COMPREHENSIVE EVERGLADES RESTORATION PLAN

LOXAHATCHEE RIVER WATERSHED RESTORATION PROJECT

DRAFT INTEGRATED PROJECT IMPLEMENTATION REPORT AND ENVIRONMENTAL IMPACT STATEMENT

March 2019

Appendix A

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APPENDIX A

ENGINEERING

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A. ENGINEERING DESIGN APPENDIX

The Engineering Appendix of the Draft Project Implementation Report (DPIR) provides a comprehensive record of the technical support provided by the U.S. Army Corps of Engineers (USACE) Jacksonville District Engineering Division and South Florida Water Management District (SFWMD) to the Loxahatchee River Watershed Restoration Project (LRWRP) with technical information and analyses provided by the following engineering disciplines: Civil, Geotechnical, Hydrology and Hydraulic, Structural, Mechanical, and Electrical. The specific component features and engineering requirements, focusing primarily on the hydrology and hydraulic designs, are presented in this appendix.

A.1 Project Objectives

The alternatives presented herein are evaluated based on their contribution to each of the five objectives using project specific performance measures. Performance measures (PM) are used to evaluate the hydrologic model output and ecosystem functions so that the restoration performance of each alternative can be quantified and compared to the 2070 Future Without Project base case condition. The ability for these objectives to be reached with the implementation of the Tentatively Selected Plan (TSP) is analyzed using evaluation criteria (EC), which is a process to evaluate project effects and to establish a standard level of acceptance identified by law or stakeholders. The project objectives, as well as the associated evaluation and measurements using the PM's and EC's, are explained in greater detail within the main body of the PIR. An abbreviation of the project objectives and performance measures are provided below, as the evaluation of these criteria are dependent on the hydrologic model output.

Performance Objectives:

1. Restore the wet and dry season flows to the Northwest Fork of the Loxahatchee River floodplain.
2. Restore and/or maintain oysters, sea grass and other estuarine communities in the Loxahatchee River Estuary.
3. Increase natural area extent of wetlands.
4. Restore connections between natural areas to improve the hydrology, sheet flow, hydroperiods, natural storage, and vegetation communities.
5. Restore native plant and animal species abundance and diversity in Loxahatchee River watershed natural areas, river, and estuary.

Performance Measures:

1. Salinity and Flow, Performance Measure 1
    a. In the dry season (December–May): supplemental flows are suggested to maintain a mean monthly flow of 68 to 90 cubic feet per second (cfs) at Lainhart Dam.
    b. In the wet season (June–November): mean daily flows of 115 cfs with a range of 110 to 130 cfs at Lainhart Dam. Mean monthly flow of 110 cfs for 120 days would result in the appropriate levels of wet season riverine floodplain stages.
2. Watershed Hydrology, Performance Measure 4

a. This performance measure is used to evaluate benefits to the watershed as measured by the Wetland Rapid Assessment Procedure, which helps measure the achievement of the appropriate depth, duration and frequency targets in the Loxahatchee watershed wetlands. General hydrologic requirements are defined for each of the major plant communities identified within the indicator regions.

3. Connectivity, Performance Measure 9

   a. Performance measure qualitatively measures criteria for evaluating connectivity between watershed areas. Connectivity is measured by four criterion:

      i. Connection provides historic hydrologic linkage which contributes to the restoration of downstream areas and improved quantity, timing and distribution of water

      ii. Connections cover majority area (>50%) of an existing or proposed greenbelt

      iii. Connectivity promotes water quality improvements and protects water quality by allowing for only sheet flow across natural lands and natural flow ways.

      iv. Connectivity contributes to expanded native habitats and the support of wildlife populations

A.2 Project Area

The LRWRP study area is approximately 480,000 acres (753 square miles) and is located in northern Palm Beach County and southern Martin County. The study area is bounded on the north by the C-44 Canal, on the south by the C-51 Canal, on the west by the L-10/L-12 Canals and Lake Okeechobee, and on the east by the Loxahatchee River Estuary and Lake Worth Lagoon. The Loxahatchee River discharges ultimately into the Atlantic Ocean near the town of Jupiter, Florida. The Northwest Fork of the Loxahatchee River, one of Florida's two federally designated National Wild and Scenic Rivers, is a natural river channel that originates in the Loxahatchee and Hungryland Sloughs. Downstream from these sloughs, the Northwest Fork receives additional input from the other major tributaries of the Loxahatchee River: Cypress Creek/Ranch Colony Canal, Hobe Grove Ditch, and Kitching Creek. The purpose of LRWRP is to restore and sustain the overall quantity, quality, timing, and distribution of freshwaters to the federally designated "National Wild and Scenic" Northwest Fork of the Loxahatchee River for current and future generations. This project also seeks to restore, sustain, and reconnect the area's wetlands and watersheds that form the historic headwaters for the river. Current features within the LRWRP area, such as canals or tributaries as well as structures of regional importance, are shown in Figure 1.

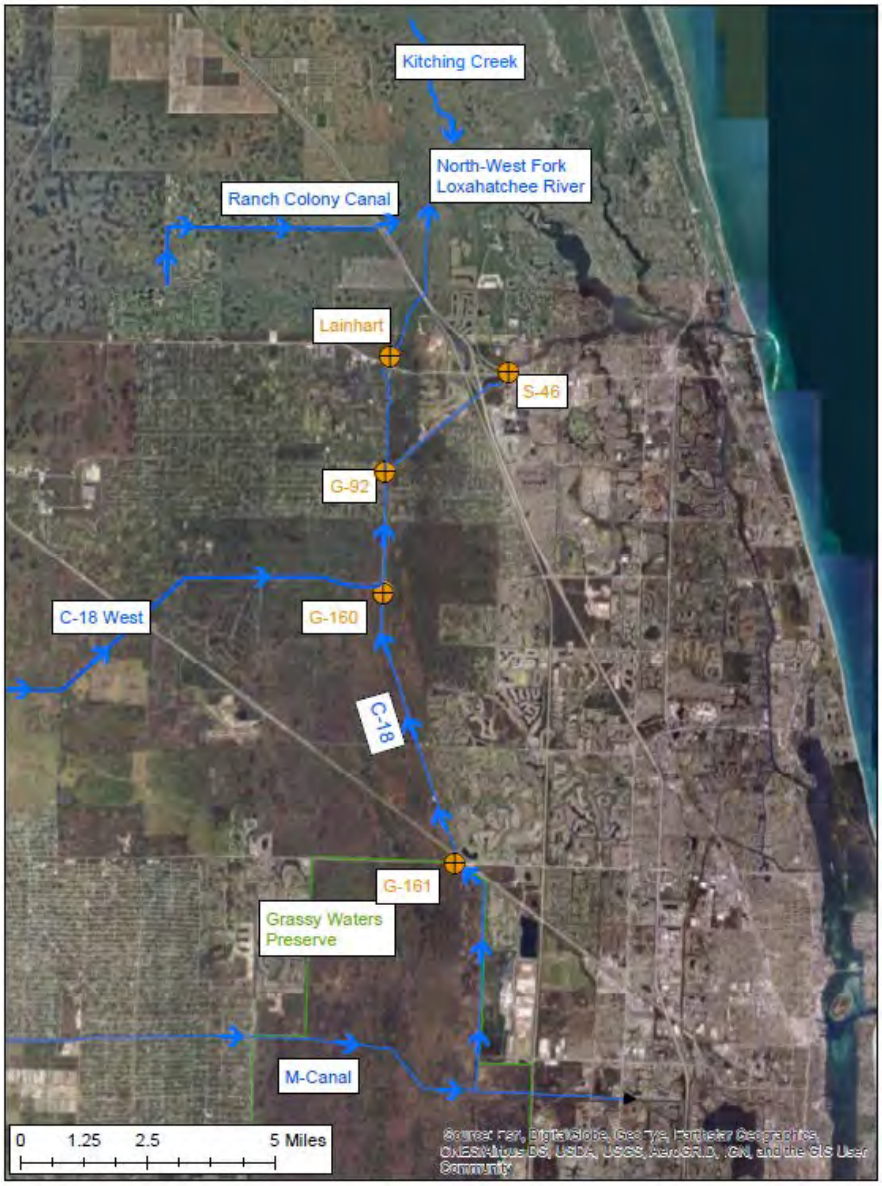


Figure 1. Canals and Structures of Regional Importance in the LRWRP area.

B. DESIGN FEATURES OF THE TENTATIVELY SELECTED PLAN

Included in this section are the general assumptions, guidance parameters, and primary references used in the conceptual design of storage, conveyance, and hydraulic control features specified in the TSP. Table 1 highlights the key features proposed in the TSP and the final array of project alternatives. The subsequent sections define each proposed feature of the selected plan for each flow-way followed by a description of non-TSP features. The Project Delivery Team (PDT) agreed that the preliminary design of features may be optimized during the preconstruction engineering and design phase (PED) at the discretion of the team.

Table 1. Design features proposed for the TSP and final array of alternatives.

Project Feature	Feature Type	TSP	Alt 2	Alt 10	Alt 13
Flow-way 1 - G-160	Conveyance	Yes	Yes	Yes	Yes
Flow-way 1 - G-161	Conveyance	Yes	Yes	Yes	Yes
Flow-way 1 - Grassy Waters Preserve Triangle	Conveyance/Storage	Yes	Yes	Yes	Yes
Flow-way 1 - M-1 Lower Pump Station	Pump Station	Yes	--	--	--
Flow-way 1 - C-51 Phase II Reservoir	Storage	--	--	44 kac-ft[1]	--
Flow-way 1 - Force Main	Conveyance	--	--	Yes	--
Flow-way 2 - C-18W Reservoir	Storage	9.5 kac-ft	7.2 kac-ft	7.2 kac-ft	--
Flow-way 2 - Aquifer Storage & Recovery (ASR)	Storage	4 wells	2 wells	--	4 wells
Flow-way 2 - M-O Canal Connector	Conveyance/Pump	Yes	Yes	Yes	Yes
Flow-way 2 - C-18WCanal Weir Modification	Conveyance	--	--	--	Yes
Flow-way 2 - L-8 Shallow	Storage	--	4.3 kac-ft	--	6.5 kac-ft
Flow-way 2 - C-18W Natural Storage	Storage	--	--	--	Yes
Flow-way 3 - Pal-Mar East	Conveyance/Storage	Yes	Yes	--	Yes
Flow-way 3 - Thomas Pepper Farm	Conveyance	Yes	Yes	--	Yes
Flow-way 3 - Ranch Colony Canal	Conveyance/Storage	Yes	Yes	Yes	Yes
Flow-way 3 - Gulfstream West	Conveyance/Storage	Yes	Yes	--	Yes
Flow-way 3 - Gulfstream East and Moonshine	Conveyance/Storage	Yes	Yes	Yes	Yes
Flow-way 3 - Kitching Creek	Conveyance/Storage	Yes	Yes	Yes	Yes

Mack Dairy Spreader Swale	Conveyance	Yes	--	--	Yes

[1]kac-ft represents 1000 acre-feet

It is important to note that the Comprehensive Everglades Restoration Plan (CERP) included the G-160 and G-161 components with the purpose of providing flows and enhancing hydroperiods in the Loxahatchee Slough, and to increase base flows to the Northwest Fork of the Loxahatchee River. The SFWMD recognized that G-160 and G-161 water control structures, features of the CERP Plan, were necessary to provide connectivity between the river and its historic headwaters and essential to deliver necessary dry season restorative flows to the Northwest Fork of the Loxahatchee River. Therefore, in parallel with the USACE CERP planning process, the SFWMD moved ahead with the design and construction of G-160 - the Loxahatchee Slough Structure and G-161 - the Northlake Boulevard Structure to provide early and necessary benefits at lower costs to the Loxahatchee Slough and the Loxahatchee River, while allowing for delivery of additional water from and maintaining a more rainfall driven hydroperiod within the Grassy Waters Preserve (GWP). G-160 was constructed in 2004 and G-161 was constructed in 2007. The 2005 Feasibility Scoping Meeting Guidance Memorandum for the North Palm Beach County Part 1 study (predecessor study to LRWRP) approved their inclusion as measures for further evaluation in the with-project conditions. The Jacksonville District and SFWMD requested that G-160 and G-161 be included as measures for evaluation in the with-project conditions and that the study alternatives include the environmental lift/benefit associated with the features. If the measures are part of the Tentatively Selected Plan and comply with USACE construction standards, then Jacksonville District and SFWMD requested the ability to provide/receive cost share credit. Therefore, although the features have already been constructed, both features will be considered as if they have yet to be constructed throughout the remainder of this document.

B.1 Flow-way 1

Flow-way 1 is located in the southernmost portion of the project area, bounded by L-8 Canal and M-Canal in the south and the G-92 spillway in the north. This flow-way uses the M-Canal and C-18 Canal to route water from upstream project area basins to the Loxahatchee River. All proposed Flow-way 1 features, including the M-1 pump station, M-Canal, Grassy Waters Preserve (GWP), G-161 culverts, GWP Triangle, the C-18 Canal, and G-160 spillway, are shown in Figure 2. Only the M-1 pump station, GWP Triangle, G-161, and G-160 required a design analysis for the TSP.

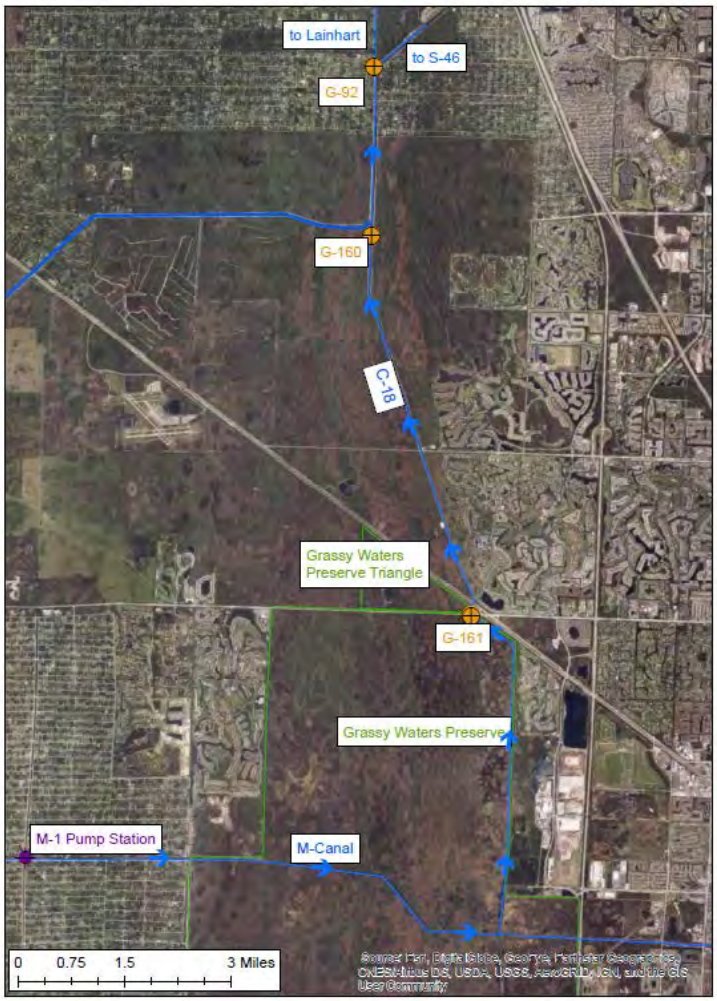


Figure 2. Location Map of Major Features in Flow-way 1.

B.1.1 G-160

The proposed G-160 structure is a reinforced concrete spillway designed to enhance delivery of the restoration flows to the Northwest Fork of the Loxahatchee River while maintaining water elevations within the Loxahatchee Slough and conserving optimum upstream water control stages in Canal-18 (C-18). Construction of the G-160 structure should achieve the following: (1) preserve sensitive wetlands in the Loxahatchee slough, (2) maintain the existing level of service of flood protection, and (3) provide water to the Northwest Fork of the Loxahatchee River. G-160 will increase stages in the Loxahatchee Slough, improving hydroperiods that have been adversely impacted by the construction and historic operations of the C&SF Project, specifically the C-18 Canal and Structure 46 (S-46). With increased stages in the slough, G-160 can deliver additional flow to the Loxahatchee River as needed. Discharges from G-160 are controlled by two stem -operated vertical lift gates. The design discharge rate, to maintain flood control capability, will be approximately 2000 cfs via two spillway bays, each 25 ft in length. The structure is operable to allow for the dual purposes of flood risk management and environmental restoration. The operable gates allow for management of upstream stages to mimic natural slough recession and ascension in water depth between the wet and dry seasons.

B.1.2 G-161

The G-161 structure will act as the gateway through which water will be transported from Grassy Waters Preserve (GWP) through the system to the Northwest Fork of the Loxahatchee River. The G-161 structure is a multi-purpose feature that will facilitate hydroperiod restoration of GWP, maintain existing level of service of flood protection, and provide improved conveyance for the regional water system. The water transfer from the G-161 structure will occur just west of the intersection of the Beeline Highway and Northlake Boulevard. Water will flow from GWP into the northern GWP Triangle area, north of Northlake Boulevard. A conveyance channel will carry the flow through the GWP Triangle between the G-161 structure and an existing culvert beneath the Beeline highway that connects GWP to the C-18 Canal. The conveyance channel also transverses under an existing railroad bridge. Flow will then pass through G-160 to G-92 structures and on to the Northwest Fork. The design allows for variable flow rates between 0 and 150 cfs, adjustable as needed for conservation or flood risk management purposes. The structure will consist of two 60-in diameter culvert barrels with a total length of 240 ft. The barrels will be controlled by slide gates and have a flow line elevation of 11.1 ft NGVD29 (9.6 ft NAVD88).

B.1.3 Grassy Waters Preserve Triangle

The GWP Triangle is located northwest of the intersection of Beeline highway (SR-710) and Northlake Boulevard. Since the construction of Northlake Boulevard, this portion of GWP has experienced hydrologic separation from the rest of the GWP area. Hydrologic restoration of this area will be accomplished through earth work and strategic construction of a swale. This swale was not modeled in LECSR-NP model due to model limitations with modifying the topographic data in the 700 by 700 ft grid cell, which may have caused an over inundation of the area. The swale will allow water discharged from G-161 to be spread west to help improve the hydroperiod in the area.

B.1.4 M-1 Lower Pump Station

A pump station will deliver up to 75 cfs to the M-canal from Indian Trails Improvement District (ITID) lower M-1 Basin when canal stage conditions allow. Operations of the M-1 Basin allow for water to be pumped to the M-Canal when stages are above 17.0 ft NGVD29 (15.5 NAVD88) in the dry season and 15.0 ft NGVD29 (13.5 NAVD88) in the wet season. The inflow pumping location within the M-Canal will be either at or downstream of the area within the M-Canal that has been widened.

B.2 Flow-way 2

Flow-way 2 is located in the central portion of the project area. Its primary canal conveyances are the M-O Canal and C-18W Canal. The watersheds that contribute to these canals include the ITID basin via the M-O Canal, J.W. Corbett Wildlife Management Area (WMA), Hungryland Slough, “Mecca” property (area of proposed C-18W Reservoir), and natural area east of the North Palm Beach County Airport via the C-18W Canal. Note existing structures of regional importance: G-92, S-46, Lainhart Dam, and Masten Dam. Figure 3 shows the proposed features of the TSP in Flow-way 2 and contributing watersheds.

Figure 3. Location of Project Features for Flow-way 2.

B.2.1 C-18W Reservoir

The only reservoir proposed in the TSP is the C-18W Reservoir. The proposed reservoir is a 9,500 ac-ft above-ground volume that will provide pumped diversion and storage of excess flows from the adjacent C-18W Canal, J.W. Corbett WMA, and from ITID upper basin via the M-O Canal. The reservoir will release water back to the C-18W Canal as needed and available during low-flow periods, for delivery to Lainhart Dam and the Loxahatchee River downstream. The purposes of the reservoir are (1) capture excess flows from J.W. Corbett WMA, ITID and the C-18W basin and, 2) deliver water to meet the target restoration flows for the National Wild and Scenic Northwest Fork of the Loxahatchee River (NWFLR), and 3) change the timing of flow distribution and reduce waste to tide. The C-18W Reservoir site is approximately 1,920 acres of former citrus grove, located on the east side of Seminole-Pratt Whitney Road approximately 0.5 mile north of Northlake Boulevard in northern Palm Beach County, Florida. It is bounded to the north by

the C-18W Canal and the Hungryland Slough Natural Area, to the south by the Indian Trail Improvement District, to the east by the future Avenir development, and to the west by the J.W. Corbett WMA.

The main inflow/discharge canal for the C-18W Reservoir is located between the C-18W Canal and the northern Mecca embankment. The inflow pump station has a 300 cfs capacity and is located within the reservoir, south of the intersection of the northern embankment and the inflow canal. The pump can bring available water into the reservoir from the C-18W Canal. The sources of water that discharge to the C-18W Canal include the Hungryland Slough and several existing culvert connections to undeveloped lands south of the C-18W Canal and west of the North Palm Beach County Regional Airport.

As stated previously, there are multiple inflow sources for the reservoir. The J.W. Corbett WMA currently discharges to the proposed C-18W Reservoir footprint via a sheet-pile weir. Multiple hydrologic changes immediately down gradient of the existing weir following the construction of the proposed LRWRP improvements are likely (*i.e.* C-18W Reservoir inlet, pump station, berms, Seminole Pratt Whitney Road access, and M-O connector). The existing weir structure is to be replaced by an operable structure that will help control discharges to the reservoir while simultaneously providing improved ecological conditions due to the operational flexibility during the wet and dry seasons. An operable structure will reduce the potential for flooding both upstream and downstream of the weir. Within the J.W. Corbett WMA, elevated stages may cause an increase in the loading frequency and duration of the berm separating the J.W. Corbett WMA from the M-O Canal (at ITID).

Uncontrolled discharge downstream of the structure into the canal network surrounding the C-18W Reservoir is also of concern. An operable structure will allow managers to better control and mitigate any flood impacts by providing the project with flexibility in timing and distribution of water from both ITID and the J.W. Corbett WMA. Retaining the ability to optimize the weir elevation following the construction of all project features provides considerable flexibility for ongoing management in the area. The proposed operable structure will be two 36-in gated culvert structures located near or at the existing sheet-pile weir was constructed. The gates will be telemetry operated and may require redundancy for flood control purposes. Minor berm improvements along the southern margin of the J.W. Corbett WMA will be required to help store water. The berm improvements shall, at a minimum, maintain a minimum berm elevation of 26.7'NAVD88 and top width of 14 feet. A multi-barrel culvert road crossing will be sized to carry the overflow discharge from the new J.W. Corbett WMA structure (and M-O connector water, explained in detail in section 2.2.3) under Seminole-Pratt Whitney Road to the new seepage canal for the impoundment. The water will be pumped from the seepage canal into the reservoir up to 250 cfs and will be located along the western perimeter of the C-18W Reservoir. This pump station is sized to pump seepage from the reservoir and inflow from J.W. Corbett WMA and M-O Canal Connector into the reservoir.

Multiple general design requirements for the C-18W Reservoir were considered in the Detailed Design Report (DDR; Arcadis, 2016). This included outflow structures, seepage management, and overall reservoir design. The general design of these features was important for two reasons: 1) to ensure that the reservoir was properly conceptualized and operated in the Lower East Coast sub-Regional (LECsR) model for alternative screenings; and 2) provide sufficient guidance to estimate the rough order of magnitude cost of features in the reservoir. Because the reservoir is above ground and the proposed location is directly north of a residential community, the C-18W Reservoir was classified as a “high” hazard impoundment due to the potential loss of life, loss of lifeline, and loss of property being significant if a breach were to occur (Arcadis, 2016). This imposes a stricter and more robust set of design criteria, as outlined in the Design Criteria Memorandum 2: DCM-2 (SFWMD, 2006), for the reservoir. Therefore the

highest, most current standards in design and construction were used for the reservoir as well as additional guidelines regarding a regular inspection program and emergency action plan will be followed once constructed.

There will be two main outflow structures at the reservoir: 1) a gated culvert discharge structure for normal operations; and 2) an emergency overflow spillway. The gated culvert structure will be located along the northern embankment of the reservoir, closely situated to the inflow pump station. The design is for a dual 48-in diameter culvert that can discharge 300+ cfs, depending on the stages within the reservoir. The proposed overflow spillway design is a 50 ft wide concrete spillway crest at an elevation lower than the embankment design elevation. It will be located adjacent to the culvert discharge structure and discharge into the C-18W Canal. The overflow spillway is designed to convey excess flood water to the C-18W Canal and away from the residential areas on the south side of the impoundment. The proposed overflow spillway crest elevation is set to provide 1 foot of freeboard above the normal pool elevation (27.5 feet NAVD88).

The seepage management system design will vary depending on location. Adjacent to the residential community to the south, Avenir property to the east, and a proposed shooting range to the north-west, a seepage cut-off wall will be installed. Total length will be approximately 2.5 miles for all segments. The seepage cut-off wall will consist of approximately 30-ft deep by 18-in wide soil-bentonite slurry mix. A seepage barrier conducted along the L-31 Canal, adjacent to Everglades National Park, serves as the basis of design during the feasibility phase (Amec Foster Wheeler Environment & Infrastructure, 2016). Other areas adjacent to the reservoir will maintain seepage through the use of seepage collection canals. The seepage canal collection system on the western perimeter of the reservoir will be managed by the 250 cfs pump station mentioned in previous paragraphs. These seepage collection canals were initially designed with 3 horizontal to 1 vertical (3H:1V) side slopes, with a depth and bottom width of 10 ft. The seepage management system needs to be evaluated for the anticipated head differences between the reservoir and the adjacent groundwater areas to verify the cutoff wall will function as intended. The seepage wall to the east of the proposed C-18W Reservoir was not modeled in LECSR-NP but seepage potentials will be analyzed further before the completion of the final PIR document.

The main components of the reservoir design were the embankment design, erosion protection, and borrow material. Initial estimates for the embankment geometry were based on standard design requirements from DCM-2 for wind setup and wave run-up over that of the normal pool elevations. Additional requirements for freeboard included the potential probable maximum flood inflow volume (direct rainfall on site). These design consideration resulted in an embankment height approximately 18.5 ft above natural ground elevation with a normal design pool depth of approximately 7.5 ft or a normal pool elevation of 27.5 ft NAVD88. The embankment crest will be 14 ft wide and the exterior and interior slopes of the basin from the toe to crest are 3H:1V. It was estimated that all of fill material for the embankment will likely come from on-site through a combination of on-site grading, and the construction of borrow and seepage canals. Riprap lining of the intake/discharge structures and along the embankment side slope was included to help with erosion control either due to higher velocities near the structures or wave action for the interior side slopes.

B.2.2 Four-Well Aquifer Storage and Recovery System

An Aquifer Storage and Recovery (ASR) system will be constructed at the C-18W Reservoir to augment surface storage capacity and provide greater flexibility in reservoir operations. The ASR system consists of four ASR wells open to permeable zones of the Floridan Aquifer System. The source of surface water

for aquifer recharge will be from the seepage collection canal along the western margin of the impoundment. Surface water will be pumped into the Floridan Aquifer System at a rate of 5 million gallons per day (MGD). Water will be recovered at a rate of 5 MGD by pumping into the reservoir, for subsequent distribution into the C-18W Canal. ASR system operation will be integrated with reservoir operations. ASR system Supervisory Control and Data Acquisition (SCADA) system will be housed within the pump station.

B.2.3 M-O Canal Connector

A connector canal between the M-O Canal and area upstream of the planned Seminole-Pratt Whitney Road Culverts is proposed to bring excess water from the ITID upper basin. Due to the topography of the area, this connector canal will require water to be pumped from the M-O Canal. The proposed pump station will be located at the eastern terminus of the M-O Canal. This pump station will be evaluated during the PED to see if it could be combined with the seepage pump station or potentially replaced with an operable structure. The connector canal will be constructed adjacent to Seminole Pratt Whitney Road, on the eastern border of the J.W. Corbett WMA. The new M-O connector canal can send up to 200 cfs to the C-18W Reservoir under the following conditions: 1) when C-18W Reservoir has available capacity and ITID upper basin water is available; and 2) when ITID water stages are above wet (16.0 ft. NGVD) or dry (17.0 ft. NGVD) season control stages. The proposed M-O Canal connection will require excavation of approximately 3,500 linear feet, totaling 50,000 cubic yards. The canal shall be sized so that water velocities from the pump station are minimized.

B.3 Flow-way 3

Flow-way 3 is located within southern Martin County and consists of the watersheds within the northern portion of the project study area. These watersheds contribute to the northwest fork of the Loxahatchee River via the Ranch Colony Canal and Cypress Creek, Moonshine Creek, Hobe Grove Ditch, and Kitching Creek tributaries. The project features for Pal-Mar East, Ranch Colony Canal, Gulfstream West, Gulfstream East, Moonshine Creek, and Kitching Creek are described below. An additional spreader swale feature, the Mack Dairy Spreader, was incorporated into the TSP due to public input and a cost/benefit analysis. Figure 4 and Figure 5, below, illustrate the western and eastern project areas and features of Flow-way 3, respectively.

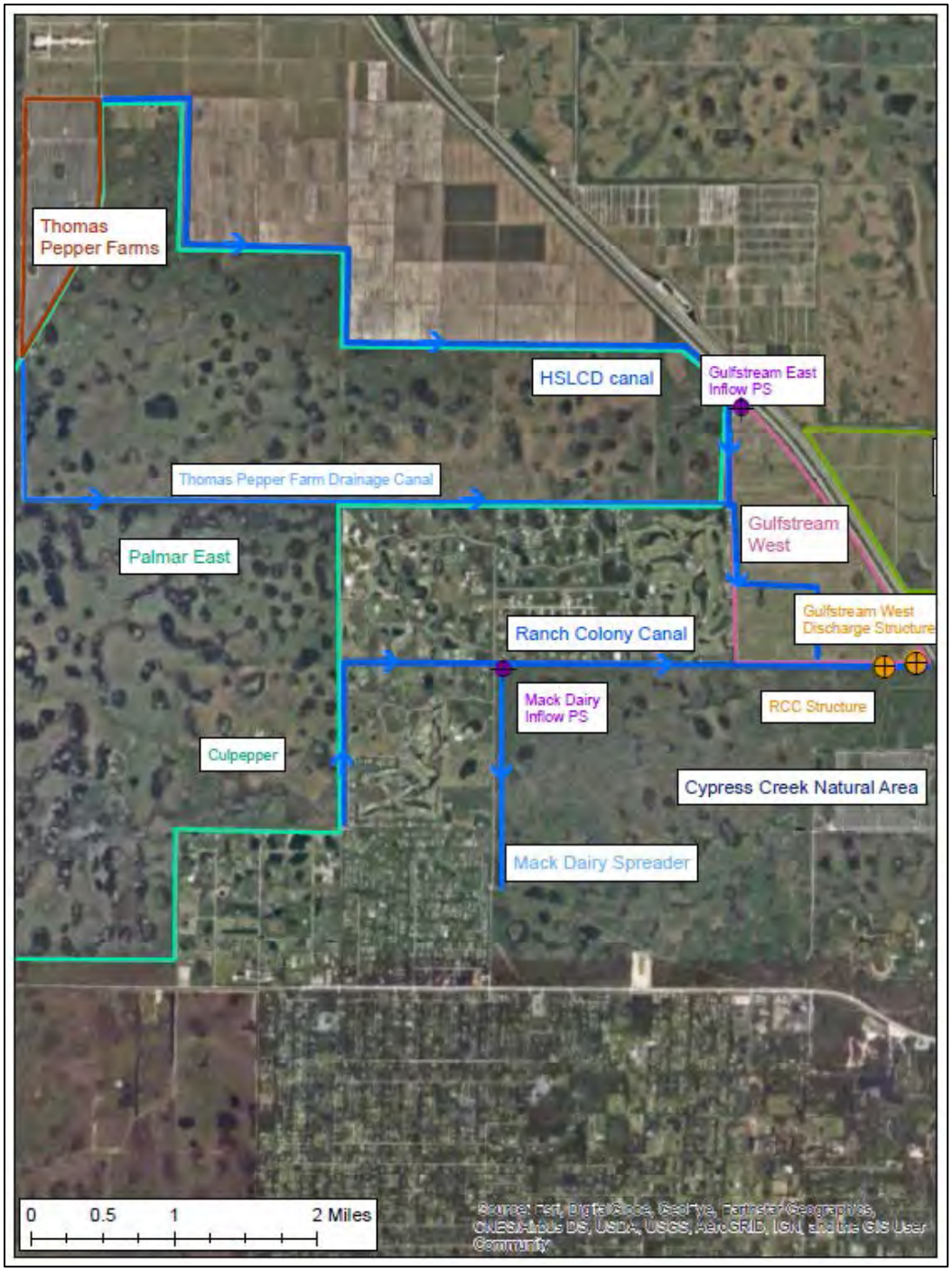


Figure 4. Location of Western Project Features of Flow-way 3.

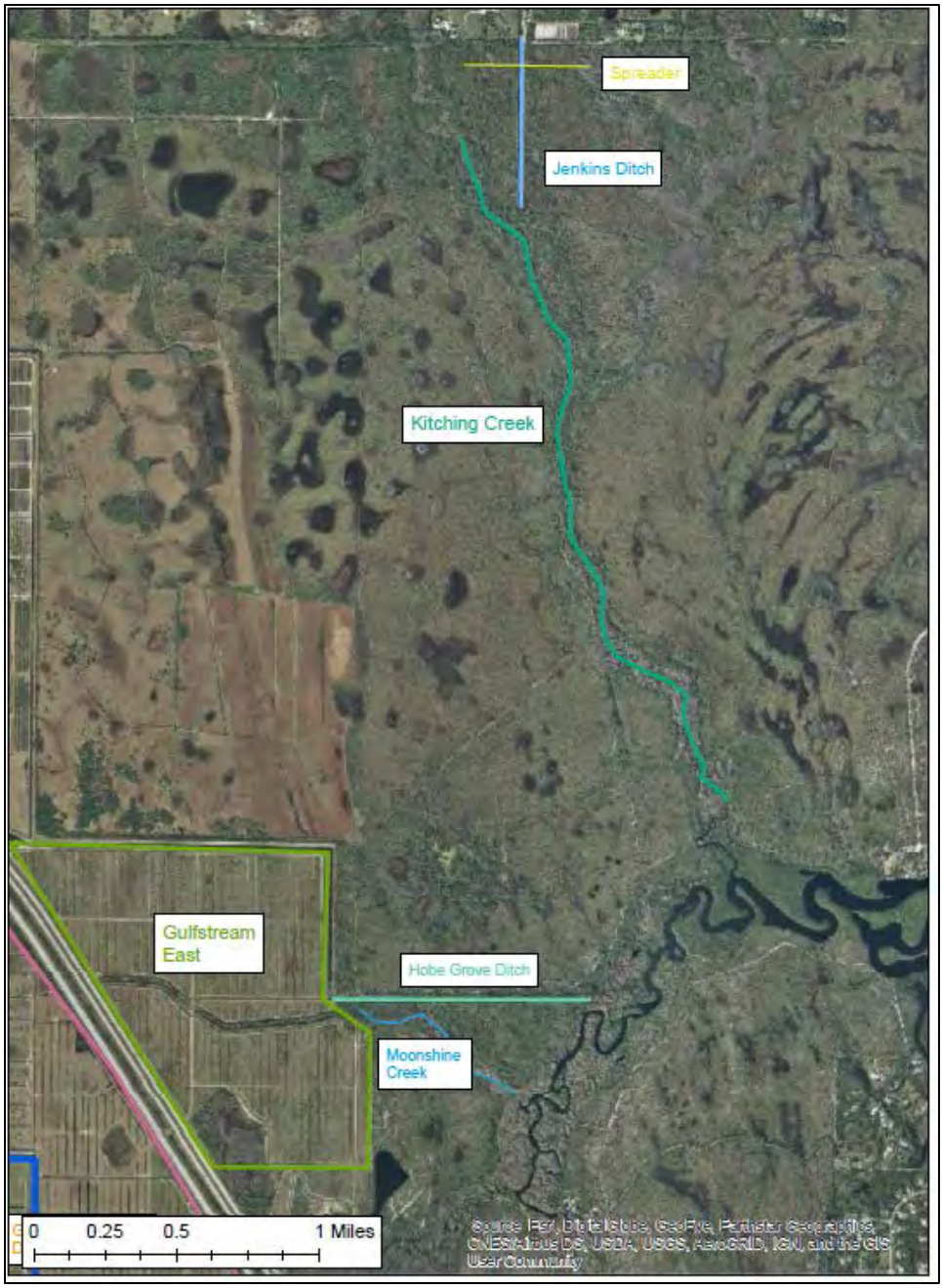


Figure 5. Location of Eastern Project Features of Flow-way 3.

B.3.1 Pal-Mar East (Nine Gems)

Multiple features within the Pal-Mar East property are proposed for the purpose of improving hydroperiods and ecology within the area. The first component is to fill the internal drainage canals within Pal-Mar East to help reduce run-off from the site. Additionally, the small drainage pipes and culverts will be removed and backfilled to further reduce the drainage of the site. Minor berm improvements will be necessary at irregular intervals along the Pal-Mar East northern and eastern border to ensure water is held on site during larger storm events.

B.3.2 Thomas Pepper Farm

The Thomas Pepper farm is located to the west of Pal-Mar East Property and Pratt Whitney Road (SR-711). Currently, the farm drains to the south through a canal that bisects the Pal-Mar East property and discharges into the existing Hobe St. Lucie Control District Drainage (HSLCD) canal and eventually to the north fork of the Loxahatchee River. The canal through which the Thomas Pepper farms drains causes a disruption in sheet flow from the southern portion of Pal-Mar East flowing in a northerly direction. Due to the topography, the northwest corner of southern portion of Pal-Mar East (to the west of Jupiter Farms equestrian center) may have periods of over-inundation due to the small berm that separates the natural area of Pal-Mar East from the Thomas Pepper drainage canal. The proposed design is to backfill the existing Thomas Pepper farms drainage canal and smooth the existing berms to promote sheet flow from southern Pal-Mar East to the north/eastern portions of the property. The new drainage pattern from the Thomas Pepper Farm is to drain along the northern border of Pal-Mar East, between Pal-Mar East and the HSLCD agricultural land. This will require modification of a drainage ditch that currently exists along the northern boundary of Pal-Mar. The existing ditch shall be widened and deepened to handle the additional outflow from Thomas Pepper Farms. Additionally, a new culvert and pump will be required to re-route the Farm's drainage under Pratt Whitney road and into the newly constructed drainage canal.

B.3.3 Ranch Colony Canal

The south eastern portion of Pal-Mar East (also known as "Culpepper") currently drains through four water control structures into the Ranch Colony Canal. The Ranch Colony Canal begins at the south-eastern corner of Pal-Mar East, extending north and east between residential communities (The Links and Ranch Colony). Additionally, the HSLCD drainage canal discharges into the downstream portion of the Ranch Colony Canal. The combined flow discharges uncontrolled under I-95 and the Florida Turnpike eventually reaching the northwest fork of the Loxahatchee River, downstream of Lainhart Dam. The system experiences periods of high discharge during wet periods or large rain events, causing scour and erosion both within the canal and downstream. Additionally, during drier periods, the canal continues to intercept adjacent groundwater seepage due to the canal's low bottom elevation. Modifications to the Culpepper control structures and to the Ranch Colony Canal are proposed for reducing the flashy nature of the system. Higher inlet control elevations as well as modifications to make the structures operable are proposed to help maintain more water on the Pal-Mar East property. This modification will help achieve a more desirable hydroperiod within the Culpepper property, while simultaneously reducing discharges into the Ranch Colony Canal.

The purpose of the proposed new control structure within the Ranch Colony Canal is to improve management of water elevations within the canal during the wet and dry season. The proposed structure is a two-bay concrete ogee spillway with telemetry operated vertical lift gates. Each bay will be 10 ft wide with a crest elevation at approximately 9 ft NAVD88. This design will allow for flexibility during the wet and dry season. During the dry season, the gates can help hold additional water in the canal, assisting in the improvement of groundwater levels by reducing groundwater draw down. The structure will be designed and operated to control discharge velocities associated with wet season releases that may cause downstream erosion. The design will maintain or improve the current flood protection for the surrounding developments. The structure location, downstream of the Cypress Creek discharge location into Ranch Colony Canal, will provide additional hydrologic improvements to the currently over-drained Cypress Creek Natural Area.

Additional modifications to ensure flood protection is maintained include the proposed berm improvements along the Ranch Colony Canal and along the eastern border of Pal-Mar East (western boarder of the Ranch Colony Community). Existing berm elevations vary and contain low spots that may be susceptible to flooding during extreme events. The berm improvements along the Ranch Colony Canal will provide a uniform berm protection elevation for the neighborhoods and account for the proposed modification to the inlet control elevations of the four water control structures, which will cause higher stages within the Culpepper property. .

B.3.4 Gulfstream West

The Gulfstream West parcel bordered by the Florida Turnpike to the east, Ranch Colony Canal to the south, and Pal-Mar East/Old Trail neighborhood to the west. The land was historically a citrus grove but is currently being used for cattle grazing. The HSLCD drainage canal extends along the western perimeter of the property before turning east, cutting through a portion of the property. The Gulfstream West area has been excessively drained due to the drainage canals and ditches from agricultural use as well as the low stages within the Ranch Colony Canal, to which the HSLCD canal drains.

The main feature proposed for the Gulfstream West property is to construct a flow-through marsh. This feature will provide multiple benefits:

1. The flow-through marsh will source water from the HSLCD drainage canal, thereby helping control discharge rates and attenuate flow.
2. A flow through marsh will provide ecosystem benefits and water quality improvements.
3. Potential reduction in stages within the HSLCD Drainage Canal and Ranch Colony Canal as the flow through marsh provides additional storage and can re-route water from the HSLCD Canal to downstream of the newly proposed structure within Ranch Colony Canal.

The flow-through marsh feature will pump water from the existing HSLCD Drainage Canal into a series of collection ditches and spreader berms that will promote sheet flow and re-hydration of the site. The design will require extensive earthwork, including the construction of a levee to ensure water is maintained and held on-site. The site will be graded and existing drainage ditches will be removed to provide a more uniform topography and slight gradient to promote flow in a southerly direction. Approximately three to four collection ditches with spreader berms will be installed perpendicular to flow. This will help reduce preferential flow path development, while controlling discharge velocities for ecological benefits. The runoff from Thomas Pepper Farms, HSLCD and Pal-Mar East is discharged into the flow through marsh at the northern end of the property via a 250 cfs pump station. If runoff exceeds 250 cfs the by-pass canal (existing HSLCD canal) is used to route the excess runoff directly to the Ranch Colony Canal. The “dog-leg” at the southern end of the existing HSLCD Canal is removed and the newly constructed portion of canal will continue north-south, along the west side of the property, with an open connection at the Ranch Colony Canal. Inflow pumping will stop when water elevations within the flow through marsh exceed 17.75 ft NGVD29 (16.25 NAVD88) (avg. depth of 3 ft). The outflow structure will be a notched weir and is designed to discharge a variable rate depending on the marsh depth, with discharges reaching over 250 cfs when water depth within the marsh exceeds 3 feet. At 1.75 feet of depth the discharge will be approximately 30 cfs as baseflow to the Loxahatchee River. All discharge from the flow-through marsh is downstream of the new Ranch Colony Canal structure.

B.3.5 Gulfstream East and Moonshine Creek

The Gulfstream East property is approximately 450 acres of fallow citrus grove located to the east of the Florida Turnpike. Historically, the run-off of this property would flow east to the Moonshine Creek and ultimately to the Northwest Fork of the Loxahatchee River. Restoration of the Gulfstream East and Moonshine Creek is proposed. The existing drainage ditches will be filled and the site will be re-graded to the historical topography. To the east of the Gulfstream East property is the unit 3 control structure, which discharges into the Hobe Grove Ditch. Approximately 250 ft downstream of the Unit 3 structure the Hobe Grove Ditch and Moonshine Creek are partially separated due to heavy vegetation and sediment. The proposed feature is to connect the Hobe Grove Ditch and Moonshine Creek. Additionally, a new weir will be installed at the eastern extent of the Hobe Grove Ditch to help hold additional water within the ditch, improving the groundwater levels while helping to promote additional flow down the historic Moonshine Creek. The proposed weir elevation is at 7.5 ft NGVD29 (6 ft NAVD88).

B.3.6 Kitching Creek

Kitching Creek discharges from the north into the north-west fork of the Loxahatchee River. Currently, Jenkins Ditch discharges flow from the northern portion of Kitching Creek via the Kitching Creek Preserve. The ditch also helps convey local runoff from surrounding residential properties. The natural area of Kitching Creek, just south of the residential areas, receives discharge from the ditch. The ditch has caused higher flow rates and a less natural run-off pattern to occur than historically observed. The proposed spreader swale is to be constructed to the east and west from Jenkins Ditch at the north end of the Jonathan Dickinson State Park. This swale will help distribute flows to historic Kitching Creek channels instead of directly down the ditch. This distribution is meant to mimic historical conditions by reducing peak discharge rates and creating a more natural flow pattern, aiding in the overall rehydration of the area. A sheet pile weir is proposed to be constructed in the ditch upstream of the main Kitching Creek channel at elevation 12.0 ft NGVD to aid in the dispersion of water into the spreader system.

B.3.7 Mack Dairy Spreader Swale

The proposed Mack Dairy Spreader Swale will be located south of the Ranch Colony Canal, parallel to Mack Dairy Road. The purpose of the spreader swale is to help rehydrate the Cypress Creek Natural Area by pumping excess water from the Ranch Colony Canal to the spreader swale, located along the western-most extent of the Cypress Creek Natural Area. This spreader swale will assist in distributing water in a southerly direction while the natural topography will cause the water to flow east. This design for the distribution of water was to mimic historical flow patterns from the west (Culpepper area) that have been interrupted due to urban development. The natural discharge location of Cypress Creek is located just upstream of the proposed Ranch Colony Canal control structure. This control structure will also help stages, and associated ecological benefits, within the natural Cypress Creek Natural Area.

The spreader swale pump station capacity is designed to send up to 50 cfs from the Ranch Colony Canal into the spreader swale. The swale will extend for approximately 3,500 feet, with an average depth of 3 feet, bottom width of 5 feet, and 3H:1V side slopes. The spoil material will be placed along the western edge of the swale as a small berm. This will assist in promoting an easterly flow direction while helping provide additional flood protection to Mack Dairy Road. To further improve the hydroperiod and flow conditions in the Cypress Creek Natural Area, re-grading of the easterly forks of Cypress Creek are proposed. This is to help maintain lower flow velocities, reduce scour, and promote natural vegetative growth and improved ecological conditions in the area.

B.4 Conceptualization of Alternative Features (Non-TSP)

The following features were components developed in alternatives that were not selected for TSP. The conceptual design of the project features specified in the final array of Alternatives are included to provide a comparative framework for the analysis of the TSP performance and selection. Many of the project features recommended in the TSP were also proposed in other Alternatives. For example, G-160, G-161, and the Grassy Waters Preserve Triangle is recommended in all Alternatives and the TSP. Other features, such as the C-51 reservoir, was unique to one alternative.

B.4.1 Flow-way 1

Features that comprise Flow-way 1 are described in the following subsections.

2.4.1.1 C-51 Reservoir, Phase II (Alternative 10)

The proposed C-51 Phase II Reservoir is located within the footprint of a proposed mined area, north of State Road 80 (Southern Boulevard) in Palm Beach County. Inflow source is the L-8 Canal, with a contributing area of the L-8 Basin, except for agricultural lands west of S-76. Releases from Lake Okeechobee are not permitted in Alternative 10 and therefore regional water is not a source for the C-51 Phase II Reservoir.

The facility is constructed and is operable to provide deliveries to the LRWRP project and water supply to the City of West Palm Beach. The reservoir discharges are routed via the M-Canal through Flow-way 1. Available capacity is assumed to be 44,000 acre feet on approximately a 1,600-acre footprint (+ or -), with 33.7 feet of storage from ground elevation. Water elevations may vary between 15.1 ft. to -18.6 ft. NGVD29 (13.6 to -17.1 ft NAVD88).

The assumptions for construction of this feature include the following: The site has not been mined at the beginning of construction and will require all on-site material to be removed and hauled away, dewatering of the basin will be required, a berm will be constructed around the perimeter, an emergency spillway will be installed, and inflow/discharge structures will be required. The current design assumptions are included in Table 2, below.

Table 2. Major Components of the Proposed C-51, Phase II Reservoir.

Component	Description
Berm around periphery of cell 1	39,900 linear feet of earth fill embankment. 3H:1V side slopes with 14-ft crest width. Embankment height 20.5-ft NAVD88. Embankment upstream slope and crest are protected with a 12-inch thick slab of Reinforced Cement Concrete (RCC).
Emergency Spillway	Vertical upstream face, 1H:1V downstream slope, crest height 7-ft, with 14-ft crest. Downstream embankment is protected by a 12-inch thick RCC slab that connects to an RCC lined channel.

Component	Description
Conveyance Canal between Reservoir and L-8 canal	Enlarge and excavate conveyance canal – 1.5 miles long, excavation volume 87,400 cy.
Outflow Pump station 2 (conveyance canal to L-8 canal)	300 cfs pump station.
Inflow culverts (conveyance canal to L-8 canal)	(3) 10-ft x 10-ft box culverts for 2000 cfs capacity with (3) 10-ft x 10-ft automated gates.
Inflow/Outflow Pump Station (reservoir to conveyance canal)	300 cfs pump station.
Outflow/Inflow culverts (reservoir to conveyance canal	(3) 10-ft x 10-ft box culverts for 2000 cfs capacity with (3) 10-ft x 10-ft automated gate.
Seepage control between Phase I and II	8.0 miles of Soil-Cement Bentonite seepage barrier along east and south around the entire perimeter, 31-ft (+11 to -20 ft NAVD88).
Seepage collection	Improve existing seepage collection ditch on east side of cell 1. 10,600 linear feet of canal, deepened 2-ft and widened to 10-ft approximately 12,500 cubic yards of excavation.
Grading within Cell 1	Existing ground elevations are 16.8 ft (south) to 19-ft (north). Remove approximately 0.5 ft from southern half (350 acres) of Cell 1.

2.4.1.2 Force Main (Alternative 10)

A force main (pressurized pipeline) is to be constructed from M-Canal at eastern Grassy Waters Preserve (GWP) perimeter to the proposed G-161 structure. A 50 cfs pump station will be placed at M-Canal intake to drive flow against the natural topographical and hydraulic gradient. The force main will be used to send water from the C-51 Phase II Reservoir through GWP upstream of the proposed G-161 structure. The purpose of the force main is to be able to send water, which may not be meeting the water quality standard that is maintained in GWP, to the Loxahatchee River. The force main will consist of approximately 24,000 linear feet of piping, 48-in in diameter. The pipeline alignment will likely be located within the existing GWP perimeter canal. The pipeline material will depend on the desired strength, hydraulic friction

characteristics, ease of handling, and corrosion resistance; availability of appropriate sizes, wall thickness, and fittings. The minimum design pressure is assumed to be 10 psi and therefore a potential booster pump may be required to maintain minimal pressure and velocities.

B.4.2 Flow-way 2

Features that comprise Flow-way 2 are described in the following subsections.

2.4.2.1 L-8 Shallow Storage, Flow Equalization Basin (FEB), Alternatives 2 and 13

The L-8 Shallow Storage feature was proposed in Alternative 2 and Alternative 13. The footprint of both reservoirs was similar but the maximum design storage capacity, water source for the reservoir, and inclusion of ASR systems were different between alternatives.

2.4.2.2 L-8 Shallow Storage, Alternative 2

The purpose of the proposed L-8 Shallow Storage is to provide additional water to the Loxahatchee River to meet restoration goals while simultaneously providing for inter-basin transfer from the L-8 Basin to the C-18 Basin. The L-8 Shallow Storage has a capacity of 4,300 acre feet on a 1,500 acre footprint. Cell inflow is from the L-8 Canal via a 200 cfs pump station. Outflow to M-O Canal is limited to 100 cfs when C-18W Reservoir has available capacity and the stage within ITID and the M-O Canal allow. The L-8 Shallow Storage was designed as three holding cells that transport water from the L-8 Canal to the M-O Canal with the purpose of improving water quality while simultaneously delivering additional water to the C-18W Reservoir.

The lower cell, or southernmost cell, has a 700 acre footprint, with water depths ranging from 4 ft. in the southern portion to 2 ft. in the northern portion of the cell. This varying depth is due to the natural north to south gradient of the existing topography of the site. The estimated storage when the lower cell is full is approximately 2300 ac-ft. An inflow pump station will be located at the southern boundary of the cell, adjacent to the L-8 canal, with a capacity of 200 cfs.

A berm will surround the entire lower cell with the purpose of retaining water. The preliminary design of the berm was as a Low Hazard Potential, as according to DCM-2 Low HPC (Hazard Potential Classification) impoundments, which consist of less than 4 ft of water with sustained vegetation. For this design a minimum of 3 ft of freeboard is required, in addition to the 100 yr-24 hour rainfall + wind setup required. As vegetation may not be present in the lower portion of the cell due to the deeper water depth, a wave run-up analysis was performed to ensure the embankment height design remained conservative. The analysis dictated an average embankment height of 5.4 ft above the maximum water storage level (MWSL). Therefore, an overall embankment height of 9.4 ft. above ground surface should be utilized for the lower cell. The length of embankment required to encompass the cell is estimated at 5 miles (26,400 ft). The designed crest width is 14 ft. with a 3H:1V side slope.

There is limited geotechnical information available at the proposed L-8 shallow site. Additional geotechnical data are available for sites that are within close proximity to the L-8 Shallow Storage, such as the “Mecca” property (proposed location of C-18W Reservoir). Initial estimates for the embankment fill material are that 50 percent of on-site material will be suitable for embankment construction while 50% of the required material will be brought from an off-site quarry. Additionally, a seepage collection system will likely be required due to the potentially sandy soils in the area. The seepage collection system will likely consist of seepage ditches and a seepage pump that will return water to the FEB.

The middle cell, situated north-east of the lower cell, has a 600 acre footprint with water depths ranging from approximately 3 to 3.5 ft. The estimated storage when full would be approximately 1,800 ac-ft. The berm design, similar to the lower cell, is based on low hazard assumption, with minimum freeboard of 3.0 ft above the max water storage level. This produced a berm design of approx. 8.2 ft. above ground surface. The length of embankment is approximately 3.15 miles (16,632 ft.) with a crest width of 14 ft. and 3H:1V side slopes. Similar assumptions regarding the seepage canal system and seepage pump station as the lower cell are also applicable for the middle cell. Approximately half of the material for the berm construction will come from the site, through grading and construction of seepage canal.

The upper cell is the northernmost cell and is adjacent to the M-O Canal. It has a 300 acre footprint, with projected water depths ranging from 1.5 to 2.5 ft. The estimated storage when full is approximately 600 ac-ft. A small berm used to separate the upper cell and middle cell will be required to assist it retaining water within the upper cell during periods of drought. The berm design will be similar to that of the middle cell, a 3.0 ft. freeboard requirement above the MWSL. This would result in a berm elevation of 7.2 ft., with an approximate length of 1.9 miles (10,032 ft.). The embankment crest width, side slopes, and material are similar to the other cells design. The outlet control would be designed for a maximum of 100 cfs to the M-O Canal. The outlet control would be a telemetry controlled dual leaf gate drop structure with 60" HDPE culvert approximately 115 ft in length.

