. The adverse water quality effects in these portions of the Chattahoochee River would principally be associated with increased treated wastewater discharges to the river rather than USACE project operations. The Georgia Environmental Protection Division (GEPD) may require changes to discharge permits for some facilities. The Corps acknowledges and agrees that the PAA will result in relatively small increases in Chlorophyll-α throughout the river system in response to increased wastewater returns and associated nutrient loads. However, the Corps questions the biological significance of a 1-5 µg/L increase in Chlorophyll-α. The Corps also notes that GDNR has suggested that minor increases in Chlorophyll-α may be beneficial to the reservoir fishery.

Reservoir Retention Time

Pg 16 and 32 - The Corps believes it provided the requested information to the FWS in the response to PAL. The April 2, 2010 PAL requested that for each alternative the "average summer retention time (days)" should be evaluated. The PAL defines summer values as May through October. The Corps provided the monthly retention times for the water quality model period (2001 through 2011) at each of the Federal reservoir projects in tabular format. At the end of the table, an overall median retention time for each reservoir is provided as well as median and average retention times for the months of April – October (note April-October corresponds with the GEPD definition of growing season and includes the May-October growing season defined by the FWS). This data demonstrates that the average summer retention time at Lake Lanier under the PAA increased by 6 days; at West Point Lake it increased by 3 days; at Walter F. George Lake it decreased by 1 day; and that there was no difference in the average summer retention time at George W. Andrews and Lake Seminole.

Phosphorus

Pg 16 and 32 – The Corps acknowledges and agrees that the PAA will result in increased phosphorus throughout the river system. The higher phosphorus observed between Atlanta and West Point Dam under the PAA simulation is not surprising since more water is being utilized for water supply and more is being returned as wastewater. This increased loading is passed through the system. Improved treatment and conservation measures in the future could alleviate some of the negative impacts to the aquatic environment associated with elevated phosphorus loads. This is supported by statements from GDNR in the Chlorophyll- α section where they note that "nutrient levels at West Point Reservoir have drastically decreased following upstream wastewater infrastructure improvements over the past two decades". The Corps also notes that GDNR has suggested that increases in phosphorus may be beneficial to the reservoir fishery. Notwithstanding this, the Corps generally agrees that increased phosphorus loads would be considered a negative impact.

Floodplain Connectivity- Chattahoochee and Apalachicola Rivers

Pg 17 and Pgs 32/33 – FWS notes that the annual maximum 30-day growing season floodplain connectivity is essentially the same for the PAA and the NAA. However, they state that it is unknown whether the calculation is for consecutive days and point out that the Corps used the period from April through Sept, not October as specified in the Floodplain Spawning Habitat Performance Measure (FSHPM). The Corps inadvertently labeled the seasonal period as April – September rather than October. The Corps utilized the FSHPM Excel workbook developed by the FWS to analyze this performance metric. Therefore, the analysis should be consistent with what the FWS was seeking. The various workbooks used to create the charts provided in the response to PAL were provided to the FWS in March 2015. The Corps agrees with the statement that there would be little difference in floodplain connectivity in the Chattahoochee River.

Reservoir Fisheries

Pg 17-19 and 33 – The Corps utilized the Reservoir Fisheries Performance Measure (RFPM) Excel workbook developed by the FWS to analyze this performance metric. In response to GDNR comments, FWS stated they continue to recommend use of the RFPM. Therefore, the RFPM analysis provided in the Corps' response to PAL is sufficient. The Corps agrees with the statement that there would be low potential for realized fisheries differences between the two alternatives.

Riverine Fisheries

Pg 19 and 33 – The FWS's PAL addendum provided revised low and high flow guidelines based on the pre-dam gage data or simulated pre-dam conditions where gage data were not available. In developing the revised low flow guidelines the FWS used the 10th, 25th, 50th, 75th, and 90th percentiles for each month to define the lower limit, dry year, average year, wet year, and upper limit, respectively. The Corps agrees with this approach and notes that the 2015 response to PAL provides a monthly flow statistics analysis of the simulated NAA and PAA depicting this information at numerous locations throughout the basin. The Corps response to PAL did not include a comparison of these simulations to the FWS's revised low flow guidelines. To the extent this analysis is still desired the Corps will provide it during the DEIS public review period.

Chattahoochee River Shoal Bass Recruitment: FWS notes that the Corps utilized water temperature data simulated by HEC-5Q for the various alternatives rather than the relationship of observed flows and water temperature utilized in the FWS's Chattahoochee River Shoal Bass Recruitment Performance Measure (CRSBPM). The Corps previously discussed this change with FWS due to the relatively small data set (during drought conditions) used to develop the relationship in the FWS's CRSBPM. The Corps believes the use of the simulated water quality data that considers multiple influences on water temperature rather than just observed flow-temperature relationships provides a more robust analysis. The FWS notes that although HEC-5Q produces lower temperatures than the FWS methodology as a function of discharge the Shoal Bass abundance trend should remain the same. The FWS determined that the PAA results in a higher abundance of shoal bass than the NAA. The Corps agrees with this assessment.

Federally Protected Species

Pg 20 and 33 - Gulf Sturgeon

Frequency (% of days) of Gulf Sturgeon spawning habitat availability (acres of potentially suitable spawning substrate inundated to depths of 8.5 to 17.8 feet) on each day March 1st through May 31st, at the two sites that support spawning. – The Corps utilized the SSHPM Excel workbook developed by the FWS for this analysis. The Corps' response to PAL noted that there were no differences between the NAA and PAA. The Corps provided the workbook supporting this determination in March 2015.

Frequency (% of years) of Gulf Sturgeon spawning habitat availability (maximum acres of potentially suitable spawning substrate inundated to depths of 8.5 to 17.8 feet for at least 30 consecutive days each year,) March 1st through May 31st, at the two sites that support spawning. – The Corps utilized the SSHPM Excel workbook developed by the FWS for this analysis. The Corps provided the workbook supporting this determination in March 2015.

Daily fall rates with respect to exposure of Gulf Sturgeon eggs and larvae. – The Corps agrees that daily fall rate results provided for the listed mussel species are specific to flows less than 10,000 cfs. The Corps notes that under the RIOP, fall rates are not limited for flows over 30,000 cfs consistent with safety requirements, flood control purposes, and equipment capabilities. The Corps also notes that the NAA and PAA include operational provisions that ensure river stage declines of 8 feet or more will not occur in less than 14 days when river flows are less than 40,000 cfs (March-May). This provision was developed by the FWS and the Corps to avoid any adverse effects to Gulf sturgeon during the spawning season. In the past this provision has satisfied the FWS's concerns regarding daily fall rates during the Gulf sturgeon spawning season. To the extent additional analysis is needed to evaluate daily fall rates and potential exposure of Gulf sturgeon eggs and larvae the Corps will work with FWS during the Section 7 consultation for the PAA.

Maximum number of consecutive days per year less than 16,000 cfs. – The Corps will provide the requested analysis during the Section 7 consultation for the PAA.

Departures from average water temperatures between March 1st to May 31st. – The Corps agrees with the FWS assessment.

While the Corps continues to believe that the information provided generally indicates that there will not be adverse impacts to the Gulf sturgeon, we acknowledge that additional information will be provided during the Section 7 consultation for the PAA.

Pg 21and Pgs 33/34 - Freshwater mussels

The FWS identified several flow parameters that could result in adverse impacts to mussels. Comparing these parameters individually and collectively, FWS stated that the PAA would result in flows that could have adverse impacts including increased mortality to mussels. The Corps agrees with this assessment and will continue to work with the FWS to evaluate impacts to listed mussel species during the Section 7 consultation for the PAA.

Analyses of Apalachicola Bay

Pgs 23-28 and 34 – The FWS states they used a combination of sources to evaluate effects to Apalachicola Bay. Taken together, the sources cited are inconclusive and the Corps disagrees that they suggest differences between the NAA and the PAA with regards to salinity levels in the bay and associated impacts.

FWS noted the HydroLogics Apalachicola Bay salinity model results (2012) indicate very limited differences between the RIOP and the then-proposed modifications to the RIOP. However, FWS did not relate that finding to the current proposed action. The Corps notes that the PAA and NAA simulated releases at Jim Woodruff Dam are similar and would likely yield the same conclusion if input to the HydroLogics Apalachicola Bay salinity model.

FWS stated that they relied on three lines of evidence for the suggested differences:

1. *The Apalachicola Bay Salinity Performance Measure (ABSPM)*. The FWS states that the ABSPM indicates a 1 part per thousand (ppt) increase in median salinity at East Bay (no difference at Cat Point and Dry Bar). The FWS acknowledges that differences among alternatives analyzed to date are relatively minor and states it may be due to the coarse temporal scale of the metric or the possibly that substantial changes in the bay salinity metric require large amounts of water. Given the small magnitude of the difference (1 ppt) and coarseness of the metric, the Corps questions the validity of the conclusion that the PAA negatively impacts salinities in the bay and juvenile Gulf sturgeon. The FWS also notes that fine resolution models of bay salinities also show little salinity differences between alternatives. Based on the FWS's assessment of the fine resolution models the Corps again questions the validity of the conclusion that the PAA negatively impacts salinities in the bay and juvenile Gulf sturgeon.

2. *Estuary Inflow Analysis*. In this analysis the FWS evaluated changes in estuary inflows using results from the Apalachicola River Mussel Performance Measure (ARMPM) and the salinity-discharge relationships in the ABSPM. The analysis did not compare bay salinities resulting from the NAA and PAA but rather assessed the change in salinity at incremental low flow discharges realized under the PAA. The Corps previously expressed concern over the use of the ABSPM due to the relatively weak correlation of the regression relationships the ABSPM uses to compute bay salinities. This analysis utilizes those same relationships. Therefore, the Corps does not agree that this line of evidence supports the suggested differences between the NAA and the PAA with regards to salinity levels in the bay.

3. The third line of evidence once again uses the ABSPM to compare the PAA bay salinities to one of the Corps' alternatives developed in 2011 (Alt2). The FWS noted that the 2011 flows were similar to the PAA flows and based on the results of the ABSPM determined that the PAA produced similar salinities to those generated from the 2011 alternative. The FWS therefore expects that the 3D salinity model for the PAA may produce similar salinity and oyster growth rate results as the 2011 (Alt2) 3D salinity model. If this assumption is true, then it stands to reason that the FWS' ongoing 3D salinity modeling will demonstrate that there is little difference in salinity or oyster growth rates between the NAA and PAA as this was the conclusion of the FWS in 2011 for the various alternatives considered (which included the same NAA and Alt2). The Corps does not see how this line of evidence supports the suggested differences between the NAA and the PAA with regards to salinity levels in the bay since the 2011 salinity modeling did not demonstrate a difference between alternatives.

   The FWS included information from their 2011 DFWCAR that they determined was relevant to the interpretation of the Apalachicola Bay salinity modeling and oyster and sturgeon responses. On pg 26 this information includes a discussion of the effects of the bay relative to historic operations. The Corps notes that the FWS omitted the actual discussion of the effects relative to historic operations. It is provided below in order to set the context for the Corps' response to the FWS's assessment of why those effects occurred.

> "There is little difference in salinity or oyster growth rates in any of the various analyses; however, simulated salinities and oyster growth rates between the no action and the proposed action alternatives differed from the observed Sumatra discharge data. However, in general, the Corps' simulated flow scenarios resulted in salinities that had slightly higher highs and lower lows than salinities estimated using Sumatra discharge data. Oyster growth rates were also slightly lower in the Corps' modeled scenarios compared to the observed Sumatra discharge data, especially in August, which is considered the peak growth period for oysters in Apalachicola Bay (Huang 2010). Similarly, the amount of habitat available for Gulf sturgeon was slightly lower in the no action and proposed action alternatives than the observed discharge data at Sumatra."

In the 2011 DFWCAR the FWS correctly states that "There is little difference in salinity or oyster growth rates in any of the various analyses; however, simulated salinities and oyster growth rates between the no action and the proposed action alternatives differed from the observed Sumatra discharge data". However, they incorrectly assume that these differences are entirely a result of changes in the volume and timing of freshwater inflow due to the reservoir operations of the RIOP and the proposed WCM alternatives. Some or all of these differences are attributable to the comparison of modeled salinities based on observed river flows to those produced by the HEC-ResSim model. The 2011 (and 2015) HEC-ResSim model includes standardized assumptions regarding consumptive demands that include the highest demand year (2007). These levels of consumptive demand did not actually occur during the period used for the simulated salinities, but were selected by the Corps for the HEC-ResSim model because they represented the most severe consumptive demands experienced to date. The Corps has no authority to limit water use in the basin, a responsibility of the States, and thus applied the highest level of demands to each year of the simulation in order to evaluate the water management alternatives ability to perform with increased consumptive demands. It is inherent that these increased demands would result in lower simulated flows in the Apalachicola River than those observed, especially during the summer peak growth period for Oysters. For this reason, the appropriate analysis to focus on regarding impacts to Apalachicola Bay is the comparison of the simulated no action and proposed action alternatives which include the same assumptions regarding consumptive demands. When this is done, the negative impacts to oysters and Gulf sturgeon habitat are no longer realized.

The Corps is willing to consider additional impact assessments for juvenile Gulf sturgeon, eastern oysters, white shrimp, and other species should the Fish and Wildlife Resources Agencies identify the appropriate analyses to utilize.

In the cited 2011 DFWCAR, the FWS recommends that the Corps "capitalize on existing datasets to evaluate the effects of sea level rise on estuary-riverine salinities, and to quantitatively evaluate the discharges required to minimize saltwater incursion". The DEIS includes climate change and sea level rise analyses consistent with Corps' regulations. However, the Corps does not agree that it is responsible for minimizing or mitigating the impacts of salt water incursion resulting from these phenomena.

EVALUATION OF THE SELECTED PLAN

The Corps notes that the scoring of impacts (Table 2) technique utilized by the FWS to compare the PAA to the NAA is similar in design to the technique developed by the Corps to compare water management alternatives during phase I of the alternative formulation, which the FWS believes to have significant problems. In Table 2 the FWS determined that the Corps has not adequately evaluated the impacts to Reservoir Retention Time, Instream Flow Guidelines, and Gulf sturgeon. The Corps response to the EVALUATION OF THE SELECTED PLAN is provided in the relevant sections above.

SUMMARY AND FWS POSITION

Pg 50/51- The FWS provided six bulleted points summarizing its reasons for not fully supporting the PAA. Five of the bulleted points are reiterations of concerns raised earlier in the DFWCAR and were addressed in the discussion preceding this section. One concern that warrants further consideration is that of the Corps' alternative selection process which was described in a separate document (Appendix XV). The following summarizes the nature of that concern and provides the Corps' response. The document is unnumbered, so page 1 refers to title page of Appendix XV, *Problems regarding United States Army Corps of Engineers (Corps) alternatives selection process for the Apalachicola-Chattahoochee-Flint (ACF) Water Control Manual (WCM) update*.

Pg 2 – The FWS states three major concerns with the Corps water management ranking methodology.

1. *Small differences within project purposes are treated the same as large differences. FWS gives examples*. The Corps used a straightforward and transparent approach to ranking the alternatives. Since the Corps treats all authorized project purposes as equal, it would not be appropriate to weight some project purposes more than others. The Corps acknowledges that relatively small differences occurred between some of the alternatives. However, the Corps maintains that the HEC-ResSim model is capable of simulating these small differences and that these small differences may be significant to the relevant stakeholder for that resource. For example, small differences in hydropower production may translate to millions of dollars when comparing alternatives. Using a more robust statistical approach that scores and ranks alternatives with small differences the same fails to account for this.

2. *An incomplete set of fish and wildlife performance measures was used to score and then rank alternatives for the Fish and Wildlife project purpose.* Because the Corps used an equal ranking methodology, the number of performance measures for a particular project purpose becomes irrelevant. While the choice of the most appropriate performance measures is relevant, when averaged, a single number representing each project purpose is used in the final ranking. Because of the huge number of potential summary statistics that can be developed from a HEC-ResSim and HEC-5Q output dataset, along with other performance measures suggested by FWS, it becomes unfeasible to use more than a few

to represent the fish and wildlife project purpose. The Corps chose a number of performance measures that it believed represented the fish and wildlife project purpose.

3. *There is no consideration regarding the uncertainty or precision of model output in the Corps' ranking process.* This concern is essentially the same as number 1. Whether performance metrics are weighted according to magnitude of differences or analyzed statistically to compare those differences, both attempt to address the concern that small differences are treated the same as large differences. The Corps believes the ranking methodology has adequate precision to rank water management alternatives. It would go beyond the intent of the ranking of alternatives to attempt to use statistical comparisons in this case.

In summary, the Corps believes that the PAA balances all authorized project purposes including fish and wildlife conservation. We believe that the currently proposed alternative including the management of the water resources over which the Corps is responsible and for which the Corps has authority, would have little adverse impact to fish and wildlife resources compared to the existing condition. The Corps appreciates the FWS efforts in preparing the DFWCAR and looks forward to continuing cooperation.

In regards to the FWS statement that "the Service needs to be an integral member of the Corps' team when formulating and evaluating operational alternatives" the Corps acknowledges the benefits of collaborating with other agencies. However, due to the fact that a WCM update is inherently a Corps function, the nature of this being an operational change, and in view of ongoing litigation at the beginning of the process, it was decided not to involve other entities as Cooperating Agencies. The Corps will continue to include participation with FWS as much as possible under current authorities.

Appendix K

HEC-5Q Water Quality Modeling Report

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FINAL REPORT

HEC-RESSIM AND HEC-5Q SIMULATION OF WATER QUALITY IN THE APALACHICOLA-CHATTAHOOCHEE-FLINT WATERSHED

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1 INTRODUCTION

An HEC-5Q model was developed for the Apalachicola-Chattahoochee-Flint (ACF) Basin in support of the Environmental Impact Statement (EIS) for the Water Control Manual Update Study (HEC, 1998). It was developed to evaluate the impacts of proposed alternative water management plans on the long-term, system-wide, stream and reservoir water quality of the ACF watershed.

The water quality model was created to serve as a defensible screening tool to make relative comparisons of the impacts among various water management alternatives. The central focus of this effort was to enable the EIS team to evaluate the differences in water quality between alternatives over the algal growing season (spring, summer, and fall). The model was evaluated to ensure that it exhibited the tendencies seen in the observed data and that it was sufficient to provide reasonable long-term estimates of water quality through the ACF system.

The principal water quality constituents simulated were temperature, ammonia, nitrate, phosphate, phytoplankton (reported as chlorophyll *a*), dissolved oxygen, and 5-day Uninhibited Biochemical Oxygen Demand (BOD5U). These constituents are consistent with impact assessment guidance from the USFWS in their April 2010 Planning Aid Letter (PAL). In addition, the percentage of flow consisting of municipal or industrial wastewater (point source loads) was modeled.

The decision to model 70 years of record allows insight regarding the frequency and duration of water quality situations resulting from water management operations. In 2011, the model was evaluated for the 2001–2008 period to best capture the effects of recent population, water usage, and land use on pollution levels. The evaluation also ensured that the model exhibited the tendencies seen in the observed data and that it was sufficient to provide reasonable long-term estimates of water quality through the ACF system. In 2014, *the model was extended through 2011*. The 2001–2011 modeling period encompassed years where hydrologic conditions were representative of "normal" in-stream flows, as well as years with high flow ("wet") or drought ("dry") conditions. Point source (wastewater) and non-point source (tributary streams) inflow water quality loadings were developed from database information compiled during this analysis.

Time and budget constraints, the physical and temporal scale of this analysis, and limitations of observed data required simplifying assumptions and methodologies to be adopted, as outlined in the Chapter 2 of this report. HEC-5Q was selected as a logical choice for the water quality model because it is compatible with HEC-ResSim (ResSim) and has been used for previous analyses of the ACF. HEC-5Q was aligned to work seamlessly with the HEC-ResSim model that was used to evaluate the water management alternatives.

HEC-5Q follows well-known solutions for key water quality values and does not attempt to simulate the concentration changes or transport of every type of constituent. Its one-dimensional nature limits the amount of input data and detail of results at sites.

Although these limitations restrict the depth of analysis possible from its results, they also relieve heavy burdens regarding prohibitively long computation time and large input data requirements. The simplified inputs and calculation, and connection to ResSim, make possible relative comparisons of the water quality impacts of water management alternatives broadly across the basin.

The 1999 Comprehensive Study used HEC-5 to perform the reservoir operations modeling in the ACF basin. The flows that were computed by HEC-5 were then input into HEC-5Q (HEC, 1999). These were used to model water quality of the streams in the ACF basin, using a daily time step. The current analysis uses ResSim to generate all flows. A plug-in for ResSim was developed by HEC and RMA to allow HEC-5Q to be operated from ResSim and facilitate input of ResSim-generated flows into the HEC-5Q model.

The HEC-5Q ACF model used for the 1999 EIS was updated to implement a 6-hour time step to capture diurnal variations, which are often important. Then the HEC-5Q ACF model was extended to include modeling of the reservoirs themselves, was adjusted to approximate the 2001–2011 observed data, and was verified with additional observations in key locations.

The revised HEC-5Q model was used to make preliminary observations using present-day water quality loading parameters applied to water levels and flows for the No Action plan and eight proposed water management alternatives. This work was performed in close coordination with water quality and water management technical staff members from Mobile District, Tetra Tech, the Hydrologic Engineering Center (HEC), and Resource Management Associates (RMA). Below is a summary of the various model specifics for the current (2001–2011) study.

1.1 HEC-5Q MODEL ASSUMPTIONS AND LIMITATIONS

The HEC-5Q water quality models previously developed have been extended and updated. When the original model was developed there were limited data for the reservoirs. For the current assessment of the water quality of the ACF, performed for the 2001–2011 period, data are available for all reservoirs. Thus the assessment has been extended to the reservoirs. Model coefficients were adjusted so that the temporal and spatial variations of the water quality parameters are reasonably represented.

To ensure a consistent approach across the full time period of the analysis, using a consistent set of model parameters, the HEC-5Q model was adjusted to produce reasonable results under a range of conditions experienced over the period of record. Therefore, it is not expected or required that the model will reproduce particular historical observations.

The modeled flows computed by ResSim reasonably approximated the observed flows over the analysis period. However, there were periods where modeled flows did not match observed flows. This is due to required exceptions to normal operations in the field, such as temporary maintenance operations. This analysis did not require that these special operations or conditions be approximated by the ResSim or HEC-5Q models.

Water quality, both modeled and observed, is sensitive to the amount of flow. The hydrology of the ResSim model for No Action (baseline) conditions was used in the model performance demonstration. The No Action flows are not historical discharges, and in situations where they differ substantially, it becomes very difficult to make calibration assessments. Furthermore, since the flows associated with observed concentrations do not always closely match the No Action flows, careful apportioning of the modeled flows is required to avoid unreasonable mass loadings. Because historical data were not used, this effort does not represent a true calibration. Rather, it is an attempt to represent the current operations strategies and reproduce the global response.

Since meteorological data were not available for all locations for the period of record, and data gaps occurred in existing records, extrapolated meteorology was used to drive the water quality model. Only maximum and minimum air temperatures were available for the full period of record at all locations. The extrapolation process used maximum and minimum air temperatures to select meteorological data from the historical record to derive meteorological forcing for each location for the analysis period. In other words, the air temperatures were used to associate all other meteorological parameters (e.g., dew point temperature) during the same time period as boundary conditions. While the imposition of a generalized daily meteorological pattern can sometimes interfere with exactly reproducing historical observations, it allows a consistent approach and enables the model to reproduce general trends of the observed data. This process is described in greater detail in section 2.3.3. With this method, model results were intended to reproduce the general trends in observed data and focus on water quality responses from changes in water management operations rather than changes in the weather.

The daily timestep of the ResSim model is too coarse for water quality modeling and must be adapted to a shorter interval. The water quality modeling team chose a six hour timestep for the HEC-5Q water quality model to better capture the diurnal temperature changes, while maintaining short enough computation times to be manageable for computing the period of record (currently 72 years). Shorter computation times facilitated making incremental improvements to the model and recomputing as plan formulations changed, which required the water quality to be recomputed with new sets of flows. Each daily flow value computed by the ResSim model was held constant throughout the day in the HEC-5Q model. The 6-hour computed water quality time series were averaged to daily values during post-processing.

The observed data represent the average over the euphotic zone, while the modeled data represent the surface layer. Rather than focus on replicating super-saturated values, the adjustment of the model was conservative, focusing on minimum dissolved oxygen values. Differences may also be due to differences in vertical location of the computed and observed values or the time of day measurements are taken (during peak algal production). The HEC-5Q model coefficients and parameters are within acceptable ranges, as reported in the literature. None of the model coefficients were skewed only to fit the data. Comparison with the observed data indicates that the model does a good job of predicting pollutant, DO, and chlorophyll *a* trends, as indicated by the data, which is important as the EIS evaluates how these trends will change with various flow release options.

No special adjustments were made to the HEC-5Q model for low flow conditions. However, non-point loadings were computed for all flows using the U.S. EPA's BASINS model, and measured point-source loadings were used, where available. One of the three hydrologic periods modeled in this analysis was a low flow period. The BASINS model provided 102 non-point source inflows and loadings for BOD, total nitrogen, and total phosphorous. The BASINS model computes tributary inflows and loadings for a wide range of flows, including low flows. Point source inflows include municipal and industrial discharges and cooling water returns. Agricultural returns and groundwater inflows were not considered as point-sources. Monthly average flow and quality characteristics were defined as the average of all the available measurements without regard to the time of month. If insufficient data were available, default values or relationships between parameters were used.

The initial conditions of each reservoir were defined using the available data and the tendencies seen in the data. An initial stream quality was not defined, but was instead computed from the reservoir releases after the first time step. Each HEC-5Q model run was started in the winter, when growth rates were slow, which leads to improved accuracy of the model results.

1.2 MODEL LOADINGS

The non-point source water quality inputs to the HEC-5Q model were developed from observed data in conjunction with BASINS model loadings that were developed during previous ACF modeling efforts (Tetra Tech, August 1998). The BASINS model computes flow and water quality (BOD, total nitrogen, and total phosphorus) as a function of precipitation, land use, antecedent conditions, and other factors. BASINS model outputs were produced for three conditions: 1995 land use conditions, anticipated 2020 conditions, and anticipated 2050 conditions. Each of these was calculated using the 1984-1989 precipitation record. The 2020 BASINS model output was used to develop extrapolation functions that relate hydrograph dynamics and ResSim incremental local flows to concentrations. This model was selected since its time period is currently the closest of the three periods to present day conditions. The extrapolation functions were then applied to the 2001–2011 ResSim flows to generate the non-point source loadings for input to HEC-5Q.

Default loading values were assumed, as outlined below, where these were not available from municipal or industrial dischargers. When point source data were available, these consisted of one value per month. These monthly data provided a seasonal pattern to the inflow quality but day-to-day variations are not captured. Since constant loading values were used instead of time series of the actual values, and modeled instead of observed flows were used as inputs, the HEC-5Q model was not expected or required to replicate individual observed concentration values. Events are captured based on setting appropriate boundary conditions and model coefficients to be able to predict all events during a simulation period. Therefore, the focus of this analysis was to achieve reasonable responses over the system for the entire analysis period, using a consistent set of model coefficients.

1.3 HEC-RESSIM ACF MODEL

This section describes the basic attributes of the ACF System model used to simulate the No Action Plan, Proposed Action Alternative, and several intermediate alternatives that resulted in the recommended plan. Figure 1.1 shows the complete ACF watershed model, which extends from the headwaters of the Chattahoochee River above Lake Lanier and the headwaters of the Flint River above Griffin through the confluence of the two rivers at Lake Seminole and down the Apalachicola River to Sumatra. Operations in the model extend from the proposed Glades reservoir above Lake Lanier through Buford dam to the tailwater of the Jim Woodruff Lock and Dam Project (represented by the USGS Chattahoochee gage 02358000). The watershed schematic shown in Figure 1.1 includes the location of the reservoirs, junctions, and diversions represented in the ACF system model by the “2014” network (used for modeling the intermediate and recommended plan alternatives). Further details can be found in HEC (2014).

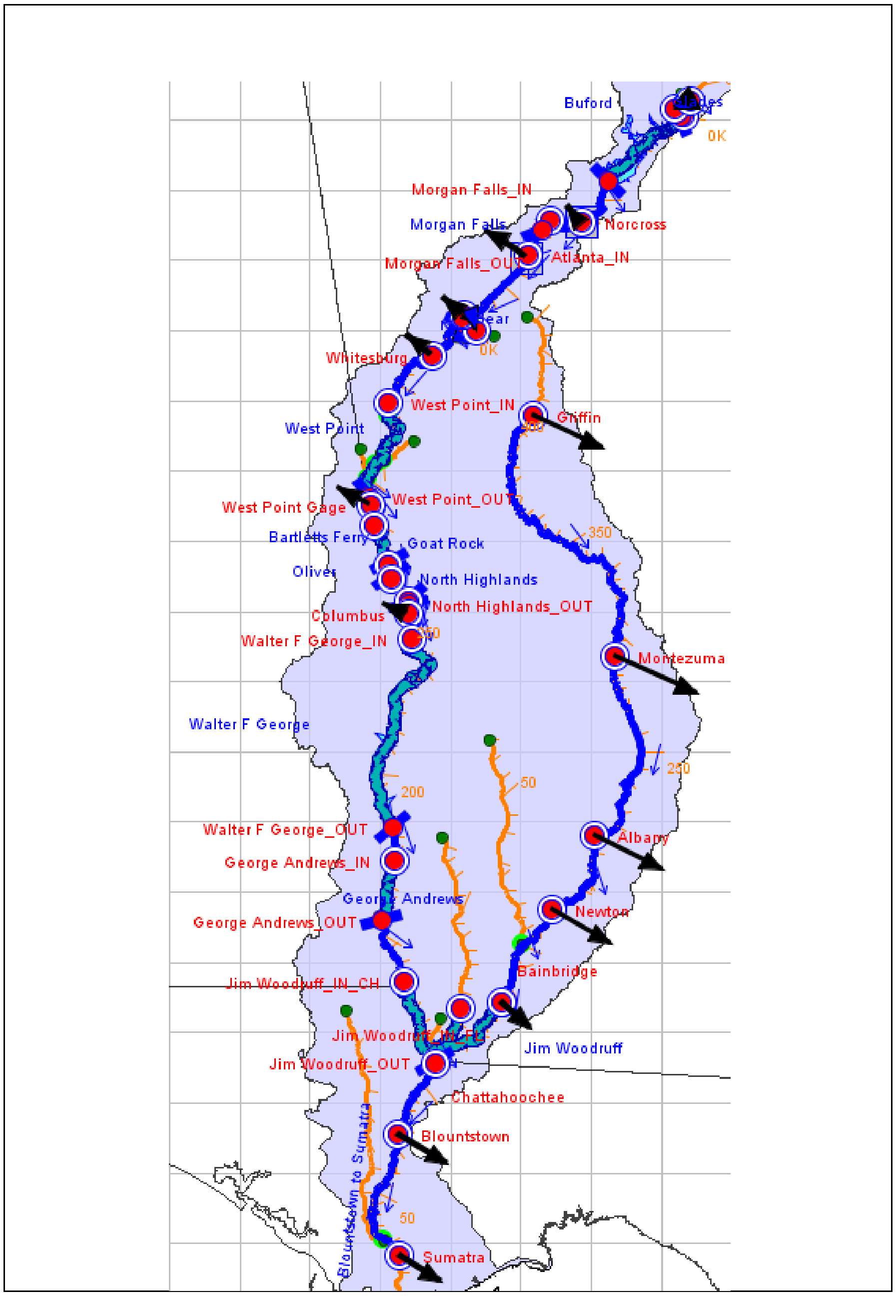

Figure 1.1. HEC-ResSim Network Schematic – "2014" Network. The small blue arrows represent the direction of flow. The large black arrows represent withdrawals.

1.4 ACF STUDY ALTERNATIVES[1]

To analyze the range of potential impacts of water allocation, a matrix of alternative flow options, representing a range of high ("wet"), moderate ("normal"), and low ("dry") in-stream flows were examined together under the No Action plan and each of several study alternatives. Each study alternative consisted of a water management alternative paired with a water supply option. Seven water management alternatives and eight water supply options were evaluated by the PDT. These are described in Table 1.1 and Table 1.2, respectively. The No Action Alternative, Alternative 1, and Alternative 7 were the three water management alternatives selected by the PDT for final analysis by ResSim and HEC-5Q.

1.4.1 NO ACTION ALTERNATIVE

The No Action Alternative includes current operations and incorporates support for water supply as mandated by a 2012 Federal Court ruling. This alternative includes an 800 cfs minimum flow target at Peach Tree Creek (Atlanta) to support the water quality objective there and account for the water supply withdrawals taken from the river. The lake withdrawals are represented at the inflow to Buford and reflect the 2007 withdrawal levels. This alternative uses the action zones defined in the draft 1989 ACF WCM, current hydroelectric power generation schedules, and current fish and wildlife conservation practices such as spawning standard operating plan (SOP), and the Revised Interim Operating Plan (RIOP) for releases from Jim Woodruff Lock and Dam.

1.4.2 ALTERNATIVE 1

ResSim Alternative 1 modifies the conditions of the No Action alternative by adding the two proposed reservoirs, Glades and Bear Creek, to the network.

1.4.3 ALTERNATIVE 7

Alternative 7 modifies Alternative 1 by adding the management measures of revised action zones, modified hydroelectric power generation schedules, 4/5 month navigation, and seasonal minimum flow at Peach Tree Creek (summarized in Alternative 2), and then changing the drought operation trigger zone from zone 4 to zone 3.

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[1] The HEC-ResSim model was revised in 2014, which included creating a new reservoir network that included Bear Creek and Glades Reservoirs. That network was used for all of the alternatives except the No Action Alternative. The operating plans and flows were altered for all alternatives. The HEC-5Q model was updated to incorporate these changes. The results presented in Chapter 4 were produced using the revised HEC-5Q model and revised ResSim flows. Comparison of the 2011 and 2014 model results for the No Action Alternative showed that the water quality differences between the two models were minor. Both models showed approximately equal agreement with the observed data. The flows used to adjust the 2011 HEC-5Q model better represent current and historical conditions under which the observed data were measured. These flows remain the logical choice for adjustment of the HEC-5Q model coefficients. Therefore, the plots in Chapter 3 have not been updated and reflect the 2011 HEC-5Q model comparisons.

1.4.4 PROPOSED ACTION ALTERNATIVE

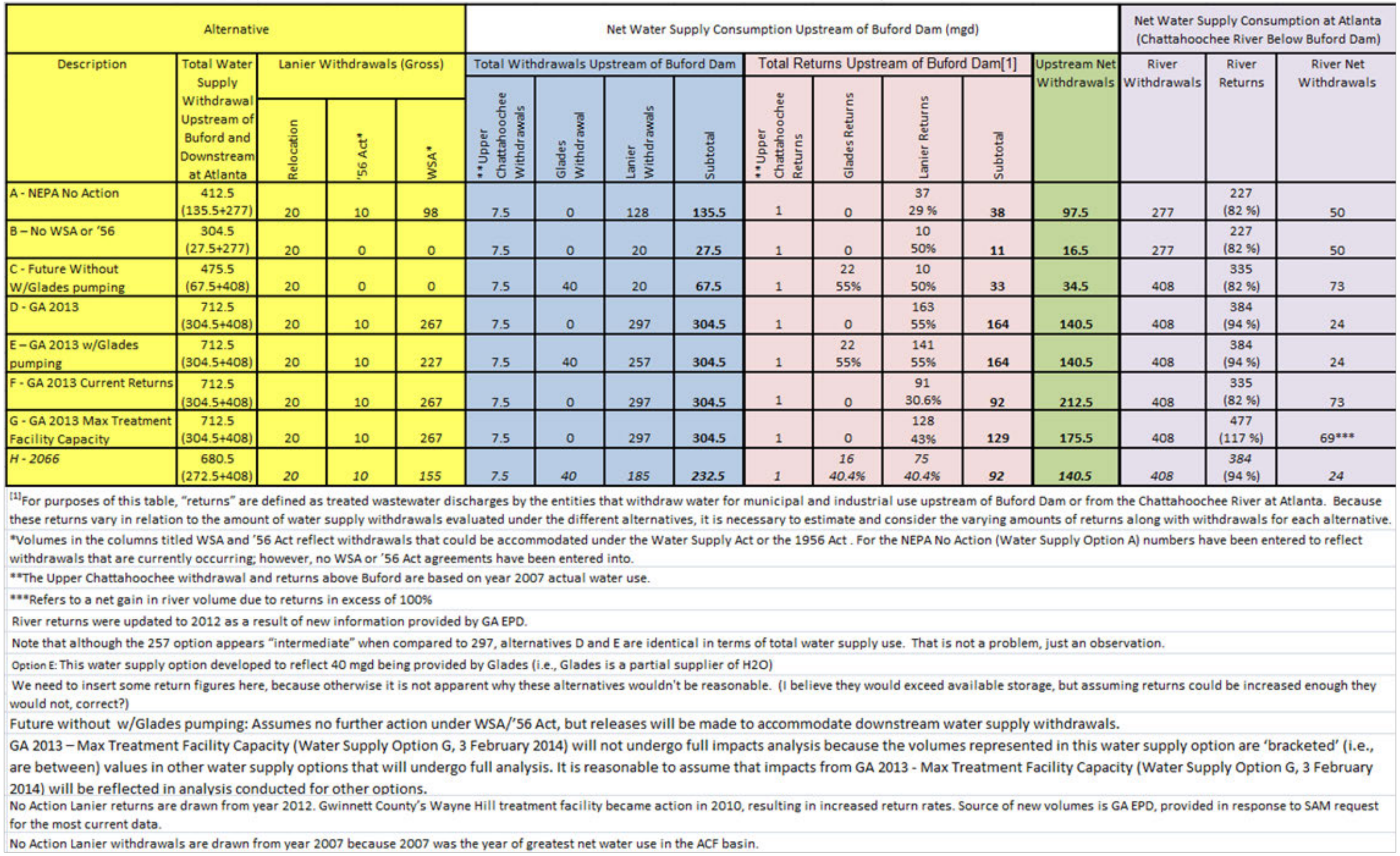
Under the Proposed Action Alternative, the Corps would continue to operate projects in the ACF Basin in a balanced manner to achieve all authorized project purposes and would support water supply withdrawals in the river by operating to meet the minimum water quality objective at Peach Tree Creek. The PDT selected Alternative 7 as the recommended alternative.

Table 1.1 Summary of Water Management Alternatives

		Alternatives							
Measures		**NOAction***	**Alt1**	**Alt2**	**Alt3**	**Alt4**	**Alt5**	**Alt6**	**Alt7**
Action Zones	Current	X	X						
	Revised			X	X	X	X	X	X
Hydropower Generation	Current	X	X					X	
	Revised			X	X	X	X		X
Navigation	4/5 Month			X		X	X	X	X
	Tri-Rivers				X				
Basin Inflow	Current	X	X	X	X			X	X
	Florida					X			
	Georgia						X		
Drought Operation Trigger	Composite Storage Zone	4	4	4	4		4	4	3
Drought Operation Suspension	Composite Storage Zone	1	1	1	1		1	3	1
Peach Tree Creek minimum flow	Current	X	X						
	Seasonal Flow			X	X	X	X		X
	Monthly Flow							X	
Flow Target at Chattahoochee	Current	X	X	X	X				X
	Florida					X			
	Georgia						X		
	FWS							X	
Ramping Rate Suspension	Drought	X	X	X	X		X	X	X
	Prolonged Low Flow			X	X			X	X
	Pulse						X		

*NOAction alternative doesn't include Glades and Bear Creek reservoirs. It is based on "2014_Base" network. These reservoirs are included in the "2014" network which is used for all other alternatives.

Table 1.2 Water Supply Withdrawal Options. All flows values are in units of mgd.



Alternative					Net Water Supply Consumption Upstream of Buford Dam (mgd)									Net Water Supply Consumption at Atlanta (Chattahoochee River Below Buford Dam)		
Description	Total Water Supply Withdrawal Upstream of Buford and Downstream at Atlanta	Lanier Withdrawals (Gross)			Total Withdrawals Upstream of Buford Dam				Total Returns Upstream of Buford Dam[1]				Upstream Net Withdrawals	River Withdrawals	River Returns	River Net Withdrawals
		Relocation	'56 Act*	WSA*	**Upper Chattahoochee Withdrawals	Glades Withdrawal	Lanier Withdrawals	Subtotal	**Upper Chattahoochee Returns	Glades Returns	Lanier Returns	Subtotal				
A - NEPA No Action	412.5 (135.5+277)	20	10	98	7.5	0	128	**135.5**	1	0	37 29 %	**38**	**97.5**	277	227 (82 %)	50
B – No WSA or '56	304.5 (27.5+277)	20	0	0	7.5	0	20	**27.5**	1	0	10 50%	**11**	**16.5**	277	227 (82 %)	50
C - Future Without W/Glades pumping	475.5 (67.5+408)	20	0	0	7.5	40	20	**67.5**	1	22 55%	10 50%	**33**	**34.5**	408	335 (82 %)	73
D - GA 2013	712.5 (304.5+408)	20	10	267	7.5	0	297	**304.5**	1	0	163 55%	**164**	**140.5**	408	384 (94 %)	24
E – GA 2013 w/Glades pumping	712.5 (304.5+408)	20	10	227	7.5	40	257	**304.5**	1	22 55%	141 55%	**164**	**140.5**	408	384 (94 %)	24
F - GA 2013 Current Returns	712.5 (304.5+408)	20	10	267	7.5	0	297	**304.5**	1	0	91 30.6%	**92**	**212.5**	408	335 (82 %)	73
G - GA 2013 Max Treatment Facility Capacity	712.5 (304.5+408)	20	10	267	7.5	0	297	**304.5**	1	0	128 43%	**129**	**175.5**	408	477 (117 %)	69***
H - 2066	680.5 (272.5+408)	*20*	*10*	*155*	*7.5*	*40*	*185*	***232.5***	*1*	*16* *40.4%*	*75* *40.4%*	***92***	***140.5***	*408*	*384* (94 %)	*24*

[1] For purposes of this table, "returns" are defined as treated wastewater discharges by the entities that withdraw water for municipal and industrial use upstream of Buford Dam or from the Chattahoochee River at Atlanta. Because these returns vary in relation to the amount of water supply withdrawals evaluated under the different alternatives, it is necessary to estimate and consider the varying amounts of returns along with withdrawals for each alternative.

*Volumes in the columns titled WSA and '56 Act reflect withdrawals that could be accommodated under the Water Supply Act or the 1956 Act . For the NEPA No Action (Water Supply Option A) numbers have been entered to reflect withdrawals that are currently occurring; however, no WSA or '56 Act agreements have been entered into.

**The Upper Chattahoochee withdrawal and returns above Buford are based on year 2007 actual water use.

***Refers to a net gain in river volume due to returns in excess of 100%

River returns were updated to 2012 as a result of new information provided by GA EPD.

Note that although the 257 option appears "intermediate" when compared to 297, alternatives D and E are identical in terms of total water supply use. That is not a problem, just an observation.

Option E: This water supply option developed to reflect 40 mgd being provided by Glades (i.e., Glades is a partial supplier of H2O)

We need to insert some return figures here, because otherwise it is not apparent why these alternatives wouldn't be reasonable. (I believe they would exceed available storage, but assuming returns could be increased enough they would not, correct?)

Future without w/Glades pumping: Assumes no further action under WSA/'56 Act, but releases will be made to accommodate downstream water supply withdrawals.

GA 2013 – Max Treatment Facility Capacity (Water Supply Option G, 3 February 2014) will not undergo full impacts analysis because the volumes represented in this water supply option are 'bracketed' (i.e., are between) values in other water supply options that will undergo full analysis. It is reasonable to assume that impacts from GA 2013 - Max Treatment Facility Capacity (Water Supply Option G, 3 February 2014) will be reflected in analysis conducted for other options.

No Action Lanier returns are drawn from year 2012. Gwinnett County's Wayne Hill treatment facility became action in 2010, resulting in increased return rates. Source of new volumes is GA EPD, provided in response to SAM request for the most current data.

No Action Lanier withdrawals are drawn from year 2007 because 2007 was the year of greatest net water use in the ACF basin.

1.4.5 SELECTED STUDY ALTERNATIVES

For final analysis with ResSim and HEC-5Q, water management Alternative 1 was paired with two water supply options, and water management Alternative 7 was paired with five water supply options. The study alternative naming convention combines the number designating the water management alternative with the letter designating the water supply option. For example, the proposed action alternative, Alternative 7H, combines water management alternative "7" with water supply option "H". This will also be referred to as "Alt 7H" in the water quality plots presented in Chapter 4. The No Action plan and eight study alternatives were simulated by ResSim, and the computed flows were input into HEC-5Q to simulate water quality for each alternative for the period 2001–2011. The study alternatives simulated by HEC-5Q are:

1. No Action Alternative (also known as "Baseline")
2. Alternative 1B
3. Alternative 1C
4. Alternative 7A
5. Alternative 7C
6. Alternative 7D
7. Alternative 7E
8. Alternative 7F
9. Proposed Action Alternative (also known as Alternative 7H)

1.5 HYDROLOGIC ANALYSIS PERIODS

To evaluate the effects of the nine operating plans on the water quality of the ACF watershed, three types of hydrologic conditions were selected for analysis. The years 2004, 2005, and 2007 were selected to represent normal, wet, and dry hydrologic conditions. These selections were based on an analysis of observed flow data recorded during the 2001–2011 modeling period. The precipitation in 2004 was the closest to the period-of-record average. The year 2004 corresponded to the median flow levels, while 2005 and 2007 corresponded to the highest and lowest flow levels, respectively, during the 2001–2011 model period. In addition, the 2001–2011 model period was summarized by plotting composite longitudinal river profiles of the percent occurrence of each water quality parameter. These analysis periods are shown in Table 1.3.

Table 1.3 Annual hydrologic conditions evaluated in this analysis, and the year(s) selected from the model results to represent these conditions.

Hydrologic Conditions	Representative Year
Normal	2004
Flood ("Wet")	2005
Drought ("Dry")	2007
Composite	2001–2011

1.6 REPORT ORGANIZATION

Modifications made to the 1998 version of HEC-5Q, updated from the version described in HEC (1986a), are described in this report. A description of the model is presented in Chapter 2, including a discussion of representation of the physical system with the model, input provided to the model, and water quality constituents simulated. A demonstration of model performance results is presented in Chapter 3. Results of the water quality model runs are presented in Chapter 4. References are provided in Chapter 5.

2 MODEL DESCRIPTION

HEC-5Q was developed so that temperature and selected conservative and non-conservative constituents could be readily included as a consideration in system planning and management. Using computed reservoir operations and system flows generated by ResSim, the water quality simulation model computes the distribution of temperature and other constituents in the reservoirs and in the associated downstream reaches. For those constituents modeled, the water quality model can be used in conjunction with ResSim to determine concentrations resulting from operation of the reservoir system for flow and storage considerations, or alternately, flow rates necessary to meet water quality objectives.

HEC-5Q can be used to evaluate options for coordinating reservoir releases among projects to examine the effects on flow and water quality at specified locations in the system. Examples of applications of the flow simulation model include examination of reservoir capacities for flood control, hydropower, and reservoir release requirements to meet water supply and irrigation diversions. The model may be used in applications including evaluation of in-stream temperatures and constituent concentrations at critical locations in the system or examination of the potential effects of changing reservoir operations or water use patterns on temperature or water quality constituent concentrations. Reservoirs equipped with selective withdrawal structures may be simulated using HEC-5Q to determine operations necessary to meet water quality objectives downstream.

HEC-5Q can be used to simulate concentrations of various combinations of a wide range of water quality constituents. For the ACF analysis, the following parameters were modeled.

- Temperature
- Point source tracer
- Dissolved oxygen
- Ammonia (NH_3) - Nitrogen
- Nitrate (NO_3) – Nitrogen
- Phosphate (PO_4) – Phosphorus
- Phytoplankton – Chlorophyll *a*[2]
- Point source dissolved organics as Biochemical Oxygen Demand (BOD)
- Non-point source dissolved organics as Biochemical Oxygen Demand (BOD)
- Particulate organic matter (POM) as Total Suspended Solids (TSS)[3]

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[2] HEC-5Q uses phytoplankton as a state variable. The relationship between phytoplankton biomass and Chlorophyll *a* (CHLA) is quite variable by speciation, available light and other environmental factors. The HEC-5Q model does not include assumptions of algal speciation. All tabular and plot references to phytoplankton or CHLA assume a ratio of 10 ug/L CHLA to 1 mg/L phytoplankton biomass (dry weight). This 1:100 ratio corresponds to a CHLA to carbon ratio of 1:45 assuming a 45% carbon ratio for phytoplankton. Nutrient interactions with phytoplankton assume a chemical composition of 0.009 and 0.05 for phosphorus (P) and nitrogen (N) respectively or CHLA:P and CHLA:N of 0.9 and 5 respectively. These values are in line with CE-QUAL-R1 (WES, 1986) guidelines.

All of these parameters are assumed passively transported by advection and diffusion. All rate coefficients regulating the parameter kinetics are temperature dependent. A brief description of the processes affecting each of these parameters is provided below. Additional documentation of hydrodynamics, transport and water quality kinetics are presented in various reports (HEC, 1996, 1999 a & b).

Temperature

The external heat sources and sinks that are considered in HEC-5Q are assumed to occur at the air-water interface and with the bed. The exchange with the bed through conductance moderates diurnal temperatures variations. The bed heat capacity is expressed as an equivalent water thickness. The method used to evaluate the net rate of heat transfer utilizes the concepts of equilibrium temperature and coefficient of surface heat exchange. The equilibrium temperature is defined as the water temperature at which the net rate of heat exchange between the water surface and the overlying atmosphere is zero. The coefficient of surface heat exchange is the rate at which the heat transfer process proceeds. All heat transfer mechanisms, except short-wave solar radiation, are applied at the water surface. Short-wave radiation penetrates the water surface and may affect water temperatures several meters below the surface. The depth of penetration is a function of adsorption and scattering properties of the water.

Point Source Tracer

The point source tracer is a tag assigned to all point discharges. A value of 100 is assigned so that the concentration of the tracer translates to the percentage of point discharge water at any location. For this analysis, no distinction is made between the types of point discharges.

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[3] The Total Suspended Solids (TSS) levels recorded at major discharge locations in Alabama and Georgia were predominantly Particulate Organic Matter (POM). A strong relationship was found between TSS and BOD. Although there was some variability, the statistical linear fit was significant. All major discharge sites measured BOD. There were 9 dischargers with flows > 5 MGD and 6 dischargers with flows > 10 MGD. For flows > 5 MGD, 82% of reported measurements (255 out of 311) contained BOD. For flows > 10 MGD, 93% of reported measurements (216 out of 232) had BOD. The remainder of these measurements contained TSS only. Therefore, the TSS:BOD relationship was primarily applied to small discharge sites (flows less than 5 MGD), which have a minor impact on the system.

Ammonia - Nitrogen

Ammonia is a plant nutrient and is consumed with phytoplankton growth. The remaining ammonia sink is decay. Sources of ammonia include phytoplankton respiration, TSS and Dissolved Organic Matter (DOM) decay, and aerobic and anaerobic release from bottom sediments.

Nitrate - Nitrogen

Nitrate is a plant nutrient and is consumed with phytoplankton growth. The remaining nitrate sink is denitrification associated with suboxic processes. Decay of ammonia provides a source of nitrate (nitrite formation phase is ignored).

Phosphate - Phosphorus

Phosphorus is the third plant nutrient considered in the model and is consumed with phytoplankton growth. Phosphates tend to sorb to suspended solids and are subject to loss by settling. Sources of phosphorus include phytoplankton respiration, TSS and DOM decay and aerobic and anaerobic release from bottom sediments.

Phytoplankton – Chlorophyll *a*

Photosynthesis acts as a phytoplankton source that is dependent on phosphate, ammonia, and nitrate. (Carbon limitation was not considered.) Therefore, Photosynthesis is a sink for these nutrients. Conversely, phytoplankton respiration releases phosphate and ammonia. Phytoplankton is an oxygen source during photosynthesis and an oxygen sink during respiration. Phytoplankton growth rates are a function of the limiting nutrient (or light) as determined by the Michaelis-Menten formulation. Respiration, settling and mortality are phytoplankton sinks.

Dissolved Oxygen

Exchange of dissolved oxygen (DO) at the water surface is a function of the surface exchange (reaeration) rate that is determined by wind speed in reservoirs and hydraulic characteristics in streams. Phytoplankton photosynthesis is a source of DO. Sinks for DO include BOD and ammonia decay, phytoplankton respiration and benthic uptake. Oxygen consumption associated with the decay of DOM and TSS is represented by BOD. Therefore, these parameters are not explicitly linked to DO.

Dissolved organics (BOD)

Dissolved organic material represents all materials that exert a biochemical oxygen demand (BOD) during decay and transformation to their chemical components. Thus, they contribute to dissolved nitrogen and phosphorus. The dissolved material is subdivided into point and non-point origins to add flexibility in assigning decay rates. It is also a measure of point source influence that considers decay and source quality.

Organic Particulate (TSS)

Sources of TSS include a component of phytoplankton mortality. TSS also exerts an oxygen demand (BOD) during decay and transformation to its chemical components. TSS sinks include decomposition to phosphate and ammonia. TSS is also subject to settling. Oxygen uptake associated with TSS decay is represented by BOD.

2.1 INTERNAL LOADING AND NUTRIENT DYNAMICS

Internal loading was accounted for in the HEC-5Q model, to a limited degree. For each model element, when the average DO concentration in that element drops below 2.5 mg/L, conditions transition smoothly from aerobic to anaerobic, with corresponding effects on nitrate, ammonia, and phosphorus. It is assumed that nitrogen enters the system as ammonia.

2.2 MODEL REPRESENTATION OF THE PHYSICAL SYSTEM

Reservoirs and rivers comprising the ACF system were represented as a network of reservoirs and streams and discretized into sections, as shown in Figure 2.1. Flow and water quality were simulated by ResSim and HEC-5Q, respectively. In HEC-5Q, stream elements are assumed well mixed. Stream reaches are typically partitioned into computational elements of approximately one mile or less in length. Because of the simplified geometry, lateral cross-stream variations cannot be evaluated, and longitudinal variations are limited to the element length. Area-capacity curves come from ResSim output. Other elements of the geometry (outlets, etc.) were taken from the 1998 HEC-5 model.

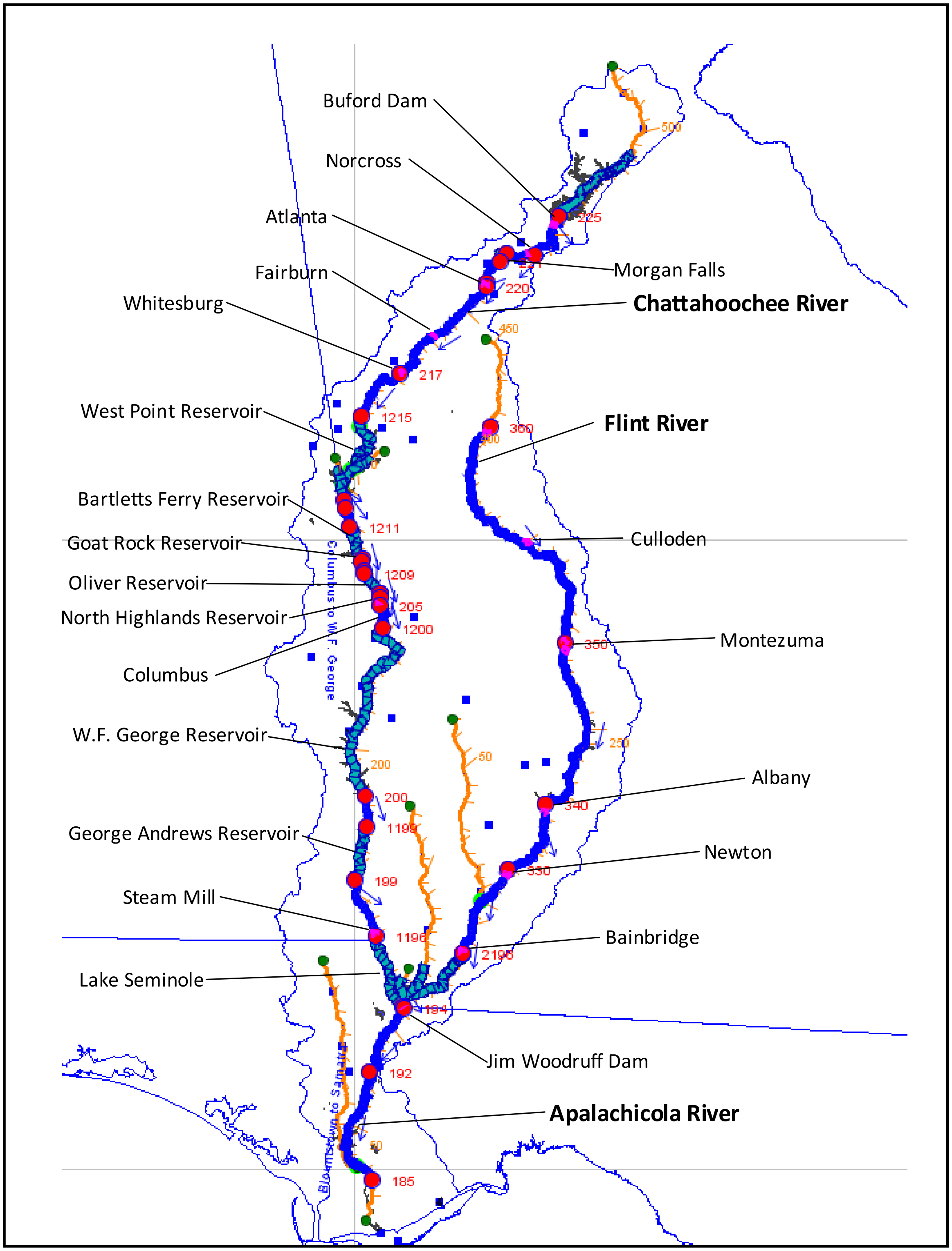

Figure 2.1 HEC-5 and HEC-5Q Model Schematic of ACF Basin. Note: the three straight blue lines indicate the state lines between Alabama, Georgia, and Florida.

2.2.1 MODEL REPRESENTATION OF RESERVOIRS

For water quality simulations, each reservoir was geometrically discretized and represented as either a vertically layered, longitudinally segmented, or a vertically layered and longitudinally segmented water body. Additionally, some of the run-of-the-river reservoirs along the Chattahoochee River extending from Langdale Reservoir to Eagle Reservoir were represented as stream reaches due to the short residence times. The reservoirs on the Flint River above Jim Woodruff were represented in this fashion. None of these small reservoirs and dams is represented in ResSim. A description of the different types of reservoir representation follows. Table 2.1 summarizes the geometric representation of the reservoirs. A list of all reservoirs, the geometric representation, inflows and tributaries is presented as an appendix to this report. Area-capacity curves come from ResSim output. Other elements of the geometry (outlets, etc.) were taken from the 1998 model.

Table 2.1 Geometric Representation of the ACF Reservoirs

Reservoir	Vertically Layered	Horizontally Segmented	Vertically Layered and Horizontally Segmented	Layer Thick-ness	# Layers	# Segments
Glades	X			1 m		
Lake Lanier	X			5 ft		
Morgan Falls		X			1	3
Bear Creek	X			1 m		
West Point			X		8	21
Bartletts Ferry			X		5	9
Goat Rock			X		4	3
Oliver			X		4	4
North Highlands			X		4	2
Walter F. George			X		9	30
George Andrews			X		5	8
Lake Seminole			X		8	38

2.2.1.1 Vertically Layered Reservoirs

Vertically stratified reservoirs are represented conceptually by a series of one-dimensional horizontal slices or layered volume elements, each characterized by an area, thickness, and volume. In the aggregate the assemblage of layered volume elements is a geometrically discretized representation of the prototype reservoir. Within each horizontal layer (or 'element') of a vertically layered reservoir, or layered volume element, the water is assumed to be fully mixed with all isopleths parallel to the water surface both laterally and longitudinally. External inflows and withdrawals occur as sources or sinks within each element and are instantaneously dispersed and homogeneously mixed throughout the layer from the headwaters of the impoundment to the dam. Consequently, simulation results are most representative of conditions in the main reservoir body and may not accurately describe flow or quality characteristics in shallow regions or near reservoir banks. It is not possible to model longitudinal variations in water quality constituents using the vertically layered configuration.

Vertical advection is one of two transport mechanisms used in HEC-5Q to simulate transport of water quality constituents between elements in a vertically layered reservoir. Vertical transport is defined as the inter-element flow that results in flow continuity and is calculated as the algebraic sum of inflows to and outflows from each layer beginning with the lowest layer in the reservoir. Any flow imbalance is accounted for by vertical advection into or out of the layer above, a process that is repeated for all layers in the reservoir. At the surface layer, an increase or decrease in reservoir volume accounts for any resulting flow imbalance.

An additional transport mechanism used to distribute water quality constituents between elements is effective diffusion, representing the combined effects of molecular and turbulent diffusion, and convective mixing or the physical movement of water due to density instability. Wind and flow-induced turbulent diffusion and convective mixing are the dominant components of effective diffusion in the epilimnion of most reservoirs.

The outflow component of the model incorporates the selective withdrawal techniques developed by Bohan (1973) for withdrawal through a dam outlet or other submerged orifice or for flow over a weir. The relationships developed for the 'WES Withdrawal Allocation Method' describe the vertical limits of the withdrawal zone and the vertical velocity distribution throughout the water column. The withdrawal zone limits and the corresponding velocity profile are calculated as a function of the water temperature distribution with depth in a stratified reservoir. In HEC-5Q, the approach velocity profile is approximated as an average velocity in each layer just upstream of a submerged weir or a dam with a submerged orifice. The computed velocity distribution is then used to allocate withdrawals from each layer. Detailed descriptions of the WES Withdrawal Allocation Method and weir formulation are provided in the HEC-5 Appendix on Water Quality (HEC, 1998).

Lake Lanier, above Buford Dam, Glades Reservoir, and Bear Creek Reservoir are the vertically segmented reservoirs in the ACF model. Lake Lanier is represented by 5-ft layers, while Glades and Bear Reservoirs are represented by 1m layers.

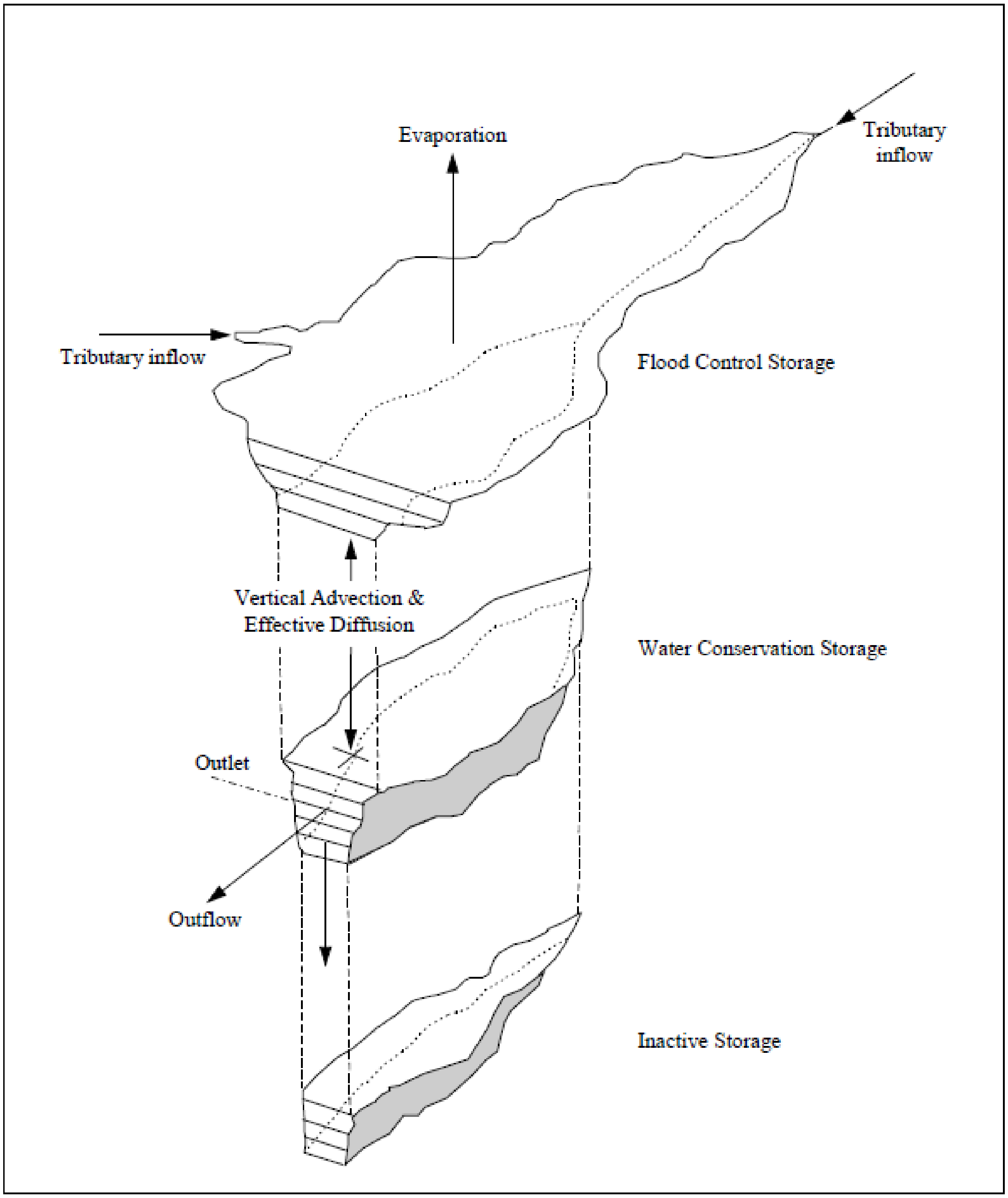

Figure 2.2 Schematic representation of a vertically layered reservoir (HEC, 1986).

2.2.1.2 Longitudinally Segmented Reservoirs

Longitudinally segmented reservoirs are represented conceptually as a linear network of a specified number of segments or volume elements. Length and the relationship between width and elevation characterize the geometry of each reservoir segment. The surface areas, volumes and cross sections are computed from the width relationship.

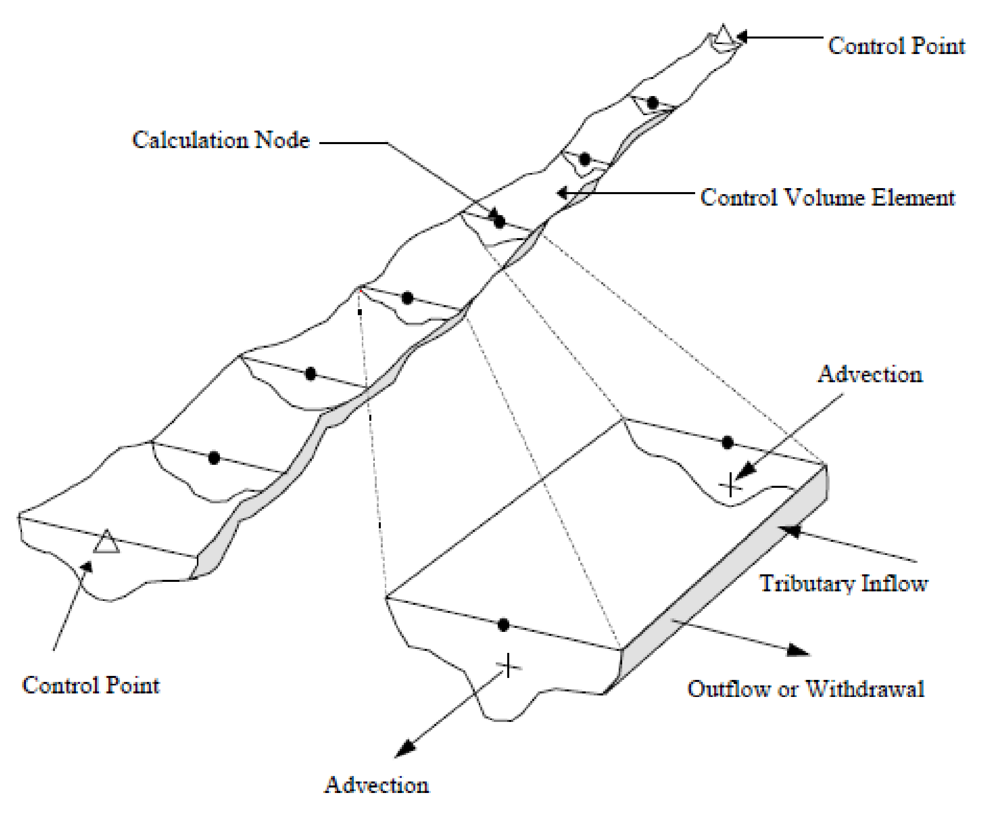

Figure 2.3 Schematic representation of a longitudinally stratified reservoir (HEC, 1986).

2.2.1.3 Vertically Layered and Longitudinally Segmented Reservoirs

Longitudinally segmented reservoirs may be subdivided into vertical elements with each element (layer) assumed fully mixed in the vertical and lateral directions. Branching of reservoirs is allowed. For reservoirs represented as vertically layered and longitudinally segmented, all cross-sections contain the same number of layers, and each layer is assigned the same fraction of the reservoir cross-sectional area. The model performs a backwater computation to define the water surface profile as a function of the hydraulic gradient based on flow and Manning's equation.

External flows such as withdrawals and tributary inflows occur as sinks or sources. Inflows to the upstream ends of reservoir branches are allocated to individual elements in proportion to the fraction of the cross-section assigned to each layer. Other inflows to the reservoir are distributed in proportion to the local reservoir flow distribution. External flows may be allocated along the length of the reservoir to represent dispersed, or non-point, source inflows including agricultural drainage or groundwater accretions.

The vertically layered and longitudinally segmented reservoirs of the ACF contain up to nine layers. The layered representation was utilized for all reservoirs that had the potential for both horizontal and vertical gradients in flow, temperature and water quality.

Vertical variations in constituent concentrations are computed for each cell of the layered and longitudinally segmented reservoir model. Mass transport between vertical layers is represented by net flow determined by mass balance and by diffusion.

Vertical flow distributions at dams are based on weir or orifice withdrawal. The velocity distribution within the water column is calculated as a function of the water density and depth using the WES weir withdrawal or orifice withdrawal allocation method (Bohan, 1973). HEC-5Q uses an elemental average of the approach velocity for each layer in the reservoir.

A uniform vertical flow distribution is specified at the upstream end of each reservoir and at any intermediate location. Linear interpolation of flow is performed for reservoir segments without specifically defined flow fields (e.g., interpolation between flows at the dam face and the defined intermediate location).

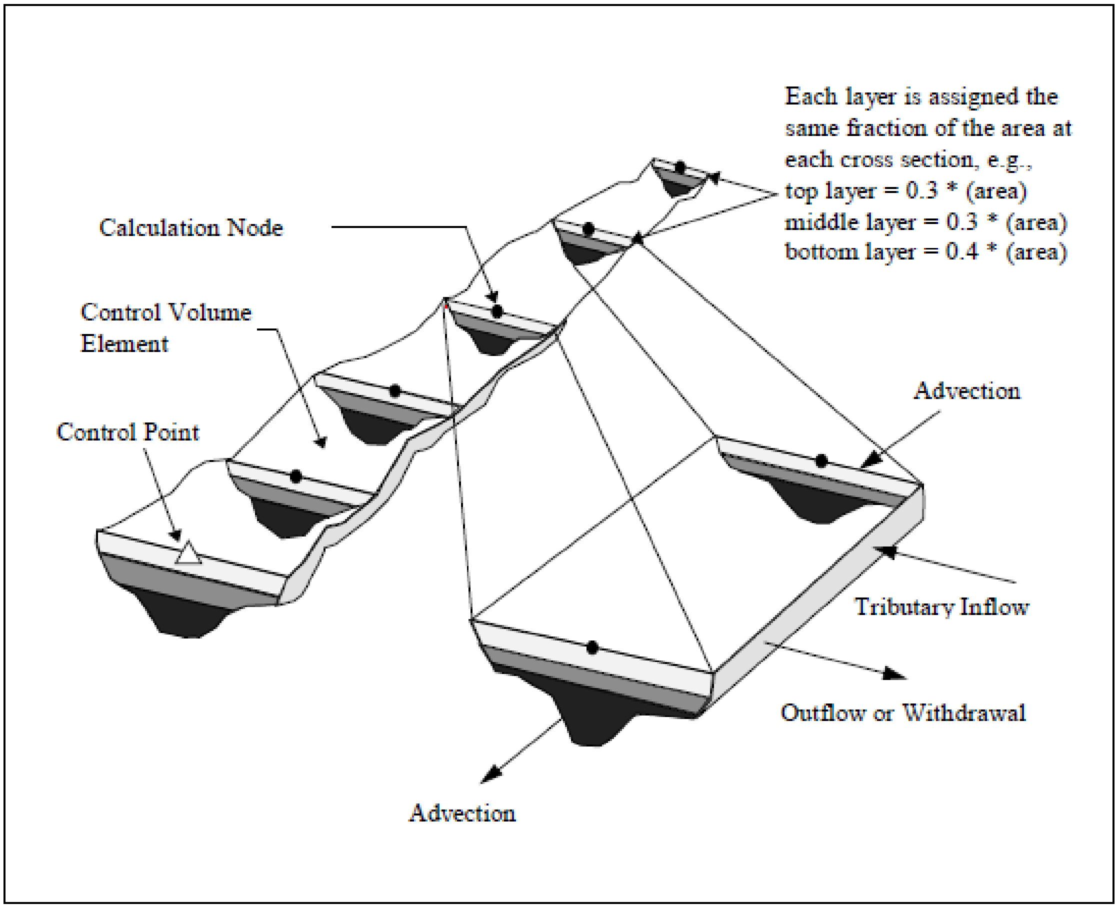

Figure 2.4 Schematic representation of a vertically layered and longitudinally segmented reservoir (HEC, 1986).

2.2.2 MODEL REPRESENTATION OF STREAMS

In HEC-5Q, a reach of a river or stream is represented conceptually as a linear network of segments or layered volume elements. Each element is characterized by its length, width and cross-sectional area as a function flow and depth. Stream flow, diversion and incremental inflow rates are provided by ResSim at stream control points. The total incremental local inflow is divided into components and placed at the actual inflow locations of the non-point source (tributary) inflow. The diversion defined by ResSim represents the net point source inflow above the control point. The individual point source inflows and withdrawals are assigned to the location of the discharge or diversion. A flow balance is used to determine the flow rate at element boundaries. Once inter-element flows are established, the water depth, surface width and cross sectional area are defined at each element boundary as a function of the user specified flow-depth relationship. Lists of all stream reaches and point and non-point source inflows and water quality are provided in Appendix A in Table 7.1 (Chattahoochee River) and Table 7.2 (Flint River).

2.3 WATER QUALITY BOUNDARY CONDITIONS AND INPUT DATA

HEC-5Q requires that in-stream flows, tributary flows and water quality, withdrawals, reservoir operations, and other point and non-point source flows and water quality loads to the system be specified for simulation of water quality.

ResSim incremental inflows are determined by difference from available and/or synthesized river flows, reservoir operation and point source inflows. This process, which assumes that the observed flows are the best depiction of historical inflow conditions, may result in computed inflows that are negative. Although negative inflows do not present a problem for ResSim, they are a problem from a water quality perspective. The issue is that the inflow quality must be defined, while the negative inflow removes ambient water quality. For example, if a -100 cfs flow is followed by a +100 cfs flow to represent an inflow of near zero, an artificial tributary load is introduced on the day of the +100 cfs flow. To mitigate this effect, the water quality load is computed from an inflow rate that is constrained as positive. Residual negative inflows are accumulated on the falling limb of the hydrograph and then allocated to future positive inflows. In some instances, the constrained inflow is developed by aggregating two or more sets of ResSim incremental inflows. The rate of decrease is further limited to 67% of the previous day’s flow (e.g., combined inflow between Buford Dam and Franklin above West Point Reservoir determines the shape of the Norcross tributary flow for defining the water quality load). Aggregation is done when adjacent control points have erratic local flows or when one of the local flows has extensive negative inflows. This constrained flow is then scaled to match the local inflow of the control point. The scaled flows are then allocated to individual tributaries above the control point proportional to tributary inflow as computed by BASINS. An example of 7-day average (with negative flows) and constrained reservoir inflows is provided in Figure 2.5 for Norcross. Since the 7-day average unconstrained flows contain negative flows, the constrained daily flows will often be higher than the 7-day average flows.

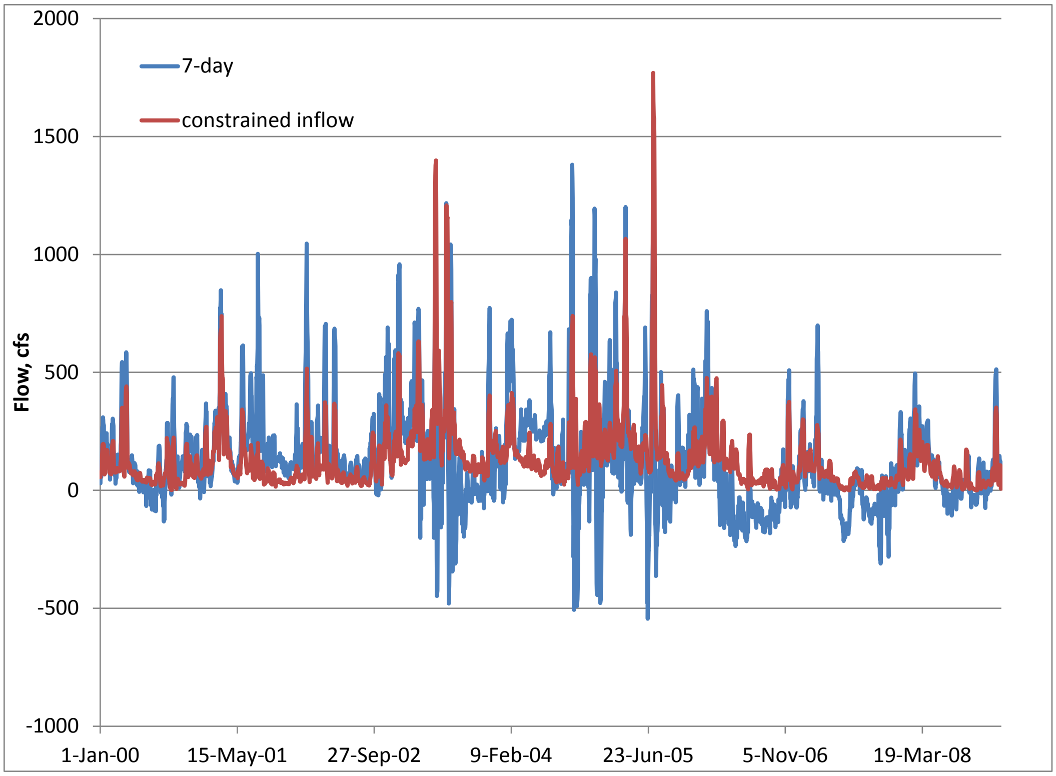

Figure 2.5 Comparison of 7-day average and constrained inflows at Norcross.

2.3.1 NON-POINT SOURCE FLOW AND WATER QUALITY DATA

The non-point source water quality inputs to the HEC-5Q model were developed from observed data in conjunction with BASINS model loadings that were developed during previous ACF modeling efforts (Tetra Tech, August 1998). The BASINS model computes flow and water quality (BOD, total nitrogen, and total phosphorus) as a function of precipitation, land use, antecedent conditions, and other factors. BASINS model outputs were produced for three conditions: 1995 land use conditions, anticipated 2020 conditions, and anticipated 2050 conditions. Each of these was calculated using the 1984-1989 precipitation record. The 2020 BASINS model output was used to develop extrapolation functions that relate hydrograph dynamics and ResSim incremental local flows to concentration. The 2020 BASINS model was selected since its time period is currently the closest of the three periods to present day conditions. The extrapolation functions were then applied to the 2001–2011 ResSim flows to generate the non-point-source loadings for input to HEC-5Q. Output for 133 ACF BASINS watersheds was available. These watersheds were consolidated to define 73 non-point source inflows for the current HEC-5Q modeling effort. The watersheds/stream names and corresponding stream / inflow locations are listed in Appendix A.

The HEC-5Q model of the ACF was designed to utilize flows computed by ResSim for the 1939–2011 period of record. The tributary flows and water quality computed by BASINS for the 1984–1989 period served two purposes: 1) as a basis for estimating the response of water quality parameters to tributary stream flow dynamics, and 2) for extrapolating a comparable record for the 1939–2011 ResSim simulation period.

The intent of the extrapolation was to establish the shape of the water quality response to flow. The extrapolation assumed that the inflowing concentration is influenced by the rate of change in flow. On the rising hydrograph, the concentration was computed as:

$$C = C_o + K_1*(\log Q_t - \log Q_{t-1})$$

C = Concentration
C_o = Minimum concentration
K_1 = Scaling factor
Q_t = Flow for current day
Q_{t-1} = Flow for previous day

On the falling hydrograph, the concentration was computed as a fraction of the previous day's concentration. For example:

$$C = C_o + K_2*(C_{t-1} - C_o)$$

1. C = Concentration
2. C_o = Minimum concentration
3. K_2 = Scaling factor
4. C_{t-1} = Concentration for previous day

The extrapolated water quality was computed as a function of ResSim based flows to align the inflow concentration with the ResSim inflow hydrographs. The C and K values were selected such that the concentration range, magnitude and response to flow dynamics were in line with those predicted by the BASINS model.

The concentrations of each parameter were then scaled to the average concentration for each tributary. The scaling factors developed from the analysis of the 1984–1989 period were applied to the entire 1939–2011 period.

Water quality field data for five tributaries to each of the Chattahoochee and Flint Rivers were compared with the BASINS-based water quality for the 2001–2011 period. The fraction of total nitrogen allocated to nitrate and ammonia was based on these observations.

Selected tributaries to the Chattahoochee River:

- Peachtree Creek (5)[4]
- Sweetwater Creek (6)
- Yellow Jacket Creek (14)
- Long Cane Creek (17)
- Pataula Creek (33)

Selected tributaries to the Flint River:

- Line Creek (39)
- Potato Creek (45)
- Patsiliga Creek (49)
- Muckalee Creek (60)
- Ichawaynochaway Creek (64)

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[4] The numbers in parentheses correspond to the tributary numbers within the HEC-5Q data set.

The observed data for these tributaries include the following water quality parameters:

- BOD5U: 5-Day Uninhibited BOD
- DO: Dissolved Oxygen
- NH3: Ammonia -nitrogen
- NO2NO3: Nitrite + Nitrate-nitrogen
- TOTALP: Total Phosphorus
- SOLIDTSS: Suspended Solids
- TEMP: Temperature
- TOC: Total Organic Carbon
- Chlorophyll *a* [5]

Table 2.2 provides a summary of available observed data, including number of samples and average, maximum, minimum and median values for the above listed tributaries and parameters. The preponderance of data is for creeks tributary to the Chattahoochee River. The sample weighted averages for the eight tributaries is also included. The ratio of average to the median value is also included to identify those parameters where the average is overly weighted by a few extreme measurements. Parameters such as PO4-P and TSS are examples of parameters where the average concentration is elevated relative to the median value. The sample weighted averages for the eight tributaries is also included.

Average non-point source inputs to the model are provided in Table 2.3. Full tables of maximum, minimum and average values can be found in the Appendix A in Table 7.1.

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[5] All references to Chlorophyll *a* assume a ratio of 10 ug/L Chlorophyll *a* to 1 mg/L phytoplankton biomass (dry weight).

Table 2.2 Summary of available observed data for inflow water quality.

	BOD5U (mg/L)	Oxygen (mg/L)	NH3-N (mg/L)	NO2+NO3-N (mg/L)	Total P (mg/L)	TSS (mg/L)	Temp. (deg C)	Chlorophyll *a* (ug/L)
	Ichawaynochaway Creek at State Road 91 near Newton, Ga.							
samples	12	19	12	12	12	12	19	0
avg	0.958	8.679	0.054	0.708	0.022	4.083	19.305	
min	0.400	6.700	0.020	0.400	0.020	1.000	7.000	
max	1.400	12.800	0.110	1.000	0.030	12.000	29.200	
median	0.800	7.900	0.050	0.700	0.020	2.000	20.800	
median/avg	0.835	0.910	0.923	0.988	0.923	0.490	1.077	
	Line Creek at State Road 16 near Digbey, Ga.							
samples	47	73	47	47	47	46	74	0
avg	1.779	7.905	0.066	0.466	0.138	9.817	16.634	
min	0.800	4.400	0.020	0.080	0.020	1.000	3.100	
max	2.100	12.500	0.380	1.100	0.370	38.000	26.600	
median	2.000	7.530	0.050	0.400	0.110	7.000	15.800	
median/avg	1.124	0.953	0.755	0.859	0.795	0.713	0.950	
	Long Cane Creek at State Road 50 near Georgetown, Ga.							
samples	48	76	48	47	48	48	76	0
avg	1.846	7.921	0.051	0.147	0.049	11.433	17.447	
min	0.600	4.800	0.020	0.020	0.020	1.000	3.290	
max	3.600	13.570	0.150	0.560	0.120	71.000	26.800	
median	2.000	7.420	0.030	0.120	0.050	6.300	18.200	
median/avg	1.084	0.937	0.584	0.819	1.013	0.551	1.043	
	Muckalee Creekat State Road 195 near Leesburg, Ga.							
samples	12	20	12	12	12	12	20	0
avg	0.850	7.635	0.055	0.442	0.065	5.333	18.255	
min	0.500	5.700	0.020	0.200	0.020	2.000	4.300	
max	1.300	10.600	0.090	0.900	0.130	14.000	26.400	
median	0.800	7.600	0.050	0.400	0.060	4.000	18.500	
median/avg	0.941	0.995	0.909	0.906	0.923	0.750	1.013	
	Pataula Creek at State Road 50 near Georgetown, Ga.							
samples	24	41	24	24	24	24	0	0
avg	1.495	8.960	0.039	0.109	0.034	8.779		
min	0.300	6.990	0.010	0.020	0.020	3.000		
max	5.000	12.400	0.090	0.200	0.160	28.000		
median	1.260	8.910	0.030	0.100	0.020	8.000		
median/avg	0.843	0.994	0.774	0.916	0.593	0.911		
	Patsiliga Creek (CR 128) near Reynolds, Ga.							
samples	10	19	11	11	11	11	19	0
avg	1.020	8.347	0.063	0.109	0.024	8.909	17.516	
min	0.600	6.200	0.030	0.100	0.020	2.000	6.500	
max	1.400	10.700	0.100	0.200	0.040	20.000	24.400	
median	1.100	8.100	0.060	0.100	0.020	7.000	17.900	
median/avg	1.078	0.970	0.957	0.917	0.846	0.786	1.022	

Table 2.2 Concluded

	BOD5U (mg/L)	Oxygen (mg/L)	NH3-N (mg/L)	NO2+NO3-N (mg/L)	Total P (mg/L)	TSS (mg/L)	Temp. (deg C)	Chlorophyll *a* (ug/L)
	Peachtree Creek at Northside Drive near Atlanta, Ga.							
samples	106	159	110	110	105	106	161	0
avg	2.387	8.531	0.080	0.527	0.070	24.116	17.519	
min	2.000	4.580	0.030	0.120	0.020	1.000	2.900	
max	7.700	14.650	0.740	1.100	0.530	300.000	27.710	
median	2.000	8.210	0.050	0.500	0.050	5.400	18.380	
median/avg	0.838	0.962	0.623	0.948	0.710	0.224	1.049	
	Potato Creek at State Road 74 near Thomaston, Ga.							
samples	12	20	12	12	12	12	20	0
avg	2.633	8.310	0.072	0.160	0.034	12.417	17.825	
min	0.700	4.900	0.040	0.020	0.020	4.000	5.000	
max	9.100	12.100	0.130	0.400	0.090	46.000	27.200	
median	1.500	7.800	0.060	0.100	0.030	7.000	15.800	
median/avg	0.570	0.939	0.837	0.625	0.878	0.564	0.886	
	Sweetwater Creek at Interstate Highway 20							
samples	106	160	110	110	104	106	161	0
avg	2.053	8.026	0.049	0.252	0.043	17.529	17.331	
min	2.000	4.730	0.030	0.030	0.020	1.000	2.580	
max	3.500	14.290	0.260	0.990	0.200	190.000	31.730	
median	2.000	7.620	0.040	0.260	0.030	8.000	18.130	
median/avg	0.974	0.949	0.813	1.031	0.699	0.456	1.046	
	Yellow Jacket Creek at Hammet Road near Hogansville, GA							
samples	102	173	89	98	98	96	173	20
avg	1.680	8.887	0.051	0.122	0.029	16.729	17.259	3.200
min	0.100	6.240	0.030	0.020	0.020	1.000	2.400	0.900
max	8.100	12.810	0.600	0.340	0.120	280.000	31.260	19.400
median	2.000	8.510	0.030	0.120	0.020	7.300	18.300	1.900
median/avg	1.191	0.958	0.589	0.980	0.692	0.436	1.060	0.594
	Sample Weighted							
samples	479	760	475	483	473	473	723	20
avg	1.907	8.377	0.059	0.302	0.055	16.049	17.392	3.200
min	1.113	5.256	0.027	0.067	0.020	1.226	3.070	0.900
max	5.346	13.401	0.412	0.778	0.251	181.252	29.147	19.400
median	1.871	8.010	0.041	0.285	0.042	6.703	18.005	1.900
median/avg	0.981	0.956	0.700	0.943	0.765	0.418	1.035	0.594

Table 2.3 Average, maximum and minimum flow and water quality inputs to the Chattahoochee River.

