

Final

SUWANNEE RIVER BASIN SURFACE WATER IMPROVEMENT AND MANAGEMENT (SWIM) PLAN

Suwannee River
Withlacoochee River
Alapaha River
Santa Fe River
Ichetucknee River

Prepared for:



November 2017



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List of Acronyms

Acronym	Term
BMAP	Basin Management Action Plan
BMP	Best Management Practice
CFS	Cubic Feet per Second
CFU	Colony Forming Units
Chl-a	Chlorophyll-a
District	Suwannee River Water Management District
DO	Dissolved Oxygen
EPA	U.S. Environmental Protection Agency
F.A.C	Florida Administrative Code
F.S.	Florida Statutes
FDACS	Florida Department of Agriculture and Consumer Services
FDEP	Florida Department of Environmental Protection
FDOT	Florida Department of Transportation
FF	Florida Forever
FFS	Florida Forest Service
FNAI	Florida Natural Areas Inventory
FSAID	Florida Statewide Agricultural Irrigation Demand
FWC	Florida Fish and Wildlife Conservation Commission
GEBF	Gulf Environmental Benefit Fund
IWR	Impaired Surface Waters Rule
LPEGDB	Longleaf Pine Ecosystem Geodatabase
LSR	Lower Suwannee River
MFLs	Minimum Flows and Levels
MGD	Million Gallons per Day
MSR	Middle Suwannee River
NFRWSP	North Florida Regional Water Supply Plan
NGO	Non-Government Organization
NNC	Numeric Nutrient Concentration
NO ₂	Nitrite
NO ₃ ⁻	Nitrate
NRCS	Natural Resource Conservation Service
NWI	National Wetlands Inventory
NWR	National Wildlife Refuge
OFW	Outstanding Florida Water
Partnership	North Florida Regional Water Supply Partnership

Acronym	Term
RAP	Reasonable Assurance Plan
SAV	Submerged Aquatic Vegetation
SB	Senate Bill
SJRWMD	St. John's River Water Management District
SMZ	Special Management Zones
SP	State Park
SRNWR	Suwannee River National Wildlife Refuge
SRP	Suwannee River Partnership
SVAEC	Suwannee Valley Agricultural Extension Center
SWIM	Surface Water Improvement and Management
TAG	Technical Advisory Group
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
TSI	Trophic State Index
UF/IFAS	University of Florida's Institute of Food and Agricultural Sciences
UFA	Upper Floridan Aquifer
USGS	United States Geological Survey
USR	Upper Suwannee River
WBIDs	Waterbody Identification
WBMP	Wildlife Best Management Practice
WRV	Water Resource Value
WWTP	Wastewater Treatment Plant

Executive Summary

This document constitutes the updated Surface Water Improvement and Management (SWIM) Plan for the Suwannee River Basin, which includes the following water bodies and their respective watersheds within the State of Florida:

- Suwannee River
- Alapaha River
- Withlacoochee River
- Santa Fe River
- Ichetucknee River.

This SWIM Plan updates the previous SWIM Plans for these water bodies with current status and trends information related to land use, water quantity, water quality, and natural systems. Another important goal of this update is to identify restoration and management priorities and related projects for integration into Florida's Gulf Environmental Benefit Fund (GEBF) Restoration Strategy.

This document has been prepared to meet or exceed with all applicable requirements of Section 373.451, Florida Statutes (F.S.), and 62-43.035, Florida Administrative Code (F.A.C.), specified for SWIM Plans. Section 1 provides an introductory overview of the study area; Section 2 presents a detailed status and trends analysis; Section 3 describes ongoing and proposed management actions; and Section 4 lists ongoing and proposed projects to address the issues identified.

Background

In 1987, the Florida Legislature passed the SWIM Act. The SWIM Act, Section 373.451, F.S., directed each of the state's five water management districts to identify and prioritize degraded surface waters within their respective boundaries, and to develop plans and programs for the improvement and management of those surface waters. It also directed the water management districts and other state agencies to conduct research to provide a better scientific understanding of the causes and effects of surface water pollution and of the destruction of natural systems in order to improve and manage these resources. The implementation of the SWIM Act is codified in 62-43.035, F.A.C..

The Florida Legislature originally funded the SWIM program annually, matched by funds raised by the water management districts; however, dedicated annual funding was ended after the 1997-98 fiscal year. Between 1988 and 1995 the Suwannee River Water Management District (District) developed and adopted SWIM Plans for six priority surface waters. These existing SWIM Plans and their respective dates of adoption included:

- Alligator Lake – 1988;
- Suwannee River – 1991;
- Aucilla River – 1991;
- Waccasassa River – 1991;

- Santa Fe River – 1995; and
- Coastal Rivers – 1995.

Updates of these SWIM Plans, and the development of new plans, by the District essentially ceased due to funding limitations. However, with the passage and implementation of the RESTORE Act in 2012, as well as other legal settlements and resulting funding streams associated with the “2010 *Deepwater Horizon*” oil spill, there is now an unprecedented opportunity to identify, prioritize and implement restoration projects in Gulf of Mexico coastal watersheds. Taking advantage of this opportunity, the District was awarded a grant from the National Fish & Wildlife Foundation’s GEBF, through FWC, to update and consolidate the original six SWIM Plans into two SWIM Plans, as summarized in the table below.

Existing SWIM Plans	Updated/Consolidated SWIM Plans
Suwannee River	Suwannee River Basin
Santa Fe River	
Alligator Lake	
Aucilla River	Coastal Rivers Basin
Coastal Rivers	
Waccasassa River	

This document constitutes the consolidated Coastal Rivers Basin SWIM Plan, and has been prepared to comply with all applicable requirements of Section 373.451, F.S., and 62-43.035, F.A.C. The primary goal was to update the existing SWIM Plans with current status and trends information related to land use, water quantity, water quality, and natural systems in the Coastal Rivers Basins. Another important goal of this effort is to identify restoration priorities and projects for integration into Florida’s GEBF Restoration Strategy.

More so than other parts of Florida, the economy of the Suwannee River/Big Bend region of Florida is largely dependent on the quality and sustainability of its natural resources. Accordingly, the District occupies a critically important niche at the intersection of environmental conservation and economic growth. Sound management of sustainable water resources and natural systems is not just the mission of the District, but also the underpinnings of future economic growth in the region. Perhaps the greatest challenge facing the District in this regard is the balancing of increasing consumptive water use demands and pollutant loads associated with the expansion of more intense agricultural and urban land uses with the maintenance of regional environmental quality and natural systems. Furthermore, due to the unique geology of the Suwannee River/Big Bend region, surface, ground, and coastal water resources are all closely interconnected.

Land Use

Managed forests (silviculture) and other forested uplands constitute 46 percent of the Basin, while wetlands (both forested and herbaceous) encompass 17 percent of the Basin. Combined, these two land use classes constitute 64 percent of the Basin area. The more intense agricultural land uses of row crops and rangeland comprise 14 and 10 percent of the Basin, respectively. Urban land development has increased slightly, mostly as growth around existing urbanized areas, but still only constitutes 10 percent of the Basin land area. The greatest amount of urbanization has occurred

east of the Suwannee River, in the Santa Fe watershed, due to its proximity to Gainesville and several other incorporated areas.

Due to the rural characteristics of the Suwannee River Basin, habitat fragmentation is relatively minimal compared to other areas in Florida. In addition, the rivers and streams in the Basin remain free flowing (e.g., virtually unimpounded or dammed). However, the expansion of more intense agricultural and urban land uses will likely put greater pressure on water resources and natural systems in the future. Therefore, conservation and management of existing natural systems, including the maintenance of minimum flows and minimum levels (MFLs), and water quality, offer the best means by which to prevent further habitat loss, fragmentation, and/or water resource degradation in the Basin.

Water Quantity

In portions of the Suwannee River Basin the use of traditional, fresh groundwater sources is at or above its sustainable limit. The Lower Santa Fe and Ichetucknee Rivers and associated priority springs are in recovery with estimated flow deficits relative to the MFLs. Recent analyses identified small magnitude changes in long-term trends for flows or water levels at some locations in the Basin. Declining groundwater levels in portions of the District (including the watersheds addressed in this SWIM Plan) have been designated as Water Supply Planning Regions/Water Resource Caution Areas. Primary threats to the hydrology of the systems with the Suwannee River Basin include jurisdictional boundaries and groundwater withdrawals.

Public supply, agriculture, commercial and industrial entities and other users, both within and outside District boundaries, create multiple demands on the water resources of the District. A majority (57 percent) of the drainage area of the Suwannee River Basin occurs in Georgia, limiting management options that may be directly controlled by the District. Additionally, the area of constrained fresh groundwater availability adjoins the St. Johns River Water Management District (SJRWMD). In this case, joint water supply planning has been initiated and conducted collaboratively with the Florida Department of Environmental Protection (FDEP), the District, and the SJRWMD as part of the North Florida Regional Water Supply Planning (NFRWSP). However, substantial increases in future agricultural water demand in the Suwannee River Basin have been projected (District 2010).

To address these potential threats, the District has identified various management actions and projects/initiatives with the ultimate goal to protect or restore the hydrologic regimes, in terms of frequency, magnitude, duration, and seasonality, in the Suwannee River Basin, ensuring the protection of critical Water Resource Values therein. Specific goals include actions to increase aquifer recharge and decrease excessive runoff and evapotranspiration. Potential projects to meet these goals include agricultural best management practices (BMPs), hydrologic restoration of over-drained lands, water reuse, and water conservation. Because water is an integrated and interconnected resource, many of these management actions, projects or initiatives involve partnerships with other agencies and stakeholders, both within and outside of the District.

Water Quality

A previous comprehensive water quality assessment conducted by Upchurch (2007), and data analyses conducted as part of this SWIM Plan update, have shown that nitrate (NO_3^-) concentrations exhibit increasing trends at several river and spring discharge stations in the western Suwannee River and Santa Fe River watersheds since the late 1980s. Data for more recent years suggest that most locations still have variable, but non-trending concentrations of NO_3^- over time. Many, but not all, of the river and stream sites previously determined to have decreasing NO_3^- concentrations are in the eastern portion of the District, where the Floridan Aquifer is confined, and where stream-aquifer interactions are mostly restricted to the surficial aquifer (Upchurch et al. 2007). Increasing trends in phosphorus concentrations have generally not been observed in the Suwannee River Basin.

The impacts of nutrient enrichment in springs and rivers are manifested through increased abundance of filamentous algae in increased biological oxygen demand, and thus adverse impacts to those natural systems that are dependent on good water quality. In addition to impacts in the springs and rivers themselves, the downstream waters of the Gulf of Mexico that are most strongly influenced by Suwannee River discharges are thought to be nitrogen-limited. Increased nitrogen loads to the Suwannee River estuary have been a topic of concern raised by FDEP in a recent report on trends in seagrass coverage in the Big Bend region. Consequently, actions taken to reduce NO_3^- loads to the springs and rivers of the Suwannee and Santa Fe Rivers are likely to benefit not only the springs and rivers, but also those portions of the nearshore waters of the Gulf of Mexico influenced by their flows.

In the Basin Management Action Plan (BMAP) for the Santa Fe River, FDEP concluded that 48 percent of the NO_3^- load to the Santa Fe River comes from fertilizer applications, with 15, 12, and two percent coming from beef production, dairies, and poultry operations, respectively. However, NO_3^- loads from human sewage were estimated to represent less than 10 percent of the TN load to the Santa Fe River. As such, wastewater upgrades could be locally important in terms of NO_3^- in the Santa Fe River, but anthropogenic sources do not appear to rise to the same level of concern as loads from agricultural practices. These general findings on the relative magnitudes of various nutrient sources are expected to apply to the Suwannee River as well. Therefore, increased compliance with existing agricultural BMPs, and the development of new BMPs, are critical to holding the line on water quality in the Suwannee River Basin.

To address these issues, the District has identified various management actions and projects/initiatives with the ultimate goal to protect or restore the water quality of the Suwannee River Basin. The majority of concerns have focused on the issues of nitrogen enrichment and pathogen abundance. Specific goals include the continuation of efforts to monitor water quality, with regular updates of the status and trends (if any) in water quality across the Basin.

Natural Systems

The natural systems of the Suwannee River Basin comprise valuable ecological, aesthetic, recreational, cultural, and economic resources. Primary threats to natural systems include:

- Land use changes (and corresponding habitat loss and fragmentation);
- Declines in water quality and quantity;
- Introduction of non-native and invasive species; and
- Climate change.

For example, conversion from upland silviculture to higher intensity row crops or animal operations results in loss of forested habitat and connectivity among habitats important to numerous species. Other examples include: disturbance and loss of native submerged aquatic vegetation (SAV) in springs due to excessive recreational use and/or algae proliferation due to increased nutrient concentrations; loss of fish habitat due to reduced flows and exposure of formerly inundated floodplains; loss of marsh habitat due to lowered groundwater levels as a result of water withdrawals; disturbance of habitat by invasive species such as wild hogs and subsequent invasion of nonnative and invasive plant species; and loss of salt marsh habitat due to sea level rise and inundation. Climate change and sea level rise in particular are expected to impact Florida's fish and wildlife across all terrestrial, freshwater, and marine habitats; and combined with other stressors, reduce the long term viability of species and associated ecosystems.

Due to the rural characteristics of the Suwannee River Basin, habitat fragmentation is relatively minimal compared to other areas in Florida. In addition, the rivers and streams in the Basin remain free flowing (e.g., not impounded or dammed). However, the expansion of more intense agricultural and urban land uses will likely put greater pressure on water resources and natural systems in the future. Therefore, conservation and management of existing natural systems, including the maintenance of minimum flows and levels, and water quality, offer the best means by which to prevent further habitat loss, fragmentation, and/or water resource degradation in the Basin.

Equally important is proper management and maintenance of habitats that historically were fire maintained, such as sand pine scrub, sandhills, prairies, and wetlands. Prescribed fire is used to reduce shrub layer vegetation, initiate seeding in some species, and improve and maintain habitats for deer, quail, turkey and many other wildlife species. Some of Florida's rare, fire-adapted plants and animals that inhabit fire maintained communities include the red-cockaded woodpecker, Sherman's fox squirrel, gopher tortoise, eastern indigo snake, and Florida scrub jay.

Finally, continued monitoring, data collection, and research to track native habitats and species and improve our understanding of how they may be impacted by land use changes, water quantity and quality, non-native and invasive species, and climate change, are important to managing natural systems in the Suwannee River Basin.

Management Actions and Projects

While the rivers and coastal waters along Florida's Big Bend coastline are often viewed as being in a close to pristine condition, the analysis of status and trends presented herein indicate that there are natural resource management issues that need to be address. The primary issues potentially affecting the surface waters and ecology of the Suwannee River Basin, both now and in the future, include:

- Increase in silviculture and more intense agricultural and urban land uses;

- Alterations to natural hydrology;
- Decreasing river and spring flows in some locations;
- Increasing nitrogen concentrations in river and springs flows in some locations;
- Habitat fragmentation due to land development and road construction;
- Loss of natural oyster bars; and
- Climate change and sea level rise.

This SWIM Plan includes proposed management actions and projects addressing various aspects of the key focus areas of water quantity, water quality, and natural systems, as summarized below.

Water Quantity

- Monitoring, Data Collection, and Research
- Water Supply Planning
- MFLs
- Water Resource Development and Aquifer Recharge
- Conservation

Water Quality

- Monitoring, Data Collection, and Research
- Implementation of Total Maximum Daily Loads (TMDLs) and Basin Management Action Plans (BMAPs)
- Wastewater and Stormwater Infrastructure

Natural Systems

- Habitat Conservation
- Habitat Restoration
- Recreation Management

A total of 56 projects are proposed to address the improvement and management of the Suwannee River Basin.

1.0 Introduction

This document constitutes the updated Surface Water Improvement and Management (SWIM) Plan for the Suwannee River Basin, which includes the following water bodies and their respective watersheds:

- Suwannee River
- Alapaha River
- Withlacoochee River
- Santa Fe River
- Ichetucknee River.

This SWIM Plan updates the previous SWIM Plans for these water bodies with current status and trends information related to land use, water quantity, water quality, and natural systems. Another important goal of this update is to identify restoration and management priorities and related projects for integration into Florida's Gulf Environmental Benefit Fund (GEBF) Restoration Strategy.

This document has been prepared to meet or exceed with all applicable requirements of Section 373.451, Florida Statutes (F.S.), and 62-43.035, Florida Administrative Code (F.A.C.), specified for SWIM Plans. Section 1 provides an introductory overview of the study area; Section 2 presents a detailed status and trends analysis; Section 3 describes ongoing and proposed management actions; and Section 4 lists ongoing and proposed projects to address the issues identified.

1.1 The SWIM Act - Purpose and Intent

In 1987, the Florida Legislature passed the SWIM Act. The impetus for the SWIM Act was the Legislature's finding that the water quality of many of the state's surface waters had been degraded, or was in danger of becoming degraded, and that the natural systems associated with many surface waters had been altered and were no longer performing the important functions that they once provided, including:

- Aesthetic and recreational pleasure for the people of the state;
- Habitat for native plants, fish, and wildlife, including listed species;
- Safe drinking water to the growing population of the state; and
- Attracting visitors and accruing other economic benefits.

Furthermore, the Legislature found that factors contributing to the decline in the ecological, aesthetic, recreational, and economic value of the state's surface waters included point and nonpoint source pollution, and the destruction of the natural systems which purify surface waters and provide habitats; that the declining quality of the state's surface waters has been detrimental to the public's right to enjoy these surface waters; and that it is the duty of the state to enhance the environmental and scenic value of surface waters.

The SWIM Act, Section 373.451, F.S., directed each of the state's five water management districts to identify and prioritize degraded surface waters within their respective boundaries, and to develop plans and programs for the improvement and management of those surface waters. It also directed the water management districts and other state agencies to conduct research to provide a better scientific understanding of the causes and effects of surface water pollution and of the destruction of natural systems in order to improve and manage these resources.

Under the Act, water management districts identify priority water bodies for inclusion in their SWIM program based on their regional significance and their need for protection and/or restoration. This process is carried out in cooperation with the Florida Department of Environmental Protection (FDEP), the Florida Fish and Wildlife Conservation Commission (FWC), the Florida Department of Agriculture and Consumer Services (FDACS), and local governments. Upon the designation of a SWIM waterbody, a SWIM Plan must be adopted by the water management district's governing board and approved by FDEP. Before the SWIM Plan can be adopted, it must undergo a review process involving the required state agencies.

The implementation of the SWIM Act is codified in 62-43.035, F.A.C. Pursuant to this rule, SWIM Plans are required to include the following information:

- Description of the waterbody system, its historical and current uses, its hydrology, and a history of the conditions which have led to the need for restoration or protection.
- Identification of all government units that have jurisdiction over the waterbody and its drainage basin within the plan area, including local, regional, state and federal units (Appendix A).
- Description of land uses within the plan area and those of important tributaries, point and nonpoint sources of pollution, and permitted discharge activities.
- List of the owners of point and nonpoint sources of pollution that discharge into each waterbody and tributary thereto and that adversely affect the public interest (by causing or significantly contributing to violations of water quality standards). This list shall include separate lists of those sources that are operating without a permit, operating with a temporary operating permit, and those presently violating effluent limits or water quality standards, and include recommendations and schedules for bringing all sources into compliance with state standards when not contrary to the public interest (Appendix B).
- Description of strategies for restoring or protecting the waterbody sufficient to meet Class III standards or better.
- List and current status of active restoration or protection projects for the waterbody (Appendix C).
- List of studies that are being or have been prepared for the waterbody (Appendix D).
- Description of the research and feasibility studies which will be performed to determine the particular strategy or strategies to restore or protect the waterbody.

- Description of the measures needed to manage and maintain the waterbody once it has been restored and to prevent future degradation.
- Schedule for restoration or protection of the waterbody.
- Estimate of the funding needed to carry out the restoration or protection strategies.

This SWIM Plan has been prepared to meet and exceed these informational requirements. Several Appendices accompany this document which provide specific information as required in the development of this SWIM Plan. All documents referenced within this document are provided in Appendix D.

1.2 SWIM in the Suwannee River Water Management District

The Suwannee River Water Management District (District) is one of five regional water management districts in Florida, created by the Florida Legislature through passage of the Water Resources Act of 1972. The District is the smallest of the state's water management districts in terms of geographic area, population served, tax base, and agency staff. The service area of the agency includes:

- 7,640 square miles;
- All or part of 15 counties in north-central Florida;
- 13 river basins; and
- A population of 320,000.

Figure 1 below shows the geographic location and extent of the District's boundaries. For the purposes of this document, the term "basin" refers to the overall study area, while the term "watershed" refers to the drainage areas for each of the individual river systems addressed in the Plan.



Figure 1. District boundary

1.2.1 Previous SWIM Plans

The District began implementing the SWIM Act in 1987 utilizing a three-step process to develop and execute the SWIM program. First, an evaluation of the District's surface waters was conducted to develop a priority list of those systems most in need of restoration or protection. Second, SWIM Plans were prepared for priority surface waters to guide the restoration and/or protection of water quality. Third, key policies, projects, and other actions identified in the SWIM Plans were implemented and monitored, including annual evaluations and modifications, as required under the SWIM Act.

The development of a priority surface waters list was first undertaken by the District in the fall of 1987. Early in the process, the District established a SWIM Technical Advisory Group (TAG) to identify regional management issues, prioritize surface water bodies, exchange data and information, and review management proposals. The TAG was comprised of representatives from the review agencies (listed in 62-43.035, F.A.C.), university staff, and appropriate federal agencies. Using the criteria developed by FDEP, water bodies were prioritized by the District in cooperation with FDEP, FWC, local units of government, and other interested parties and stakeholders.

In order of priority, the first six SWIM priority water bodies were the Upper Suwannee River (USR), Lower Suwannee River (LSR), Santa Fe River, Steinhatchee River, Alligator Lake, and Falling Creek. In later years, the priority list was revised to include the USR, LSR and Falling Creek into an overall Suwannee River System. In addition, during the same year the Steinhatchee plan was expanded to include the entire Coastal Rivers Basin, as well as the addition of the Aucilla and Waccasassa rivers. All SWIM rivers include coastal waters to the state waters limit in the Gulf of Mexico (nine nautical miles seaward of the shoreline). In all, the District adopted SWIM Plans for six priority surface waters. These existing SWIM Plans and their respective dates of adoption are as follows:

- Alligator Lake – 1988;
- Suwannee River – 1991;
- Aucilla River – 1991;
- Waccasassa River – 1991;
- Santa Fe River – 1995; and
- Coastal Rivers – 1995.

Given the rural nature of the Suwannee River region, the six original SWIM Plans were predominantly “preservation” rather than “restoration” oriented, and primarily addressed public land acquisition priorities as well as the need for ongoing monitoring programs related to land cover, water quality, and aquatic resources. However, several restoration projects were identified in the SWIM Plans. The status of prior SWIM Plan projects and programs is summarized in Appendix C.

Throughout the development and execution of its SWIM program, the District has advocated for a regional watershed approach to resource management, which recognizes that surface water bodies, groundwater aquifers, and their related natural systems are not confined to political jurisdictions. The land area that drains to a surface waterbody - defined as the watershed or basin - often includes the jurisdictions of many levels of government, each of which has different interests, responsibilities, and capabilities. Accordingly, the District has promoted interagency coordination and cooperation between the various jurisdictions within its boundaries to improve resource protection and management.

Land use is an important determinant of surface water quality, and the authority to regulate land uses in Florida - including land use allocation, density, and intensity controls through land use planning - lies principally with local units of government. However, local governments within the District boundaries are mostly small and rural, and lacking in staff and fiscal resources. In recognition of these challenges, the District has focused on providing technical and planning assistance to local governments within its jurisdiction to identify public land acquisition priorities, and to promote land use planning practices that are compatible with sound water resource management across multiple political boundaries.

Finally, the District has developed effective non-regulatory partnerships with other agencies, private landowners, and key economic interest groups within its jurisdiction. Agricultural and forestry land uses are predominant within the District boundaries, and these land uses are typically less regulated than more intense urban land uses with respect to water quality. While the 1991 SWIM Plan for the Suwannee River does not highlight concerns related to nitrate (NO_3^-) contamination and/or excessive algal growth, elevated NO_3^- concentrations and related eutrophication symptoms began to be identified as a problem in both the Suwannee and Santa Fe Rivers as well as the Floridan aquifer and several springs in the District just a few years later. This led to the creation of the Suwannee River Partnership (SRP) in 1999, the goal of which was to educate and assist agricultural interests – primarily dairy, beef, poultry, agronomic crops, and nurseries – in the implementation of best management practices (BMPs) to reduce their nutrient related impacts. The SRP has sought to effectively pursue a balance between protecting natural systems and sustaining the region’s agricultural economy.

1.2.2 SWIM Plan Update and Consolidation

The Florida Legislature originally funded the SWIM program annually, matched by funds raised by the water management districts; however, dedicated annual funding was ended after the 1997-98 fiscal year. Since then many SWIM water bodies around the state have benefited from significant individual legislative appropriations throughout the years, associated with the Community Budget Issue Request water project funding process under Section 403.885, F.S. Furthermore, the water management districts and FDEP continue to use the SWIM planning process and plans to guide their resource management efforts.

In recent years, the identification of water quantity issues has been led by Florida’s various water management districts through the Minimum Flows and Minimum Levels (MFLs) program, while issues related to water quality have been the focus of FDEP led efforts to develop Total Maximum Daily Loads (TMDLs) and the subsequent Basin Management Action Plan (BMAP) program. The TMDL program is meant to identify pollutant load reductions necessary to restore impaired waterways, while the BMAP program is meant to guide the implementation of load reductions identified in the TMDL process.

With the passage and implementation of the RESTORE Act in 2012, as well as other legal settlements and resulting funding streams associated with the “2010 *Deepwater Horizon*” oil spill, there is now an unprecedented opportunity to identify, prioritize and implement restoration projects in Gulf of Mexico coastal watersheds. Taking advantage of this opportunity, the District

was awarded a grant from the National Fish & Wildlife Foundation’s GEBF, through the FWC, to update the original six SWIM Plans. GEBF was established in early 2013 as a result of the plea agreements resolving the criminal cases against BP and Transocean after the oil spill. The agreements required a total of \$2.544 billion to be paid to GEBF over a five-year period with \$356 million allocated for projects within Florida. The funds are to be used for projects that remedy harm to natural resources injured by the oil spill. To bring a more consistent and comprehensive planning focus to the SWIM Plan updates, the District decided to consolidate the six original SWIM Plans into two SWIM Plans, as summarized in Table 1 below.

Table 1. Existing SWIM Plans to be Consolidated into Two SWIM Plans

Existing SWIM Plans	Updated/Consolidated SWIM Plans
Suwannee River	Suwannee River Basin
Santa Fe River	
Alligator Lake	
Aucilla River	Coastal Rivers Basin
Coastal Rivers	
Waccasassa River	

The primary goal of this effort is to update the existing SWIM Plans with current status and trends information related to land use, water quantity, water quality, and natural systems in the greater Suwannee River and Coastal Rivers Basins. Another important goal of this effort is to identify restoration priorities and projects for integration into Florida’s GEBF Restoration Strategy, which is being developed by the District as the deliverable under their GEBF grant. Restoration projects identified in the SWIM Plans and submitted to the state project portal at www.deepwaterhorizonflorida.com will be considered for future “2010 *Deepwater Horizon*” funding (e.g., Natural Resource Damage Assessment, GEBF, and/or RESTORE funds). Specific parameters will be applied for each funding stream to determine eligibility of projects.

1.2.3 Integrating Water Management and the Economy

The geographic region encompassed by the District is a land of working farms, forests, rivers, springs, and estuaries where the local economy is dependent upon the services provided by the natural resources of the region. The Big Bend coastal region has the most extensive contiguous stretch of undeveloped coastline along the U.S. Gulf of Mexico, which provides important nursery habitat for a variety of commercially and recreationally important species of finfish and shellfish. As such, the people of this rural region rely more on the natural systems for their livelihood and recreation than most Floridians. The region has not experienced the dramatic increases in population growth that have characterized other regions of Florida, and the landscape mostly reflects the dominant land uses of forestry and agriculture. It is also important to recognize that this region is not homogeneous, either in terms of its natural systems or economic drivers. The Suwannee River Basin is dominated by intense agricultural land uses including crops and livestock; whereas the Coastal Rivers Basin is characterized by managed forest lands, small coastal communities, and aquaculture operations.

Many of the community leaders in the region are seeking economic growth, but also recognize that growth is dependent on the protection of the areas' natural resources. To ensure economic growth, mature industries such as farming, forestry, and natural resource-based manufacturing (e.g., paper) must continually innovate to stay competitive while also sustaining the natural resources upon which they rely. Aquaculture is a growing industry in the region and offers great potential for expansion, both geographically and in terms of product diversity. Similarly, aquaculture is also dependent on the maintenance of pollution free coastal waters. Finally, nature-based and experiential tourism, especially focused on the regions' numerous springs, can also capitalize on the rich natural systems so long as they are adequately protected, accessible, and the appropriate tourism infrastructure exists.

In preparing the SWIM Plan updates, the District conducted an extensive public outreach program to identify issues of concern as well as priorities and projects for the preservation, conservation and restoration of water resource and natural systems. Through this public outreach process several key economic and environmental connections were identified (Appendix E) and are summarized below.

1.2.3.1 Preserving Working Forests to Protect Water Quantity and Quality

The Suwannee River/Big Bend region includes some of the most heavily forested areas in Florida. The majority of these areas are managed pine and hardwood forests that are periodically harvested for timber production. Although silviculture – the term for managed timber production - is a form of agriculture, forestry BMPs are generally considered to be compatible with the maintenance of healthy water resources, supporting clean rivers, creeks, and springs, fish and wildlife habitat, and drinking water (Ursic and Douglass 1978). Forested lands serve as natural filters reducing nutrient and sediment loads, benefitting receiving waters and downstream coastal estuaries.

FDEP and FWC have recently raised concerns about increased nutrient loads from the Suwannee River Basin impacting seagrass coverage in the Big Bend Seagrasses Aquatic Preserve. Reducing nutrient loads in the both the Suwannee River Basin and the Coastal Rivers Basin will not only directly benefit receiving waters, but will also benefit the downstream health of the Big Bend coastal estuaries, including the extensive seagrass beds that characterize the region. Furthermore, sustaining forest lands in the Big Bend region will continue to provide a buffer between Gulf coastal waters on the west and more intense agriculture on the east, and will maintain undeveloped land area to allow for habitat adaptation to rising sea levels, thus increasing the coastal resiliency of the region.

Preserving working forests and managed forested lands also benefit water quantity. FDACS and University of Florida's Institute of Food and Agricultural Sciences (UF/IFAS), with funding support from the five water management districts, is two years into a four-year research project to quantify the water yield benefits of different forest management techniques to local and regional water resources. Preliminary results indicate that reducing biomass and leaf area through different management techniques, like thinning or prescribed fire, will reduce forest water losses through evapotranspiration, thus increasing water yield to surface water bodies and aquifers.

These forests are critical to the regional economy and quality of life. Big Bend forests form the basis of the strong timber, paper, and wood products industries that employ many of the area's residents. Forestry and forest product manufacturing generated over \$2 billion dollars in economic output for the region and directly supports over 12,000 jobs in 2013 (Hodges 2013). Over 6,500 of those jobs are in Taylor County alone. The new Klausner sawmill in Suwannee County will also employ 350 people, and create over 700 jobs in construction and related supply chains (Vann 2014). Although it is unlikely that the acreage of working forests in the region will expand significantly in the future, steps should be taken to maintain and protect existing managed forest lands through the development of stronger partnerships between the state, the District and forest-based industries in the region. Such partnerships will support economic growth, markets, and jobs, as well as sound water resource management.

Industry leaders stress the importance of scientifically-sound and continually-improving silviculture BMPs, as well as the need for reforestation acres to equal or exceed harvest acres to ensure long-term resource sustainability. However, there are increasing regional economic pressures to convert managed forest lands into more intense agricultural uses, including row crops and livestock operations, due to higher short-term returns. If the conversion of managed forest lands to other land uses increases beyond a presently unknown "tipping point" related to silviculture (i.e., if available land for forest products becomes limiting to local mill operations), then such land use conversions could be accelerated. Measures to sustain managed forest lands in the Suwannee River Basin are consistent with natural systems protection.

1.2.3.2 Improving Water Quality to Promote Aquaculture in Coastal Communities

The Big Bend coastal region of Florida is characterized by long stretches of undeveloped shoreline and extensive salt marshes punctuated by a few small coastal residential communities, including Cedar Key, Suwannee, Steinhatchee, Horseshoe Beach, and Keaton Beach. While these uniquely isolated communities have largely retained their rural character and maritime culture, they offer great potential for emerging aquaculture industries. The quality of coastal waters, and the sustainability of marine resources, in the region is largely dependent on the quality and quantity of waters discharged from the major regional rivers, with the Suwannee River being by far the most important in terms of total discharge volume.

Cedar Key has enjoyed an economic renaissance, largely due to its burgeoning hard-shell clam aquaculture industry. Prior to 1990, the seafood industry in Cedar Key was limited to local wild oyster harvests and net-caught fish. However, in 1990 the U.S. Food and Drug Administration closed the area's commercial oyster harvest in the Suwannee Sound due to high and persistent levels of sewage-borne bacteria seeping from local septic tanks. Then in 1994 Florida voters approved a commercial net ban which essentially shut down the local mullet fishing industry. Beginning in 1992, the Cedar Key Water and Sewer District was created and multiple infrastructure upgrades to replace septic tanks with a central sewage treatment facility were initiated. The District was a partner in this effort, contributing substantial funding for improvements to wastewater and stormwater treatment facilities on Cedar Key. Completed in 2003, the Cedar Key wastewater treatment plant (WWTP) now treats up to 180,000 gallons per day of domestic wastewater, and produces a high quality treated effluent that is distributed as reclaimed irrigation

water on the island. These infrastructure upgrades, and the resulting improvements in coastal water quality, were critical to the emergence of the Cedar Key shellfish industry.

Following the fishing net ban in Florida, the UF/IFAS and Sea Grant programs began working with local investors to develop a clam aquaculture industry using northern quahog clams (*Mercenaria mercenaria*) transplanted from the Florida east coast. With improved local water quality conditions, the shallow, well-flushed, muddy bottomed waters around Cedar Key proved to be ideal habitat for clams. Today, the clam industry in Cedar Key represents roughly 80 percent of Florida's clam industry, which has an overall statewide economic impact of over \$53 million annually. Due to the Cedar Key success, UF/IFAS/Sea Grant is now exploring the feasibility of farming the Sunray Venus clam (*Macrocallista nimbosa*), a species native the Florida Gulf coast, as well as oyster aquaculture.

In addition to providing a substantial economic impact to the region, shellfish farms also provide significant environmental benefits. As active filter feeders, clams constantly strain surface water, removing particulate matter that shades light penetration that is required by seagrasses. Through projects ranging from wastewater infrastructure improvements and land acquisitions, to living shoreline and artificial reef projects, the District continues to work with public and private partners to improve water quality in the Big Bend coastal region, benefiting the coastal industries. This emerging market offers a tremendous economic opportunity that is both environmentally and culturally compatible with the coastal communities of the region.

1.2.3.3 Innovative Agricultural Practices to Promote a Sustainable Regional Economy

Agriculture is a major economic driver in the Suwannee River Basin, and an integral part of the heritage of the region. In 2013 alone, agriculture and related industries generated \$4.5 billion in economic output and supported over 20,000 jobs in the Suwannee River Basin. Finding the right balance between water resource management, environmental protection, and agricultural production is a critical mission of the District.

The District was key in the formation and implementation of the SRP. Through the SRP, the District works with state, federal, and regional agencies, local governments, and agricultural operations to reduce nutrient loading and conserve water use through the voluntary implementation of BMPs. Now with 64 partners, the coalition has mobilized 89 percent of the dairies and 94 percent of the poultry farms in Florida's Suwannee River Basin to participate in a voluntary program to reduce nutrient loadings and to conserve water use throughout the region. The SRP works closely with FDACS to assist producers in enrolling in the FDACS BMP program.

Through agricultural cost-share programs, the District and FDEP partner with agricultural producers to increase irrigation efficiency, water conservation, and improve nutrient management. Cost-share funding is available for various projects including irrigation retrofits, soil moisture probes, fertigation systems, pump upgrades, and dairy wastewater system and nutrient management improvements. In July of 2016, FDEP awarded \$6 million in springs grant funding for the Sustainable Suwannee Pilot Program, which will offer financial incentives for agricultural producers to transition to less intensive, low input cropping systems, or possibly permanent conservation easements. The Pilot Program will also offer financial assistance for implementing

advanced water quality improvement technologies that can cost effectively reduce nutrient inputs. Potential technologies may include pump and treat processes, permeable reactive barriers, wood chip bioreactors, or denitrification and treatment wetlands. The goal of the Sustainable Suwannee Pilot Program is to reduce nutrient impacts on water resources while maintaining a strong, sustainable agricultural industry and private land ownership.

Continuing to work collaboratively, the District, FDEP, FDACS, UF/IFAS and UF Water Institute partnered together in 2015 to study advanced irrigation management technology and management strategies for row and field crops. This study will develop improved irrigation and fertilizer management practices to guide producers in the Suwannee River Basin. Field demonstrations will replicate various irrigation schedules and fertilizer regimes, and will examine and evaluate water savings and the potential nutrient movement across soil types specific to this region with corn, peanut, and cotton rotations. Each plot is equipped with a sensor that monitors key parameters at multiple depths. The measurements are captured and reported in real time. This information will be used to automate irrigation schedules and assist with fertilizer application schedules. Nutrient leaching will be measured using special meters and soil borings from the land surface to the top of the water table. Outcomes of this pilot project will provide producers research-based irrigation scheduling based on soil moisture sensor readings. These data will be used across the District to reduce the groundwater pumping and nutrient loading to water bodies. The results will help reduce water use and leaching of nutrients to the environment and potentially increase net farm income.

Agriculture in the Suwannee River Basin is changing rapidly due to market forces, technological advancements, and growing regulatory constraints (e.g., MFLs). Based on FDACS modeling data presented as the Florida Statewide Agricultural Irrigation Demand (FSAID; Marella et al. 2016), water use for agriculture is projected to increase by approximately 40 percent by 2040 in the Suwannee Basin. Considering these changes, continuing research and implementation of technologies and innovative agricultural practices, through programs like the Sustainable Suwannee Pilot Program, are key to meeting the challenge of protecting water resources and sustaining the region's agricultural economy.

1.2.3.4 Springs-Based Recreation and Tourism

The District encompasses a region defined by world-renowned springs, including the highest concentration of springs in Florida and the highest concentration of first-magnitude springs in the United States. Springs provide habitat for wildlife and plant species, as well as natural, recreational, and economic value. Recreational use of springs supports ecotourism in the region providing opportunities for swimming, diving, fishing, kayaking and canoeing, and wildlife viewing. A study completed in 2014 by the UF concluded that recreational use of springs constitutes a significant economic driver to the region (Borisova et al. 2015). From 2008 to 2013, spending attributed to springs recreation was \$83.8 million per year, including \$45.2 million from nonlocal visitors. The estimated total economic benefits associated with recreational use (due to direct spending, supply chain activity and income re-spending) supported 1,160 full-time and part-time jobs, labor income of \$30.42 million annually, value added of \$52.58 million annually, and industry

output (revenue) of \$94 million annually. This economic impact is expected to increase as a growing Florida population discovers the unique treasures of the regions' springs.

Springs in the District are vulnerable to increased nutrient loading and declining flows. Long-term preservation of this international resource is a major priority of the District, and this objective has recently been underscored by the Legislature which designated 14 springs and springs groups within the District as Outstanding Florida Springs. Significant legislative appropriations for springs projects have helped make this commitment a reality. The District is putting these funds to work by partnering with various agencies, local governments, landowners, and organizations through cost-share programs and projects to conduct restoration activities at numerous springs. Many of these projects are designed to restore groundwater levels and to reduce nutrient loading within priority water bodies and springsheds throughout the District. With the passage of Senate Bill (SB) 552, it is anticipated that funding levels for springs protection and restoration initiatives will be significant for years to come. Through these initiatives the District will continue to work with the FWC to ensure that springs-dependent species are adequately protected.

Through the District's land acquisition and Florida Forever (FF) programs, the District has purchased fee title and conservation easements to protect springs like the Turtle Spring tract in 2015. The purchase of the Turtle Spring tract, along the west bank of the Suwannee River, provides floodplain protection for the Suwannee River, Turtle Spring, and a portion of Fletcher Spring run. Springs preservation and restoration will continue to be a major priority of the District.

1.2.3.5 Hydrologic Restoration and Aquifer Recharge

The Suwannee River/Big Bend region of Florida is unique regarding the extent and degree of interaction between surface water and groundwater. In most parts of the state, the deeper Floridan aquifer is confined from the surficial aquifer and surface waters via layers of clay and other impervious strata. However, in large swaths of the Middle Suwannee River (MSR), LSR and Santa Fe River watersheds, the confining layer is thin and discontinuous or absent altogether. In these unconfined areas, the Floridan aquifer system is highly vulnerable to activities on the land surface but these areas also provide opportunities for more rapid recharge of groundwater from infiltration. Hydrologic restoration projects target historic floodplains, wetlands, and drainage patterns that had been altered to drain naturally wet areas prior to Florida's current environmental regulations. These projects in the District re-establish and improve natural systems such as wetlands, floodplains, native ecological communities, and aquifer recharge areas, which provide valuable water resource functions including: water quality treatment, water supply, flood water conveyance, attenuation, fish and wildlife habitat, and recreation.

An ongoing hydrologic restoration effort is the "Middle Suwannee River and Springs Restoration and Aquifer Recharge" project which is designed to increase groundwater levels and restore natural spring flows along the MSR in Lafayette and Dixie counties. The project involves the installation of hydraulic structures such as culverts, low-water crossings, and flashboard risers in southeast Lafayette and northeast Dixie counties with the objective of restoring natural water drainage patterns in a landscape that was previously altered decades ago; to the detriment of local water supplies. The project will recharge the aquifer with about 10 million gallons of water a day over about 1,500 acres of ponds and 4,000 acres of wetlands. The District will continue to

look for opportunities to restore natural hydrology and to encourage “assisted recharge” with the objectives of rehydrating wetlands, recharging aquifers, and improving both water quality and flood control. The District continues to look for opportunities to restore natural hydrology and to encourage “assisted recharge” with the objectives of rehydrating wetlands, recharging aquifers, and improving both water quality, and providing flood protection.

1.2.3.6 Summary

As discussed above, the economy of the Suwannee River/Big Bend region of Florida is largely dependent on the quality and sustainability of its natural resources. Accordingly, the District occupies a critically important niche at the intersection of environmental conservation and economic growth. Sound management of sustainable water resources and natural systems is not just the mission of the District, but also the underpinnings of future economic growth in the region.

Perhaps the greatest challenge facing the District in this regard is balancing increasing consumptive water use demands and pollutant loads associated with the expansion of more intense agricultural and urban land uses with the maintenance of regional environmental quality and natural systems. Furthermore, due to the unique geology of the Suwannee River/Big Bend region, surface, ground and coastal water resources are all closely interconnected. For this reason, increasing NO_3^- concentrations and associated symptoms of eutrophication in the Suwannee River Basin impacts the springs and rivers, and the coastal waters to which they discharge.

1.3 Suwannee River Basin Planning Area Description

The Suwannee River Basin drains a total area of approximately 9,950 square miles, of which approximately 4,250 square miles (43 percent) are in Florida, and 5,700 square miles (57 percent) are in Georgia. Appendix A identifies all government units that have jurisdiction over the Suwannee River Basin, including local, regional, state and federal units. The planning area for this Suwannee River Basin SWIM Plan encompasses approximately 4,250 square miles, including the following watersheds and their respective surface areas:

- Alapaha River Watershed = 108 square miles;
- Withlacoochee River Watershed = 275 square miles;
- Upper Suwannee River Watershed = 905 square miles;
- Suwannee River Watershed = 1,578 square miles; and
- Santa Fe River Watershed = 1,384 square miles.

The planning area also includes approximately seven linear miles of shoreline along the Gulf of Mexico. Figure 2 shows the boundaries of the Suwannee River Basin SWIM Plan area and the respective watersheds. For the purposes of this document, the term “basin” refers to the overall study area, while the term “watershed” refers to the drainage areas for each of the individual river systems addressed in the Plan.

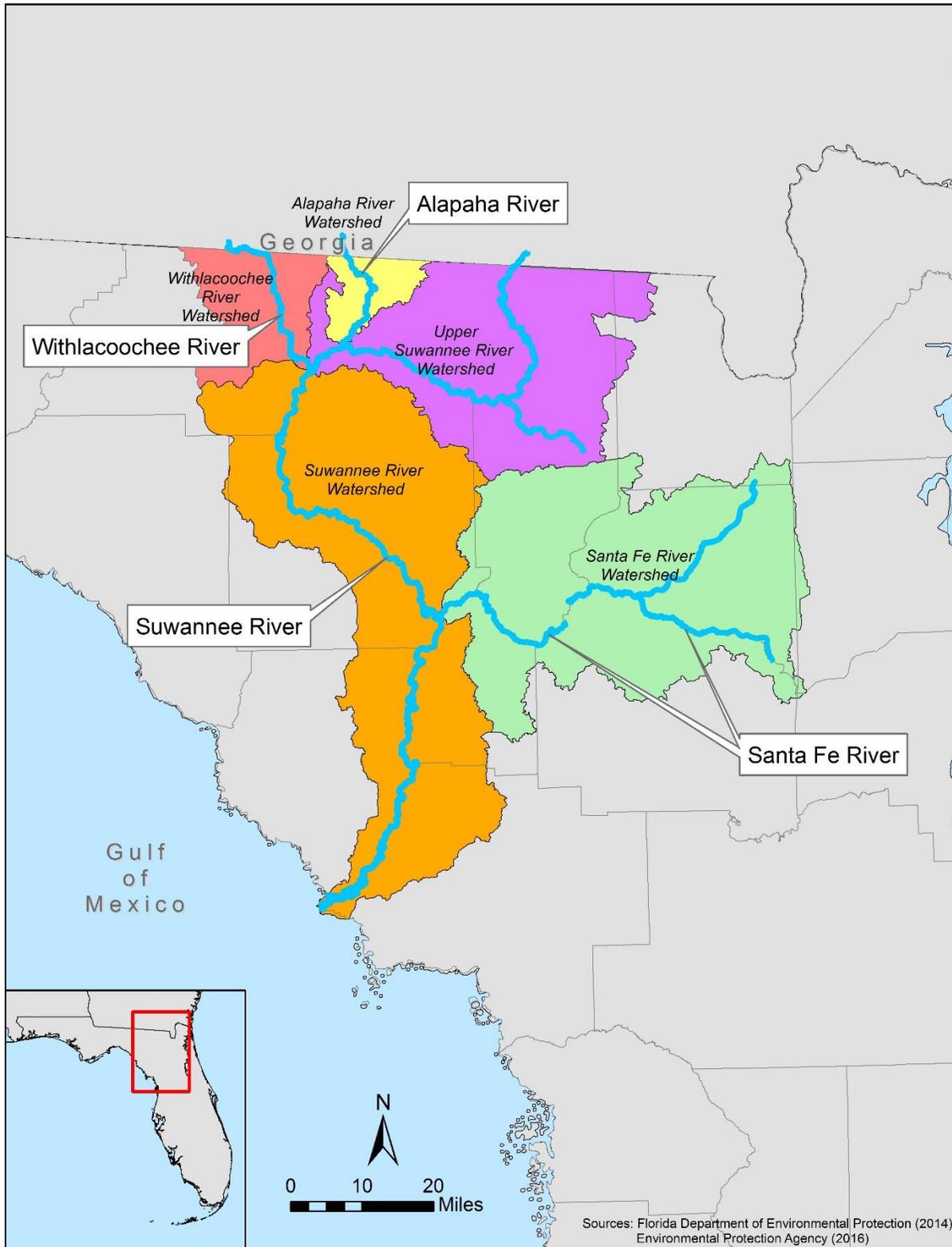


Figure 2. Consolidated Suwannee River Basin Watersheds

The subsections that follow provide a general characterization of Suwannee River Basin SWIM Plan area with respect to: physiography and topography; hydrogeology; hydrology and water chemistry; and ecological communities.

1.3.1 Physiography and Topography

The two major physiographic provinces in the District include the Northern Highlands and Gulf Coastal Lowlands (White 1970, Ceryak et al. 1983; Figure 3). Characteristics of the Northern Highlands include gently rolling topography, generally from 100 - 200 feet above mean sea level. Soils typically range from sand to clayey sand. Clayey sediments in the subsurface retard infiltration of rainwater. Because of the relatively low permeability sediments at or near the surface, local rainfall drainage in the Northern Highlands (i.e., the USR and Santa Fe River watersheds) is characterized by surface water features as shown in Figure 3. The Gulf Coastal Lowlands are characterized by elevations ranging from sea level to about 100 feet above mean sea level. The Gulf Coastal Lowlands feature a low relief, karstic topography, and shallow sandy soils with muck in many wetland areas. Karst landforms are widespread in the lowlands, with abundant sinkholes, sinking streams and springs, and a high degree of interconnection between surface water and groundwater systems. The Gulf Coastal Lowlands therefore have high rates of recharge to the limestone aquifer and extensive karst development, resulting in a groundwater-dominated (subsurface) drainage pattern throughout much of this region.