2.4.2.3 L-8 Shallow Storage, Alternative 13

The L-8 Shallow Storage feature is similar to that explained in Section 2.4.2.2 L-8 Shallow Storage, Alternative 2, except for an increase in storage capacity, both in above ground reservoir storage and from ASR storage. Additionally the L-8 Shallow Storage feature in Alternative 13 uses source water from the ITID basin via the M-O Canal. The proposed lower cell will contain water depths of approximately 4 ft. to 4.5 ft on a 700 acre footprint. The estimated storage when the lower cell is full is 2,800 to 3,100 acre-ft. Extensive re-grading, or scrape down of the northern portion of cell, will be required to maintain a uniform depth. An estimate of approximately 600,000+ CY of material re-grading would be required to have a uniform depth (bottom elevation) of the cell. The re-graded material will be used in the berm construction. It was assumed that half of the re-graded material would be suitable for berm construction whereas the remaining material would be brought from an off-site quarry. The lower cell will contain both a gravity inflow structure, that receives discharge from the middle cell, as well as a discharge pump station that can pump water back into the middle cell.

The berm design would be considered a Significant Risk Hazard according to the DCM-2 due to potential impacts on surrounding communities due to the water elevations being 4+ feet within the cell. The Probable Maximum Precipitation (PMP) and 100-year wind values were used to determine appropriate embankment height. The calculations suggest 8.5 ft. of embankment height (freeboard) above the normal maximum water surface elevation. Therefore, the overall embankment height would be approximately 12.5 ft. Length of embankment required was estimated at 5 miles (26,400 ft). A crest width of 14 ft. and 3H:1V side slopes results in an overall embankment material requirement of 600,000+ cubic yards. A similar seepage collection design and seepage pump station, as proposed in Alternative 2, would also be necessary.

The middle cell and upper cell design shall be similar to that proposed in Alternative 2. The only additional feature will be a 200 cfs inflow pump station from the M-O Canal into the upper cell. It is important to note the source water change for the L-8 Shallow Storage for Alternative 13, which is different than that proposed in Alternative 2.

2.4.2.4 M-O Canal Connector

The main components of the M-O Canal Connector feature are included in Section M-O Canal Connector, as proposed for the TSP and Alternative 10. The M-O Connector Canal, as proposed in Alternative 2 and 13, brings excess water from both ITID (upper basin) and discharges from the L-8 Shallow Storage. Flow from L-8 Shallow Storage will supplement water to C-18W Reservoir, when capacity is available, via the M-O Canal Connector pump station. Therefore, the M-O Canal Connector in Alternative 2 and 13 have differing upstream basin run-off potential than the TSP and Alternative 10. The proposed pump station capacities were 120 cfs and 180 cfs for Alternative 2 and 13, respectively.

2.4.2.5 C-18W Reservoir (Alternatives 2 and 10)

Many of the design features as specified in Section 2.2.1 C-18W Reservoir are maintained in the design for the C-18W Reservoir for Alternatives 2 and 10. The main difference is the reduction in storage capacity to 7,200 acre-ft for the C-18W Reservoir proposed in Alternative 2 and 10. Due to the proposed reduction in storage capacity, the normal design pool elevation is estimated to be approximately 5.7 ft with an embankment height of 15 ft. This will require a reduction in earth work and embankment material placement and compaction than was proposed in the TSP. The proposed reservoir for Alternative 2 will contain an ASR system consisting of two wells, increasing the overall storage capacity above that of Alternative 10, for which no ASR wells were proposed. Other design features, as proposed in the TSP, such as the M-O Canal Connector, inflow pump stations, and discharge structures will remain the same.

2.4.2.5 C-18W Natural Storage (Alt 13)

C-18W natural storage area is a project feature proposed for construction in northern Palm Beach County on approx. 1,920 acres of SFWMD-owned land previously known as Mecca Farm (26°50'27.41"N, 80°16'51.60"W); the former citrus grove is east of J.W. Corbett WMA and Seminole Pratt Whitney Road, west of the Avenir planned unit development, south of C-18W Canal and Hungryland Slough, and less than 1 mile north of Northlake Boulevard and the ITID. The former Mecca property is to be managed as a wetland system, with source water from the L-8 Shallow impoundment, J.W. Corbett WMA and the ITID upper basin. The purpose of the C-18W natural storage is to provide a hydrologic connection between the aforementioned basins and the C-18W Canal to help with flows to the river while simultaneously rehydrating land for ecological benefits. The natural storage will occur on the Mecca property, previously identified in the other alternatives as the site for the C-18W Reservoir. In addition to hydrating this property, the natural storage will also provide additional flow east, to the Avenir property. The M-O Canal Connector and pump station, as described in Section M-O Canal Connector, will be necessary for the design to provide inflows to the site at a proposed pump capacity of 180 CFS.

Additionally, the operable weir controlling discharges from J.W. Corbett WMA and culverts under Seminole Pratt Whitney Road will also be necessary. The expected inlet and 250 cfs pump station location will be just north of the existing East Corbett Weir, in the middle of the western boundary of the storage area. This pump will be used to transport the collected water from J.W. Corbett WMA and/or the M-O Canal Connector onto the C-18W natural storage area, with a desired we season target stage of 21 ft NGVD29 (19.5 ft NAVD88). A small spreader swale and berm will be constructed to help eliminate back flow and aid in the distribution of water onto the site.

Three preferential flow paths will be constructed through the property to aid in moving the water to the Loxahatchee River. When stages in the natural storage are above 21.5 ft NGVD29 (20 ft NAVD88), a 50 cfs

flow path will link the inflow pump station to the C-18W Canal for deliveries to the river. The outlet is assumed to be located on the northern boundary at the C-18W Canal, approximately in the middle of the northern property line. Two smaller flow paths will discharge to the Avenir wetland restoration area, requiring a single 25 cfs pump station to help move the water east, due to the topography of the area. This project feature would require earthwork to restore the natural topography and build the desired flow paths. Shallow seepage barriers may be required adjacent to the communities to the south and gun-range to the northeast. Finally, additional culverts under the Beeline Highway, south of the North Palm Beach County Airport, are required to facilitate flow westward to the Loxahatchee Slough.

2.4.2.6 C-18W Weir Relocation (Alternative 13)

The C-18W Weir is currently located on the C-18W Canal just east of the Beeline Highway. The weir controls stages within the C-18W basin upstream of the weir. Currently, the weir invert elevation is controlled by the bottom cord elevation of the Beeline Highway Bridge and CSX railway bridge upstream of the weir. The current weir elevation must be maintained lower so water elevations do not impact these two bridges. This increase in C-18W Canal elevations will help increase hydroperiods for lands surrounding or draining to the canal.

2.4.2.7 ASR Systems

Aquifer Storage and Recovery (ASR) systems consist of a surface facility with water pre-treatment components, intake and outfall structures, one or more recharge/recovery (or ASR) wells, and groundwater monitoring wells. The proposed ASR systems, including location and number of wells, vary depending on the alternative. Alternative 2 contains two ASR wells within the C-18W Reservoir whereas Alternative 13 proposes four ASR wells within the L-8 shallow storage. Alternative 10 does not propose any ASR wells.

All project ASR systems are integrated with C-18W Reservoir or L-8 Shallow Storage operations. ASR system design and construction will be optimized to have many ASR wells associated with a minimum number of water pre-treatment lines. Monitoring wells will be located so that the fewest number of wells will be required to evaluate groundwater quality and flow yet still maintain permit compliance. Conceptual construction impact acreage is provided in the final PIR document. Because ASR systems occupy a relatively small footprint, generally less than a few acres, these impacts are expected to be minimal.

B.4.3 Flow-way 3

There are minimal differences between the features proposed for Flow-way 3 for the TSP, Alternative 2 and Alternative 13. The only feature not proposed in Alternative 2 is the Mack Dairy Spreader system and the minor re-grading of the lower forks of Cypress Creek. Alternative 10 only contains those features proposed in the Ranch Colony Canal, Gulfstream West, and Kitching Creek area.

C. DESIGN DATA

C.1 Civil – Site Design Data

Features identified in the Tentatively Selected Plan have been designed to a level of detail necessary to provide rough order of magnitude cost estimates. Best professional judgment as well as previous design efforts for the C-18W Reservoir and restoration of the Culpepper property were used during plan

formulation development and design efforts (Arcadis, 2016; Tomasello, 2016). All project components will be optimized either prior to the final PIR or during the pre-construction engineering and design (PED) phase for cost efficiency and performance, incorporating updated data and information as it becomes available. Data collected solely for civil site design is expected to be minimal during PED, as most of the explorations (geotechnical, LiDAR, survey) is either currently available or will be collected for use by all engineering disciplines and incorporated into the civil site design.

C.1.1 Light Detection and Ranging (LiDAR) Survey Data

Survey data for the portions of the project located within Martin County, Florida were generated using airborne LiDAR in January 2016. The LiDAR data was not collected in relation to this planning project but is of sufficient detail in the project area to be used for planning purposes. The horizontal datum for the project is the Florida State Plane Coordinate System (East Zone), referenced to the North American Datum 1983, 2011 readjustment (NAD83/2011) expressed in U.S. survey feet. The vertical datum is the North American Vertical Datum of 1988 (NAVD88), also expressed in U.S. survey feet. The LiDAR was collected and processed to meet a maximum Nominal Post Spacing (NPS) of 2.3 ft or 0.7 meter. It is anticipated that the LiDAR data will be used more extensively in future design efforts. There is limited LiDAR data for portions of the project area within Palm Beach County. The areas that do contain LiDAR coverage are from the HHD EAA LiDAR Project from 2007, except for the proposed location of the C-18W Reservoir. The SFWMD has specific purpose LiDAR in the area of the reservoir. Other areas do not contain any LiDAR coverage. During the detailed design phase for LRWRP, additional LiDAR data as well as conventional land surveys will be conducted as appropriate for each structure as well as levee and canal alignments. No additional LiDAR is planned as part of the planning phase of this project.

C.1.2 Land Survey Data

No land survey data was collected during the planning phase of this project. Previous land survey data was used to assist in the design of the alternative features to their current level of detail. Survey data reviewed includes, but is not limited to: Cross sectional data for portions of the Ranch Colony Canal, C-18W Canal, M-Canal, M-O Canal and Culpepper containment berm. Additionally portions of the C-18W Reservoir site have survey data available. Land survey requirements will be developed during the PED phase. The cost for these surveys has not been estimated.

C.1.3 Access

Preliminary Analyses indicate that access/agreement with Thomas Pepper Farms (private) may be needed. Additionally, access to ITID canals and berms may be necessary. No additional lands, besides Thomas Peppers Farms and ITID, is excepted to be needed for access, ingress and/or egress purposes. Ingress and egress will be via Federal, state, municipal and county roads and SFWMD rights of way and available to the non-Federal sponsor for project purposes. While much of the work can be conducted on existing SFWMD or proposed lands, preliminary analyses indicate that temporary construction easements may be required in several areas owned by Indian Trail Improvement District (ITID), City of West Palm Beach, Martin County, Palm Beach County and the State of Florida.

No temporary work areas will be required on privately owned property with the exception of efforts related to construction of a pump station on Thomas Pepper Farms and increasing the existing berm heights in areas adjacent to the Ranch Colony, Links, and Old Trail communities. This effort directly benefits these areas, thus it is expected the easement can be obtained without cost.

C.1.4 Material Balance and Disposal

Cut and fill quantities will be completed during PED phase to balance the design for the C-18W Reservoir and Gulfstream West flow-through marsh area. Unsuitable material will be hauled to a certified land fill. If enough material is not available on site, from either the site grading or canal construction, to provide suitable levee construction material then material will be brought from an offsite borrow area.

C.1.5 Utility Relocations

Based on a review of existing conditions, some utilities and roads are located within the footprint of the management measures that make up the TSP. At this juncture, but subject to further engineering analysis, it is not expected that the TSP will adversely impact the existing infrastructure. Areas of potential concern include the railroad bridge directly upstream of Beeline Highway on the C-18W Canal. Additional utility lines will need to be provided for those proposed structures with telemetry operations or for the proposed pump stations. If further studies and engineering design reveal that other roads, facilities, utilities, railroads, pipelines, bridges, and/or cemeteries will be impacted then a preliminary legal opinion on whether a substitute facility is required will be completed and the Real Estate Plan for the selected plan will include the following:

- A description of the facility or utility relocations that must be performed including information regarding the general nature of the impact to each facility or utility; the identity of the owners of the affected facilities and utilities;
- The purpose of the affected facilities and utilities;
- Whether the owners have compensable real property interests in the land on which the impacted portion of the facility or utility is located;
- The conclusions reached in the Attorney's Opinion of Compensability prepared in support of the relocation determinations;
- Whether special legal authority or direction affects relocation.
- Other information relevant to the proper identification and performance of relocations necessitated by construction, operation, or maintenance of the project.

C.2 Geotechnical Design

Aspects of geotechnical design of selected features of the alternatives and ultimately the TSP requires soils characterization, seepage/slope-stability analyses, bearing capacity and settlement analyses, cofferdam design, filter design, other foundation/excavation/ dewatering design analyses, and definition of the hydrogeological setting for ASR. Seepage analysis will be performed on two important structures of the TSP: the C-18W Reservoir and the Gulfstream West Flow-way. Geotechnical analysis for the C-18W Reservoir, including additional soil borings, were previously completed and portions may be used or updated during PED. These analyses will be included in the final PIR.

C.2.1 Surface and Shallow Subsurface Soils

Ditching and draining, and subsequent development throughout much of the project area has reduced the magnitude and duration of wetland hydroperiods and also fragmented unaffected wetland areas. Over-drained wetlands result in the loss by oxidation of the surface organic layer, and exposure of sandy soils (Ecology and Environment, 2009).

Surface soils in the area of flow-way 3 consist primarily of Wabasso sand, and Pineda and Riviera fine sands, which are classified as SP-SM and SP, respectively (National Resource Conservation Service (NRCS), 2018; Figure 6) The western portion of flow-way 3, in the Pal Mar area, represents the natural condition of the northern Everglades wetlands, in which depressional wetlands pond in sandy soils. Farther east in the Nine Gems and Gulfstream East areas, construction of canals has resulted in over-drained conditions in current and former agricultural areas.

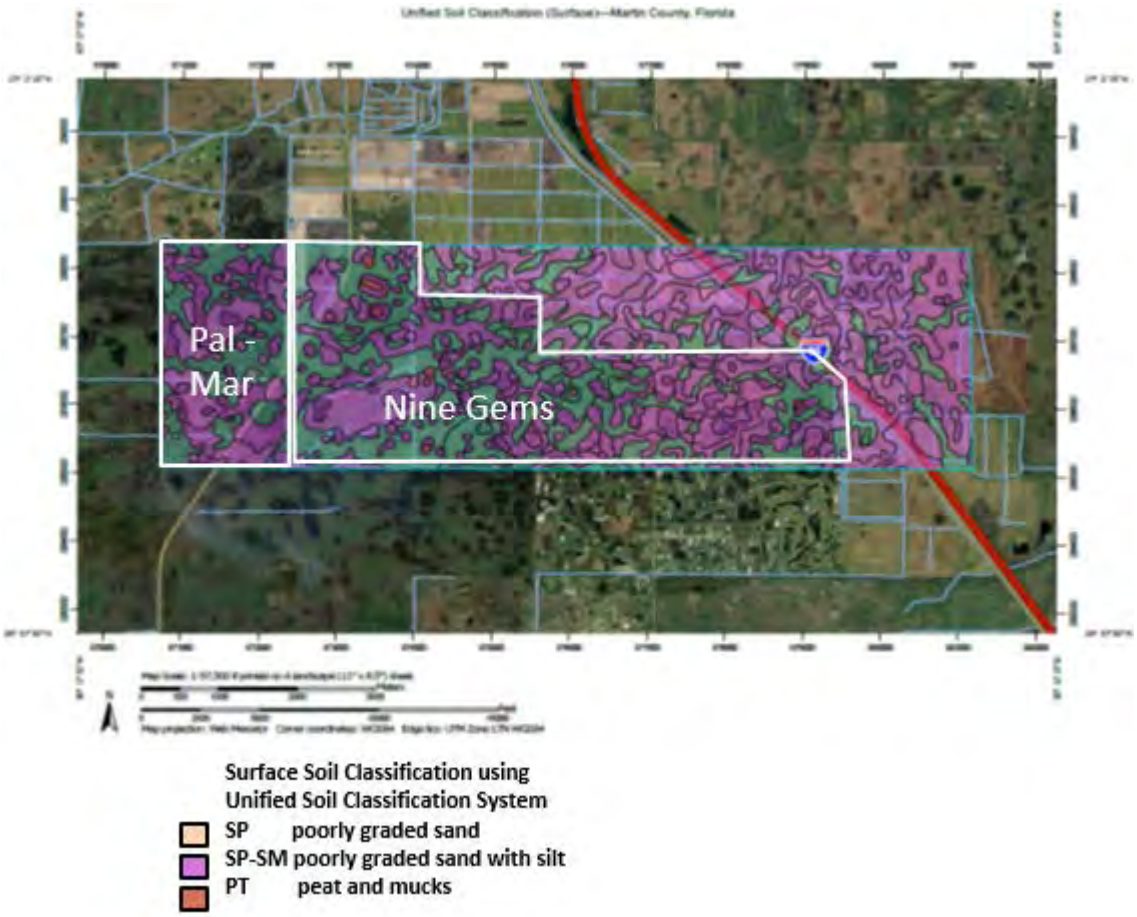


Figure 6. Map showing surface soil classification in Flow-way 3, Martin County, Florida.

Surface soils in the area of flow-way 2 are finer grained than those in flow-way 3, and consist primarily of drained and ponded Riviera fine sands, which are classified as SP-SM (NRCS, 2018; Tierra, Inc., 2004; Figure 7). The western portion of flow-way 2, in the J.W. Corbett WMA, represents the natural condition the northern Everglades wetlands in which depressional wetlands pond in sandy soils. Farther east in the C-18W Reservoir, and toward the developed portion Loxahatchee Slough, construction of canals has resulted in over-drained conditions in current and former agricultural areas.

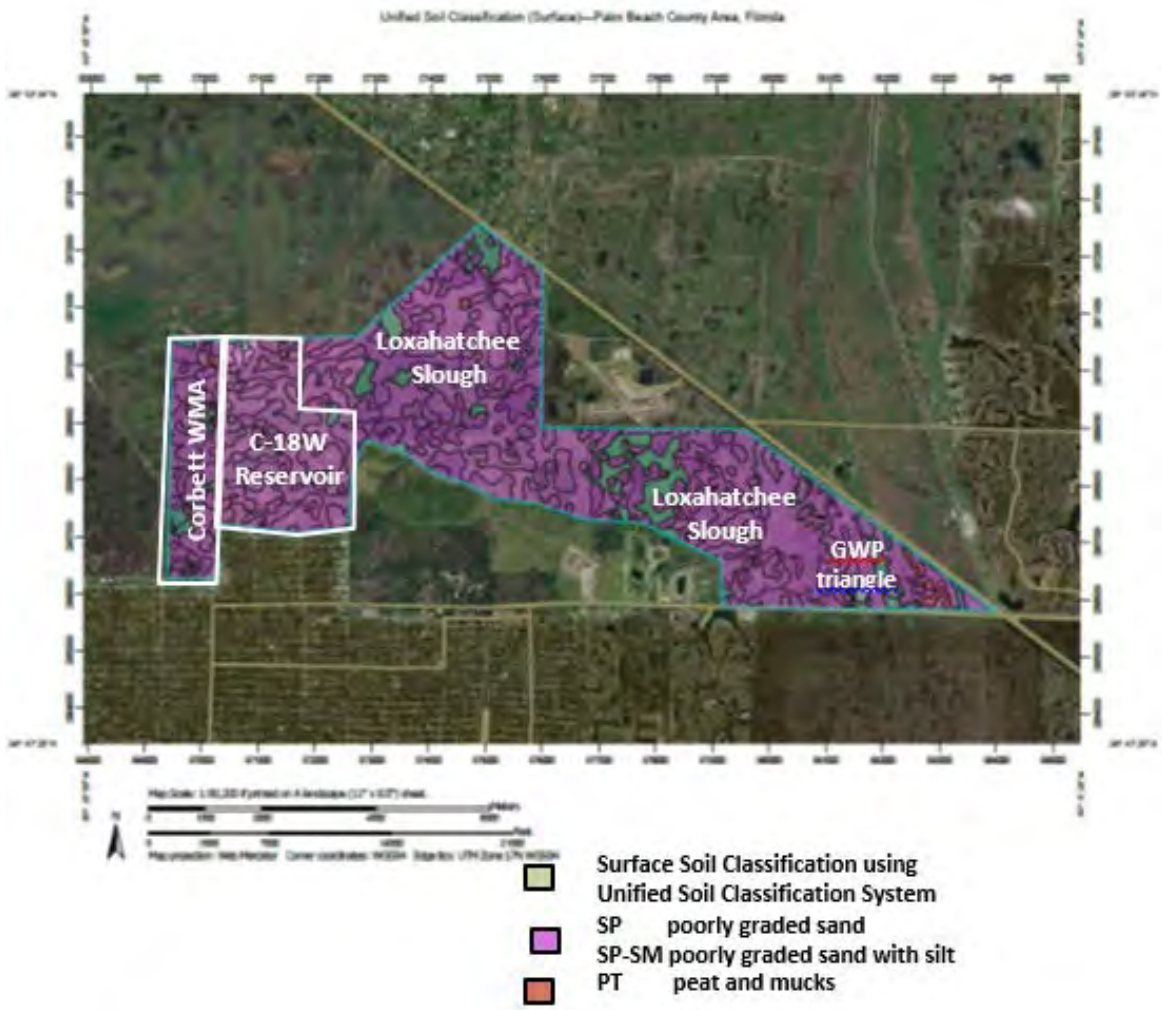


Figure 7. Map showing surface soil classification in Flow-way 2, Palm Beach County, Florida.

Most of the geotechnical data available for the shallow subsurface soils in the project area were obtained within the footprint of the C-18W Reservoir. A preliminary geotechnical investigation at the C-18W Reservoir site showed shallow subsurface soils to a depth of 25 ft below land surface (bls) in 24 core borings (Tierra, Inc., 2004). These borings showed soils interpreted as "silty clayey sand" (SM/SC-SM) at depths between 5 ft and 25 ft bls, interlayered with sand (SP) with shell or cemented sand.

A subsequent geotechnical investigation at the C-18W Reservoir site (URS Corporation, 2008) showed shallow subsurface soils to a depth of 40 ft bls in eight Standard Penetration Test (SPT) borings, with analysis of selected samples to define geotechnical characteristics of shallow subsurface soils for preliminary slope stability evaluation and fill requirements. Four laboratory permeability measurements using remolded samples yielded moderate hydraulic conductivity values ranging between 9×10^{-5} cm/sec and 2×10^{-3} cm/sec (URS Corporation, 2008) over the depth range of 5 ft to 40 ft bls. A preliminary slope stability analysis was performed using Slope/W (GeoStudio; Calgary, Canada) to evaluate the excavation configuration for a flow-way across the C-18W Reservoir footprint. This slope stability analysis supported flow-way design, not a reservoir embankment as is currently proposed.

An expanded geotechnical investigation (Arcadis, 2016) was completed at the C-18W Reservoir as part of the Detailed Design Report (DDR). Twenty-four borings were completed around the periphery of the proposed impoundment, plus two interior borings completed as piezometers. Generally, surficial (0 ft to 15 ft bls) soils consist of interbedded poorly graded sand with silt (SP-SM). Deeper sediments are predominantly poorly graded sand with silt (SP-SM), silty sand (SM) and poorly graded sand (SP) with shell and occasional clayey sand (SC) layers. Limestone is encountered at depths below approximately 30 ft bls. The upper surface of the Hawthorn Group is encountered at depths greater than 150 ft bls. Constant rate aquifer performance tests in interior piezometers yielded hydraulic conductivity values that ranged between 3.53×10^{-3} cm/sec and 1.59×10^{-2} cm/sec using the Cooper-Jacob solution for a leaky aquifer.

A geotechnical and hydrogeological investigation was completed in the J.W. Corbett WMA (Gannett Fleming, Inc., 2016), which provided lithological and hydrogeological data for the undeveloped area in the western portion of flow-way 2. One SPT boring (to -80 ft NAVD88, 100 ft bls) was completed, and samples consisted of surficial peat, and SP-SM (poorly graded sand with silt) and SP (poorly graded sand) at depth. Three groundwater monitor wells were constructed, with screened intervals at 95 to 100 ft bls, 34 to 39 ft bls, and 10 to 15 ft bls. A geophysical log was obtained from the deepest borehole, which showed an increase in fine-grained sediment at a depth range between 40 and 60 ft bls. Constant rate aquifer performance tests in each monitor well yielded hydraulic conductivity values that ranged between 1.41×10^{-4} cm/sec and 2.65×10^{-4} cm/sec using the Hantush solution.

C.2.2 Seepage Analysis of Selected Features

Preliminary seepage analysis of selected features will be performed for the C-18W Reservoir and the Gulfstream East features. Analyses are based on existing data. These revised analyses will appear in the final Engineering Appendix that accompanies the final PIR.

C.2.3 Slope Stability and Settlement Analyses of Selected Features

Slope stability analyses will be performed using SLOPE/W, a component of the GeoStudio 2012 software suite (Version 8.12.3.7901). The analyses will consider soil parameters from the subsurface investigations already performed, any laboratory test results, and historical information. SLOPE/W's formulation is based on the general limited equilibrium method and uses an iteration scheme to find the critical slip surface and corresponding minimum factor of safety. The method of analysis chosen to determine the factor of safety with respect to stability will be Spencer's procedure (Spencer 1967, Wright 1970) – which is the preferred method of the USACE because it fully satisfies static equilibrium for each slice within the failure area.

Foundation conditions (upland sandy soils) are such that side slopes of 3 horizontal to 1 vertical (3H:1V) are anticipated to be adequate for the project embankments and canals. Given the sandy nature of the foundation soils, some form of bank stabilization will likely be necessary in order to keep the canal banks from being compromised by natural weathering and erosion. Any additional project features that could influence the stability of the embankments (e.g. exterior seepage trench, toe drain system, etc.) will be modeled to verify the overall stability of the system.

C.2.4 Settlement Analysis

Settlement analyses will be performed for each of the project embankments and structures. Based on the limited field investigations performed to date, it is anticipated that the majority of the settlement will be

elastic (i.e. immediate), with some consolidation settlement occurring in the clayey sand layers encountered by the borings.

C.2.5 Foundation Design for Structures

With respect to each of the anticipated water control structures required for this portion of the project, a site specific foundation design will be performed that will include seepage/slope-stability analyses, bearing capacity and settlement analyses, cofferdam design, filter design, and other foundation/excavation/dewatering design analyses.

C.2.6 Excavatability Analysis

Based on borings performed within the project limits, the foundation materials are unconsolidated and consist mainly of upland sands with silt. As a result, it is anticipated that typical earthmoving equipment will be used and that rippers and blasting will not be necessary.

C.2.7 Soil Cement

It is anticipated that 12 to 18 inches of flat-plate soil cement will be required to armor each embankment crown and interior slope of the proposed reservoirs. The coarse aggregate for the soil-cement production will come from interior borrow sources and will likely consist of sands classified as SP, SP-SM, and SM (per the Unified Soil Classification System). As such, it is also anticipated that the cement content of the soil-cement mix will fall between 8 and 12 percent (by weight) of dry soil used.

Uplift/stability analyses will be performed to determine the factor of safety against flotation/sliding during a controlled (i.e. emergency), rapid drawdown condition. Other conditions commonly analyzed for uplift are wind and wave set-up and breach with full pool loss. However, these conditions are considered to be too conservative and could lead to design features and armoring thicknesses that exceed what will adequately withstand the rigors of normal and emergency operations.

C.2.8 Anticipated Construction Techniques

All embankment materials (excluding soil-cement armor) will be placed in horizontal lifts (6 to 12 inches loose lift prior to compaction) and compacted in a direction which is parallel to the embankment axis. Placement of embankment materials will be in the dry, and will not be allowed on any portions of the embankment foundation until that portion has been mapped, proof-rolled, inspected, tested, and approved. Mixing of materials from adjacent embankment sections will not be allowed. Dumping ahead of the lift being placed will not be allowed. All spreading equipment will be required to have a "u" type blade, unless otherwise approved.

C.2.9 Re-grading and Earthwork

Re-grading and earthwork will be completed as necessary to achieve the project feature purpose. All the proposed features will require some level of earthwork or re-grading. Those features that require extensive earthwork include the C-18W Reservoir in Flow-way 2 and flow-through marsh in Gulfstream West in Flow-way 3. Both sites require extensive re-grading of the site as well as berm construction. Please refer to the below details of the geotechnical characteristics for the project site.

C.2.10 Dewatering

Two types of dewatering systems have been assumed for this project: steel sheet pile cofferdam with underwater concrete seal and open excavation with well points and sump pumps. Sheet pile cofferdams with tremie concrete slabs to facilitate dewatering and dry construction are typically incorporated into the construction of these features. Discharge of dewatering effluent will be to the adjacent canal after appropriate treatment. Dewatering is typically accomplished by sump pumps within the excavation pit with supplemental groundwater lowering via well point rows. Other methods for dewatering may be utilized for construction efficiency and cost savings. A dewatering evaluation will be performed with seepage analysis during the design phase.

C.3 Hydrogeologic Setting for Aquifer Storage and Recovery Wells

A desk-top analysis was conducted using existing hydrogeologic data to evaluate the feasibility of Aquifer Storage and Recovery (ASR) at the C-18W Reservoir site and adjacent to the L-8 shallow storage feature. Surface water from the L-8 Canal, or M-O Canal extension and seepage collection canal will be recharged into the Floridan Aquifer System at each site. Stored water will be recovered into the C-18W Reservoir for subsequent distribution. For this evaluation, hydrogeologic data obtained from exploratory boreholes completed in western Palm Beach and Martin Counties are interpreted for comparison to the C-18W Reservoir site. Locations of existing exploratory boreholes that were converted into monitoring wells or deep injection wells are shown in Figure 8.

For the two locations proposed for ASR implementation, hydrogeologic data are available from the following subsurface investigations. These subsurface investigations indicate that the Upper Floridan Aquifer is permeable, and can serve as an ASR storage zone.

Pratt & Whitney Injection Well: The closest well that penetrates the entire Floridan Aquifer System (FAS) is located at the Pratt & Whitney (P&W) injection deep well facility, approximately 4 miles north of the C-18W Reservoir. The wells at this facility are completed within the Boulder Zone (approximately 3,000 feet bls). Information from the P&W investigation reveals that the top of the Upper Floridan Aquifer (UFA) occurs within the Suwannee Limestone at approximately 800 feet bls. Additionally, there are deeper, permeable dolomitic portions of the aquifer that may be also available for storage.

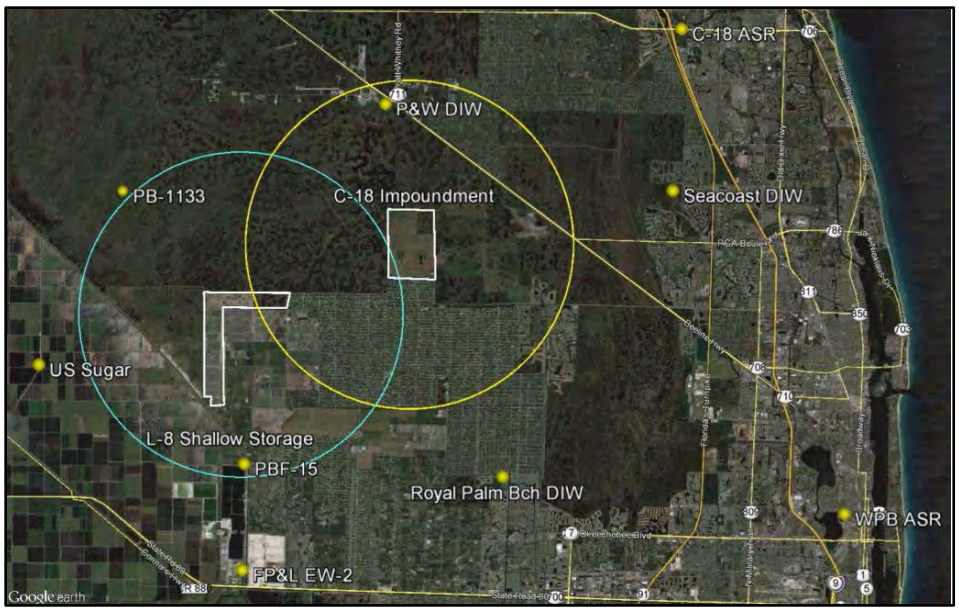


Figure 8. FAS wells and boreholes near locations proposed for ASR implementation with circles showing a 5-mile radius around L-8 shallow storage site and C-18W Reservoir.

Seacoast Injection Well: The stratigraphy at the Seacoast Utility deep injection well system, located 9 miles east of the C-18W Reservoir footprint is similar to that in the P&W deep injection well system. This investigation shows that there are several potential storage zones within the upper portions of the FAS, at 900 feet bls, and in underlying dolomitic intervals to a depth of approximately 2,500 feet bls.

C-18 Test ASR Well: During 1976, the Florida Department of Natural Resources constructed and tested an ASR system along the C-18 Canal, approximately 11 miles northeast of the proposed C-18W Reservoir site. A 12-inch diameter test ASR well drilled within the upper FAS, underwent 4 short test cycles, at recharge rates of 3 million gallons per day (MGD) at relatively low pressures. During the fourth cycle, the system exhibited a recovery efficiency of 36 percent after recharging for only one month and a storage period of 120 days. The testing indicated that the Upper Floridan Aquifer would be conducive to future implementation of larger-capacity ASR at this site at rates of 5 MGD, with high recovery efficiency.

West Palm Beach ASR Well: The City of West Palm Beach is currently operating an ASR system approximately 11 miles southeast of the C-18W impoundment. The ASR system is operating at recharge rates in excess of 7 MGD within the upper FAS, and is currently conducting test cycles using filtered surface water. The City has obtained a water quality criteria exemption from the FDEP that is allowing the ASR system to operate without a disinfection treatment process. This regulatory mechanism may be available for pursuit at this project.

US Sugar ASR Test Well: During 1992, United States Sugar Corporation constructed a test well system approximately 11 miles to the west of the C-18W Reservoir footprint. A 6-inch test well, cased to the top of the FAS at a depth of 925 feet bls, with an open-hole extending to 1,690 feet bls. The well was hydraulically tested and indicated that the upper FAS exhibited a transmissivity of 540,000 gpd/ft and a

corrected specific capacity of between 68 and 97 gallons per minute per foot of drawdown. These attributes indicate that a larger diameter ASR well at this location could be pumped at rate of 5 MGD while exhibiting reasonable drawdowns and recharge pressures. Additionally, the water within the upper FAS exhibited chloride concentrations of between 1,100 and 1,800 mg/L, which are similar to other ASR facilities that have experiences high recovery efficiencies in the lower east and west coasts of Florida.

Royal Palm Beach Injection Well: The stratigraphy at the Royal Palm Beach deep injection well, located seven miles south of the C-18W Reservoir footprint, confirms that the upper FAS is present at a depth of 900 feet bls, and artesian limestone and dolomitic intervals are present to a depth of over 2,500 feet bls. These findings indicate that multiple, vertically "stacked" zones may available for high capacity water recharge and storage in this area.

PB-1133: In 1955, Amerada completed a petroleum exploration borehole to a depth of 11,000 ft in what is now J.W. Corbett WMA, immediately northwest of the proposed C-18W Reservoir. The UFA was identified at depths between 685 and 1,172 feet bls, and was characterized as permeable.

PBF-15: A tri-zone monitor well was constructed by the SFWMD to measure groundwater levels continuously in FAS permeable zones. Two permeable zones suitable for storage were identified between depths of 890 to 1,100 feet bls. While drilling through this interval, the well drilling process experienced numerous lost circulation zones, indicating highly fractured or otherwise permeable strata within the upper FAS that would be capable of accommodating high-capacity recharge and recovery rates.

C.4 Hydraulic Design

C.4.1 Hydraulic Design Approach

Due to the short timeframe between the choice of the TSP and the completion of the Draft Engineering Appendix, information presented herein describes the activities that occurred prior to the TSP selection, during the formulation of project alternatives in the plan formulation and evaluation phase. This includes a feasibility level of design and additional modeling to support the LECSR-NP model development. An overview of the hydrologic and hydraulic design and analyses, including documentation of the hydrologic modeling and model results is presented below.

Hydraulic data were gathered from several sources, including canal and structure "As-Built" drawings and flow and stage recorders. The project canals were assumed to be maintained to "As-Built" specifications. Operations of the proposed project structures will be detailed in a Project Operating Manual which will also address the operations of related SFWMD and local water control district structures. Detailed design and construction will also require coordination with many agencies. The design and construction of project features will meet all applicable federal, state, and local regulatory requirements.

C.4.2 Canals

Current canal design capacities will be maintained in existing canals in the LRWRP area, unless modifications are required due to the proposed project features (

Table 3). Based on initial analysis, the existing canals (M-Canal, western portion of the M-O Canal, C-18 Canal, and C-14 Canal) have adequate capacity to convey water from the reservoir to the Northwest Fork of the Loxahatchee River. However, with increased discharges proposed from the C-18W Reservoir, it is possible that the C-18W Canal may need to be widened or deepened.

Table 3. Canals in the LRWRP project area

Canal	Flow-way	Design needed
M	1	No, existing
L-8	1	No, existing
C-18	1	No, existing
L-8 Tieback	1	No, existing
C-18W	2	Yes, Possible Modifications
M-O	2	Yes, Modifications to Eastern Portion
M-O Connector	2	Yes, New diversion canal
Ranch Colony	3	Yes, Modifications
HSLCD	3	Yes, Modifications
C-18E	1 & 2	No, existing
C-14	1 & 2	No, existing

Several local drainage canals will need to be relocated or modified, including the southern portion of Hobe St. Lucie Control District (HSLCD) outfall canal and Thomas Pepper Farms outlet canal. The eastern portion of the M-O Canal will require modifications to ensure the appropriate conveyance capacity to the M-O Canal Connector pump station. One new canal is proposed as part of this project, the M-O Canal Connector. Preliminary design of diversion canals for the project or improvements to existing canals will be based initially on the relationship Q = vA, where Q is the flow rate, v is the flow velocity, and A is the cross-sectional area. Cross-sectional area of proposed or modified canals will be sized such that velocities and associated scour or canal embankment erosion is minimized. Canals will be designed to maintain a velocity of 2.0 ft-per-second (fps) or less to avoid potential erosion damage. The hydraulic performance of any necessary conveyance canals will be verified through additional analysis such as HEC-RAS modeling. It is expected that material excavated from canals will be used to fill other canals as part of wetland restoration efforts, side cast along the canal bank or if suitable used to form berms around wetland perimeters or as fill for the proposed reservoir components.

C.4.3 Culvert

The proposed project includes either modifying or designing 8 gated culvert structures, as described in Table 4. Gated culvert structures provide control of culvert flow using sliding gates. The design discharges

for the project gated culverts will assume the gates are completely open, out of the water, and do not restrict flow through the structures. The conceptual designs of these structures will be standardized whenever possible to simplify design, construction, and future operations and maintenance. Culverts are hydraulically short conduits that convey flow through embankments or past some other obstruction to flow. They are constructed from a variety of materials and are available in many different shapes and configurations. They may be single-barrel or multiple-barrel structures. An exact theoretical analysis of culvert flow is extremely complex because the flow is usually non-uniform, with regions of varying flow. Hydraulic jumps often form inside or downstream of the culvert barrel. As the flow rate and tail water elevations change, the flow type within the barrel changes. An exact hydraulic analysis involves backwater and drawdown calculations, energy and momentum balance, and application of the results of hydraulic studies. An extensive hydraulic analysis is usually impractical and not warranted for the design of most culverts. Culvert design, therefore, is often based on empirical approximations. One of the first steps is to establish the type of control that applies.

Table 4. Gated Culverts Requiring Further Design

Location	Proposed Q (cfs)	Purpose	Length (ft)	Flow-way
Cypress Creek Canal	Variable	Automate inlet control on WCS 1 through 4	Variable, 50 - 86	3
G-161	150	Multipurpose, connect GWP to LRWRP	240	1
C-18W Reservoir	200	Discharge Structure from Reservoir	Approx. 300	2
J.W. Corbett WMA	150	Connection of J.W. Corbett WMA run-off to the C-18W Reservoir	50	2
Seminole-Pratt Whiney Road	200	Connection between J.W. Corbett WMA area and M-O Canal connector to the C-18W Reservoir	50	2

The types of control used in the design of culverts are:

Inlet Control – Culverts under inlet control generally function with tail water elevation below the top of the culvert. Supercritical flow is usually encountered within the culvert barrel.

Outlet Control – Culverts under outlet control generally function with submerged outlets and subcritical flow within the culvert barrel. For each type of control, different factors and formulas are used to compute the hydraulic capacity of a culvert. Under inlet control, the cross-sectional area of the culvert, inlet geometry, and elevation of headwater at entrance are of primary importance. Outlet control involves the additional consideration of the tail water elevation of the outlet channel and the slope, roughness and length of the culvert barrel. Outlet control will be used for the design of the LRWRP project culverts. A

discussion of these two types of control with charts for selecting a culvert size for a given set of conditions is included in the Federal Highway Administration (FWHA) Hydraulic Design Series No. 5, "Hydraulic Design of Highway Culverts." HEC-RAS modeling and spreadsheet tools will be used to perform the necessary calculations. The design flow that is provided for a project culvert is for the entire structure, whether it is single- or multiple barrel. Stilling basins and riprap will be added to many of the culvert designs to provide energy dissipation and erosion protection. Computational methods for culvert design are described further in EM 1110-2-1602, Hydraulic Design of Reservoir Outlet Works, EM 1110-2-2902, Conduits, Culverts and Pipes, and FHWA-IP-85-15, Hydraulic Design of Highway Culverts.

C.4.4 Weir or Gated Spillway

The TSP includes the design of multiple gated spillways or weir structures. An ogee weir concrete spillway with steel vertical lift gates is proposed for both the G-160 structure and the Ranch Colony Canal Structure. The vertical gates allow for controlled discharge operations which are desired for operational flexibility and to facilitate adaptive management. Gated structures are proposed in key areas or where higher flows need to be more actively managed. The Hobe Grove Ditch Weir will be a passive structure with no gate. Spillway design will be in conformity with engineering guidance found in USACE EM-1110-2-1603.

3.4.4.1 Emergency Discharge Structure

The C-18W Reservoir is to be located directly north of the Acreage residential community. Due to the proximity of the proposed impoundment to the community, the impoundment was designated as "High" hazard, requiring an overflow emergency spillway. Emergency overflow spillways are non-gated non-mechanical structures that do not require human intervention for uncontrolled discharge operations. An emergency overflow spillway allows for increase public safety, as excess water is able to be discharged from the spillway at a higher rate than the normal discharge structure would allow, thus lowering the maximum surcharge pool level. The proposed emergency discharge structure will have a 50-ft width and invert elevation set to 1 foot above the designed normal pool elevation.

C.4.5 Reservoir Design

The TSP features proposed include one high hazard potential classification (C-18W Reservoir) and one low hazard potential classification (Gulfstream West, Flow-through Marsh) features per Design Criteria Memorandum (DCM-1) Hazard Potential Classification (DCM-1, 2005). This classification dictates additional reservoir design criteria presented in DCM-2 through DCM-5. This criteria as well as USACE criteria are presented in Table 5 below and will be followed during PED phase.

Table 5. USACE Engineering Manuals & DCM Reservoir Design Criteria.

Engineering Analysis	Description
Seepage	1110-2-1901 Seepage Analysis and Control from Dams
Slope Stability	1110-2-1902 Slope Stability
Settlement	1110-1-1904 Settlement Analysis
Canals	1110-2-1601 Hydraulic Design of Flood Control Channels
Embankments	1110-2-1614 Design of Coastal revetments, Seawalls, and Bulkheads
DCM-1	Hazard Potential Classification

DCM-1	Wind and Precipitation Design Criteria for Freeboard
DCM-3	Spillway Capacity and Reservoir Drawdown Criteria
DCM-4	Minimum Dimensions of Dams and Embankments
DCM-5	Major Pump Station Engineering Guidelines

C.4.6 Pump Station

The TSP includes multiple pump stations, as specified in Table 6. The project pump stations include the M-1 Basin pump station, M-O Canal Connector pump station, Mack Dairy Spreader pump station, Gulfstream West flow-through marsh pump station, pump station for the redirection of the Thomas Pepper Farms, one inflow pump station and one to two perimeter canal seepage return pump stations for the C-18W Reservoir, and the pump stations required for the ASR system. Pump station capacities were originally estimated for the LECSR-NP model using historical knowledge of the proposed pump station upstream and downstream conditions as well as the desired hydrologic outcome with the addition of the pump station. Prior to the final PIR, pump station capacities may be further refined through analysis of the LECSR-NP results as well as additional hydrologic modeling for optimization of the TSP. The expected range of water surface elevations on both the intake and discharge sides of each pump station may be determined through canal stage records, local ground elevations, and operational parameters from the hydrologic modeling. These elevations will be used to define the normal pumping head differential and the maximum pumping head differential for each pump station. These head differentials provide mechanical engineers with the static head component of the total head value that the pumps must overcome. Pump mixes will also be suggested to provide flexible operations during varying headwater and tail water conditions, while minimizing pump cycling. Redundancy of pump sizes will be utilized to reduce operations and maintenance costs. Redundancy and telemetry operations will also be required for pump stations that have a flood control component. For the medium and large pump stations, a separate smaller pump will handle base flow from seepage. The preliminary designs of these structures will be standardized whenever possible to simplify design, construction, and future operations and maintenance. Computational methods for pump station design are described further in EM 1110-2-3102, General Principles of Pump Station Design and Layout, EM 1110-2-3104, Structural and Architectural Design of Pumping Stations, and EM 1110-2-3105, Mechanical and Electrical Design of Pump stations.

Table 6. TSP Proposed Pump Stations.

Location	Purpose (from to); size	Flow-way	Provides Flood Control
M-1 Basin	Transfer of water from the lower M-1 Basin (Lower ITID) to the M-Canal for deliveries to the River; 75 cfs	1	No
M-O Canal Connector	Connect the M-O Canal (ITID Basin) to the C-18W Reservoir; 200 cfs	2	No
C-18W Reservoir	Inflow to reservoir from C-18W Canal and inflow/seepage management along western perimeter of proposed reservoir footprint; 300 cfs and 250 cfs, respectively	2	Yes
Ranch Colony Canal/Cypress Creek Canal	Mack Dairy Spreader – Deliver water from the Ranch Colony Canal to the Cypress Creek Natural area for rehydration; 50 cfs	3	No
Gulfstream West	Distribute water from the HSLCD Canal to the flow through marsh; 250 cfs	3	Yes
Thomas Pepper Farms	Redirect Thomas Pepper Farms drainage to the northern Pal-Mar East drainage canal; 40 cfs	3	Yes

C.4.7 Aquifer Storage and Recovery System

ASR systems consist of a surface facility with water pre-treatment components, intake and outfall structures, one or more recharge/recovery (or ASR) wells, and groundwater monitoring wells. Surface water will enter the ASR well through an intake structure consisting of a wet well in which the recharge pump is submerged. Recharge pump specifications are:

- Vertical turbine pump
- 3,500 GPM (5 MGD) capacity
- 300 horsepower
- Stages
- Constant speed drive
- Nominal efficiency 95.4 percent

Pumped water passes through a filter to remove particulates, and is then conveyed by pipe to the ASR wells which are constructed to convey flow at a rate of 5 MGD (3,500 gallons per minute), resulting in velocities of 2.5 ft per second in the well bore. Wells have telescoping casings, with a 42-inch diameter steel pit casing, enclosing a 34-inch diameter steel surface casing through the surficial aquifer. A 24-inch steel production casing extends to the depth of the storage zone. Water is pumped into the limestone rock storage zone at an uncased, unscreened “open interval” at depths of approximately 800 ft to 1000 ft bls. Precise depths of each cased interval, well and final well construction specifications are determined during construction of the exploratory borehole.

Stored water is recovered using a separate recovery pump located on the ASR wellhead. Recovery pump specifications are:

- Vertical turbine pump
- 3,500 GPM (5 MGD) capacity
- 3 stages
- 150 horsepower
- Constant speed drive

Recovered water is then released into the C-18W Reservoir via a pipe. The pipeline connecting the ASR well with the impoundment interior must traverse a high-head embankment. The design of the outlet structure will be defined further pending hydraulic analysis of flows and geotechnical evaluation of embankment construction.

C.4.8 Hydraulic References

Hydraulic design of the water control structures is based on U.S. Army Corps of Engineers Engineering Manuals, U.S. Department of Transportation, FHWA Design Criteria, and SFWMD rules and regulations. Applicable guidance includes:

- EM 1110-2-1412 Storm Surge Analysis and Design Water Level Determinations
- EM 1110-2-1414 Water Levels and Wave Heights for Coastal Engineering Design
- EM 1110-2-1415 Hydrologic Frequency Analysis
- EM 1110-2-1420 Hydrologic Engineering Requirements for Reservoirs
- EM 1110-2-1601 Hydraulic Design of Flood Control Channels
- EM 1110-2-1602 Hydraulic Design of Reservoir Outlet Works
- EM 1110-2-1603 Hydraulic Design of Spillways
- EM 1110-2-1901 Seepage Analysis and Control for Dams
- EM 1110-2-1913 Design & Construction of Levees
- EM 1110-2-2220 Gravity Dam Design
- EM 1110-2-2300 Earth & Rock-Fill Dams General Design & Construction Considerations
- EM 1110-2-2400 Structural Design of Spillways & Outlet Works
- EM 1110-2-2701 Vertical Lift Gates
- EM 1110-2-2902 Conduits, Culverts and Pipes
- EM 1110-2-3102 General Principles of Pumping station Design and Layout
- EM 1110-2-3104 Structural and Architectural Design of Pumping Stations
- EM 1110-2-3105 Mechanical and Electrical Design of Pump stations
- EM 1110-2-5027 Confined Disposal of Dredged Material

- ER 1110-8-2(FR) Inflow Design Floods for Dams and Reservoirs
- FHWA-IP-85-15 Hydraulic Design of Highway Culverts
- Basis of Review for Environmental Resource Permit Applications within the South Florida Water Management District, Appendix 6-Above Ground Impoundments
- CERP Standard Design Manual

C.5 Structural Design

C.5.1 Structural Design Criteria

Structural design of the proposed structures will be completed during the design phase. During design phase the structural calculation will be completed after survey, hydraulic design, and geotechnical investigations are performed. The structural design will conform to the appropriate Engineering Manuals (EM), Engineering Regulations (ER), or Design Criteria Memorandums (DCM).

Structural design criteria is governed by multiple Engineering Manuals published by the Army Corps of Engineers as well as manuals from the American Society of Civil Engineers (ASCE) and American Concrete Institute (ACI). All designs use the Load Resistance Factor Design (LRFD) methodology which assigned factors to increase the ultimate loading from dead and live loads experienced by the structure. More detailed descriptions of the loading conditions and design can be found below.

C.5.2 Loading Conditions

Each standard design will be developed to withstand usual, unusual, and extreme loading conditions. Usual loading conditions include loads most frequently experienced by the structural system when performing its primary function throughout its normal service life. Unusual loading conditions, such as construction or maintenance operations, produce short duration loads, and their occurrence is not frequent. Extreme conditions such as the standard project floods, and hurricane wind force represent the worst case scenario; extreme loads represent the widest deviation from the usual and unusual loading conditions.

C.5.3 Stability

EM 1110-2-2100, Stability Analysis of Concrete Structures, will be followed for flotation, overturning, and sliding stability analyses. According to EM 1110-2-2100, a factor of safety is required in sliding and flotation stability analyses to provide a suitable margin of safety between the loads that can cause instability and the strength of the materials along potential failure planes that can be mobilized to prevent instability. The required factor of safety is a product of a basic factor of safety, a loading condition factor to account for load condition probability, a structure importance factor to account for the different risk levels accepted for critical and normal structures, and a site information factor to account for the knowledge of the structure and foundation strength parameters.

C.5.4 Concrete

EM 1110-2-2104, Strength Design for Reinforced Concrete Hydraulic Structures, and ACI-318-14, Building Code Requirements for Structural Concrete, will be used for structural concrete design. According to EM 1110-2-2104, dead and live loads are multiplied by a hydraulic load factor of 1.3 in addition to the basic

load factor. Basic load factors for dead and live loads are both multiplied by 1.7 for hydraulic structures. If a structure has large dead loading and limited fluid pressures, ACI 318 load factors can be used. The compressive strength of concrete is designed to resist the factored loads on the hydraulic structure.

C.5.5 References

The following additional design manuals were used in the development of standard designs:

- ASCE 7-10 Minimum Design Loads for Buildings and Other Structures
- EM 1110-2-2105 Design of Hydraulic Steel Structures
- EM 1110-2-2502 Retaining and Flood Walls
- EM 1110-2-3102 General Principles of Pump station Design and Layout
- EM 1110-2-3104 Structural and Architectural Design of Pump stations
- EM 1110-2-2400 Structural Design of Spillways
- EM 1110-2-2902 Conduits, Culverts, and Pipes
- EM 1110-2-2007 Structural Design of Concrete Lined Flood Control Channel
- CERP Standard Design Manual

C.6 Mechanical and Electrical Design

Pump stations will be designed in accordance with (but not limited to) the following:

- EM 1110-2-3102 General Principles of Pump station Design and Layout
- EM 1110-2-3105 Mechanical and Electrical Design of Pump Stations
- Hydraulic Institute (HI) Standards
- SFWMD's Major Pump Station Engineering Guidelines (MPSEG)
- CERP Standard Design Manual

The pump mix for the proposed Gulfstream West, Mack Dairy Spreader, C-18W Reservoir, Thomas Pepper Farms, and M-O Canal Connector pump stations will be further developed during the design phase of the project. Pump drivers will be selected during the PED phase, and will be based on flood control requirements and available utilities.

The pumping station electrical design shall be in accordance with NEC, NFPA, IESNA, TIA/IEA, IEEE, and recommended practice. During design phase the mechanical and electrical calculations will be completed after the hydraulic design is performed, the pump mix is determined, and the structures' normal and emergency operating parameters are finalized.

D. HYDROLOGIC MODELING

D.1 Approach

Modeling has been a central aspect of project planning for the Loxahatchee River Watershed Restoration Project. The objective was to demonstrate the extent to which each of the PDT proposed alternatives met

specific ecological measures and performed relative to the project area's base condition. Modeling results increased the PDT's understanding of the existing hydrologic system and the range of expected responses of proposed project features. Two complementary hydrologic and hydraulic modeling approaches were used to evaluate alternatives and identify the TSP.

The PDT selected the LECSR-NP model (Giddings *et al.,* 2006) to simulate regional hydrology and Hydrologic Engineering Center River Analysis System (HEC-RAS) for evaluating local canal stages for savings clause performance. The LECsR model was developed by the SFWMD as a regional water resources planning tool for the entire southeast coast of Florida. It was refined specifically for LRWRP in order to adequately address the proposed CERP project assumptions for plan formulation and evaluation. The resulting sub-model is referred to as LECSR-North Palm Version (NP) (Obeysekera et al, 2018, Giddings and Obeysekera 2018). HEC-RAS was developed by the U.S. Army Corps of Engineers and is designed to perform one-dimensional and two-dimensional hydraulic calculations for a full network of natural and constructed channels. The current version supports steady and unsteady flow water surface profile calculations. The LECSR-NP and HEC-RAS model software are both approved by the USACE Hydrology, Hydraulics & Coastal (HH&C) Community of Practice. Table 7 provides a summary of the models used and their application. Historic planning level hydrology and hydraulic modeling efforts in the LRWRP project area are available at the Statewide Model Management System (SMMS). http://apps.sfwmd.gov/smmsviewer.

It is expected that higher resolution hydrologic and hydraulic modeling tools will be required to further analyze localized and possibly regional-scale effects of specific components of the LRWRP Recommended Plan, with the scope of these analyses identified during the PED phase of the project. The optimization and refinement of features is possible in LECSR-NP and HEC-RAS. However, optimization simulations have been deferred to the PED phase.

Table 7. Summary of Key Hydrology and Hydraulics Models for current LRWRP study.