Stream Name	Flow	Temp	NO3-N	PO4-P	Chl_*a*	NH3-N	DO	DOM2 (BOD)	TSS (org)
	cfs	C	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Chattahoochee River	1453	15.5	0.17	0.02	1.65	0.04	8.8	3	1.6
Swannee Creek	185	16.5	0.25	0.04	1.65	0.06	8.6	3.4	3.2
Big Creek	200	16.5	0.33	0.06	1.65	0.07	8.6	3.7	4.2
Sope Creek	141	16.5	0.55	0.13	1.65	0.12	8.6	5.3	8.1
Nancy and Peachtree Creek	311	16.5	0.46	0.1	1.65	0.1	8.6	4.5	6.3
Utoy Creek	396	16.5	0.38	0.08	1.65	0.08	8.6	4.1	5.3
Camp Creek	111	16.5	0.31	0.06	1.65	0.07	8.6	3.6	4.1
Bear Creek	84	16.5	0.23	0.03	1.65	0.05	8.6	3.2	2.4
Snake Creek	172	16.5	0.26	0.04	1.65	0.06	8.6	3.2	2.7
Chattahoochee: misc.trib-1	90	16.5	0.31	0.05	1.65	0.07	8.6	3.3	3
Centralhatchee Creek	27	16.5	0.32	0.05	1.65	0.07	8.6	3.2	2.6
Hillabatchee Creek	61	16.5	0.23	0.03	1.65	0.05	8.6	3.1	1.9
New River	140	16.5	0.26	0.03	1.65	0.05	8.6	3.2	2.2
Yellowjacket Creek	144	16.5	0.25	0.03	1.65	0.05	8.6	3.2	2.1
Wehadkee Creek	120	16.5	0.25	0.03	1.65	0.05	8.6	3.1	1.9
Oseligee Creek	345	16.5	0.22	0.02	1.65	0.04	8.6	3.1	1.8
Long Cane Creek	70	16.5	0.25	0.04	1.65	0.05	8.6	3.3	2.7
Flat Shoal Creek	243	16.5	0.22	0.02	1.65	0.04	8.6	3.2	2
Mountain Creek	162	16.5	0.21	0.02	1.65	0.04	8.6	3.1	1.8
Halawakee Creek	87	16.5	0.22	0.02	1.65	0.04	8.6	3.2	2
Mulberry Creek	312	16.5	0.21	0.02	1.65	0.04	8.6	3.2	2
Standing Boy Creek	31	16.5	0.21	0.02	1.65	0.04	8.6	3.1	2
Chattahoochee: misc.trib-2	88	16.5	0.3	0.05	1.65	0.07	8.6	3.5	3.4
Chattahoochee: misc.trib-3	68	16.5	0.37	0.07	1.65	0.08	8.6	4.2	5.1
Bull Creek	62	16.5	0.33	0.06	1.65	0.07	8.6	3.9	4.3
Upatoi Creek	301	16.5	0.28	0.05	1.65	0.06	8.6	3.7	3.8
Uchee Creek	207	16.5	0.24	0.03	1.65	0.05	8.6	3.2	2.4
Hichitee Creek	75	16.5	0.24	0.04	1.65	0.05	8.6	3.4	3
Hannahatchee Creek	175	16.5	0.22	0.04	1.65	0.05	8.6	3.4	2.9
Grass Creek	54	16.5	0.3	0.05	1.65	0.07	8.6	3.5	3.3
Cowikee Creek	353	16.5	0.24	0.04	1.65	0.05	8.6	3.4	3
Barbour Creek	128	16.5	0.25	0.04	1.65	0.06	8.6	3.4	3
Pataula Creek	367	16.5	0.26	0.05	1.65	0.06	8.6	3.5	3.2
Cemochechobee Creek	81	16.5	0.21	0.03	1.65	0.05	8.6	3.2	2.2

Table 2.3 Concluded

	Flow	**Temp**	**NO3-N**	**PO4-P**	**Chl_*a***	**NH3-N**	**DO**	**DOM2 (BOD)**	**TSS (org)**
Stream Name	cfs	C	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Kolomoki Creek	178	16.5	0.3	0.04	1.65	0.07	8.6	3.2	2.3
Sandy Creek	201	16.5	0.25	0.03	1.65	0.06	8.6	3.2	2.1
Omusee Creek	260	16.5	0.34	0.04	1.65	0.08	8.6	3.2	2.2
Sawhatchee Creek	67	16.5	0.27	0.05	1.65	0.06	8.6	3.4	3.5
Chattahoochee: misc.trib-4	635	16.5	0.29	0.02	1.65	0.07	8.6	3.1	2.1
Flint R.	286	16.5	0.31	0.04	1.65	0.07	8.6	3.1	2.4
Line Creek	157	16.5	0.18	0.02	1.65	0.04	8.6	3	1.6
White Oak Creek	194	16.5	0.18	0.02	1.65	0.04	8.6	3	1.5
Red Oak Creek	211	16.5	0.18	0.02	1.65	0.04	8.6	3	1.4
Elkins Creek	164	16.5	0.17	0.02	1.65	0.04	8.6	3	1.6
Pigeon Creek	102	16.5	0.16	0.02	1.65	0.03	8.6	3	1.6
Lazer Creek	192	16.5	0.19	0.02	1.65	0.04	8.6	3	1.7
Potato Creek	261	16.5	0.17	0.02	1.65	0.04	8.6	3	1.6
Swift Creek	218	6.5	0.17	0.02	1.65	0.04	8.6	3	1.8
Ulcohatchee Creek	171	16.5	0.21	0.03	1.65	0.05	8.6	3.1	2.2
Patsiliga Creek	271	16.5	0.23	0.02	1.65	0.05	8.6	3.1	2.1
Horse and Toteover Creek	93	16.5	0.17	0.02	1.65	0.04	8.6	3	1.7
Whitewater Creek	153	16.5	0.18	0.02	1.65	0.04	8.6	3	2
Montezuma WWTP	80	16.5	0.32	0.05	1.65	0.07	8.6	3.2	2.6
Buck Creek	127	6.5	0.31	0.03	1.65	0.07	8.6	3	2
Camp Creek	178	16.5	0.34	0.03	1.65	0.07	8.6	3	2.1
Turkey Creek	157	16.5	0.28	0.02	1.65	0.06	8.6	3	1.7
Lime Creek	39	16.5	0.4	0.05	1.65	0.09	8.6	3.1	2.2
Gum Creek	230	16.5	0.4	0.05	1.65	0.08	8.6	3	2
Swift Creek	123	16.5	0.38	0.05	1.65	0.08	8.6	3.1	2.2
Jones Creek	105	6.5	0.32	0.04	1.65	0.07	8.6	3.1	2.6
Abrams Creek	94	16.5	0.44	0.07	1.65	0.09	8.6	3.3	3.2
Piney Woods Creek	178	6.5	0.25	0.03	1.65	0.06	8.6	3.1	2.2
Kinchafoonee Creek	676	16.5	0.43	0.07	1.65	0.09	8.6	3.5	3.8
Dry Creek	190	6.5	0.37	0.04	1.65	0.08	8.6	3	1.9
Racoon Creek	178	16.5	0.23	0.02	1.65	0.05	8.6	3	1.6
Cooleewahee Creek	101	6.5	0.2	0.02	1.65	0.05	8.6	3	1.7
Ichawaynochaway Creek	1121	6.5	0.26	0.02	1.65	0.06	8.6	3	1.9
Flint: misc.trib-1	239	16.5	0.26	0.03	1.65	0.06	8.6	3.3	2.8

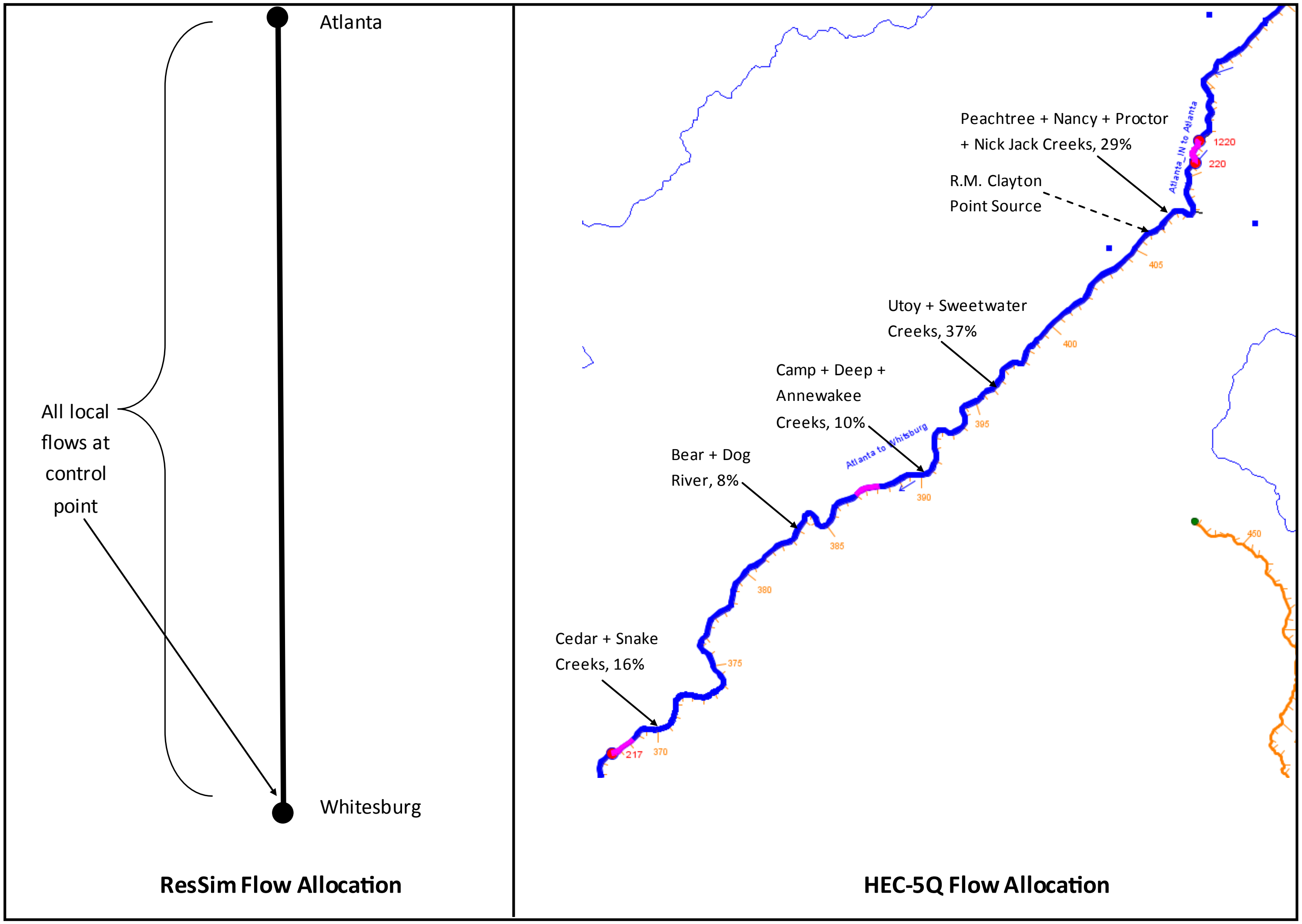

Figure 2.6 Example comparison between ResSim and HEC-5Q flow allocation.

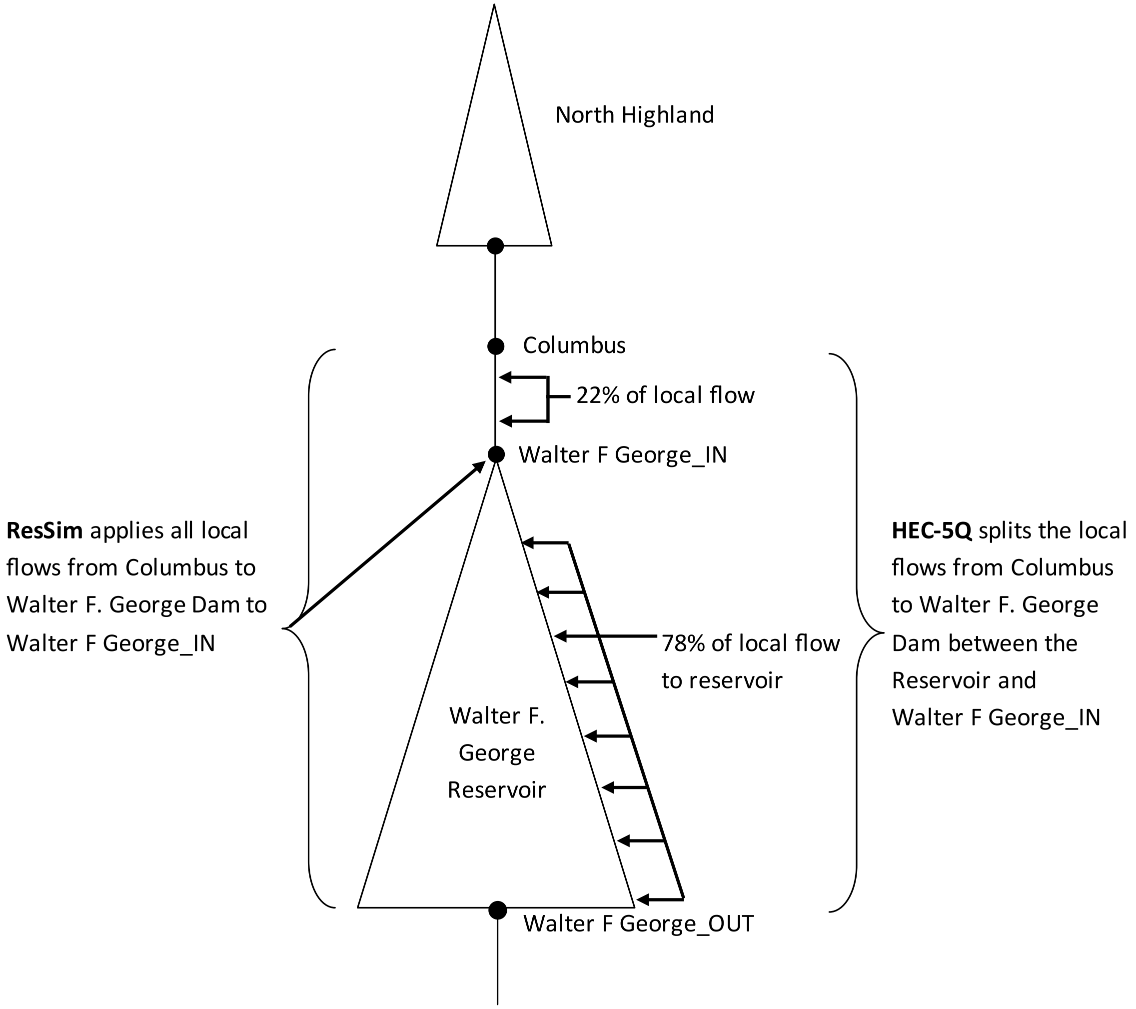

Figure 2.7 Illustration of ResSim versus HEC-5Q flow allocation at W.F. George Reservoir.

2.3.2 POINT SOURCE FLOW AND WATER QUALITY DATA

Point source inflows represent non tributary inflows and include municipal and industrial discharges and cooling water returns. Agricultural returns and groundwater inflows were not considered. Discharge rate and water quality were defined seasonally for each discharge where sufficient data were available

The seasonal discharge rates and quality were based on point source discharge data provided by Tetra Tech for the 2001–2011 period. Monthly average flow and quality characteristics were defined as the average of all the available measurements without regard to the time of month.

If insufficient data were available, default values or relationships between parameters were used. The following assumptions were used for those discharges and parameters that could not be defined monthly[6].

- Temperature - Available water temperature data were used to develop a relationship with equilibrium temperature that defined daily average inflow temperature.
- Dissolved oxygen – A uniform concentration ranging from 5 mg/L for BOD < 10 mg/L to 2 mg/L for BOD > 50 mg/L was specified. Linear interpolation was used between these values.
- Total Nitrogen (Municipal) – A uniform NO3-N concentration of 10 mg/L was specified for advanced treatment facilities. Smaller NO3-N and larger NH3-N concentrations were assumed for plants without nitrification.
- Total Nitrogen (Industrial) – Uniform NO3-N and NH3-N concentrations were assigned based on the industry. Of special interest is the NH3-N concentration of 4 mg/L assigned for pulp mills. This value is considered conservative and results in elevated ammonia levels in the model predictions. Sensitivity to pulp mill NH3 is evaluated in Chapter 3.
- Total Phosphorus – A uniform concentration of 0.7 mg/L was assigned to Georgia dischargers and discharger specific concentrations were assigned for Alabama dischargers.

For DOM, either BOD or TSS data were generally available and so DOM was calculated from Uninhibited BOD as (BOD*2.5). For municipal dischargers, BOD was estimated as the equivalent of TSS. For industrial loads, the TSS to BOD ratio is 2 to 1. This ratio was based on correlations developed from discharge data where both parameters were available.

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[6] Tables of the default loadings are available upon request.

Average point source inputs are summarized in Table 2.4. Inputs marked with a "*" were developed from 2000–2008 monitoring data. Data were averaged by month; for example, for each source, data for January of all years were averaged and applied to the model for January of each year. Those marked with "**" were also developed using this method, but data were very limited. The table values for "*" and "**" are the average of the 12 monthly values. An example of the actual monthly inputs for R. M. Clayton is provided in Table 2.5. Full tables of maximum, minimum and average values can be found in the appendix in Table 7.1 (Appendix A). Inputs marked with a "#" were updated based on most recent monitoring data because previous values appeared unrealistic. All other inputs are either default values or are referenced to values produced by an earlier analysis by the EIS team using the PIPES model. Some of the point inflows that were in the 1998 version of the model have been removed because their impacts were already included in the tributaries, and were therefore being double accounted. The impact of eliminating these sources was minimal, with a change on the order of 1%. The average, maximum and minimum concentrations are also summarized in Table 7.1 and Table 7.2 in Appendix A.

Table 2.4 Summary of point source inflow and quality.

CP - Location	flow (mgd)	NO3-N (mg/L)	total P (mg/L)	NH3-N (mg/L)	DO (mg/L)	5-day BOD (mg/L)	TSS (mg/L)
76 - GAINESVILLE FLAT CREEK	9.18*	10	0.28*	1.5	6.56*	4	3.47*
78 - FULTON COUNTY - CAULEY	4.28*	10	0.09*	0.20*	7.17*	3	3.08*
80 - FULTON COUNTY - JOHNS CR	5.97*	10	0.58*	1.17*	6.20*	6	7.28*
81 - FULTON CO. BIG CREEK WPCP	21.80*	10	0.46*	0.83*	6.06*	2	1.39*
83 - RM CLAYTON WPCP / MI = 407	78.49*	10	0.22*	0.86*	7.37*	4	3.75*
84 - ATLANTA SOUTH RIVER	31.95*	10	0.29*	0.58*	6.71*	3	2.67*
85 - ATLANTA CREEK WPCP / MI = 400	27.81*	10	0.18*	0.20*	6.75*	4	3.68*
86 - COBB COUNTY - SUTTON WPCP	30.86*	10	0.33*	0.43*	7.20*	2	2.21*
87 - SOUTH COBB WPCP / MILE = 403	23.57*	10	0.37*	1.13*	8.08*	7	6.95*
89 - DOUGLASVILLE DOUGLAS COU	1.46*	10	0.42*	1.29*	7.33*	4.83*	6.60*
90 - CAMP CREEK WPCP / MI = 392	14.22*	10	0.25*	2.77*	7.25*	5	5.07*
92 - LA GRANGE WPCP / MI = 302	5.72*	10	0.51*	0.08*	6.74*	3	2.90*
93 - COLUMBUS G42101	30.19*	10	2.24*	2.97*	7.31*	10	10.81*
94 - WEST POINT	0.65*	10	0.62*	2.58*	5.98*	10.92*	10.76*
95 - COLUMBUS - FORT BENNING	1.73*	1	8.12*	12.63*	3.48*	21.47*	20.35*
96 - EAST ALABAMA WWTP / MI = 300	2.49*	5.81*	1.73*	2.09*	4.45*	3.61*	16.17*
97 - LANETT WWTP / MI = 310	2.48*	10	0.7	0.59*	7.33*	2.70*	7.73*
98 - MEAD COATED BOARD / MI = 225	24.07*	0.26#	0.12#	5	0.91#	4.89*	11.10*
99 - EUFAULA WWTP / MILE = 218 (NO DATA) - USE LANETT WQ	2.48*	10	0.7	0.59*	7.33*	2.70*	7.73*
100 - PHENIX CITY (NO DATA) USE EAST ALABAMA WWTP	2.49*	5.81	1.73	2.09	4.45	3.61	16.17
105 - GRIFFIN	1.35*	10	1.77*	1.85*	7.18*	6.12*	7.51*
112 - ALBANY - JOSHUA ST	18.12*	10	0.99*	1.21*	6.17*	6.18*	7.61*
114 - DECATUR COUNTY INDUSTRIAL	0.55*	6.4#	0.45*	0.31*	3.67*	3.85*	4.22*
115 - MERC & CO.	1.34*	2.0#	5.1#	20.2#	2	57.95*	140.10*
116 - BAINBRIDGE WWTP / MILE = 148	1.12*	10	0.97*	7.65*	7.02*	10.53*	10.59*
117 - BLAKELY WPCP	1.17*	10	1.01*	0.48*	7.04*	3.80*	5.67*
118 - FLORIDA STATE HOSPITAL (OLD DATA)	0.62	10	0.7	1	5	5	5
119 - MONTEZUMA WWTP	0.84*	10	2.47*	0.73*	5.26*	22.39*	22.92*
120 - LOCKHEED	1.66*	8.6#	0.27*	0.03#	7.93*	2.87*	3
121 - FARLEY NUCLEAR PLANT	83.99*	0.5#	0.15#	0.2	5	4	4
124 - MILLER BREWERIES	1.86*	27.7#	7.2#	0.71#	7.24*	20.17*	10.48*
125 - OPELIKA EASTSIDE WWTP	0.69*	9.52*	9.24*	2.03*	7.90*	4	4.21*
126 - SOUTHERN POWER COMPANY	1.63*	4.7**	0.1**	0.6**	5	5	5.1#
127 - GREAT SOUTHERN PAPER CO.	47.31*	1	0.3	4	5	24.94*	30.98*

*Monthly averages used – overall average is listed

**Monthly averages of limited data used – overall average is listed

Based on most recent monitoring data

All other values default or referenced to original PIPES data

Table 2.5 Example monthly flow and water quality values for R. M. Clayton.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avg
Flow (mgd)	80.2	83.7	83.2	80.2	78.7	80.0	80.3	77.7	76.2	72.3	74.6	74.8	78.5
Total P, mg/L	0.270	0.277	0.181	0.205	0.181	0.211	0.194	0.227	0.187	0.194	0.227	0.239	0.217
NH3-N, mg/L	1.600	1.627	1.388	1.131	0.854	0.592	0.366	0.267	0.255	0.643	0.810	0.831	0.864
DO, mg/L	7.7	7.8	8.0	7.0	7.5	7.3	7.2	7.1	7.2	7.4	7.2	7.2	7.4
BOD5U/TSS, mg/L	4.85	5.08	3.76	4.47	2.84	3.28	3.19	3.29	3.26	3.08	4.45	3.46	3.75

2.3.3 METEOROLOGICAL DATA AND TRIBUTARY WATER TEMPERATURES

2.3.3.1 Water Quality Monitoring

Water quality in the ACF Basin is monitored by a number of federal, state, and local agencies as well as by industries for compliance with standards. Table 2.4 summarizes water quality conditions along the main-stem rivers in the ACF Basin using data collected by the states of Alabama, Georgia, and Florida as part of their monitoring efforts. States use their monitoring data to make decisions about violations of water quality standards. These data were used in this EIS to develop the HEC-5Q water quality model of the ACF Basin.

2.3.4 HISTORICAL METEOROLOGICAL DATA AND TRIBUTARY WATER TEMPERATURES

Meteorological data were developed for a five year period (1984–1989) during a previous effort using three-hour observations of wind speed, cloud cover, air temperature and dew point (or wet bulb) temperature. These data were provided for Class A National Weather Service (NWS) stations throughout the ACF watershed. Daily average equilibrium temperature, heat exchange rate, wind speed and solar radiation were computed for nine data zones for model input. These daily values were downscaled to 6-hour values using typical diurnal variations because diurnal variations are often important and daily time steps (used in previous ACF applications) cannot capture these variations. Therefore, a six hour time step data set was developed that included 6-hour meteorology data (heat exchange parameters) and revised model coefficients.

Normally, six-hour heat exchange inputs are generated from short interval air temperature, relative humidity, wind speed and solar radiation. However, because sufficient one-hour data are unavailable, the 24-hour average heat exchange parameters were downscaled based on typical diurnal variations. Figure 2.8 is an example of the typical and downscaled equilibrium temperature. The exchange rate was downscaled such that the 24-hour and six-hour data produced the same end of day computed water temperature.

The current effort requires a water quality model that is capable of simulating part or all of the 1939–2011 hydrologic period. Detailed meteorological data of the type required to compute model inputs do not exist for the entire period.

Extrapolation of model inputs for the 2001–2011 study period was based on 2000–2011 National Weather Service (NWS) daily maximum and minimum air temperature data. This approach assigns model inputs for each day of the extrapolation period based on the similarity of the temperature extremes and precipitation in the 1984–1988 record. As an example, data with the best match of the temperature extremes and precipitation within two calendar days before or after the NWS calendar date could be selected. Thus up to seven days from each of the five years of model input data (a total of 35 days) would be available for assignment to each day of evaluation period.

Specification of water surface heat exchange data requires designation of 'meteorological zones' within an area. Meteorological zones may represent data from a single weather station or a combination of two or more stations. Each control point within the system or sub-system used in temperature or water quality simulation must be associated with one of the defined meteorological zones. Within a river basin, it may be appropriate to apply different atmospheric conditions over different regions. Reasons for defining more than one meteorological zone within a system include availability of data, and variations in topography and vegetation within a region.

Data from four meteorological zones in the ACF basin were used to compute water temperatures in tributary streams in each basin, as shown in Table 2.6. Water temperatures were approximated based on an equilibrium temperature assumption, i.e., the water temperature at which the net heat flux across the air-water interface is zero.

Table 2.6. Meteorological data sources for the ACF basin

Met Zone	River	Latitude of Met data application	Met station data source (specified by location)
1	Apalachicola River	up to 30.6°	Average of Tallahassee, FL and Columbus, GA
2	Chattahoochee and Flint Rivers	up to Latitude 31.5°	Montgomery, AL
3	Chattahoochee and Flint Rivers	Latitude 31.5° to 33.2°	Columbus, GA
4	Chattahoochee and Flint Rivers	Latitude 33.2° and above	Atlanta, GA

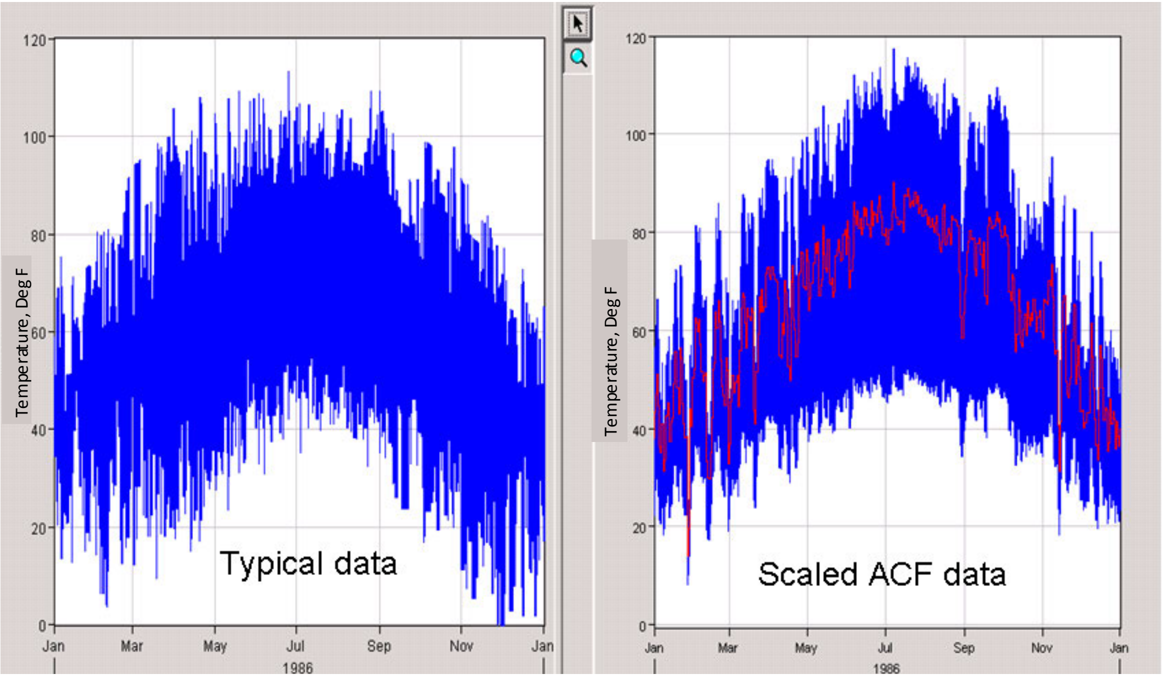

Figure 2.8 Typical and downscaled 6-hour equilibrium temperature (red line is the 24-hour data).

2.4 WATER QUALITY SIMULATIONS

Water quality simulations were performed using a six hour time step, with a 5-year simulation period for each of the demand levels specified, i.e., 1995, 2020, and 2050. The results were reported as daily averages. For each 5-year simulation, 1984–1988 meteorological and hydrologic data were used together with the point and non-point source data described previously. The following water quality constituents were simulated:

The following parameters were simulated for the ACF basin:

- Water temperature
- Dissolved oxygen (DO)
- 5-Day Uninhibited carbonaceous BOD (BOD5U)
- Nitrate as Nitrogen (NO_3-N)
- Ammonia as Nitrogen (NH_3-N)
- Phosphate as Phosphorous (PO_3-P)
- Municipal and Industrial Wastewater as Percent of Flow
- Phytoplankton reported as Chlorophyll *a*

2.4.1 CLIMATE CHANGE

The HEC-5Q ACF model was used to simulate water quality for the Proposed Action Alternative using climate-change-projected flows and air temperatures for three sets of hydrologic conditions. Projected incremental local flows were derived by the USACE Institute of Water Resources (IWR, 2014). The IWR climate analysis included a set of readily available hydrologic projection data developed by USACE in cooperation with the National Center for Atmospheric Research (NCAR), as well as utilizing and leveraging cooperative analysis performed with the Department of Interior Bureau of Reclamation and US Geological Survey, Lawrence Livermore National Laboratory, Santa Clara University, Climate Central, and Scripps Institution of Oceanography. The hydrologic projections utilized numerical model outputs from the Coupled Model Intercomparison Project, phase 5 (CMIP5) organized by the World Meteorological Organization.

Climate change impacts were projected for two time periods: 2021–2050 and 2060–2090. Delta values were calculated relative to the equivalent 30 year antecedent period 1970–1999. The comparison of projections to modeled antecedent conditions was the basis for assessing the impacts of the potential future hydrologic conditions of the ACF. The 10th, 50th, and 90th (Q1, Q2, and Q3) quantiles were selected as analogs for the "Dry", "Median", and "Wet" hydrologic conditions for each future time period. Monthly scaling factors were developed for each month, each quantile, and each future time period. Therefore, six different monthly scaling factors were applied to the unimpaired incremental local flows (1978–2008) to estimate the climate change flows. Further details can be found in IWR (2014).

The 2021–2050 period was selected for analysis of the Proposed Action Alternative with HEC-ResSim and HEC-5Q. The ResSim ACF model was computed using the incremental local flows derived for the three hydrologic conditions (Q1, Q2, and Q3) for this period. These three scenarios are referred to as Dry (2050-Q1), Avg (2050-Q2), and Wet (2050-Q3). Climate model air temperature projections for the ACF were taken from the corresponding climate model output.

The input meteorological data set for the HEC-5Q ACF model was derived using an extrapolation procedure. For each climate scenario, the climate-change-projected air temperature for that day was used to locate the most similar record from the 1984–1988 period. The meteorology from that record was then used as input to the HEC-5Q ACF model. The rationale for this approach is that the meteorology can be characterized by the air temperature extremes. Through this process, different days are generally selected for the historical and climate change conditions.

This process results in a meteorological record that does not represent a uniform temperature increment. Many climate change studies suggest that future meteorological conditions will become more varied with larger extremes. This extrapolation approach adds variability (noise) to the model input data.

This climate change analysis did not use projected changes in radiation budget and wind forcing that could be associated with climate change. Full-scale climate modeling, analyzing multiple possible scenarios, may better characterize the overall response of water quality to the expected composite change in forcings in each of several scenarios.

3 DEMONSTRATION OF MODEL PERFORMANCE

Extensive comparison of modeled and observed time series (streams) and profiles (reservoirs) was performed on the HEC-5Q ACF model. Since ResSim flows differ from actual historical flows, this comparison is not referred to as model validation, but it represents the same process. In addition, a model sensitivity analysis was performed, as detailed in Appendix B. For model performance demonstration, the point source and non-point source water quality described in section 2.3 was assumed. Constituents chosen for presentation of model demonstration results include temperature, dissolved oxygen (DO), nitrate (NO3), ammonia (NH3), phosphate (PO4) and chlorophyll *a*. Nutrient and chlorophyll *a* data are typically available at monthly intervals during the spring, summer and fall months (growing season) and represent conditions in the photic zone.

3.1 RESERVOIRS

Model performance demonstration results for reservoirs are shown in Figure 3.1 through Figure 3.21. Computed and observed temperature and DO profiles are provided for Lake Lanier (Buford), West Point Reservoir and W. F. George Reservoir. Observed data are available at mid-lake and forebay locations in each reservoir. Profiles are primarily provided for the years 2004, 2005, 2006 and 2007. Each figure contains six profiles. The year 2004 ("normal" hydrology) and 2006 figures begin with the first available profile (April) to demonstrate the stratification progression. The year 2007 ("dry" hydrology) figures end with the last available profile to demonstrate the stratification progression beyond September. Dissolved oxygen plots follow the temperature plots by reservoir to facilitate comparison of DO with temperature stratification.

For the 1-D vertically segmented reservoirs, there is only one profile result to compare with observed data. Observed data, however, are often available at multiple locations within a reservoir for the same date. Lake Lanier was the only 1-D vertically segmented reservoir in the HEC-5Q model of the ACF.

For longitudinally segmented reservoirs, West Point and Walter F. George, computed data are plotted at the dam and mid-lake locations to give the best comparison with data from multiple locations. The observations and model results that extend to the greatest depths are closest to the dam. Each figure contains 6 vertical profiles with the earliest profile representing conditions in April. The sequence of the remaining profiles shows a typical seasonal progression.

Figure 3.1 through Figure 3.3 show the computed and observed temperature profiles for Lake Lanier (Buford). Computed temperatures tend to be slightly higher than observed in the hypolimnion, but otherwise the model does an excellent job of representing the seasonal progression of thermal stratification seen in the observed data.

Computed and observed DO profiles in Lake Lanier are plotted in Figure 3.4 through Figure 3.6. Observed data show large DO differences between the two observation locations. The two surface concentrations and model surface concentration are comparable at all times. Several plots exhibit characteristics of phytoplankton production and respiration. The July plot of Figure 3.4 shows two distinctly different observed profiles. The DO suppression at elevation 1,040' is typical of phytoplankton respiration below the photic zone while the other suggests photosynthesis at that level. The model exhibits the influence of respiration. The seasonal progression to anoxic conditions at the reservoir outlet elevation (940') is reasonably well represented. The resulting downstream DO, which is the primary focus, confirms the seasonal progression is adequately represented for the purposes of the modeling analysis.

Computed and observed temperature profiles in West Point Reservoir Figure 3.7 through Figure 3.9) are plotted at mid-lake and forebay locations. The mid-summer profiles consistently show less stratification than observed, however the date of destratification is approximated. Computed surface temperatures tend to be slightly less than observed. Both the model and observed data have approximately the same longitudinal variation. The cooler hypolimnion temperatures seen in the observed tends to delay destratification slightly (September 2006 and 2007).

Computed and observed DO profiles in West Point Reservoir (Figure 3.10 through Figure 3.12) are also plotted at mid-lake and forebay locations. The seasonal trends and computed DO profiles tend to be in reasonably good agreement with observed data. The earlier time of model destratification results in an earlier recovery of DO and a corresponding time of DO recovery in the computed release concentration.

W.F. George Reservoir temperature profile results (Figure 3.13 through Figure 3.15) are plotted at mid-lake and forebay locations to correspond with locations and timing of available data. Temperatures are reasonably well represented. Model results tend to show slightly more stratification than observed and also tend to show more variation between the mid-lake and forebay locations than observed. The seasonal trends are well represented.

W.F. George Reservoir DO profile results (Figure 3.16 through Figure 3.18) are plotted at mid-lake and forebay locations to correspond with locations of available data. In spring of 2004 the model results show more variation between the two lake locations than observed. The progression to anoxic conditions at the elevation of the dam outlet (155 ft) is well represented. The August profile shows the impact of thermal destratification timing. The modeled DO reflects weak stratification while the observed reflects a vertically mixed environment. By September 2004, both the model and data reflect a mixed environment. Observed mixing occurred before August 14 while the model mixing occurred after. Since the observed profiles represent snapshots in time, it is not possible to determine the time difference. During 2006, mixing occurred between August 23 and September 20 in both the data and model. During 2007, model mixing was delayed.

Both West Point and Walter F. George Reservoirs are weakly stratified and may destratify and then restratify as weather conditions change. Since the model meteorology was developed to represent seasonal variations and not actual data for a particular day, the focus is the general response of the reservoirs.

Time series of computed and observed chlorophyll *a* in Lake Lanier, West Point Reservoir and W.F. George Reservoir are plotted in Figure 3.19 through Figure 3.21. For each reservoir, observed data are the average of growing area concentrations at two locations within the reservoir.

In Lake Lanier, average computed concentrations in the upper 15 ft of the reservoir are plotted. Data are too sparse to discern clear seasonal trends, however the highest observed values do tend to occur during late summer, whereas the highest computed values occur during late April and early May and are somewhat higher than any observations. The initial computed algal bloom reflects the abundance of nutrients at the beginning of the growing season. Otherwise, the magnitude of computed chlorophyll *a* is in the general range of observed data.

In West Point Reservoir, computed chlorophyll *a* is plotted for the surface layer at mid-lake and forebay locations for comparison with observed data. Observed data are available April through October of each year. Computed values are generally within the range of observed values for most years. During 2003 and 2004 computed values tend to be somewhat lower than observed. Surface variations seen in the observed data are often in response to the timing and location of algal blooms while the model tends to represent a more global response.

In W.F. George Reservoir, computed chlorophyll *a* is plotted for the surface layer at mid-lake and forebay locations for comparison with observed data. Observed data are available April through October of each year. Results are similar to those for West Point. Computed values are generally within the range of observed values for most years. During 2003 and 2004 computed values tend to be somewhat lower than observed. Computed peaks tend to occur in the spring, whereas observed peaks tend to occur during the summer for several of the years.

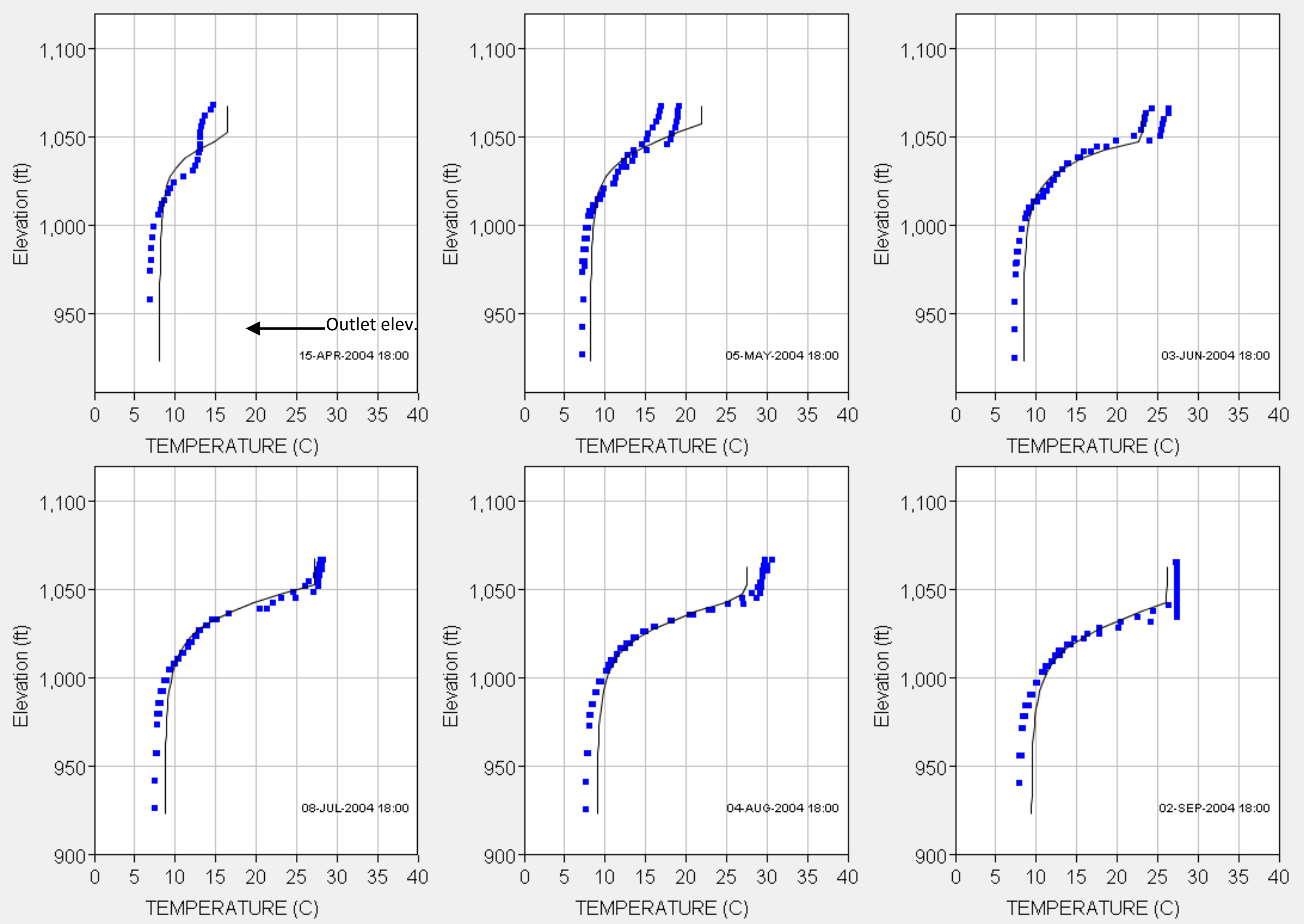

Figure 3.1 Computed and observed temperature profiles in Lake Lanier for dates between April - September 2004. Black line = computed; Blue dots = observed.

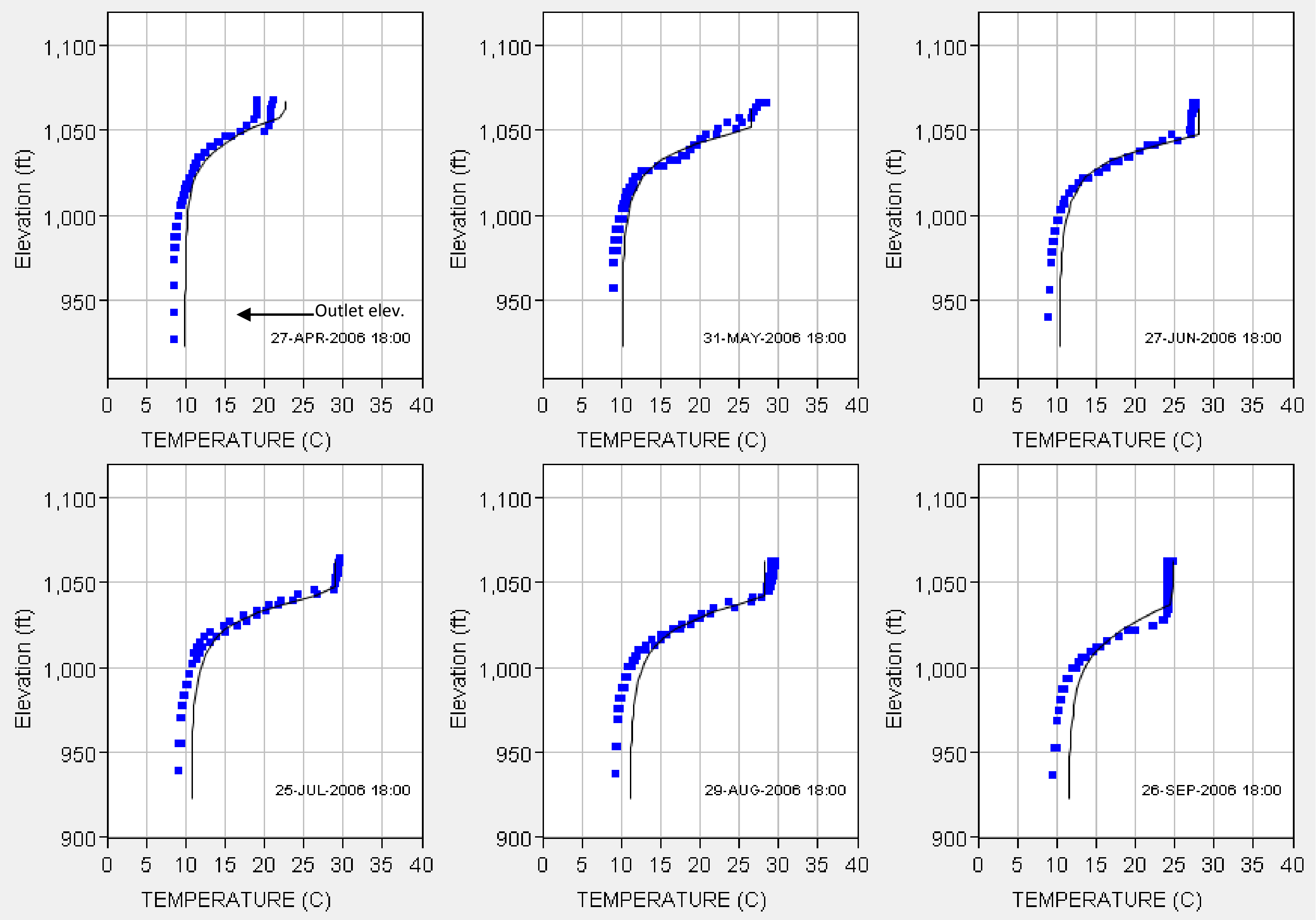

Figure 3.2 Computed and observed temperature profiles in Lake Lanier for dates between April–September 2006. Black line = computed; Blue dots = observed.

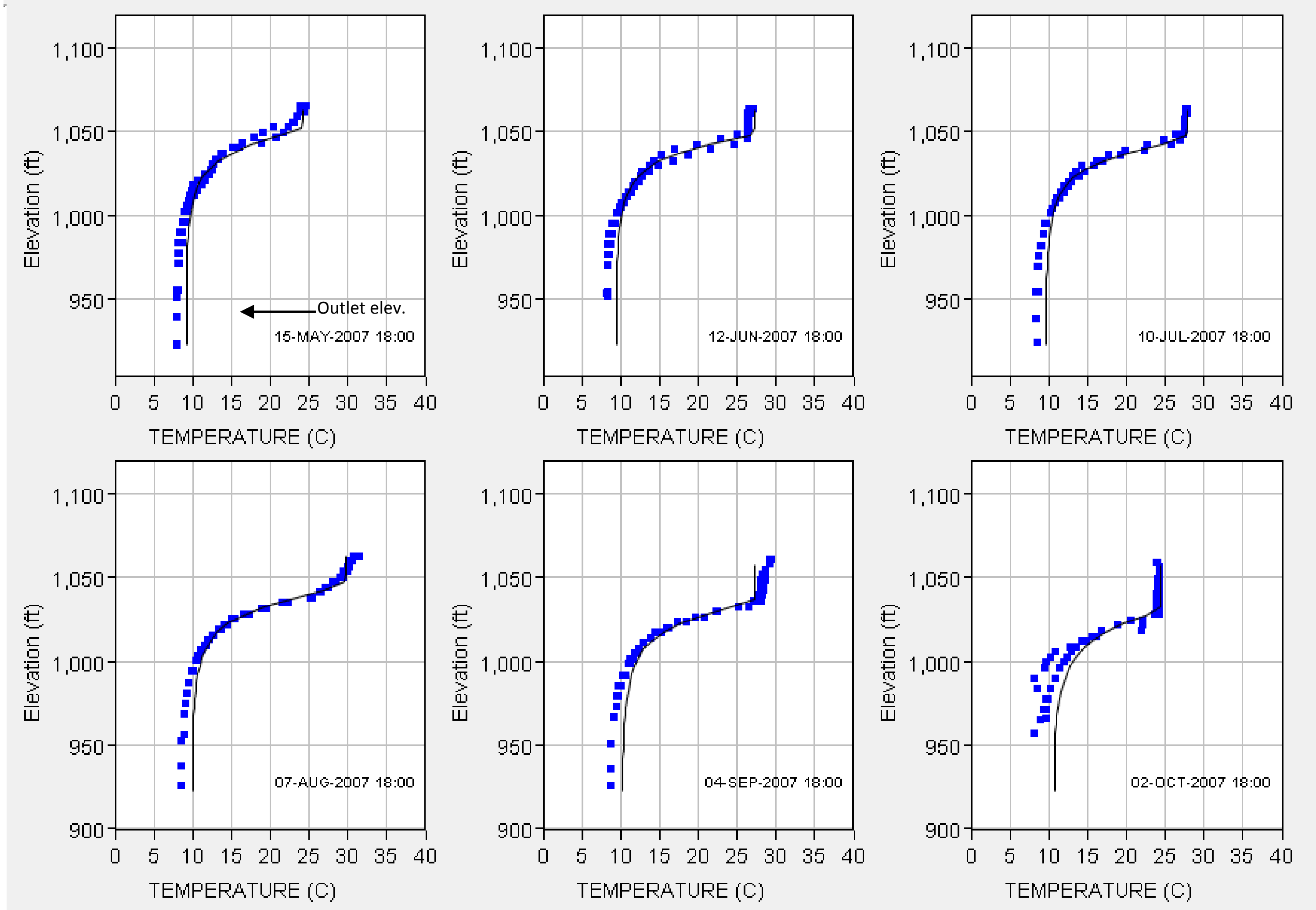

Figure 3.3 Computed and observed temperature profiles in Lake Lanier for dates between May–October 2007. Black line = computed; Blue dots = observed.

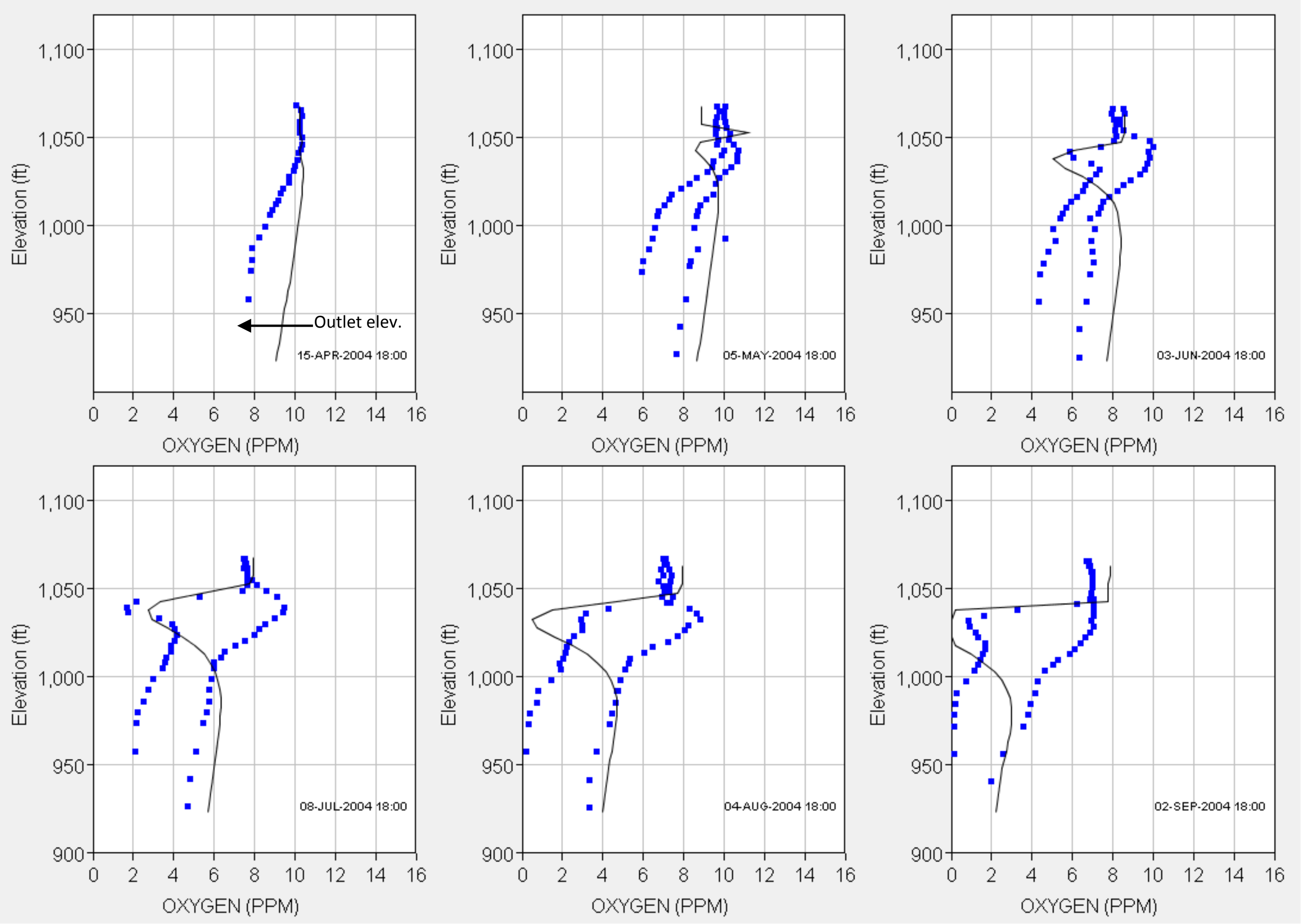

Figure 3.4 Computed and observed DO profiles in Lake Lanier for dates between April–September 2004. Black line = computed; Blue dots = observed.

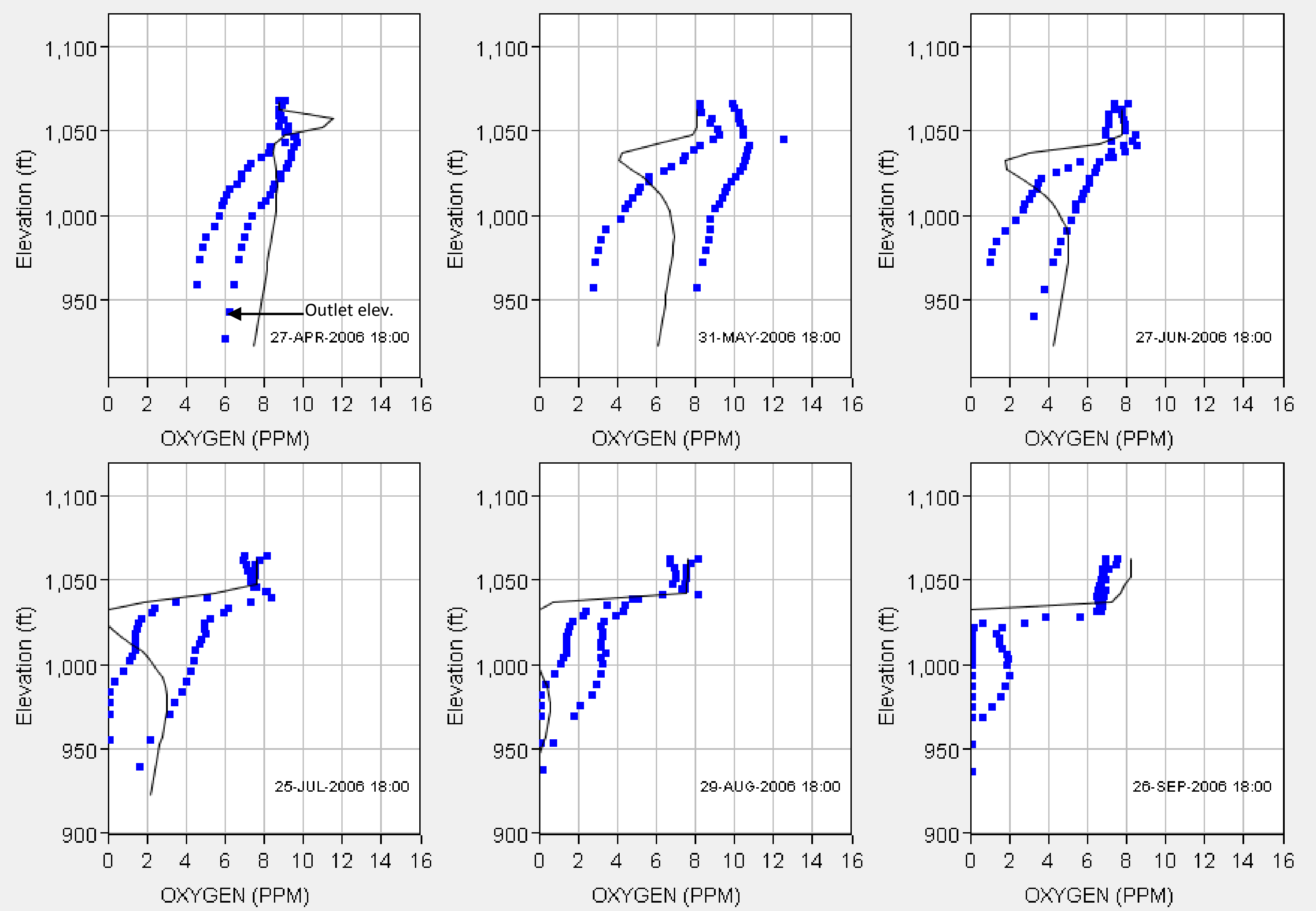

Figure 3.5 Computed and observed DO profiles in Lake Lanier for dates between April–September 2006. Black line = computed; Blue dots = observed.

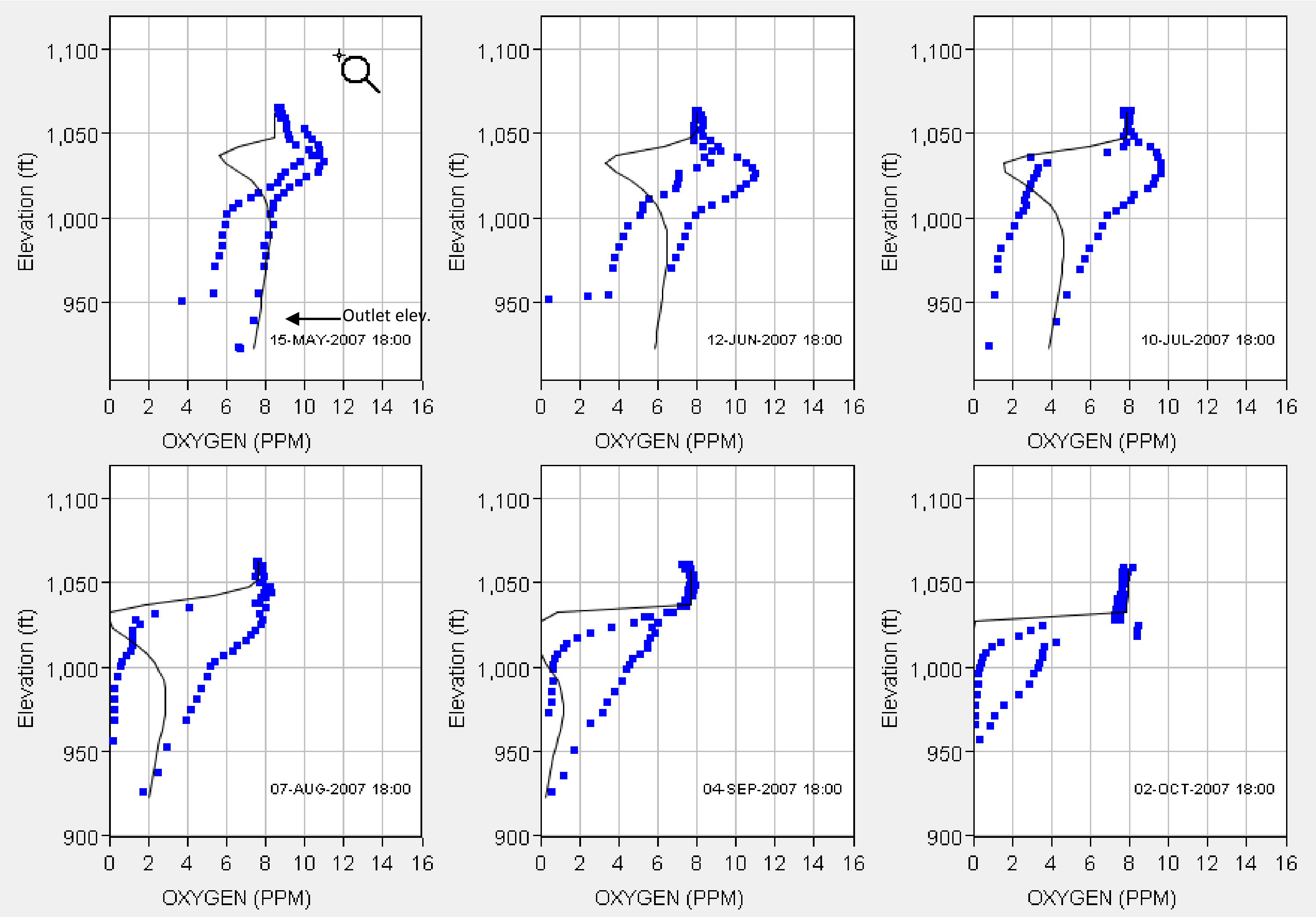

Figure 3.6 Computed and observed DO profiles in Lake Lanier for dates between May - October 2007. Black line = computed; Blue dots = observed.

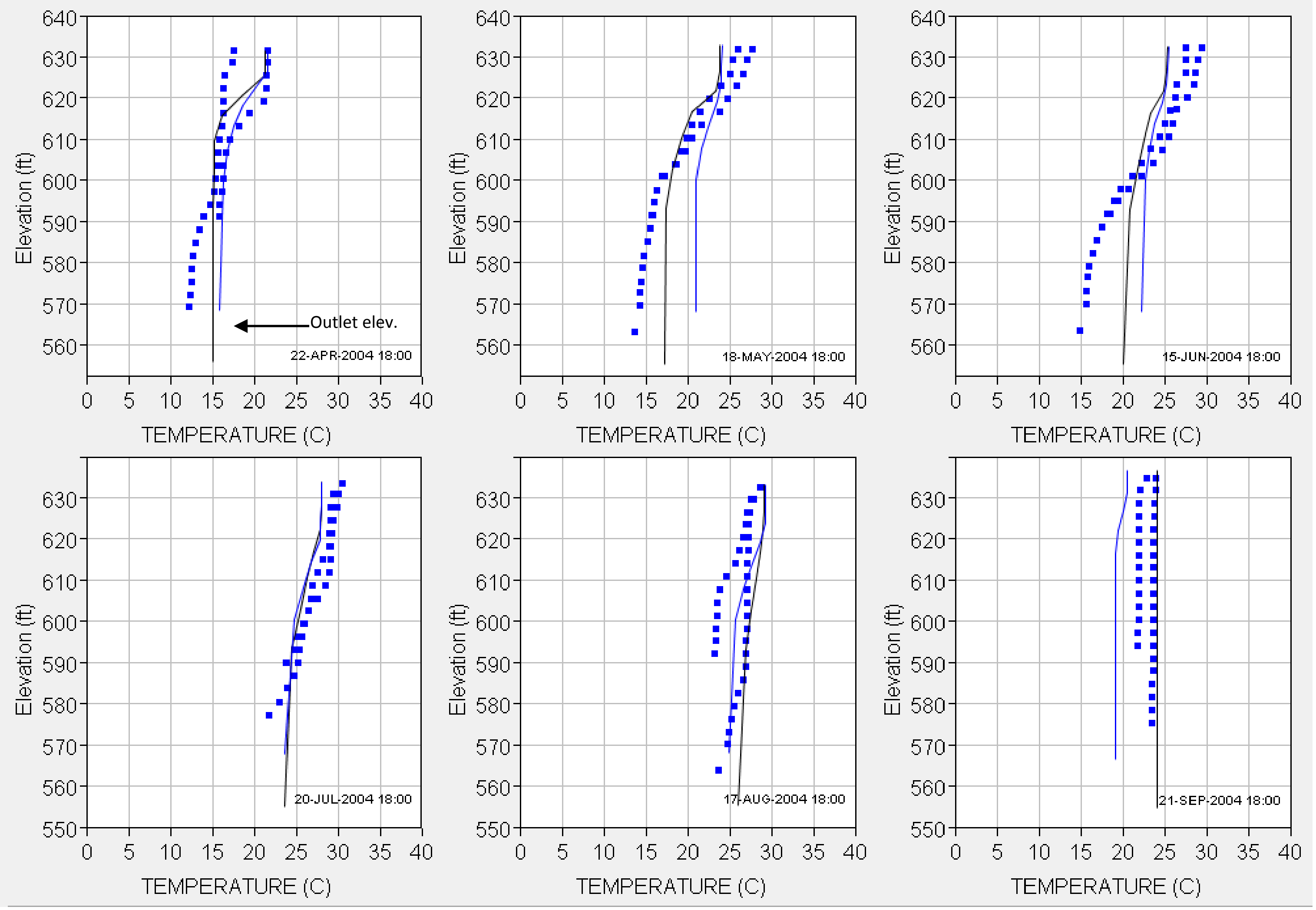

Figure 3.7 Computed and observed mid-lake and forebay temperature profiles in West Point Reservoir for dates between April–September 2004. Black line = computed (dam); Blue line = computed (mid-lake); Blue dots = observed.

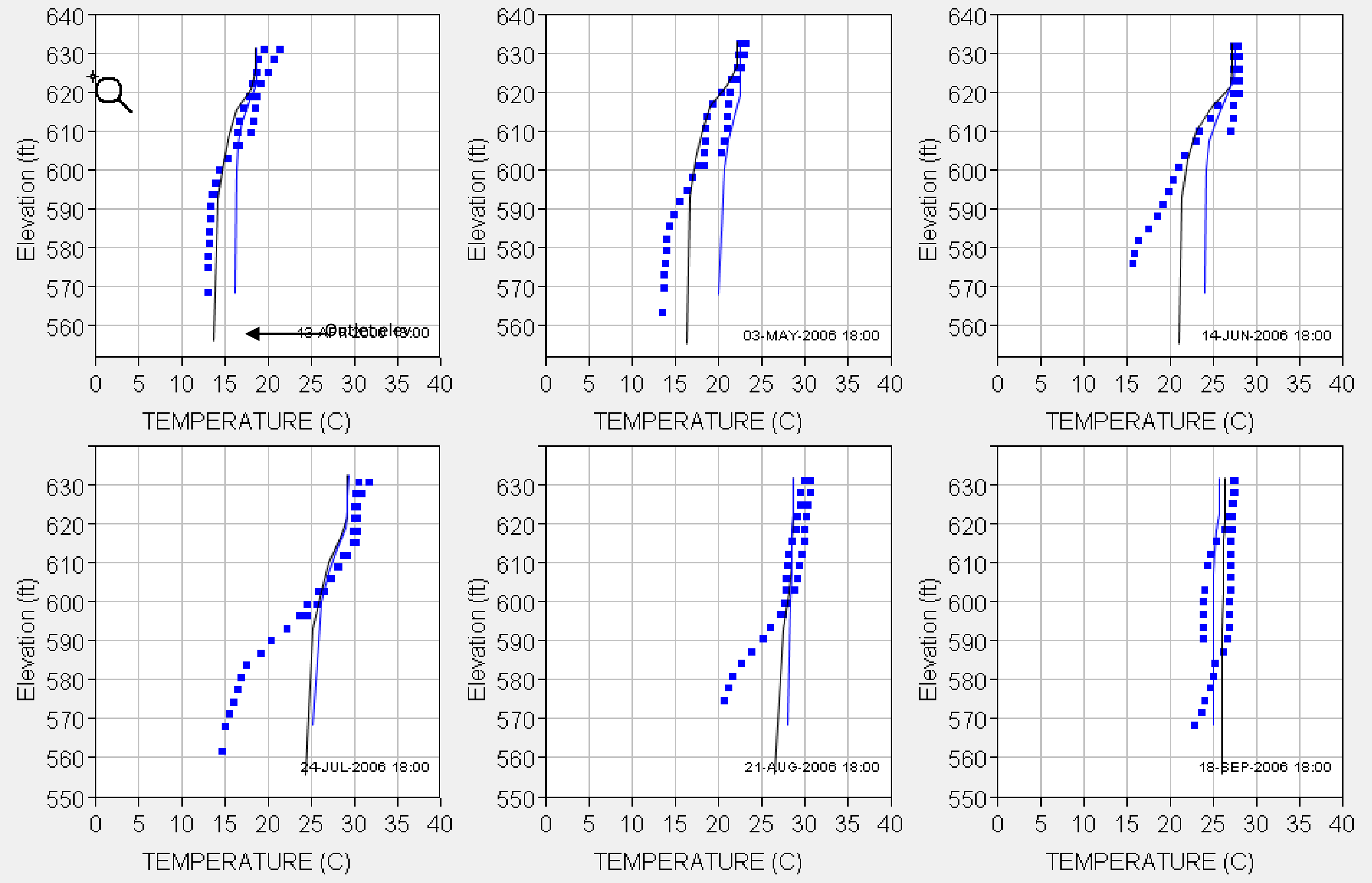

Figure 3.8 Computed and observed mid-lake and forebay temperature profiles in West Point Reservoir for dates between April–September 2006. Black line = computed (dam); Blue line = computed (mid-lake); Blue dots = observed.

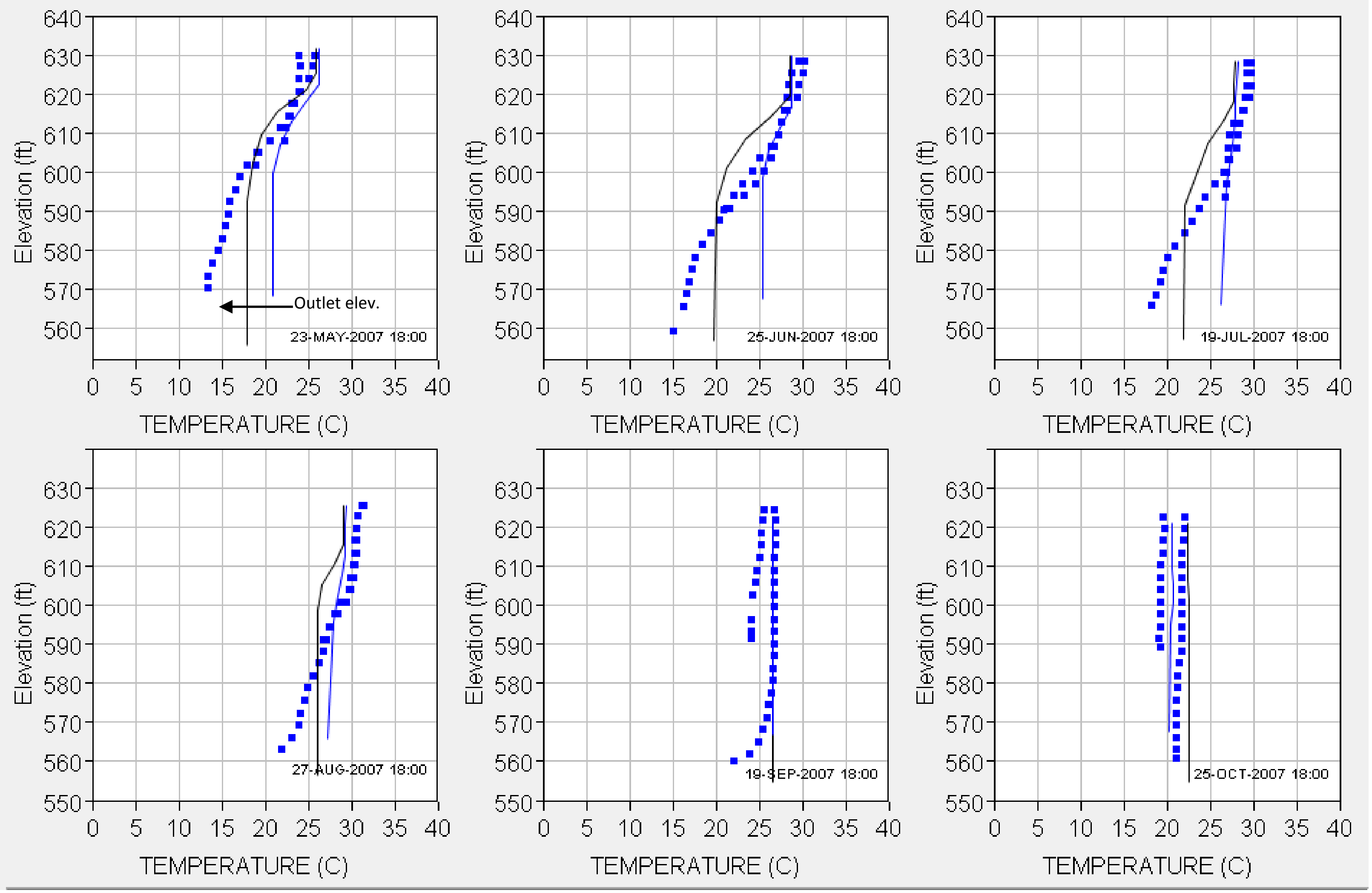

Figure 3.9 Computed and observed mid-lake and forebay temperature profiles in West Point Reservoir for dates between May - October 2007. Black line = computed (dam); Blue line = computed (mid-lake); Blue dots = observed.

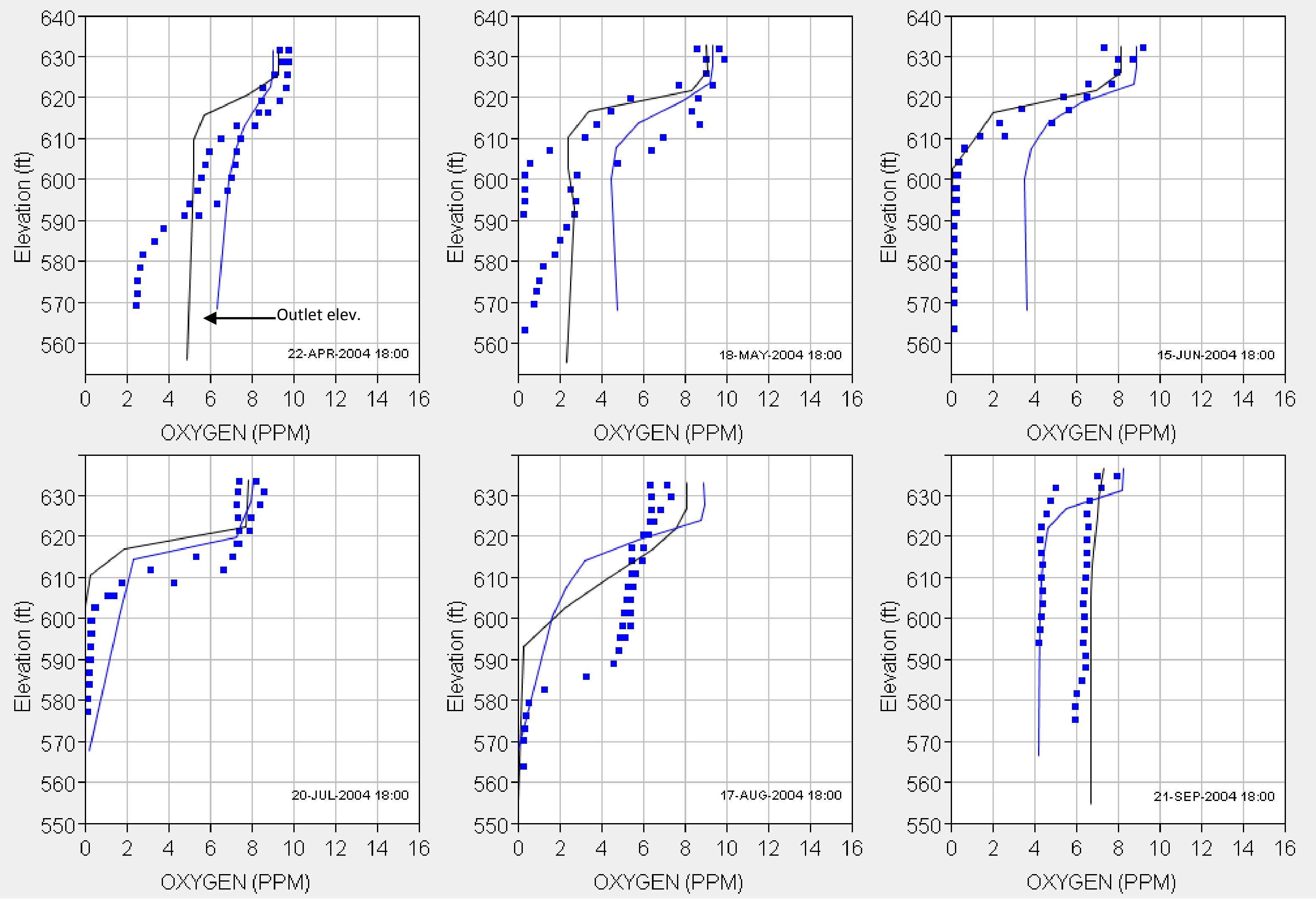

Figure 3.10 Computed and observed mid-lake and forebay DO profiles in West Point Reservoir for dates between April–September 2004. Black line = computed (dam); Blue line = computed (mid-lake); Blue dots = observed.

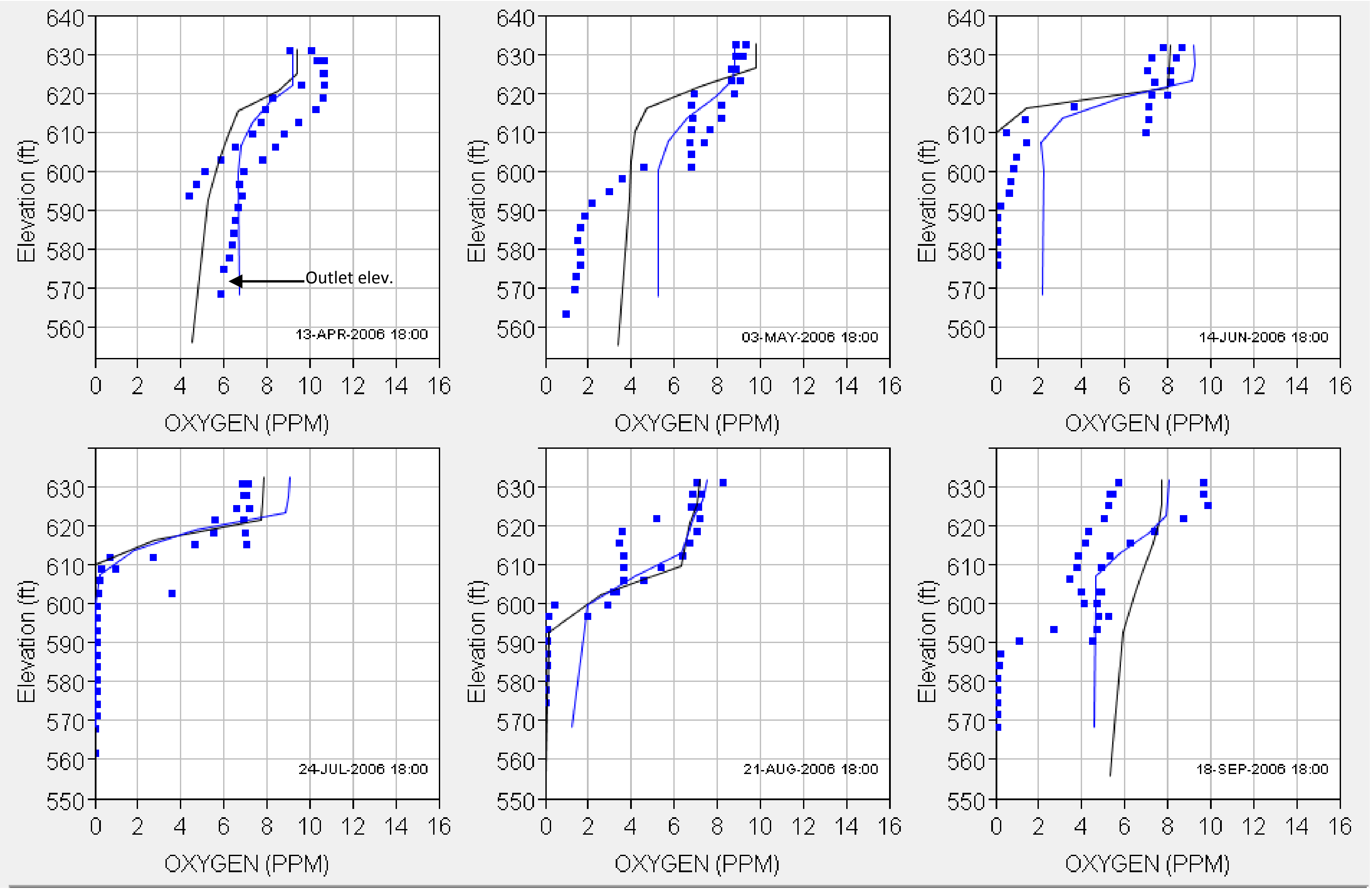

Figure 3.11 Computed and observed mid-lake and forebay DO profiles in West Point Reservoir for dates between April–September 2006. Black line = computed (dam); Blue line = computed (mid-lake); Blue dots = observed.

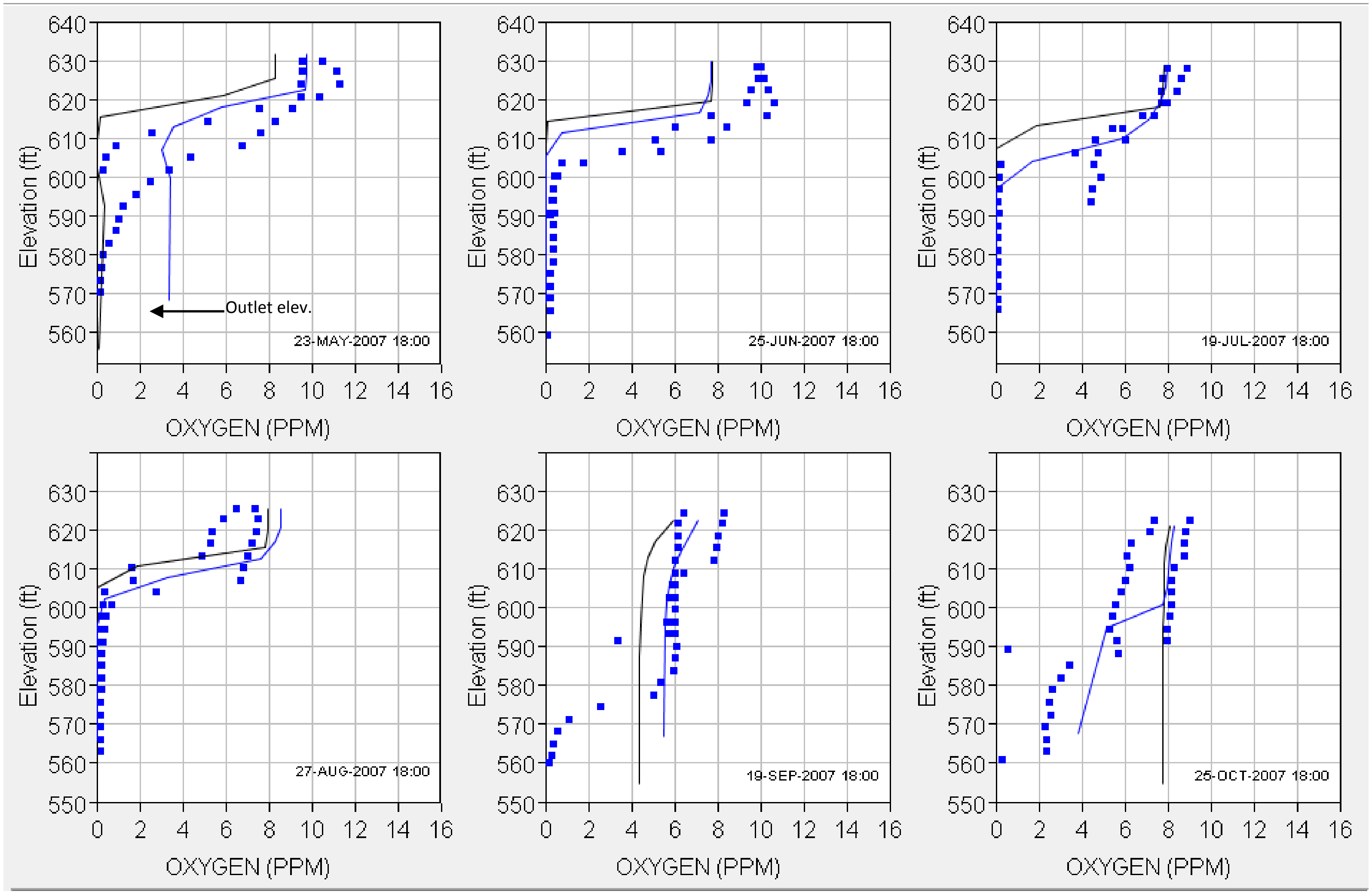

Figure 3.12 Computed and observed mid-lake and forebay DO profiles in West Point Reservoir for dates between May - October 2007. Black line = computed (dam); Blue line = computed (mid-lake); Blue dots = observed.

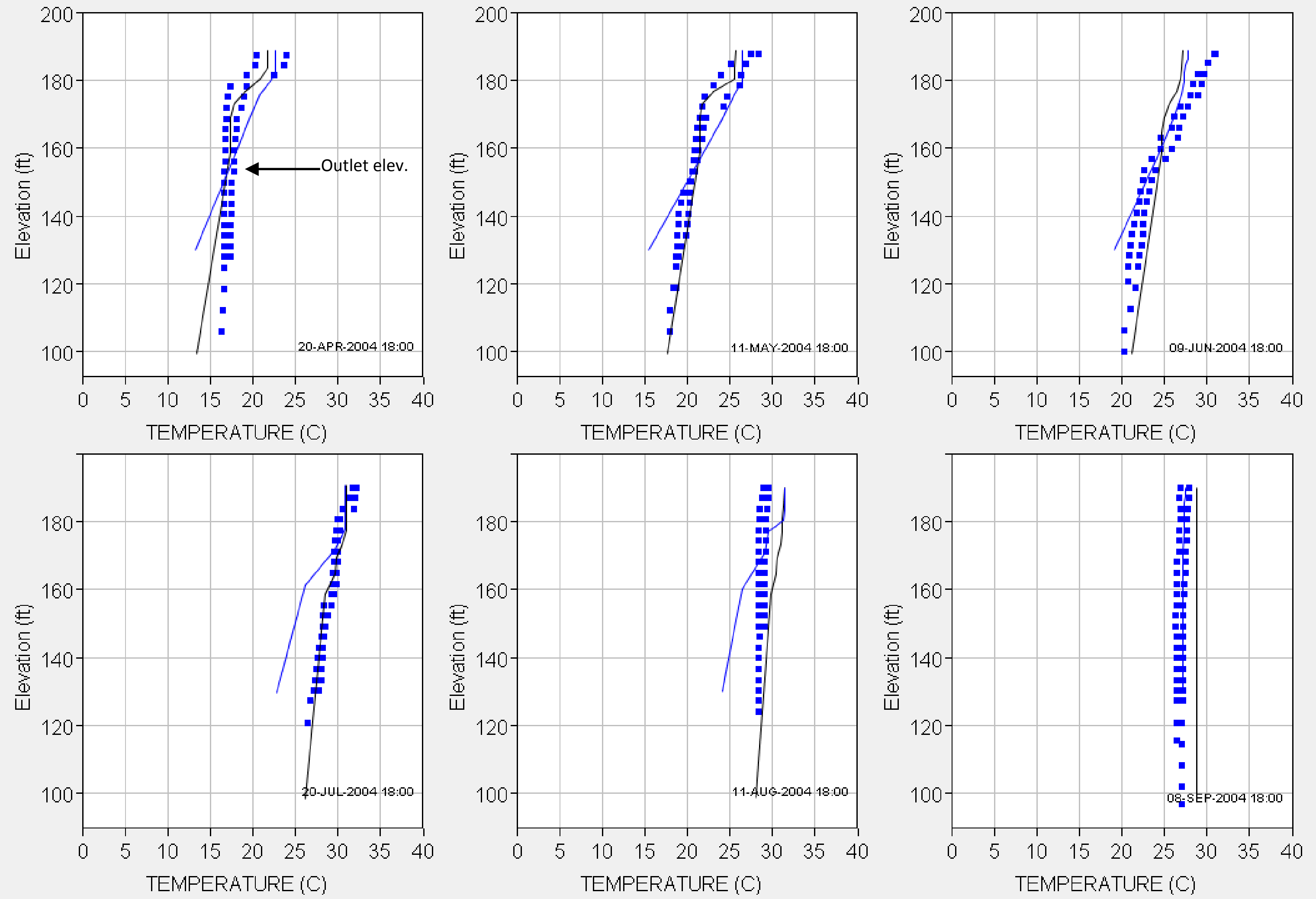

Figure 3.13 Computed and observed mid-lake and forebay temperature profiles in W.F. George Reservoir for dates between April–September 2004. Black line = computed (dam); Blue line = computed (mid-lake); Blue dots = observed.

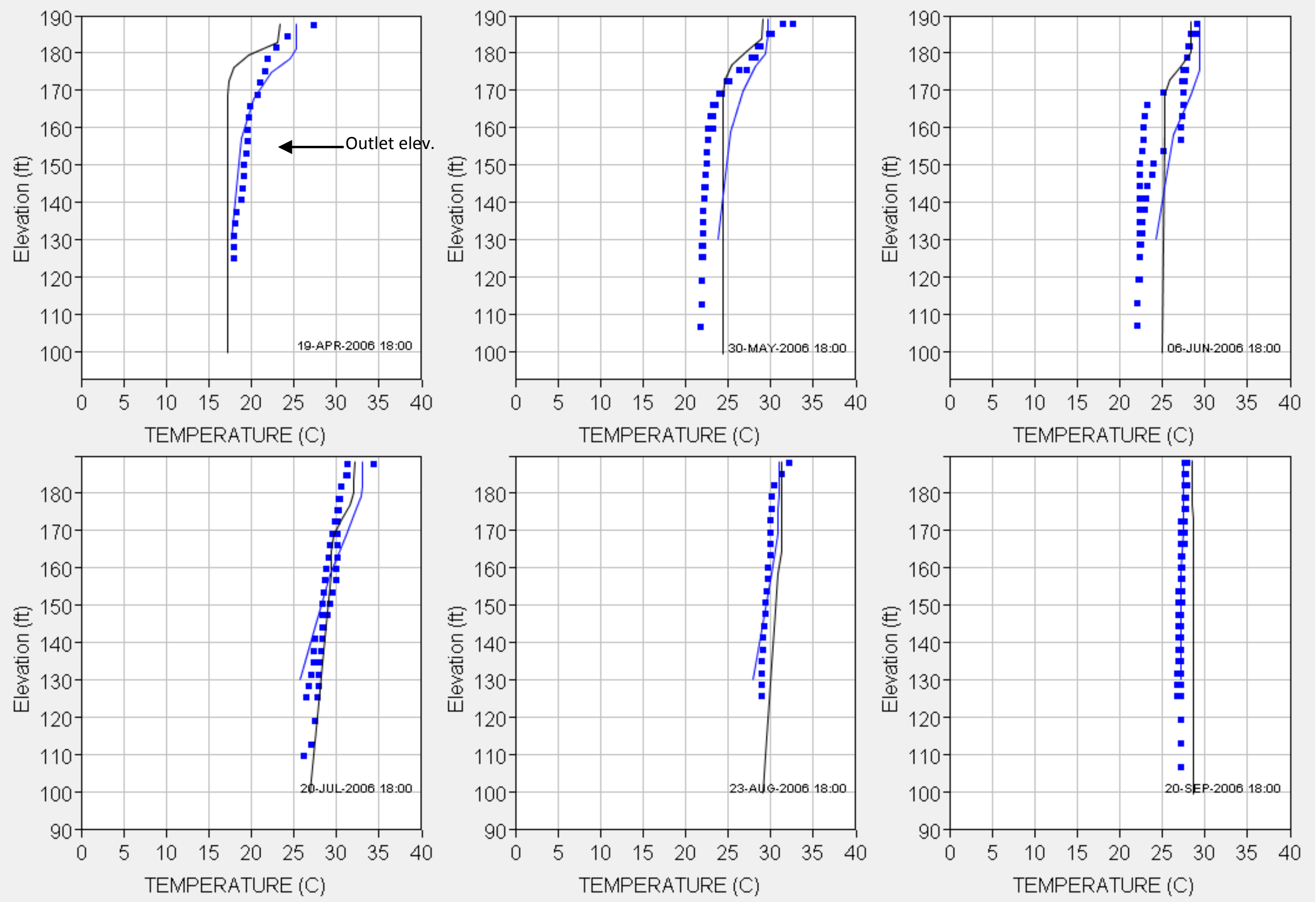

Figure 3.14 Computed and observed mid-lake and forebay temperature profiles in W.F. George Reservoir for dates between April–September 2006. Black line = computed (dam); Blue line = computed (mid-lake); Blue dots = observed.