A significant geologic feature separating the two major physiographic provinces is the Cody Escarpment or Cody Scarp (depicted as a red line in Figure 3), which generally separates the Northern Highlands Physiographic Province and the Gulf Coastal Lowlands Physiographic Province. The Cody Scarp is an erosional geomorphologic feature which represents the break between the surface water dominated hydrology of the Northern Highlands, and the groundwater dominated hydrology of the Coastal Lowlands. The Cody Scarp region is characterized by active sinkholes, springs, sinking streams, and river rises (Ceryak et al., 1983). During average and lower flows, except for the Suwannee River, all rivers and streams, including the Santa Fe and Alapaha Rivers, are completely captured by sinkholes as they cross the Cody Scarp. Some subsequently re-emerge down gradient as river rises.

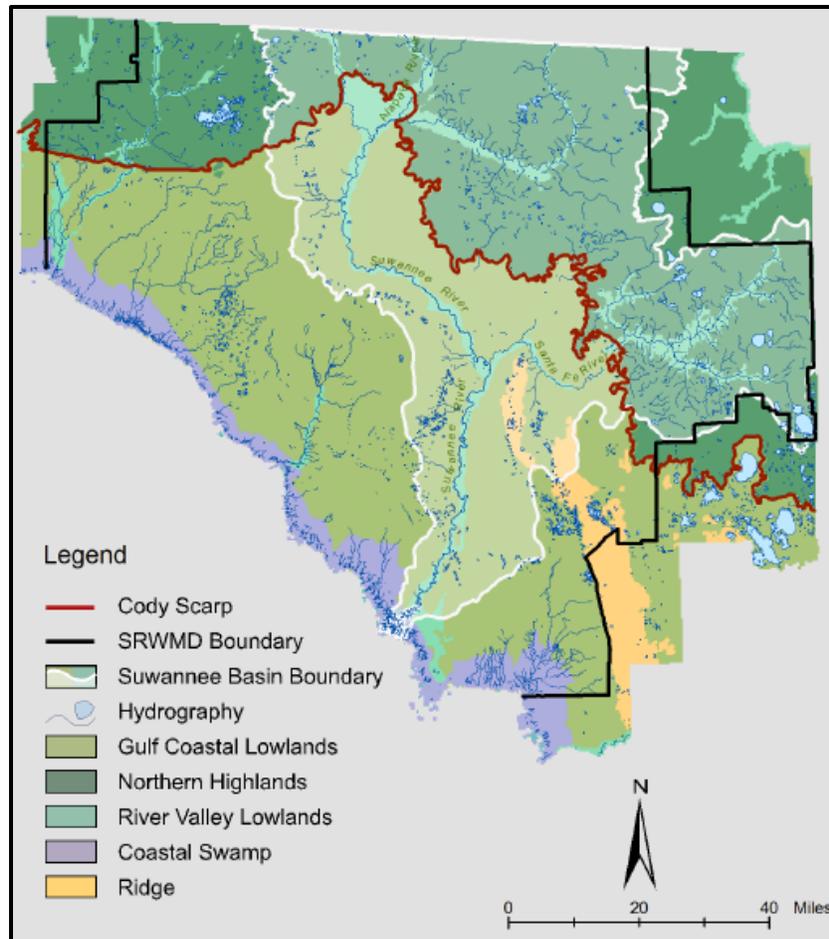


Figure 3. Physiographic Regions of the District (District 2010)

1.3.2 Hydrogeology

The District has three primary hydrostratigraphic units which are, in descending order, the unconfined surficial aquifer system, the intermediate aquifer system/intermediate confining unit (located in the northeastern and eastern portions of the District), and the upper Floridan aquifer (UFA). The UFA is highly productive and represents the primary source of water supply for all water use types in the District and provides baseflow to rivers and springs in much of the District.

The Cody Scarp approximates the transitional area between the confined and unconfined UFA (Figure 4). In the Northern Highlands region, which includes the USR and Santa Fe River watersheds, the UFA is overlain by a thick layer of clay that provides good confinement which delays recharge into the UFA, whereas, to the south and west in the Gulf Coastal Lowlands, these clay layers are generally absent and the UFA is generally unconfined. The UFA in the Gulf Coastal Lowlands region experiences very high rates of recharge by way of sinking streams, sinkholes, and diffuse recharge through the land surface. Therefore, in this area maintenance of groundwater levels is critically important to maintaining springflow and baseflow in rivers (e.g., the Lower Santa Fe and Ichetucknee Rivers).

The presence or absence of the Hawthorn Group, a low permeability geologic unit, determines whether the UFA is confined/semi-confined or unconfined (Scott 1988, 1992), respectively (Figure 4). In addition, the relative recharge rate is generally inversely proportional to the degree of confinement (i.e., the less confinement, the higher the recharge).

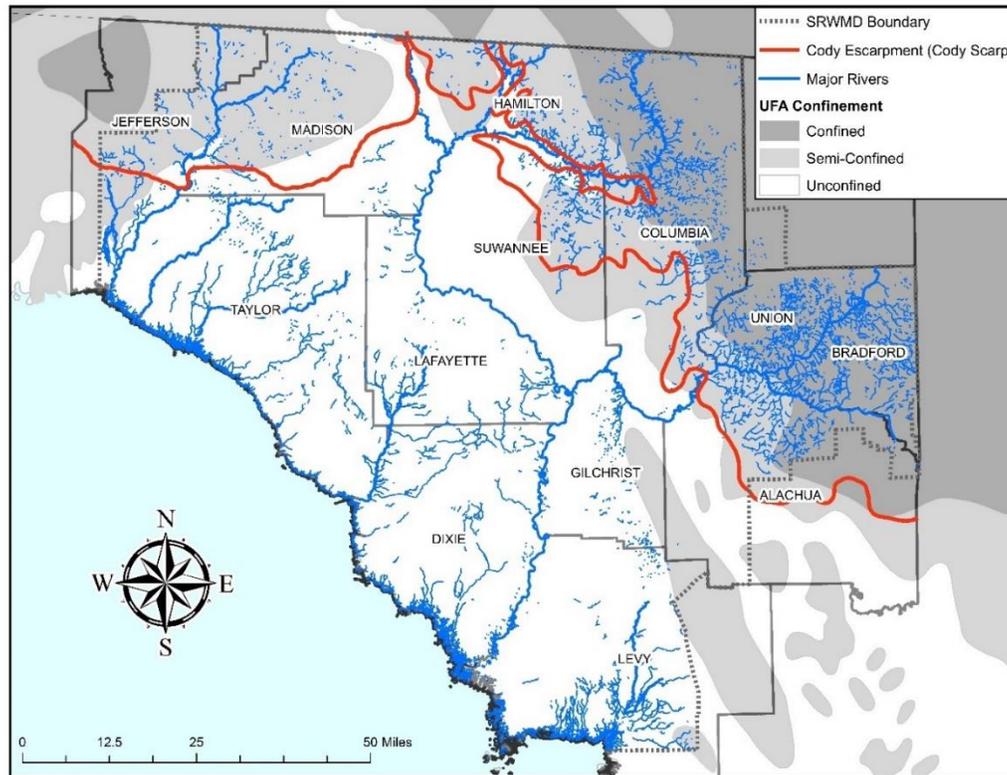


Figure 4. Confinement Conditions of the UFA within the District (confinement conditions from Miller, 1986)

1.3.3 Hydrology and Water Chemistry

The Suwannee River originates in the Okefenokee Swamp in southeastern Georgia, exiting the swamp through the remains of an earthen sill constructed in 1960 to provide fire protection for the Okefenokee National Wildlife Refuge (NWR). The Alapaha and Withlacoochee rivers originate in south-central Georgia and flow in a southerly direction until merging with the Suwannee within several miles of each other upstream of Ellaville. They contribute an average of 15 and 24 percent, respectively, to the average annual flow of the Suwannee (GEPD 2002). Surface flows in the USR and its two major tributaries fluctuate throughout the year, with the peak flows generally occurring during March and April. The Alapaha River is completely captured during low flows by solution sinks, leaving a dry river bed for much of its course in Florida. The river reemerges several miles to the south and joins the Suwannee at Alapaha Rise and Holton Creek.

From the river's origin in the Okefenokee Swamp to just upstream of White Springs its flow is heavily dependent upon surface drainage from the river's tributaries and seepage from the surficial aquifer. The Hawthorn Group thins in this region and the river enters the Gulf Coastal Lowlands, cutting into the Floridan Aquifer. From this area downstream, the river flow is

augmented by numerous springs and groundwater seepage, changing the chemistry and appearance of the waters.

Surface water chemistry of these river systems is largely dependent on the local geology through which the rivers are flowing. The cationic composition of the river is dominated by calcium and magnesium, because of limestone and dolomite dissolution in karst regions. The anionic composition displays an even more distinct change in response to geologic changes. The upper reaches of the river are dominated by chloride and sulfate. Downstream, as groundwater from the Floridan Aquifer enters the river, the anionic composition becomes dominated by bicarbonate-based chemical influence, because of the karst geology. Surface water drainage from swampy headwaters results in waters colored by tannins, with lower pH levels from organic acids derived from detrital decomposition, and lower specific conductivity. By contrast, those segments with more significant groundwater inputs typically exhibit higher pH and specific conductivity; however, dissolved oxygen (DO) levels are typically lower due to naturally low DO concentrations in groundwater aquifers.

Water quantity and water quality status and trends in the Suwannee River Basin are discussed in detail in sections 2.1 and 2.2 of this document, respectively.

1.3.4 Natural Systems

Natural systems are communities of plants and animals that are generally associated with a specific hydrologic regime. In the Suwannee River Basin natural systems include:

- Upland habitats;
- Freshwater habitats; and
- Marine/estuarine habitats.

These natural systems are briefly discussed below, using terminology of the Florida Natural Areas Inventory (FNAI 2010). A more detailed presentation on the natural systems in the Suwannee River Basin, including habitat for species designated as threatened or endangered, either by the State of Florida or the U.S. Fish and Wildlife Service (USFWS), and threats to habitats and species, are provided in Section 2.3.

1.3.4.1 Upland Habitats

Upland or terrestrial habitats in the Basin have historically been dominated by pine flatwoods (District 1991). Natural upland habitats in the Basin include communities such as upland hardwood forest, upland pine (e.g. longleaf pine (*Pinus palustris*) and scrubby flatwoods), upland mixed forest, mesic hammock, and sandhill and scrub communities that provide habitat for numerous wildlife species. Hardwood forested uplands may be mesic or xeric, dominated primarily deciduous or deciduous/evergreen upland species such as American beech (*Fagus grandifolia*), southern magnolia (*Magnolia grandiflora*), dogwood (*Cornus spp.*), and others. Mesic hammocks are characterized by a closed evergreen canopy of species such as live oak (*Quercus virginiana*), southern magnolia, pignut hickory (*Carya glabra*), and saw palmetto (*Serenoa repens*). Xeric hammocks include a closed canopy of evergreen hardwoods such as sand live oak (*Quercus geminata*) and saw palmetto. These upland habitats represent areas important for

groundwater recharge in the Basin and therefore important to maintaining flows in the springs in the Suwannee River Basin.

- High pine and scrub occur on elevated areas or hills characterized by mesic or xeric forest or shrublands of pine or pine mixed with deciduous hardwoods. These forests can be mixes of southern red oak (*Quercus falcata*), longleaf or shortleaf pine (*Pinus echinata*), and other mixed hardwoods; upland pine savannas of longleaf pine, loblolly pine (*Pinus taeda*), and/or shortleaf pine, and wiregrass (*Aristida stricta*); sandhill forests with longleaf pine and turkey oak (*Quercus laevis*) on high sandy areas; scrub, also sandy, with sand pine and scrub oaks with or without Florida rosemary (*Ceratiola ericoides*).
- Mesic flatwoods and dry prairies are flatland areas with scattered pines over saw palmetto, longleaf pine, and wiregrass. In the absence of trees (due to frequent fire), dry prairies may occur, supporting a low cover of shrubby live oak, wiregrass, stunted saw palmetto, and broomsedge bluestem (*Andropogon virginicus*).

The transition between upland and wetland communities is characterized by habitat ecotones that reflect changes in soil, hydrology, and vegetation. Transitional habitats (between wetlands and uplands) often represent areas subject to infrequent flood events and/or the gradient along which elevation and hydrologic changes occur, for example, along geologic scarps between floodplains and upland communities. Vegetation in these communities may shift between wetland and upland species, depending on flood waters, runoff, or disturbance. Representative habitats in the Suwannee River Basin include:

- Coastal wet prairie and pine flatwoods areas: These areas, located landward of the coastal marshes, are vegetated with sand cordgrass (*Spartina bakeri*), various sedges, cabbage palm (*Sabal palmetto*), red cedar (*Juniperus virginiana*), slash pine (*Pinus elliotii*), salt bushes (*Baccharis spp.*), and wax myrtle (*Morella cerifera*).
- Lowland hardwood hammocks: These areas are landward of forested riparian swamps and along the landward edge of forested wetland areas. They are vegetated with live and laurel oak (*Quercus laurifolia*), pignut hickory, loblolly pine, red cedar, and cabbage palm.
- Low pine flatwoods: These are areas dominated by a sparse overstory of pine (slash or loblolly pine) with an understory of fetterbush (*Lyonia lucida*), gallberry (*Ilex glabra*), mixed sedges, and rushes.

1.3.4.2 Freshwater Habitats

Freshwater habitats include riparian forests, floodplains, seepage slopes, wet prairies, and floodplain wetlands dominated by flood tolerant species such as cypress trees (*Taxodium spp.*), as well as spring systems and lakes. These wetland resources fulfill a variety of functions including fish and wildlife habitat, flood storage, runoff filtration, coastal storm surge buffering, and nursery areas for economically important species (commercial and recreational fisheries and game species).

- The Suwannee River and its tributaries are characterized by a variety of forested wetland communities or swamps. In the upper portions of the river, riparian areas along the riverbank include cypress and Ogeechee tupelo (*Nyssa ogeche*). Floodplain areas adjoining the upper river tend to be dominated by mixed hardwood and pine forests which are infrequently flooded. Downstream, various types of bottomland hardwood swamp and floodplain swamp communities predominate in the floodplain. More frequently flooded swamps ("floodplain swamps" according to the FNAI description) are dominated by bald and pond cypress (*Taxodium distichum* and *T. ascendens*, respectively), water tupelo (*Nyssa aquatica*), swamp tupelo (*Nyssa sylvatica* var. *biflora*), ash (*Fraxinus* spp.), and other tree species adapted to frequent flooding. Areas flooded less frequently exhibit a more mixed canopy which includes various oak species (live oak, laurel oak, swamp chestnut oak (*Quercus michauxii*), black oak (*Quercus velutina*)), hickory (*Carya* spp.), sweetgum (*Liquidambar styraciflua*), blackgum (*Nyssa sylvatica*), American elm (*Ulmus americanus*), American hornbeam (*Carpinus caroliniana*), hop hornbeam (*Ostrya virginiana*), hackberry (*Celtis laevigata*), and other species. The composition of the floodplain forest at a particular site is determined by a complex array of environmental factors, including topography, frequency, depth, and duration of flooding, and soil types. Tidal forests are another major feature in the Suwannee River Basin, and occur along the freshwater portions of the river that are under tidal influence.
- Marshes in the Basin are characterized by herbaceous plant species and range from sedge bogs to wet prairies (vegetated with pickerelweed (*Pontederia cordata*), arrowhead (*Sagittaria* spp.), sawgrass (*Cladium jamaicense*) and other sedges) to permanently flooded marshes dominated by floating leaved aquatics such as waterlily (*Nymphaea* spp.) and pondlily (*Nuphar* spp.). Ponds and lakes are inundated depressions deep enough to limit light penetration over most of the waterbody and limit emergent vegetation to primarily the shallower perimeter.
- Springs and spring-run streams are also conspicuous in the Suwannee River Basin. These systems that occur as perennial flow ways with clear water from deep aquifer headwaters, often with a limestone bottom with submerged aquatic vegetation (SAV) and emergent aquatic vegetation (EAV), but this habitat is based on the presence of the spring rather than dominant vegetation.
- Lakes and their associated palustrine wetland communities occur in the Northern Highlands physiographic region of the USR watershed. The Northern Peninsula Karst Plains region characterizes the upper portions of the Suwannee basin and is generally a "well-drained flat to rolling karst upland containing a diverse group of small lakes" (Griffith et al. 1994). Agriculture is extensive throughout this region and nutrient levels are variable, but many lakes have high phosphorus and nutrient values, which are some of the highest in northern Florida. Chemical and physical characteristics range widely, but in general the lakes tend to be slightly acidic, with low to moderate alkalinity, high nutrients, and some color. Downstream of the Northern Highlands, the region is characterized by karst at or near the surface, across the District from Jefferson County south to Levy County. Pine flatwoods and swamp forest occur on poorly drained soils. Reflecting the limestone

influence, pH, alkalinity, and conductivity values in lakes are very high for this part of Florida; nutrients are moderately low and lake color is variable but generally low.

1.3.4.3 Marine/Estuarine Habitats

The tremendous freshwater flow volume from the Suwannee River supports a large estuary at the mouth of the river, including oyster reefs, seagrass beds, and hard and soft bottom habitat, and is large enough to significantly affect conditions outside the Basin proper along the coastline. Estuarine and coastal habitats are influenced most strongly by salinity and tidal inundation from the sea and occur landward or upstream until soil or water salinities are less than 0.5 ppt (and are therefore considered freshwater systems). These systems are described based on substrate, fauna, or vegetation, depending on the dominant features.

- Hard bottom habitat (consolidated bottom) consists of subtidal, intertidal, and supratidal area of relatively hard, naturally formed mineral matter (e.g., coquina limerock and relic reefs); it includes corals, algae, blue-green mat-forming algae, and can include sparse seagrasses sparse, if present. Soft bottom habitat is composed of unconsolidated substrates in subtidal, intertidal, and supratidal areas of loose mineral matter such as gravel, marl, sand and shell, or mud, with corals, algae, and possibly seagrasses.
- Oyster reefs occur in subtidal or intertidal areas formed by oysters that build and grow on successive generations of oysters. The reefs may be subtidal or intertidal and are dominated by the eastern oyster (*Crassostrea virginica*).
- Seagrass beds may occur across subtidal or intertidal areas, and are characterized by rooted vascular macrophytes. Florida's Big Bend encompasses the largest contiguous seagrass bed in the state. Dominant seagrass inshore includes shoal grass (*Halodule wrightii*), widgeon grass (*Ruppia maritima*), and Engelmann's seagrass (*Halophila engelmannii*). Offshore areas are dominated by manatee grass (*Syringodium filiforme*) and turtle grass (*Thalassia testudinum*), as well as red drift algae (*Gracilaria spp.*, *Digenia simplex*, *Laurencia poitei*).

1.3.5 Land Use

Land use conversions from native habitats to farming by humans were recorded as early as 1562 when the French encountered the Timucuan along the Big Bend coast (Thom et al. 2015). After the near-eradication of aboriginal populations by disease and slavery, European settlers began farming the land as early as the 1800s. The Suwannee River Basin remains mostly rural, with relatively little urban development or intense agriculture. Utilizing District GIS land use data, Table 2 summarizes 1995 and 2011 land use distribution in acres, and shows the net change in the various land use categories over this time period. Figures 5 and 6 show the distribution of land uses in 1995 and 2011, respectively. It is important to note that the District 2011 land use data are not available for the entirety of the USR or Santa Fe watersheds. The net change in land use categories between 1995 and 2011 are based upon the Suwannee River Basin where data are available for both years.

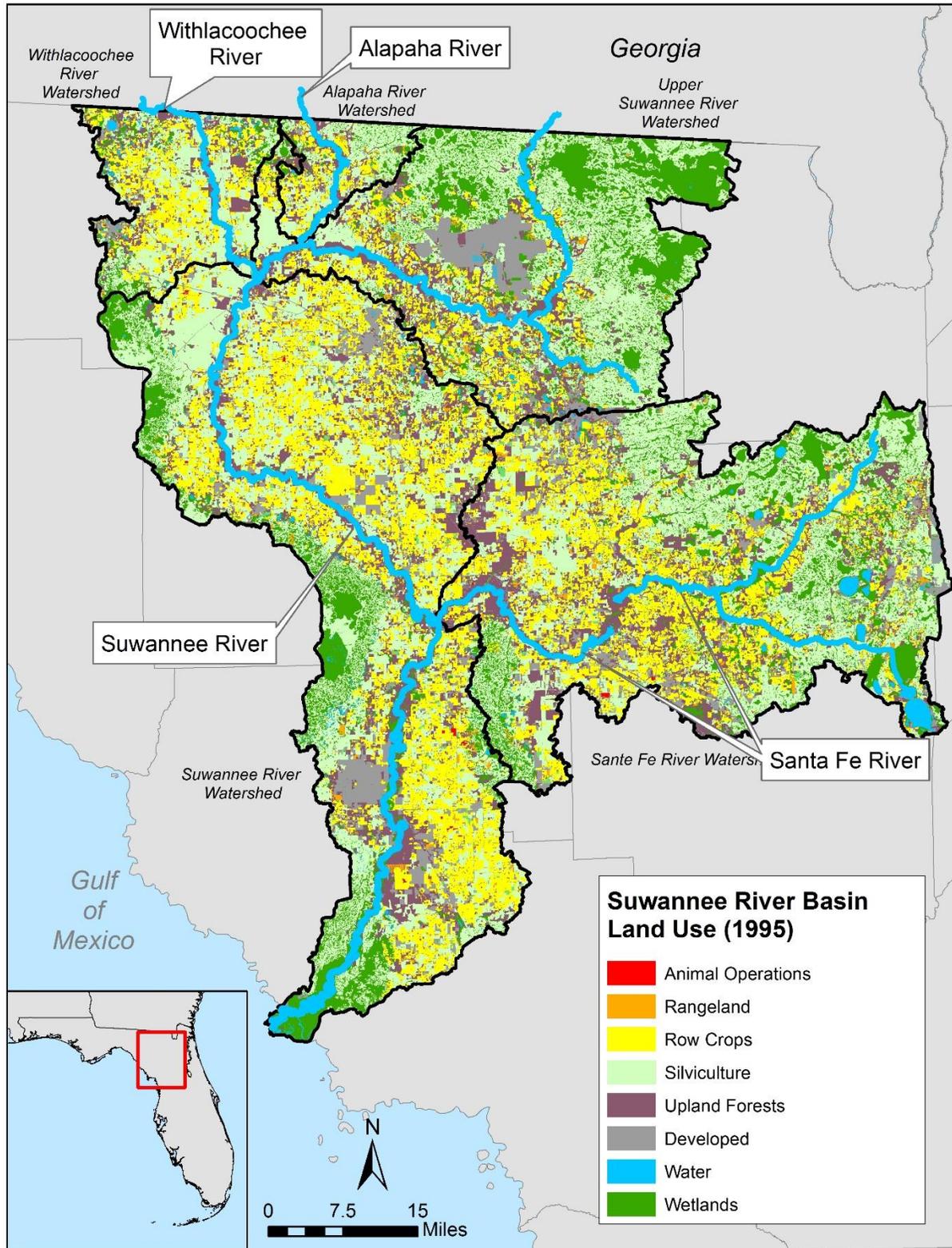


Figure 5. Land use/ Land cover in the Suwannee River Basin in 1995

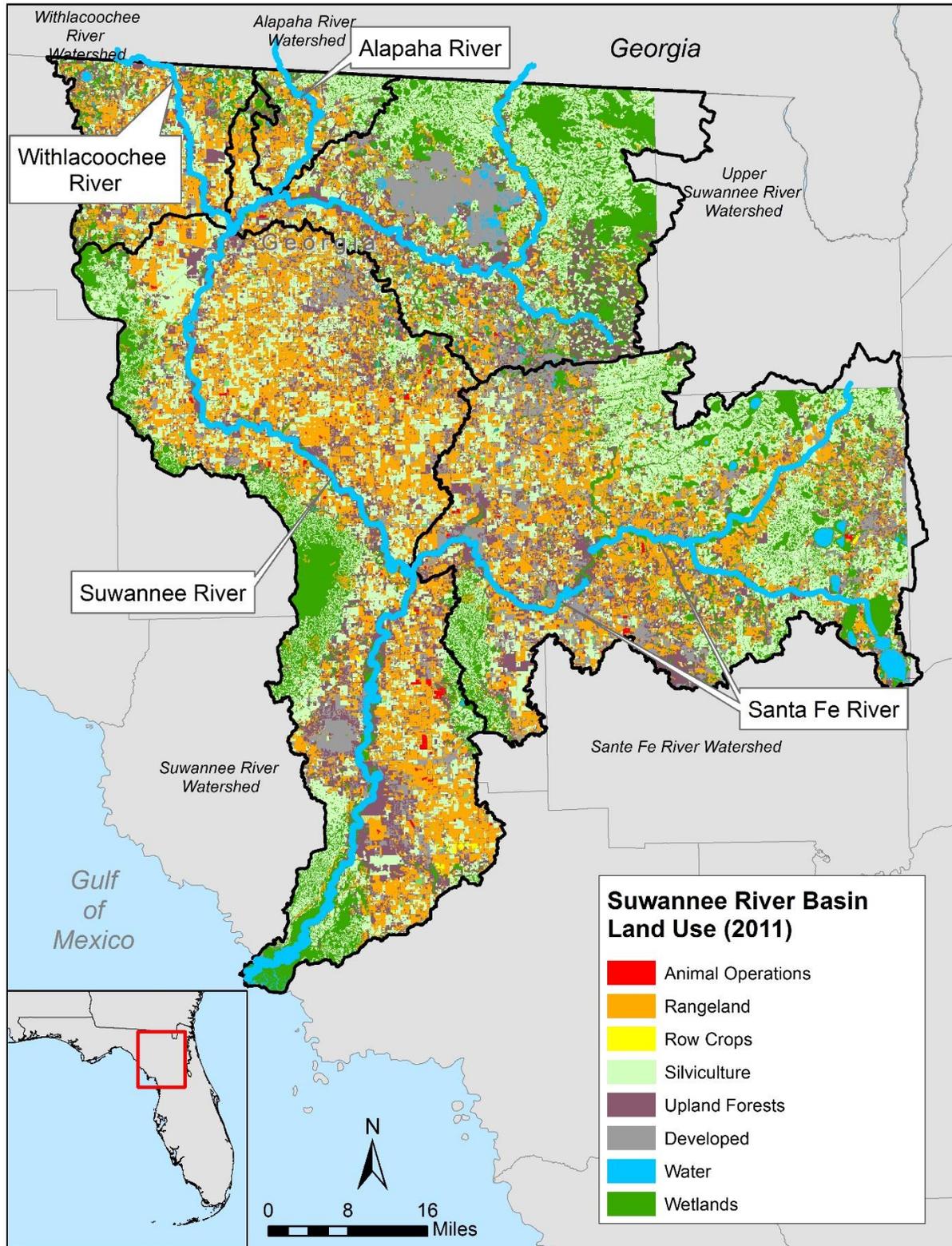


Figure 6. Land use/ Land cover in the Suwannee River Basin in 2011 (note: the watershed boundary extends beyond the District land use coverage available)

Table 2. Land Use Changes in the Suwannee River Basin 1995 to 2011

Land Use Category	1995 Acres	2011 Acres	Net Change Acres
Animal Operations	4,956	9,881	4,925
Rangeland	31,521	257,205	225,683
Row Crops	583,354	373,900	-209,454
Rural Open Land	14,161	11,312	-2,850
Silviculture	945,218	782,944	-162,274
Upland Forests	410,876	451,186	40,310
Developed	245,173	276,904	31,731
Water	36,324	32,880	-3,445
Wetlands	387,198	462,466	75,268

As with any land use mapping information effort, accurate photointerpretation is critical, and classification errors can lead to misleading conclusions. In the Suwannee River Basin, the distinction between silviculture and natural upland forests can be difficult. Nonetheless this analysis shows that over the 15-year period between 1995 and 2011 forested lands dedicated to silviculture operations, and row crops, have declined, mostly giving way to cleared rangeland for cattle grazing and livestock operations. Livestock operations (dairy, cattle, poultry, and swine) have increased near the confluences of the Suwannee River with the Withlacoochee and Ichetucknee rivers. Silviculture and agriculture are the primary land uses west of the river. Much of the coastal lowlands and the flatwoods on the east side of the Alapaha River are in privately held pine plantations. Recent land use changes identified by FDEP (2014a) include phosphate mining in southeastern Hamilton County and aquaculture increases along the coast, particularly in Levy County.

Conversely, both wetlands and other upland forests (non-silviculture) have increased substantially. The large increase in wetlands could potentially be explained by the clearing of forested wetlands for timber production in areas that were previously classified as silviculture (the loss of trees reduces evapotranspiration and increases surface water which may be mapped as wetlands). However, these increases could also reflect public land acquisition over this time. The District's 2017 Florida Forever (FF) Work Plan Update reports that 129,690 acres have been purchased for conservation in the Suwannee River Basin through outright purchases or conservation easements. The total area of publicly owned lands within the Suwannee River Basin in 2016 is approximately 309,069 acres (FDEP and DMS 2016). Figure 7 shows the current extent of publicly-owned conservation lands in the Suwannee River Basin.

In all cases, agriculture (including silviculture) alters the water budgets (Blann et al. 2009), the volume and timing of runoff, and the effects of vegetation (e.g., reduced erosion, nutrient uptake) in natural watersheds. However, the hydrologic impacts of agriculture vary substantially based on the intensity of land disturbance. The impact of agriculture operations involving only land clearing (e.g., cattle grazing) tend to be less severe with respect to water resources than those that also involve the alteration of natural drainage patterns and groundwater levels (e.g., row crops).

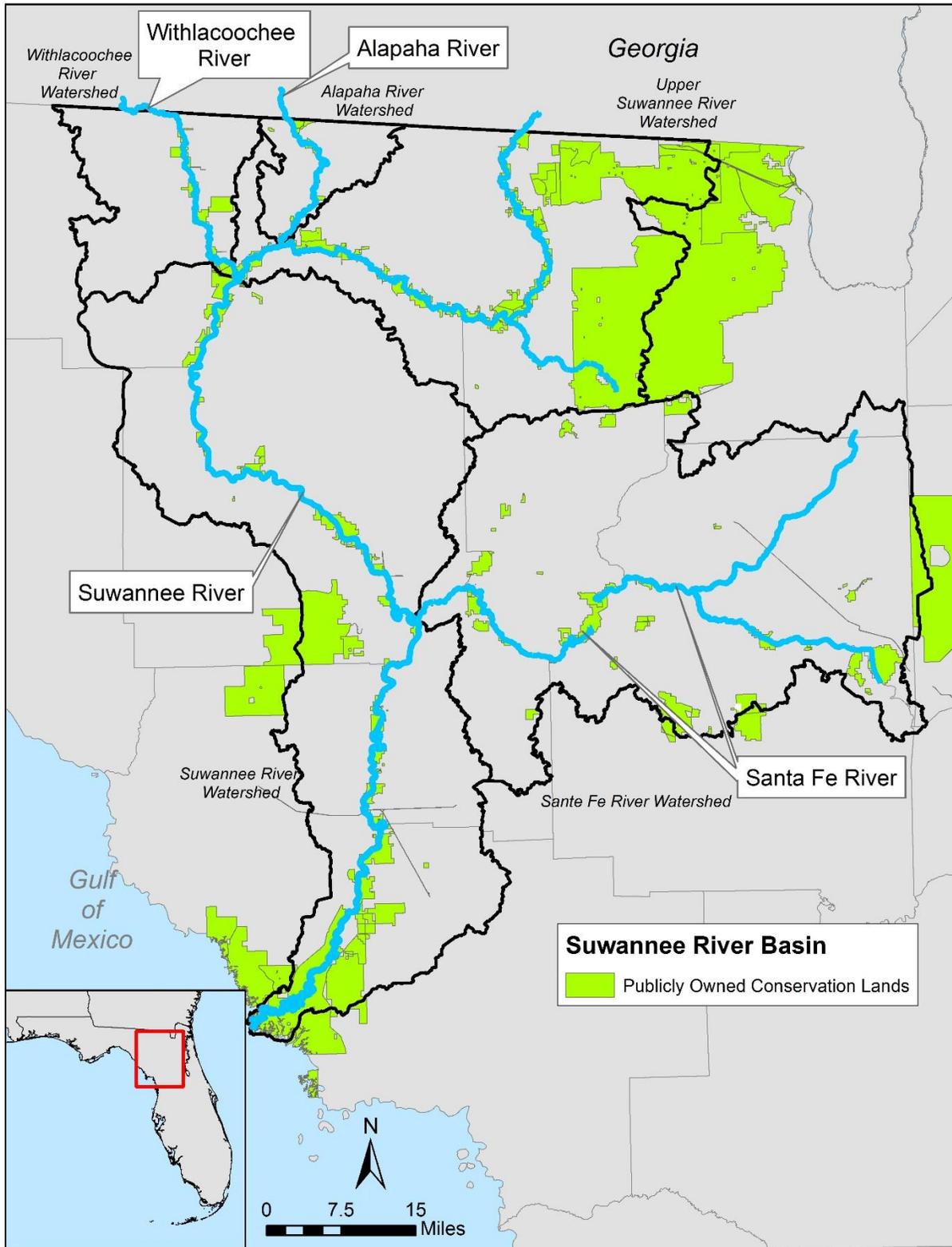


Figure 7. Extent of publicly owned conservation lands in the Suwannee River Basin (FDEP and DMS 2016)

In summary, managed forests (silviculture) and other forested uplands constitute 46 percent of the Basin, while wetlands (both forested and herbaceous) encompass 17 percent of the Basin. Combined, these two land use classes constitute 64 percent of the Basin area. The more intense agricultural land uses of row crops and rangeland comprise 14 and 10 percent of the basin, respectively. Urban land development has increased slightly, mostly as growth around existing urbanized areas, but still only constitutes 10 percent of the Basin land area. The greatest amount of urbanization has occurred east of the Suwannee River, in the Santa Fe watershed, due to its proximity to Gainesville and several other incorporated areas (Thom et al. 2015).

Due to the rural characteristics of the Suwannee River Basin, habitat fragmentation is relatively minimal compared to other areas in Florida. In addition, the rivers and streams in the Basin remain free flowing (e.g., not impounded or dammed). However, the expansion of more intense agricultural and urban land uses will likely put greater pressure on water resources and natural systems in the future. Therefore, conservation and management of existing natural systems, including the maintenance of minimum flows and levels, and water quality, offer the best means by which to prevent further habitat loss, fragmentation, and/or water resource degradation in the Basin.

2.0 Issues and Drivers

As discussed in Section 1.2.3 above, the economic vitality of the Suwannee River Basin is closely related to the health of the Basin's natural systems. Over the past few decades, concerns have been raised related to the ecology of the springs and streams of the Suwannee River Basin. The primary issues affecting the ecology of the Suwannee River Basin have included changes in spring discharge and stream flow, changes in water quality - especially as related to the increased amount of nitrogen and algae in surface waters – and changes in the health of various natural system components, both on the landscape and in the waterways. This chapter focuses on the topics of water quantity, water quality, and natural systems. A description of the primary issues affecting the health of the Suwannee River Basin is included in this chapter to provide the reader with sufficient background information to understand the basis for the various management activities and projects that are proposed in this SWIM Plan.

The status and trends and primary factors influencing spring discharge and stream flows are discussed in Section 2.1, which focuses on water quantity. Section 2.2 addresses the primary factors affecting water quality within the Basin, and Section 2.3 focuses on the status and trends of natural systems of the Suwannee River Basin.

2.1 Water Quantity

Ensuring that sustainable natural system is maintained while meeting a full range of water needs is a strategic priority of the District. In portions of the Suwannee River Basin, the use of traditional, fresh groundwater sources is at or above its sustainable limit, therefore water supply planning, establishing water withdrawal limits that avoid environmental impacts, and supporting the management of lands to enhance water supply are critical to maintaining a sustainable water supply. This section summarizes the ongoing activities of the Water Supply Planning, MFLs, and Land Management Programs, and highlights the challenges facing the District. An overview of the significant water bodies in the Suwannee River Basin, their current status, and current and future challenges facing the Suwannee River Basin are described. This information provides the basis for the management activities and projects proposed in Sections 3 and 4.

Flow in natural systems can be altered by climate patterns, consumptive use of water, and the type and intensity of land use in spring recharge areas and river drainage basins. Seasonal differences in precipitation intensity, along with longer-term (decadal and longer) oscillations in climate alter the magnitude of precipitation and the volume of spring and river flow in the District (Cao 2000, Kelly and Gore 2008). Flow can also be altered by the consumptive use of groundwater and human alterations to the landscape. Groundwater withdrawals may reduce spring flow, and diminish natural discharge from the aquifer to rivers. Land use alterations such as ditching and draining, or the addition of impervious surfaces common in urban settings may increase the rate and magnitude of surface runoff to rivers, and diminish storage and aquifer recharge. The result is more rapid peak flows following storms and diminished flow in rivers during low flow periods. Projects to enhance and restore natural flow regimes will be a priority for the District in reaching its long-term sustainability goal.

2.1.1 Regulatory Framework

As stated in the District's Strategic Plan for 2017-2022, the District's mission is to protect and manage water resources using science-based solutions to support natural systems and the needs of the public. To meet this mission, the District's regulatory framework includes establishing MFLs for priority water bodies within the District and implementing multi-district water supply planning and complimentary consumptive use regulatory practices. These regulatory programs are briefly summarized below.

2.1.1.1 Minimum Flows and Minimum Water Levels (MFLs)

The District is currently establishing and implementing, through its regulatory authority, environmental flows and levels for all priority water bodies within the District. Minimum Flows and Levels, known as MFLs under Florida statutes, are established by determining a baseline hydrology and assessing the allowable flow reduction from the baseline hydrologic regime that will prevent "significant harm" to the water resources or ecology of the system.

The District's MFLs program is a means to protect water resources from significant harm. The District's adopted MFLs can be found in 40B-8, F.A.C. Established MFLs are used as a basis for imposing limitations on withdrawals of groundwater and surface water, for reviewing proposed surface water management and storage systems and stormwater management systems, and for imposing water shortage restrictions (40B-8.011(4), F.A.C.). Computer simulation models are used to evaluate the effects of existing and proposed consumptive uses and the likelihood they might cause significant harm. Regardless of whether there is an established MFL, to obtain a water use permit, the use may not cause harm to the water resource (40B-2.301(2)(g), F.A.C.). Additionally, the use will not be permitted if it will cause any MFL to be violated. Information on MFLs adopted to date by the District and their status and trends is provided above in Sections 2.1 and 2.1.1.

Priority water bodies, including rivers, springs, and lakes, are identified on the District's MFLs Priority List and Schedule, which is reviewed and updated annually (District 2016). In developing MFLs, current State Water Policy (62-40.473, F.A.C.) provides that consideration be given to natural seasonal fluctuations in water flows or levels, non-consumptive uses, and environmental water resource values (WRVs), including:

- WRV 1 - Recreation In and On the Water;
- WRV 2 - Fish and Wildlife Habitats and the Passage of Fish;
- WRV 3 - Estuarine Resources;
- WRV 4 - Transfer of Detrital Material;
- WRV 5 - Maintenance of Freshwater Storage and Supply;
- WRV 6 - Aesthetic and Scenic Attributes;
- WRV 7 - Filtration and Absorption of Nutrients and other Pollutants;
- WRV 8 - Sediment Loads;
- WRV 9 - Water Quality; and

- WRV 10 – Navigation.

MFLs are the primary benchmark for evaluating the status of riverine health from a quantity perspective. The basis for establishing and adopting protective MFLs on each priority waterbody, or group of priority water bodies is detailed in the MFL technical documents. Rules specifying these MFLs are established for use by the District's Resource Management Division in evaluating consumptive use permits. The status of priority waterbodies is evaluated as MFL rules are adopted and monitored thereafter. If MFLs are below, or projected to fall within 20 years below, the applicable MFL, a MFL Prevention or Recovery Strategy must be developed in compliance with Section 373.0421, F.S., to recover the system. Details on the status of each coastal river are included below.

2.1.1.2 Consumptive Use

The District also conducts Water Supply Assessments to evaluate regional-scale groundwater availability and water supply demand and determine whether adequate water is available to meet water demands while protecting natural systems. Estimates of current use and projections of future demands over a 20-year planning horizon are prepared for six categories: Public Supply, Domestic Self-Supply, Agriculture, Commercial/Industrial/Institutional, Power Generation, and Landscape/Recreational/Aesthetic. These current and future demands are evaluated against established MFLs or interim constraints, where MFLs are not yet complete on priority waterbodies, to identify regions where the use of fresh groundwater to meet current or future demands could cause a negative impact to natural systems. Regional water supply plans are subsequently developed to address identified future resource constraints. Water Supply Assessments are updated on a five-year cycle to incorporate changing trends, additional MFLs, and improved statistical and modeling tools to estimate impact.

The District completed a Water Supply Assessment in 2010, with the planning period through the year 2030 (District 2010). The assessment included low-range and high-range demand projections for six water-use categories ranked from highest to lowest pursuant to 2010 volumes:

- Agricultural;
- Industrial Commercial and Institutional;
- Public Supply;
- Domestic Self Supply;
- Thermo-Electric Power Generation; and
- Landscape/Recreation/Aesthetic.

The District also reviews and issues Consumptive Water Use permits as a means to control and maintain public and private water use in a manner consistent with Water Supply Assessment projections.

2.1.2 Status and Trends

The Suwannee River is the second largest river system in Florida by mean annual flow and drains approximately 9,950 square miles, of which about 57 percent is located in Georgia. The river is

about 246 miles long. Originating at its headwaters in the Okefenokee Swamp in southeastern Georgia, the Suwannee River flows south and southwest, gaining significant volume from the Alapaha, Withlacoochee, and Santa Fe rivers, to its mouth at the Gulf of Mexico near Suwannee, Florida, about 15 miles northwest of Cedar Key. Decaying vegetation in the Okefenokee Swamp and floodplain wetlands is responsible for the river's tannic color, which is maintained as the river flows south.

The Suwannee River is the largest blackwater river system in the southeastern United States (Katz and Raabe 2005). The watershed comprises a mixture of subtropical forests, wetlands, springs, blackwater rivers, and estuarine habitats. This variety of habitats supports a range of species from temperate to subtropical, including several endangered and protected species. The Basin and estuary support an economy based primarily on forestry, agriculture, commercial and recreational fisheries, clam farming, and ecotourism. The Suwannee River is designated by the State of Florida as an Outstanding Florida Water (OFW) and as "special waters" within the OFW designation.

This section provides an overview of the hydrology of each watershed in the Suwannee River Basin, as well as proposed or adopted MFLs (and associated priority WRVs) for water bodies in the Basin. Updated analyses of long-term trends in river/spring discharge were performed, and a description of these analyses and results are provided in Appendix F1.

2.1.2.1 Upper Suwannee River

The USR refers to the portion of the Suwannee River upstream of the United States Geological Survey (USGS) gage near Ellaville (02319500) to its headwaters at the Okefenokee Swamp in Georgia. The focus of the MFL study is that portion of the USR within the state of Florida (Figure 8). There are 56 identified springs along the USR, with six classified by the District as Priority Springs for MFLs assessment. The USR was designated as a Water Resource Caution area in 2011, and is part of the North Florida Regional Water Supply Planning (NFRWSP) Region. The USR MFL is scheduled for adoption in 2018.

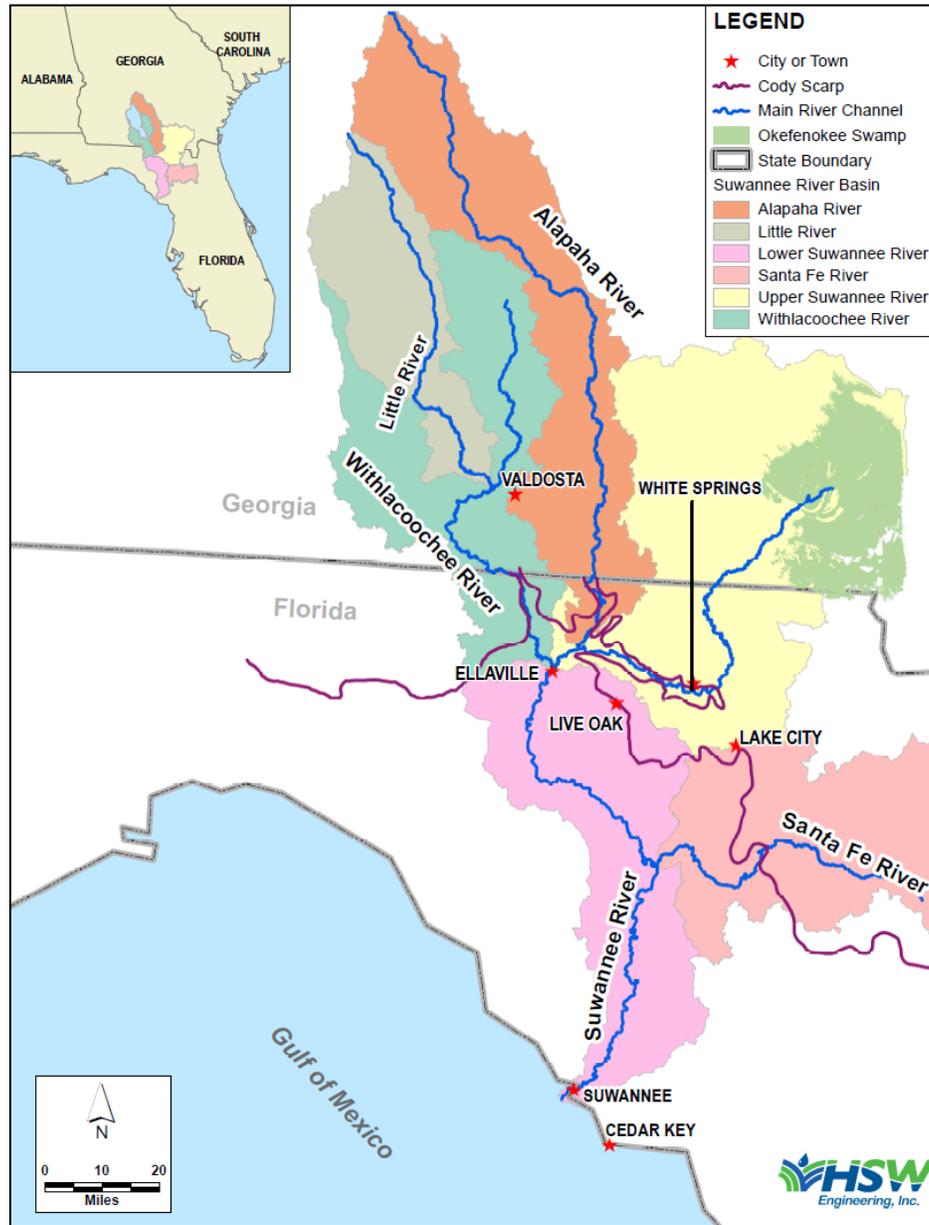


Figure 8. Suwannee River Basin in Florida and Georgia (HSW Draft MFL Report 2016)

2.1.2.2 Alapaha River

The Alapaha River is the first major tributary joining the Suwannee River. The Alapaha River watershed encompasses roughly 108 square miles of Hamilton County. This area represents less than 10 percent of the total drainage watershed, which covers approximately 1,400 square miles and extends northward nearly 100 miles into southern Georgia (Figure 9). When the river flows are below average, much of the river is captured by sinkholes about four miles south of the Florida-Georgia state line, and the remainder of the river channel in Florida is dry for a substantial portion of the year (Ceryak 1977). The river re-emerges at the Alapaha Rise (Ceryak 1977) and at Holton Creek, two of the priority springs of the USR. The Alapaha River was designated as a Water Resource Caution area in 2011, and is part of the NFRWSP Region. The Alapaha River MFL is scheduled for adoption in 2018.



Figure 9. Total extent of the Alapaha River drainage watershed

2.1.2.3 Withlacoochee River and Madison Blue Spring

The Withlacoochee River has a 2,360 square-mile watershed area and is the second major tributary to the Suwannee River. Only about 30 miles of river length are in Florida, and it serves as the border between Madison and Hamilton counties. The upper stretch of the river extends into the southern portion of Georgia near Tifton and Moultrie. The river contains two priority springs, one of which, Madison Blue Spring, has an established MFL (Figure 10). The Withlacoochee River MFL is scheduled for adoption in 2018.