Model	Application
LECSR-NP	Regional hydrology (stages and flows over through structures) – SFWMD
HEC-RAS	Canal routing and changes in canal stages - USACE

D.2 LECSR-NP

In August 2016, the LRWRP PDT selected the LECSR-NP hydrologic model (Giddings *et al.,* 2006) to simulate and compare the performance of four alternatives relative to a future without project and existing base condition. The LECsR model boundaries were changed and refinements were made for the LRWRP project during the development of the sub-model, LECSR-NP (Obeysekera *et al.*, 2018 and Giddings and Obeysekera, 2018). During the 2016 LECSR-NP model implementation, multiple significant model updates were completed, including:

- Incorporated updated topography and land use as well as additional hydrogeologic information.
- Revised control structure operations and weir elevations in Martin County and portions of Palm Beach County.
- Improve simulation of coastal well fields.

- Revised active model domain and wetland assumptions.
- Included multiple model refinements in the Flow-way 3 area.
- Revised evapotranspiration, rainfall and runoff calculations
- Revised calibration period 2006-2014, includes a number of additional wetland and groundwater monitoring sites recently installed

D.2.1 Conceptual Model

The LECSR-NP utilizes USGS MODFLOW (Harbaugh and McDonald 1996, Harbaugh et al., 2000) computer code with independent subroutines called modules. The modules, in turn, have been grouped into packages which deal with a particular hydrologic process or solution algorithm. Further details can be found in the Model Calibration Report (Obeysekera et al., 2018) and Model Application Report (Giddings et al., 2018). While there are limitations to the model (e.g., no canal conveyance capabilities, limited ability to handle complex water management operations), it provides reasonably good estimates of water stages and flows over/through structures over a period of record. The LECSR-NP should not be applied for detailed engineering analyses and results should only to be used comparatively for predictions (Obeysekera et al, 2018, Giddings and Obeysekera 2018). The project boundary and model domain are shown in Figure 8.

To simulate surface water processes, several additional packages were implemented in the code to allow for routing of overland flow in wetland systems and operational packages to simulate canal structure operations and weir flow equations. The MOD-FLOW packages used are described in Table 8.

Table 8. MOD-FLOW packages used in the LECSR-NP model for the LRWRP.

Package	Application
River (RIV)	Used to simulate rivers and canals that can contribute water or drain water from the groundwater aquifer. Head values are specified in the river package for each cell.
Drain (DRN)	Used to simulate the effects of existing drainage canals and ditches. Removes water from the model when the elevation is above the control elevation for the drain.
Reinjection Drainflow (RDF)	Similar to the Drain package except that it allows water to be redirected to another location in the model instead of being permanently removed from the model
Diversion (DIV)	Simulates the effects of water control structures (e.g., pumping stations, gravity flow drains, weirs) on water levels
Wetland (WTL)	Simulates overland flow in wetlands using the uppermost model layer and barriers to flow.

The LECSR-NP Model is a three-dimensional numerical model consisting of 704 x 704 foot cells with 3 vertical layers. There are 292 rows and 408 columns which cover portions of southern Martin County and northern Palm Beach County. Temporal discretization is applied as a daily time step in a daily stress period

which allows for an adequate level of sub-regional accuracy. Additional information on model conceptualization can be found in Giddings and Obeysekera (2018) and Obeysekera et al (2018).

The LECSR-NP Model uses historical climatic conditions to represent rainfall and reference ET across the model domain. Tidal stages are also represented by historical conditions. For model calibration, canal stages for Lake Okeechobee, L-8, C-44, and C-51 are governed by historical conditions, while model application uses canal stages from the South Florida Water Management Model (SFWMM). Additionally, during model calibration historical flows from the Control 2 structure along the M-Canal to the City of West Palm Beach are used, while the model application uses flows from SFWMM.

The LECSR-NP model provided output for water stages at cells located throughout the study area as well as flows at key locations such as Lainhart Dam, C-18W Weir, S-46, G-92, G-160, and G-161. The model also tracked reservoir stages to determine the storage capacity and water supply availability at any given time. Output was in many forms including, but not limited to, stage-duration curves, stage hydrographs and flow-frequency curves. The modeling results are to be evaluated comparatively (i.e., evaluating the relative difference between two simulations); results from a particular simulation should not be taken as absolutes.

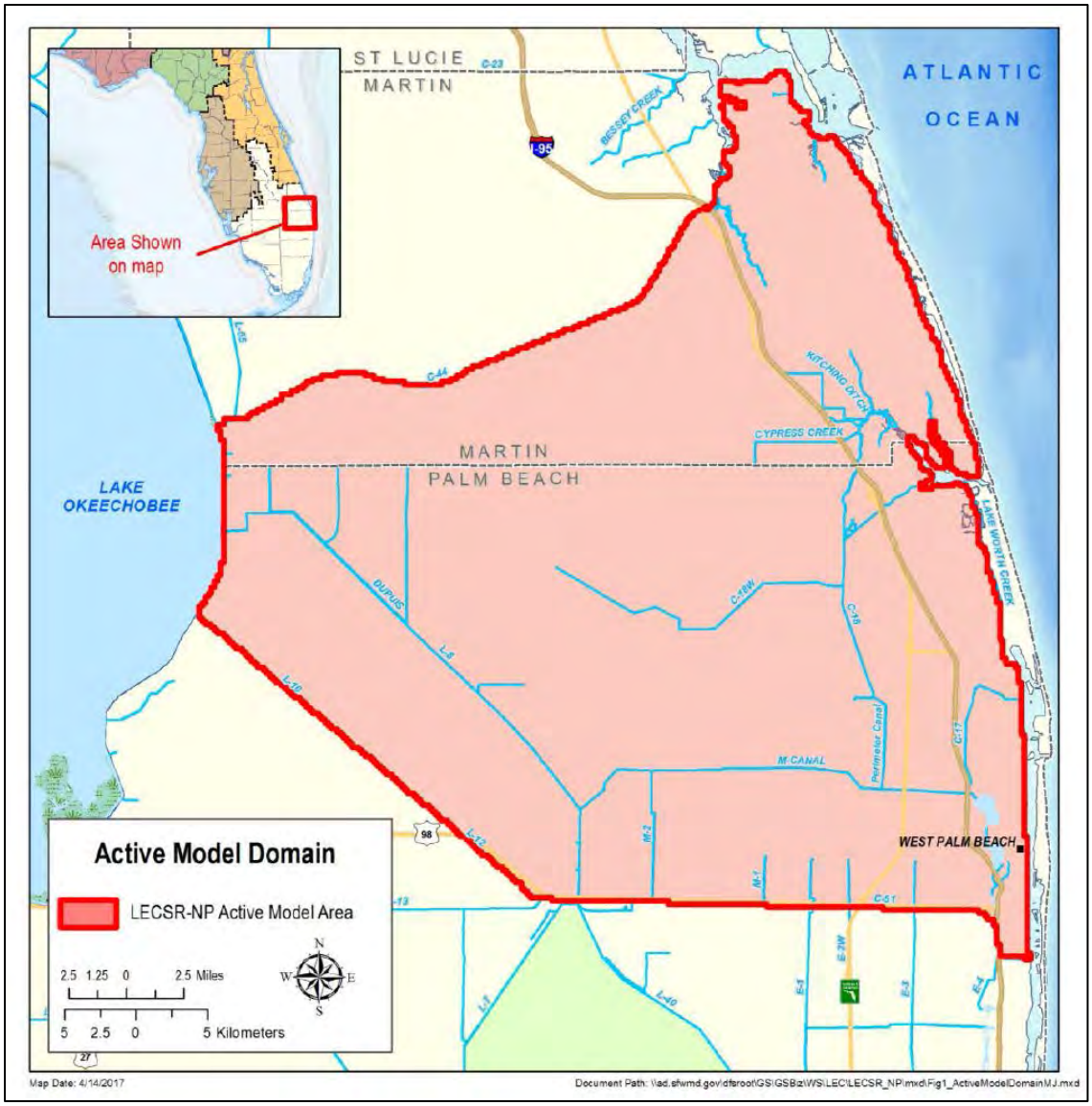


Figure 8. Project Boundary and LECsR-NP Model Domain

D.2.2 Model Calibration

To ensure the model simulates the proper hydrologic processes, the model is calibrated to the observed conditions during the period from 2006 to 2014. This period included both wet (tropical or subtropical events) and dry conditions. The primary goal of the calibration process is to meet both the qualitative and quantitative criteria and targets identified. The modeled error, as measured by statistical analysis, should be minimized by the calibration process. Both flow and water level stages (groundwater and surface water) were used for quantitative calibration criteria for overall performance whereas a qualitative analysis was performed for the water budgets and the Wetland Rapid Assessment Procedure (WRAP) cells. The quantitative analysis was performed using statistical calibration criteria and targets, as specified in Table 9.

Table 9. Calibration and Validation Statistical Analysis

Criteria	Analysis	Description
Coefficient of Determination (R^2)	Structure Flow	Coefficient of determination measures the goodness of fit. The target is a R^2 value greater than 0.4.
Nash-Sutcliffe (NS)	Structure Flow	Nash-Sutcliffe is a model efficiency coefficient that indicates the predictive power of models. The target is a NS value greater than 0.4.
Deviation of Volume (DV%)	Structure Flow	Deviation of volume measures the difference between historical and simulated flow volumes. Positive values indicate that the model is underpredicting, negative values indicate that the model is overpredicting. The target is a DV within + 15%.
±Range Error Target (% of time target met)	Water Level Elevations (groundwater and surface water)	Percentage of time that simulated head lies within a plus or minus range error target (ft) of the observed head. Each individual calibration location has its own criteria based on 20% of the absolute difference of minimum and maximum observed values during the calibration period.
Mean Error (ft)	Water Level Elevations (groundwater and surface water)	The mean error is the mean difference between measured and simulated heads.
Mean Absolute Error (ft)	Water Level Elevations (groundwater and surface water)	The mean absolute error is the mean of the absolute value of the differences in measured and simulated heads.
Root Mean Squared Error (ft)	Water Level Elevations (groundwater and surface water)	The root mean squared error is the average of the root of the squared differences in measured and simulated heads.

Each water level calibration location has its own criteria. The acceptance range error target for mean error, mean absolute error, and root mean squared error also are based on the 20% range of the absolute difference of minimum and maximum observed values. The calibration statistics for the flow locations (structure flow) are shown in Table 10 and the overall calibration statistic for the water level elevations are in

Table 11. The wetland and groundwater monitor well calibration gage locations are shown in

Figure 9.

Manual sensitivity analysis was conducted by SFWMD to determine which model input parameters were most sensitive within the LECSR-NP model domain. Both simulated heads and simulated flows were checked during the sensitivity analysis. The tested parameters include vertical hydraulic conductivity,

horizontal hydraulic conductivity, river, drain, and general head boundary conductance, specific yield, groundwater recharge, and saturated zone et. Additional details and results of the sensitivity analysis can be found in the calibration report from Obeysekera et al. (2018).

The model was considered reasonably calibrated and could be used to compare between alternatives and base conditions for the purpose of identifying a TSP. Multiple agencies participated in the discussion during calibration, including the Florida Department of Environmental Protection, Interagency Modeling Center, U.S. Army Corps of Engineers, and South Florida Water Management District. Calibration and verification results were presented to PDT in meeting on 13 December 2017. A further discussion of the packages and the overall calibration processes and results of the LECSR-NP Model can be found in Obeysekera et al., 2018.

Table 10. Calibration Statistics for Structure Flow, 2006 to 2014

Monitoring Station	R^2	DV (%)	NS
C-18 Weir	0.57	-1	0.57
Lainhart Dam	0.82	-9	0.80
S-46	0.85	-5	0.82
G-92	0.74	2	0.74
G-160	0.76	-5	0.75
Cypress Creek and Hobe Grove Ditch	0.73	-4	0.70
Kitching Creek	0.79	-6	0.78

Table 11. Calibration Statistics for Groundwater and Surface Water (wetland) Elevations

Location	Overall Mean Absolute Error (ft.)
Groundwater Monitor Wells	0.56
Wetland Gages	0.68

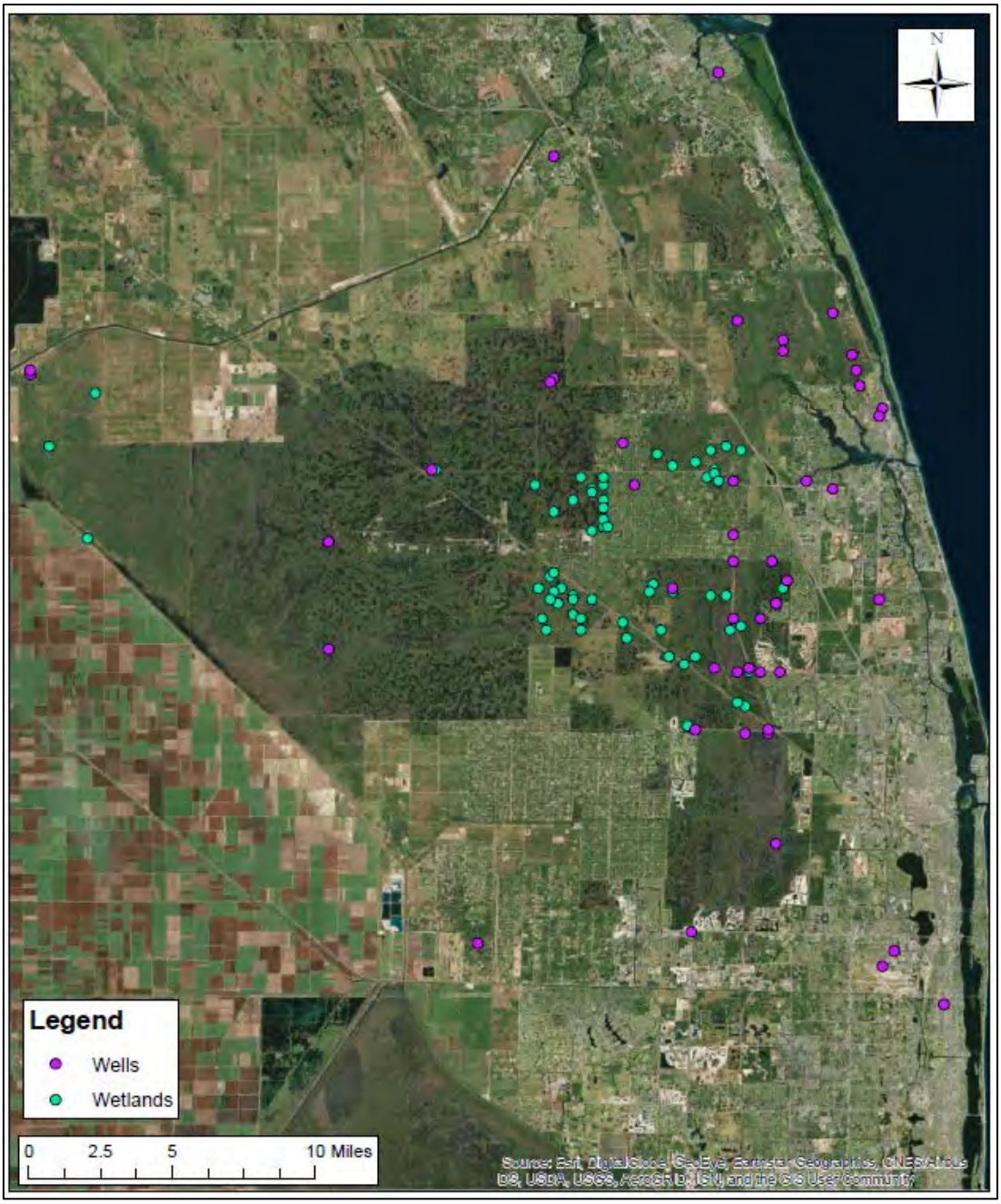


Figure 9. Calibration Gage Locations within the Model Domain for Wetland Gages and Groundwater Monitoring Well Gages

D.2.3 Model Verification

Model Verification is the process to demonstrate that the calibrated model matches a set of field data independent of what was used to calibrate the model. The model verification period was from 2000-2005, as compared to the calibration period that was from 2006-2014. Minor differences in the verification and calibration period are included below:

G-160 and G-161 structures were not operational during the verification period

Significant restoration areas undertaken by Palm Beach County in recent years had not occurred or were just beginning

Large parcels of State owned lands in the project area had not be acquired or recently acquired during the period and had not undergone significant alterations

Similar to the model calibration, statistical analysis were used to compare the model performance against observed data. The validation statistics for the structure flows and water surface elevations are included in Table 12 and Table 13, respectively.

Table 12. Overall Verification Statistics for Structure Flow, 2000 to 2005

Monitoring Station	R2	DV (%)	NS
C-18 Weir	0.71	3	0.71
Lainhart Dam	0.80	-6	0.71
S-46	0.85	6	0.82
G-92	0.60	2	0.56
Cypress Creek and Hobe Grove Ditch	0.88	7	0.87
Kitching Creek	0.83	3	0.81

Table 13. Overall Calibration & Verification Statistics for Groundwater and Surface Water (wetland) Elevations

Element	Overall Mean Absolute Error (ft)
Groundwater Monitor Wells	0.57
Wetland Gages	0.65

D.2.4 Simulations

The model simulates a 2014 Existing Condition Base case (ECB) and a 2070 Future Without Project base case (FWO). Four additional alternatives are simulated: Alternative 2, Alternative 5 (TSP), Alternative 10 and Alternative 13. The two base cases and 4 alternatives are simulated with a period of record from January 1, 1965 through December 31, 2005 (41 years). Historical climate conditions were used for the simulation period, and permitted allocations were used for the demands for all public water supply utilities. The ECB and FWO project bases included most features operating today with some exceptions.

The existing features that are not simulated in either of the base case conditions are the G-160 and G-161 structures and the project culverts along the southern leg of the C-18 Canal. Features simulated in the ECB include the recent modifications to the G-92 structure, the North Lake Boulevard weir, wetland improvement areas constructed by Palm Beach County, regional system deliveries to the City of West Palm Beach, the east J.W. Corbett WMA weir and the existing canal operations for the SFWMD canals, water control districts (298 Districts) and local developments. The main change from ECB not presently observed is the Public Water Supply Utility demands which are based upon the SFWMD permitted allocation and not upon recently observed usage. The FWO project base includes all the ECB assumptions, except it is assumed that the L-8 Flow Equalization Basin is operational and is receiving water from outside of the L-8 Basin. In addition, the FWO project base includes the recent proposal for the Avenir property, which creates two wetland areas on the northern portion of the property and an urban development at the southern section of the property. All alternatives include the components of the FWO project base assumptions unless otherwise specified.

The model simulation period is 14,975 days, or 41 years, and includes rainfall, evapotranspiration, infiltration, runoff, groundwater withdrawals, canal operations, land use, and other factors affecting surface and groundwater flow in South Florida. Output from the model includes daily structure flow, groundwater/surface levels and numerous flow budget terms, for example, groundwater seepage into the Loxahatchee River. Please refer to Giddings and Obeysekera (2018) for additional details regarding the LECSR-NP model application, assumptions, and results.

D.3 HEC-RAS

The HEC-RAS modeling system is designed to perform one-dimension and two-dimensional hydraulic calculations for multiple types of river analysis. The HEC-RAS model was deemed an appropriate tool to analyze surface water impacts in the Flow-way 3 area as proposed project features may cause potential issues with flood protection. HEC-RAS was used as a preliminary screening tool as an aid in refining the proposed project features for modeling in LECSR-NP. It was the goal of the PDT to use HEC-RAS as a means of determining preliminary geometries for a portion of the Flow-way 3 project features for two reasons 1) the LECSR-NP model would not have to run multiple iterations 2) the team would have a greater level of confidence regarding potential changes in the Flow-way 3 hydraulics when all project features were implemented.

The HEC-RAS model of Flow-way 3 requires further refinements, but would assist in accomplishing the following:

- The HEC-RAS model may refine the topographic, drainage, and hydraulic processes that occur at a scale less than can be captured in a 704 by 704 ft cell used in the LECSR-NP model. These processes, such as flow velocity and water stages, may therefore be captured in the evaluation with a greater level of accuracy.
- HEC-RAS will be used as necessary to address hydraulic design considerations of potential canal conveyance and structural modifications of the TSP. HEC-RAS can be applied as a hydraulic design tool to aid with design of new gravity water control structures and pump stations. Additionally, HEC-RAS can be applied to determine stages in the project area for the TSP versus the ECB and FWO condition.
- The HEC-RAS model may capture local variability in hydraulic properties and operations at a resolution that is able to more accurately assess project impacts.

Due to the limitations of LECSR-NP model in the Flow-way 3 area, this is the primary alternative means for evaluating Project Assurances (flood protection) to residential communities resulting from project improvements.

Examples of how HEC-RAS may be implemented with future model refinements includes the following:

- To test if stages in Culpepper can be met while maintaining discharge capabilities, evaluate if berm improvements and proposed management measures will reduce the hydraulic load on the berm that was previously overtopped at Culpepper;
- To ensure that Thomas Pepper Farm drainage is redirected and channel modifications are appropriate, determine if the Hobe St. Lucie Control District canal is adequately sized based on proposed project conditions;
- To determine the appropriate pumping size and pump conditions for the Gulfstream West flow-through marsh and Mack Dairy spreader.

The HEC-RAS model for Flow-way 3 is still in development, and existing model runs are preliminary. More detailed model simulations will be run and results reported in the final Engineering Appendix.

D.3.1 Conceptual Model

The model domain includes the proposed features of Flow-way 3, including the Ranch Colony Canal structure, Gulfstream West modification, WCS 1-4 modifications in Pal-Mar East (Culpepper area), and the Mack Dairy Spreader system. The purpose of the model is to determine whether the proposed features, when implemented together, will cause increased stages within the Ranch Colony Canal greater than the existing conditions. Stages within Ranch Colony Canal are of importance because overtopping of the canal can cause both flooding and neighborhood drainage issues, as the outlet structures for the neighborhood depend on a particular tail-water stage within Ranch Colony Canal.

The model is constructed using both 1D/2D for existing conditions and the with-project condition, as shown in Figure 10 and Figure 11, respectively. The 1-D areas include the existing and proposed modifications to the HSLCD canal and Ranch Colony Canal. The 1-D cross sectional areas for Ranch Colony Canal were based on survey data from Martin County, recorded in 2000. The HSLCD canal cross sections were estimated based on an average bottom width, side slope, and depth recorded during field investigations. The 1-D Manning's n value was 0.024 for the channels and 0.035 for the overbank due to the presence of vegetation.

The 2-D areas represent the more natural areas that experience unsteady flow through a network of floodplains. The 2-D areas were created using recently flown LiDAR for Martin County (2016) and input into the model as a terrain map layer. The grid cell sizing for the 2-D flow areas averaged at approximately 200 ft by 200 ft. The Manning's n value for the 2-D area varied depending on the land use in the area, which was overlain and imported into the HEC-RAS model.

Preliminary HEC-RAS model simulations were run to provide planning-level detail for input into the modeling assumptions table of the LECSR-NP model output. The model was run using a 25-year, 24-hour storm event as that is the permitting requirement for many of the discharge structures in the area. The boundary conditions for offsite inflow entering the site were estimated using known maximum permitted

discharges. This included the HSLCD canal and all surrounding neighborhood drainage discharges, which were input into the model using a flow hydrograph and lateral inflow hydrograph, respectively. The precipitation was input directly onto the 2-D areas, including Pal-Mar East (Culpepper), Cypress Creek Natural area, and the Gulfstream West property. The downstream boundary conditions were defined using a normal depth of the channel friction slope, estimated using LiDAR imagery of the area.

The preliminary design features for the with-project condition model were incorporated into the HEC-RAS model through manipulation of the terrain map layer or by modifying/adding structures. The design for the flow-through marsh in Gulfstream West was incorporated by smoothing the existing "dog-leg" of the HSLCD canal and extending the existing cross-sectional area to create the new north-south extension. The spreader berms and areas upstream and downstream of the pump intake & discharge were also included in the terrain modifications. Similar terrain adjustments were made for the Mack Dairy pump intake/discharge areas and spreader system. The modifications to the WCS 1-4 in Pal-Mar East were incorporated by modifying the invert elevations for the culverts. Finally, the proposed design for the Ranch Colony Canal was incorporated as an inline structure within the Ranch Colony Canal.

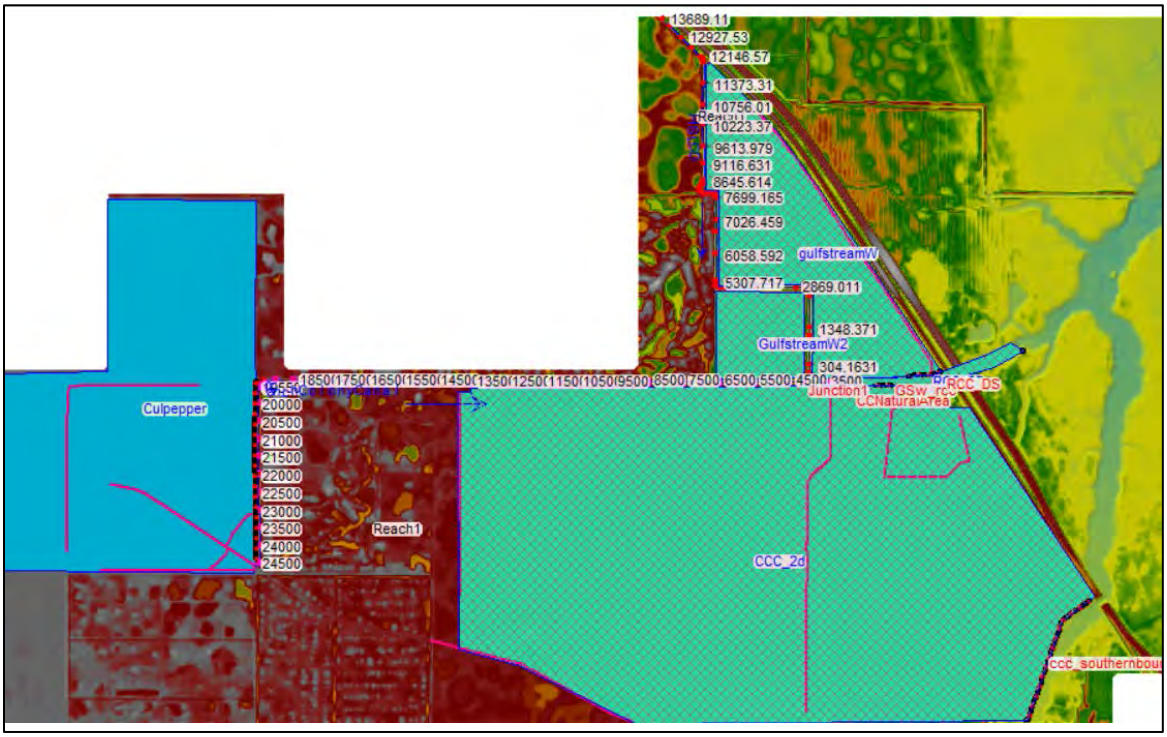


Figure 10. HEC-RAS Existing Conditions for a portion of the Flow-way 3 area.

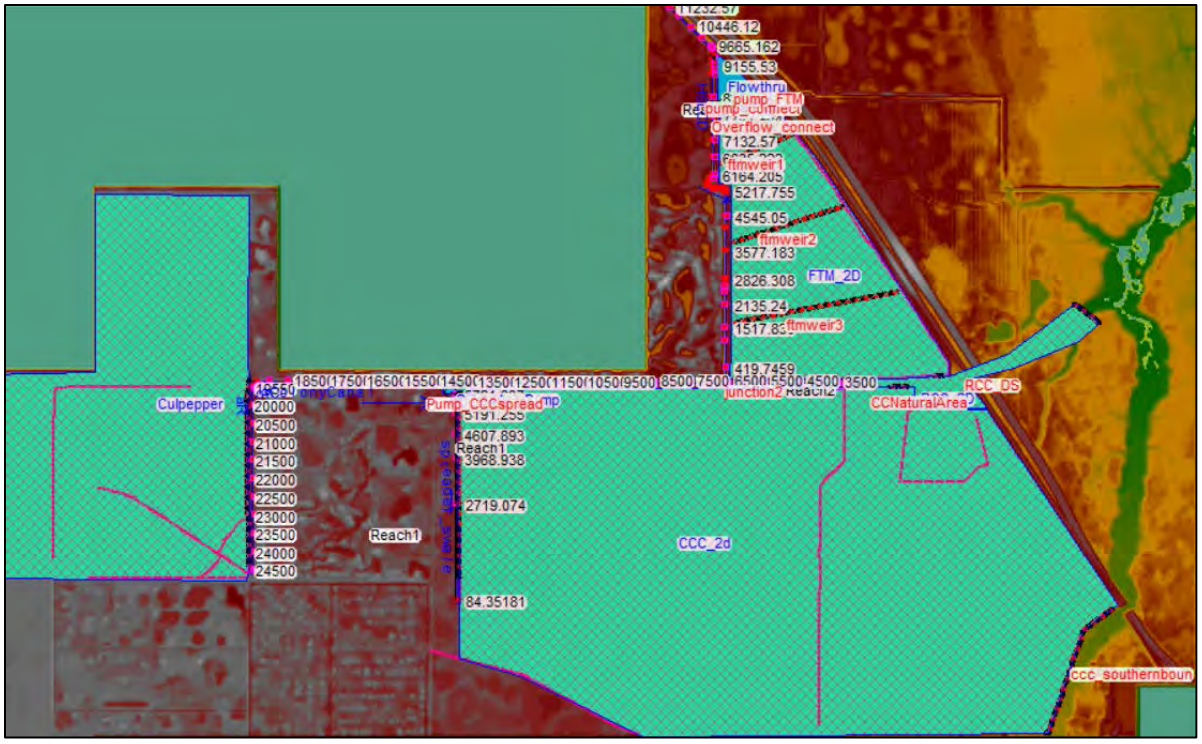


Figure 11. HEC-RAS With-project Condition for a portion of the Flow-way 3 area

D.3.2 HEC-RAS Model Calibration

The HEC-RAS model has not been calibrated to known discharge or stage levels because the Flow-way 3 area has limited stage and discharge gages. Additionally, for proper calibration the model would require either of the following: 1.) model the entire Flow-way 3 area with both a hydrologic and hydraulic model to ensure the rainfall, runoff, and routing processes were properly captured; or 2.) that the upstream boundary conditions, including inflow hydrographs and stages, were taken from a calibrated hydrologic model such as LECSR-NP. At the time of the HEC-HMS model development, the LECSR-NP model was not fully calibrated and verified, so upstream boundary conditions were estimated using the best known data at the time.

The Flow-way 3 HEC-RAS model has not been re-run using the calibrated LECSR-NP output for this draft Engineering Appendix. For the final Engineering Appendix, calibration of the HEC-RAS model will occur if data is available and the model will be refined and re-run for the with-project condition to help refine the TSP component designs.

D.3.3 HEC-RAS Simulations

Preliminary HEC-RAS model simulations were run to compare the stages within Ranch Colony Canal for the existing condition and the with-project condition. There was concern that the addition of a control structure within the Ranch Colony Canal could cause stages upstream of the structure to rise. The model simulations evaluated using varying structure invert elevations to ensure that the proposed Ranch Colony Canal spillway structure (to be simulated in LECSR-NP) did not cause adverse impacts. The modeling results confirmed that the proposed Ranch Colony Canal control structure invert elevation could be set at 9.0 ft NGVD29 (7.54 ft NAVD88) and will not cause adverse impacts to surrounding communities.

As stated above, the model has not been calibrated or verified to date. The HEC-RAS model will be verified for the final Engineering Appendix or during the PED phase.

D.4 Modeling Results

D.4.1 LECSR-NP

The LECSR-NP modeling output was analyzed using multiple types of performance measure graphics at key locations within the model domain. The types of performance measure graphics evaluated included storage reservoirs, profile points, indicator regions, other indicators, profiles, difference maps, flow transects, ASR, structure flows, water supply, and water budget. These performance graphics were utilized by the entire PDT to evaluate the model performance for the base case conditions and the various proposed Alternative conditions. Although all performance measure graphics provide beneficial insight to the model's performance and potential project benefits, the main subset of graphics used for model evaluation, from an engineering design perspective, are discussed below. There are approximately 1,500 performance measure graphics produced from the LECSR-NP output, therefore only a small subset of graphics will be included within this report to aid in the understanding of the analysis and evaluation process performed to ensure the project objectives were met and justified for the TSP. See Giddings and Obeysekera (2018) for further description of modeling application and discussion of results.

4.4.1.1 Flow-way 1 Model Performance, TSP Features

G-160 and G-161

The G-160 structure helps meet project objectives and delivers project benefits by providing additional control and management of water surface elevations within the C-18 Canal and the Loxahatchee Slough. This can be seen in the stage-duration curve for location LS-2 in **Figure 12**, which is located south-east of the proposed G-160 structure within the Loxahatchee Slough. The targeted operations for the G-160 structure are included below:

- December to April: Gate opens at 16.2 ft. NGVD and closes at 15.5 ft. NGVD
- November and May gate opens at 17.1 ft. NGVD and closes at 16.2 ft. NGVD
- June to October (wet season); gate opens at 17.5 ft. NGVD and closes at 17.1 ft. NGVD

G-160 allowable discharge is up to 150 cfs for environmental deliveries, and to maintain flood control capability as necessary for non-environmental deliveries. The modeling results illustrate that the proposed G-160 structure creates the desired effect, namely improvement in the ecology through hydrologic lift of the Loxahatchee Slough area. Additionally, the G-160 structure aids in both the management of water levels within the C-18 and C-18E Canals and the timing of water deliveries to Northwest fork of the Loxahatchee River during the wet and dry seasons. The average monthly structure flow rates for the proposed G-160 structure can be seen in **Figure 13**.

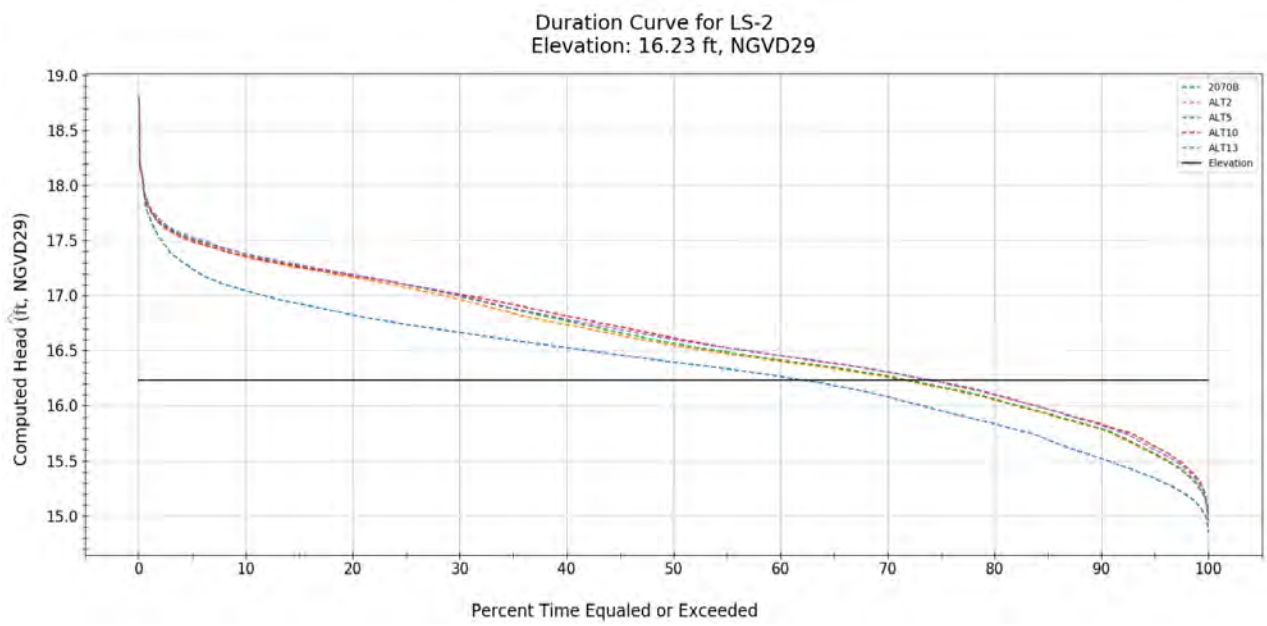


Figure 12. Loxahatchee Slough Stage-Duration Curve

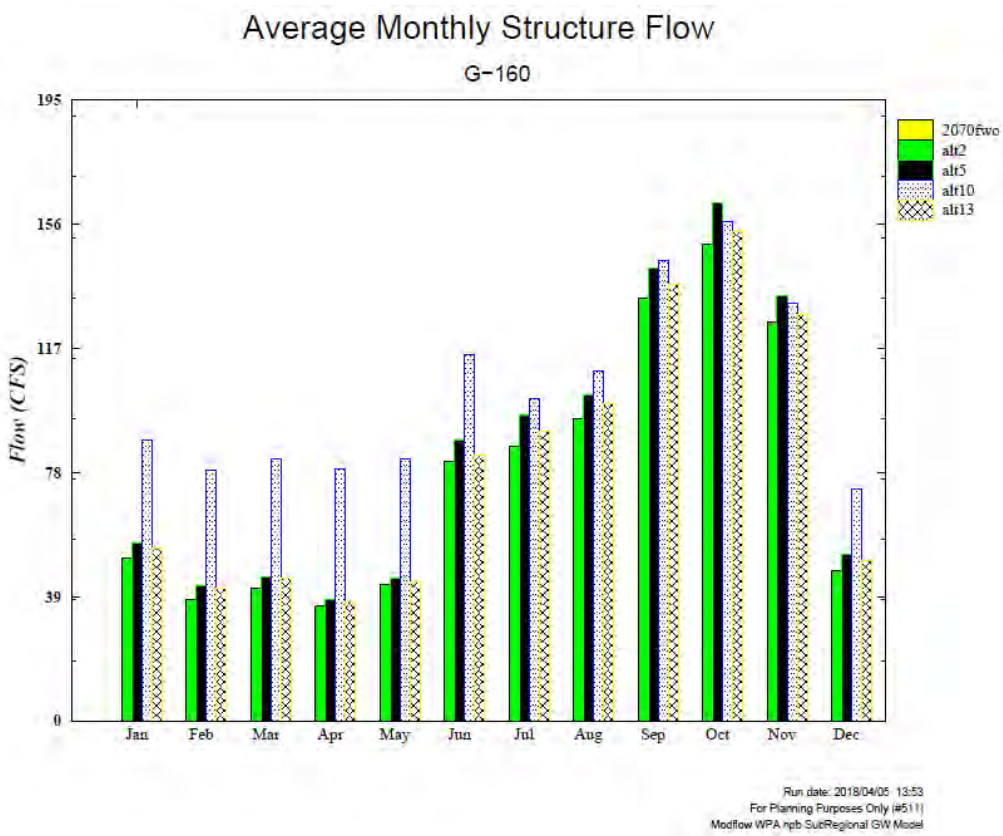


Figure 13. Average Monthly Structure Flow for the Proposed G-160 Structure

The G-161 structure can aid in achieving the target stages in the Grassy Waters Preserve area while simultaneously sending excess water to G-160 and onto the Northwest Fork of the Loxahatchee River. G-161 provides connectivity to the Flow-way 1 features, including GWP, the C-18 Canal and the Northwest Fork of the Loxahatchee River. For Alternatives 2, 5, and 13, up to 20 cfs can move from the northern area of GWP into the C-18 Canal north of the G-160 structure if northern GWP is above 18.4 feet NGVD. Water only moves into the C-18 Canal south leg when stages are below G-160 wet/dry seasonal control elevations described in the section above and if replacement water is available. For Alternative 10, flows through G-161 are up to 50 cfs via the forcemain. Although the average monthly structure flow in Figure 14 illustrates a relatively minor amount of flow being sent through G-161, it is assumed that current model operational assumptions limit the availability of water that can be sent through the G-161 structure. Additional model optimization, through modification of upstream or downstream constraints, may further increase flow rates through the structure. The G-161 structure also provided additional lift within the GWP triangle area, as illustrated in the stage-duration curve in Figure 15. Compared to the 2070 FWO condition, the G-161 structure helps improve the hydrology over a longer duration during the simulation period, potentially leading to improved vegetation communities and additional freshwater availability to the Loxahatchee River.

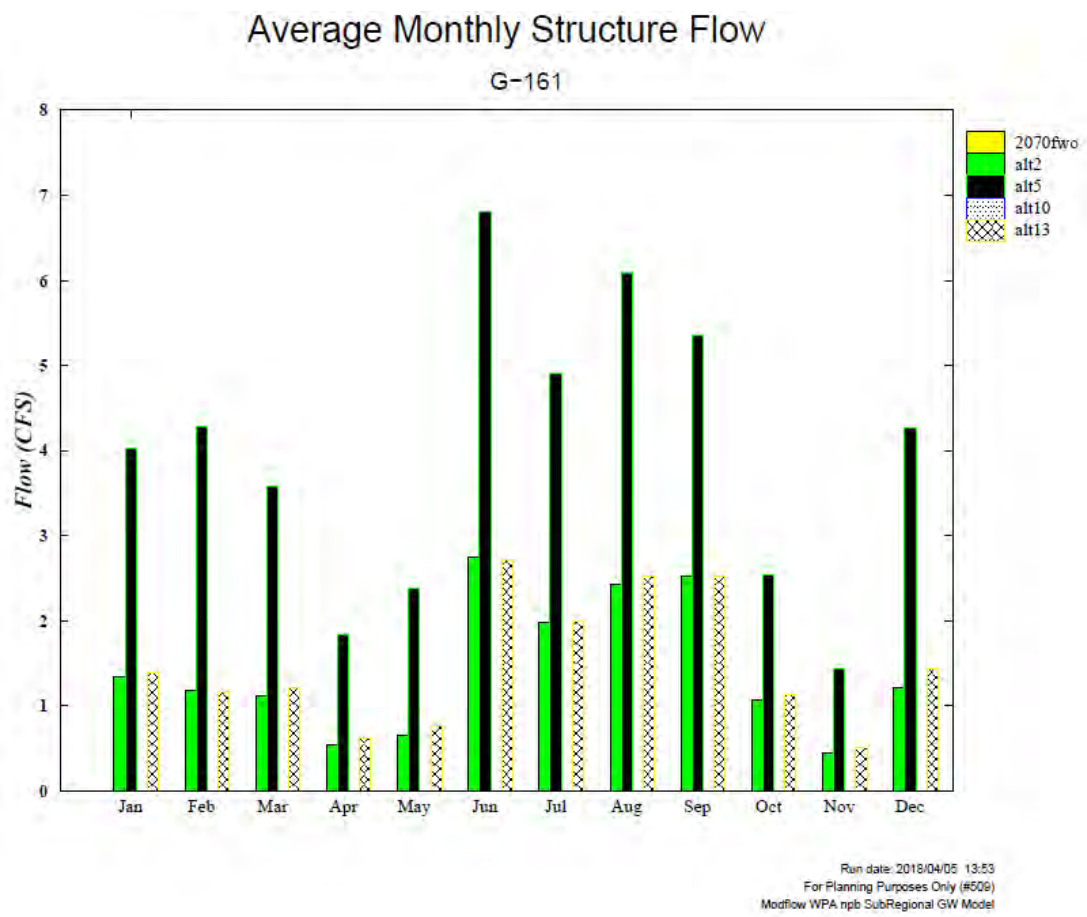


Figure 14. Average Monthly Structure Flow for the Proposed G-161 Structure

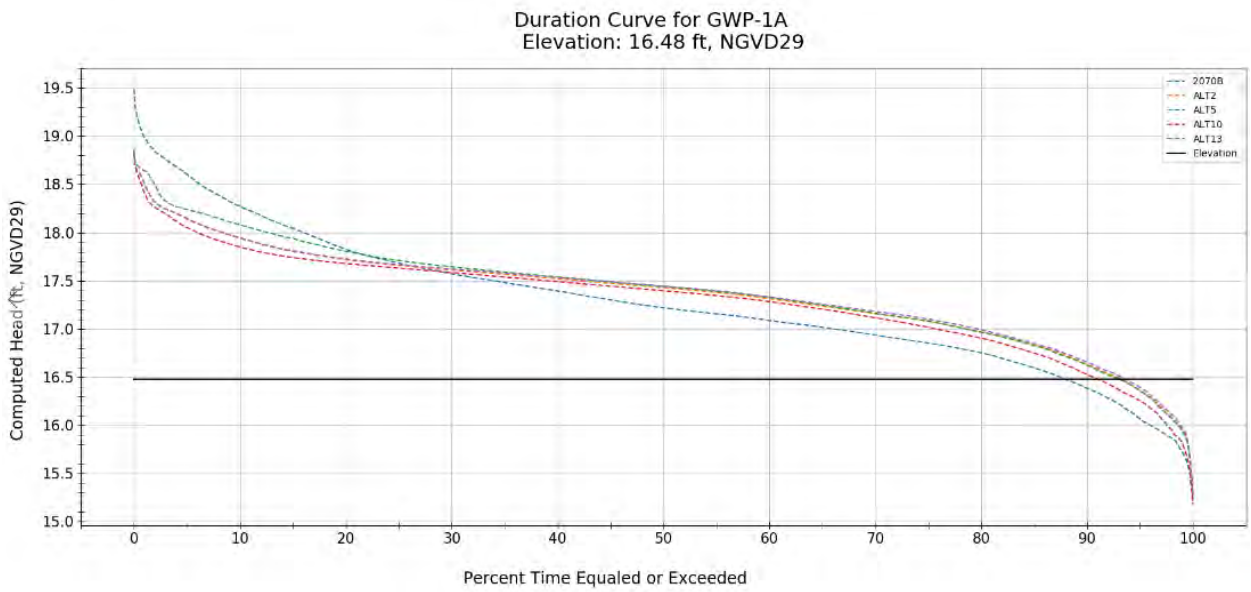


Figure 15. Grassy Waters Preserve Triangle Stage-Duration Curve

M-1 Pump Station

The proposed M-1 Pump station was designed to bring extra water into the M-Canal and GWP. Through the construction of G-161, excess water can be sent to the C-18 Canal and Northwest Fork of the Loxahatchee River from GWP. Figure 16 demonstrates that for Alternative 5, the only alternative with the proposed M-1 pump station, the average daily flow frequency to the GWP is improved over the 41-year simulation. This increase in flow is also seen in Figure 14, where Alternative 5R (TSP) continuously sends more water through G-161 than the other proposed alternatives. Figure 17 shows greater flow rates over the Northlake Weir for Alternative 5, aiding in the rehydration of the GWP triangle. This increase is flow is due to the additional water hydrating GWP from the M-1 basin.

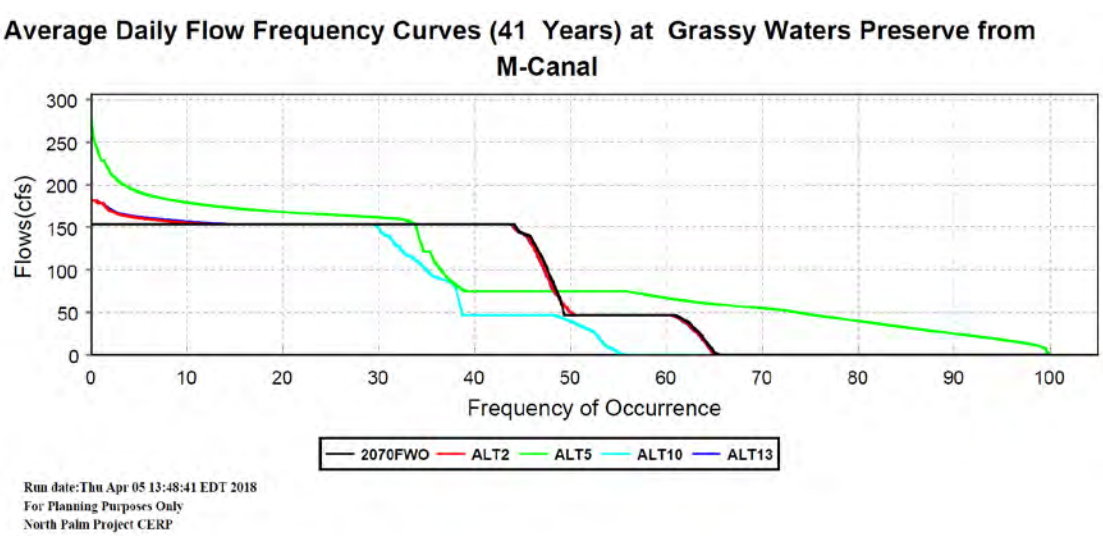


Figure 16. Average Daily Flow Frequency Curve for M-Canal at Grassy Waters Preserve

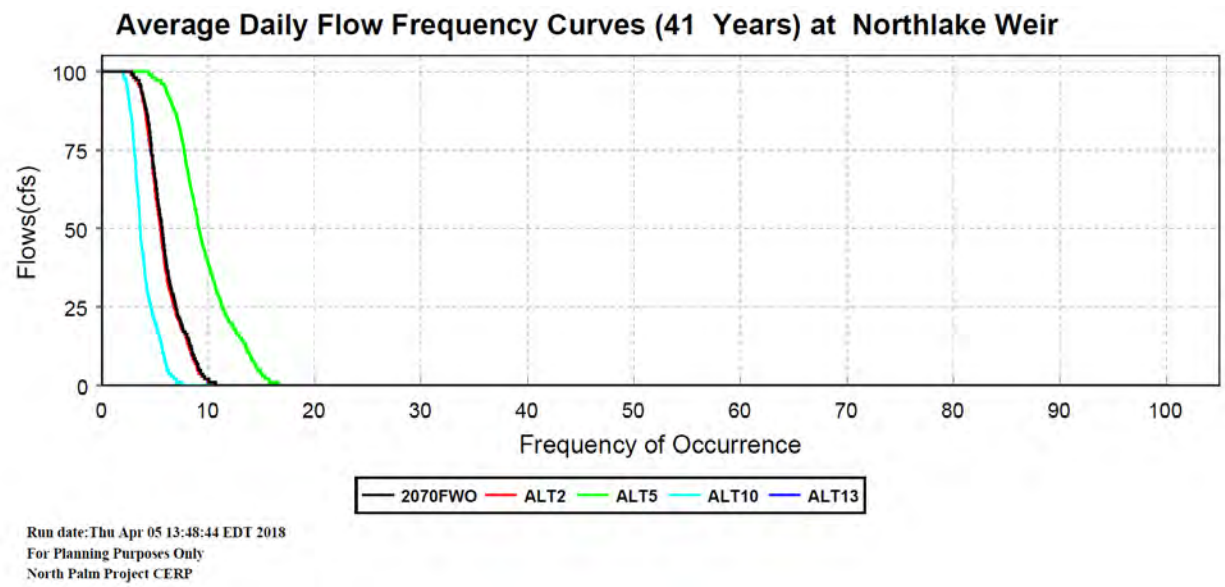


Figure 17. Average Daily Flow Frequency Curve for Northlake Weir

4.4.1.2 Flow-way 1 Model Performance, Non-TSP Features

C-51 Phase II Reservoir and Force Main

The C-51 Phase II Reservoir and Force main are proposed features in Flow-way 1 for the purpose of supplying water to GWP and the upstream portion of the C-18 Canal. The force main allows a direct connection between the M-Canal (within GWP) and the C-18 Canal, without requiring an increase in stage or adversely affecting water quality within GWP. The benefits of the C-51 Reservoir and force main are realized as increased flow rates through the G-160 structure and flows to Lainhart Dam, as seen in Figure 13, above. Increased flows to Lainhart are important especially during the dry season, when the quantity of flow is difficult to maintain. Figure 18 illustrates the average daily flow frequency for the C-51 phase II reservoir to the force main, whereas Figure 19 shows the flow frequency for the C-51 Phase II Reservoir total outflow. The excess discharge of water from the C-51 Phase II Reservoir is directed to the City of West Palm Beach for water supply purposes. Therefore, it is important to note per the graphics, that the reservoir discharges to the force main at a much lower flow rate and frequency than it does for water supply. Water supply is not an identified project objective and therefore cannot be claimed as a project benefit. Due to the relatively high construction and operation and maintenance costs of the C-51 Phase II Reservoir and force main, the efficiency, or project benefits versus project costs, was analyzed and it was determined that the features should not be carried forward as part of the TSP.

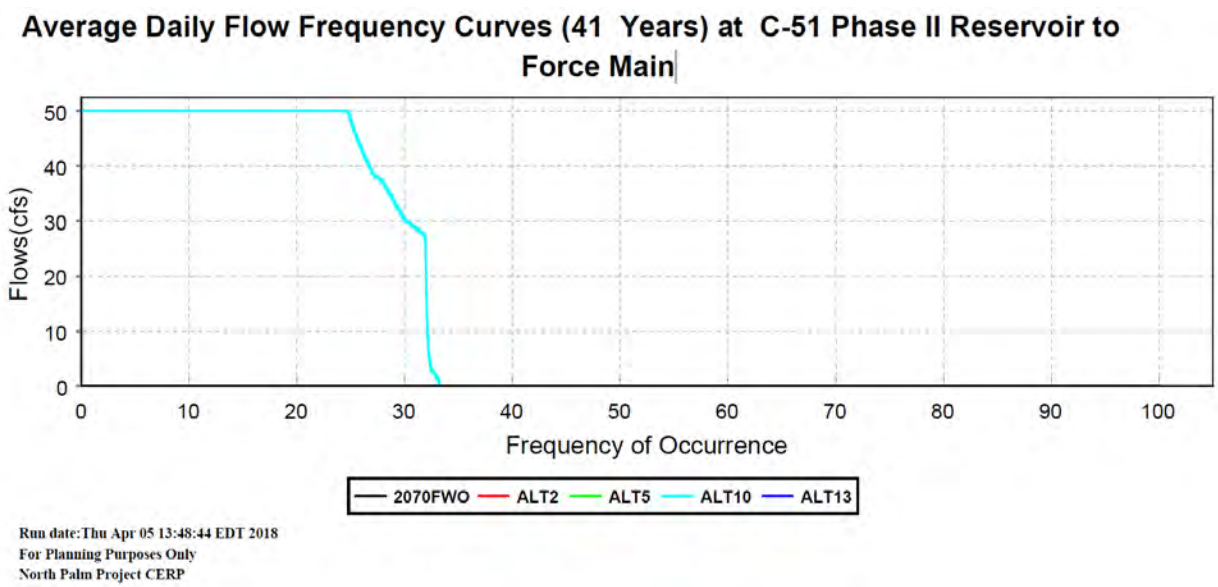


Figure 18. Average Daily Flow Frequency Curves for the Force Main (from C-51 Reservoir)

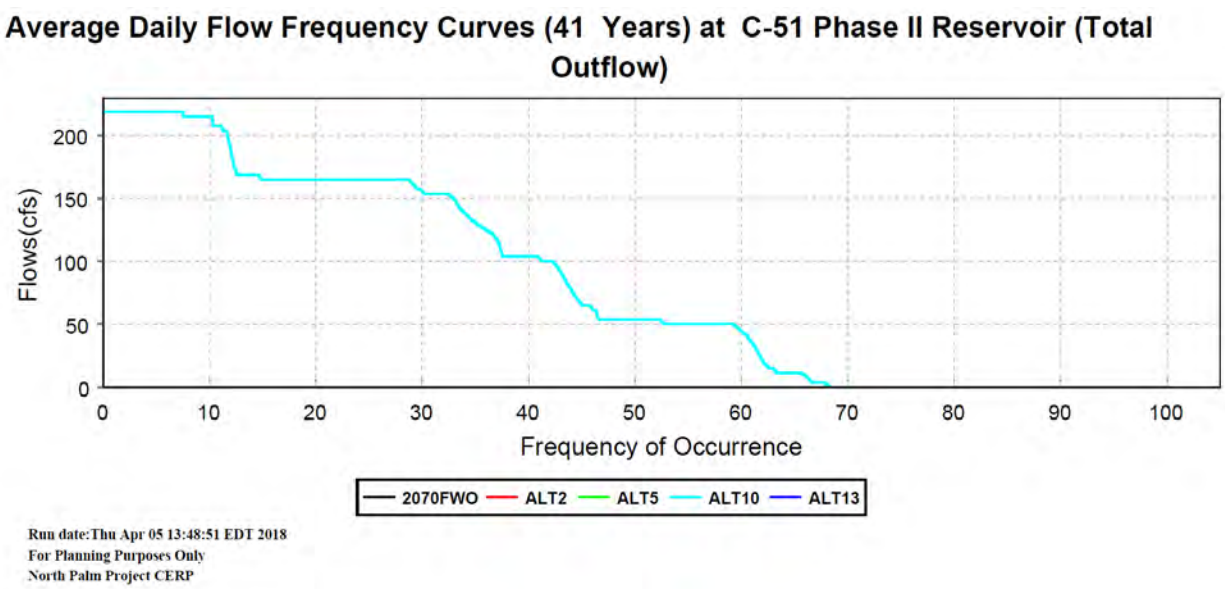


Figure 19. Average Daily Flow Frequency Curves for C-51 Reservoir Total Outflow

4.4.1.3 Flow-way 2 Model Performance, TSP features

C-18W Reservoir (9,500 acre-ft) & M-O Canal Connector

The construction of the C-18W Reservoir allows excess runoff from the C-18W basin, J.W. Corbett WMA, and inflows from the ITID upper basin via the M-O Canal to be collected and discharged when the Loxahatchee River requires additional water to achieve restoration targets. Without the proposed C-18W Reservoir, excess flows cannot be captured and dispersed in a hydrologically improved manner. During wetter periods, much of the runoff from C-18W basin and J.W. Corbett WMA may potentially be lost to

tide through the S-46 structure because there is no storage facility to capture and store the water. Similarly, flows from the ITID upper basin may be lost to the C-51 and/or L-18 to the Lake Worth Lagoon (also to tide). The improved timing and flow quantities to the Loxahatchee River from the C-18W Reservoir can be seen from the C-18W weir average monthly flow rates, as shown in the Figure 20.The C-18W weir is located downstream of the reservoir within the C-18W Canal. The TSP (Alternative 5R) performance illustrates a discernable improvement over the FWO conditions for both the wet and dry season. Alternative 5 shows additional improvement over the other alternatives in Figure 21. This graphic shows that the larger reservoir size coupled with the addition of the ASR wells provides a greater overall C-18W outflow capability. This additional capacity allows for greater flexibility in reservoir operations and additional robustness in providing flows to the river during the dry season or periods of drought. Optimization of reservoir capacity and number of ASR wells may be performed prior to the completion of the final PIR.