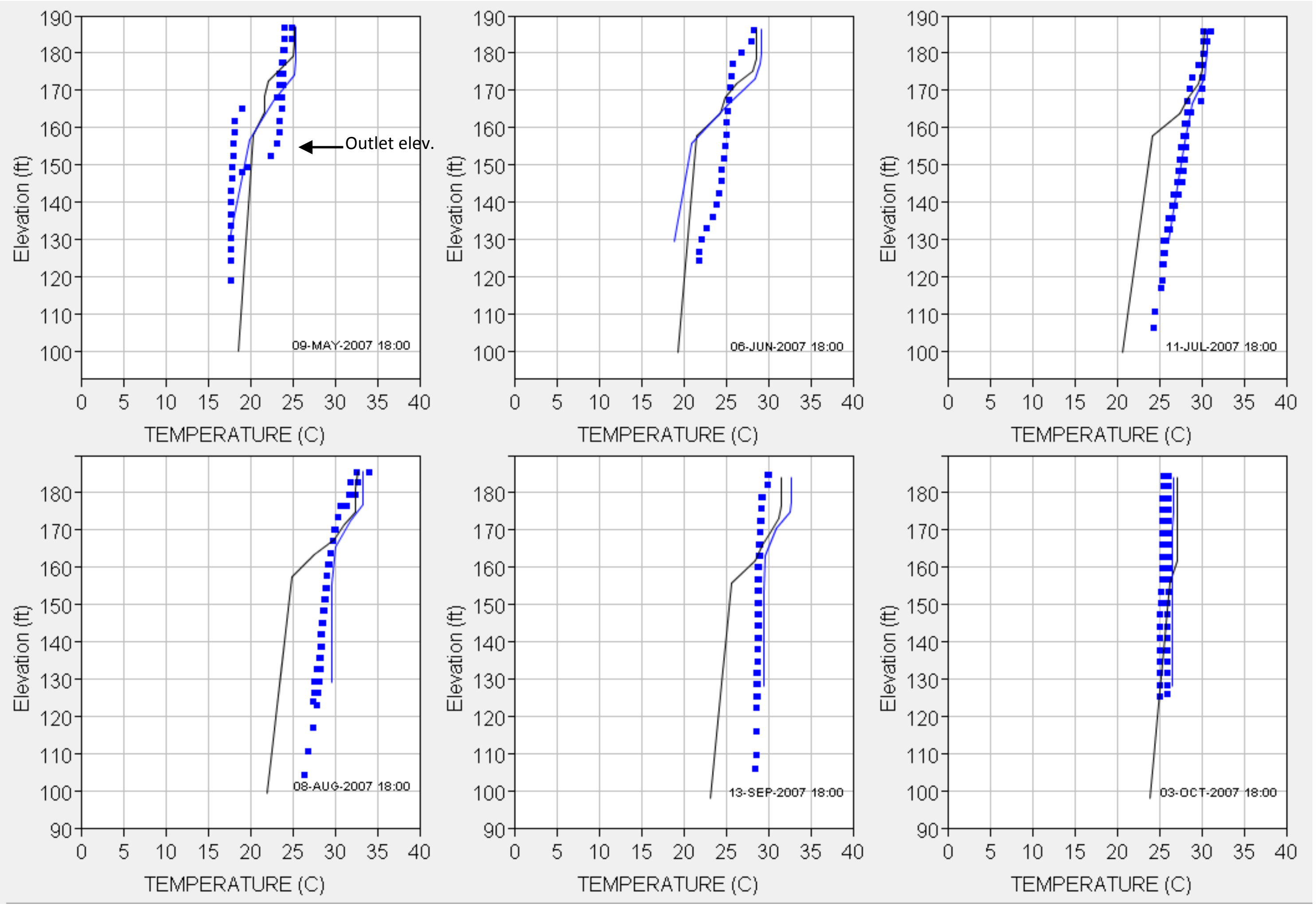

Figure 3.15 Computed and observed mid-lake and forebay temperature profiles in W.F. George Reservoir for dates between May - October 2007. Black line = computed (dam); Blue line = computed (mid-lake); Blue dots = observed.

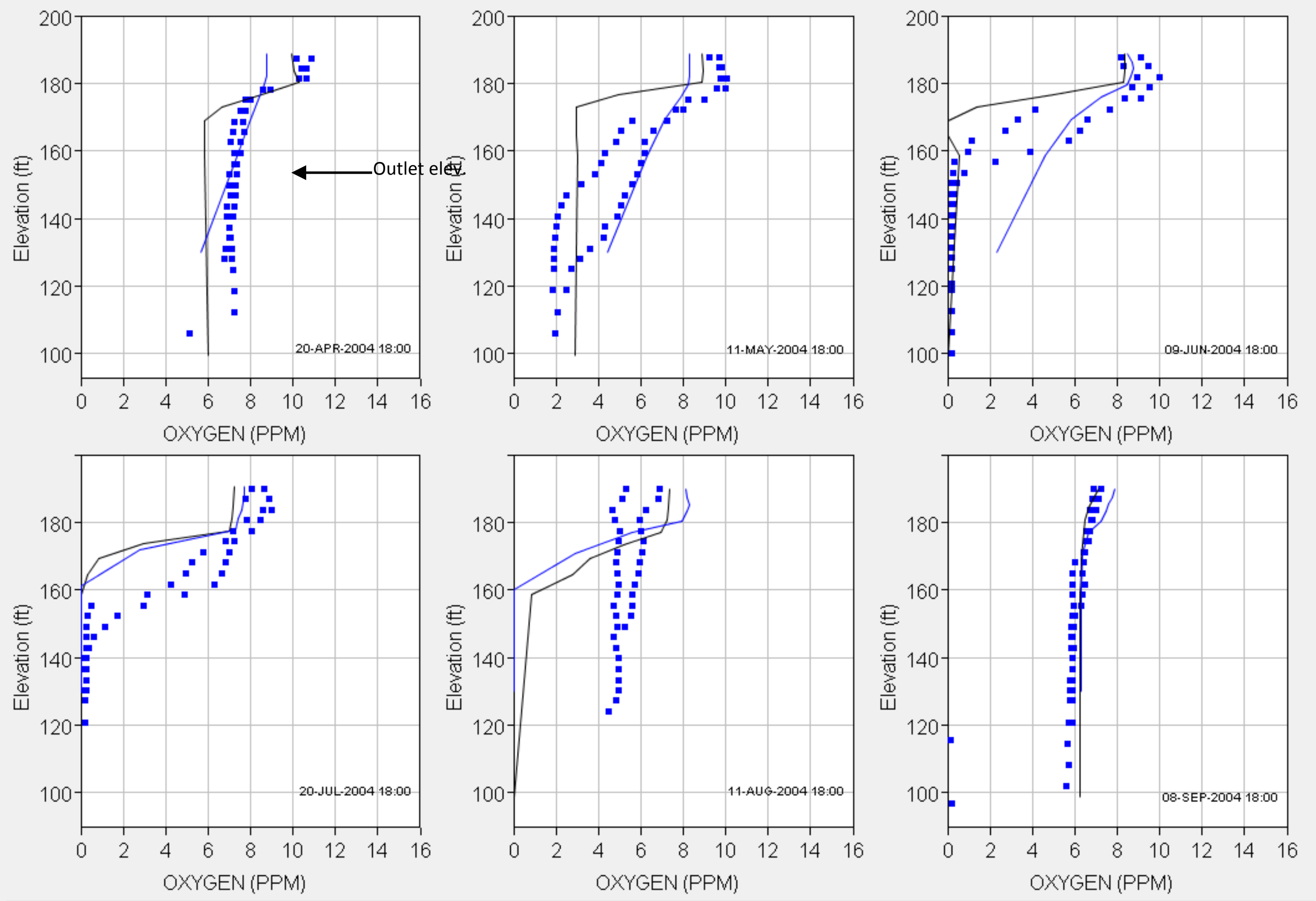

Figure 3.16 Computed and observed mid-lake and forebay DO profiles in W.F. George Reservoir for dates between April–September 2004. Black line = computed (dam); Blue line = computed (mid-lake); Blue dots = observed.

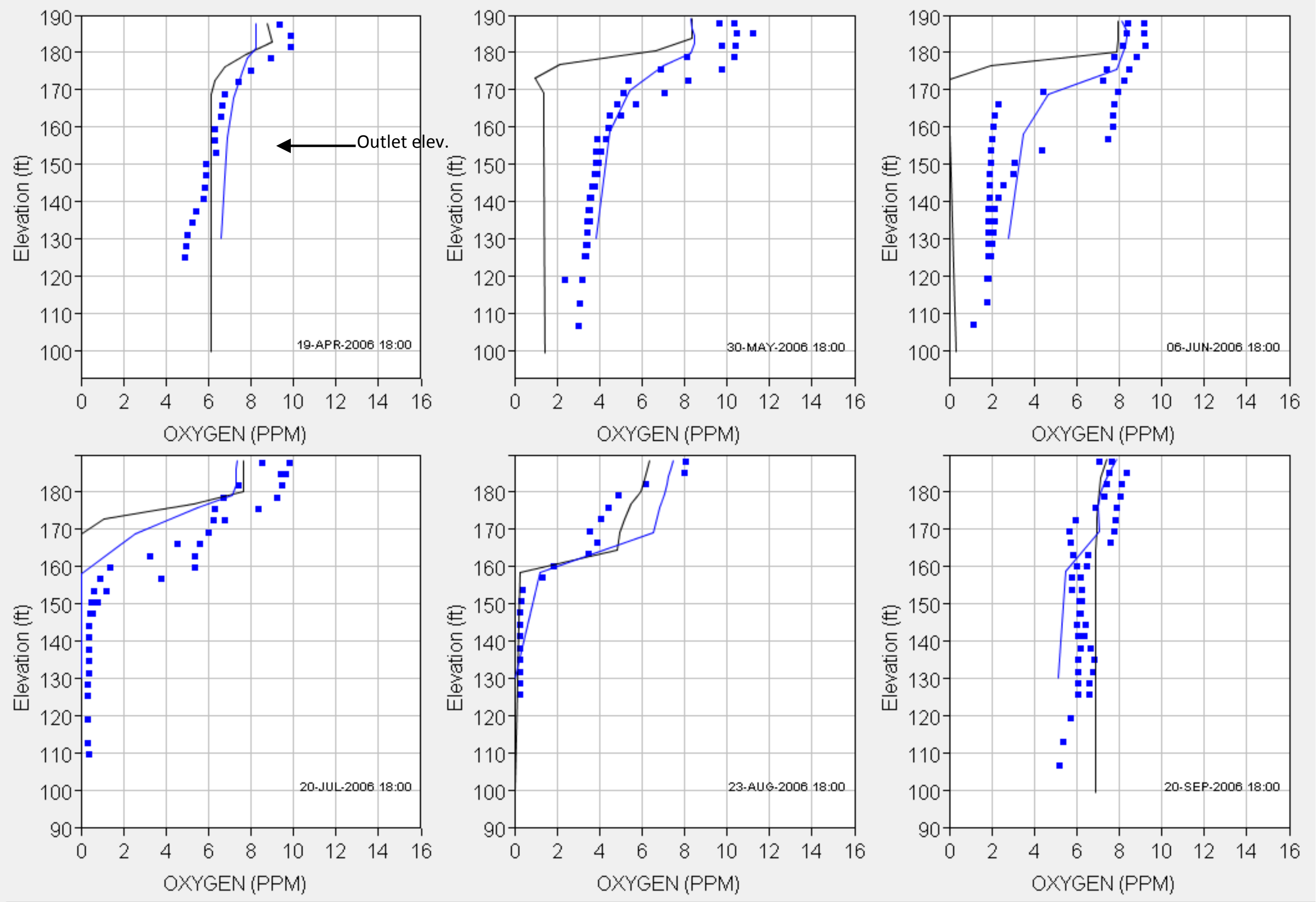

Figure 3.17 Computed and observed mid-lake and forebay DO profiles in W.F. George Reservoir for dates between April–September 2006. Black line = computed (dam); Blue line = computed (mid-lake); Blue dots = observed.

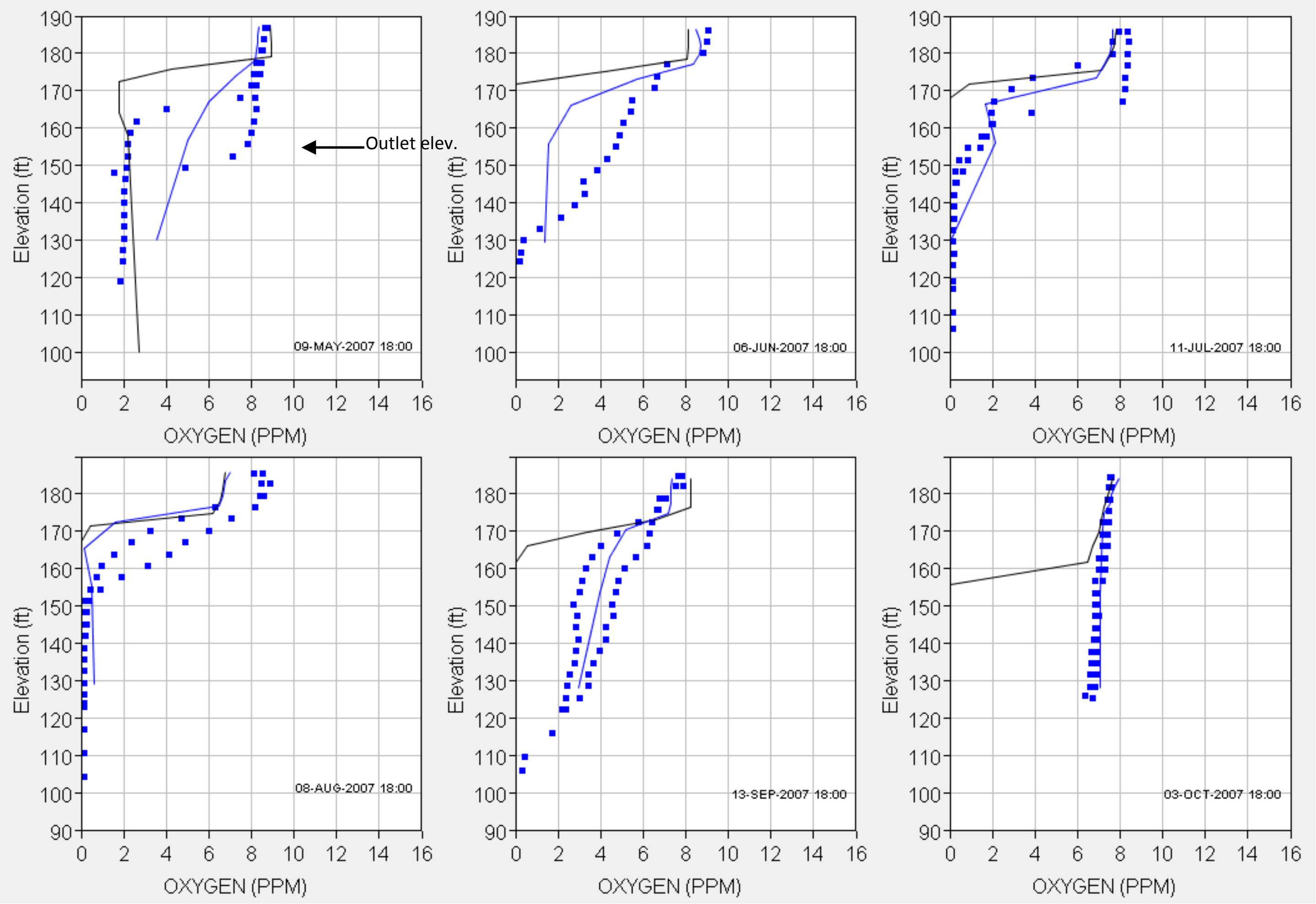

Figure 3.18 Computed and observed mid-lake and forebay DO profiles in W.F. George Reservoir for dates between May - October 2007. Black line = computed (dam); Blue line = computed (mid-lake); Blue dots = observed.

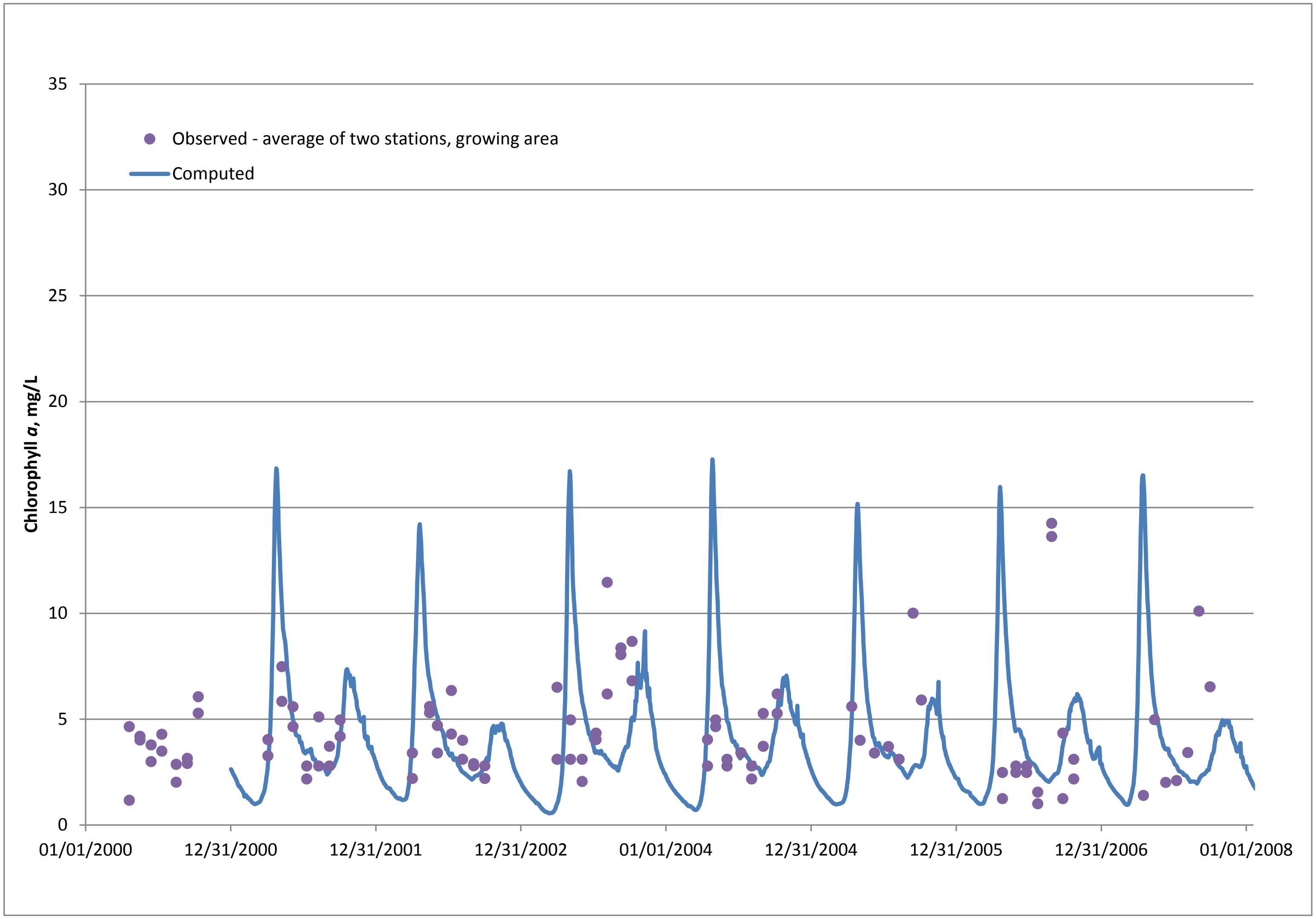

Figure 3.19 Time series of computed and observed chlorophyll *a* in Lake Lanier.

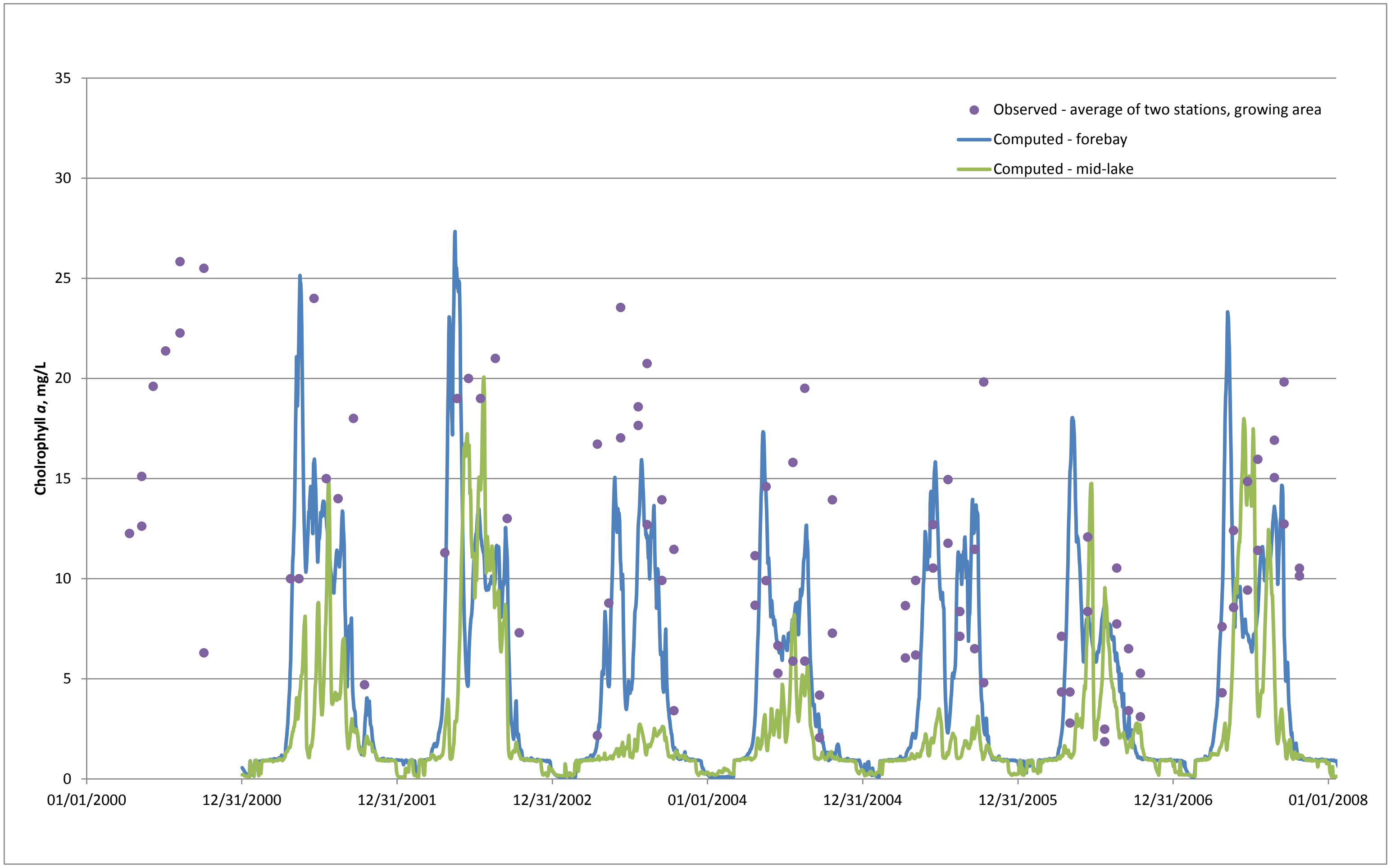

Figure 3.20 Time series of computed and observed chlorophyll *a* in West Point Reservoir.

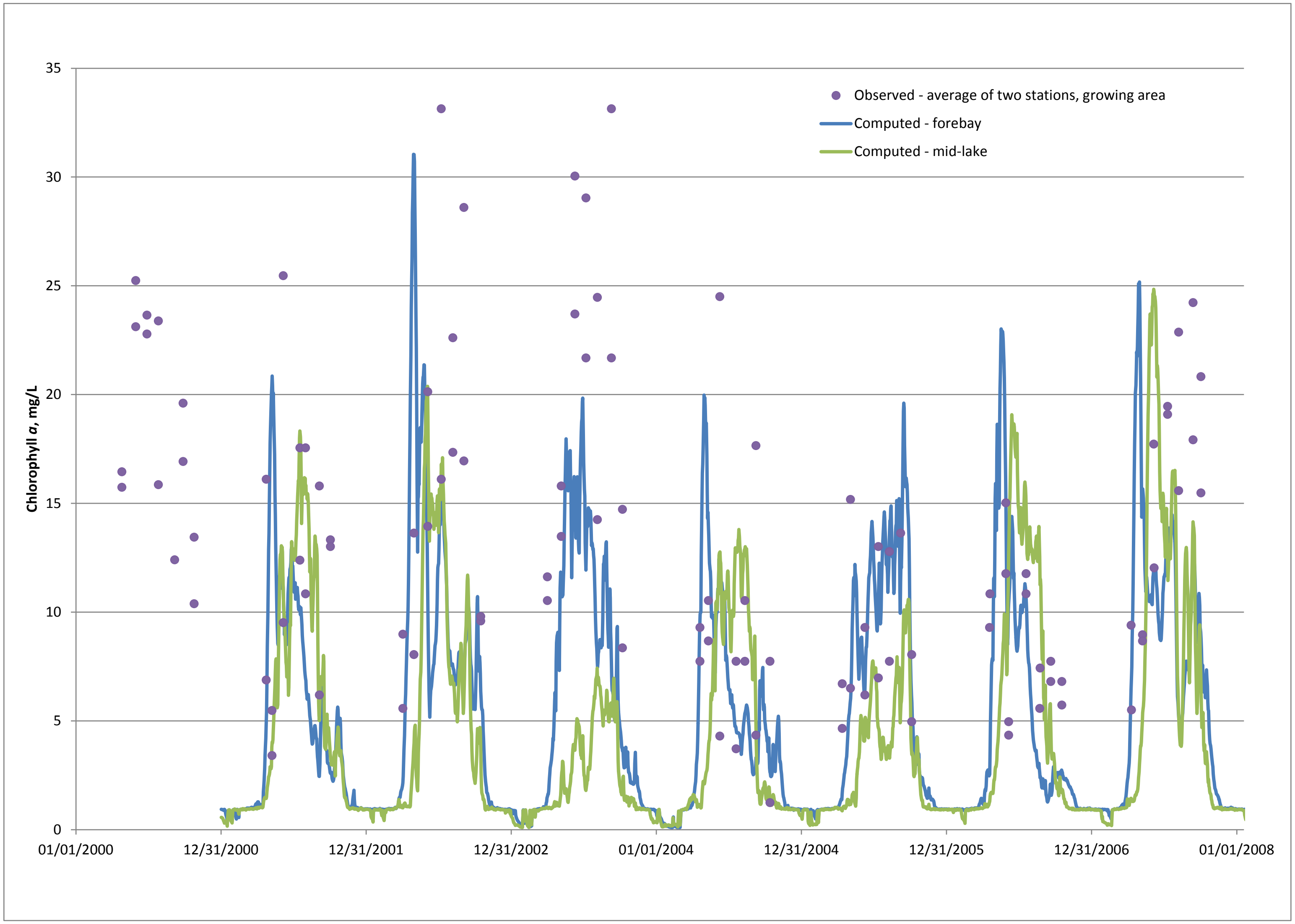

Figure 3.21 Time series of computed and observed chlorophyll *a* in W.F. George Reservoir.

3.2 STREAMS

Time series of computed and observed temperature, DO, NO3-N, NH3-N, and PO4-P are provided at locations (Figure 2.1) throughout the ACF basin where data are available. Model results are plotted at 6-hour intervals. Additionally, longitudinal profiles of computed and observed nitrate and ammonia nitrogen, phosphorus, and BOD (growing season values) are plotted from the Apalachicola River along the Chattahoochee River.

The 5, 25, 50 (median), 75 and 95% occurrence levels of the observed data were computed from near surface (growing zone) measurements at two locations in the Reservoir. Measurements were typically made monthly during the April through November period. The corresponding computed profiles are for the surface element and represent various depths/thicknesses computed as a fraction of the total cross sectional area (e.g., the surface element thickness in West Point Reservoir would represent 1/8 of the total cross section at each reservoir segment). This profile plot format was used for comparison of alternatives.

In Figure 3.22 - Figure 3.55, the HEC-5Q computed values are daily averages. The observed temperature and DO values are often the daily minimum/maximum values. Sparse observations are spot samples.

Computed and observed temperatures at two locations below Buford Dam are plotted in Figure 3.22 and Figure 3.23, respectively. Model results are plotted at 6-hour intervals. Observed data are daily maximums and minimums. Large daily temperature fluctuations are the result of Buford Dam power peaking. Low temperatures occur during power generation. When power generation is minimal there is little flow and warming in the tailrace elevates temperatures. The model is run with daily average flows as though power generation is always occurring, and thus the results at Buford Dam should match the minimum observed temperatures. However, due to the slightly elevated hypolimnion temperatures in the reservoir, the tailwater temperatures are higher than the observed minimums.

This is seen downstream at Norcross (Figure 3.24) as well. The computed temperatures reflect average flow conditions and the diurnal variation is due solely to surface heat exchange. The observed temperatures reflect both surface heat exchange and variable flow and associated travel time. At peak power flows, the shorter travel time and increased water depth results in less heating. Model coefficients were selected to bias towards the maximum temperatures since this reach is a cold water fishery.

Computed temperatures at Atlanta (Figure 3.24 and Figure 3.25) have lower summertime peak temperatures than observed but are, otherwise, in agreement with the seasonal trends seen in the observed data. The impact of Buford Dam power peaking is considerably less at this location since flow rates are moderated within Morgan Falls Reservoir. This is similarly true at Fairburn (Figure 3.26) and Whitesburg (Figure 3.27), and Columbus (Figure 3.28). Excellent agreement between computed and observed temperature is achieved at Steam Mill (Figure 3.29). Below Jim Woodruff Dam (Figure 3.30), reasonable agreement between the computed and observed temperature is achieved during the short period data are available. The temperature reduction seen in the observed data in July could not be achieved since both the Chattahoochee and Flint River inflows to Lake Seminole are above 30° C.

Flint River computed and observed temperature time series at Bainbridge are plotted in Figure 3.31. The computed results are in good agreement with observed data at this location (inflow to Lake Seminole). Observed data are relatively sparse.

Computed and observed time series of DO are plotted in Figure 3.32 through Figure 3.37. In the Chattahoochee River below Buford Dam (Figure 3.32), the impacts of power peaking are also seen during the summer and fall. The low DO values occur during power production while the higher observations are influence by reaeration at off-peak times. Additionally, the power plant is occasionally offline for maintenance and flow is released from the sluice gates located at a higher elevation. This condition was not simulated since power plant maintenance schedules were not considered in the ResSim model.

In the Chattahoochee River at Fairburn (Figure 3.33) the computed seasonal DO fluctuations tend to be smaller than observed. In particular, winter time peak DO is lower than observed. At Whitesburg (Figure 3.34) the data are sparse, but the model results are in agreement with observed data. At Columbus (Figure 3.35), again data are sparse, but it appears that the model tends to not reach the peak winter time DO or the low summer time DO. This location is in the vicinity of the City Mills and Eagle & Phoenix Dams that are represented as equivalent stream sections. Since the observed DO generally exceeds the computed and also exceeds 6 mg/L, DO does not appear to be problematic and the lower computed DO results in a conservative analysis. At Steam Mill (Figure 3.36) computed seasonal peaks are low, but the model otherwise matches observed data reasonably well.

Flint River computed and observed DO time series at Bainbridge are plotted in Figure 3.37. The computed results are in good agreement with observed data at this location (inflow to Lake Seminole). Observed data are relatively sparse.

Nutrient time series at locations with available data and longitudinal profiles of computed and observed nutrients and BOD from the Apalachicola River along the Chattahoochee and Flint Rivers are plotted in Figure 3.38 through Figure 3.55. Longitudinal profiles of computed and observed nutrients and BOD start on the Apalachicola River and proceed up the Chattahoochee River to Lake Lanier. Computed values are plotted as the 5th percentile, median and 95th percentile of results for the entire simulation period at each location along the profile. Plotted observed values are similarly the 5th percentile, median and 95th percentile of available observed data; therefore, three data points are plotted at each sampling location. Where more than three data points are present, two observation locations are very close together.

Nitrate concentrations are impacted by the treatment plant inflows (point loads) which are set at a constant concentration of 10 mg/L. At locations most influenced by these inflows, computed concentrations tend to be higher than observed. Computed nitrate in the Chattahoochee River at Whitesburg does not drop as low as some of the observed data, but otherwise corresponds well with the range of observed values. The sensitivity to the point source default nitrate concentration is demonstrated in Figure 3.39. A 50 % reduction in load results in a nearly 50% reduction in computed nitrate concentration. Since the point load flows are relatively constant, the temporal variation in the computed nitrate is due to dilution of non-point inflows and reservoir release rates. Computed nitrate at Columbus ranges from about 0.2 to 2.4 mg/L, whereas observed data only range from about 0.3 to 1.1 mg/L. Seasonal trends are reasonably well represented. At Steam Mill the model produces seasonal trends and low values that are in agreement with observed data, however the seasonal peaks (winter months with minimal biological uptake) are at times more than twice as high as observed. In the Flint River at Bainbridge, model results correspond only with the lowest observed values. In all stream locations, there is ample nitrate for phytoplankton growth throughout the year. A longitudinal profile of computed and observed nitrate in Apalachicola and Chattahoochee Rivers is shown in Figure 3.43. Model results show generally good agreement with the longitudinal trend. Highest values occur between Morgan Falls and West Point. Lowest values occur upstream at Buford Dam and reflect Lake Lanier photic zone concentrations. Peak values from the model are higher than observed downstream of West Point. The 95% values are dominated by winter concentrations when biological uptake is minimal.

Computed ammonia in the Chattahoochee River at Whitesburg is in agreement with observed data in 2000, well above observed in 2001 and 2002 and slightly higher than observed in 2003. The nature of the point load assumption (same inflow assumption for all years) makes it difficult to approximate all years. Computed ammonia at Columbus is reasonably within the range of observed data, although tends to not drop as low as the minimum observed values. At Steam Mill the model results are overall higher than observed. Steam Mill is located below a pulp mill and is influenced by the default pulp mill ammonia concentration of 4 mg/L. The large fluctuation in the computed ammonia is due to weekday and weekend flow differences caused by reservoir operation. Figure 3.47 demonstrates the influence of the pulp mill discharge assumption. The minimum observed values are more closely approximated but the higher values are not. These sensitivity results suggest that the pulp mill discharge is variable in flow and quality. In the Flint River at Bainbridge (Figure 3.48), model results correspond well with observed values. Nearly all of the measured and observed data are less than 0.1 mg/L.

A longitudinal profile of computed and observed ammonia in Apalachicola and Chattahoochee Rivers is shown in Figure 3.49. The computed and observed results are in general agreement.

Computed phosphate in the Chattahoochee River at Whitesburg (Figure 3.50) is generally slightly higher than observed. The maximum observed values exceed the computed. The computed phosphate exceeds the observed throughout most of the simulation period at both Columbus (Figure 3.51) and Steam Mill (Figure 3.52), as well as in the Flint River at Bainbridge (Figure 3.53). The higher than observed computed phosphate concentration tends to accentuate phytoplankton production and accentuates the impacts of system operation resulting in a more conservative analysis when comparing alternatives.

A longitudinal profile of computed and observed phosphate in Apalachicola and Chattahoochee Rivers is shown in Figure 3.54. The observed and model concentrations exhibit the same general trends progressing downstream. The observed data show more variability than the computed values.

A longitudinal profile of computed and observed BOD in Apalachicola and Chattahoochee Rivers is shown in Figure 3.55. There are no strong trends in either the computed or observed data. Computed median and 95th percentile results tend to be lower than observed suggesting that the point load inflow characteristics do not capture the normal variability (as expected).

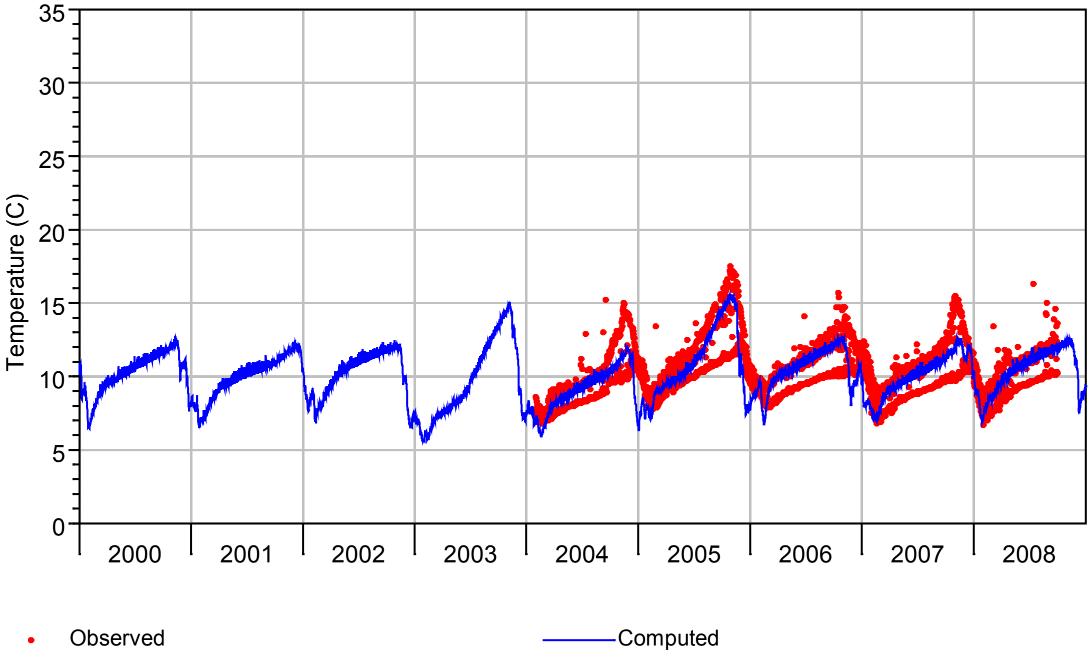

Figure 3.22 Computed and observed temperature time series on the Chattahoochee River at Buford dam tailwater.

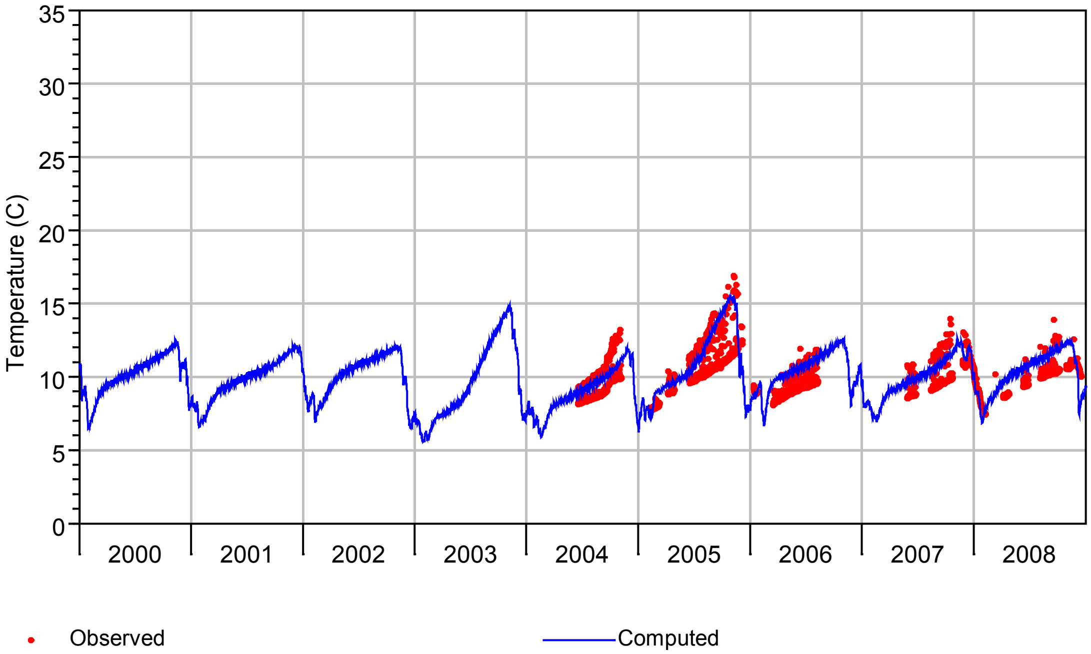

Figure 3.23 Computed and observed temperature time series on the Chattahoochee River at Buford.

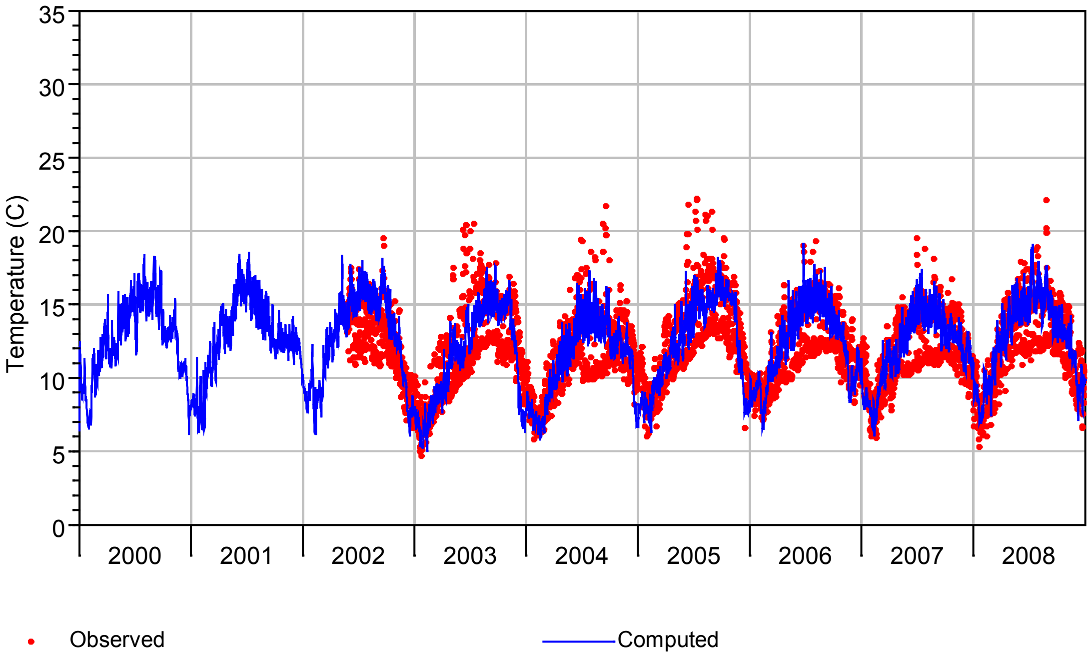

Figure 3.24 Computed and observed temperature time series on the Chattahoochee River at Norcross.

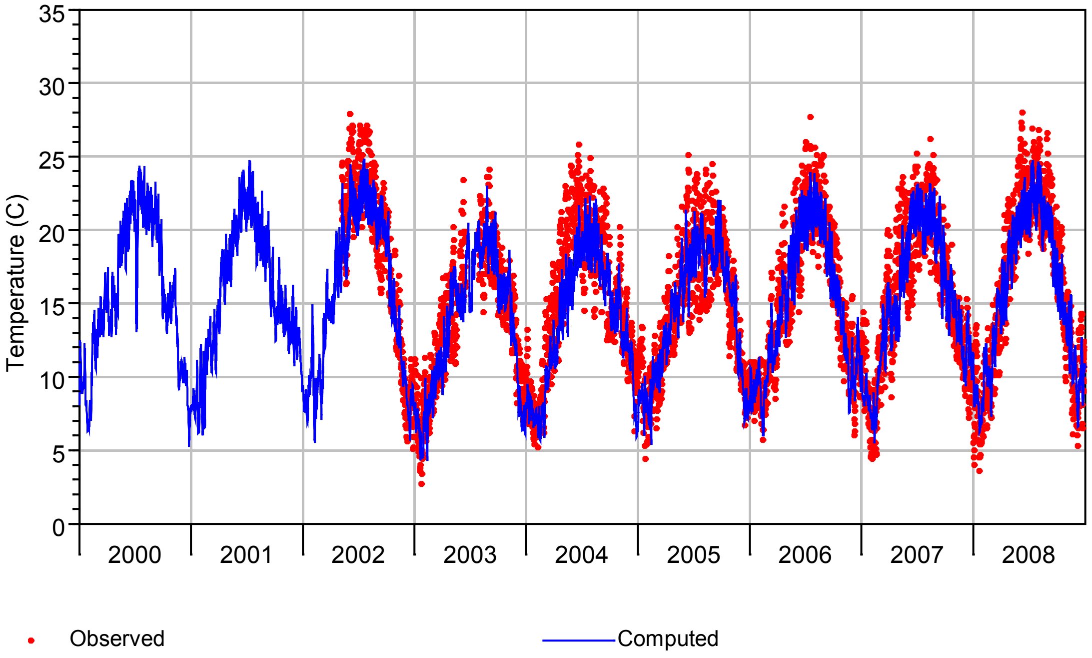

Figure 3.25 Computed and observed temperature time series on the Chattahoochee River at Atlanta.

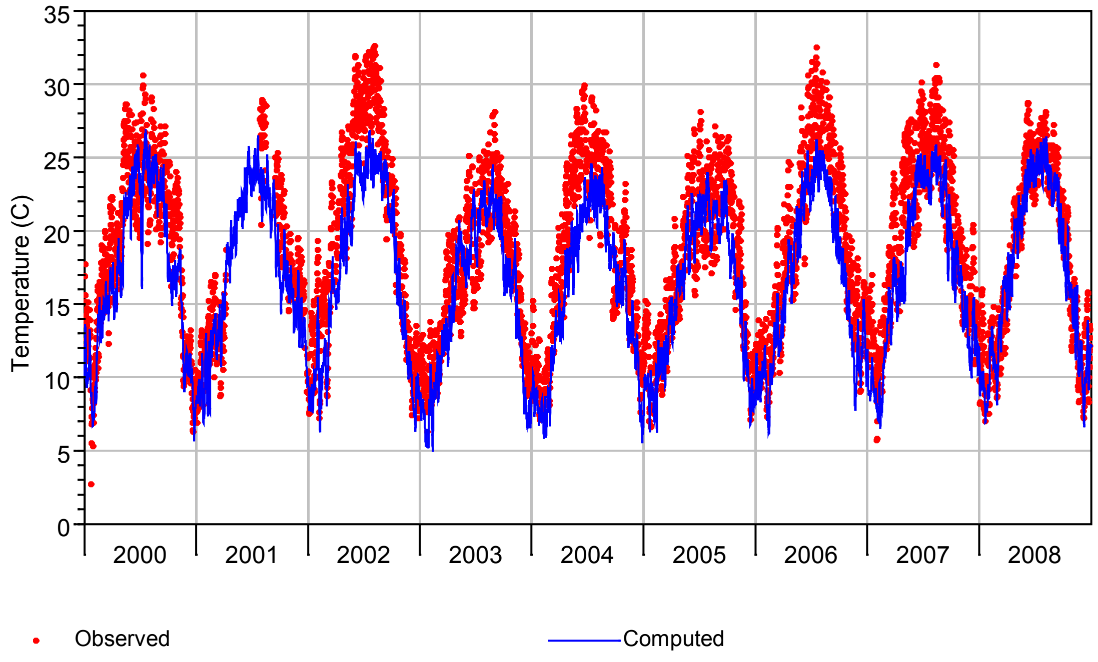

Figure 3.26 Computed and observed temperature time series on the Chattahoochee River at Fairburn.

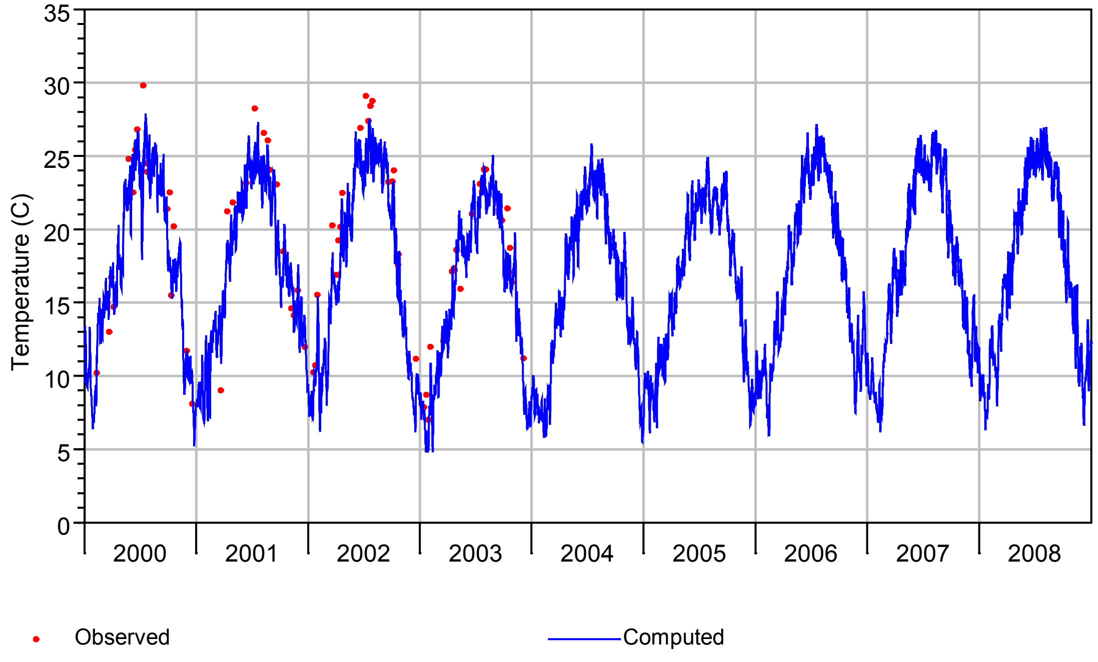

Figure 3.27 Computed and observed temperature time series on the Chattahoochee River at Whitesburg.

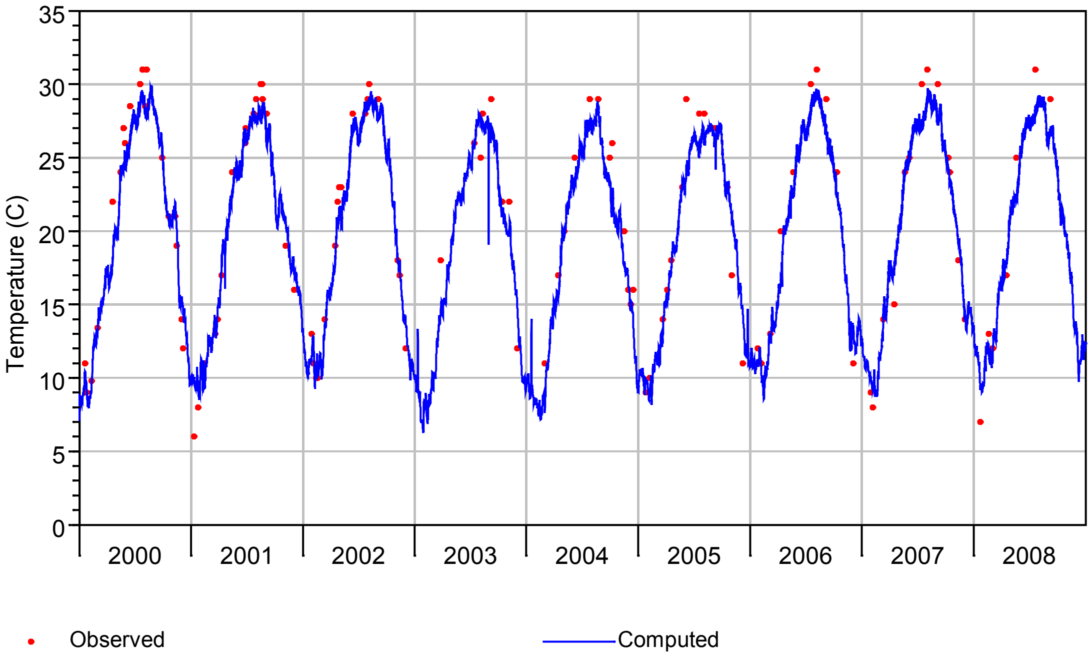

Figure 3.28 Computed and observed temperature time series on the Chattahoochee River at Columbus.

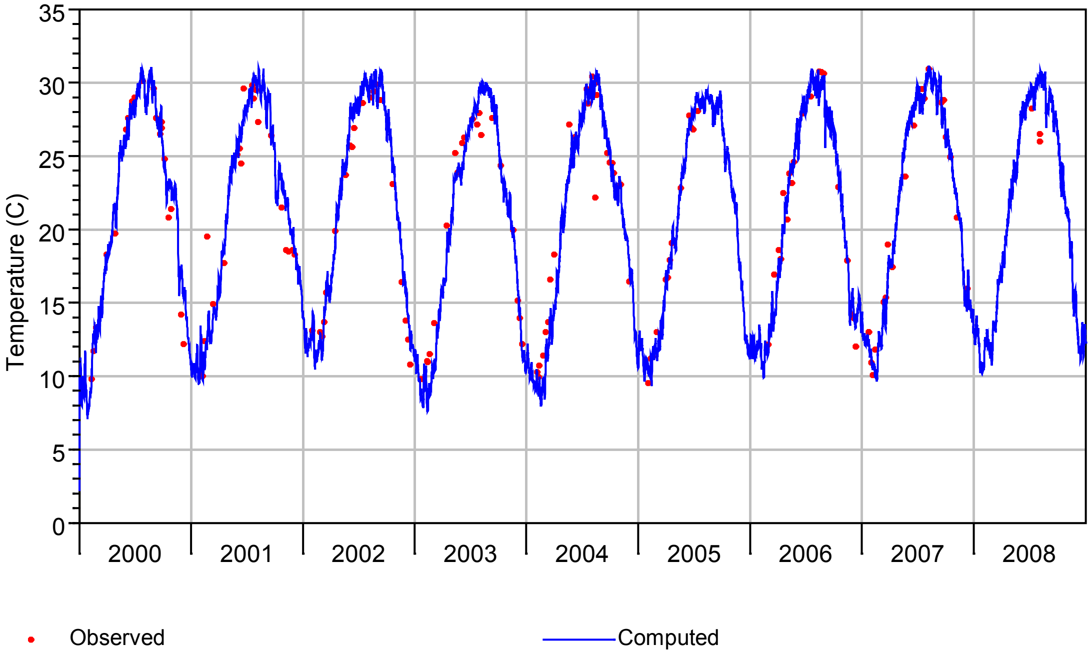

Figure 3.29 Computed and observed temperature time series on the Chattahoochee River at Steam Mill.

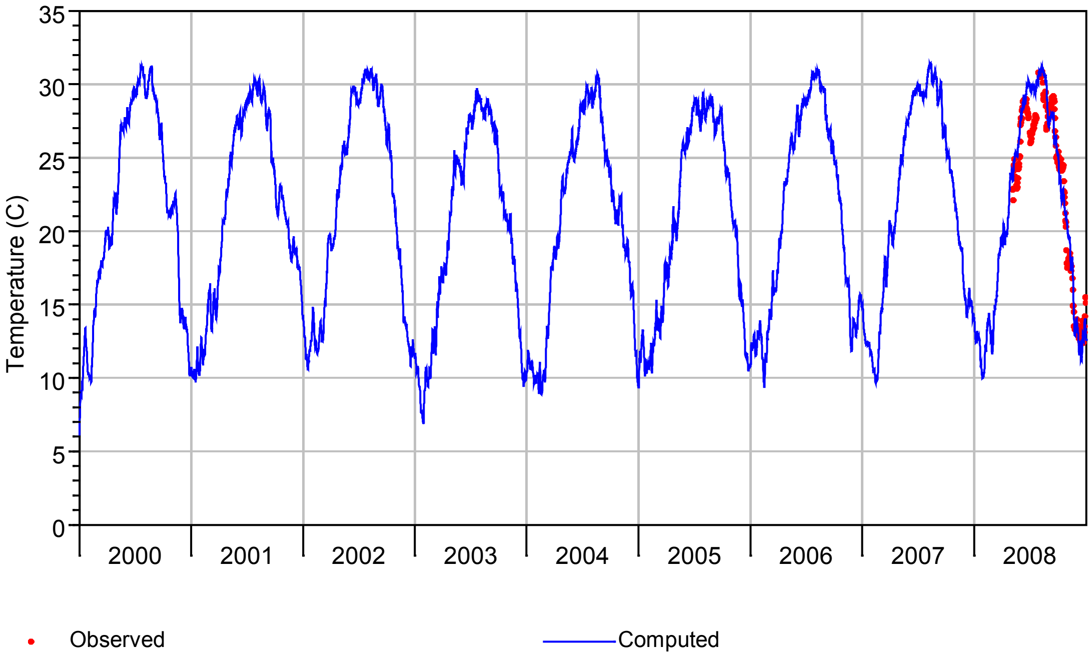

Figure 3.30 Computed and observed temperature time series on the Apalachicola River at Jim Woodruff Dam tailwater.

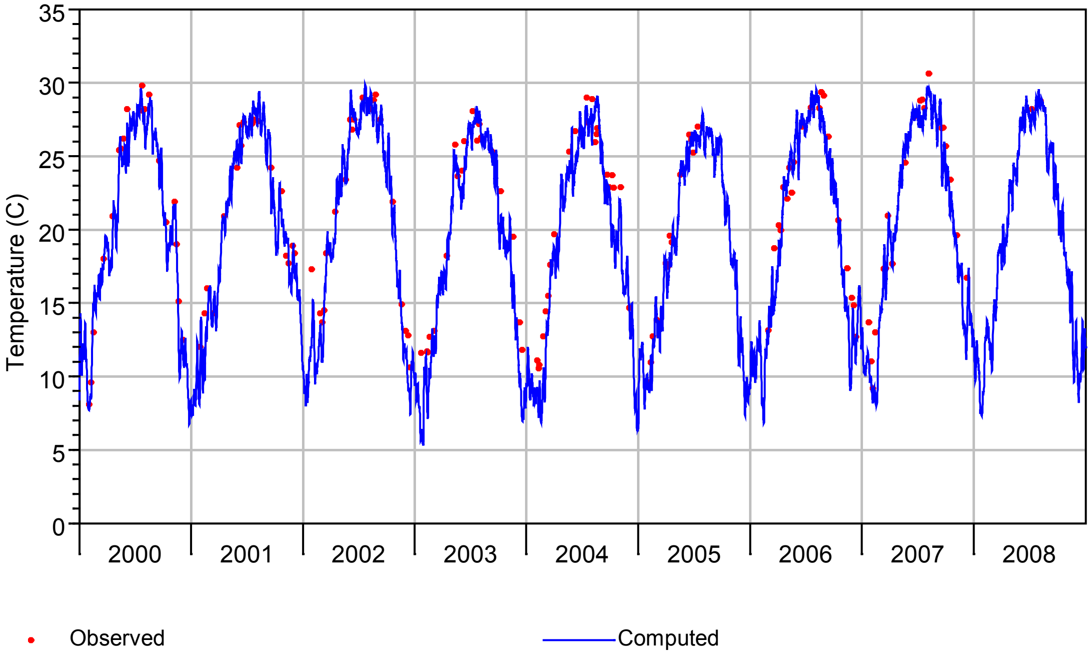

Figure 3.31 Computed and observed temperature time series on the Flint River at Bainbridge.

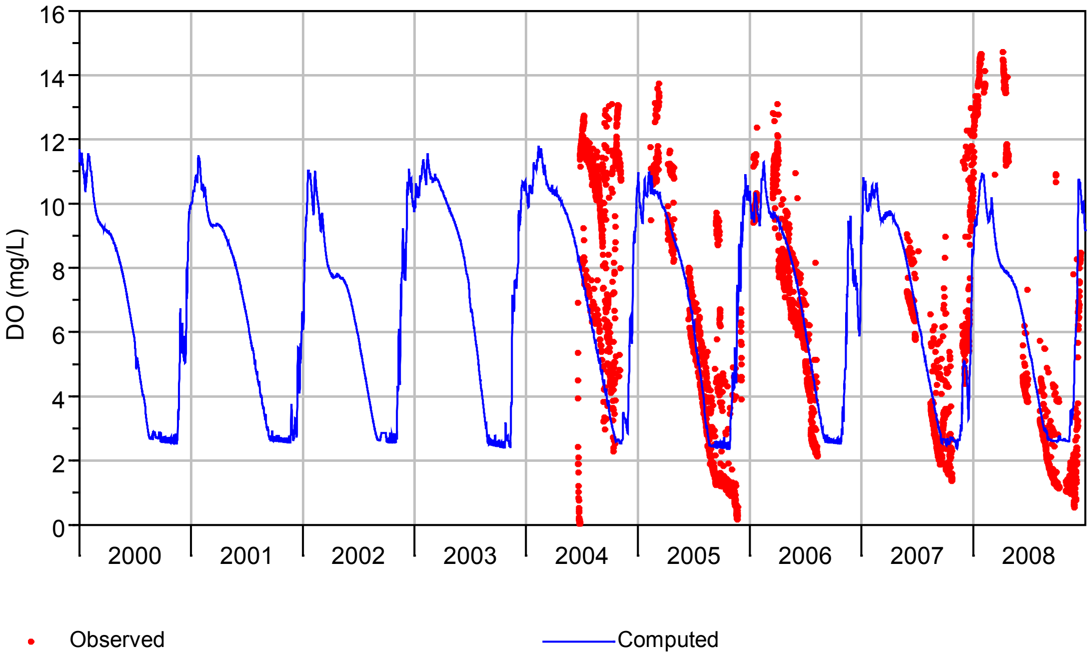

Figure 3.32 Computed and observed DO time series on the Chattahoochee River below Buford Dam.

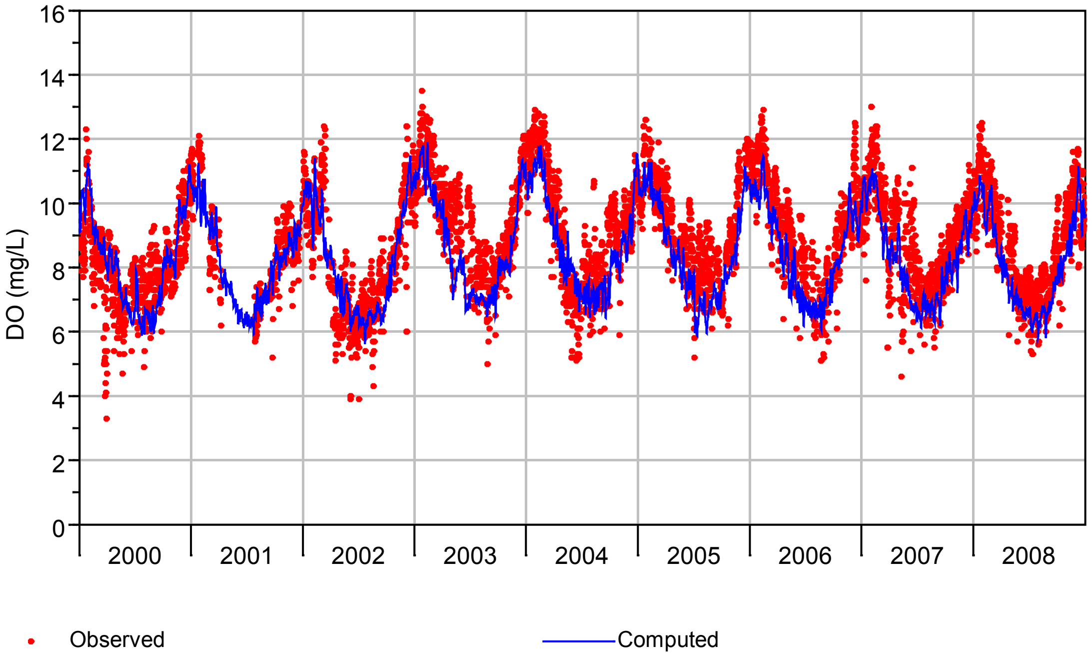

Figure 3.33 Computed and observed DO time series on the Chattahoochee River at Fairburn.

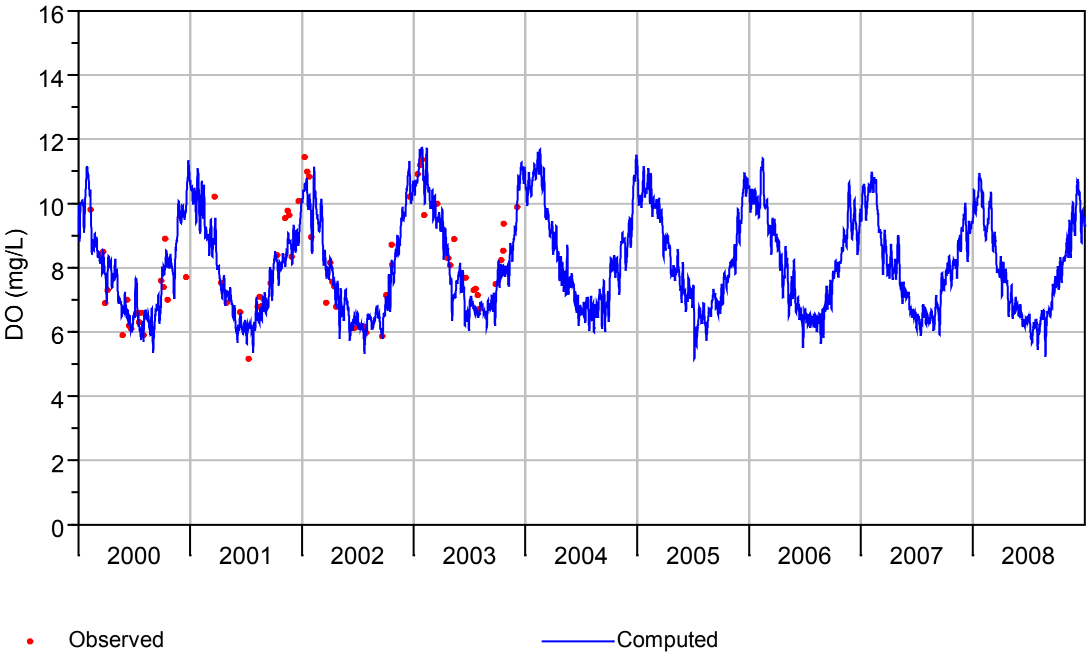

Figure 3.34 Computed and observed DO time series on the Chattahoochee River at Whitesburg.

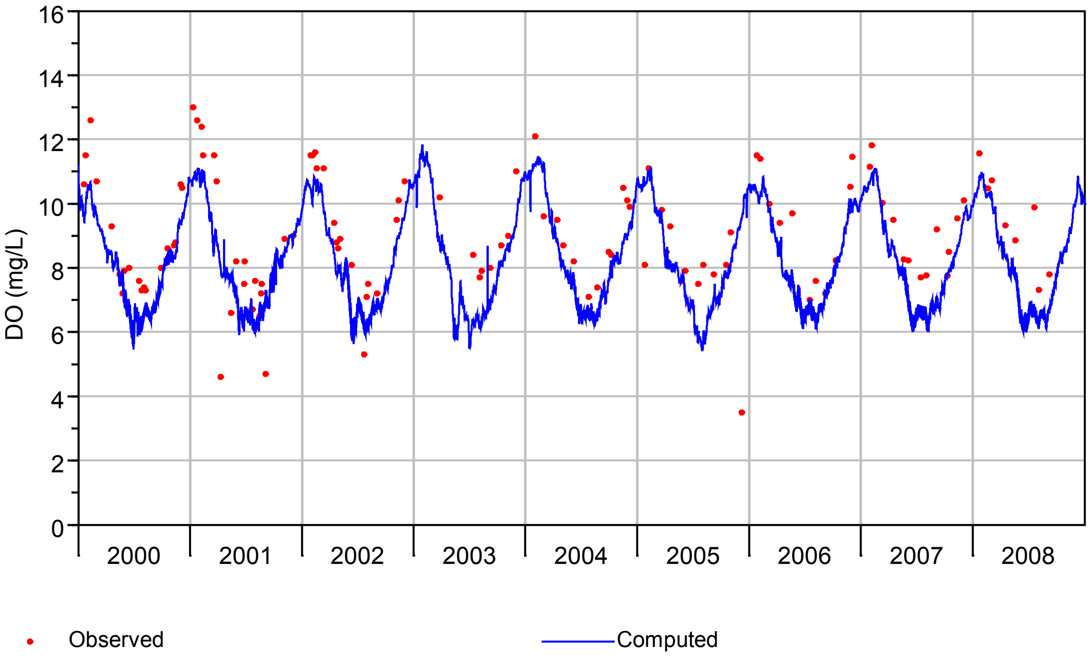

Figure 3.35 Computed and observed DO time series on the Chattahoochee River at Columbus.

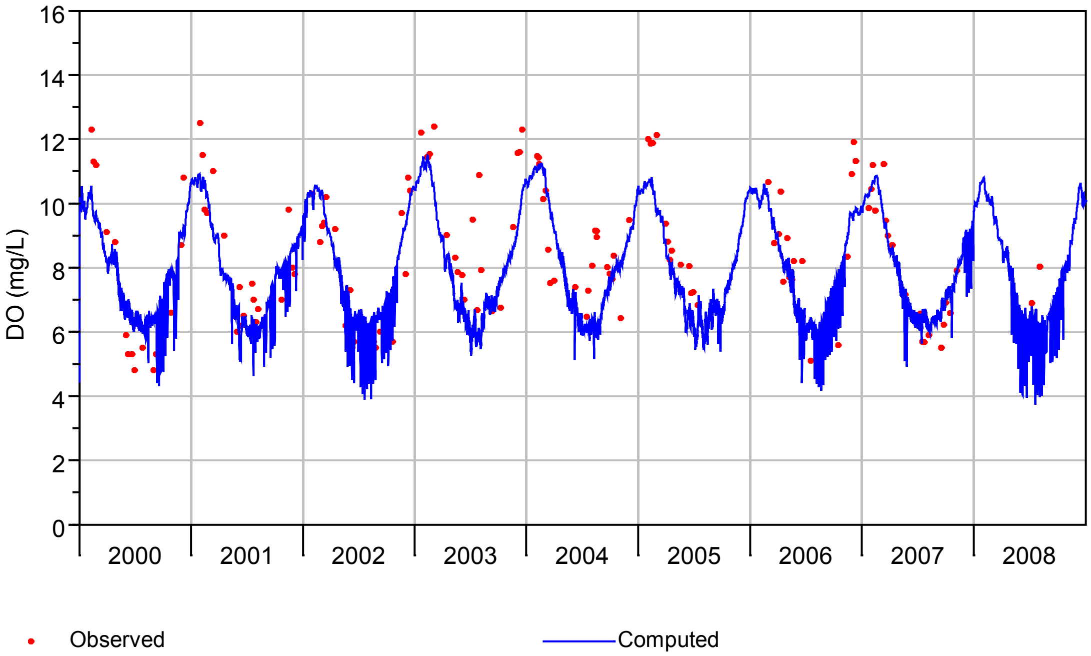

Figure 3.36 Computed and observed DO time series on the Chattahoochee River at Steam Mill.

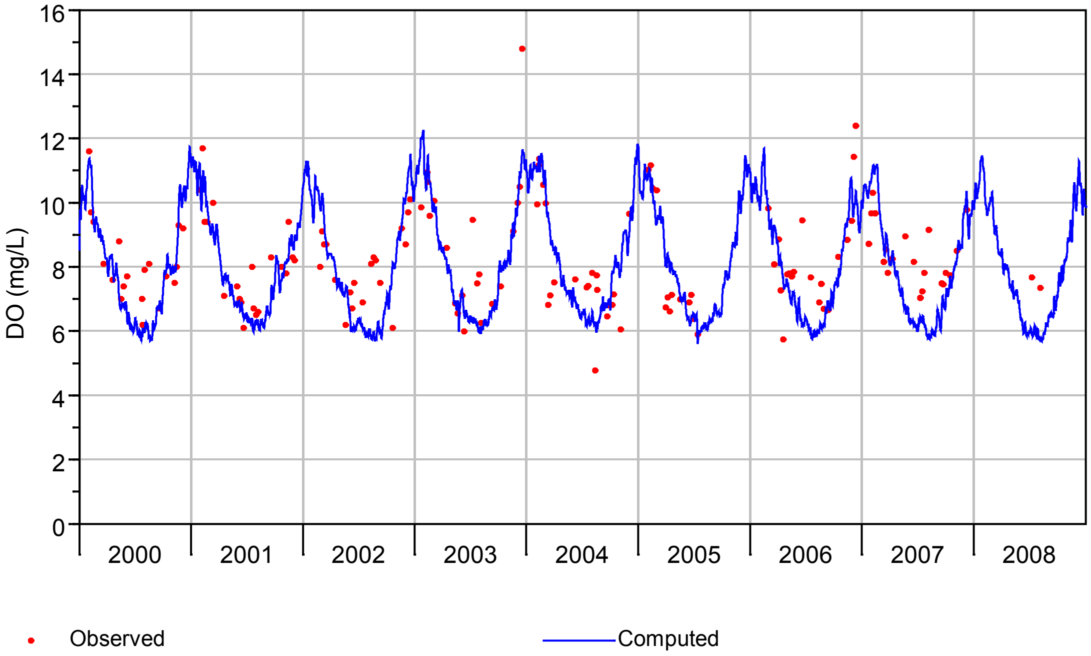

Figure 3.37 Computed and observed DO time series on the Flint River at Bainbridge.

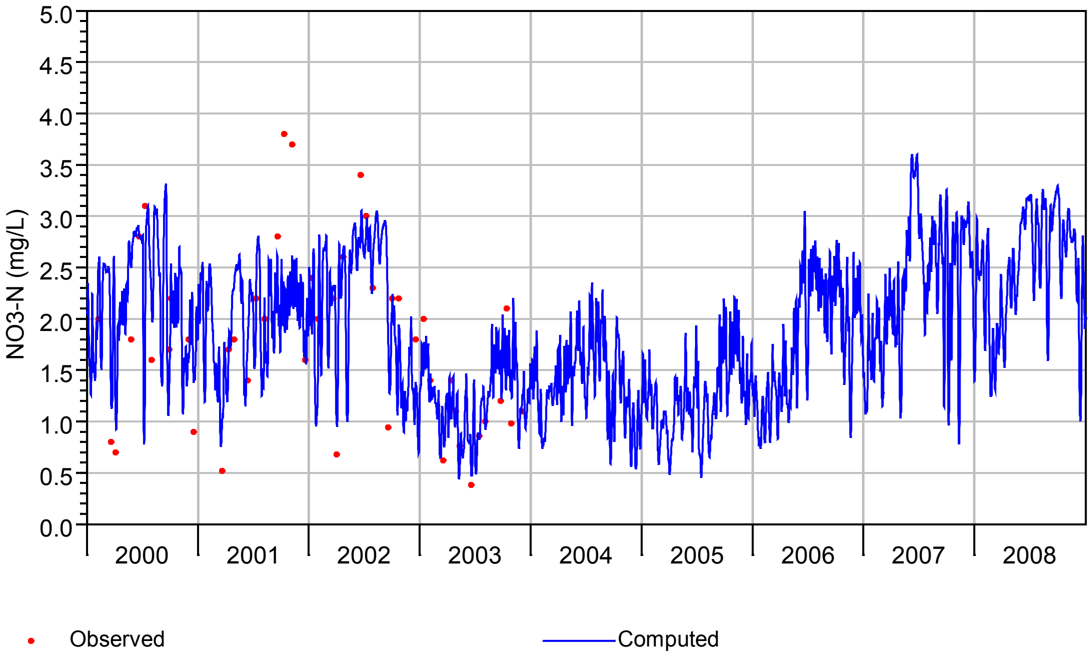

Figure 3.38 Computed and observed nitrate in the Chattahoochee River at Whitesburg.

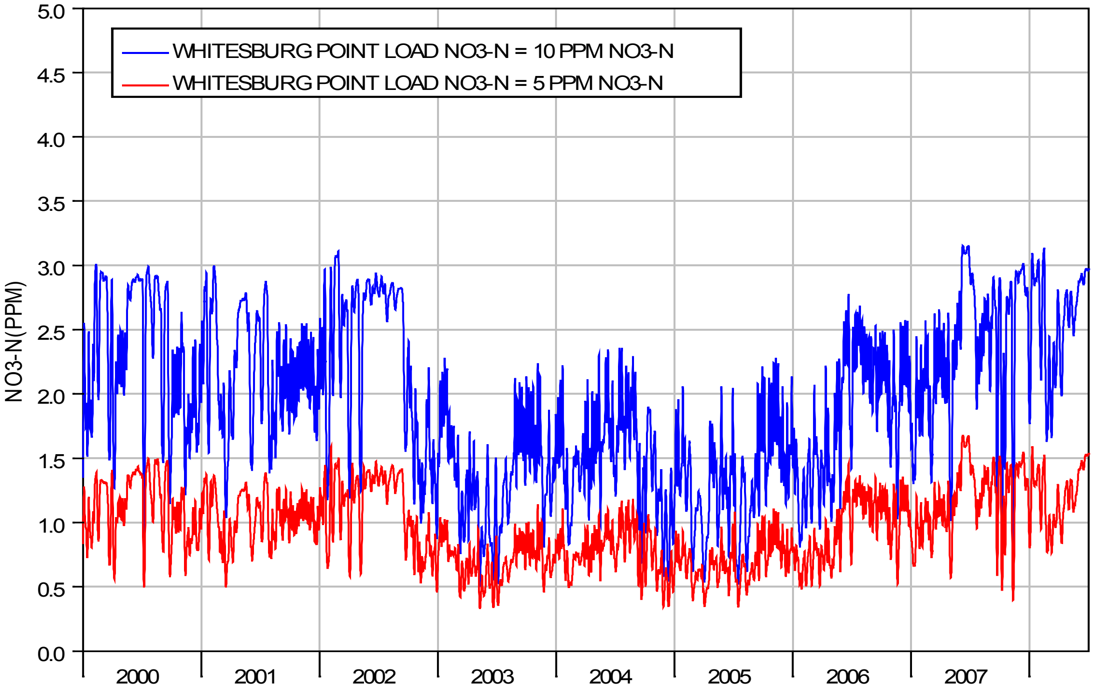

Figure 3.39 Time series of computed nitrate at Whitesburg Point illustrating sensitivity to point source NO3 default value – 5 mg/L versus 10 mg/L.

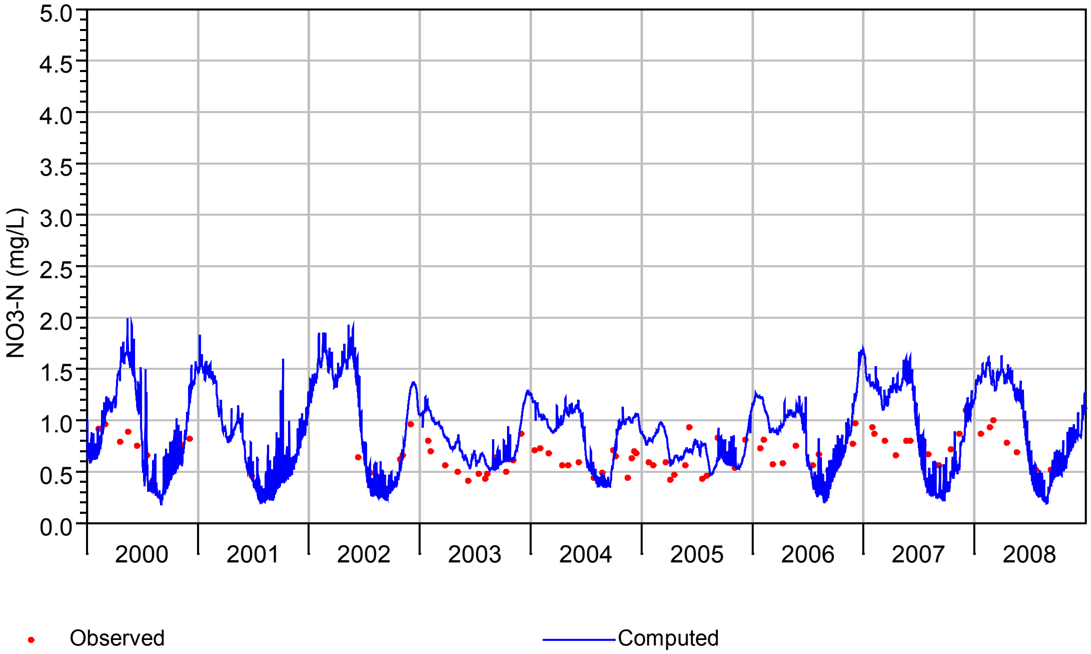

Figure 3.40 Computed and observed nitrate in the Chattahoochee River at Columbus.

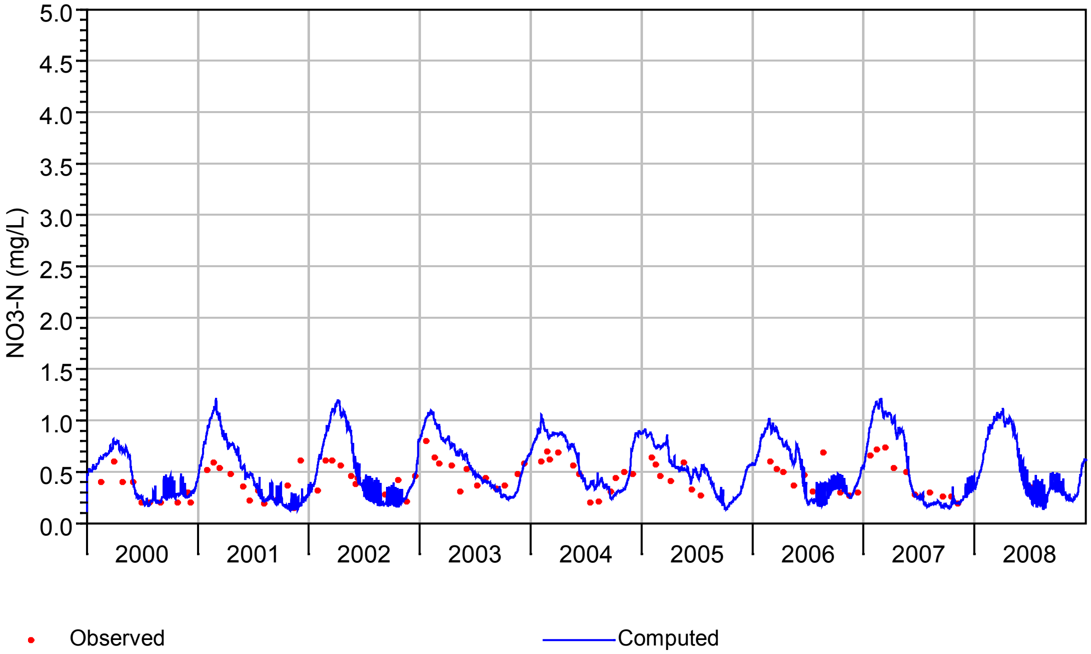

Figure 3.41 Computed and observed nitrate in the Chattahoochee River at Steam Mill.

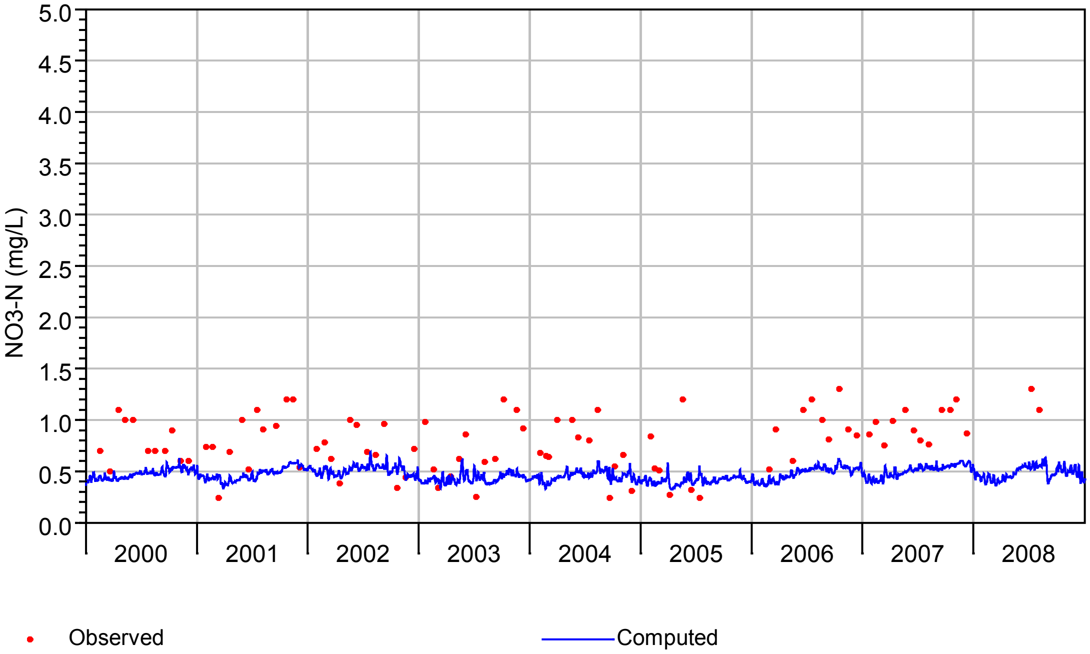

Figure 3.42 Computed and observed nitrate in the Flint River at Bainbridge.

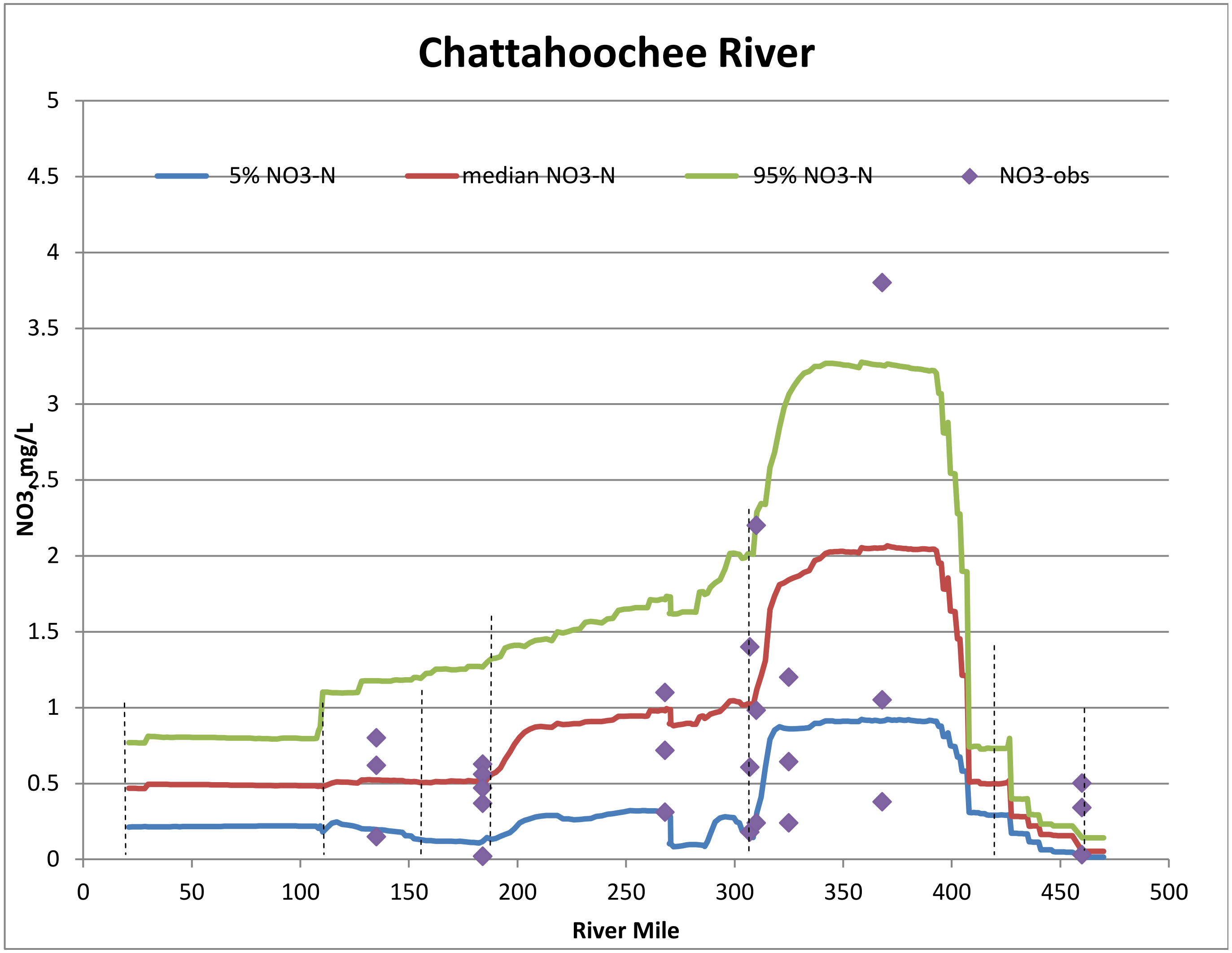

Figure 3.43 Longitudinal profile of observed and computed nitrate in Chattahoochee River up to river mile 460. All data are plotted as 5% occurrence, median and 95% occurrence.