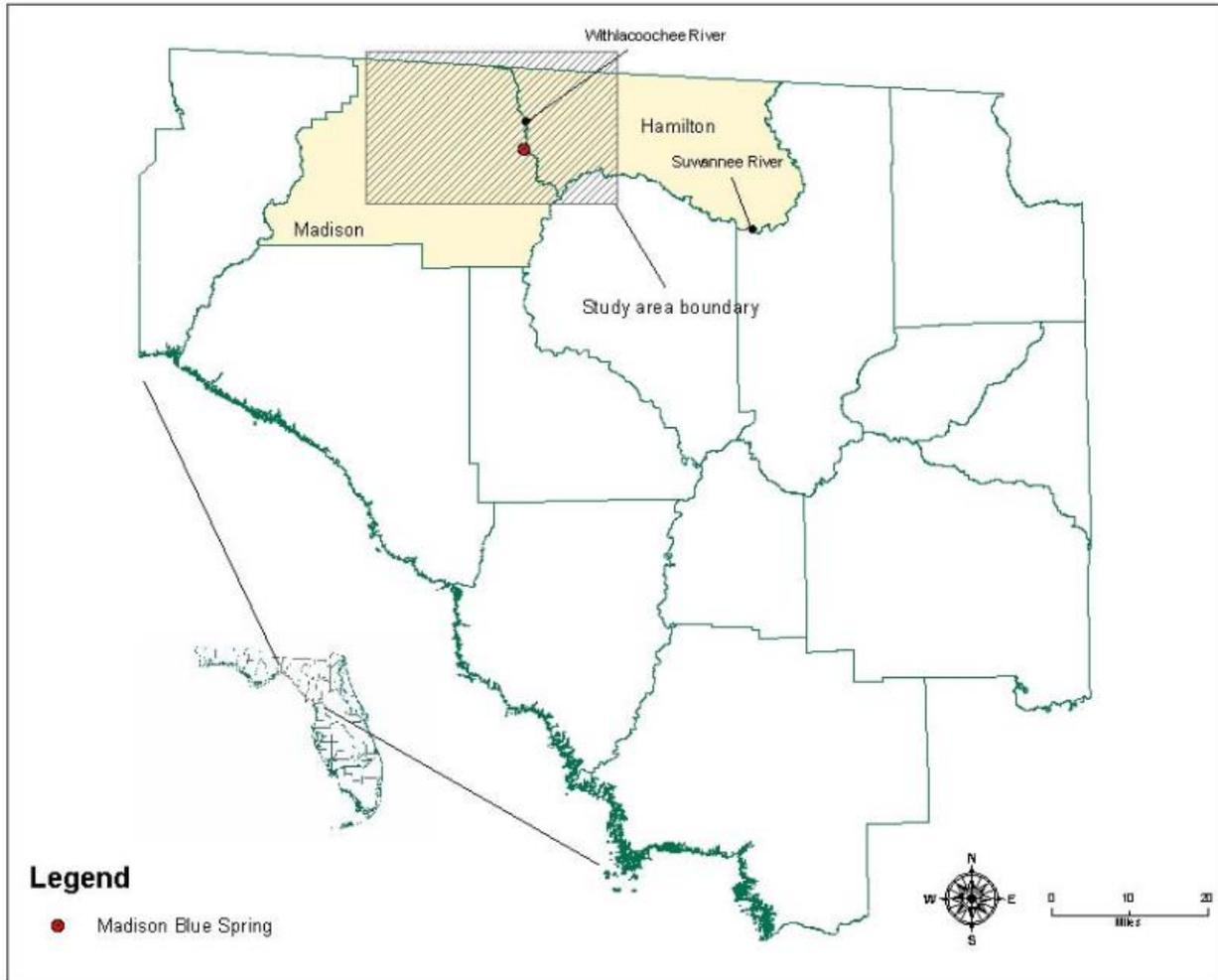


Figure 10. Location of the Withlacoochee River within the District boundary (Madison Blue Spring is shown for reference)

The Madison Blue Spring MFL was established in 2005. During the development of the spring MFL, five of the ten WRV were either directly or indirectly applicable as the available data were identified, collected, and analyzed. Those included the following: Recreation In and On the Water (WRV 1), Fish and Wildlife Habitats and the Passage of Fish (WRV 2), Maintenance of Freshwater Storage and Supply (WRV 5), Aesthetic and Scenic Attributes (WRV 6), and Water Quality (WRV 9). Established MFLs were set to ensure the spring's contribution of flow to the Withlacoochee River, protect the critical ecological value of shoal habitat, provide protection from significant harm to the aquatic habitat and fish passage in the river, and provide adequate flow to prevent significant harm to the recreational and scenic/aesthetic attributes to the spring.

2.1.2.4 Middle Suwannee River

The Middle Suwannee River (MSR), a 92-mile portion of the Suwannee River, includes the section of the river between the long-term USGS gages between Ellaville and Branford (Figure 11). The MSR of the Suwannee River system is highly utilized for public recreation and includes several important conservation areas, including three State Parks (SPs), District-owned lands, and various county and municipal parks. Twenty-two springs that contribute flow to the MSR have

been prioritized for MFL establishment. Of these, three are categorized as first magnitude springs, sixteen are second magnitude, and the remaining two are third magnitude. In 2016, the Florida Legislature passed the Florida Springs and Aquifer Protection Act, designating Outstanding Florida Springs. Fourteen springs or spring groups are listed as Outstanding Florida Springs including: Falmouth, Lafayette Blue, Peacock, and Troy (Section 373.802(4), F.S.). These four outstanding springs had emergency MFLs adopted in July 2017, pending final adoption of the MSR MFL (Section 373.042(2), F.S.). The MSR is set for MFL adoption in 2018, at which time WRVs will be analyzed to determine impacts from allowable percent flow reductions of the baseline flow regime.



Figure 11. Middle Suwannee River MFL study area (AMEC Draft MFL Report, 2016)

2.1.2.5 Santa Fe River System

The Santa Fe River is the third major tributary of the Suwannee River system and is the only major tributary wholly located within Florida and the District. The Santa Fe River system is in the eastern part of the District (Figure 2) and is designated as an OFW. The Santa Fe system includes a significant transition between the upper and lower river segments regarding the extent and degree of interaction between surface water and groundwater. In the upper watershed, the deeper Floridan aquifer is confined from the surficial aquifer and surface waters via layers of clay and other impervious strata. However, below the River Rise the confining layer is thin and discontinuous or absent altogether. This lack of a distinct confining layer gives rise to numerous artesian springs.

The Santa Fe River has a total length of approximately 80 miles from where it originates in the Santa Fe and Little Santa Fe lakes, flowing westward and eventually going completely underground at the Santa Fe Sink. The River travels underground for around three miles before it resurfaces at the Santa Fe Rise, having gained significant groundwater contribution, and continues approximately 30 miles below River Rise to its confluence with the Suwannee River. The natural land bridge by the 3-mile underground portion of the river acts as a divide forming two distinct reaches of the river: The Upper Santa Fe and the Lower Santa Fe. The Lower Santa Fe is fed mainly by groundwater discharge and multiple major springs occur in the Lower Santa Fe River Basin (Table 3), including six springs or spring groups designated as Outstanding Florida Springs (Section 373.802(4), F.S.): Hornsby, Columbia, Treehouse, Poe, Devil's Ear, and the Ichetucknee Group, which feeds the Ichetucknee River. The Ichetucknee River is an entirely spring-fed system which receives water from multiple spring vents along its six-mile reach. The Ichetucknee River contributes approximately 15 to 20 percent of the total flow of the Lower Santa Fe River and has heavy recreational use as a Florida SP.

Table 3. List of Priority Springs in the Santa Fe River Basin

- | | |
|---------------------------|--|
| • Santa Fe Rise | • ALA112971 (Treehouse) Spring |
| • Hornsby Spring | • Columbia Spring |
| • Poe Spring | • COL101974 (Unnamed) Spring |
| • Rum Island Spring | • Devil's Ear Spring (Ginnie Spring Group) |
| • July Spring | • GIL1012973 (Siphon Creek Rise) |
| • Ichetucknee Head Spring | • Mission Spring |
| • Devil's Eye | • Grassy Hole |
| • Mill Pond | • Blue Hole Spring |

The District's MFLs for the Santa Fe river and springs were developed in 2007 (Upper Santa Fe) and 2013 (Lower Santa Fe) respectively. A baseline period of flow was specified for each system. The reports also specified the maximum flow reduction due to withdrawals from the baseline hydrologic regime to avoid significant harm to the water resources or the ecology of these systems. A further description of each of these MFLs is provided below.

Upper Santa Fe River

A baseline was determined from available data to establish the MFL regime for this segment. The available literature and data, along with refined hydraulic modeling, was used to identify the

relationship between baseline flows and the impacts of flow reduction. The analysis focused on Wildlife Habitats and the Passage of Fish (WRV 2) at two USGS gages on the river: Graham (02320700) and Worthington Spring (02321500). The limiting fish passage depths, and habitat relationships through analysis of wetted perimeter and aquatic habitat modeling, were investigated. The final recommendation was based on the wetted perimeter and limited withdrawals to times when the mean daily flow in the river is equal to or greater than a specific frequency flow at each gage. No change in the historic condition, due to withdrawals, is allowed when flow is below a certain frequency. The Upper Santa Fe River is in a Water Resource Caution Area, and is included in the NFPWSP. Proposed projects in this region include water storage and aquifer recharge to sustain baseflows and recover aquifer levels. Projects may be implemented to store water and sustain baseflows in this river reach.

Lower Santa Fe and Ichetucknee River and Priority Springs

The available literature and data, along with refined hydraulic modeling, was used to identify the relationship between baseline flows and the impacts of flow reduction. The analysis focused on Wildlife Habitats and the Passage of Fish (WRV 2) at the Fort White USGS gage (02322500) on the Lower Santa Fe River and a separate gage on the Ichetucknee River (02322700), which was also analyzed for recreation impacts. The limiting fish passage depths, and habitat suitability relationships, through analysis of wetted perimeter and aquatic habitat modeling, were closely investigated. The final flow recommendations were found to be already exceeded at the time of MFL adoption (62-42.300, F.A.C.). The Lower Santa Fe and Ichetucknee Rivers and associated priority springs are in recovery with estimated flow deficits of 17 cubic feet per second (cfs) at the Ft White gage and 3 cfs at the Ichetucknee River gage. The Recovery Strategy for the Lower Santa Fe River Basin was approved in April 2014 and outlined the actions needed to restore minimum flows in the region (District 2014). The Lower Santa Fe River is in a Water Resource Caution Area, and is included in the NFPWSP. The identification and implementation of water supply projects to recover the Lower Santa Fe and Ichetucknee Rivers is ongoing.

2.1.2.6 Lower Suwannee River, Fanning/Little Fanning Spring, and Manatee Spring

The Lower Suwannee River (LSR), as described in this document, includes the Suwannee River from the USGS gauge at Wilcox (02323500) to the river mouth, including the estuary of the river (the region including Suwannee Sound, Horseshoe Cove, Cedar Key, and the nearshore waters of the Gulf of Mexico influenced by freshwater discharge from the river) (Figure 12). The LSR study area includes several important conservation areas, including two NWRs, two SPs, a state Wildlife Management Area (WMA), and numerous parcels of District conservation lands. The LSR has two historic first magnitude springs, Fanning and Manatee Springs which are designated as Outstanding Florida Springs (Section 373.802(4), F.S.).

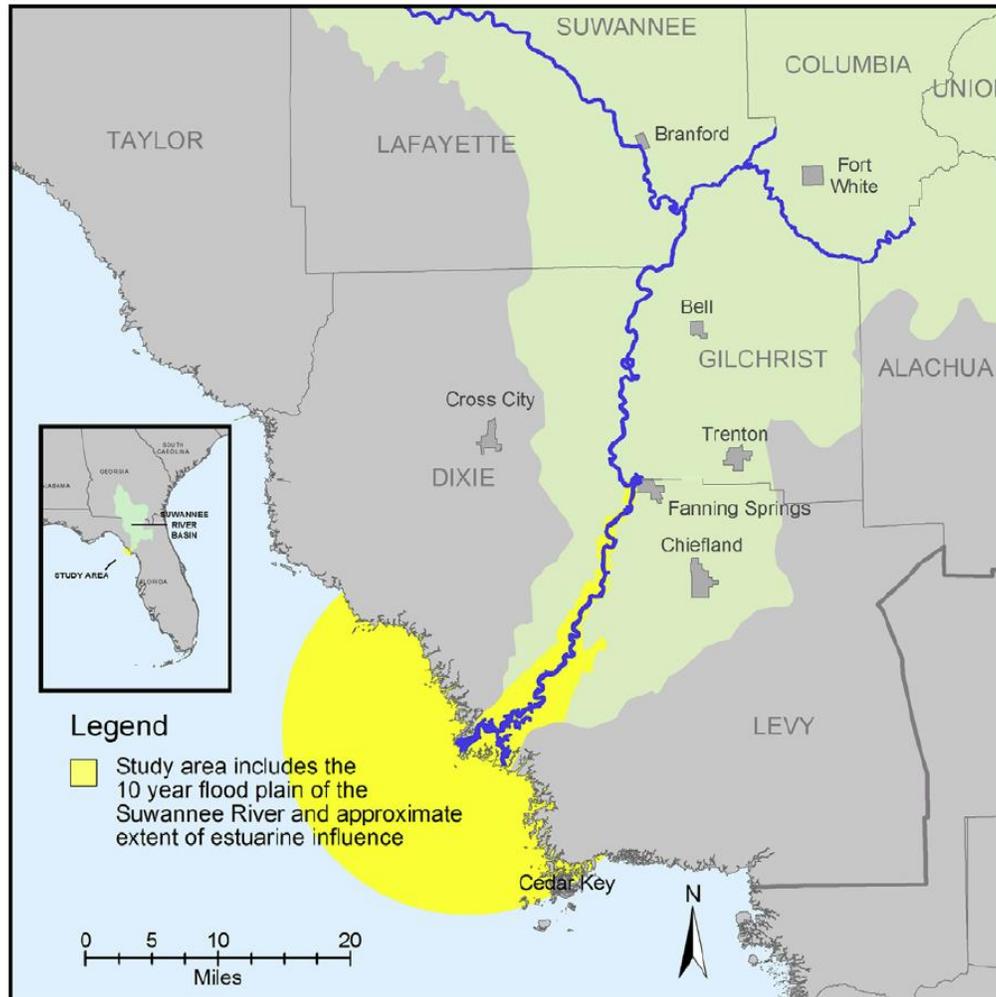


Figure 12. Map showing the Lower Suwannee River study area

The limiting WRVs of Recreation In and On the Water (WRV 1), Fish and Wildlife Habitats and the Passage of Fish (WRV 2), and Aesthetic and Scenic Attributes (WRV 6) were selected for both the Fanning/Little Fanning and Manatee Spring MFLs. For Fanning/Little Fanning Spring a minimum level to be met a certain percent of time each year was recommended during the cold season for manatee passage and the prevention of extended temporal river water intrusion into the spring. For Manatee Spring a MFL was established during the cold time each year to allow manatee access to the spring and limit river water intrusion. An annual MFL value was also established to maintain a certain percentage of each spring's historic flow regime.

The MFL for the LSR recommended two seasonal minimum flows for protection of downstream freshwater SAV along with the elevation necessary for manatee access at Fanning Spring. All WRVs were explicitly addressed during MFL establishment including the established limiting values of Fish and Wildlife Habitats and the Passage of Fish (WRV 2), Estuarine Resources (WRV 3), and Water Quality (WRV 9). The MFL rule for Manatee, Fanning/Little Fanning, and the LSR system was established in 2006 (F.A.C. 40B-8.041).

2.1.3 Regulatory Issues

The District's 2010 Water Supply Assessment identified four regions in the northeastern portion of the Suwannee River Basin where the availability of fresh groundwater may be constrained based on water supply demands in this District and the adjacent St. John's River Water Management District (SJRWMD). Four water resource caution areas were designated for the USR, Upper Santa Fe River, Lower Santa Fe River, and Alapaha River (Figure 13). Joint water supply planning was initiated for the northeastern portion of this District and the northern portion of SJRWMD. This planning effort was conducted collaboratively with FDEP, this District, and the SJRWMD as part of the North Florida Regional Water Supply Partnership (NFRWSP). The Partnership encompasses 14 counties, five of which are wholly within this District and three located within both districts (Figure 14). This Partnership resulted in approval of NFRWSP.

The NFRWSP provides a detailed examination of available water supplies, projected groundwater demands in this region, and potential alternative water supply projects to meet groundwater demand where fresh groundwater use is constrained. Within the planning region (see Figure 14), the NFRWSP projects 117 million gallons per day (MGD) in increased demand by 2035. Of the 117 MGD increase, 46 MGD are within this District's portion of the planning area. Districtwide water demands are projected to increase by 71 MGD through 2035.

The NFRWSP determined that fresh groundwater alone cannot supply the projected 117 MGD increase in water demand within the planning region through 2035 without causing unacceptable impacts to water resources. Projects to reduce or offset demand along with projects to develop and manage alternative water supplies are critical to ensuring sustainable water supplies. Demand related scenarios include increased water conservation and increased use of reclaimed water. Supply side techniques that can be implemented by water users and suppliers to sustain water resources and optimize water yield from water supply sources include aquifer recharge, aquifer storage and recovery, hydration of wetlands, water storage projects, water supply system optimization and interconnection, and non-potable and potable reuse.

Alternative water supply sources need to be developed to help meet projected demand for certain water uses that don't require drinking water quality. These alternative sources include brackish groundwater, reclaimed water, desalinated seawater, stormwater, and surface water. These alternative sources typically require greater treatment than groundwater to produce drinking water quality; however, when lesser quality is acceptable, these sources can offset groundwater demand for irrigation and industrial uses. Projects implemented within the NFRWSP planning region are expected to provide water supply benefits that sustain freshwater flow to the Gulf. Project concepts detailed in the plan can be applied outside the planning region to sustain freshwater flows to the Gulf. Continued identification and implementation of water supply projects throughout the District is a strategic priority. These projects will enhance groundwater flow to priority water bodies and sustain freshwater flow to the Gulf.

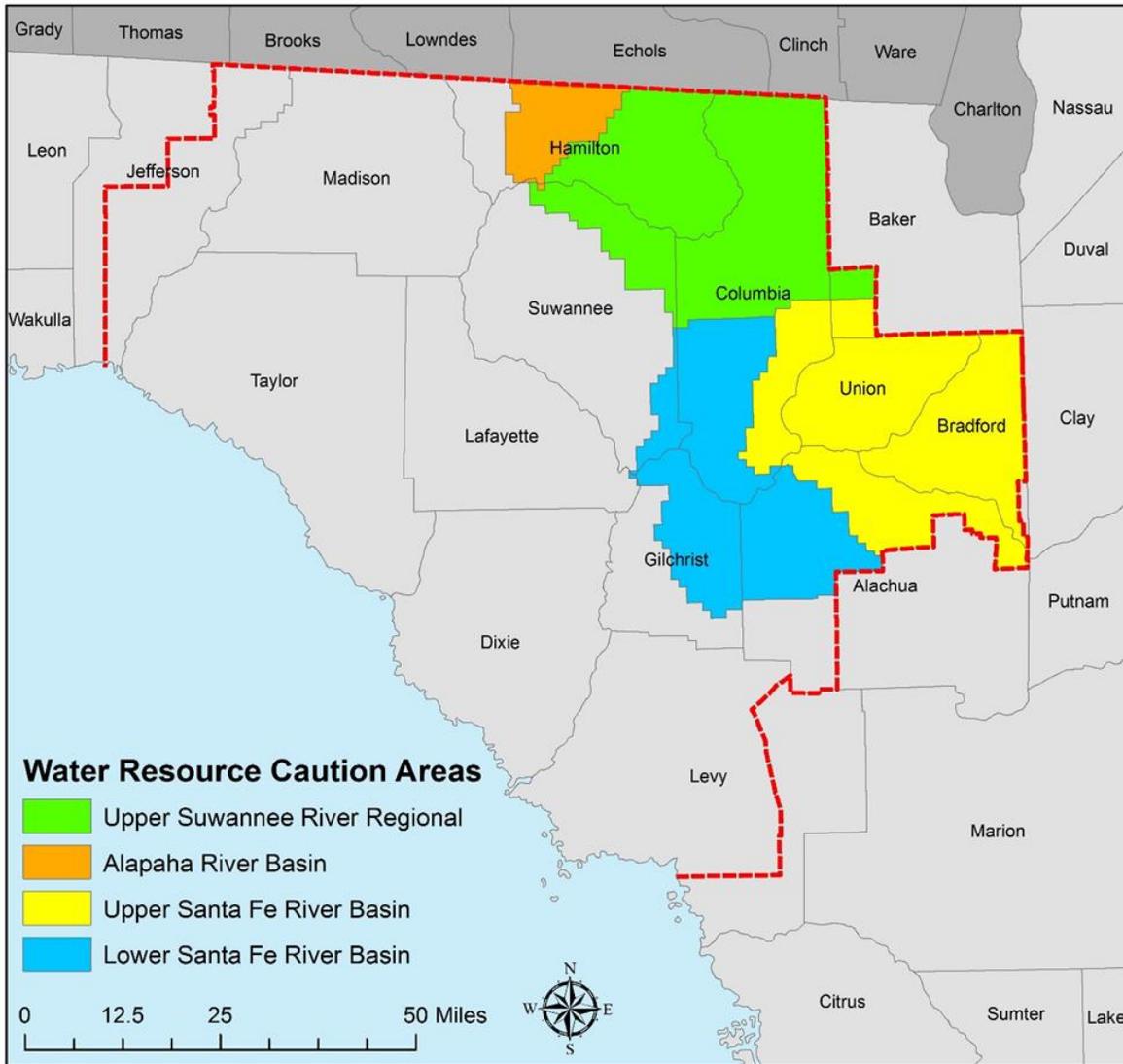


Figure 13. Water Resource Caution Areas

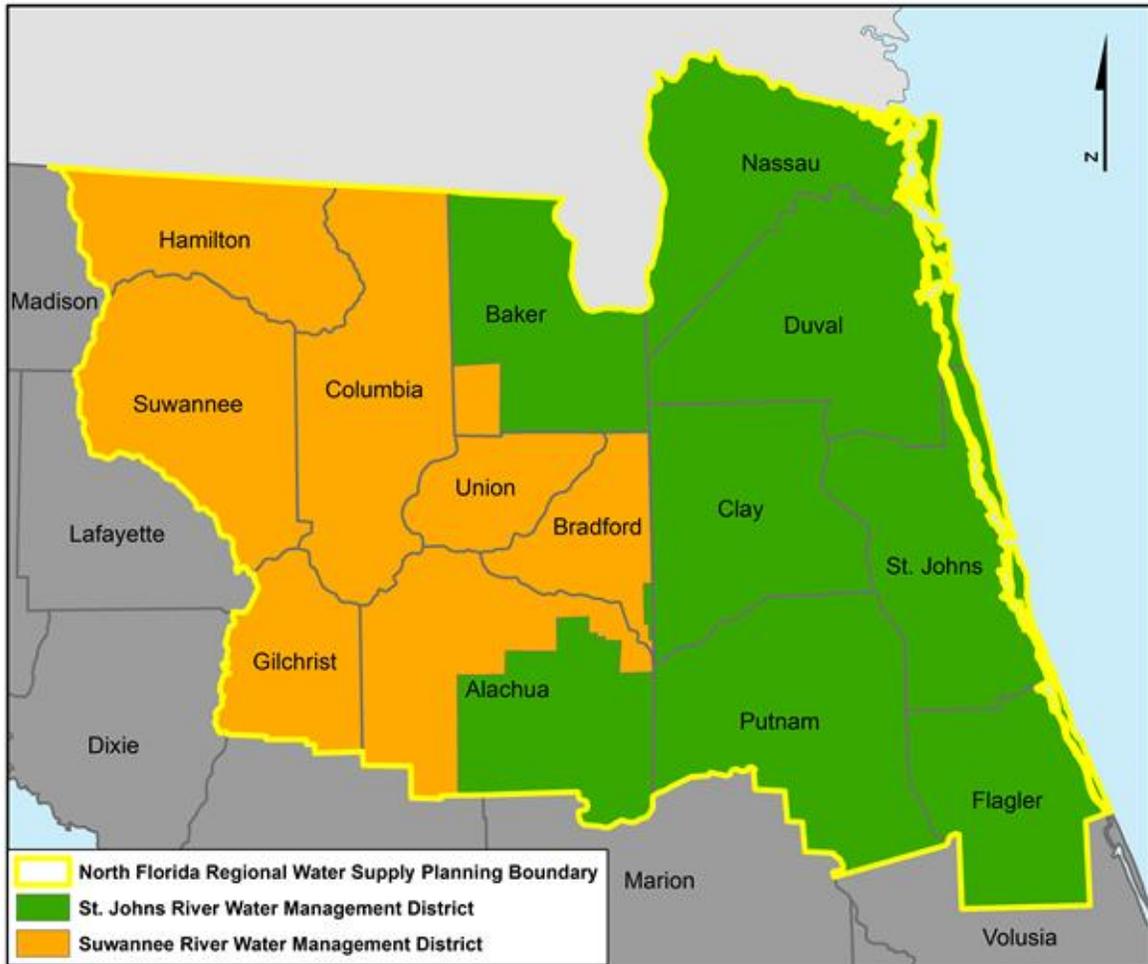


Figure 14. North Florida Regional Water Supply Planning Partnership. From SJRWMD and District 2016

2.1.4 Threats to Water Quantity

In portions of the Suwannee River Basin the use of traditional, fresh groundwater sources is at or above its sustainable limit. The Lower Santa Fe and Ichetucknee Rivers and associated priority springs are in recovery with estimated flow deficits relative to the MFLs. Recent analyses identified small magnitude changes in long-term trends for flows or water levels at some locations in the Basin (see Appendix F1). Declining groundwater levels in portions of the District (including the watersheds addressed in this SWIM Plan) have been designated as Water Supply Planning Regions/Water Resource Caution Areas. Primary threats to the hydrology of the systems with the Suwannee River Basin include jurisdictional boundaries and groundwater withdrawals.

Public supply, agriculture, commercial and industrial entities and other users, both within and outside District boundaries, create multiple demands on the water resources of the District. A majority (57 percent) of the drainage area of the Suwannee River Basin occurs in Georgia, limiting management options that may be directly controlled by the District. Additionally, the area of constrained fresh groundwater availability adjoins the SJRWMD. In this case, joint water supply planning has been initiated and conducted collaboratively with FDEP, the District, and The

SJRWMD as part of the NFRWSP. Substantial increases in future agricultural water demand in the Suwannee River Basin also have been projected.

To address these potential threats, the District has identified various management actions (Section 3) and projects/initiatives (Section 4) with the ultimate goal to protect or restore the hydrologic regimes, in terms of frequency, magnitude, duration, and seasonality, in the Suwannee River Basin, ensuring the protection of critical WRVs therein. Specific goals include actions to increase aquifer recharge and decrease excessive runoff and evapotranspiration. Potential projects to meet these goals include agricultural BMPs, hydrologic restoration of over-drained lands, water reuse, and water conservation. Because water is an integrated and interconnected resource, many of these management actions, projects or initiatives involve partnerships with other agencies and stakeholders, both within and outside of the District.

2.2 Water Quality

Water quality refers to the chemical, and to a lesser extent the physical and biological characteristics of water. It is primarily a measure of the chemical condition of water relative to the requirements of one or more biotic species and/or to any human need or purpose. It is most frequently used by reference to a set of standards against which compliance can be assessed.

2.2.1 Regulatory Framework

The State of Florida's approach to managing water quality involves a multi-step process. In the first step, water quality data are compared to standards, which vary as a function of the designated use classification of the waterbody (e.g., public water supply, shellfish harvesting, or recreational use). If the waterbody does not meet water quality criteria appropriate for its designated use, then it is designated as "impaired" with respect to those constituents for which criteria are not met. The development of a TMDL is most often the next step in the process. A TMDL is a determination of the maximum amount of a given pollutant that a waterbody can receive without exceeding the water quality standards for its designated use. After a TMDL is established, local stakeholders typically work together to come up with a BMAP to allocate load reductions so that the TMDL can be implemented. It should be noted that FDEP has the statutory authority in the State of Florida to regulate and manage water quality. The State's water management districts provide additional support to the FDEP primarily with regard to water quality data collection and reporting, and the implementation of projects aimed at improving water quality.

2.2.2 Status and Trends

This section summarizes prior studies on the water quality of the springs and streams in the Suwannee River Basin, while also including updated information that was reviewed to determine if trends in water quality might have changed in recent years. For this section, trends are discussed for both NO_3^- and Total Nitrogen (TN). The term "nitrate" typically refers to the combination of the two molecules NO_3^- and nitrite (NO_2^-). In most waters, NO_2^- is a small fraction of the amount of the sum of NO_3^- plus NO_2^- , and so the term "nitrate" is used interchangeably as the more correct term " NO_3^- plus NO_2^- ." The term TN refers to both dissolved and particulate forms of both inorganic and organic nitrogen, and so includes NO_3^- and NO_2^- , ammonia and ammonium

(both dissolved inorganic nitrogen forms), and both dissolved organic and particulate organic nitrogen.

It is important to note that there are two different regulatory standards for nutrient concentrations in the Suwannee River Basin: 1) state numeric nutrient concentration (NNC) criteria for streams and spring vents, and, 2) TMDL site-specific criterion. Rule 62-302.531, F.A.C. establishes both the NNC for TN of 1.87 mg/l for streams in north central Florida, including the Suwannee River Basin, and the NNC for spring vents for $\text{NO}_3^- - \text{NO}_2^-$ of 0.35 mg/l. This rule also establishes NNC for Total Phosphorus (TP) of 0.30 mg/l in north central Florida. Under 62-302.531, F.A.C., if site-specific numeric criteria, such as TMDLs, have not been adopted for a waterbody, the NNC apply. In the Suwannee River Basin, FDEP has established a TMDL for NO_3^- of 0.35 mg/l for the Suwannee River (Downstream of the confluence of the Withlacoochee River), the Lower Suwannee Estuary, Branford Springs, Falmouth Springs, Royal Springs, Ruth Springs, Troy Springs, Fanning Springs, Manatee Springs, and the Santa Fe River (62-304.405, F.A.C., 62-304.410, F.A.C.).

The TMDL for the Santa Fe and Suwannee River Basins is based on levels of NO_3^- , as FDEP had previously determined that increased concentrations of NO_3^- can stimulate algal growth in these water bodies (FDEP 2008a). The most common form of nitrogen in groundwater is NO_3^- , which can travel for miles through karst geology with little or no chemical change or biological assimilation. As such, the dominant form of nitrogen discharging from springs and entering the rivers through groundwater seepage is NO_3^- . Once NO_3^- enters the water column, it can be assimilated by photosynthetic organisms such as attached algae (e.g., *Lyngbya*) and free-floating microscopic algae (i.e., phytoplankton). After assimilation by either attached or free-floating algae, the nitrogen is no longer in the form of NO_3^- , but will be either part of the attached algal mass, or will be in the form of particulate organic nitrogen (i.e., FDEP 2008a).

2.2.2.1 Nitrate in Rivers and Streams

In an earlier assessment, 10 of 81 stations in the Santa Fe and Suwannee River watersheds exhibited a trend of increased NO_3^- concentrations during the period of 1989 to 2007 (Upchurch 2007). More than twice as many locations, 23, showed trends of decreasing NO_3^- concentrations, while 48 of 81 stations exhibited no statistically significant trends in NO_3^- concentrations during that 18-year period examined (Upchurch 2007). Using data up to the year 2016, water quality trends were examined for 10 representative stations (out of the 81 previously examined). This updated assessment, with details shown below, found that 6 of 10 stations had no statistically significant trends in NO_3^- over time, while three stations showed evidence of an increase, and only one showed evidence of a decrease. While the stations examined are a small subset of the 81 previously examined, data for more recent years suggest that most locations still have variable, but non-trending concentrations of NO_3^- over time.

Many, but not all, of the river and stream sites previously determined to have decreasing NO_3^- concentrations are in the eastern portion of the District, as was previously found by Upchurch et al. (2007). Figure 15 shows an original figure from that prior study, which extended over a wider area than that covered by this SWIM Plan. The areas with decreasing NO_3^- concentrations were

mostly regions where the Floridan Aquifer is confined, and where stream-aquifer interactions are mostly restricted to the surficial aquifer (Upchurch et al. 2007).

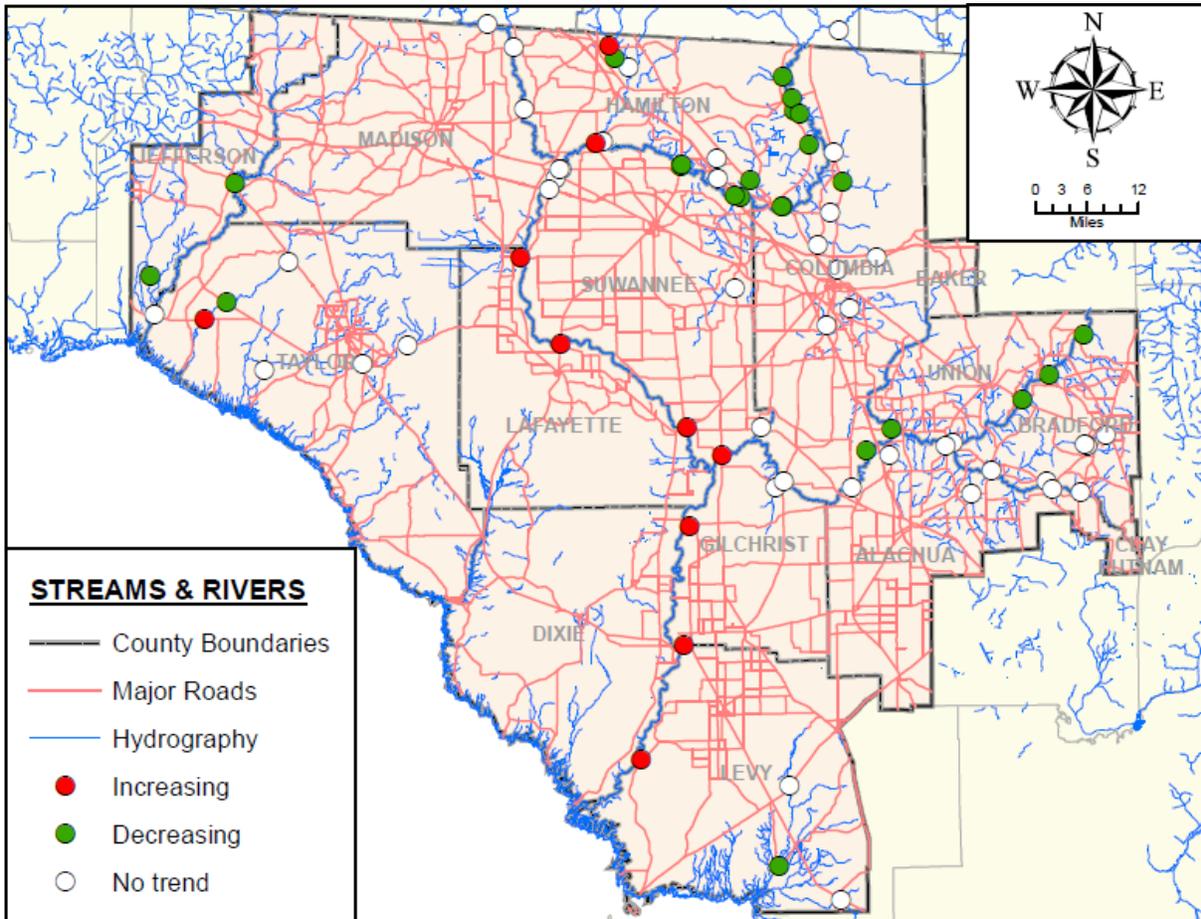


Figure 15. Spatial distribution of nitrate trends in rivers and streams in the Suwannee River Basin. Figure from Upchurch et al. (2007)

The impacts of nutrient enrichment in springs and rivers are manifested through increased abundance of filamentous algae in increased biological oxygen demand, and thus adverse impacts to those natural systems that are dependent on good water quality (e.g., FDEP 2008a). In addition to impacts in the springs and rivers themselves, the downstream waters of the Gulf of Mexico that are most strongly influenced by Suwannee River discharges are thought to be nitrogen-limited (Mattson et al. 2007). Increased nitrogen loads to the Suwannee River estuary have been a topic of concern raised by FDEP in a recent report on trends in seagrass coverage in the Big Bend region (FDEP 2014a). Consequently, actions taken to reduce NO_3^- loads to the springs and rivers of the Santa Fe and Suwannee Rivers are likely to benefit not only the springs and rivers, but also those portions of the nearshore waters of the Gulf of Mexico influenced by their flows.

In the eastern portions of the District, where NO_3^- concentrations in rivers and streams were found to be declining over time (at least during the period of 1989 to 2007), the Floridan aquifer is confined and NO_3^- concentrations in surface water are most strongly influenced by local land use

and rainfall. While useful for understanding the physical scale of NO_3^- trends in the Santa Fe and Suwannee River watershed, the data summarized by Upchurch et al. (2007) is now almost a decade old. To determine if newer information would validate or require the modification of earlier findings, an updated trend analysis was performed, with details contained in Appendix F2.

This update was for a representative sampling of long-term stations in the Santa Fe and Suwannee Rivers, as resources and time were not available to replicate trend analysis for the full suite of 81 river and stream locations examined by Upchurch et al. (2007). Nonetheless, a similar spatial pattern of trends was found, using data up to 2016 (Figure 16).

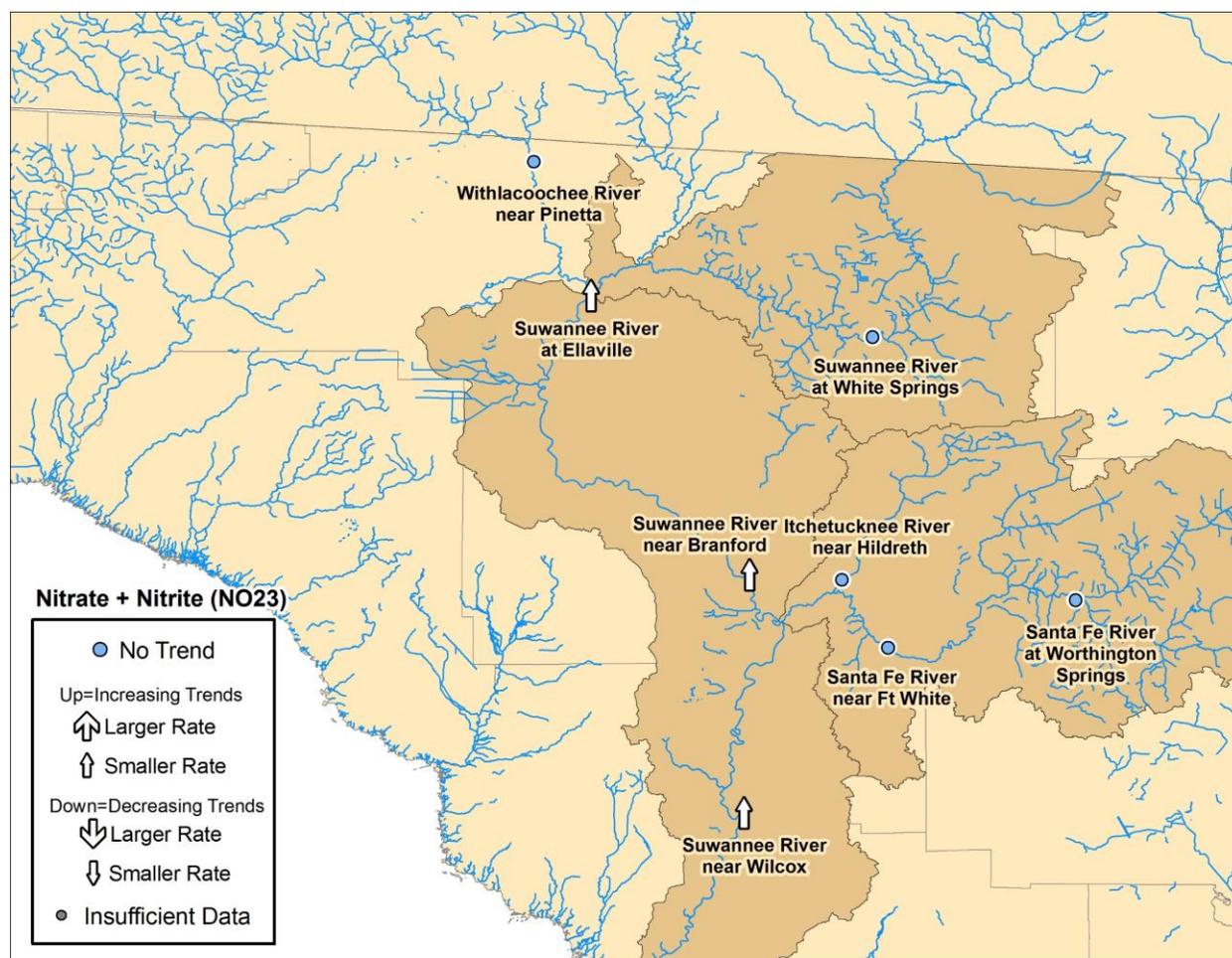


Figure 16. Spatial distribution of NO_3^- plus NO_2 trends in rivers and streams in the Suwannee River Basin. Data updated to the year 2016. Details found in Appendix F2

Consistent with the results found by Upchurch et al. (2007), NO_3^- trends in the Suwannee River proper continued to increase over the past few years at long-term monitoring stations near Wilcox, near Branford, and at Ellaville.

In the Santa Fe River, both Upchurch et al. (2007) and this updated trend assessment found no evidence of a trend over time at the upstream location of Worthington Springs, nor was a trend detected downstream at Ft. White. In locations studied by Upchurch et al. (2007), but not assessed here, declining trends in NO_3^- were found, at least during that earlier time period. This

had previously been suggested as being due to the semi-confined nature of the aquifer in the eastern portions of the Suwannee River watershed (Upchurch et al. 2007). Combined, the data suggest that NO_3^- levels are mostly non-trending or decreasing in the Santa Fe River, with some degree of spatial and temporal variation. But in the Suwannee River, NO_3^- trends are increasing in most locations and, as previously noted, increases in NO_3^- appear to be continuing across most of the watershed.

Within the Santa Fe River watershed, the targets for TN appear to be met both at the upstream location of Worthington Springs (Figure 17), as well as the downstream location of Fort White (Figure 18).

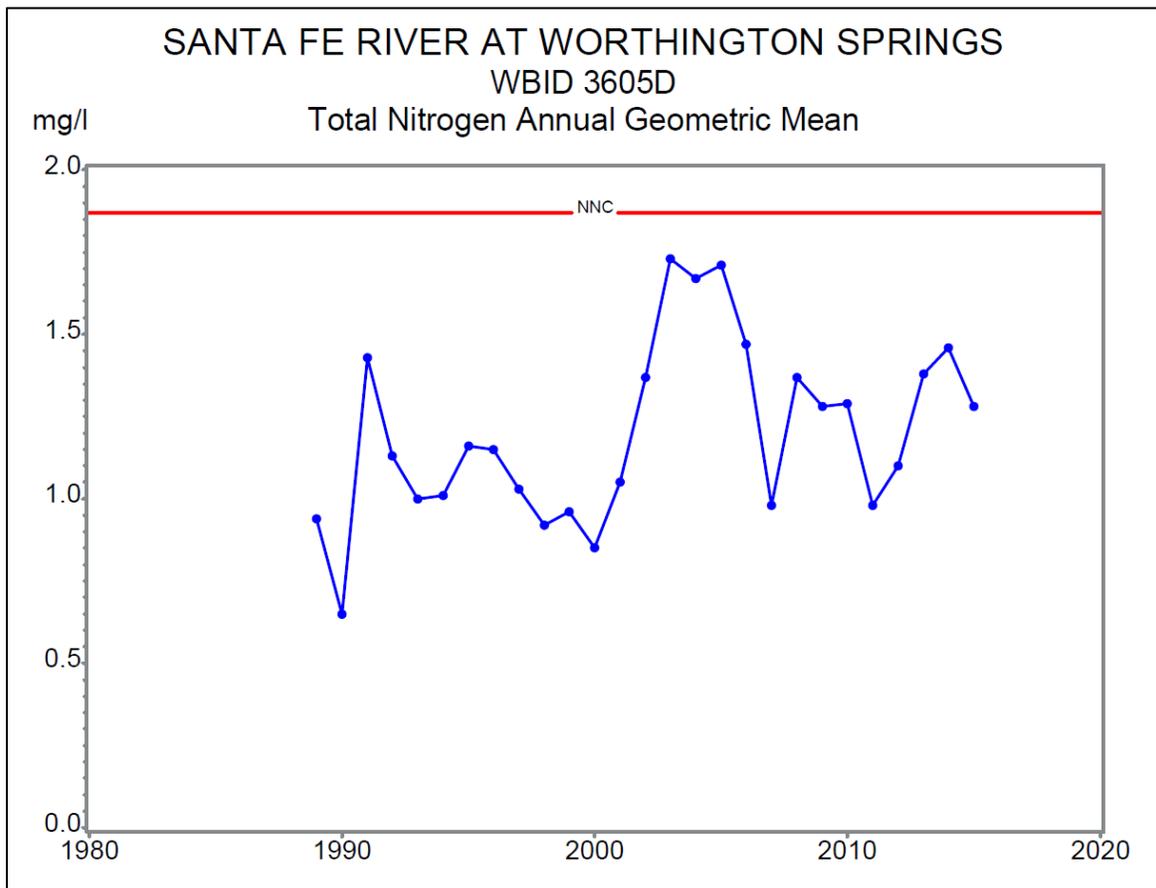


Figure 17. TN trend for the Santa Fe River at Worthington Springs. Annual geometric means compared against NNC criteria (as per 62-302.531, F.A.C.)

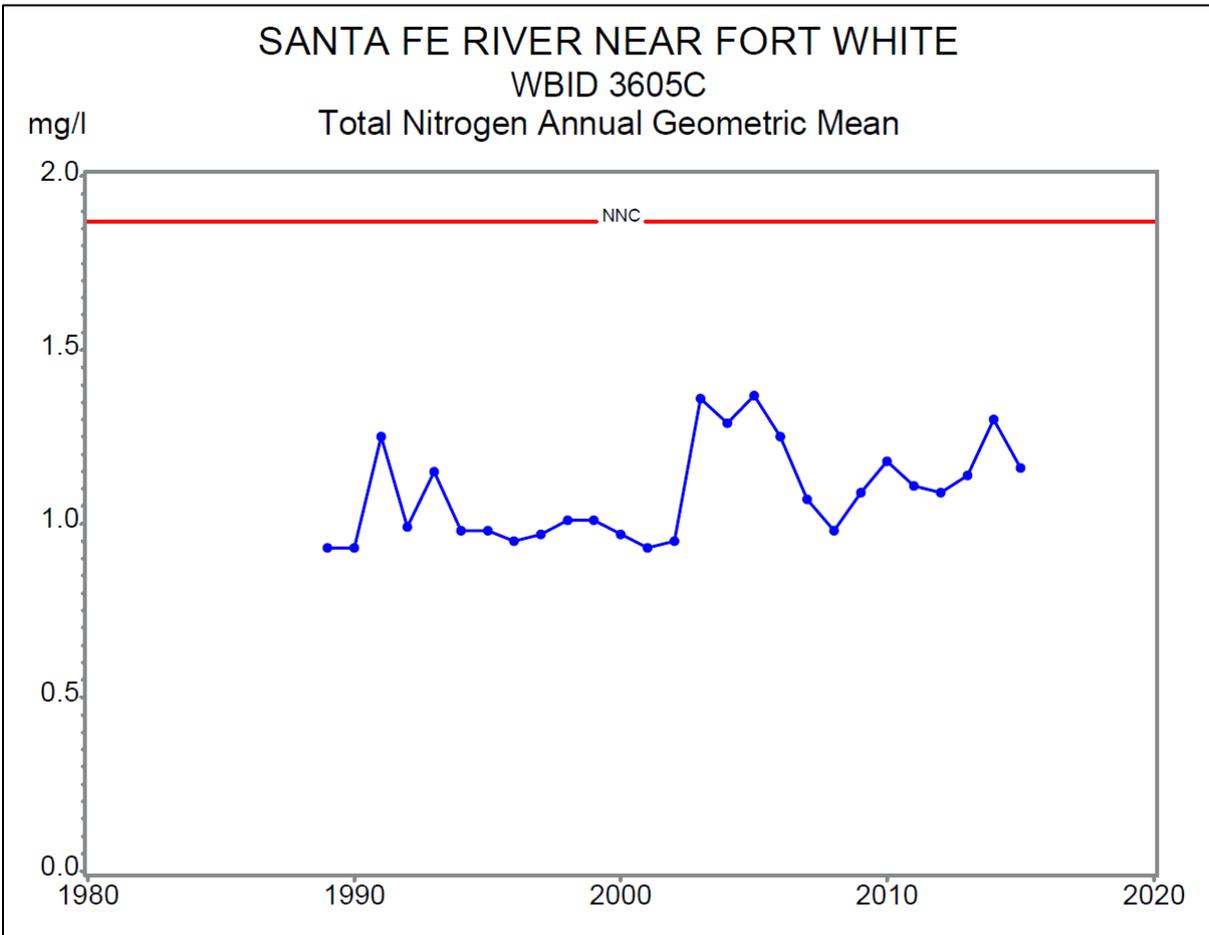


Figure 18. TN trend for the Santa Fe River near Fort White. Annual geometric means compared against NNC criteria (62-302.531, F.A.C.)