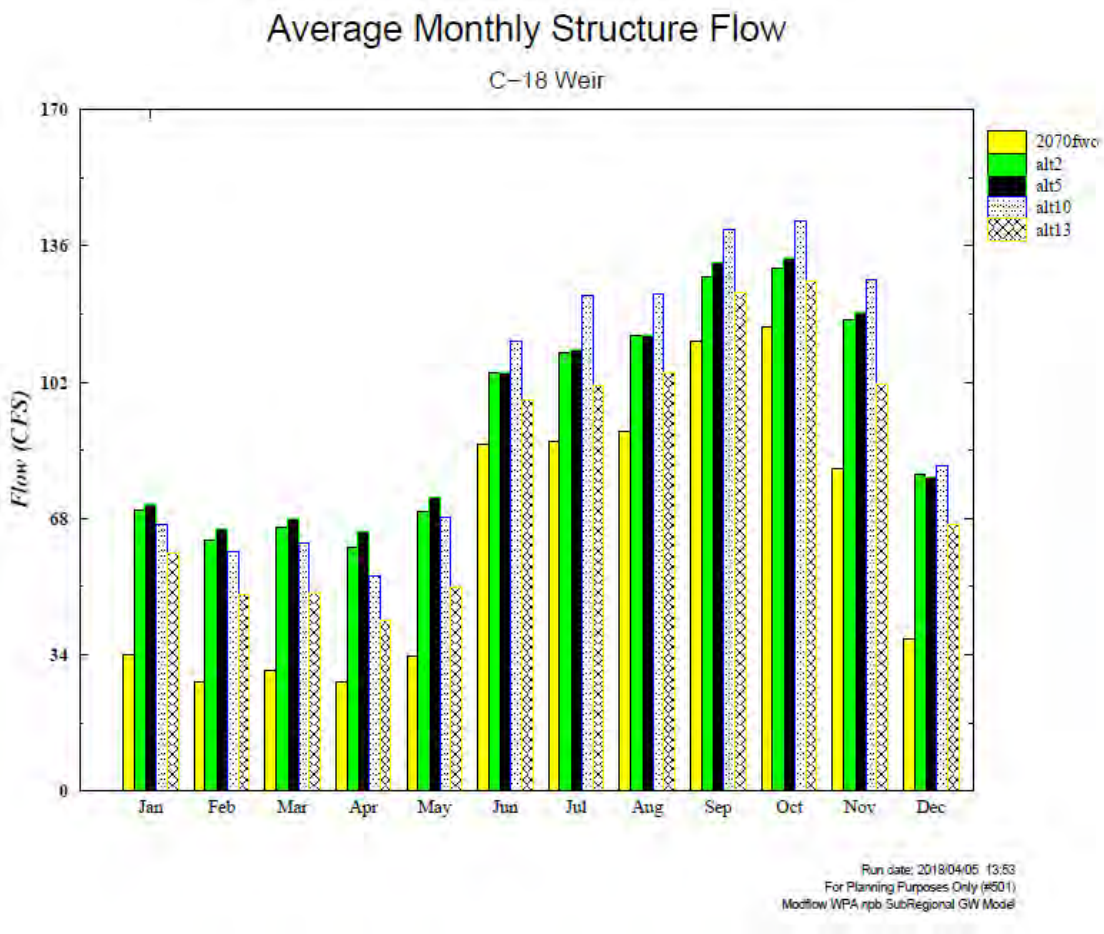


Figure 20. Average Monthly Structure Flow at the C-18W Weir

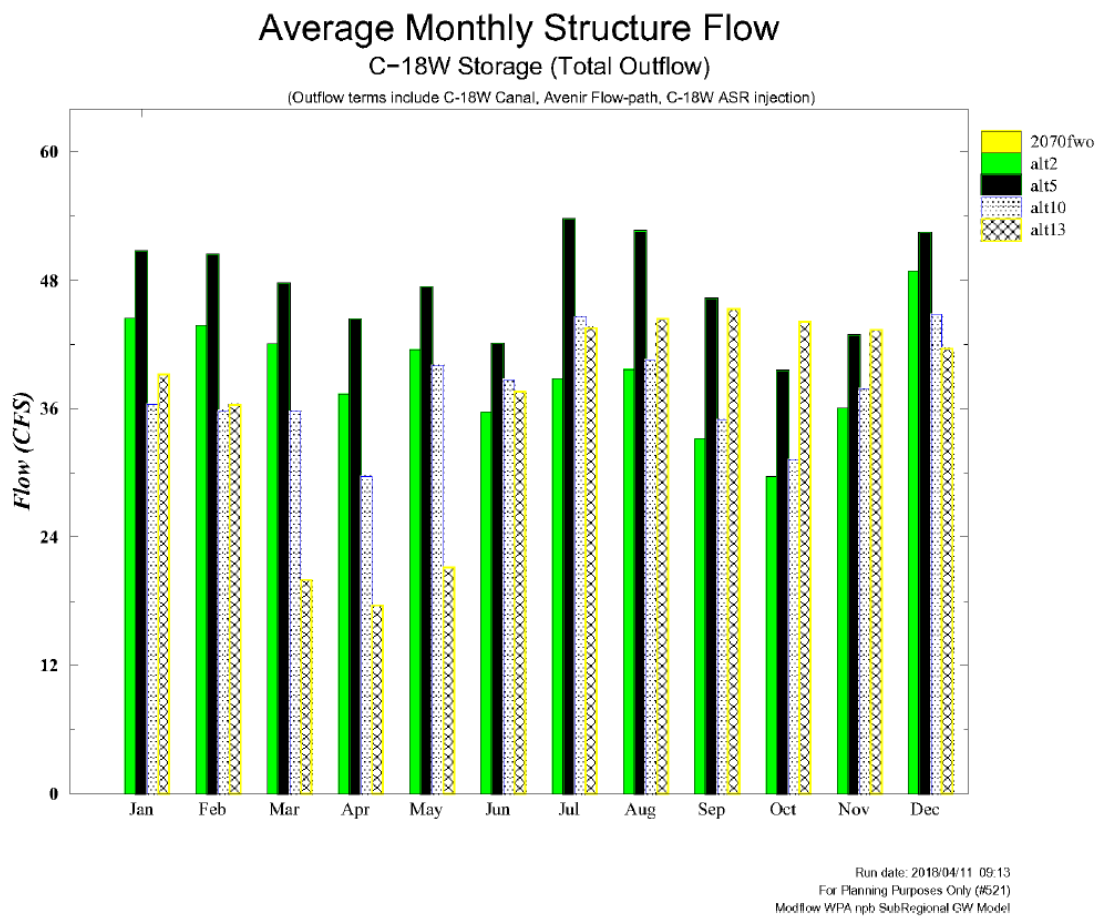


Figure 21. Average Monthly Flow for the Total Outflow of the C-18W Reservoir

The M-O Canal connection and pump station deliver excess water from the ITID basin to the C-18W Reservoir. Figure 22 shows that on average, the ITID basin supplies the C-18W Reservoir between 25 and 60 cfs, which accounts for a large percentage of the total inflow into the reservoir. The ASR performance is shown in Figure 23 and highlight the performance of the 4 ASR well systems for the C-18W Reservoir. The ASR wells are able to recover during the dry season an approximate monthly average of 13.4 cfs. From the months of March to May, when the dry season flows can be at their lowest, the average recovery is 15.5 cfs, which is accounting for D-59 approx. 23% of the flow for the dry season river targets (15.5/68 cfs). This illustrates the importance of the ASR wells and their contribution to the river during the dry season.

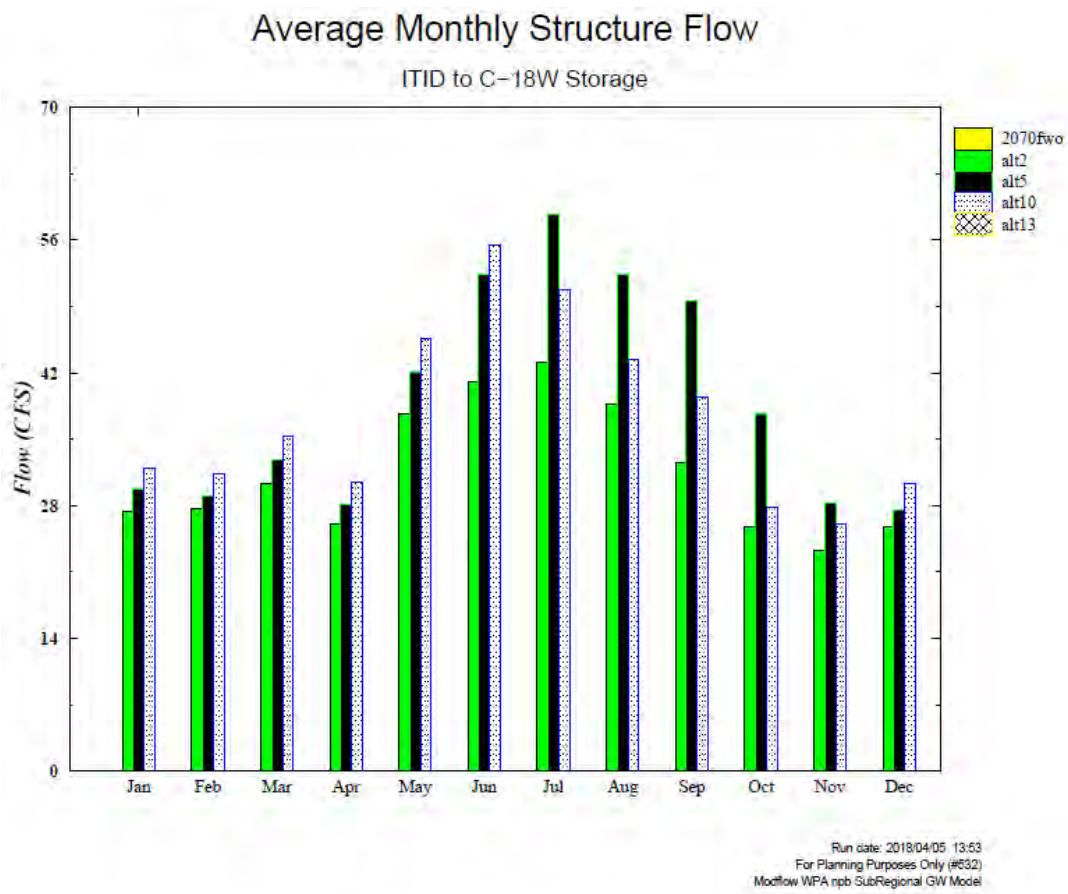
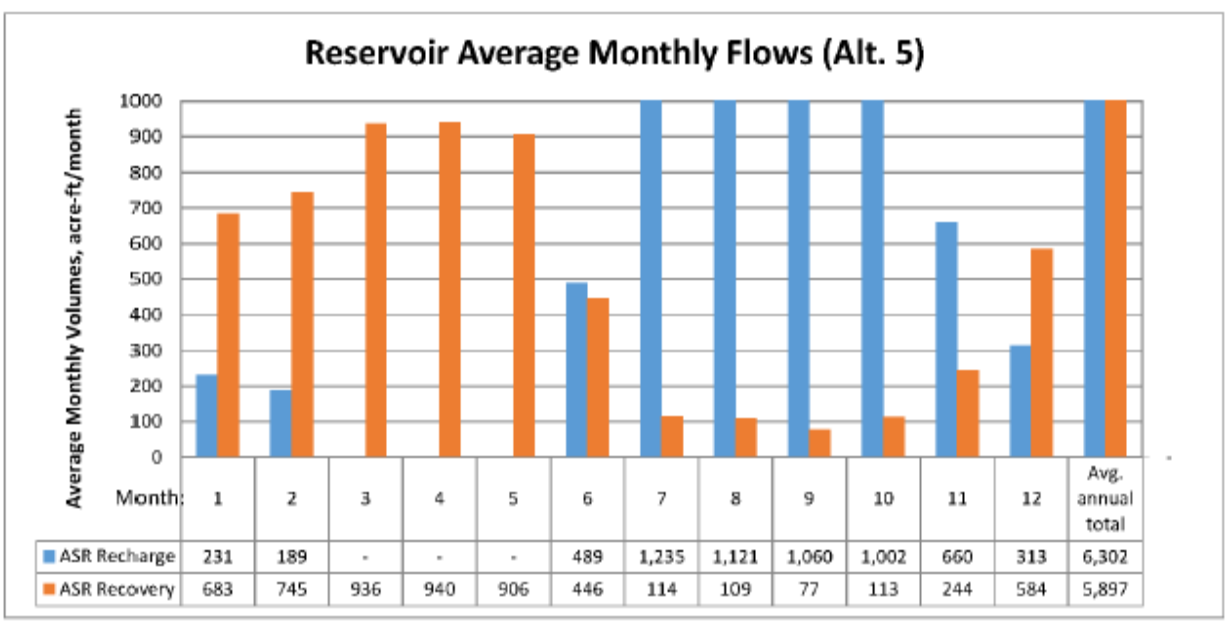


Figure 22. Average Monthly Structure Flow to C-18W Reservoir from ITID Basin



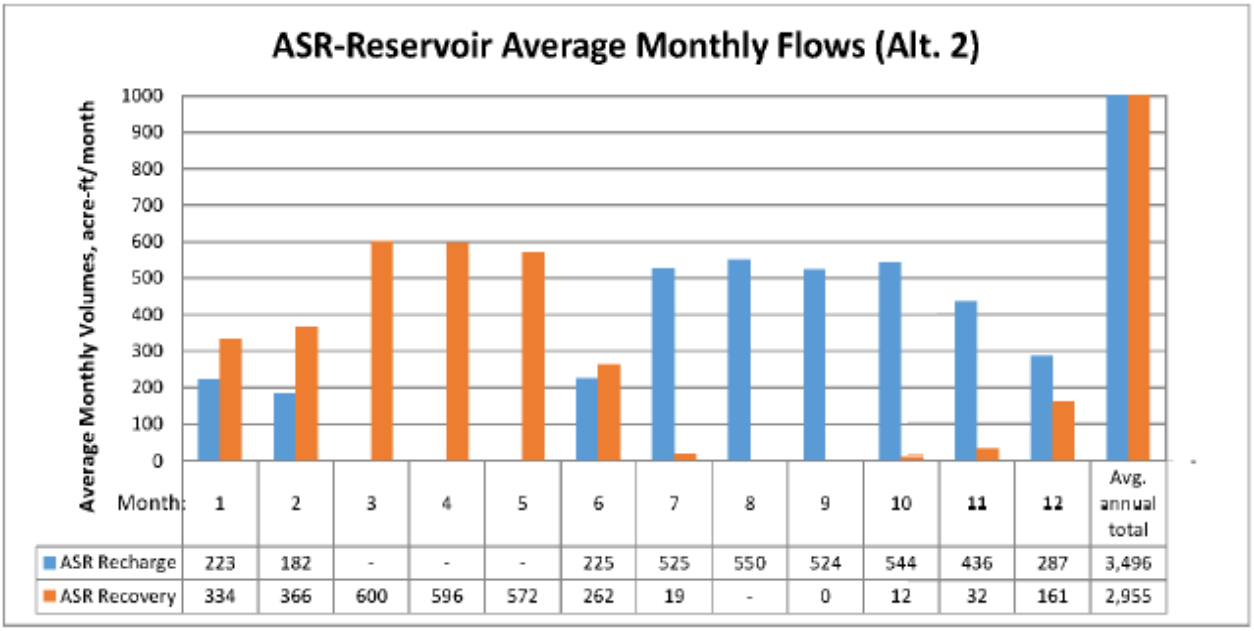
Month:	1	2	3	4	5	6	7	8	9	10	11	12	Avg. annual total
ASR Recharge	231	189	-	-	-	489	1,235	1,121	1,060	1,002	660	313	6,302
ASR Recovery	683	745	936	940	906	446	114	109	77	113	244	584	5,897

Figure 23. ASR-Reservoir Average Monthly Flows for Alternative 5

4.4.1.4 Flow-way 2 Model Performance, non-TSP Features

4.4.1.4.1 C-18W Reservoir (7,200 acre-ft)

The smaller C-18W Reservoir, proposed in Alternatives 2 and 10 was not carried forward to the TSP as due to the reasons included in section 4.1.1.3., above. This includes improved performance at the C-18 Weir and Lainhart Dam and greater flexibility and robustness in reservoir operations. Although the 7,200 acre-ft reservoir sizing was not a part of Alternative 5R (TSP), optimization of reservoir capacity and number of ASR wells may be performed prior to the completion of the final PIR. The ASR performance for Alternative 2, which is associated with the 7,200 acre-ft reservoir is shown in Figure 24. The average recovery from the ASR wells during the dry season is 7.4 cfs, close to half of that provided in Alternative 5.



Month	1	2	3	4	5	6	7	8	9	10	11	12	Avg. annual total
ASR Recharge	223	182	-	-	-	225	525	550	524	544	436	287	3,496
ASR Recovery	334	366	600	596	572	262	19	-	0	12	32	161	2,955

Figure 24. ASR Reservoir Average Monthly Flows for Alternative 2

4.4.1.4.2 C-18W Natural Storage

The C-18W natural storage feature does not include a reservoir component but is designed to pump water into a more natural flow path for the purpose of rehydrating and restoring historical wetlands and providing additional water to the C-18W Canal. Figure 25 demonstrates the shortcomings of the natural storage feature, as proposed in Alternative 13, due to the decreased deliveries to the C-18W Canal and to the river. Alternatives 2, 5, and 10 contain reservoir features and show that increased restoration flows can be provided throughout the wet and dry season to the river. The increase in flow to the C-18W Canal during the dry season is especially important as river targets are more difficult to maintain due to the limited water available within the watershed.

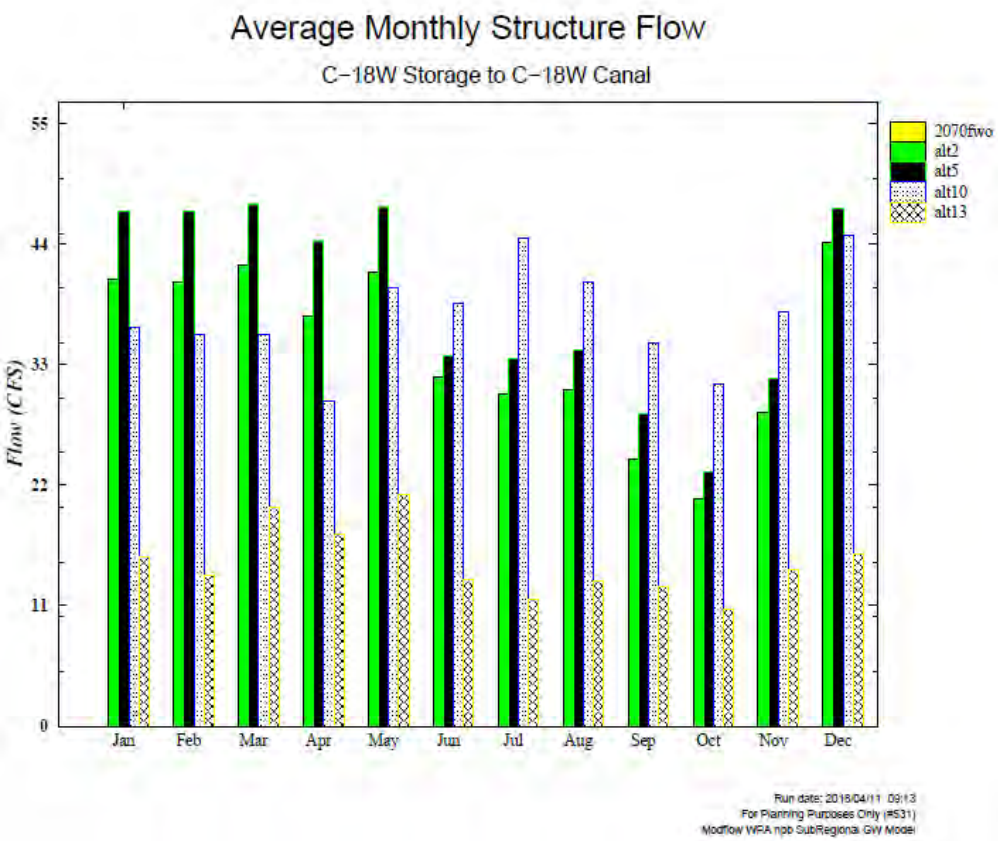


Figure 25. Average Monthly Structure Flow from C-18W Reservoir/Natural Storage to the C-18W Canal

4.4.1.4.3 L-8 Basin Shallow Storage

The L-8 Shallow Storage feature was designed as an additional means for water storage to supplement flows to the C-18W Reservoir or natural storage, depending on the alternative. The model results with respect to the L-8 shallow storage feature indicated multiple problems including losses due to seepage, operational complexities, and minimal outflow to the C-18W Reservoir or natural storage feature. The losses due to seepage were noticed when reviewing the difference maps, which are maps that highlight the change in water levels between two model runs (with alternative against the base-case). Figure 26 illustrates the average monthly flow discharged from the L-8 Shallow Storage feature, which is minimal. The operational complexities arise from both the stage constraints in the M-O Canal as well as the distribution of water from the L-8 Shallow Storage since there are multiple transfers before flows reach the Loxahatchee River. Connectivity from the L-8 shallow storage to the river requires the water to be transported through the M-O Canal, M-O Canal Connector, C-18W Reservoir (or natural storage feature), C-18W Canal and the C-14 Canal. At each location the water may be subject to losses either by drainage canals, via the M-O Canal, or through seepage and evaporation. The ASR performance for Alternative 13 is shown in Figure 27. The average dry season flow contributions from the ASR wells is approximately 11.2 cfs. This accounts for approximately 30 to 50 percent of the outflow from the L-8 Shallow impoundment.

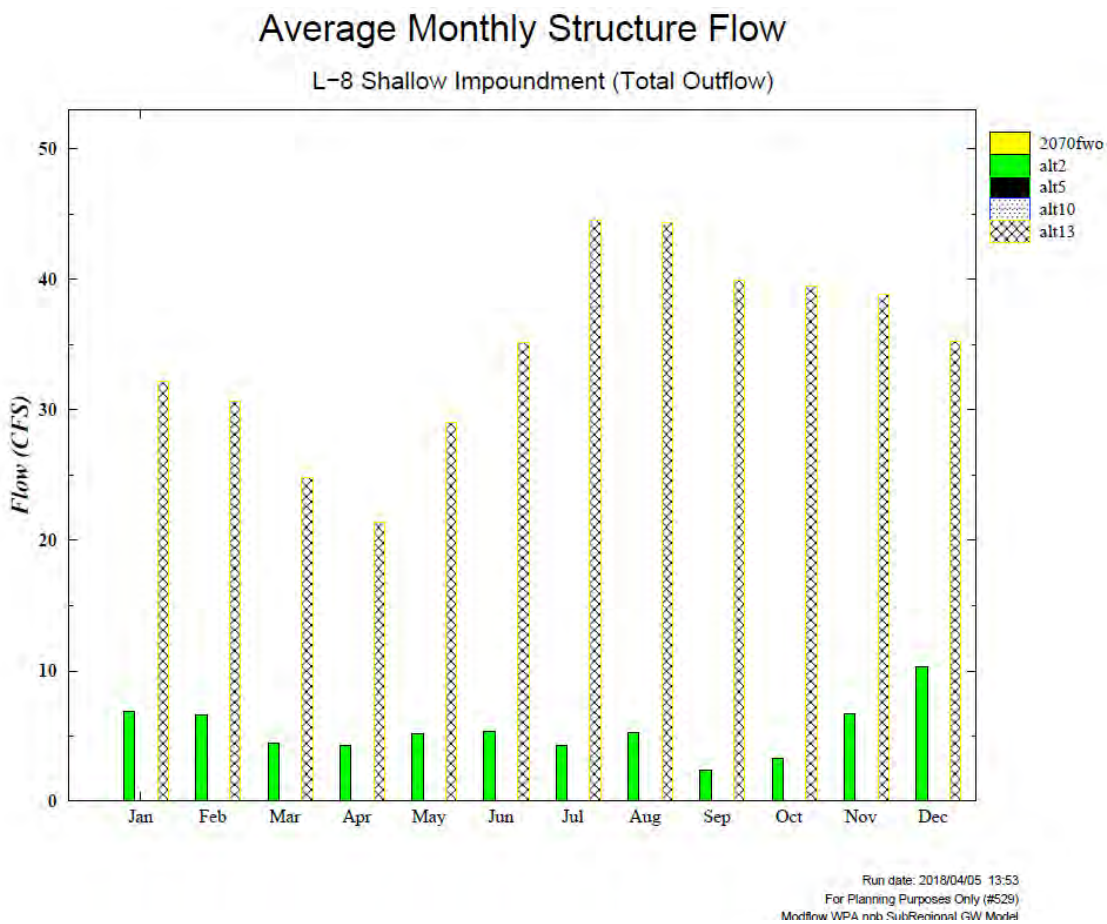
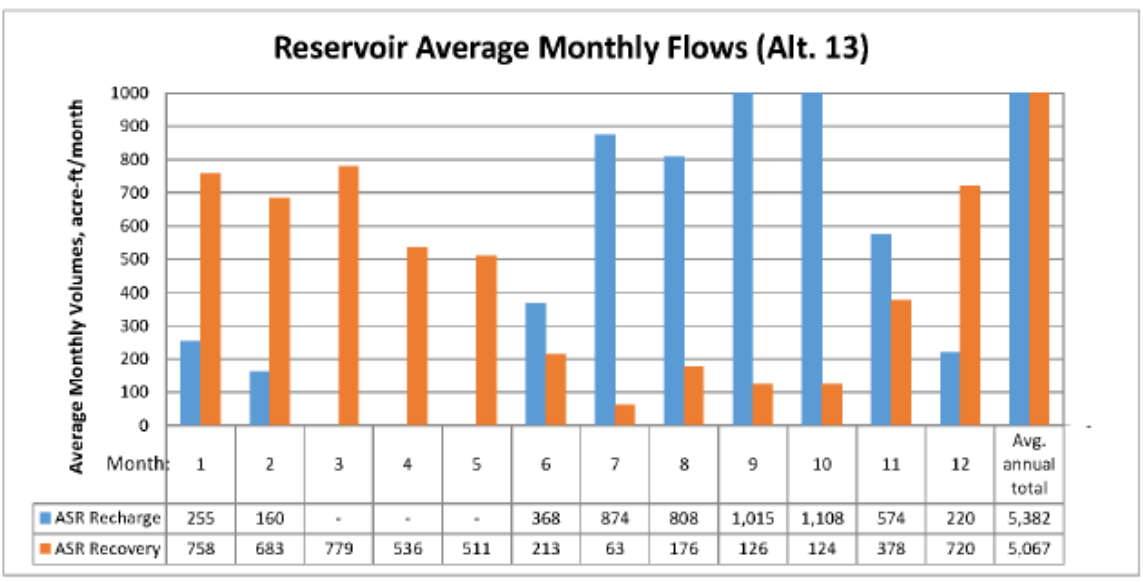


Figure 26. Average Monthly Outflow of the L-8 Shallow Storage



Month:	1	2	3	4	5	6	7	8	9	10	11	12	Avg. annual total
ASR Recharge	255	160	-	-	-	368	874	808	1,015	1,108	574	220	5,382
ASR Recovery	758	683	779	536	511	213	63	176	126	124	378	720	5,067

Figure 27. ASR Reservoir Average Monthly Flows for Alternative 13

4.4.1.5 Flow-way 3 Model Performance, TSP features

4.4.1.5.1 Pal-Mar East (Nine Gems) & Thomas Pepper Farms

The improvements in Pal-Mar East were designed to improve the hydroperiod, mainly within the Nine Gems, by reducing the run-off capacity while improving the hydrology through re-connection of the Pal-Mar East parcels. The stage-duration curve, shown in Figure 28, reflects this improvement of the hydrology within the Nine Gems area, which results in improved ecological benefits including increased wetland habitat. The PM-1.1 cell is located within the middle of the Nine Gems area, north of the existing Thomas Pepper Farms drainage canal. The resulting increase in stage at this location, and the associated project benefits, are assumed to derive from the applied alternative measures in this area. With the removal of the existing Thomas Pepper Farms drainage canal (currently bisecting Pal-Mar East), hydrologic re-connection of flow occurs between the two parcels, further improving the wetland structure and function within the area. It is important to note that the modifications in Pal-Mar East were proposed in Alternative 2, Alternative 5R (TSP) and Alternative 13. Therefore, there is no discernable difference between the results of these alternatives and the resulting graphical display of the results are overlapping and the results shown in the graphic for Alternative 13 can also be assumed for Alternative 2 and 5. Similarly, Alternative 10 and the FWO condition do not contain any features within Pal-Mar East so the resulting lines on the stage-frequency graphic are also overlapping.

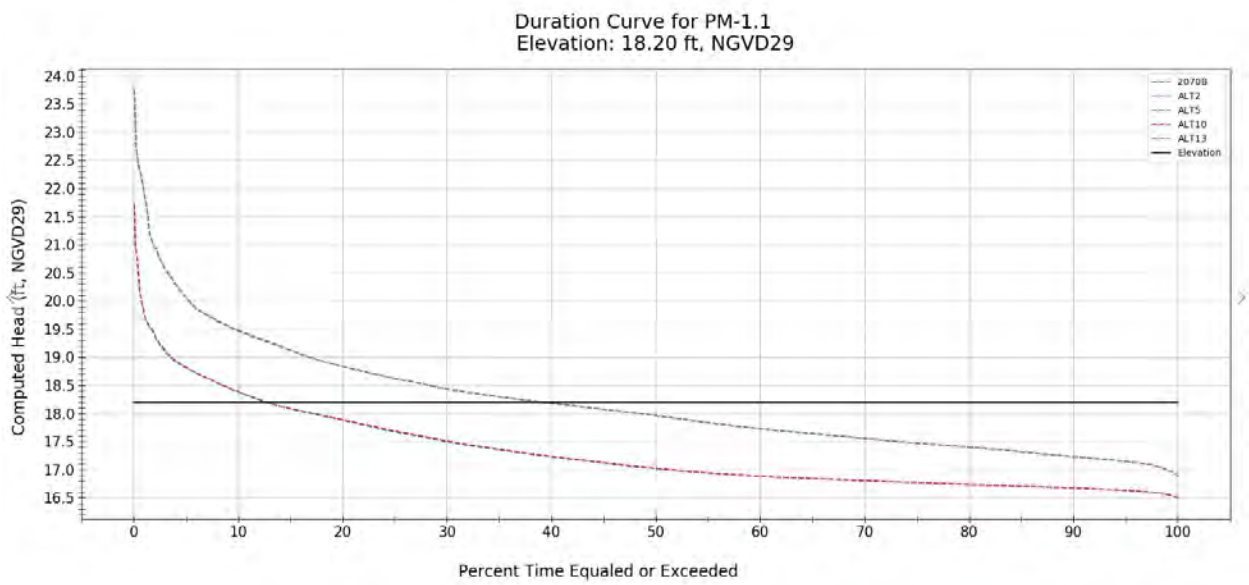


Figure 28. Stage-Duration Curve for Pal-Mar East

4.4.1.5.2 Ranch Colony Canal

The proposed Ranch Colony Canal improvements include modifications to the existing water control structures at Culpepper as well as adding an additional control structure within the canal. The improved hydroperiod and natural storage within Culpepper is shown in Figure 29, and is the product of the proposed modification to the WCS 1-4 inlet elevations. It is estimated that further improvements of the stage-duration curve are expected if the structures are operated specifically for wet, dry, and possible transition periods to assist in achieving the most desirable hydroperiod for wetland habitat. This

optimization of an operation schedule may occur prior to the final PIR. The proposed Ranch Colony Canal structure also achieved the desired project benefits by improving the surrounding groundwater (and surface water) elevations for a greater duration during the simulation period. As can be seen from Figure 30, all alternatives create hydroperiod improvements within the Cypress Creek Natural Area, with CC-4.1 representing a cell within the north-central portion of the property. Though Alternative 5 shows a relatively large improvement, Alternative 13 shows greater improvement due to the Mack Dairy Spreader System, which was a feature that has been added to the TSP (Alternative 5R). Therefore, the final hydrologic response expected from the implementation of the alternative features for the TSP are expected to mirror that of Alternative 13 in this area.

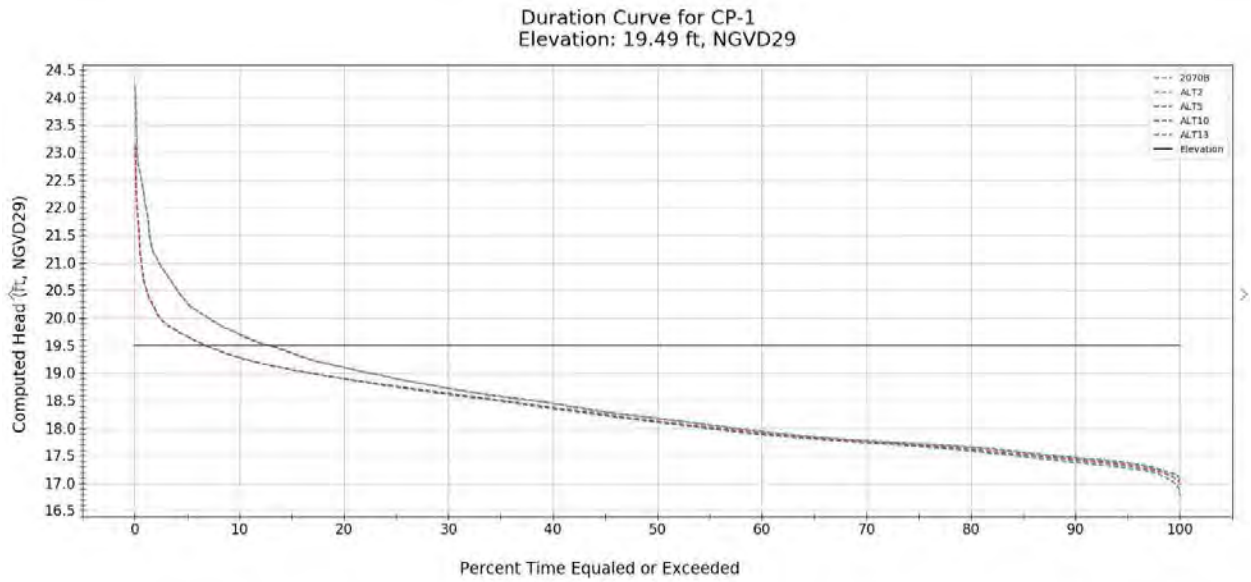


Figure 29. Stage-Duration Curve for Pal-Mar East, Culpepper Property

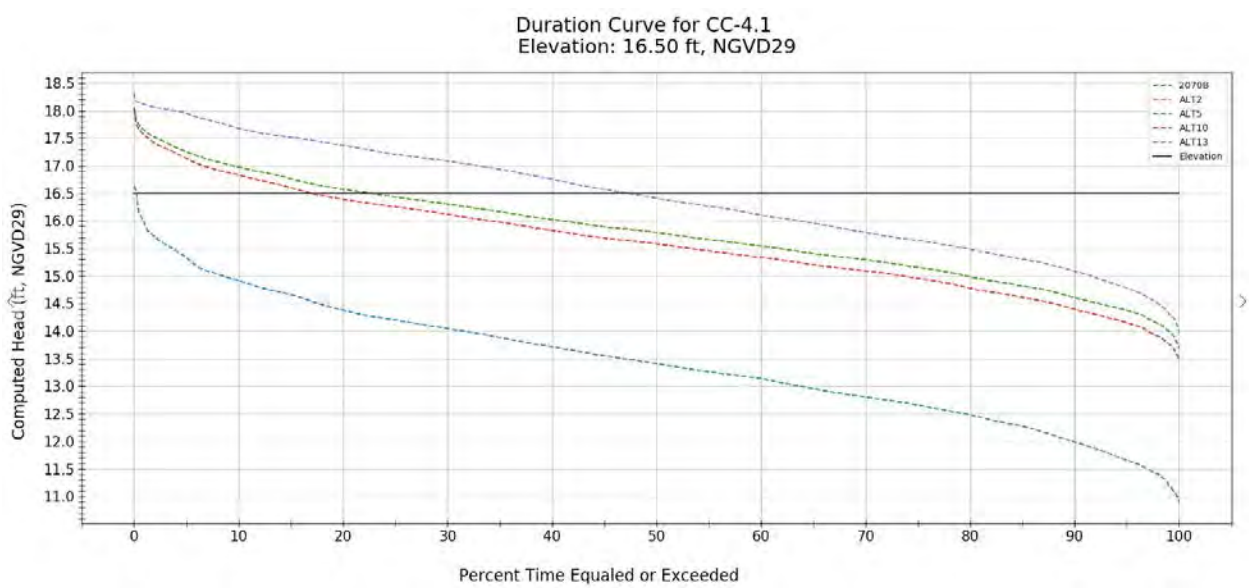


Figure 30. Stage-Duration Curve for Cypress Creek Natural Area

4.4.1.5.3 Gulfstream West

The proposed flow through marsh within the Gulfstream West property was designed to transform the existing overly drained agricultural land to marsh or wetland habitat, thereby increasing the natural extent of wetlands. A drastic improvement in the hydroperiod for the Gulfstream West property can be seen in Figure 31. Similar to other graphics, Alternatives 2, 5, and 13 have similar results and therefore the lines may overlap on the graphic. This feature allows excess water from HSLCD to be stored, reducing peak inflows into the Ranch Colony Canal while providing natural storage, improved wetland function, and potential incidental water quality improvements. Additionally, the purpose of the proposed features west of Interstate 95 (Pal-Mar East, Ranch Colony, Cypress Creek, and Gulfstream West) was to assist in reducing peak flows in the wet season and provide additional flow during drier periods. As shown in Figure 32, the average monthly flow rates, measured at the confluence of the Cypress Creek Natural area and Ranch Colony Canal, are reduced in the wet season and either reasonably maintained or improved in the dry season.

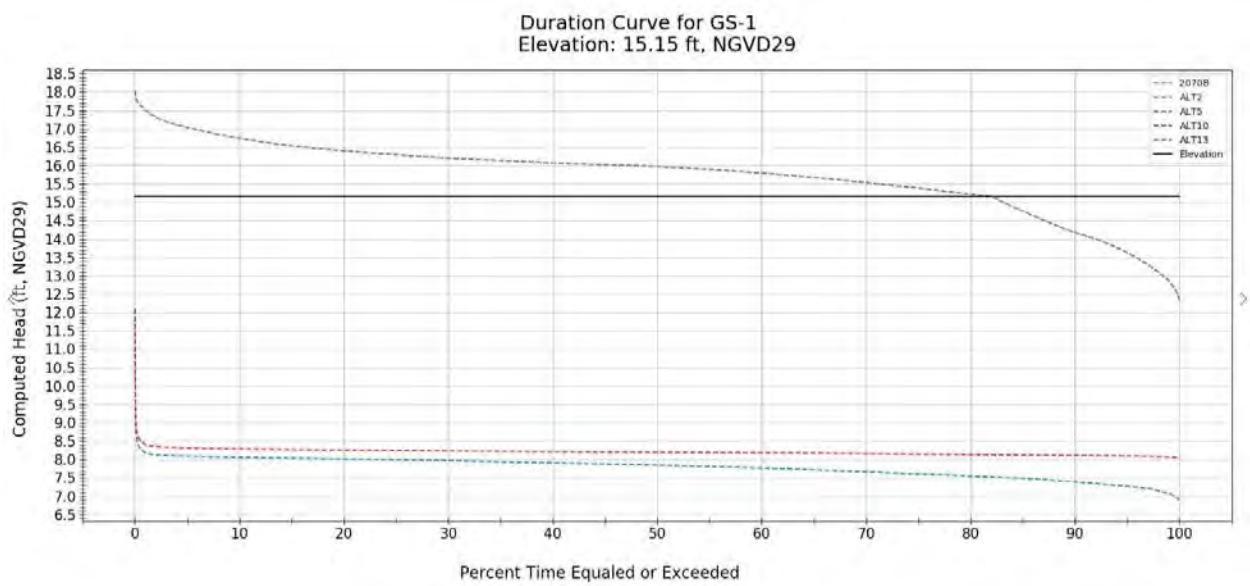


Figure 31. Stage-Duration Curve for Gulfstream West

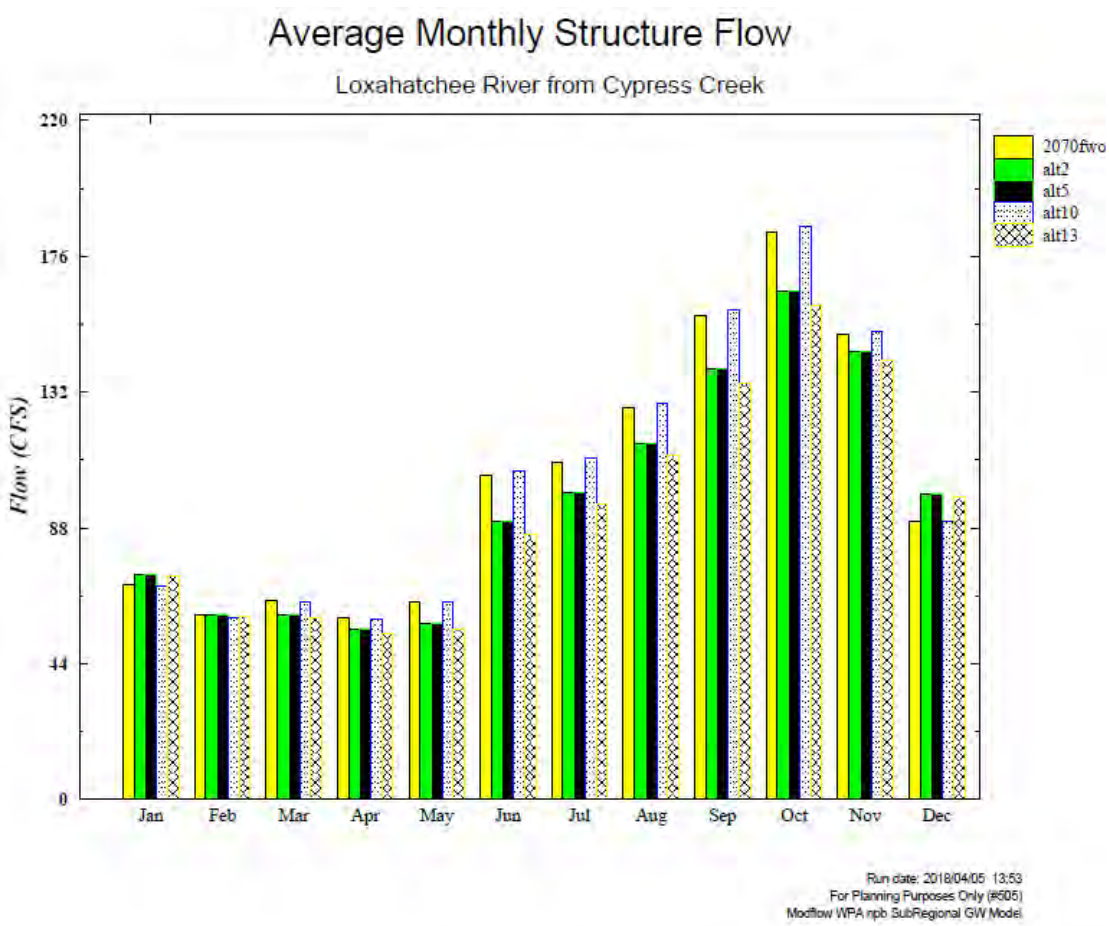


Figure 32. Average Monthly Structure Flow Downstream of Cypress Creek and Ranch Colony Canal

4.4.1.5.4 Gulfstream East and Moonshine Creek

The earthwork modifications to Gulfstream East, including the hydrologic connection to Moonshine Creek, were proposed to help improve hydroperiods within the area. Figure 33 and Figure 34 representing Gulfstream East and Moonshine Creek, respectively, demonstrate that the proposed improvements aid in restoring a more natural hydroperiod necessary for ecosystem restoration. Both locations experience a large increase in the depth and duration of inundation compared to the FWO project conditions.

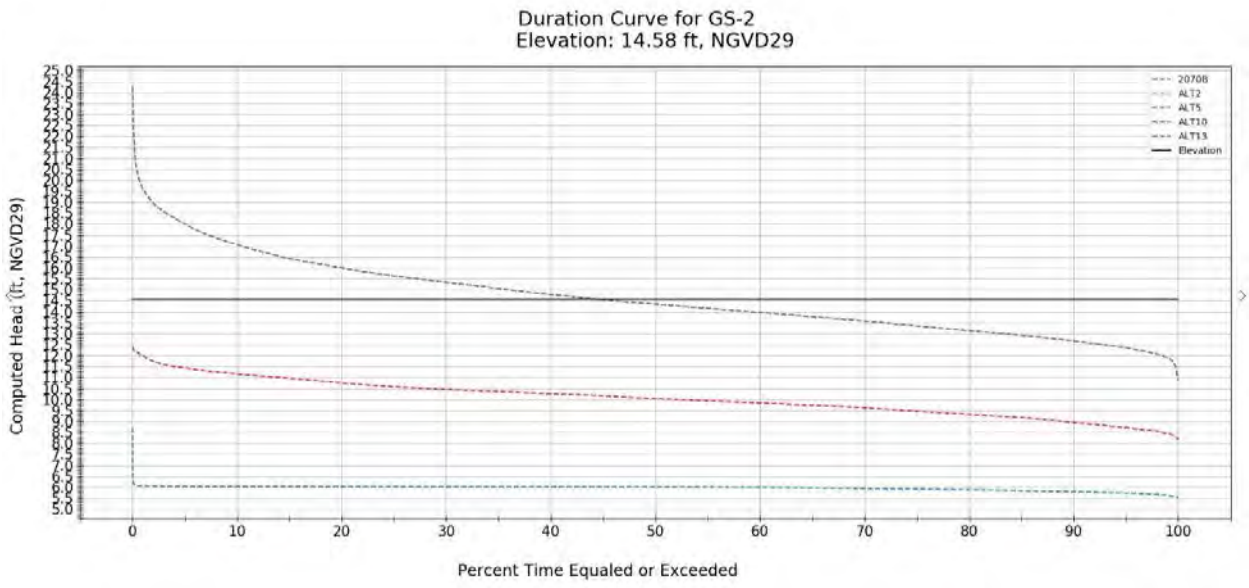


Figure 33. Stage-Duration Curve for Gulfstream East

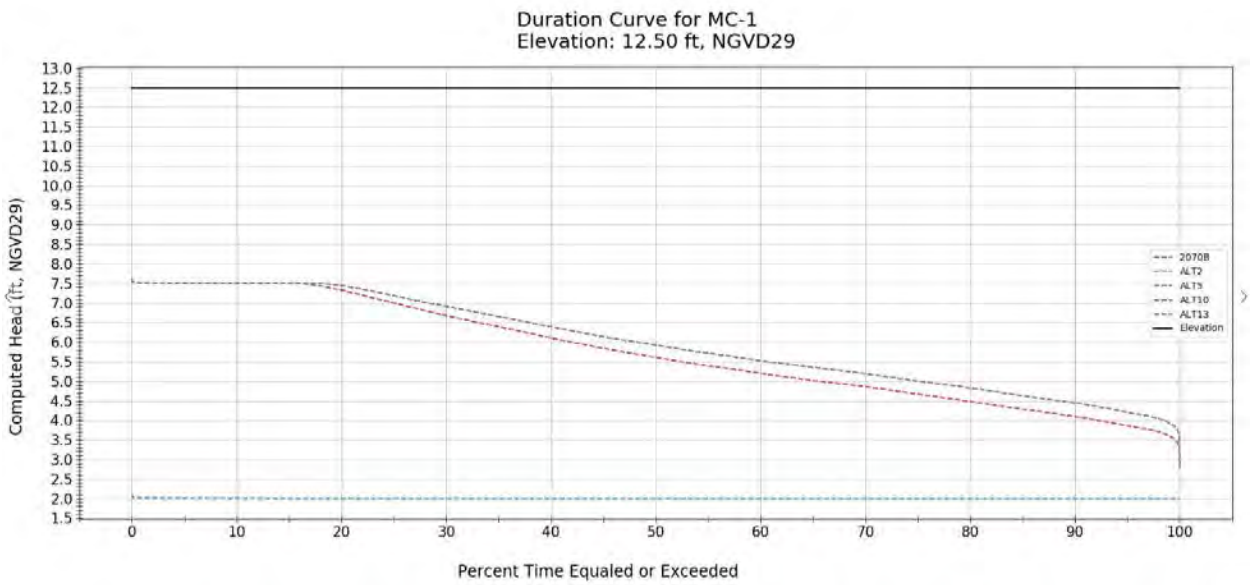


Figure 34. Stage-Duration Curve for Moonshine Creek

4.4.1.5.5 Kitching Creek

Similar to other locations within Flow-way 3, the Kitching Creek modifications were proposed to help rehydrate areas surrounding Jenkins Ditch and create a more natural hydroperiod for the upstream portions of Kitching Creek. The cell for KC-1.2, shown in Figure 35 represents the surrounding area of Jenkins ditch and demonstrates that a greater water surface elevation can be achieved throughout almost the entire simulation period due to the features proposed in the TSP (also proposed in Alternative 2 and

13). This increase in stage correlates to improved floodplain inundation and hydrology regimes, aiding the restoration of wetland habitat.

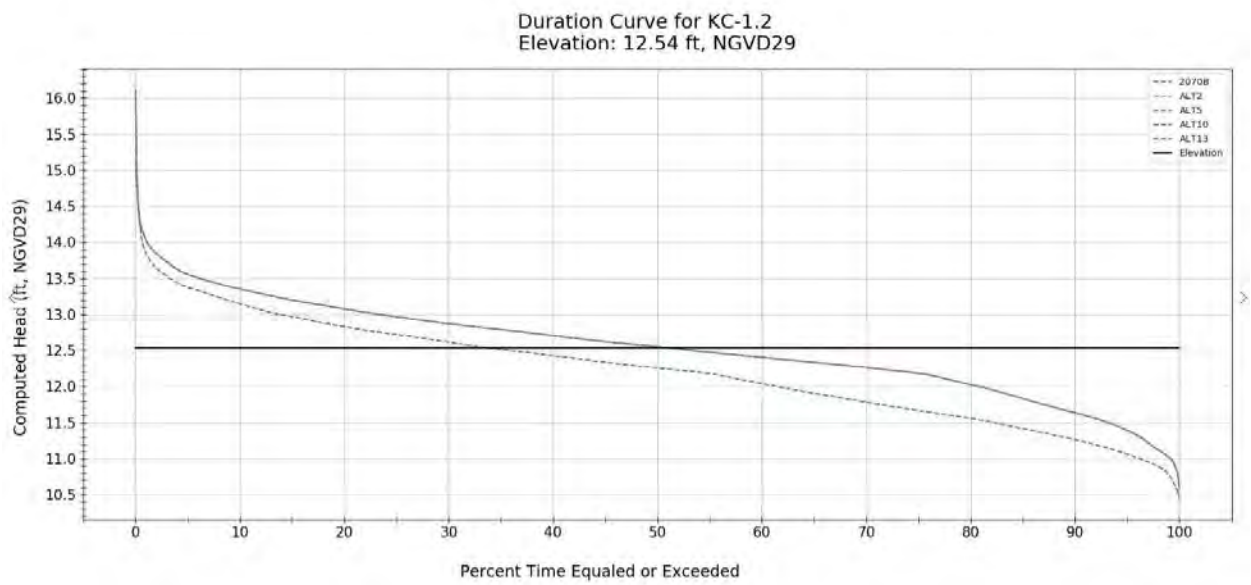


Figure 35. Stage-Duration Curve for Kitching Creek

4.4.1.5.6 Mack Dairy Spreader Swale

As was seen in Figure 30, above, the addition of the Mack Dairy Spreader system helps improve the hydroperiod and ecological restoration of the Cypress Creek Natural Area. Additionally, it allows excess water within the Ranch Colony Canal to be distributed to the natural areas, further improving the timing, quantity, and potentially water quality of deliveries from the Ranch Colony Canal to the Northwest Fork of the Loxahatchee River.

4.4.1.6 Flow-way 3 Model Performance, non-TSP features

All features proposed in Flow-way 3 were included as part of the TSP as each proposed feature successfully met the key project objectives and performance measures.

D.4.2 Key Performance Measure Locations

As specified in Section A.1 Project Objectives, each alternative is evaluated based on how well it met the performance measures, evaluation criteria, and other metrics identified by the PDT. Locations of importance within the model domain that are either directly or indirectly related to the PM's and EC include the following locations: Lainhart Dam, S-46, and the total contributions to the Northwest Fork of the Loxahatchee River.

Lainhart Dam was identified as a location that preferred restoration flow targets shall be met as part of the project objectives and specifically to meet performance measure 1. The performance at Lainhart Dam can be seen in Figure 36, which illustrates the improvement of flows over the future without condition for the various alternatives. Alternative 10 shows the greatest improvement in flow, likely due to the C-51 outflow and force main combination. Alternative 5 (TSP) and 2 preform similarly, with Alternative 5

showing minor improvement over that of Alternative 2 during lower flow conditions due to the increased reservoir size and addition of ASR wells. Alternative 13 consecutively performs worse than the other alternatives but does show improvement over that of the FWO condition.