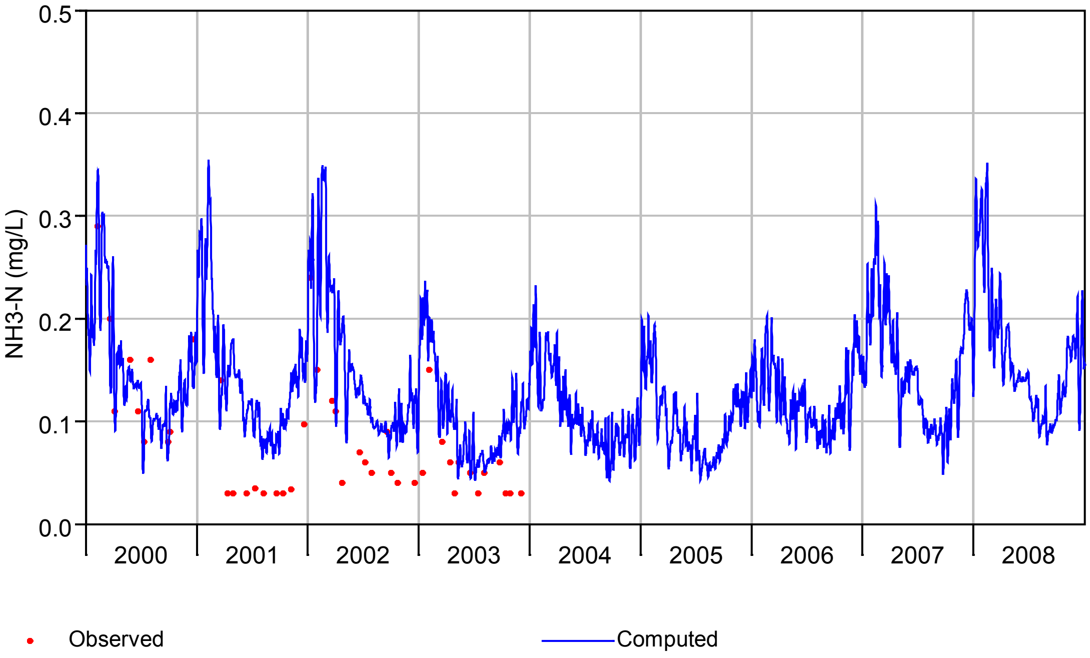

Figure 3.44 Computed and observed ammonia in the Chattahoochee River at Whitesburg.

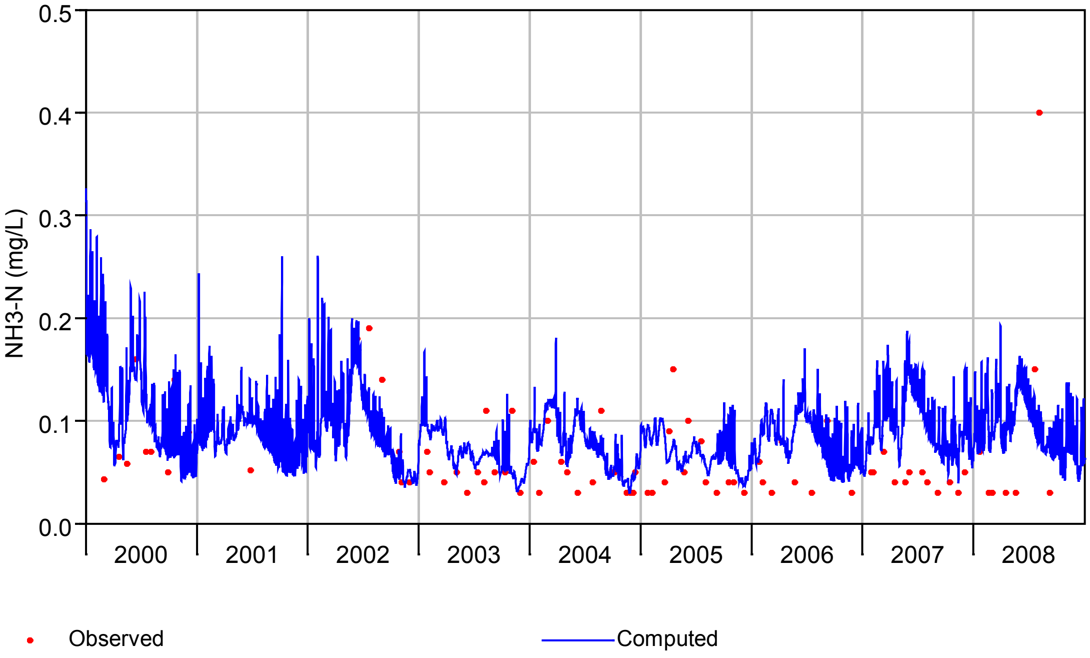

Figure 3.45 Computed and observed ammonia in the Chattahoochee River at Columbus.

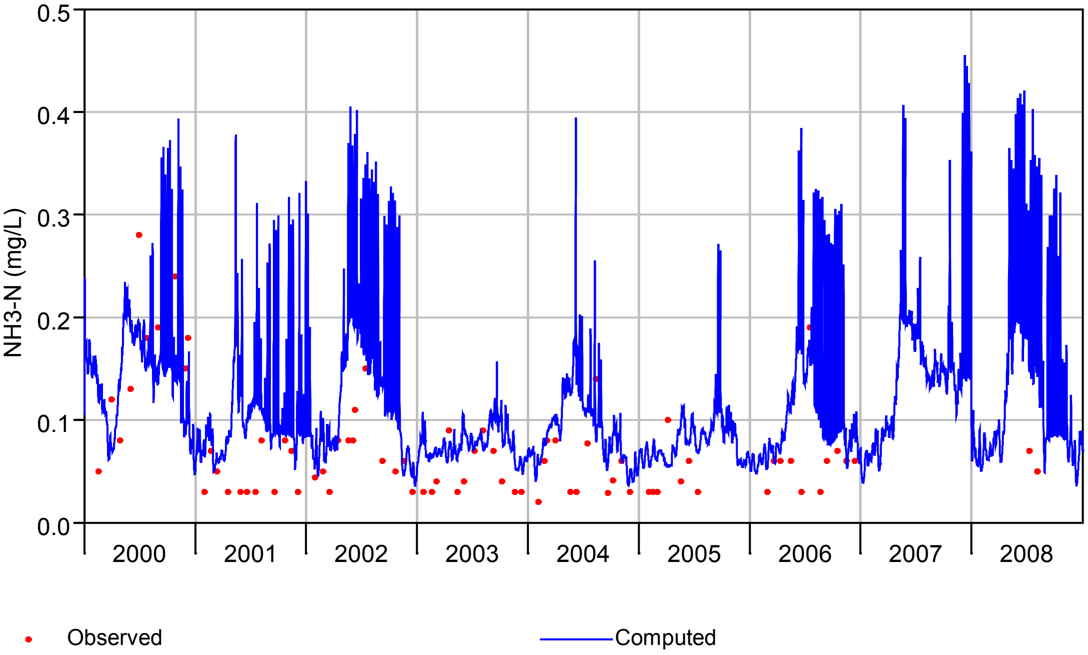

Figure 3.46 Computed and observed ammonia in the Chattahoochee River at Steam Mill.

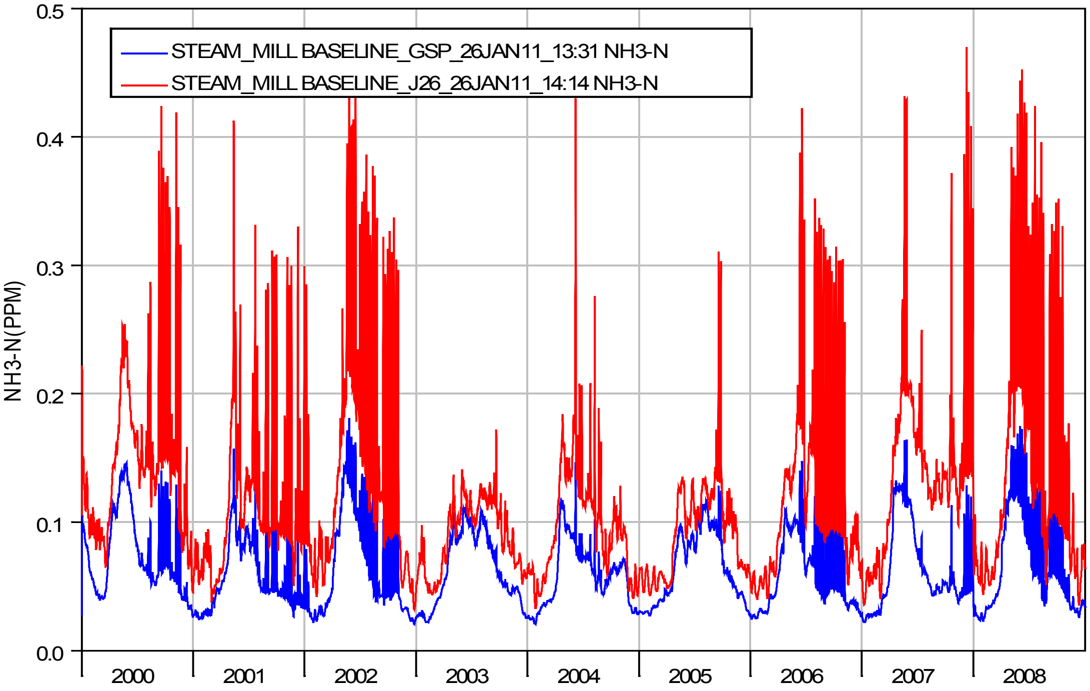

Figure 3.47 Time series of computed ammonia at Steam Mill illustrating sensitivity of ammonia to paper mill ammonia default value (4.0 mg/L versus 1.0 mg/L).

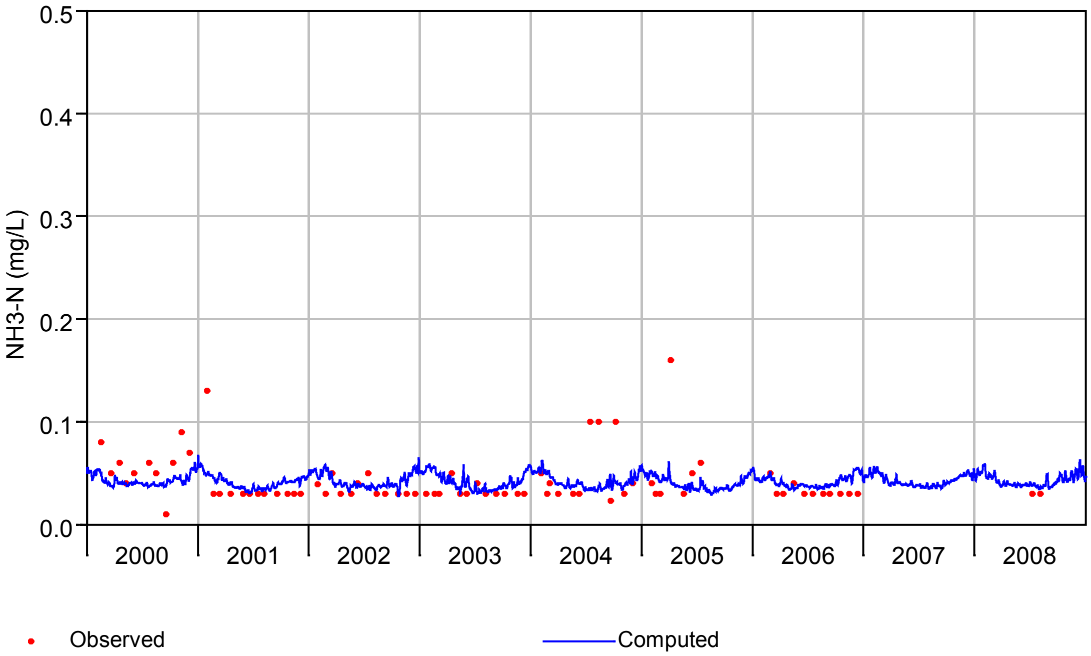

Figure 3.48 Computed and observed ammonia in the Flint River at Bainbridge.

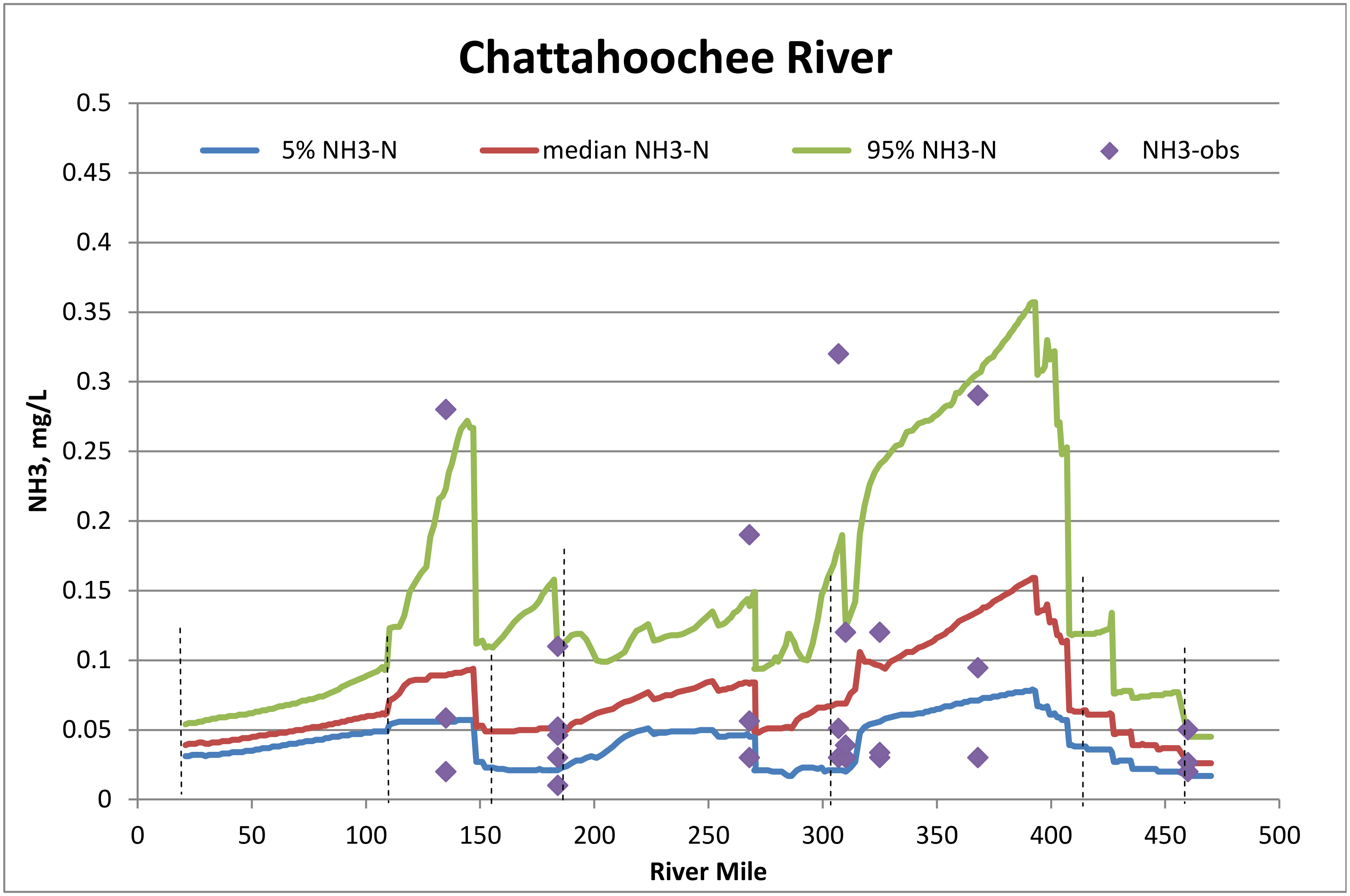

Figure 3.49 Longitudinal profile of observed and computed ammonia in Chattahoochee River up to river mile 460. All data are plotted as 5% occurrence, median and 95% occurrence.

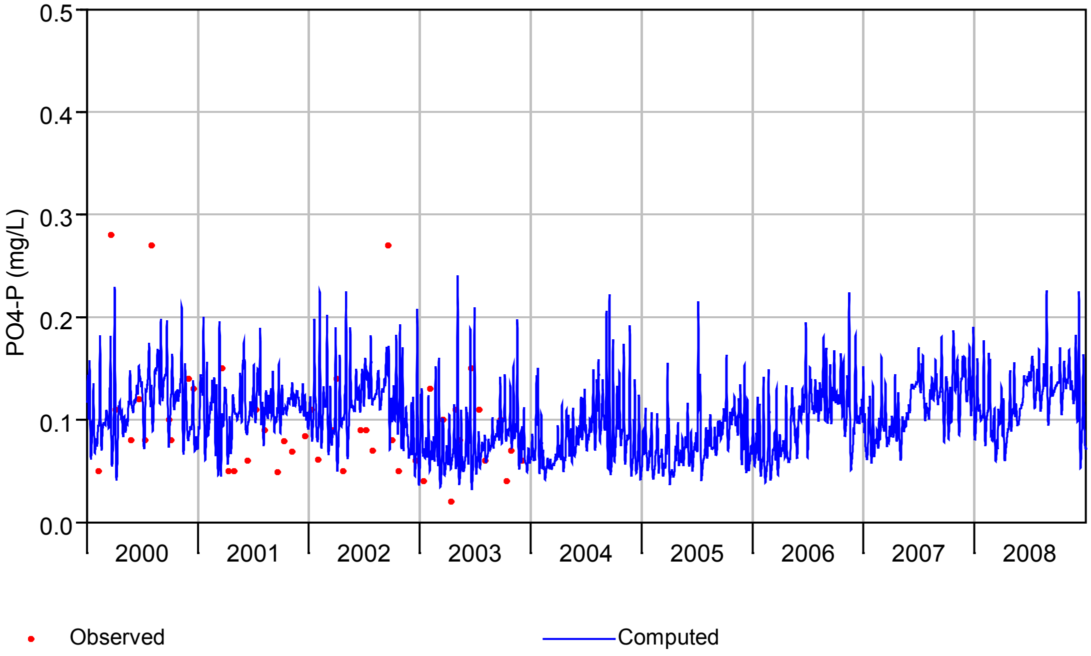

Figure 3.50 Computed and observed phosphate in Chattahoochee River at Whitesburg.

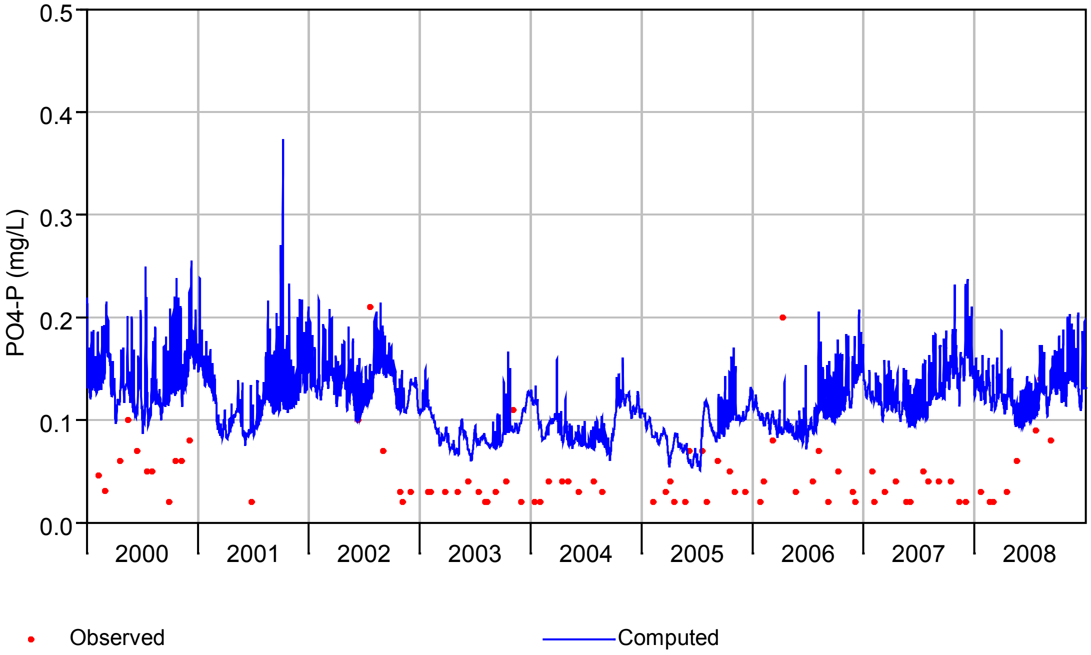

Figure 3.51 Computed and observed phosphate in Chattahoochee River at Columbus.

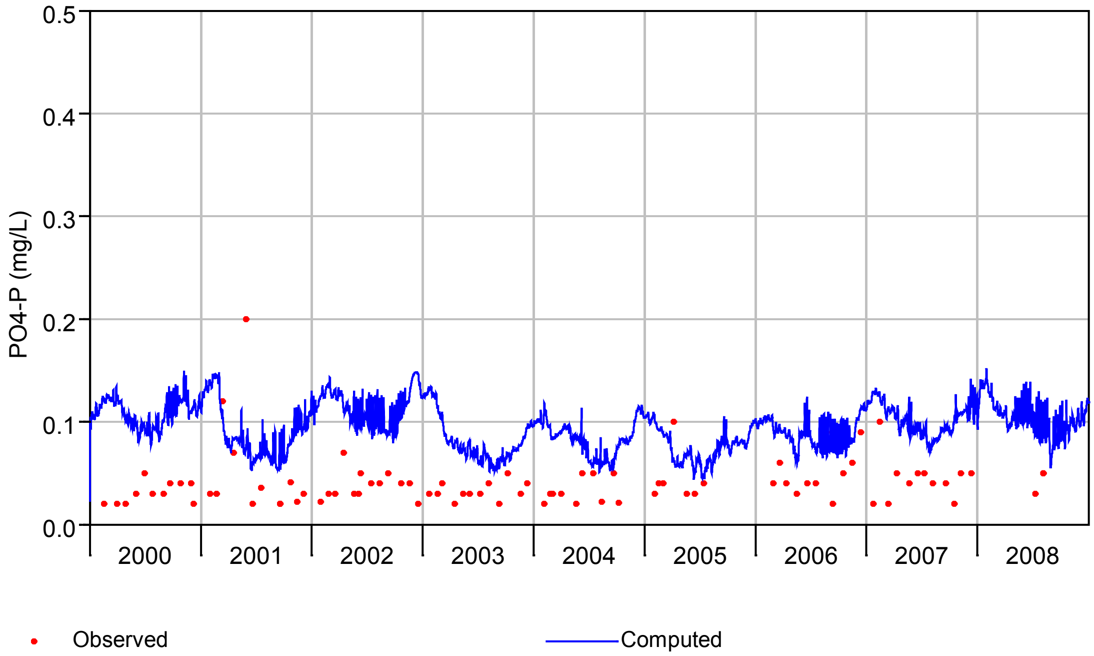

Figure 3.52 Computed and observed phosphate in Chattahoochee River at Steam Mill.

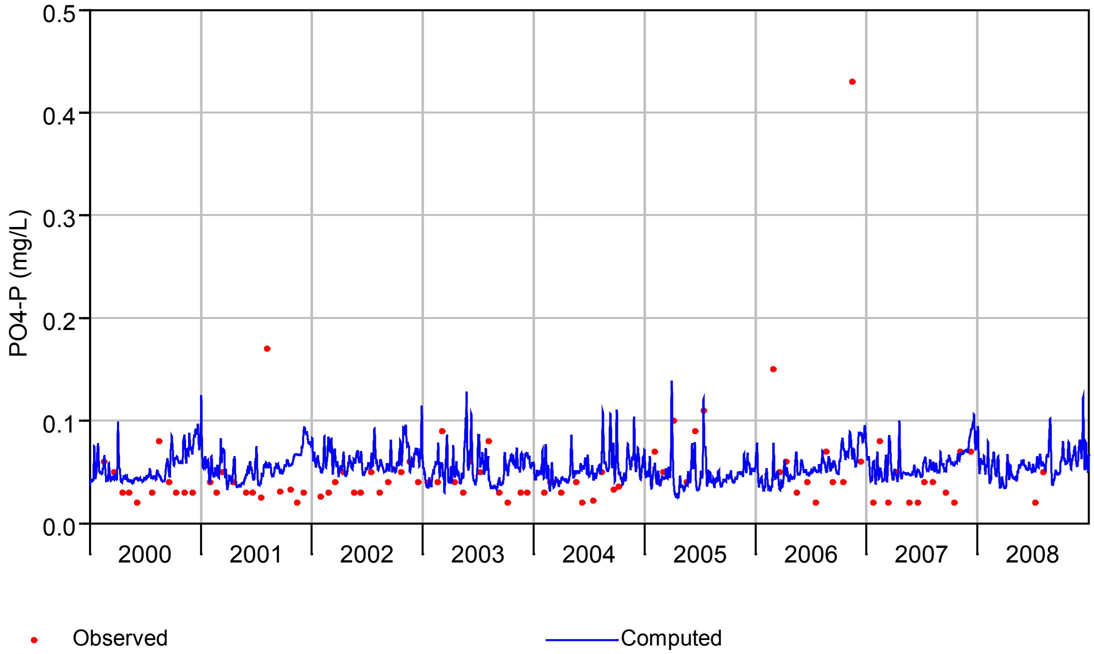

Figure 3.53 Computed and observed phosphate in the Flint River at Bainbridge.

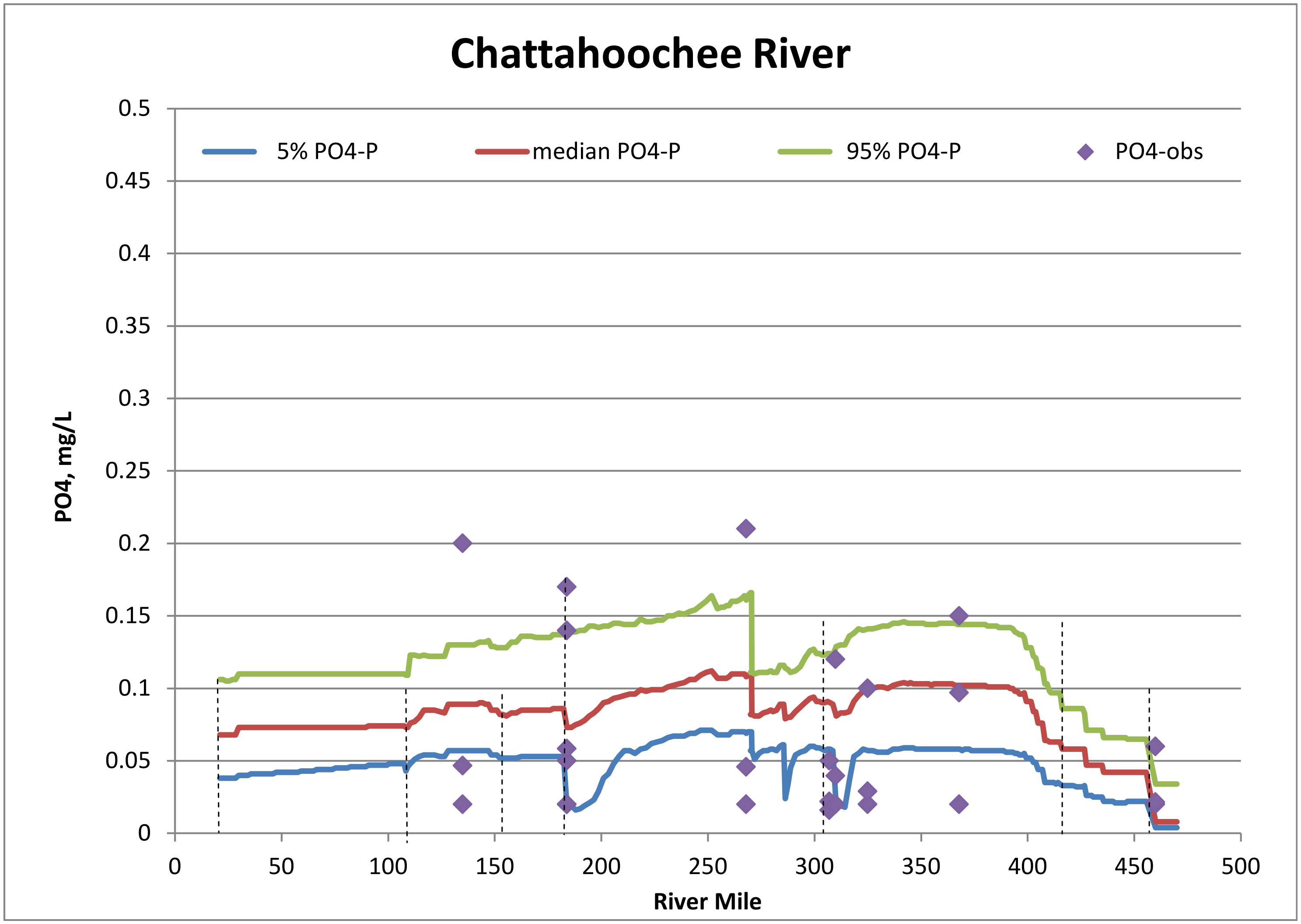

Figure 3.54 Longitudinal profile of observed and computed phosphate in Chattahoochee River up to river mile 460. All data are plotted as 5% occurrence, median and 95% occurrence.

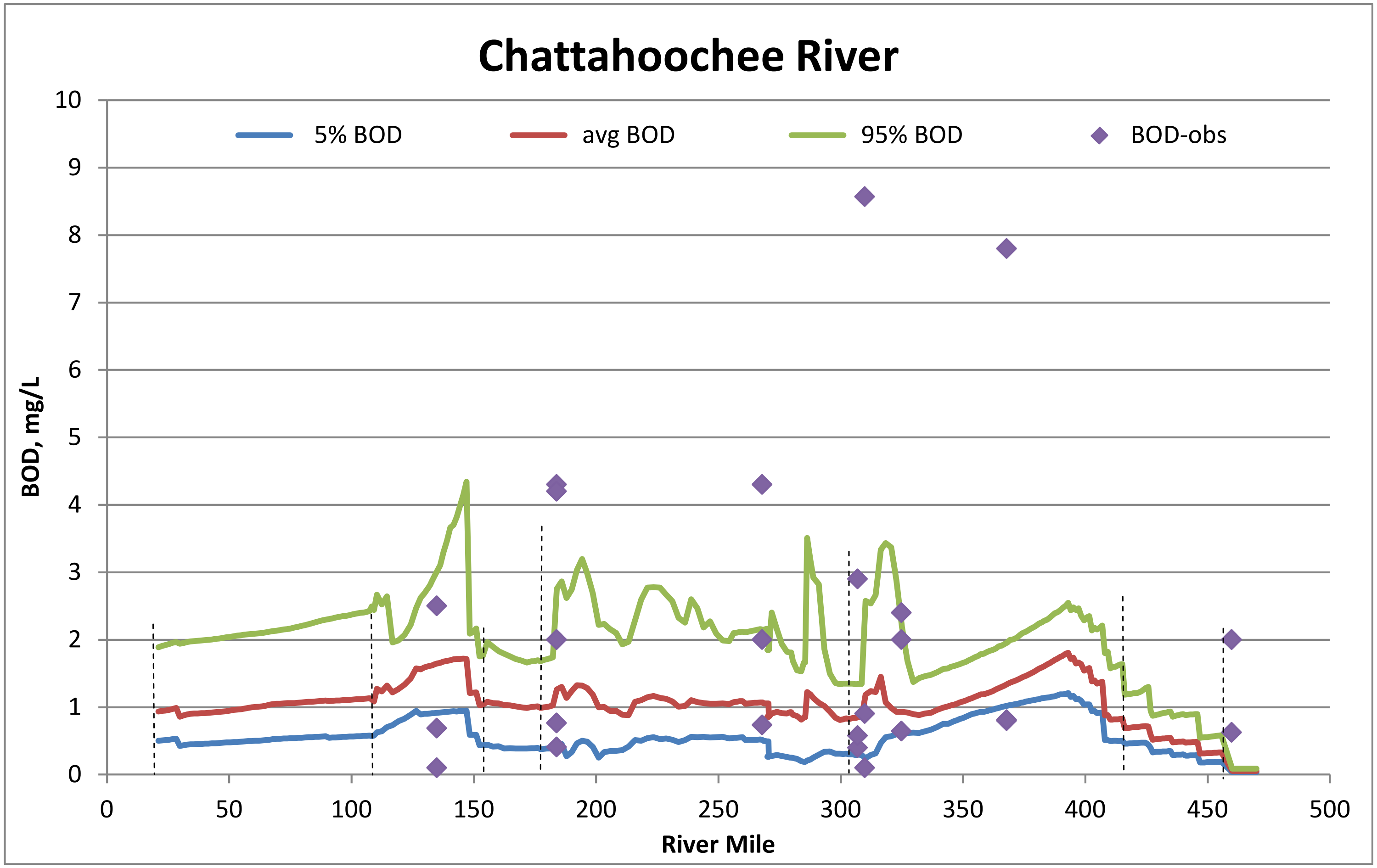

Figure 3.55 Longitudinal profile of observed and computed BOD in Chattahoochee River up to river mile 460. All data are plotted as 5% occurrence, median and 95% occurrence.

4 MODEL RESULTS

HEC-5Q was used to simulate water quality in the ACF basin for the No Action plan and each of eight study alternatives. These results consist of plots of time series, cumulative percentage occurrence by station, and longitudinal profiles of percent occurrence of each water quality parameter. The details of these results are outlined below, and representative plots are shown. All plots and the HEC-DSS files used to create the plots are available upon request. The model output in the DSS files may be viewed in tabular form or plotted using HEC-DSSVue. This program may be downloaded from: http://www.hec.usace.army.mil/software/hec-dssvue/downloads.aspx

The simulation results for stream sections represent the average concentration of each water quality parameter at each river mile. In the reservoirs, the simulation results represent the average concentration in the approximate euphotic zone (top 5 to 10 ft) of each reservoir.

Time series were output for several model locations along the Chattahoochee, Flint, and Apalachicola Rivers. These locations are shown in Table 4.1. The time series were used to compute the cumulative occurrence of each water quality parameter shown in Table 4.2. Then the percent occurrence was computed for several different annual and seasonal periods and plotted by river mile to create longitudinal occurrence profiles for each parameter. The definition of each plot type and the various computation periods applied to derive each set of plots are detailed in the following sections.

Table 4.1 Time Series Output Locations (Upstream to Downstream)

River (A Part)	River Mile (HEC-5Q)	Location	DSS Path Identifier
Chattahoochee	460.0	Lake Lanier (Buford Dam)	BUFORD_LAKE
Chattahoochee	455.6	Buford Outflow	BUFORD_OUT
Chattahoochee	438.1	Norcross	NORCROSS
Chattahoochee	419.9	Morgan Falls	MORGAN_FALLS
Chattahoochee	410.2	Atlanta	ATLANTA
Chattahoochee	368.2	Whitesburg	WHITESBURG
Chattahoochee	325.0	West Point Mid-lake	WEST_PT_MID
Chattahoochee	310.2	West Point Dam	WEST_PT_DAM
Chattahoochee	308.6	West Point Outflow	WEST_PT_OUT
Chattahoochee	286.3	Bartlett's Ferry Dam	BARTLETTS_DAM
Chattahoochee	285.5	Bartlett's Ferry Outflow	BARTLETTS_OUT
Chattahoochee	267.1	Columbus	COLUMBUS
Chattahoochee	218.4	W.F. George Mid-lake	WFGEORGE_MID
Chattahoochee	183.9	W.F. George Dam	WFGEORGE_DAM
Chattahoochee	182.3	W.F. George Outflow	WFGEORGE_OUT

Chattahoochee	155.5	George Andrews Dam	GEORGEAN_DAM
Chattahoochee	153.7	George Andrews Outflow	GEORGEAN_OUT
Chattahoochee	135.0	Jim Woodruff Inflow	JIM_WOOD_IN
Apalachicola	108.3	Jim Woodruff Dam	JIM_WOOD_DAM
Apalachicola	107.4	Jim Woodruff Outflow	JIM_WOOD_OUT
Apalachicola	78.1	Blountstown	BLOUNTSTOWN
Apalachicola	20.3	Sumatra	SUMATRA
Flint	288.4	Montezuma	MONTEZUMA
Flint	209.9	Albany	ALBANY
Flint	139.1	Bainbridge	BAINBRIDGE

Table 4.2 Water quality parameters modeled by HEC-5Q.

Water Quality Parameter
• Water Temperature
• Dissolved Oxygen (DO)
• 5-Day Uninhibited BOD (BOD5U)
• Nitrate as Nitrogen (NO3-N)
• Ammonia as Nitrogen (NH3-N)
• Orthophosphate as Phosphorous (PO4-P)
• Phytoplankton (Algae), reported as Chlorophyll a
• Municipal and Industrial (M&I) Wastewater as % of Flow

Three categories of plots were created from the HEC-5Q model output to summarize the results: Time Series, Cumulative Occurrence, and River Profiles. These are described in following sections.

4.1 TIME SERIES

Time series are shown for each parameter computed for the 2001–2011 model period. A time series plot was created for each location (Table 4.1) along the Chattahoochee, Flint, and Apalachicola Rivers. Each of the water quality parameters shown in Table 4.2 was plotted.

Representative plots of DO, Chlorophyll *a*, and temperature are shown in Figure 4.1 – Figure 4.6 at two sample stations (Lake Lanier and Whitesburg) along the Chattahoochee River. To improve the clarity of the plots, two sets were plotted. The first set contains the No Action (Option A) Alternative and alternatives 1B, 1C, 7A, and 7C. The second set contains the No Action Alternative(Option A) and alternatives 7D, 7E, 7F, and 7H (Proposed Action Alternative).

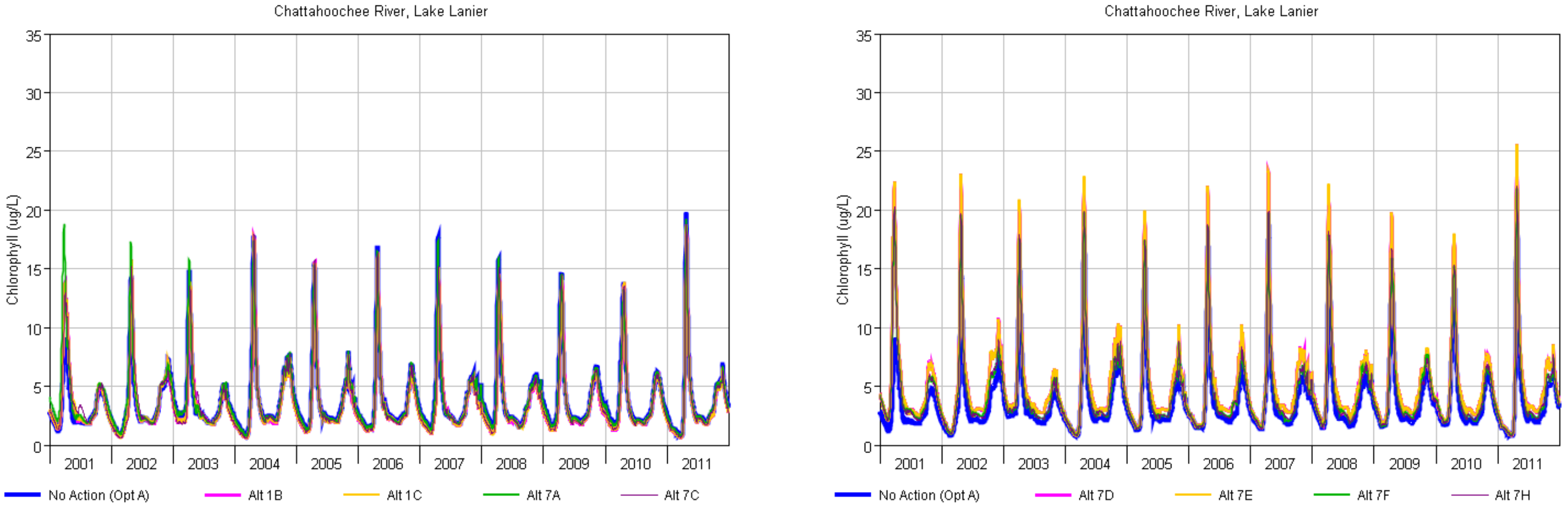

Figure 4.1 Time series of c*hlorophyll a* computed for the Chattahoochee River at Lake Lanier, above Buford Dam, during the 2001-2011 modeling period.

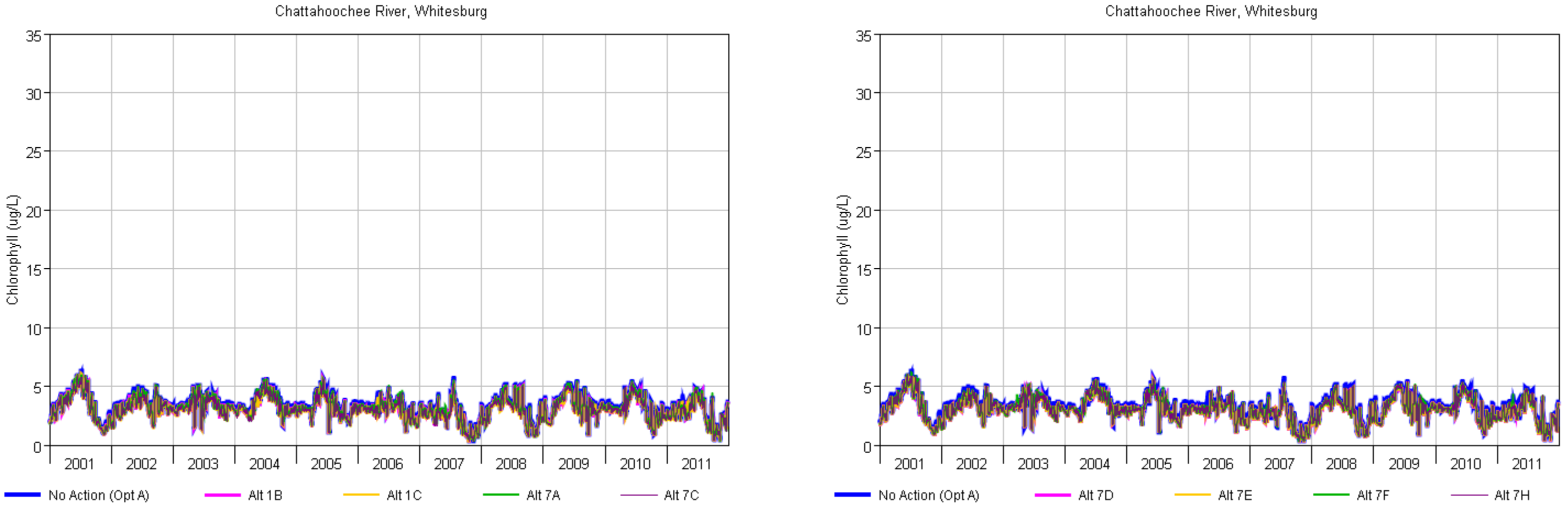

Figure 4.2 Time series of c*hlorophyll a* computed for the Chattahoochee River at Whitesburg during the 2001-2011 modeling period.

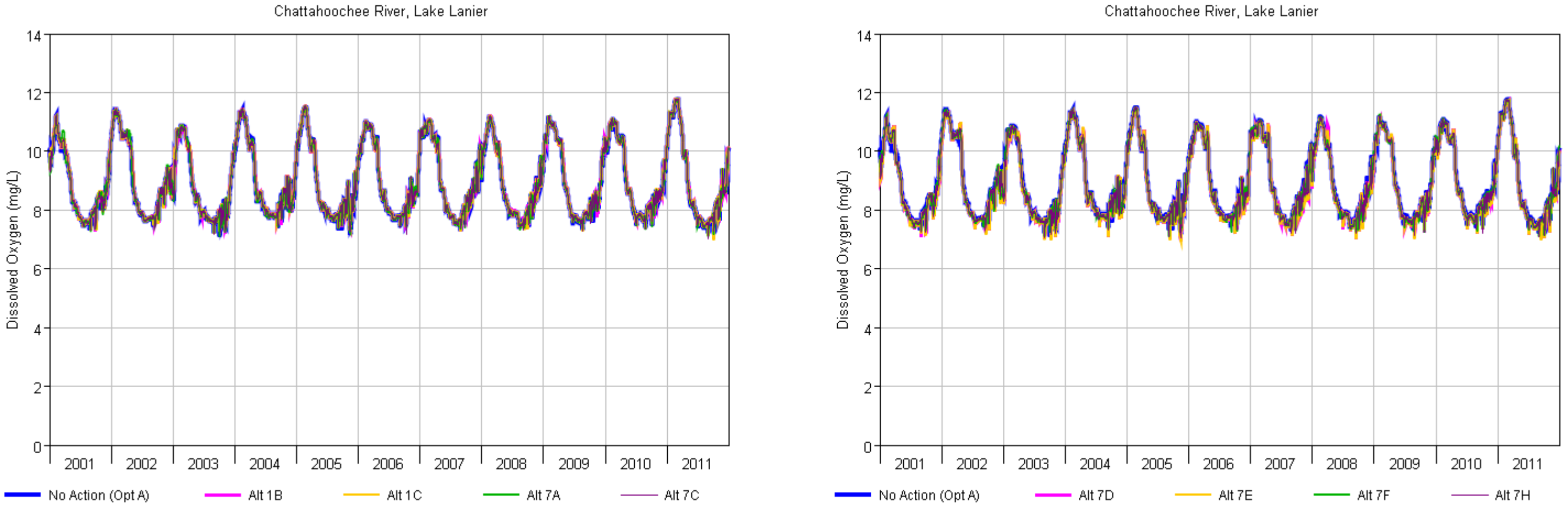

Figure 4.3 Time series of *DO* computed for Chattahoochee River at Lake Lanier, above Buford Dam, during the 2001-2011 modeling period.

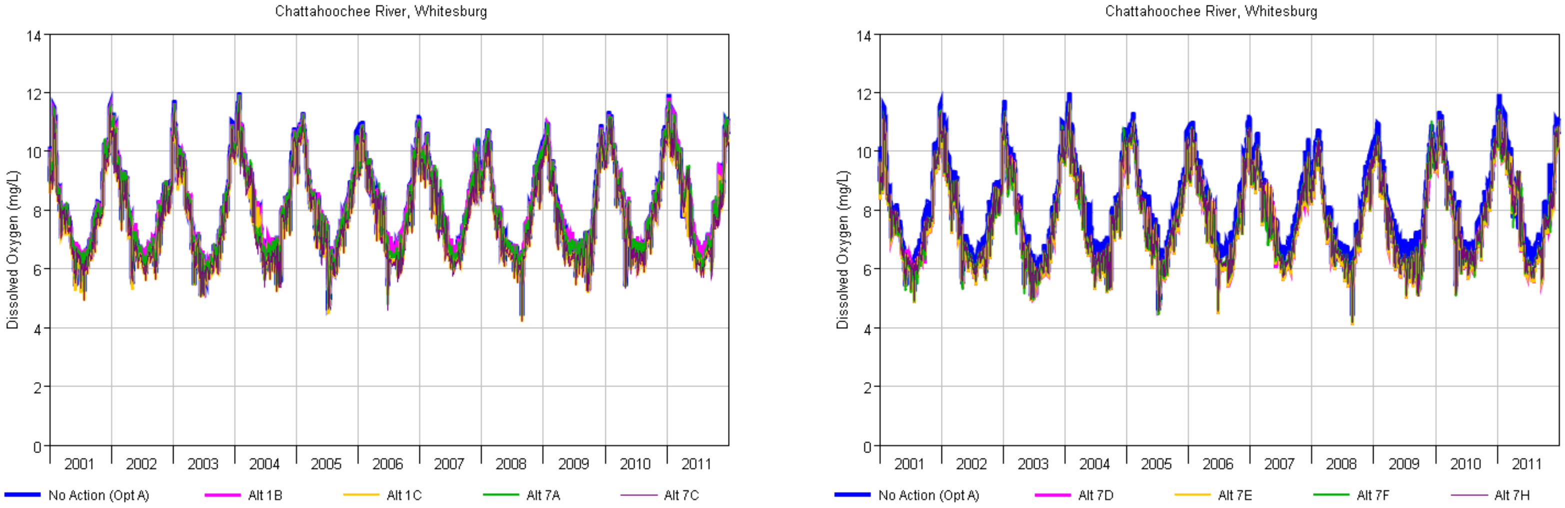

Figure 4.4 Time series of *DO* computed for Chattahoochee River at Whitesburg, above Buford Dam, during the 2001-2011 modeling period.

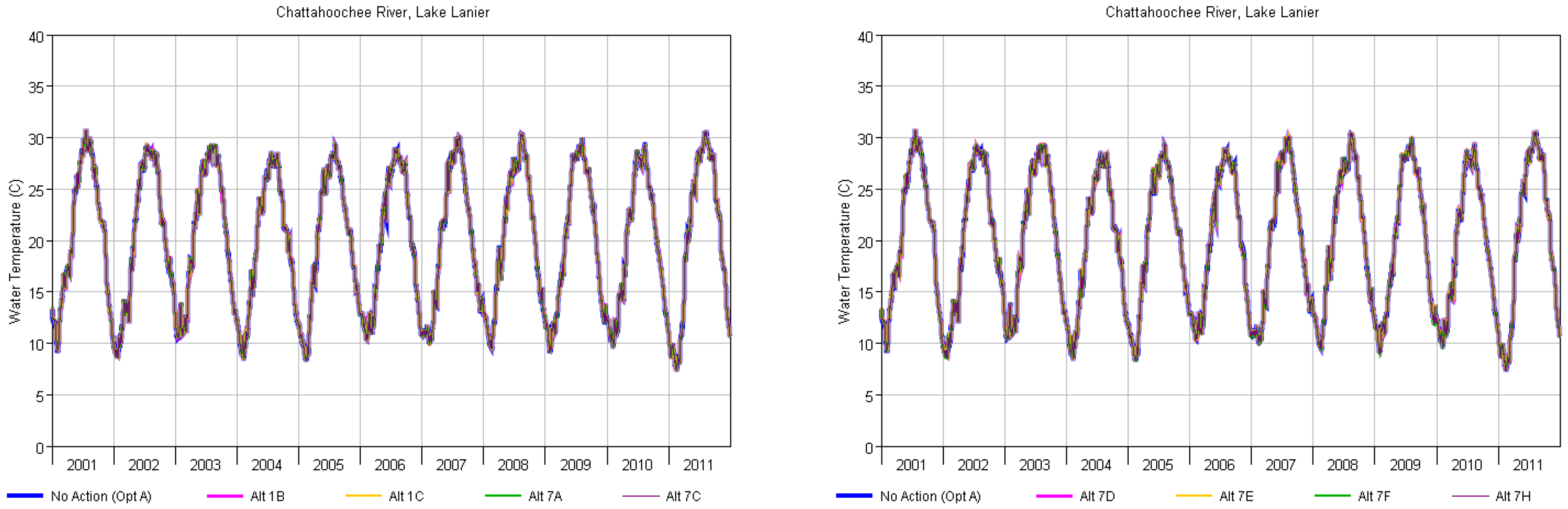

Figure 4.5 Time series of *water temperature* for the Chattahoochee River at Lake Lanier, above Buford Dam, during the 2001-2011 model period.

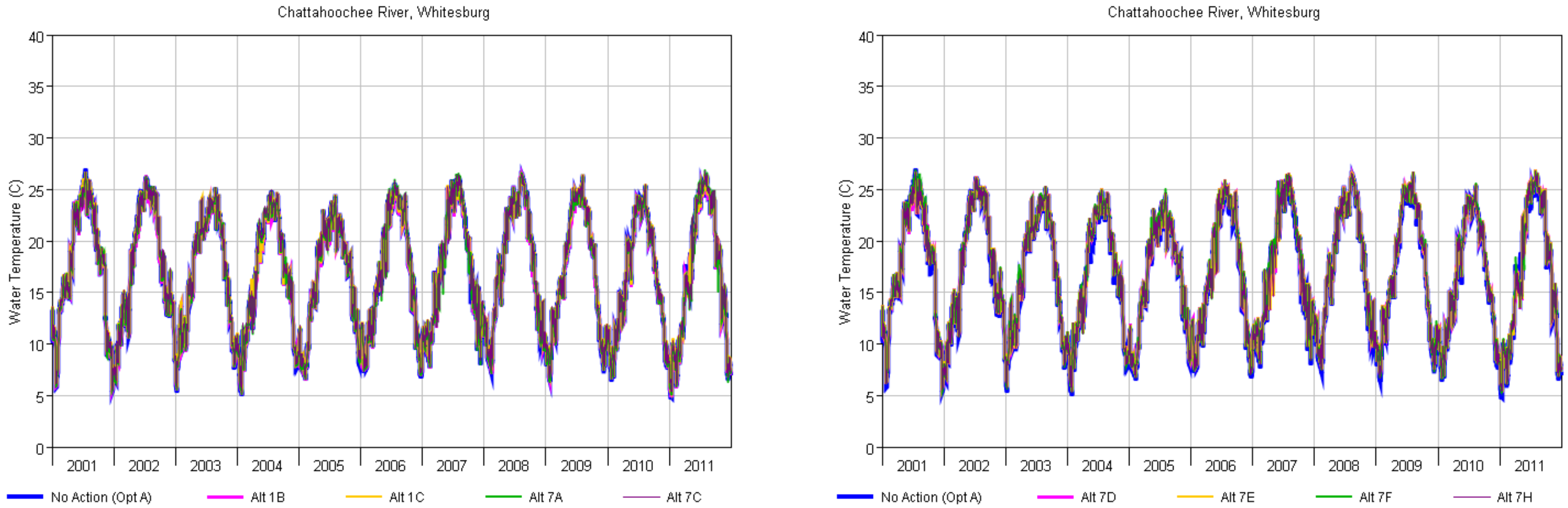

Figure 4.6 Time series of *water temperature* for the Chattahoochee River at Whitesburg, during the 2001-2011 model period.

4.2 CUMULATIVE OCCURRENCE

The cumulative percentage of occurrence of each water quality parameter shown in Table 4.2 was computed for the 2001–2011 modeling period using the computed daily HEC-5Q time series from each location shown in Table 4.1 along the Chattahoochee, Flint, and Apalachicola Rivers. The cumulative occurrence plots show the percentage of time each parameter was lower than a certain concentration level. For example, if a DO plot shows a 5% occurrence level at 6 mg/L, then 5% of the observations were *lower* than this level. An occurrence level of 95% at 12 mg/L shows that 95% of model values fell *below* 12 mg/L. Conversely, this would indicate that 5% of the model values were *higher* than 12 mg/L. The 0% and 100% levels represent the theoretical minimum and maximum values, respectively, of a parameter. These proxies for the minimum and maximum values eliminated reporting of water quality spikes, due to "negative" inflows and other factors. In the longitudinal river profiles shown below, the 5%, 50%, and 95% occurrence levels are plotted to show the lower, median, and upper range of concentration values.

The DO plots indicate the DO standard specified by the USFWS. The USFWS DO standard for fish habitat in pristine water bodies is 6 mg/L, while the USFWS standard for the rest of the ACF system is 5 mg/L. The point where the cumulative occurrence curve intersects the top of the zone shows the percentage of time this standard is violated. If the curve does not cross this zone, then the standard was never exceeded during the modeling period. Only Lake Lanier (Buford) is labeled with a 6 mg/L DO standard. All locations modeled and plotted in this analysis, except Lake Lanier (Buford), required the 5 mg/L standard. The plots of Buford (Lake Lanier) are labeled with the 6 mg/L DO standard.

To improve the clarity of the plots, two sets were plotted. The first set contains the No Action Alternative (Option A) and alternatives 1B, 1C, 7A, and 7C. The second set contains the No Action Alternative (Option A) and alternatives 7D, 7E, 7F, and 7H (Proposed Action Alternative).

Representative plots of chlorophyll a, DO, and temperature are shown in Figure 4.7 – Figure 4.12 at two sample locations on the Chattahoochee River. The first is Buford station at Lake Lanier, which is above Buford Dam, and the second is Whitesburg station. All of the plots in Figure 4.7 – Figure 4.12 represent the cumulative occurrence over the 2001–2011 modeling period. Figure 4.7 – Figure 4.8 show the cumulative occurrence of chlorophyll *a* at Lake Lanier and Whitesburg, respectively. Figure 4.9 and Figure 4.10 show the cumulative occurrence for DO at Lake Lanier and Whitesburg, respectively. The DO plots at Lanier and Whitesburg indicate that their respective DO standards are not violated for any of the alternatives. Finally, Figure 4.11 and Figure 4.12 show the cumulative occurrence for water temperature over the 2001–2011 modeling period.

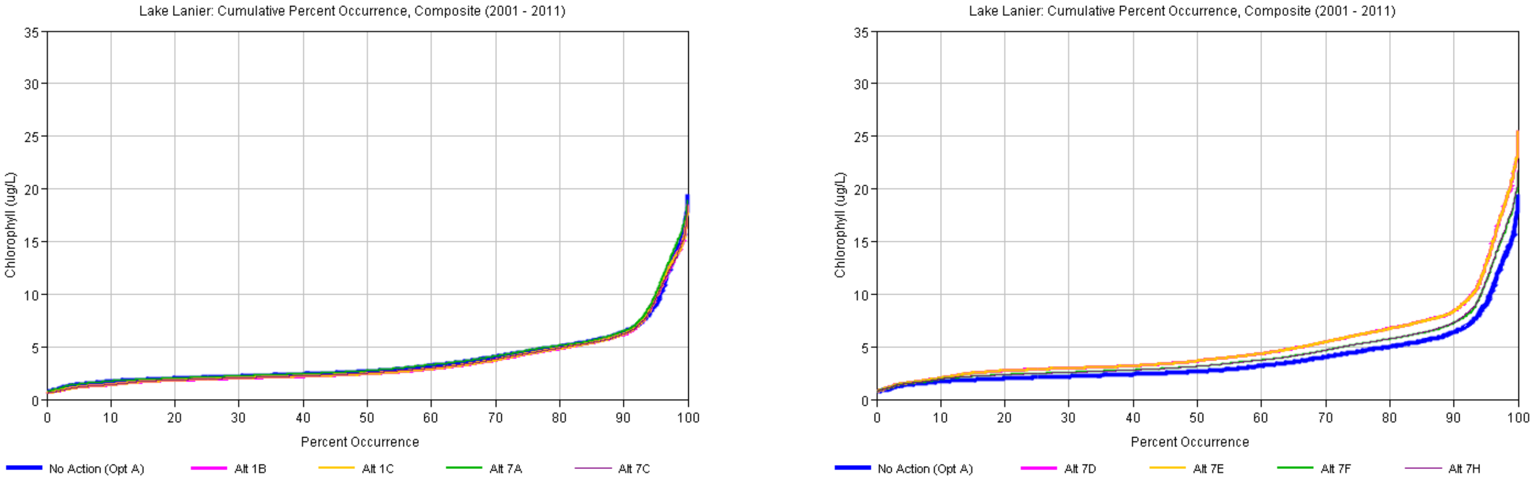

Figure 4.7 Cumulative occurrence of *chlorophyll a* computed for the Chattahoochee River at Lake Lanier, above Buford Dam, for the 2001-2011 modeling period.

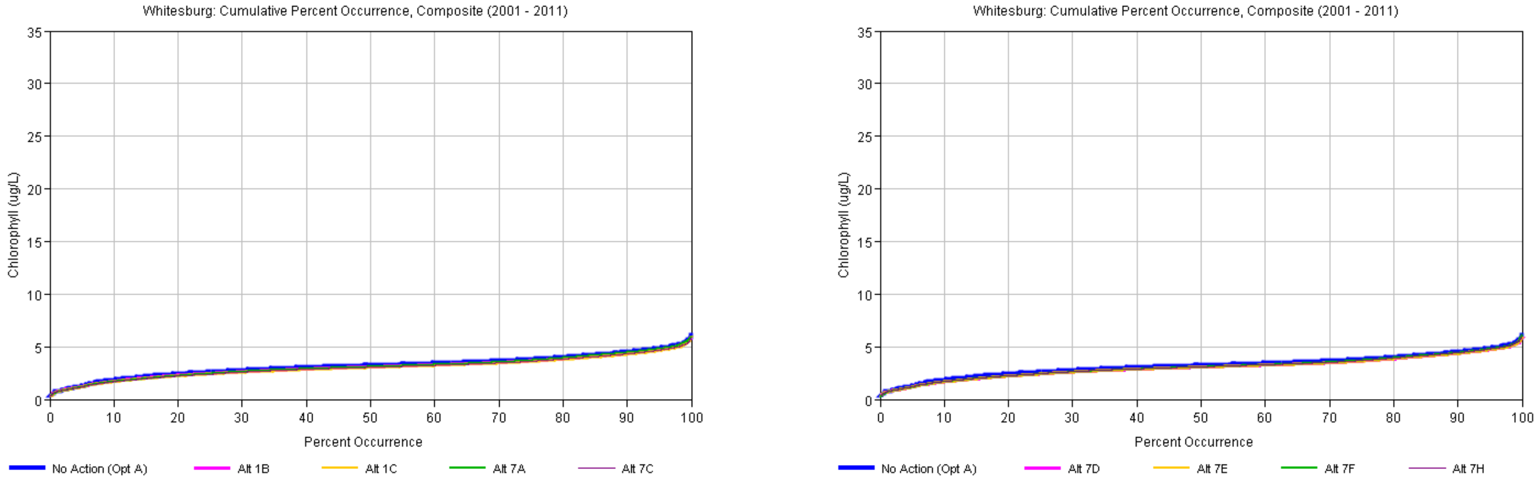

Figure 4.8 Cumulative occurrence of *chlorophyll a* computed for the Chattahoochee River at Whitesburg for the 2001-2011 modeling period.

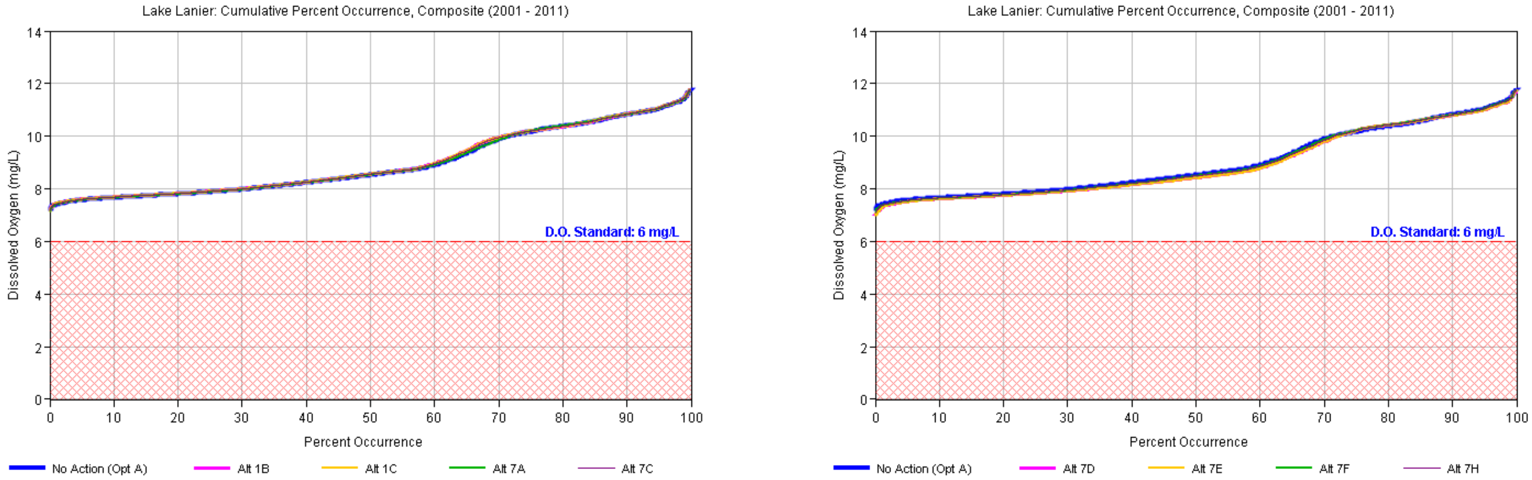

Figure 4.9 Cumulative occurrence of *DO* computed for the Chattahoochee River at Lake Lanier, above Buford Dam, for the 2001-2011 modeling period. The USFWS standard of 6 mg/L (for Lake Lanier) is denoted by the red shaded zone.

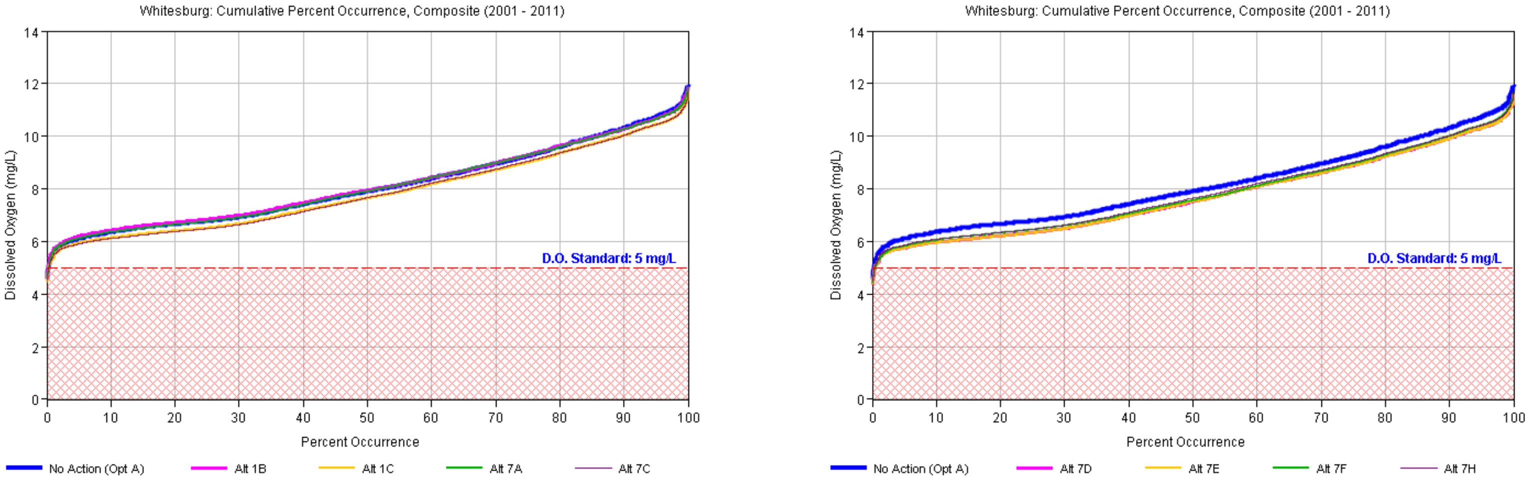

Figure 4.10 Cumulative occurrence of *DO* computed for the Chattahoochee River at Whitesburg for the 2001-2011 modeling period. The USFWS standard of 5 mg/L is denoted by the red shaded zone.

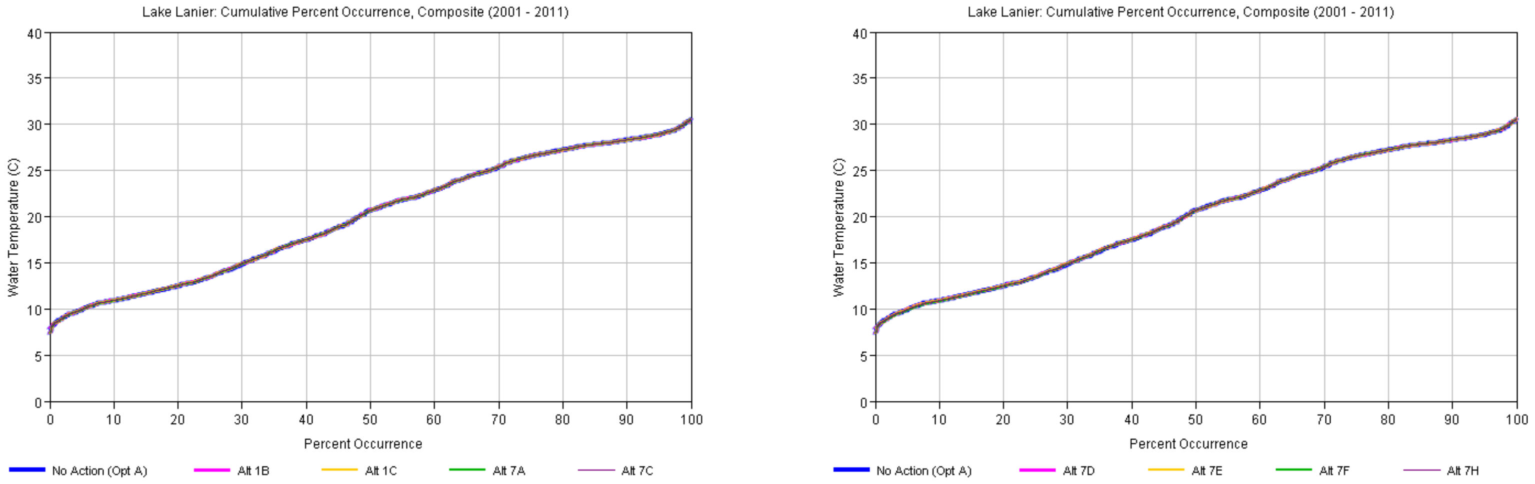

Figure 4.11 Cumulative occurrence of *water temperature* computed for the Chattahoochee River at Lake Lanier, above Buford Dam, for the 2001-2011 modeling period.

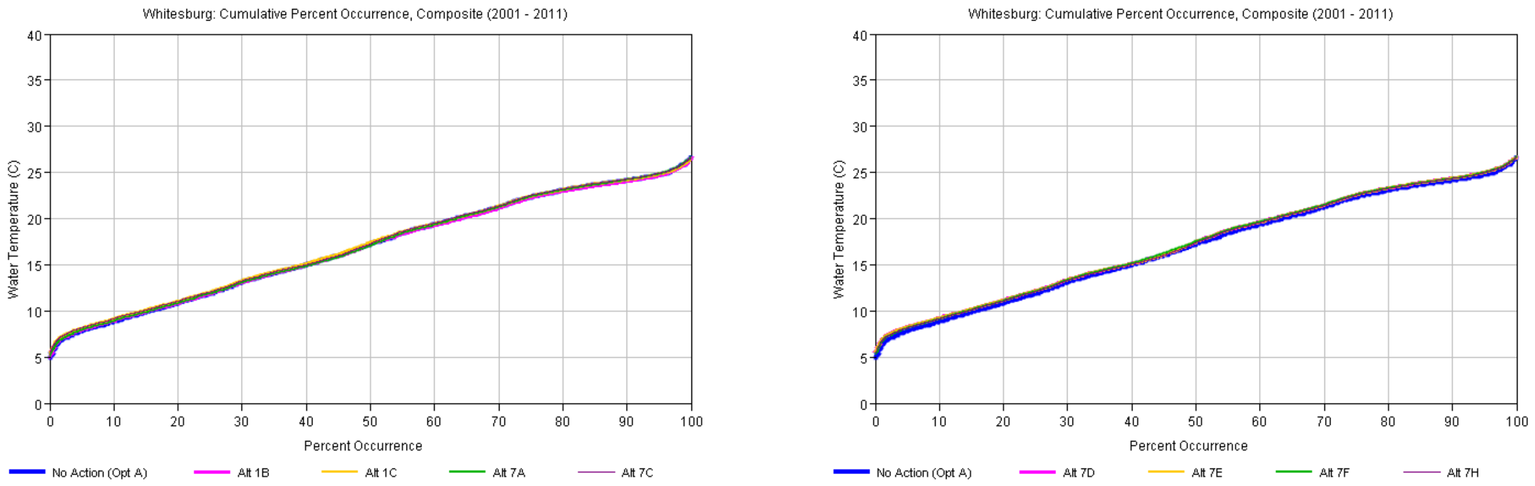

Figure 4.12 Cumulative occurrence of *water temperature* computed for the Chattahoochee River at Whitesburg for the 2001-2011 modeling period.

4.3 RIVER PROFILES

4.3.1 OVERVIEW

Cumulative occurrence levels of each water quality parameter shown in Table 4.2 were computed from the daily HEC-5Q time series output for each river mile along the Chattahoochee and Flint Rivers for No Action conditions and each of the alternatives. The occurrence levels were plotted by river mile to show longitudinal profiles of occurrence for each parameter. Occurrence profiles were plotted to show how water quality varies along each reach, and how it may be affected by dams, other structures, or discharges (point source and non-point source). Peak values may shift longitudinally during a dry year vs. a wet year. Therefore, these can serve as validation of the model accuracy.

The 50% occurrence level shows the median concentration of each parameter. The 5% and 95% occurrence were selected as proxies of the minimum and maximum values, respectively. A minimum/maximum value computed by the model may not be representative of the true minimum/maximum, but instead may be a function of minor model error due to missing data or other factors. The 5% and 95% occurrence levels are expected to be better representations of the lower and upper bounds of parameter values in the ACF basin. Therefore, low occurrence levels are analogous to low values of a given parameter, while high occurrence levels are analogous to high values.

4.3.2 COMPUTATION

A post-processing program was used to compute the percentage exceedance of each parameter at multiple exceedance levels. The exceedance shows the percentage of time a parameter exceeded a particular concentration. To avoid confusion with the water quality definition of exceedance as a violation of a standard, the percentage of occurrence is shown instead. This was computed by subtracting the exceedance level from 100%. While a 95% exceedance level indicates that 95% of values are greater than the concentration at that level, the 5% occurrence indicates that 5% of values are less than that level.

4.3.3 COMPUTATION PERIODS

While cumulative occurrence was computed for the entire model period in Section 1.1, several different weekly, seasonal, and annual model periods were computed and shown as longitudinal occurrence profiles.

To show how the ACF system functions during different annual hydrologic conditions, three different years were selected from the 2001–2011 model period to represent normal (2004), wet (2005), and dry (2007) hydrologic conditions. These are plotted along with profiles of the composite of the 2001–2011 modeling period.

In addition to showing the annual percentage of occurrence of each parameter, the functioning of the ACF system is particularly important during the growing season. There are two major definitions of growing season in the ACF basin. Three growing season definitions had to be considered for the ACF basin to address requirements by the States of Georgia and Alabama as well as the USFWS. These definitions are as follows:

1. State of Georgia: April–October
2. State of Alabama: April–November
3. USFWS: May–October

Occurrence profiles were computed for each of these growing seasons. To improve the clarity of the plots, two sets were plotted. The first set contains the No Action Alternative (Option A) and alternatives 1B, 1C, 7A, and 7C. The second set contains the No Action Alternative (Option A) and alternatives 7D, 7E, 7F, and 7H (Proposed Action Alternative).

These results are available in the HEC-DSS model output files, which are available upon request. Several samples of the weekly intervals are shown below.

__Composite Period__: Occurrence profiles were computed and plotted for the “composite” 2001 – 2011 model period for eight water quality parameters: dissolved oxygen (DO), chlorophyll *a*, temperature, point-source load percent of flow (Percent Point Load), 5-day uninhibited biochemical oxygen demand (BOD5), ammonia-nitrogen (NH_3-N), nitrate-nitrogen (NO_3-N), and phosphate-phosphorus (PO_4-P). Example plots are shown of DO (Figure 4.13), chlorophyll *a* (Figure 4.14), water temperature (Figure 4.15), Percent Point Load (Figure 4.16), BOD5 (Figure 4.17), NO_3-N (Figure 4.18), and PO_4-P (Figure 4.19).

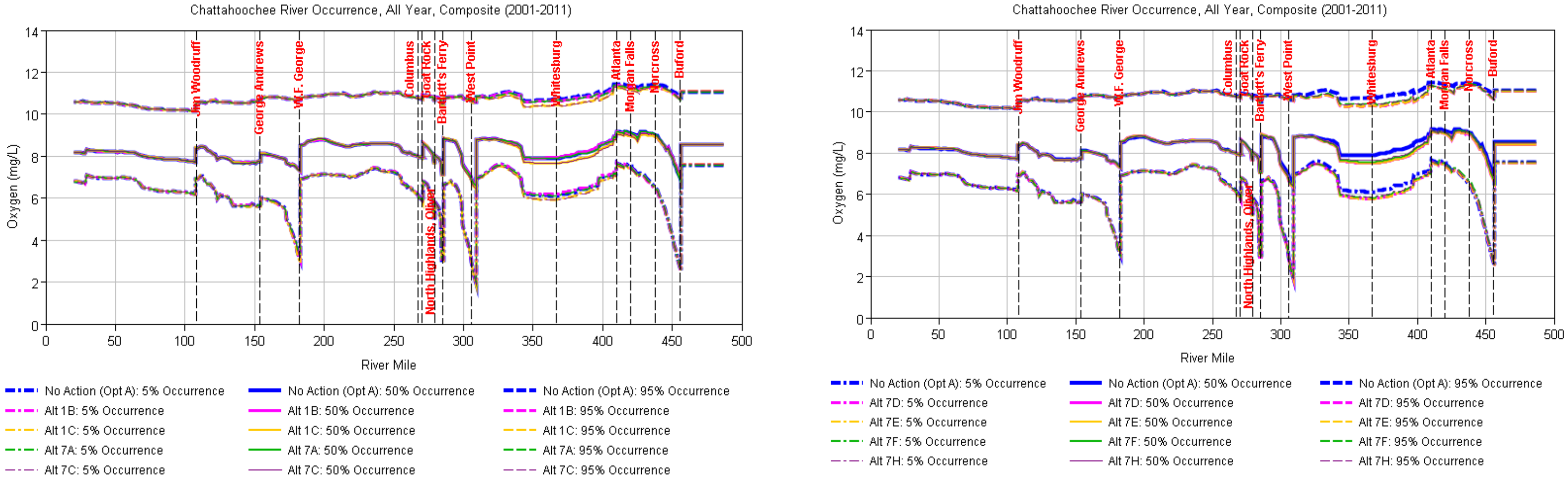

Figure 4.13 Longitudinal occurrence profiles of *DO* were computed along the Chattahoochee Rivers for the 2001-2011 modeling period. The 5, 50, and 95 percent occurrence levels are shown for the No Action plan and eight alternatives. Alternative 7H is the Proposed Action alternative.

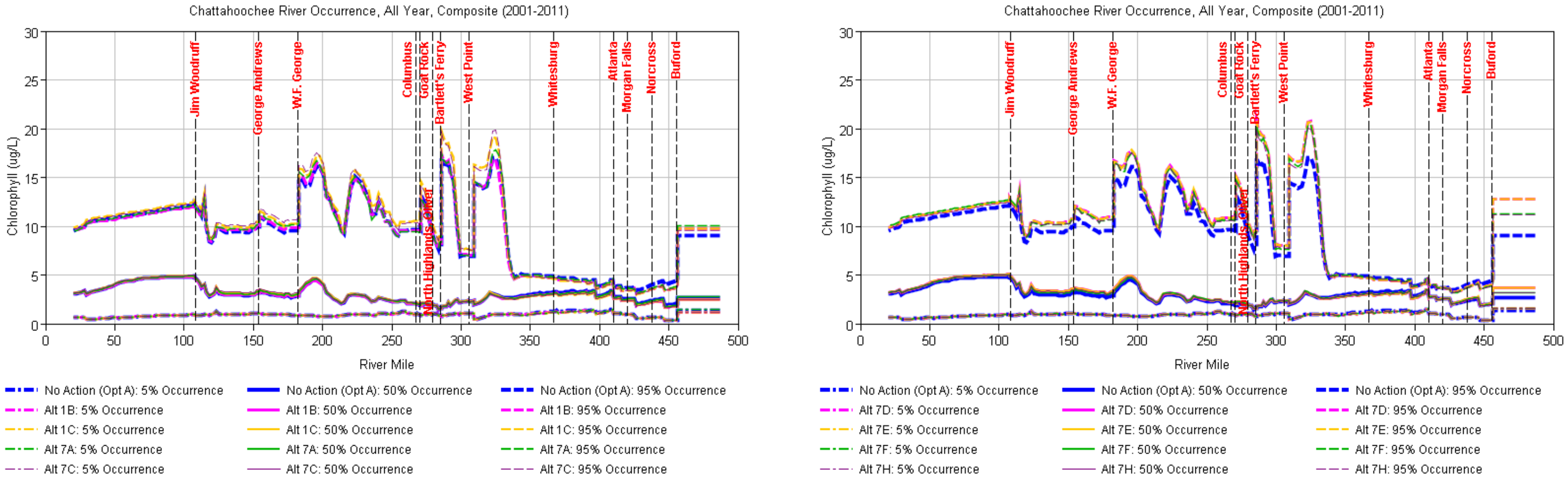

Figure 4.14 Longitudinal occurrence profiles of *chlorophyll a* were computed along the Chattahoochee Rivers for the 2001-2011 modeling period. The 5, 50, and 95 percent occurrence levels are shown for the No Action plan and eight alternatives. Alternative 7H is the Proposed Action alternative.

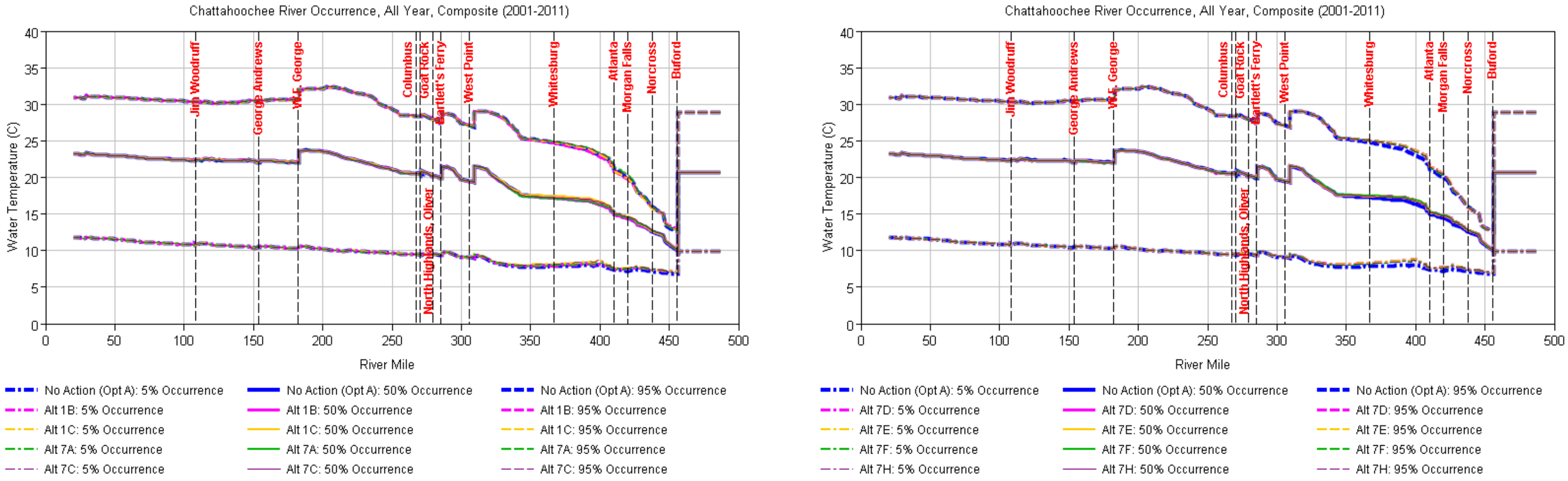

Figure 4.15 Longitudinal occurrence profiles of *water temperature* were computed along the Chattahoochee Rivers for the 2001-2011 modeling period. The 5, 50, and 95 percent occurrence levels are shown for the No Action plan and eight alternatives. Alternative 7H is the Proposed Action alternative.

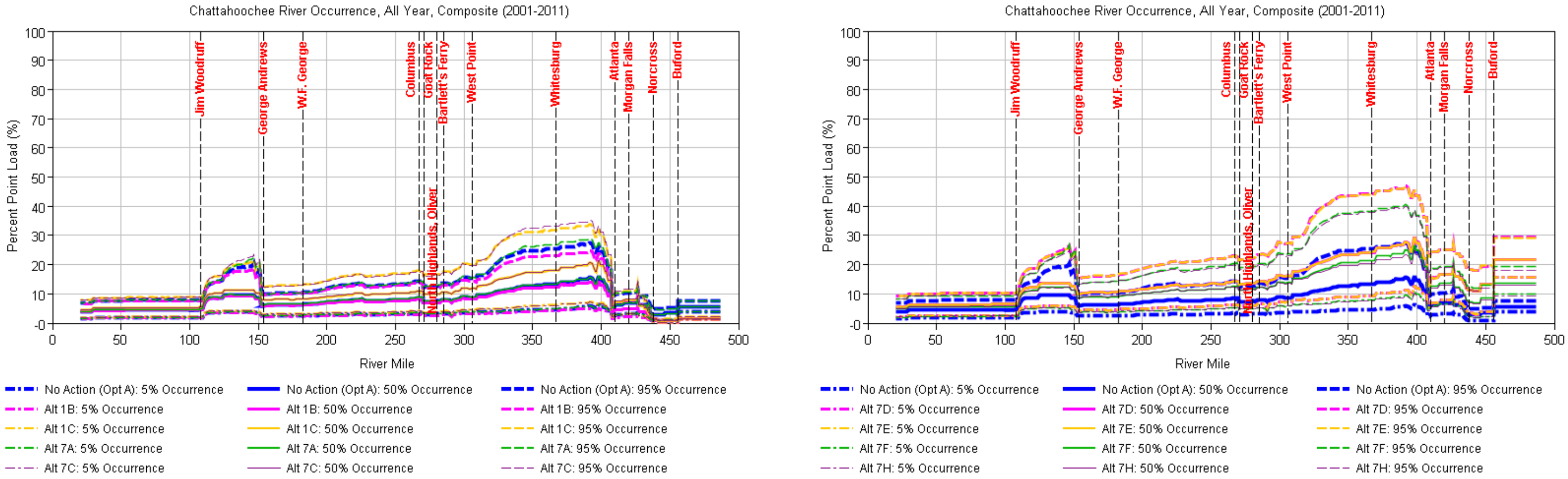

Figure 4.16 Longitudinal occurrence profiles of *wastewater percentage of flow* were computed along the Chattahoochee Rivers for the 2001-2011 modeling period. The 5, 50, and 95 percent occurrence levels are shown for the No Action plan and eight alternatives. Alternative 7H is the Proposed Action alternative.

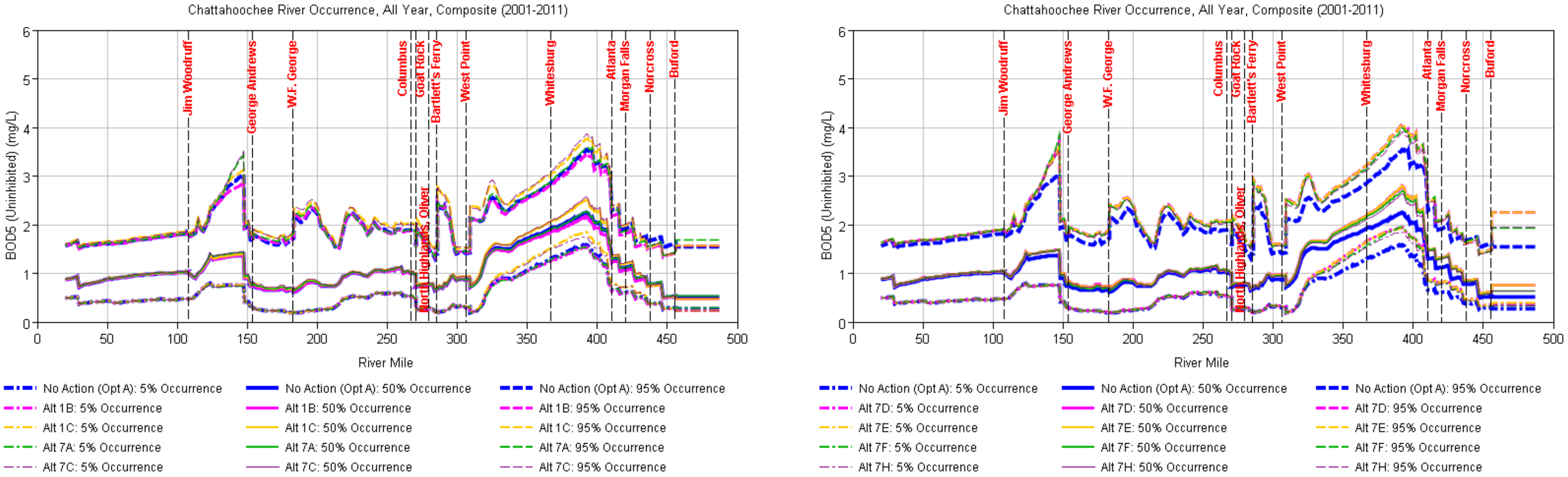

Figure 4.17 Longitudinal occurrence profiles of *5-Day uninhibited biochemical oxygen demand (BOD5U)* were computed along the Chattahoochee Rivers for the 2001-2011 modeling period. The 5, 50, and 95 percent occurrence levels are shown for the No Action plan and eight alternatives. Alternative 7H is the Proposed Action alternative.

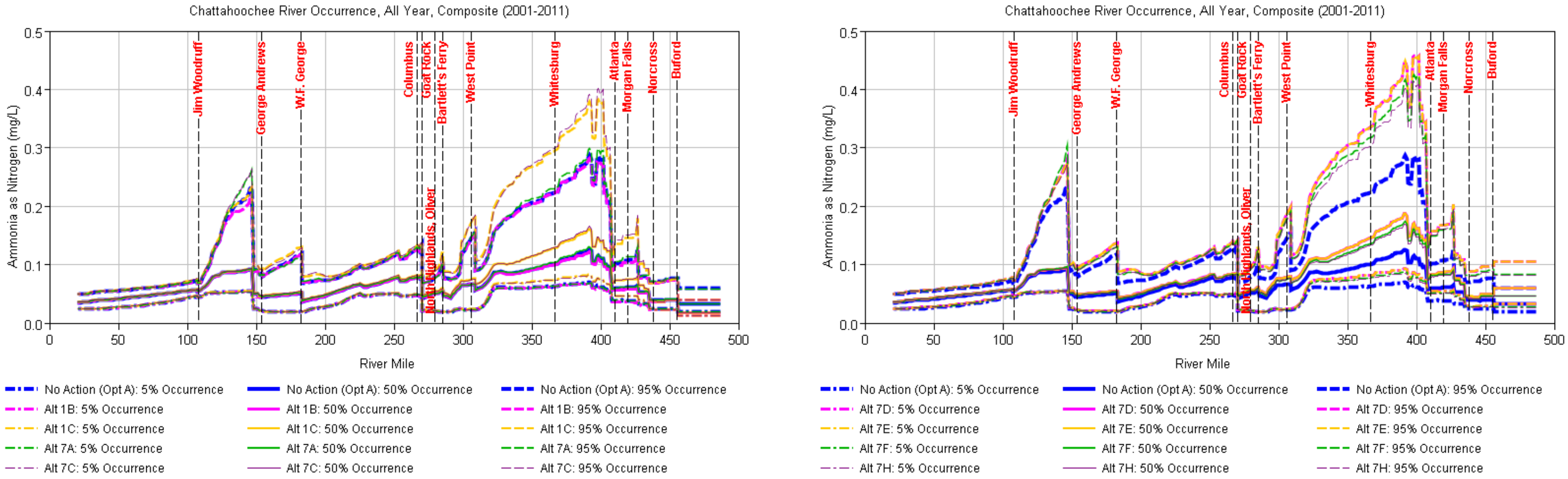

Figure 4.18 Longitudinal occurrence profiles of *ammonia as nitrogen (NH_3-N)* were computed along the Chattahoochee Rivers for the 2001-2011 modeling period. The 5, 50, and 95 percent occurrence levels are shown for the No Action plan and eight alternatives. Alternative 7H is the Proposed Action alternative.