While figures 17 and 18 show that the Santa Fe River at both Worthington Springs and Fort White meet the NNC for TN as specified in 62-3011.531, F.A.C., the Santa Fe River continues to exceed the TMDL for NO_3^- (62-304.410, F.A.C.). That portion of TN that is comprised of NO_3^- remains problematic, even if the quantity of TN does not exceed guidance criteria.

In the Suwannee River watershed, concentrations in the river itself do not yet exceed NNC for TN established in 62-3011.531, F.A.C., but they appear to be increasing over time, and are much closer to exceedance values than is seen in the Santa Fe River. As an example, the trends of TN are displayed against NNC for the Suwannee River at Branford, and in the farther downstream location of the Suwannee River near Wilcox (Figures 19 and 20, respectively).

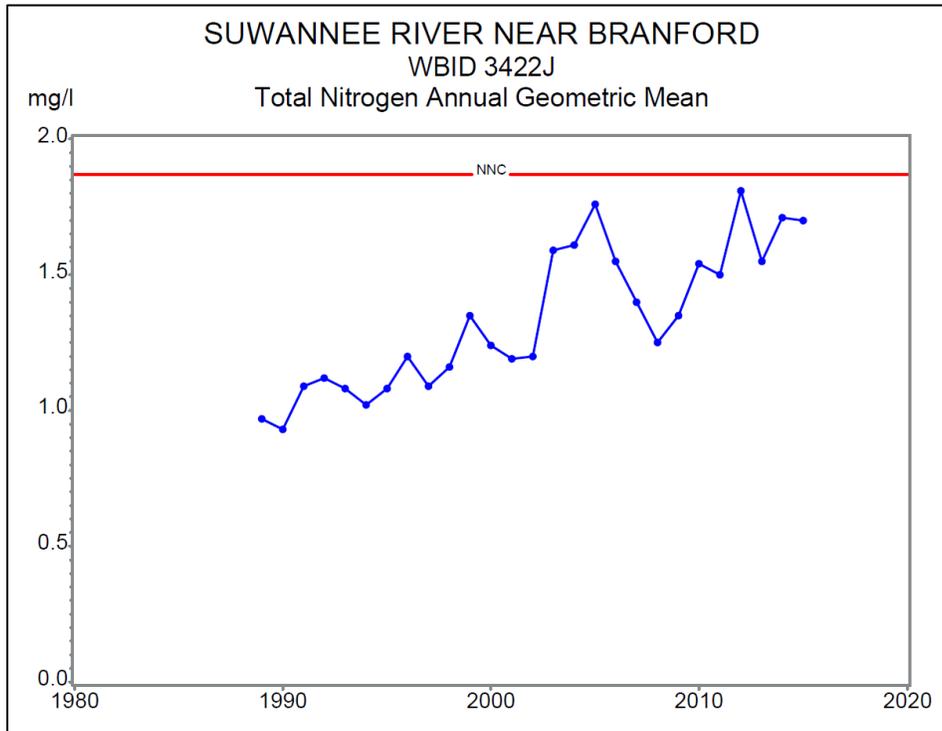


Figure 19. TN trend for Suwannee River at Branford. Annual geometric means compared against NNC criteria (62-302.531, F.A.C.)

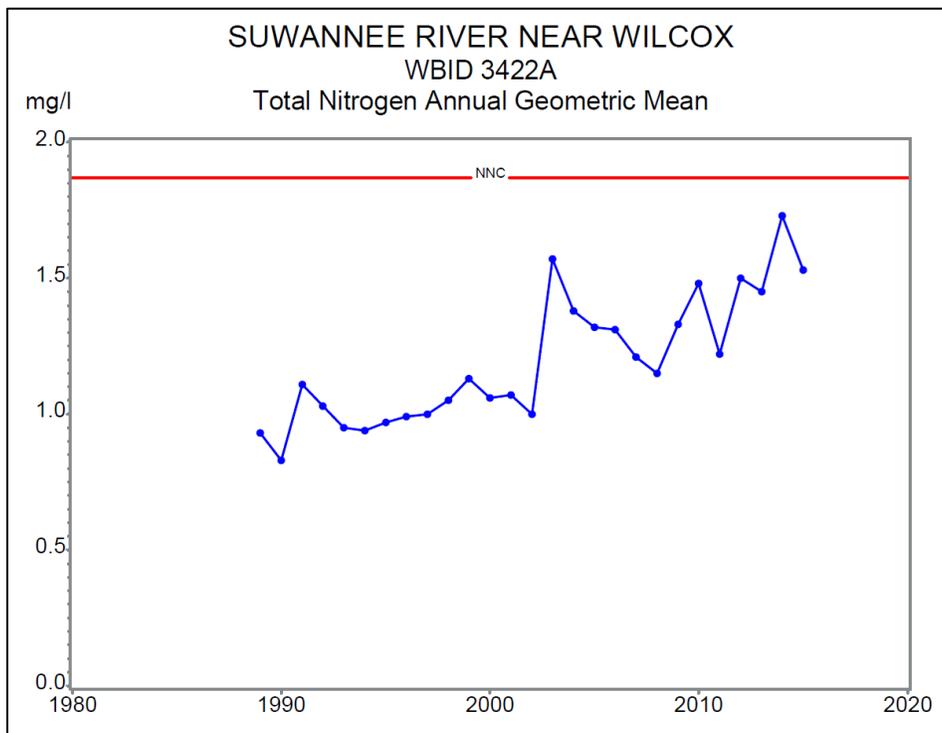


Figure 20. TN trend for Suwannee River near Wilcox. Annual geometric means compared against NNC criteria (62-302.531, F.A.C.)

2.2.2.2 Phosphorus in Rivers and Streams

The TMDL report for the Santa Fe and Suwannee River watersheds noted that phosphorous concentrations had decreased across those two watersheds since the mid-1980s, and suggested that an eight to ten-year time lag between fertilizer sales and TP concentrations in the MSR was "...explained by the time it takes for phosphorus to move through the soils and into the surrounding groundwater and surface waters" (FDEP 2008a). However, it was also suggested that a similarly noted decline in TP concentrations in the Suwannee River - starting in about 1985 - was related to "increased regulation" of phosphate mining operations in Hamilton and Columbia Counties (Hornsby 2007).

Using data updated to the year 2016, concentrations of TP are either non-trending or decreasing across the District (Figure 21), a result consistent with earlier findings from Hornsby (2007) and FDEP (2008a).

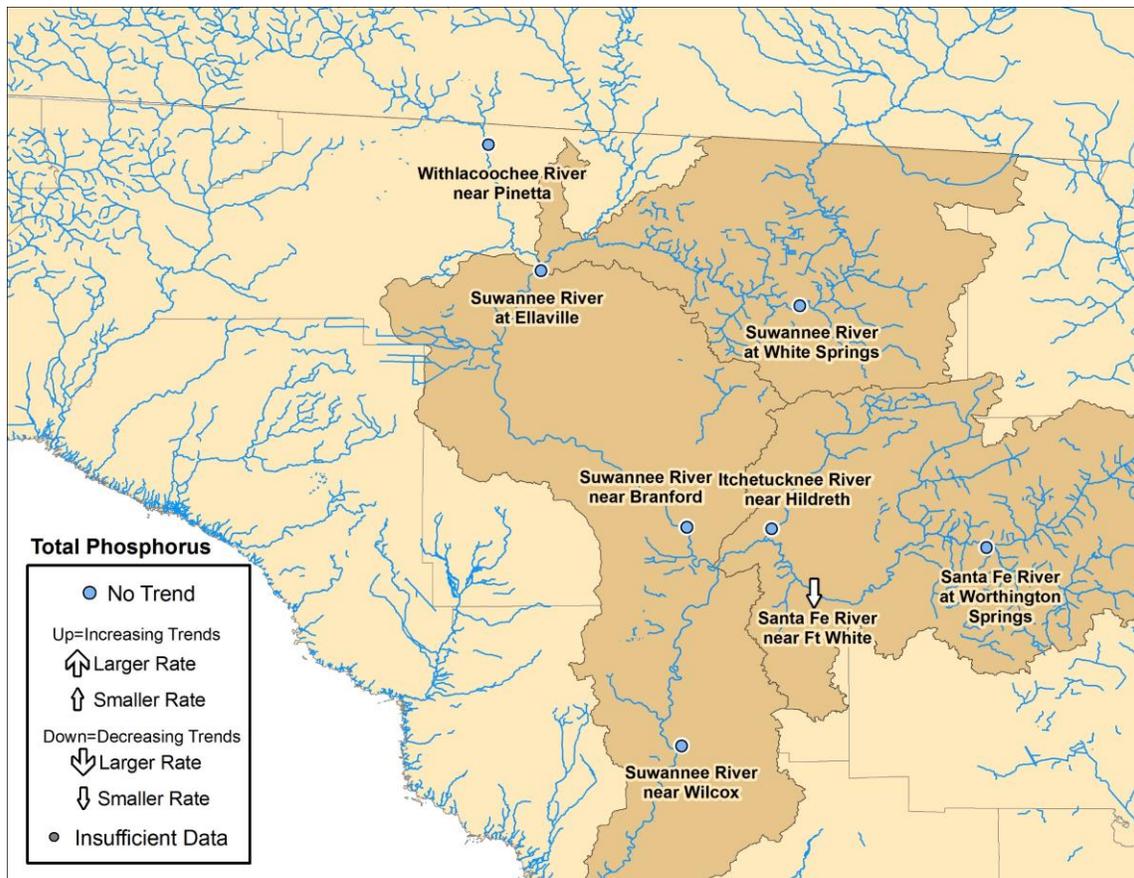


Figure 21. Spatial distribution of TP trends in rivers and streams in the Suwannee River Basin. Data updated to the year 2016. Details found in Appendix F

2.2.2.3 Nitrate in Springs

In an earlier assessment, 14 out of 68 spring locations exhibited increased NO_3^- trends during the period of 1989 to 2007, while 17 showed trends of decreasing NO_3^- concentrations (Upchurch et al. 2007). About half of the springs, 37 out of 68, did not have statistically significant trends in NO_3^- concentrations over time (Upchurch et al. 2007; Figure 22). Figure 22 includes stations

outside of the geographic boundaries of this SWIM Plan, but the spatial pattern of trends is illustrative, and is included here in its original format.

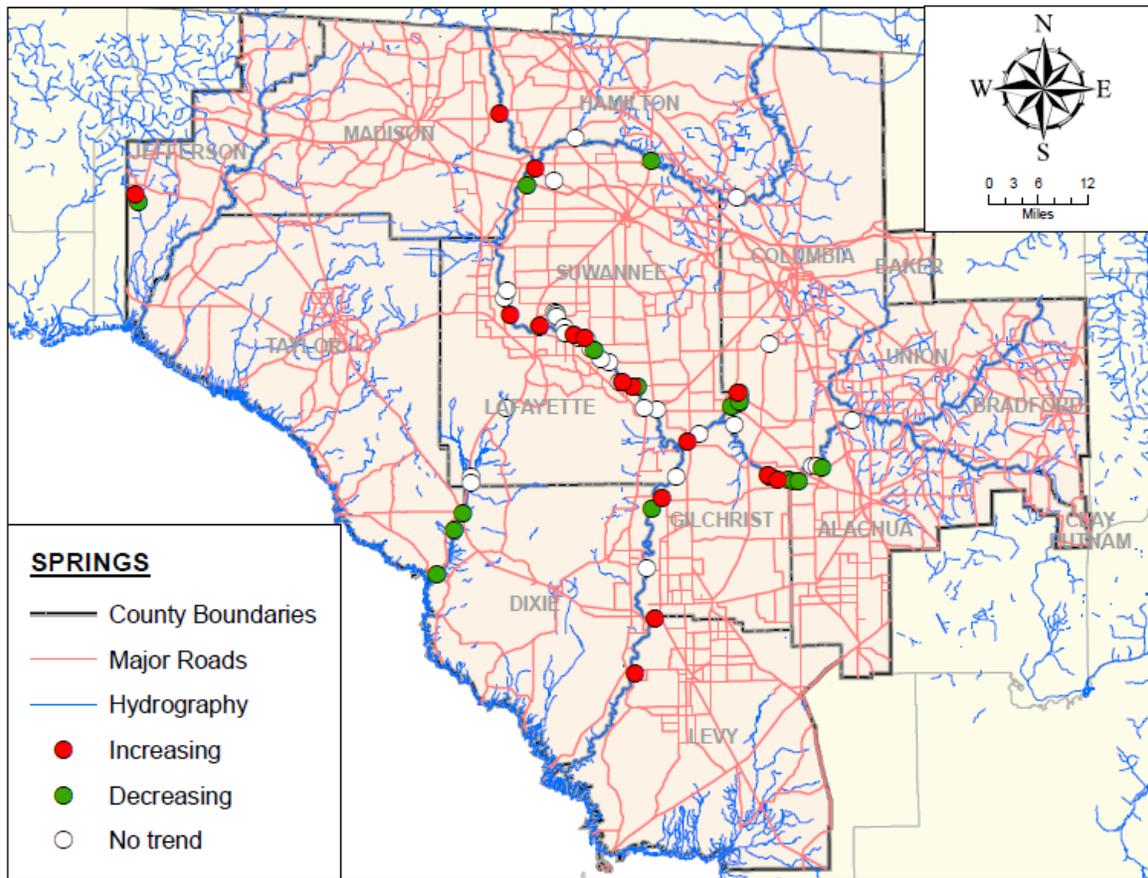


Figure 22. Spatial distribution of NO_3^- trends in springs in the Suwannee River Basin. Figure from Upchurch et al. (2007)

Using data up to the year 2016, water quality trends were examined for seven representative springs, out of the 68 previously examined by Upchurch (2007). This updated assessment, with results shown below (Figure 23), found six out of the seven spring locations had evidence of increased NO_3^- concentrations, when including these more recent years. While the stations examined are a small subset of the 68 previously examined, data from more recent years do suggest that most spring sites seem to be exhibiting evidence of continued increasing concentrations of NO_3^- (see details in Appendix F2).

In the Santa Fe River watershed, NO_3^- trends were previously found to have as many springs with decreasing trends as increasing trends (Upchurch et al. 2007). In this update, NO_3^- concentrations were decreasing (updated to 2016) in Poe Springs, but increasing in Gilchrist Blue Springs. In the Suwannee River watershed, NO_3^- trends continued to increase (up to 2015) at all five stations examined.

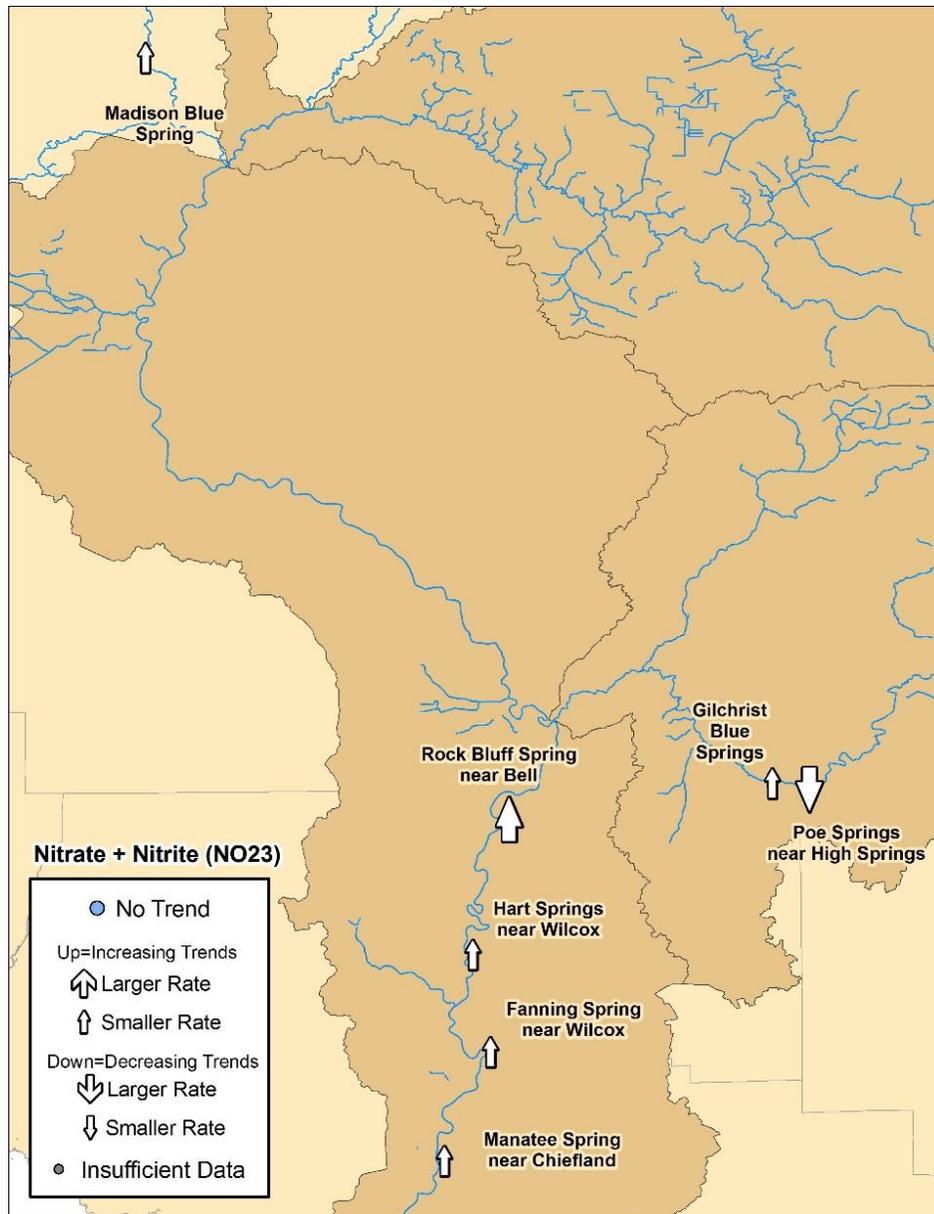


Figure 23. Spatial distribution of NO₃⁻ trends in springs in the Suwannee River Basin. Data updated to the year 2016. Details found in Appendix F

The eastern portion of the District, where the aquifer is confined to semi-confined, is characterized for the most part by stable or decreasing trends for NO₃⁻ in the Santa Fe River. Springs within the Santa Fe River appear to be approximately equally likely to have decreasing NO₃⁻ trends as increasing NO₃⁻ trends, but the Santa Fe River itself appears to have NO₃⁻ levels that are stable (in downstream regions) or decreasing over time (in upstream regions). Previous studies have suggested that NO₃⁻ concentrations in the upper reaches of the Santa Fe River are more strongly influenced by local sources, since the Floridan Aquifer's influence on streamflow is reduced in this region (Upchurch et al. 2007). Therefore, it could be that local management actions focused on NO₃⁻ reduction have already shown themselves to be working, at least in the upper reaches of the Santa Fe River.

If the sites examined for trend analysis in Figure 23 are representative of the watershed as a whole, NO_3^- concentrations are not decreasing in the majority of the Suwannee River proper (excluding the Santa Fe River), suggesting that either management actions, such as the retrofitting of fertigation systems on agricultural lands, are not sufficient to bring about a regional decline, or that the actions have not yet manifested themselves in a reduction in NO_3^- concentrations, perhaps due to issues related to the age of water in the aquifers and the lag time between management actions and system responses. As noted in the Draft Reasonable Assurance Plan (RAP) for the Suwannee River (FDEP 2002), evidence of the effectiveness of various management actions may take 20 years to show up, due to the stronger influence of the unconfined Floridan aquifer in this portion of the District, and that water discharging from the springs in this region of the District can be up to 40 years in age (Upchurch et al. 2007).

Two examples illustrate the seemingly different trajectories of NO_3^- in the Santa Fe vs. Suwannee River systems. In the Santa Fe River watershed, NO_3^- concentrations in Poe Springs (unadjusted for seasonality; Figure 24) exhibit a clear pattern of decline over time. Upon conversion to the correct units, NO_3^- data from Poe Spring now meet NNC of 0.35 mg/l for spring vents (62-302.531, F.A.C., Figure 25).

The pattern of decreased NO_3^- concentrations over time in Poe Spring could be due to three, perhaps unrelated phenomena: 1) higher nutrient load land uses have been replaced by other land uses with lower nutrient loading potential (although this does not appear to be the case); 2) implemented nutrient management activities have brought about a reduction in NO_3^- concentrations in the spring, and also that portion of the Santa Fe River influenced by the spring; or 3) conditions in the spring are more reducing than in the past, and therefore more denitrification is occurring in the aquifer prior to discharge. In their most recent BMAP update, FDEP (2012) showed a value of 0.11 mg NO_3^- liter at Poe Springs, which is consistent with the non-impaired status shown here (as N). The BMAP update (FDEP 2013) shows that Hornsby Spring also has NO_3^- concentrations (at the time sampled) that fall below the NNC of 0.35 mg/l.

In the Suwannee River watershed NO_3^- trends continue to increase over time for most of the river and in many of the springs. As an example, the trend in NO_3^- in Manatee Spring is shown in Figure 26 (low values are due to backwater conditions from the Suwannee River), and in Figure 27, where the NO_3^- levels in Manatee Springs are shown to be well above the TMDL limit of 0.35 mg/l.

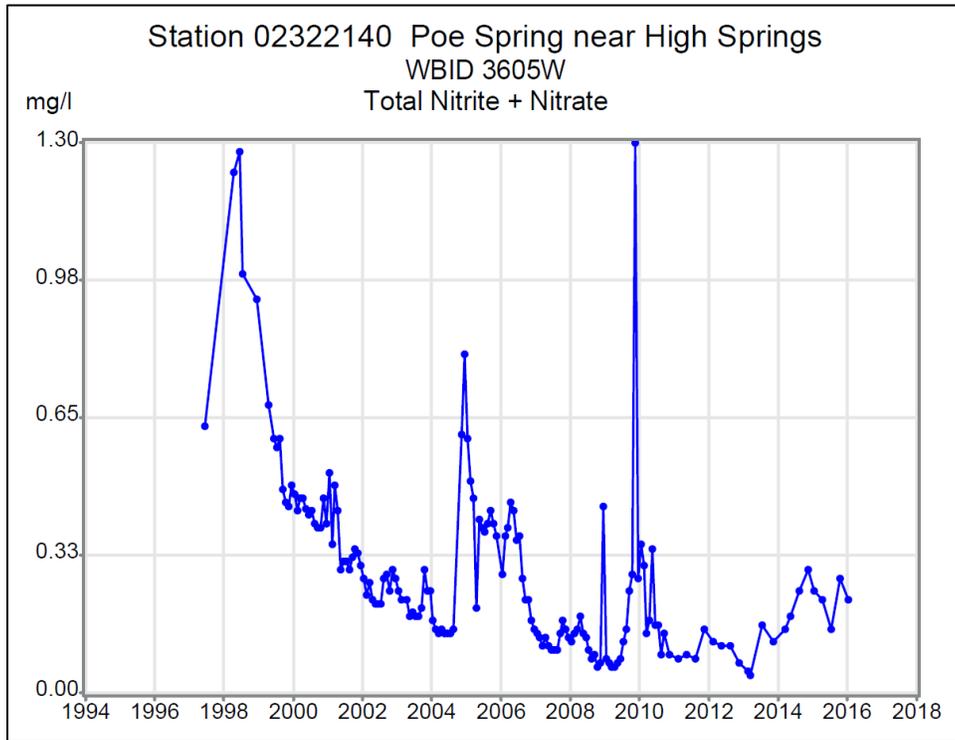


Figure 24. NO_3^- plus NO_2^- trend (raw data) for Poe Spring near High Springs, in the Santa Fe River watershed

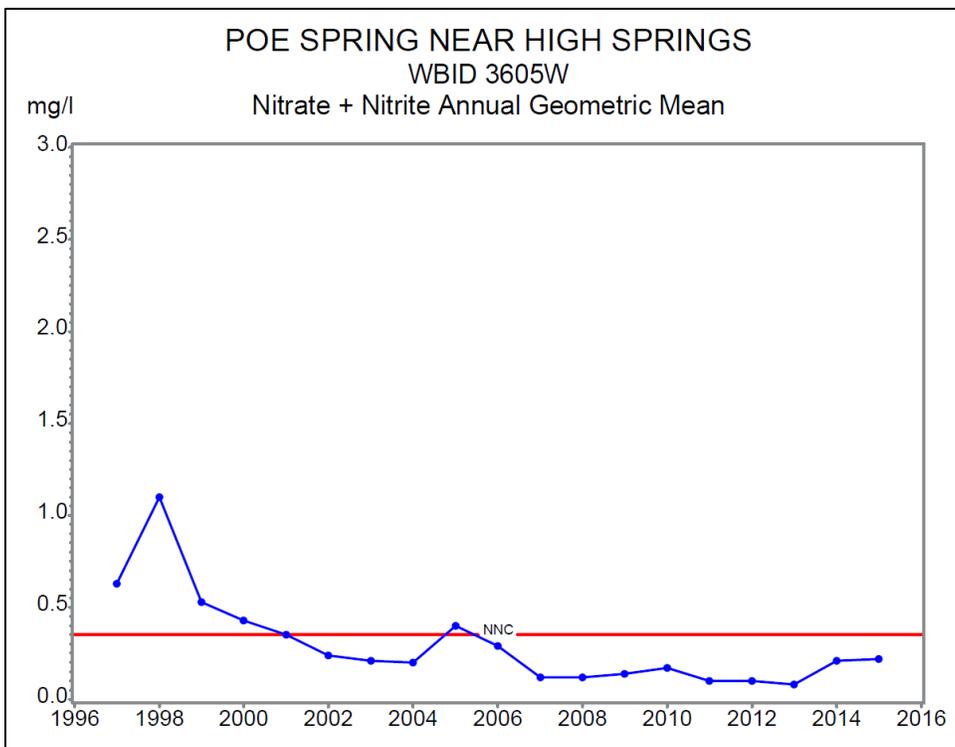


Figure 25. NO_3^- plus NO_2^- trend in Poe Spring near High Springs, in the Santa Fe River watershed. Annual geometric means compared against NO_3^- criteria (as per 62-302.531, F.A.C.)

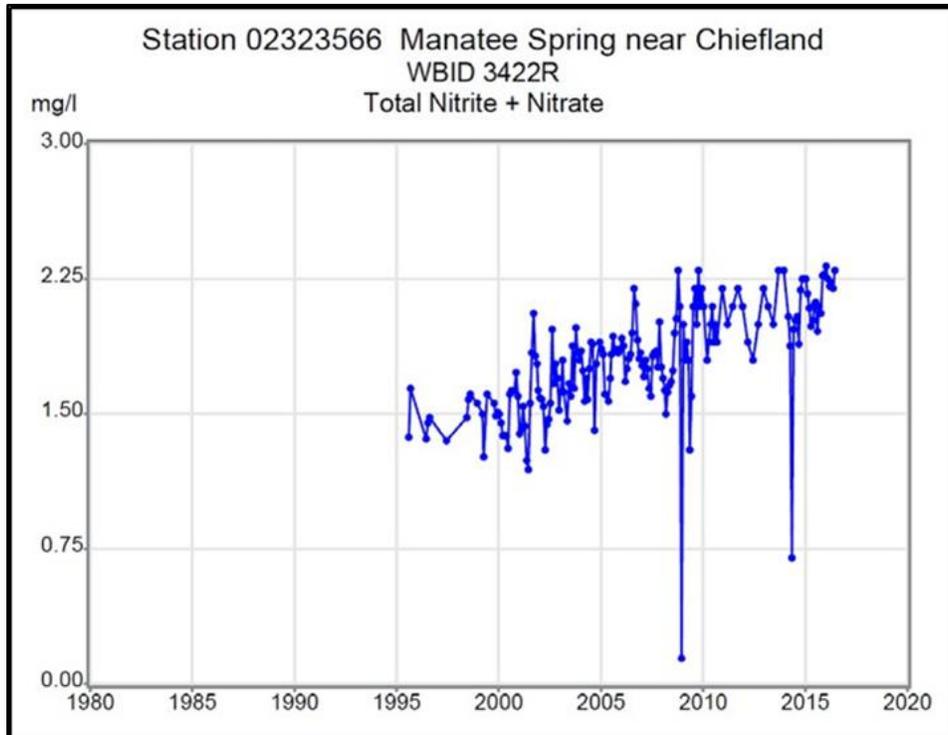


Figure 26. NO_3^- plus NO_2^- trend (raw data) for Manatee Spring near Chiefland, in the Suwannee River watershed

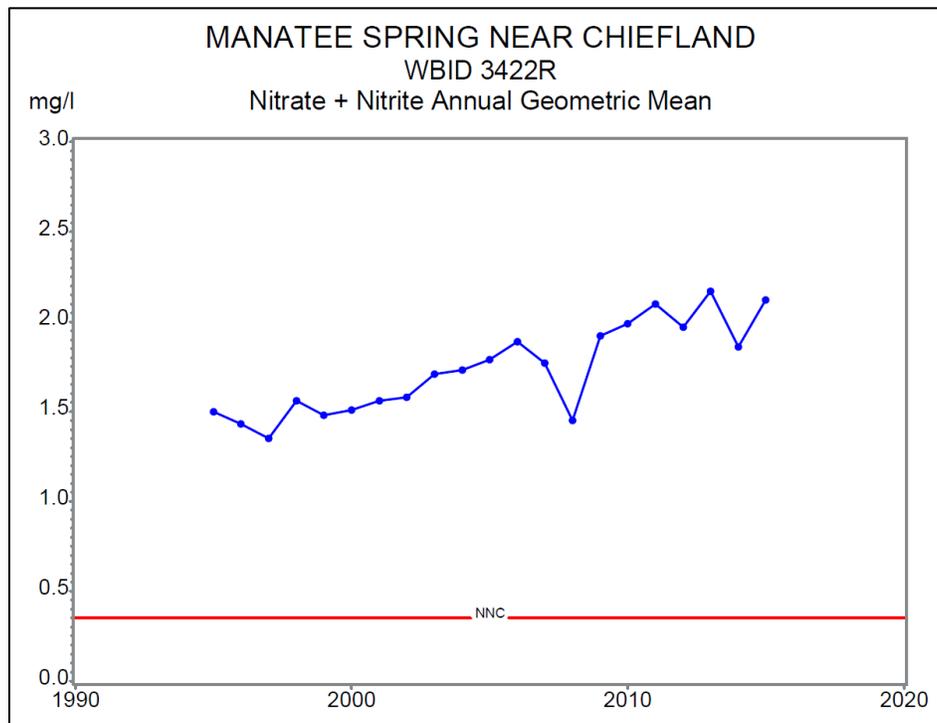


Figure 27. NO_3^- plus NO_2^- trend in Manatee Spring near Chiefland, in the Suwannee River watershed. Annual geometric means compared against NO_3^- criteria (as per 62-302.531, F.A.C.)

2.2.3 Regulatory Issues

This section provides a discussion of water quality regulatory issues related to impairments, TMDLs and BMAPs, and changes in regulatory standards applicable to the Suwannee River Basin.

2.2.3.1 Impairments

In the 2014 Comprehensive Verified Impaired List, FDEP identified more than 70 waterbodies (WBID)-impairment combinations within the boundaries of the District. More than half of all impairment determinations are based on exceedance of bacterial standards, which are in turn based on the criteria for fecal coliform bacteria. Nutrient impairments were numerous (Figure 28) and were associated with findings of low DO, elevated levels of chlorophyll-a (chl-a) and/or exceedance of existing (at the time) criteria for FDEP's Trophic State Index (TSI).

However, a complicating factor, in terms of prioritizing actions to protect and/or improve water quality is that many of the impairments of water quality in the Santa Fe and Suwannee River watersheds in that 2014 list were based on water quality criteria that have changed in recent years. The implications, if any, of changes in water quality criteria are discussed below for DO, bacteria, and nutrient availability.

2.2.3.2 Potential Effects of Revisions to Water Quality Standards

While there is a general scientific consensus that NO_3^- concentrations are problematic in much of the Santa Fe and Suwannee River watersheds, many of the water quality impairments listed by FDEP in their 2014 Comprehensive Verified Impaired List are based on prior criteria that have since been updated by FDEP.

Dissolved Oxygen

The 2014 Comprehensive Verified Impaired List shows portions of the Santa Fe River and the USR as impaired for DO based on the finding that DO levels in those systems failed to meet the standard of 5 mg DO / liter. In the Santa Fe River, as a whole, impairment for DO was related to nutrients, without a specific nutrient (nitrogen or phosphorus) being identified. In some portions of the Santa Fe River, TN was identified as the nutrient of concern, while in other areas, DO impairment was attributed to TP when the 2014 Comprehensive Verified Impaired list was compiled.

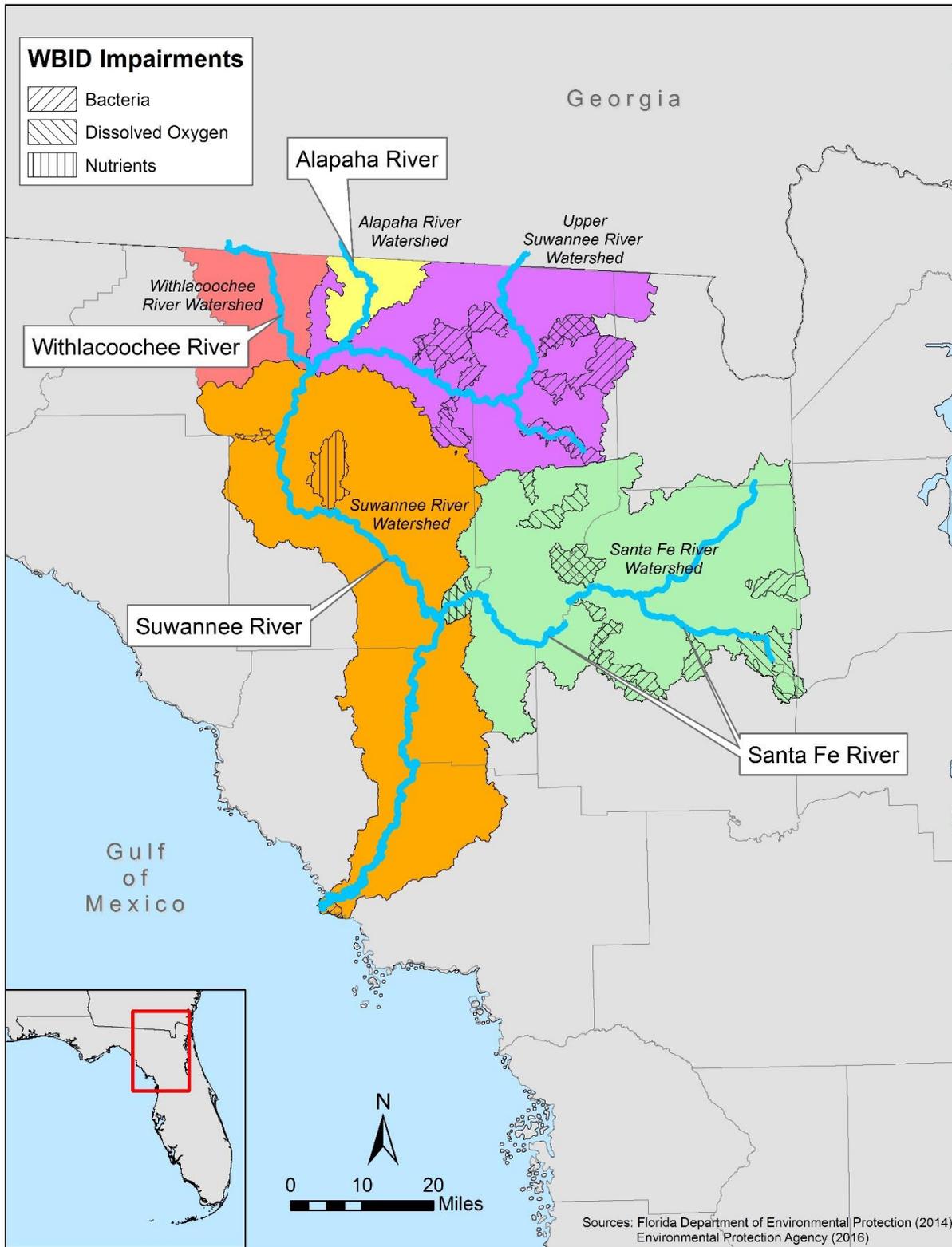


Figure 28. Map showing WBID-impairment combinations in the Suwannee River Basin. See legend for basis for impairment

On September 9, 2013, the U.S. Environmental Protection Agency (EPA) approved revisions to FDEP's DO criteria as part of the Triennial Review of surface water quality standards. The revised DO criteria then came into effect for both FDEP and the EPA. As of February 17, 2016, the revised criteria for DO, 62-302.533, F.A.C., requires that "...in the portions of the Suwannee, Withlacoochee (North), and Santa Fe Rivers utilized by the Gulf Sturgeon, and in the portions of the Santa Fe and New Rivers utilized by the Oval Pigtoe Mussel, DO levels shall not be lowered below the baseline distribution such that there is 90 percent confidence that more than 50 percent of measurements are below the median of the baseline distribution or more than 10 percent of the daily average values are below the 10th percentile of the baseline distribution for the applicable waterbody." Outside of the areas designated above, the relevant DO criteria requires "No more than 10 percent of the daily average percent DO saturation values shall be below...38 percent (saturation)".

Consequently, in 2017, FDEP produced the Statewide Comprehensive Delist List, which lists those WBIDs which FDEP no longer considers impaired. As a result of the changes in the DO criteria, a number of previously impaired WBIDs are no longer considered to be impaired. For example, the USR in Hamilton and Suwannee Counties (WBID 3341) is no longer considered impaired for DO. The LSR in Dixie, Gilchrist, Lafayette, Madison and Suwannee Counties (WBIDs 3422 and 3422B) are also no longer considered impaired for DO.

However, the practical implications of revised criteria for DO might not be overly problematic for the Santa Fe and Suwannee River watersheds, as the TMDLs within their watersheds are focused on impairments due to fecal coliform bacteria and elevated levels of NO_3^- , not levels of DO.

Bacteria

For bacteria, FDEP's 2014 Comprehensive Verified Impaired list shows 14 WBIDs as being impaired for "fecal coliform" bacteria, based on the criteria for Class III freshwater systems of 400 colony forming units (CFU) / 100 ml. At the July 26, 2016 meeting of FDEP's Environmental Regulation Commission, FDEP proposed new criteria that would eliminate the reliance on fecal coliform bacteria, for Class III freshwater systems and replace it with criteria based on the species *Escherichia coli*. The proposed criteria for *E. coli* would be based on counts not exceeding a monthly mean quantity of 126 / 100 ml of water. As this standard is applied for monitoring programs that collect at least 10 samples per month, most water bodies would likely be reviewed based on the higher "Ten Percent Threshold Value" of 410. If a single value of *E. coli* exceeds 410 / 100 ml, then the waterbody would be in violation of bacteria standards.

The revised bacteria standard for *E. coli* of 410 m / 100 ml is almost identical to the prior quantity for fecal coliform bacteria of 400 CFU / 100 ml. Since *E. coli* bacteria are a subset of the larger grouping of "fecal coliform" bacteria, it is likely that the number of bacterial impairments will decrease if the proposed criteria are adopted by both FDEP and the EPA. This may have implications for entities affected by the TMDL for Fecal Coliform Bacteria for the Santa Fe and Suwannee Rivers (FDEP 2014b, FDEP 2014c) as the determination of "impairment" for bacteria may be revised for some portions of the Suwannee River Basin with the adoption of proposed criteria for bacteria.

2.2.3.3 Total Maximum Daily Loads (TMDLs) and Basin Management Action Plans (BMAPs)

FDEP develops and adopts TMDLs for waterbodies identified as impaired. The TMDL is the maximum amount of a pollutant that a waterbody can receive and still maintain is designated uses. The waterbodies within the Suwannee River and Santa Fe River Basins are designated as Class III waters. Class III waters must support recreation and the propagation and maintenance of a healthy, well-balanced population of fish and wildlife (62-302.400, F.A.C.). The spatial extent of areas covered by established TMDLs in the Suwannee and Santa Fe River watersheds are illustrated in Figure 29.

Nutrients

In the TMDL report for the Suwannee and Santa Fe Rivers, FDEP determined that there were “significant positive relationships” between the amount of NO_3^- in the Santa Fe and Suwannee Rivers and the amount of algal biomass in these two systems, and that there was evidence of increased abundance of filamentous algae in both the Santa Fe and Suwannee Rivers in recent years (FDEP 2008a). The TMDL for nutrients for the Santa Fe River and Suwannee River watersheds is based on a target NO_3^- value of 0.35 mg NO_3^- (as N) per liter (FDEP 2008a). In the MSR, the TMDL calculated a 51 percent reduction in NO_3^- concentrations would be required, with reductions in the LSR and the Santa Fe River of 58 and 35 percent, respectively (FDEP 2008a). Meeting these concentration reductions will require continued investment of time and resources into managing nutrient loads, mostly as they affect groundwater. In addition, there are water quality impairments for DO in various portions of the Santa Fe and Suwannee River watersheds that have been attributed to elevated concentrations of phosphorus (e.g., FDEP’s 2014 Verified Impaired List), although no TMDLs have yet been developed for those waterbodies. In addition to nutrient related TMDLs, the entirety of the Santa Fe and Suwannee River watersheds are included within the geographic boundaries of TMDLs focused on bacterial impairments.

While TMDLs exist for water quality parameters other than NO_3^- alone, such as the TMDLs for fecal coliform bacteria in the Santa Fe and Suwannee Rivers (e.g., FDEP 2014b, FDEP 2014c), most studies on water quality in the District region have focused on determining the source(s) of NO_3^- . In a study conducted in 1997, using nitrogen isotopes and land use maps to determine contributions from various sources, it was concluded that in most springs in the Suwannee River watershed elevated NO_3^- concentrations were attributed to a combination of nutrients from the application of fertilizer and animal wastes from poultry operations and/or dairies (Katz and Hornsby 1998). Based on two separate techniques to determine the relative age of groundwater, it was estimated that water discharging from spring vents was, on average, 12 to 20 years old (Katz and Hornsby 1998). As such, the NO_3^- discharging from spring vents studied in 1997 likely represents the influence of land use and land use practices during the period of 1977 to 1985.

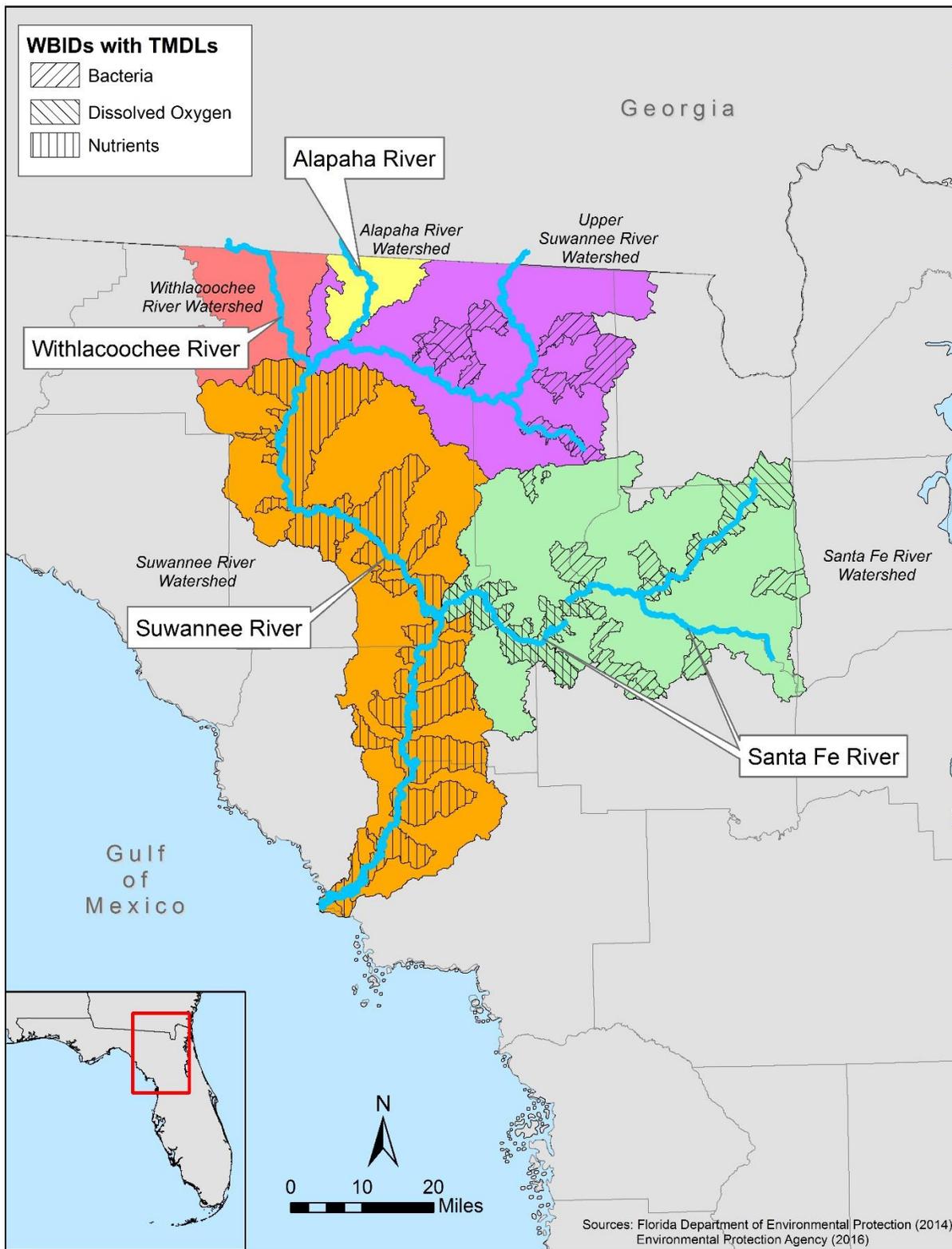


Figure 29. Map showing areas covered by TMDLs in the Suwannee River Basin.

In a 1999 report, it was concluded that the overall nitrogen load to groundwater in the District increased from 1950 to the late 1990s, but the pattern differed spatially (Katz et al. 1999). In Gilchrist

and Lafayette Counties, nitrogen loads increased at a steady rate up to the late 1990s, while in Suwannee, Alachua and Columbia Counties, peak nitrogen loading occurred in the 1970s (Katz et al. 1999). In Columbia, Gilchrist, Lafayette, and Suwannee Counties, substantial increases in nitrogen loads occurred in the early to late 1990s, although to levels lower than those found in the 1970s in Columbia and Suwannee Counties. The age of discharged water from the springs was estimated at between five and 80 years, with most springs discharging water that had spent less than 40 years in the aquifer system. In general, NO_3^- levels appear to be higher in the "newer" water being discharged by spring vents, which could reflect some combination of increased loads to the aquifer in recent years (at least up to the late 1990s) and/or a reduced amount of denitrification of NO_3^- due to reduced water age (Katz et al. 1999).

The SRP (FDEP 2002) concluded that the agricultural land uses of poultry farms, row crops, and dairies contributed approximately 32, 28, and 20 percent respectively of the estimated nitrogen load to groundwater in that watershed. For this reason, agricultural BMPs are the primary focus of the SRPs activities.

Agricultural BMPs include guidance on the collection, transportation, storage, and utilization of nutrients, including recommendations related to application rates and crops. Results shown above suggest that implemented actions have not yet resulted in the Suwannee River and its many springs meeting TMDL NO_3^- concentrations of 0.35 mg/l. For the Suwannee River, itself, water quality does not yet appear to exceed established criteria of 1.87 mg/l for TN, but the trend is such that exceedance is likely to occur in the near future (i.e., within 5 to 10 years) as shown above in Figures 19 and 20. The Draft RAP concluded that it may take 20 years, on average, before it can be determined if implementation of agricultural BMPs and other programs and projects have been sufficient (or more than sufficient).