Table 14 compares the percentage of time the wet and dry season target at Lainhart are met for the ECB, FWO, and Alternatives 2, 5, 10, and 13. The table illustrates that Alternative 5 (TSP) and 10 are the best performing alternatives for achieving the desired Lainhart flow rates during the wet and dry season.

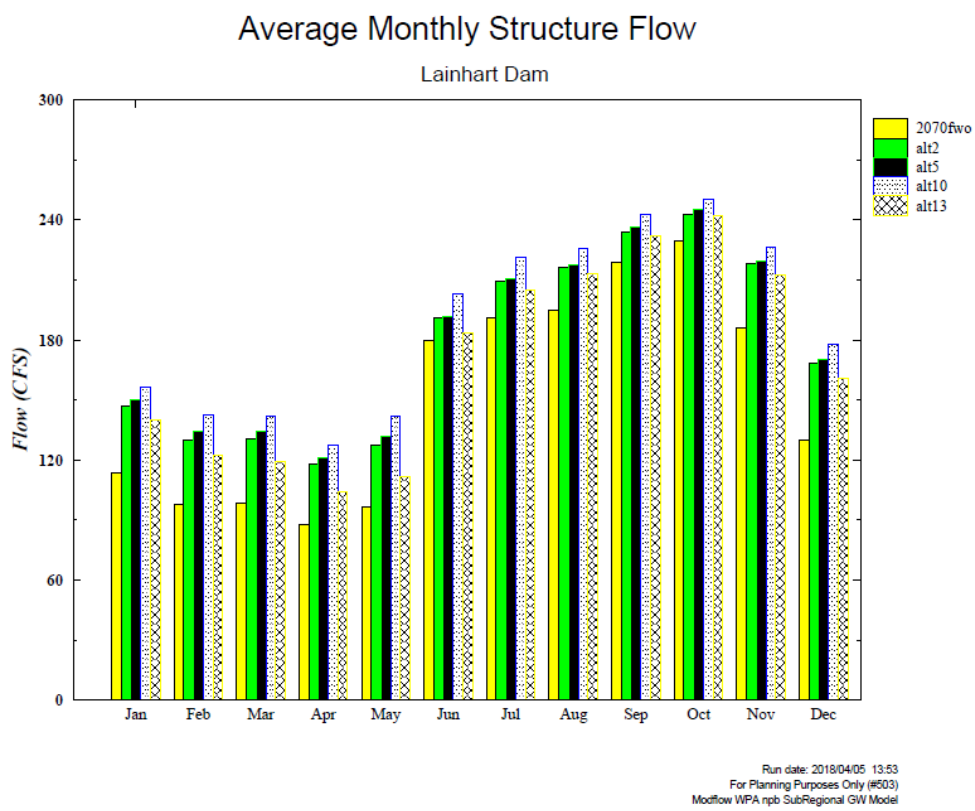


Figure 36. Average Monthly Structure Flow for Lainhart Dam

Table 14. Percentage of Time Wet and Dry Season Targets are Met

Season	ECB	FWO	Alt 2	Alt 5	Alt 10	Alt 13
Wet season	76%	78%	98%	98%	100%	93%
Dry Season	65%	65%	87%	91%	95%	75%

The construction of the C&SF Project S-46 Discharge Structure for flood control has resulted in increased discharges into the Loxahatchee Estuary. Lack of storage in the tributary basins results in periods of excessive freshwater inflow, followed by periods of insufficient freshwater inflow to the estuary. The net result is an unnatural oscillation of salinity conditions. Large pulsed releases cause impacts to seagrasses, shellfish populations, and other fish and invertebrate communities residing in the estuary. The percent reduction in frequency and duration of S-46 structure peak flow discharges that relate to salinity threshold

criteria for seagrasses is directly related to the planning objectives. Additionally, a more regulated release or fewer large releases from S-46 correlates to a more controlled system upstream or that additional water is being sent to the Northwest fork of the Loxahatchee River. Figure 37 illustrates that the flows sent to S-46 are similar between the Alternative conditions and the FWO condition. Additional optimization of the features may be required to realize additional benefits at the S-46 structure.

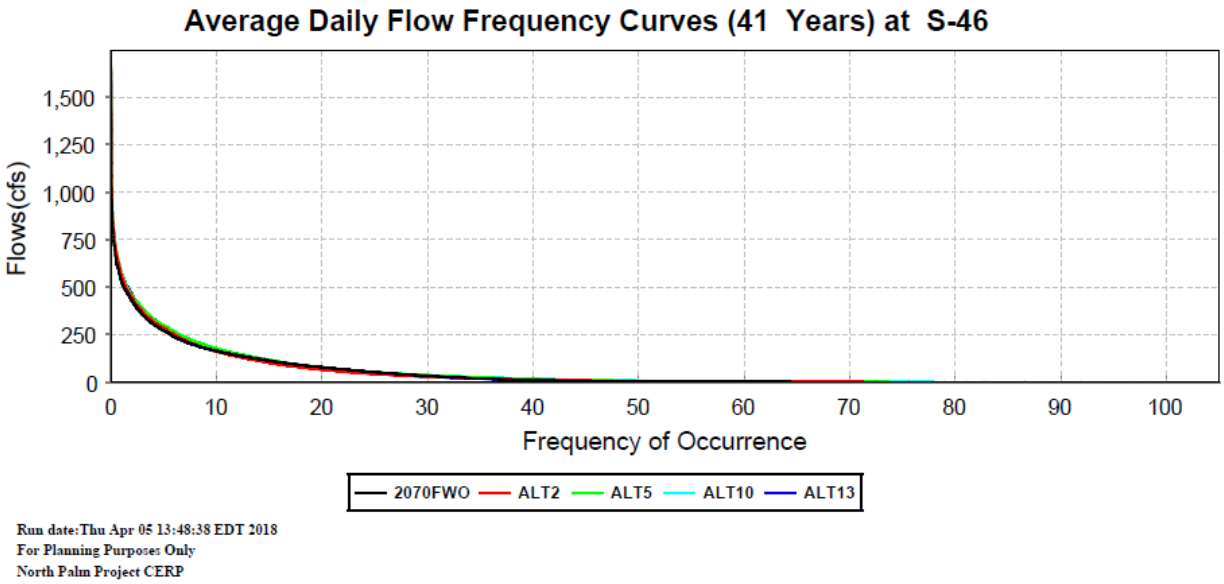


Figure 37. Average Daily Flow Frequency Curve for S-46

Finally, Figure 38 shows the average daily contribution for Lainhart Dam, Cypress Creek, Hobe Grove Ditch, and Kitching Creek to the Northwest Fork of the Loxahatchee River. From Lainhart, average flow values are expected to increase due the implementation of the alternatives. Cypress Creek, Kitching Creek, and Hobe Grove display lower daily flow values reaching the Northwest fork due to the water being dispersed to aid in increasing the natural extent of the wetlands while improving the hydrology and hydroperiods within these areas. Decreased flows from these areas are a hydrologic improvement as these tributaries are currently very flashy in nature with high uncontrolled discharge rates that can cause adverse impacts to the river.

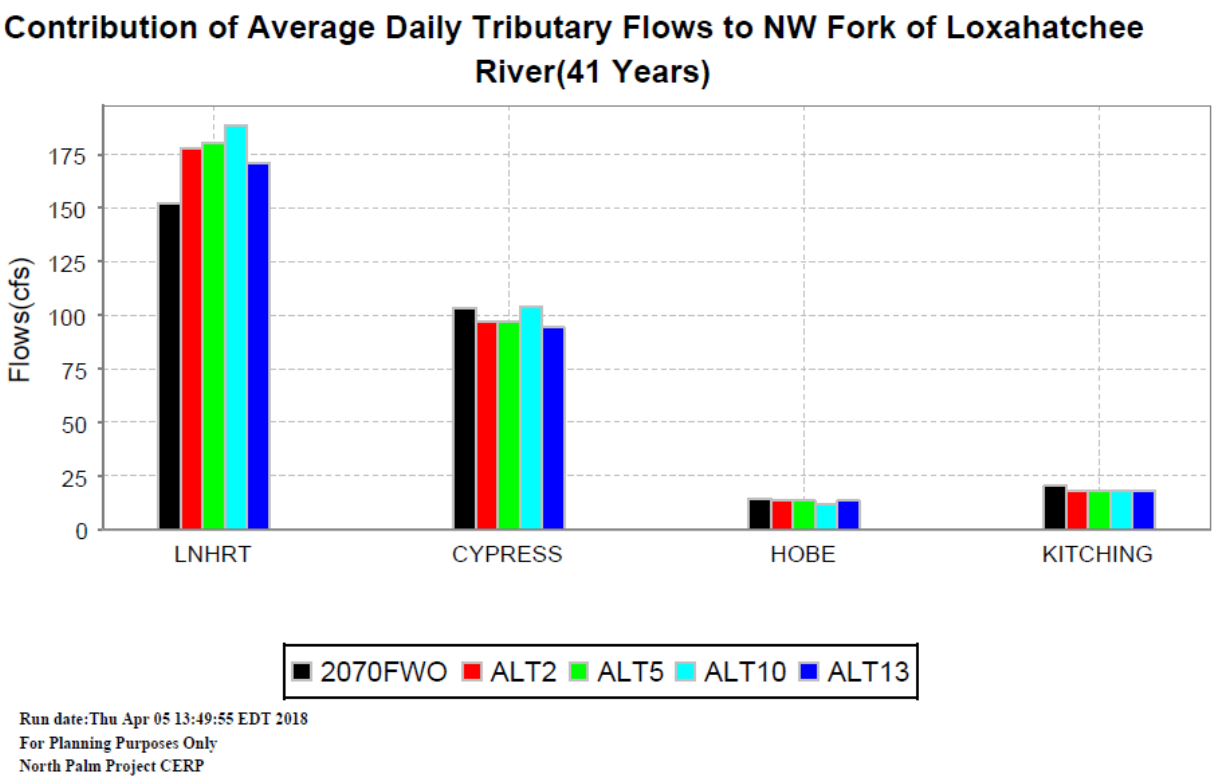


Figure 38. Total Average Daily Flow to the Northwest Fork of the Loxahatchee River

D.4.3 Modeling Assumptions and Limitations

The modeling assumptions for the alternatives are organized into a tabular format within the Model Application Report (Giddings *and Obeysekera.,* 2018). The model limitations are discussed in the Model Calibration Report (Obeysekera *et al.,* 2018).

D.4.4 HEC-RAS

Several key findings included:

- By redirecting sheet flow and controlling stages, restoration of the Nine Gems, Gulfstream, Culpepper, and Shiloh Farms properties and surrounding publically owned lands is viable.
- Based on a preliminary single storm analysis (25-year, 24-hour), privately owned lands do not appear to be adversely impacted by the increased surface water stages on the restored wetlands or within the Ranch Colony Canal.
- Some improvements to the timing and quantity of water to Ranch Colony Canal and Cypress Creek are predicted with a reduction in some high flows during the wet season and an increase in low flows during dry periods which is most beneficial to the Northwest Fork of the Loxahatchee River.
- Further model refinements are needed to capture the local variability in hydraulic properties and operations at a resolution that is able to more accurately assess environmental and project benefits or impacts

D.4.5 Model Approval

Model approval is focused on evaluation and acceptance of the modeling software or code. Model software performance is reviewed by the HH&C Community of Practice. If appropriate, the software is approved for USACE applications. The two models used for alternative analysis for the LRWRP, LECsR-NP and HEC-RAS, have been “allowed for use” for LECsR-NP and “USACE endorsed” for HEC-RAS.

E. REFERENCES

Arcadis Design and & Consultancy, 2016. Mecca Impoundment Palm Beach County, Florida. Work Order No. 4600003011-WO01. Final Design Documentation Report.

Amec Foster Wheeler Environment & Infrastructure, 2016. L31N Phase 2 As-Built drawings. Accessed on July 25, 2018 at http://www.l31nseepage.org/index6.html

Ecology and Environment, Inc., 2009. Nine Gems Restoration: Field Studies and Recommendations Report. Report prepared for SFWMD dated February 2009, 29 p.

Gannett Fleming, Inc., 2016. Final Geotechnical Data Report for the J.W. Corbett Wildlife Management Area Hydrologic Assessment. Report prepared for South Florida Engineering and Consulting, LLC, dated 28 January 2016, 71 p.

Giddings, J.B, Obeysekera, A.N. (2018) Model Application Report for Loxahatchee River Watershed Restoration Project. South Florida Water Management District.

Harbaugh, A.W. and M.G. McDonald. 1996. Documentation for MODFLOW-96, and Update to the U.S. Geological Survey Modular Finite-Difference Ground Water Flow Model. Techniques of Water-Resources Investigations of the USGS. Open-File Report 96-485, USGS, Reston, VA.

Kuebler, L.L., 2010. Model Documentation for the Application of the Northern Palm Beach County Version of the Lower East Coast Sub-regional Model (LECsR-NP). South Florida Water Management District, West Palm Beach, Florida.

Montoya, A., Kuebler, L., Radin, H., Mullen, V. (2010) Model Implementation of the Northern Palm Beach County Version of the Lower East Coast Sub-regional Model (LECsR-NP). South Florida Water Management District.

NRCS (Natural Resources Conservation Service), 2018. Soil Maps of Flow-ways 2 and 3 defined using the Web Soil Survey App accessed at https://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx on 1 and 4 July 2018.

Obeysekera, A.N., Giddings, J.B, and Bandara, D.U. (2018). Model Calibration Report for Lower East Coast Sub-regional Model - North Palm Version. South Florida Water Management District.

Tierra, Inc., 2004. Preliminary Geotechnical Engineering Services Report for the Palm Beach County Biotechnology Research Park, Palm Beach County, Florida. Report prepared for Miller, Legg and Associates, Inc., dated August 2, 2004, 23 p.

Tomasello Consulting Engineers. (2016) Cypress Creek Modeling of Operations.

URS Corporation, 2008. Geotechnical Investigation & Soils Evaluation, Mecca Farms Flow Way, Palm Beach County, Florida. Report prepared for RCT Engineering dated January 15, 2008, 64 p.

COMPREHENSIVE EVERGLADES RESTORATION PLAN

LOXAHATCHEE RIVER WATERSHED RESTORATION PROJECT

DRAFT INTEGRATED PROJECT IMPLEMENTATION REPORT AND ENVIRONMENTAL IMPACT STATEMENT

March 2019

Appendix B

APPENDIX B

COST ENGINEERING AND RISK ANALYSIS

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1 COST ESTIMATES

This appendix describes the construction cost estimates used during the comparison of alternative plans and the methods used to develop the estimates.

1.1 General Information

Corps of Engineers cost estimates for planning purposes are prepared in accordance with the following guidance:

- Engineer Regulation (ER) 1110-1-1300, Cost Engineering Policy and General Requirements, 26 March 1993
- ER 1110-2-1302, Civil Works Cost Engineering, 30 June 2016
- ER 1110-2-1150, Engineering and Design for Civil Works Projects, 31 August 1999
- ER 1105-2-100, Planning Guidance Notebook, 22 April 2000, as amended
- Engineer Manual (EM) 1110-2-1304 (Tables Revised 31 March 2017), Civil Works Construction Cost Index System, 31 March 2017
- CECW-CP Memorandum for Distribution, Subject: Initiatives to Improve the Accuracy of Total Project Costs in Civil Works Feasibility Studies Requiring Congressional Authorization, 19 September 2007
- CECW-CE Memorandum for Distribution, Subject: Application of Cost Risk Analysis Methods to Develop Contingencies for Civil Works Total Project Costs, 3 July 2007
- Cost and Schedule Risk Analysis Process, March 2008
- DCM

The objective of the cost estimates for the Loxahatchee River Watershed Restoration Project (LRWRP) is to present a Total Project Cost (Construction and non-Construction costs) for the recommended plan at the current price level to be used for project justification/authorization, and to escalate costs for budgeting purposes. In addition, the costing efforts are intended to produce a final product (cost estimate) that is reliable and accurate, and that supports defines the Government's and non-Federal sponsor's obligations.

The cost estimates used for plan selection rely on construction feature unit pricing obtained from the 2010 Cost Appendix developed by the Huntington District for the alternatives on the North Palm Beach County project (precursor to LRWRP), ARCADIS/MECCA cost estimate, and the MWH cost estimate for C-51 features; and escalated to FY19 dollars. A fully funded, escalated for inflation through project completion, cost estimate, (i.e. the Baseline Cost Estimate or Total Project Cost Summary), has also been developed.

1.1.1 Plan Formulation Cost Estimates

For the plan formulation cost estimates, unit prices per features were obtained from the 2010 Cost Appendix developed by the Huntington District for the alternatives on the North Palm Beach County project, ARCADIS/MECCA cost estimate, and the MWH cost estimate; and escalated to FY19 dollars. Other

unit prices were obtained from SFWMD from historical data. Design details, information and assumptions are provided in the report. Plan formulation alternatives and cost estimates were developed by the Project Delivery Team (PDT) and descriptions of the alternatives are contained in the Main Report. An abbreviated cost risk analysis was used to establish contingencies for plan formulation purposes based on the project's main features. A formal risk analysis will be conducted later to establish the contingency for the preferred plan. Non-construction costs were included as percentages based on historical data compiled from previous construction projects. Refer to the Main Report for additional details of the final plan formulation and associated cost tables.

1.1.2 Recommended Plan

A MCACES/MII cost estimate for the Tentatively Selected Plan (TSP) has not yet been developed yet. As a more detail level of is developed, a comprehensive MCACES/MII estimate will ve completed.

1.1.3 Construction Cost

Construction costs were developed using unit prices obtained from the 2010 Cost Appendix developed by the Huntington District for the alternatives on the North Palm Beach County project, ARCADIS/MECCA cost estimate, and the MWH cost estimate; and escalated to FY19 dollars.

1.1.4 Non-construction Cost

Non-construction costs typically include Lands and Damages (Real Estate), Planning Engineering & Design (PED) and Construction Management Costs (Supervision & Administration, S&A). These costs were provided by the PDT either as lump sum costs associated with historic records, or as a percentage of the total construction contract cost. Lands and Damages are provided by SAJ Real Estate Division and are described in the Real Estate Report. In addition, percentages, for Engineering During Construction (EDC) and Planning During Construction (PDC) were provided by the project manager. Construction Management costs are for the supervision and administration of a contract and include Project Management and Contract Administration costs. These costs were provided by the project manager and are included as a percentage of the total construction contract cost.

The main report will provide details of both cost allocation and cost apportionment for the federal government and the non-federal sponsor for the TSP. Also, the Main Report will identify the non-federal sponsor's obligations (items of local cooperation).

1.1.5 Operations and Maintenance Costs

Additional Operations and Maintenance (O&M) costs for each of the features at the Reservoirs per alternatives were considered for the Economic Analysis; O&M costs were omitted from the cost estimates but included in the Economic Analysis. Refer to the Main Report for additional details.

1.1.6 Construction Schedule

A construction schedule will be prepared later on for the TSP utilizing input from the PDT and to reflect project construction components. The schedule will consider the duration of construction as well as the timing of construction contract award based on funding for the TSP.

The construction schedule will be combined with the project schedule to create an overall schedule that can be used to generate the Total Project Cost Summary (TPCS), as well as the schedule portion of the Cost and Schedule Risk Analysis (CSRA).

1.1.7 Total Project Cost Summary

A cost estimate for the recommended plan will be prepared in MII/MCACES using an identified price level date 2019. Escalation factors will be used to adjust the pricing to the project schedule for the TSP refined. The estimate is known as either the fully funded cost estimate or Total Project Cost Summary (TPCS). It will include all federal and non-federal costs: lands, easements, rights of way and relocations, construction features, preconstruction engineering and design construction management, contingency, and escalation.

1.2 Plan Formulation Cost Estimates

The plan formulation is described in the Main Report. The final alternatives considered for the project are:

- Alternative 2
- Alternative 5
- Alternative 5R
- Alternative 10
- Alternative 13

1.2.1 Alternatives Description

Each alternative is described below.

- **Alternative 2:** This alternative includes: C-18W reservoir of 7,200 ac-ft; L-8 shallow storage area including cells 1, 2, 3, and a rehydratation area; M-O canal with 100 cfs pump station; 2-well ASR system; structures G-160 and G-161; improvements to the canals at Ranch Colony and Cypress Creek; restoration of all components of the Gulfstream West property; improvements to Moonshine Creek, Gulfstream East and Kitching Creek; improvements to Pepper Farm / Hobe Farms drainage facilities; and restoration of the Nine Gems property; among other improvements.
- **Alternative 5**: This alternative includes: C-18W reservoir of 9,400 ac-ft; M-1 canal pump station; M-O Canal with 100 CFS pump station; a 4-well ASR system; improvements to the canals at Ranch Colony and Cypress Creek; restoration of all components of the Gulfstream West property; improvements to Moonshine Creek, Gulfstream East and Kitching Creek; improvements to Pepper Farm / Hobe Farms drainage ponds; restoration of Nine Gems property; structures at G-160 and G-161; Grassy Water Preserve; among other improvements.
- **Alternative 5R**: This alternative includes: Shiloh Farms & Mack Dairy Rd. spreader; C-18W reservoir of 9,400 ac-ft; M-1 canal pump station; M-O Canal with 100 CFS pump station; a 4-well ASR system; improvements to the canals at Ranch Colony and Cypress Creek; restoration of all components of the Gulfstream West property; improvements to Moonshine Creek, Gulfstream East and Kitching Creek; improvements to Pepper Farm / Hobe Farms drainage ponds; restoration of Nine Gems property; structures at G-160 and G-161; Grassy Water Preserve; among other improvements. **(TSP)**

- **Alternative 10:** This alternative includes: C-18 reservoir of 7,200 ac-ft; C-51 reservoir of 44,000 ac-ft; M-O Canal with 100 CFS pump station; improvements to the canals at Ranch Colony and Cypress Creek; improvements to Moonshine Creek, Gulftream East and Kitching Creek; Force Main; among other improvements.
- **Alternative 13**: This alternative includes: L-8 shallow storage area cells 1, 2, 3, and rehydratation area; M-O Canal with 100 cfs pump station; a 4-well ASR system ; flow-way across Avenir and Mecca; Pine Glades seepage barrier; improvements to the canals at Ranch Colony and Cypress Creek; restoration of all components of the Gulfstream West property; improvements to Moonshine Creek, Gulftream East and Kitching Creek; improvements to Pepper Farm / Hobe Farms drainage ponds; restoration of Nine Gems property; Shiloh flow-way and pump station; among other improvements.

1.2.2 Budget Estimates

Budget construction costs are summarized in Table B-1.

Table 1. Alternatives Budget Estimate Summary of Construction Costs.

Alternative	Budget Construction Cost
Alternative 2	$218,530,000.00
Alternative 5	$196,240,000.00
Alternative 5R (TSP)	$199,800,000.00
Alternative 10	$298,030,000.00
Alternative 13	$140,490,000.00

Notes:
1. The Budget Project Cost includes construction costs.
2. The Budget Project Cost is shown in FY19 price level.
3. O&M Costs are not included in Budget Project Cost.
4. Refer to Addendums A for more details on the Budget Project Cost
5. These costs don't include contingency.

1.2.3 Contingencies

An abbreviated risk analysis was used to develop contingencies for the alternatives. A formal Risk Analysis will be performed for the TSP Refine.

1.2.4 Non-Construction Costs

The Pre-Construction Engineering and Design (PED) costs, Engineering during Construction (EDC) costs and Supervision & Administration (S&A) costs were provided as a percentage of the total construction contract cost per the project manager. A 10.8% combined PED, EDC and S&A percentage was applied to the estimated construction costs of the alternatives.

1.3 Recommended Plan – This section will be updated with the TSP.

The recommended plan will be refined later.

1.3.1 Contingencies

A cost and schedule risk analysis will be completed for the recommended plan. During the alternatives evaluation, an Abbreviated Risk Analysis was developed to facilitate the screening process. The PDT participated in the Abbreviated Risk Analysis brainstorming session to identify risks associated with each alternative.

1.3.2 Non-construction Costs

Real Estate costs were assessed and provided by Real Estate Division (See Real Estate appendix).

Planning, Engineering and Design costs (Account 30); and Construction Management costs (Account 31) were established as percentages of the construction cost; 5.2% for Account 30 and 5.6% for Account 31. These percentages are standard and are applied to the construction cost.

1.4 Schedule

The project schedule will cover the lifecycle phases of the recommended plan (Planning Phase, Preconstruction Engineering and Design (PED) Phase, and the Construction Phase).

1.5 Risk and Uncertainty Analysis

A Cost and Schedule Risk Analysis will be conducted according to the procedures outlined in the following documents and sources:

- Cost and Schedule Risk Analysis Process guidance prepared by the USACE Cost Engineering MCX.
- Engineer Regulation (ER) 1110-2-1302 CIVIL WORKS COST ENGINEERING, dated September 15, 2008.
- Engineer Technical Letter (ETL) CONSTRUCTION COST ESTIMATING GUIDE FOR CIVIL WORKS, dated September 30, 2008.

1.5.1 Risk Analysis Methods

The risk analysis process for this study will determine the probability of various cost outcomes and quantify the required contingency needed in the cost estimate to achieve the desired level of cost confidence.

The PDT participates in a risk analysis brainstorming session to identify risks associated with the project. The risks are listed in the risk register, which is a tool commonly used in project planning and risk analysis, and then evaluated by the PDT. Assumptions are made as to the likelihood and impact of each risk item, as well as, the probability of occurrence and magnitude of the impact if it were to occur. The risk model within the tool is then run in order to establish contingencies to apply to the project cost.

After the risk model is run, the results are reviewed and all parameters are re-evaluated by the PDT as a check of assumptions and inputs. Adjustments are made to the analysis accordingly, and the final contingency is established.

- For the Alternative Evaluation phase, risks were evaluated using the Abbreviated Risk Analysis (ARA) tool, which is a simplified tool to calculate contingencies on a project. The ARA tool only

evaluates impacts to the project cost. Each alternative was evaluated separately and the results can be seen on the shables shown in Appendix A.

- After the TSP Refine, risks will be evaluated using the Oracle Crystall Ball tool, which is a more complete tool to calculate contingencies on a project. The Cystall Ball tool evaluates impacts to both project cost and and schedule. The contingency will be applied to the Recommended Plan estimate in the Total Project Cost Summary in order to obtain the Fully Funded Cost.

1.5.2 Risk Analysis Results

Risk analysis results are intended to provide project leadership with contingency information for scheduling, budgeting, and project control purposes, as well as, to provide tools to support decision-making and risk management as the project progresses through planning and implementation.

Based on the risks that were assessed during the Alternative Evaluation Phase, using the ARA tool, the resultant contingency for the TSP was 38%. The complete breakdown of results for all alternatives can be viewed in the tables shown in Attachment A.

1.6 Total Project Cost Summary

The Total Project Cost Summary (TPCS) will addresses inflation through project completion (accomplished by escalation to mid-point of construction per ER 1110-2-1302, Appendix C, Page C-2). It will be based on the scope of the recommended plan and the official project schedule. The TPCS will includes federal and non-federal costs for lands and damages, all construction features, PED, S&A, along with the appropriate contingencies and escalation associated with each of these activities. The TPCS will be formatted according to the CWWBS and uses Civil Works Construction Cost Index System (CWCCIS) factors for escalation (EM 1110-2-1304) of construction costs and Office of Management and Budget (EC 11-2-18X, 20 Feb 2008) factors for escalation of PED and S&A costs.

The Total Project Cost Summary will be prepared using the MCACES/MII cost estimate for the recommended plan, as well as, the contingency set by the risk analysis, and escalation factors, per the project schedule.

1.6.1 Total Project Cost Summary Spreadsheet

The Total Project Cost Summary spreadsheet will be developed for the Recommended Plan. (TSP) after the TSP Refine.

For each of the Alternatives, the costs were developed in the Abbreviated Risk Analysis tool, and shown in Appendix A.

1.7 Cost Certification

The recommended plan estimate, formal cost and schedule risk analysis, and total project cost summary will undergo cost review and certification by the Walla Walla Mandatory Cost Center of Expertise following the final ATR, prior to submittal of the final report. A copy of the issued certification will be included in the future with this appendix.

A copy of the Budget Estimate for the TSP has been included in the Attachment A.

ATTACHMENT A – ABBREVIATED RISK ANALYSIS (ARA) & ALTERNATIVES BUDGET ESTIMATE BREAKDOWN

Abbreviated Risk Analysis

Project Development Stage/Alternative: **Loxahatchee River Watershed Restoration Project** / **Alternative Formulation**

Risk Category: **Moderate Risk: Typical Project Construction Type**

Alternative: **Alternative 2**

Meeting Date:

Updated: **8/16/2018**

Total Estimated Construction Contract Cost = $ 218,530,000

CWWBS	Feature of Work	Contract Cost		% Contingency	$ Contingency	Total
01 LANDS AND DAMAGES	Real Estate	$ 131,068,198		30.00%	$ 39,320,459	$ 170,388,657
03 RESERVOIRS	C-18 Reservoir 7,200 Ac-ft (All the components)	$ 102,830,000		55.61%	$ 57,179,659	$ 160,009,659
15 FLOODWAY CONTROL AND DIVERSION STRUCTURES	L-8 Shallow Storage (Cells 1, 2 and 3 + Rehydratation Area)	$ 48,900,000		49.88%	$ 24,389,185	$ 73,289,185
09 02 CANALS	M-0 canal + 100 cfs pump station	$ 6,610,000		24.41%	$ 1,613,528	$ 8,223,528
32 05 COLLECTION & INJECTION OF GROUND WATER	2-Well ASR System	$ 13,950,000		29.84%	$ 4,162,605	$ 18,112,605
15 FLOODWAY CONTROL AND DIVERSION STRUCTURES	Ranch Colony Canal & Cypress Creek Canal Improvements	$ 5,500,000		34.69%	$ 1,908,160	$ 7,408,160
15 FLOODWAY CONTROL AND DIVERSION STRUCTURES	Gulfstream West (All components)	$ 20,250,000		42.74%	$ 8,654,513	$ 28,904,512.77
15 FLOODWAY CONTROL AND DIVERSION STRUCTURES	Moonshine Creek + GS East + Kitching Creek Improvements	$ 3,260,000		24.21%	$ 789,147	$ 4,049,146.53
15 FLOODWAY CONTROL AND DIVERSION STRUCTURES	Hobe Farm Drainage and Nine Gems	$ 6,580,000		26.13%	$ 1,719,397	$ 8,299,397.30
All Other	**Remaining Construction Items**	$ 10,650,000	5.1%	10.00%	$ 1,065,000	$ 11,715,000
30 PLANNING, ENGINEERING, AND DESIGN	**Planning, Engineering, & Design (5.2%)**	$ 11,363,560		22.35%	$ 2,539,897	$ 13,903,457
31 CONSTRUCTION MANAGEMENT	**Construction Management (5.6%)**	$ 12,237,680		20.12%	$ 2,462,562	$ 14,700,242
FIXED DOLLAR RISK ADD (EQUALLY DISPERSED TO ALL, MUST INCLUDE JUSTIFICATION SEE BELOW)						

Totals					
Real Estate	$ 131,068,198	30.00%	$ 39,320,459	$ 170,388,657.40
Total Construction Estimate	$ 218,530,000	46.44%	$ 101,481,195	$ 320,011,195
Total Planning, Engineering & Design	$ 11,363,560	22.35%	$ 2,539,897	$ 13,903,457
Total Construction Management	$ 12,237,680	20.12%	$ 2,462,562	$ 14,700,242
Total Construction Cost	**$ 373,199,438**	**39%**	**$ 145,804,113**	**$ 519,003,551**

Abbreviated Risk Analysis

Project Development Stage/Alternative: **Loxahatchee River Watershed Restoration Project** **Alternative Formulation**

Risk Category: **Moderate Risk: Typical Project Construction Type**

Alternative: **Alternative 5**

Meeting Date:

Updated: **9/5/2018**

Total Estimated Construction Contract Cost = $ 196,240,000

CWWBS	Feature of Work	Contract Cost		% Contingency	$ Contingency	Total
01 LANDS AND DAMAGES	Real Estate	$ 88,526,323		30.00%	$ 26,557,897	$ 115,084,220
03 RESERVOIRS	C-18 Reservoir 9400 ac-ft (All the components)	$ 125,940,000		55.61%	$ 70,030,208	$ 195,970,208
15 FLOODWAY CONTROL AND DIVERSION STRUCTURES	M-1 Canal Pump Station	$ 4,950,000		14.07%	$ 696,249	$ 5,646,249
09 02 CANALS	M-0 canal + 100 cfs pump station	$ 6,610,000		24.41%	$ 1,613,528	$ 8,223,528
32 05 COLLECTION & INJECTION OF GROUND WATER	ASR System (4 ASR wells and surface facility)	$ 15,920,000		29.84%	$ 4,750,443	$ 20,670,443
15 FLOODWAY CONTROL AND DIVERSION STRUCTURES	Ranch Colony Canal & Cypress Creek Canal Improvements	$ 5,500,000		34.69%	$ 1,908,160	$ 7,408,160
15 FLOODWAY CONTROL AND DIVERSION STRUCTURES	Gulfstream West (All components)	$ 20,250,000		42.74%	$ 8,654,513	$ 28,904,512.77
15 FLOODWAY CONTROL AND DIVERSION STRUCTURES	GS East + Moonshine Creek + Kitching Creek Improvements	$ 3,260,000		24.21%	$ 789,147	$ 4,049,146.53
15 FLOODWAY CONTROL AND DIVERSION STRUCTURES	Hobe Farm Drainage and Nine Gems	$ 6,580,000		26.13%	$ 1,719,397	$ 8,299,397.30
15 FLOODWAY CONTROL AND DIVERSION STRUCTURES	G160, G161, GWP	$ 7,230,000		10.00%	$ 723,000	$ 7,953,000.00
All Other	Remaining Construction Items	$ -	*0.0%*			
30 PLANNING, ENGINEERING, AND DESIGN	Planning, Engineering, & Design (5.2%)	$ 10,204,480		22.35%	$ 2,280,828	$ 12,485,308
31 CONSTRUCTION MANAGEMENT	Construction Management (5.6%)	$ 10,989,440		20.12%	$ 2,211,381	$ 13,200,821
FIXED DOLLAR RISK ADD (EQUALLY DISPERSED TO ALL, MUST INCLUDE JUSTIFICATION SEE BELOW)						

Totals					
Real Estate	$ 88,526,323	30.00%	$ 26,557,897	$ 115,084,219.90	
Total Construction Estimate	$ 196,240,000	46.31%	$ 90,884,644	$ 287,124,644	
Total Planning, Engineering & Design	$ 10,204,480	22.35%	$ 2,280,828	$ 12,485,308	
Total Construction Management	$ 10,989,440	20.12%	$ 2,211,381	$ 13,200,821	
Total Construction Cost	**$ 305,960,243**	**40%**	**$ 121,934,750**	**$ 427,894,993**	

Abbreviated Risk Analysis

Loxahatchee River Watershed Restoration Project — **Alternative:**

Project Development Stage/Alternative: **Alternative Formulation** — **Alternative 5R**

Risk Category: **Moderate Risk: Typical Project Construction Type** — **Meeting Date:**

Updated: 9/5/2018

Total Estimated Construction Contract Cost = $ 199,800,000

CWWBS	Feature of Work	Contract Cost		% Contingency	$ Contingency	Total
01 LANDS AND DAMAGES	Real Estate	$ 103,765,969		30.00%	$ 31,129,791	$ 134,895,760
15 FLOODWAY CONTROL AND DIVERSION STRUCTURES	Shiloh Farms Flowway and Mack Dairy Rd. Spreader	$ 3,560,000		26.78%	$ 953,462	$ 4,513,462
03 RESERVOIRS	C-18 Reservoir 9400 ac-ft (All the components)	$ 125,940,000		55.61%	$ 70,030,208	$ 195,970,208
15 FLOODWAY CONTROL AND DIVERSION STRUCTURES	M-1 Canal Pump Station	$ 4,950,000		14.07%	$ 696,249	$ 5,646,249
09 02 CANALS	M-0 canal + 100 cfs pump station	$ 6,610,000		24.41%	$ 1,613,528	$ 8,223,528
32 05 COLLECTION & INJECTION OF GROUND WATER	ASR System (4 ASR wells and surface facility)	$ 15,920,000		29.84%	$ 4,750,443	$ 20,670,443
15 FLOODWAY CONTROL AND DIVERSION STRUCTURES	Ranch Colony Canal & Cypress Creek Canal Improvements	$ 5,500,000		34.69%	$ 1,908,160	$ 7,408,160
15 FLOODWAY CONTROL AND DIVERSION STRUCTURES	Gulfstream West (All components)	$ 20,250,000		42.74%	$ 8,654,513	$ 28,904,512.77
15 FLOODWAY CONTROL AND DIVERSION STRUCTURES	GS East + Moonshine Creek + Kitching Creek Improvements	$ 3,260,000		24.21%	$ 789,147	$ 4,049,146.53
15 FLOODWAY CONTROL AND DIVERSION STRUC	Hobe Farm Drainage and Nine Gems	$ 6,580,000		26.13%	$ 1,719,397	$ 8,299,397.30
15 FLOODWAY CONTROL AND DIVERSION STRUC	G160, G161, GWP	$ 7,230,000		10.00%	$ 723,000	$ 7,953,000.00
All Other	Remaining Construction Items	$ -	0.0%			
30 PLANNING, ENGINEERING, AND DESIGN	Planning, Engineering, & Design (5.2%)	$ 10,389,600		22.35%	$ 2,322,205	$ 12,711,805
31 CONSTRUCTION MANAGEMENT	Construction Management (5.6%)	$ 11,188,800		20.12%	$ 2,251,498	$ 13,440,298
FIXED DOLLAR RISK ADD (EQUALLY DISPERSED TO ALL, MUST INCLUDE JUSTIFICATION SEE BELOW)						

Totals					
Real Estate	$ 103,765,969	30.00%	$ 31,129,791	$ 134,895,759.70
Total Construction Estimate	$ 199,800,000	45.97%	$ 91,838,106	$ 291,638,106
Total Planning, Engineering & Design	$ 10,389,600	22.35%	$ 2,322,205	$ 12,711,805
Total Construction Management	$ 11,188,800	20.12%	$ 2,251,498	$ 13,440,298
Total Construction Cost	$ 325,144,369	39%	$ 127,541,600	$ 452,685,969

Abbreviated Risk Analysis

	Loxahatchee River Watershed Restoration Project	**Alternative:**	
Project Development Stage/Alternative:	**Alternative Formulation**		**Alternative 10**
Risk Category:	**Moderate Risk: Typical Project Construction Type**	**Meeting Date:**	
		Updated:	**8/16/2018**

Total Estimated Construction Contract Cost = $ 298,030,000

CWWBS	Feature of Work	Contract Cost		% Contingency	$ Contingency	Total
01 LANDS AND DAMAGES	Real Estate	$ 75,573,661		30.00%	$ 22,672,098	$ 98,245,759
03 RESERVOIRS	C-51 Reservoir (44,000 ac-ft)	$ 161,610,000		53.84%	$ 87,010,324	$ 248,620,324
03 RESERVOIRS	C-18 Reservoir (All the components)	$ 102,830,000		53.84%	$ 55,363,354	$ 158,193,354
09 02 CANALS	M-0 canal + 100 cfs pump station	$ 6,610,000		24.41%	$ 1,613,528	$ 8,223,528
15 FLOODWAY CONTROL AND DIVERSION STRUCTURES	Ranch Colony Canal & Cypress Creek Canal Improvements	$ 5,500,000		34.69%	$ 1,908,160	$ 7,408,160
15 FLOODWAY CONTROL AND DIVERSION STRUCTURES	GS East + Moonshine + Kitching Creek Improvements	$ 3,260,000		24.21%	$ 789,147	$ 4,049,147
15 FLOODWAY CONTROL AND DIVERSION STRUCTURES	Force Main	$ 10,980,000		31.04%	$ 3,408,028	$ 14,388,028.32
All Other	**Remaining Construction Items**	**$ 7,240,000**	2.5%	10.00%	$ 724,000	$ 7,964,000
30 PLANNING, ENGINEERING, AND DESIGN	**Planning, Engineering, & Design (5.2%)**	$ 15,497,560		22.35%	$ 3,463,897	$ 18,961,457
31 CONSTRUCTION MANAGEMENT	**Construction Management (5.6%)**	$ 16,689,680		20.12%	$ 3,358,429	$ 20,048,109
FIXED DOLLAR RISK ADD (EQUALLY DISPERSED TO ALL, MUST INCLUDE JUSTIFICATION SEE BELOW)					$ -	

Totals					
Real Estate	$ 75,573,661	30.00%	$ 22,672,098	$ 98,245,759.30
Total Construction Estimate	$ 298,030,000	50.60%	$ 150,816,541.54	$ 448,846,542
Total Planning, Engineering & Design	$ 15,497,560	22.35%	$ 3,463,897	$ 18,961,457
Total Construction Management	$ 16,689,680	20.12%	$ 3,358,429	$ 20,048,109
Total Construction Cost	**$ 405,790,901**	**44%**	**$ 180,310,966**	**$ 586,101,867**

Abbreviated Risk Analysis

	Loxahatchee River Watershed Restoration Project	**Alternative:**	
Project Development Stage/Alternative:	**Alternative Formulation**		**Alternative 13**
Risk Category:	**Moderate Risk: Typical Project Construction Type**	**Meeting Date:**	
		Updated:	**9/5/2018**

Total Estimated Construction Contract Cost = $ 140,490,000

CWWBS	Feature of Work	Contract Cost		% Contingency	$ Contingency	Total
01 LANDS AND DAMAGES	Real Estate	$ 177,119,562		30.00%	$ 53,135,869	$ 230,255,431
15 FLOODWAY CONTROL AND DIVERSION STRUCTURES	Shiloh Flowway and pump station and Mack Dairy Rd Spreader	$ 3,560,000		26.78%	$ 953,462	$ 4,513,462
15 FLOODWAY CONTROL AND DIVERSION STRUCTURES	L-8 Shallow Storage (Cells 1, 2 and 3 + Rehydratation Area)	$ 55,240,000		49.88%	$ 27,551,301	$ 82,791,301
09 02 CANALS	M-0 canal + 100 cfs pump station	$ 6,610,000		24.41%	$ 1,613,528	$ 8,223,528
32 05 COLLECTION & INJECTION OF GROUND WATER	ASR System at L-8 shallow storage	$ 15,920,000		29.84%	$ 4,750,443	$ 20,670,443
15 FLOODWAY CONTROL AND DIVERSION STRUCTURES	Ranch Colony Canal & Cypress Creek Canal Improvements	$ 5,500,000		34.69%	$ 1,908,160	$ 7,408,160
15 FLOODWAY CONTROL AND DIVERSION STRUCTURES	Gulfstream West (All components)	$ 20,250,000		42.74%	$ 8,654,513	$ 28,904,512.77
15 FLOODWAY CONTROL AND DIVERSION STRUCTURES	GS East & Moonshine Creek + Kitching Improvements	$ 3,260,000		24.21%	$ 789,147	$ 4,049,146.53
15 FLOODWAY CONTROL AND DIVERSION STRUC	Hobe Farm Drainage and Nine Gems	$ 6,580,000		26.13%	$ 1,719,397	$ 8,299,397.30
15 FLOODWAY CONTROL AND DIVERSION STRUC	Flowway Across Avenir and Mecca	$ 7,420,000		38.51%	$ 2,857,765	$ 10,277,764.81
15 FLOODWAY CONTROL AND DIVERSION STRUC	Pine Glades Seepage Barrier/Natural Storage	$ 1,910,000		10.00%	$ 191,000	$ 2,101,000.00
All Other	**Remaining Construction Items**	**$ 14,240,000**	*11.3%*	0.00%	$ -	$ 14,240,000
30 PLANNING, ENGINEERING, AND DESIGN	**Planning, Engineering, & Design (5.2%)**	$ 7,305,480		22.35%	$ 1,632,866	$ 8,938,346
31 CONSTRUCTION MANAGEMENT	**Construction Management (5.6%)**	$ 7,867,440		20.12%	$ 1,583,148	$ 9,450,588
FIXED DOLLAR RISK ADD (EQUALLY DISPERSED TO ALL, MUST INCLUDE JUSTIFICATION SEE BELOW)						

Totals					
Real Estate	$ 177,119,562	30.00%	$ 53,135,869	$ 230,255,430.60
Total Construction Estimate	$ 140,490,000	36.29%	$ 50,988,715	$ 191,478,715
Total Planning, Engineering & Design	$ 7,305,480	22.35%	$ 1,632,866	$ 8,938,346
Total Construction Management	$ 7,867,440	20.12%	$ 1,583,148	$ 9,450,588
Total Construction Cost	**$ 332,782,482**	**32%**	**$ 107,340,597**	**$ 440,123,079**

COMPREHENSIVE EVERGLADES RESTORATION PLAN

LOXAHATCHEE RIVER WATERSHED RESTORATION PROJECT

DRAFT INTEGRATED PROJECT IMPLEMENTATION REPORT AND ENVIRONMENTAL IMPACT STATEMENT

March 2019

Appendix C

APPENDIX C.1
EXISTING AND FWO PROJECT CONDITIONS

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C.1 Existing and Future Without Project Conditions

This appendix provides a detailed discussion of the potential environmental effects of current existing conditions (ECB) and considers the environmental conditions in the affected regions without the Proposed Action. For consistency of the report, the No Action Alternative is referred to as the **Future Without [FWO]** for the remainder of the report. Twenty-four resource conditions were evaluated including climate, physical landscape, geology, soils, aquifers, vegetative communities, threatened and endangered species, essential fish habitat, state-listed species, fish and wildlife, hydrology, groundwater resources, surface water quality, air quality, hazardous, toxic and radioactive waste (HTRW), noise, aesthetics, land use, recreation, socioeconomics, environmental justice, cultural resources, invasive species, and airport-wildlife strike hazards.

C.1.1 System Overview

The Loxahatchee River Watershed Restoration Project (LRWRP) study area extends from the Jupiter Inlet and Atlantic Ocean on the east to Lake Okeechobee on the west. The study area encompasses more than 700 square miles and includes diverse natural communities, concentrated on the western and northern sides of the study area, and transitions to densely urbanized areas, bisected by the Florida interstate highway system and turnpike on the eastern side of the area. It includes the portion of Martin County south of the C-44 Canal and the portion of Palm Beach County north of the C-51 and L10/L12 Canals. Undeveloped key natural features of the study area include Pal-Mar, Jonathan Dickenson State Park (JDSP), J.W. Corbett Wildlife Management Area (WMA), Dupuis Reserve, Grassy Waters Preserve (GWP), the Loxahatchee Slough, three branches of the Loxahatchee River (NW Fork, SW Fork and the North Fork) and two primary tributaries (Cypress Creek, Kitching Creek) to the Loxahatchee River. A third tributary, Moonshine Creek, was cut off from historical flow by the Hobe Grove Ditch.

The Northwest Fork of the Loxahatchee River (NWFLR) is one of only two federally designated “Wild and Scenic” Rivers in the state of Florida. The NWFLR extends from south of Indiantown Road, beginning at the G-92 structure, flowing through Riverbend Park, and then north into Martin County before turning back southeast to join the North and SW forks to form the central embayment of the Loxahatchee River estuary, which connects to the Atlantic Ocean via the Jupiter Inlet. The length of the river from Jupiter Inlet to Riverbend Park is 15.5 miles and the “Wild and Scenic” portion of the river is 9.5 miles in length (SFWMD 2006). Approximately 240 square miles currently drain to the river, an area considerably smaller than the natural pre-developed Loxahatchee River watershed that included approximately 350 square miles of inland sloughs (CERP Monitoring and Assessment Plan, Appendix A, 2004). The historical drainage area was comprised primarily of pine flatwoods interspersed with cypress sloughs, hardwood swamps, marshes and wet prairies.

Historically, the Loxahatchee and Hungryland Sloughs drained from the watershed to the NWFLR. The watershed has been altered by the construction of roadways to support urbanization, and canals for drainage. The construction of Northlake Boulevard isolated the southern portion of Loxahatchee Slough (now known as GWP) from the northern portion, and the construction of Beeline Highway isolated Hungryland Slough to the west. The South Indian River Water Control District (SIRWCD) Canal 14, constructed before 1940, and the C-18 Canal, constructed in the 1960s, channelized the slough systems and diverted flows via the S-46 structure away from the NWFLR to the SW Fork for flood control purposes. These reduced flows, combined with the permanent opening of the Jupiter Inlet in 1947, resulted in saltwater encroachment into the upstream reaches of the river, particularly in the dry season. The

reduced flows are not sufficient to retard the saltwater encroachment, which has adverse impacts to the floodplain, replacing the freshwater, bald-cypress dominated community with salt-tolerant mangroves. The G-92 structure (also known as the 'diversion structure'), was constructed in the late 1970s and allows water to be delivered to the NW Fork via SIRWCD's Canal 14 when available, however, dry season flows continue to be too low to offset saltwater intrusion and, as such, salt tolerant species continue moving upstream into the floodplain.

C.1.2 Climate

Climatic conditions are a driving factor in the development, operation, maintenance and repair of the vast water management system in the Loxahatchee watershed.

C.1.2.1 Existing Conditions

The climate of the LRWRP study area is considered subtropical with distinct wet and dry seasons, high evapotranspiration (ET) rates, and weather extremes that include floods, droughts and tropical cyclones (USACE 1999). Average temperatures range from 66°F in January to 83°F in July, making the annual mean temperature 75°F. The average annual rainfall is about 56 inches but has ranged from a low of 37 inches to a high of 106 inches. The annual rainfall cannot be reduced to a single value, however, as there is a high degree of spatial variability. Higher average totals of 55 to 63 inches occur in the coastal zone, while annual totals are as low as 42 to 46 inches closer to the shore of Lake Okeechobee.

The wet season runs from mid-May through mid-October and accounts for nearly 70% of the annual total rainfall. Of the wet season months, May and October are considered to be transitional and are generally not as wet. In May, a rapid and sometimes instantaneous onset of rains can occur and, at the end of the wet season, a precipitous decline is common. During the wet season, rainfall is bimodally distributed and shows an absolute maximum in June, a relative minimum in July, and a second maximum from late August through early September. Increased convective heating and instability, combined with a large influx of tropical moisture interacting with transient mid-latitude weather systems, help to explain the early season peak in rainfall. The prevalence and stabilizing effect of Saharan Air/Dust carried across the Atlantic and Caribbean from late June through early or mid-August is one factor that accounts for the mid-season lull in rains. The downturn in July also coincides with the peak strength of the subtropical ridge of high pressure extending from the Atlantic Ocean to Florida. Strong sinking motion (and *subsidence*) associated with this weather feature warms and dries the mid-levels of the atmosphere over a large expanse, resulting in reduced rainfall over Florida and the LRWRP project area. As Atlantic high pressure diminishes in strength during the late summer and Saharan Air outbreaks subside, rainfall increases again due to more favorable large-scale conditions. The greater favorability of environmental factors in conjunction with occasional tropical cyclone activity at the peak of Atlantic hurricane season contributes to the second maximum of rainfall during the late summer.

Environmental conditions on most days during the wet season are conducive for the formation of showers and thunderstorms (also known as *convection*) over or near the LRWRP. Factors modulating the convective potential include variations in moisture, stability and the prevailing low- to mid-level winds that are often, but not always, related to transient weather systems. From June through September westward-moving tropical waves (also known as *African easterly waves*) enhance moisture and convergence as they move through the Caribbean and occasionally extend their influence northward through the Florida peninsula. Rainfall production temporarily increases over the LRWRP during their passage, but dry air masses dense with Saharan Dust often follow in their wake and suppress typical

patterns of rain for sometimes days at a time. Large-scale patterns of convergence or divergence associated with mid-latitude weather systems and their companion upper-level disturbances can also exert an influence on rainfall, most often early and late in the wet season when jet stream winds are more active. These large-scale features occasionally persist in the same location for a longer period of time (e.g., a stalled frontal boundary) and can be responsible for significant rainfall or the lack of thereof for several days and far less frequently for up to a week.

On a smaller scale, the day-to-day variability of rainfall within the LRWRP during the wet season is typically controlled by the interaction of the east coast sea breeze circulation and the prevailing large-scale wind flow. The resulting zones of convergence help to organize the initial growth of rain-bearing clouds, but complex interactions between adjacent or even remote areas of convective activity strongly affect the evolution of future storms. In some cases, the interaction can cause rains to quickly diminish while other interactions produce explosive bursts of new activity. Surface features like Lake Okeechobee, the nearby conservation areas, and the coastal configuration play varying roles in the generation, maintenance, and decay of other local circulations that help to modulate convective activity. All of these factors combined result in considerable variability of rainfall amounts, with accumulations often differing by orders of magnitude between one location and the next.

Rainfall over the LRWRP is much lower during the dry season, averaging about 2 inches each month from November through April. The more southern position of the jet stream during the late fall, winter and spring causes migratory fronts to sweep southward and transport much cooler and drier continental air through Florida and the LRWRP once or sometimes twice a week. As a result, the LRWRP experiences long periods of little to no rainfall. Warmer, moist and more unstable air masses briefly overspread Florida ahead of the migratory fronts and produce generally light rainfall for a day or two. The interval between one rainfall event and the next during the dry season is highly variable but can sometimes be longer than a couple of weeks.

Interannual variability of rainfall in the LRWRP is governed in large part by the El Nino-South Oscillation (ENSO), with the region's dry season rainfall from December through February seeing the strongest dependence on this phenomenon. At that time of year, El Nino tends to enhance cyclonic activity in the Gulf of Mexico through the southeast U.S., creating an active 'storm track' across Florida. This pattern typically results in above normal rainfall over the LRWRP, with the magnitude of the enhanced rainfall anomalies generally correlated with the strength of the El Nino. Strong events like the ones in 1997-1998 and 2015-2016 often produce copious rains while weaker events can have a mixed effect. La Niña is characterized by a cooling of the water in the equatorial Pacific Ocean is associated with widespread changes in weather patterns that are complementary to those of El Niño. La Niña, characterized anomalous cooling of the waters in the equatorial Pacific Ocean can have an entirely different effect on the weather over the LRWRP. During La Nina winters, a stronger than normal subtropical ridge of high pressure extends from the western Atlantic into the southeastern U.S., which causes a northward-displaced 'storm track' and fewer frontal passages across Florida. Long periods of dry weather and much reduced rainfall – well less than the climatological average – are favored across the LRWRP under this pattern.

C.1.2.2 Future Without Project Conditions

Though there is evidence of anthropogenic changes to global climate patterns that are likely to have an impact on south Florida and the LRWRP area in terms of rainfall, evapotranspiration, and temperature (Intergovernmental Panel on Climate Change 2007), climatic conditions are expected to remain sub-

tropical with distinct wet and dry seasons, high evapotranspiration rates, and periodic extreme events (floods, droughts, and hurricanes). Ambient temperature and sea level rise could be expected because of climate change. Climatologists predict air temperatures will increase, with projections of summer temperatures being up to 3°F to 7°F warmer by 2100 (Twilley et al. 2001, Union of Concerned Scientists 2008). Concurrent increases in evapotranspiration would be expected along with predicted increases in air temperature, solar radiation, and water vapor deficit. Models used by Calanca et al. (2006) predict a 20% increase in evapotranspiration if summer temperatures do increase from 4°F to 7°F.

Other sources of climate modeling predict a 1.5°C increase of temperatures in the Everglades and +/-10% change in precipitation by 2060 (Obeysekera et al. 2011). The temperature change equates to a 7% increase in evapotranspiration. If precipitation does not similarly increase (+7% to +10%), then drought frequency would be expected to increase in the Everglades. As a peat soil ecosystem, increasing drought would reduce available water to keep the soils wet, resulting in higher peat oxidation and loss of soil elevations in the freshwater wetlands (FAU 2013). Hydrological modeling indicates that surface water duration may decrease by 10%-50% in the Everglades by 2060 (FAU 2013). Though most of the wetland communities throughout the LRWRP planning area are comprised of mineral based soils interspersed with some peat and muck soils, interpolating this same information to the LRWRP project area could potentially result in shortened hydroperiods for the extensive wetland systems that are found throughout the planning area, and in concurrent changes to the biota consistent with shorter hydroperiod systems.