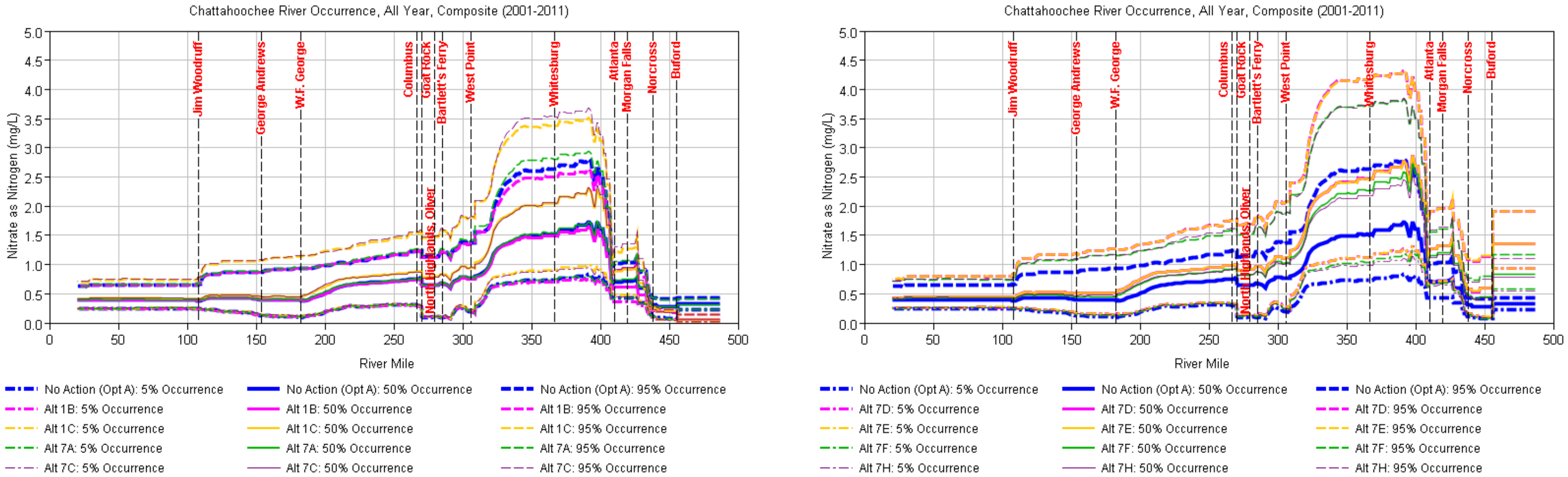

Figure 4.19 Longitudinal occurrence profiles of *nitrate as nitrogen (NO_3-N)* were computed along the Chattahoochee Rivers for the 2001-2011 modeling period. The 5, 50, and 95 percent occurrence levels are shown for the No Action plan and eight alternatives. Alternative 7H is the Proposed Action alternative.

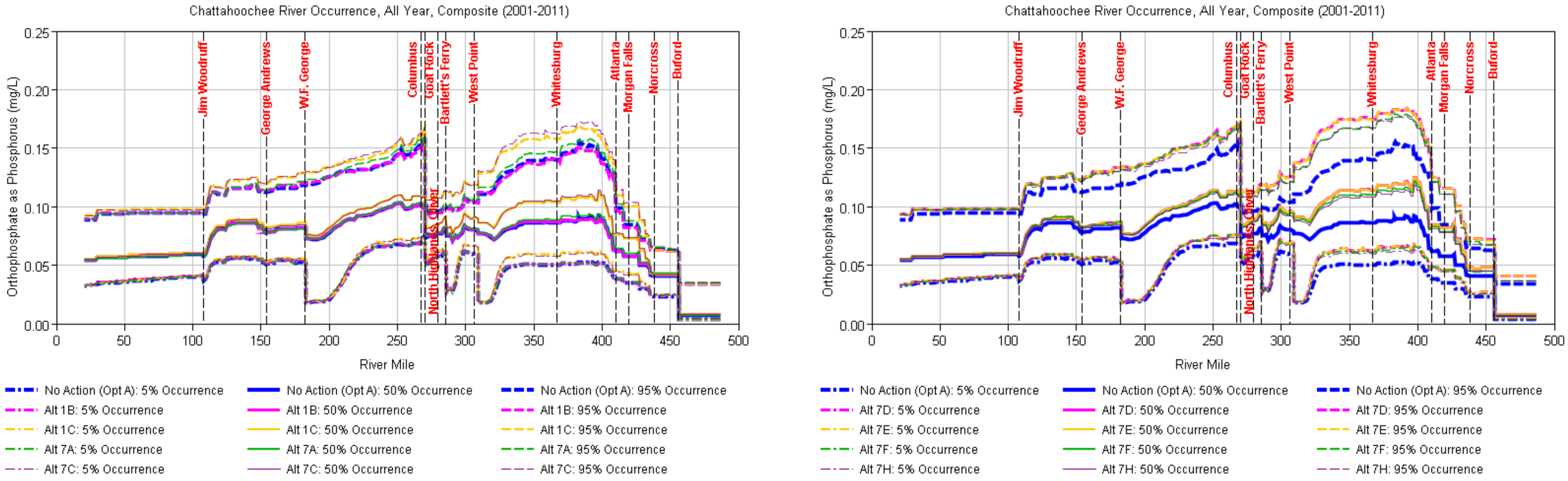

Figure 4.20 Longitudinal occurrence profiles of *orthophosphate as phosphorous (PO$_3$-P)* were computed along the Chattahoochee Rivers for the 2001-2011 modeling period. The 5, 50, and 95 percent occurrence levels are shown for the No Action plan and eight alternatives. Alternative 7H is the Proposed Action alternative.

Annual Hydrologic Periods: Occurrence profiles were computed and plotted for each water quality parameter for representative wet, normal, and dry years during the 2001–2011 modeling period. Figure 4.21, Figure 4.22, and Figure 4.23, show example plots of DO for the years 2004 (Normal), 2005 (Wet), and 2007 (Dry), respectively.

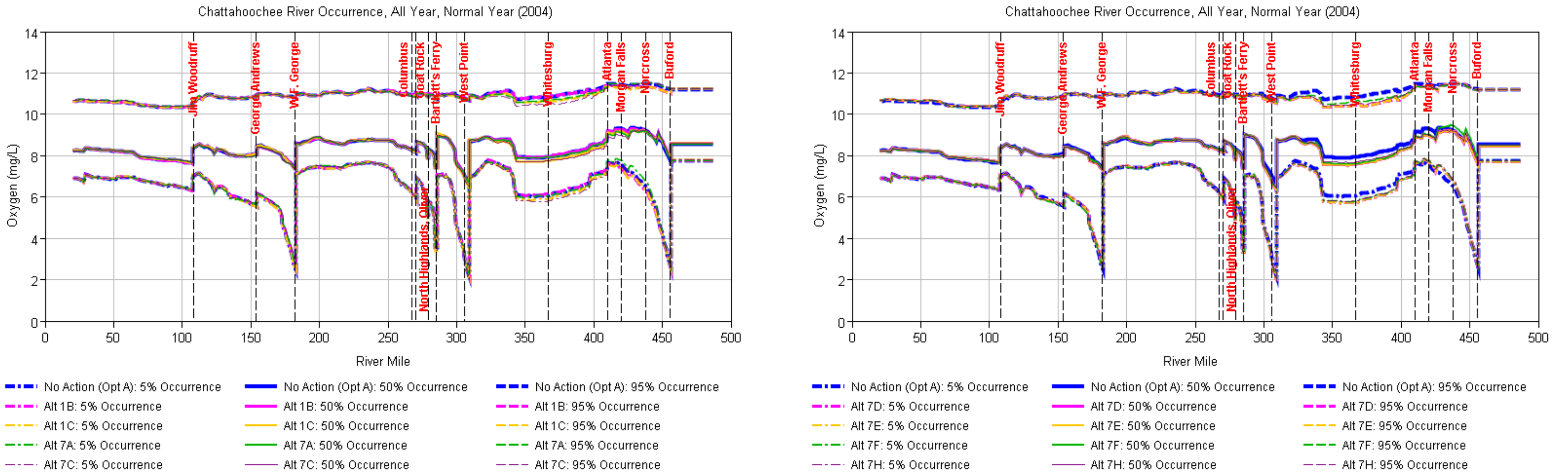

Figure 4.21 Longitudinal occurrence profiles of *DO* were computed along the Chattahoochee River during a "normal" year (2004). The 5, 50, and 95 percent occurrence levels are shown for the No Action plan and eight alternatives. Alternative 7H is the Proposed Action alternative.

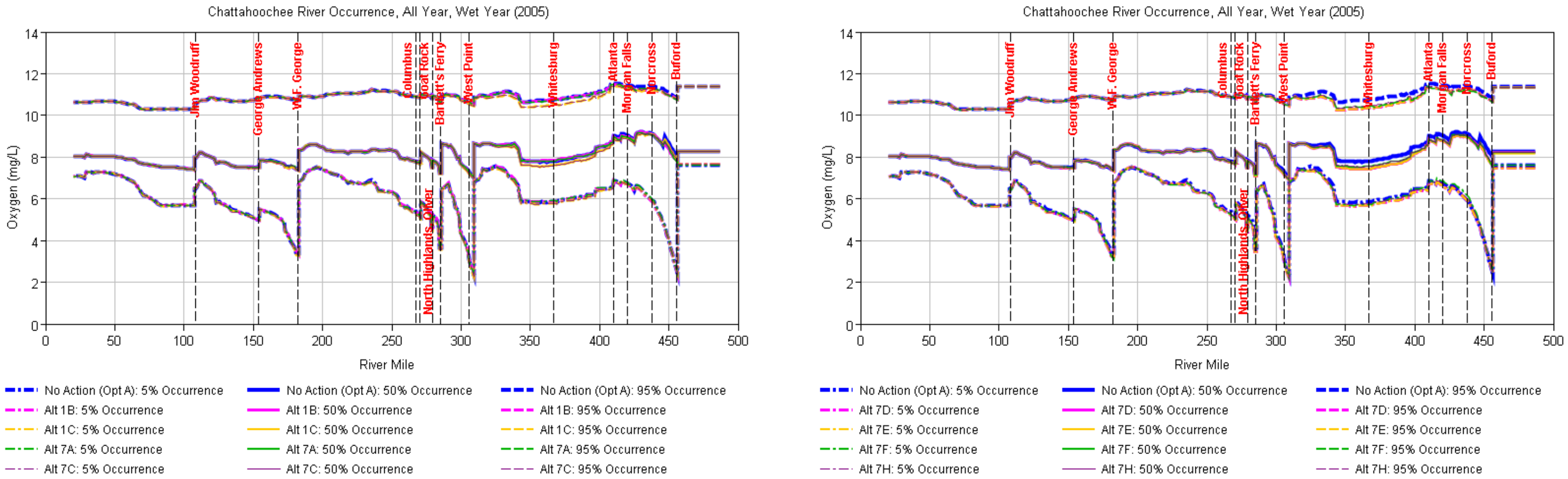

Figure 4.22 Longitudinal occurrence profiles of *DO* were computed along the Chattahoochee River during a "wet" year (2005). The 5, 50, and 95 percent occurrence levels are shown for the No Action plan and eight alternatives. Alternative 7H is the Proposed Action alternative.

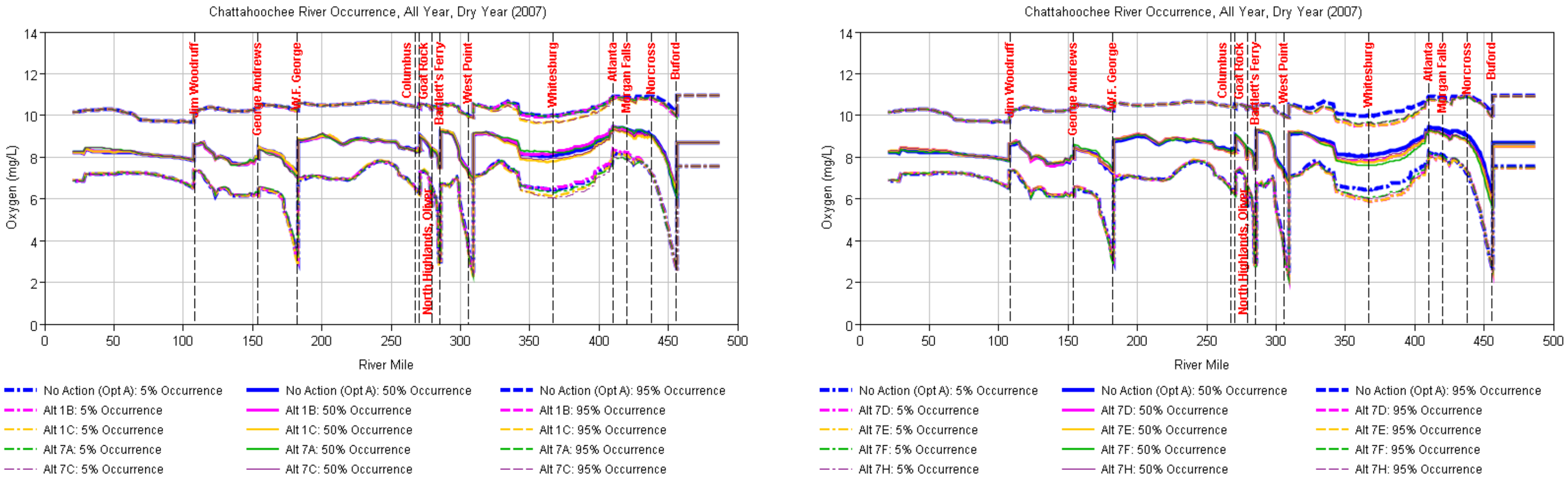

Figure 4.23 Longitudinal occurrence profiles of *DO* were computed along the Chattahoochee River during a "dry" year (2007). The 5, 50, and 95 percent occurrence levels are shown for the No Action plan and eight alternatives. Alternative 7H is the Proposed Action alternative.

__Growing Seasons__: Occurrence profiles were computed and plotted for each water quality parameter and hydrologic period for the “composite” 2001–2001 model period, as well as for two growing seasons, as defined by the U.S. Fish and Wildlife Service (May-Oct) and the State of Georgia (Apr-Oct). Figure 4.24 and Figure 4.25, respectively, show example occurrence profiles of DO computed over the 2001-2011 model period for the May-Oct growing season and Apr-Oct growing season.

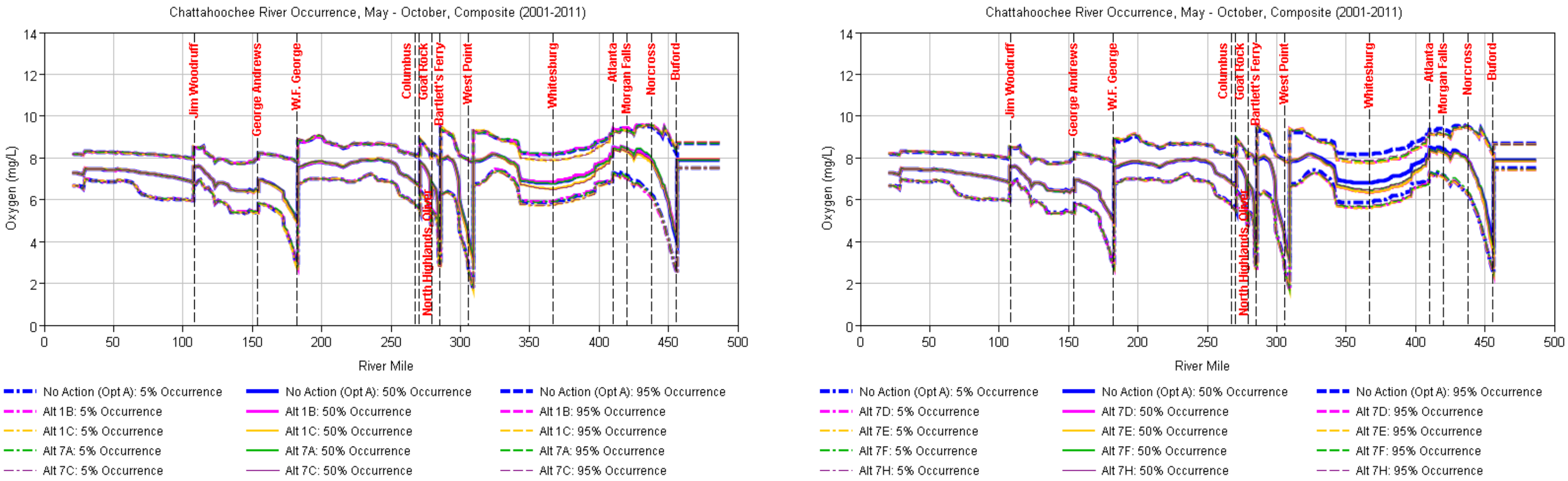

Figure 4.24 To address the standards of the U.S. Fish and Wildlife Service, longitudinal occurrence profiles of *DO* were computed for the months of May-October at the Chattahoochee River during the 2001-2011 modeling period. The 5, 50, and 95 percent occurrence levels are shown for the No Action plan and eight alternatives. Alternative 7H is the Proposed Action alternative.

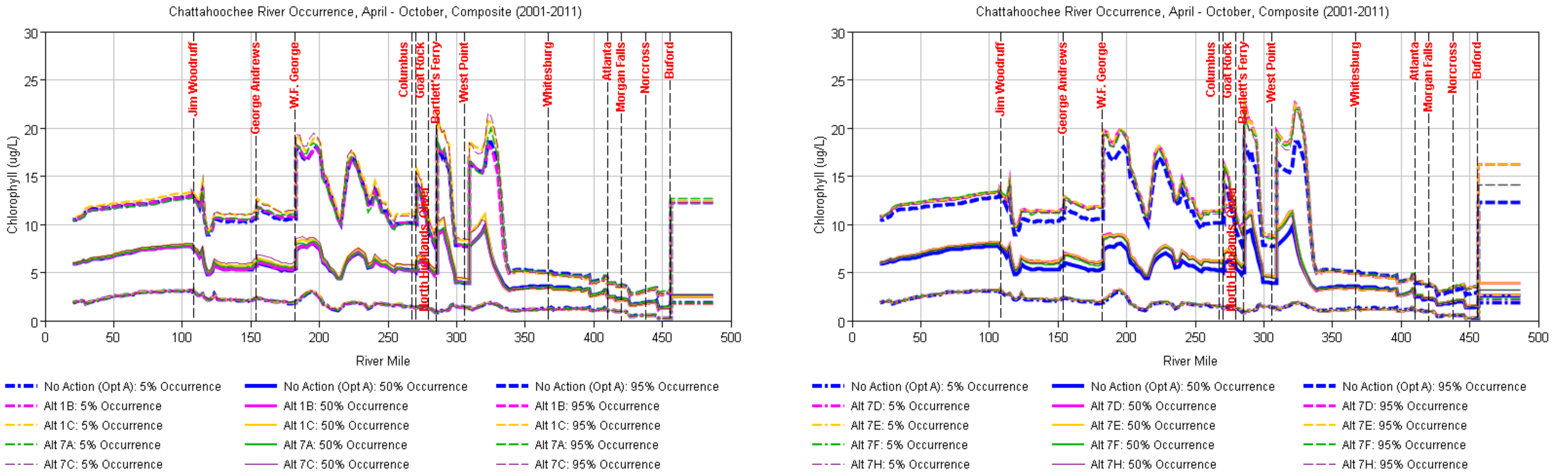

Figure 4.25 To address the standards of the state of Georgia, longitudinal occurrence profiles of *chlorophyll a* were computed for the months of April-October at the Chattahoochee River during the 2001-2011 modeling period. The 5, 50, and 95 percent occurrence levels are shown for the No Action plan and eight alternatives. Alternative 7H is the Proposed Action alternative.

5 CLIMATE CHANGE ANALYSIS

The HEC-5Q ACF model was used to simulate water quality for the Proposed Action Alternative using climate-change-projected flows and air temperatures for three sets of hydrologic conditions. Projected incremental local flows were derived by the USACE Institute of Water Resources (IWR, 2014). Climate change impacts were projected for the 2021–2050 period. Delta values were calculated relative to the equivalent 30 year antecedent period 1970-1999 to determine “Dry”, “Median”, and “Wet” conditions for the 2021–2050 period, denoted in the plots as Q1, Q2, and Q3, respectively. Monthly scaling factors were developed for each month and each quantile of the 2021–2050 period.

The ResSim ACF model was computed using the incremental local flows derived for the three hydrologic conditions (Q1, Q2, and Q3) for this period. These three scenarios are denoted in the plots as Dry (2050-Q1), Avg (2050-Q2), and Wet (2050-Q3). Climate model air temperature projections for the ACF were taken from the corresponding climate model output, and an extrapolation approach was used to derive the equilibrium temperatures. Further details are provided in Section 2.4.1 and IWR (2014).

Water quality was simulated for the Proposed Action alternatives under these conditions, and these results were compared to the Proposed Action plan under existing/historical conditions. Longitudinal profiles of occurrence levels were plotted for all water quality parameters, summarizing the results for the full year and the three growing seasons for the 2001–2011 model period and each of the three hydrologic periods (2004, 2005, and 2007) that were used for the analysis of the historical conditions. Representative plots of chlorophyll a, DO, and water temperature are shown in Figure 5.1, Figure 5.2, and Figure 5.3, respectively.

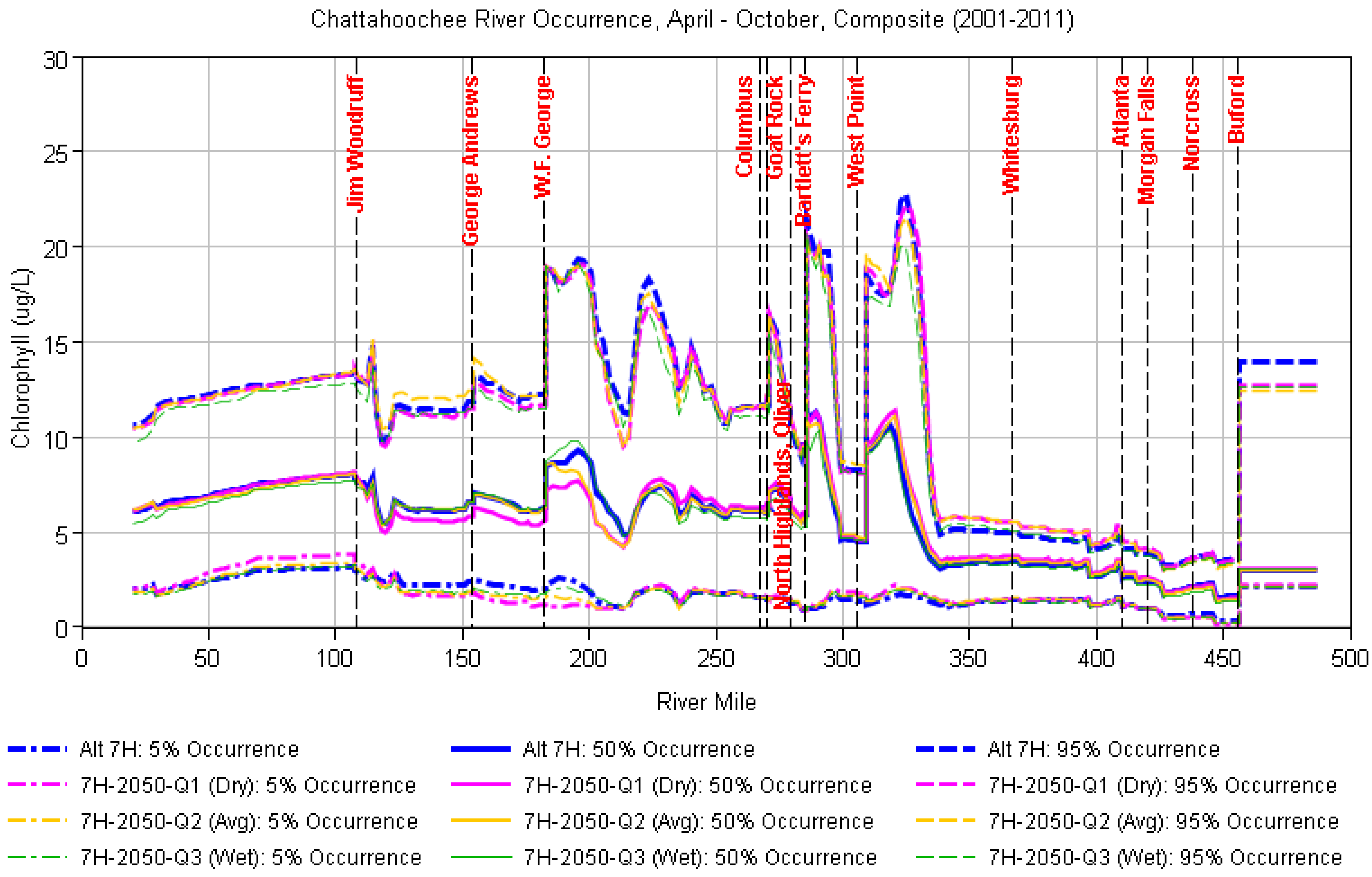

Figure 5.1 Longitudinal occurrence profiles of chlorophyll *a* for the April-November growing season along the Chattahoochee River during the 2001–2011 modeling period.

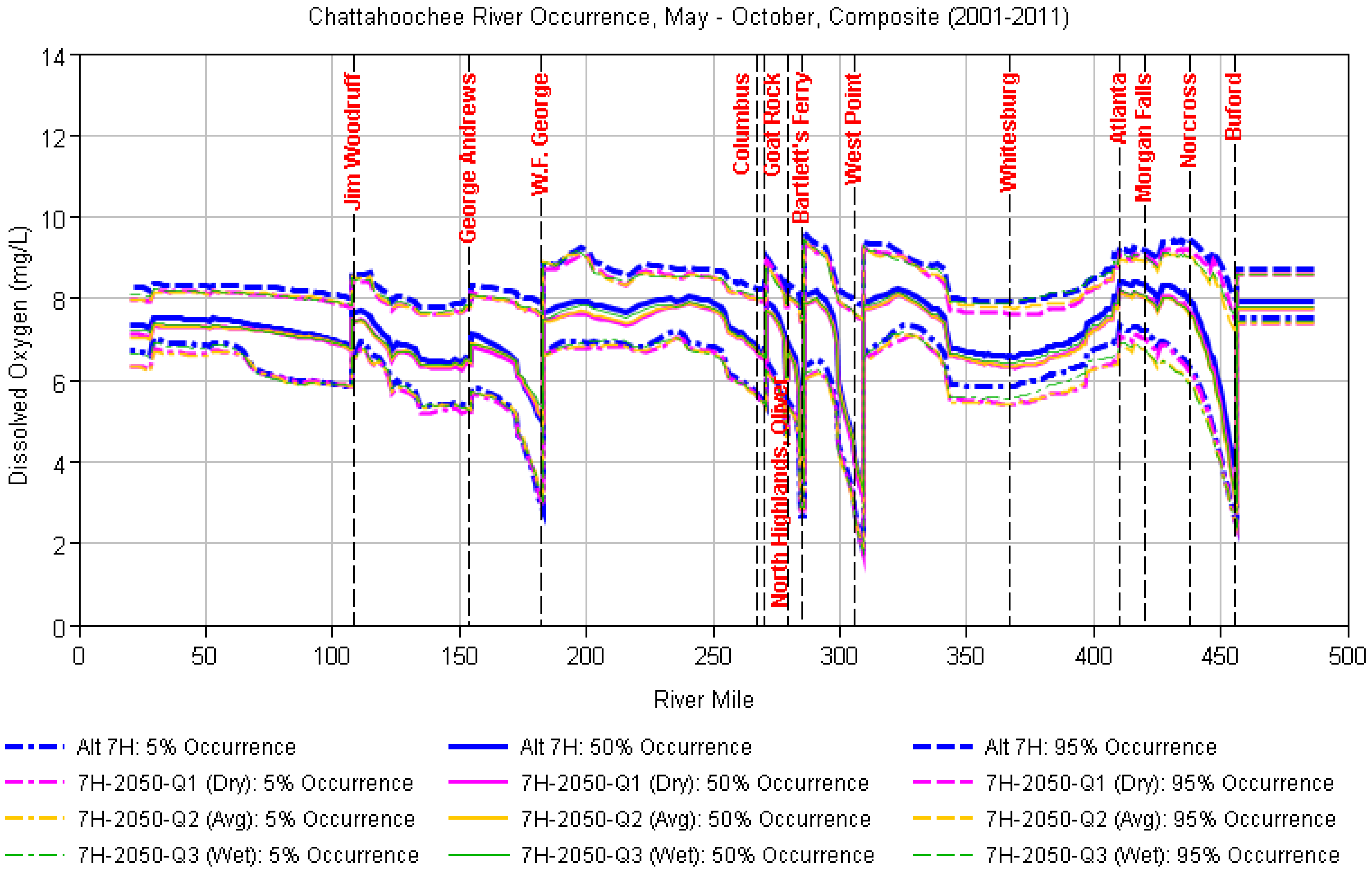

Figure 5.2 Longitudinal occurrence profiles of DO for the May-October growing season along the Chattahoochee River during the 2001–2011 modeling period.

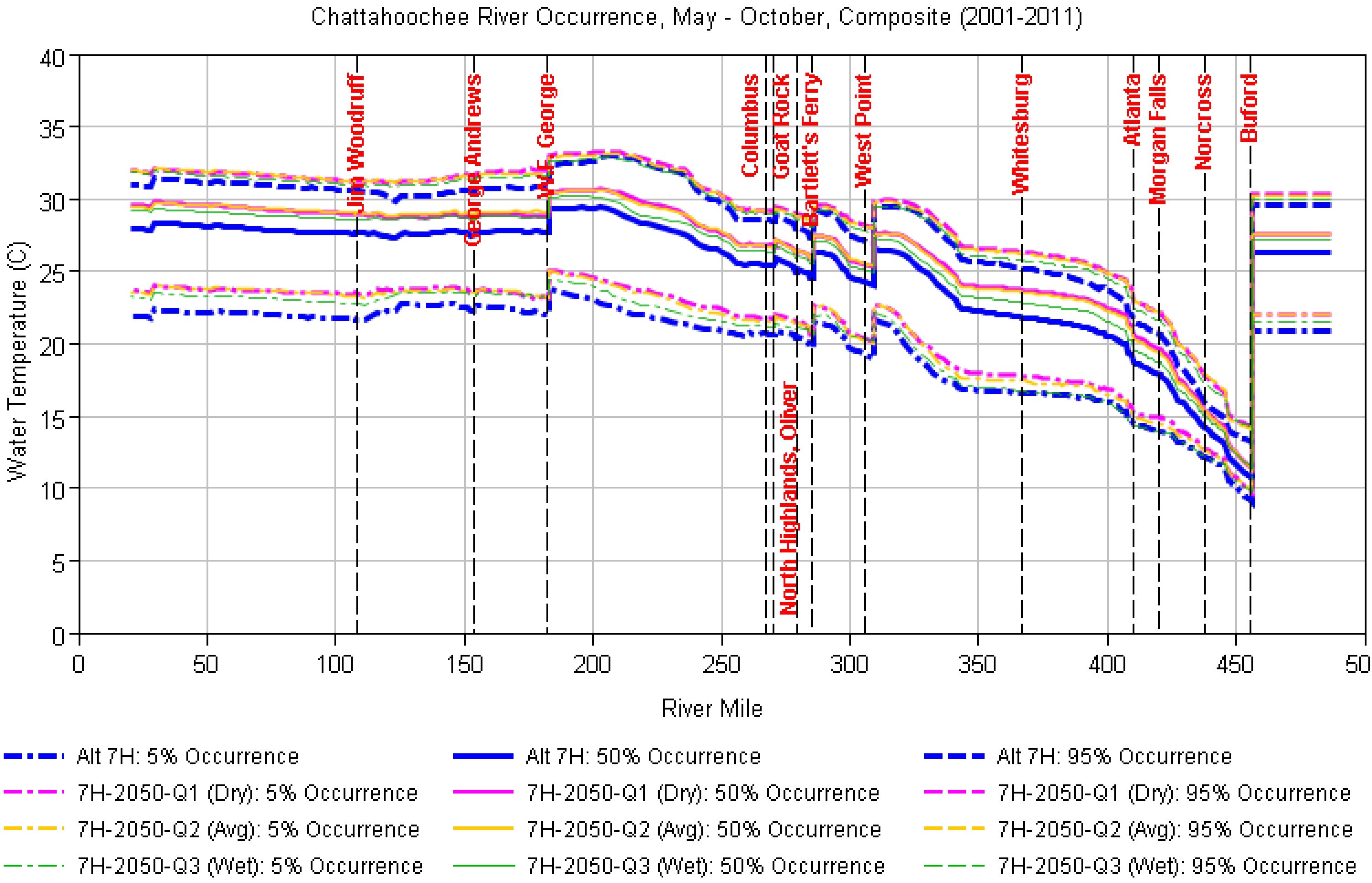

Figure 5.3 Longitudinal occurrence profiles of water temperature for the May-October growing season along the Chattahoochee River during the 2001–2011 modeling period.

6 REFERENCES

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7 APPENDIX A – TRIBUTARY FLOW AND WATER QUALITY INPUTS

Table 7.1 Average, maximum and minimum tributary flow and water quality inputs to the Chattahoochee River.

Reach/ Name (point load)**	**River Mile**	**Flow**	**Temp**	**Point inflow**	**NO3-N**	**PO4-P**	**Chl_*a***	**NH3-N**	**DO**	**DOM1 (BOD)**	**DOM2 (BOD)**	**TSS (org)**	**avg max min**
	mile	**cfs**	**C**	**tracer**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	
Lake Lanier (Buford)	456.1												
Chattahoochee River	490	1453	15.5	-	0.17	0.02	1.65	0.04	8.8	-	3.0	1.6	(avg)
			25.8	-	1.14	0.23	10.00	0.22	13.0	-	7.2	11.1	(max)
			4.0	-	0.15	0.01	1.00	0.03	5.8	-	3.0	1.1	(min)
Gainesville - Flat Creek **	460	11.69	20.8	100	10.00	0.28	-	1.50	5.7	10.0	-	3.5	(avg)
			28.0	100	10.00	0.43	-	1.50	7.3	10.0	-	3.5	(max)
			12.0	100	10.00	0.22	-	1.50	4.1	10.0	-	3.5	(min)
Buford Dam to Norcross	456.1												
Swannee Creek	446	185	16.5	-	0.25	0.04	1.65	0.06	8.6	-	3.4	3.2	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.15	0.01	1.00	0.03	3.0	-	3.0	1.1	(min)
Fulton County - Cauley **	440	6.7	23.7	100	10.00	0.09	-	0.20	6.2	7.5	-	3.1	(avg)
			27.2	100	10.00	0.11	-	0.25	7.5	7.5	-	3.1	(max)
			18.6	100	10.00	0.06	-	0.18	4.9	7.5	-	3.1	(min)
Norcross to Morgan Falls_IN	438.5												
Fulton County - Johns Cr **	435	9.3	20.8	100	10.00	0.58	-	1.17	5.4	15.0	-	7.3	(avg)
			28.0	100	10.00	0.70	-	2.29	7.0	15.0	-	7.3	(max)
			12.0	100	10.00	0.51	-	0.40	3.8	15.0	-	7.3	(min)

Reach/ Name (** point load)	River Mile	Flow	Temp	Point inflow	NO3-N	PO4-P	Chl_*a*	NH3-N	DO	DOM1 (BOD)	DOM2 (BOD)	TSS (org)	avg max min
	mile	cfs	C	tracer	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	
Fulton Co. Big Creek WPCP **	427	33.7	20.8	100	10.00	0.46	-	0.82	5.2	5.0	-	1.4	(avg)
			28.0	100	10.00	0.53	-	1.83	6.3	5.0	-	1.4	(max)
			12.0	100	10.00	0.35	-	0.27	4.1	5.0	-	1.4	(min)
Big Creek	426	200	16.5	-	0.33	0.06	1.65	0.07	8.6	-	3.7	4.2	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.15	0.01	1.00	0.03	3.0	-	3.0	1.2	(min)
Morgan Falls to Atlanta_IN	420.4												
Sope Creek	415	141	16.5	-	0.55	0.13	1.65	0.12	8.6	-	5.3	8.1	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
Lockheed **			4.0	-	0.23	0.01	1.00	0.05	3.0	-	3.0	1.5	(min)
	413	2.6	20.8	100	8.60	0.27	-	0.03	6.9	7.2	-	3.0	(avg)
			28.0	100	8.60	0.38	-	0.03	9.2	10.9	-	3.0	(max)
			12.0	100	8.60	0.18	-	0.03	4.8	5.2	-	3.0	(min)
Atlanta to Whitsburg	410.7												
Nancy and Peachtree Creek	409	311	16.5	-	0.46	0.10	1.65	0.10	8.6	-	4.5	6.3	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.19	0.01	1.00	0.05	3.0	-	3.0	1.3	(min)
RM Clayton WPCP **	407	121.4	20.8	100	10.00	0.22	-	0.86	6.4	10.0	-	3.8	(avg)
			28.0	100	10.00	0.28	-	1.63	8.0	10.0	-	3.8	(max)
			12.0	100	10.00	0.18	-	0.26	4.9	10.0	-	3.8	(min)
Cobb County - Sutton WPCP **	404	47.8	21.3	100	10.00	0.33	-	0.43	6.2	5.0	-	2.2	(avg)
			25.1	100	10.00	0.45	-	1.10	7.8	5.0	-	2.2	(max)
			16.7	100	10.00	0.25	-	0.18	4.8	5.0	-	2.2	(min)
South Cobb WPCP **	402	36.5	21.3	100	10.00	0.37	-	1.12	7.0	17.5	-	7.0	(avg)
			26.1	100	10.00	0.49	-	2.79	8.5	17.5	-	7.0	(max)
			15.6	100	10.00	0.30	-	0.12	5.2	17.5	-	7.0	(min)

Reach/ Name (** point load)	River Mile	Flow	Temp	Point inflow	NO3-N	PO4-P	Chl_*a*	NH3-N	DO	DOM1 (BOD)	DOM2 (BOD)	TSS (org)	avg max min
	mile	cfs	C	tracer	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	
Atlanta South River **	399	49.3	20.8	100	10.00	0.29	-	0.58	5.8	7.5	-	2.7	(avg)
			28.0	100	10.00	0.42	-	0.91	7.3	7.5	-	2.7	(max)
			12.0	100	10.00	0.19	-	0.25	4.4	7.5	-	2.7	(min)
Utoy Creek	397	396	16.5	-	0.38	0.08	1.65	0.08	8.6	-	4.1	5.3	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.15	0.01	1.00	0.04	3.0	-	3.0	1.3	(min)
Atlanta Creek WPCP **	395	43	20.8	100	10.00	0.18	-	0.20	5.8	10.0	-	3.7	(avg)
			28.0	100	10.00	0.26	-	0.39	7.2	10.0	-	3.7	(max)
			12.0	100	10.00	0.13	-	0.09	4.4	10.0	-	3.7	(min)
Camp Creek WPCP **	393.5	22	20.8	100	10.00	0.25	-	2.76	6.3	12.5	-	5.1	(avg)
			28.0	100	10.00	0.34	-	5.07	7.6	12.5	-	5.1	(max)
			12.0	100	10.00	0.21	-	0.93	5.0	12.5	-	5.1	(min)
Douglasville Douglas County **	392	2.3	20.8	100	10.00	0.42	-	1.29	6.4	12.1	-	6.6	(avg)
			28.0	100	10.00	0.50	-	2.20	8.4	16.2	-	6.6	(max)
			12.0	100	10.00	0.36	-	0.84	4.7	8.8	-	6.6	(min)
Camp Creek	390	111	16.5	-	0.31	0.06	1.65	0.07	8.6	-	3.6	4.1	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.15	0.01	1.00	0.03	3.0	-	3.0	1.2	(min)
Bear Creek	383	84	16.5	-	0.23	0.03	1.65	0.05	8.6	-	3.2	2.4	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.15	0.01	1.00	0.03	3.0	-	3.0	1.1	(min)
Snake Creek	370	172	16.5	-	0.26	0.04	1.65	0.06	8.6	-	3.2	2.7	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.15	0.01	1.00	0.03	3.0	-	3.0	1.1	(min)

Reach/ Name (** point load)	River Mile	Flow	Temp	Point inflow	NO3-N	PO4-P	Chl_*a*	NH3-N	DO	DOM1 (BOD)	DOM2 (BOD)	TSS (org)	avg max min
	mile	cfs	C	tracer	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	
Whitesburg to Franklin	367.6												
Chattahoochee: misc.trib-1	358	90	16.5	-	0.31	0.05	1.65	0.07	8.6	-	3.3	3.0	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.15	0.01	1.00	0.03	3.0	-	3.0	1.1	(min)
Centralhatchee Creek	344	27	16.5	-	0.32	0.05	1.65	0.07	8.6	-	3.2	2.6	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
West Point Lake	343.2		4.0	-	0.15	0.01	1.00	0.03	3.0	-	3.0	1.1	(min)
Hillabatchee Creek	342	61	16.5	-	0.23	0.03	1.65	0.05	8.6	-	3.1	1.9	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.15	0.01	1.00	0.02	3.0	-	3.0	1.0	(min)
New River	335	140	16.5	-	0.26	0.03	1.65	0.05	8.6	-	3.2	2.2	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.15	0.01	1.00	0.02	3.0	-	3.0	1.1	(min)
Yellowjacket Creek	322	144	16.5	-	0.25	0.03	1.65	0.05	8.6	-	3.2	2.1	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.15	0.01	1.00	0.02	3.0	-	3.0	1.1	(min)
Wehadkee Creek	312	120	16.5	-	0.25	0.03	1.65	0.05	8.6	-	3.1	1.9	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.15	0.01	1.00	0.02	3.0	-	3.0	1.0	(min)
West Point Dam to West Point Gauge	309.2												
Oseligee Creek	308.9	345	16.5	-	0.22	0.02	1.65	0.04	8.6	-	3.1	1.8	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.15	0.01	1.00	0.02	3.0	-	3.0	1.0	(min)
Lanett WWTP **	306.9	3.9	20.8	100	10.00	0.70	-	0.59	6.4	6.8	-	7.7	(avg)
			28.0	100	10.00	0.70	-	1.07	8.9	11.0	-	7.7	(max)
			12.0	100	10.00	0.70	-	0.14	4.4	5.5	-	7.7	(min)

Reach/ Name (** point load)	River Mile	Flow	Temp	Point inflow	NO3-N	PO4-P	Chl_*a*	NH3-N	DO	DOM1 (BOD)	DOM2 (BOD)	TSS (org)	avg max min
	mile	cfs	C	tracer	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	
West Point Gauge to Bartletts Ferry	306.7												
Long Cane Creek	304.5	70	16.5	-	0.25	0.04	1.65	0.05	8.6	-	3.3	2.7	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.15	0.01	1.00	0.02	3.0	-	3.0	1.1	(min)
La Grange WPCP **	302.5	8.8	20.5	100	10.00	0.51	-	0.08	5.8	7.5	-	2.9	(avg)
			30.0	100	10.00	0.72	-	0.22	7.3	7.5	-	2.9	(max)
			8.0	100	10.00	0.32	-	0.03	4.3	7.5	-	2.9	(min)
East Alabama WWTP **	299.5	3.9	20.8	100	5.82	1.73	-	2.09	3.9	9.0	-	16.2	(avg)
			28.0	100	12.87	2.63	-	5.24	5.7	11.8	-	16.2	(max)
			12.0	100	2.94	0.75	-	0.08	2.2	7.0	-	16.2	(min)
Bartletts Ferry	299.0												
Flat Shoal Creek	296	243	16.5	-	0.22	0.02	1.65	0.04	8.6	-	3.2	2.0	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.15	0.01	1.00	0.02	3.0	-	3.0	1.0	(min)
Mountain Creek	291	162	16.5	-	0.21	0.02	1.65	0.04	8.6	-	3.1	1.8	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.15	0.01	1.00	0.02	3.0	-	3.0	1.0	(min)
Halawakee Creek	288	87	16.5	-	0.22	0.02	1.65	0.04	8.6	-	3.2	2.0	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.15	0.01	1.00	0.02	3.0	-	3.0	1.1	(min)
Opelika Eastside WWTP **	286	1.1	20.8	100	9.51	9.21	-	2.02	6.9	10.0	-	4.2	(avg)
			28.0	100	12.88	14.43	-	7.94	9.0	10.0	-	4.2	(max)
			12.0	100	5.35	3.48	-	0.94	4.8	10.0	-	4.2	(min)

Reach/ Name (** point load)	River Mile	Flow	Temp	Point inflow	NO3-N	PO4-P	Chl_*a*	NH3-N	DO	DOM1 (BOD)	DOM2 (BOD)	TSS (org)	avg max min
	mile	cfs	C	tracer	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	
Goat Rock	284.7												
Mulberry Creek	282	312	16.5	-	0.21	0.02	1.65	0.04	8.6	-	3.2	2.0	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.15	0.01	1.00	0.02	3.0	-	3.0	1.1	(min)
Oliver	279.0												
Standing Boy Creek	275	31	16.5	-	0.21	0.02	1.65	0.04	8.6	-	3.1	2.0	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.15	0.01	1.00	0.02	3.0	-	3.0	1.0	(min)
North Highlands	270.7												
Chattahoochee: misc.trib-2	270.5	88	16.5	-	0.30	0.05	1.65	0.07	8.6	-	3.5	3.4	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.15	0.01	1.00	0.03	3.0	-	3.0	1.1	(min)
North Highlands Dam to Columbus	270.3												
Columbus WWTP **	270	46.7	20.8	100	10.00	2.24	-	2.96	6.3	25.0	-	10.8	(avg)
			28.0	100	10.00	3.11	-	4.93	7.7	25.0	-	10.8	(max)
			12.0	100	10.00	1.47	-	1.61	4.9	25.0	-	10.8	(min)
West Point WWTP **	269.3	1.1	20.8	100	10.00	0.62	-	2.58	5.2	27.3	-	10.8	(avg)
			28.0	100	10.00	1.04	-	4.03	6.4	32.3	-	10.8	(max)
			12.0	100	10.00	0.29	-	1.11	3.9	24.2	-	10.8	(min)
Southern Power Company **	268.7	2.5	23.3	100	4.70	0.10	-	0.60	4.3	12.5	-	5.1	(avg)
			29.3	100	4.70	0.10	-	0.60	5.0	12.5	-	5.1	(max)
			17.8	100	4.70	0.10	-	0.60	3.5	12.5	-	5.1	(min)
Chattahoochee: misc.trib-3	268	68	16.5	-	0.37	0.07	1.65	0.08	8.6	-	4.2	5.1	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
Columbus to W.F. George	267.7		4.0	-	0.15	0.01	1.00	0.03	3.0	-	3.0	1.3	(min)

Reach/ Name (point load)**	**River Mile**	**Flow**	**Temp**	**Point inflow**	**NO3-N**	**PO4-P**	**Chl_*a***	**NH3-N**	**DO**	**DOM1 (BOD)**	**DOM2 (BOD)**	**TSS (org)**	**avg max min**
	mile	**cfs**	**C**	**tracer**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	
Phenix City **	267.5	3.9	22.3	100	5.82	1.73	-	2.09	3.9	9.0	-	16.2	(avg)
			28.0	100	12.87	2.63	-	5.24	5.7	11.8	-	16.2	(max)
			12.3	100	2.94	0.75	-	0.08	2.2	7.0	-	16.2	(min)
Bull Creek	265	62	16.5	-	0.33	0.06	1.65	0.07	8.6	-	3.9	4.3	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.15	0.01	1.00	0.03	3.0	-	3.0	1.2	(min)
Upatoi Creek	260	301	16.5	-	0.28	0.05	1.65	0.06	8.6	-	3.7	3.8	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.15	0.01	1.00	0.03	3.0	-	3.0	1.2	(min)
Walter F George	256												
Columbus - Fort Benning **	256	2.6	22.3	100	1.00	8.12	-	12.63	3.0	53.6	-	20.4	(avg)
			28.0	100	1.00	9.02	-	13.47	4.1	61.3	-	20.4	(max)
			12.3	100	1.00	7.37	-	11.26	2.1	49.7	-	20.4	(min)
Uchee Creek	252	207	16.5	-	0.24	0.03	1.65	0.05	8.6	-	3.2	2.4	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.15	0.01	1.00	0.03	3.0	-	3.0	1.1	(min)
Hichitee Creek	244	75	16.5	-	0.24	0.04	1.65	0.05	8.6	-	3.4	3.0	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.15	0.01	1.00	0.03	3.0	-	3.0	1.2	(min)
Hannahatchee Creek	234	175	16.5	-	0.22	0.04	1.65	0.05	8.6	-	3.4	2.9	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.15	0.01	1.00	0.03	3.0	-	3.0	1.2	(min)
Mead Coated Board **	225	37.3	22.3	100	0.26	0.12	-	0.91	4.3	12.2	-	11.1	(avg)
			28.0	100	0.26	0.12	-	0.91	5.0	18.5	-	11.1	(max)
			12.3	100	0.26	0.12	-	0.91	3.5	8.1	-	11.1	(min)

Reach/ Name (** point load)	River Mile	Flow	Temp	Point inflow	NO3-N	PO4-P	Chl_*a*	NH3-N	DO	DOM1 (BOD)	DOM2 (BOD)	TSS (org)	avg max min
	mile	cfs	C	tracer	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	
Grass Creek	224	54	16.5	-	0.30	0.05	1.65	0.07	8.6	-	3.5	3.3	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.15	0.01	1.00	0.04	3.0	-	3.0	1.2	(min)
Eufaula WWTP **	218	3.9	22.3	100	10.00	0.70	-	0.59	6.4	6.8	-	7.7	(avg)
			28.0	100	10.00	0.70	-	1.07	8.9	11.0	-	7.7	(max)
			12.3	100	10.00	0.70	-	0.14	4.4	5.5	-	7.7	(min)
Cowikee Creek	216	353	16.5	-	0.24	0.04	1.65	0.05	8.6	-	3.4	3.0	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.15	0.01	1.00	0.03	3.0	-	3.0	1.2	(min)
Barbour Creek	204	128	16.5	-	0.25	0.04	1.65	0.06	8.6	-	3.4	3.0	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.15	0.01	1.00	0.03	3.0	-	3.0	1.2	(min)
Pataula Creek	193	367	16.5	-	0.26	0.05	1.65	0.06	8.6	-	3.5	3.2	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.15	0.01	1.00	0.03	3.0	-	3.0	1.2	(min)
Walter F George Dam to Andrews	182.9												
Cemochechobee Creek	182	81	16.5	-	0.21	0.03	1.65	0.05	8.6	-	3.2	2.2	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.15	0.01	1.00	0.03	3.0	-	3.0	1.1	(min)
Kolomoki Creek	176	178	16.5	-	0.30	0.04	1.65	0.07	8.6	-	3.2	2.3	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.15	0.01	1.00	0.04	3.0	-	3.0	1.1	(min)
George Andrews	172.9												
Sandy Creek	164	201	16.5	-	0.25	0.03	1.65	0.06	8.6	-	3.2	2.1	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.15	0.01	1.00	0.03	3.0	-	3.0	1.1	(min)

Reach/ Name (** point load)	River Mile	Flow	Temp	Point inflow	NO3-N	PO4-P	Chl_*a*	NH3-N	DO	DOM1 (BOD)	DOM2 (BOD)	TSS (org)	avg max min
	mile	cfs	C	tracer	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	
Omusee Creek	156	260	16.5	-	0.34	0.04	1.65	0.08	8.6	-	3.2	2.2	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.17	0.01	1.00	0.04	3.0	-	3.0	1.1	(min)
Sawhatchee Creek	142	67	16.5	-	0.27	0.05	1.65	0.06	8.6	-	3.4	3.5	(avg)
			26.8	-	0.89	0.32	10.00	0.18	13.0	-	11.6	18.1	(max)
			4.0	-	0.19	0.01	1.00	0.05	3.0	-	3.0	1.5	(min)
George Andrews to Jim Woodruff_IN_CH (Lake Seminole)	154.4												
Farley Nuclear Plant **	151	129.9	20.8	100	0.50	0.15	-	0.20	4.3	10.0	-	4.0	(avg)
			33.4	100	0.50	0.15	-	0.20	5.0	10.0	-	4.0	(max)
			0.8	100	0.50	0.15	-	0.20	3.5	10.0	-	4.0	(min)
Great Southern Paper Co. **	148	73.2	29.4	100	1.00	0.30	-	4.00	4.3	62.3	-	31.0	(avg)
			41.7	100	1.00	0.30	-	4.00	5.0	77.7	-	31.0	(max)
			16.4	100	1.00	0.30	-	4.00	3.5	49.4	-	31.0	(min)
Lake Seminole, Chattahoochee Arm	134.3												
Chattahoochee: misc.trib-4	130	635	16.5	-	0.29	0.02	1.65	0.07	8.6	-	3.1	2.1	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.16	0.01	1.00	0.04	3.0	-	3.0	1.1	(min)

Table 7.2 Average, maximum and minimum flow and water quality inputs to the Flint and Apalachicola Rivers.

Reach/ Name (point load)**	**River Mile**	**Flow**	**Temp**	**Point inflow**	**NO3-N**	**PO4-P**	**Chl_*a***	**NH3-N**	**DO**	**DOM 1 (BOD)**	**DOM 2 (BOD)**	**TSS (org)**	**avg max min**
	mile	**cfs**	**C**	**tracer**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	
Griffin to Montezuma	412.2												
Flint R.	405	286	16.5	-	0.31	0.04	1.65	0.07	8.6	-	3.1	2.4	(avg)
			26.8	-	1.00	0.24	10.00	0.20	13.0	-	7.0	10.7	(max)
			4.0	-	0.21	0.01	1.00	0.05	3.0	-	3.0	1.3	(min)
Line Creek	399	157	16.5	-	0.18	0.02	1.65	0.04	8.6	-	3.0	1.6	(avg)
			26.8	-	0.54	0.10	10.00	0.11	13.0	-	3.6	5.3	(max)
			4.0	-	0.15	0.01	1.00	0.03	3.0	-	3.0	1.1	(min)
White Oak Creek	391	194	16.5	-	0.18	0.02	1.65	0.04	8.6	-	3.0	1.5	(avg)
			26.8	-	0.57	0.10	10.00	0.12	13.0	-	3.0	4.3	(max)
			4.0	-	0.15	0.01	1.00	0.03	3.0	-	3.0	1.1	(min)
Red Oak Creek	385	211	16.5	-	0.18	0.02	1.65	0.04	8.6	-	3.0	1.4	(avg)
			26.8	-	0.58	0.09	10.00	0.12	13.0	-	3.0	3.5	(max)
			4.0	-	0.15	0.01	1.00	0.03	3.0	-	3.0	1.1	(min)
Elkins Creek	378	164	16.5	-	0.17	0.02	1.65	0.04	8.6	-	3.0	1.6	(avg)
			26.8	-	0.52	0.10	10.00	0.11	13.0	-	3.2	4.7	(max)
			4.0	-	0.15	0.01	1.00	0.03	3.0	-	3.0	1.1	(min)
Pigeon Creek	362	102	16.5	-	0.16	0.02	1.65	0.03	8.6	-	3.0	1.6	(avg)
			26.8	-	0.43	0.08	10.00	0.09	13.0	-	3.3	4.9	(max)
			4.0	-	0.15	0.01	1.00	0.03	3.0	-	3.0	1.1	(min)
Lazer Creek	359	192	16.5	-	0.19	0.02	1.65	0.04	8.6	-	3.0	1.7	(avg)
			26.8	-	0.59	0.12	10.00	0.12	13.0	-	3.7	5.4	(max)
			4.0	-	0.15	0.01	1.00	0.03	3.0	-	3.0	1.1	(min)
Griffin WPCP **	358	2.2	20.8	100	10.00	1.77	-	1.85	6.2	15.3	-	7.5	(avg)
			28.0	100	10.00	2.32	-	2.51	8.0	24.3	-	7.5	(max)
			12.0	100	10.00	1.30	-	1.18	4.6	10.3	-	7.5	(min)

Reach/ Name (** point load)	River Mile	Flow	Temp	Point inflow	NO3-N	PO4-P	Chl_*a*	NH3-N	DO	DOM 1 (BOD)	DOM 2 (BOD)	TSS (org)	avg max min
	mile	cfs	C	tracer	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	
Potato Creek	351	261	16.5	-	0.17	0.02	1.65	0.04	8.6	-	3.0	1.6	(avg)
			26.8	-	0.50	0.10	10.00	0.10	13.0	-	3.4	4.9	(max)
			4.0	-	0.15	0.01	1.00	0.03	3.0	-	3.0	1.1	(min)
Swift Creek	337	218	6.5	-	0.17	0.02	1.65	0.04	8.6	-	3.0	1.8	(avg)
			26.8	-	0.50	0.12	10.00	0.10	13.0	-	4.4	6.5	(max)
			4.0	-	0.15	0.01	1.00	0.03	3.0	-	3.0	1.2	(min)
Ulcohatchee Creek	322	171	16.5	-	0.21	0.03	1.65	0.05	8.6	-	3.1	2.2	(avg)
			6.8	-	0.67	0.18	10.00	0.14	13.0	-	5.8	8.8	(max)
			4.0	-	0.15	0.01	1.00	0.04	3.0	-	3.0	1.2	(min)
Patsiliga Creek	308	271	16.5	-	0.23	0.02	1.65	0.05	8.6	-	3.1	2.1	(avg)
			6.8	-	0.75	0.16	10.00	0.15	13.0	-	5.5	8.4	(max)
			4.0	-	0.16	0.01	1.00	0.04	3.0	-	3.0	1.2	(min)
Horse and Toteover Creek	295	93	16.5	-	0.17	0.02	1.65	0.04	8.6	-	3.0	1.7	(avg)
			26.8	-	0.51	0.10	10.00	0.11	13.0	-	4.0	5.9	(max)
			4.0	-	0.15	0.01	1.00	0.03	3.0	-	3.0	1.1	(min)
Whitewater Creek	289	153	16.5	-	0.18	0.02	1.65	0.04	8.6	-	3.0	2.0	(avg)
			26.8	-	0.56	0.13	10.00	0.12	13.0	-	5.0	7.5	(max)
			4.0	-	0.15	0.01	1.00	0.03	3.0	-	3.0	1.2	(min)
Montezuma to Albany	288.4												
Montezuma WWTP	287	80	16.5	-	0.32	0.05	1.65	0.07	8.6	-	3.2	2.6	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.15	0.01	1.00	0.03	3.0	-	3.0	1.1	(min)
Buck Creek	275	127	6.5	-	0.31	0.03	1.65	0.07	8.6	-	3.0	2.0	(avg)
			26.8	-	2.00	0.50	10.00	0.45	13.0	-	12.0	20.4	(max)
			4.0	-	0.22	0.01	1.00	0.05	3.0	-	3.0	1.3	(min)

Reach/ Name (point load)**	**River Mile**	**Flow**	**Temp**	**Point inflow**	**NO3-N**	**PO4-P**	**Chl_*a***	**NH3-N**	**DO**	**DOM 1 (BOD)**	**DOM 2 (BOD)**	**TSS (org)**	**avg max min**
	mile	**cfs**	**C**	**tracer**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	
Camp Creek	262	178	16.5	-	0.34	0.03	1.65	0.07	8.6	-	3.0	2.1	(avg)
			6.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	21.0	(max)
			4.0	-	0.24	0.01	1.00	0.05	3.0	-	3.0	1.3	(min)
Turkey Creek	259	157	16.5	-	0.28	0.02	1.65	0.06	8.6	-	3.0	1.7	(avg)
			26.8	-	2.00	0.48	10.00	0.42	13.0	-	9.5	14.7	(max)
			4.0	-	0.20	0.01	1.00	0.05	3.0	-	3.0	1.2	(min)
Lime Creek	247	39	16.5	-	0.40	0.05	1.65	0.09	8.6	-	3.1	2.2	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	23.5	(max)
			4.0	-	0.29	0.01	1.00	0.06	3.0	-	3.0	1.3	(min)
Gum Creek	241	230	16.5	-	0.40	0.05	1.65	0.08	8.6	-	3.0	2.0	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	20.5	(max)
			4.0	-	0.28	0.01	1.00	0.06	3.0	-	3.0	1.3	(min)
Swift Creek	233	123	16.5	-	0.38	0.05	1.65	0.08	8.6	-	3.1	2.2	(avg)
			6.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	23.3	(max)
			4.0	-	0.27	0.01	1.00	0.06	3.0	-	3.0	1.3	(min)
Jones Creek	226	105	6.5	-	0.32	0.04	1.65	0.07	8.6	-	3.1	2.6	(avg)
			26.8	-	2.00	0.50	10.00	0.48	13.0	-	12.0	25.0	(max)
			4.0	-	0.23	0.01	1.00	0.05	3.0	-	3.0	1.4	(min)
Abrams Creek	220	94	16.5	-	0.44	0.07	1.65	0.09	8.6	-	3.3	3.2	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.31	0.01	1.00	0.07	3.0	-	3.0	1.5	(min)
Piney Woods Creek	217	178	6.5	-	0.25	0.03	1.65	0.06	8.6	-	3.1	2.2	(avg)
			6.8	-	1.90	0.50	10.00	0.37	13.0	-	12.0	23.8	(max)
			4.0	-	0.17	0.01	1.00	0.04	3.0	-	3.0	1.3	(min)

Reach/ Name (** point load)	River Mile	Flow	Temp	Point inflow	NO3-N	PO4-P	Chl_*a*	NH3-N	DO	DOM 1 (BOD)	DOM 2 (BOD)	TSS (org)	avg max min
	mile	cfs	C	tracer	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	
Albany to Newton	210.0												
Albany - Joshua St **	209	28	23.2	100	10.00	0.99	-	1.21	5.3	15.4	-	7.6	(avg)
			28.0	100	10.00	3.29	-	1.69	6.7	22.0	-	7.6	(max)
			13.8	100	10.00	0.54	-	0.79	4.2	10.9	-	7.6	(min)
Merc & Co. **	206	2	23.2	100	2.00	5.10	-	0.20	1.7	98.6	-	140.1	(avg)
			8.0	100	2.00	5.10	-	0.20	2.0	99.0	-	140.1	(max)
			13.8	100	2.00	5.10	-	0.20	1.4	94.4	-	40.1	(min)
Miller Breweries **	204.5	2.9	20.8	100	27.70	7.20	-	0.71	6.3	50.4	-	10.5	(avg)
			28.0	100	27.70	7.20	-	0.71	8.0	64.4	-	10.5	(max)
			12.0	100	27.70	7.20	-	0.71	4.8	39.7	-	10.5	(min)
Kinchafoonee Creek	200	676	16.5	-	0.43	0.07	1.65	0.09	8.6	-	3.5	3.8	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.28	0.01	1.00	0.06	3.0	-	3.0	1.2	(min)
Dry Creek	188	190	6.5	-	0.37	0.04	1.65	0.08	8.6	-	3.0	1.9	(avg)
			26.8	-	2.00	0.50	10.00	0.45	13.0	-	9.9	15.4	(max)
			4.0	-	0.25	0.01	1.00	0.06	3.0	-	3.0	1.1	(min)
Racoon Creek	178	178	16.5	-	0.23	0.02	1.65	0.05	8.6	-	3.0	1.6	(avg)
			26.8	-	1.45	0.30	10.00	0.28	13.0	-	6.8	10.4	(max)
			4.0	-	0.15	0.01	1.00	0.04	3.0	-	3.0	1.0	(min)
Newton to Bainbridge	177.3												
Cooleewahee Creek	161	101	6.5	-	0.20	0.02	1.65	0.05	8.6	-	3.0	1.7	(avg)
			26.8	-	1.28	0.20	10.00	0.25	13.0	-	7.9	12.2	(max)
			4.0	-	0.15	0.01	1.00	0.04	3.0	-	3.0	1.0	(min)
Blakely WPCP **	154	1.9	20.8	100	10.00	0.99	-	0.48	6.1	9.5	-	5.7	(avg)
			28.0	100	10.00	3.30	-	0.82	7.2	12.6	-	5.7	(max)
			12.0	100	10.00	0.28	-	0.28	4.6	6.6	-	5.7	(min)

Reach/ Name (point load)**	**River Mile**	**Flow**	**Temp**	**Point inflow**	**NO3-N**	**PO4-P**	**Chl_*a***	**NH3-N**	**DO**	**DOM 1 (BOD)**	**DOM 2 (BOD)**	**TSS (org)**	**avg max min**
	mile	**cfs**	**C**	**tracer**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	
Decatur County Industrial **	152	0.9	0.8	100	6.40	0.46	-	0.31	3.2	9.6	-	4.2	(avg)
			28.0	100	6.40	1.02	-	0.78	3.7	11.8	-	4.2	(max)
			12.0	100	6.40	0.27	-	0.15	2.5	6.6	-	4.2	(min)
Bainbridge WWTP **	150	1.7	20.8	100	10.00	0.97	-	7.65	6.1	26.3	-	10.6	(avg)
			28.0	100	10.00	1.24	-	9.74	7.8	32.0	-	10.6	(max)
			2.0	100	10.00	0.66	-	5.08	4.5	22.9	-	10.6	(min)
Ichawaynochaway Creek	148	1121	6.5	-	0.26	0.02	1.65	0.06	8.6	-	3.0	1.9	(avg)
			26.8	-	1.65	0.26	10.00	0.32	13.0	-	10.1	15.8	(max)
			4.0	-	0.17	0.01	1.00	0.04	3.0	-	3.0	1.1	(min)
Lake Seminole - Flint Arm	139												
Flint: misc.trib-1	136	239	16.5	-	0.26	0.03	1.65	0.06	8.6	-	3.3	2.8	(avg)
			6.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.15	0.01	1.00	0.04	3.0	-	3.0	1.2	(min)
Big Slough	130	588	16.5	-	0.28	0.02	1.65	0.06	8.6	-	3.1	2.0	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.15	0.01	1.00	0.04	3.0	-	3.0	1.1	(min)
Spring Creek	140	834	16.5	-	0.29	0.03	1.65	0.06	8.6	-	3.1	2.2	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.16	0.01	1.00	0.04	3.0	-	3.0	1.1	(min)
Fishpond Drain	120	287	16.5	-	0.25	0.02	1.65	0.06	8.6	-	3.1	1.9	(avg)
			26.8	-	2.00	0.47	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.15	0.01	1.00	0.03	3.0	-	3.0	1.1	(min)
Apalachicola River													
Jim Woodruff Dam to Chattahoochee	107.6												

Reach/ Name (point load)**	**River Mile**	**Flow**	**Temp**	**Point inflow**	**NO3-N**	**PO4-P**	**Chl_*a***	**NH3-N**	**DO**	**DOM 1 (BOD)**	**DOM 2 (BOD)**	**TSS (org)**	**avg max min**
	mile	**cfs**	**C**	**tracer**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	
Florida State Hospital **	107.1	0.9	23.9	100	10.00	0.70	-	1.00	4.3	12.5	-	5.0	(avg)
			28.0	100	0.00	0.70	-	1.00	5.0	12.5	-	5.0	(max)
			15.3	100	10.00	0.70	-	1.00	3.5	12.5	-	5.0	(min)
Chattahoochee to Blountstown	107.0												
Apalachicola misc.trib-1	90	167	16.5	-	0.26	0.04	1.65	0.06	8.6	-	3.3	3.0	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.15	0.01	1.00	0.04	3.0	-	3.0	1.2	(min)
Blountstown to Sumatra	78.9												
Apalachicola misc.trib-2	52	334	16.5	-	0.19	0.02	1.65	0.04	8.6	-	3.1	2.3	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.15	0.01	1.00	0.03	3.0	-	3.0	1.1	(min)
Chipola River	28	2035	16.5	-	0.22	0.03	1.65	0.05	8.6	-	3.2	2.4	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.15	0.01	1.00	0.03	3.0	-	3.0	1.1	(min)
Sumatra	20.3												

8 APPENDIX B- SENSITIVITY RESULTS

The focus of the sensitivity runs was to quantify the relative impact of various model coefficients and sources on model predictions. The primary emphasis was the impact on phytoplankton (chlorophyll *a*) since phytoplankton dynamics have a major impact on DO and high concentrations are associated with degraded water quality. A total of fourteen sensitivity runs were performed in which the following model parameters or sources were incremented 25%. A fifteenth simulation evaluated the model's sensitivity to the reaeration coefficient by scaling all reaeration coefficients to 75% of the calibrated model. The values within the brackets are the typical baseline ranges.

1. Phytoplankton growth rate, 1/day (1.6 - 2.2)
2. Phytoplankton respiration rate, 1/day (0.25 - 0.3)
3. Phytoplankton settling velocity, m/day (0.15 - 0.5)
4. Benthic oxygen uptake/demand, mg/m^2/day (500 - 1250)
5. Benthic nitrogen source rate, mg/ m^2/day (5 - 12)
6. Benthic phosphorus source rate, mg/ m^2/day (2 - 4)
7. Ammonia decay rate, 1/day (0.1 - 0.2)
8. Dissolved organics decay rate, 1/day (0.06 - 0.2)
9. Non-point/tributary stream dissolved organics, mg/l (variable - BASINS based)
10. Point/municipal and industrial dissolved organics, mg/l (variable - treatment plant specific)
11. Non-point/tributary stream nitrogen (NH3+NH4), mg/l (variable - BASINS based)
12. Point/municipal and industrial nitrogen (NH3+NH4), mg/l (variable - treatment plant specific)
13. Non-point/tributary stream phosphorus (PO4), mg/l (variable - BASINS based)
14. Point/municipal and industrial phosphorus (PO4), mg/l (variable - treatment plant specific)
15. Reaeration rate, m/sec (variable - function of stream flow velocity and lake surface wind speed)

Each sensitivity run impacts multiple parameters throughout the ACF. It is impossible to quantify the impacts at all locations and times, therefore the impacts are demonstrated as a longitudinal profile plot for the Chattahoochee and Apalachicola River system bounded by Lake Lanier (Buford Dam) at river mile 456 and Sumatra at river mile 20. This reach encompasses the entire river system regulated by existing Corps dams. However, the Apalachicola River beginning at Jim Woodruff Dam is impacted by the Flint River. Plots for chlorophyll *a* and the parameter specific to the incremented parameter is presented to show the global impact. Each of these plots is for the phytoplankton growing season of April through October over the 2001 - 2011 simulation period. The average lines are bold for reference clarification.

Additionally, the incremental changes relative to the baseline simulation are listed in an extensive set of tables (available upon request). A decrease (i.e., where the Sensitivity value minus the Base value is negative) indicates a reduction associated with the sensitivity run. The criterion for table listing is an incremental difference between the baseline and sensitivity run greater than |0.5%|. The river segments and each of the time periods and increments for the 5, 25, 50 (median), 75 and 95 percent exceedance levels are included. The table columns are as follows

1) River segment (Chattahoochee or Flint)
2) Parameter
3) Units
4) Year period
5) Monthly time period, baseline label, sensitivity run label & increment label
6-10) Percentage label and length weighted average concentration
11) Average percentage change

Results of the sensitivity runs (SR) are described below.

8.1.1 SENSITIVITY TO PHYTOPLANKTON GROWTH (SR1)

A 25% higher growth rate results in larger phytoplankton concentrations as shown in the chlorophyll *a* profiles in Figure 8.1. The higher growth rate increases phytoplankton concentration at a fairly uniform rate from below Buford Dan to below Whitesburg. The higher growth rate is analogous to longer residence time (lower flow velocity). The percentage increase remains fairly uniform below Whitesburg.

The increase in growth rate decreases the nutrient concentrations (Figure 8.2 and Figure 8.3); however, the percentage impact on phosphorus is greater, indicating that the system is phosphorus limited in the model. Both nutrients are greatly reduced in West Point Lake (mile 343–309) due to phytoplankton uptake. DO (Figure 8.4) generally remains the same or higher throughout the system. The peak oxygen in West Point Lake is moved upstream. Note that these plots reflect the near-surface concentrations. DO is essentially unchanged below the dams.

8.1.2 Sensitivity to Phytoplankton Respiration (SR2)

A 25% higher respiration rate results in much smaller phytoplankton concentrations (Figure 8.5). The rate of increase in West Point Lake is reduced by approximately half. The effect is fairly uniform below West Point Dam. The increase in respiration rate increases the nutrient concentrations (Figure 8.6 and Figure 8.7) since uptake is less due to the smaller phytoplankton concentrations, and the nutrient byproducts of respiration are greater due to the increased respiration rate. The greatest rate of change is in West Point Lake. The greatest percentage impact is on phosphorus since it is the limiting nutrient in the model. DO concentrations are generally lower (Figure 8.8) since lower phytoplankton concentration results in less photosynthesis production. However, uptake associated with respiration is likely lower since the lower phytoplankton concentration offsets the higher respiration rate. Slight increases are computed below some dams since the smaller phytoplankton concentration at depth offsets the higher respiration rates.

Changes seen in the appendix table show impacts normally not associated with phytoplankton dynamics. BOD5U decreases because there is a smaller respiration component due to the lower phytoplankton concentration.

8.1.3 Sensitivity to Phytoplankton Settling (SR3)

A higher phytoplankton settling rate results in lower phytoplankton concentrations (Figure 8.9). The effect is greatest beginning in West Point Lake. A fairly uniform percentage change is computed below West Point Dam. The response to settling is similar to the response to the respiration rate. The net increase in phosphorus (Figure 8.10) is slightly less than the increase due to the respiration rate since the settled phytoplankton is lost to the bottom sediments. The impact on DO is shown in Figure 8.11.

Small changes in the growth, respiration and settling rates can have a measurable effect on the magnitude and timing of phytoplankton dynamics.

8.1.4 Sensitivity to Benthic Oxygen (SR4)

Benthic oxygen demand reduces DO levels slightly throughout the Chattahoochee River. A larger decrease is computed in the Apalachicola River due to the influence of the Flint River. The profile plots in Figure 8.12 show the near surface concentrations that are impacted the least. At depth in stratified reservoirs, the impacts are slightly greater as indicated by the decrease below dams. This model input is of particular importance during DO calibration of the deeper reservoirs such as Lake Lanier (Buford Dam).

8.1.5 Sensitivity to Benthic Nitrogen Source Rate (SR5)

The benthic source rate for nitrogen has very little impact on chlorophyll *a* since phytoplankton growth is phosphorus limited in the model. Ammonia nitrogen (NH4-N), which is the parameter directly impacted by the benthic nitrogen source rate, is increased only slightly as seen in Figure 8.13. The small increase indicates that the benthic source is not the major nitrogen contributor at the rates assumed in the calibrated model. The impact on nitrogen is relatively small since the default NO3-N concentration of 10 mg/L assumed in the model provides the bulk of the nitrogen in the Chattahoochee River.

8.1.6 SENSITIVITY TO BENTHIC PHOSPHORUS SOURCE RATE (SR6)

The benthic source rate for phosphorus increases phosphorus (Figure 8.14) and chlorophyll *a* (Figure 8.15) slightly within and below West Point Lake. Since phosphorus is limiting within the model, an increase in the source rate will result in a direct increase in both chlorophyll *a* and phosphorus. Only very small changes in the other parameters were computed.

8.1.7 SENSITIVITY TO AMMONIA DECAY (SR7)

A higher ammonia decay rate hastens the transformation of ammonia to nitrate resulting in decreases in ammonia nitrogen (Figure 8.16) and corresponding increases in nitrate nitrogen (Figure 8.17). Since the nitrate concentration is approximately ten times that of ammonia, the nitrogen increment is nearly undetectable in Figure 8.17. There is little impact on other parameters, including chlorophyll, since the model is phosphorus limited.

8.1.8 SENSITIVITY TO DISSOLVED ORGANIC MATERIAL DECAY RATE (SR8)

The dissolved organics decay rate has little impact on any parameter. The maximum change of any parameter is less than 4% as seen in the appendix table.

8.1.9 SENSITIVITY TO NON-POINT SOURCE DISSOLVED ORGANIC MATERIAL CONCENTRATION (SR9)

The change in the dissolved organics material (DOM) concentration of the non-point sources (tributary streams) does not have a major impact on any other parameter. With a few exceptions, the maximum change of any parameter is less than 5% as seen in the appendix table. One of the reasons for the insensitivity is the relatively low decay rate assigned to the more refractory DOM of tributary stream origin. Point source DOM is assumed to decay at a higher rate (labile dominated). Note that there are no DOM plots since only the effects on BOD5U are referenced in the report. The largest impact on DO occurs below Atlanta as seen in Figure 8.18.

8.1.10 SENSITIVITY TO POINT SOURCE DISSOLVED ORGANIC MATERIAL CONCENTRATION (SR10)

As with the 25% increase in the non-point source DOM, the change in the dissolved organic material (DOM) concentration of the point sources (treatment plants) does not have a major impact on other parameters. The maximum change of any parameter is less than 5% as seen in the appendix table. Although the point source concentrations are greater than those of the non-point sources, the average non-point flows are considerably less. As with the non-point DOM, the largest impact on DO occurs below Atlanta, as seen in Figure 8.19.

8.1.11 SENSITIVITY TO NON-POINT SOURCE NITROGEN (SR11)

A 25% increase in non-point source nitrogen (both NH3 and NO3) concentration results in higher total nitrogen throughout the river system (Figure 8.20). Chlorophyll *a* and DO are impacted only slightly since the limiting nutrient in the model is phosphorus.

8.1.12 SENSITIVITY TO POINT SOURCE NITROGEN (SR12)

As with the 25% increase in the non-point source nitrogen, model results for 25% increase in the point source nitrogen (both NH3 and NO3) result in higher total nitrogen throughout the system (Figure 8.22). However, the incremental change due to the point source increment is greater than that for the non-point increment. Chlorophyll *a* and DO are impacted only slightly since the limiting nutrient in the model is phosphorus.

8.1.13 SENSITIVITY TO NON-POINT SOURCE PHOSPHORUS (SR13)

A 25% increase in non-point source phosphorus results in higher total phosphorus throughout the system (Figure 8.23). Maximum levels of chlorophyll *a* are increased by up to 10% (Figure 8.24) and near-surface DO (Figure 8.25) is increased slightly.

8.1.14 SENSITIVITY TO POINT SOURCE PHOSPHORUS (SR14)

A 25% increase in point source phosphorus results in higher total phosphorus (Figure 8.26). The impact of the point source phosphorus is less than that of the non-point sources due to the high level of treatment and source control in the watershed above Whitesburg. The impacts on chlorophyll *a* (Figure 8.27) and near-surface DO are similar to the non-point phosphorus impacts.

8.1.15 SENSITIVITY TO LAKE AND STREAM REAERATION (SR15)

The lake and stream reaeration coefficients were reduced to 75% of those of the calibrated model. A reduction in DO (Figure 8.28) occurs throughout the system. However there is little impact on the DO below dams since the outflow source is the lake hypolimnion. The location, magnitude and recovery of the oxygen sag above Whitesburg can be affected by scaling the reaeration coefficients.

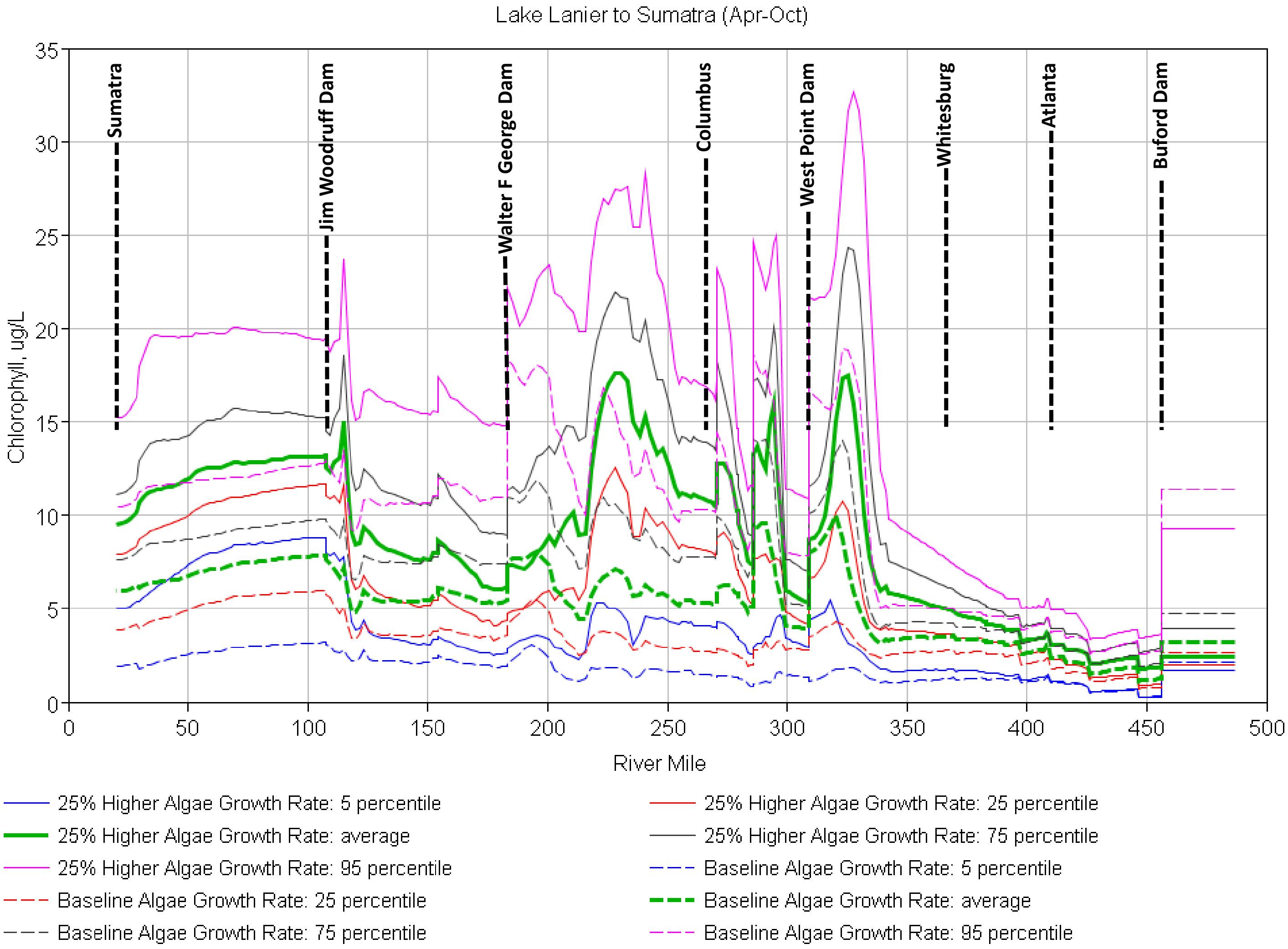

Figure 8.1 Longitudinal profiles of chlorophyll (average and 5, 25, 75 and 95 percentile) computed between Lake Lanier and Sumatra during April – October illustrating sensitivity to a 25% increase in phytoplankton growth rate.

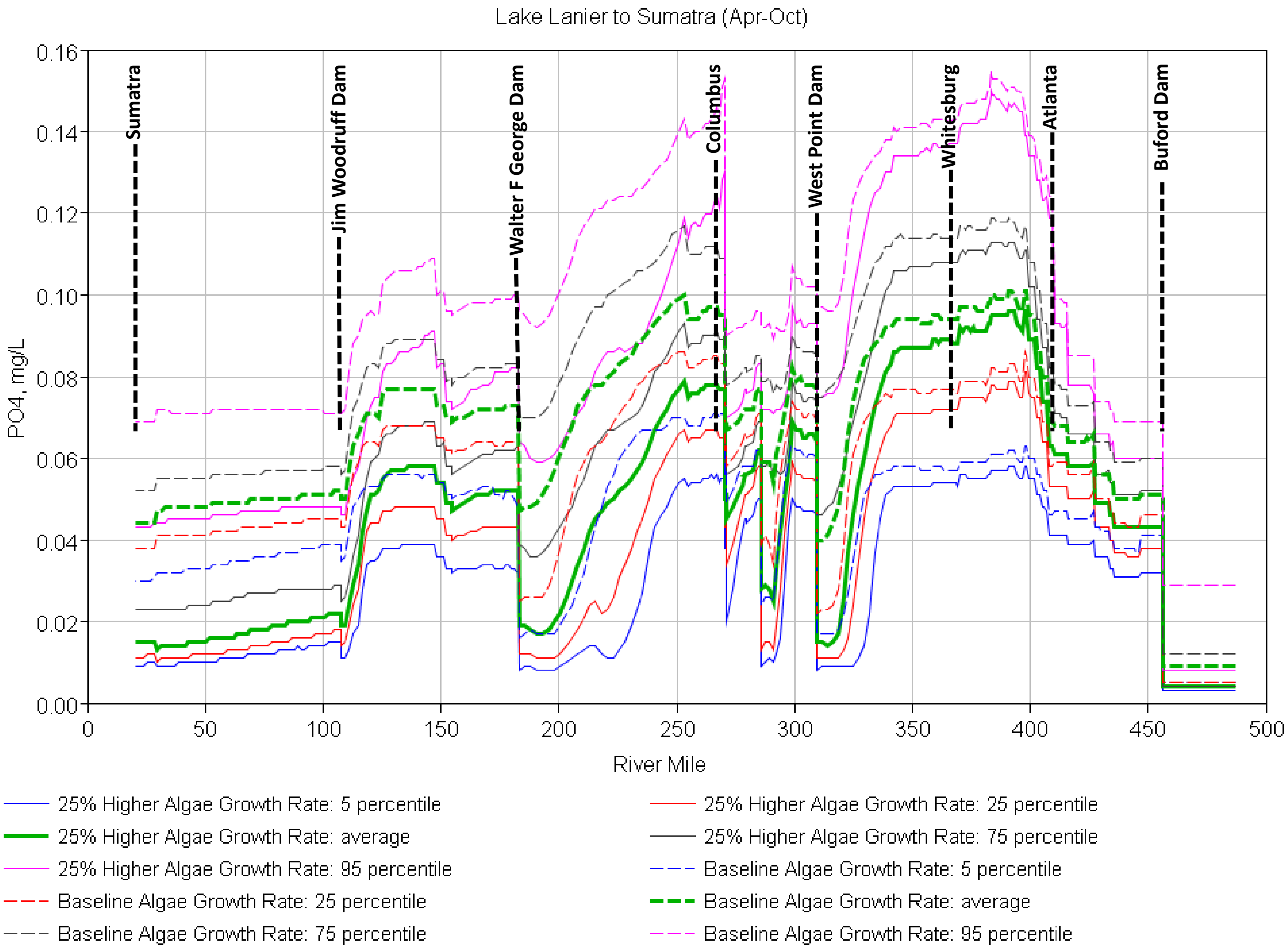

Figure 8.2 Longitudinal profiles of phosphate (average and 5, 25, 75 and 95 percentile) computed between Lake Lanier and Sumatra during April – October illustrating sensitivity to a 25% increase in phytoplankton growth rate.

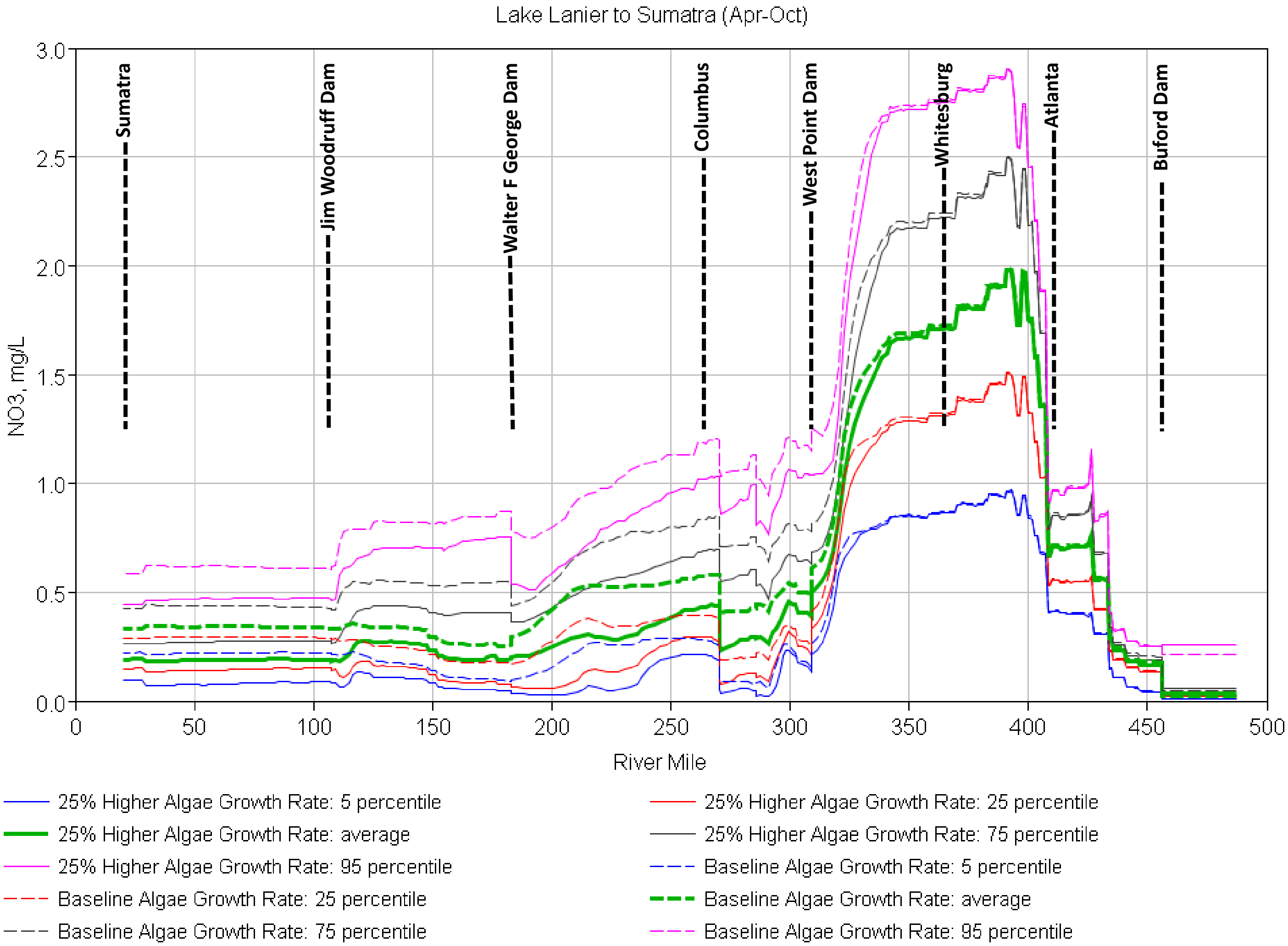

Figure 8.3 Longitudinal profiles of nitrate (average and 5, 25, 75 and 95 percentile) computed between Lake Lanier and Sumatra during April – October illustrating sensitivity to a 25% increase in phytoplankton growth rate.