In the BMAP for the Santa Fe River, FDEP concluded that 48 percent of the NO_3^- load to the Santa Fe River comes from fertilizer applications, with 15, 12, and two percent coming from beef production, dairies, and poultry operations, respectively (FDEP 2012). NO_3^- loads from human sewage were estimated to represent less than 10 percent of the TN load to the Santa Fe River (FDEP 2013). As such, wastewater upgrades could be locally important in terms of NO_3^- in the Santa Fe River, but anthropogenic sources do not appear to rise to the same level of concern as loads from agricultural practices. Within the Santa Fe River itself, TN concentrations at both upstream and downstream locations meet their established NNC of 1.87 mg/l. However, NO_3^- concentrations remain problematic. NO_3^- concentrations in the Santa Fe River are more often decreasing than in the Suwannee River watershed, however concentrations continue to exceed the TMDL for NO_3^- .

Bacteria

The TMDLs for bacteria for both the Santa Fe and Suwannee Rivers (FDEP 2014b, FDEP 2014c) are based on data showing sections of both rivers do not meet the Impaired Surface Waters Rule (IWR) standard of 400 CFU / 100 ml for fecal coliform bacteria. These two TMDLs do not attribute loads to any sources or watersheds, but they both conclude that stormwater discharges should not exceed 400 CFU / 100 ml criteria, and that point source discharges should be at levels that "meet permit limits".

Alligator Lake

The TMDL for Alligator Lake (FDEP 2008b) was based upon the lake not meeting the IWR standard of 5 mg DO / liter. The TMDL was based on estimating loads from the developed watershed and calibrating the model to match up with measured nutrient concentrations. Those relationships were then used to predict concentrations of Chl-a. The model was then set to replicate an undeveloped watershed, and nutrient concentrations were then predicted and used to estimate Chl-a. The target "pre-development" Chl-a value was allowed to degrade by 5 TSI units, and load reductions were based on that target value. The TMDL calls for a 28 percent reduction in watershed-wide TN loads, and a 61 percent reduction in watershed-wide TP loads.

2.2.4 Threats to Water Quality

A previous comprehensive water quality assessment conducted by Upchurch (2007), and data analyses conducted as part of this SWIM Plan update, have shown that NO_3^- concentrations exhibit increasing trends at several river and spring discharge stations in the western Suwannee River and Santa Fe River watersheds since the late 1980s. Data for more recent years suggest that most locations still have variable, but non-trending concentrations of NO_3^- over time. Many, but not all, of the river and stream sites previously determined to have decreasing NO_3^- concentrations are in the eastern portion of the District, where the Floridan Aquifer is confined, and where stream-aquifer interactions are mostly restricted to the surficial aquifer (Upchurch et al. 2007). Increasing trends in phosphorus concentrations have generally not been observed in the Suwannee River Basin.

The impacts of nutrient enrichment in springs and rivers are manifested through increased abundance of filamentous algae in increased biological oxygen demand, and thus adverse impacts to those natural systems that are dependent on good water quality (e.g., FDEP 2008a). In addition to impacts in the springs and rivers themselves, the downstream waters of the Gulf of Mexico that are most strongly influenced by Suwannee River discharges are thought to be nitrogen-limited (Mattson et al. 2007). Increased nitrogen loads to the Suwannee River estuary have been a topic of concern raised by FDEP in a recent report on trends in seagrass coverage in the Big Bend region (FDEP 2014a). Consequently, actions taken to reduce NO_3^- loads to the springs and rivers of the Santa Fe and Suwannee Rivers are likely to benefit not only the springs and rivers, but also those portions of the nearshore waters of the Gulf of Mexico influenced by their flows.

In the BMAP for the Santa Fe River, FDEP concluded that 48 percent of the NO_3^- load to the Santa Fe River comes from fertilizer applications, with 15, 12, and two percent coming from beef production, dairies, and poultry operations, respectively (FDEP 2012). NO_3^- loads from human sewage were estimated to represent less than 10 percent of the TN load to the Santa Fe River (FDEP 2013). As such, wastewater upgrades could be locally important in terms of NO_3^- in the Santa Fe River, but anthropogenic sources do not appear to rise to the same level of concern as loads from agricultural practices. Therefore, increased compliance with existing agricultural BMPs, and the development of new BMPs is critical to holding the line on water quality in the Suwannee River Basin.

The mostly rural nature of the Suwannee River Basin has resulted in the widespread use of septic tank systems as a means of waste disposal. Figure 30 shows the locations of permitted septic tanks in the Basin. In low enough densities, with adequate separation between the bottom of the drainfield and the wet season water table, septic tank systems can be an entirely appropriate technique for disposing of domestic wastewater. However, various locations have developed over time such that densities and higher water tables might be problematic. Septic tank replacement programs are extremely expensive, but they can also be the most required management action in some locations. Documentation of impacts to pathogen and nutrient loads from septic tank systems should be a near-term focus, to determine those places where conversion to central sewerage would be appropriate. The identification of locations with excessive amounts of pathogens is complicated by the recently shift from the use of fecal coliform bacteria to a combination of fecal coliform bacteria, *Enterococci* bacteria and *E. coli* bacteria.

To address these issues, the District has identified various management actions (Section 3) and projects/initiatives (Section 4) with the ultimate goal to protect or restore the water quality of the Suwannee River Basin. Concerns vary, but the majority of concerns have focused on the issues of nitrogen enrichment and pathogen abundance. Specific goals include the continuation of efforts to monitor water quality, with regular updates of the status and trends (if any) in water quality across the Basin.

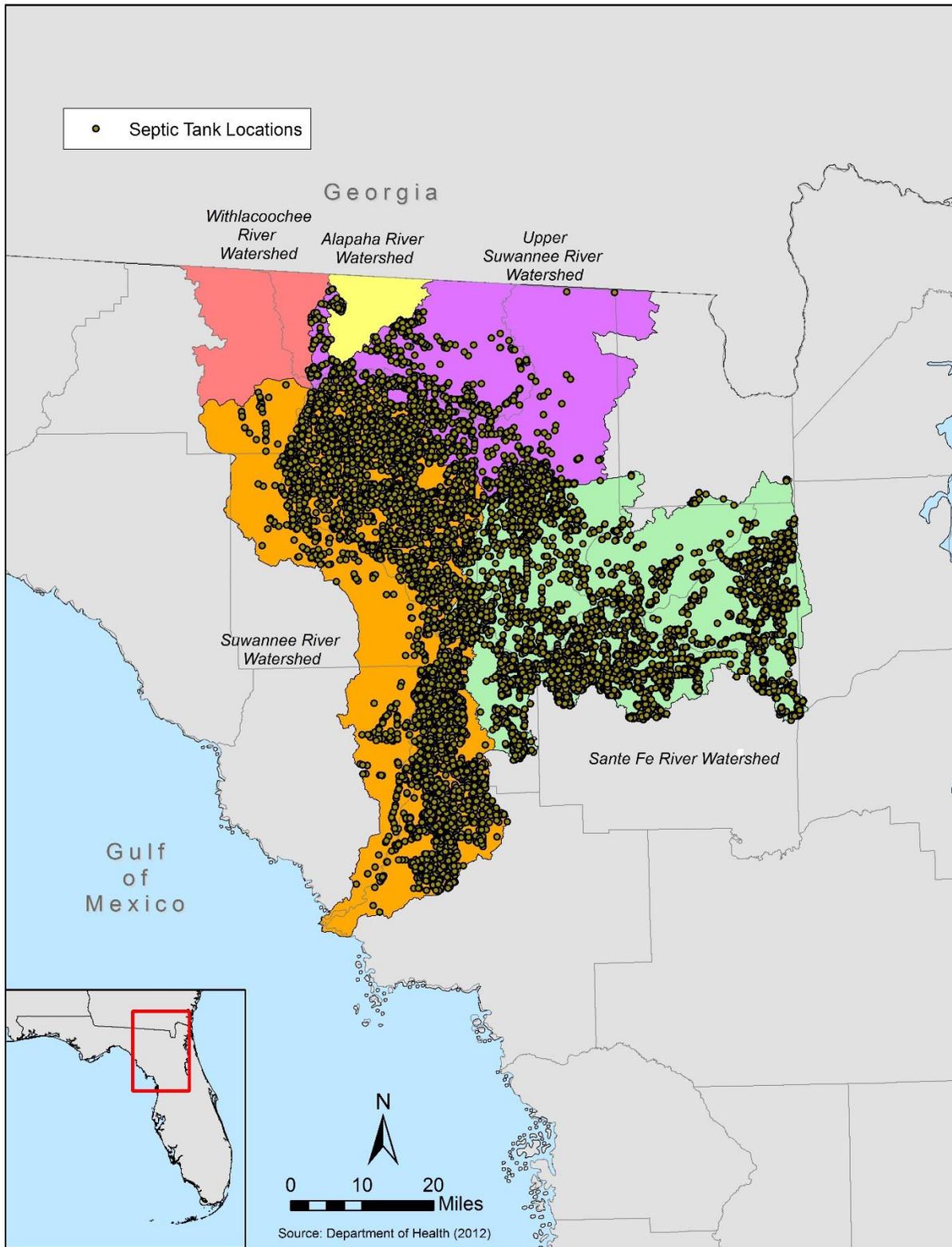


Figure 30. Suwannee River Basin permitted septic tanks

2.3 Natural Systems

The 1987 SWIM Act identified habitat for native plants, fish, and wildlife, including listed species, as resources affected by water quantity and quality. Therefore, SWIM Plans are required to address “natural systems” as a component of strategies to improve and manage surface waters. Natural systems in the Suwannee River Basin include aquatic, wetland, and terrestrial habitats; and the biological communities and species that comprise and utilize these habitats. This section discusses the status and trends of natural systems utilizing summary data from technical publications and reports, and other information available from resource management agencies.

Habitats in the Suwannee River Basin also support numerous rare, endemic, and protected species, including the threatened frosted flatwoods salamander (*Ambystoma cingulatum*), the eastern indigo snake (*Drymarchon couperi*), the Gulf sturgeon (*Acipenser oxyrinchus desotoi*), and the West Indian manatee (*Trichechus manatus latirostris*). The Big Bend Seagrasses Aquatic Preserve along the Gulf Coast of the District is the largest aquatic preserve in the state, and includes over 984,000 acres of submerged lands (FDEP 2014a). The preserve is home to over 2,000 native species of plants and animals, including threatened and endangered species such as the West Indian manatee, loggerhead (*Caretta caretta*), green (*Chelonia mydas*), and leatherback (*Dermochelys coriacea*) sea turtles. These and other species are referenced, as appropriate, in the natural systems descriptions presented here.

Numerous species rely on these systems for nesting, roosting, spawning, foraging, and other uses throughout or during different stages of their lives. Natural systems in the Suwannee River Basin are grouped into:

- Upland habitats;
- Freshwater habitats; and
- Marine/ coastal habitats.

As described earlier, during average and lower flows, rivers and streams in the Basin, except for the Suwannee River, are completely captured by sinkholes as they cross the Cody Scarp and some re-emerge downstream at “river rises”. These natural systems are briefly discussed below, using information from the FNAI (FNAI 2010), previous District reports, and other relevant literature. Continued mapping of these systems provides a means of tracking changes in land cover, habitat, and fish and wildlife.

Habitats for listed animal species are specifically addressed by FWC and conservation of many of these species are also included in FWC’s *Florida’s Imperiled Species Management Plan* (ISMP), approved in November 2016. The ISMP combines Species Action Plans (SAPs) addressing individual species needs with Integrated Conservation Strategies benefiting multiple species and shared habitats. Habitats are presented in this section of the Suwannee River SWIM Plan with reference to associated listed species. A complete listing of state and federally threatened and endangered species in the Basin is presented in Section 2.3.4.

2.3.1 Upland Habitats

Habitat (and ecosystems) in the District are addressed in this SWIM Plan because of the link between habitats and water management and are presented here. Habitat change is the most significant cause of species population declines worldwide (e.g., Gardner et al., 2007, Sala et al., 2000) and habitats are directly influenced by the amount and quality of water. Consistent with the District's goals, Richter et al. (2003) concluded that "ecologically sustainable water management protects the ecological integrity of affected ecosystems while meeting intergenerational human needs". Coastal habitats in the Suwannee River Basin include seagrasses, salt marshes, oyster reefs, tidal flats and sand bars, and coastal swamps and hammocks (Raabe et al. 2004). Interior habitats include tidal freshwater swamps, freshwater marshes, sloughs, rivers and streams, and 18 of Florida's 33 first-magnitude springs.

Almost half the land area in Suwannee River Basin is developed, primarily as agriculture, but also including phosphate mining (Hamilton County), urbanized areas such as White Springs, Branford, Fanning Springs, and the town of Suwannee along the river, as well as Dowling Park and Fowler's Bluff communities and numerous residential subdivisions along the river corridor (District 1995). Uplands in the lower portion of the Basin are predominantly forested and undeveloped, interspersed with agriculture and silviculture.

Natural upland habitats in the Basin have historically been dominated by pine flatwoods of slash, longleaf, or loblolly pine (the species depending largely on soil type and degree of wetness) (District 1995). These uplands are typically desirable for development and remaining uplands may be altered by reduced fire regimes due to urbanization, increases in non-native and invasive species, and fragmentation due to proximate development and roads. Landward edges of forested wetland areas typically include live and laurel oak, pignut hickory, loblolly pine, red cedar, and cabbage palm. Landward of the coastal marshes, transitional areas are vegetated with sand cordgrass, various sedges, cabbage palm, red cedar, slash pine, salt bushes, and wax myrtle (District 1995).

Upland habitats are important to numerous species, for example, Sherman's fox squirrel (*Sciurus niger shermani*), a state listed species of special concern, inhabits open, fire-maintained longleaf pine, turkey oak, sandhills, and flatwoods. Loss of upland habitat also affects habitat for state threatened Florida burrowing owl (*Athene cunicularia floridana*), southeastern American kestrel (*Falco sparverius paulus*), and Florida scrub jay (*Aphelocoma coerulescens*), as well as the federally endangered red-cockaded woodpecker (*Picoides borealis*) all use upland habitat for nesting and foraging. Reptiles similarly threatened due to loss of upland habitat include the state threatened gopher tortoise (*Gopherus polyphemus*), short-tailed snake (*Lampropeltis extenuata*), and pine snake (*Pituophis melanoleucus*), and the federally threatened eastern indigo snake. Some upland habitats are used for particular life stage. For example, the federally threatened flatwoods salamander leaves its upland burrow to deposit eggs in ephemeral wetlands.

Agricultural lands provide a valuable benefit to the conservation of fish and wildlife, including many of the State's Imperiled Species which are integral to the overall ecosystem. This Wildlife Best Management Practices (WBMP) for State Imperiled Species Manual (FDACS 2015) has been developed to enhance agriculture's contribution to the conservation and management of

freshwater aquatic life and wildlife in the state, and to provide guidance to landowners and others who choose to implement these important practices. However, this manual addresses only State Imperiled Species in Florida and not those federally listed by the U.S. Fish and Wildlife Service. Fish and wildlife species currently on the State Imperiled Species list were evaluated for the potential for incidental take to occur during agricultural activities. Based on current knowledge, 16 of the State Imperiled Species were determined to occur in areas where agricultural activities have the potential to influence habitat that supports essential behaviors or directly impact individuals. Designated State Imperiled Species addressed in the WBMP and included in the Suwannee River Basin include the gopher tortoise, Florida burrowing owl, little blue and tricolored herons (*Egretta caerulea* and *E. tricolor*, respectively), Florida sandhill crane (*Antigone canadensis pratensis*), and the southeastern American kestrel, and Barbour's map turtle (*Graptemys barbouri*). While all the BMPs that prevent erosion, sedimentation, groundwater contamination, and protect stream geomorphology are important, the most practical and effective are those associated with maintaining adequate vegetated Conservation Buffers and Stream Crossing.

Upland plant species that are state listed as endangered include Florida flame azalea (*Rhododendron austrinu*), karst pond xyris (*Xyris longisepala*), and browneyed susan (*Rudbeckia triloba*). Upland plant species identified as threatened include Chapman's sedge (*Carex chapmanii*), Florida beargrass (*Nolina atopocarpa*), and giant orchid (*Pteroglossaspis ecristata*). The variation in habitats in the Suwannee River Basin is reflected in differences in species among the individual watersheds. For example, many of the seepage slope species, e.g., the state endangered night flowering wild petunia (*Ruellia noctiflora*), state threatened pinewoods bluestem (*Andropogon arctatus*), and the federally endangered Florida skullcap (*Scutellaria floridana*) occur in the LSR watersheds but are not documented in any of the other four watersheds in the Suwannee River Basin. In contrast, hydric hammocks and mesic flatwoods in the Santa Fe River watershed include the state endangered hammock fern (*Blechnum occidentale var. minor*) and variable-leaf crownbeard (*Verbesina heterophylla*), as well as the state threatened many flowered grass-pink (*Calopogon multiflorus*) (see Appendix G).

Natural upland habitats in the Basin include communities such as upland hardwood forest, upland pine (e.g. longleaf pine and scrubby flatwoods), upland mixed forest, mesic hammock, sandhill and scrub communities that provide habitat for numerous wildlife species. The transition between upland and wetland communities is characterized by habitat ecotones that reflect changes in soil, hydrology, and vegetation.

- Hardwood forested uplands may be mesic or xeric, dominated primarily deciduous or deciduous/evergreen upland species such as American beech, southern magnolia, dogwood, and others. Mesic hammocks are characterized by a closed evergreen canopy of species such as live oak, southern magnolia, pignut hickory, and saw palmetto. Xeric hammocks include a closed canopy of evergreen hardwoods such as sand live oak and saw palmetto.
- High pine and scrub occur on elevated areas or hills characterized by mesic or xeric forest or shrublands of pine or pine mixed with deciduous hardwoods. These forests can be mixes of southern red oak, longleaf or shortleaf pine, and other mixed hardwoods; upland

pine savannas of longleaf pine, loblolly pine, and/or shortleaf pine, and wiregrass; sandhill forests with longleaf pine and turkey oak on high sandy areas; scrub, also sandy, with sand pine (*Pinus clausa*) and scrub oaks (*Quercus ilicifolia*) with or without Florida rosemary.

- Mesic flatwoods and dry prairies are flatland areas with scattered pines over saw palmetto, longleaf pine, saw palmetto, and wiregrass. In the absence of trees (due to frequent fire), dry prairies may occur, supporting a low cover of shrubby live oak, wiregrass, stunted saw palmetto, and broomsedge bluestem.

Notable among the high pine forests is the longleaf pine forests. Although longleaf forests and savannas once dominated the southeastern coastal plain, they have been drastically reduced from an estimated 90 million acres to less than three million, largely due to urbanization, over-utilization, conversion to other land uses, and exclusion of natural fire regimes. Longleaf pine ecosystems are among the most diverse in North America, supporting a large array of herbaceous plant species as well as rare animal species such as red-cockaded woodpeckers and gopher tortoises. Much of the remaining acreage exists as fragmented stands in varying degrees of isolation. The Florida Forest Service (FFS) and FNAI have partnered to develop the Longleaf Pine Ecosystem Geodatabase (LPEGDB), a spatial database that will serve as the central repository for data on the distribution and ecological condition of longleaf pine ecosystems in Florida. The LPEGDB contributes to this effort by providing detailed, baseline data on the location and current ecological condition of remaining longleaf sites in Florida. In Florida, longleaf pine is primarily in the northern Panhandle in the clay-rich soils north of the Cody scarp (Myers 1990) from the western Florida boundary to at least Hamilton County. Longleaf pine is limited along the Suwannee River corridor and becomes more common above Fanning Springs and along the upper Suwannee, Alapaha, and Santa Fe Rivers.

Upland pine is a woodland of widely spaced pines with a sparse to moderate shrub layer and a dense, species-rich groundcover of grasses and herbs, occurring on gently rolling terrain. The canopy is dominated by longleaf pine; shortleaf pine may also be present. Characteristic canopy trees include southern magnolia, pignut hickory, sweetgum, Florida maple (*Acer saccharum* ssp. *floridanum*), and loblolly pine. There is an intermittent subcanopy layer of smaller pines, and hardwoods including southern red oak, blackjack oak (*Quercus marilandica*), flowering dogwood (*Cornus florida*), bluejack oak (*Q. incana*), post oak (*Q. stellata*), sassafras (*Sassafras albidum*), laurel oak, winged sumac (*Rhus copallinum*), common persimmon (*Diospyros virginiana*), sand post oak (*Q. margaretta*), and mockernut hickory (*Carya tomentosa*). Species commonly found in Florida Panhandle and northern peninsula but not farther south includes American beech, white oak (*Quercus alba*), and spruce pine (*Pinus glabra*, Nelson 1994).

Upland hardwood forest occurs in the Florida Panhandle south to the central peninsula (Schwartz 1988; USFWS 1999). Upland hardwood forest most commonly occurs within the inland portions of the state and FNAI (2010) lists the Ichetucknee State Forest as an exemplary site. Upland hardwood forest is a well-developed, closed-canopy forest dominated by deciduous hardwood trees on mesic soils in areas sheltered from fire. It typically has a diverse assemblage of deciduous and evergreen tree species in the canopy and midstory, shade-tolerant shrubs, and a sparse groundcover. Characteristic canopy trees include southern magnolia, pignut hickory,

sweetgum, Florida maple, live oak, laurel oak, swamp chestnut oak, hackberry, white ash (*Fraxinus americana*), and loblolly pine. Species commonly found in Florida Panhandle and northern peninsula but not farther south included American beech, white oak, and spruce pine.

The Big Bend region, including the Suwannee River Basin, includes some of the most heavily forested areas in Florida, in the heart of Florida's "woodbasket"- the area north of Orlando where counties have at least 50 percent forestlands. BMPs for silviculture operations are published by the FDACS (2008). The BMP practices are designed as the minimum standards necessary for protecting and maintaining the State's water quality as well as certain wildlife habitat values, during forestry activities (FDACS 2008). For example, Special Management Zones (SMZs) are a BMP which consist of a specific area associated with a stream, lake, or other waterbody that is designated and maintained during silviculture operations to protect water quality by reducing or eliminating forestry related inputs of sediment, nutrients, logging debris, chemicals and water temperature fluctuations that can adversely affect aquatic communities. SMZs provide shade, streambank stability and erosion control, as well as detritus and woody debris which benefit the aquatic ecosystem in general. In addition, the SMZ is designed to maintain certain forest attributes that will provide specific wildlife habitat values. Snags, den and cavity trees as well as mast producing trees, left in the SMZ, are necessary to meet habitat requirements for certain types of wildlife. More specific activities within an SMZ may include prohibited harvest, prohibited clearcutting, selective harvest, protection of large or old trees or tree snags, prohibited road clearing, and prohibited mechanical site preparation. BMPs are specific to wetlands, streams, canals, waste disposal, wet weather, and other locations and/or conditions.

Native pine and hardwood forests maintain the health of water resources, supporting clean rivers, creeks, and springs, fish and wildlife habitat, and drinking water (FNAI 2010). However, uplands are typically desirable for development and those that remain are altered by reduced fire regimes due to urbanization, increases in non-native and invasive species, and often fragmented due to proximate development and roads. Upland activities can adversely affect wetlands and other surface waters. For example, land clearing can result in greater and more rapid stormwater runoff to wetlands, increasing sediment loads and turbidity in wetlands and open waters, and potentially increase floodwater levels. BMPs are implemented to reduce impacts to adjacent lands and protect water quality and natural systems and fire management is important to the maintenance of many upland habitats.

Silviculture practices in the southern U.S. have been shown to have minor water-quality problems relative to other land uses and conversion to row crops can result in increased runoff to wetlands, although roads without BMPs are the major source of sedimentation (Sun et al. 2004). BMPs for silviculture operations are published by the FDACS Forest Service (FDACS 2008). The BMP practices are designed as the minimum standards necessary for protecting and maintaining the State's water quality as well as certain wildlife habitat values, during forestry activities (FDACS 2008). For example, a SMZ is a BMP which consists of a specific area associated with a stream, lake, or other waterbody that is designated and maintained during silviculture operations to protect water quality by reducing or eliminating forestry related inputs of sediment, nutrients, logging debris, chemicals, and water temperature fluctuations that can adversely affect aquatic communities.

The conversion of longleaf pine to pine plantations has changed the landscape within the Suwannee River Basin (Thom et al. 2015). Nash et al. (2013) compared land use in Florida from 1995 to 2008 and found decreases in forest cover in the upper/middle watershed, compared with an increase in the eastern lower watershed, with no change near the estuary. Increase in cropland/pasture class occurred within the Ichetucknee River watershed and Withlacoochee River watersheds near their confluence with the Suwannee River and in the LSR watershed. Livestock operations increased in Lafayette and Gilchrist counties. Open land class (cattle grazing) increased in Hamilton County (mining area reclamation) and the headwaters of Santa Fe River, but decreased along the middle and lower Suwannee. Combined livestock operations, cropland, and open land classes increased in the lower Withlacoochee River (which has periods of being dry) and Ichetucknee River watersheds. There has been an increase in cattle in the Suwannee River Basin since Kissimmee River operations were bought out and moved north in 1990s.

2.3.2 Freshwater Habitats

As noted previously, the Suwannee River is the largest blackwater river system in the southeastern United States (Katz and Raabe 2005). From its beginning in the Okefenokee Swamp to White Springs (Hamilton County), Suwannee River flows are primarily dependent on surface drainage from tributaries and seepage from the surficial aquifer. Just upstream from White Springs, the river cuts into Suwannee Limestone of the Floridan Aquifer and for the remainder of its course to the Gulf, flows are augmented by numerous springs and groundwater seepage, changing the chemistry and appearance of the river.

The USFWS National Wetlands Inventory (NWI) is a publically available data source of wetlands in the U.S. In the Suwannee River Basin, NWI data indicate freshwater marshes (freshwater emergent) and freshwater forested wetlands are the dominant freshwater wetland (Figure 31). These wetlands are typically associated with rivers, spring runs, and springs, although they are also associated with the few lakes and ponds that appear in the Basin. Freshwater habitats in the Suwannee River Basin are primarily associated with the river and include springs, spring runs, forested wetlands, marshes, and occasional lakes (Figure 31), for example, Lake Santa Fe in the far southeastern portion of the Basin. Lakes in the Basin include acidic, soft-water lakes of low mineral content (Townsend Pond in Lafayette County), to alkaline, hard-water lakes of higher mineral content (Governor Hill Lake in Dixie County); and acidic, soft-water lakes of low mineral content, in a portion of the USR Basin in Madison County). Springs and spring runs are typically characterized by SAV due to the clear water, and often have adjacent marshes due to adequate light penetration at the spring or wide spring run. The tidal freshwater river system along the LSR (Figure 31) has been extensively studied, as have many of the springs and spring runs in the Basin. Forested wetlands and herbaceous marshes are the most conspicuous habitats along the river and floodplain and generally include:

- Forested wetlands dominated by needle-leaved deciduous trees; bald or pond cypress, and/or needle-leaved evergreen trees; slash pine, loblolly pine, pond pine or spruce pine

- Forested wetlands dominated by various types of broadleaf evergreen hardwoods (including sweet bay (*Magnolia virginiana*), southern magnolia, and loblolly bay (*Gordonia lasianthus*)
- Forested wetlands dominated by various types of broadleaved deciduous hardwoods (oaks, various gums, hickory, river birch (*Betula nigra*), red maple (*Acer rubrum*))
- Herbaceous marshes ranging from sedgebogs, through wet prairies (vegetated with *pickernelweed*, *arrowhead*, sawgrass, and other sedges) to permanently flooded marshes dominated by floating leaved aquatics such as waterlilies and pondlilies

Freshwater wetlands along the rivers begin in the headwaters and end where the Gulf waters meet flows from the river, and the 0.5 ppt isohaline is the downstream boundary of wetlands characterized by species intolerance of persistent salinities. Freshwater vegetation includes trees, shrubs, persistent emergent plants, and emergent mosses or lichens. Freshwater habitats in the Suwannee River Basin include springs and spring runs, freshwater and estuarine marshes, and forested wetlands. Springs and spring runs are not as conspicuous in this Basin when compared with the Suwannee and only three of the 57 springs in the Basin are first magnitude and freshwater marshes are not extensive. The rivers vary somewhat in each of the Basins and forested wetlands are described for each river watershed.

Water management activities focused on protecting these natural wetland systems are important to the numerous ecological, and economic, benefits to the region, including (FDEP 2011):

- Providing food for numerous species such as oysters, crabs, fish, and wildlife;
- Providing protective habitat for migratory fish and juveniles of many commercial fishery species;
- Providing feeding, breeding, spawning, and nesting habitat for waterfowl and migratory birds, state and federally listed threatened and endangered species, and many commercial and recreational fish and shellfish;
- Maintaining the biodiversity of native species with sufficient space and community health;
- Improving water quality by absorbing sediment loads and filtering pollutants;
- Influencing climate through evaporation and transpiration;
- Protecting human life and property by reducing floodwater flow and volume; and
- Enhancing human community resilience by buffering environmental conditions (e.g., hurricanes, floods, climate, and sea level rise), reducing erosion, and providing groundwater recharge areas.

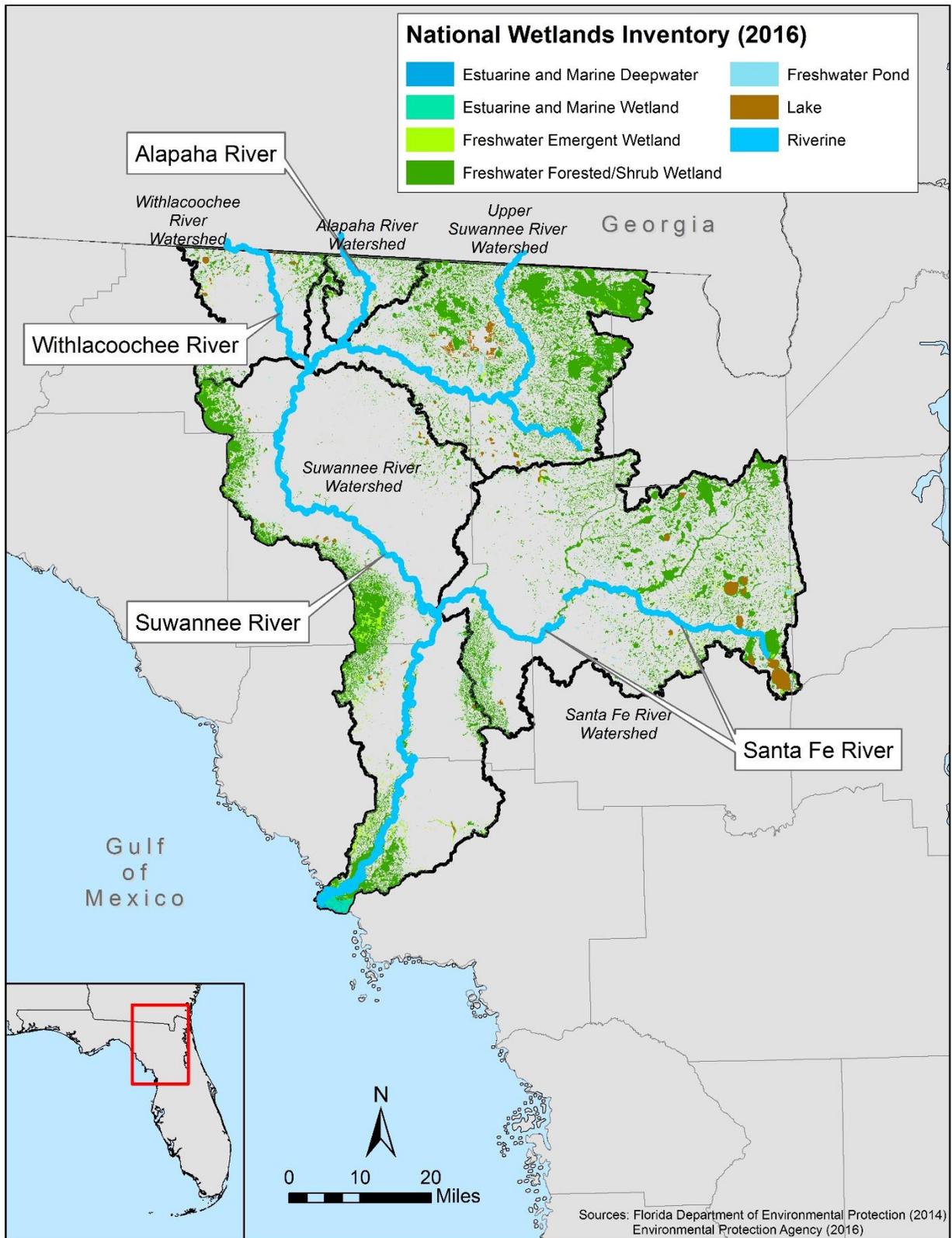


Figure 31. NWI wetlands in the Suwannee River Basin

Freshwater habitats support many animal species designated as threatened or endangered due to loss of habitat and approximately 85 percent of riverine fish species use the floodplain and swamp for some part of their life history (Leitman et al 1991, Burgess et al, 2013). Mussels also occur in the river and creeks, including the federally endangered oval pigtoe (*Pleurobema pyriforme*) in the Santa Fe River watershed, and the federally threatened Suwannee moccasinshell (*Medionidus walkeri*) in all five watersheds. The alligator snapping turtle (*Macrochelys temminckii*) is also found in freshwater forested wetlands.

However, many species use both freshwater and estuarine/marine habitats, including: the federally threatened Gulf sturgeon that lives in the Gulf and returns to natal freshwater rivers and streams to spawn, the federally threatened West Indian manatee that lives and travels along the Gulf coast and seeks refuge in freshwater springs in the winter, the federally threatened American alligator (*Alligator mississippiensis*) (due to similarity in appearance to the federally threatened American crocodile (*Crocodylus acutus*)) that inhabits freshwater and estuarine waters, and the federally threatened wood stork (*Mycteria americana*), which can be found from estuarine tidal marshes to spring runs, to sandhill lakes. Other fish and wildlife species should also be identified as using these habitats such as the following wading birds: little blue heron, tricolored heron.

Loss of wetland habitats such as seepage slopes can affect numerous plant species, for example, 11 plant species identified as endangered or threatened by the State of Florida inhabit seepage slopes in the Suwannee River Basin. Species such as the state endangered Florida willow (*Salix floridana*) in spring runs and hydric hammocks and the state threatened corkwood (*Leitneria floridana*) of estuarine tidal marshes (Appendix G lists all 61 plant species and associated habitat).

2.3.2.1 Springs and Spring Runs

Springs and spring-run streams in Florida occur as perennial flow ways of clear water from deep aquifer headwaters, often with a limestone bottom. Springs along the Suwannee River are numerous, as described earlier. Individual springs are stable systems, with very little change in water temperature, water flow, or chemical composition, but those characteristics can vary from one spring to the next. The bottoms of spring runs are generally sand or exposed limestone along a central, stable channel. Vegetation in spring and spring run habitats consist of SAV, aquatic algae covering limestone outcroppings, and species such as tape grass, wild rice, and giant cutgrass located in the spring runs (FWC 2016b). Submersed and emergent vegetation are typically present, but this habitat is based on the presence of the spring rather than dominant vegetation. Freshwater SAV provides habitat for benthic macroinvertebrates, fish, and other aquatic wildlife. Benthic substrates in the rivers vary widely, ranging from fine grained muck sediments to generally sand, limestone shelves with pebbly gravel and exposed large rock, and bedrock. SAV in the rivers, springs, and spring runs with adequate water clarity include dense growth of rooted aquatic plants, species such as spring tape grass (*Sagittaria kurziana*), tape grass (*Vallisneria americana*), and pondweed (*Potamogeton illinoensis*) are common, along with infestation by such invasives as *Hydrilla verticillata*. Wild rice (*Zizania aquatica*) is typical of the river edges, with species of rooted or floating aquatic vegetation such as lily pads like yellow pondlily (*Nuphar lutea*) and American white waterlily (*Nymphaea odorata*), pickerelweed, and duck potato (*Sagittaria laticifolia*) in the deeper areas.

Issues associated with springs include physical disturbance of SAV beds in spring runs, caused by heavy recreational use. Boating, diving, paddling, and other types of recreation can disturb SAV, result in the erosion and disturbance to springs and channels, and adversely affect habitat and associated species. Combined with increased nutrient concentrations, physical disturbances can also create conditions for the proliferation of undesirable rooted aquatics (e.g., *Hydrilla*) as well as filamentous algae mats composed of invasive species, primarily *Lyngbya spp.*

SAV provides forage to manatees and other aquatic species, shelter for fish and benthos, assimilation of nutrients and other chemicals, and stabilization of the river channel to reduce erosion and turbidity. River SAV habitat provides structural habitat for benthic invertebrates and fish, and forage for manatees, and is a significant component of the rivers' primary production. SAV habitat and substrate also drive a variety of biochemical processes and cycles in the water column (Cohen, et al. 2013, Heffernan and Cohen 2010). High biomass of SAV in the Ichetucknee River, compared to other spring-fed rivers in northcentral and west Florida, has been attributed to optimal sediment conditions and current velocity for SAV growth (PBS&J 2003).

Monitoring SAV condition can help identify trends in water quality and flows. For example, MFLs in the Ichetucknee River require water levels sufficient to protect the SAV critical to habitat for fish and wildlife. During low water levels, SAV is vulnerable to damage from recreational activities such as boating, and especially tubing, on the Ichetucknee River. Recreational activity has probably been the most important factor affecting the health of the Ichetucknee River and associated SAV beds from the 1970s to present (PBS&J 2004, District 2005).

Physical disturbance of SAV beds in spring runs caused by heavy public use can result in the erosion and destruction of native species. Combined with increased nutrient concentrations, physical disturbances can create conditions for the proliferation of undesirable rooted aquatics (e.g., *Hydrilla*) as well as filamentous algae mats composed of invasive species, primarily *Lyngbya spp.* Monitoring by Ichetucknee SP staff indicates a decline in SAV coverage during the high use summer period, followed by an increase through the spring. The rate of decline in SAV coverage was determined to be significantly correlated with headspring water levels at one of four monitoring stations, and weakly correlated with groundwater levels and park use (number of people).

SAV in Manatee Springs and spring run appear to be affected by both long term and seasonal changes in water quality (highly tannic waters from the Suwannee River) and grazing by manatees. Restoration of SAV in this spring system will be difficult due to the high recreation use. However, protection (e.g., using exclusion zones) of existing, albeit sparse SAV, may result in future increases and persistence of this important habitat. The lower Santa Fe River is less suitable for SAV due to solid rock channel bottoms at shoals, unconsolidated, mainly sandy sediments, and marl banks along the downstream portions, compared with the finer grained sediments of the Ichetucknee that are suitable for SAV (District 2005). Analysis of water quality data provides no evidence that MFLs that increase flows to springs will reduce NO_3^- concentrations (Stevenson et al. 2004, Upchurch et al. 2007).

In Florida, the greatest karst biodiversity is found in the northern peninsula and east-central panhandle. Franz and Morris (1994) reviewed the cave faunas of Florida and southern Georgia

and identified 267 biologically important caves serving as critical habitat for populations of 27 invertebrates and one vertebrate taxa, of which nearly all species (93 percent) are aquatic (Walsh 2001). Some species are limited to these habitats, such as the state threatened Santa Fe cave crayfish (*Procambarus erythroptus*) that is limited to freshwater aquatic caves in the LSR watershed. Because surface water runoff can introduce sediments, nutrients, and other contaminants, management of surface water runoff is important to protecting these sensitive systems. Florida has expansive karst areas that include a combination of diverse and globally unrivaled large- magnitude springs, caverns, caves, sinks, disappearing streams and lakes, and complex subterranean aquifers (Rosenau et al. 1977; Lane 1986; Miller 1997, after Walsh 2001). The aquatic fauna is a major component of the karst biota and includes about one third of all known cave species. In fact, the distribution of the aquatic biota across karst habitats accounts for an estimated 4 percent of the total surface area of the contiguous U.S. (Culver et al. 2000). Karst systems of Florida contain among the most diverse aquatic faunas nationwide.

2.3.2.2 Freshwater Marshes

Emergent freshwater marshes along the river channel occur at average low water salinities less than 0.5 ppt and occur from just below the headwaters, along the USR, Santa Fe, and Alapaha, to the freshwater portions of tidally influenced portion of the Suwannee River. These marshes are directly influenced by river flooding on an annual or semi-annual basis (Toth et al. 1998). Marsh species are typically herbaceous (Cowardin et al. 1979 classify marshes as having less than 40 percent tree cover) and may include sawgrass and maidencane (*Panicum hemitomon*) as dominant plant species. Species such as bulltongue arrowhead (*Sagittaria lancifolia*), bladderworts (*Utricularia spp.*), pickerelweed, and yellow pond lily occupy the deepest, most frequently flooded sites (FNAI 2010).

Emergent freshwater marshes are directly influenced by river flooding on an annual or semi-annual basis where most of the marsh is inundated from approximately 120 to 350 days per year (Toth et al. 1998). Freshwater tidal marsh plant species include pickerelweed, softstem bulrush (*Schoenoplectus tabernaemontani*, formerly *Scirpus validus*), cattails (*Typha spp.*), false nettle (*Boehmeria cylindrica*), and other plants common in the estuary marshes in salinities ranging over 3-7 ppt,

Freshwater marshes occur in shallow wetlands and along portions of rivers with adequate light and velocities that are low enough that vegetation can become established rather than scoured by currents. Permanently flooded marshes may be dominated by floating leaved aquatics such as waterlilies and pond lilies. Freshwater marshes may be associated with river edges, typically on inside meander of rivers where flow velocity slows and deposition occurs, and herbaceous species can become established.

Upstream freshwater marshes are important habitat for black rail (*Laterallus jamaicensis*), limpkin (*Aramus guarana*), bald eagle (*Haliaeetus leucocephalus*), and wading birds, particularly great egret (*Ardea alba*), white ibis (*Eudocimus albus*), little blue heron, snowy egret (*Egretta thula*), tricolored heron, black-crowned night-heron (*Nycticorax nycticorax*), yellow-crowned night-heron (*Nyctanassa violacea*), and glossy ibis (*Plegadis falcinellus*). Historically, snail kites (*Rostrhamus sociabilis plumbeus*) were found in floodplain marshes but are now absent, probably due to habitat degradation (Sykes, Jr. 1984, after Thom et al. 2015).

Species in freshwater marshes may be threatened due to loss or degradation of this habitat. The state threatened tricolored heron occurs in freshwater marshes and salt marshes, as well as most waters of coastal lowlands. The state threatened Florida sandhill crane also occurs in freshwater marshes, swales, and wet and dry prairies.

2.3.2.3 Forested Wetlands

Freshwater flows are important to maintaining the forested wetlands along the Suwannee and other rivers in the District and tree species in these freshwater habitats reproduce only under freshwater conditions. Light et al. (2002) studied the Suwannee River specifically and considered salinity the primary limiting factor influencing the community structure of the lower tidal forests and in setting the downstream limit of the “tree line,” where tidal forest grades into tidal marsh. Salinity influence is from several sources; intrusion of saline water via the river channel at low flows, marine aerosols, and deposition of salt water from storm surges during hurricanes and tropical storms. Similarly, saltwater intrusion into freshwater marsh, which is the source of freshwater for bird species nesting in the salt marshes, results in a shift to salt marsh.

While marine systems have salinities greater than 30 ppt, estuarine systems, forested wetlands are limited to freshwater conditions (less than 0.5 ppt salinity). General wetland classes (National Wetlands Inventory (NWI) mapping data 2007-2010) in the LSR watershed are mapped in Figure 31 (after Thom et al. 2015). Forested wetlands are the primary wetland habitat type throughout the Suwannee River Basin. These wetlands occur along the rivers, in the floodplain, or depressions and may be dominated by various types of evergreen hardwoods (including sweet bay, southern magnolia, and loblolly bay); various types of deciduous hardwoods (oaks, gum trees, river birch, red maple); swamps dominated by cypress and tupelo trees (*Nyssa spp.*); hydric hammock of live oak, cabbage palm, red cedar and mixed hardwoods; wet flatwoods with slash pine, pond pine (*Pinus serotina*), cabbage palm, and wiregrass. Coastal swamps occur at the most downstream freshwater influence along the coast, but tidal swamps are not as developed here as they are along the Suwannee River, where freshwater flows are much larger support an extensive floodplain.

Forested systems occur upstream of salinity influence with the exception of species tolerant of storm and infrequent saltwater flooding such as sabal palms and junipers. Seeds and seedlings of tree species are intolerant of salt, although adult trees can tolerate infrequent exposure. Isolated wetland systems (those present in the Basin but not hydrologically connected with the river or its tributaries) are also an important component of the wetland resources in the Basin and may include various types of forest wetlands (District 1995):

- Forested wetlands dominated by needle-leaved deciduous trees, bald or pond cypress, and forested wetlands dominated by an overstory of needle-leaved evergreen trees (typically slash pine or loblolly pine)
- Forested wetlands dominated by various types of broadleaf evergreen hardwoods (including sweet bay, southern magnolia, and loblolly bay)
- Forested wetlands dominated by various types of broad-leaved deciduous hardwoods (oaks, various gums, river birch, red maple).

- Bottomland forests on terraces and levees in riverine floodplains and in shallow depressions also occur, with species such as sweetgum, spruce pine, and loblolly pine prevalent. Nearly all bottomland forests have been impacted from timbering operations and some have been converted to pine plantations. Sweetgum is often favored by disturbance due to its ability to sprout following damage to the tree. A wide variety of wetland types occur the rivers, often depending on the amount of spring flow and the land surface drainage.

Flooding is critical to fish access to the floodplain for forage and the rich organic debris is essential to the functional integrity of downriver ecosystems such as estuaries. In floodplain swamps located within tidal influence, flooding patterns, tidal range, and storm events are major driving factors. These swamps are subject to daily freshwater inundation associated with tidal fluctuations (Day et al. 2007). Floods redistribute detrital accumulations to other portions of the floodplain or into the main river channel. The flooding is critical to fish access to the floodplain for forage and the rich organic debris is essential to the functional integrity of downriver ecosystems such as estuaries. In floodplain swamps influenced by tide, flooding patterns, tidal range, and storm events are major driving factors. These swamps are subject to daily freshwater inundation associated with tidal fluctuations (Day et al. 2007) and are affected by freshwater flows. Flow reductions during low flows when inundated and saturated areas of the floodplain are already limited are expected to adversely impact these forested wetlands (Light et al. 2002). For example, Tillis (2000) estimated that a 1,000 ft³/sec withdrawal from the Suwannee River would move the freshwater–saltwater interface (0.5 ppt isohaline) 1.58 miles upstream during typical low flow conditions, compared with 0.06 miles upstream during high flow conditions

Virtually all cypress/tupelo stands along the Suwannee River are second growth, following intensive logging by the first half of the 20th century. Forested systems occur upstream of the salinity influence with exceptions for species tolerant of storm and infrequent saltwater flooding such as sabal palms and junipers. Seeds and seedlings of tree species are intolerant of salt, although adult trees can tolerate infrequent exposure. Isolated wetland systems (those present in the Basin but not hydrologically connected with the river or its tributaries) are also an important component of the wetland resources of the Suwannee River Basin. Forested wetlands may also be dominated by needle-leaved deciduous trees such as bald or pond cypress, and/or needle-leaved evergreen trees such as slash pine, loblolly pine, pond pine or spruce pine; forested wetlands dominated by various types of broadleaf evergreen hardwoods (including sweet bay, southern magnolia, and loblolly bay), and forested wetlands dominated by various types of broadleaved deciduous hardwoods (oaks, various gums, hickory, river birch, red maple).

Intertidal areas beyond the influence of salinity are characterized by tidal freshwater swamps that have been described in detail by several authors (Wharton et al., 1982; Clewell et al., 1999; Light et al., 2002; Darst et al. 2002, Darst et al. 2003, Light et al. 2007). Light et al. (2007) provide the following summary and reference the potential impacts of future increases in upstream water use on the river habitats:

Fourteen specific forest types were mapped ... Riverine high bottomland hardwoods have higher canopy species richness than all other forest types (40-42 species), with Quercus virginiana the most important canopy tree by basal area.

The canopy composition of riverine low bottomland hardwoods is dominated by five species with Quercus laurifolia the most important by basal area. Riverine swamps occur in the lowest and wettest areas with Taxodium distichum the most important canopy species by basal area. Upper tidal bottomland hardwoods are differentiated from riverine forests by the presence of Sabal palmetto in the canopy. Upper tidal mixed forests and swamps are differentiated from riverine forests, in part, by the presence of Fraxinus profunda in the canopy. Nyssa aquatica, the most important canopy species by basal area in upper tidal swamps, is absent from most forests in the lower tidal reach where its distribution is probably restricted by salinity. Hydric hammocks, a wetland type that is rare outside of Florida, are found in the lower tidal reach and are flooded every 1-2 years by either storm surge or river floods. Lower tidal mixed forests and swamps have continuously saturated muck soils and are differentiated from upper tidal forests, in part, by the presence of Magnolia virginiana in the canopy. Lower tidal swamps have the highest density of canopy trees (about 1,200 trees per hectare) of all floodplain forest types, with Nyssa biflora the most important canopy species by basal area.