Increases in the rate of evapotranspiration can also be expected to affect regional surface water storage systems (lakes, rivers, canals, reservoirs, water conservation areas) with rapid water loss as compared with current levels, which could have an impact on the availability of water supplies. Water supply sources in the LRWRP planning area include both groundwater and surface water (from GWP, and from Lake Okeechobee). Increased evapotranspiration may increase water demand for irrigation and may impact hydroperiods in natural wetlands areas.

Despite the evidence with respect to the certainty of changes to the global climate environment, future scenarios for the LRWRP area, as well as the rest of peninsular Florida, can be expected to be highly variable, uncertain, and difficult to predict and extrapolation to 2070 and beyond is speculative at best. Though hurricane activity does tend to be cyclical, these cycles vary inter-annually (decadal or multi-decadal) and they are not perfectly periodic. On a global scale, there are strong indications that the latitude at which tropical cyclones are achieving peak intensity is shifting toward the poles. There are also observed data that tropical cyclones in general are moving more slowly, and this is a trend that can be expected to continue as future warming occurs. Consequently, these more slowly moving tropical systems would generally be expected to produce more rainfall. Under a scenario where the climate continues to warm, additional increases in rainfall seem likely, aside from the contributions of tropical cyclones. Air that is warmer can hold more water vapor and hence there is greater potential for heavier rainfall production. There is a consensus among the global climate models indicating that within the next century the frequency of global tropical cyclone activity would decrease, though this is not necessarily the case for the Atlantic basin. Of the storms that do form, a greater fraction of them is likely to achieve higher intensity and, thus, the damage potential is also likely to increase.

Several studies have indicated that there is the potential for drought frequency to increase in peninsular Florida (Neelin et al. 2003, Xie et al. 2010, Rauscher et al. 2011), while at least one more recent study refutes these conclusions and indicates that the impact of local processes (specifically the impact of bathymetry on near ocean currents) could impact the magnitude and moisture flux convergence over peninsular Florida and potentially change the onset and cessation and the magnitude of rain during the

wet season (Mishra and Mishra 2016). These contrasting studies illustrate the uncertainty of long scale predictions on Florida climate.

C.1.3 Physical Landscape

This section compares the existing physical landscape conditions to those expected in the FWO scenario.

C.1.3.1 Existing Conditions

The northwestern and western portions of the project area consist of the Pal-Mar, Gulfstream West, Culpepper, and Shiloh Farms properties. An extensive canal network drains most of this project area to facilitate drainage of wetland and agricultural lands. This drainage has resulted in the conversion of tracts that were characterized as depressional and freshwater wetland communities to evolve into drier, upland flatwoods communities. North-south trending ditches and canals around the periphery of the Nine Gems and Gulfstream parcels have drained the area to support cattle grazing and citrus groves since 1958 (Ecology & Environment Inc. 2009). Field observations confirmed that a community consisting of younger (less than 30 years) slash pines and invasive species such as the Old World climbing fern, Brazilian pepper, and melaleuca now occupy the landscape previously occupied by cypress swamps, hydric pine flatwoods, and wet prairies. The organic-rich hydric soils characteristic of the area progressively oxidized as hydroperiod durations were reduced.

The landscape gently slopes from west to east across the Nine Gems, Shiloh Farms, and Gulfstream West properties, from approximately 16.5 ft NGVD29 to 12.9 ft NGVD29. Pre-drainage conditions show the existence of natural flow-ways with few upland environments. Sheet flow along these flow-ways conveyed water during the wet season ultimately to Cypress Creek and the Loxahatchee River. The northern portions of the Nine Gems property may also have drained naturally to the south fork of the St. Lucie River (Ecology & Environment 2009, 2010).

The major drainage feature of the Pal-Mar/Nine Gems/Gulfstream West portion of the project area is Cypress Creek, which was modified from the historic creek into Ranch Colony Canal and Cypress Creek Canal. These canals no longer receive drainage from Pal-Mar, and serve primarily for flood control of adjacent developed areas, and the Culpepper property to the west.

East of the I-95/Florida Turnpike corridor, drainage flows through three sub-basins to the NWFLR: Cypress Creek, Moonshine Creek, and Kitching Creek. Lands in the northeastern portion of the project area are relatively undisturbed, consisting of wetlands and upland forest (Ecology & Environment 2010), with agriculture and developed properties away from the floodplains and Jonathan Dickson State Park.

The southern portion of the project area is situated mostly within the C-18 basin and consists of the J.W. Corbett Wildlife Management Area (WMA), Hungryland Slough, former Mecca Farms property, Avenir property (formerly the Vavrus Ranch), and tracts of the Loxahatchee Slough including Sweetbay Tract, the Southwest Tract, the Sandhill Crane Tract, Lucky Tract, and GWP lands north of Northlake Blvd. The Sweetbay and Southwest Tracts surround the North Palm Beach County Municipal Airport.

The J.W. Corbett WMA and Hungryland Slough are mostly undeveloped, and are characterized by extensive hydric and mesic flatwoods, depressional marshes, wet prairies, and cypress dome swamps (Ecology & Environment, Inc. 2010). These areas drain to the C-18W Canal.

The former Mecca Farms and Avenir properties were formerly agricultural properties used for cattle ranching, row crop production, timber harvest, and citrus groves. These lands remain largely unimproved, and evidence of clearing, ditching, and crop rotation still exist on these sites. There are no state jurisdictional wetlands on the Mecca Farms property (Arcadis Design & Consultancy 2016). A conceptual Compensatory Wetland Mitigation Plan has been prepared for the northern portion of the Avenir property, located east of Mecca Farms (EW Consultants, Inc. 2017).

During the wet season and storms (e.g., Tropical Storm Isaac, August 2012) flooding occurs in the J.W. Corbett WMA, and sheetflow can extend into the peripheral M-O Canal and onto a low section of Seminole Pratt-Whitney Rd adjacent to the Mecca Farms property. A 139.5-ft long fixed-crest (20.1 ft NAVD88) sheet pile weir was constructed to control sheet flow in the area between J.W. Corbett WMA and the Mecca Farms property (Arcadis Design & Consultancy 2016).

The Loxahatchee Slough is the most prominent natural drainage feature in the project area, and consists of the headwaters of the northwest and southwest forks of the Loxahatchee River. The tracts of the Loxahatchee Slough are among the most ecologically diverse in the region (Ecology & Environment Inc. 2009). However, the Loxahatchee Slough was bisected by the C-18 Canal, resulting in reduced natural surface water flows and reduced hydroperiod leading to invasive species in upland locations. The southern half of Loxahatchee Slough was impounded to form the GWP, which serves as a water storage area for the City of West Palm Beach. The “triangle area” between GWP (Northlake Blvd.) and the Beeline Highway has been improved slightly by grading to convey sheet flow to the northwest in this area.

C.1.3.2 Future without Project Conditions

Changes that occur to the physical landscape without project implementation focus primarily on conversion of undeveloped or former agricultural lands to residential and commercial development. In the project area, there are large properties that have been acquired by state and/or local agencies with the expectation that these areas would be available for ecosystem restoration. State and local-owned tracts include the former Pal-Mar, Nine Gems, Mecca Farms property, J.W. Corbett WMA, Hungryland Slough, tracts of the Loxahatchee Slough, Gulfstream West and properties adjacent to Cypress Creek and Moonshine Creek . If not incorporated into the project, these properties would be subject to continual political pressure to be listed as surplus, which would allow continued development within the watershed and the opportunity to improve the base flow and groundwater levels in direct proximity to the river would be forfeited.

C.1.4 Geology

This section compares the existing geological conditions to those expected in the FWO scenario.

C.1.4.1 Existing Conditions

The shallow subsurface geological setting is most important as it pertains to ecosystem restoration and construction activities. The geologic setting of the deeper units also will be discussed because Aquifer Storage and Recovery (ASR) in the Floridan Aquifer System is a component to augment storage at the C-18W Reservoir. More hydrogeologic data are available in northern Palm Beach County, compared to the project area in Martin County. A diagram of the general hydrogeologic setting is shown for the Lake Okeechobee region (Figure C.1-1).

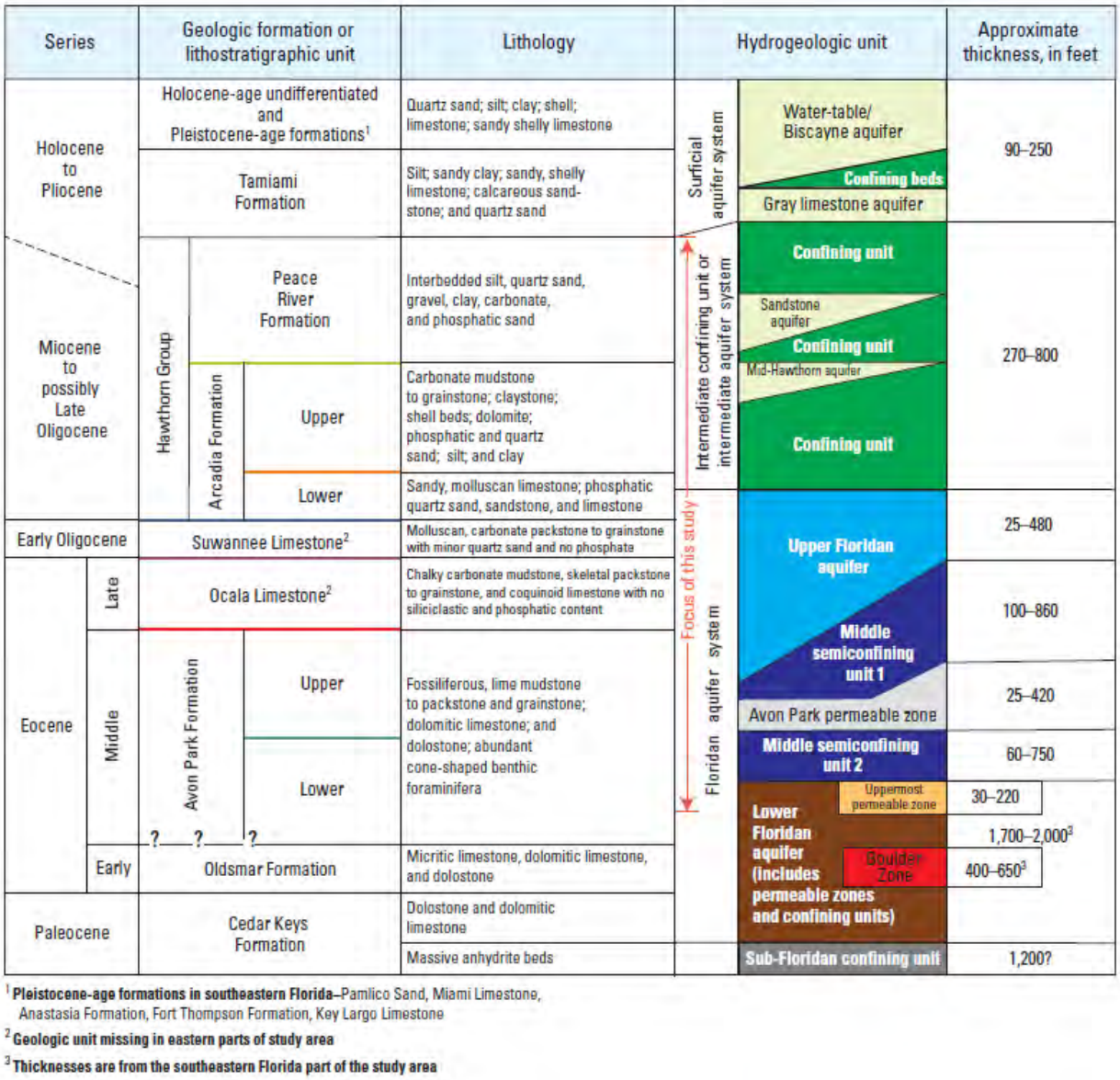

Figure C.1-1. Diagram showing general hydrogeologic setting in the area of Lake Okeechobee. Diagram from Reese (2014).

Fossiliferous marine sands and silts of Quaternary and Pliocene ages underlie Holocene freshwater sediments. The Fort Thompson and Tamiami Formations consist of marine limestone, quartz sandstone, and sandy limestone that was deposited during many high sea level stands during the last 2 million years (Reese and Wacker 2009). If marine fossils are not present, this unit typically is referred to as undifferentiated Quaternary sand and silt. Geotechnical borings obtained at the C-18W Reservoir terminate in these marine sands and silts at depths of 35 ft or 100 ft below land surface (bls) (Arcadis Design & Consultancy 2016). Boreholes in the J.W. Corbett WMA (PB-1613 and PB-1550; SFWMD 2018) indicate that the base of the Quaternary marine sand and silt unit occurs at a depth of approximately 140 ft to 153 ft below land surface.

The Hawthorn Group of Miocene age comprises a thick sequence of marine silts, clay, calcareous clay, dolosilt, quartz sand, shell, phosphate grains limestone and dolomite (Anderson 2008). The Hawthorn Group consists of two formations: The Peace River Formation, underlain by the Arcadia Formation. The thickness of the Hawthorn Group extends from a depth of 200 ft to 885 ft bls (685 ft thick; PBF-15). A former exploratory oil and gas borehole in the J.W. Corbett WMA showed the Hawthorn Group sediments extended from a depth of 105 ft to 685 ft bls (580 ft thick; PB-1133; Miller 1986). Gamma-ray geophysical logs show a pronounced peak at the base of the Arcadia Formation caused by an increase in phosphorite content, and this geophysical signature is a regional feature (Reese 2014).

A thick sequence of Eocene and Oligocene marine limestones and dolostones underlie the Hawthorn Group sediments throughout south Florida. The Ocala Limestone is a chalky carbonate mudstone with little or no quartz sand and phosphorite content. The Avon Park Formation is a fossiliferous lime mudstone and dolomitic limestone or dolostone (Reese 2014; Reese and Richardson 2008). The depth of the Ocala Limestone and Avon Park Formation extends from approximately 800 ft to 1450 ft bls in the project area (650 ft thickness, OKE-2, Plate 17, Miller 1986). The upper contact of the Ocala Limestone is at approximately 800 ft bls, and is unconformable indicating that this limestone was eroded after deposition. The upper contact of the Avon Park Formation is approximately 1,200 ft bls in the project area (Reese and Richardson 2008). The Oldsmar Formation is the lowest, oldest of the Eocene marine limestones in south Florida, and consists of micritic limestone and dolostone, with common anhydrite and gypsum (Reese and Richardson 2008). Where present, the “Boulder Zone” occurs within the Oldsmar Formation at a minimum depth of 2,900 ft to 3,000 ft bls (Reese and Richardson 2008).

C.1.4.2 Future Without Project Conditions

There are no active mining operations in the LRWRP project area. Active and proposed limestone mines are located west of the project area in the L-8 Basin between the L-8 and C-51 canals. Expansion of the lime rock mining footprint is likely to continue into the future. Lime rock mines are converted to in-ground reservoirs when the maximum depth of the operation is reached.

C.1.5 Soils

The magnitude and duration of wetland hydroperiods throughout much of the project area has been reduced by ditching and draining, and subsequent development, which has also fragmented unaffected wetland areas. Over-drained wetlands result in the loss by oxidation of the surface organic layer, and exposure of sandy soils (Ecology and Environment 2009). The shallow subsurface soils consists of Holocene sands, silts and freshwater muck soils that developed on marine sand, silt, and shell parent material deposited during Quaternary high sea level stands.

C.1.5.1 Existing Conditions

Surface soils in the area of Flow-way 3 consist primarily of Wabasso sand, and Pineda and Riviera fine sands, which are classified as SP-SM and SP, respectively (NRCS 2018; **Figure C.1-2**). The western portion of Flow-way 3, in the Pal-Mar area, represents the natural condition the northern Everglades wetlands in which depressional wetlands pond in sandy soils. Farther east in the Nine Gems and Gulfstream East areas, construction of canals has resulted in over-drained conditions in current and former agricultural areas.

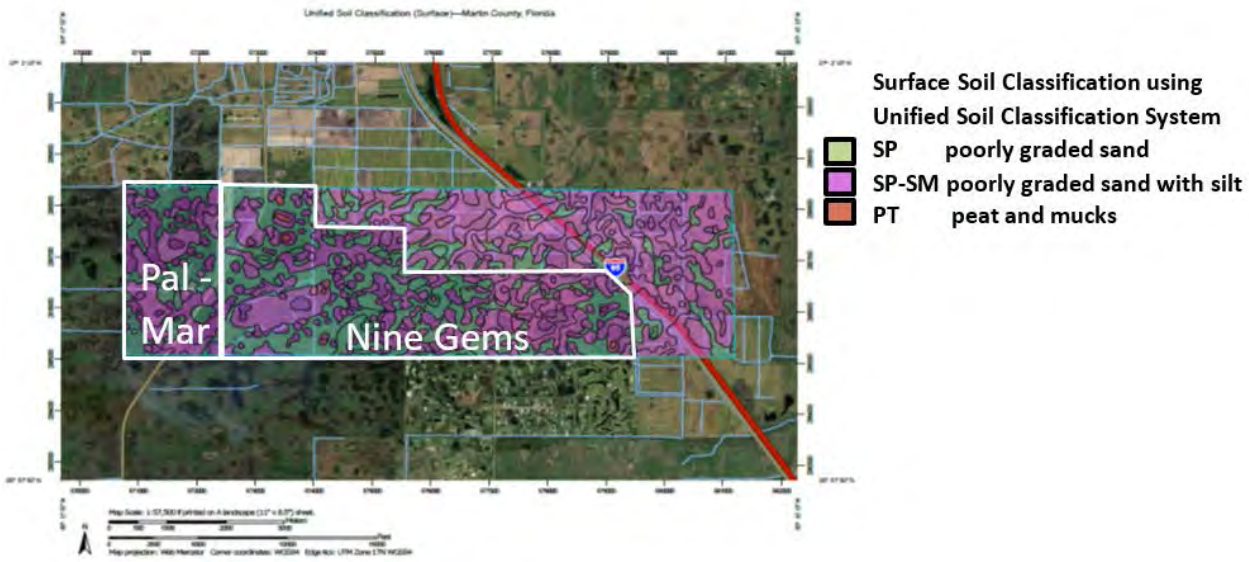

Figure C.1-2. Map showing surface soil classification in Flow-way 3, Martin County, Florida.

Surface soils in the area of Flow-way 2 are finer grained than those in Flow-way 3, and consist primarily of drained and ponded Riviera fine sands, which are classified as SP-SM (NRCS 2018, Tierra, Inc. 2004**; Figure C.1-3**). The western portion of Flow-way 2, in the J. W. Corbett WMA, represents the natural condition the northern Everglades wetlands in which depressional wetlands pond in sandy soils. Farther east in the C-18W Reservoir, and toward the developed portion Loxahatchee Slough, construction of canals has resulted in over-drained conditions in current and former agricultural areas.

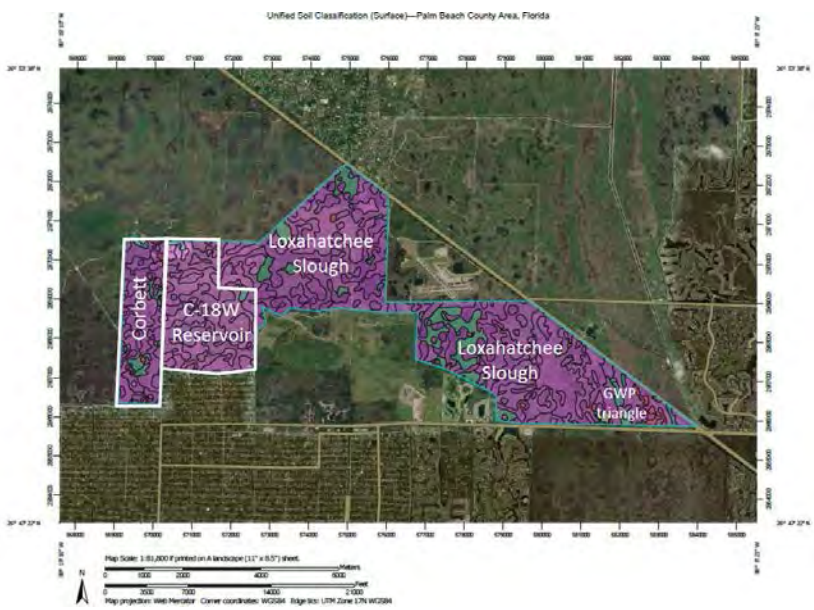

Figure C.1-3. Map showing surface soil classification in Flow-way 2, Palm Beach County, Florida.

Most of the geotechnical data available for the shallow subsurface soils in the project area were obtained within the footprint of the C-18W Reservoir. A preliminary geotechnical investigation at the C-18W Reservoir site showed shallow subsurface soils to a depth of 25 ft bls in 24 core borings (Tierra, Inc. 2004).

These borings showed soils interpreted as “silty clayey sand” (SM/SC-SM) at depths between 5 ft and 25 ft bls, interlayered with sand (SP) with shell or cemented sand.

A subsequent geotechnical investigation (URS Corporation 2008) at the C-18W Reservoir site showed shallow subsurface soils to a depth of 40 ft bls in eight Standard Penetration Test (SPT) borings, with analysis of selected samples to define geotechnical characteristics of shallow subsurface soils for preliminary slope stability evaluation and fill requirements. Four laboratory permeability measurements using remolded samples yielded moderate hydraulic conductivity values ranging between 9×10^{-5} cm/sec and 2×10^{-3} cm/sec (URS Corporation 2008) over the depth range of 5 ft to 40 ft bls. A preliminary slope stability analysis was performed using Slope/W (GeoStudio; Calgary, Canada) to evaluate the excavation configuration for a flow-way across the C-18W footprint. This slope stability analysis supported flow-way design, not a reservoir embankment as is currently proposed.

An expanded geotechnical investigation (Arcadis Design and Consultancy 2016) was completed at the C-18W Reservoir as part of the Detailed Design Report (DDR). Twenty-four borings were completed around the periphery of the proposed impoundment, plus two interior borings completed as piezometers. Generally, surficial (0 ft to 15 ft bls) soils consist of interbedded poorly graded sand with silt (SP-SM). Deeper sediments are predominantly poorly graded sand with silt (SP-SM), silty sand (SM) and poorly graded sand (SP) with shell and occasional clayey sand (SC) layers. Limestone is encountered at depths below approximately 30 ft bls. The upper surface of the Hawthorn Group is encountered at depths greater than 150 ft bls. Constant rate aquifer performance tests in interior piezometers yielded hydraulic conductivity values that ranged between 3.53 x 10-3 cm/sec and 1.59 x 10-2 cm/sec using the Cooper-Jacob solution for a leaky aquifer.

A geotechnical and hydrogeological investigation was completed in the J. W. Corbett WMA (Gannett Fleming, Inc. 2016), which provided lithological and hydrogeological data for the undeveloped area in the western portion of Flow-way 2. One SPT boring (to -80 ft NAVD88, 100 ft bls) was completed, and samples consisted of surficial peat, and SP-SM (poorly graded sand with silt) and SP (poorly graded sand) at depth. Three groundwater monitor wells were constructed, with screened intervals at 95 ft to 100 ft bls, 34 ft to 39 ft bls, and 10 ft to 15 ft bls. A geophysical log was obtained from the deepest borehole, which showed an increase in fine-grained sediment at a depth range between 40 and 60 ft bls. Constant rate aquifer performance tests in each monitor well yielded hydraulic conductivity values that ranged between 1.41×10^{-4} cm/sec and 2.65×10^{-4} cm/sec using the Hantush solution

C.1.5.2 Future without Project Conditions

Soils within the project area are primarily sands in the upland dry prairies, and fine sands and silt in the alluvial floodplain and depressional wetland areas. Without the project, the landscape and soils are likely to remain over-drained until converted from ranch and agricultural lands to developed areas.

C.1.6 Aquifers

Aquifers are saturated permeable lithologic units in which groundwater can flow. There are two aquifer systems that are relevant to this project: the unconfined Surficial Aquifer System (SAS), and the upper portions of the confined Floridan Aquifer System (FAS). Within the upper portions of the FAS are two major permeable zones: the upper Floridan Aquifer (UFA), and the Avon Park Permeable Zone (APPZ). In the project area, rock that includes the UFA and APPZ generally occur a depths between 600 ft and 1800 ft below land surface. Thick confining units prohibit upward transport of groundwater from the upper portions of the FAS, so flow from wells open to the FAS flow under artesian pressure. Upper confinement

of the FAS (and the UFA) is provided by the Hawthorn Group sediments, and is known as the intermediate confining unit (ICU). Confinement between the UFA and the APPZ is provided by less permeable units of the upper Avon Park Formation, and is known as the middle (semi-)confining unit 1 (MCU1). Confinement between the APPZ and the lower portions of the FAS is known as the middle confining unit 2 (MCU2). **Figure C.1-1** shows the relationship between the geologic units and aquifers.

C.1.6.1 Existing Conditions

The SAS includes all permeable material stratigraphically overlying the FAS and ICU. In the project area, this aquifer is mostly unconfined, and is included in Quaternary and Pliocene sands and limestone. The thickness of the SAS is approximately 150 ft thick in the project area, and thickens eastward towards the Atlantic coast (Williams and Kuniansky 2016).

The intermediate confining unit (ICU) comprises a thick, low permeability sequence of marine phosphatic sands, silts, and clay which confines the FAS. The ICU is approximately 600 ft to 700 ft thick in the project area, as shown in exploratory boreholes for ASR and deep injection wells (for example, Anderson 2008; Geraghty and Miller 1986). Hydraulic conductivities of the confining units range between 5×10^{-6} ft/day to 0.5 ft/day (USACE and SFWMD 2015).

The Floridan Aquifer System consists of three major permeable zones: the UFA, the APPZ, and the Lower Floridan Aquifer (LFA). Only the UFA and APPZ are relevant for this project. The UFA is included in a thick sequence of carbonate rock with permeable zones characterized by artesian flow. The top of the UFA occurs at depths of approximately 700 ft to 800 ft bls, and often shows a regionally extensive, thin (approximately 20 ft) flow zone that contributes most of the flow in the UFA (Williams and Kuniansky 2016). Hydraulic characteristics of permeable zones within the FAS are often favorable for successful ASR applications. Transmissivity values from aquifer performance and specific capacity tests range between 10,000 ft^2/day and 25,000 ft^2/day (Kuniansky et al. 2012). Although variable, hydraulic conductivities in permeable portions of the FAS range between 1.0 ft/day to 10,000 ft/day (USACE and SFWMD 2015).

The UFA and APPZ permeable zones are separated by a leaky confining unit called the MCU1 (Reese and Richardson 2008) or the Ocala-Avon Park Lower Permeability Zone (Williams and Kuniansky 2016). This (semi-) confining unit is thickest in western Palm Beach and Martin counties (approximately 300 ft) and thins eastward towards the Atlantic Coast (Reese 2016).

The Avon Park Permeable Zone is included entirely within the fractured dolostone of the Avon Park Formation. Transmissivity in the APPZ is approximately an order of magnitude greater than that of the UFA, ranging between 100,000 ft^2/day to over 1 million ft^2/day (Reese and Richardson 2008). Thickness of the APPZ within a very thick Avon Park Formation is not well defined in Martin County because few boreholes penetrate the entire formation. At Port Mayaca (MF-37), the APPZ is 150 ft thick, and occurs at depths between 1,500 and 1,650 ft bls (Reese 2016). The thickness and elevation of the APPZ in Palm Beach County varies significantly, such that the APPZ may not correlate between wells. In southwestern Palm Beach county, the APPZ is thin (approximately 60 ft), and occurs at depths of 1,680 ft to 1,740 ft bls (Reese 2014). In southeastern Palm Beach County, the APPZ is thicker (approximately 150 ft) and shallower (1,300 ft to 1,600 ft bls; Reese 2016). The MCU2 confines the base of the APPZ.

C.1.6.2 Future without Project Conditions

As population increases with development, there will be additional pressure on the UFA to provide alternate water supply sources. Use of brackish groundwater from the UFA coupled with reverse osmosis

treatment is a method already in use at coastal municipalities, and may be applied in the interior of the state to augment surface water supplies.

C.1.7 Vegetative Communities

Of the more than 700 square miles in the study area, most of land within the study area can be included in three broad land use categories: natural areas (including wetlands, forested and unforested uplands and open water), agricultural lands, and urban (residential/commercial) space. Natural areas comprise approximately 351 square miles (224,600 acres; 51%). Project area ecosystems, each with an inter-related group of plant communities, are grouped into three categories: upland ecosystems (forested, scrub-shrub, and herbaceous), freshwater wetlands (palustrine, riverine), and estuarine ecosystems (**Table C.1-1**). This classification represents the major plant communities and associated fauna found in the project study area, and is adapted from the Florida Natural Area Inventory's guide to the natural communities of Florida (FNAI 2010).

C.1.7.1 Existing Conditions

Natural Area Descriptions

JDSP is an 11,471 acre park about 5 miles wide (east-west dimension), lying within ½ mile of the Intracoastal Waterway in southern Martin County. Two branches of the Loxahatchee River, the Northwest Fork and the upper North Fork and its upstream tributaries (Cypress Creek, Moonshine Creek, Hobe Grove Ditch, Wilson's Creek, and Kitching Creek) flow through the park. The NWFLR, one of Florida's two federally designated National Wild and Scenic Rivers, is a natural river channel that originates in the Loxahatchee and Hungryland Sloughs. Downstream from these sloughs, the NWFLR receives additional input from the other major tributaries of the Loxahatchee River: Cypress Creek/Ranch Colony Canal, Hobe Grove Ditch, and Kitching Creek. A cypress river swamp community historically dominated the floodplain of the Loxahatchee River with freshwater stream swamps and cypress communities present upstream from river mile 6.5 and dominant within the floodplain above river mile 8.0.

Pal-Mar comprises more than 37,000 acres in southern Martin and northern Palm Beach counties, and forms a linkage between J.W. Corbett WMA and JDSP. Cypress Creek historically drained the Pal-Mar area but was re-aligned and confined to the Cypress Creek Canal, and part of the flow was diverted to the Ranch Colony Canal, so that flows into the creek have been greatly altered and it is no longer a receiving body of Pal-Mar surface water. Western Pal-Mar is primarily a natural area and occurs as a mosaic of wetland/upland communities including depression marsh, wet prairie, dome and strand swamps, pine flatwoods and sloughs. Northern and eastern Pal-Mar have been converted to agricultural use and are drained by a network of ditches.

J.W. Corbett WMA encompasses approximately 62,000 acres of hydric/mesic flatwoods, depression marshes, wet prairies, strand and dome swamps and hydric/mesic hammocks. A band of intact Everglades sawgrass marsh, considered a remnant portion of the Greater Everglades ecosystem, lies along the southern boundary of the WMA.

Loxahatchee Slough was historically one of the most prominent flow-ways in the study area and contained a large portion of the historic headwaters of the Northwest and Southwest Forks of the Loxahatchee River. The 11,000 acre site is the single most ecologically-diverse tract of protected land in Palm Beach County, including nine distinct community types. The slough used to extend continuously to what is now Loxahatchee National Wildlife Refuge, but has been cut off by the levees that surround the Refuge and by

the C-51 and C-18 Canals. These features have altered historic drainage patterns in this area and have facilitated extensive invasions of melaleuca.

GWP was formed by impounding the southern half of the historical Loxahatchee Slough. The GWP is a managed wetland ecosystem, approximately 12,800 acres (20 square miles), which is owned and operated by the City of West Palm Beach, and is also known as the West Palm Beach Water Catchment Area. GWP serves as a surface water catchment, groundwater recharge, and storage system for public water supply. The City's management of the GWP as an element of the water supply system has protected and sustained most of this system as a mosaic of undrained wet prairies (sawgrass and spikerush), sloughs, and cypress and other tree islands in a high quality wetland condition.

Table C.1-1. Relative coverage of major plant communities within the project area [*adapted from the AFB document].*

Landscape Position	Natural Community Type	Relative Coverage (%)	FNAI Description
Upland	Pine Flatwood / transitional The LRWRP project combines mesic and wet flatwoods, including transitional areas, because the flatwoods within the vast project area were not specifically delineated during project planning. Cumulatively, flatwoods are estimated to cover approximately 41.0% of the project area.	41.0% total Mesic and wet flatwoods are grouped as 'flatwoods' for project planning purposes.	Mesic Flatwoods (G4/S4) –flatland with sand substrate; mesic; statewide except extreme southern peninsula and Keys; frequent fire (2-4 years); open pine canopy with a layer of low shrubs and herbs; longleaf pine and/or slash pine, saw palmetto, gallberry, dwarf live oak, wiregrass.
Upland/Wetland	Pine Flatwoods/ transitional	Mesic and wet flatwoods are grouped as 'flatwoods' for project planning purposes.	Wet Flatwoods (G4/S4)– flatland with sand substrate; seasonally inundated; statewide except extreme southern peninsula and Keys; frequent fire (2-4 years for grassy wet flatwoods, 5-10 years for shrubby wet flatwoods); closed to open pine canopy with grassy or shrubby understory; slash pine, pond pine, large gallberry, fetterbush, sweetbay, cabbage palm, wiregrass, toothache grass.
Upland	Dry Prairie	0.1	Dry Prairie (G2/S2)– flatland with sand soils over an organic or clay hardpan; mesic-xeric; central peninsula; annual or frequent fire (1-2 years); treeless with a low cover of shrubs and herbs; wiregrass, dwarf live oak, stunted saw palmetto, bottlebrush threeawn, broomsedge bluestem
Upland	Sandhill	0.1	Sandhill (G3/S2) –upland with deep sand substrate; xeric; Panhandle to central peninsula; frequent fire (1-3 years);

Landscape Position	Natural Community Type	Relative Coverage (%)	FNAI Description
			savanna of widely spaced longleaf pine and/or turkey oak with wiregrass understory.
Upland	Scrub	0.5	Scrub (G2/S2) – upland with deep sand substrate; xeric; statewide except extreme southern peninsula and Keys, mainly coastal in Panhandle; occasional or rare fire (usually 5-20 years); open or dense shrubs with or without pine canopy; sand pine and/or scrub oaks and/or Florida rosemary.
Upland	Hammock	1.8	Mesic Hammock (G3/S3?) –flatland with sand/organic soil; mesic; primarily central peninsula; occasional or rare fire; closed evergreen canopy; live oak, cabbage palm, southern magnolia, pignut hickory, saw palmetto.
Wetland	Hammock		Hydric Hammock (G4/S4) – lowland with sand/clay/organic soil over limestone or with high shell content; mesic-hydric; primarily eastern Panhandle and central peninsula; occasional to rare fire; diamond-leaved oak, live oak, cabbage palm, red cedar, and mixed hardwoods.
Wetland	Freshwater Marsh	21.7	Depression Marsh (G4/S4) –small, isolated, often rounded depression in sand substrate with peat accumulating toward center; surrounded by fire-maintained community; seasonally inundated; still water; statewide excluding Keys; frequent or occasional fire; largely herbaceous; maidencane, sawgrass, pickerelweed, longleaf threeawn, sand cordgrass, peelbark St. John's wort
Wetland	Inland Pond and Slough	4.0	Slough (G3/S3) – broad, shallow channel with peat; inundated except during droughts; flowing water; statewide excluding Keys; rare fire; sparsely canopied or with emergent or floating plants; alligator flag, American white waterlily.
Wetland	Wet Prairie	13.4	Wet Prairie(G2/S2)– flatland with sand or clayey sand substrate; usually saturated but only occasionally inundated; statewide excluding extreme southern peninsula; frequent fire (2-3 years); treeless, dense herbaceous community with few shrubs; wiregrass, blue

Landscape Position	Natural Community Type	Relative Coverage (%)	FNAI Description
			maidencane, cutthroat grass, wiry beak sedges, flattened pipewort, toothache grass, pitcher plants, coastal plain yellow-eyed grass
Wetland	Strand Swamp	10.1	Strand Swamp(G2/S2) –broad, shallow channel with peat over mineral substrate; situated in limestone troughs; seasonally inundated; slow flowing water; vicinity of Lake Okeechobee and southward; occasional or rare fire; closed canopy of cypress and mixed hardwoods; cypress, pond apple, strangler fig, willow, abundant epiphytes.
Wetland	Floodplain Swamp	0.5	Floodplain Swamp (G4/S4)– along or near rivers and streams with organic/alluvial substrate; usually inundated; Panhandle to central peninsula; rare or no fire; closed canopy dominated by cypress, tupelo, and/or black gum.
Wetland	Dome Swamp	4.5	Dome Swamp (G4/S4)–small or large and shallow isolated depression in sand/marl/limestone substrate with peat accumulating toward center; occurring within a fire-maintained community; seasonally inundated; still water; statewide excluding Keys; occasional or rare fire; forested, canopy often tallest in center; pond cypress, swamp tupelo.
Wetland	Mangrove Swamp	0.3	Mangrove Swamp (G5/S4) – estuarine wetland on muck/sand/or limestone substrate; inundated with saltwater by daily tides; central peninsula and Keys; no fire; dominated by mangrove and mangrove associate species; red mangrove, black mangrove, white mangrove, buttonwood
Exotic/Invasive	Exotic/Invasive	1.9	Plant communities overgrown by invasive exotic plant species, or 'nuisance' plants typically controlled to maintain a desired plant community
-	Total	100	-

C.1.7.1.1 Upland Communities

Upland plant communities include expanses of pine flatwoods with inclusions of hardwood hammocks, and scrub, sandhill and dry prairies, which are present in low acreages in the study area.

C.1.7.2 Pine Flatwoods

The dominant upland habitats are widely distributed upland forests pine flatwoods and hardwood hammocks comprise approximately 44% of the project study area. In most of South Florida, and including the project study area, the overstory of this community consists of South Florida slash pine (*Pinus elliotii*). Generally, flatwoods dominated by slash pine occur on moderately moist area. Depending upon the hydrology, flatwoods communities are xeric, mesic or hydric. Hydric flatwoods are considered wetlands by FNAI.

Over drainage throughout the watershed has resulted in the conversion of many areas of formerly wet pine flatwoods to mesic pine flatwoods, which exist as an open canopy forest of widely spaced slash pine trees with little or no understory but including a dense ground cover of herbaceous plants and low shrubs. They provide essential forested upland habitat furnishing refuge and cover in the form of tree canopy, tree cavity, and nesting. FNAI characterizes mesic flatwoods as flatland with a sand substrate visited by annual or frequent fires. They may be dominated by wiregrass (*Aristida heyrichiana*) if a frequent fire regime is maintained, however, in areas where burning is infrequent the understory reverts to saw palmetto (*Serenoa repens*). Other typical plants within the mesic flatwoods include gall berry *(Ilex glabra*), wax myrtle (*Myrica cerifera),* fetterbush (*Lyonia lucida*), and bog buttons (*Lachnocaulon* spp.). These flatwoods provide the principal dry ground in the watershed and are the most widespread ecosystem in Florida, covering 30% to 50% of the state's uplands. In undrained mesic flatwoods, water depths typically are within 48 inches of the ground surface (Abrahamson and Hartnett 1990), and within 6 to 12 inches of the surface during the wet season.

Scrubby flatwoods occupy the elevations above the other types of flatwoods, and generally consist of widely scattered pine trees and numerous areas of barren white sand. The dominant canopy species is slash pine, as in mesic flatwoods, but the understory is characterized by more scrubby vegetation, such as turkey oak or scrub oak. In the project area, scrubby flatwoods are present on two central ridges, located within a portion of the Atlantic Coast Ridge within JDSP. Another scrubby flatwoods community if found near the southeastern corner of the park, and a third on the crest of the floodplain of the Loxahatchee River (FDEP 2002).

C.1.7.3 Dry Prairie

Dry prairies are treeless (or nearly treeless) grass-dominated areas that occur on very flat terrain. Without regular fire (on a one to four-year interval) to suppress canopy development, these areas would succeed toward mesic flatwoods communities. These communities are dominated by wiregrass and saw palmetto and have a high diversity of other grasses and sedges.

C.1.7.4 Sandhill

Sandhill communities are upland savanna-like ecosystems with sandy, well drained, low nutrient soils that occur on hilltops and slopes of gently rolling hills. Most of these areas in the southeast are characterized by longleaf pine, however, at its southern limit, this community type is dominated by slash pine and turkey oaks that are wildly spaced, along with a ground cover of grasses and herbs. Without the appropriate fire

return frequency of two to five years, these areas will succeed toward hardwood hammock or sand pine scrub communities. These are found in the study area within three locations in JDSP.

C.1.7.5 Scrub

Scrub communities are areas of high elevation, where the soils are well drained and have low nutrients. The dominant plant species are sand pine (*Pinus clausa*) or scrub oaks, which also lend their names to the two common types of scrub (Sand Pine Scrub or Oak Scrub) communities. Even-aged stands of sand pines dominate the canopy of the Sand Pine Scrub community. That canopy can be open or closed, depending upon fire return frequency. One or two species of oak will be present in the sub-canopy. Oak scrub is dominated by a canopy of oaks (dwarf live oak – *Quercus minima*, laurel oak (*Quercus laurifolia*), Turkey oak and Chapman's oak. Oak scrub contains very little or no sand pine. Other common vegetation includes Florida rosemary (*Ceratiola ericoides*), saw palmetto and rusty lyonia (*Lyonia ferruginea*). Ground cover is sparse with open patches of sand. One of the last remaining areas of intact scrub habit is located along the coastal ridge and within JDSP.

C.1.7.6 Hammocks

Hammocks communities are the result of successional changes in response to physical factors related to hydrology or geography, where hardwoods have outcompeted the pines and now dominate the community. These are typically narrow bands of vegetation and are generally confined to slopes between upland sand/clayhill pinelands and bottomland floodplain forests. The soils are fairly rich sandy soils, the canopy relatively closed and comprised of hardwood species such as oak and cabbage palms and by a fairly open shrub layer and a sparse and species poor herbaceous layer. Variations in local soil-moisture regimes, soil types and geographic locations may result in species composition differences throughout the project study area. Hardwood hammocks can be divided into three groups based on hydrology: hydric, mesic and dry, with mesic and hydric types dominant in the project study area. As is the case with hydric flatwoods, hydric hammocks are considered wetland communities.

Mesic hammocks represent a successional change from a mesic or wet pine flatwoods to a hardwood dominated community. These are often transitional areas between wet and dry hammocks. The canopy is well developed and closed, consisting of live oak and laurel oak. Saw palmetto, marlberry and wild coffee are present in the shrub layer, and generally the diversity of grasses, sedges, herbs and vines is high. The communities also support many epiphytes, such as *Tillandsia* spp. Burn cycles are infrequent and generally of low intensity. Catastrophic fires, if they occur, may completely destroy these communities, allowing invasion by weedy and exotic species. Hardwood hammocks are distributed widely within the study area, with some concentration in the J.W. Corbett WMA. Maritime hammocks are also present along coast ecosystems. Marine hammocks are coastal communities and consist of narrow bands of hardwood forest just inland of coast strand or mangrove communities. Dominant trees include gumbo limbo (*Bursera simaruba*), cabbage palm, strangler fig (*Ficus aurea*) and pigeon plum (*Coccoloba diversifolia*). Natural fires are inhibited due to mesic conditions and insular locations, with return frequencies of 26 to 100 years (FNAI 2010). Maritime hammocks are important travel corridors for migratory songbirds which depend heavily on the cover and food available in these habitats. Little of this type of community remains within the project study area; examples are found only within John D. MacArthur State Park in Palm Beach County, and Maggy's Hammock, of which roughly half of the preserve is maritime hammock and the remainder is sand pine scrub, in Rocky Point in Martin County. Hydric hammocks often occurring adjacent to coastal marshes where species composition is limited by occasional salt water intrusion, and common species are cabbage palm, red cedar, and live oak.

C.1.7.6.1 Wetland Communities

Wetland plant communities are vital components of the project area and dominate much of the western landscape. In the study area, wetland habitats include wet (hydric) flatwoods, hydric hammocks and freshwater marshes and swamps (**Figure C.1-4**). The annual average water depth and annual inundation duration for wetland plant communities increases as the wetland type becomes more permanent (Table C.1-2; source: LRWRP WRAP analysis). The conversion of natural areas for urban and agricultural uses and the network of C&SF Project canals has altered the natural system, causing complete shifts in vegetative communities. Wetland habitats are the most impacted areas within the project boundary, consistent with the remainder of Florida, where more than half of wetlands have been lost to drainage and filling, mostly during the last 50-70 years (Myers and Ewel 1990). A wetland assessment study conducted within the Pal-Mar/Cypress Creek and the Groves Basins reported a substantial net loss in total wetland acreage ranging from 25 to 90 percent within the selected project study areas, based on photo-interpretation of 1999 and 2000 aerial photographs (C&N Environmental Consultants 2002). Key project area wetlands are located in the Loxahatchee Slough, Pal-Mar, Cypress Creek, J.W. Corbett WMA, JDSP, GWP, Dupuis Reserve, Hungryland and the floodplain of the Loxahatchee River and tributaries.

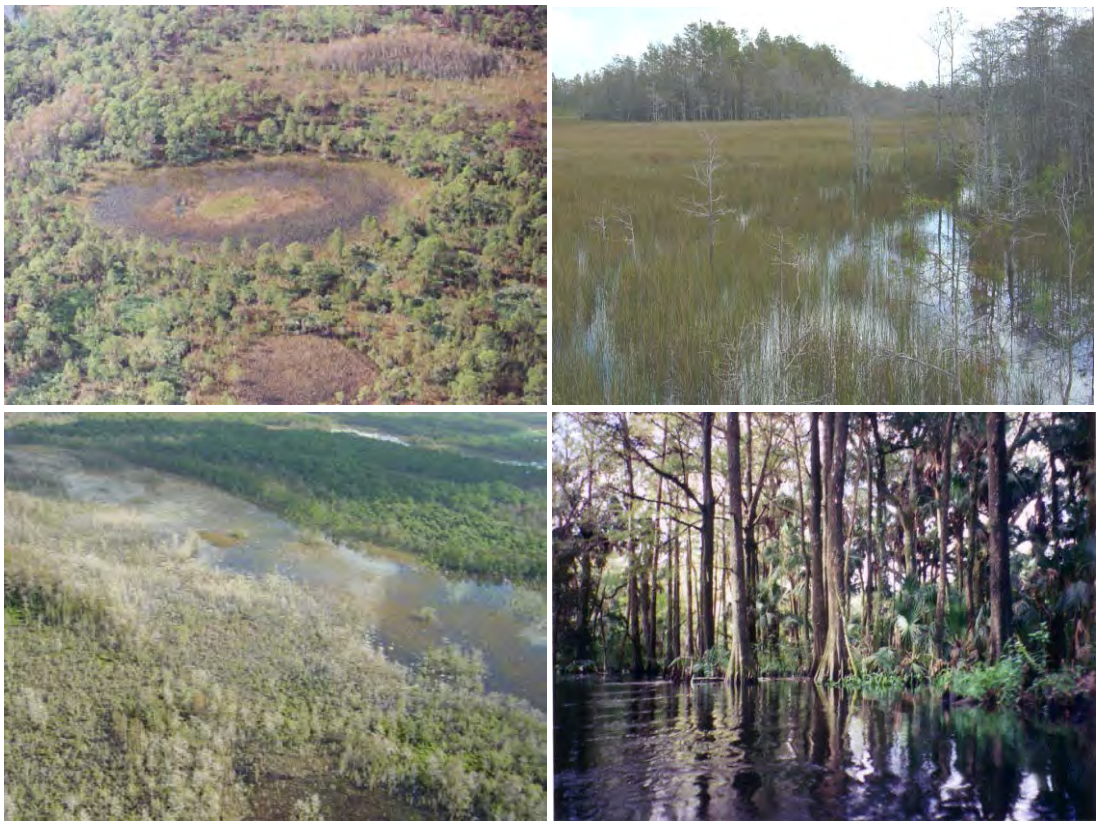

Figure C.1-4. Typical habitats, from top left clockwise; depressional marsh, freshwater marsh, freshwater slough and floodplain swamp.

Table C.1-2. Annual average water depth and annual inundation duration for wetland plant communities (source: WRAP analysis).

Plant Community Type	Annual Avg. Water Depth (inches)	Inundation Duration* (days/yr)	Median Inundation Duration (days/yr)
Mesic Flatwood	Below ground	< or = 30	15
Mesic (Oak) Hammock	Below ground	0-60	30
Hydric Flatwood	0-6	30-60	45
Hydric Hammock	0-6	30-60	45
Wet Prairie	6-16	60-180	120
Floodplain Swamp	12-30	120-240	180
Depression Marsh	12-24	180-300	240
Dome Swamp	12-24	210-300	255
Strand Swamp	18-36	210-300	255

Note: *Frequency coincides with wet weather patterns and existing groundwater conditions

Freshwater Marshes, Sloughs and Wet Prairies

Freshwater marshes are predominantly herbaceous wetland systems that make up a large and important part of the LRWRP area's landscape. In general, less than one-third of the coverage of a marsh consists of trees and shrubs. These areas tend to have evolved under a high-frequency fire regime. This fire interval inhibits the successional change to swamp or flatwoods, however, in many of the project area's marshes, shrubby species such as wax myrtle (*Myrica cerifera),* salt bush (*Baccharus halimifolia*), slash pine (*Pinus elliotti*) and a number of other woody species have invaded marsh areas where fire has been suppressed, and where artificial drainage has affected the hydrology. For example, in Loxahatchee Slough, comparison of historical and current vegetation aerial photos indicates a significant decrease in the extend of marshes (60%) and a large increase in the extent of forested wetlands (50%) between 1940 and 2000 due to reduced hydroperiods (SFWMD 2006).

The dominant types of marshes within the project area include depression marshes, sloughs and wet prairies. Swale areas are present to a lesser extent. Depression marshes, which are sometimes also called flatwoods ponds, are shallow, usually rounded depressions on sand substrate. Herbaceous vegetation in depression marshes usually occurs in concentric bands, and is highly correlated with elevation, as the marshes are generally deeper in the center. These wetlands are typically small in size and are hydrologically separate from other surface water bodies. Supported along their upland edges are plants such as saw palmetto (*Serenoa repens*). And moving toward the center where inundation is more prevalent will be plants such as St. Johns' wort (*Hypericum* spp.*)*, corkwood (*Stillengia aquatica*), maindencane (*Panicum hemitomon*), sawgrass (*Cladium jamaicense*) and pickekerelweed (*Pontederia cordata*).

Sloughs are vast landscape channels of usually slow moving water that support species such as water lily (*Nymphaea odorata*), floating heart (*Nymphoides aquatica*), bladderwort (*Utricularia* spp.), spatterdock (*Nuphar lutea*), fanwort (*Cabomba caroliniana*), and may include large stands of spike rush (*Eleocharis interstincta* and other spp.*),* generally with attached algal communities. The Loxahatchee Slough, GWP and Hungryland Slough are several distinct slough within the project area. Many project area sloughs have been degraded by altered hydrologic patterns and excessive draining.

Wet prairies are the most species-rich of all marshes and include a variety of grasses, sedges and flowering plants. They are typically characterized by marl, rather than peat, soils. Wet prairies are the least frequently flooded marsh type and are maintained by a combination of hydropattern and a 2 to 4-year fire return frequency (FNAI 2010). The herbaceous vegetation generally consists of St. John's wort, corkwood, fuirena rush (*Fuirena scirpoidea*), yellow-eyed grass (*Xyris* spp.), bog buttons (*Lachnocaulon* spp.), narrowleaf blue-eyed grass (*Sysyrinchium augustifolium*), marsh pinks (*Sabatia* spp.) and star-rush (*Dichromena* spp.). Historic areas indicate a decrease in coverage of the wet prairies and sloughs within the project area.

Swamps, Including the Loxahatchee River and Slough

Swamp systems are characterized as forested wetland areas fed by either groundwater or surface water flow, that have standing water for most of, or all the growing season. Due to the low fire potential and saturated soils, these areas are generally dominated by hardwoods. There are three types of swamps within the study area; floodplain swamps, strand swamps, and dome swamps.

Flood plain swamps occur on flooded soils along stream channels and in low spots and oxbows within river floodplains (FNAI 2010). In the southeastern U.S., these riparian forests are generally referred to as bottomland hardwood forests. They contain diverse vegetation that varies along gradients of flooding frequency. These forests are generally considered to be more productive than the adjacent upland forests because they receive a periodic inflow of nutrients, especially when flooding is seasonal rather than continuous (Mitsch and Gosselink 2015). These are located along the NWFLR and its tributaries. The freshwater floodplain of the NWFLR represents the last vestige of pristine subtropical cypress swamp habitat within southeast Florida. Over a century of water control and structure modifications has resulted in diminished flow. Combined with the opening and stabilization of the Jupiter Inlet, navigation channel dredging and sea level rise, this reduced flow has increased tidal prism penetration of the river and its tributaries. As a result of the reduced freshwater inflows and the influx of saline waters into what were formerly freshwater river reaches, mangroves have replaced cypress and other freshwater native vegetation in some river reaches. Today the floodplain swamp of the Loxahatchee River is primarily comprised of bald cypress (*Taxodium distichum*), with red and white mangroves (*Rhizophora mangle, Languncularia racemosa*), pop ash (*Fraxinus caroliniana*) and pond apple (*Annona glabra*) (SFWMD 2006).

Dome swamps are depressional areas within flatwoods or prairies that have larger trees in a deeper middle region and smaller trees towards the edges where the water is shallower, and often in a circular shape. Periodic fires also serve to maintain this dome shape by burning the outer fringes to a greater extent. Surface runoff from adjacent surrounding wetlands is normally a major contributor to the hydrologic input to these swamps, but groundwater flow may also contribute. These dome swamps generally function as reservoirs that recharge the aquifer when adjacent water tables receded. The normal hydroperiod for dome swamps is 210 to 300 days with water being deepest and remaining longest near the center of the dome (FNAI 2010). In the project area, dome swamps are primarily pond cypress (*Taxodium ascendens*). The density of the herbaceous layer may vary, depending upon the development of the canopy, and the impact of the hydrologic regime. Herbaceous species that are present in dome swamps include Virginia chain fern (*Woodwardia virginica*), maidencane (*Panicum hemitomon*), and a variety of grasses and sedges. Their distribution is widespread in the project study area. Cypress dome swamps can be found in the Loxahatchee Slough, JDSP, J.W. Corbett WMA, Dupuis Reserve and in the Pal-Mar/Cypress Creek areas.

Strand swamps are shallow, forested and usually elongated depressions or channels. They are found primarily in areas where diffused freshwater flows through a shallow forested depression on a relatively flat marsh or limestone plain. The predominant tree of this ecosystem is the bald cypress (*Taxodium distichum*), including a number of trees aged 300-500 years old. Scattered slash pine (*Pinus elliotti*) and cabbage palm (*Sabal palmetto*) with cocoplum (*Chrysobalanus icaco*) understory are common around the transitional fringes of the swamps. Other typical plants are red maple (*Acer rubrum*), myrsine (*Myrsine* spp.) pond apple (*Annona glabra*), laurel oak (*Quercus laurifolia*), arrowhead (*Sagittaria latifolia*) and pickerelweed (*Pontederia cordata*) (SFWMD 2002b). Within the JDSP boundaries, several tributaries and their headwaters that flow into the NWFLR are classified as strand swamps (FDEP 2000). Narrow strands of cypress also occur along the boundary between the main body of the Loxahatchee slough and the adjacent palm hammock islands.

C.1.7.7 Future without Project Conditions

The once vast, naturally connected landscape was dissected by various canals and drainage features into a mosaic of variously-sized habitat patches. Possible future development of privately owned lands, changes in the availability and distribution of freshwater, and further disruption of natural sheet flow from discontinuities in hydrology due to construction of levees, roads, canals, etc. could exacerbate the fragmentation of wetland communities. Local initiatives to restore selected parcels will likely continue, dependent on funding and project selection. As the municipalities continue to grow there will be pressure to develop presently undeveloped areas and such developments may impinge on planned ongoing restoration activities within the watershed, such as the USFWS refuge projects to restore functionality to historic wetlands.