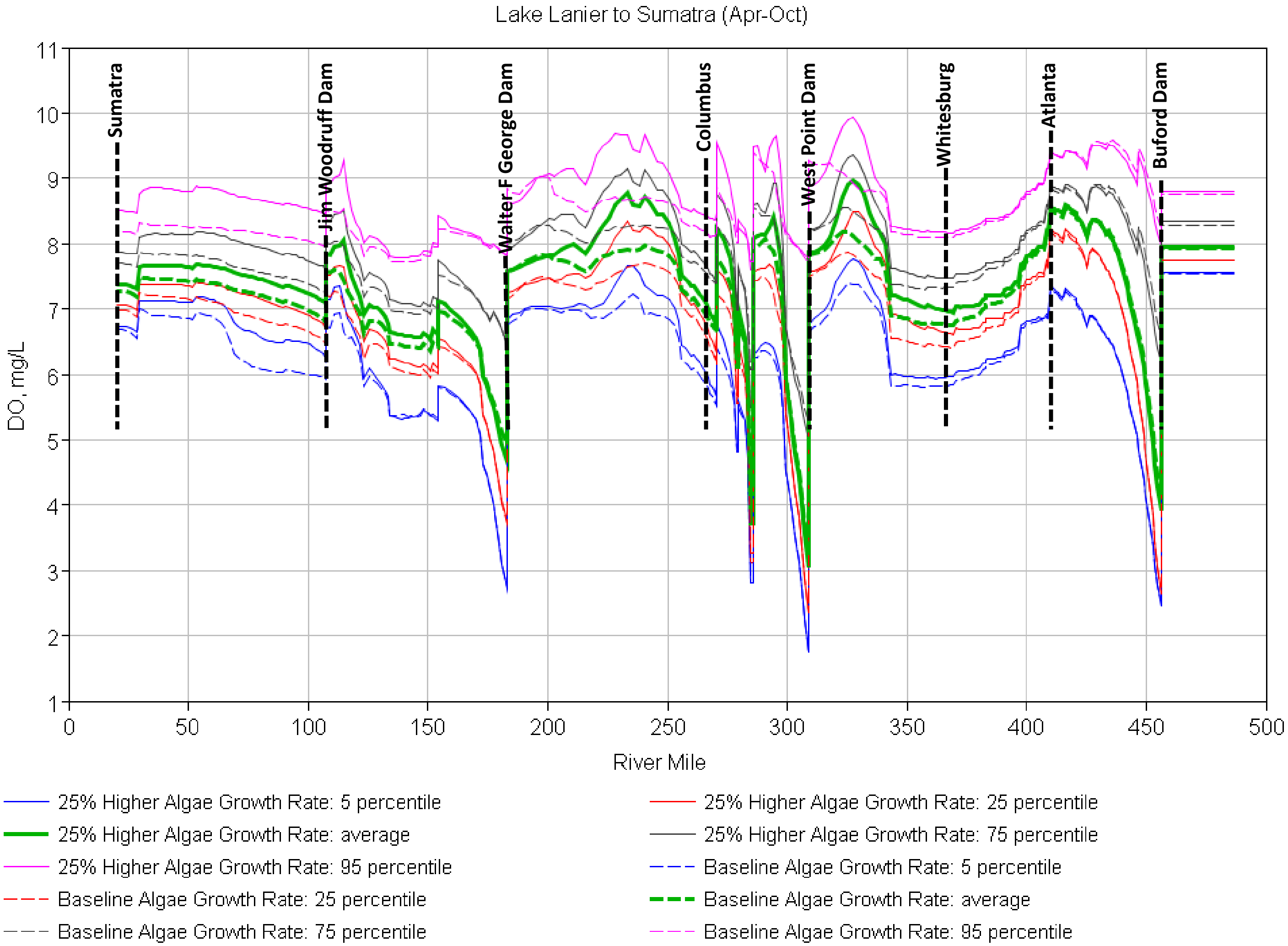

Figure 8.4 Longitudinal profiles of DO (average and 5, 25, 75 and 95 percentile) computed between Lake Lanier and Sumatra during April – October illustrating sensitivity to a 25% increase in phytoplankton growth rate.

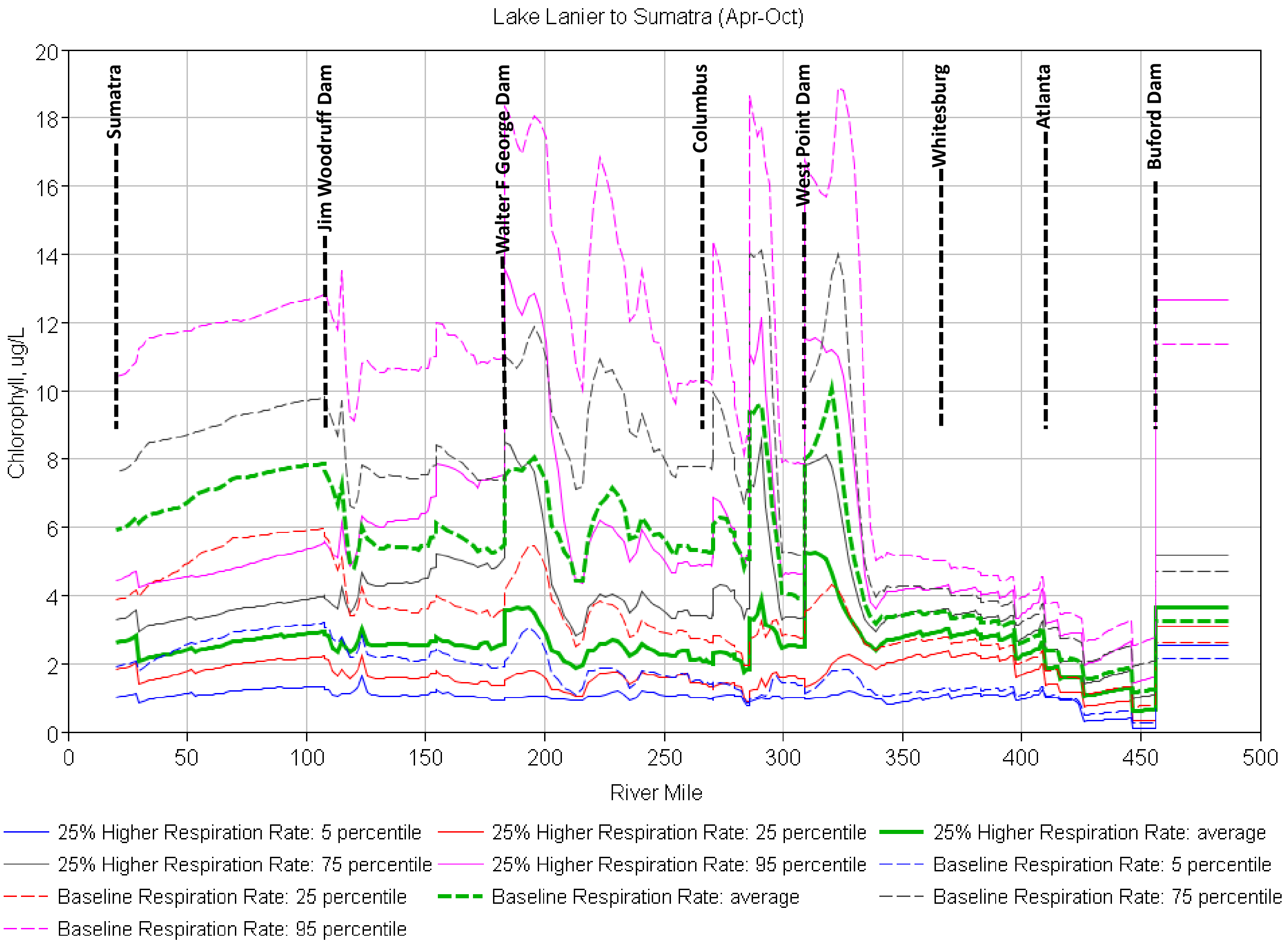

Figure 8.5 Longitudinal profiles of chlorophyll (average and 5, 25, 75 and 95 percentile) computed between Lake Lanier and Sumatra during April – October illustrating sensitivity to a 25% increase in phytoplankton respiration rate.

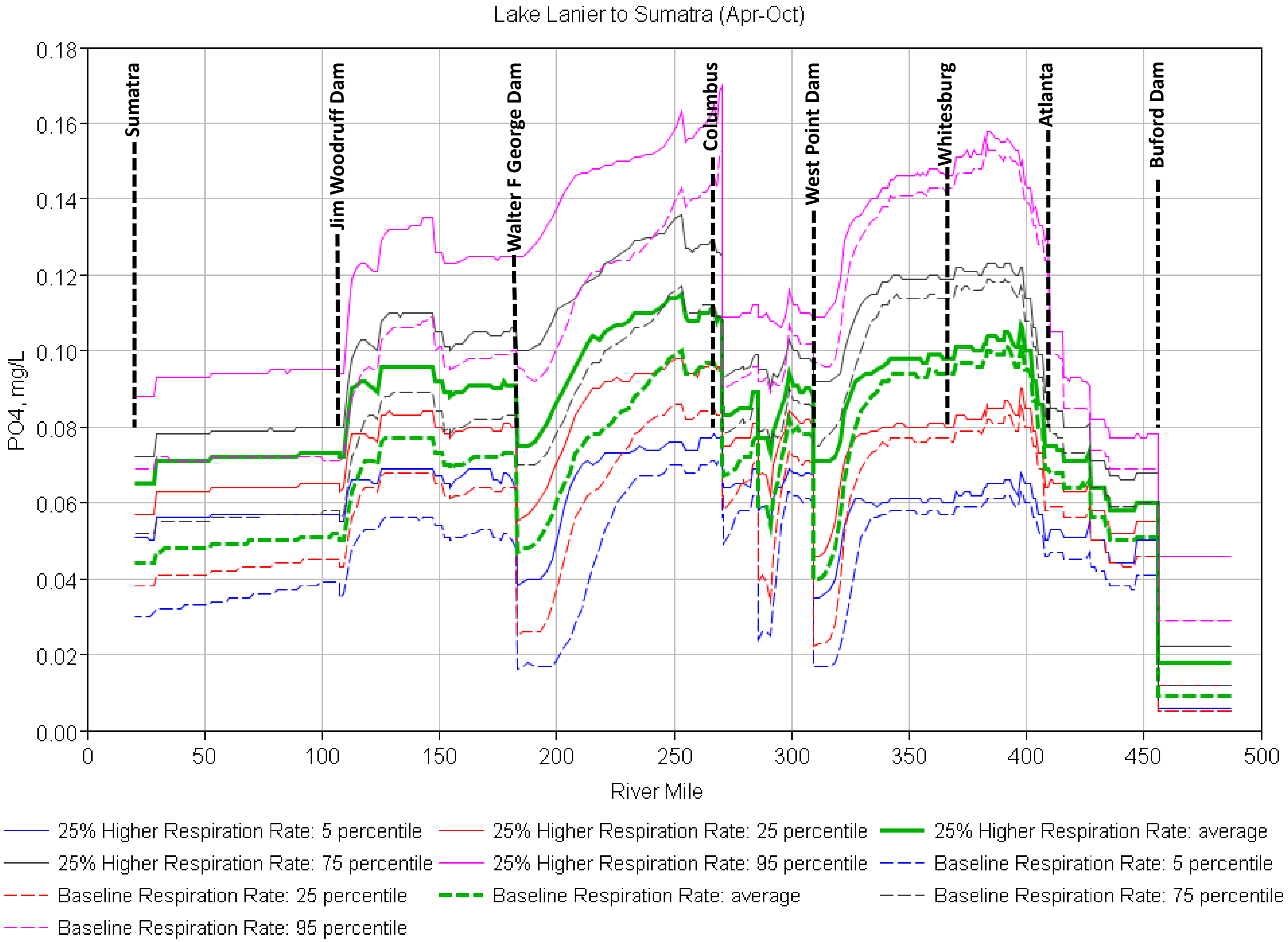

Figure 8.6 Longitudinal profiles of phosphate (average and 5, 25, 75 and 95 percentile) computed between Lake Lanier and Sumatra during April – October illustrating sensitivity to a 25% increase in phytoplankton respiration rate.

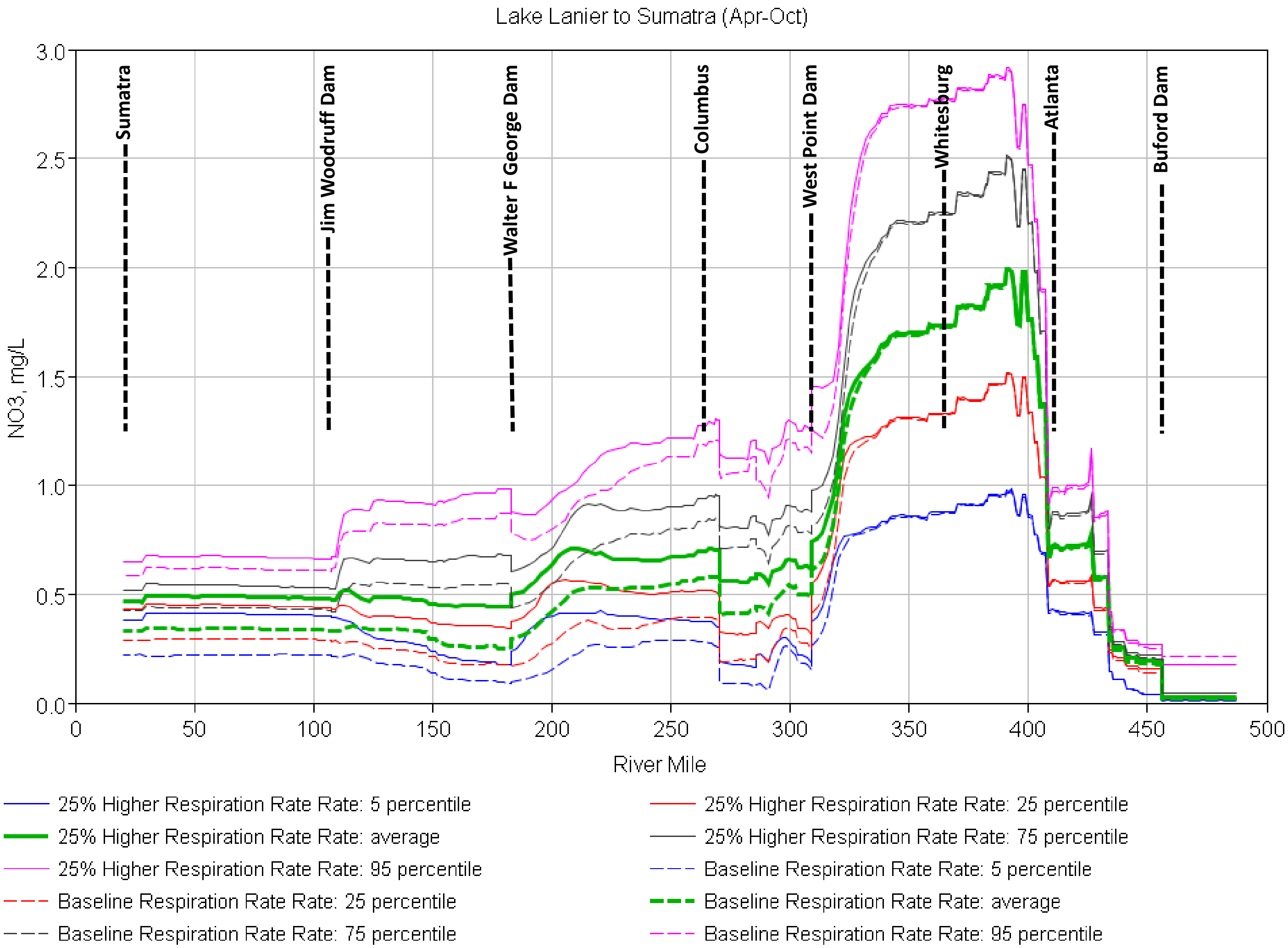

Figure 8.7 Longitudinal profiles of nitrate (average and 5, 25, 75 and 95 percentile) computed between Lake Lanier and Sumatra during April – October illustrating sensitivity to a 25% increase in phytoplankton respiration rate.

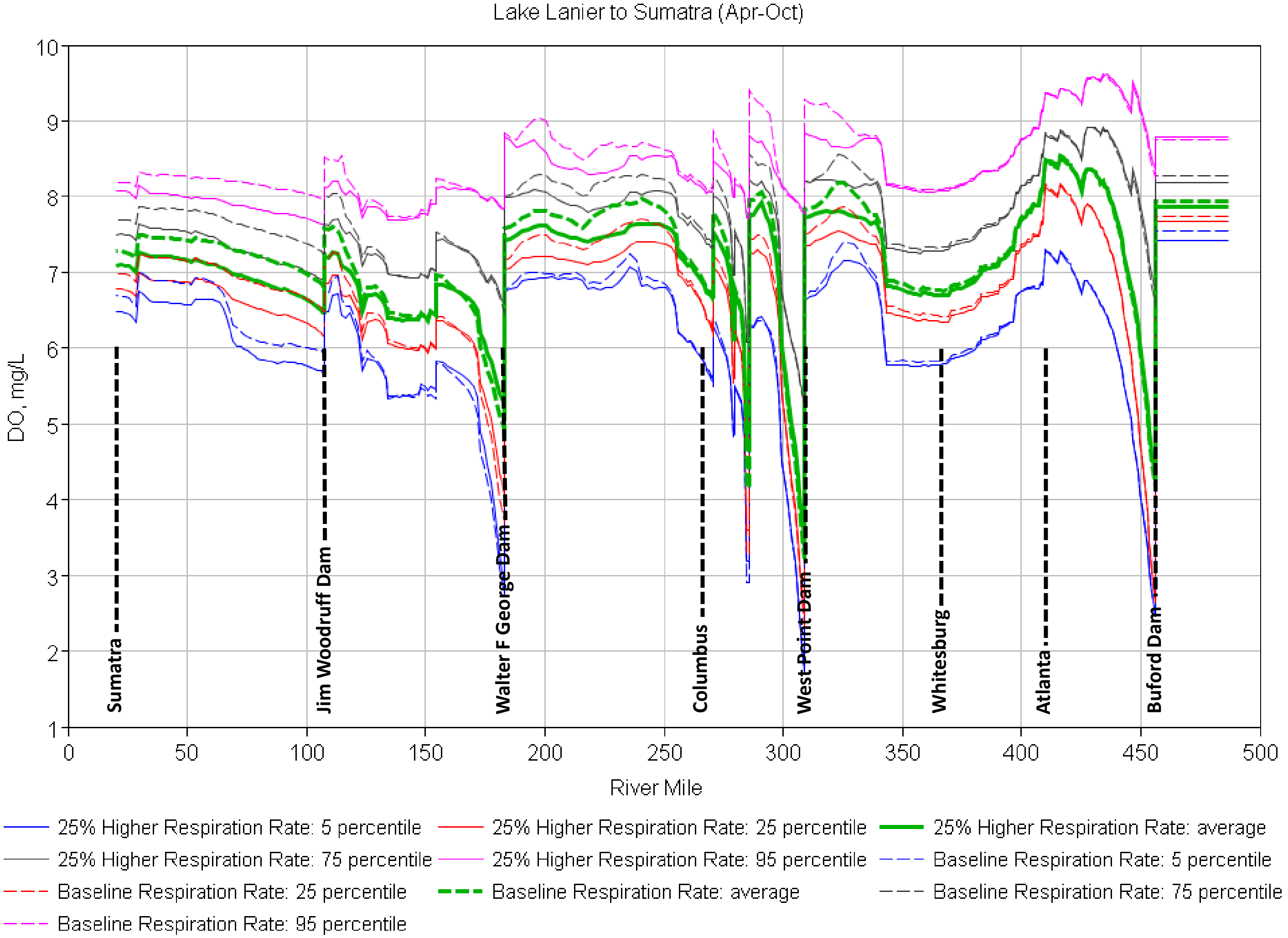

Figure 8.8 Longitudinal profiles of DO (average and 5, 25, 75 and 95 percentile) computed between Lake Lanier and Sumatra during April – October illustrating sensitivity to a 25% increase in phytoplankton respiration rate.

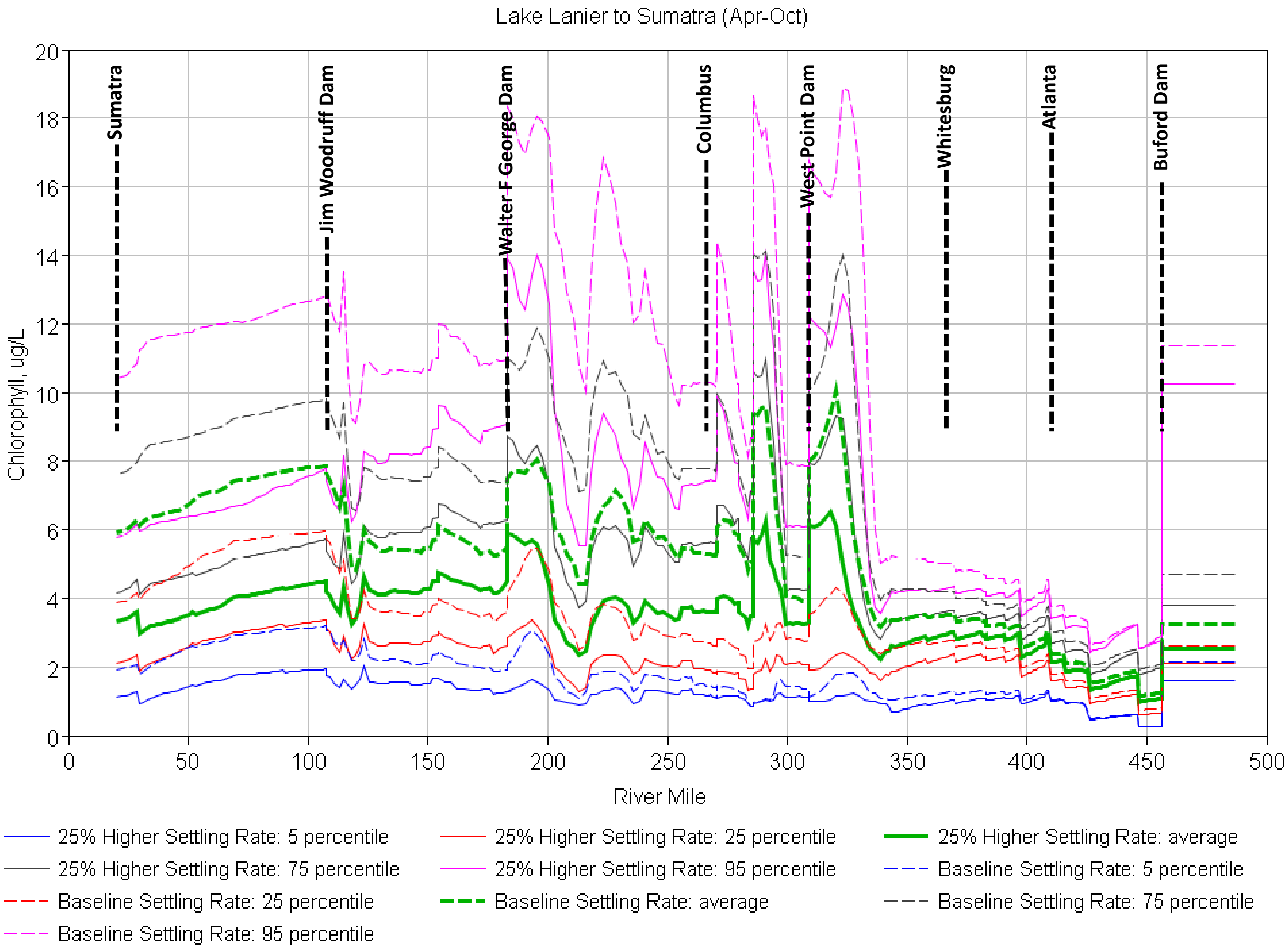

Figure 8.9 Longitudinal profiles of chlorophyll *a* (average and 5, 25, 75 and 95 percentile) computed between Lake Lanier and Sumatra during April – October illustrating sensitivity to a 25% increase in phytoplankton settling rate.

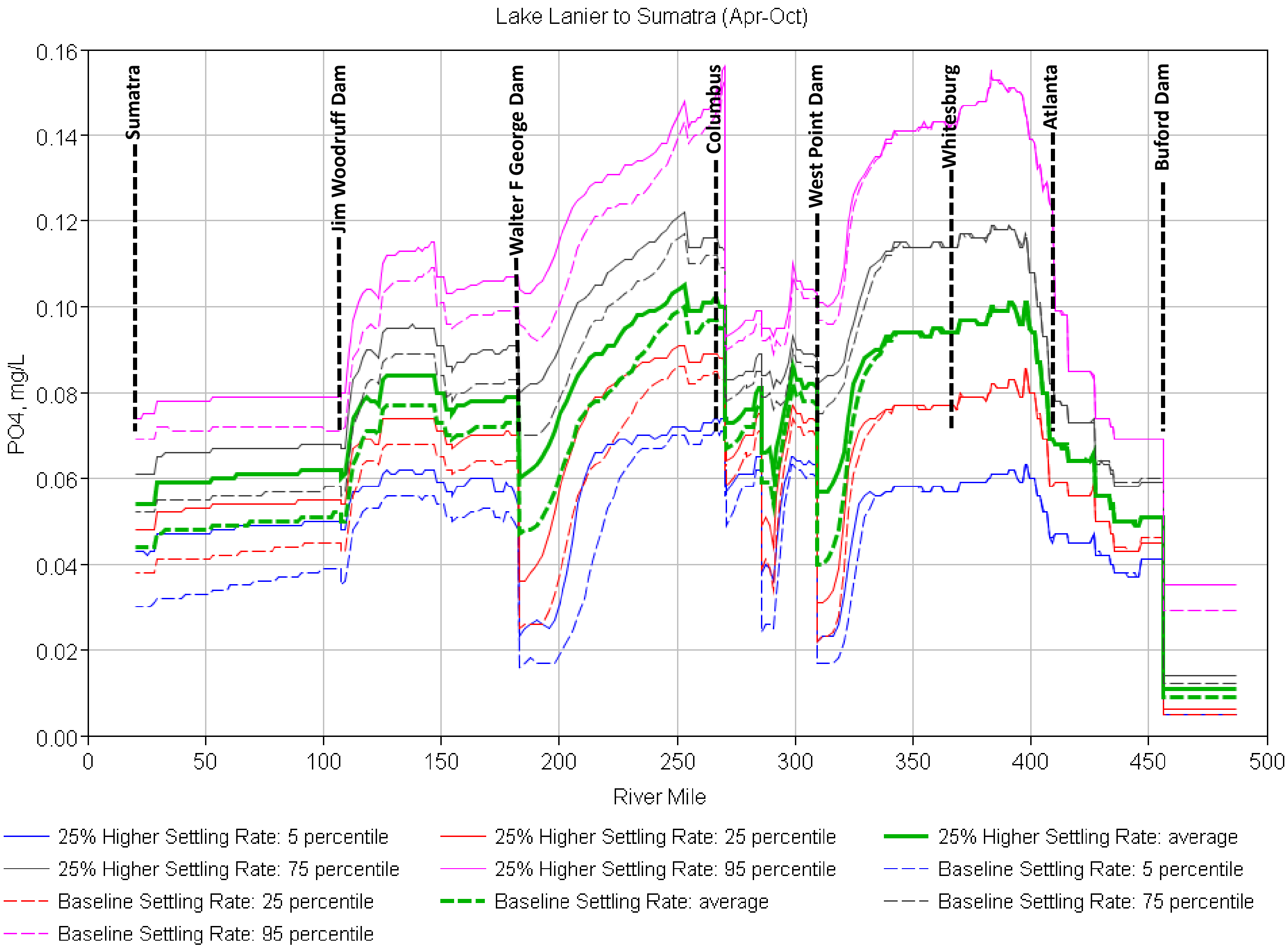

Figure 8.10 Longitudinal profiles of phosphorus (average and 5, 25, 75 and 95 percentile) computed between Lake Lanier and Sumatra during April – October illustrating sensitivity to a 25% increase in phytoplankton settling rate.

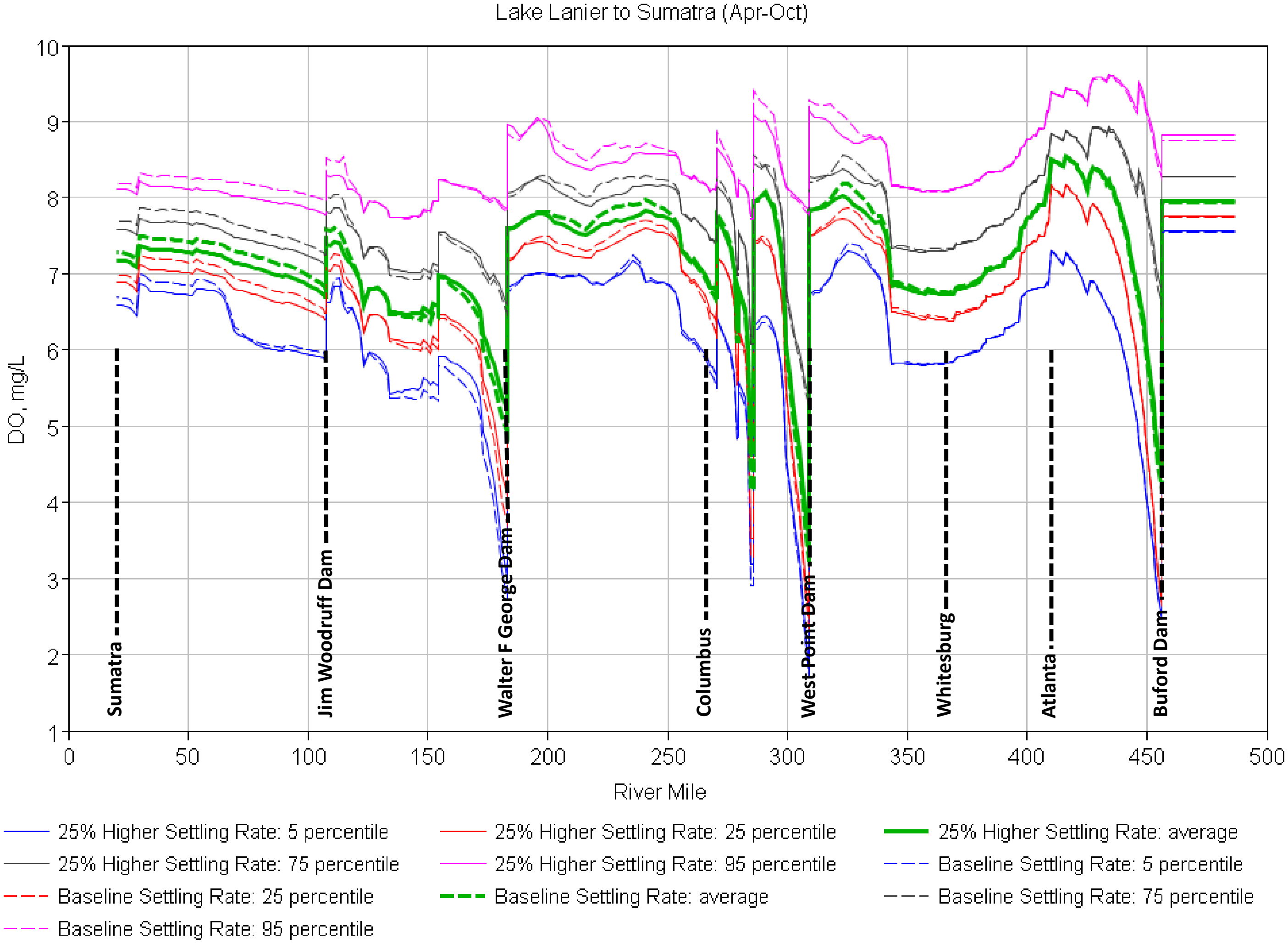

Figure 8.11 Longitudinal profiles of DO (average and 5, 25, 75 and 95 percentile) computed between Lake Lanier and Sumatra during April – October illustrating sensitivity to a 25% increase in phytoplankton settling rate.

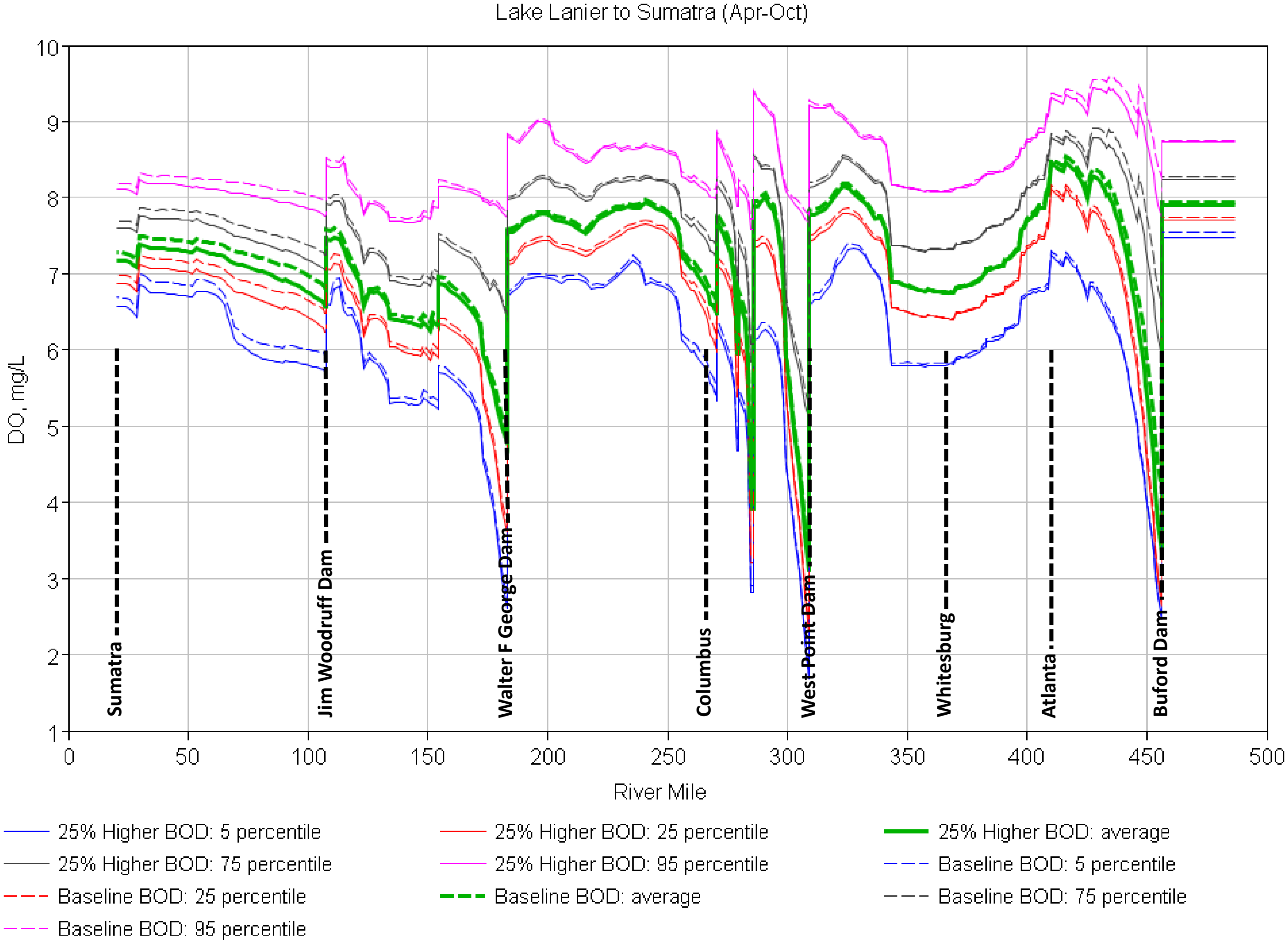

Figure 8.12 Longitudinal profiles of DO (average and 5, 25, 75 and 95 percentile) computed between Lake Lanier and Sumatra during April – October illustrating sensitivity to a 25% increase in bottom sediment BOD.

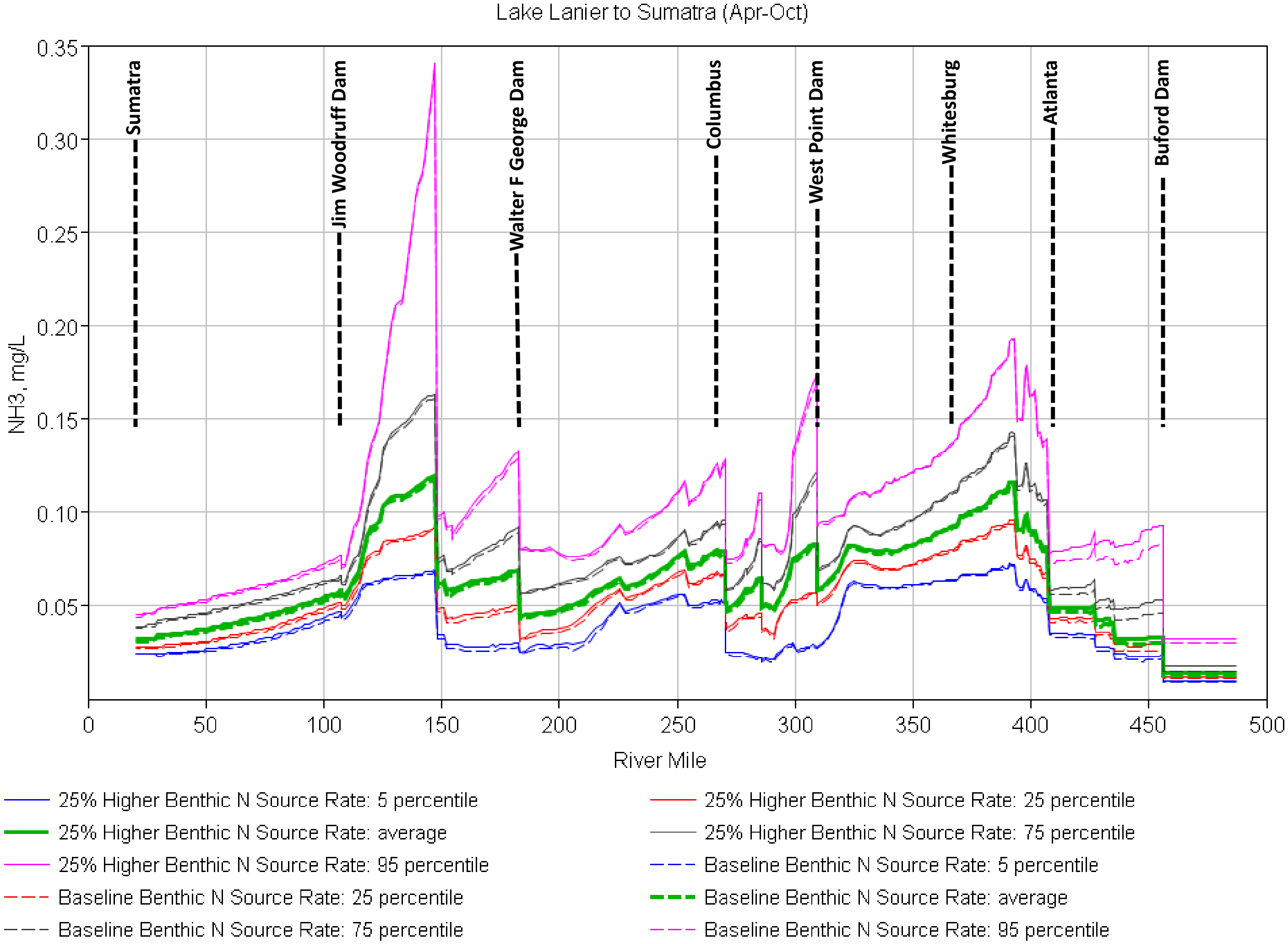

Figure 8.13 Longitudinal profiles of ammonia (average and 5, 25, 75 and 95 percentile) computed between Lake Lanier and Sumatra during April – October illustrating sensitivity to a 25% increase in benthic nitrogen source rate.

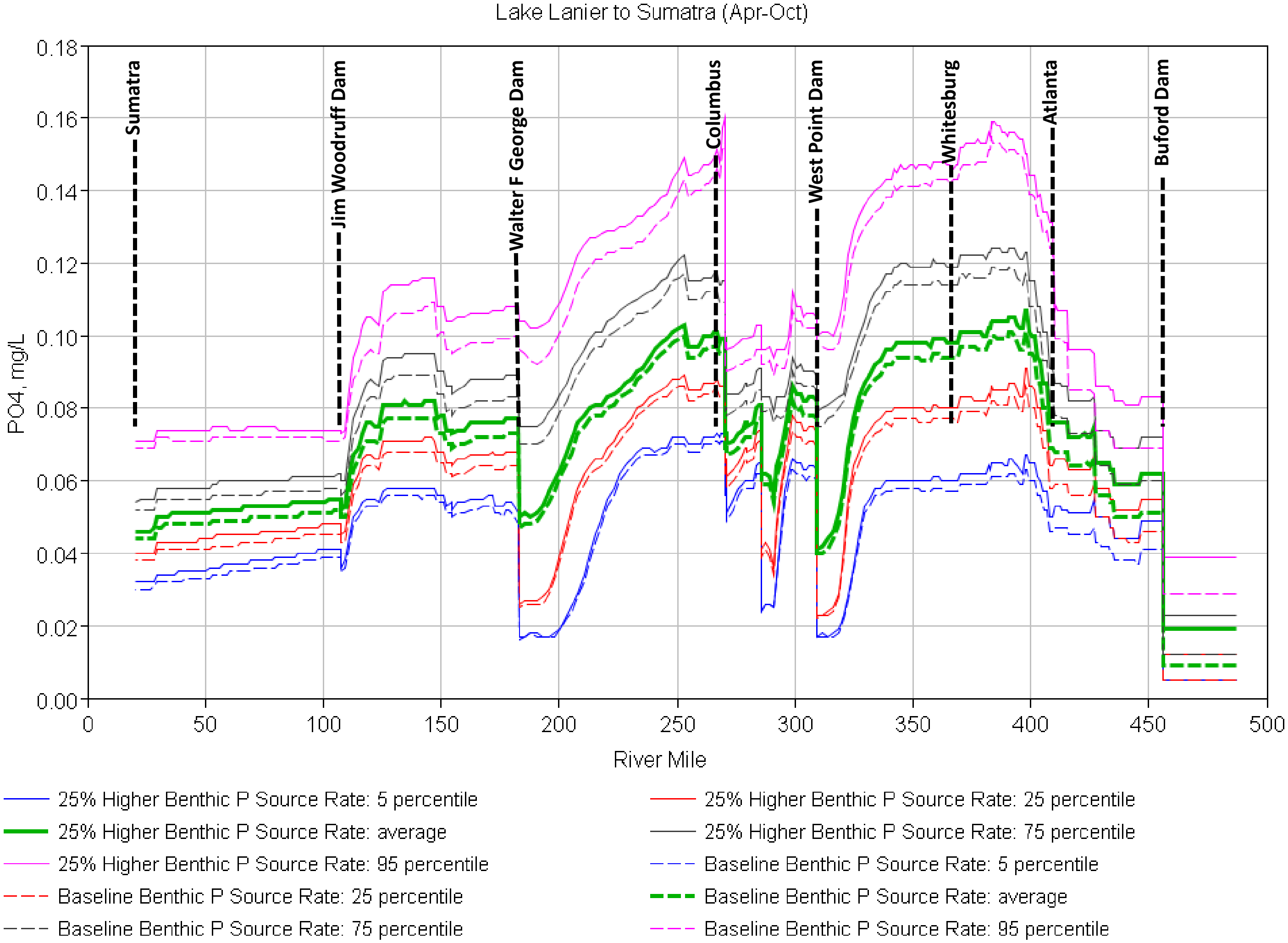

Figure 8.14 Longitudinal profiles of phosphate (average and 5, 25, 75 and 95 percentile) computed between Lake Lanier and Sumatra during April – October illustrating sensitivity to a 25% increase in benthic phosphorus source rate.

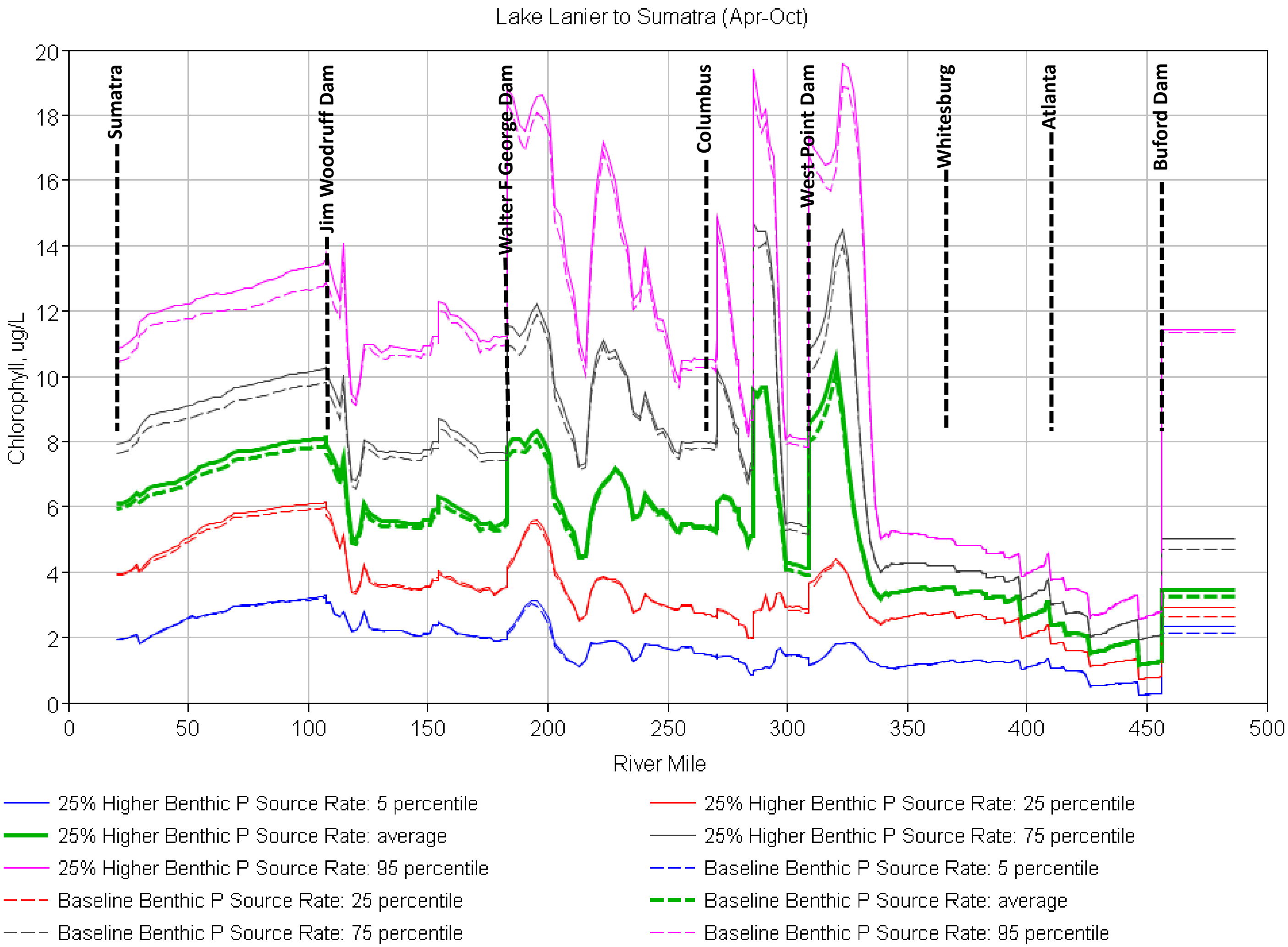

Figure 8.15 Longitudinal profiles of chlorophyll *a* (average and 5, 25, 75 and 95 percentile) computed between Lake Lanier and Sumatra during April – October illustrating sensitivity to a 25% increase in benthic phosphorus source rate.

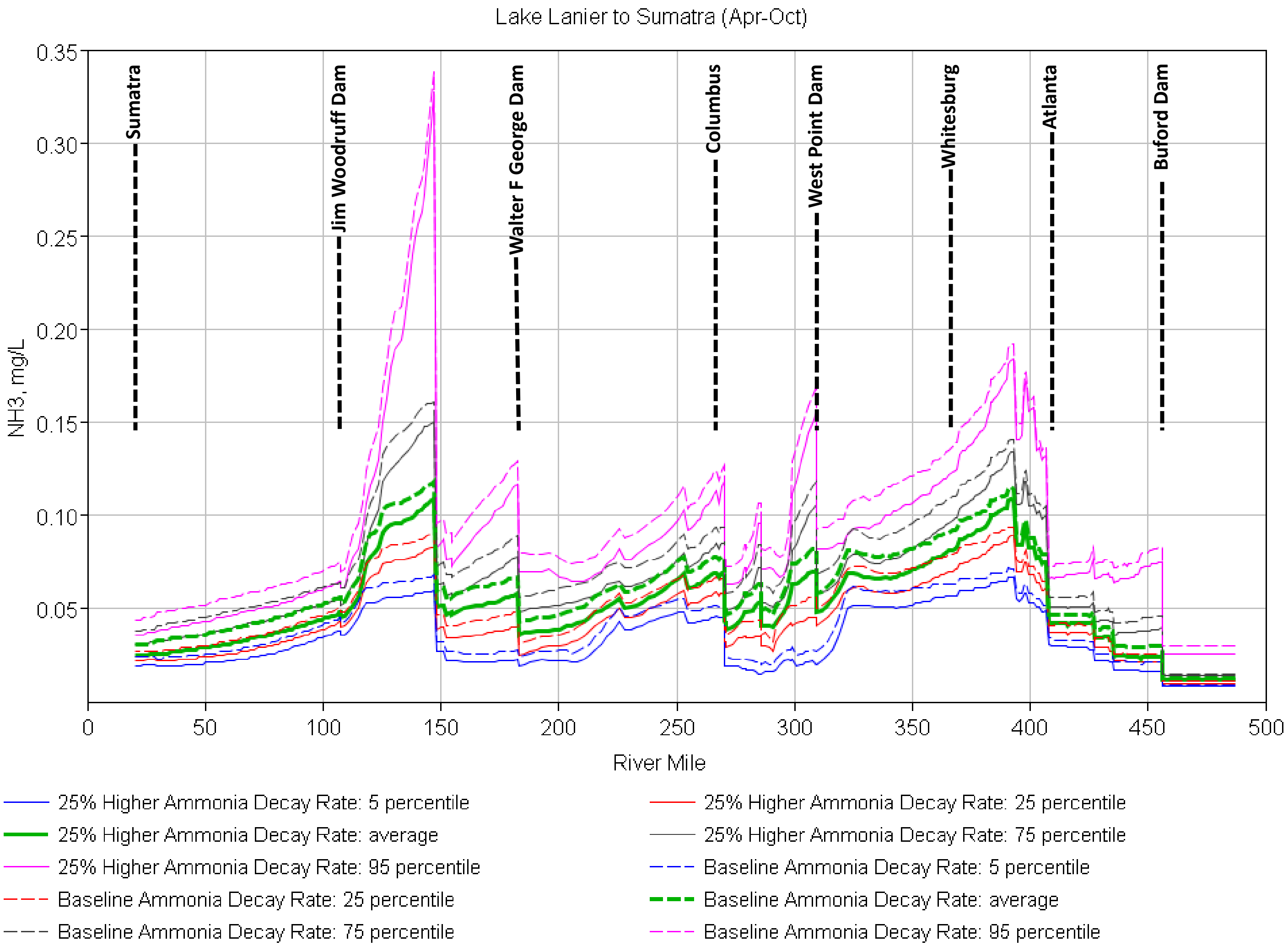

Figure 8.16 Longitudinal profiles of ammonia (average and 5, 25, 75 and 95 percentile) computed between Lake Lanier and Sumatra during April – October illustrating sensitivity to a 25% increase in ammonia decay rate.

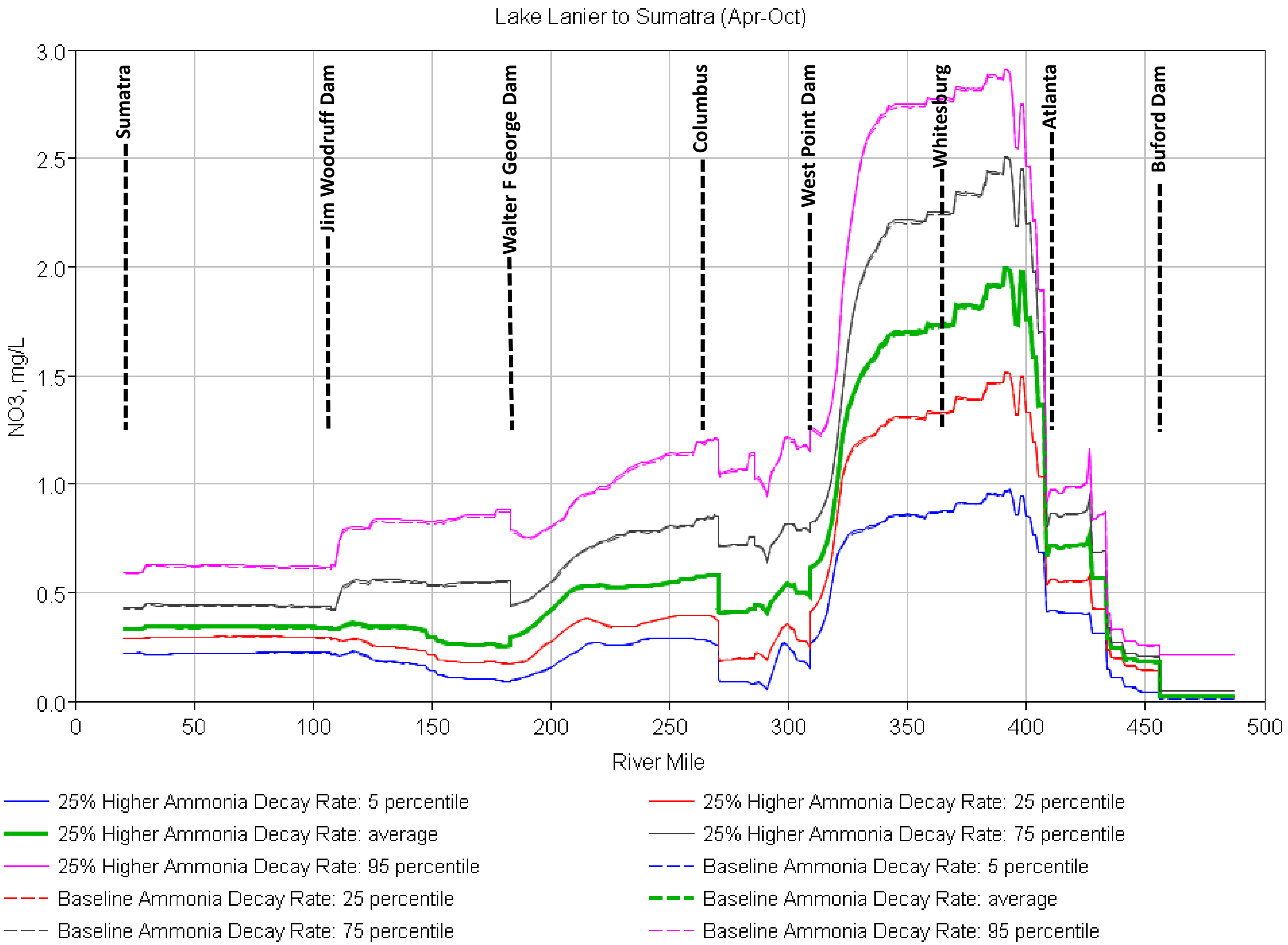

Figure 8.17 Longitudinal profiles of nitrate (average and 5, 25, 75 and 95 percentile) computed between Lake Lanier and Sumatra during April – October illustrating sensitivity to a 25% increase in ammonia decay rate.

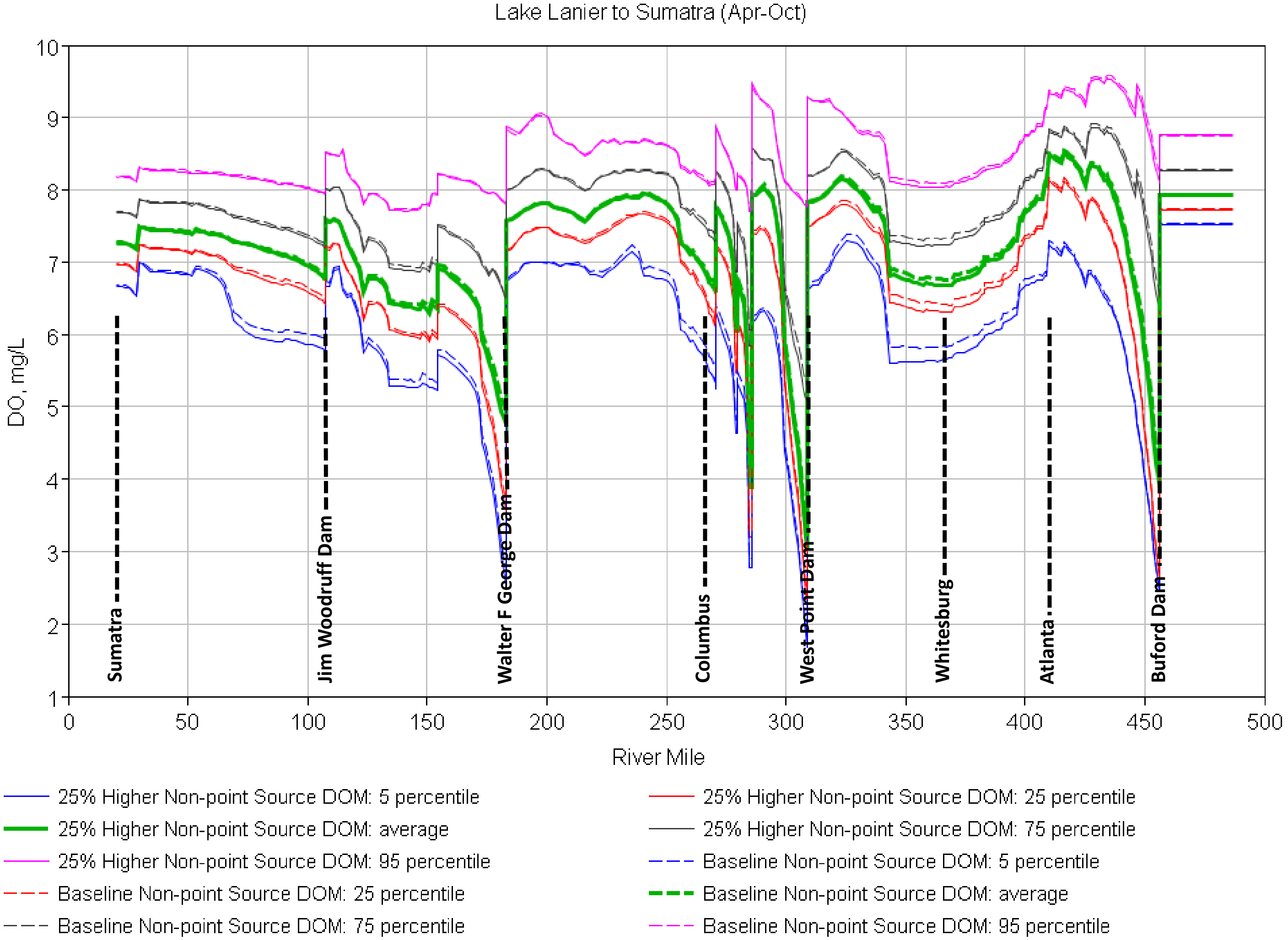

Figure 8.18 Longitudinal profiles of DO (average and 5, 25, 75 and 95 percentile) computed between Lake Lanier and Sumatra during April – October illustrating sensitivity to a 25% increase in non-point source DOM.

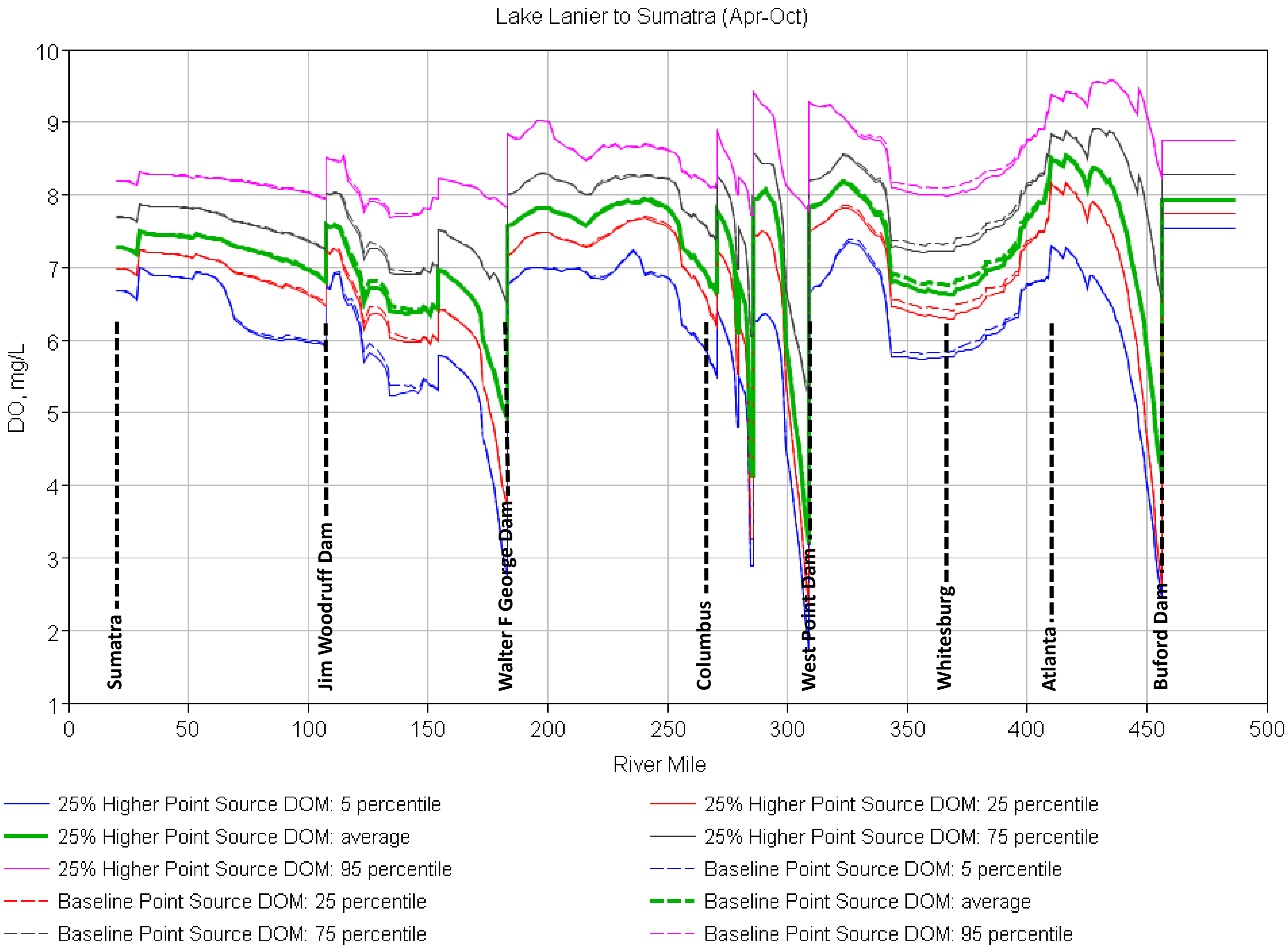

Figure 8.19 Longitudinal profiles of DO (average and 5, 25, 75 and 95 percentile) computed between Lake Lanier and Sumatra during April – October illustrating sensitivity to a 25% increase in point source DOM.

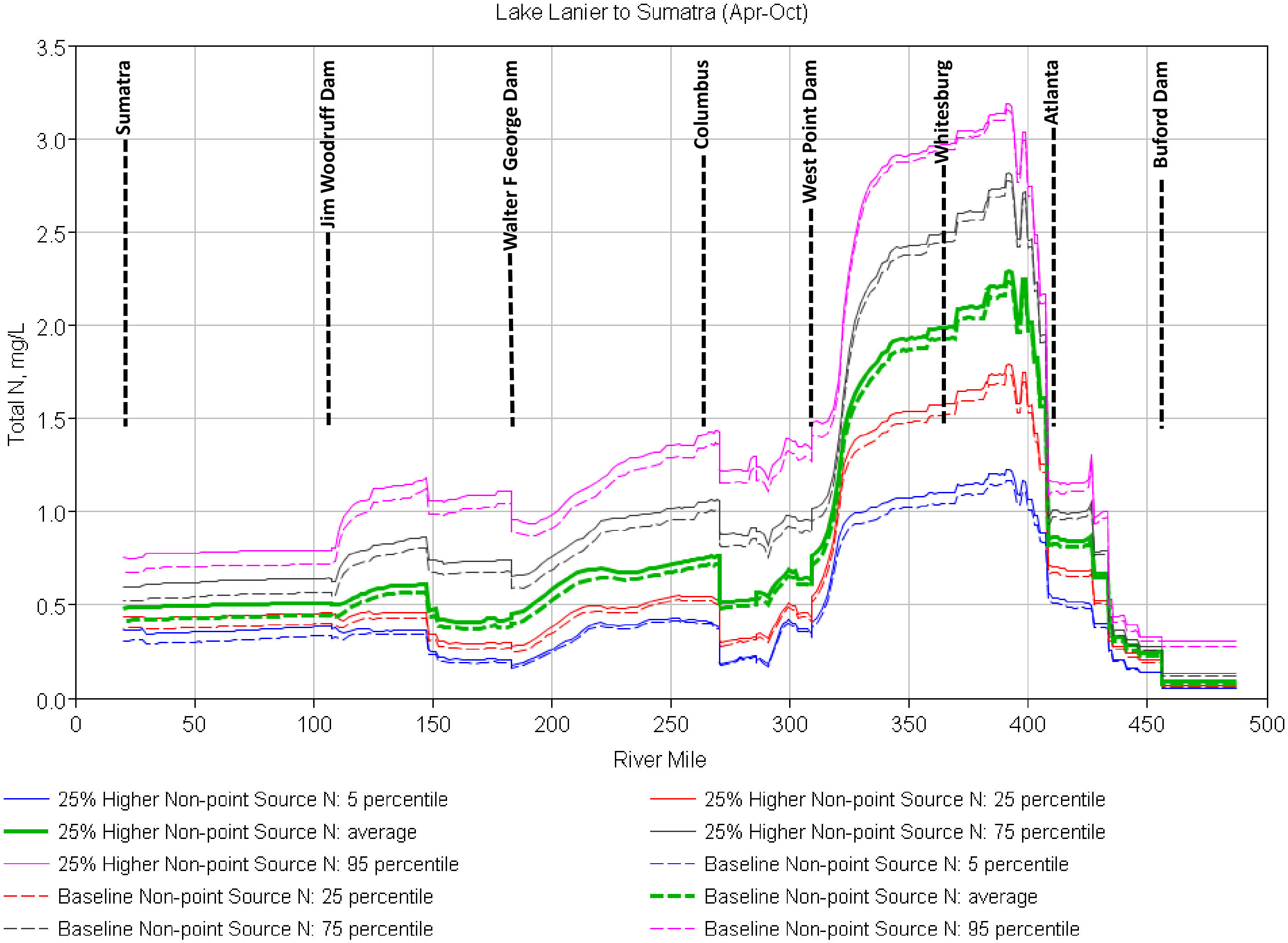

Figure 8.20 Longitudinal profiles of total nitrogen (average and 5, 25, 75 and 95 percentile) computed between Lake Lanier and Sumatra during April – October illustrating sensitivity to a 25% increase in non-point source nitrogen.

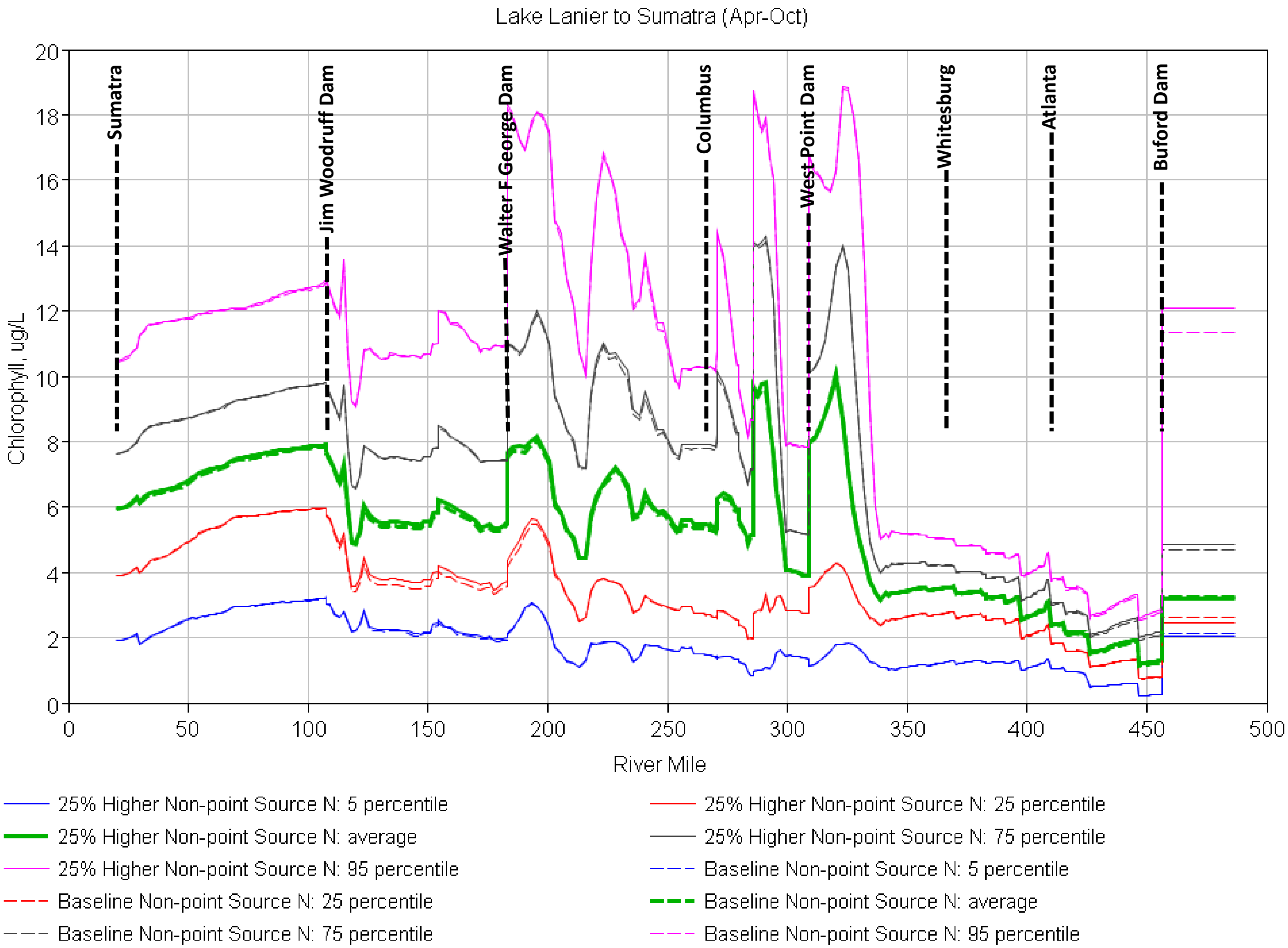

Figure 8.21 Longitudinal profiles of chlorophyll *a* (average and 5, 25, 75 and 95 percentile) computed between Lake Lanier and Sumatra during April – October illustrating sensitivity to a 25% increase in non-point source nitrogen.

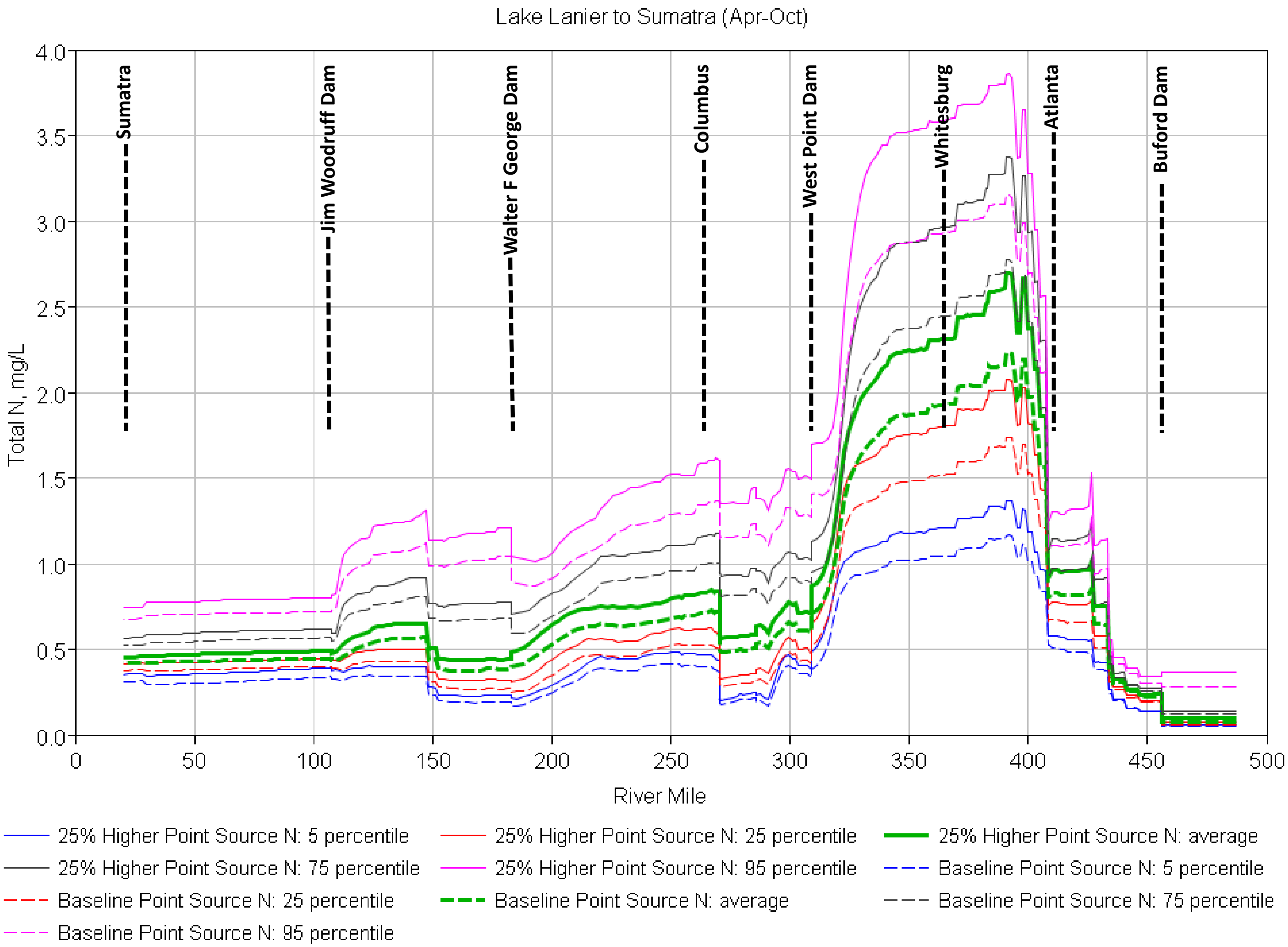

Figure 8.22 Longitudinal profiles of total nitrogen (average and 5, 25, 75 and 95 percentile) computed between Lake Lanier and Sumatra during April – October illustrating sensitivity to a 25% increase in point source nitrogen.

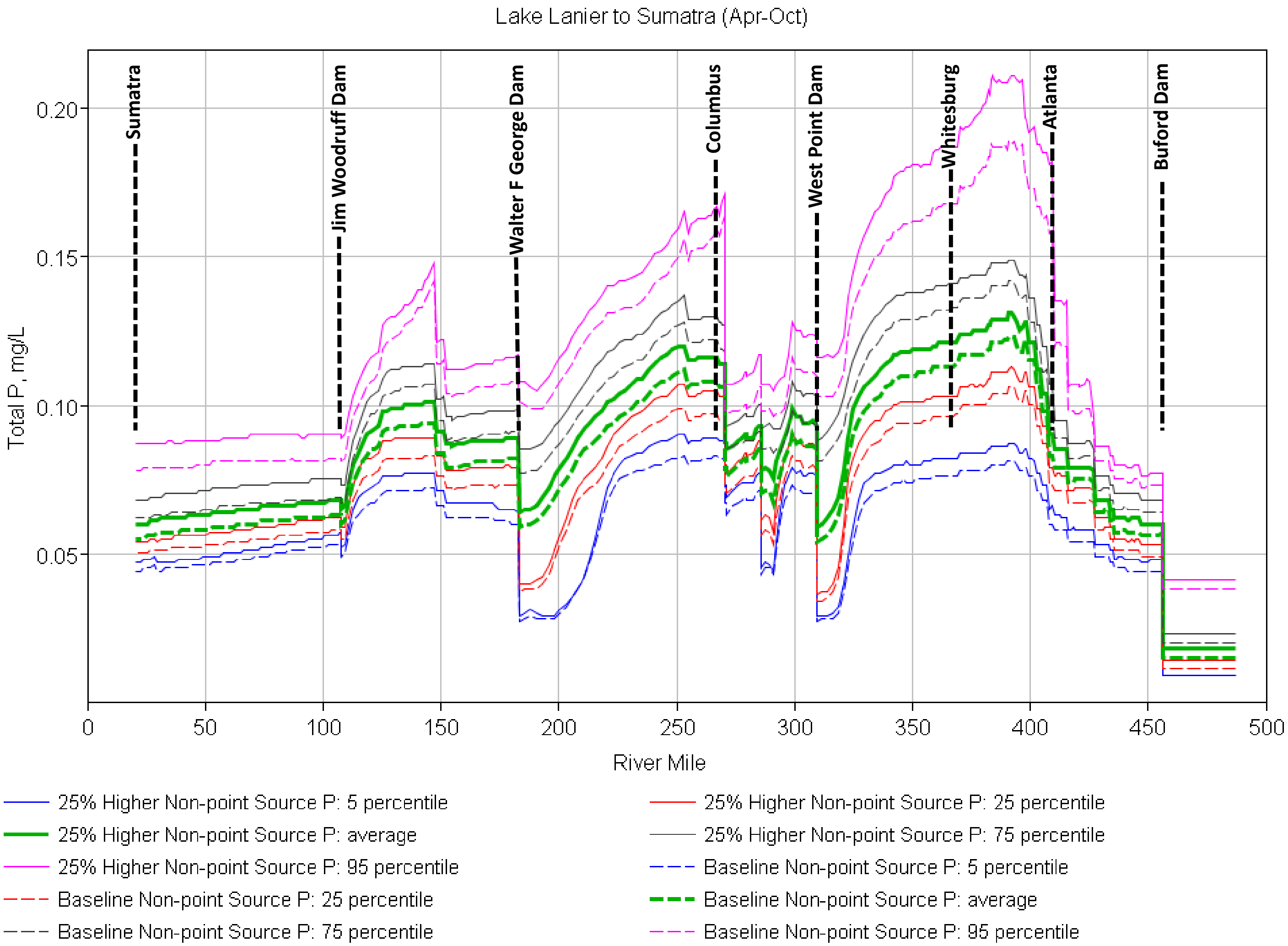

Figure 8.23 Longitudinal profiles of total phosphorus (average and 5, 25, 75 and 95 percentile) computed between Lake Lanier and Sumatra during April – October illustrating sensitivity to a 25% increase in non-point source phosphorus.

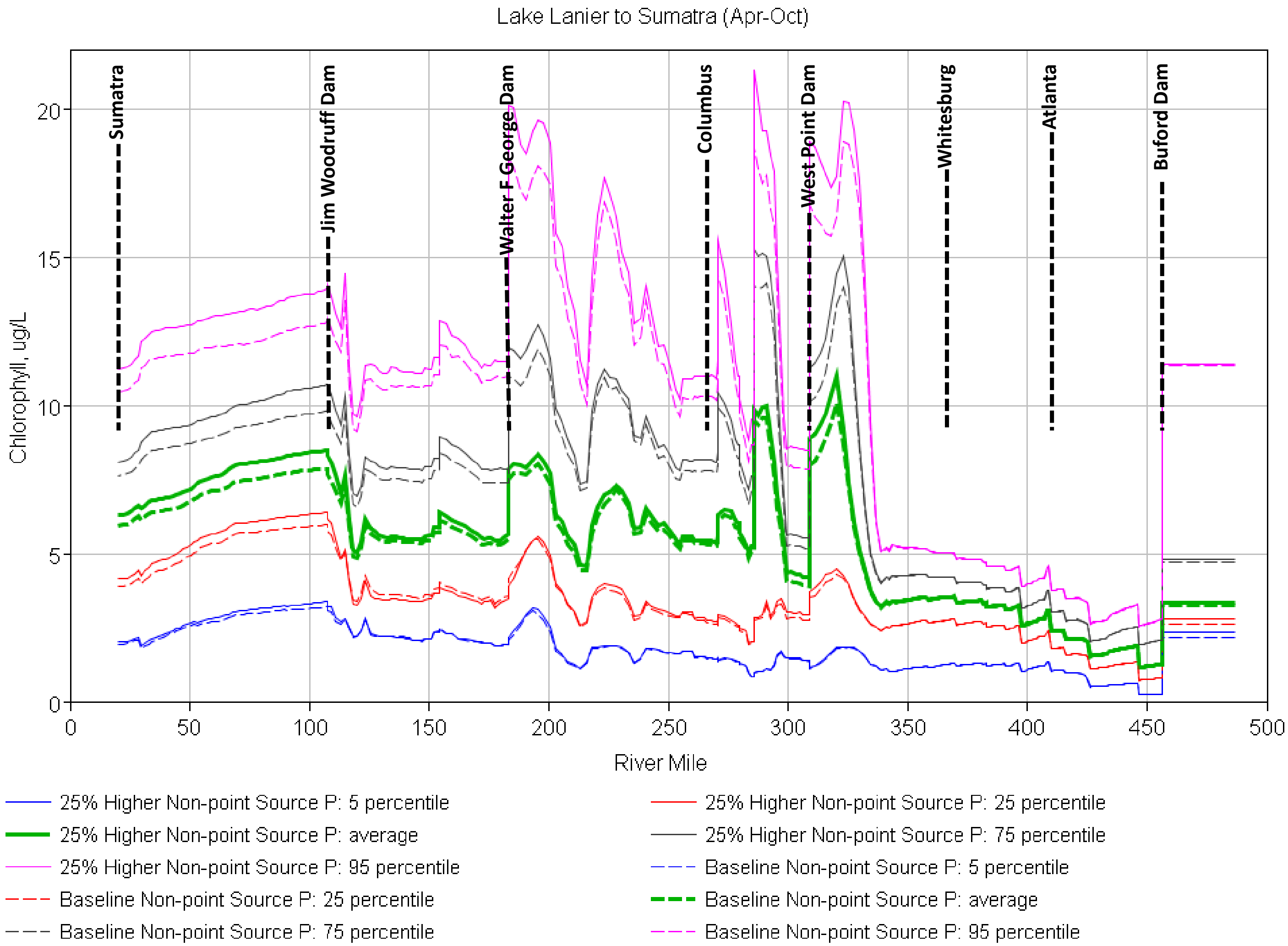

Figure 8.24 Longitudinal profiles of chlorophyll *a* (average and 5, 25, 75 and 95 percentile) computed between Lake Lanier and Sumatra during April – October illustrating sensitivity to a 25% increase in non-point source phosphorus.

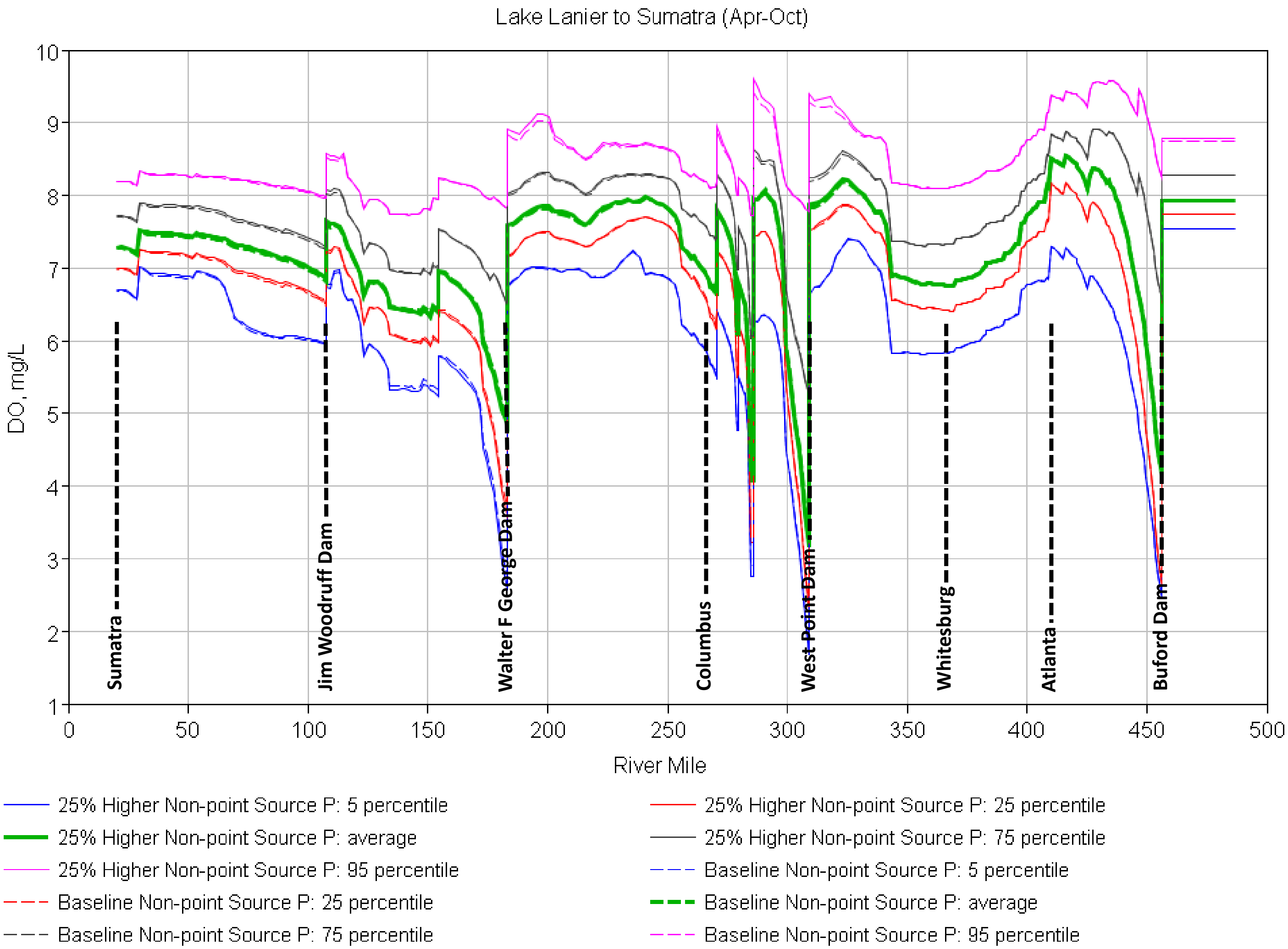

Figure 8.25 Longitudinal profiles of DO (average and 5, 25, 75 and 95 percentile) computed between Lake Lanier and Sumatra during April – October illustrating sensitivity to a 25% increase in non-point source phosphorus.

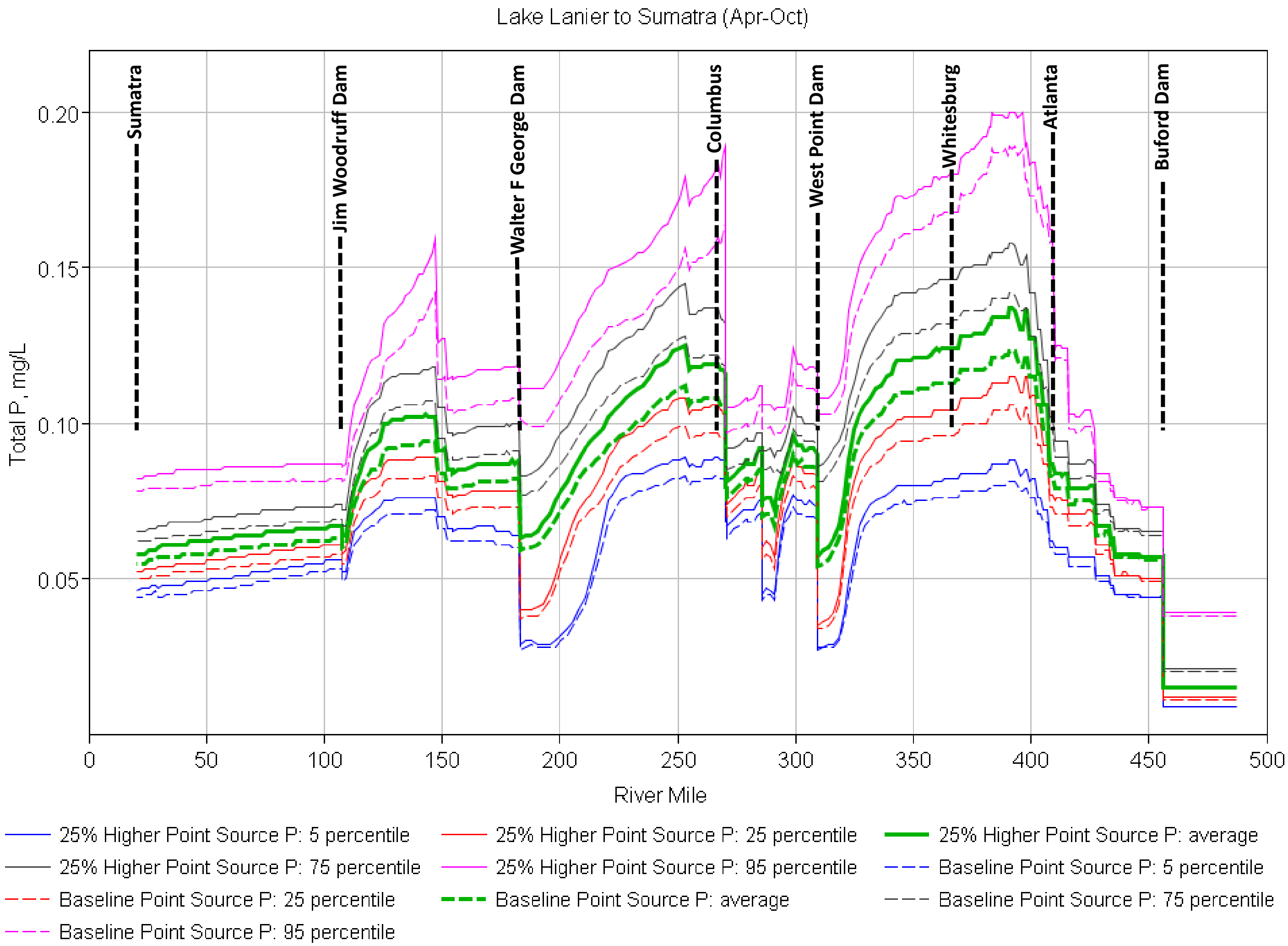

Figure 8.26 Longitudinal profiles of total phosphorus (average and 5, 25, 75 and 95 percentile) computed between Lake Lanier and Sumatra during April – October illustrating sensitivity to a 25% increase in point source phosphorus.