These tidal swamps provide important nesting habitat for numerous mammals, birds, and especially fish species in the Basin. The abundance of fiddler and shore crabs in these swamps suggests they may provide important forage habitat for crab-feeding birds, such as yellow-crowned night heron and little blue heron, and mammals such as raccoon and mink. The leaf detritus produced in these swamps is likely an important food base for the downstream estuarine aquatic communities.

Bottomland forest is a deciduous, or mixed deciduous/evergreen, closed canopy forest on terraces and levees within riverine floodplains and in shallow depressions. Dominant species include sweetgum, spruce pine, loblolly pine, and other species. Nearly all bottomland forests have been impacted from timbering operations, which frequently leave long-lasting scars from soil disturbance. In addition to clearcutting, some bottomland forests have been converted to pine plantations, usually with severe effects on species composition and leaving exposed topsoil that would normally have been bound by tree roots (Wharton et al. 1977). Sweetgum is often favored by disturbance due to its ability to sprout following damage to the tree (Sharitz and Mitsch 1993).

2.3.3 Marine/Estuarine Habitats

Marine and estuarine systems (Figure 31) are influenced most strongly by salinity and tidal inundation from the sea and occur landward or upstream until soil or water salinities are less than 0.5 ppt (where freshwater systems begin). The dominant wetland habitat along the Big Bend coast and at the mouth of the Suwannee River are estuarine marshes. Coastal forests occur just landward of salt marshes and are tolerant of short periods of salt water from storm surge events.

Potential loss or degradation of marine and estuarine habitats are of particular importance to the federally endangered Hawksbill (*Eretmochelys imbricata*), Kemp's Ridley (*Lepidochelys kempii*), and leatherback sea turtles, and federally threatened green and loggerhead sea turtles, which spend their lives in open water and in seagrasses and coral reefs in the Gulf. Seagrass beds also provide important habitat for the federally endangered West Indian manatee and dwarf seahorses (*Hippocampus zosterae*), which are declining, and petitioned for federal listing (FWC 2016). The

most common physical destruction to seagrasses is damage and loss due to boat propellers and vessel groundings on shallow seagrass beds (FNAI 2010). Estuarine and coastal habitats in the Basin are also important to plant species designated as endangered by the State of Florida, for example, the sand dune spurge (*Chamaesyce cumulicola*), and the state threatened plant of maritime hammocks, corkwood (Appendix G).

Estuarine and marine tidal marshes and tidal forests in the Suwannee River Basin are also important to the state threatened, corkwood (*Leitneria floridana*), which is found in the lower and USR and Santa Fe River watersheds (Appendix G).

2.3.3.1 Tidal Wetlands

Tidal wetlands in the Suwannee River Basin includes primarily tidal marshes and coastal forests (Figure 31), where wetlands may be exposed to regular tidal inundation or intermittent storm surges.

Coastal Forests

Similar to the rest of the Big Bend coast, coastal forests characterized by hydric hammocks dominate the shoreline along the LSR, with red cedar and cabbage palm becoming more dominant in the canopy of this community type and cypress no longer appearing. These tidal swamps provide important nesting habitat for swallow-tailed kites (*Elanoides forficatus*) in the region (Sykes et al., 1999). Coastal hydric hammock can be found on scattered islands within the tidal marsh, and on a low chain of discrete, slightly elevated islands along an ecotone that separates the high salt marsh from interior plant communities and is tolerant of Gulf waters. Coastal islands are scattered throughout the marsh, consisting of cabbage palm, red cedar, and Christmas berry (*Lycium carolinianum*) which is the more heavily marine-influenced hammock portion of the islands. The center of an island may consist of wet mesic flatwoods (slash pine, saw palmetto) or an oak-dominated xeric hammock community.

The State endangered sand-dune sprurge (*Chamaesyce cumulicola*) also occurs in the coastal forests along the lower Suwannee River watershed (Appendix G).

Salt and Estuarine Marshes

Slightly salt-tolerant herbaceous plants such as sawgrass and bulrush (*Scirpus spp.*) appear as the conditions shift from freshwater tidal to estuarine. Near the river mouth, salt marsh becomes the dominant vegetation community type, with black needlerush, and salt-meadow cordgrass (*Spartina patens*) and the marshes dissected by numerous tidal creek branches and drainages from interior freshwater seepage areas (FDEP 2006).

Along the Big Bend, low energy salt marshes, affected by tides and seawater and protected from large waves, either by the broad, gently sloping topography of the shore, by a barrier island, or by location along a bay or estuary, represents the greatest salt marsh acreage in Florida. Salt marshes are a conspicuous feature along the coastal portions the Suwannee River Basin and are vegetated by smooth cordgrass (*Spartina alterniflora*), needlerush (*Juncus spp.*), and salt-meadow cordgrass. These wetland resources provide fish and wildlife habitat and nursery areas for economically important species (commercial and recreational fisheries and game species).

Farther upstream, intertidal areas beyond the influence of salinity are characterized by tidal freshwater swamps (Wharton et al. 1982; Clewell et al. 1999; Light et al. 2002).

Salt marshes are some of the most biologically productive natural communities (FNAI 2010). The base of the food chain is supported by vegetation as well as algae and detritus plants, on the sediment surface, and suspended in the water column of tidal creeks. Commercial marine species that spend all or part of their life cycle in tidal creeks include mullet (*Mugil spp.*), spot (*Leiostomus xanthurus*), blue crabs (*Callinectes sapindus*), oysters, and shrimp (*Penaeus spp.*). The smaller minnows and juvenile fish in tidal creeks provide food for many recreationally important, predatory fish, such as tarpon (*Megalops atlanticus*), snook (*Centropomus undecimalis*), red drum (*Sciaenops ocellatus*), and spotted seatrout (*Cynoscion nebulosus*) (Montague and Wiegert 1990). In addition, the federally endangered Florida salt marsh vole (*Microtus pennsylvanicus dukecampbelli*) is known to use a specific type of salt marsh plant, saltgrass, as habitat, indicating even greater importance of this particular salt marsh. Potential impacts of SLR on salt marshes have also been investigated.

The abundance of fiddler and shore crabs in these swamps offer forage habitat for crab-feeding birds, such as yellow-crowned night heron and little blue heron, and mammals such as raccoons and the federally endangered salt marsh vole.

Many wading birds occur in estuarine marshes, such as the state threatened Marian's marsh wren (*Cistothorus palustris marianae*) and Scott's seaside sparrow (*Ammodramus maritimus peninsulae*). Others prefer coastal wetlands but also occur in freshwater forests and marshes, such as the state threatened little blue heron. Birds such as the federally threatened piping plover (*Charadrius melodus*) and state threatened American oystercatcher (*Haematopus palliatus*) prefer coastal sands or unconsolidated substrates along shorelines.

Salt marshes are some of the most biologically productive natural communities known (FNAI 2010) and occur along low energy shorelines, at the mouth of rivers, and in bays, bayous, and sounds. While salt marshes are infrequent along the Panhandle of Florida west of Apalachicola Bay, the Big Bend portion of the Gulf Coast, including the LSR and Sound, are dominated by salt marshes. Marshes are subject to tidal inundation and freshwater that transport sediments and nutrients necessary for the growth and formation of a marsh system. These marsh habitats are at the base of the food chain supported by vegetation as well as algae and detritus plants, on the sediment surface, and suspended in the water column of tidal creeks. Commercial marine species that spend all or part of their life cycle in tidal creeks include mullet, spot, blue crabs, oysters, and shrimp. The smaller minnows and juvenile fish in tidal creeks provide food for many recreationally important, predatory fish, such as tarpon, snook, red drum, and spotted seatrout (Montague and Wiegert 1990). Salinity tolerances of many of the dominant animal taxa found in the tidal marshes of the Suwannee estuary are generally quite broad (PBS&J 2003). Two characteristic taxa are the olive nerite snail (*Neritina usnea*) and the freshwater fiddler crab (*Uca minax*). The olive nerite is reported to tolerate an exceptionally wide range of salinities of (Heard 1982, PBS&J 2003). In addition, the Florida salt marsh vole was discovered in 2004 on the Suwannee River National Wildlife Refuge (SRNWR), which occurs only in these particular salt marshes.

The USR estuary, comprising both oligohaline and mesohaline zones, is bordered by tidal freshwater swamp and brackish marsh habitat (District 2005). The lower and nearshore estuary is a mix of salt marsh, tidal creeks, and mudflats. Seagrasses are much less abundant within this estuary when compared to other estuaries along Florida's Big Bend coast, primarily due to the highly colored surface water which limits light penetration (Bledsoe 1998) though possibly also due to the highly variable salinity.

Salt marshes typically have distinct zones of vegetation, each dominated by a single species of grass or rush. Salt marsh cordgrass dominates the seaward edge and borders of tidal creeks, areas most frequently inundated by the tides. Needlerush dominates higher, less frequently flooded areas (Eleuterius and Eleuterius 1979). On the Gulf coast, with a low tidal range of 0.6 to 0.9 meters (2 to 3 feet) and gentle seaward slope, most of the marsh is above mean high water level and is dominated by needlerush, with salt marsh cordgrass often forming only a fringe along the seaward edge of the marsh and along tidal creeks. The numbers of plant species increase farther upstream, as salinities decline, and farther landward, as the elevation increases (and flooding decreases).

The landward edge of the marsh is influenced by freshwater influx from the uplands and may include high marsh and inland species, including needlerush, sawgrass, salt-meadow cordgrass, Gulf cordgrass (*Spartina spartinae*), and sand cordgrass. A border of salt-tolerant shrubs, such as groundsel tree (*Baccharis halimifolia*) and saltwater falsewillow (*Baccharis angustifolia*), often marks the transition to upland vegetation or low berms along the seaward marsh edge (Clewell 1997).

2.3.3.2 Hard and Soft Bottom Habitats

Hard and soft bottom habitats are marine systems that may be vegetated, e.g., seagrasses, or occupied by organisms such as oysters, scallops, and clams. The coastal waters of the District support commercial and recreational finfish and shellfish (Coen and Grizzle 2007), which can both affect, and be affected by, water quality. For example, shellfish harvesting waters must meet Class II standards for water quality to remain open to harvest, requiring adequate management of surface water runoff. Ecological benefits of successful shellfish restoration include improved water clarity resulting from the removal of phytoplankton and suspended particles by shellfish the restoration of keystone species; the creation of habitat for other species; and, in the case of reef-building species, shoreline protection through wave dampening. The harvest, culture, and processing of shellfish seafood products are a source of economic benefit to the local communities (Shumway et al. 2003, Leverone 2010).

Oyster Reefs

Oyster habitats, dominated by eastern oysters, are the main structural habitat feature in Suwannee Sound and have both ecological value as habitat and economic value as a commercially harvested resource (Figure 32; Mattson 2002). Reef structures formed by oysters are complex and provide refuge for hundreds of other species, including the juvenile stages of several fishes. The bulk of eastern oyster harvesting in Florida occurs on the Gulf coast, primarily in the Panhandle and Big Bend regions. The Suwannee River estuary and Suwannee Sound are the only commercial oyster harvest areas in Florida other than Apalachicola Bay.



Figure 32. Oyster reefs in the Suwannee River estuary. Data sources: USGS aerial imagery and District map data. (District 2005)

Along the Florida Gulf coast, spat settlement occurs throughout the spring and summer (Patillo et al. 1997) and freshwater flows that maintain salinities of approximately 22 ppt in Suwannee Sound (where most of the oyster coverage is found) in spring and summer and maximum salinities of approximately 35 ppt during low flow seasons (winter) have been recommended (Livingston et al. 2000). Most of Florida's production of eastern oysters occurs on the Gulf Coast (97 percent of the landings by weight), primarily in counties in the Florida Panhandle and Big Bend regions. Only about 3.4 percent of commercial oyster harvest was landed on the Atlantic coast during 2013 (FWC 2014). In addition, Gulf landings averaged about five million pounds during 1982–1985 but have declined by more than 60 percent, reaching 1.4 million pounds in 2005. Trends in oyster habitat along Florida's Big Bend coastline (Gulf of Mexico coast from Crystal River to Apalachee Bay) were assessed by Seavey et al. (2011) for the period between 1982 and 2011 and indicated a 66 percent net loss of oyster reef area (124.05 ha) in the region. Losses were more concentrated offshore (88 percent) than nearshore (61 percent) and inshore (50 percent) reefs and the oyster reefs were found to be moving landward. The investigators suggest, based on multiple lines of evidence, that the losses are due primarily to reduced survival and recruitment, likely a result of reduced freshwater inputs that increase reef vulnerability to wave action and sea level rise,

although “it seems most likely that increasing human uses of freshwater inland may be an important factor resulting in habitat loss”. The authors conclude by recommending additional monitoring to further evaluate trends in oyster habitat along the Big Bend. Consistent with these recommendations, The Gulf States Marine Fisheries Commission regional management plan for the eastern oyster fishery and oyster production in Florida (FWC 2014) includes increased cultch planting; restoration of freshwater flows; encouragement of aquaculture and replanting; size, gear, season, and area restrictions; limited access; and quota and bag limits (Berrigan et al. 1991).

Scallops

Bay scallops (*Argopecten irradians*) are found in seagrass beds that also support numerous other organisms, as described above, and have been impacted by poor water clarity of discharges from the Suwannee River. Scallops support a major recreational fishery along the Big Bend, although scallops are largely limited to areas north/west and south of the Suwannee River. The economic value of this recreational fishery has not been calculated. Maintaining good water quality and seagrass beds are important to scallops and recreational scalloping. Due to their sensitivity to pollution, bay scallops are considered to be excellent biological indicators of ambient water quality conditions.

Bay scallops are easily distinguished from other bottom-dwelling animals by their numerous blue eyes along the edge of their shells (Figure 33). They “swim” by opening and closing their shells rapidly to generate thrust, which allows them to move under changing conditions.



Figure 33. Photo of scallop in (left) grass bed and (right) showing numerous blue eyes (photos by Florida Sea Grant)

Historically, bay scallop abundances in Florida were better than one scallop per square meter, and capable of supporting a commercial fishery. The number of scallops declined so much by the early 1990s that all commercial harvesting was banned after 1994 and recreational harvesting was limited to coastal areas north and west of the Suwannee River between July 1st and September 10th (FWC 2016a). Following the implementation of restoration programs by the FWC, the Florida Marine Research Institute, and the University of South Florida, scallop populations increased in some areas, and in 2002 the coastal area between the Suwannee River and the Weeki Wachee River was reopened for recreational harvesting between July 1st and September 10th (FWC 2016). In the last 20 years, however, the greatest average density observed at a study site in a given year was 0.50 scallop per square meter. FWC (2016a) reports that in most years,

populations within the open harvest areas have been stable or vulnerable, with only occasional collapses, typically attributed to major environmental events such as an El Niño (1998), hurricanes (2004), or tropical storms (2010).

Although closely related to bay scallops, calico scallops (*Argopecten gibbus*) live in deeper, offshore waters along the east and west coasts of Florida. Calico scallops are found on sandy or shelly bottoms. No formal stock assessment of the Florida's calico scallop stocks is available at the present time. Since 1989, the statewide landings have ranged from zero to about 7.0 million pounds. Calico scallops are infrequently landed along the gulf coast of Florida except in "boom" years, e.g., 1994, 1998, 1999.

Clams

The northern quahog clam, burrows shallowly in sediments of either mud or sand. It is among the most commercially important species of invertebrates along the Big Bend coast. On the Gulf of Mexico side, though, only Sunray Venus clams are native, and not in abundance. Their population was nearly extinguished in the early 1900s by over-collecting. However, the hard clam is grown for commercial purposes, primarily in the Cedar Key area.

The commercial hard clam industry in Florida includes more than 300 shellfish growers on submerged land leases totaling over 2,100 acres (Adams and Sturmer 2012). While not a reef species, two species of hard clam are found in sandy or muddy bottoms throughout Florida: the northern quahog and the southern quahog (*Mercenaria campechiensis*). Historically, clams served as a food source and currency for Native Americans (Thom 2015) and approximately 71 percent of the landings of wild harvested clams were made on the Gulf coast, primarily in the Cedar Key area of Levy County, and there are no known recreational or subsistence landings of hard clams in Florida.

Following the commercial net ban in 1994, the UF/IFAS and Sea Grant program began working with local investors to develop a clam aquaculture industry using northern quahog clams transplanted from the Florida east coast. With improved local water quality conditions, the shallow, well-flushed, muddy bottomed waters around Cedar Key proved to be ideal habitat for clams. UF/IFAS reports that today, the clam aquaculture industry in the State of Florida generates an annual economic impact of about \$53 million (includes growers, hatcheries, boat builders, harvesting, processing, and other activities and employment), which far exceeds that of other shell-fishing industries in Florida. Due to the Cedar Key success UF/IFAS/Sea Grant is now exploring the feasibility of farming the Sunray Venus clam, a species native the Florida Gulf coast, as well as oyster aquaculture.

The responsibilities for monitoring hard clam aquaculture now reside with FDACS, and reporting to the FWC on trip tickets of aquacultured clams is voluntary. In 2000, aquaculture operations produced 538,000 pounds of clams. Gulf coast landings (wild harvest) of hard clams were historically low and the wild harvest dropped to essentially zero from 2000-2009. Commercial catch rates for wild-caught hard clams on the Gulf coast, (FWC 2014) were "essentially non-existent from 2004-2008," although more recently, there has been a small increasing trend.

2.3.3.3 Seagrass Beds

Along the Big Bend coast of Florida (from Anclote Key north to Apalachee Bay), seagrass coverage is extensive (3,000 km² or 1,158 mi²) (see Zieman and Zieman 1989; Mattson 2000). In fact, seagrass beds are often the dominant structural feature in the shallow, subtidal estuaries and nearshore, coastal waters in the region (Mattson et al. 2007). As such, seagrasses provide essential refuge and forage habitats for a myriad of ecologically and economically important fauna. Approximately 85 percent of the recreational and commercial fishery species in Florida spend some portion of their life in estuaries (Comp and Seaman, 1985), and many of these species are considered obligate seagrass inhabitants. Blue crabs and bay scallops, for example, are largely dependent on seagrass resources (Orth and van Montfrans, 1987, 1990). The Big Bend region accounts for between 25 and 33 percent of the total commercial blue crab fishery landings in Florida and supports the largest recreational scallop fishery in the State. Seagrass beds are considered essential to the ecological integrity and health of Florida's estuarine and nearshore coastal ecosystems.

Over half of the entire Big Bend region is part of the Big Bend Seagrasses Aquatic Preserve, managed by FDEP. The LSR Basin includes portions of the Lower Suwannee NWR and the Cedar Keys NWR. The immense seagrass ecosystem that forms a part of these conservation areas is one of the key components of their natural value. The lower and nearshore estuary and coast is a mix of salt marsh, tidal creeks, and mudflats. Seagrasses are also generally much less abundant in the Suwannee River estuary and Suwannee Sound when compared to other estuaries along the southern Big Bend coast, primarily due to the highly colored surface water which limits light penetration (Bledsoe 1998), though highly variable salinity may also affect its distribution.

There was a total of 1,652 acres of seagrass mapped in the Suwannee Sound in 2001 along the offshore reef west and south of the mouth of the Suwannee River and nutrients and poor water clarity of the discharge from the Suwannee River affect seagrass beds close to the mouth of the river (Yarbro and Carlson 2016; Figure 34). Yarbro and Carlson (2016) also report limited seagrass beds in Suwannee Sound occur mostly near the reef offshore and to the south of the river mouth and that "In recent years, turbidity and resulting light attenuation have made it impossible to map seagrasses near the Cedar Keys and in Waccasassa Bay, and these conditions might also be causing seagrass losses. Without recent mapping data or a monitoring program, the status of seagrasses in Suwannee Sound and Waccasassa Bay cannot be determined".

Between 2001 and 2006, the southern Big Bend experienced a net loss of about 3,500 acres (6 percent) of seagrass, which reflects the deterioration of 7,100 acres of continuous beds into 3,600 acres of patchy beds. Seagrass density in beds has also declined sharply in the past 10 years throughout the region, and the occurrence of shoal grass dropped sharply over the same period (Carlson et al. 2010).

Stressors to seagrasses include reduced optical water quality, which has resulted from elevated phytoplankton concentrations and increased water color in the region, as well as variable salinity over seagrass beds due to heavy rainfall events each year since 2012 (Yarbro and Carlson 2016). Tropical storms Debby and Andrea in early summers of 2012 and 2013, respectively, and heavy

rains in July 2013 caused local rivers to discharge large volumes of darkly colored, nutrient-rich waters, reducing water clarity and dramatically increasing phytoplankton levels during the remainder of the growing season.

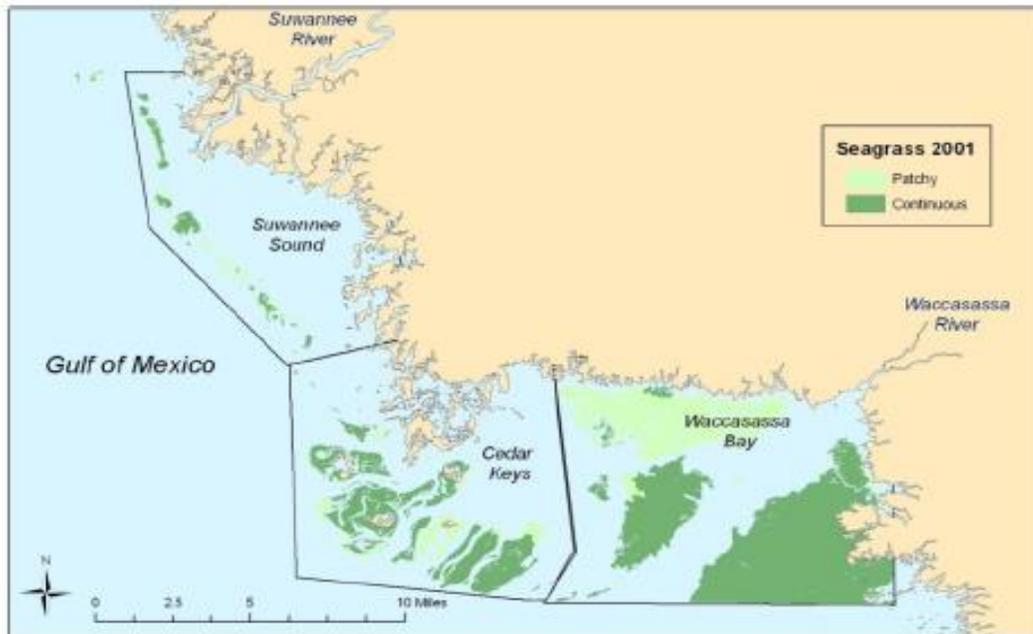


Figure 34. Seagrass cover in the Suwannee Sound, Cedar Keys, and Waccasassa Bay (after Yarbro and Carlson 2016)

Downstream limits of SAV species in the river correspond to patterns of mean salinity and salinity variability, while upstream limits are based on the availability of shallow substrata suitable for SAV and the greater influence of freshwater. Permanently reduced flows in the Suwannee River will increase salinity in the lower river and could cause an upstream retreat and overall reduction of SAV beds (Esteves 2002). Mattson (2002) found that the downstream limit of SAV in both East and West Passes corresponds to an annual average bottom salinity, 8 ppt, and average annual surface salinity of 0.5 ppt (District 2005). Odum et al. (1984) characterize tape grass as occurring in the tidal fresh (0.5 ppt annual average salinity) and oligohaline (0.5 ppt to 5 ppt annual average salinity) estuarine zones. Doering et al. (1999), using experimental and field studies, showed that tape grass had a maximum salinity tolerance of about 15 ppt, with reduced growth at salinities above 9 ppt. Estuarine salinities of <10 ppt may be critical for recruitment of many fish taxa (Rogers et al. 1984) and low-salinity creeks (< 5 ppt) are important nursery habitat for commercial and recreational fishery species (Rozas and Hackney 1984). The narrow range of the 5 ppt oligohaline zone in the LSR suggests a high degree of sensitivity to habitat alterations.

2.3.4 Listed Species

Listed species are one of the natural resource components addressed by the District's SWIM Plan and come under review by the FWC per Section 373.453(3), F.S. and the USFWS. The ISMP presents an approach for the conservation of state-listed species that outlines the threats and conservation approaches for 57 animal species in Florida that are state listed species and have not undergone a Biological Status Review in a decade (61 species), sans four species that have

a draft plan or became federally listed. The ISMP includes Species Action Plans (SAPs) that outline the management actions necessary to minimize the impacts of known threats, improve habitat conditions, and streamline efforts to conserve and recover imperiled species in the state. Therefore, the ISMP can be referenced for identified threats and proposed conservation actions for species and their habitats.

Federally and state listed species and their corresponding habitats are detailed in Appendix G and numbers of state and federally listed species in the Suwannee River Basin are summarized in Table 4. Numerous listed species occur in the District and may be affected by activities that alter the amount or quality of water available to them and their habitats. For example, the frosted flatwoods salamander is federally threatened due to loss of seasonally wet ponds (uninhabited by predatory fish) required for breeding and egg laying. The oval pigtoe is a mussel that inhabits the Santa Fe River and is affected by changes in water quality, especially sediment loads, since it is immobile. Other federally listed species include the West Indian manatee, hawksbill sea turtle, and wood stork. Threats to species include habitat loss and fragmentation caused by conversion of habitat to development, agriculture, silviculture, and associated fire suppression (FWC 2016, Dixon et al. 2006, Hctor et al. 2000). Over-use or recreational use of a site, disturbance by anthropogenic activities and/or invasive species, and inadequate management can also have adverse effects on listed species.

Two federally threatened plant species are listed in the Suwannee River Basin. The federally endangered Chapman's rhododendron (*Rhododendron chapmanii*) is documented as occurring in seepage slopes and wet and mesic flatwoods in the Santa Fe River, while the federally threatened Florida skullcap, which also occurs in seepage slopes and wet and mesic flatwoods, is documented as occurring in the LSR watershed. An additional 59 plant species are designated as threatened or endangered by the Florida's Division of Plant Industry, FDACS, which regulates endangered, threatened and commercially exploited plants of Florida.

Table 4. Numerical summary of species listed as federally endangered (FE), federally threatened (FT), federally threatened due to similarity of appearance (FT/(S/A)), state threatened (ST), or species of special concern (SSC) in the Suwannee River Basin

Status Designation	Fish	Amphibians	Reptiles	Birds	Mammals	Invertebrates	Total
FE	0	0	1	1	1	1	4
FT	1	1	3	3	1	1	10
FT (S/A)	0	0	1	0	0	0	1
FXN	0	0	0	0	0	0	0
ST	0	0	3	8	0	1	12
SSC	0	0	1	1	1	0	3
Total	1	1	9	13	3	3	30

2.3.5 Threats to Natural Systems

The natural systems of the Suwannee River Basin comprise valuable ecological, aesthetic, recreational, cultural, and economic resources. Primary threats to natural systems include (Thom et al. 2015, Katz and Raabe 2005):

- Land use changes (and corresponding habitat loss and fragmentation);
- Declines in water quality and quantity;
- Introduction of non-native and invasive species; and
- Climate change.

For example, conversion from upland silviculture to higher intensity row crops or animal operations results in loss of forested habitat and connectivity among habitats important to numerous species. Other examples include: disturbance and loss of native SAV in springs due to excessive recreational use and/or algae proliferation due to increased nutrient concentrations; loss of fish habitat due to reduced flows and exposure of formerly inundated floodplains; loss of marsh habitat due to lowered groundwater levels as a result of water withdrawals; disturbance of habitat by invasive species such as wild hogs and subsequent invasion of nonnative and invasive plant species; and loss of salt marsh habitat due to sea level rise and inundation. Climate change and sea level rise in particular are expected to impact Florida's fish and wildlife across all terrestrial, freshwater, and marine habitats; and combined with other stressors, reduce the long term viability of species and associated ecosystems.

Due to the rural characteristics of the Suwannee River Basin, habitat fragmentation is relatively minimal compared to other areas in Florida. In addition, the rivers and streams in the Basin remain free flowing (e.g., not impounded or dammed). However, the expansion of more intense agricultural and urban land uses will likely put greater pressure on water resources and natural systems in the future. Therefore, conservation and management of existing natural systems, including the maintenance of minimum flows and levels, and water quality, offer the best means by which to prevent further habitat loss, fragmentation, and/or water resource degradation in the Basin.

Equally important is proper management and maintenance of habitats that historically were fire maintained, such as sand pine scrub, sandhills, prairies, and wetlands. Prescribed fire is used to reduce shrub layer vegetation, initiate seeding in some species, and improve and maintain habitats for deer, quail, turkey and many other wildlife species. Some of Florida's rare, fire-adapted plants and animals that inhabit fire maintained communities include the red-cockaded woodpecker, Sherman's fox squirrel, gopher tortoise, eastern indigo snake, and Florida scrub jay.

Finally, continued monitoring, data collection, and research to track native habitats and species and improve our understanding of how they may be impacted by land use changes, water quantity and quality, non-native and invasive species, and climate change, are important to managing natural systems in the Suwannee River Basin.

2.3.5.1 Land Use Changes

Land use and land use changes in the Suwannee River Basin are described in detail in Section 1.3.5 above. Urban land development has increased slightly, mostly as growth around existing urbanized areas, but still only constitutes 11 percent of the Basin land area. The greatest amount of urbanization has occurred east of the Suwannee River, in the Santa Fe watershed, due to its proximity to Gainesville and several other incorporated areas (Thom et al. 2015).

Due to the extensive coverage of forested uplands and wetlands in the Suwannee River Basin, habitat fragmentation is less when compared with other parts of Florida. In addition, the rivers and streams in the Basin remain undammed. Therefore, conservation and management of existing natural systems offer the best means by which to prevent further habitat loss, fragmentation, and/or degradation in the Basin.

Development associated with population growth can alter, fragment, and eliminate habitat and pose direct and indirect threats to individual species and local populations (FWC 2016). The FWC has prepared *Florida's Imperiled Species Management Plan* (ISMP), which presents an approach for the conservation of state-listed species that outlines the threats and conservation approaches for 57 animal species in Florida that are state listed species and have not undergone a Biological Status Review in a decade (61 species), sans four species that have a draft plan or became federally listed. Improving habitat connectivity and reducing fragmentation of habitats used by listed and/or imperiled species, especially during critical times (e.g., breeding seasons), is essential to supporting imperiled species populations.

The ISMP identifies habitat loss, degradation, disturbance, and conversion of natural habitat to typically urban, silviculture, or agriculture lands as threats to several listed species, including the state threatened short-tailed snake, Florida pine snake, southeastern American kestrel, American oystercatcher, black skimmer (*Rynchops niger*), and Sherman's fox squirrel. Species associated with shoreline habitats, e.g., the American oystercatcher, are also susceptible to recreation impacts that can disturb foraging and nesting behavior and result in habitat degradation or loss. Restoration of habitat and habitat connectivity is also anticipated to increase species resilience to sea-level rise and increasing storm activity (FWC 2016).

Fragmentation is an issue for many species, especially large mammals, and reductions in fragmentation via greater connectivity and corridors have been proposed (Hector et al. 2000, Dixon et al. 2009). Many imperiled species depend on intact coastal, riparian, and streamside habitat to facilitate travel between, and use of, essential feeding and breeding behaviors.

Many state listed species in the Suwannee River Basin are threatened due to fragmentation that may result from disturbance, habitat loss, fire suppression, dredging and filling, and/or and other anthropogenic activities. For example, while the Florida black bear (*Ursus americanus floridanus*) historically occurred throughout Florida and the southern portions of Georgia, Alabama, and Mississippi, its distribution and abundance were significantly reduced from the 1850s to the 1970s as a result of habitat loss, fragmentation, and overhunting (Dixon et al. 2006). The Florida black bear is presently limited to several fragmented populations due to residential and commercial development throughout the available habitat (Dixon et al. 2006, Maehr et al. 2001). Other species threatened by fragmentation that occur in the Suwannee River Basin include the state threatened

Florida sandhill crane, Marian's marsh wren, Scott's seaside sparrow, often due to dredge and fill activities in wetlands, and the southeastern American kestrel and Florida pine snake, that rely on habitat often converted to agriculture or development. Sherman's fox squirrel (Species of Special Concern), the federally endangered salt marsh vole, and the imperiled Florida mouse (*Podomys floridana*) (imperiled but not listed as state or federally as threatened or endangered) are also threatened by habitat fragmentation due to these same activities FWC 2016).

Conversion of many existing low-intensity agricultural lands to more intensive row crops represents a threat to many of Florida's terrestrial, wetland, and freshwater habitats (FWC 2012) due to direct loss of habitat, as well as water quality and quantity issues associated with irrigation. Conversions include both new conversion of natural habitat to agricultural uses and conversion of existing low-intensity agricultural lands with embedded natural habitat to more intensive agricultural operations. Associated pressures include incompatible agricultural practices, grazing and ranching, and forestry practices; nutrient loads (agriculture, surface water diversion and withdrawal, and management of nature); and addition of water control structures.

2.3.5.2 Declines in Water Quantity and Quality

More so than other areas in Florida, the natural systems in the District are closely linked to the hydrogeology of the region which is characterized by thick porous carbonate deposits, rapid groundwater movement, high groundwater recharge from surface water, artesian groundwater flows to surface waters, and water chemistry affected by the dissolution of the carbonate deposits. Increased groundwater and surface water withdrawals can reduce water levels in wetlands and lakes, and reduce spring flows and stream discharges. In addition, fertilizers and other agricultural chemicals can leach rapidly into the porous aquifer and degrade both ground and surface water quality (Tihansky and Knochenmus 2001).

Changes in water flows, levels, and quality can in turn substantially impact the ecological integrity of natural systems. Declines in freshwater flows alter salinity regimes in coastal areas, affecting oyster reefs and associated species, such as the state threatened American oystercatcher. Withdrawals for agricultural are greatest during low flows and reduced flows can also alter fish access to floodplains where they forage, or alter fluctuation and salinity patterns that would normally serve as biological cues to fish and wildlife.

The effects of water withdrawals for public water supply can also affect habitat by reducing groundwater levels and resulting in potential threats to habitat of listed species such as the Florida sandhill crane, wading birds (e.g., little blue heron, tricolored heron), and osprey (*Pandion haliaetus*) (FWC 2016). Flow diversions and withdrawals, altered water level fluctuations, and changes in salinity can all alter habitat for water-dependent species. Identifying and conserving resources such as these and increasing the amount of suitable habitat by restoring hydrology and managing species' habitats provide a means of reducing the threat to endangered and threatened species.

Increased nutrient inputs due to increased runoff from, for example, row crops and urbanized areas, can degrade water quality and affect freshwater and estuarine habitats directly. Increased turbidity associated with runoff from agricultural fields can reduce water clarity and light availability, thereby reducing SAV production. Increased nutrients can also result in phytoplankton

blooms that also reduce the amount of light available to SAV and may outcompete native algae. For example, reduced optical water quality due to elevated phytoplankton concentrations and increased water color, combined with reduced salinities, have affected seagrass beds following heavy rainfall events since 2012. Tropical storms Debby and Andrea in early summers of 2012 and 2013, respectively, and heavy rains in July 2013 caused local rivers to discharge large volumes of darkly colored, nutrient-rich waters, reducing water clarity and dramatically increasing phytoplankton levels in the coastal region during the remainder of the growing season (Yarbro and Carlson 2016). Local runoff from ditching and draining activities may have similar effects.

2.3.5.3 Introduction of Non-Native and Invasive Species

Florida's SWAP and ISMP are comprehensive, statewide plan for conserving the state's wildlife and vital natural areas for future generations. The plans identify critical native wildlife and habitats, threats to these species and habitats, and current and future actions to reduce and mitigate threats (FWC 2012). The introduction of non-native and invasive species is identified as a serious threat to both native habitats and the species that are dependent upon them.

Many introduced species in Florida never become established and have few, if any, negative effects. However, those species that become established and spread, may have both ecological and economic impacts and costs. These species can change community structure and composition, alter hydrological and fire regimes, alter soil sedimentation and erosion processes, and impose direct threats to wildlife through competition, predation and pathogen movement. The influence of nonnative species on Florida's indigenous plant and animal species is undisputed; entire ecosystems are changing and native species are under increasing pressures. In their review of 329 marine invasive species, Molnar et al. (2008) concluded the most common pathway for marine species was shipping (ballast and/or fouling; 228 species, 57 percent of which are harmful), and the second is the aquaculture industry (134 species, 64 percent of which are harmful). Ornamental landscaping and tropical fish trades also result in the escape or release of non-native species into the wild.

Actions that alter the hydrology and/or water quality of native habitats also provide the opportunity for invasive species to become established. For example, Hydrilla was introduced into Florida from Sri Lanka in the early 1950s through the aquarium trade. It is a submersed aquatic freshwater plant which grows from shallow waters to water depths of over 20 feet. It is widely distributed in warm areas of the world, spread rapidly throughout Florida in the 1970s and 1980s and is particularly problematic in shallow and nutrient rich lakes, but is a persistent nuisance in flowing waters as well. Since its introduction, hundreds of millions of dollars have been spent controlling Hydrilla throughout Florida. Impacts from terrestrial invasive plants and animals can also threaten the integrity of the riverine corridors.

Another example of invasive species in the Suwannee River Basin include the lionfish (*Pterois volitans*), which has a presence along the Gulf of Mexico as far as Apalachicola as of 2010, and continues to be a problem. Other species, such as blue tilapia (*Oreochromis aureus*) and the Mediterranean gecko (*Hemidactylus turcicus*) are not documented as a threat to native wildlife. However, species such as Muscovy duck (*Cairina moschata*) that may transmit disease to and interbreed with Florida's native waterfowl, and wild hogs (*Sus scrofa*) that occur in all of Florida's

67 counties, occur in nearly habitats, root and disturb the soil and ground cover vegetation and leave the area looking like it has been plowed.

Domestic pets that are not controlled pose threats to species such as the Florida pine snake, and fire ants and pets threaten the short-tailed snake (FWC 2016). Feral cats pose the greatest threat to species such as the Florida mouse and also contribute to the status of the state threatened Sherman's short-tailed shrew (*Blarina carolinensis shermani*). Keeping pets indoors and on leashes can substantially reduce these kinds of threats to small animals.

The occurrence of 26 nuisance aquatic species has been documented in the LSR watershed, including several introduced fishes, reptiles, frogs, mollusks, and two mammals (nutria (*Myocastor coypus*) and capybara (*Hydrochaeris hydrochaeris*)) (Table 5, Thom et al. 2015). Of particular concern is the South American suckermouth armored catfishes (*Loricariidae*, *Pterygoplichthys spp.*), in the Santa Fe River drainage (Nico et al. 2012). Impacts from terrestrial invasive plants and animals can also threaten the integrity of habitats in the Basin.

Table 5. Nuisance Aquatic Species Documented in the Lower Suwannee River Basin

Group	Nuisance Aquatic Species	Group	Nuisance Aquatic Species
Fishes	Green sunfish (native)	Mammals	Nutria
	Red-bellied pacu		Capybara
	Jack Dempsey	Mollusks	Asian clam
	Blue tilapia		Giant applesnail
	American shad (native)		Florida applesnail (native)
	Grass Carp		Chinese mystery snail
	Fathead catfish (native)	Frogs	Greenhouse Frog
	Leopard pleco		Cuban Tree Frog
	Vermiculated sailfin catfish	Jellyfish	Freshwater jellyfish
	Sailfin catfish	Turtles	Mississippi map turtle (native)
	Wiper (native hybrid)		False map turtle (native)
	Guppy		Red-eared slider (native)
	Blue catfish (native)		

2.3.5.4 Climate Change

Climate change is considered the third greatest threat to native habitats in Florida (FDEP 2011) and one of the primary issues and drivers affecting natural systems along the Gulf Coast (Thom et al. 2015, Katz and Raabe 2005). Climatic changes are expected to impact Florida's fish and wildlife across all terrestrial, freshwater, and marine habitats and, combined with other stressors, reduce the long term viability of species and associated ecosystems (FWC 2016b). FWC has developed an adaptation guide to help the development of adaptation strategies to address the anticipated effects of climate change on species and habitats (FWC 2016b). For example, model predictions indicate many coastal species, such as Scott's seaside sparrow and Marian's marsh wren are expected to lose more than 98 percent of their existing habitat with sea level rise of one to three meters (FWC 2016b).

Natural systems along the coast, e.g., marshes and forested wetlands, provide a means of buffering and delaying the impacts of sea level rise on urban areas. Sea level rise due to climate change is changing natural coastal ecosystems in Florida and presents “challenges to those responsible for maintaining drainage systems, recreational beaches, coastal highways, and emergency preparations,” as the state’s coastal ecosystems and infrastructure are affected (Florida Oceans and Coastal Council 2010). Climate change stressors can include, but are not limited to, predicted changes in rainfall (increase in northern Florida and increase or decrease in the south), increase in temperatures, and sea-level rise (FWC 2016). Salt marsh species that may be affected by loss of habitat due to sea level rise associated with climate change include Marian’s marsh wren, Scott’s seaside sparrow, and salt marsh vole.

Wetlands of the Big Bend provide examples of retreating coastal forests and freshwater swamps that may be replaced by salt-marsh vegetation or open water (Williams et al., 1999; Raabe et al., 2004; DeSantis et al., 2007, after Florida Oceans and Coastal Council 2010). Light et al. (2002) mapped the extent of potential loss of forested wetlands along the Suwannee River anticipated under a reduced freshwater flow scenario (Figure 35) and concluded that even without freshwater inflows, the same patterns can be expected to occur through the effects of sea level rise alone.

In addition, a decrease in annual freeze events associated with regional warming over the past two decades has extended the range of mangroves (primary the black mangrove (*Avicennia germinans*) on the Florida Gulf coast northward, well into the Big Bend region. This range expansion can be seen in the replacement of salt marshes by mangroves as far north as Cedar Key.

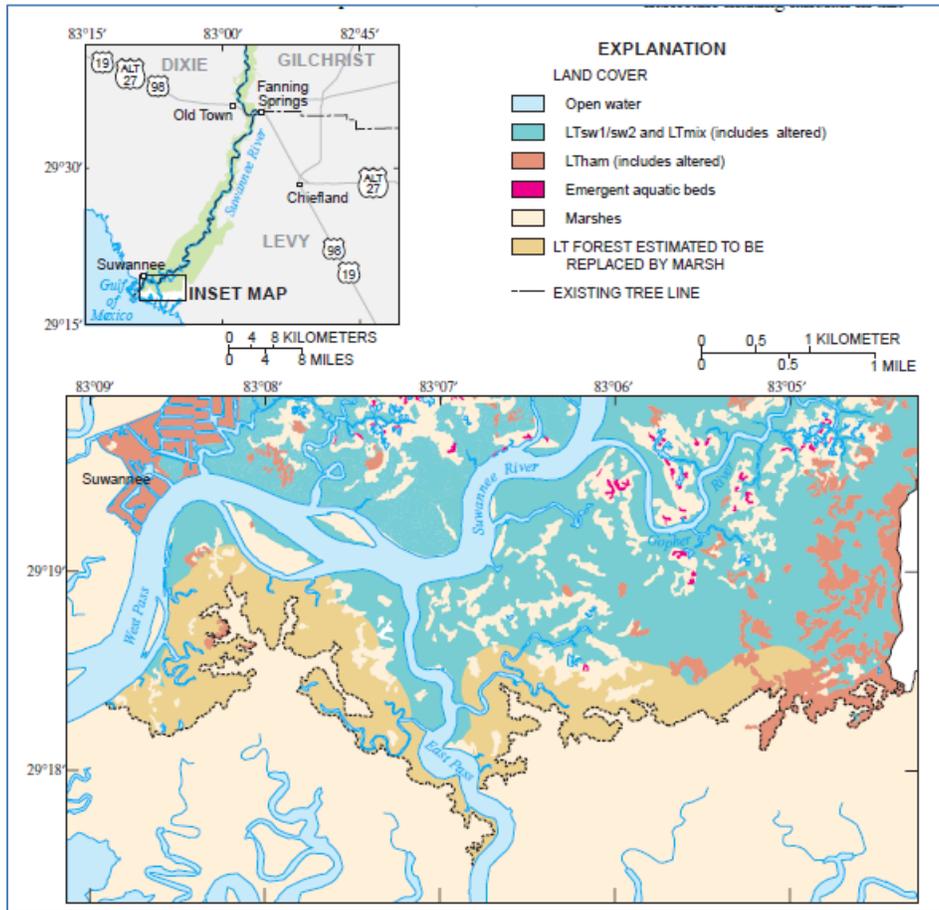


Figure 35. Area of lower tidal forests estimated to convert to marsh if flows were reduced 28 cms (1000 cfs) in the lower Suwannee River (Light et al. 2001)

3.0 Management Actions

Over the past few decades, stakeholders in the Suwannee River Basin, working with a variety of state and local government partners, have worked together to better understand the status and trends in water quantity, water quality, and natural systems in the Basin. These efforts have led to the identification of the primary drivers affecting the Basin's main concerns, and the development of strategies to protect and improve conditions in the river and its watershed. One of the goals of this SWIM Plan is to promote the implementation of these management actions to address the major issues and drivers and ultimately restore and/or preserve the ecological balance of the Suwannee River Basin.

As discussed in Section 1.2.3, the economic vitality of the Suwannee River Basin is closely tied to the health of its natural resources. And while the rivers and coastal waters along Florida's Big Bend coastline are often viewed as being in a close to pristine condition, the analysis of status and trends presented herein indicate that there are natural resource management issues that need to be addressed. The primary issues potentially affecting the surface waters and ecology of the Suwannee River Basin, both now and in the future, include:

- Increase in more intense agricultural and urban land uses;
- Alterations to natural hydrology;
- Decreasing river and spring flows in some locations;
- Increasing nitrogen concentrations in river and springs flows in some locations;
- Habitat fragmentation due to land development and road construction;
- Loss of natural oyster bars in the coastal Suwannee River; and
- Climate change and sea level rise.

The proposed management actions designed to address concerns within the Suwannee River Basin are discussed in terms of water quantity, water quality, and natural systems. Actions intended to address issues related to spring discharge and stream flows are summarized in Section 3.1, which focuses on water quantity. Section 3.2 focuses on actions intended to address issues related to water quality within the Basin, and Section 3.3 focuses on activities intended to address issues related to the natural systems of the Suwannee River Basin.

3.1 Water Quantity

Adequate water quantity is the basis upon which the ecological integrity of riverine and estuarine systems is built. Both physical and biogeochemical characteristics of the rivers and their watersheds are largely dependent upon river hydrology. The overarching water quantity goal for the Suwannee River Basin is to protect and restore the natural hydrologic regimes of surface waters and their contributing watersheds wherever feasible, as measured in terms of: frequency,

magnitude, duration, seasonality, and spatial distribution. Meeting this goal will ensure the protection of critical WRVs therein. Table 6 identifies management actions necessary to address these priorities. The lead entity (or entities) that should be primarily responsible for each action has also been identified.

Table 6. Water Quantity Management Actions

Management Actions	Lead Entity
Monitoring, Data Collection, and Research	
Maintain existing and add new river and spring monitoring gages, where appropriate and feasible	District/USGS
Produce annual reports of flow data with summary reports of flow trends every 4-5 years	District/USGS
Establish a comprehensive groundwater monitoring network to support planning efforts	District/USGS/Other Districts
Work with other agencies to develop a strategy for data collection, data analysis and groundwater modeling to better define current and future regional water resource impacts	District/Other Districts/ USGS/State of Georgia
Water Supply Planning	
Implement the NFRWSP	District/Other Districts
Complete Water Supply Assessments	District
Coordinate with FDEP and other agencies to ensure regulatory efforts reflect challenges identified in water supply planning	District//FDEP/Other Districts
Minimum Flows and Minimum Levels	
Reassess adopted MFLs on a timely basis	District/FDEP
Adopt remaining MFLs for priority waterbodies	District/FDEP
Water Resource Development and Aquifer Recharge	
Continue and implement new hydrologic restoration projects, where appropriate and feasible	Local/District/FDEP
Assist aquifer recharge through drainage-well replacement and rehabilitation	Local/District/FDEP
Expand use of alternative water supplies	Local/District/FDEP
Conservation	
Work with partners to increase agricultural water conservation through cost-share and education	District/SRP/FDACS

Management Actions	Lead Entity
Educate the public on importance of water conservation	District
Increase beneficial reuse in communities throughout the District	District

3.2 Water Quality

Appropriate water quality standards have been developed by the FDEP to correspond with the various designated uses of surface waters. The overarching water quality goal for the Suwannee River Basin is to protect and restore water quality in coastal rivers and springs to be compliant with their applicable standards.