C.1.7.7.1 Upland Communities

Because of their well-drained soils, upland plant communities are most vulnerable to future development pressures.

C.1.7.7.2 Wetland Communities

Wetland plant communities also would be vulnerable to future development pressures, as evidenced by projected future land use analyses. Without implementation of project features, some wetland areas would continue to have hydrologic regimes that do not mirror the historic hydrologic patterns. The NWFLR would continue to receive atypical flow patterns and the cypress floodplain forests would be vulnerable to creeping salinity intrusion.

C.1.8 Threatened and Endangered Species

The U.S. Fish and Wildlife Service (USFWS), National Marine Fisheries Service (NMFS), and State of Florida Fish and Wildlife Conservation Commission (FWC) have designated certain species of fish, amphibians, reptiles, birds, mammals, gastropods, and plants and lichens in Martin and Palm Beach counties as threatened or endangered. Several of these listed species have been observed within the project area.

C.1.8.1 Existing Conditions

Federally listed threatened and endangered species are either known to exist or potentially exist within the project area and, consequently, may be affected by the proposed project (**Table C.1-3**). Many of these species have been previously affected by regional land use changes (e.g., uplands conversion, wetland

drainage, hydroperiod alteration, wildfire, or water quality degradation) resulting in various habitat impacts. A review of federally threatened and endangered species, their critical habitats, and life history descriptions, is included in the Biological Assessment (BA) (**Annex A**). USACE has consulted on federally listed species with the United States Fish and Wildlife Service and National Marine Fisheries Service, as appropriate.

Table C.1- 3. ESA-listed species in LRWRP area.

Group	Common Name	Federal Status	ECB	FWO
Mammals	West Indian Manatee	Threatened	Existing streamflow pattern adversely affects manatee access and forage availability. .	Streamflow pattern would continue to adversely affects manatee access and forage availability.
Mammals	West Indian Manatee	Critical Habitat	Federal critical habitat includes the Loxahatchee River and its headwaters, ICWW including Jupiter Inlet.	Federal critical habitat status would continue, barring other regulatory action.
Mammals	Florida panther	Endangered	Project area is not within the primary or secondary concentration areas. No individuals reported within project area.	Individuals may be observed in the future.
Mammals	Bonneted bat	Endangered	USFWS reports no observations of bat roosts within project area.	Existing habitat conditions would persist and/or future land development initiatives could alter some habitat.
Birds	Audubon's crested caracara	Threatened	USFWS reports no nesting records within project area; widespread roosting and foraging activity documented by eBird / other observations.	Caracaras would continue to use available habitat. Land use changes could affect some habitat.
Birds	Everglade snail kite	Endangered	Nesting in Hungryland Slough and GWP, number of nests and productivity dependent on annual hydrological variation.	Nesting in Hungryland Slough and GWP would persist, number of nests and productivity would be dependent on annual hydrological variation.
Birds	Everglade snail kite	Critical Habitat	Outside Final Critical Habitat.	Outside Final Critical Habitat, barring future regulatory action
Birds	Wood stork	Threatened	Two nesting colonies occur within project area; eastern half of project area within core foraging areas; widespread roosting and foraging activity documented by eBird / other observations.	Nesting colonies would persist at existing sites, barring disturbance causing colony collapse; eastern half of project area would remain designated as core foraging areas; widespread roosting and foraging activity would continue to be documented by eBird / other observations.

Birds	Red-cockaded woodpecker	Endangered	Recovering population from transplanted birds.	Nesting population would persist at existing sites, or would colonize other areas.
Reptiles	Eastern indigo snake	Threatened	No comprehensive surveys of snake occurrence have been conducted; snakes probably are widely distributed and using available habitat.	Snakes probably would continue to be widely distributed in available habitat.
Flowering Plants	Okeechobee gourd	Endangered	Typical habitat not present; no reported populations in project area	Gourds would not occur within project area, barring future habitat changes.

Notes: FWS provided Loxahatchee River Watershed Restoration Project list of species in letter dated April 20, 2017 and in the Fish and Wildlife Coordination Report dated February 1, 2019; E: Endangered, T: Threatened, CH: Critical Habitat.

C.1.8.1.1 West Indian Manatee

The West Indian manatee (*Trichechus manatus)* is a large, plant-eating aquatic mammal that can be found in the shallow coastal waters, rivers, and springs of Florida. The West Indian manatee was listed as endangered throughout its range for both the Florida and Antillean subspecies (*T. manatus latirostris* and *T. manatus manatus*) in 1967 (32 FR 4061) and received Federal protection with the passage of the Endangered Species Act (ESA) in 1973. Because the manatee was designated as an endangered species prior to enactment of ESA, there was no formal listing package identifying threats to the species, as required by section 4(a)(1) of the Act. On May 5, 2017, the manatee was reclassified as threatened due to habitat improvements and population expansion; the existing federal protections remain in place.

Florida manatees can be found throughout the southeastern United States; however, within this region, they are at the northern limit of their range. Because they are a subtropical species with little tolerance for cold, they remain near warm water sites in peninsular Florida during the winter. During periods of intense cold, Florida manatees will remain at these sites and will tend to congregate in warm springs and outfall canals associated with electric generation facilities. During warm interludes, Florida manatees move throughout the coastal waters, estuaries, bays, and rivers of both coasts of Florida and are usually found in small groups. During warmer months, Florida manatees may disperse great distances. Florida manatees have been sighted as far north as Massachusetts and as far west as Texas and in all states in between. Warm weather sightings are most common in Florida and coastal Georgia, and manatees will once again return to warmer waters when the water temperature is too cold. Florida manatees live in freshwater, brackish, and marine habitats, and can move freely between salinity extremes. They occur in both clear and muddy water. Water depths of at least three to seven feet (one to two meters) are preferred and flats and shallows are avoided unless adjacent to deeper water (USFWS 2007).

Historically, the principal causes of manatee mortality have been opportunistic hunting by man and deaths associated with unusually cold winters. Presently, poaching is rare, but many manatee die annually from various human-related causes. The greatest single mortality factor is collision with boats and barges, followed by entrapment or crushing in flood gates and canal locks, by entanglement or ingestion of fishing gear, and through loss of habitat and pollution.

Critical habitat for the Florida manatee was designated in 1976 [50 Code of Federal Regulations [CFR] §17.95(a)]. No specific primary or secondary constituent elements were included in the critical habitat designation. However, experts agree essential habitat features for the manatee include SAV or seagrasses for foraging, shallow areas for resting and calving, channels for travel and migration, warm-water refuges during cold weather, and fresh water for drinking (USFWS 2007). Designated critical habitat in Martin and West Palm Beach counties includes the Loxahatchee River and its headwaters; that section of the intracoastal waterway from the town of Sewalls Point, Martin County to Jupiter Inlet, Palm Beach County; and the entire inland section of water known as the Indian River, from its northernmost point immediately south of the intersection of U.S. Highway I and Florida State Highway 3, Volusia County, southward to its southernmost point near the town of Sewalls Point, Martin County. Critical habitat for the West Indian manatee is shown in Figure C.1-**5.**

Manatees occur in the Loxahatchee River system from the ICWW upstream to the NWFLR until access is blocked by the Masten Dam. They are common in local residential canals, and are attracted to freshwater sources such as the C-18 Canal, and others (Palm Beach County Department of Environmental Resource Management n.d.).

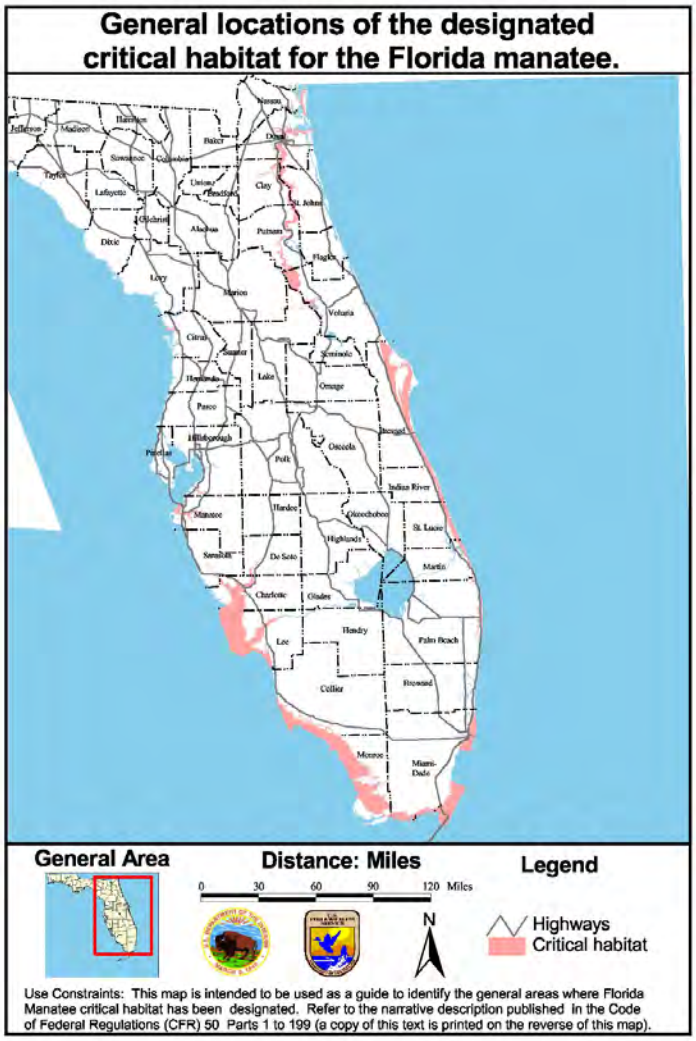

Figure C.1-5. Designated critical habitat for the West Indian manatee.

C.1.8.1.2 Florida Panther

The panther, also known as cougar, mountain lion, puma and catamount, was once widely distributed in North and South America, but it is now generally extirpated in the eastern United States. In Florida, the subspecies known as the Florida panther, one of 30 cougar subspecies, has a restricted range centered in southwest Florida (**Figure C.1-6**). The population estimate for the areas south of the Caloosahatchee River identified as suitable breeding habitat based on a habitat analysis by Kautz et al. (2006) is 120 to 230 adult and subadult Florida panthers (FWC 2017). Preferred habitat consists of cypress swamps, pine and hardwood hammock forests. Males have a home range of up to 400 square miles and females about 50 to 100 square miles. Panthers are generally carnivorous, and typical prey includes white-tailed deer, wild hog, rabbit, raccoon, armadillo and birds. The main survival threats to the Florida panther include habitat loss due to human development and population growth, collision with vehicles, parasites, feline distemper, feline alicivirus (an upper respiratory infection), and other diseases.

The Florida panther uses mesic pine flatwoods in combination with other forested communities and movement patterns are associated with natural drainage patterns defining travel corridors. There is no designated critical habitat for the Florida panther. The LRWRP project area is not within the panther focus zone (primary, secondary, dispersal zones and dispersal/expansion areas) of Florida panther habitat as shown on the revised Panther Key and Panther Focus Area Map used in determining effects to the Florida panther (USFWS 2007, unpublished data). Using the effects determination key, the Project is greater than 1 acre in size and will have a net increase and/or change in vehicle traffic patterns or other identifiable effects to panthers or their habitat during intermittent construction projects. The FWC Panther Sightings Map indicates that the nearest sighting to the LRWRP project area was at Allapattah Flats in northern Martin County in November 2015 (https://public.myfwc.com/hsc/panthersightings/MapPoints.aspx, accessed September 5, 2018) (**Figure C.1-7, Figure C.1-8**).

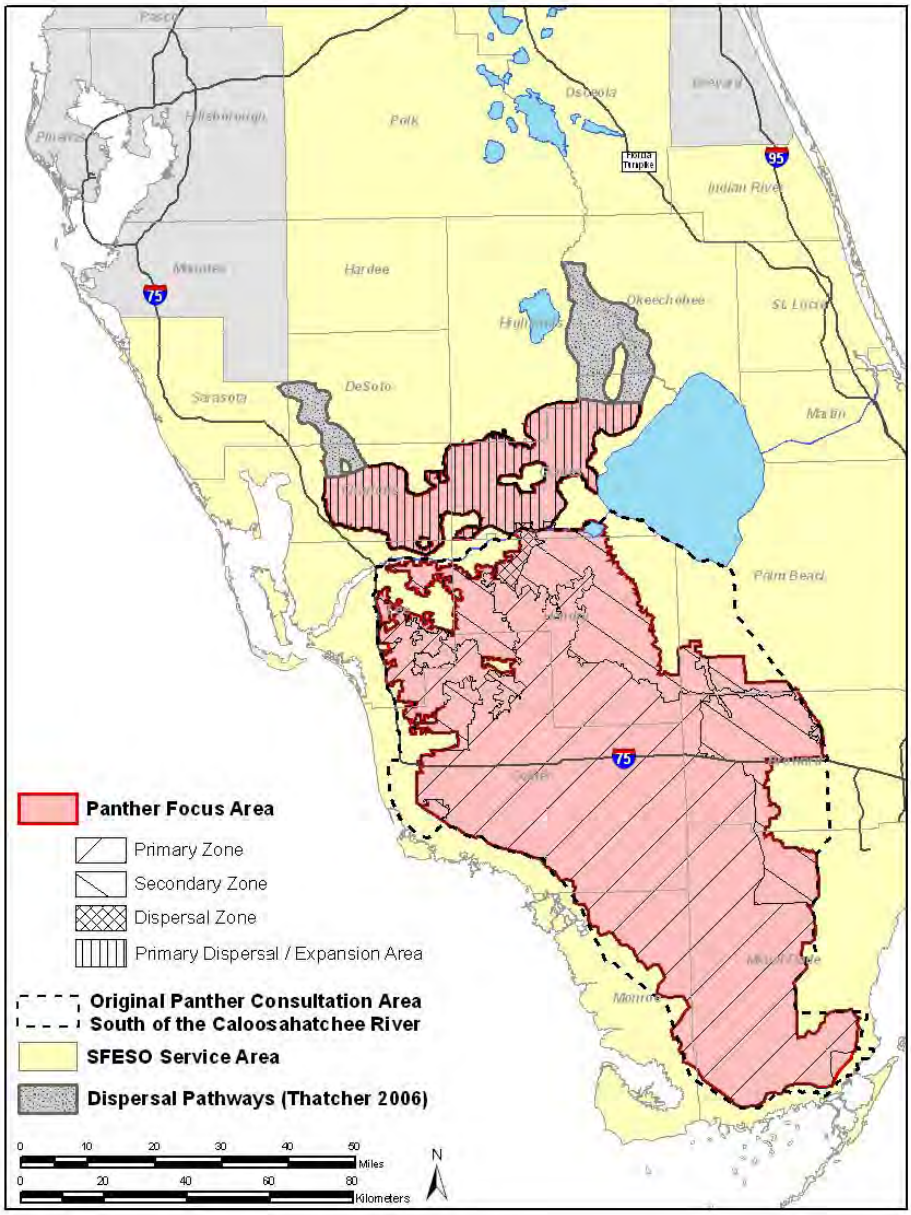

Figure C.1-6. Florida panther zones in South Florida (Source USFWS 2015).

Figure C.1-7. Florida panther observation in LRWRP project area (source: FWC, accessed October 17, 2018).

Figure C.1-8. Florida panther observation ID2759 (source: FWC, accessed October 17, 2018).

C.1.8.1.3 Florida Bonneted Bat

The Florida bonneted bat (*Eumops floridanis*) Florida's largest bat, weighing approximately 1.1 to 2.0 ounces, with a 19 to 21 inch wingspan, and a body length of 5.1 to 6.5 inches. The species has dark brown fur and large broad ears that join together and slant forward over the eyes. Relatively little is known regarding the ecology and habitat requirements of this species. In general, bats will forage over ponds, streams, and wetlands and require roosting habitat for daytime roosting, protection from predators and rearing of young (Marks and Marks 2006). The Florida bonneted bat is Florida's only endemic bat and is listed by US FWS as a federally endangered species under the ESA. The range of this species appears to include areas from Tampa Bay to south Florida, although ongoing surveys are improving knowledge of the species' distribution in Florida. Due to the species' small range, the greatest threats to Florida bonneted bats are loss of habitat, including the destruction of natural roost sites, and natural disasters such as hurricanes, since the impact could occur throughout its entire range. Other perceived threats include pesticide and herbicide use, which decreases the population of insects, the bats' primary prey. Critical habitat has not yet been designated for this species. **Figure C.1-9** shows the consultation and focus area of the Florida bonneted bat.

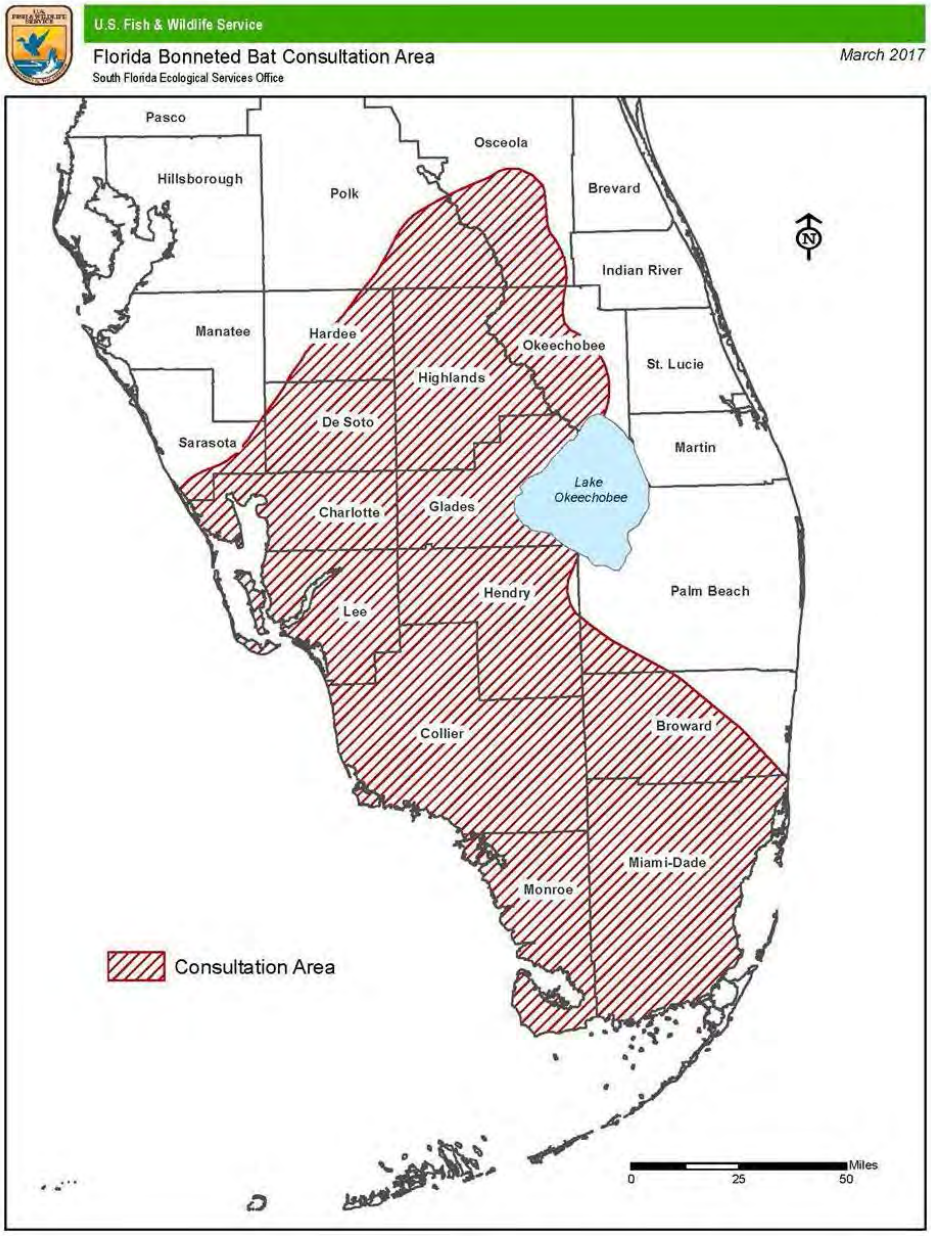

Figure C.1-9. 2017 Florida bonneted bat (FBB) consultation and focal area (USFWS 2017).

C.1.8.1.4 Audubon's Crested Caracara

The overall range of the crested caracara is from Florida, southern Texas, southwestern Arizona, and northern Baja California, through Mexico and Central America to Panama, including Cuba and the Isle of Pines. It is accidental in Jamaica. Other subspecies range into South America as far as Tierra del Fuego and the Falkland Islands. The crested caracara is found in greatest abundance in five counties north and west of Lake Okeechobee (Glades, Desoto, Highlands, Okeechobee, and Osceola), and occurs less commonly in Martin and Palm Beach counties. The majority of Florida's crested caracara population presently occurs on large cattle ranches with improved pastures and scattered cabbage palms (*Sabal palmetto*), and in

lightly wooded areas with saw palmetto (*Serenoa repens*), cypress (*Taxodium* spp.), and scrub oaks (*Quercus geminata*, *Q. minima*, *Q. pumila*) with more limited stretches of open grassland (U.S. Fish & Wildlife Service, n.d.). Caracara nest sites in south-central Florida are typically cabbage palms including the cabbage palm/live oak "islands" of mesic temperate hammocks surrounded by open habitats with low ground cover and low density of tall or shrubby vegetation, and home ranges are strongly associated with improved pasture. Caracaras use pine flatwoods during cooler months. Within these habitats, caracaras typically nest during a nesting season that typically continues from September through June with a concentration during November to April (Humphrey and Morrison 1997, Morrison 1998, Morrison and Dwyer 2012).

Caracaras are non-migratory and home ranges average approximately 1,200 ha (approximately 3,000 acres), corresponding to a radius of two to three kilometers (1.2 to 1.9 miles) surrounding the nest site (Morrison and Humphrey 2001). Foraging typically occurs opportunistically throughout the home range during nesting and non-nesting seasons, within a variety of habitats including mesic cabbage palm clusters, wet and dry prairies, rangeland, improved pastures, adjacent to dwellings and farm buildings, newly plowed or burned fields, agricultural lands, including sod and cane fields, citrus groves, dairies, and wetland habitats. This large raptor is a dietary generalist and opportunistic feeder. Prey species include invertebrates such as crayfish, beetles, grasshoppers and small mammals, amphibians, reptiles, fish, and birds (Morrison 1998).

Threats to Florida's caracara population are loss or degradation of nesting and feeding habitat. Such loss is most commonly due to conversion of pasture and other grassland habitats and wetlands to citrus, sugar cane, other agriculture, and urban development. The caracara is known to occur and nest in the project area (USFWS data; eBird data). Cornell University's eBird records show that caracaras are widely distributed and seen flying, foraging, and roosting in the LRWRP study area (**Figure C.1-10**). **Figure C.1-**11 shows the reported caracara nesting surrounding the project area.

A management concern for caracara conservation is habitat conversion from improved pasture and other upland habitats to wetland restoration areas (Comprehensive Everglades Restoration Plan (CERP) (USACE 1999). Proposed construction of C-18W reservoir covering about 5,000 ha and increasing sheet flow in the LRWRP flow-ways could reduce habitat, depending on final designs, which could convert acreages of improved pasture and other uplands within some of the caracara's current range to reservoirs and wetter marshes.

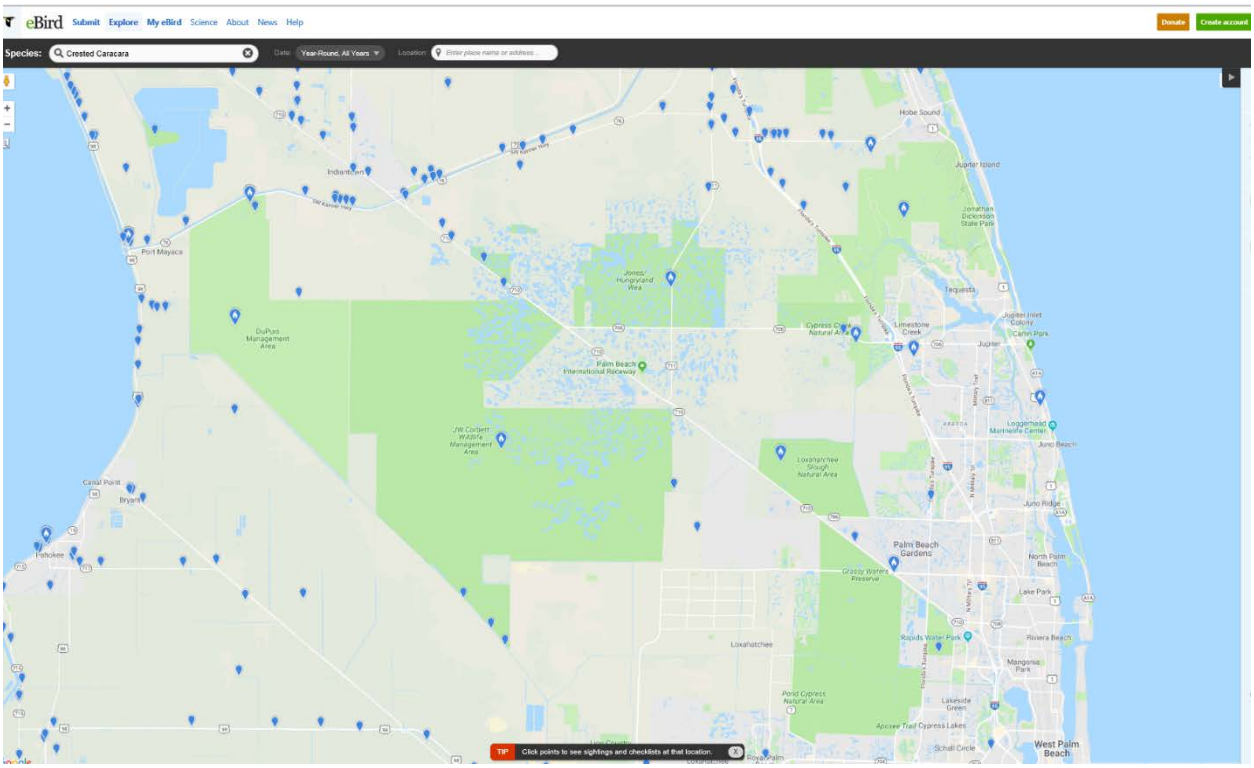

Figure C.1-10. eBird caracara observations in study area (accessed 19 July 2018).

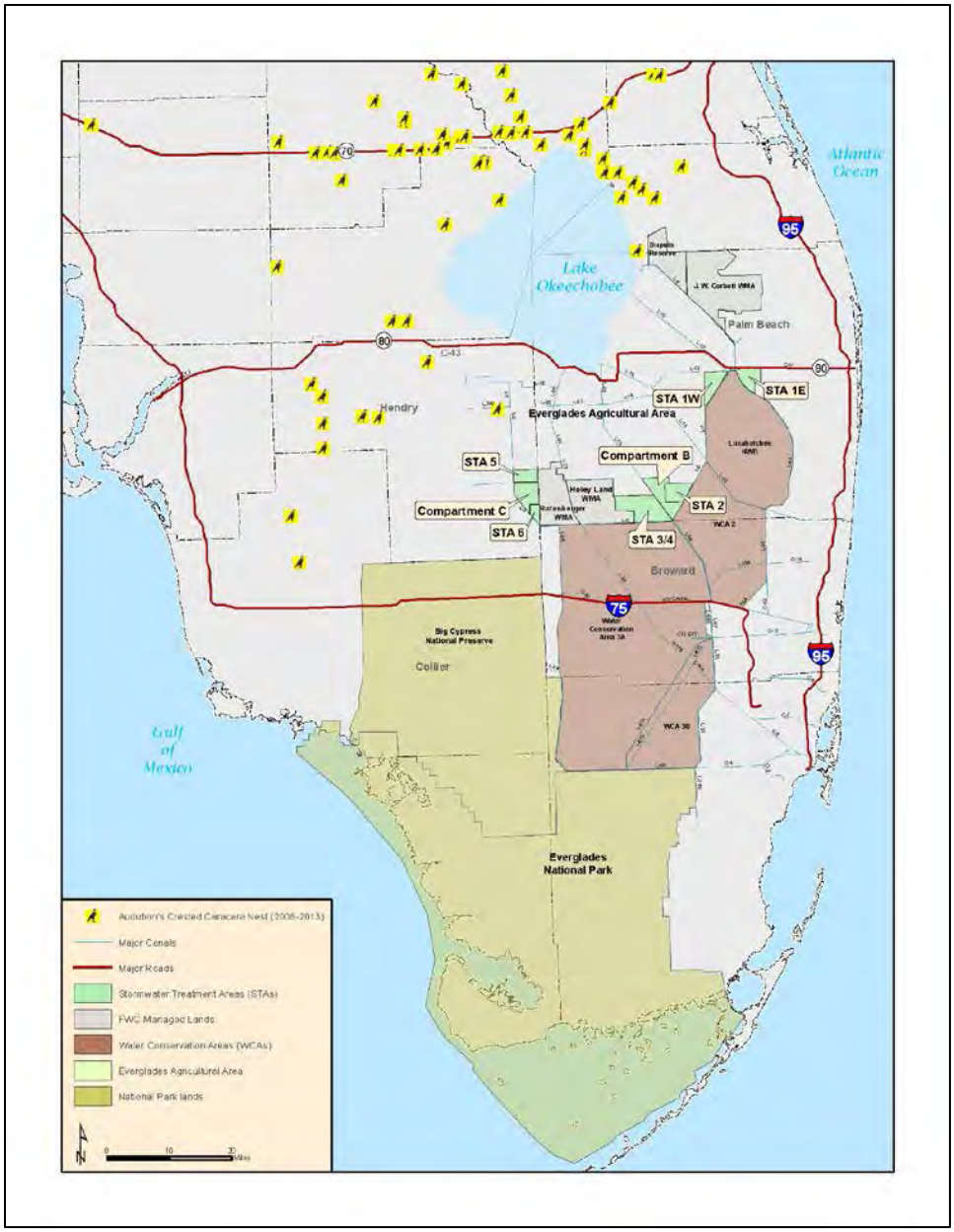

Figure C.1-11. Reported caracara nest locations (USFWS 2008-2013; Tim Breen, USFWS, pers .comm. October 2018).

C.1.8.1.5 Everglade Snail Kite

The snail kite (*Rostrhamus sociabilisis*) listed as an endangered species by both the USFWS and Florida. Although previously located in freshwater marshes over a considerable area of peninsular Florida, the range of the snail kite is now limited to central and southern portions of Florida. Six large freshwater systems are located within the current range of the snail kite: Upper St. Johns marshes, Kissimmee Chain of Lakes (KCOL), Lake Okeechobee, Loxahatchee Slough, the Everglades, and the Big Cypress basin. Habitats that have supported snail kites include the East Orlando Wilderness Park, the Blue Cypress Water Management Area, the St. Johns Reservoir, and the Cloud Lake, Strazzulla, and Indrio impoundments. In the KCOL, snail kites may occur within most of the lakes and adjacent wetlands, with the majority of snail

kite nesting occurring within Lake Kissimmee, Lake Tohopekaliga, and East Lake Tohopekaliga. In the KCOL, snail kites have also nested in lower numbers on Lakes Hatchineha and Jackson. Snail kite nesting also has occurred periodically since about 2002 in Lake Istokpoga.

Lake Okeechobee and surrounding wetlands represent significant snail kite nesting and foraging habitats that have historically supported snail kites. In the Loxahatchee Slough region of Palm Beach County, snail kites may occur in the Loxahatchee National Wildlife Refuge (NWR; WCA-1) and throughout the remaining marshes in the vicinity, most frequently nesting within GWP, also known as the West Palm Beach Water Catchment Area. Snail kites may occur within nearly all remaining wetlands of the Everglades region, including WCA-2B, WCA-3A, WCA-3B, and Everglades National Park (ENP).

Lake Okeechobee is of particular importance since it serves as a critical stopover point as snail kites traverse the network of wetlands within their range. A loss of suitable habitat and refugia, especially during droughts in the lake, may have significant demographic consequences. Lake Okeechobee is critical to the snail kite's long-term population persistence, especially given the susceptibility of juvenile snail kites in the Kissimmee River Valley to an increased frequency of local disturbance events due to cold weather and the treatment of hydrilla. The kite's apple snail diet is dependent on the hydrology and water quality of the watersheds. Foraging habitat requires shallow open-area ponds with low marsh areas; nesting/roosting sites are located over water. Foraging conditions have expanded recently due to the increase in exotic apple snail population (since about 2010). As a result, the snail kite breeding season has lengthened (sometimes into fall) and some previous unsuitable foraging areas now have the more robust exotic apple snail and are being utilized by kites.

Snail kite critical habitat was designated in 1977. Nine critical habitat units were identified: two small reservoirs, the littoral zone of Lake Okeechobee, and areas of the Everglades' marshes within the WCAs and ENP. Since this designation, the utilization of these units by snail kites as productive nesting areas has varied significantly. In 2012, the KCOL, Lake Tohopekaliga in particular, supported the greatest number of snail kites in Florida. This shift in productive nesting areas was in response to regional droughts as well as habitat degradation in historic breeding locations. While the KCOL is now considered an important habitat for the snail kite, this was not the case when critical habitat was designated in 1977, and the KCOL was not included in the original designation. And, while the St John's Reservoir critical habitat in Indian River County does not seem to be used, across the street (SR 60), the St. John's Marsh (not critical habitat) was used in most years (from 1996 to 2016) by nesting snail kites. Critical habitat near the project area is shown in **Figure C.1-**12 (USFWS 2015); however, the project area does not overlie critical habitat. Nesting occurs at numerous locations in south Florida (**Figure C.1-13**).

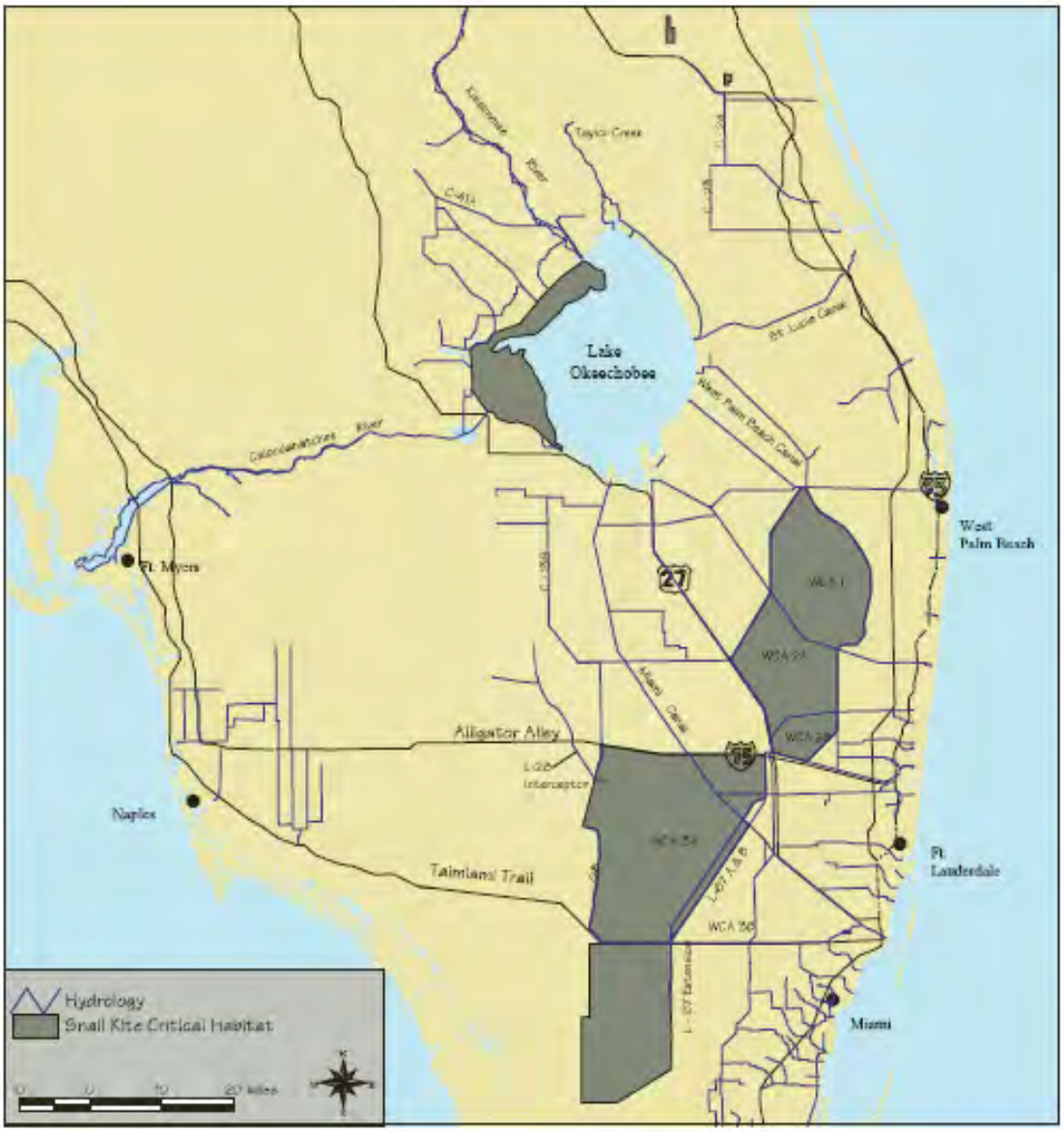

Figure C.1-12. Critical habitat for Everglade snail kite (source: USFWS 2015).

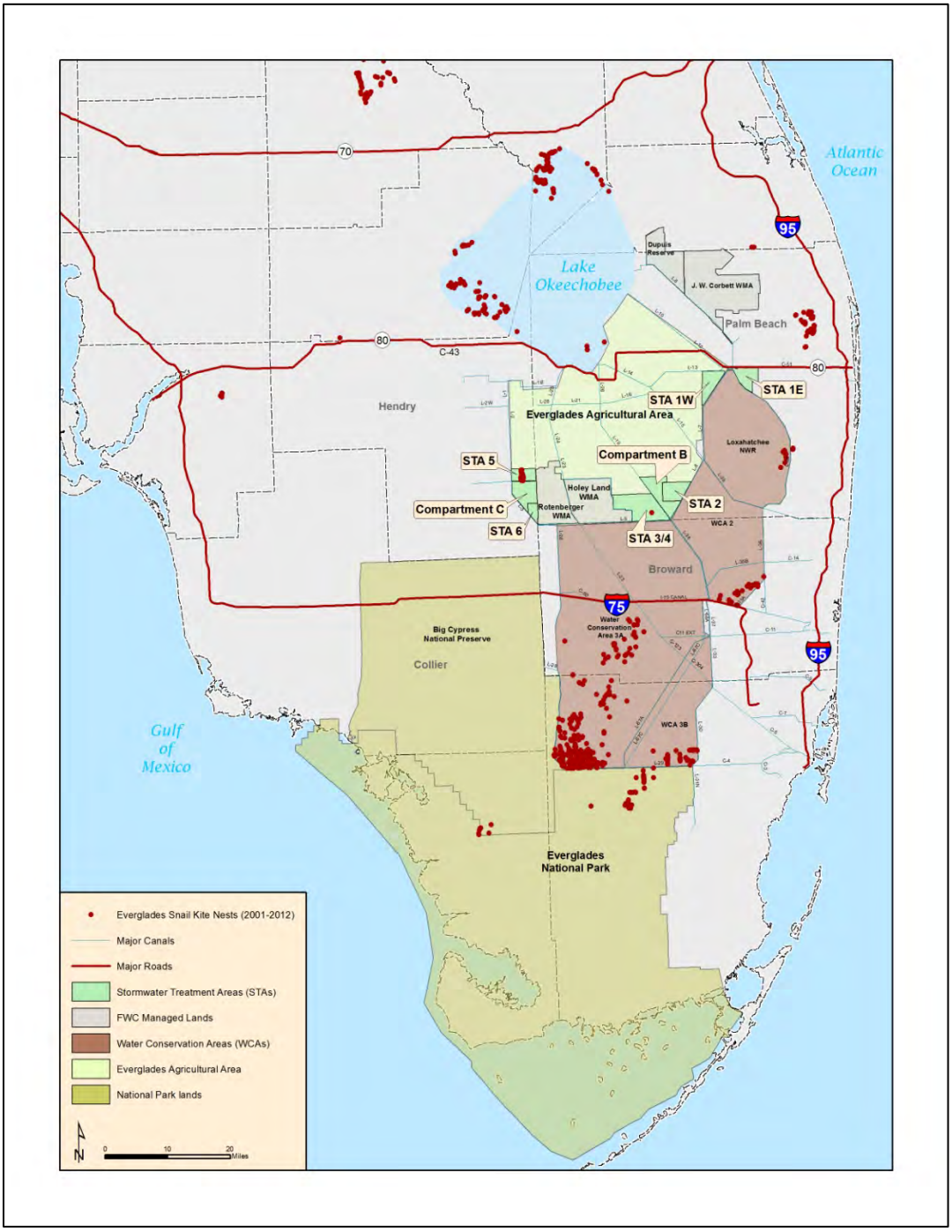

Figure C.1-13. Snail kite nesting locations between 2001-2012.

Within the LRWRP project area, snail kite nesting is reported in some years, dependent on water depths and persistence, clustered along a drainage slough in Hungryland Slough and in GWP (**Figure C.1-14**). Water conditions and recession rates in these two areas are managed independently of the LRWRP.

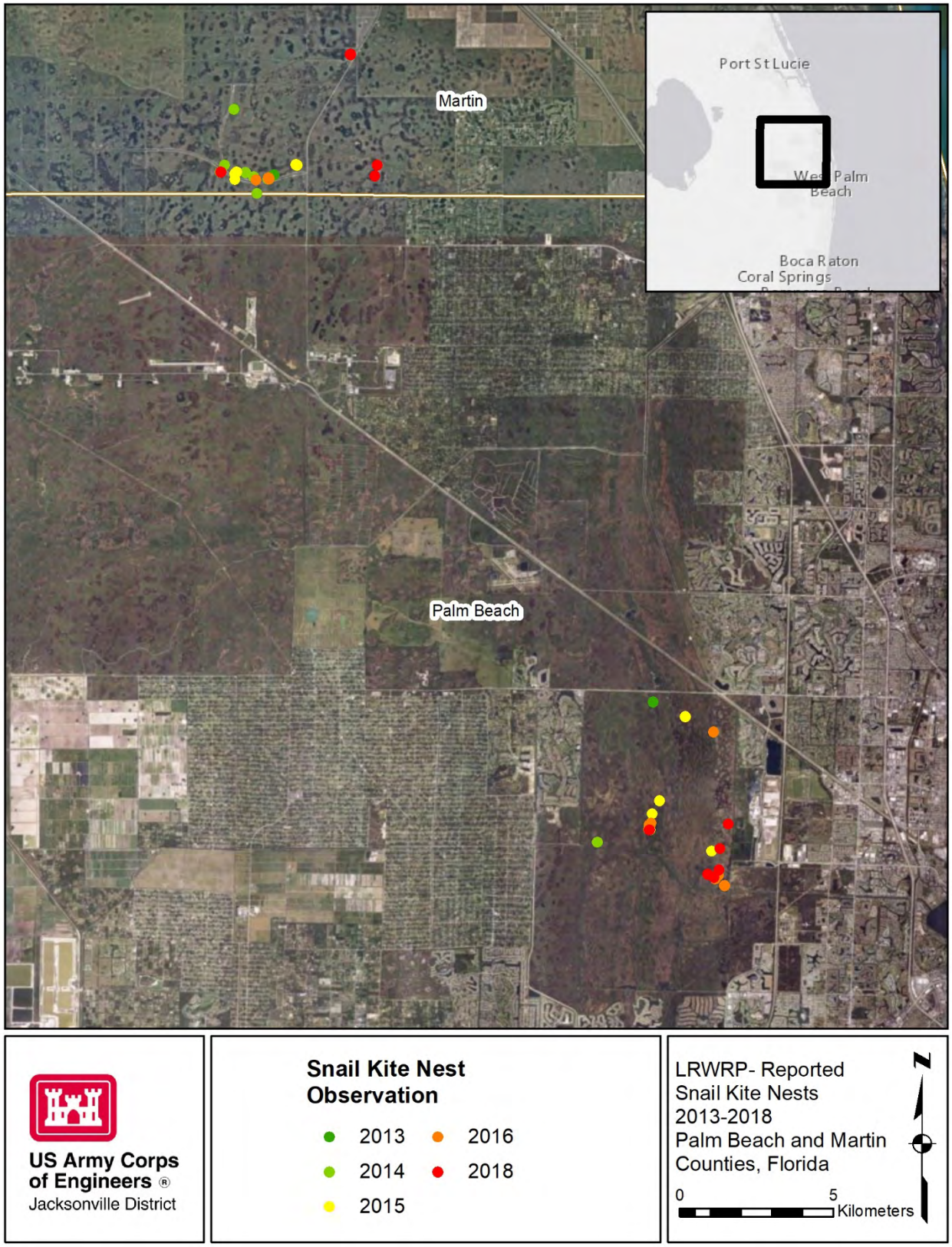

Figure C.1-14. Snail kite nesting locations in the LRWRP project area from 2013-2018.

Numerous eBird observations of snail kites (including some photos clearly documenting foraging) have been reported in the LRWRP study area (https://ebird.org/map/) (**Figure C.1-15**).

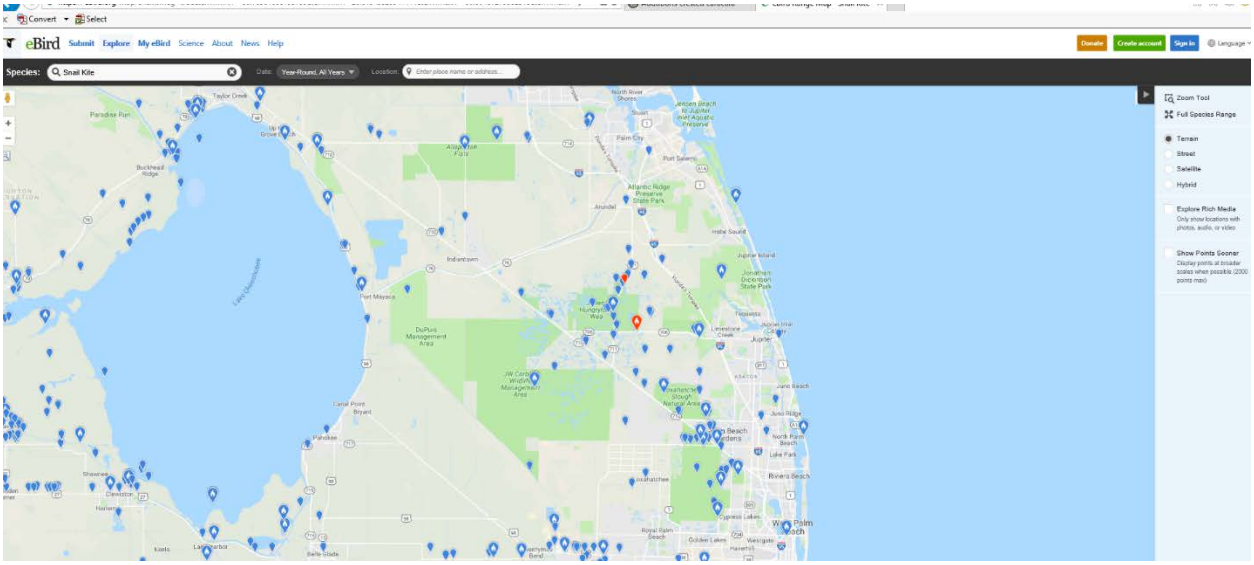

Figure C.1-15. Snail kite eBird observations in Martin and Palm Beach counties.

C.1.8.1.6 Wood Stork

The wood stork (*Mycteria americana*) was federally listed as endangered under the ESA on February 28, 1984. No critical habitat has been designated for the wood stork. This a large, white, long-legged wading bird that relies upon shallow, freshwater wetlands for foraging. Black primary and secondary feathers, a black tail and a blackish, featherless neck distinguish the wood stork from other wading birds species. This species

In the United States, wood storks were historically known to nest in all coastal states from Texas to South Carolina (Wayne 1910, Bent 1926, Howell 1932, Oberholser 1938). Dahl (1990) estimates these states lost about 38 million acres, or 45.6%, of their historic wetlands between the 1780s and the 1980s. However, it is important to note wetlands and wetland losses are not evenly distributed in the landscape. Hefner et al. (1994) estimated 55% of the 2.3 million acres of the wetlands lost in the southeastern United States between the mid-1970s and mid-1980s were located in the Gulf-Atlantic coastal flats. These wetlands were strongly preferred by wood storks as nesting habitat. Currently, wood stork nesting is known to occur in Florida, Georgia, South Carolina, and North Carolina from March to late May. However, in south Florida, wood storks lay eggs as early as October and fledge in February or March. Breeding colonies of wood storks are currently documented in all southern Florida counties except for Okeechobee County (**Figure C.1-16**).

The wood stork population in the southeastern United States appears to be increasing. Preliminary population totals indicate that the wood stork population has reached its highest level since it was listed as endangered in 1984. In all, approximately 11,200 wood stork pairs nested within their breeding range in the southeastern United States. Wood stork nesting was first documented in North Carolina in 2005 and wood storks have continued to nest in this state through 2009. This suggests that the northward expansion of wood stork nesting may be continuing.

The primary cause of the wood stork population decline in the United States is loss of wetland habitats or loss of wetland function resulting in reduced prey availability. Almost any shallow wetland depression where fish become concentrated, either through local reproduction or receding water levels, may be used as feeding habitat by the wood stork during some portion of the year; but only a small portion of the available wetlands support foraging conditions (high prey density and favorable vegetation structure) that wood storks need to maintain growing nestlings.

Wood storks forage primarily within freshwater marsh and wet prairie vegetation types, but can be found in a wide variety of wetland types, as long as prey are available and the water is shallow and open enough to hunt successfully (Ogden et al. 1978; Coulter 1987; Gawlik et al. 2004; Herring and Gawlik 2007). Calm water, about 5 to 25 centimeters in depth, and free of dense aquatic vegetation is ideal, however, wood storks have been observed foraging in ponds up to 40 centimeters in depth (Coulter and Bryan 1993; Gawlik 2002). Typical foraging sites include freshwater marshes, ponds, hardwood and cypress swamps, narrow tidal creeks or shallow tidal pools, and artificial wetlands such as stock ponds, shallow, seasonally flooded roadside or agricultural ditches, and managed impoundments (Coulter and Bryan 1993, Herring and Gawlik 2007). During nesting, these areas must also be sufficiently close to the colony to allow wood storks to efficiently deliver prey to nestlings.

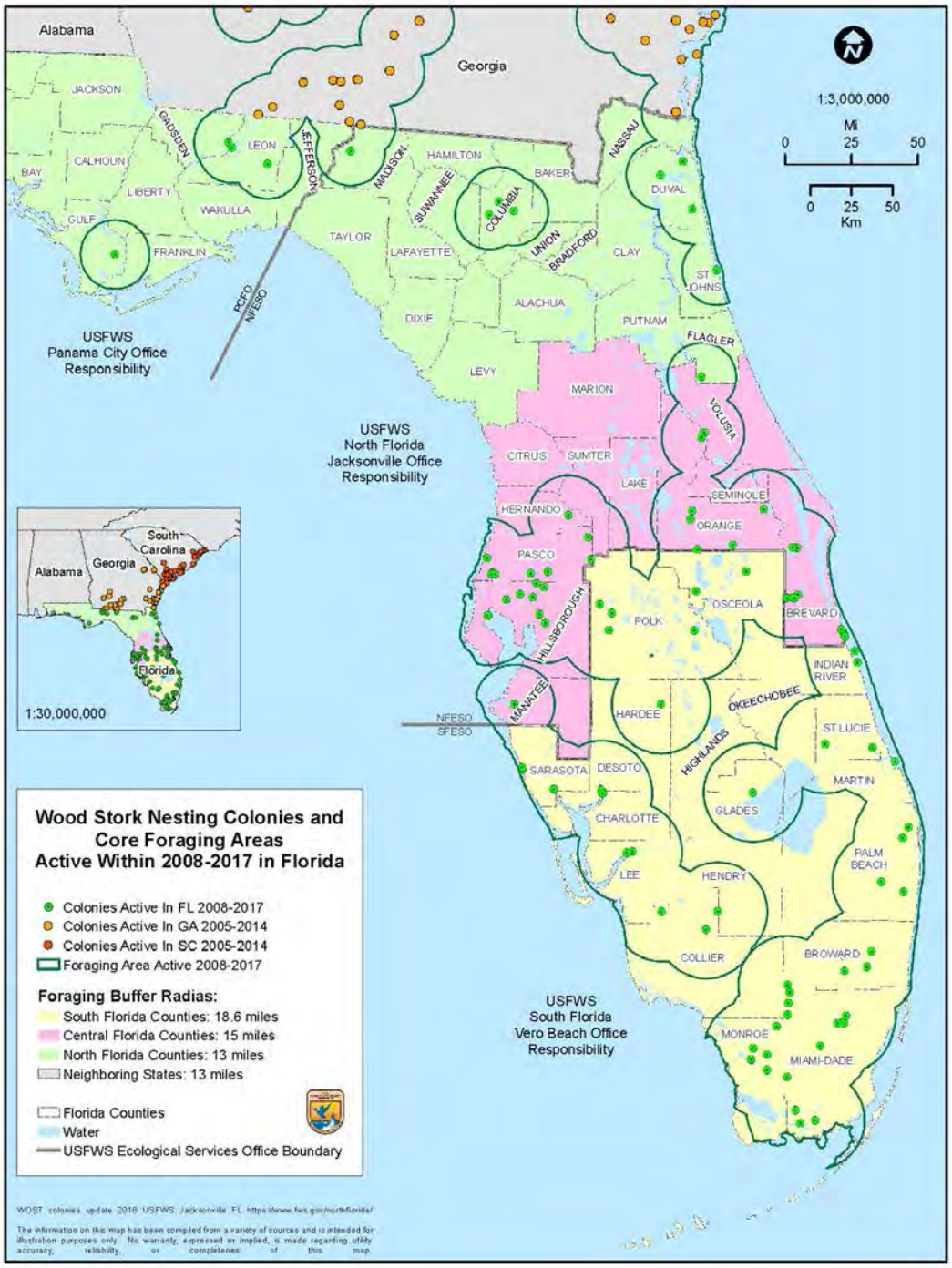

Figure C.1-16. Wood stork colonies (2008-2017) in Florida (USFWS 2017).

Two stork colonies occur in the LRWRP area – the Palm Beach County Solid Waste Authority site and the Ballen Isles Country Club colony in a golf course storm water pond 340 m west of N. Military Trail. Most of the central and eastern side of the project area lies within wood stork core foraging areas used by the

two colonies lying within the project area and other colonies with foraging distances overlapping the project area (**Figure C.1-17**).