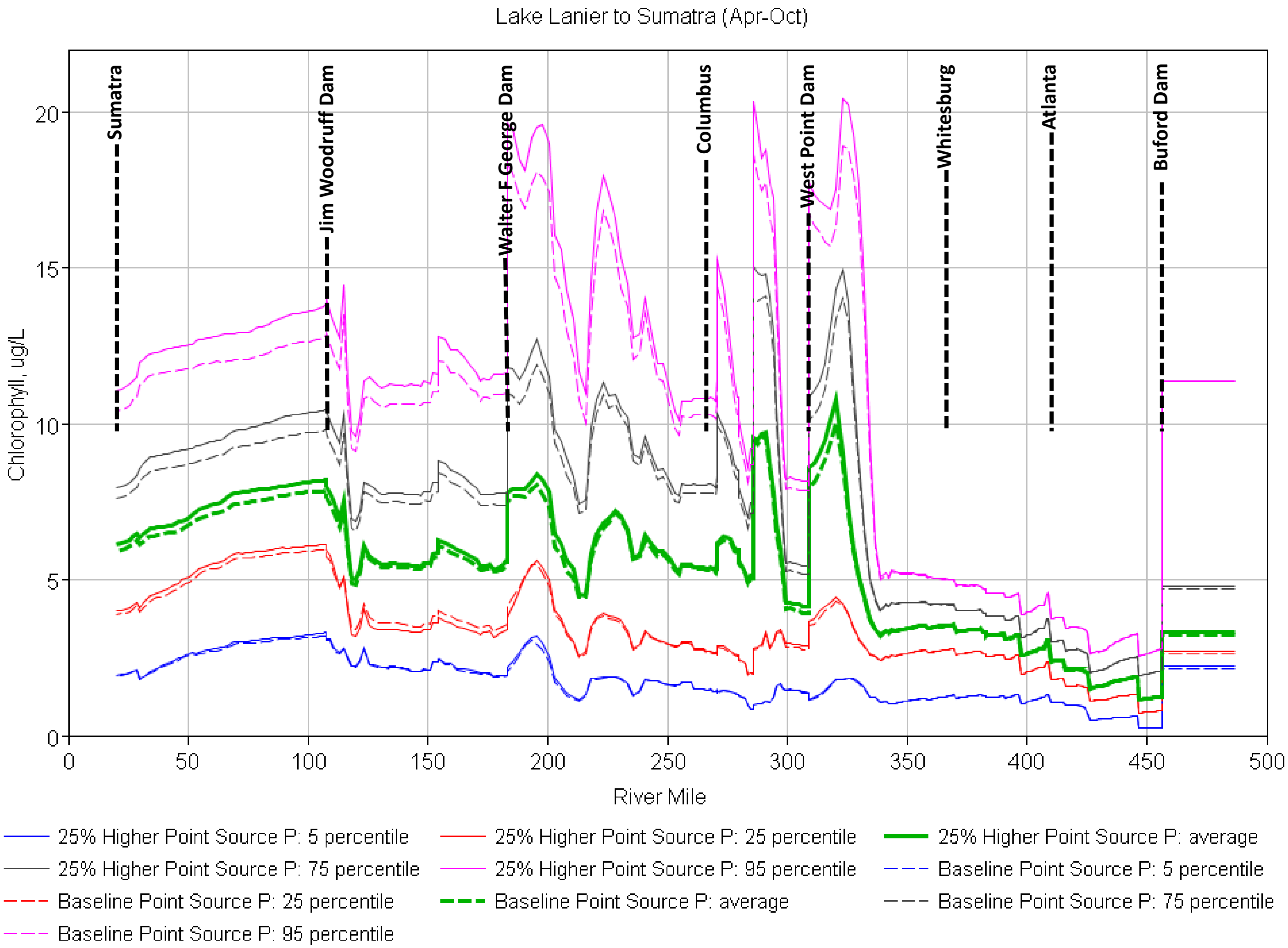

Figure 8.27 Longitudinal profiles of chlorophyll *a* (average and 5, 25, 75 and 95 percentile) computed between Lake Lanier and Sumatra during April – October illustrating sensitivity to a 25% increase in point source phosphorus.

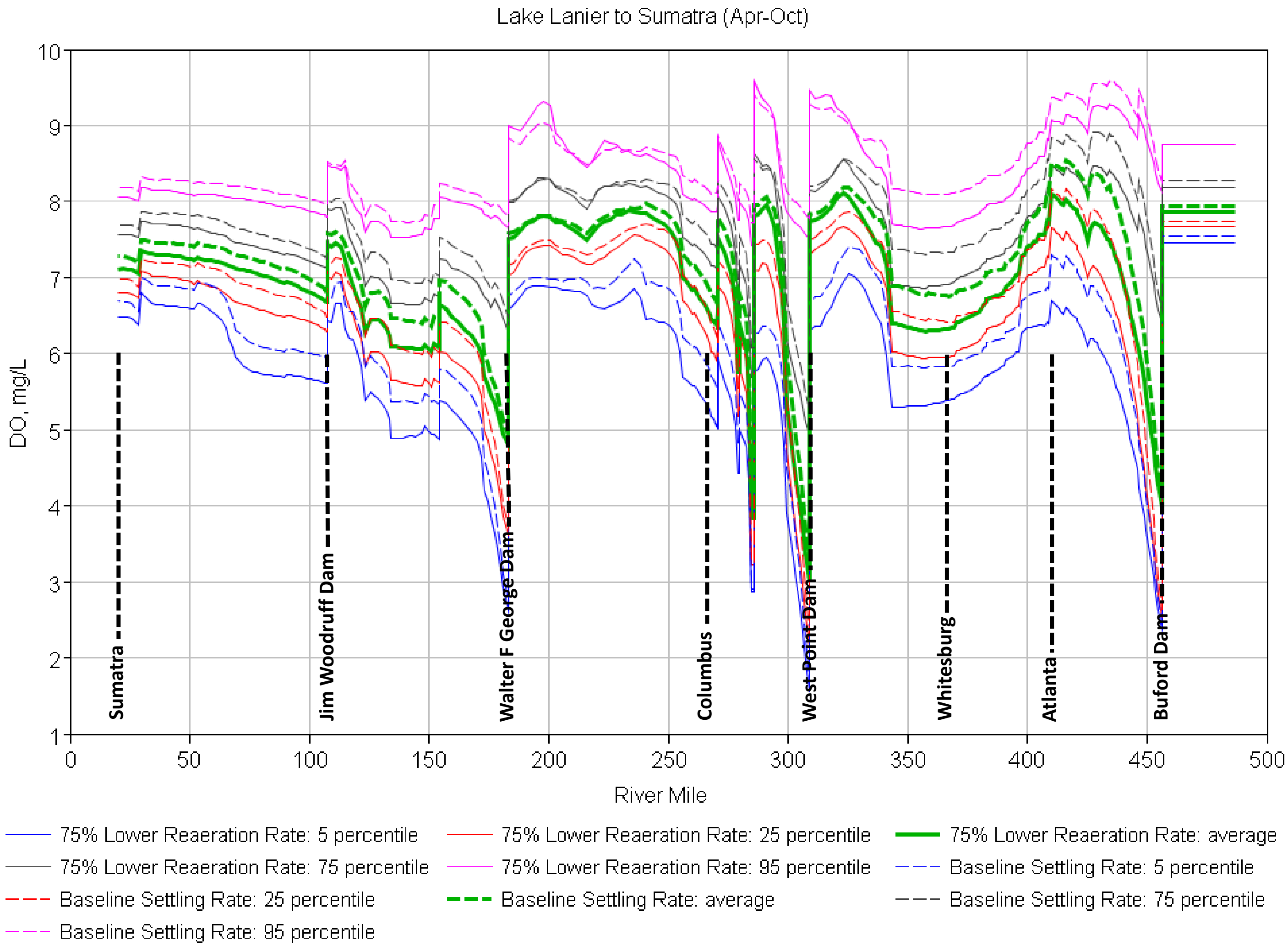

Figure 8.28 Longitudinal profiles of DO (average and 5, 25, 75 and 95 percentile) computed between Lake Lanier and Sumatra during April – October illustrating the relative impact of reducing the stream and lake reaeration rates to 75% of the calibrated model rates

Appendix L

Federal Agency Consistency Determination Under the Coastal Zone Management Act

Florida Coastal Management Program

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COASTAL ZONE MANAGEMENT ACT (16 U.S.C. §1456)
FEDERAL AGENCY CONSISTENCY DETERMINATION
FLORIDA COASTAL MANAGEMENT PROGRAM

Federal Agency: U.S. Army Corps of Engineers, Mobile District

Project: Apalachicola-Chattahoochee-Flint River Basin, Master Water Control Manual Update and Water Supply Storage Assessment

Location: Apalachicola River and Bay, Florida

Introduction

The U.S. Army Corps of Engineers (USACE) proposes to update the ACF Master Water Control Manual (WCM), including a water supply storage assessment (WSSA) to address potential reallocation of reservoir storage in Lake Sidney Lanier, Georgia, for water supply. The purpose and need associated with the update of the ACF Master WCM/WSSA are fully described in the draft environmental impact statement (EIS) to which this federal agency consistency determination is appended.

This document provides the state of Florida with the USACE's federal agency consistency determination for the proposed project pursuant to the Coastal Zone Management Act, section 307 (16 U.S.C. § 1456), as amended, and its implementing regulations at 15 CFR Part 230.

Proposed Federal Agency Action

The Proposed Action Alternative (PAA) for the update of the ACF Master WCM/WSSA is identified as Alternative 7H and described in detail in section 5.2.9 of the draft EIS.

The draft EIS evaluates potential impacts to the natural and human environment, including Florida's coastal zone, associated with the PAA and the other identified alternatives (including the No Action Alternative). The impacts are presented in section 6 of the draft EIS, along with an assessment of the status of the proposed project with respect to compliance with applicable federal laws, policies, and executive orders.

The Florida Coastal Management Program

Florida has developed and implemented a federally approved coastal management program (CMP) describing current coastal legislation and enforceable policies. The Florida CMP is based on a network of state agencies and the five regional water management districts implementing 24 statutes that protect and enhance the state's natural, cultural, and economic coastal resources. The goal of the program is to coordinate local, state, and federal agency activities using existing laws to ensure that Florida's coast is as valuable to future generations as it is to today's generation. Florida's Department of Environmental Protection is responsible for directing the implementation of the statewide coastal management program.

Federal Consistency Review

Statutes addressed as part of the Florida CMP consistency review and considered in the analysis of the PAA are discussed in the following table. Based upon information, data, and analyses discussed in the draft EIS, USACE has determined that the PAA is consistent with the enforceable policies of the Florida CMP to the maximum extent practicable.

Florida Coastal Management Program Consistency Review Apalachicola-Chattahoochee-Flint (ACF) River Basin Master Water Control Manual (WCM) Update/Water Supply Storage Assessment (WSSA)			
Statute	**Scope**	**Consistency**	**EIS Reference**
Chapter 161 *Beach and Shore Preservation*	Authorizes the Florida Department of Environmental Protection, Bureau of Beaches and Coastal Systems, to regulate construction on, or seaward of, the state's beaches.	**Not applicable**—The Proposed Action Alternative (PAA) for the Master WCM update/ WSSA would not involve construction activity on, or seaward of, Florida beaches.	Section 1.2; section 1.4.4
Chapter 163, Part II *Growth Policy; County and Municipal Planning; Land Development Regulation*	Requires local governments to prepare, adopt, and implement comprehensive plans that encourage the most appropriate use of land and natural resources in a manner consistent with the public interest.	**Consistent**—The PAA would have a negligible incremental effect on flow conditions in the Apalachicola River compared to the No Action Alternative (NAA). Thus, the PAA would not conflict with any county and municipal plans in Florida affecting land use and natural resource use.	Section 6.3.5
Chapter 186 *State and Regional Planning*	Details state-level planning requirements and requires development of special statewide plans governing water use, land development, and transportation.	**Consistent**—The PAA would have a negligible incremental effect on flow conditions in the Apalachicola River compared to the NAA. Thus, there would be no adverse effect on relevant state plans governing water use, land development, and transportation.	Section 6.1.1.2.5
Chapter 252 *Emergency Management*	Provides for planning and implementation of the state's response to, recovery from, and mitigation of the effects of natural and man-made disasters.	**Consistent**—The PAA would have a negligible incremental effect on flow conditions in the Apalachicola River downstream of Jim Woodruff Lock and Dam compared to the NAA. Thus, the PAA would be consistent with any pertinent emergency response, recovery, and/or mitigation plans.	Section 6.1.1.2.5; section 6.5.5
Chapter 253 *State Lands*	Addresses the state's administration of public lands and state property and provides guidance and direction regarding the acquisition, disposal, and management of all state lands.	**Consistent**—The PAA would not have an adverse effect on administration and management of state lands in the Apalachicola River corridor.	Section 6.3.5
Chapter 258 *State Parks and Preserves*	Addresses administration and management of state parks and preserves.	**Consistent**—The PAA would not have an adverse effect on administration and management of state parks and preserves in the Apalachicola River corridor.	Section 6.3.5
Chapter 259 *Land Acquisition for Conservation or Recreation*	Authorizes acquisition of environmentally endangered lands and outdoor recreation lands.	**Consistent**—The PAA would not be in conflict with any planned acquisition of environmentally endangered lands or outdoor recreation lands in the Apalachicola River corridor.	Section 6.3.5

Florida Coastal Management Program Consistency Review Apalachicola-Chattahoochee-Flint (ACF) River Basin Master Water Control Manual (WCM) Update/Water Supply Storage Assessment (WSSA)			
Statute	**Scope**	**Consistency**	**EIS Reference**
Chapter 260 *Recreational Trails System*	Authorizes acquisition of lands to create a recreational trails system and to facilitate management of the system.	**Consistent**—The PAA would not have an adverse effect on acquisition and management of recreational trails within the Apalachicola River corridor.	Section 6.3.5
Chapter 267 *Historic Resources*	Addresses management and preservation of the state's archaeological and historical resources.	**Consistent**—The PAA is not expected to have an adverse effect on archaeological and historic resources along the Apalachicola River compared to the NAA.	Section 6.7.3
Chapter 288 *Commercial Development and Capital Improvements*	Provides the framework for promoting and developing the general business, trade, and tourism components of the state's economy.	**Consistent**—The PAA would generally have a negligible effect on business and trade in the Florida portion of the ACF Basin. Commercial navigation could potentially benefit under the PAA. The incremental effects of the PAA on ecotourism and commercial fisheries in the Apalachicola River and Bay would be negligible compared to the NAA.	Section 6.5.2; section 6.4.2.3
Chapter 334 *Transportation Administration*	Addresses the state's policy concerning transportation administration.	**Not applicable**—This statute is not applicable to the ACF Master WCM update/WSSA.	Section 2.10
Chapter 339 *Transportation Finance and Planning*	Addresses the financial and planning needs of the state's transportation systems.	**Not applicable**—This statute is not applicable to the ACF Master WCM update/WSSA.	Section 2.10
Chapter 370 *Saltwater Fisheries*	Addresses the management and protection of the state's saltwater fisheries.	**Consistent**—Implementation of the PAA would be expected to have a negligible incremental effect on flow conditions in the Apalachicola River compared to the NAA. Therefore, the PAA would not be expected to have an incremental effect on salinity and hydrodynamic conditions in the Apalachicola Bay estuary compared to the NAA. No incremental change in water quality in the Apalachicola River is expected as a result of the PAA, and thus no changes would be expected in the Apalachicola Bay estuary. Overall, no change is expected in the Apalachicola Bay estuary or its fishery resources as a result of implementing the PAA.	Section 6.4.2.3; section 6.4.3

Florida Coastal Management Program Consistency Review Apalachicola-Chattahoochee-Flint (ACF) River Basin Master Water Control Manual (WCM) Update/Water Supply Storage Assessment (WSSA)			
Statute	**Scope**	**Consistency**	**EIS Reference**
Chapter 372 *Wildlife*	Addresses the management of the wildlife resources of the state.	**Consistent**—Implementation of the PAA would be expected to have a negligible incremental effect on flow conditions in the Apalachicola River compared to the NAA. Therefore, the PAA would not be expected to have an incremental effect on salinity and hydrodynamic conditions in the Apalachicola Bay estuary compared to the NAA. No incremental change in water quality in the Apalachicola River is expected as a result of the PAA, and thus no changes would be expected in the Apalachicola Bay estuary compared to the NAA. The PAA would continue to support conservation of protected species in the Apalachicola River (Gulf sturgeon and endangered mussels species) based upon consultation with the U.S. Fish and Wildlife Service under section 7 of the Endangered Species Act. Therefore, the PAA would likely have a negligible effect on the wildlife resources of the Apalachicola River and Bay compared to the NAA.	Section 6.4.1; section 6.4.2; section 6.4.3
Chapter 373 *Water Resources*	Addresses the state's policy concerning water resources.	**Consistent**—Implementation of the PAA would be expected to have a negligible incremental effect on flow conditions in the Apalachicola River compared to the NAA. Therefore, the PAA would not be expected to have an incremental effect on salinity and hydrodynamic conditions in the Apalachicola Bay estuary compared to the NAA. No incremental change in water quality in the Apalachicola River is expected as a result of the PAA, and thus no changes would be expected in the Apalachicola Bay estuary.	Section 6.1.1.2.5; section 6.1.2
Chapter 375 *Outdoor Recreation and Conservation Lands*	Provides for comprehensive outdoor recreation planning to document recreational supply and demand, describe current recreational opportunities, estimate need for additional recreational opportunities, and propose means to meet the identified needs.	**Consistent**—The PAA would not have an adverse effect on existing outdoor recreation plans in the Apalachicola River corridor or any proposed plans to meet future recreation needs in the corridor.	Section 6.3.5

Florida Coastal Management Program Consistency Review Apalachicola-Chattahoochee-Flint (ACF) River Basin Master Water Control Manual (WCM) Update/Water Supply Storage Assessment (WSSA)			
Statute	**Scope**	**Consistency**	**EIS Reference**
Chapter 376 *Pollutant Discharge Prevention and Removal*	Regulates transfer, storage, and transportation of pollutants and cleanup of pollutant discharges.	**Consistent**—Implementation of the PAA would not be expected to directly involve the transfer, storage, and transportation of hazardous and toxic pollutants. Operations at Jim Woodruff Lock and Dam might involve handling small amounts of hazardous and toxic materials. Pertinent protocols and contingency plans are in place to properly handle those materials and to manage any unexpected releases.	Section 2.12
Chapter 377 *Energy Resources*	Addresses regulation, planning, and development of energy resources of the state.	**Consistent**—The PAA would not affect regulation, planning, and development of energy resources of the state.	None
Chapter 380 *Land and Water Management*	Establishes land and water management policies to guide and coordinate local decisions relating to growth and development.	**Consistent**—The PAA would not be expected to affect local decisions relating to growth and development in the Apalachicola River corridor.	Section 6.3.5
Chapter 381 *Public Health, General Provisions*	Establishes public policy concerning the state's public health system to promote, protect, and improve the health of all people in the state.	**Not applicable**—This statute does not apply to the ACF Master WCM update/WSSA.	Not applicable
Chapter 388 *Mosquito Control*	Addresses mosquito control efforts in the state to protect human health and safety, promote economic development of the state, and facilitate the enjoyment of the state's natural attractions.	**Consistent**—The PAA would not affect any ongoing mosquito control efforts in the ACF Basin.	None
Chapter 403 *Environmental Control*	Establishes public policy concerning environmental control in the state to conserve state waters, protect and improve water quality, and maintain air quality.	**Consistent**—The PAA would not have an incremental effect on air quality. Water quality in the Apalachicola River and Bay would not be incrementally affected under the PAA compared to the NAA.	Section 2.8; section 6.1.2
Chapter 553 *Building and Construction Standards*	Addresses building construction standards and provides for a unified Florida Building Code.	**Not applicable**—This statute does not apply to the ACF Master WCM update/WSSA.	Not applicable

Florida Coastal Management Program Consistency Review Apalachicola-Chattahoochee-Flint (ACF) River Basin Master Water Control Manual (WCM) Update/Water Supply Storage Assessment (WSSA)			
Statute	**Scope**	**Consistency**	**EIS Reference**
Chapter 582 *Soil and Water Conservation*	Provides for the control and prevention of soil erosion.	**Consistent**—The PAA would not incrementally affect erosion and sedimentation patterns in the Apalachicola River compared to the NAA.	Section 6.2
Chapter 597 *Aquaculture*	Establishes public policy concerning the cultivation of aquatic organisms in the state to enhance the growth of aquaculture, while protecting the state's environment.	**Consistent**—Implementation of the PAA would not affect any ongoing aquaculture activities in the ACF Basin.	None

Appendix M

Recreation Benefit Analysis

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APALACHICOLA-CHATTAHOOCHEE-FLINT RIVER BASIN ENVIRONMENTAL IMPACT STATEMENT FOR WATER CONTROL MANUAL UPDATE

RECREATION ANALYSIS SUMMARY MEMORANDUM

DRAFT

AUGUST 2015

APALACHICOLA-CHATTAHOOCHEE-FLINT RIVER BASIN ENVIRONMENTAL IMPACT STATEMENT FOR WATER CONTROL MANUAL UPDATE

RECREATION ANALYSIS SUMMARY MEMORANDUM

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1. INTRODUCTION

1.1. PURPOSE, SCOPE, AND OBJECTIVES

The purpose of this memorandum is to summarize the objectives, methods, and results of the recreation analysis performed for the Environmental Impact Statement (EIS) of updates to the Water Control Manual for the Apalachicola-Chattahoochee-Flint (ACF) River Basin.

Both federal and non-federal recreation facilities and use were included in the evaluation. The most recent available recreation use data was provided by the resource managers at each federal project. The federal project resource managers also participated in scoring of the quality of recreation resources per the Unit Day Value analysis framework (discussed further in Section 2). This analysis provides decision makers a quantitative characterization of the effects of recreation that is consistent across the three projects.

1.2. STUDY AREA

For this analysis, the study area includes the ACF River Basin located in Georgia, Florida and Alabama. More specifically, it includes the federal and non-federal recreation facilities at Lake Sidney Lanier, West Point Lake, and Walter F. George Lake. Figure 1 provides a map showing the location of the three projects within the basin.

2. UNIT DAY VALUE ANALYSIS

2.1. GENERAL METHODOLOGY

The value of recreation can be estimated through approximation of visitors' willingness to pay for the recreation resource. Willingness-to-pay is assumed to represent the economic value, in dollars, that a visitor places on a recreation resource. Estimating the economic value of the recreation resource under current water control operations and comparing it to the value of alternative operational scenarios, allows the calculation of net effects on recreation benefits resulting from a scenario.

The appropriate valuation methodology was selected based on the guidelines in Appendix E, ER 1105-2-100 Planning Guidance Notebook, dated 22 April 2000, paragraph E-50b(4). For this study, there is no regional model available for recreation; the project is not creating specialized recreation activities as defined in the ER; and there is no increase in Federal costs for recreation, since the water management alternatives do not include recreation features. As such, the Unit Day Value (UDV) methodology was selected as the appropriate valuation method.

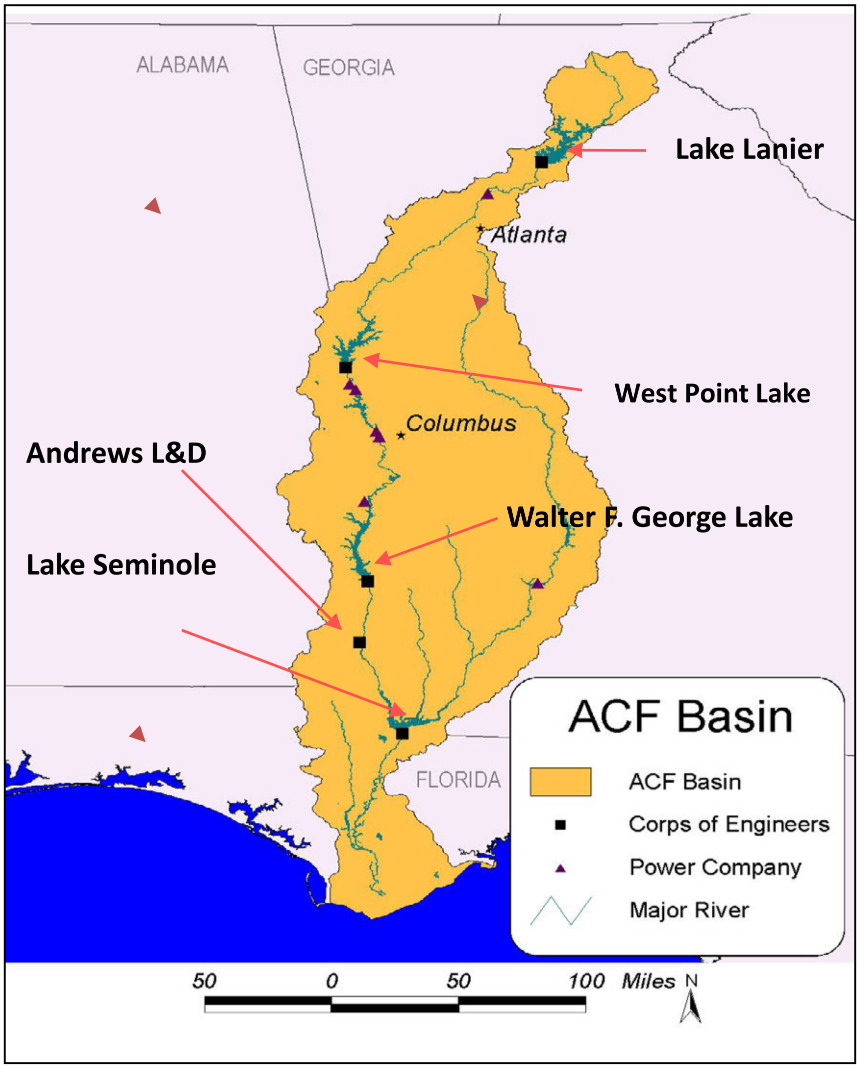

Figure 1. Study Area

When applying the UDV methodology, two categories of outdoor recreation visits, general and specialized, may be differentiated for evaluation purposes. “General” refers to a recreation visit involving primarily those activities that are attractive to the majority of outdoor users and that generally require the development and maintenance of convenient access and adequate facilities. “Specialized” refers to a recreation visit involving those activities for which opportunities in general are limited, intensity of use is low, and a high degree of skill, knowledge, and appreciation of the activity by the user may often be involved (USACE, Economic Guidance Memorandum 15-03, Unit Day Values for Recreation, Fiscal Year 2015). All of the activities at the ACF reservoirs, with and without project, were determined to fall into the general recreation category.

The UDV method for estimating recreation benefits relies on expert or informed opinion and judgment to approximate the average willingness to pay of users of Federal or Federally assisted recreation resources. By applying a unit day value per visitor, an approximation of project recreation benefits is obtained.

The UDV process includes scoring of the project site using five guidance-defined criteria to yield a point score for the groups of recreation activities at the site. The point score is converted to dollars per visit using tables provided in the UDV guidance (updated annually). The final dollars-per-visit value is the UDV. The UDV is then multiplied by the number of annual visitors to generate an estimate of the annual recreation value at the site. This annual value is then projected over the 50 year period of analysis based on visitation projections for the study area.

This method of estimating annual recreation value is completed twice. First, a valuation is completed for the No Action Alternative. Second, a valuation is completed for the "with" project alternatives. The difference between the two estimates is the net recreation value attributable to the alternative being evaluated.

2.2. APPLICATION FOR THIS ANALYSIS

In this analysis, a separate UDV evaluation is presented for each of the three reservoirs (Lake Sidney Lanier, West Point Lake, and Walter F. George Lake). This approach required site-specific visitation data as well as separate UDV scorings for each of the three reservoirs.

No recreation features are proposed for construction as part of the alternatives. The water management alternatives affect recreation by altering reservoir pool levels during the recreation season. The extent to which recreation is affected was accounted for as a function of the amount of time the pool is held at or below four pool levels as defined by ResSim modeling. For the No Action Alternative and for the revised operations under each alternative, ResSim modeled the amount of time the pool level of each reservoir would remain at or below these four levels. See Section 2.3 for a detailed summary by alternative.

- Full Pool (No Effect)
- Initial Impact Level
- Recreation Impact Level
- Water Access Limited Level

Next, UDV scores were elicited from the project resource managers from each reservoir. A UDV score was developed for each pool level at each reservoir (12 scores in total). In doing so, the effect on recreation for each alternative could be measured as a function of effect on pool level. This approach reflects that pool levels which are less than optimal for recreation would result in reduced value of the recreation resource (i.e., visitors have a lower willingness to pay for recreation at these reservoirs as pool levels drop below optimal levels).

These scores were converted to a dollar value per recreation visit (see Section 2.6) and then applied to estimates of annual visitation obtained from the project resource managers. This method resulted in an estimate of recreation value at each reservoir for the time spent at each pool level. Adding up the value for each pool level based upon the amount of time at each level resulted in an estimate of recreation value across the 50-year period of analysis. This value was annualized using the Fiscal Year (FY) 2015 Federal discount rate of 3.375 percent to yield an estimate of the average annual recreation value for each alternative. These average annual values can be compared to the without project average annual value to assess the incidental effect of each alternative water control alternative on recreation value.

2.3. WATER MANAGEMENT ALTERNATIVES SUMMARY

This recreation analysis estimated the effects of the following proposed water management alternatives on recreation resources at Lake Sidney Lanier, West Point Lake, and Walter F. George Lake. Following the bulleted list below, Table 1 summarizes these alternative according to their modeled effects on pool level in terms of the percent of time spent in each zone during the recreation season.

- No Action A; Current Operations w/Water Supply Option A
- Alt 1B (Current Operations w/Water Supply Option B)
- Alt 1C (Current Operations w/Water Supply Option C)
- Alt 7A (Water Management Alternative 7 w/Water Supply Option A)
- Alt 7C (Water Management Alternative 7 w/Water Supply Option C)
- Alt 7D (Water Management Alternative 7 w/Water Supply Option D)
- Alt 7E (Water Management Alternative 7 w/Water Supply Option E)
- Alt 7F (Water Management Alternative 7 w/Water Supply Option F)
- Alt 7H (Water Management Alternative 7 w/Water Supply Option H)

Table 1. Alternatives Summary

Alternative	Description	Impact Level*											
		Lake Sidney Lanier				West Point Lake				Walter F George Lake			
		F.P.	I.I.L.	R.I.L.	W.A.L.	F.P.	I.I.L.	R.I.L.	W.A.L.	F.P.	I.I.L.	R.I.L.	W.A.L.
No Action Opt A	Current Operations w/Water Supply Option A	77 percent	17 percent	5 percent	1 percent	75 percent	21 percent	3 percent	1 percent	97 percent	3 percent	0 percent	0 percent
Alt 1 - Opt B	Current Operations w/Water Supply Option B	85 percent	13 percent	2 percent	0 percent	76 percent	20 percent	3 percent	1 percent	98 percent	2 percent	0 percent	0 percent
Alt 1 - Opt C	Current Operations w/Water Supply Option C	78 percent	16 percent	5 percent	1 percent	77 percent	20 percent	2 percent	1 percent	98 percent	2 percent	0 percent	0 percent
Alt 7 - Opt A	Water Management Alternative 7 w/Water Supply Option A	75 percent	19 percent	5 percent	1 percent	74 percent	22 percent	3 percent	1 percent	95 percent	5 percent	0 percent	0 percent
Alt 7 - Opt C	Water Management Alternative 7 w/Water Supply Option C	80 percent	15 percent	4 percent	1 percent	77 percent	21 percent	2 percent	0 percent	95 percent	5 percent	0 percent	0 percent
Alt 7 - Opt D	Water Management Alternative 7 w/Water Supply Option D	71 percent	22 percent	5 percent	2 percent	77 percent	21 percent	2 percent	0 percent	95 percent	5 percent	0 percent	0 percent
Alt 7 - Opt E	Water Management Alternative 7 w/Water Supply Option E	71 percent	22 percent	5 percent	2 percent	77 percent	21 percent	2 percent	0 percent	95 percent	5 percent	0 percent	0 percent
Alt 7 - Opt F	Water Management Alternative 7 w/Water Supply Option F	49 percent	31 percent	14 percent	6 percent	74 percent	24 percent	2 percent	0 percent	96 percent	4 percent	0 percent	0 percent
Alt 7 - Opt H	Water Management Alternative 7 w/Water Supply Option H	71 percent	22 percent	5 percent	2 percent	76 percent	22 percent	2 percent	0 percent	95 percent	5 percent	0 percent	0 percent

**NOTE: F.P. = Full Pool (No Effect); I.I.L. = Initial Impact Level; R.I.L. = Recreation Impact Level; W.A.L = Water Access Limited Level*

2.4. VISITATION ESTIMATE

Visitation estimates were provided by the project resource managers for Lake Sidney Lanier, West Point Lake, and Walter F. George Lake. These estimates included visitation at both federal and non-federal facilities over approximately the last decade. The data over the period of record was averaged to generate a typical baseline annual visitation for each reservoir. Expected annual growth in visitation over time was estimated to be 2 percent, based upon the mean annual population growth rate of the 27 counties within a 10-mile radius of the three lakes. To reflect consideration of facility carrying capacity at the reservoirs, available capacity data was reviewed and discussed with project resource managers, resulting in the assumption that visitation growth be capped after ten years and remain constant for the rest of the period of analysis. Table 2 summarizes the estimated annual visitation projections for each of the projects.

Table 2. Visitation Over the Period of Analysis

Years	Lake Sidney Lanier Visits	West Point Lake Visits	Walter F. George Lake Visits
1	5,891,000	1,880,000	2,500,000
2	6,009,000	1,918,000	2,550,000
3	6,129,000	1,956,000	2,601,000
4	6,252,000	1,995,000	2,653,000
5	6,377,000	2,035,000	2,706,000
6	6,504,000	2,076,000	2,760,000
7	6,634,000	2,117,000	2,815,000
8	6,767,000	2,160,000	2,872,000
9	6,902,000	2,203,000	2,929,000
10	7,040,000	2,247,000	2,988,000
11-50	7,181,000	2,292,000	3,047,000

2.5. UDV SCORING / POINT ASSIGNMENT

UDV scoring was developed through expert elicitation from the project resource managers. For each project, scores were developed for each pool level at each reservoir (12 scores in total). In doing so, the effect on recreation for each alternative could be measured as a function of effect on pool. The five UDV criteria for which points are assigned were:

- Recreation Experience: score increases in proportion to the number of available activities at the site
- Availability of Opportunity: score is based on availability of substitute sites; the fewer the sites in the region that offer comparable recreation experience, the higher the score
- Carrying Capacity: score rates level of facilities at the site to support the activities
- Accessibility: score rates ease of access to the site
- Environmental: rates the aesthetic/environmental quality of the recreation site/activities

Scoring was based on the consideration of general recreation activities that would be affected at each project. Table 3 provides a copy of the USACE guidance which contains the scoring rubric. Table 4 shows the scores developed by the team. In the sections following the table, the rationale is provided for the point assignments according to the five UDV criteria. In Section 2.6, these scores are converted to dollar value equivalents.

Table 3. UDV Scoring Rubric

Criteria	Judgment Factors				
Recreation Experience (1) Points Possible: 30	Two general activities (2) 0-4	Several general activities 5-10	Several general activities: one high quality value activity (3) 11-16	Several general activities: more than one high quality value activity 17-23	Numerous high quality value activities; some general activities 24-30
Availability of Opportunity (4) Points Possible: 18	Several within 1 hr travel time; a few within 30 min travel time 0-3	Several within 1 hr travel time; none within 30 min travel time 4-6	One or two within 1 hr travel time; none within 45 min travel time 7-10	None within 1 hr travel time 11-14	None within 2 hr travel time 15-18
Carrying Capacity (5) Points Possible: 14	Minimum facility for development for public health and safety 0-2	Basic facility to conduct activity(ies) 3-5	Adequate facilities to conduct without deterioration of the resource or activity experience 6-8	Optimum facilities to conduct activity at site potential 9-11	Ultimate facilities to achieve intent of selected alternative 12-14
Accessibility Points Possible: 18	Limited access by any means to site or within site 0-3	Fair access, poor quality roads to site; limited access within site 4-6	Fair access, fair road to site; fair access, good roads within site 7-10	Good access, good roads to site; fair access, good roads within site 11-14	Good access, high standard road to site; good access within site 15-18
Environmental Quality Points Possible: 20	Low aesthetic factors (6) that significantly lower quality (7) 0-2	Average aesthetic quality; factors exist that lower quality to a minor degree 3-6	Above average aesthetic quality; any limiting factors can be reasonably rectified 7-10	High aesthetic quality; no factors exist that lower quality 11-15	Outstanding aesthetic quality; no factors exist that lower quality 16-20

Guidance Notes:

(1) Value for water-oriented activities should be adjusted if significant seasonal water level

(2) General activities include those that are common to the region and that are usually of normal quality. This includes picnicking, camping, hiking, riding, cycling, and fishing and hunting of normal quality.

(3) High quality value activities include those that are not common to the region and/or Nation, and that are usually of high quality.

(4) Likelihood of success at fishing and hunting.

(5) Value should be adjusted for overuse.

(6) Major esthetic qualities to be considered include geology and topography, water, and vegetation.

(7) Factors to be considered to lowering quality include air and water pollution, pests, poor climate, and unsightly adjacent areas.

Table 4. UDV Score Summary

	Criteria					
	Recreation Experience	Availability of Opportunity	Carrying Capacity	Accessibility	Environ-mental	Total
Lake Sidney Lanier						
Full Pool	30	14	14	18	19	**95**
Initial Impact	28	14	14	18	17	**91**
Recreation Impact	25	14	12	18	15	**84**
Water Access Limited	17	12	9	18	9	**65**
West Point Lake						
Full Pool	27	4	11	15	15	**72**
Initial Impact	24	4	10	15	13	**66**
Recreation Impact	20	4	8	15	11	**58**
Water Access Limited	20	4	6	15	9	**54**
Walter F George Lake						
Full Pool	30	14	12	17	17	**90**
Initial Impact	30	14	10	17	14	**85**
Recreation Impact	30	14	6	17	10	**77**
Water Access Limited	16	14	3	17	6	**56**

2.5.1. RECREATION EXPERIENCE

2.5.1.1. LAKE SIDNEY LANIER

FULL POOL

This criteria was scored 30 out of 30 points. All high quality and general activities would be available at the lake, including all of the 10,000 private boat docks. Lake Sidney Lanier offers the largest quantity of recreation development of the tree projects.

INITIAL IMPACT

This criteria scored 28 out of 30 points. Most facilities remain available, but beaches are beginning to experience an impact. Beach surface areas are increased while swim areas (water) are decreased and the effects on visitation are offset. Boating access is not significantly affected due to extended boat ramps and marinas which have been designed to accommodate a fluctuating pool level. Private boat docks are minimally affected at this lake level (approximately 10 percent of total docks on the lake).

RECREATION IMPACT

This criteria scored 25 out of 30 points to reflect some additional effect compared to the Initial Impact level, but not enough to drop the score into the 17-23 point range.

WATER ACCESS LIMITED

This criteria scored 17 out of 30 points. At this pool level, land based activities are still minimally affected but numerous water based activates are significantly affected.

2.5.1.2. WEST POINT LAKE

FULL POOL

This criteria was scored 27 out of 30 points. This score reflects that at full pool all recreation facilities are operational at the project and are in in a usable and safe condition.

INITIAL IMPACT

This criteria was scored 24 out of 30 points. At this level, recreation begin to be noticeable. Swimming areas become marginally usable, commercial marinas prepare to shift docks/boat slips outward, approximately one third of private docks become marginally usable, and boat launching ramps begin for to accumulate silt which hinders boat launching into the lake. Safety becomes a factor as some unmarked, potential hazards to navigation begin to appear.

RECREATION IMPACT

This criteria was scored 20 out of 30 points. At this impact level significant impacts to recreation are noticeable and all swimming beaches become unusable, necessitating the drop in point score. Commercial marinas have to shift docks/boat slips outward to prevent them from becoming unusable, approximately 50 percent of private docks become only marginally usable, and 25 percent of courtesy docks at public boat ramps become unusable. The remaining 75 percent of them are only marginally usable. Boat launching ramps have silt build-up that requires frequent removal. Access to upper reaches of the reservoir, beyond Ringer Park, is limited by silt accumulation and a braided river channel. Unmarked navigation hazards continue to emerge. Shallow tributaries become unsafe for skiing.

WATER ACCESS LIMITED

This criteria was scored 20 out of 30 points. At this impact level, there may be some additional effects but the number of activities is unlikely to change, so the point score is maintained. Business at Marinas drops significantly, approximately 70 percent of private docks are unusable, over 60 percent of courtesy docks at boat ramps are unusable. Shallow tributaries are not accessible by boat.

2.5.1.1. WALTER F. GEORGE LAKE

FULL POOL

This criteria was scored 30 out of 30 points. At full pool all recreation facilities are operational, including the high quality bass fishery, nicknamed the "Bass Capital of the World." Also regionally unique are the two navigation locks providing access to the Gulf of Mexico, both of which operate normally at full pool.

INITIAL IMPACT

This criteria was scored 30 out of 30 points. It was judged that the score would remain the same at this pool level, as all activities would remain viable somewhere on the lake, and the score it based on the number of activities available. However, impacts to recreation may begin to become noticeable, including safety issues related to barely-submerged obstacles, minor reduction in the size of swim beaches, the beginning effects on boat ramps and the potential for 30 percent of private docks to become unusable.

RECREATION IMPACT

This criteria was scored 30 out of 30 points. At this level significant impacts to recreation are noticeable. However, activities remain available at certain points on the lake and gulf access may still be available, still meeting the criteria for recreation experience score based on the number of activities available. Effects include: swimming beaches become undesirable or unusable, approximately 35 percent of private docks become marginally usable, 10 percent of courtesy docks at boat ramps become unusable, and 90 percent of them marginally usable. All boat launching ramps have frequent silt build-up and several become unusable. Prime fishing sites become inaccessible. Marina operations become affected with some inaccessible boat slips. Unmarked navigation hazards continue to emerge, with vast areas of the project having less than three feet of water. Conditions may allow invasive aquatics to establish a strong hold in normally deeper areas of the lake. Gulf access may be impacted by reduced releases downstream.

WATER ACCESS LIMITED

This criteria was scored 16 out of 30 points. The substantial drop in score reflects that activities may no longer be viable anywhere on the lake. At this level major impacts to recreation are noticeable. All swimming beaches will be unusable, commercial marinas will have impacts causing them to become unusable and business at Marinas would likely dip significantly. Approximately 85-90 percent of private docks would be unusable, and over 75 percent of courtesy docks at boat ramps become unusable. Boat launching ramps would be significantly impacted. A significant number of unmarked navigation hazards would continue to emerge. Shallow tributaries and large areas of the main lake become unsafe for skiing and boat traffic, moving skiers to main river channels. Access to the Gulf may be lost at this impact level.

2.5.2. AVAILABILITY OF OPPORTUNITY

2.5.2.1. LAKE SIDNEY LANIER

FULL POOL

This criteria was scored 14 out of 18 points. This score reflects that other high quality value activities and general activities are available in the Metro-Atlanta area just within a one hour travel time.

INITIAL IMPACT

This criteria was scored 14 out of 18 points. This impact level would have minimal additional effect on land-based activities and navigation would be minimally affected by a reduction in surface acreage available for recreational boating traffic. Under water boating hazards are not a concern until lower lake levels. At this impact level, there would still not be more than one suitable substitute with an hour travel time, thus the score is maintained.

RECREATION IMPACT

This criteria was scored 14 out of 18 points as well. While effects would be increased, the team judged that there would still not be more than one suitable substitute with an hour travel time, thus score is maintained rather than reduced to the next category on the rubric. The score reflects that Corps-operated boat ramps are marginally affected at pool elevation 1063. At this lake level, 17 boat ramps have lanes that are unusable. Private boat docks would be marginally affected at this lake level (approximately 20 percent of total docks on the lake). Marinas/Clubs with boat slips in shallow areas are minimally affected. Approximately 2 percent or 142 slips are unusable. Most Corps-operated swim areas are unusable for swimming except where swim lines have been safely relocated to allow for at least 2 feet of water at the line. Navigation hazards would become more numerous and vessels would need to be operated with increased caution.

WATER ACCESS LIMITED

This criteria was scored 12 out of 14 points. This small reduction from the Recreation Impact level reflects that Corps operated boat ramps are significantly affected at pool elevation 1060. At this lake level, 39 boat ramps would have lanes that are unusable. Navigation hazards would become more numerous and vessels would need to be operated with increased caution. Private boat docks would be significantly affected at this lake level (approximately 50 percent of total docks on the lake).

2.5.2.2. WEST POINT LAKE

ALL IMPACT LEVELS

This criteria was scored 4 out of 18 points. This score reflects that there are several locations within one hour drive time that provide similar recreational opportunities to the public. This score was held constant across all impact levels.

2.5.2.1. WALTER F. GEORGE LAKE

ALL IMPACT LEVELS

This criteria was scored 14 out of 18 points. The team judged that there are no locations within one hour drive time that provide the unique recreational opportunities listed above to the public. This score was held constant across all impact levels.

2.5.3. CARRYING CAPACITY

2.5.3.1. LAKE SIDNEY LANIER

FULL POOL

This criteria was scored 14 out of 14 points, reflecting that Sidney Lake Lanier is one of the most developed lake recreation projects in the region.

INITIAL IMPACT

This criteria was scored 14 out of 14 points, reflecting that the Initial Impact pool level would not substantially affect land-based or water activities.

RECREATION IMPACT

This criteria was scored 12 out of 14 points. This reduced score reflects that at this pool level, the project would may see reduced visitation due lack of accessible boat ramp facilities and other lake access for water-based recreation. Land based facilities would still not be affected significantly.

WATER ACCESS LIMITED

This criteria was scored 9 out of 14 points. Further reduction in the score reflects that the number of accessible boat ramps and other water access points would be further reduced at this pool level.

2.5.3.2. WEST POINT LAKE

FULL POOL

This criteria was scored 11 out of 14 points. The score reflects that the project consists of favorable and commonly requested facilities/amenities as evidenced by public demand and use. Because of relatively intensive maintenance, most areas accommodate frequent public use without severe deterioration facilities and resources.

INITIAL IMPACT

This criteria was scored 10 out of 14 points. This score reflects that there would be only minor decrease in carrying capacity due to reduced lake levels.

RECREATION IMPACT

This criteria was scored 8 out of 14 points. This score reflects that at this lower reservoir level, recreational opportunities would be reduced by limiting the number of usable facilities available. Potential visitors may perceive that boating conditions are unsafe and stay away from the project. Some major tributaries may be too shallow for boat operation, shifting boat traffic to deeper water and making navigation channels more congested.

WATER ACCESS LIMITED

This criteria was scored 6 out of 14 points. At this lowest level many of the project's courtesy docks are unusable. Visitors may shift to other parks with usable courtesy docks, creating more impact to those recreation areas. Both marinas' boat ramps are unusable, again shifting visitors to other Corps parks for water access. Business at marinas is negatively impacted. The majority of boat traffic is focused on the main river channel, making navigation channels more congested. Many potential lake users perceive that the lake is inaccessible at this level.

2.5.3.1. WALTER F. GEORGE LAKE

FULL POOL

This criteria was scored 12 out of 14 points. The project consists of favorable and the most commonly requested facilities/amenities as evidenced by public demand and use. Most areas can easily accommodate high use with no deterioration to the resource due to overuse.

INITIAL IMPACT

This criteria was scored 10 out of 14 points. The drop in score reflects loss of access to some boat ramps and reduced swimming areas which would impacts visitation and enjoyment of the resource.

RECREATION IMPACT

This criteria was scored 6 out of 14 points. Further reduction in score reflects that at this level, 50 percent of the courtesy docks become unusable which could potentially shift lake access users to other parks with usable courtesy docks, therefore creating more impact to those recreation areas. Additionally, tributaries will be too shallow for boat operation, shifting boat traffic to deeper water and making navigation channels more congested. Risk of erosion due to wave action on exposed shoreline may increase.

WATER ACCESS LIMITED

This criteria was scored 3 out of 14 points. An even lower score reflect lower water levels, which result in exposed shoreline and increased soil erosion risk. At this level, most critical fish habitat structure would be compromised and esthetic quality would decrease as well. Floating debris and trash may begin to be deposited on the exposed shoreline.

2.5.4. ACCESSIBILITY

2.5.4.1. LAKE SIDNEY LANIER

ALL IMPACT LEVELS

This criteria was scored 18 out of 18 points. This score reflects that all access roads to parks and interior roads within parks have been improved and paved to provide year round safe access to all facilities. This score was held constant across all impact levels.

2.5.4.2. WEST POINT LAKE

ALL IMPACT LEVELS

This criteria was scored 15 out of 18 points. The score reflects that recreation areas and facilities at the project are easily accessible via suitable public roadways, and roads within parks are maintained in reasonably good condition. Signage on most roads directs users to parks around the project. This score was held constant across all impact levels.

2.5.4.1. WALTER F. GEORGE LAKE

ALL IMPACT LEVELS

This criteria was scored 17 out of 18 points. The score reflects that many roads provide access to the project's parks and campgrounds. Roads are paved, adequate width to accommodate types of vehicles entering/exiting, and all areas and are maintained in good condition. Signage directs users to park areas around the project. This score was held constant across all impact levels.

2.5.5. ENVIRONMENTAL

2.5.5.1. LAKE SIDNEY LANIER

FULL POOL

This criteria was scored 19 out of 20 points. The score reflects that the project offers clear water, unique topography (foothills of the Appalachian Mountains), four distinct seasons effecting vegetation, and high water quality despite some industrial and municipal water treatment feeding tributaries.

INITIAL IMPACT

This criteria was scored 17 out of 20 points. While the team judged that environmental quality would not be substantially affected by this pool level, there was concern related to the migration of existing silt beds to deeper water.

RECREATION IMPACT

This criteria was scored 15 out of 20 points. At this pool level, additional concerns were raised related to reduced aesthetic quality of the exposed banks.

WATER ACCESS LIMITED

This criteria was scored 9 out of 20 points, reflecting still further reduction of aesthetic quality due to the exposed banks.

2.5.5.2. WEST POINT LAKE

FULL POOL

This criteria was scored 15 out of 20 points. At this level, the project provides many areas of high aesthetic quality with few factors that lower the environmental quality. There are minimal impacts from noise and water quality. Numerous positive environmental factors are present such excellent wildlife habitat, suitable water clarity, lush vegetation, etc. Positive outdoor recreation experiences are available.

INITIAL IMPACT

This criteria was scored 13 out of 20 points. At this level, the project continues to provide areas of high aesthetic quality. Visitors may begin to express concern about the lower reservoir level during the recreation season, negatively impacting their recreational experience. Positive outdoor recreation experiences remain available.

RECREATION IMPACT

This criteria was scored 11 out of 20 points. At this level, lower water levels result in exposed shoreline which increases the opportunity for soil erosion. Some critical fish habitat structure would be compromised, and esthetic quality would decrease as well. Floating debris and trash begins to be deposited on the exposed shoreline.

WATER ACCESS LIMITED

This criteria was scored 9 out of 20 points. At this level, the appearance of the reservoir is negatively affected, with a large expanse of exposed, bare soil surrounding the water's edge. Critical fish habitat structure is compromised and esthetic quality decrease as the water level continues to decline.

2.5.5.1. WALTER F. GEORGE LAKE

FULL POOL

This criteria was scored 17 out of 20 points. At this level, the project provides many areas of high aesthetic quality with few factors that lower the environmental quality. There are minimal impacts from noise and water quality and numerous positive environmental factors are present such as wildlife viewing, water clarity, solitude, and high quality natural value (such as scenic rivers with zero development).

INITIAL IMPACT

This criteria was scored 14 out of 20 points. The reduction in score at this impact level reflects that exposed mudflats would detract from the natural beauty.

RECREATION IMPACT

This criteria was scored 10 out of 20 points. Further score reduction reflects that lower water levels would result in significant exposed shoreline and increased risk of soil erosion. Some critical fish habitat structure would be compromised and esthetic quality would decrease as well. Exposed mudflats continue to detract from the natural beauty at this impact level. Floating debris and trash begins to be deposited on the exposed shoreline, and sedimentation begins to accrue in normal deep water areas.

WATER ACCESS LIMITED

This criteria was scored 6 out of 20 points. Additional score reduction reflects that soil erosion impacts begin to expand exponentially at this water level, critical fish habitat structure is compromised, and aesthetic quality decreases as the water level continues to decline. Shoreline and access to water is limited by mud at this impact level, and floating debris and trash continues to be deposited on the exposed shoreline.

2.6. UNIT DAY VALUE CONVERSION

The points described above were converted to a dollar value based on the FY2015 UDV conversion table in EGM 15-03 (USACE 2014). The scores were interpolated linearly as necessary. Table 5 shows the point conversion table from the guidance, and Table 6 summarizes the converted values.

Table 5. FY15 UDV Conversion

General Recreation	
Point Values	**Values ($)**
0	$3.91
10	$4.64
20	$5.13
30	$5.86
40	$7.32
50	$8.30
60	$9.03
70	$9.52
80	$10.50
90	$11.23
100	$11.72
USACE CECW-CP EGM 15-03 for FY2015	

Table 6. Assigned Scores Converted

	Total Points	Value per Visit ($)
Lake Sidney Lanier		
Full Pool	95	$11.48
Initial Impact	91	$11.28
Recreation Impact	84	$10.79
Water Access Limited	65	$9.28
West Point Lake		
Full Pool	72	$9.72
Initial Impact	66	$9.32
Recreation Impact	58	$8.88
Water Access Limited	54	$8.59
Walter F George Lake		
Full Pool	90	$11.23
Initial Impact	85	$10.87
Recreation Impact	77	$10.21
Water Access Limited	56	$8.74

3. RECREATION VALUE CALCULATIONS

Having completed estimates of visitation for each of the three projects and the UDV scoring, the two are combined to estimate recreation value. Recreation value was estimated for each alternative, including the without project, and for each of the three projects.

The following example considers only Lake Sidney Lanier and the without project condition. In order to estimate recreation value, the annual visits in each year of the period of analysis were proportionally applied to the four pool levels (full, initial, recreation, water access limited) according to the data shown in Table 1. Then visits for each pool level are multiplied by the corresponding UDV value in Table 6 to estimate recreation value by pool level. Adding up the four values corresponding to the four pool levels in a single year gives the estimate of total recreation value in that year. The total value for each year is then discounted using the FY 2015 discount rate of 3.375 percent to give the present value of recreation in that year. Then the values for each year in the period of analysis are summed to calculate the total present value of recreation for that scenario . This value is amortized to give average annual recreation value over the period of analysis.

This same calculation was completed for all the alternatives at each of the projects. Tables 7 through 9 summarize the results of the recreation valuation calculations. In the tables, the without project is the first row, and the alternatives are sorted according to increasing annual recreation value.

Table 7. Lake Sidney Lanier Recreation Value Summary

	Annualized Recreation Value ($)	Present Value ($)	Annualized Change vs. Without Project	Percent Change
Without Project	$78,721,000	$1,888,815,000	$0	-
Alt 1 B	$79,069,000	$1,897,165,000	$348,000	0.44%
Alt 1 C	$78,734,000	$1,889,140,000	$13,000	0.02%
Alt 7 A	$78,694,000	$1,888,165,000	($27,000)	-0.03%
Alt 7 C	$78,795,000	$1,890,598,000	$74,000	0.09%
Alt 7 D	$78,501,000	$1,883,540,000	($220,000)	-0.28%
Alt 7 E	$78,501,000	$1,883,540,000	($220,000)	-0.28%
Alt 7 F	$77,345,000	$1,855,817,000	($1,376,000)	-1.75%
Alt 7 H	$78,501,000	$1,883,540,000	($220,000)	-0.28%

Table 8. West Point Lake Recreation Value Summary

	Annualized Recreation Value ($)	Present Value ($)	Annualized Change vs. Without Project	Percent Change
Without Project	$21,177,000	$508,115,000	$0	-
Alt 1 B	$21,186,000	$508,323,000	$9,000	0.04%
Alt 1 C	$21,204,000	$508,763,000	$27,000	0.13%
Alt 7 A	$21,168,000	$507,908,000	($9,000)	-0.04%
Alt 7 C	$21,220,000	$509,151,000	$43,000	0.20%
Alt 7 D	$21,220,000	$509,151,000	$43,000	0.20%
Alt 7 E	$21,220,000	$509,151,000	$43,000	0.20%
Alt 7 F	$21,194,000	$508,528,000	$17,000	0.08%
Alt 7 H	$21,211,000	$508,943,000	$34,000	0.16%

Table 9. Walter F. George Lake Recreation Value Summary

	Annualized Recreation Value ($)	Present Value ($)	Annualized Change vs. Without Project	Percent Change
Without Project	$32,919,000	$789,848,000	$0	-
Alt 1 B	$32,929,000	$790,104,000	$10,000	0.03%
Alt 1 C	$32,929,000	$790,104,000	$10,000	0.03%
Alt 7 A	$32,897,000	$789,334,000	($22,000)	-0.07%
Alt 7 C	$32,897,000	$789,334,000	($22,000)	-0.07%
Alt 7 D	$32,897,000	$789,334,000	($22,000)	-0.07%
Alt 7 E	$32,897,000	$789,334,000	($22,000)	-0.07%
Alt 7 F	$32,908,000	$789,590,000	($11,000)	-0.03%
Alt 7 H	$32,897,000	$789,334,000	($22,000)	-0.07%

4. SUMMARY CONCLUSIONS

As shown in Tables 6 through 8, only Alternatives 1C and 1B would be expected to provide positive net recreation effects compared to the without project condition at all three of the projects. The magnitude of effect, positive or negative, estimated for nearly all the alternatives does not exceed 0.5 percent; with the only exception being Alternative 7F at Lake Lanier, which was estimated to result in a negative recreation effect of -1.03 percent compared to the without project. If the estimated recreation effects for all three projects are combined for each alterative, the results show that Alternative 7C would also provide positive net effects compared to the without project, as shown in Table 10. Based on this analysis, Alternative 1C, 7C or 1B would all provide positive effects on recreation when looking at net effects across all three lakes.

Table 10. Combined Recreation Value Summary (All 3 Lakes)

	Annualized Recreation Value ($)	Present Value ($)	Annualized Change vs. Without Project	Percent Change
Without Project	$132,816,150	$3,186,777,520	$0	0.0%
Alt 1 B	$133,183,517	$3,195,592,095	$367,367	0.28%
Alt 1 C	$132,867,435	$3,188,008,035	$51,285	0.04%
Alt 7 A	$132,758,986	$3,185,405,934	($57,164)	-0.04%
Alt 7 C	$132,912,222	$3,189,082,653	$96,072	0.07%
Alt 7 D	$132,618,043	$3,182,024,164	($198,107)	-0.15%
Alt 7 E	$132,618,043	$3,182,024,164	($198,107)	-0.15%
Alt 7 F	$131,447,367	$3,153,935,074	($1,368,783)	-1.03%
Alt 7 H	$132,609,391	$3,181,816,570	($206,759)	-0.16%

5. REFERENCES

(USACE) U.S. Army Corps of Engineers. 15 October 2014. EGM 15-03 Unit Day Values for Recreation for Fiscal Year 2015. CECW-CP Memorandum for Planning Community of Practice. Retrieved online via http://planning.usace.army.mil/toolbox/library/EGMs/EGM15-03.pdf.

(USACE) U.S. Army Corps of Engineers. 15 October 2014. EGM 15-01 Federal Interest Rates for Corps of Engineers Project for Fiscal Year 2015. CECW-P Memorandum for Planning Community of Practice. Retrieved online via http://planning.usace.army.mil/toolbox/library/EGMs/EGM15-01.pdf.

Appendix N

USACE Institute for Water Resources
ACF Climate Change Support Analysis

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Scientific evidence from the immediately preceding decades demonstrates that the natural climate might be changing (Stocker et al. 2013[1]), and the changes are expected to continue over the course of the 21st century. The anticipated changes might reflect shifts in the average or baseline conditions, regional meteorological phenomena, and the range of variability of those phenomena. The potential changes are raising concerns about the capacity of U.S. Army Corps of Engineers (USACE) projects and operations to accommodate different climatological baselines, greater climatological variation, and a wider range of meteorological conditions.

In response to public interest and USACE guidance, the Apalachicola-Chattahoochee-Flint (ACF) River Basin Master Water Control Manual Update Project Delivery Team engaged the Institute for Water Resources (IWR) to develop a numerical modeling analysis that can be used to evaluate the resilience and limitations of proposed ACF water management scenarios in relation to climate change. The ACF numerical model was written to correlate with the Hydrologic Engineering Center-Reservoir System Simulation (HEC-ResSim) and System Water Quality Modeling (HEC-5Q) of the ACF system. The HEC-ResSim and HEC-5Q software was developed by the USACE Hydrologic Engineering Center (HEC) and is now the standard for USACE reservoir operations modeling. Allowing the model-projected unimpaired flow (UIF) to be run in HEC-ResSim and HEC-5Q would give a sense of the effects of prospective climate change on hydrology and water quality in the ACF Basin. (UIF is also used interchangeably with antecedent data in this summary.) The objective of the IWR effort was a quantitative analysis of potential climate change in ACF Basin hydrology and, by extension, ACF Basin management.

The effort capitalized on existing data and analysis developed by a coalition of agencies and academic institutes as part of the Coupled Model Intercomparison Project phase 5 (CMIP5). In broad terms, an atmospheric general circulation model (GCM) numerically representing the physical processes (e.g., atmospheric, ocean, land surface) was employed to estimate the potential range of climate change due to man-made influences. The GCM outputs were statistically scaled to a finer time and space scale, and bias-corrected to describe anticipated conditions in the ACF Basin. The scaled and bias-corrected GCM outputs were applied to a variable infiltration capacity (VIC) model to predict rainfall-runoff relationships for the basin (Liang et al. 1994[2]). The Liang VIC model is a globally applied, open-source, macroscale hydrologic model that solves full water-energy balances (Liang et al. 1994). VIC model output for future climate model projections has been calculated for the contiguous U.S. and is available

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[1] Stocker, T.F., D. Qin, G.-K. Plattner, L.V. Alexander, S.K. Allen, N.L. Bindoff, F.-M. Bréon, J.A. Church, U. Cubasch, S. Emori, P. Forster, P. Friedlingstein, N. Gillett, J.M. Gregory, D.L. Hartmann, E. Jansen, B. Kirtman, R. Knutti, K. Krishna Kumar, P. Lemke, J. Marotzke, V. Masson-Delmotte, G.A. Meehl, I.I. Mokhov, S. Piao, V. Ramaswamy, D. Randall, M. Rhein, M. Rojas, C. Sabine, D. Shindell, L.D. Talley, D.G. Vaughan, and S.-P. Xie, 2013: Technical summary. In Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. T.F. Stocker, D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Doschung, A. Nauels, Y. Xia, V. Bex, and P.M. Midgley, Eds. Cambridge University Press, 33-115, doi:10.1017/CBO9781107415324.005.

[2] Liang, X., Lettenmaier, D.P., Wood, E.F., Burges, S.J. (1994). *A simple hydrologically based model of land surface water and energy fluxes for general circulation models*. Journal of Geophysical Research, Volume 99, No. D7, Pages 14,415-428.) retrieved from http://www.hydro.washington.edu/Lettenmaier/Models/VIC/index.shtml

at http://gdo-dcp.ucllnl.org/downscaled_cmip_projections/. It should be noted that these models have not been certified in accordance with USACE model certification guidance.

The U.S. Geological Survey (USGS) has classified watershed drainage areas using a hierarchical system in which each contiguous drainage area is assigned a hydrologic unit code (HUC). The first two levels of the hierarchy identify the region (HUC 2) and subregion (HUC 4). The U.S. contains 222 HUC 4s with an average size of 16,800 mi^2. To detail the ACF numerical model, the hydrological features of the HUC 4 for the ACF Basin were employed as the UIF. The VIC model, building from the UIF, generated local and cumulative flow projections of the ACF HUC 4.

The CMIP5 global carbon projects evaluated a number of different representative concentration pathways (RCPs) that describe different trajectories of greenhouse gas emissions (i.e., carbon dioxide, methane, nitrous oxide, and fluorocarbons). For the ACF Basin, the range of hydrologic responses produced from different GCMs is larger than the difference among RCPs; therefore, the decision was made not to select specific RCPs but rather to treat them all as equally plausible for this analysis.

The full set of 100 available ACF Basin HUC 4 hydrologic projections was tabulated for two future time periods: Years 2021–2050 and years 2061–2090. An empirical cumulative distribution function (ECDF) was developed for both sets of hydrologic projections (i.e., 2021–2050 and 2061–2090). The purpose of the ECDF is to support an estimate of the frequency and degree of climate change occurrences throughout the period of analysis.

With regard to ACF Basin analysis, the ECDF approximates potential changes in volume of runoff from in the basin. The approximations are used to develop monthly volumes that can be compared to the ACF Basin UIF antecedent flow set (1970–1999). ECDF change ratios were created by dividing the 30-year hydrologic projections (2021–2050 and 2061–2090) by the antecedent UIF for 1970–1999 to establish a ratio for each HUC 4 data point.

The ECDF-generated ratio values were plotted against three quantiles representing basin hydrologic conditions (10th percentile [wet], 50th percentile [median], and 90th percentile [dry]) (see Figure 1). These values were further subdivided to create plots that represented each quantile by month for both the 2021–2050 and the 2061–2090 hydrologic projections.

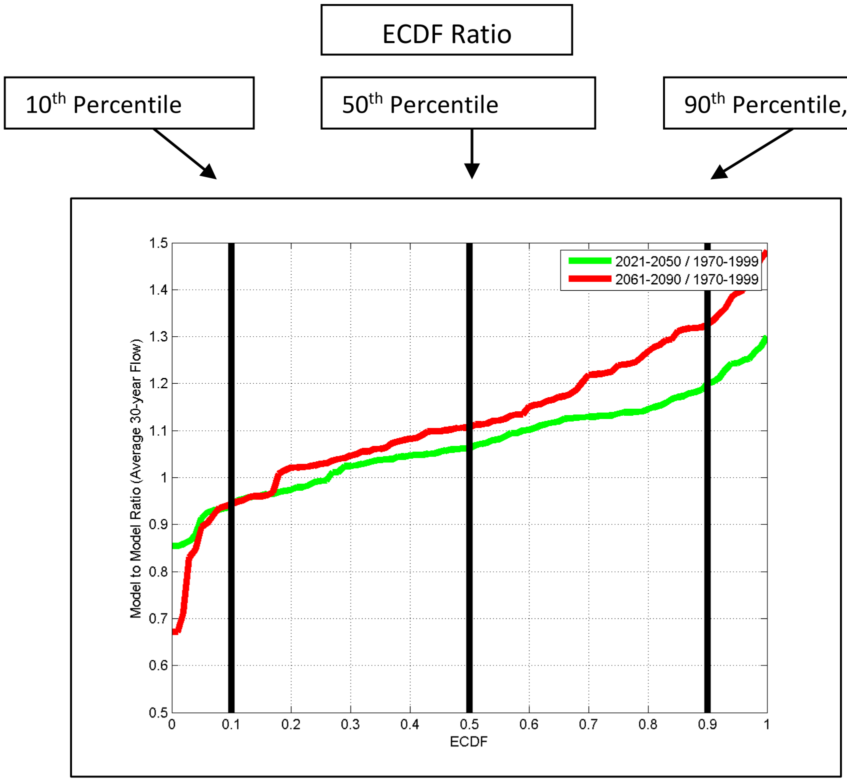


Figure 1. ECDF-generated model to model ratio for two time periods

The UIF antecedent data set was averaged by month, then the monthly average flows were mapped to the appropriate quantile plot. This process yielded a series of plots that represented the future hydrologic ECDF ratios and the antecedent UIF ECDF for each month in each quantile, resulting in a visual representation of the same drainage location in the same month (see Figure 2 for an example of the 10th percentile [Quartile 1] dry projection for 2021–2050 [Time Period 1]). The projected future ECDF HUC 4 data point was divided by the newly positioned antecedent ECDF data point to yield a new ratio. The new ratio was applied to the antecedent UIF to produce a new UIF that reflects climate change conditions.

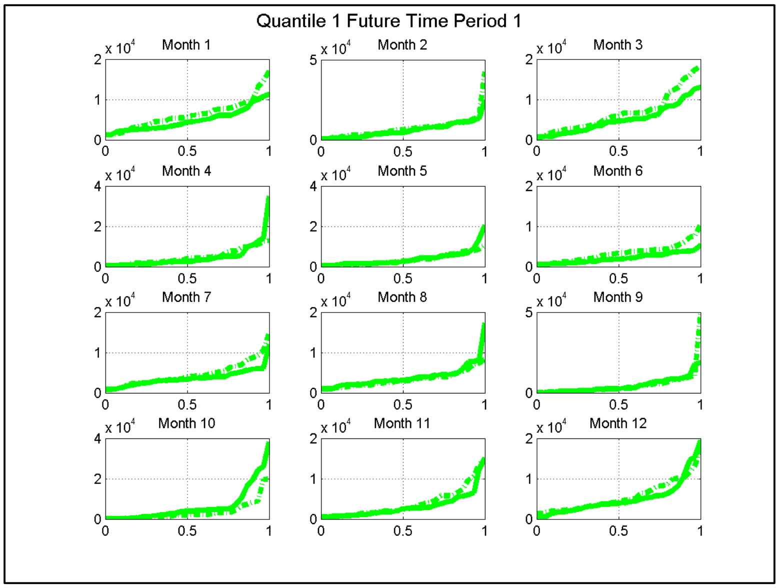


Figure 2. Example of the 10th Percentile (Quartile 1) Dry Projection for 2021–2050 (Time Period 1)

To ensure compatibility with the HEC-ResSim and HEC-5Q models, it was necessary to convert the climate change-affected UIF monthly values produced to a daily time step. A monthly ratio was applied to the UIF daily value for each month. The process output was a climate change-adjusted UIF adapted to a daily time step that can be used in the HEC-ResSim model to speculate how climate change might affect the ACF Basin. This climate change-affected UIF was run in the ACF HEC-ResSim model to generate outputs that approximate the effects of ACF water management scenarios under the climate change-influenced hydrology.

Details of this process are provided in *Apalachicola-Chattahoochee-Flint Climate Change Support Analysis*, performed by USACE Institute for Water Resources, and authored by Dr. David Raff, PhD, P.E., D.WRE, and Dr. Jeff Arnold, PhD.

For the purposes of the ACF Master Water Control Manual Update climate change analysis, only the climate change-affected UIF for 2021–2050 was carried forward. Years 2021–2050 most closely match the anticipated project lifespan used in the National Environmental Policy Act documentation and in the water supply storage assessment analyses. The climate change-affected UIF was used in the ACF HEC-ResSim model to craft a hydrologic range that might occur if climate change trends continue.

This analysis generally assesses the capacity of the operations described as the Proposed Action Alternative (PAA)—or Alt7H—to meet the congressionally authorized purposes of the ACF system of federal reservoirs under climate change-adjusted conditions. The analysis, using water quality as an analytic proxy, also makes a general appraisal of impacts to biological resources.

The PAA and No Action Alternative (NAA) were plotted against the climate change-adjusted UIF to ascertain if operational scenarios could be supported by the projected future hydrology. The plots indicated that the climate change-adjusted flows are sufficient to support current water management activities as well as water management activities described in the PAA, illustrating that either operational scenario would be achievable given the ACF system's climate-adjusted flows.

The plotting analysis brought to light no noteworthy deviations between the baseline (i.e., the NAA) and the PAA (see Figure 3 through Figure 16). This finding implies that the effects of operating under the PAA are essentially the same as those resulting from operating under the NAA. Both scenarios are sufficiently resilient to effectively management the federal projects for congressionally authorized purposes under the climate change-affected UIFs.

The climate-adjusted UIF follows the same seasonal trends as the present-day UIF. However, the climate change-adjusted UIF high and low boundaries show greater extremes. Comparing the climate change-adjusted high and low extremes to the period of record identify no conditions that were consistently more severe than those that have been historically experienced in the ACF Basin.

HEC-5Q water quality model outputs were developed to provide a general sense of environmental impacts when the PAA was run under climate change-affected conditions. The dry (90th percentile) scenarios yielded ACF flows similar to actual flows experienced in 2001–2011. This result implies that more water could be in the ACF system under climate change conditions.

Concentrations of water quality constituents in the PAA and those projected to occur in 2050 are similar; median concentrations during wet years are generally less. Figure 17 through Figure 25 illustrate this finding for various water quality parameters. The ranges are reasonable for the parameters considered. The chlorophyll *a* range is also reasonable, but can be expected to be a function of nutrient loads in the ACF system.

The climate change-adjusted water quality scenario displayed increased water temperature throughout the length of the ACF Basin. The systemwide consistency of the increased temperatures implies that it is the function of a systemic condition that is outside the influence of the NAA or PAA. For the purposes of modeling and analysis of the model outputs, it was assumed that the increased water temperature was attributable to the increased air temperature projected in the climate change model.

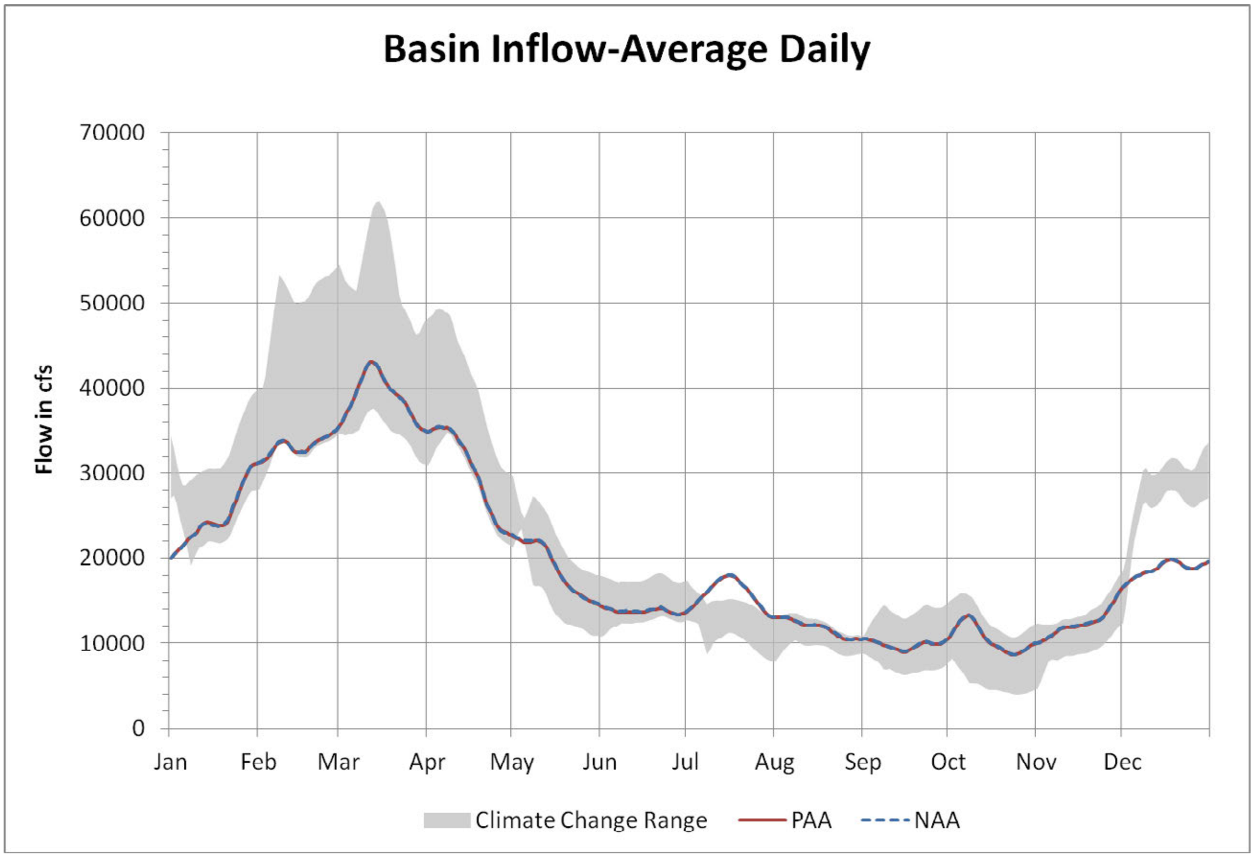


Figure 3. Comparison of Daily Average Basin Inflow between the NAA, PAA and Range of Climate Change

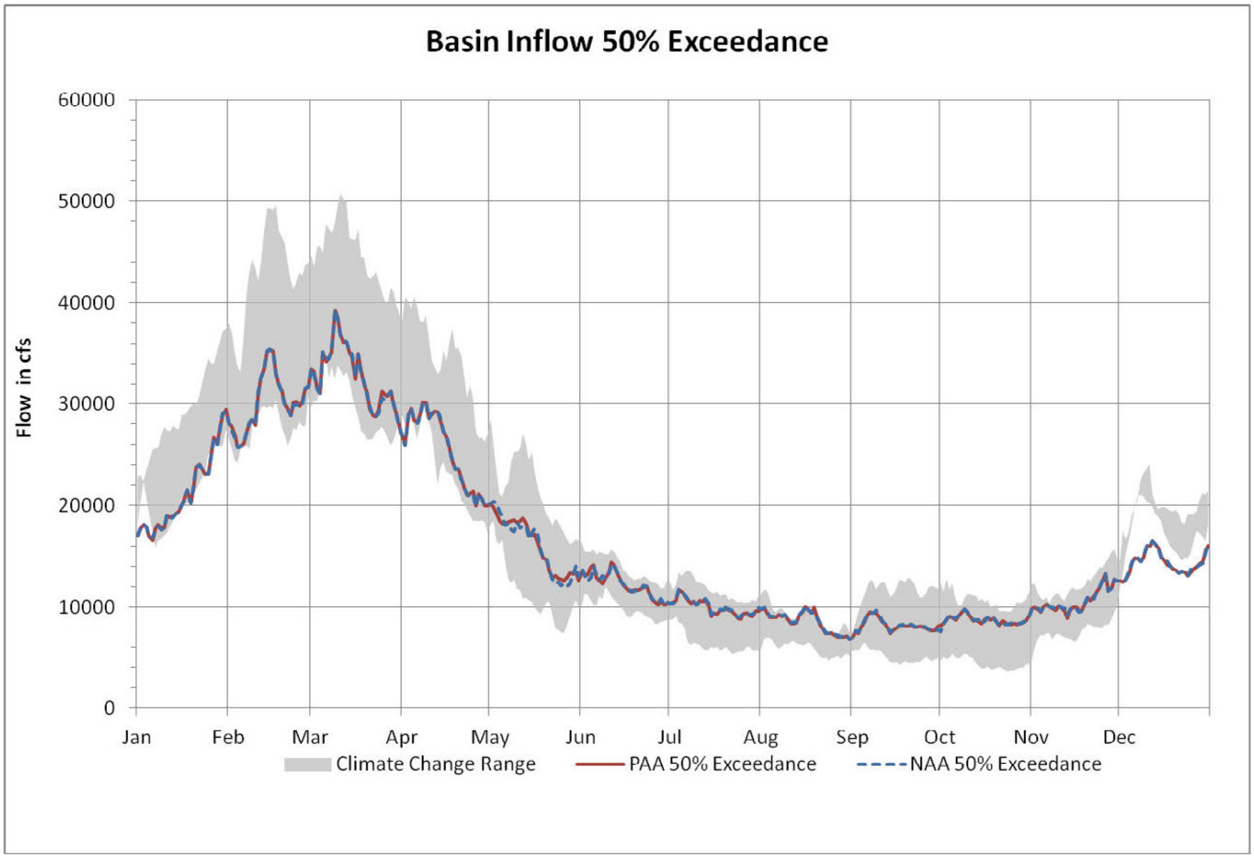


Figure 4. Comparison of Basin Inflow Median Exceedance between the NAA, PAA and Range of Climate Change

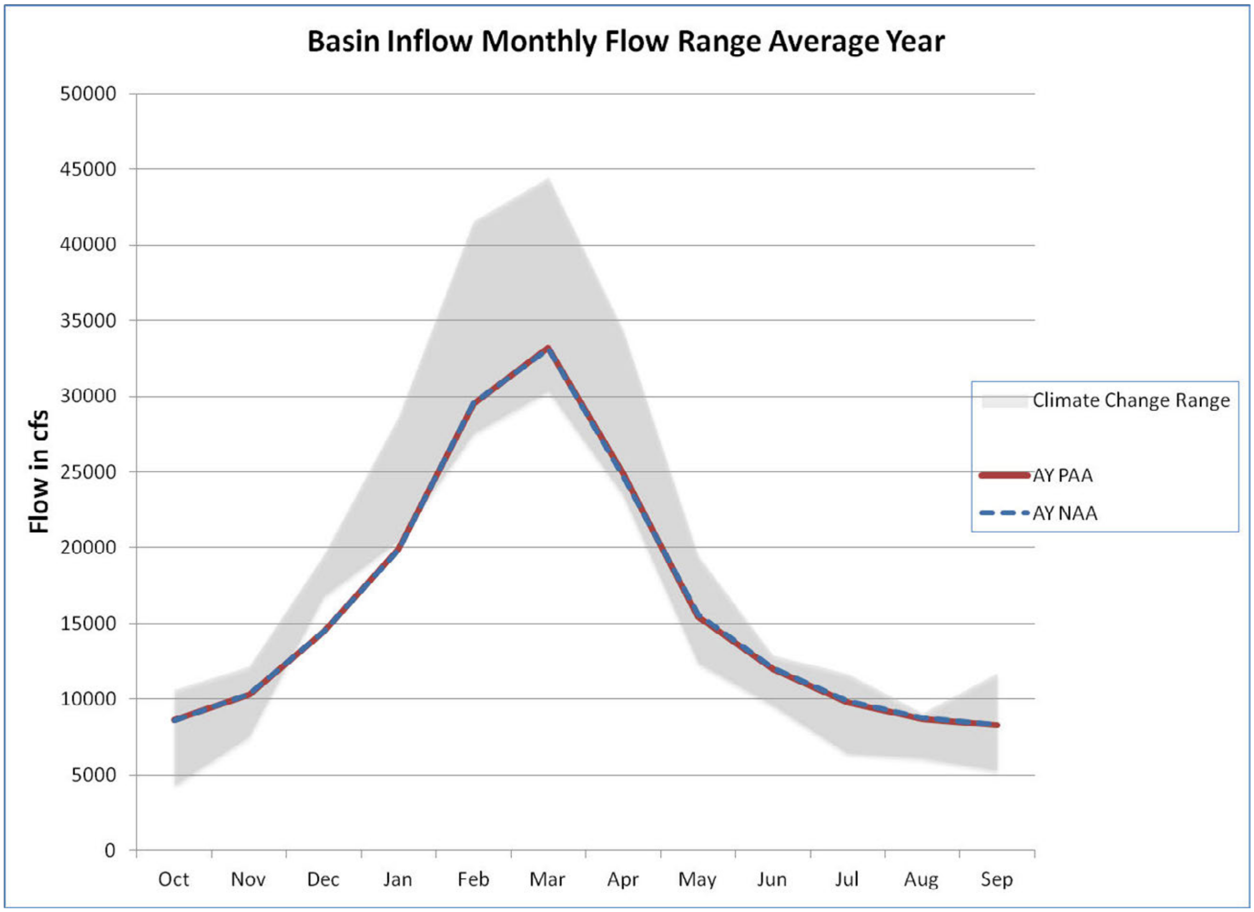


Figure 5. Comparison of Monthly Basin Inflow in an Average Year between the NAA, PAA and Range of Climate Change

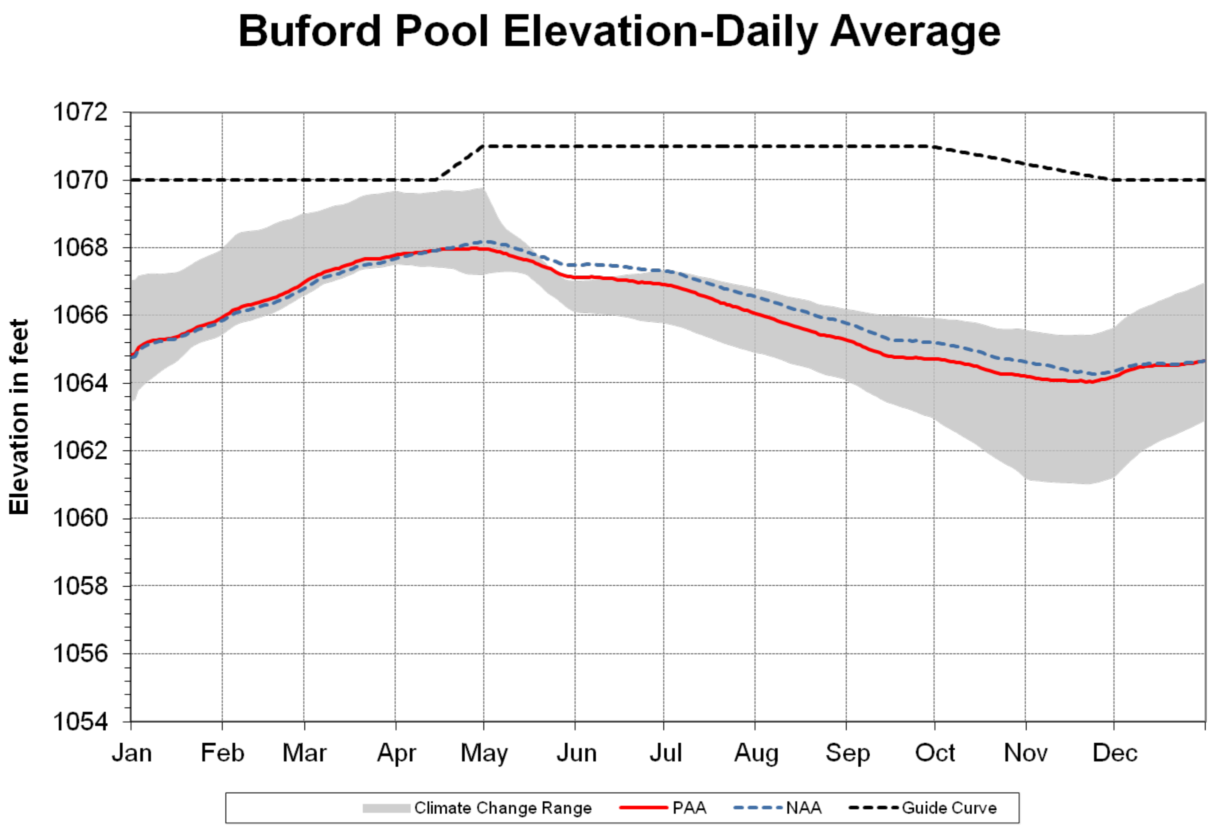


Figure 6. Comparison of Daily Average Buford Pool Elevation between the NAA, PAA and Range of Climate Change

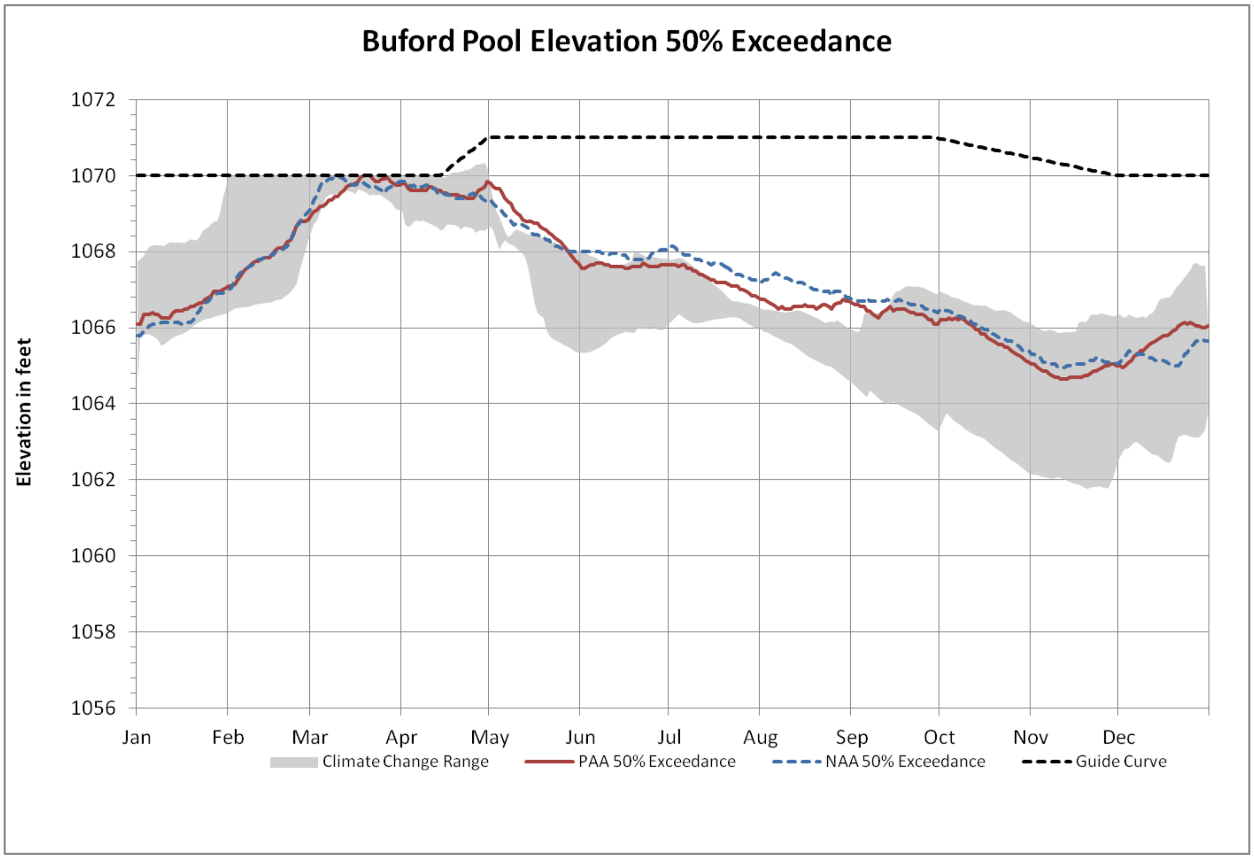


Figure 7. Comparison of Median Exceedance of Buford Pool Elevation between the NAA, PAA and Range of Climate Change

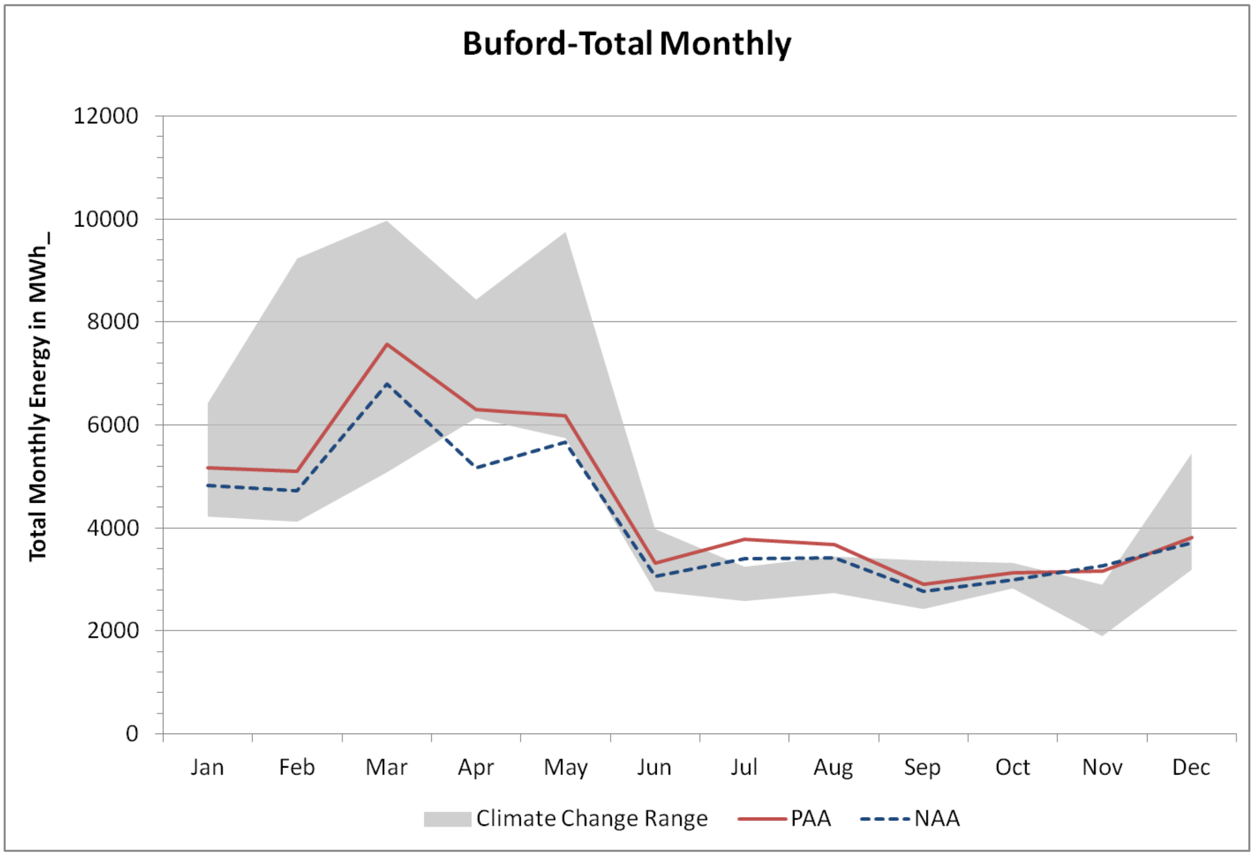


Figure 8. Comparison of Total Monthly Energy Generated in Megawatt Hours from the Buford Pool between the NAA, PAA and Range of Climate Change