The water quality management actions for the Suwannee River SWIM plan are primarily focused on reducing NO_3^- concentrations in the springs, thus providing downstream benefits to the river, in accordance with the adopted TMDL of 0.35 mg/l of NO_3^- for the springs themselves. As detailed in Section 2.2, data shows elevated nutrient levels, specifically NO_3^- , in rivers and springs throughout this Basin. Table 7 below identifies management actions to address this issue in the Suwannee River Basin. The lead entity (or entities) that could be primarily responsible for each action has also been identified.

Table 7. Water Quality Management Actions

Management Action	Lead Entity
Monitoring, Data Collection, and Research	
Monitor water quality throughout the springs and streams of the Suwannee River Basin	District/ FDEP
Report on the status and trends (if any) of water quality	District/ FDEP
Determine if impairment determinations and targets based upon the prior standard using fecal coliform bacteria differ from those based upon proposed criteria based on E. coli (freshwater Class III) and/or enterococci bacteria (marine Class III and Class II)	FDEP/Universities
Determine if impairments for DO, based upon older criteria of 4 mg /liter differ from impairment determinations based upon newly adopted criteria based on percent saturation	FDEP/Universities
Refine time lag estimates involved between implementation of agricultural BMPs and decreased NO_3^- concentrations in springs and streams in the Suwannee River Basin	District/ FDEP/ Universities
Source identification efforts to ensure that source(s) of bacteria are appropriately identified for waterbodies with identified impairments	Local/FDEP/Universities

Implementation of BMAPs and BMPs	
Work with partners on outreach and education	District/FDEP/SRP
Research and evaluate current BMPs success	District/FDACs/UF-IFAS/FFWCC
Continue Agricultural Cost-Share programs	District/FDACs/FDEP/FFWCC
Coordinate cost-share programs to provide for timely adoption of BMPs	District
Implement pilot projects in key springsheds to reduce NO ₃ ⁻ levels beyond full implementation of BMPs	District/FDEP
Wastewater and Stormwater Infrastructure Upgrades	
Convert septic tanks to sewer systems where needed and practical	Local/District/FDEP
Upgrade wastewater treatment facilities	Local/District/FDEP
Implement stormwater treatment/retrofits	Local/District/FDEP

3.3 Natural Systems

Natural systems in the Suwannee River Basin include upland, freshwater, and estuarine/marine habitats which have been degraded, replaced or fragmented, and/or converted to another use due to urban or agricultural development. In addition to direct physical alterations, the integrity natural systems, and the species populations they support, are highly dependent on water quantity and quality. The overarching natural systems goal for the Suwannee River Basin is to protect, conserve, and restore native habitats and species populations to maintain the overall ecological integrity of the Basin. Natural systems management actions for the Suwannee River Basin directly address the District's core mission and are consistent with the District's strategic plan. Management actions focus on protecting, restoring, and maintaining quality habitats for fish and wildlife in the District, including rivers, springs, wetlands, uplands, SAV, and shellfish habitat. The management actions also address impacts of invasive species and climate change on these priority habitats. Conserving coastal habitats would also contribute coastal economic resilience in the region by protecting developed areas from storms and sea level rise. Table 8 identifies proposed management actions to address threats to natural systems. The lead entities that should be primarily responsible for each action have also been identified.

Table 8. Natural Systems Management Actions

Management Action	Lead Entity
Monitoring, Data Collection, and Research	
Continue and expand monitoring and mapping of aquatic, wetland, and terrestrial habitats and fish and wildlife species, e.g. Gulf sturgeon, Marian's marsh wren, saltmarsh vole	District/ USFWS/ FWC/Universities
Improve understanding of trophic dynamics (i.e. food webs) and nutrient cycling in spring and river systems	District/USGS/Universities
Develop and test restoration techniques for improving fish and wildlife habitat in spring, river, and estuarine systems	District/ USGS/ USFWS/ FWC/ Universities
Continue to monitor and evaluate effects of sea level rise on habitat	District/ USGS/ USFWS/ FWC/ FDEP/ Universities
Map, monitor status and evaluate human and wildlife impacts to submerged aquatic vegetation (SAV)	District/ USGS/ USFWS/ FWC/ Universities
Continue to monitor and develop restoration techniques for longleaf pine habitat	District/ FWC/ Universities/ FNAI/ FDACS
Continue to monitor the population and develop habitat restoration techniques and projects for Gulf sturgeon	District/ USGS/ USFWS/ FWC/ Universities
Continue to monitor and test restoration techniques for improving oyster reef habitat	District/ USFWS/ FDEP/ FWC/ Universities/ FDACS
Continue to monitor and control nonnative and invasive species	District/ USFWS/ FWC/ FDEP/ Universities/ Non-government organization (NGO)/ FNAI/ FDACS
Improve understanding of aquatic cave habitats and species	District/ USFWS/ FWC
Continue monitoring and developing restoration techniques for listed mussels and host fish	District/ USFWS/ FWC/ Universities
Continue to improve understanding of effects of changes in freshwater flows on habitats and listed species	District/ USGS/ USFWS/ Universities
Continue to improve understanding of gear and/or harvest restrictions on listed species, e.g. impacts of marine debris such as crab traps and fishing gear on sea turtles and other species; effects of silviculture on habitat fragmentation	USFWS/ FWC
Continue to improve, develop, monitor, and evaluate the effects of silviculture, crop, and livestock operation BMPs on habitats	District/ USFWS/ FWC/ FDEP/ Universities/ FDACS

3. Management Actions

Management Action	Lead Entity
Continue to identify and evaluate lands for acquisition	District/ USFWS/ FWC/ FDEP/ Counties
Continue to monitor and evaluate the effects of tubing and other recreation on habitats and species	FDEP
Develop and disseminate enhanced modeling tools, such as but not limited to suitability models for estuarine habitat restoration/enhancement and for threatened and endangered species habitat within the watershed	District/ USGS/ USFWS/ FWC/ FDEP/ Universities/ NGO/ FNAI/ FDACS
Communicate monitoring and research results to watershed stakeholders and participating agencies	District/ USGS/ USFWS/ FWC/ FDEP/ Universities/ NGO/ FNAI/ FDACS
Habitat Conservation	
Continue land acquisition programs to purchase land throughout the Basin	District/ FWC/ FDEP/ NGO/ FNAI
Develop and refine management plans for acquired lands	District/ FWC/ FDEP/ NGO/ FNAI
Develop management standards for shoreline disturbance	District/ FWC/ FDEP/ NGO/ FNAI / FDACS/ Counties
Continue to improve land use planning to reduce fragmentation of habitats	District/ FWC/ FDEP/ Universities/Counties
Improve BMP development and implementation for silviculture, crop, livestock operation, and other agriculture	District/ FDEP/ Universities/ NGO/ FNAI/ FDACS/ FWC/ Counties
Improve education and outreach to riparian homeowners and recreation organizations	District/ FWC/ FDEP/ Universities/ FDACS/ Counties
Improve habitat connectivity through corridors, managed areas, and riparian zones to enhance movement of wildlife	District/ FWC/ FDEP/ NGO/ FNAI / FDACS/ Counties
Habitat Restoration	
Restore and enhance oyster reef habitat where water quality and hydrological conditions are appropriate	District/ FWC/ FDEP/ Universities
Remove invasive species where appropriate	District/ Local/USFWS/ FWC/ FDEP/ FDACS
Restore and enhance submerged and/or emergent aquatic vegetation where water quality and hydrological conditions are appropriate	District/ USFWS/ FWC/ FDEP/ FDACS
Restore and maintain longleaf pine habitats where appropriate	District/ USGS/ USFWS/ FWC/ FDEP/ Universities/ NGO/ FNAI

Management Action	Lead Entity
Restore and maintain riparian habitat where appropriate	District/ USFWS/ FWC/ FDEP
Create, restore and enhance living shorelines where water quality and hydrological conditions are appropriate	District/ FWC/ FDEP/ Universities/ NGO
Continue to develop MFLs for priority waterbodies	District/ FDEP
Continue and implement hydrologic restoration projects, where appropriate and feasible	District/FDEP/USFWS/FWC
Identify and enhance/restore upstream Gulf sturgeon habitat	District/ USGS/ USFWS/ FDEP/ FWC
Integrate restoration efforts across multiple habitats where possible, e.g., creation/ restoration/ enhancement of oyster reef, submerged and emergent aquatic vegetation, living shorelines, and tidal marsh habitats	District/ USGS/ USFWS/ FWC/ FDEP/ Universities/ NGO/ FNAI
Facilitate native shoreline/estuarine habitat migration along the coastal elevation and latitudinal gradients with anticipated sea level rise, increases in storm frequency/intensity and climate change effects on native vegetation distribution to enhance adaptation capacity and habitat resiliency	District/ USGS/ USFWS/ FWC/ FDEP/ Universities/ NGO/ FNAI
Develop and implement system-wide shellfish management plans that address sustained provision of ecological, economic and cultural services	District/ USGS/ USFWS/ FWC/ FDEP/ Universities/ NGO/ FNAI
Recreation Management	
Continue to develop, improve, and implement comprehensive recreation management plans	District/ USFWS/ FWC/ FDEP/ NGO/ FNAI/ FDACS
Promote responsible/ low impact recreation activities	District/ USGS/ USFWS/ FWC/ FDEP/ Universities/ NGO/ FNAI/ FDACS

4.0 Projects and Initiatives

One of the main goals of this SWIM Plan is to identify potential projects and initiatives that will, if implemented, help protect and improve water quantity, quality, and natural systems within the Coastal Rivers Basin. The projects and initiatives included in this Plan implement the management actions discussed in the previous section. Project ideas and proposals were solicited from District staff, local governments, state agencies, and other interested stakeholders. Ongoing projects currently being implemented by the District described in Tables 9 through 11, while proposed new projects are described in Tables 11 through 14.

4.1 Ongoing Projects and Initiatives

This section provides a summary of major ongoing projects and initiatives being implemented by the District and/or its partners in the SWIM Plan study area.

4.1.1 Water Quantity

Table 9. Ongoing Water Quantity Projects

Monitoring, Data Collection and Research
<p>Water Quantity Monitoring</p> <p>Lead Entity: District</p> <p>The District currently routinely monitors 273 stations throughout the District for water levels and/or flow. This monitoring effort is focused primarily on freshwater resources and does not currently include coastal monitoring.</p> <p>Cost: \$1,000,000</p>
<p>Silviculture Water Yield Research Project</p> <p>Lead Entity: University of Florida</p> <p>Project is part of a collaborative statewide effort, supported by the five water management districts, FDACS, UF/IFAS, to advance the understanding of the impact of forest management practices on water yield, and whether this water is held in surficial systems or makes it way to the aquifer. The project, within the District, has five plots on District-owned land near the Little River Tract, one plot on adjacent private land, and six plots near the Gainesville wellfield on private land and Gainesville Regional Utilities land. This project will continue through 2019.</p> <p>Cost: TBD</p>
<p>Monitoring Well Improvement Plan</p> <p>Lead Entity: District</p> <p>In 2014, the District Water Supply and Water Resources Divisions identified groundwater monitoring data gaps in areas throughout the District and developed a monitoring well network improvement plan to close those gaps. This plan includes the installation of 25 new monitoring wells. Over the 2016 fiscal year, District staff identified and cleared land to allow for the installation of five monitoring wells on District lands.</p> <p>Cost: \$1,500,000</p>

Water Supply Planning
MFLs
<p>Upper and Middle Suwannee MFL</p> <p>Lead Entity: District</p> <p>Set MFLs for the USR and MSR. This MFL will have potential impacts in both District and SJRWMD boundaries and as such will require further coordination with FDEP. The draft MFL document was sent to FDEP for approval in June 2017.</p> <p>Cost: \$315,000</p>
<p>Withlacoochee and Associated Springs MFL</p> <p>Lead Entity: District</p> <p>Development of MFLs for the Withlacoochee and associated priority springs. Technical work is ongoing. The Madison Blue Spring MFL is being reevaluated and incorporated into the Withlacoochee and Associated Springs MFL.</p> <p>Cost: \$60,000</p>
<p>Alapaha MFL</p> <p>Lead Entity: District</p> <p>Development of MFLs for the Alapaha River. Technical work is ongoing.</p> <p>Cost: \$75,000</p>
<p>Hampton Lake MFL</p> <p>Lead Entity: District</p> <p>The Hampton Lake MFL is currently going through the peer review process.</p> <p>Cost: \$11,000</p>
<p>Lake Butler MFL</p> <p>Lead Entity: District</p> <p>The Lake Butler MFL is currently going through the peer review process.</p> <p>Cost: \$72,000</p>
<p>Santa Fe Lake MFL</p> <p>Lead Entity: District</p> <p>The technical work for this Santa Fe Lake MFL is ongoing.</p> <p>Cost: \$50,000</p>
<p>Lake Alto MFL</p> <p>Lead Entity: District</p> <p>The technical work for this MFL is ongoing.</p> <p>Cost: \$44,000</p>

Water Resource Development and Aquifer Recharge
<p>Suwannee County Reuse Connection</p> <p>Lead Entity: City of Live Oak</p> <p>The project will provide a connection from the Suwannee Country Club to the City of Live Oak's Public Access Reuse System. The Country Club currently utilizes onsite wells to provide irrigation for the golf course. This project will allow the Country Club to utilize public access reuse in lieu of withdrawing valuable water from the aquifer for irrigation purposes. This project is estimated to conserve 0.1 MGD.</p> <p>Cost: \$129,344</p>
<p>City of Lake City Reclaimed Water System Upgrade (Phase 1)</p> <p>Lead Entity: City of Lake City</p> <p>The project will provide upgrades to the City's existing system allowing reclaimed water to be used by a local golf course and farmer. This project has the potential to offset approximately 0.54 MGD of groundwater withdrawals.</p> <p>Cost: \$545,470</p>
<p>Oakmont Gainesville Regional Utilities Reclaimed Water Main Extension</p> <p>Lead Entity: Gainesville Regional Utilities</p> <p>This project will provide reclaimed water to irrigate 136 residential properties and over three acres of common area. This project is expected to result in an estimated 0.05 MGD of groundwater offset.</p> <p>Cost: \$452,571</p>
<p>Oakmont/GRU Recharge Wetland</p> <p>Lead Entity: Gainesville Regional Utilities</p> <p>This project will construct a recharge wetland in an existing stormwater retention basin in the Oakmont Subdivision in Alachua County. The project will provide recharge to the UFA with reclaimed water at very low nutrient levels using a recharge wetland. Recharge wetlands are constructed wetlands that are designed to biologically reduce nutrients to low levels using natural wetland processes while simultaneously recharging the aquifer.</p> <p>Cost: \$1,156,740</p>
<p>Middle Suwannee River and Springs Restoration and Aquifer Recharge Project</p> <p>Lead Entity: District</p> <p>This project is a partnership between the District, FDEP, and Dixie County to provide hydrologic restoration activities in Dixie and Lafayette counties. The District began restoration efforts at Mallory Swamp several years ago after purchasing 31,000 acres within the swamp. This project will build upon those efforts by implementing hydrologic restoration activities on the property to rehydrate roughly 1,500 acres of ponds, 4,000 acres of wetlands and recharge the aquifer up to an estimated 10 MGD. The project will enhance surface water storage and recharge the aquifer to benefit spring flows in the MSR region and to augment domestic and agricultural groundwater supplies in Lafayette and Dixie counties.</p> <p>Cost: \$1,852,000</p>

Lower Suwannee Drainage Basin Aquifer Recharge Project

Lead Entity: Dixie County

This project will restore approximately 500 acres of sand ponds and rehydrate approximately 1,250 acres of wetlands by re-establishing natural flow through natural recharge features and an aquifer recharge well. The project will conserve approximately 3.26 MGD in water that will support spring flow of Fanning Springs, Manatee Springs, Otter Springs, Copper Springs, Little Copper Springs, and Bell Springs.

Cost: \$2,406,359

Cow Pond Drainage Basin Aquifer Recharge Project

Lead Entity: Dixie County

This project will re-establish natural drainage patterns and use natural recharge features and aquifer recharge wells to enhance aquifer recharge and rehydrate wetlands and currently dry lakes in the Lower Suwannee Drainage Basin. The project will restore approximately 300 acres of sand ponds and rehydrate approximately 1,750 acres of wetlands while conserving approximately 1.69 MGD of water that will support spring flow of Turtle Spring, Pothole Spring, Guaranto Spring, Rock Sink, Sun Spring, and McCrabb Spring.

Cost: \$1,600,000

Madison Blue Spring Aquifer Recharge

Lead Entity: Madison County

This project is a partnership between the District, FDEP, Madison County, City of Madison and Nestle Water to rehabilitate or replace up to six existing drainage wells to improve recharge rates. Each well will be upgraded with innovative pretreatment technology which may include the installation of biosorptive activated media or the construction of treatment wetlands. This will prevent further clogging of the wells and improve the water quality of the recharge. Estimated recharge of up to 5 MGD.

Cost: \$2,500,000

Upper Suwannee River Regional Aquifer Recharge

Lead Entity: District

Installation of at least four recharge wells in the USR basin in locations where wetlands were historically ditched and drained into the river. This project intends to capture water during high flow conditions that occur after large rainfall events and during the winter months, provide additional water quality treatment, and provide significant beneficial aquifer recharge to the Upper Floridan. Recharge estimated up to 4 MGD.

Cost: \$2,500,000

Scriven Avenue Drainage Improvements

Lead Entity: City of Live Oak

Replacement of a Class V injection well in the City of Live Oak. An existing well will be properly abandoned and a new well will be constructed of the same diameter, casing depth, and total depth. Benefits include up to .03 MGD of recharge.

Cost: \$92,439

<p>Reuse of Reclaimed Water from City of Newberry</p> <p>Lead Entity: District</p> <p>Reclaimed water storage, transmission and use to offset withdrawals of fresh groundwater.</p> <p>Cost: \$4,000,000</p>
<p>Reuse of Reclaimed Water from City of High Springs</p> <p>Lead Entity: District</p> <p>Store and transmit reclaimed water to a regional reclaimed water system for beneficial use for power plant cooling water to offset withdrawal of groundwater.</p> <p>Cost: \$5,000,000</p>
<p>Conservation</p>
<p>District-wide Agricultural Cost-Share Program</p> <p>Lead Entity: District</p> <p>Beginning in 2012, this program provides cost-share funding assistance for agricultural producers to implement projects that increase irrigation efficiency and water conservation, and assist with nutrient management technology. This includes irrigation retrofits, new water savings technologies and alternative water supply projects.</p> <p>Cost: TBD</p>
<p>Suwannee BMAP Center Pivot Retrofits Water Conservation Project</p> <p>Lead Entity: District</p> <p>This project will assist agricultural operations in retrofitting approximately 120 center pivot irrigation systems to make them more efficient. Increasing the efficiency of center pivots allows agriculture operations to use less water when irrigating crops. A 5.26 MGD reduction is estimated in the withdrawal from center pivot irrigation use due to cost-share retrofits along the Middle and LSR on the groundwater discharge to rivers and springs in the District.</p> <p>Cost: \$2,428,975</p>
<p>Improved Water Conservation and Nutrient Optimization of Dairy Wastewater</p> <p>Lead Entity: District</p> <p>This project is a partnership between the District, FDEP, FDACS, and local cooperators. The project is estimated to reduce nutrient loadings by 62,000 pounds annually and increase irrigation efficiency by saving an estimated 0.3 MGD, benefitting springs within Upper and Lower Santa Fe Basins and MSR and LSR. The project will improve the management of dairy wastewater to achieve greater nutrient uptake and irrigation efficiencies.</p> <p>Cost: \$1,885,590</p>
<p>Lake City Plumbing Retrofit</p> <p>Lead Entity: City of Lake City</p> <p>This project will replace existing toilets and faucets with high efficiency fixtures. Upgrades are estimated to conserve approximately .002 MGD.</p> <p>Cost: \$98,850</p>

Improved Nutrient Application Practices in Dairy Operations – Phase 2

Lead Entity: District

Through a state springs grant, this project will assist dairy operations in reducing nutrient leaching by an estimated 34,000 pounds annually while saving an estimated 0.32 MGD. Within the District, most dairies use overhead impact sprinklers on center pivots to apply their effluent. The project will enable the dairies to retrofit their irrigation systems from overhead impact sprinklers to drop nozzles and therefore, apply wastewater more uniformly over their crops.

Cost: \$2,670,000

Sustainable Suwannee Springs Pilot Program – Low Input Agriculture

Lead Entity: District

This program will incentivize land uses that conserve water and reduce nutrient loading. Agricultural operations within specific springsheds will be invited to submit proposals to transition to less intensive cropping systems, change the type of cropping system or agriculture crop altogether, including changes to silviculture, or change the land use to a fallow or native landscape for a certain amount of time or even a permanent conservation easement. The project is anticipated to reduce nutrients by 375,000 pounds per year and conserve approximately 5.10 MGD of water.

Cost: \$5,000,000

Dairy Wastewater System Improvement

Lead Entity: District

Through a state springs grant from FDEP, this project will provide cost-share funds to dairies throughout the MSR and Lower Santa Fe watershed to improve their wastewater systems. Improvements could include additional wastewater storage, advance manure solids separation, and/or advanced treatment technologies. The project will result in approximately 10,000 pounds of nutrient reductions each year in addition to conserving approximately 0.14 MGD. The project will benefit the springs along the MSR and Lower Santa Fe river basins.

Cost: \$1,800,000

Precision Agricultural Practices

Lead Entity: District

This project will provide cost-share funds to agricultural producers within the District BMAP areas to implement precision management technology. Additional priority will be given to producers within both the BMAP and Florida Outstanding Springs areas. The project will assist producers implement practices that allow for precision nutrient and irrigation management. Water conservation benefits are estimated at 8 MGD.

Cost: \$2,500,000

Florida Gateway College Cooling Towers and Pond Makeup Water System

Lead Entity: Florida Gateway College

This project will install new replacement cooling towers that can utilize stormwater in lieu of potable water. This project will conserve approximately 0.01 MGD.

Cost: \$1,077,166

Columbia County Water Conservation Initiative

Lead Entity: City of Lake City/Columbia County

This project will provide local businesses, such as hotels/motels or office buildings, and multi-family residential units with ultra-high efficiency technology indoor plumbing retrofit packages including at least one 0.8 GPF toilet and one 1.0 GPM bathroom aerator. When applicable, retrofit packages will also include one 1.5 GPM showerhead, one 1.5 GPM kitchen aerator, and one additional 1.0 GPM bathroom aerator. Projected benefits of these coordinated efforts include water savings of approximately 21 million gallons per year through reduced gallons of water used per flush. This project will result in permanent and cost-effective improvements in water use efficiency benefitting the Ichetucknee Springs Group as well as other springs along the Lower Santa Fe River.

Cost: \$350,000

Lawtey Water System Improvements

Lead Entity: City of Lawtey

Project will construct a new public water supply well to serve the City of Lawtey's existing water treatment plant and distribution system. This project will also provide upgrades to other treatment plant components including high service pumps, aerator, chlorination system, and electrical controls.

Cost: \$92,700

Starke Fire Hydrant Replacement Project

Lead Entity: City of Starke

This project will reduce unaccounted-for water loss throughout the City of Starke, currently estimated to be 24 percent. The City has identified fire hydrants that are non-functional, broken, leaking, inaccessible, and/or difficult to use that will be replaced, leading to estimated water savings of 2 million gallons per year.

Cost: \$142,080

City of Hampton Water Supply Improvement and Conservation

Lead Entity: City of Hampton

This project will increase water conservation, improve water service quality and reliability, and improve fire protection. The project includes improved access to fire hydrants, water meter replacements, installation of isolation valves, and water storage tank repair. Approximately 50 percent of City residents will benefit from improved fire protection, and approximately 54 residences will benefit from increased water conservation efforts, and improved water quality/reliability will provide a system-wide benefits.

Cost: \$113,530

Newberry Potable Water and Central Wastewater System Improvements

Lead Entity: City of Newberry

This project will replace existing water and wastewater lines to a community within close proximity to the City's historic district, reducing unaccounted for water loss and preventing potential sewage spills associated with aged wastewater infrastructure. This project will directly benefit existing businesses and residences, with general water quantity and quality benefits to the UFA.

Cost: \$65,000

Leaky Fire Hydrant and Water Main Replacements

Lead Entity: City of Jasper

The City of Jasper has numerous old and non-operational fire hydrants. Several fire hydrants are also located near a dead end water main, requiring quarterly system flushing. This project will conserve water through replacement of 11 leaky fire hydrants and looping water lines to reduce flushing. Benefits include up to .011 MGD of water conserved.

Cost: \$156,715

4.1.2 Water Quality**Table 9. Ongoing Water Quality Projects**

Monitoring and Research
<p>Water Quality Monitoring</p> <p>Lead Entity: District</p> <p>The District currently has 133 groundwater and surface water stations for water quality. Thirteen of these stations are continuous monitoring stations.</p> <p>Cost: \$500,000</p>
Implementation of BMAPs and BMPs
<p>Sustainable Suwannee Springs Agriculture Pilot Program – Low Input Agriculture</p> <p>Lead Entity: District</p> <p>This pilot project will incentivize low-nutrient land-uses through contracts, easements and acquisitions, while maintaining a strong, sustainable agricultural industry and private land ownership. Agricultural operations within the project areas will be invited to submit proposals to transition to less intensive cropping systems, change the type of cropping system or agriculture crop altogether, including changes to silviculture, or change the land use to a fallow or native landscape for a certain amount of time or even a permanent conservation easement. The project is anticipated to reduce nutrients by 375,000 pounds per year and conserve approximately 5.10 MGD of water.</p> <p>Cost: \$5,000,000</p>
<p>Sustainable Suwannee Springs Agriculture Pilot Program – Advanced Water Quality Improvement Technologies</p> <p>Lead Entity: District</p> <p>This pilot project will invite landowners, government, private, and/or other entities to submit proposals outlining advanced water quality improvement technologies that can cost effectively reduce nutrients in groundwater that contributes to spring flow. Technologies could include processes that use pump and treat, permeable reactive barriers, wood chip bioreactors, denitrification, wetland treatment, advanced animal wastewater treatment, and other technologies. The project is anticipating 66,000 pounds of nutrients per year.</p> <p>Cost: \$1,000,000</p>

Dairy Wastewater System Improvements

Lead Entity: District

The project will provide cost-share funds to dairies throughout the MSR and Lower Santa Fe watershed to improve their wastewater systems. Improvements could include additional wastewater storage, advance manure solids separation, and/or advanced treatment technologies. The project will result in approximately 10,000 pounds of nutrient reductions each year in addition to conserving approximately 0.14 MGD of water. The project will benefit the springs along the MSR and Lower Santa Fe river basins. The project will include investments in advanced treatment technologies (bioreactors), additional wastewater storage and advanced manure solid separation.

Cost: \$1,800,000

Improved Water Conservation and Nutrient Optimization of Dairy Wastewater

Lead Entity: District

This project is a partnership between the District, FDEP, FDACS, and local cooperators. The project is estimated to reduce nutrient loadings by 62,000 pounds annually and increase irrigation efficiency by saving an estimated 0.3 MGD, benefitting springs within the USR, Lower Santa Fe watershed, MSR and LSR. The project will improve the management of dairy wastewater to achieve greater nutrient uptake and irrigation efficiencies.

Cost: \$1,885,590

Improved Nutrient Application Practices in Dairy Operations – Phase 2

Lead Entity: District

Through a state springs grant, this project will assist dairy operations in reducing nutrient leaching by an estimated 34,000 pounds annually while saving an estimated 0.32 MGD. Within the District, most dairies use overhead impact sprinklers on center pivots to apply their effluent. The project will enable the dairies to retrofit their irrigation systems from overhead impact sprinklers to drop nozzles and therefore, apply wastewater more uniformly over their crops.

Cost: \$2,670,000

Ravine and Convict Springs Nutrient Capture and Treatment Program

Lead Entity: District

The project will use interceptor wells to capture high NO_3^- groundwater. A denitrifying system will be installed at each spring basin that will reduce nutrient loads by an estimated 4,300 pounds annually and return the groundwater at the two locations.

Cost: \$630,000

Precision Agricultural Practices

Lead Entity: District

This project will provide cost-share funds to agricultural producers within the District BMAP areas to implement precision management technology. Additional priority will be given to producers within both the BMAP and Florida Outstanding Springs areas. The project will assist producers implement practices that allow for precision nutrient and irrigation management. This project is estimated to reduce TN loading by 7,500,000 pounds per year.

Cost: \$2,500,000

Madison Blue Spring Aquifer Recharge

Lead Entity: Madison County

Partnership between the District, FDEP, Madison County, City of Madison and Nestle Water to rehabilitate or replace up to six existing drainage wells to improve recharge rates. Each well will be upgraded with innovative pretreatment technology which may include the installation of biosorptive activated media or the construction of treatment wetlands. This will prevent further clogging of the wells and improve the water quality of the recharge. Water quality benefits include an estimated 41,850 lbs/yr of nutrient reduction.

Cost: \$2,500,000

Wastewater and Stormwater Infrastructure

City of Chiefland Nutrient Reduction – Biosolids Treatment Unit Replacement

Lead Entity: City of Chiefland

This project will reconstruct the City of Chiefland's aged biosolids treatment unit (digester). The project will include two new tanks and other equipment to better treat the biosolids, which will reduce nutrient loading to Fanning Springs and Manatee Springs, by approximately 600 pounds per year.

Cost: \$418,400

Hart and Otter Springs Water Quality Improvement Project

Lead Entity: Gilchrist County

This is a three-phase project. The first phase will decommission the existing septic tanks at Otter Springs Park and remove the drain fields, construct a 6" transmission line to the City of Fanning Springs WWTP, and construct the collection system at Otter Springs. The second phase of the project will construct a 4" transmission line Hart Springs, construct the collection system at Hart Springs, and remove and connect nearby existing homes on septic tanks to the system. The final phase of the project will decommission the existing wastewater package plant and sprayfield at Hart Springs Park. This three-phase project will connect both Otter and Hart springs to the City of Fanning Springs' WWTP, providing an estimated 1,724 pounds per year reduction in nitrogen loading.

Cost: \$5,979,740 (all three phases)

Fanning Springs Water Quality Improvement Project

Lead Entity: City of Fanning Springs

This project is a multi-phase plan to expand municipal sewer service, remove existing septic tanks and prevent future septic tanks. The District, FDEP, and the City have partnered together on three phases of this project. Phase I removed 65 septic tanks and is estimated to reduce nitrogen loadings by 1,300 pounds annually. Phase II is currently under construction and will eliminate 60 septic tanks and connect them to the City's wastewater collection system, reducing nitrogen loadings by 4,300 pounds annually. Phase III, funded in July of 2016, will eliminate and prevent 198 septic tanks, reducing nutrient loading by approximately 4,554 pounds annually. Additional phases/expansions are planned and will require future funding.

Cost: Phase I - \$1,726,000

Phase II- \$ 3,316,400

Phase III - \$ 3,395,100

High Springs Wastewater Collection System Extensions – Phase A1

Lead Entity: City of High Springs

This project consists of three phases. The overall project will provide central sewer service to the remaining areas of the City of High Springs that are currently on septic and reduce nutrient loading to the Santa Fe watershed area and Hornsby and Poe springs. This phase of the project is anticipated to eliminate 132 septic tanks and reduce nutrients by 2,640 pounds per year.

Cost: \$3,432,700 (for this phase)

Hornsby Spring Water Quality Improvement Project

Lead Entity: City of High Springs

This project will reduce nutrient loading to Hornsby Spring by nearly 100 pounds annually. This project will decommission Camp Kulaqua's on-site wastewater plant and effluent disposal system (rapid infiltration basins), construct a lift station, and install 6000 linear feet of wastewater line that will take the effluent to the City of High Springs WWTP.

Cost: \$450,000

High Springs Septic Tank Abatement

Lead Entity: City of High Springs

This project will remove at least 13 septic tanks and connect those residences to the City's centralized sewer system with grinder pumps. The project will reduce nitrogen loading to the Santa Fe River.

Cost: \$175,000

Florida Department of Transportation Water Quality Pilot Project

Lead Entity: Florida Department of Transportation (FDOT)

This project is a comparison study of the nutrient removal effectiveness of two different types of Biosorptive Activate Media in a roadside swale just east of the City of Fanning Springs. One material was developed by the University of Central Florida and the other is a wood chip blend used by the District in denitrifying wall projects.

Cost: \$180,101

Mill Creek Sink Water Quality Improvements

Lead Entity: City of Alachua

This project will provide water quality improvements to an area of direct recharge at the Mill Creek sink and swallet in the City of Alachua. The project will involve the purchase of property to install water quality BMPs to reduce pollutant loads currently directly discharging into the sink. The stormwater management improvements will capture runoff from approximately 5 acres of impervious, including an FDOT roadway, designed to reduce nutrient loading by up to 66 percent to meet TMDL of 0.35 mg/L.

Cost: 1,400,000

Santa Fe Park and Boat Ramp

Lead Entity: Gilchrist County

This project will provide upgrades to the Gilchrist County Santa Fe River Park located on SR47 adjacent to the Santa Fe River. The project will include enhancing the access to the river at the park by replacing the boat ramp, adding docks and a separate canoe launch and fixing drainage which will reduce sediment and nutrients going to the river.

Cost: \$129,800

Dream Inn WWTP Closure

Lead Entity: Columbia County

This project will remove the current non-compliant wastewater treatment system that serves the Dream Inn Motel and hook the motel up to Columbia County's sanitary sewer service. This also includes relocating, upgrading and enlarging the existing County wastewater treatment facility to include the flow from the Dream Inn plant and lift stations and force mains to collect the flow.

Cost: 1,650,000

Branford Wastewater Effluent Pond Failure Repairs

Lead Entity: Town of Branford

This project involves the installation of a new 300,000-gallon effluent storage tank on a prepared/grouted foundation replacing the failed existing wastewater effluent pond. The work will also include a duplex transfer submersible pump station, duple sprayfield pump station, and associated piping, valves fittings, controls, and appurtenances.

Cost: 264,500

Lake Francis Sediment Control

Lead Entity: City of Madison

This project will improve the quality of stormwater discharged to Lake Frances, located in the City of Madison at the southeastern intersection of US90 and SR53. Lake Frances receives most stormwater in the City, an approximately 61-acre watershed, and the stormwater improvements will facilitate the removal of sediment, oil, trash, and other water-born contaminates. The project will include the design, installation, and maintenance of two advanced separation units, one each at the two stormwater inlets that service the greatest portion of the runoff area.

Cost: \$77,525

City of Waldo Well Pump No. 2 Replacement and Lift Station Rehabilitation Project

Lead Entity: City of Waldo

This project will restore the City of Waldo's fire protection backup water supply and eliminate groundwater and surface water pollution from lift station overflows. Securing water supply for fire suppression and rehabilitating the lift stations will provide benefits to 970 residents in the area. The project will include the replacement of the submersible pump in Well No. 2 and the rehabilitation of Lift Station Nos. 2 and 3. Rehabilitation of the lift stations will include the installation of new control panels, new pumps, and any other related items deemed necessary to restore the stations to full operation.

Cost: \$100,000

49/90 Lift Station Improvements

Lead Entity: City of Live Oak

This project will ensure proper function of a lift station at the intersection of US 90 and CR 49 in Live Oak, Florida, thereby eliminating sewage spills due to lift station malfunction. This improvement will offer an additional layer of water quality protection to a Class V drainage well located at District headquarters, less than 500 feet south of the previous sewage spills.

Cost: \$16,000

Jennings Wastewater Lift Station at Turkett Creek

Lead Entity: Town of Jennings

This project will construct a new lift station outside of the 100-year floodplain of Turkett Creek and remove the existing lift station and piping from the floodplain.

Cost: \$231,000

I-75/SR 47 Cannon Creek Sink Public Wastewater Improvement Project (Phase 1)

Lead Entity: City of Lake City

Phase 1 of this project involves the elimination of septic tanks from 30 businesses and five residences. Future phases, if completed, will eliminate up to 900 septic tanks and reduce up to 64,600 pounds of nutrient loading per year. Phase 1 is estimated to reduce TN by 11,950 pounds annually. The project is located within the Santa Fe River BMAP area.

Cost: \$3,400,871

I-75/CR-136 Wastewater Improvements, Septic Elimination

Lead Entity: Suwannee County

Construct a new WWTP plant with wetland treatment/aquifer recharge for effluent disposal, eliminating 32 existing commercial septic tanks. This project is estimated to reduce TN loading by 39,894 pounds annually.

Cost: \$3,300,000

Infiltrative Wetlands for WWTP Effluent Treatment/Disposal Phase I

Lead Entity: City of High Springs

Project will involve the conversion of the City's existing effluent sprayfield into infiltration wetlands. Initial phase of the project would involve the design and permitting of approximately 20 acres (10 lined, 10 unlined) of infiltrative wetlands having a total treatment/disposal capacity of 0.48 MGD. Only 10 acres would be constructed in Phase 1 which would provide sufficient capacity for the City's current wastewater treatment capacity of 0.24 MGD. Phase 2 would be constructed concurrently with the planned expansion of the City's WWTP to 0.48 MGD. This project is estimated to reduce TN loading by 4,870 pounds annually.

Cost: \$2,795,000 (Phase 1 and 2)

Poe Springs Domestic Sewage Infrastructure Upgrade

Lead Entity: Alachua County

Phase 1 - improvements consisting of installation of new waterless restrooms immediately adjacent to the springhead with larger holding tanks and assessing the on-site treatment and disposal system septic tanks. Phase 2 would include septic tank replacement resulting in 576 pounds of NO_3^- removed per year.

Cost: \$346,600

Rum Island Park

Lead Entity: Columbia County

Provide bank stabilization and erosion and sediment control; install public restrooms (none existing) with a lift station and septic system (off-site, out of floodplain) to allow for the removal of the portable toilets and protect the spring and river from contamination by human waste; use innovative practices, such as installation of BAM, to reduce nutrients around septic system.

Cost: \$300,000

4.1.3 Natural Systems

Table 10. Ongoing Natural Systems Projects

Monitoring and Research
Habitat Conservation
<p>District Land Acquisition Program</p> <p>Lead Entity: District</p> <p>Most District-owned fee and conservation easement lands are located along rivers and streams, headwaters, and water recharge areas. Public ownership of these lands and conservation easements provides a host of benefits including:</p> <ul style="list-style-type: none"> • Preserving and restoring springs and surrounding areas to protect and improve surface and groundwater; • Preserving floodplain areas to maintain storage capacity, attenuate floodwaters, and mitigate flood risk; • Preserving natural buffers along water bodies where adjacent uses have a high potential to degrade surface water quality; • Protecting groundwater quality by maintaining low intensity land uses; • Providing land for dispersed water storage, restoration, and water resource development projects; and • Preserving and/or restoring natural communities to support or enhance populations of native species. <p>The land acquisition program is strictly voluntary — all land acquisition projects are negotiated with willing sellers within the constraints of appraised market value.</p> <p>Cost: TBD</p>
<p>Suwannee and Santa Fe River Basins Land Acquisition</p> <p>Lead Entity: District and Alachua County</p> <p>Fee simple or less than fee (conservation easement) acquisition of lands to protect the springs on the Suwannee and Santa Fe Rivers. Acquisitions include Rock Bluff Springs along the Suwannee River and 240 acres surrounding and upstream of Mill Creek Swallet.</p> <p>Cost: \$7,202,968</p>
Habitat Restoration
<p>Middle Suwannee River and Springs Restoration and Aquifer Recharge</p> <p>Lead Entity: District</p>

This project is a partnership between the District, FDEP, and Dixie County to provide hydrologic restoration activities in Dixie and Lafayette counties. The District began restoration efforts at Mallory Swamp several years ago after purchasing 31,000 acres within the swamp. This project will build upon those efforts by implementing hydrologic restoration activities on the property to rehydrate roughly 1,500 acres of ponds, 4,000 acres of wetlands and recharge the aquifer up to an estimated 10 MGD. The project will enhance surface water storage and recharge the aquifer to benefit spring flows in the MSR region and to augment domestic and agricultural groundwater supplies in Lafayette and Dixie counties.

Cost: \$1,852,000

Lower Suwannee Drainage Basin Aquifer Recharge

Lead Entity: Dixie County

This project will restore approximately 500 acres of sand ponds and rehydrate approximately 1,250 acres of wetlands by re-establishing natural flow through natural recharge features and an aquifer recharge well. The project will conserve approximately 3.26 MGD in water that will support spring flow of Fanning Springs, Manatee Springs, Otter Springs, Copper Springs, Little Copper Springs, and Bell Springs.

Cost: \$2,406,359

Cow Pond Drainage Basin Aquifer Recharge

Lead Entity: Dixie County

This project will re-establish natural drainage patterns and use natural recharge features and aquifer recharge wells to enhance aquifer recharge and rehydrate wetlands and currently dry lakes in the Lower Suwannee Drainage Basin. The project will restore approximately 300 acres of sand ponds and rehydrate approximately 1,750 acres of wetlands while conserving approximately 1.69 MGD of water that will support spring flow of Turtle Spring, Pothole Spring, Gornto Spring, Rock Sink, Sun Spring, and McCrabb Spring.

Cost: \$1,600,000

Pot Springs Restoration

Lead Entity: District

This project will stabilize the shoreline along the spring run to prevent sediment from entering Pot Spring and the Withlacoochee River. The project includes the reconstruction of an existing boardwalk and deck area near the spring to improve public access and safety. Work to be completed includes bank restoration and stabilization, and deck and boardwalk improvement. Additionally, the 6,500 -7,000-square foot public parking area will be designated with traffic stops and impediments to eliminate vehicle traffic in the near-field spring area and grade work to prevent sediment from reach the spring. The project will result in 1,135 square feet of bank stabilization and restoration equating to 0.4 acres of sediment/erosion prevention.

Cost: \$183,600

Habitat Restoration through Aeration and Revegetation at Hornsby Spring

Lead Entity: Alachua County

The limestone substrate of Hornsby Spring pool and vent has experienced undesirable sedimentation, become overgrown with algae, and experienced loss of SAV. This project proposes to improve conditions at the spring through the installation of a temporary aerator to improve DO conditions, removal of sediment to improve spring flow, and installation of SAV to improve water quality. Benefits include removal of organic sediments containing nitrogen and by nitrogen utilization by SAV. Based on 200 cubic yards of sediments removed (from the springs and upper run), the nitrogen load reduction from sediment removal is estimated to be up to 1,260 pounds. The restored SAV in the Hornsby spring and upper run will also utilize nitrogen. Based on SAV nitrogen utilization of 5 percent it is estimated that 980 pounds/year of nitrogen may be utilized by established SAV at maturity.

Cost: \$443,480

Edwards Bottomlands Wetland Restoration

Lead Entity: District

To improve hydrologic conditions within the floodplain and reduce some of the sediment load from going to Lake Rowell down Alligator Creek, the District, in cooperation with the FWC, plans to conduct a floodplain restoration project which will re-establish the flow connection from the portion of the altered creek to a 47-acre floodplain parcel known as the Edwards Bottomlands.

Cost: \$1,442,000

Starke Bypass Wetland Mitigation

Lead Entity: FDOT and District

The U.S. 301 truck route around Starke is now in fiscal year 2016 at an estimated \$90 million. The purpose of this new roadway is to relieve congestion on the U.S. 301 corridor within Starke and provide the needed capacity for future traffic growth.

Wetland impacts that will result from the construction of this project will be mitigated pursuant to Section 373.4137 F.S. to satisfy all mitigation requirements of Part IV, Chapter 373, F.S. and 33 U.S.C.s, 1344 (Clean Water Act). The District will coordinate with FDOT to design mitigation to address water resource objectives including surface water storage and groundwater recharge.

Cost: \$2,980,000

Woods Ferry Hydrologic Restoration

Lead Entity: District

This project is to replace nine damaged or destroyed culvers on the District's Woods Ferry Tract which will solve erosion problems and reconnect hydrological flow between existing wetlands.

Cost: TBD

Prescribed Fire

Lead Entity: FWC and District

The District's prescribed fire program targets sandhills, upland pine, scrubby flatwoods, mesic flatwoods and wet flatwoods communities for maintenance and restoration purposes. Combined, these targeted communities make up approximately 59,879 acres or 71 percent of the total acres of District Lands that were historically influenced by fire. Over the 2016 fiscal year, there was prescribed burning on 12,528 acres.

Cost: TBD

Non-native, Invasive Plant Control

Lead Entity: District

Over the 2016 fiscal year, 53 invasive plant infestations were monitored and 65 were treated with herbicides, and six infestations were reclassified as inactive. Active infestations are reclassified as inactive when no remaining living plants are observed at/or within close proximity of the infestation for four consecutive years. With funding provided by FWC, 59 acres containing multiple infestations on the Lake Rowell tract in Bradford County were treated.

Cost: TBD

Recreation Management

Recreation Management on District-owned Lands

Lead Entity: District

District lands provide many resource-based recreational opportunities. Over 97 percent of District-owned lands are open to the public for recreation. Planning for public uses and facilities considers the sensitivity of the site, the proximity of similar recreational opportunities, the time and financial requirements to provide the use, and public demand for the particular use.

The District has developed facility standards that detail recreational facility, road and trail, sign and kiosk, and fence design, construction and maintenance procedures. These standards ensure that facilities provide a safe, aesthetically pleasing, outdoor environment for the public that can be effectively maintained and minimizes the potential impacts to water resources.

Cost: TBD

4.2 Proposed Projects

In preparing this SWIM Plan update, the District conducted an extensive outreach program to identify projects for the preservation, conservation and restoration of water resources and natural systems. Project ideas were solicited from District staff, local governments, state agencies, and other interested stakeholders. In addition, the FDEP *Deepwater Horizon* project portal was accessed and screened for projects relevant to the study area. Through this process, several key projects were identified and are summarized below. It should be noted that the list of projects provided below is fluid is expected to change in future SWIM Plan updates as projects are implemented and/or new priorities are identified.

4.2.1 Water Quantity

Table 11. Proposed Water Quantity Projects

Monitoring, Data Collection, and Research
<p>Radar Rainfall</p> <p>Lead Entity: District</p> <p>Create a cloud-based radar rainfall data depository for remote access by Base Station-equipped irrigation systems that would utilize near-real time rainfall data to optimize irrigation system efficiencies. The radar rainfall data would be gage-adjusted and processed by a third-party contractor at a standard 1 kilometer square grid cell spacing within a maximum 15-minute interval and delivered to the cloud-based location with no greater than a 15-minute lag. Participating base stations would access mapped grid cell(s) specific to the irrigation system and adjust irrigation application rates accordingly.</p> <p>Components of project:</p> <ul style="list-style-type: none"> • Calculation and delivery of 1 km gage-adjusted radar rainfall product on a District-wide basis

- Design and implementation of cloud-based server hosting of radar rainfall data with capability of responding to automated data requests on an immediate and 24-hour basis

Cost: Expected initial project cost \$125,000

Operational costs (per year) \$10,000

Quantifying Groundwater Recharge and Discharge to Improve Tools for Protecting Water Supplies and Natural Systems

Lead Entity: District

The public relies on groundwater models to inform critical decisions affecting water availability and the protection of natural systems. This is particularly the case in Florida, where aquifers are the dominant source of water for public and private water supply, commercial uses, and sustain many critical ecosystems and fisheries.

The predictive accuracy of these groundwater flow models depends on our ability to estimate inputs needed to construct and calibrate these models before they can be applied in a decision-making context. Some of the most critical inputs for model construction and calibration are estimates of groundwater recharge and exchanges of water between aquifers, rivers, and springs. Unfortunately, these components of the water budget are also some of the most poorly understood at present. The objective of this project is to improve estimates of groundwater recharge and aquifer-river-spring water exchanges to reduce the uncertainty associated with important predictions made with groundwater flow models.

Improved estimates of recharge will be sought through several potential approaches. These include (1) the operation of stations for measuring soil moisture and evapotranspiration (or correlated variables such as net solar radiation) for key combinations of crop type, land cover, and soil type; (2) use of data from these stations to validate or improve remotely-sensed estimates of ET and soil moisture; (3) analysis of the potential for improving the accuracy of remotely-sensed estimates of ET and soil moisture by incorporating higher resolution land-cover, topographic, soil, or hydrographic data; and (4) evaluation of the use of improved land-surface, unsaturated-zone, or rainfall runoff models to estimate recharge.

Improved estimates of exchanges of water between aquifers, rivers, and springs will also be sought through a variety of approaches. These include (1) chemical baseflow separation analyses in which water quality and flow data from stream gages are used to quantify the fraction of the total streamflow that is derived from groundwater (stream 'baseflow'), (2) measurement of flows at springs with limited historical data over a range of hydrologic conditions, and (3) regression or other types of statistical analyses to estimate spring and stream baseflows with explanatory variables such as antecedent rainfall or nearby groundwater levels.