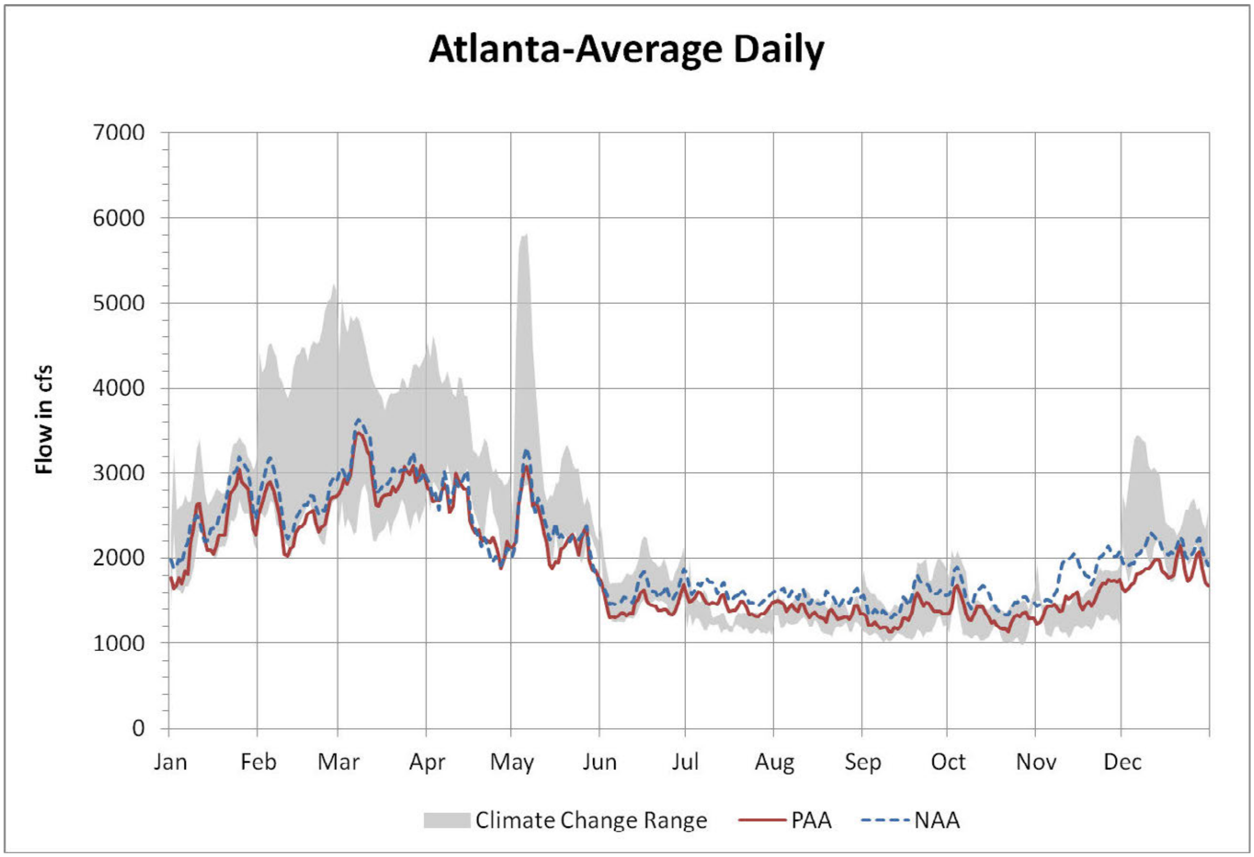


Figure 9. Comparison of Daily Average Flow between the NAA, PAA and Range of Climate Change in Atlanta, Georgia

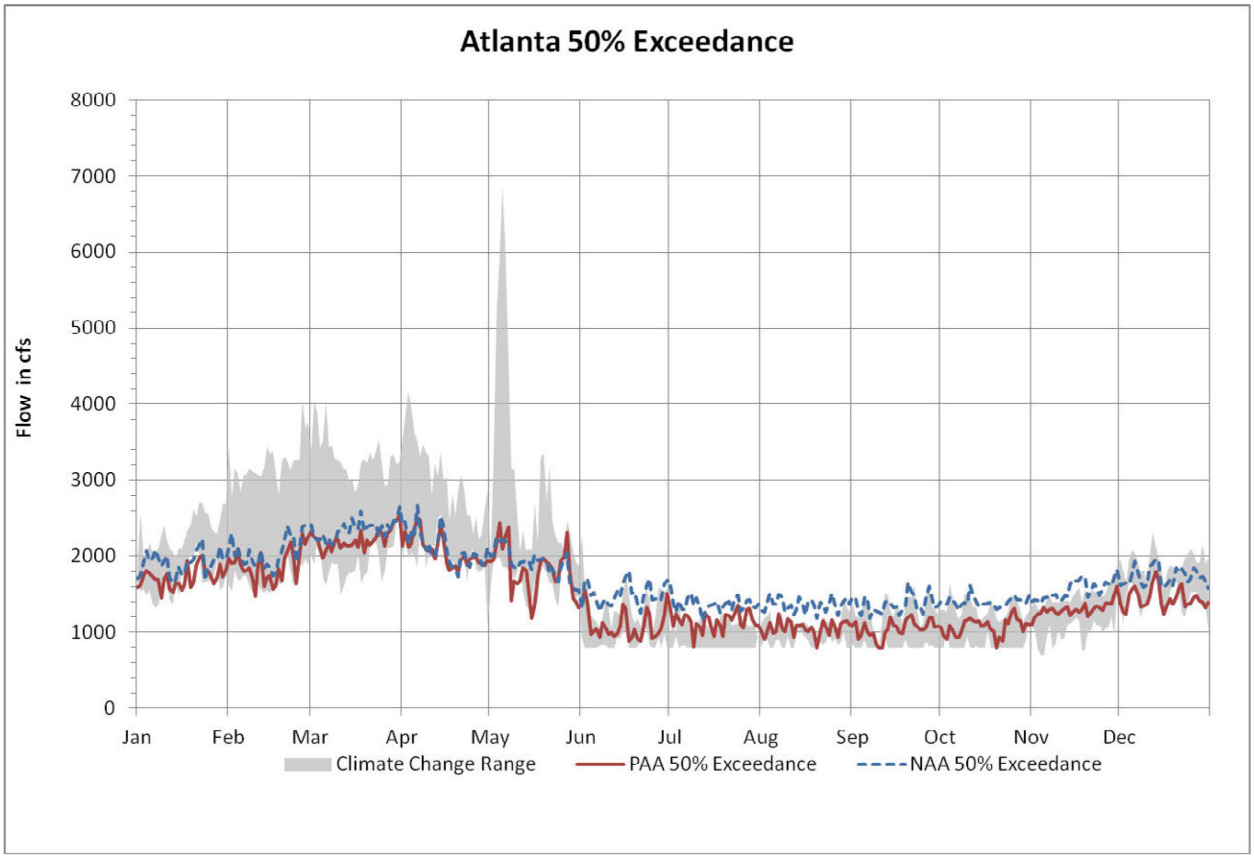


Figure 10. Comparison of the Median Exceedance of Flow between the NAA, PAA and Range of Climate Change in Atlanta, Georgia

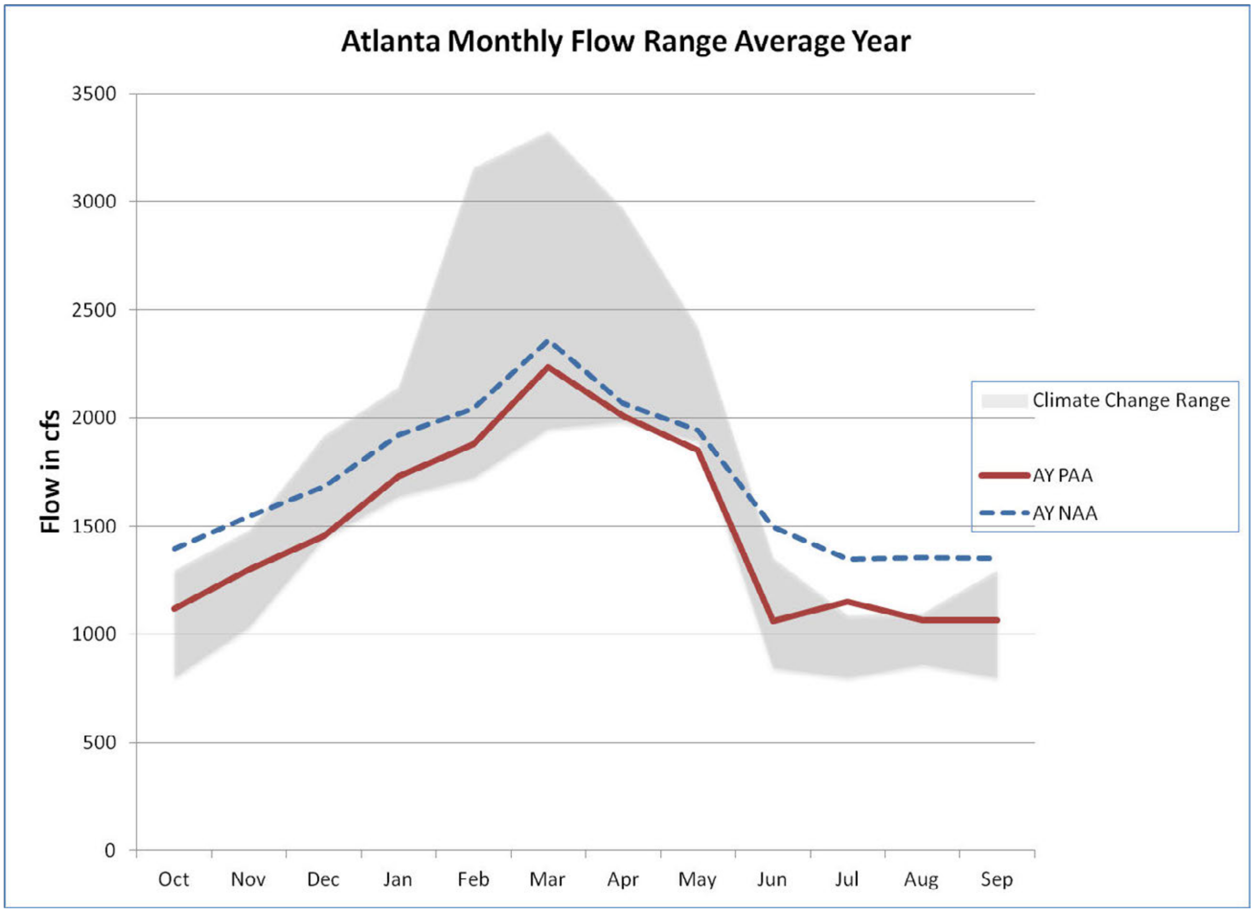


Figure 11. Comparison of Monthly Flow in Atlanta, Georgia in an Average Year between the NAA, PAA and Range of Climate Change

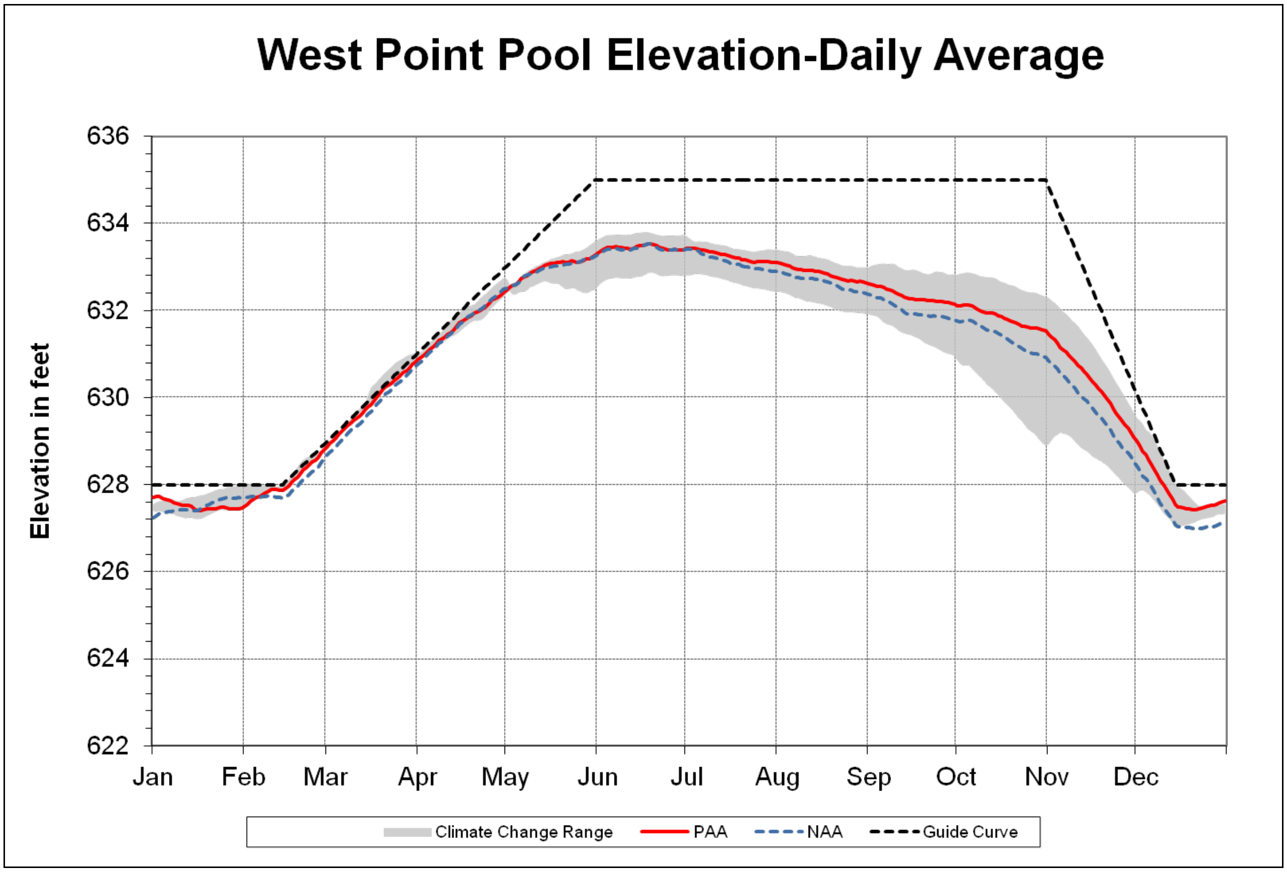


Figure 12. Comparison of Daily Average West Point Pool Elevation between the NAA, PAA and Range of Climate Change

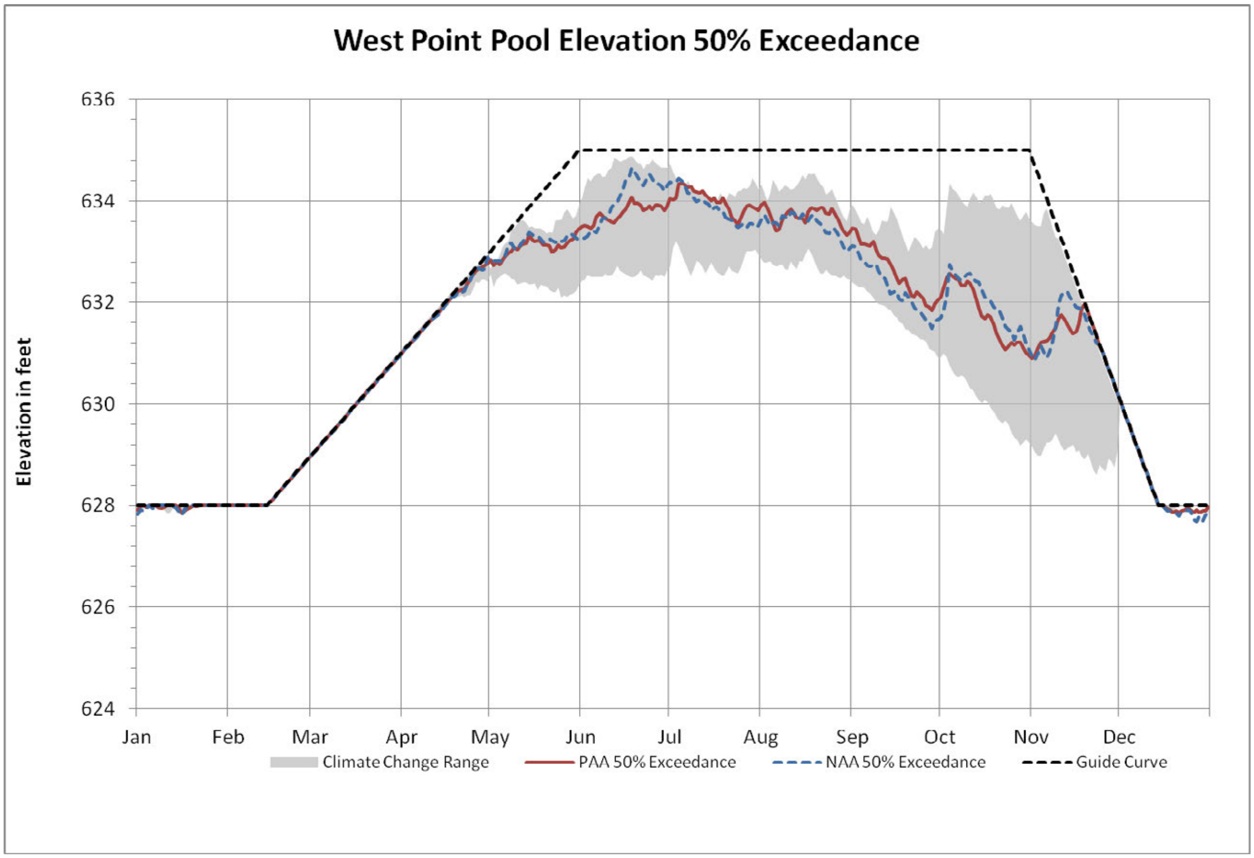


Figure 13. Comparison of Median Exceedance of West Point Pool Elevation between the NAA, PAA and Range of Climate Change

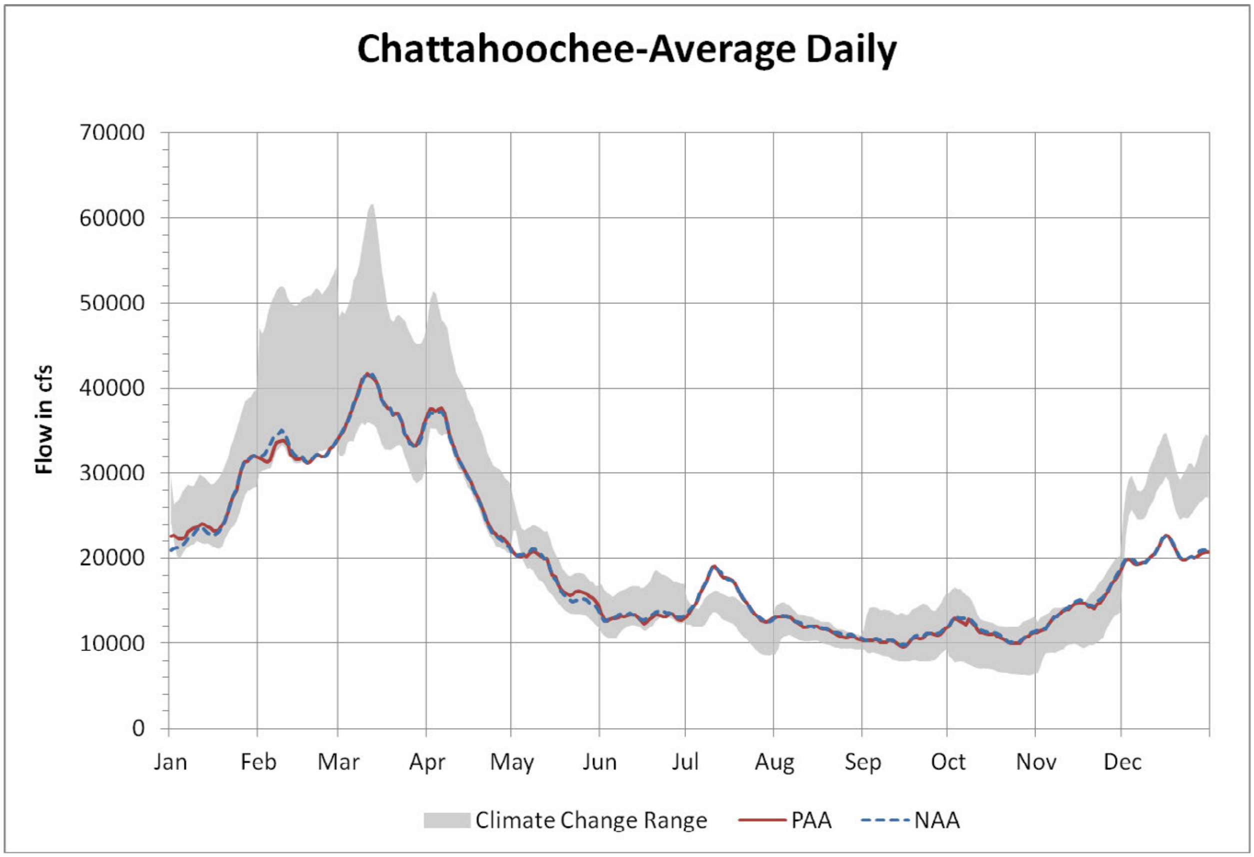


Figure 14. Comparison of Daily Average Flow between the NAA, PAA and Range of Climate Change in Chattahoochee, Florida

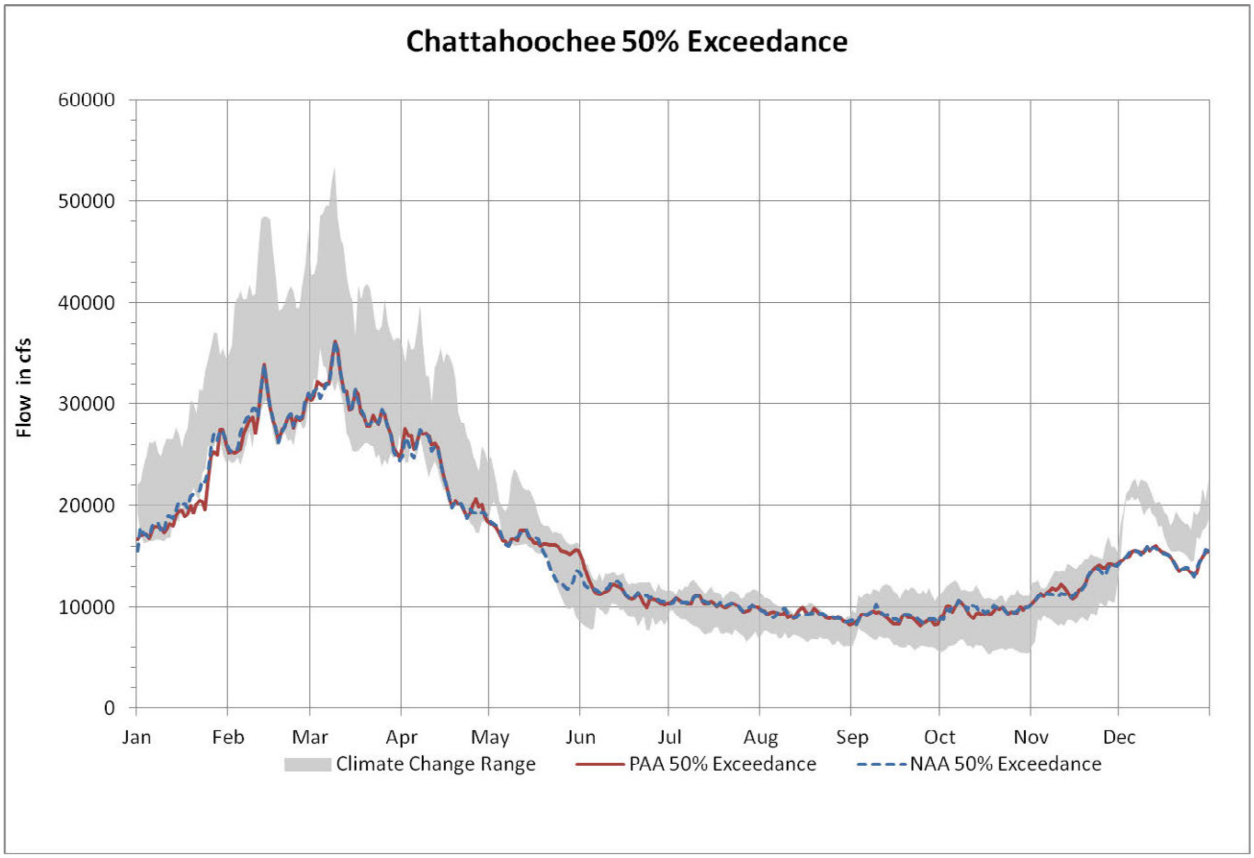


Figure 15. Comparison of the Median Exceedance of Flow between the NAA, PAA and Range of Climate Change in Chattahoochee, Florida

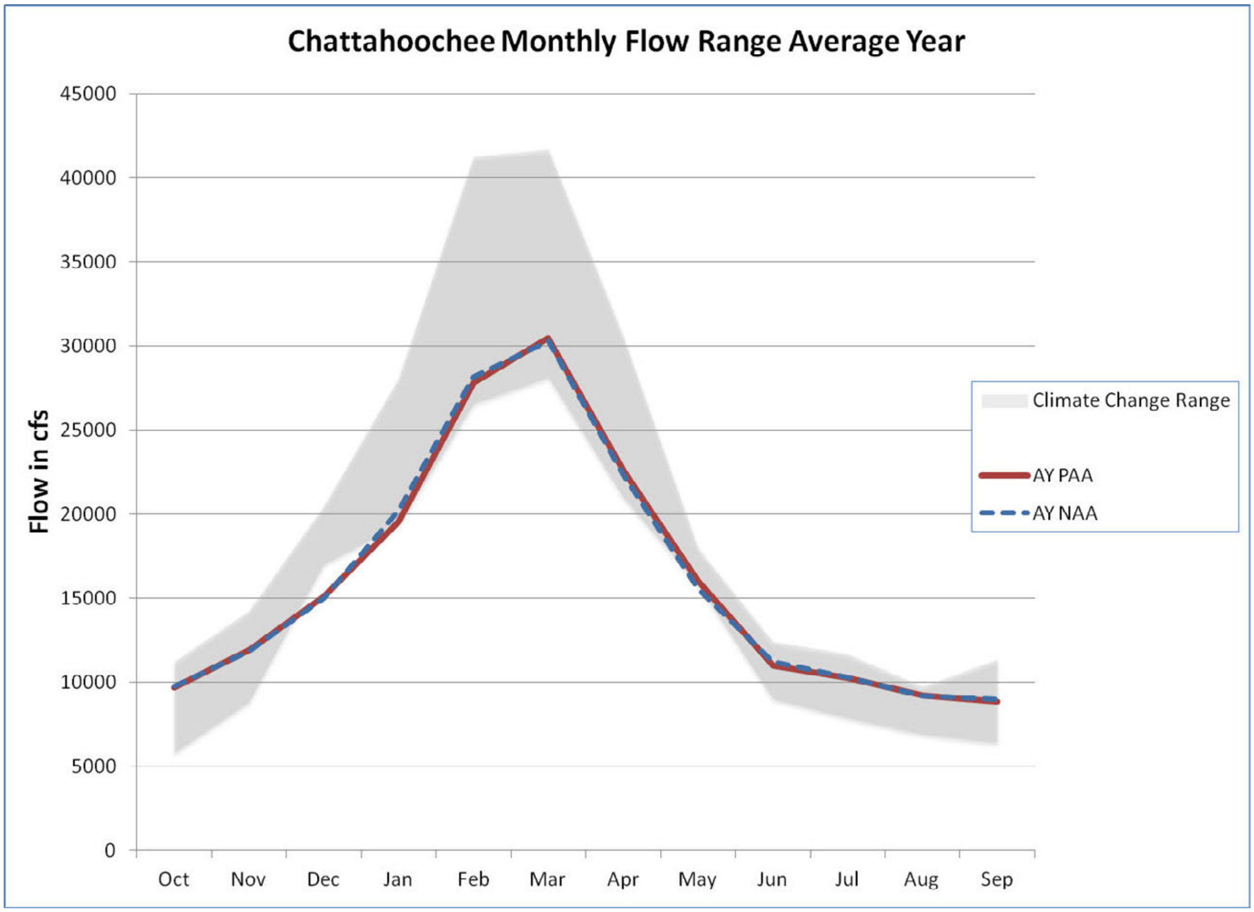


Figure 16. Comparison of Monthly Flow in Chattahoochee, Florida in an Average Year between the NAA, PAA and Range of Climate Change

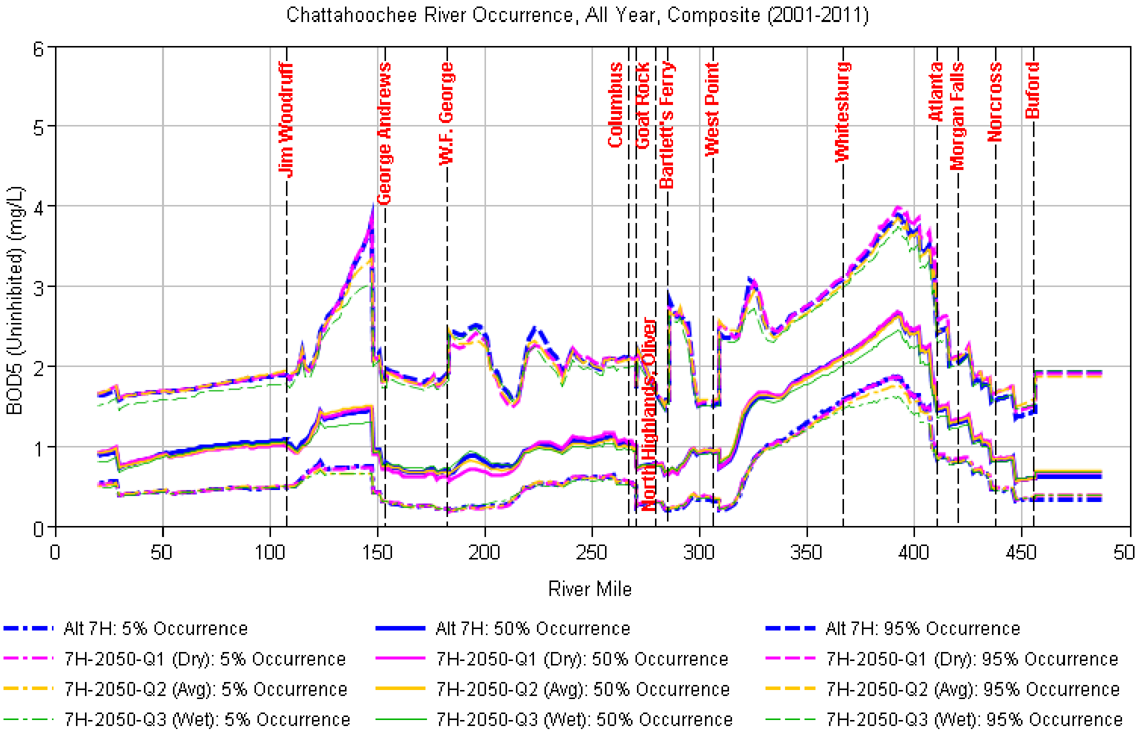


Figure 17. Longitudinal Profile of Modeled BOD5 in ACF Basin for 2001–2011 for PAA (Alt7H) and Three Climate Scenarios

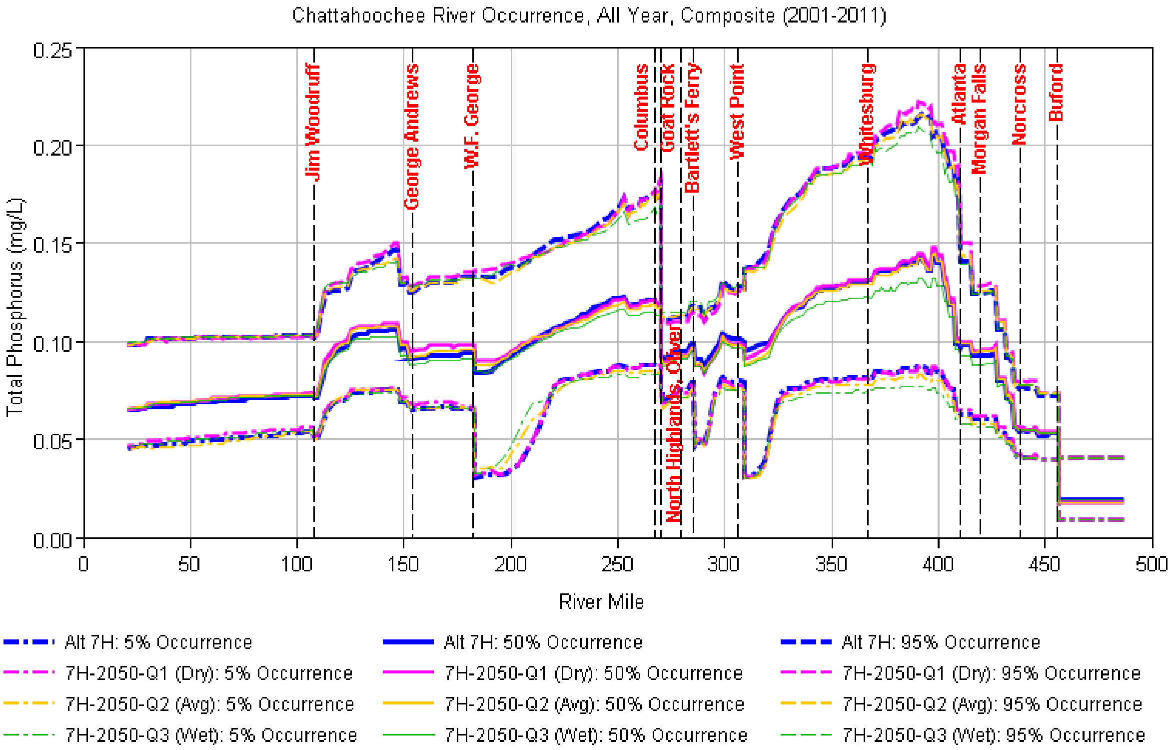


Figure 18. Longitudinal Profile of Modeled Total Phosphorus in ACF Basin for 2001–2011 for PAA (Alt7H) and Three Climate Scenarios

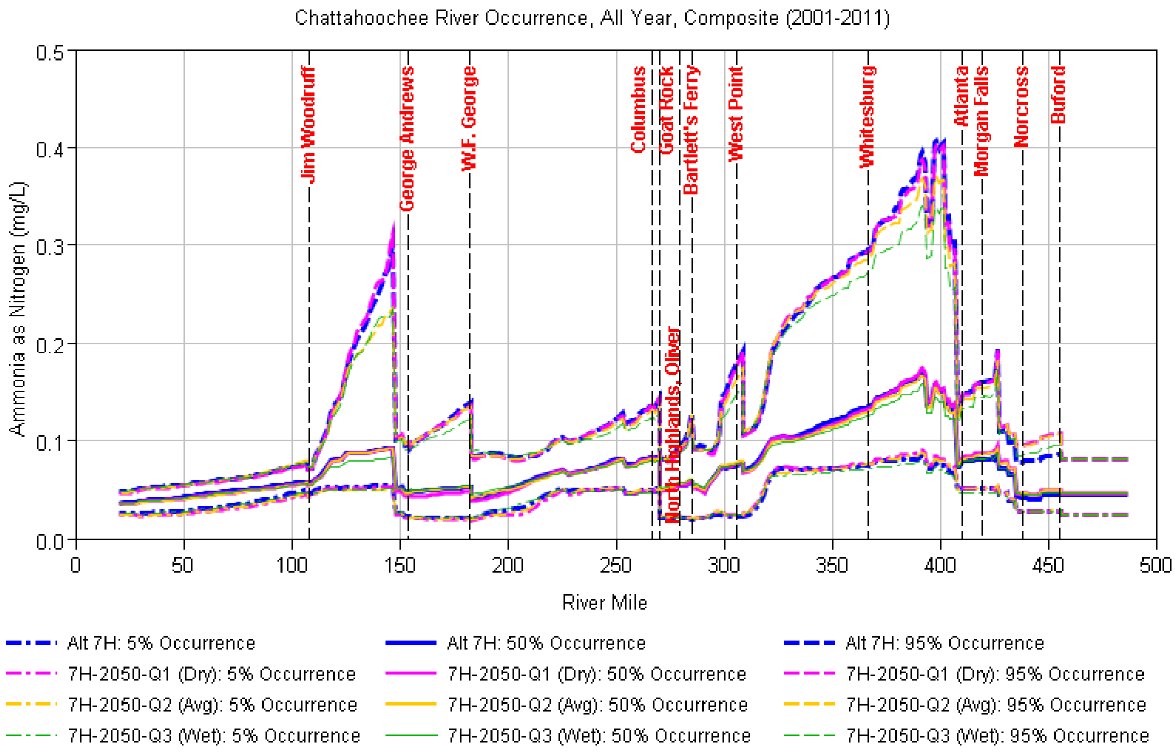


Figure 19. Longitudinal Profile of Modeled Ammonia in ACF Basin for 2001–2011 for PAA (Alt7H) and Three Climate Scenarios

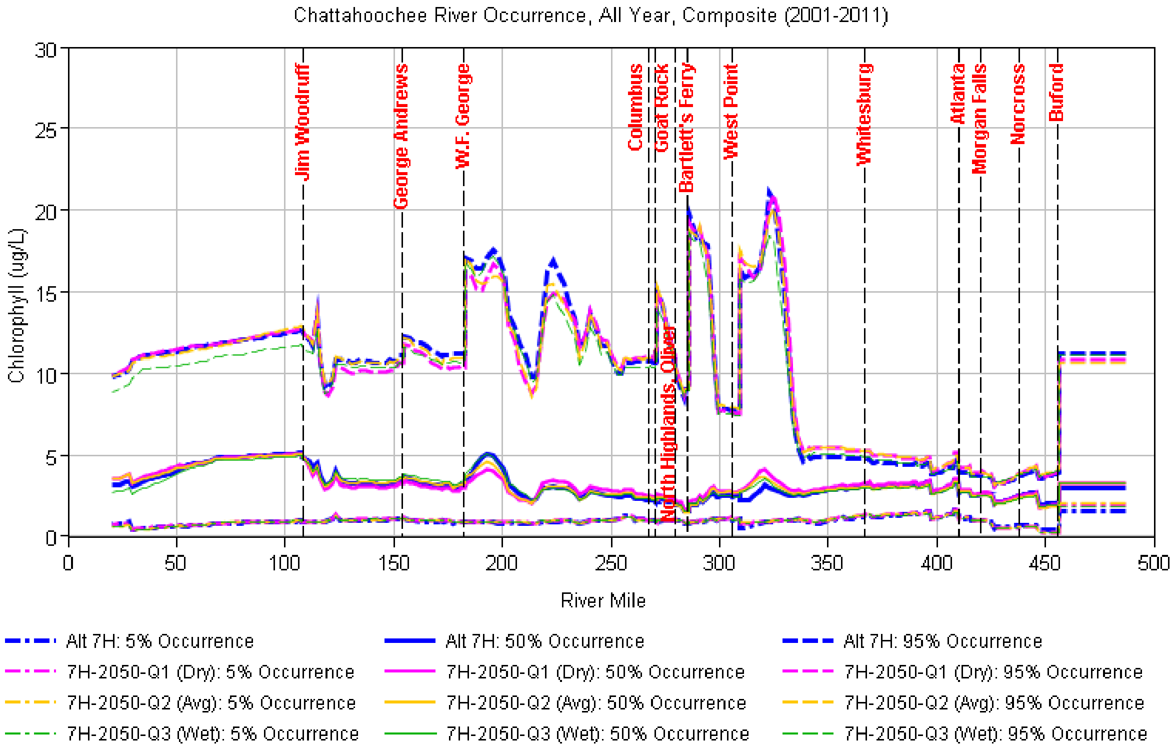


Figure 20. Longitudinal Profile of Modeled Chlorophyll in ACF Basin for 2001–2011 for PAA (Alt7H) and Three Climate Scenarios

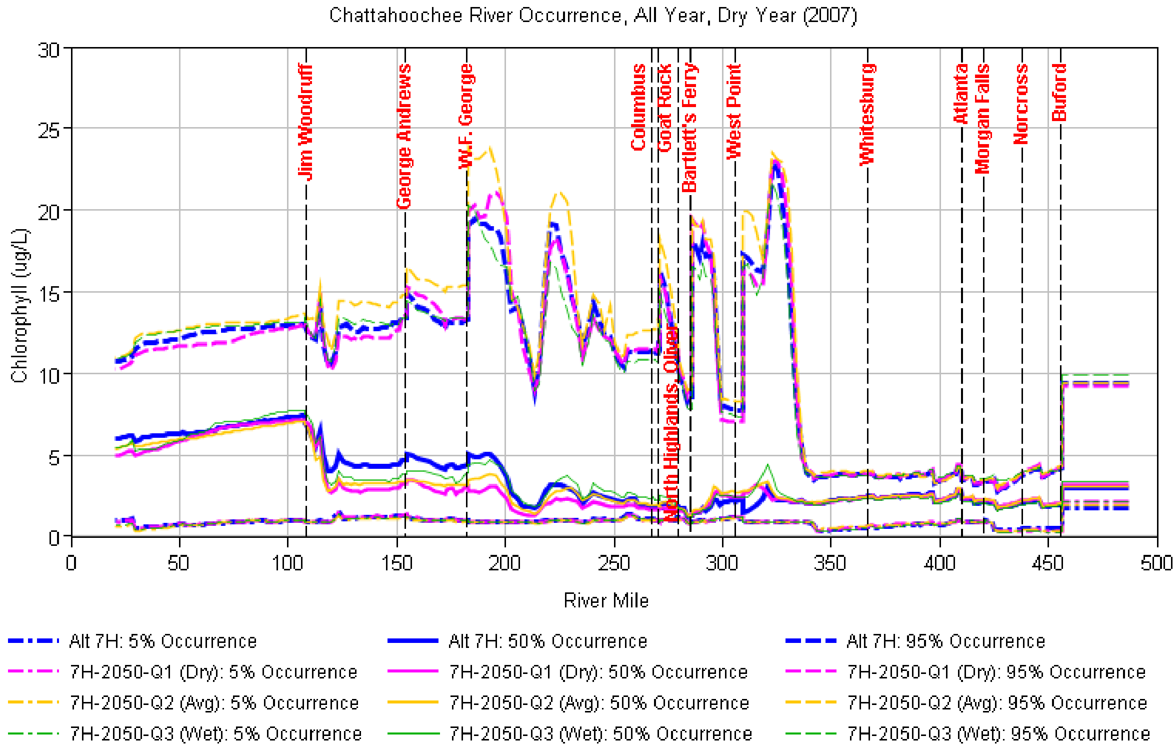


Figure 21. Longitudinal Profile of Modeled Chlorophyll in ACF Basin for Representative Dry Period (2007) for PAA (Alt7H) and Three Climate Scenarios

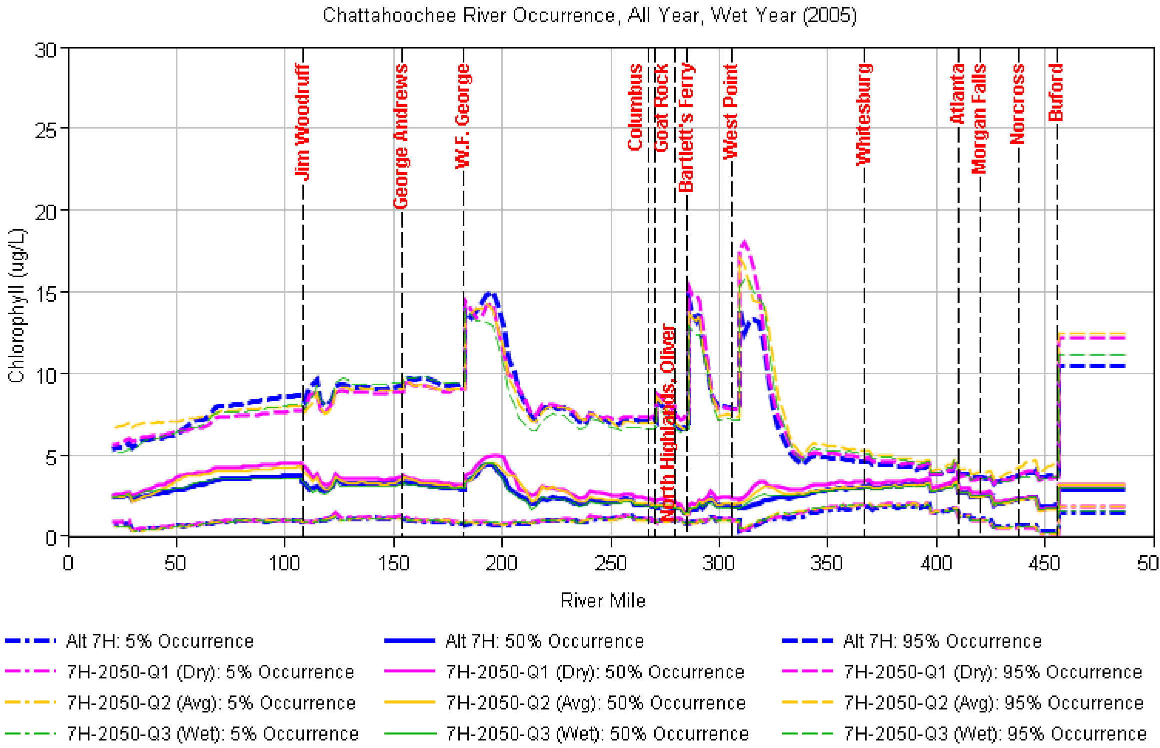


Figure 22. Longitudinal Profile of Modeled Chlorophyll in ACF Basin for Representative Wet Period (2005) for PAA (Alt7H) and Three Climate Scenarios

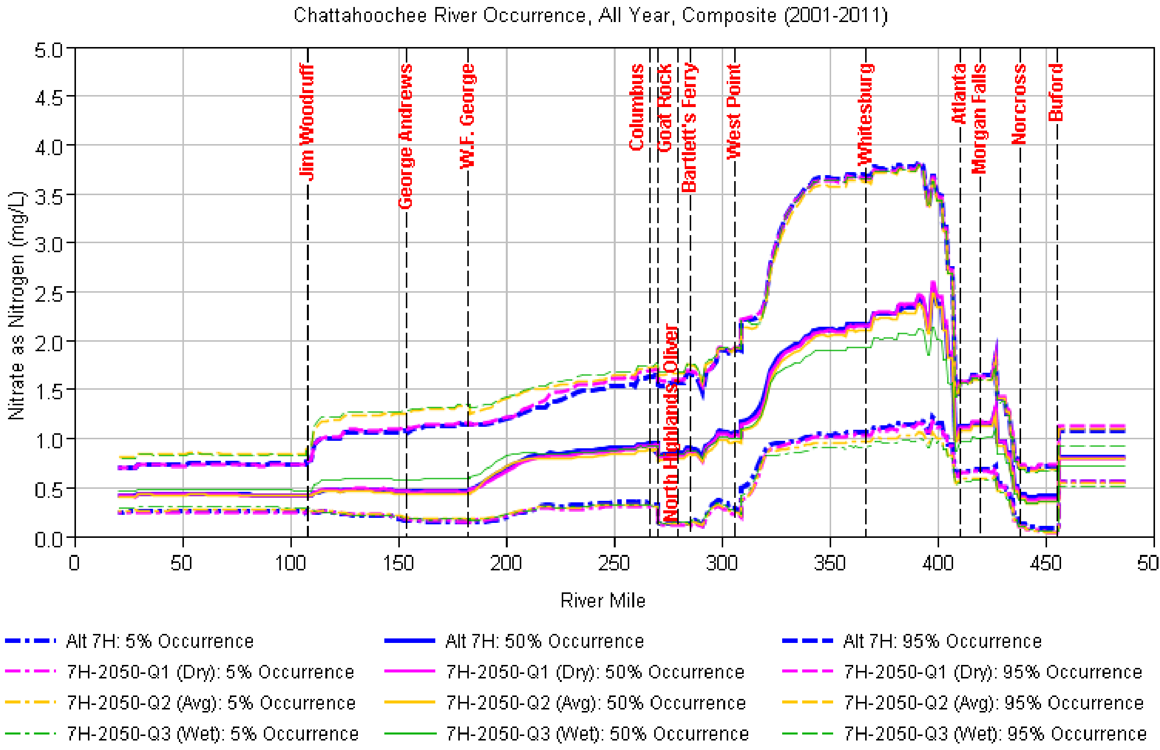
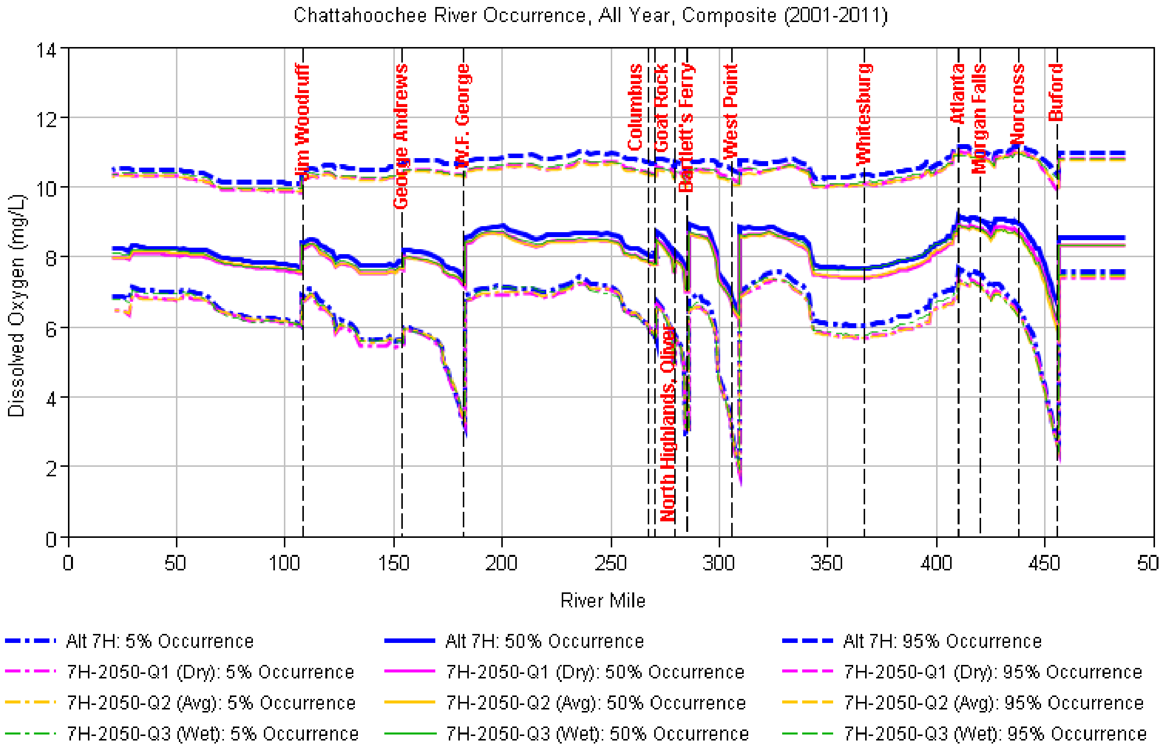


Figure 23. Longitudinal Profile of Modeled Nitrate as Nitrogen in ACF Basin for 2001–2011 for PAA (Alt7H) and Three Climate Scenarios

1



2

3 Figure 24. Longitudinal Profile of Modeled Dissolved Oxygen in ACF Basin for 2001–2011 for PAA (Alt7H)
4 and Three Climate Scenarios

5

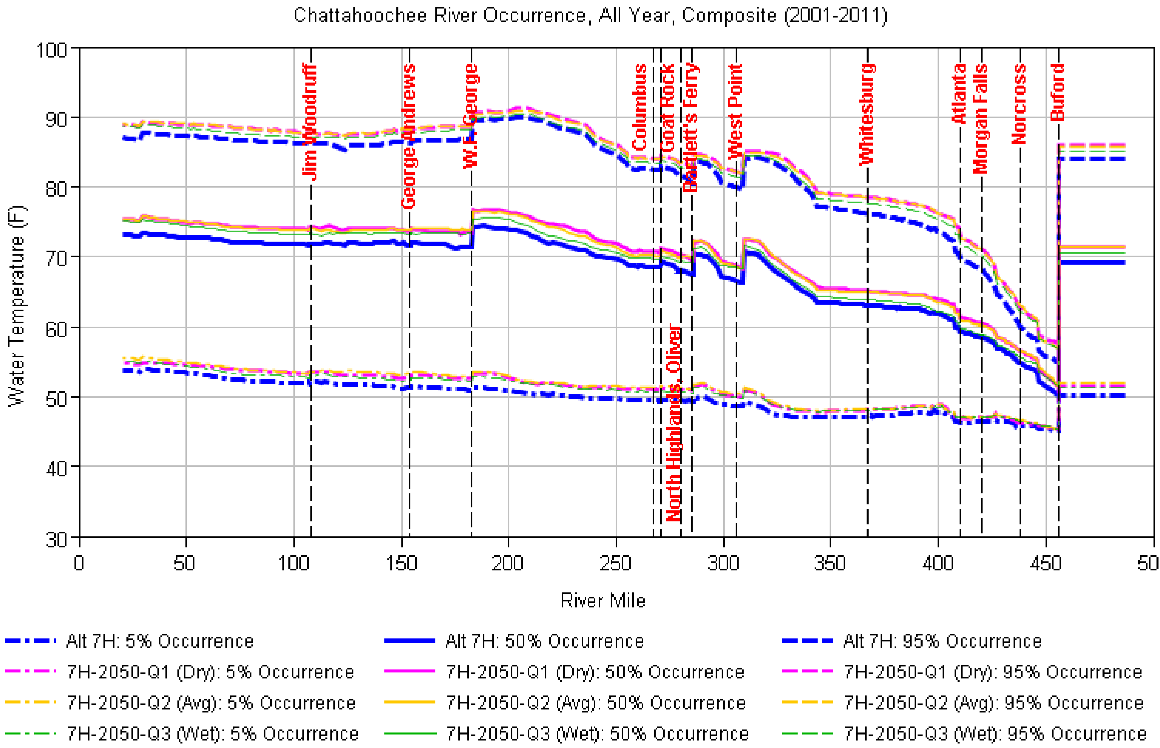


Figure 25. Longitudinal Profile of Modeled Water Temperature in ACF Basin for 2001–2011 for PAA (Alt7H) and Three Climate Scenarios

Apalachicola-Chattahoochee-Flint Climate Change Support Analysis

Performed by USACE Institute for Water Resources
POC: David Raff, PhD, PE, D.WRE (david.raff@usace.army.mil)
Jeff Arnold, PhD (jeffrey.r.arnold@usace.army.mil)

Introduction: USACE SAM is currently in the process of producing an environmental impact statement (EIS) for the Apalachicola-Chattahoochee-Flint (ACF) watershed and is interested in including the potential impacts from climate change within that EIS. There is currently an expectation both within USACE as well as with stakeholders in the watershed that climate change be considered within the development of project alternatives and ultimately decision making processes.

Dr. David Raff (IWR) briefed SAD in October 2013 on upcoming climate change inland hydrology guidance intended to go beyond current expectations for considering climate change but which describes the requirements of inclusion of climate change within USACE inland hydrology projects and studies. After this briefing Beverley Stout (SAM) contacted David to discuss possibilities for supporting the ACF EIS. Dr. Jeff Arnold (IWR) joined a series of ACF working team meetings to discuss various approaches ranging from a strictly qualitative presentation of climate change information to a quantitative analysis of climate change impacts on hydrology and operations within the basin. All types of approaches are consistent with the qualitative approaches to be required by the forthcoming USACE climate change guidance. Following these discussions, SAM would like to proceed with a numerical modeling assessment of firm yield impacts due to climate change that can be included within the EIS. A scope of work – attached here as Appendix A - for USACE IWR support was developed and approved in December 2013 that outlines the climate change analysis steps that can support the firm yield impacts desired by SAM.

The form of this project report follows the order of tasks in that scope of work. The individual tasks represented by the scope have been accomplished and climate change hydrologic projections have been transmitted to SAM.

The analysis includes a set of readily available hydrologic projection data developed by USACE in cooperation with the National Center for Atmospheric Research (NCAR) as well as utilizing and leveraging cooperative analysis performed with the Department of Interior Bureau of Reclamation and US Geological Survey, Lawrence Livermore National Laboratory, Santa Clara University, Climate Central, and Scripps Institution of Oceanography. The hydrologic projections utilize numerical model outputs from the Coupled Model Intercomparison Project, phase 5 (CMIP5) (Taylor et al. 2011) organized by the World Meteorological Organization. Model outputs from CMIP5 are used in very many climate change applications including in support of the Intergovernmental Panel on Climate Change's (IPCC) Fifth Assessment Report (AR5). This represents the latest generation of General Circulation Models (GCMs) used to create projections of climate change due to anthropogenic forcings. For CMIP5, the experimental design utilized four projections of anthropogenic atmospheric forcings called representative concentration pathways (RCPs) which are identified by their 2100 radiative forcings from 2.6, 4.5, 6.0, and 8.5 W/m^2, respectively (van Vuuren et al. 2011). For this work on the ACF, GCM projections, which consist of an antecedent period from 1950 – 2010 and projections from 2011 – 2099, were bias corrected and spatially downscaled (BCSD) in conjunction with an ongoing archive of projections for use within water management agencies (Reclamation 2013). The BCSD projections were used as external forcings with the Variable Infiltration Capacity (VIC) (Liang, X. et al. 1994) model to generate Hydrologic Unit Code level 4 (HUC4) hydrologic projections.

The hydrologic projections consist of total runoff for each HUC4 within the continental United States (as well as transboundary basins for much of the NLDAS domain) and were computed for each HUC4 basin (local) and for cumulative totals relevant for the SAM application to the ACF (cumulative). The change in HUC4 hydrologic projections against the modeled historical flows were computed for two future time periods:

- Time Period 1: 2021 - 2050
- Time Period 2: 2061 - 2090

Delta values were calculated relative to the equivalent 30 year antecedent period 1970 – 1999; that comparison of projections to modeled antecedent conditions is the basis for making assertions about potential future climate changed altered hydrology for the ACF.

Outline Step 1. Information provided by SAM on December 12, 2013, via email from Ryan Crane. That information set included two sets of flow data for the ACF. Both sets were for 22 sites within the basin and were cumulative values at those sites, including all upstream flows. One site included naturalized flows that allowed negative numbers, assumed for mass balance purposes, the second data set was "smoothed" and eliminated any negative values.

Following a presentation of interim status held on Tuesday, January 14th, 2014, Mr. James Hathorn (SAM), Chief, Water Management Section, requested that the analysis be performed on local flows in addition to a single set of cumulative flows. This required an additional data transfer which took place on Wednesday January 15th, 2014. The hydrologic outputs that used the localized flows and the single set of cumulative flows described here and which accompany this project report supersede any previous analysis and presentation of interim results.

Outline Step 2. In order to access the appropriate HUC 4 hydrologic projections produced by USACE with NCAR, the sites provided by SAM were placed within a GIS layer of HUC4 boundaries. All sites provided by SAM are located within a single HUC 4 (0313 - Apalachicola).

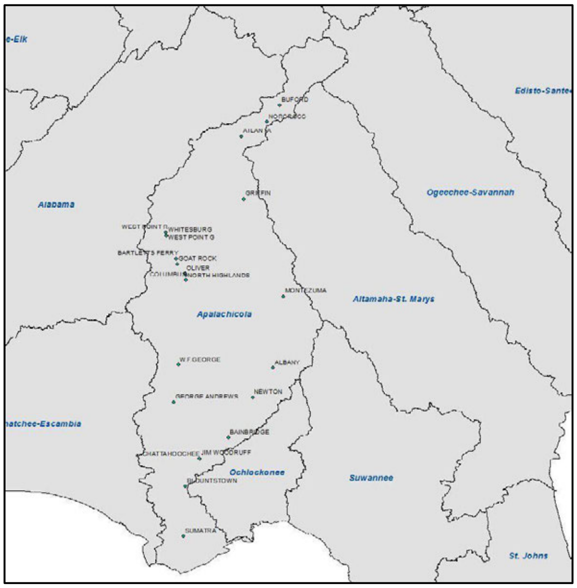


Figure 1: Map of input nodes provided by USACE SAM to be evaluated as part of the ACF Climate Change project. All nodes exist within HUC4 – 0313 – Apalachicola.

Outline Step 3.

The HUC4 - 0313 data is accessed from the hydrologic projection total data set. Before making a selection about which projections to consider (Outline Step 4) an intermediate step was deemed prudent given the substantially wide range of radiative forcings considered within the CMIP5 experiment. The HUC4 hydrologic responses were evaluated to determine the degree and type of differences as a function of RCPs to determine whether all or only selected RCPs needed to be used. The two figures below show this analysis. The first indicates the range of all hydrologic projections (yellow band) and the RCP medians at each month for the entire antecedent and future time periods considered wtihin the USACE-NCAR project. The second figure is a box and whiskers plot for each RCP as well as the dataset as a whole. Based upon visual inspection of these figures it was determined that for this location, the hydrologic projection responses computed using these methods are not obviously dependent on RCP. Therefore, there is no reason to sub-select from the RCPs but rather to treat them all as equally plausible for this analysis.

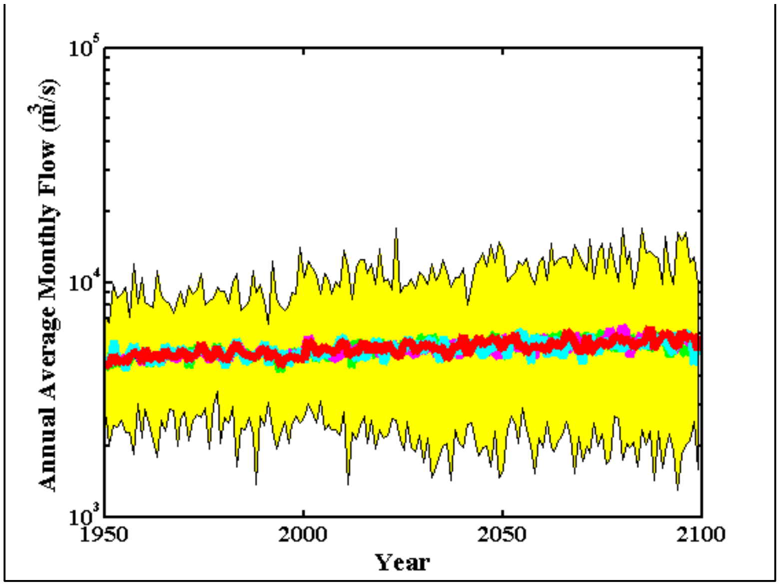


Figure 2: Full spread (yellow shading) of the 100 monthly hydrologic simulations that were developed as part of the VIC CMIP5 project at the HUC 4 level. The mean values at each month for each RCP are shown as the four solid (overlapping) lines. Visual evaluation indicates that the mean trends are indistinguishable across the various RCPs used in the analysis.

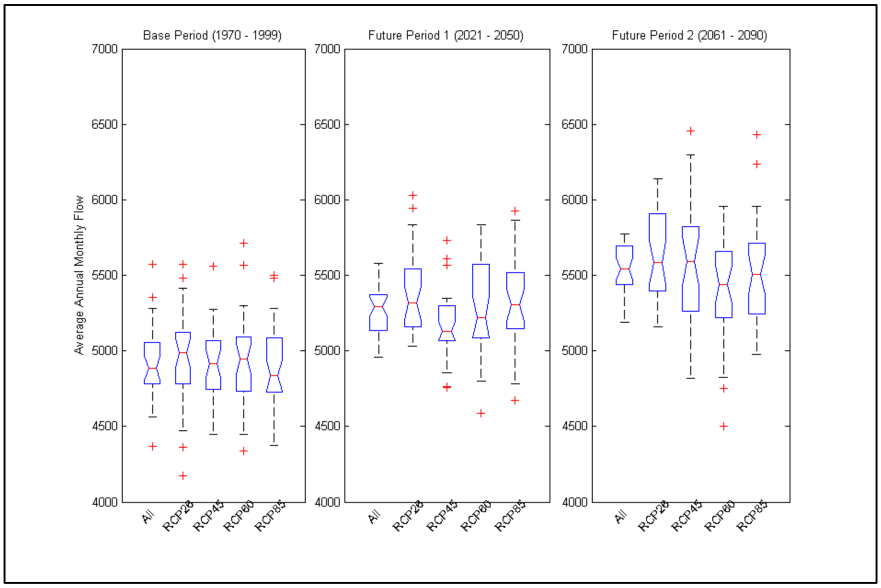


Figure 3: For each of the two time periods (2021 – 2050, 2061-2090) being explored for this climate change analysis GCM-projected spread for each RCP is presented. Visual analysis indicates no clear trend in the different W/m^2 at 2100 radiative forcings for this HUC 4 hydrologic analysis.

Outline Step 4.

Based upon the determination to consider all 100 projections equally plausible, empirical cumulative distribution functions (ECDFs) were developed for a climate change metric for the two future time periods (2021-2050, 2061-2090). The ECDFs represent the mean of all months for each of the 100 hydrologic projections within the 30-year time period ratioed against the mean of all months from the same model for the antecedent time period. Selection of the particular hydrologic projections to be utilized further was made by determining a "Dry", "Median", and "Wet Condition" for the two future time periods which are the 10th, 50th, and 90th quantiles, respectively (shown in Figure 4 by the black vertical lines).

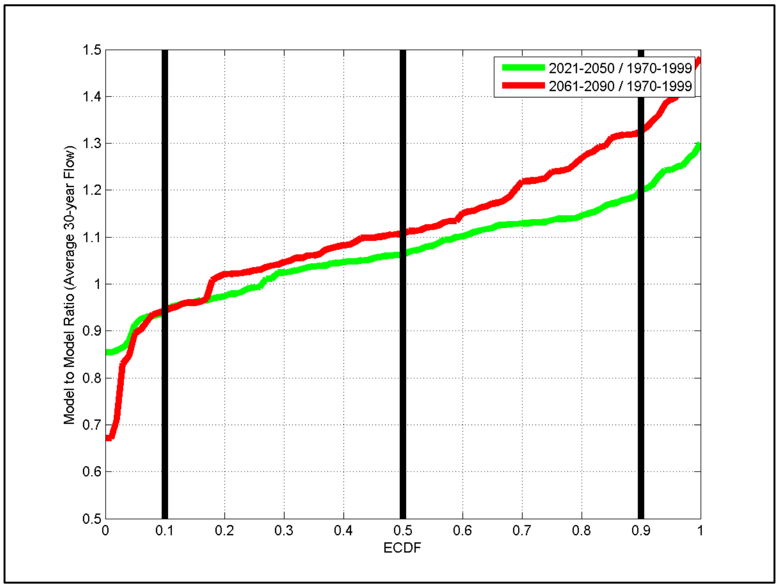


Figure 4: Empirical Distribution Functions for the 100 available HUC4 hydrologic projections for the Apalachicola. The ratios represent model to model of future period to antecedent period 30 year average monthly values.

Table 1: Selected hydrologic projections for further analysis.

	10% Quantile (DRY)	**50% Quantile (AVERAGE)**	**90% Quantile (WET)**
Time Period			
2021 - 2050	HadGEM2-ES.rcp60.monthly.runoff.1950-2099.HUC4.SUM.nc	HadGEM2-CC.rcp85.monthly.runoff.1950-2099.HUC4.SUM.nc	CCSM4.rcp60.monthly.runoff.1950-2099.HUC4.SUM.nc
2061 - 2090	HadGEM2-AO.rcp60.monthly.runoff.1950-2099.HUC4.SUM.nc	ACCESS1-0.rcp85.monthly.runoff.1950-2099.HUC4.SUM.nc	CCSM4.rcp60.monthly.runoff.1950-2099.HUC4.SUM.nc

We acknowledge the World Climate Research Programme's Working Group on Coupled Modeling, which is responsible for CMIP, and we thank the climate modeling groups listed in Table 2 of this documentation for producing and making available their model output. For CMIP, the U.S. Department of Energy's Program for Climate Model Diagnostics and Intercomparison provides coordinating support and led development of software infrastructure in partnership with the Global Organization for Earth System Science Portals.

Table 2: Recognition of climate modeling groups within the World Climate Research Programme's Working Group on Coupled Modeling being utilized within final analyses.

WCRP CMIP5 Climate Modeling Group[1]	WCRP CMIP5 Climate Model ID	RCP 2.6 Runs	RCP 4.5 Runs	RCP 6.0 Runs	RCP 8.5 Runs
Met Office Hadley Centre (additional HadGEM2-ES realizations contributed by Instituto Nacional de Pesquisas Espaciais)	HadGEM2-AO HadGEM2-CC HadGEM2-ES	0 0 0	0 0 0	1 0 1	0 1 0
Commonwealth Scientific and Industrial Research Organization and Bureau of Meteorology, Australia	ACCESS1-0	0	0	0	1
National Center for Atmospheric Research	CCSM4	0	0	1	0

[1] http://cmip-pcmdi.llnl.gov/cmip5/docs/CMIP5_modeling_groups.pdf

Outline Step 5.

For each of the three selected hydrologic projections for each time period ECDF maps are created for the full 30 year projection period against the full 30 year selected retrospective material for each month separately. An example of those maps is provided as Figure 5. The "map" that will be utilized to scale the ACF naturalized flows is created by taking each future ECDF point and dividing by the equivalent plotting position from the antecedent ECDF point. The remaining maps are provided within Monthly_VIC_Figs.zip.

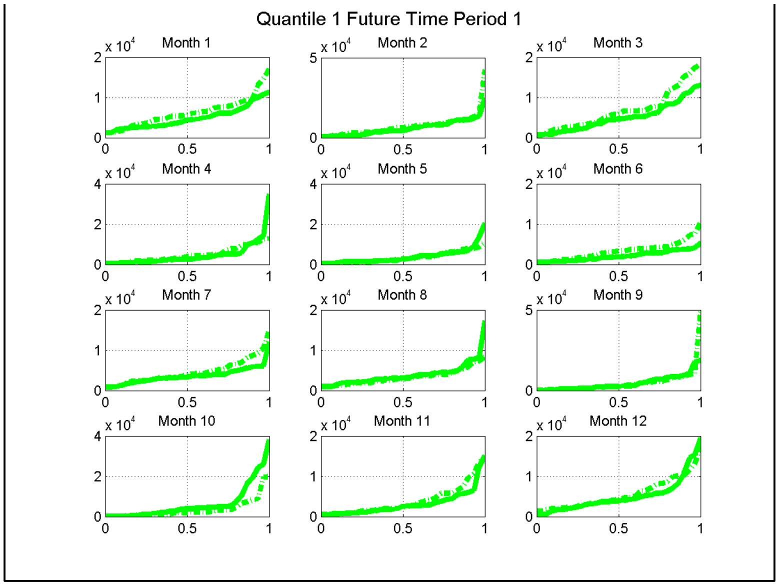


Figure 5. Example ECDF map for Quantile 1 (Dry 10% Projection) for Future Time Period 1 (2021 – 2050). Dashed line within each month figure represents the antecedent ECDF and the solid line represents the future ECDF.

Outline Step 6.

Utilizing the maps created in Outline Step 5 each of the 22 ACF sites is scaled by the appropriate monthly map. To accomplish this, each of the 22 ACF sites is subdivided into months utilizing the monthly average flow from the naturalized data set provided by SAM. An example for Jim Woodruff for future time period 1 (2021 – 2050) for quantile 1 (Dry 10%) is provided as Figure 6 for local flows and an example for Chattahoochee for future time period 1 for quantile 1 is provided as Figure 7. The remaining scaled flows for site 1 are provided as Monthly _ACF_Figs.zip.

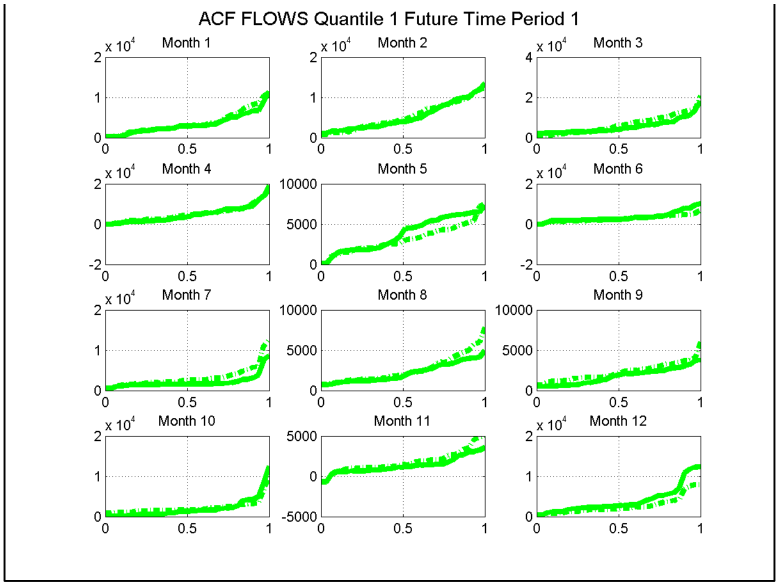


Figure 6. Example scaling of monthly flows for the local naturalized flows at Jim Woodruff. The dashed line indicates the naturalized ECDF flows for Jim Woodruff for each month and the solid line represents the climate changed ECDF flows.

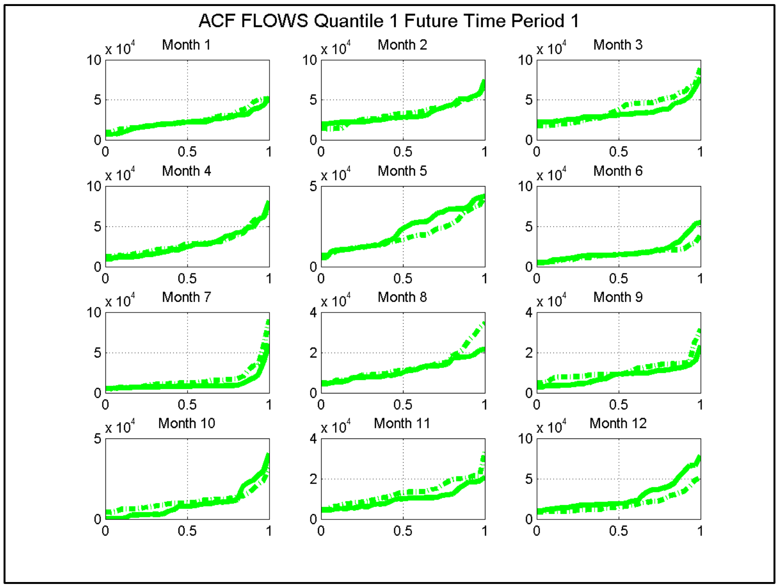


Figure 7. Example scaling of monthly flows for the cumulative naturalized flows at Chattahoochee. The dashed line indicates the naturalized ECDF flows for Chattahoochee for each month and the solid line represents the climate changed ECDF flows.

Outline Step 7.

Reconstituting the climate changed flows by ACF node site requires reassigning the appropriate month from the ECDF into chronological order. At this point that has been accomplished to the monthly basis. An example time series for Chattahoochee utilizing the cumulative flows is shown within Figure 8.

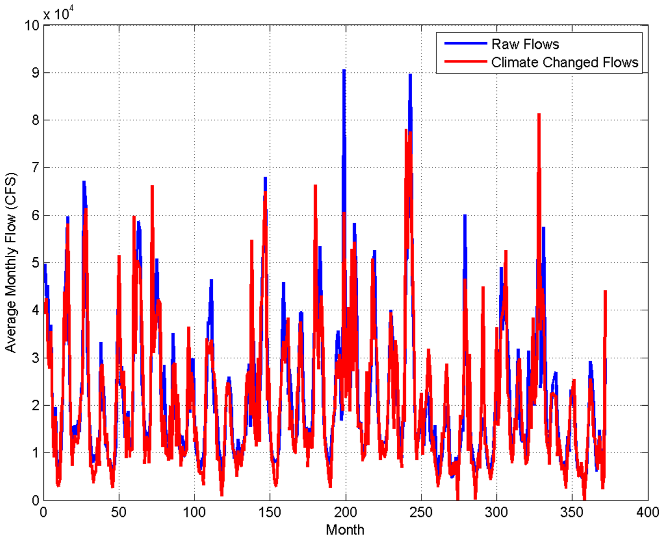


Figure 8. Example Monthly time series reconstituted from climate changed ECDF for the cumulative flows for Chattahoochee. The blue line represents the raw naturalized flows received from SAM averaged for the month. The red line represents the average monthly values reconstituted from the climate changed flows.

As a measure of quality control and assurance, as well as for communication purposes, the climate-altered monthly flows for each site were compared to the original projection selection represented within Figure 4. For each site the ratio of average monthly values for the future period was taken with respect to the antecedent period. The comparisons are shown within Figure 9 and Figure 10 for the local and cumulative naturalized flows, respectively. Sites, individually and collectively, may not match exactly the model-to-model ratio that was initially utilized to select quantiles for analysis. Upon further investigation it was determined that this is due, in some part, to the skew of the VIC flows relative to the skew of the naturalized raw flows. When the skews do not match and the quantile map is applied flows get "pulled" either wetter or drier depending on whether the skew of the VIC is greater than the skew of the raw naturalized flows, or vice versa.

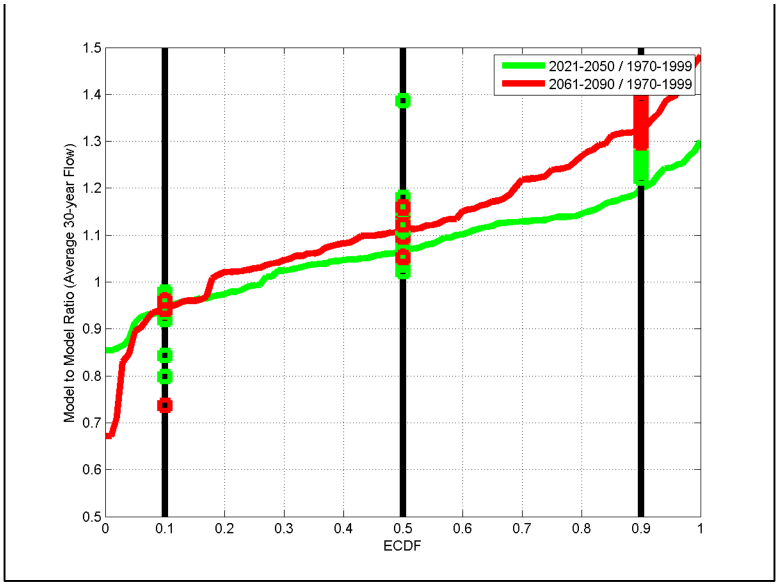


Figure 9. Figure shows the average monthly values of future to antecedent ratios for each of the sites for the ACF analysis for the climate change local naturalized flows. The green open circle values are for time period 1 (2021 – 2050) and the red open circle values are for time period 2 (2061 – 2090). The distribution of site ratios is indicative of differences amongst "skew" of the flow data with respect to the skew of the VIC quantile maps as described just above.

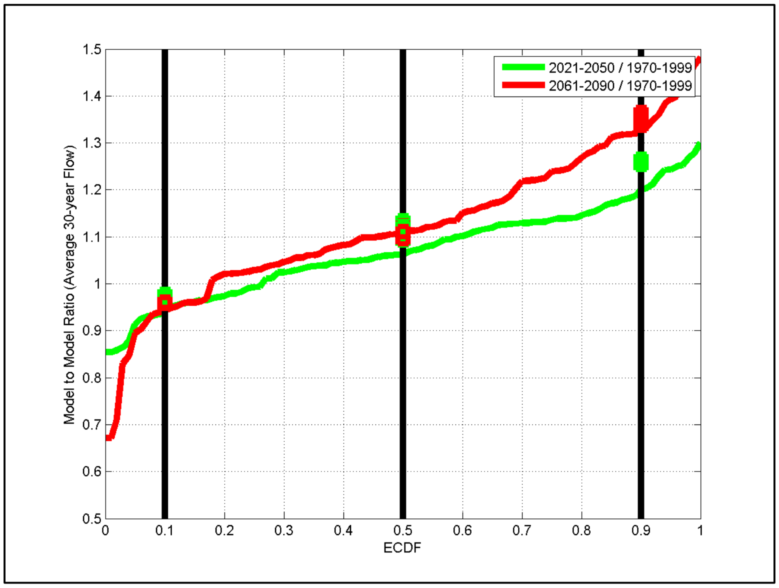


Figure 10. As for Figure 9 but here for cumulative naturalized flows.

Outline Step 8.

In order to utilize the climate-changed hydrology within the operational models of the ACF, which is the goal of the project on sensitivity analysis, it is required to reconstitute daily values from the monthly values created within Outline Step 7. Daily values for each site for each month were calculated by assigning the same daily percentage of monthly flows that were represented within the original naturalized flow files for both the local and cumulative values. In this manner the same day for the same month represents the same percentage of monthly flows within the climate-changed analysis. An example of the daily scaling is provided within Figure 11 for the cumulative flows at Chattahoochee for time period 1 and quantile 1. The figure represents the first January scaled to the climate-changed values. The daily values were then exported to an excel file in the same order of sites as was the original data. There is one excel file for each quantile for each of two time periods. Therefore, there are 6 total files of daily values for the climate change local naturalized flows and 6 total files of daily values for the climate change cumulative naturalized flows.

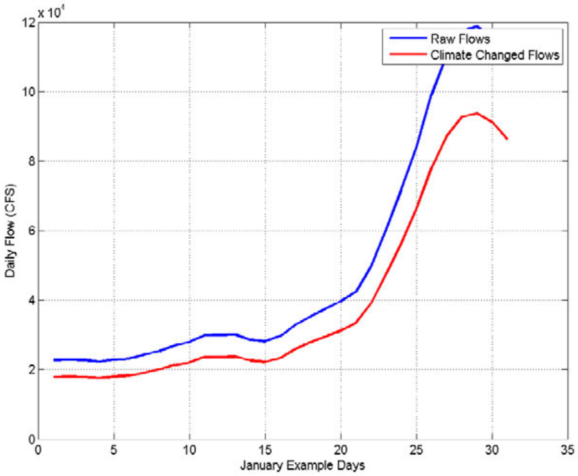


Figure 11: Example reconstitution of daily values for the first January in the time series for the cumulative flows at Chattahoochee for time period 1 and quantile 1. The blue line represents the raw daily values and the red line represents the climate changed values.

As a measure of quality control and assurance, the final daily values were compared to the original projection selection represented within Figure 4 as well as to the expectation of monthly flows represented within Figures 9 and 10. The ratio of the average daily values for the 30 year period of future to antecedent was taken for each site and these values are shown within Figure 12 and Figure 13 for the local and cumulative naturalized flows, respectively.

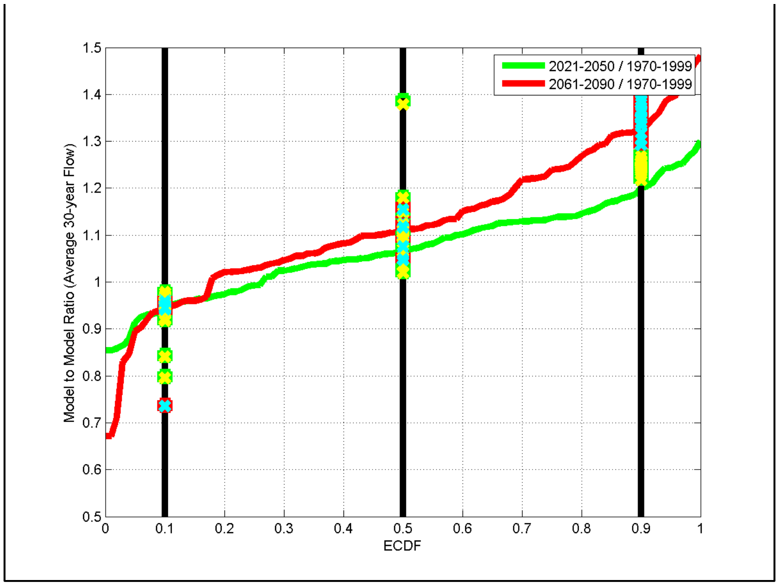


Figure 12. Figure shows the average daily values of future to antecedent ratios for each of the sites for the ACF analysis for the climate change local naturalized flows. The yellow "X" values are for time period 1 (2021 – 2050) and the blue "X" values are for time period 2 (2061 – 2090). The agreement between the "X" values and the "O" values (monthly ratios) is indicative of the daily disaggregation achieving the desired outcome.

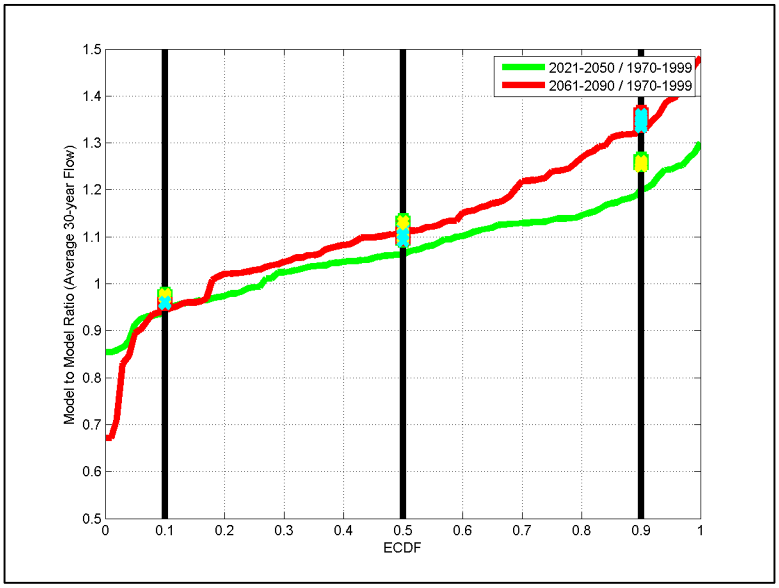


Figure 13. Figure shows the average daily values of future to antecedent ratios for each of the sites for the ACF analysis for the climate change cumulative naturalized flows. The yellow "X" values are for time period 1 (2021 – 2050) and the blue "X" values are for time period 2 (2061 – 2090). The agreement between the "X" values and the "O" values (monthly ratios) is indicative of the daily disaggregation achieving desired outcome.

References:

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Appendix A: Scope of Work for IWR support of climate change analysis for ACF EIS 2014.

Climate Change Analysis Support Apalachicola-Chattahoochee-Flint (ACF) Study
Scope of Work – Prepared by Dr. David Raff (IWR)
11/19/2013

Background: Dr. David Raff (IWR) briefed SAD on upcoming climate change inland hydrology guidance in October 2013. Following that presentation Beverley Stout (SAM) contacted David to discuss possibilities for including a climate change analysis within an ongoing EIS for the ACF. Dr. Jeff Arnold (IWR) joined a series of ACF working team meetings to discuss various approaches including a strictly qualitative presentation of climate change information through a quantitative analysis of climate change impacts on hydrology and operations within the basin. All types of approaches are consistent with the qualitative approaches to be required by the forthcoming climate change guidance. Following these discussions SAM would like to proceed with a numerical modeling assessment of firm yield impacts due to climate change that can be included within the EIS.

Outline Numerical Modeling Assessment.

1. Identify input nodes to HEC ResSim used within SAM ACF planning model.
2. Map input notes to HUC 4s.
3. Access BCSD – VIC HUC 4 hydrological simulations for the HUC 4s identified in 2. Simulations are those created as part of Responses to Climate Change and Actions for Change work with National Center for Atmospheric Research developed in 2013. No additional activity assumed to be necessary to develop hydrologic simulations.
4. For each future time periods 2020 – 2050 and 2060 – 2090 identify 3 VIC simulations that represent dry, median, and wet conditions for those time periods based on average annual flows across all HUC 4s. ** Want to use the same model for all subbasins in each run. Option is to identify key subbasins and use those for identifying a series of dry, median, and wet conditions -> could lead to more than 3 total. **
5. For those models selected on a monthly basis identify the future to base cumulative distribution function (CDF) shift for each of the models identified in 4.
6. Rank (create empirical distribution function) a 30 year sequence of unimpaired flows currently used by SAM for current modeling efforts.
7. Using the CDF shifts of 5 alter the unimpaired flows of 6 on a monthly basis such that the new CDFs match the projected shifts from 5.
8. Take the altered unimpaired flows from 7 and run through HEC ResSim model to identify range of firm yield impacts.
9. QA / QC of all work completed
10. Documentation for work performed.

IWR Scope of Work.

Outline Step	Responsibility	Product	Cost 1,000$ (IWR)	Proposed Completion
1	SAM	SAM will provide IWR with lat / long of nodes. SAM will provide IWR with a chosen 30 year sequence of unimpaired flows at all nodes	N/A	December 15, 2013
2	IWR	Matrix of HUC 4s for nodes	2	December 21, 2013
3	IWR	100 hydrology simulations for each HUC 4	2	January 5, 2013
4	IWR / SAM	3 hydrology simulations for all HUC 4s	2	January 10, 2013
5	IWR	CDF Maps	7	January 31, 2013
6	IWR	EDF for unimpaired flows	2	February 7, 2013
7	IWR	Altered unimpaired flows in same format as those provided by SAM to IWR in step 1. Passed to SAM.	4	February 19, 2013
8	SAM / HEC*			March 7, 2013
9	SAM / IWR		5	March 14, 2013
10	SAM / IWR		7	March 21, 2013
Total			31	

*HEC – Assumed this is HEC support of firm yield modeling.

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