Cost: \$900,000

Integration of Livestock and Agronomic/Vegetable Cropping Systems

Lead Entity: UF/IFAS Extension Suwannee Valley Agricultural Extension Center (SVAEC)

The UF/IFAS has been researching, evaluating and demonstrating a system of livestock integration with row crop farming at North Florida Research and Education Center sites in Quincy and Marianna for the last 14 years. This farming system has shown many potential benefits to the environment while at the same time increasing the potential profitability and sustainability of agricultural producers and local economies. Data collected for the past 14+ years at both locations has shown water savings, fertilizer savings, increased soil health, reduced financial risk to farmer, increased yields of all crops grown in rotation, and reduced need for offsite inputs. This system uses 2 to 4 years of perennial grass (bahia grass) grazed by livestock and then is rotated to 2 years of crops (i.e., peanuts, cotton) before returning it back to perennial grass to start the cycle over again. Conservation practices such as no till, strip till, cover crops, optimum irrigation and nutrient management, integrated pest management, and rotational grazing are used in this system. This system has the potential to work with other agronomic and vegetable crops important in the Suwannee Valley as well.

The UF/IFAS and the SVAEC proposes to set up long term demonstrations at a site adjacent to the SVAEC farm with cooperation of neighboring cattle producer and with other willing agricultural producers in the basin. UF/IFAS, with help from the SRP, will use these demonstrations to learn and teach about topics such as the verification of BMPs used in this system, economic advantages of this system, how risk can be mitigated in volatile crop markets, and managing risk from extreme weather events. Information gathered and successes learned from ongoing FDACS demonstrations of on-farm 4-year integrated cattle and cropping systems projects will be used to further plan these demonstrations. Potential impacts of this project include:

- 50 to 70 percent water savings
- 30 to 50 percent less N inputs
- less dependence on pesticides
- less risk from weather extremes
- reduced financial risk
- long term soil health improvement
- improved local economies
- reduced carbon foot print on farm
- transferability to other farms in the Georgia portion of Suwannee Basin

Cost: TBD

Agricultural Water Security and UFA Sustainability: An Integrated Assessment of Economic and Environmental Benefits

Lead Entity: UF/IFAS Extension SVAEC

The North Florida-SW Georgia region that depends on the UFA for its water supply generates approximately \$9 billion in agriculture-related economic activity. The UFA is among the largest and most productive aquifers in the world and represents a vital regional resource. Nevertheless, this region is experiencing intense competition between urban, agricultural and environmental water uses and stringent new environmental regulations that threaten agricultural water security. The goal of this project is to create and disseminate unbiased knowledge that ensures the economic sustainability of agriculture/silviculture in North Florida-SW Georgia, while protecting water quantity, quality and habitat. We will achieve this goal by: (1) Developing stakeholder-informed biophysical and economic models to quantify the impacts of agricultural/silvicultural management practices on the water quantity, water quality, and economy of the region; (2) Evaluating the ability of BMPs to meet water quality and quantity standards under current land uses, technologies and policies; and evaluate economic-environmental tradeoffs of potential future climate, land use, technology, BMP adoption and policy scenarios; (3) Developing incentive programs and communication strategies that effectively motivate landowners to adopt land use and management changes needed to meet environmental standards while sustaining regional food and fiber production; (4) Developing new Extension BMP demonstrations, educational programs and products to bring about preferred changes in production systems and incentive programs; (5) Incorporating project findings into an on-line graduate course and offering it across partner institutions. This project directly addresses Priority Areas 3 through 5 identified in the National Institute of Food and Agriculture Water for Agriculture Challenge Area request for proposals.

Cost: TBD

Impacts of Crop Diversification and New Crop Rotations and Production Systems on Water Quality

Lead Entity: UF/IFAS Extension SVAEC

North Florida has a great diversity of soil, micro-climates and markets, three ingredients that allow for widespread row crops, fruits and vegetables. As new crops become adopted in the region, dedicated funding is needed to determine the impact of those crops on our water quantity and quality. Efforts and funding dedicated to research and extension on new crops will aid in the development of BMPs for those crops and would also increase the possibilities for new choices for lower impact crop rotations.

Cost: TBD

Water Supply Planning

MFLs

Water Resource Development and Aquifer Recharge

Brooks Sink Phase II

Lead Entity: District and Rayonier Operating Co.

The Brooks Sink Aquifer Recharge Project, located in Bradford County, is a public-private partnership with Rayonier Operating Company, LLC, to restore a natural hydrologic connection to Brooks Sink. Brooks Sink is known as one of the largest cover collapse sinkholes in the State of Florida and is directly connected to the IAS, which overlies the UFA. The first phase of this project was completed in early 2015, restoring overland flow from 1,000 acres that had previously been diverted away from the sink. Total recharge from March 1, 2015 through October 15, 2017, was 190 million gallons or 0.2 MGD. The second phase of this project is projected to add another 1,020 acres of potential runoff as recharge to the sink feature.

Cost: TBD

Upper Suwannee River Recharge Project

Lead Entity: District

The proposed USR recharge project would utilize available surface water in tributaries to the USR that exceeds environmental flow requirements. Available water would be recharged into the UFA through passive well structures, which would be constructed adjacent to the stream beds of the tributaries. Each passive well structure would include an intake structure to capture high flows. The captured flow would then recharge to the UFA via gravity.

As this is an in-line, passive capture and recharge concept; the project does not include treatment of the water before recharge. If treatment is required prior to recharge, a storage pond and treatment facility would be required, as well as the property on which to construct this infrastructure. The four proposed well locations (Rocky Creek, Sandlin Bay, Deep Creek, and Robinson Branch) are located in streambeds of tributaries to the USR. The wells will be passive well structures that will directly recharge the UFA by collecting excess flow from the tributaries during high flow events. Diversions would be limited to protect the preliminary MFLs proposed for the Suwannee River and priority springs in the area.1

Cost: TBD

San Pedro Bay and Mallory Swamp Hydrologic Restoration

Lead Entity: District

The Coastal Rivers Basin contains extensive 'pocosin swamps' in its furthest reaches. The largest of these are known as San Pedro Bay in Madison, Taylor and Lafayette counties; and Mallory Swamp in Lafayette and Dixie counties. The Waccasassa Flats area is another similar feature. These swamps were historically ditched and drained in the early-mid 20th century to reduce groundwater saturation of the pocosin soils so that more intensive plantings of pine species for silviculture could occur. While successful in increasing plantation densities, derivative impacts included declines in the Floridan aquifer system underlying the swamps, periodic drying of sand-bottom lakes at the perimeter of the swamps, and increased suspended solids in the canals and eventual riverine systems leading to the Gulf of Mexico.

San Pedro Bay and Mallory Swamp constitute both the surface water and groundwater divide between the Coastal Rivers Basin and the MSR Basin and its numerous springs. In the early 2000's the District purchased nearly 30,000 acres of the interior of Mallory Swamp, and began initial restoration efforts with assistance from the Natural Resource Conservation Service (NRCS). Restoration activities included the installation of 311 culverts and 57 ditch blocks to restore natural drainage patterns and increase the ability of the property to store water, thereby rehydrating wetlands and inducing aquifer recharge. However, because the District-owned property did not include the perimeter ditching to the east and extensive drainage features to the south and west of the swamp, overall benefits are less than what is potentially feasible. To date, no such restoration activities have occurred in San Pedro Bay or the Waccasassa Flats.

The goal of future hydrologic restoration projects in these critical areas is to restore natural hydrology and thereby improve wetland conditions, enhance aquifer recharge both at the swamp perimeters to aid in perimeter lake level recovery, as well as, to provide increased springflows to major river systems, and to reduce discharge of suspended solids via the extensive remaining canal networks to natural receiving water bodies and eventually the Gulf of Mexico.

These goals can be accomplished by the acquisition of large conservation easements within the swamp boundaries and along man-made drainage features to permit construction of and perpetual maintenance access for control structures (culverts, ditch blocks, controlled gates), recharge wells and related conveyances, and other restoration activities.

These projects are still in the conceptual design phase, however based on past restoration efforts, expected restoration costs per acre are on the order of \$1,000, including a conservation easement estimated value of \$500 per acre. An estimated minimum practicable project size would be 4,000 acres. Total acreage within the three swamps is in excess of 400,000 acres.

Cost: \$4,000,000

Lake Sampson Drainage Wells

Lead Entity: District and Bradford County

This project proposes to replace abandoned drainage wells with two new wells that will both provide aquifer recharge and flood protection in the Lake Sampson Basin. Flow into the well(s) will be monitored with telemetry using a flume and water levels. Volumes will be reported in million gallons per day and per year. Any positive flows into the well will provide a benefit to down gradient springs in the Lower Santa Fe River Water Use Caution Area as well as of related Minimum Flows and Levels, currently in recovery status. Recharge benefits are estimated at up to 2 MGD. This project is currently in the conceptual design phase, and project cost is being determined.

Cost: \$1,000,000

Prairie Creek Diversion Structure Replacement and Recharge Enhancement

Lead Entity: District

Evaluation, design and construction of a replacement structure on Prairie Creek that will allow variable diversion of water between Camps Canal / Orange Lake and Paynes Prairie. The structure is owned by the Florida Park Service as it is located within Paynes Prairie State Park, who will operate the structure following completion of construction. The structure would be used for flood control management on Paynes Prairie to protect US Highway 441 from flooding. Modifications to US441 would allow the proposed structure to be used to optimize water level management between Paynes Prairie and Orange Lake for environmental and aquifer recharge benefits. Aquifer recharge from Paynes Prairie is via Alachua Sink and supports the Prevention/Recovery strategy for the Santa Fe River and its springs. Aquifer recharge from Orange Lake is via the Heagy Burry Sink which supports Silver Springs and its PR strategy.

Cost: \$500,000

Drainage Well Replacement/Rehabilitation

Lead Entity: District

During the early to mid-20th Century, many municipal areas across the District employed the use of drainage wells to convey excess rainfall runoff to the Floridan Aquifer and thereby reduce flooding impacts. While successful to a limited extent during that era, over time most of the wells have fallen into disuse, abandoned, or lost entirely. The goal of these well projects would be to enhance aquifer recharge while providing increased flood protection. This goal can be accomplished by the identification of existing and/or abandoned drainage wells within the Northern Highland geographic region. The District karst landscape is characterized by frequent interaction between groundwater and surface water through sinkholes. In the past, municipalities have used this phenomenon to their advantage by accelerating rainfall drainage and reducing flooding impacts using drainage wells. While successful to a limited extent during that era, over time most of the wells have fallen into disrepair or have been plugged entirely. The goal of drainage well replacement projects would be to accelerate aquifer recharge and provide increased flood protection, while incorporating modern flow conveyances which allow a greater level of control and water quality improvement and protection than past designs.

Cost: TBD

Middle Suwannee River and Springs Restoration and Aquifer Recharge Project

Lead Entity: District, FDEP and Dixie County

The MSR and Springs Restoration and Aquifer Recharge Project is a partnership between the District, DEP, and Dixie County to provide hydrologic restoration activities in Dixie and Lafayette counties. The District began restoration efforts at Mallory Swamp after purchasing 31,000 acres within the swamp. The initial phase of this project built upon those efforts by implementing hydrologic restoration activities on the property to rehydrate roughly 1,500 acres of ponds, 4,000 acres of wetlands and recharge the aquifer up to an estimated 10 MGD. Additional phases are needed to continue to enhance surface water storage and recharge the aquifer to benefit spring flows in the MSR region and to augment domestic and agricultural groundwater supplies in Lafayette and Dixie counties.

Cost: TBD

Double Run Creek Water Resource Development Area

Lead Entity: District

The Double Run Creek Water Resource Development Area project is located in eastern Bradford County and includes 1,910 acres of District-owned land adjacent to the National Guard's Camp Blanding. The purchase was funded by a grant from the National Guard through the Department of Defense as part of a program designed to secure buffers around military installations. This project presents an excellent opportunity for flood protection, natural resource enhancement and restoration (particularly wetlands), aquifer recharge to the UFA providing water to springs in the Lower Santa Fe River, and to augment low flows to the upper Santa Fe River. This project is in the conceptual design phase and the project cost is being determined.

Cost: TBD

Inter-District Water Resource Development Project

Lead Entity: District

This Inter-District Water Resource Development Project is located in southeastern Bradford County and will utilize lands adjacent to the National Guard's Camp Blanding. This project presents an excellent opportunity for flood protection, natural resource enhancement and restoration (particularly wetlands), aquifer recharge to the UFA providing water to springs in the Lower Santa Fe River, and to augment low flows to the upper Santa Fe River. Aquifer recharge associated with this project will have regional cross-boundary benefits for stressed water resources in both the District and SJRWMD due to its proximity to the Keystone Heights potentiometric high, which is a regional recharge area for the UFA. The project is in the initial phases of feasibility and is dependent upon successful acquisition of property by the District.

Cost: TBD

Santa Fe River Basin Aquifer Recharge/Flood Mitigation Project

Lead Entity: District

The District is working with Bradford County to develop aquifer recharge and flood mitigation projects, particularly to mitigate flooding and associated water quality issues in and around City of Starke. The purpose of the projects is to capture and store high flows in the upper Santa Fe River basin and use the water for aquifer recharge and maintenance of flows during drought to support proposed minimum flows and levels for the Lower Santa Fe River.

Cost: \$5,000,000

Upper Suwannee River Watershed Hydrologic Restoration Assessment (USFS - 10)

Lead Entity: National Forest Service and District

The Osceola National Forest has recently acquired over 30,000 acres of lands within the Forest's administrative boundary and intends to purchase an additional 30,000 acres in the near future. Because most of these areas were very poorly drained, the previous owners severely altered their hydrology through extensive ditching and bedding to create more favorable conditions for industrial pine production. The USB Basin has been identified as a "Water Resource Caution Area" meaning that existing sources of water (groundwater) will not be adequate to satisfy future water demands and sustain water resources. The District has recommended that the Forest Service restore the hydrology of these areas so as to retain as much surface water on the site as possible. This hydrologic restoration assessment will be a critical component to prioritizing restoration efforts within newly acquired lands.

Cost: \$220,000

Hydrologic Restoration on the Lower Suwannee National Wildlife Refuge - Dixie County

Lead Entity: Lower Suwannee NWR

This project proposal focuses on hydrologic restoration within Dixie County portions of the Refuge. In the Dixie County portion of the Refuge, the most significant impacts appear to occur in the California Swamp basin east of the Dixie Mainline Road and portions of the California Creek and Shired Creek basins, all of which were likely tidal in the early 1900s prior to road construction. Using easily proven methodologies, existing data sets including LiDAR, and working with key partners including the District, University of Florida, USGS, FWC, USFWS, and others, the NWR, through this proposal seeks to restore hydrology on Dixie County portions of the Refuge through:

- The replacement of undersized and dilapidated culverts.
- The installation of additional culverts, low water crossings, ditch plugs, and bridges.
- The removal or breaching of underutilized roads and trails and subsequent filling of roadside ditches.

With the Dixie County portion of the Refuge, approximately 10 miles of underutilized roads and trails are identified for removal or breaching, as well as locations for 32 low water crossings, 47 pipe culverts, and 76 box culverts with hydrologic improvements affecting approximately 70,000 acres (112 square miles) within the Refuge and surrounding watersheds.

This project is part of a greater initiative taking shape within the LSR resulting from the availability of *Deepwater Horizon* funds. A synergistic suite of projects has been submitted to restore water quality, recreational and commercial fisheries and habitat within the various watersheds of the Big Bend region and the Suwannee estuary which is suffering due to low freshwater inputs.

This project will complement other proposed projects described in this section and previously funded projects in this region such as the Recovery and Resilience of Oyster Reefs in the Big Bend of Florida project funded through GEBF. Additional information can be found at the following pathway: <http://www.nfwf.org/gulf/Documents/fl-oyster-recovery-16.pdf>

Cost: \$6,556,000

Hydrologic Restoration on the Lower Suwannee National Wildlife Refuge - Levy County

Lead Entity: District and Lower Suwannee NWR

This project would focus on the Levy County portion of the property, with the most significantly impacted areas in Sandfly Creek, Black Point Swamp, and Gopher River Basins. Within the Levy County Implementation, approximately 2.5 miles of abandoned roads and trails are identified for removal or breaching, as well as locations for 50 low water crossings, 20 pipe culverts, and 8 box culverts with hydrologic improvements affecting approximately 16,000 acres within the Refuge. Additional benefits are expected beyond the Refuge boundary and include state and private lands and state waters in creeks, the Suwannee River, and extensive coastal areas of the Gulf of Mexico. Additional hydrologic restoration work is anticipated in this area and will be identified and prioritized in the engineering assessment.

The project is the first step in the restoration of the natural hydrology and movement of water through the Refuge to the lower Suwannee Sound. The project will not only improve the health of the estuary through restored freshwater inputs, but will also help sustain the economic viability of recreational and commercial fishing, ecologically important oyster reefs, protected species at large (including state-listed species), and the significant shellfish industry in the region.

Cost: \$1,493,000

Sandlin Bay Restoration (USFS - 9)

Lead Entity: National Forest Service and District

Restoration of the natural hydrology by converting 5,200 ac of offsite slash pine plantations to wetland and longleaf pine, thinning 500 acres of mature plantations and modifying bedding and ditches on these sites to reduce storm runoff and increase natural sheet flow. This area of the state has suffered from overconsumption of ground water and a dramatic lowering of the aquifer as well as numerous catastrophic wildfires. In 2011, the Suwannee River reached its lowest level in recorded history and many private wells ran dry. Consequently, this has led the District to designate this area as a "Water Resource Caution Area," an area where existing water sources will not be adequate to satisfy future water demands and sustain water resources. Work is proposed for 17,000 acres purchased by the Suwannee River Water Management district and recently acquired by the U.S. Forest Service. While under private ownership, the normal hydrology of this area was altered to support intensive pine production. This has disrupted normal sheet flow across the surface and has altered hydroperiods in swamps and water levels in ephemeral ponds. During major rain events the ruts created by bedding channel water into swamps as well as into firelines, roadside ditches and holding ponds below road bridges. The ruts can also prevent drainage, depending on local soil topography, and prevent water from flowing into natural ponds and swamps linked to the Suwannee River basin and ultimately the Gulf of Mexico.

Cost: \$3,410,000

Conservation**Suwannee Valley "Water Schools"**

Lead Entity: UF/IFAS Extension SVAEC

Workshops, called "water schools", designed to educate target audiences have already been successfully implemented in various regions of Florida. The aim of these schools is to engage elected officials, water managers, and other decision makers at the county and city levels in conversation about water resources. Through these schools, science-based educational materials with regard to current research on water quality, quantity and supply are delivered. Water schools, not only provide decision makers with the tools to make more informed decisions, they also provide an opportunity for agents of every entity a chance to converse constructively with one another.

At the SVAEC, we have an opportunity to create water schools with the cooperation of the members of the SRP. The collaboration of the SRP will provide an ideal pool of contributors from FDACS, District, UF/IFAS, and NRCS to guide area water schools. With this collaboration, area water schools will address watershed issues with an audience representing the entire basin. By doing this, we will be able to impact change on a scale not previously realized in other areas of the state. The goals of the project will be to connect decision makers within the basin, provide science-based decision support, and promote collaboration among all participants. The schools will be designed to convene once a year for one day, and at each meeting a tour will be organized to showcase a different aspect of the water supply chain.

Cost: TBD

4.2.2 Water Quality

Table 12. Proposed Water Quality Projects

Monitoring, Data Collection, and Research
<p>Deep Coastal Wells for Freshwater-Saltwater Interface Monitoring</p> <p>Lead Entity: District</p> <p>Knowing the groundwater distribution between fresh and saline water resources is imperative for coastal community resiliency and habitat restoration. Currently on the Florida gulf coast within the District (Taylor, Dixie, and Levy counties) the depth and stability of the freshwater-saltwater interface is unknown. Establishing the depth of the freshwater-saltwater interface and evaluating the stability of this interface will enable the District to improve regional water supply models and identify threats to the long-term freshwater supply in the region. This data will provide small coastal communities with key information for long-range planning and ensure resiliency to environmental changes. To sample water from the lower Florida the District plans to install four sampling wells across Taylor, Dixie and Levy counties at Rosewood, Horseshoe Beach, Steinhatchee, and Dekle Beach. Rosewood is a few miles inland of Cedar Key and Horseshoe Beach is North of the Suwannee River and Cedar Key on the coast. Dekle Beach is along the coast and approximately 20 miles north of the Steinhatchee river and 40 miles north of Horseshoe Beach. The various well locations will indicate the saline water interface along the North West peninsular Florida coast and aid in monitoring future changes of the fresh-salt water distribution.</p> <p>Monitoring the fresh-salt water interface will enable Florida gulf coast communities to identify locations where mitigation projects will be needed to address groundwater changes in the face of sea level rise. From 1914 to 2006 the MSL rise per year was 1.8 mm at Cedar key (NOAA, 2009). In Florida, the sea level is expected to increase an additional 1.5 to 4.5 feet by 2100 (Jevrejeva. et al., 2012). Due to current and projected sea level rise, monitoring wells are needed to help communities prepare and to mitigate foreseen changes.</p> <p>Monitoring the fresh-salt water interface along the Northwest peninsular coast of Florida will aid and set the basis for project implementation in areas where increases in salt-water and low freshwater flows would harm tidal ecosystems. Each of the four wells will cost approximately \$300k where each 1,000-ft. borehole will cost \$220k and the FLUTE valve tubing sampling system will cost approximately \$80k for five to seven sampling ports in a 1,000-ft. borehole.</p> <p>Cost: \$1,200,000</p>
<p>Estuarine Water Quality Assessment Project</p> <p>Lead Entity: District</p> <p>This project would expand the District's water quality monitoring program into the coastal river estuaries and near-shore coastal areas which currently have limited water quality data available. This project would identify areas in need of targeted water quality improvement projects, provide data for nutrient cycling models of the estuary, and would be used in conjunction with hydrologic and biological data to assess the health of the tidal river and coastal estuaries. Stations will be established in the near shore area at the mouth of each coastal river to capture the mixing that occurs between river water and the Gulf of Mexico.</p> <p>Cost: TBD</p>

Santa Fe River and Springs Environmental Analysis

Lead Entity: Florida Springs Institute

In May 2017, Florida Springs Institute and partners completed a Phase 1 Lower Santa Fe River and Springs Baseline Report. That document provides a detailed and up-to-date summary of existing studies and data relevant to the Santa Fe River and springs. FSI's Phase 1 report recommends initiation of a comprehensive environmental monitoring effort for the Lower Santa Fe River and springs, to start as soon as funding is available.

Phase 2 includes a comprehensive, multi-year monitoring program to fill existing data gaps, evaluate the environmental health of the entire river and springs aquatic ecosystem, and provide input to a holistic Lower Santa Fe River and springs management plan and road map for recovery. This proposed monitoring will also inform the update on FDEP Santa Fe River BMAP, and the District SWIM Plan, and update of MFLs and the Recovery Strategy for the river and springs.

Work tasks proposed for the proposed Phase 2 Lower Santa Fe River and Springs Environmental Analysis include the following:

- Task 1 – Finalization of the Data Collection Plan with Responsible Parties
- Task 2 – Data Collection (physical, chemical, and biological for three years)
- Task 3 – Reporting and Public Input (quarterly data reports, annual summary reports, and final integrative report)
- Task 4 – Interactive database

Cost: \$602,000

Developing and Adopting Integrated Pest Management Strategies to Minimize Pesticide Impacts on Water Resources

Lead Entity: UF/IFAS SVAEC

Pesticide use in the Suwannee Valley remains at a very high level, especially for certain crops with high incidence of damage from insects, diseases, weeds and nematodes. For example, carrots may require more than a dozen fungicide applications for *Alternaria* leaf blight, tomatoes have several insect and disease problems typically requiring weekly pesticide applications, and many cucurbits may require weekly fungicide applications for as many as six common diseases. Further research on a systems approach to managing pesticide applications could assist growers in reducing dependence on frequent pesticide use. This project will focus on research and extension programs to reduce pesticide impacts on the water resources in the region, and will focus on high pesticide-use crops and/or target whole farm IPM strategies for diversified farms.

One example of a successful pilot extension program is the "Living IPM Laboratory" located at SVAEC. Increased interest among farmers in Florida to adopt innovative pest management strategies, led a group of University of Florida Extension faculty and allied industry, agencies and organizations under the leadership of Regional Extension Agent, Robert Hochmuth, and Extension IPM Specialist, Dr. Norm Leppla, to initiate a new long range plan to teach hands-on IPM principles and practices. In 2010, the group secured a three-year Extension IPM grant from USDA, National Institute of Food and Agriculture to transform a 330-acre farm at the SVAEC in Live Oak, FL into a teaching field laboratory. The overall goal of this project was to create a unique, hands-on, whole farm approach to teaching IPM.

As a result of implementing the IPM Living Lab project during the period from 2009 to 2014, the overall number of insecticide applications per year on the spring vegetable crop area was reduced from 15.5 for 2009-10 to an average of 8 from 2011-14, a 51.6 percent reduction. Reduction in total insecticide costs per season was approximately 40 percent, not the full 51.6 percent due to the average higher cost for "softer" insecticide choices. Broad spectrum insecticide applications (IRAC Groups 1-3) were reduced from an average of 10.5 during 2009-10, to 2.5 during 2011-12, to 0 in 2013-14.

Cost: TBD

Advanced Agricultural Technologies for Farmers

Lead Entity: UF/IFAS Extension SVAEC

New technologies for precision agriculture are appearing on the market through various vendors every day. Many show promise in the eternal quest to micro-manage the application of water, chemicals and nutrients.

As water quality issues are changing farm management, various impaired waterways are implementing stronger regulations on the type and process for agricultural inputs. Increasingly farmers are asked to be more efficient with nutrient and irrigation applications. Breakthrough technology hopes to reduce the complexity of implementation. Next generation millennial farmers are certainly eager to understand the value technology plays in greater efficiency. The goal of all university and industry research is to make newly recommended products or methods profitable. This project component will focus on applied research and demonstration of those technologies most applicable to farms in the region.

Cost: TBD

Management and Utilization of Animal Manure Resources in Cropping Systems

Lead Entity: UF/IFAS Extension SVAEC

Livestock and poultry production has been increasing in the Suwannee River region. Animal production, pasture, and rangeland now occupy nearly 1/3 of all farmland in the region, and sales of animal products exceed \$800 million (USDA 2012 and BEA 2014). As new legislation in 2016 passed to monitor and assess water quality (Florida State Bill 552), pressure on ranchers has increased to better manage the animal manure. Although many dairies already make use of their manure for silage production on nearby land, other larger facilities do not have formal markets for their valuable by-product.

The SVAEC envisions that greater cooperation between animal-based businesses and crop producers would lead to better recycling of manure and potentially help create a new business to meet the niche for a consistent slow release fertilizer. Such products in other states carry a higher market value per pound than synthetics and have strong followings for a diversity of agricultural uses. As regulations for impaired waterways and water quality come into adoption throughout the state of Florida, future research on optimal processing and utilization of animal manures can have a larger impact on agricultural sustainability in the region and beyond.

Cost: TBD

Economics of BMPs, Alternative Crops, and Farming Systems

Lead Entity: UF/IFAS Extension SVAEC

The effectiveness of BMP programs at achieving water conservation goals depends critically on farmers' adoption decisions. As farmers evaluate different options they want information about the likely impacts on farm profitability. For example, installing a new irrigation system, transitioning to a sod-based rotation, adopting conservation tillage or organic production, planting a new crop, using soil moisture probes, or adjusting fertilization rates all have economic implications for the farm. These changes in farming practices can entail upfront costs (or forgone revenues); changes in operating and ownership costs over time; differences in machinery, labor, and skill requirements; and changes in yield, harvest timing, product quality, and risk. Economic analysis of changes in farming practices, systems, and crops would help inform decisions by farmers in the region.

Understanding the economic incentives and constraints for BMP adoption is important for guiding research and extension, and for designing cost-effective policies. For example, investments in research will be most effective if they produce economically viable alternatives or lower cost policy options. Extension agents and outreach specialists will be more effective when they understand barriers to adoption (including knowledge barriers) and can explain economic implications. Economic information also can help government agencies find ways to achieve conservation goals and sustain agricultural economies with the most efficient use of public funds.

This proposed program will integrate economic components into research and extension activities related to BMPs and alternative crops and farming systems. We will collect data on agricultural production costs and yields under alternative scenarios and assess farm-level economic feasibility of various BMPs, crops and farming systems. Methods may include partial budget analysis, cash flow analysis, investment analysis, and stochastic simulation. Results of the economic analyses will be presented in educational materials and extension programs. Ultimately, the goal of this program is to provide farmers, extension agents, and government agencies with useful information to support efforts to conserve water resources, protect water quality, and sustain agriculture in the region.

Cost: TBD

Impact of Transitioning to Organic Agriculture on Water Resources

Lead Entity: UF/IFAS Extension SVAEC

Organic production on a large scale is new to North Florida, and as a result, little or no research is available on the impact on water quality in the Suwannee Valley region. Research is needed that will determine organic nutrient management programs that will maintain high yield and quality while at the same time minimize the impact on the environment. Research needs include: evaluation of various nutrient sources, such as locally-sourced and other readily available poultry manure and other approved sources of nutrients for organic production; and to evaluate the impact of organic fertilizer practices on potential leaching losses in those practices. The goal of this project is to develop evidence-based recommendations for nutrient management in organic vegetables and other crops to support the success of North Florida producers while conserving our state's natural resources.

Cost: TBD

Implementation of BMAPs and BMPs

Cost Share Program for Implementing Best Management Practices for Agriculture

Lead Entity: District, FDACS and Counties

This project involves the development of a cost share program to implement BMPs for farming water usage. This entails education, planning and implementation of mini-projects on individual enterprises to reduce the amount of water consumed and to improve the quality of groundwater and water runoff from agricultural operations.

Cost: \$750,000

Santa Fe River Basin Management Action Plan Implementation

Lead Entity: FDEP, Counties, Municipalities, and District

The Santa Fe River and its associated springs are impaired for nutrients. In order to implement the adopted BMAP, this project proposes to improve water quality and conserve water through a cost-share program to retrofit agricultural irrigation systems and fertigation systems.

Cost: \$2,000,000

Sustainable Suwannee Pilot Program

Lead Entity: District and FDACS

This program will coordinate agricultural operations, landowners, and other entities to submit proposals of non-regulatory cost effective strategies to reduce water use and improve water quality by reducing and removing nutrient loads. Potential strategies are divided into two categories - low-input agriculture and land conservation; and advanced water quality improvement technologies.

Cost: \$6,000,000

Suwannee River and Bay Agricultural Water Quality and Conservation Initiative

Lead Entity: FDACS, NRCS, and District

The objective of this project is to reduce the discharge of sediments and pollutants from agricultural operations within the tributary streams and groundwater that drain to the Suwannee River and Bay. Both state and federal agencies have verified nutrient and excess water discharge issues within this watershed. Multiple agencies and organizations have efforts underway to begin to address these water quality and quantity issues. This initiative will strengthen efforts to help agricultural landowners reduce nutrient loadings and reduce withdrawals of groundwater that contributes flow to the Suwannee River and Bay. Efforts will target land currently managed for the production of agricultural commodities within the watershed. The cost-share program will include appropriate USDA NRCS nutrient management, irrigation management, water resource protection and water conservation practices, as well as FDACS commodity-specific BMPs.

Cost: \$8,000,000

Suwannee River Watershed Water Quality - Nutrient Reduction Project

Lead Entity: NRCS, FDACS and District

NRCS and its conservation partners would help voluntarily participating landowners by developing conservation plans that identify natural resource concerns and conservation practices the landowner can implement to reduce nutrient and sediment runoff. Through this project, landowners would receive financial assistance to apply conservation practices near the source of soil erosion and nutrient application with additional conservation practices used in riparian areas to trap nutrients and sediments that are not stopped at the source.

Cost: TBD

Continued Improvement and Implementation of Agricultural Best Management Practices

Lead Entity: FDACS and District

BMPs describe methods of managing agricultural lands and activities to reduce or prevent water pollution, and to conserve water use. BMPs are voluntarily implemented by farmers and other agricultural entities. FDACS develops, adopts and assists with the implementation of agricultural BMPs. Each fiscal year, FDACS considers proposals for BMP research funding. Proposals are reviewed with the help of a broad-based committee made up of technical experts and stakeholder representatives.

Given the dominance of agricultural land uses in the Suwannee River Basin, and the porous confining layer of the Floridan Aquifer throughout the region, maximum voluntary compliance with current BMPs, and the development of new BMPs to meet changing agricultural practices in the region, are critical to improving and managing surface waters within the District. This project involves increased funding to address the following research priorities:

- Collecting data that lead to new or enhanced agricultural BMPs; and
- Quantifying the positive effects of BMPs on water quality and water conservation.

In addition, this project includes continued education of the agricultural community with regard to the importance of BMPs, and the development of incentives to increase voluntary compliance with BMP implementation.

Cost: TBD

Wastewater and Stormwater Infrastructure

Wastewater Septic to Sewer Conversions in the Big Bend

Lead Entity: Counties, Municipalities, FDEP, and District

Wastewater has been identified as a significant source of pollution from domestic and industrial sources to groundwater and surface waters. The benefit of these projects is to reduce untreated or poorly treated wastewater effluent discharged to groundwater and surface waters, thus reducing pollutant loads. Efforts to reduce wastewater pollution may include the elimination of small wastewater package plants and septic tanks that have low levels of treatment and redirect the wastewater to larger regional plants with higher treatment levels. Eliminating septic tanks and package plants can be accomplished by installing service connections to existing sanitary sewer collection systems which directly connect to regional WWTP.

Costs vary greatly depending on the existence of a collection system and the capacity of the WWTP. If the plant can handle the additional wastewater and the collection system is close by, the scope simply involves pumping out the wastewater, crushing the septic tank, and adding a sanitary sewer service connection line. If grinder pumps are needed project costs will increase.

The District will continue to work with local partners to develop wastewater infrastructure upgrades and septic to sewer conversion projects in communities with high septic tank densities. Projects should focus on those areas determined to have failing septic tanks and associated drainfields, and documented pollution impacts to nearby surface waters and groundwater. Project costs will be determined as individual projects are identified.

Cost: TBD

Pilgrim's Pride Wastewater Reuse Feasibility Assessment

Lead Entity: District

This project is located in eastern Suwannee County and is to investigate, and potentially implement, the reuse of the wastewater stream from the Pilgrim's Pride poultry processing facility along U.S. Highway 90 near Falmouth Spring. Reuse of the wastewater eliminate a permitted discharge into the Suwannee River and provide an alternate source to a potential user(s) to the Floridan Aquifer, thereby helping maintain base flows to nearby springs as well as to the Suwannee River. The project is to assess reuse potential within at least a 5-mile radius from the facility, and includes local agricultural irrigation, dairy pasture irrigation, and a sawmill as possible end users.

Cost: TBD

4.2.3 Natural systems

Table 13. Proposed Natural Systems Projects

Monitoring, Data Collection and Research
<p>Airborne LiDAR Bathymetry for Oyster Reefs</p> <p>Lead Entity: District</p> <p>Conduct airborne LiDAR bathymetry (ALB) data acquisition and processing to support the District's oyster reef/bed mapping and restoration activities. The bathymetric LiDAR sensor is designed to discriminate water depths and land elevations in the coastal zone. The shallow water bathymetry will provide the District with an accurate dataset of the oyster bed and substrate up to ~ 1.5 times Secchi depth, and also including sections of oyster reefs that are exposed at low tide. The ALB data can be used for a variety of purposes such as oyster reef restoration, mitigation, and cultch placement projects to enhance and improve oyster populations.</p> <p>Cost: \$100,000 per 30 linear kilometers of existing or relict (needing restoration) oyster reef.</p>
Habitat Conservation
<p>Deer Island Acquisition in Lower Suwannee Sound</p> <p>Lead Entity: USFWS, FDEP and District</p> <p>This project is a full-fee acquisition of Deer Island, the northernmost barrier island in the Cedar Key Archipelago. Acquiring and permanently protecting Deer Island will benefit "injured" and at-risk species while also enhancing recreational opportunities within the Big Bend region. It is approximately 80 acres in size (1,300 m long from north to south and is 250 m across at its widest point) and the highest elevation is 14 feet above sea level. Thirty-five acres are considered uplands. The northern tip of the island is already owned by the federal government and is part of the Lower Suwannee NWR. The remainder is a private inholding within the Refuge and the Big Bend Seagrass Aquatic Preserve. The western edge of the island is fringed by a 0.8-mile-long beach that extends above the high tide line. Beach habitat is rare and ecologically important in this part of the Big Bend region. East of the island are extensive salt marshes and mudflats crisscrossed with oyster shoals and shallow channels.</p> <p>Permanent protection of Deer Island will help maintain the natural ecological functions of a barrier island and contribute to the ecological integrity of the Suwannee estuary. It will also be protective of living resources by allowing for the enforcement of federal laws that are protective of wildlife and water quality, and by the implementation of management actions to benefit injured species and other resources of conservation concern.</p> <p>Deer Island and the surrounding salt marshes and seagrass beds provide habitat for numerous species including many that were injured as a result of the <i>Deepwater Horizon</i> oil spill. Some injured bird species documented foraging or loafing on the island include the brown pelican, American oystercatcher, wilsons plover, piping plover, black skimmer, least tern, Caspian tern, reddish egret, roseate spoonbill, little blue heron, snowy egret, tricolored heron and white ibis. the adjacent seagrass beds provide habitat for several federally-listed species including green, loggerhead and kemp's ridley sea turtles, gulf sturgeon, and West Indian manatee.</p> <p>On the west side of the island is one of the few beaches along the Big Bend to have beach habitat that extends above the high tide line. Consequently, horseshoe crabs nest on the beach and Rufa Red Knots have been observed feeding along the west side and northern tip of the island. The beach also provides habitat for the Cedar Key mole skink, a species petitioned for listing that has only been found on the Cedar Keys, and Ornate diamondback terrapins. This subspecies of diamondback terrapin is endemic to the west coast of Florida and it has been documented to nest on Deer Island. The State has ranked the diamondback terrapin as one of the species of greatest conservation need.</p> <p>Cost: \$1,647,500</p>

Lower Suwannee River and Gulf Watershed Conservation Easement

Lead Entity: The Conservation Fund

This 46,500-acre project is a rare opportunity to protect an expansive tract of land in a critical location. Building on the success of the adjacent 32,000-acre California Lake Conservation Easement, this proposed project is directly adjacent to both the Lower Suwannee NWR and the Big Bend Wildlife Management Area and will vastly expand the protected area along Florida's pristine "Big Bend." This project is a high priority for the State of Florida, USFWS, and Dixie County.

The project will buffer and protect a vast area of conservation lands, creating a contiguous protected area of 196,000 acres. The project will protect habitat for an abundance of wildlife, including Gulf sturgeon, gopher tortoise, eastern indigo snake, Florida black bear, and a host of migratory and resident bird species, including a large population of nesting swallow-tailed kites.

The project consists of a 72 square-mile area that drains into the Suwannee River and the Gulf of Mexico. Freshwater inputs are critical to the health of estuaries, and a large portion of the freshwater entering the Suwannee River's estuary comes from the project site. The site will also protect water quality/quantity within the ±980,000-acre Big Bend Seagrasses Aquatic Preserve, located just offshore, which includes habitat for several species of sea turtles, West Indian manatees, bottlenose dolphins, one of the state's largest populations of wintering American oystercatchers, and numerous other bird and fish species.

Cost: The State of Florida acquired ±8,100-acre easement in 2016; thereby, reducing the unpurchased project acreage to approximately 38,400 acres. The estimated cost to acquire the remaining conservation easement is ±\$24 million (subject to appraisal).

Lyme Gilchrist Forest

Lead Entity: The Conservation Fund

This project is a 14,400-plus-acre conservation easement in Gilchrist County. Gilchrist Forest is near both the Santa Fe and Suwannee rivers (and within both sub-watersheds), and is located within a larger area known as the Waccasassa Flats. The property includes mostly forested uplands and flatwoods. About half of the property is classified by FNAI as functional wetlands, and nearly all is considered natural floodplain. In addition, the entire site is located within an aquifer recharge area and thus will protect the region's springs. The site would continue to be owned and managed by private landowners, most likely for timber production, negating the need for ongoing public management funds.

Cost: \$9,125,000

Lyme Gilman Forest

Lead Entity: The Conservation Fund

The proposed 22,000-acre +/- Gilman Forest Conservation Easement is an opportunity to protect a vast tract of land in Florida's "woodbasket" region – at a very low per-acre cost (less than \$480/acre). Most of the project is located within the San Pedro Bay FF project boundary, and is located near the privately-held San Pedro Bay mitigation bank. FF refers to San Pedro Bay as the largest area of privately owned roadless land remaining in Florida. Much of the property is considered an important functional wetland, and is of interest to the District for potential water resource development projects that will benefit this portion of the Gulf region. Located in the Suwannee, Econfina, and Fenholloway river watersheds, this project will protect water quantity and quality in these rivers and receiving estuaries on the Gulf of Mexico.

Cost: \$10,520,000

Lyme Lafayette Forest

Lead Entity: The Conservation Fund

The proposed 6,724-acre +/- Lafayette Forest Conservation Easement is an exciting opportunity to protect a large tract of land in Florida's "woodbasket" region. Most of the project is located within the Lafayette Forest FF project boundary, and is located adjacent to the District's Mallory Swamp Restoration Area. Conservation of the property will help to connect approximately 50,000 acres of existing conserved land. The landscape consists of basin swamps, wet prairies, and floodplain swamps; interspersed between pine silvicultural plantations established on disturbed mesic and hydric flatwoods and sandhill communities. Roughly half of the Lafayette Forest property is classified by FNAI as high or medium priority functional wetlands, and two-thirds is considered high or medium priority natural floodplain. Located in the Suwannee River watershed, this project will protect water quantity and quality in the river and receiving estuaries on the Gulf of Mexico.

Cost: \$4,575,000

FDEP/District Land Acquisition for Habitat Conservation

Lead Entity: FDEP and District

The land acquisition projects listed below are proposed as FF projects led by the FDEP and/or District. FF funding in recent years has been limited; however, supplementation with GEBF funds could make these projects more feasible in the short term. Additional projects may be identified in updates to the District FF Work Plan.

Gulf Hammock Acquisition

FF proposed acquisition in Levy County. This project is a 3,652 acre proposed acquisition for public recreation and watershed protection. It would add to the 23,248 acres in the project area currently managed in cooperation with the FWC as a WMA.

https://www.dep.state.fl.us/lands/FFAnnual/Gulf_Hammock.pdf

Cost: TBD

Caber Coastal Connector Acquisition

FF proposed acquisition in Levy County. This project includes a portion of a total 3,674-acre planned acquisition northeast of Cedar Key to preserve watershed swamps, hammocks, and marshes.

https://www.dep.state.fl.us/lands/FFAnnual/Caber_Coastal_Connector.pdf

Cost: TBD

Suwannee River Basin Land Acquisition

Lead Entity: District and FDEP

The Suwannee River Basin Land Acquisition project is a watershed approach to land acquisition to improve water quality and enhance public recreational opportunities. The project includes three individual acquisition proposals that are surrounded by and connect other parcels in public ownership.

Cost: \$4,680,000

Habitat Restoration

Big Bend Oyster Reef Restoration Project(s)

Lead Entity: FWC, Counties, UF, District

This project(s) would restore and enhance oyster reefs which provide ecological benefit to the Big Bend estuarine habitat, including habitat for fish and wildlife species. Reef structures formed by oysters are complex and provide refuge for hundreds of other species, including the juvenile stages of several fishes. Recent studies show oyster bar declines are due primarily to reduced survival and recruitment, likely a result of reduced freshwater inputs that increase reef vulnerability to wave action and sea level rise. This is still a conceptual project and may include the planning and design of multiple reef restorations in the Big Bend. The project will evaluate appropriate techniques, such as that used in the Recovery and Resilience of Oyster Reefs in the Big Bend of Florida GEBF funded project, to increase the sustainability of reefs. Further monitoring to evaluate success.

Cost: TBD

FDEP's Florida Park Service Project Proposals for State Parks

Lead Entity: Florida Park Service

Below are the Florida Park Services potential project ideas for restoration and resource management within the facilities in the District:

Big Shoals SP

- Suwannee River portage area shoreline erosion: stabilize natural contours with minimal hardening at 1-2 locations of major erosion and sedimentation

Cost: TBD

Devils Millhopper Geological SP

- Deer Run neighborhood/Alachua County retention pond retrofit because of major erosion and sedimentation into Millhopper sinkhole.

Proposed project to retrofit the stormwater retention system located on NW 52nd Terrace in the Deer Run residential community, Gainesville Florida. The existing retention system was installed in the early late 1970's. Since the installation of this system, stormwater events often exceed the storage capacity of the pond and excess water overflows into a historically natural creek (topographically referred to as Deer Run) that is directly connected to the Devils Millhopper Sink. Heavy stream bank erosion occurs, and upstream sedimentation and contaminants regularly wash into the sink. Proposal is to enlarge portions of the existing retention system as well as upstream drainage way to increase the storage capacity of stormwater runoff.

Cost: TBD

Fanning Springs SP

- Restore and maintain SAV in spring run of Fanning and Little Fanning Springs.

Cost: TBD

Ichetucknee Springs SP

- Comprehensive SAV mapping every five years following the Southwest Florida Water Management District model for the Rainbow River (Marion County) SAV monitoring.

This project involves mapping, monitoring, and evaluating submerged aquatic vegetation (SAV) and macroalgae in the Ichetucknee River and to conduct a change analyses between mapping years. The SAV/Macroalgae change analysis project should be conducted every five years to detect changes in the spring ecosystem and to act as an indicator for overall ecological health of this natural system. Collection of this information is also important to evaluate recreation management within Ichetucknee River. Understanding changes in SAV/macroalgae abundance and diversity will greatly enhance the effectiveness of management strategies.

Cost: \$100,000 every five years

- Wastewater treatment retrofit Dampier's Landing Bath house: Relocate septic currently in highly karstic area of upland hardwood forest by tying into and expanding an existing wastewater treatment connection.

Proposed project to retrofit the Dampier's Landing Bath house and septic system. The bath house and septic system will be removed entirely and consolidated with the upslope concession area. The existing septic system for the concession will need to be retrofitted and upgraded to advanced treatment.

Cost: TBD

Manatee Springs SP

- Restore and maintain SAV in spring run
- Spring run natural shoreline restoration: Remove hardened shoreline features and reconfigure recreational access points
- Wastewater treatment retrofit: Advanced wastewater septic connection within the park.

The proposed project would be to retrofit several additional conventional septic systems to advanced wastewater treatment.

Cost: TBD

O'Leno SP

- Wastewater treatment retrofit: Advanced wastewater septic connection within the park.

O'Leno has at least 12-15 conventional septic systems that are located within a small area adjacent to the Santa Fe River and upstream from the river sink. The Santa Fe at O'Leno is an OFW and falls within a significant Basin Management Action Planning area. As a cautionary note, the entire foot print of the proposed septic treatment area is in a significant archaeological zone.

The proposed project would be to consolidate existing septic systems collectively into a fewer number and retrofit into advanced wastewater treatment.

Cost: TBD

Stephen Foster Folk Cultural Center SP

- Seepage stream restoration: Removal of remnant concrete dam that impedes seepage stream flow
- Suwannee River shoreline restoration: stabilize natural contours with minimal hardening at 2-3 locations of major erosion and sedimentation
- Suwannee River stormwater runoff retrofit at the area between White Sulphur Spring Springhouse and the south entrance ranger station.

Retrofit the stormwater retention system to alleviate extreme shoreline erosion, prevent runoff and sedimentation from entering the Suwannee River/White Sulphur Spring and to prevent water quality degradation of these two OFW.

Additionally, much of the project area is underlain by numerous old large drainage pipes that may need further assessment to determine if there are unwanted subsurface connections.

Cost: TBD

Troy Spring SP

- Spring run shoreline restoration: Spring run erosion and sedimentation on east and west shoreline; stabilize natural contours with minimal hardening

Cost: TBD

Wes Skiles Peacock Springs SP

- Main access road stabilization: multiple phased project to stabilize a fragile unpaved access road above extensive aquatic cave system that leads to springs; use natural contours with minimal hardening at several erosion and sedimentation locations.

Stabilize park drive; erosion control/stabilization to prevent runoff from entering the springs and prevent further sediment buildup. Several areas along park drive from the park entrance to the Peacock I-III parking area need erosion and stabilization control to alleviate direct runoff into Orange Grove Sink, and Peacock Springs to prevent water quality issues and sediment buildup in these important natural features. Park drive is an unimproved road through the park, which will remain unpaved due to the fragile nature of the honeycomb limestone cave system beneath the park surface.

In April 2008, FDEP Springs Initiative funded Phase I of this project. Road stabilization from park entrance to Peacock Springs Parking area was initiated. Geotechnical analysis of the site was added during the phase I project to understand hauling truck weight limits on the potentially fragile road system due to underground caves. Phase I was 80% complete. Materials ran out. A request for Phase II was initiated at the end of the 2008 fiscal year.

Cost: \$30,000

Recreation Management

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