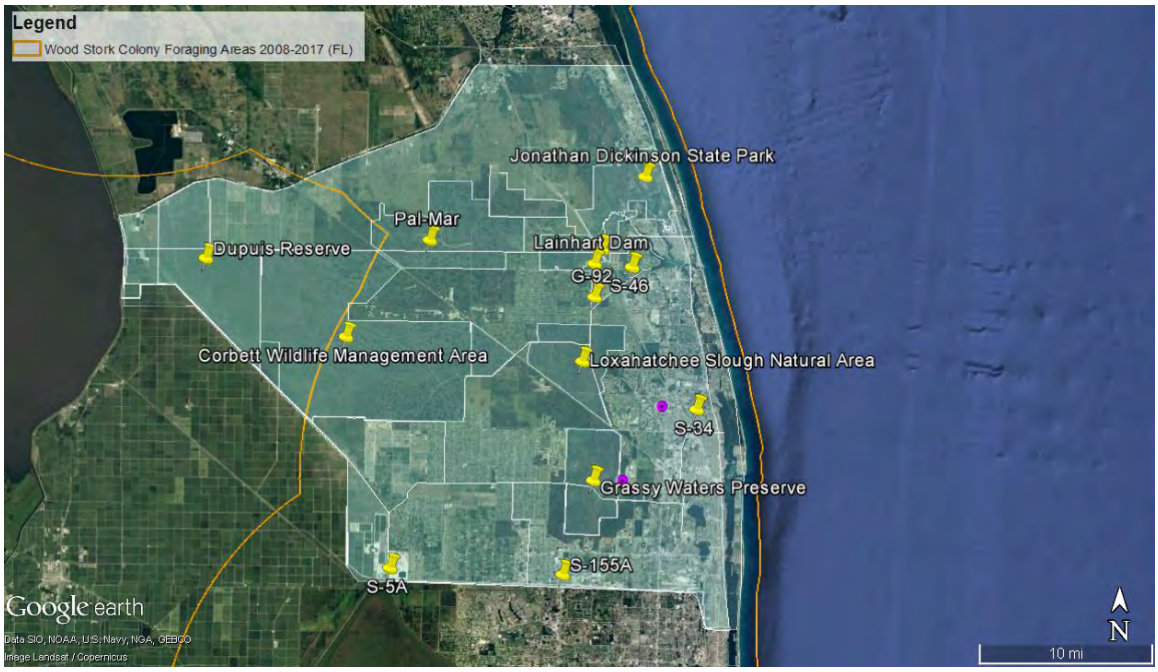

Figure C.1-17. Wood stork colonies and core foraging areas in the LRWRP area (colonies are shown as purple dots, core foraging area is within orange lines).

C.1.8.1.7 Red-cockaded Woodpecker

Red-cockaded woodpeckers (RCWs) were once considered common throughout the longleaf pine ecosystem, which covered approximately 90 million acres before European settlement. Historical population estimates are 1-1.6 million "groups", the family unit of RCWs. The birds inhabited the open pine forests of the southeast from New Jersey, Maryland and Virginia to Florida, west to Texas and north to portions of Oklahoma, Missouri, Tennessee and Kentucky.

The longleaf pine ecosystem initially disappeared from much of its original range because of early 1700s European settlement, widespread commercial timber harvesting and the naval stores/turpentine industry in the 1800s. Early to mid-1900 commercial tree farming, urbanization and agriculture contributed to further declines. Much of the current habitat is also very different in quality from historical pine forests in which RCWs evolved. Today, many southern pine forests are young and an absence of fire has created a dense pine/hardwood forest.

The red-cockaded woodpecker makes its home in mature pine forests. Longleaf pines (*Pinus palustris*) are most commonly preferred, but other species of southern pine are also acceptable. While other woodpeckers bore out cavities in dead trees where the wood is rotten and soft, the red-cockaded woodpecker is the only one which excavates cavities exclusively in living pine trees. Cavities are excavated in mature pines, generally over 80 years old. The older pines favored by the red-cockaded woodpecker often suffer from a fungus called red heart disease which attacks the center of the trunk, causing the inner wood, the heartwood, to become soft. Cavity excavation takes one to six years.

The aggregate of cavity trees is called a cluster and may include 1 to 20 or more cavity trees on 3 to 60 acres. The average cluster is about 10 acres. Cavity trees that are being actively used have numerous, small resin wells which exude sap. The birds keep the sap flowing apparently as a cavity defense mechanism against rat snakes and possibly other predators. The typical territory for a group ranges from about 125 to 200 acres, but observers have reported territories running from a low of around 60 acres, to an upper extreme of more than 600 acres. The size of a particular territory is related to both habitat suitability and population density.

The red-cockaded woodpecker plays a vital role in the intricate web of life of the southern pine forests. Red-cockaded woodpeckers are 'primary' cavity nesters, meaning they are responsible for the construction of cavities. In the southern pine ecosystem there are many 'secondary' cavity users that benefit from the RCWs work. RCWs are considered a ‘keystone’ species because use of their cavities by these animals contributes to the species richness of the pine forest.

At least 27 species of vertebrates have been documented using RCW cavities, either for roosting or nesting. Species include insects, birds, snakes, lizards, squirrels and frogs. Many of these species, for example wood ducks, only use the cavities that have been abandoned by RCWs; abandonment usually occurs because the entrance tunnel was enlarged by pileated woodpeckers. However, southern flying squirrels, red-bellied woodpeckers, red-headed woodpeckers, eastern bluebirds, brown-headed nuthatches, tufted titmice and great crested flycatchers are the species most commonly seen in RCW cavities, and can use normal, unenlarged cavities that RCWs could also use. RCW cavities are a valued resource for many species and competition occurs for their use [Species account: USFWS 2019].

RCWs often nest in wet pine flatwoods and formerly occurred in JDSP and other locations within the project area. In 1999, only about 25 clans composed of two to eight individuals were known to occur within J.W. Corbett WMA. Since 2006, 92 of these birds have been relocated from public land in Florida and Georgia to the Dupuis WMA in the western watershed. An average of 45% of these woodpeckers have stayed in the area for a least one year. Additionally, the number of breeding pairs and young produced has increased, and in 2015 12 breeding pairs produced 17 fledglings (http://www.ces.fau.edu/dupuis/wildlife-studies.php). The most unprotected area for the red-cockaded woodpecker is Pal-Mar, which creates a corridor from J.W. Corbett WMA to JDSP (TCRPC 1999).

C.1.8.1.8 Eastern Indigo Snake

The eastern indigo snake is the largest, native, non-venomous snake in North America. It is an isolated subspecies occurring in southeastern Georgia and throughout peninsular Florida. The eastern indigo snake prefers drier habitats, but may be found in a variety of habitats from xeric sandhills, to cabbage palm hammocks, to hydric hardwood hammocks. It has also been found in citrus groves and sugar cane. The eastern indigo snake needs relatively large areas of land to maintain their population. Because it is such a wide-ranging species, the eastern indigo snake is especially vulnerable to habitat fragmentation that makes travel between suitable habitats difficult. The main reason for its decline is habitat loss due to development. Further, as habitats become fragmented by roads, the eastern indigo snake becomes increasingly vulnerable to highway mortality as they travel through their large territories.

In south Florida, the eastern indigo snake is thought to be widely distributed. Given their preference for upland habitats, eastern indigo snakes are not commonly found in great numbers in wetland complexes, though they have been found in pinelands, tropical hardwood hammocks, and mangrove forests in extreme south Florida. Within the range of the gopher tortoise, tortoise burrows are favorite refugia for

indigo snakes. They are known to use burrows made by cotton rats and land crabs, hollows at bases of trees and stumps, ground litter, trash piles and rock piles lining banks of canals and pipes or culverts. The eastern indigo snake is found in a variety of upland and wetland communities in the watershed, including mesic hammocks. A study conducted on a 60,000 acre abandoned citrus grove in Martin County determined that hundreds of snakes were present in the grove (Florida Gulf Coast University -- C-44 reservoir and stormwater treatment area included in the Central and Southern Florida Project of the Comprehensive Everglades Restoration Plan). Total home range size varied from 9.71 - 65.78 ha. All individuals tracked remained active all year long and showed no significant difference in activity based on mean meters traveled per day when compared between seasons. The two male snakes tracked for the longest period of time showed a significant preference for artificial refugia in cooler temperatures and natural refugia in warmer temperatures.

Habitat use in Florida has historically been more varied than in Georgia with snakes using habitats such as mangrove swamps, wet prairies, xeric pinelands, hydric hammocks, citrus groves, and scrub. In the southernmost reaches of the snakes' range tropical hardwood hammocks and pine uplands appear to be preferred, however, freshwater marshes, fallow fields, coastal prairie, mangrove swamps, and human impacted habitats such as residential areas are also used to a lesser degree.

Home range sizes appear to vary geographically and by sex, with home ranges for males ranging from 12.8 – 538.4 ha (Breininger et al. 2011) and 30 to 115 ha for females. Although the size of the home range of an indigo snake varies by the snake's age and sex as well as seasonally, indigos require immense tracts to flourish. Adult females range over ranges that average 80 (45 to120) acres in size and adult males utilize up to 4 times that amount of space. They are traditionally associated with scrub and open pinelands. If gopher tortoises are present their burrows serve as retreats for the snakes. Indigos may survive on cleared agricultural and pasture land as long as adequate cover is present. These snakes wander most widely during the warm months of the year but are active throughout the winter on all but the coldest days. In south Florida, snakes use crab holes in canal banks as refugia in lieu of gopher tortoise burrows. The diverse diet and high vagility of this species allow it to forage successfully in numerous habitats. Both male and female snakes remain active all year long with peak activity months falling in the winter season for both sexes.

Sexual maturity appears to occur around 3-4 years of age. In North Florida, breeding occurs November to April with females laying 4-12 eggs in May-June (Moler 1992). Most hatching of eggs occurs August-September, with yearling activity peaking in April-May (USFWS 1999). Limited data on reproduction in south Florida indicate the breeding season is extended; breeding occurs from June-January, egg deposition is April to July, and hatchlings are born through early fall (USFWS 1999).

C.1.8.1.9 Okeechobee Gourd

The Okeechobee gourd is a climbing annual or perennial vine with heart to kidney-shaped leaves. The cream-colored flowers are bell-shaped and the light green gourd is globular or slightly oblong. Historically, the Okeechobee gourd was found on the southern shore of Lake Okeechobee in Palm Beach County and in the Everglades. Currently, this species is limited to two disjunct populations, multiple sites along the St. Johns River in Volusia, Seminole, and Lake counties in northern Florida and 11 sites along the southeastern shore of Lake Okeechobee, including Torry Island, Ritta Island, Kreamer Island, Bay Bottom Dynamite Hole Island, South Shore Dynamite Hole Island and the southern shore of the Lake Okeechobee Rim Canal in south Florida (Walters et al. 1992, Walters and Decker-Walters 1993, FWS 1999). It does not occur presently in the LRWRP area. The conversion of the pond apple forested swamps and marshes for

agricultural purposes, as well as water-level regulation of Lake Okeechobee, have been the principal causes of the reduction in both the range and population size of the Okeechobee gourd.

C.1.8.2 Future Without Project Conditions

Federally listed threatened and endangered species are either known to exist or potentially exist within the project area. Under FWO conditions, the area's natural areas, parks, and environmental areas would continue to be operated as conservation lands. The area's rural and agricultural nature would remain largely unchanged or, given the regional future land use projections, would transition in some areas to more intensive land development. Water management features would continue to operate under existing operations plans or future plan revisions. Agricultural lands could convert between crop types depending on market demands, which could result in habitat loss for various species, particularly crested caracara, which appears to prefer habitats provided by undeveloped grazing lands. Without the LRWRP project, potential benefits to listed species may not be realized. The water storage and wetland restoration proposed by LRWRP could benefit Everglade snail kites, and wood storks. In the NWFLR and estuary, benefits to Florida manatees from a more natural hydroperiod would not be realized under FWO conditions. Future federal actions unrelated to the proposed action but located in the study area, will require separate consultations pursuant to ESA Section 7. The BA further discusses potential impacts to federally listed threatened and endangered species as a result of changes that occur between the present and the future without project condition (**Annex A).**

C.1.9 Essential Fish Habitat

Estuarine systems and coastal areas within the project area support fishery resources of recreational and commercial importance. At least 70% of Florida's recreationally or commercially sought–after fishes depend on estuaries for at least part of their life histories.

The Magnuson-Stevens Fishery Conservation and Management Act, Congress define Essential Fish Habitat (EFH) as:

> "*...those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity*."

Essential fish habitat includes all types of aquatic habitat—wetlands, coral reefs, seagrasses, and mangroves—where fish spawn, breed, feed, or grow to maturity. Three fishery management councils (FMC)—the Gulf of Mexico, South Atlantic, and U.S. Caribbean—are responsible for identifying EFH for federally managed species in the southeast United States. The definition of EFH may include habitat for an individual species or an assemblage of species, whichever is appropriate within each FMP. Also, highly migratory species, such as tunas, billfish, and sharks, are managed by NMFS and have EFH designations in these areas of the Southeast as well.

Federal agencies are required to consult with NMFS when their activities, including permits and licenses they issue, may adversely affect EFH and to respond to NMFS' recommendations for protecting and conserving EFH. NMFS' responsibilities also include recommending measures to minimize the adverse effects of fishing gear and fishing activities on EFH.

For the purpose of interpreting the definition of essential fish habitat: "waters" includes aquatic areas and their associated physical, chemical, and biological properties that are used by fish. When appropriate, this may include historically used areas. Water quality, including but not limited to nutrient levels, oxygen

concentration, and turbidity levels, is also considered to be a component of this definition. Examples of "waters" that may be considered EFH include open waters, wetlands, estuarine habitats, riverine habitats, and wetlands hydrologically connected to productive water bodies.

EFH is designated for fish species that spawn, grow, or live in a chosen location. For species with distinct life-stages, important locations may vary by individual life stage. USACE used the NMFS EFH Mapper, based on NOAA's ocean and nautical charts as the base maps, which are updated monthly and immediately available through the EFH Mapper (https://www.habitat.noaa.gov/protection/efh/efhmapper/), to obtain maps for essential fish habitat, habitat areas of particular concern, and EFH areas protected from fishing.

C.1.9.1 Existing Conditions

The on-shore project area is within the jurisdiction of the South Atlantic Fishery Management Council (SAFMC). The state of Florida recognized the important habitats in the area by designating the Loxahatchee River Lake Worth Creek Aquatic Preserve, which encompasses all forks of the river. EFH is mapped within the Loxahatchee River, Jupiter Inlet, Indian River Lagoon, and waters immediately offshore for five management groups(National Marine Fisheries Service [NMFS] 2000): snapper-grouper complex (e.g., grouper (*Epinephelus* spp.), gray snapper (*Lutjanus griseus*), white grunt (*Haemulon plumieri*), red porgy (*Pagrus pagrus*)) (**Figure C.1-18**,), spiny lobster (*Panulirus argus*) (**Figure C.1-19**), coral, coral reefs, and live/hard bottom habitats of the South Atlantic Region (Ahermatypic stony corals, Black corals, Hermatypic stony corals, Octocorals, Pennatulacea) (**Figure C.1-20**), coastal migratory pelagics of the gulf of Mexico and South Atlantic (cobia, king mackerel, Spanish mackerel) (**Figure C.1-21**) and several highly migratory species (the range is offshore, no figure is provided). The golden crab fishery of the South Atlantic region occurs offshore and a figure depicting its range is not provided in this discussion.

All life stages of the snapper-grouper complex may occur in the river and estuary, and the nearshore hardbottom habitat outside of the Loxahatchee Estuary/Jupiter Inlet is designated as Essential Fish Habitat-Habitat Areas of Special Concern (EFH-HAPC) for the snapper-grouper complex[1].

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[1] Species List for South Atlantic EFH

List of EFH species included in data download: -- Coastal Migratory Pelagics of the Gulf of Mexico & South Atlantic -- Coastal Migratory Pelagics (Cobia, King Mackerel, Spanish Mackerel); -- Amendment 4 to: Coral, Coral Reefs, & Live/Hard Bottom Habitats of the South Atlantic Region; -- Corals (Ahermatypic stony corals, Black corals, Hermatypic stony corals, Octocorals, Pennatulacea);-- Amendment 1 to: Golden Crab Fishery of the South Atlantic Region -- Golden Crab (Golden Crab, Jonah Crab, Red Crab); -- Amendment 3 to: Shrimp Fishery of the South Atlantic Region -- Shrimp (Brown Shrimp, Pink Shrimp, Royal Red Shrimp, Rock Shrimp, White Shrimp); -- Amendment 10 to: Snapper Grouper Fishery of the South Atlantic Region -- Snapper Grouper (Almaco Jack, Atlantic Spadefish, Banded Rudderfish, Bank Sea Bass, Bar Jack, Blackfin Snapper, Black Grouper, Blueline Tilefish, Black Margate, Black Sea Bass, Blue Runner, Black Snapper, Bluestriped Grunt, Coney, Cottonwick, Crevalle Jack, Cubera Snapper, Dog Snapper, French Grunt, Gag, Grass Porgy, Gray Snapper, Graysby, Gray Triggerfish, Greater Amberjack, Hogfish, Jolthead Porgy, Knobbed Porgy, Lane Snapper, Lesser Amberjack, Longspine Porgy, Mahogany Snapper, Margate, Misty Grouper, Mutton Snapper, Ocean Triggerfish, Porkfish, Puddingwife, Queen Snapper, Queen Triggerfish, Red Grouper, Red Hind, Red Porgy, Red Snapper, Rock Hind, Rock Sea Bass, Sailors Choice, Sand Tilefish, Saucereye Porgy, Scamp, Schoolmaster, Scup, Sheepshead, Silk Snapper, Smallmouth Grunt, Snowy Grouper, Spanish Grunt, Speckled Hind, Tiger Grouper, Tilefish, Tomtate, Vermilion Snapper, Warsaw Grouper, Whitebone Porgy, White Grunt,

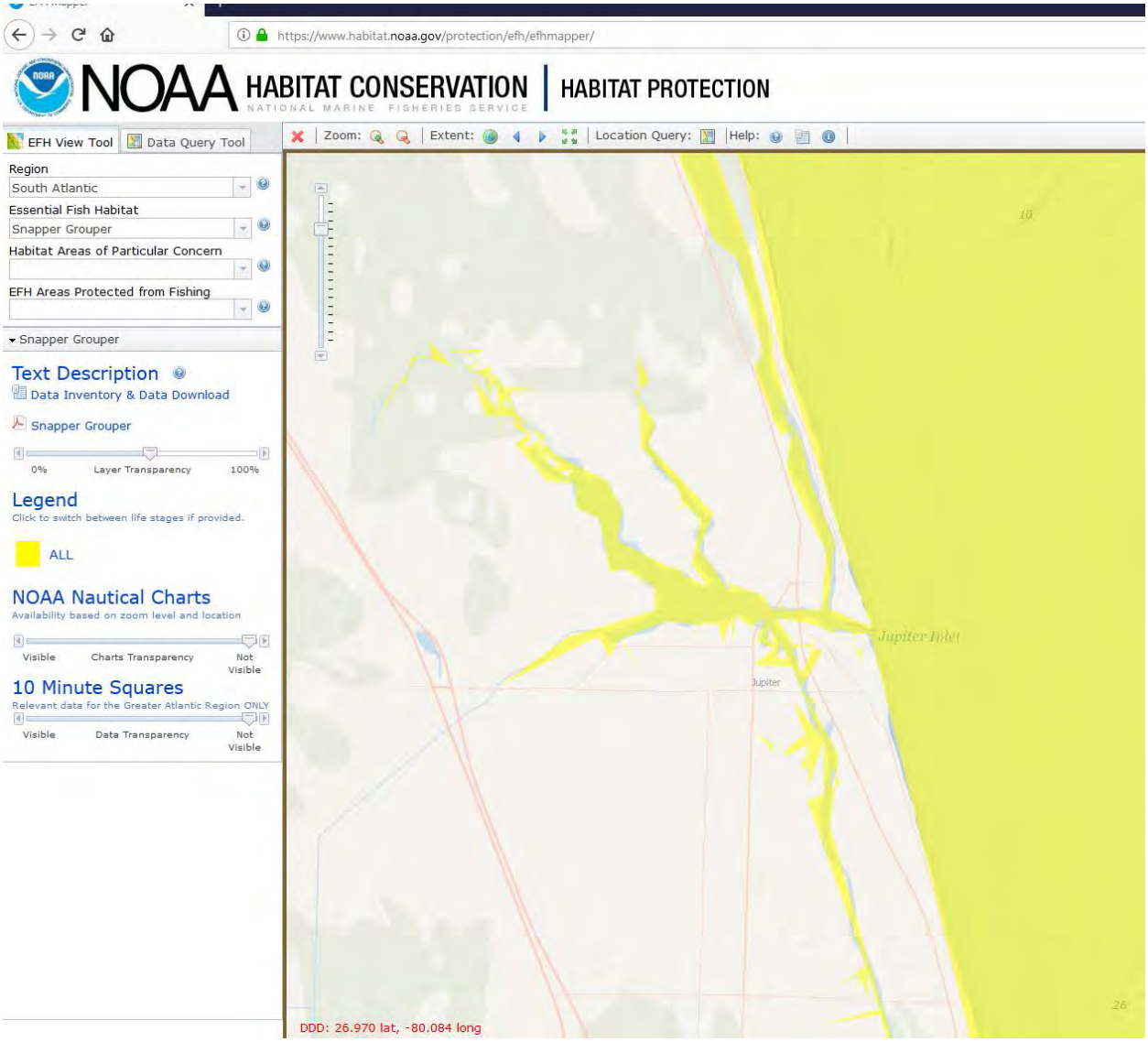

Figure C.1-18. Snapper-grouper complex EFH in the Loxahatchee River / LRWRP project area.

Wrechfish, Yellowedge Grouper, Yellowfin Grouper, Yellow Jack, Yellowmouth Grouper); -- Amendment 5 to: Spiny Lobster Fishery of the Gulf of Mexico & South Atlantic -- Spiny Lobster (Slipper Lobster, Spiny Lobster).

List of EFH migratory species currently mapped for this area: -- Amendment 10 to the 2006 Consolidated HMS FMP: EFH -- (Atlantic Highly Migratory Species): Albacore Tuna, Bigeye Tuna, Bluefin Tuna, Skipjack Tuna, Yellowfin Tuna, Swordfish, Blue Marlin, Longbill Spearfish, Roundscale Spearfish, Sailfish, White Marlin, Atlantic Angel Shark, Atlantic Sharpnose Shark (Atlantic Stock), Basking Shark, Bigeye Thresher Shark, Blacknose Shark (Atlantic Stock), Blacktip Shark (Atlantic Stock), Blue Shark, Bonnethead Shark (Atlantic), Bull Shark, Caribbean Reef Shark, Common Thresher Shark, Dusky Shark, Finetooth Shark, Great Hammerhead Shark, Lemon Shark, Longfin Mako Shark, Night Shark, Nurse Shark, Oceanic Whitetip Shark, Sand Tiger Shark, Sandbar Shark, Scalloped Hammerhead Shark, Shortfin Mako Shark, Silky Shark, Smoothhound Shark Complex (Atlantic Stock), Spinner Shark, Tiger Shark, Whale Shark, White Shark.

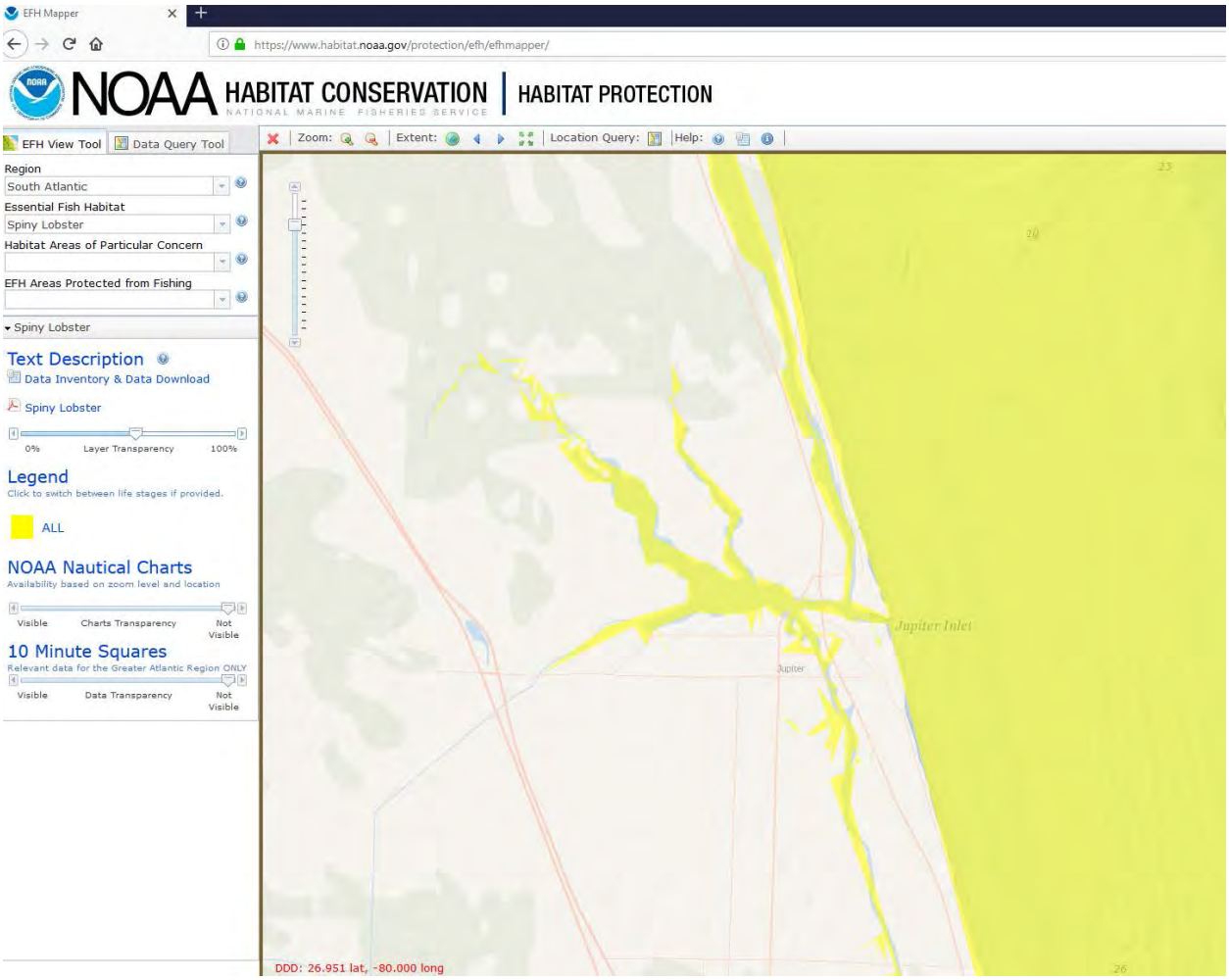

Figure C.1-19. Spiny lobster EFH in the Loxahatchee River / LRWRP project area.

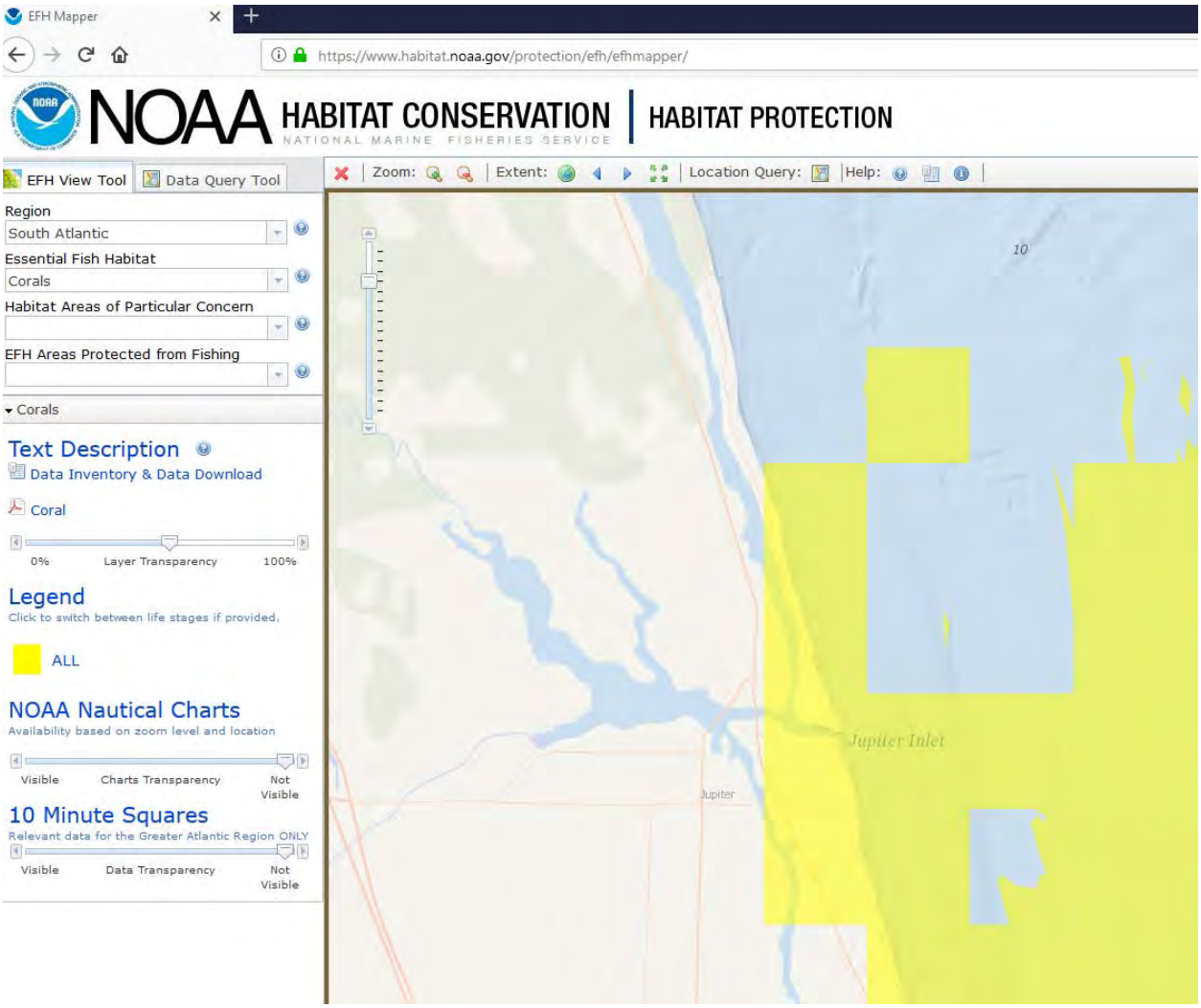

Figure C.1-20. Coral EFH in the Loxahatchee River / LRWRP project area.

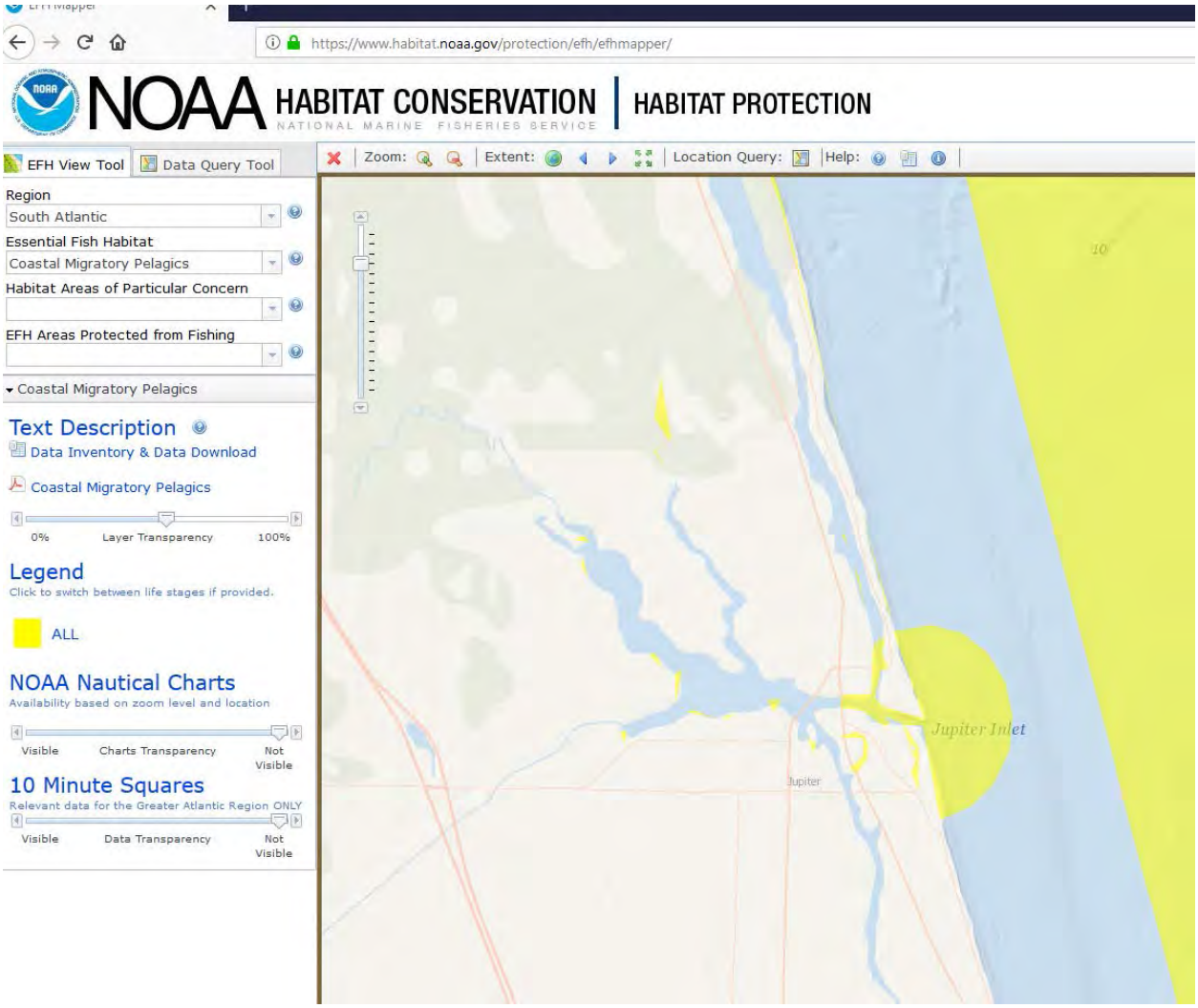

Figure C.1-21. Coastal migratory pelagics EFH in the Loxahatchee River / LRWRP project area.

The Florida Department of Environmental Protection Coral Reef Conservation Program also mapped nearshore shallow-water habitat and characterized coral reef communities. The benthic habitat in the "Northern Florida Reef Tract / North Palm Beach Region" includes all marine benthos in 0 m - ~ 10 m depth (FDEP 2018). The St. Lucie Reef is 4.5 miles long and supports 21 stony coral species, more than 100 other invertebrates, 23 algae species, loggerhead, hawksbill, and green sea turtles, and more than 450 fish species. The reef is affected by the freshwater discharge from the St. Lucie Inlet, which derives from the St. Lucie River, Indian River Lagoon, and three Lake Okeechobee drainage canals (C-23, C-24, and C-44). Corals are most common in the nearshore hardbottom and along two reef tracts (20 m, 30 m), which consist of ledges of up to 3 m relief; while the outer 30 m shelf tract runs through the majority of this region, the 20 m shelf tract runs intermittently. Coral assemblages include octocorals (*Lophogorgia*, *Leptogorgia*, *Eunicea*, and *Antillorgia* spp.) and scleractinian coral (*Oculina diffusa*, *O. varicose*, and *Siderastrea* spp.). Increasing riverine freshwater discharge can threatens coral communities, as most coral species are intolerant of salinities deviating significantly from normal seawater (20-35 psu).

Other groups occur including the shrimp fishery (pink shrimp (*Farfantepenaeus* [*Penaeus*] *duorarum*), white shrimp (*Litopenaeus* [*Penaeus*] *setiferus*), brown shrimp (F. [*P.*] *aztecus*)), and redfish (*Sciaenops ocellatus*)).

C.1.9.2 Future without Project Conditions

The FWO conditions would not improve the inflow of freshwater to the Loxahatchee estuary and Jupiter Inlet. Seasonal flows (quantity and timing) not characteristic of pre-development conditions would continue to cause harm to the estuarine system and affected nearshore coastal areas during the period of analysis (2018 through 2072). The absence of freshwater flow into estuarine systems and nearby coastal areas would continue to promote conditions that are likely to result in a decrease in species richness and abundance within those habitats.

C.1.10 State Listed Species

USACE reviewed the Florida Imperiled Species Management Plan to determine the potential effects of the project on state-listed fish and wildlife species (Florida Fish and Wildlife Conservation Commission 2016[2]).

C.1.10.1 Existing Conditions

The LRWRP project area encompasses habitat suitable for the presence, breeding, and/or foraging of 11 state-listed threatened and endangered species and one species of special concern (**Table C.1-4**). Threatened wildlife species include the American oystercatcher (*Haematopus palliatus*), black skimmer (*Rynchops niger*), least tern (*Sternula antillarum*), little blue heron (*Egretta caerulea*), roseate spoonbill (*Platalea ajaja*), tricolored heron (*Egretta tricolor*), reddish egret (Egretta rufescens), burrowing owl (*Athene cunicularia*), Florida sandhill crane (*Grus canadensis pratensis*), Southeastern American kestrel (*Falco sparverius paulus*), gopher tortoise (*Gopherus polyphemus*), and Florida pine snake (*Pituophis melanoleucus mugitus*). Sherman's fox squirrel (*Sciurus niger shermani*) is a species of special concern. The following sub-sections provide brief descriptions of the life histories of these species.

Table C.1-4. State-listed species and project effect.

Taxonomic Group	Common Name	Scientific Name	Florida Status	Project Effect
Bird	American oystercatcher	*Haematopus palliatus*	ST	No project-induced alterations to beaches; may be found within the estuary where oysters provide forage, or in short-hydroperiod wetlands.
Bird	black skimmer	*Rynchops niger*	ST	No project-induced alterations to beaches
Bird	least tern	*Sternula antillarum*	ST	No project-induced alterations to beaches; occasionally nest inland on disturbed stockpiled material;

[2] Florida Fish and Wildlife Conservation Commission. 2016. Florida's Imperiled Species Management Plan. Tallahassee, Florida.

Taxonomic Group	Common Name	Scientific Name	Florida Status	Project Effect
				construction best management practices
Bird	little blue heron	*Egretta caerulea*	ST	Beneficial alterations to future hydrological regime
Bird	roseate spoonbill	*Platalea ajaja*	ST	Beneficial alterations to future hydrological regime
Bird	tricolored heron	*Egretta tricolor*	ST	Beneficial alterations to future hydrological regime
Bird	Reddish egret	*Egretta rufescens*	ST	No project-induced alterations to beaches
Bird	burrowing owl	*Athene cunicularia floridana*	ST	Project induced reductions in mesic habitat
Bird	Florida sandhill crane	*Antigone canadensis pratensis*	ST	Beneficial alterations to future hydrological regime
Bird	southeastern American kestrel	*Falco sparverius paulus*	ST	Adverse effects from future hydrological regime shift to more hydric wetlands; project-induced reductions in upland communities may affect nesting success
Reptile	Florida pine snake	*Pituophis melanoleucus mugitus*	ST	Project induced reductions in dry upland habitat
Reptile	gopher tortoise	*Gopherus polyphemus*	ST	Project induced reductions in mesic habitat
Mammals	Sherman's fox squirrel	*Sciurus niger shermani*	SSC	Project induced reductions in mesic habitat

C.1.10.1.1 State-listed Beach-Nesting Birds (American Oystercatcher, Black Skimmer, Least Tern)

The state listed beach-nesting birds include the American oystercatcher (*Haematopus palliatus*), black skimmer (*Rynchops niger*) and least tern (*Sternula antillarum*). These species nest directly in sand, shell, or small gravel in coastal areas, in shallow scrapes in sand, shell, or gravel along the coast, occasionally on bare ground in construction areas, and occasionally on flat, gravel-covered rooftops. Threats to these species include habitat loss and degradation, largely due to coastal development and incompatible recreational use, disturbance during breeding, causing nest failure and resulting in loss of eggs and/or chicks, changes to water quality that impact bivalves (e.g., pollution, turbidity, depth, and temperature) and predation that is magnified by human disturbance.

C.1.10.1.2 State-listed Wading Birds (Little Blue Heron, Roseate Spoonbill, Tricolored Heron, Reddish Egret)

The state listed wading bird species in the project area include the little blue heron (*Egretta caerulea*), roseate spoonbill (*Platalea ajaja*), tricolored heron (*Egretta tricolor*), and reddish egret (*Egretta rufescens*). These wading birds prey on small fishes, aquatic crustaceans, amphibians, snakes, and insects.

Though their diets are diverse, they do require shallow wetlands for foraging. Threats to these species include habitat degradation, including diversion of natural water-flow, altered levels of water fluctuation, lower water-tables, and nutrient enrichment in waters; loss of suitable foraging and breeding areas due to human disturbance, especially during key phases of reproduction (e.g., continued disturbance near nesting colonies); increased presence of predators that cause nest failure and magnified vulnerability to pesticides, heavy metals, and other environmental contaminants.

C.1.10.1.3 Florida Sandhill Crane

The Florida sandhill crane (*Grus canadensis pratensis*) is non-migratory and inhabit prairies, improved pastures, and freshwater marshes. They occur throughout peninsular Florida north to the Okefenokee Swamp in southern Georgia. Degradation or direct loss of habitat due to wetland drainage or conversion of prairie for development or agricultural use is the primary threat that they face. The prairies, improved pastures, and freshwater marshes on which the species depends are especially vulnerable to overgrowth, development, and alteration. Predation and road mortality are exacerbated by habitat fragmentation as cranes travel farther between breeding and foraging areas. The proximity of wetlands to upland areas is key to crane survival.

C.1.10.1.4 Burrowing Owl

The burrowing owl (*Athene cunicularia*) occurs throughout the state although its distribution is considered local and spotty. The presence of burrowing owls is primarily dependent upon habitat. Humans have created new habitat for burrowing owls by clearing forests and draining wetlands. Burrowing owls inhabit open native prairies and cleared areas that offer short groundcover including pastures, agricultural fields, golf courses, airports, and vacant lots in residential areas. Historically, the burrowing owl occupied the prairies of central Florida. The drainage of wetlands, although detrimental to many organisms, increases the areas of habitat for the burrowing owl. Recently, these populations have decreased because of disappearing habitat while populations in south Florida coastal areas have increased due to modification of habitat by humans. Burrowing owls live as single breeding pairs or in loose colonies consisting of two or more families. Burrowing owls use burrows year-round; for roosting during the winter and for raising young during the breeding season (February–July). Florida's owls typically dig their own burrows but will use gopher tortoise or armadillo burrows. Burrows extend 4 to 8 feet underground and are lined with materials such as grass clippings, feathers, paper, and manure (www.myfwc.com 2014).

C.1.10.1.5 Southeastern American Kestrel

The southeastern American kestrel (*Falco sparverius paulus*) is a non-migratory subspecies of the American kestrel closely tied to sandhills in the southeastern U.S with preferred habitat consisting of open fields, grasslands, savannahs, or other habitats that contain widely scattered trees or similar perches. Population declines of southeastern American kestrels in Florida have been largely attributed to clearing of older pine forests and conversion of sandhill and other upland habitats for agriculture and urban development. Kestrels are secondary cavity nesters, and suitable nest sites can be a limiting factor for kestrel populations. In addition to a lack of natural nesting sites and loss of suitable foraging habitat, environmental contaminants also pose a threat to the species.

C.1.10.1.6 Florida Pine Snake

The Florida pine snake (*Pituophis melanoleucus mugitus*) is found in the project area and prefers habitats with well-drained, sandy soils and moderate to open canopy cover. The most common natural habitat of

pine snakes in Florida is sandhill, but they also are found in scrub, xeric hammock, scrubby flatwoods, and mesic pine flatwoods and dry prairie with dry soils. Florida pine snakes are fossorial, spending ca. 80% of their time in underground retreats, primarily burrows of the southeastern pocket gopher (*Geomys pinetis*) as well as other retreats such as stumpholes, mole runs, and burrows of gopher tortoises (*Gopherus polyphemus*), nine-banded armadillos (*Dasypus novemcinctus*), and mice. Threats to the Florida pine snake include habitat loss, fragmentation, and degradation from the loss of dry uplands and fire suppression; roads, which fragment habitat and may contribute to reduced genetic diversity and mortality; operations that result in stump removal, soil compaction, and root removal; and predation by domestic pets and other nonnative species, and intentional killing by humans. Habitat removal, including gopher tortoise burrow removal, will adversely affect pine snakes within the project area.

C.1.10.1.7 Gopher Tortoise

The gopher tortoise is a moderate-sized, terrestrial turtle, averaging 23–28 cm (9–11 in) in length. The species is identified by its stumpy, elephantine hind feet and flattened, shovel-like forelimbs adapted for digging. The shell is oblong and generally tan, brown, or gray in coloration. Gopher tortoises can live 40 to 60 years in the wild. Gopher tortoises live in well-drained sandy areas with a sparse tree canopy and abundant low growing vegetation. They are commonly found in habitats such as sandhill, pine flatwoods, scrub, scrubby flatwoods, dry prairies, xeric hammock, pine-mixed hardwoods, and coastal dunes which have historically been maintained by periodic wild fires. When fire is suppressed in gopher tortoise habitat, small trees, shrubs, and brambles begin to grow making it difficult for the gopher tortoise to move around and eventually shade out the low growing plants that gopher tortoises eat. During winter, tortoises are much less active; although on warm afternoons some individuals trudge to the earth's surface to bask on the sandy aprons of their burrows. A superb earth-mover, it lives in long burrows that offer refuge from cold, heat, drought, forest fires and predators. The record length for a burrow is over 47 feet long, however, the burrows average 15 feet long and 6.5 feet deep. The burrows maintain a fairly constant temperature and humidity throughout the year and protect the gopher tortoise and other species from heat, cold, drought, and predators. Burrows also act as a refuge from the periodic, regenerative fires that are required to maintain the quality of their habitat. Gopher tortoises have adapted to living in dry habitats with frequent fire occurrence by digging burrows deep into the sandy soil. The absence of natural cycles of burning in pine forests spells hardship for tortoises. The dense vegetation (shrubs, brambles, small trees) that grows in a forest in the absence of fire shades out the tender herbs tortoises like to eat, and limits their food supplies. Fire is vital in maintaining many native ecosystems, like longleaf pine sandhills, where gophers live.

Tortoises feed on low-growing plants like wiregrass, broadleaf grasses, and legumes (bean family plants). They also eat prickly pear cactus, blackberries, paw-paws, and other seasonal fruits. In addition to needing open areas with abundant food, gopher tortoises require relatively deep, sandy soils for burrowing and sunny spots for laying eggs. Gopher tortoises are commensal (shares its burrow) with more than 350 other species, including burrowing owls, Florida mice, indigo snakes, opossums, rabbits, gopher frog, eastern diamondback rattlesnakes and gopher crickets. For this reason it is called a keystone species. Animals that use the gopher tortoise burrows are known as commensal species. Since many commensal species depend on the burrows for survival, decreases in gopher tortoise populations result in a decline of other species.

C.1.10.1.8 Sherman's Fox Squirrel

Sherman's fox squirrel (*Sciurus niger shermani*) is a species of special concern and is a large tree squirrels that inhabit mature, open, fire-maintained longleaf pine (*Pinus palustrus*), turkey oak (*Quercus laevis*) sandhills and flatwooods. To accommodate the large home-ranges and fluctuating food resources, suitable habitat also includes more productive lower slopes of sandhills. This species also inhabits mixed hardwood pine, mature pine forests, cypress domes, pastures, the ecotone between bayheads and pine flatwoods, and other open habitats with pines and oaks. Habitat loss has been significant as it is estimated that only 10-20% of original Sherman's fox squirrel native habitat is still intact, most of it having been logged, converted to pasture, degraded by lack of fire, or used for agriculture, commercial and residential development. Improperly burned longleaf pine communities also affect the fox squirrel's population as it prevents longleaf pine seeds from properly reproducing in the bare ground. This species also has an increased chance of getting hit by a vehicle due to their typically slow gait (locomotion).

C.1.10.2 Future without Project Conditions

State-listed threatened and species of special concern are either known to exist or potentially exist within the project area. Under FWO conditions, the Corps has determined that the character of existing natural areas would be generally unchanged – the areas would remain remote, undeveloped except for relatively isolated water management infrastructure facilities, and the intensity of human visitation and recreational activity would not generally increase. Project-related effects on specific taxonomic groups or individual species are summarized as: the beach-nesting birds would be unaffected because the project will not cause beach-related alterations or development; the colonial wading birds (little blue herons, roseate spoonbills, and tricolored herons) would be unaffected to beneficially affected as existing nesting colony locations within the study area would be maintained and conserved, other areas may become more suitable for nesting, and increased areas of hydrologically suitable habitat and increased prey populations would become available from the wetland restoration induced by LRWRP; sandhill cranes would be unaffected to minor adverse effects, to beneficially affected depending on the character of existing natural areas. Some areas will be unchanged and general habitat characteristics will remain suitable, some areas will become wetter via hydrologic restoration – these may be more attractive nesting areas and produce more forage. American kestrels are arboreal nesters and would be adversely affected by loss of foraging and nesting habitat, largely due to loss of upland communities, and habitat degradation resulting from fire suppression or fragmentation of remaining habitat, which likely magnifies the impact of habitat loss and forage availability. The potential transition of upland and mesic areas to wetter hydrological regimes may result in a loss of suitable upland and mesic habitat for the Florida burrowing owl, gopher tortoise, and its commensal species, including pine snakes.

The Corps expects an increase in water management features (i.e., dispersed water projects) that are not part of the LRWRP, as water supply become scarcer, or potentially less reliable. Without the LRWRP project, potential benefits to listed species may not be realized.

C.1.11 Fish and Wildlife

Florida's diverse South Florida ecosystems support diverse fish and wildlife species.

C.1.11.1 Existing Conditions

A great diversity of fish and wildlife species occur throughout the Loxahatchee River watershed, a 260 square mile ecosystem, as the Loxahatchee River meanders from lands above the headwaters through

freshwater creeks, down into a brackish estuary, and finally empties through the Jupiter Inlet into the Atlantic Ocean. The river itself has three main forks that flow to the central embayment area before heading out the Jupiter Inlet. Ten major freshwater and saltwater habitats provide homes for a wide variety of wildlife: cypress swamp, pine uplands and scrub, freshwater marshes, hardwood hammock, mangrove swamp, seagrass beds, oyster reefs or beds, estuary (lagoons and inlets), and coastal dunes. Upstream marshes and creeks are freshwater; but once the river reaches the central embayment, the water becomes brackish, part freshwater and part saltwater, as it mixes with incoming tides from the Jupiter Inlet. Species of many taxonomic groups contribute to the important fish and wildlife resources in the project area: aquatic macroinvertebrates, freshwater and saltwater fish – both forage fishes and sport fish, amphibians and reptiles, birds, including raptors and wading birds, and mammals. Within the watershed, while 63% of the watershed is in natural area, the remainder has been converted to agricultural or residential development and much of the area has been altered hydrologically. The ecological character of the watershed is the sum of its diverse mosaic of ecological communities and the variety of wildlife species for which the communities provide food, cover, roosting, and nesting. Some communities have great wildlife diversity and also differ broadly according to community quality and size just as species vary diversely in community use – some species use a single habitat (e.g., the limpkin uses only marsh wetlands) while others (e.g., Florida black bear and bald eagle) use a broad array of habitats as they move through their extensive ranges. The Northwest Fork of the river is Florida's first federally designated Wild and Scenic River, and area-specific regulations affect the management of fish and wildlife in this reach.

C.1.11.1.1 Shellfish

The estuary supports a variety of commercial estuarine shellfish such as blue crabs and stone crabs. Other crab species occurring within the region are the spider, fiddler, horseshoe, stone and hermit. Various mollusk species use the soft and rocky benthic habitats in the estuary - the wedge clam and marsh clam are commonly found associated with mud and sandy bottoms. Several shrimp species occur including pistol, common, grass and broken-back. Sand dollar and starfish are predatory invertebrates also found within the estuary.

Mollusk reefs are communities of sessile organisms from the phylum Mollusca and class Bivalva and are heavily influenced by tidal regimes. Eastern oyster is the dominant species in the oyster reef community. Oyster bars serve as a food source and provide habitat for numerous estuarine species including other mollusks, polychaete worms, decapod crustaceans, and various boring sponges. These are a valuable ecosystem component of the estuarine habitat (FNAI 2010; SFWMD et al. 2012 in FDEP 2018). Like seagrasses, oysters are sensitive to changes in salinity. Juvenile oysters can experience mortality in less than a week depending on the severity of the drop in salinity and, although adults can withstand lowered salinities for longer periods, mortality is known to occur when conditions persist for approximately one month. Mollusk reefs within the Loxahatchee River have been monitored by many partners over the past 30 years to record changes in densities, abundance and parasitic infection rates. In 1991, substantial presence of oyster bars was reported in the Northwest and Southwest forks (SFWMD et al. 2012). In 2008, 13.9 acres were found within the Northwest Fork, the highest abundance and densities of the three forks. In 2010, Martin County and Loxahatchee River District (LRD), with funding from the American Recovery & Reinvestment Act through NOAA, coordinated the successful restoration of more than 5.8 acres of oyster reefs in the NWFLR to augment existing oyster reefs and provide additional habitat. Just 20 months after the 5.8 acre oyster restoration project, the reef supported almost 5,000 pounds of non-oyster animal biomass (small fish, crabs and shrimp) at the restoration site. In 2013, LRD reassessed mollusk reef density, vitality, and size which identified a decrease in abundance of living bivalves, most notably in the Northwest

Fork (north of Island Way Bridge). Attributing factors identified were flood control measures taken during intense natural disturbances such as tropical storms and increased freshwater flows through the Northwest and Southwest forks in the previous years (LRD 2013). The increased flows were a predicted outcome of the 2006 Restoration Plan, which resulted in the decrease in oysters. While the Loxahatchee Estuary has experienced a recent increase in oyster populations and distribution, the magnitude and duration of salinity changes in the Lake Worth Lagoon (particularly the central portion) continues to prohibit the establishment of substantial oyster communities.

C.1.11.1.2 Fish

Fish abundance, distribution and diversity are affected by season, salinity, and habitat availability. More than 250 species of fish representing 78 families have been identified within the Loxahatchee River and its estuary (Christensen 1965). In the Loxahatchee River, the upstream area (above river mile 9) is characterized by freshwater species and the lower portion (from Jupiter Inlet to river mile 5) is characterized by marine and estuarine species. The most abundant fishes in the Loxahatchee Estuary include striped anchovy, bay anchovy, spotfin mojarra, silver jenny, and spot. Common fish species such as red drum, mangrove snapper, Crevalle jack and Florida gar reside the Loxahatchee River estuary and central embayment to the Wild and Scenic portion of the river.

Many species of small and large fish occur throughout the freshwater marshes and freshwater reaches of creeks and the river. Small fish are important processors of algae, plankton, macrophytes, and macroinvertebrates. These forage fishes provide an important food source for wading birds, amphibians, and reptiles. Common small freshwater fish include the native and introduced golden topminnow (*Fundulus chrysotus*), least killifish (*Heterandria formosa*), Florida flagfish (*Jordenella floridae*), golden shiner (*Notemigonus crysoleucas*), sailfin molly (*Poecilia latipinna*), bluefin killifish (*Lucania goodei*), oscar (*Astronotus ocellatus*), eastern mosquitofish (*Gambusia holbrookii*), and small sunfishes (*Lepomis* spp.) (USACE 1999). The density and distribution of fish populations fluctuate with seasonal changes in water levels. Populations of marsh fishes increase during extended periods of continuous flooding during the wet season. As marsh surface waters recede during the dry season, marsh fishes become concentrated in areas that hold water through the dry season. Concentrated dry season assemblages of marsh fishes are readily vulnerable to predation and provide an important food source for wading birds (USACE 1999). Larger freshwater fish occur in deeper ditches, canals, and the upper reaches of the Loxahatchee River, where tapegrass, a freshwater submerged aquatic plant occurs in widespread beds on the river bottom: largemouth bass (*Micropterus salmoides*), bluegill (*Lepomis macrochirus*), redear sunfish (*Lepomis microlophus*), speckled perch, black crappie (*Pomoxis nigromaculatus*), yellow bullhead (*Ameiurus natalis*), white catfish (*Ameiurus catus*), bowfin (*Amia calva*), and tilapia (*Tilapia* spp.) (USACE 1999). Many are also prey for birds, alligators, and piscivorous mammals (otters, raccoons, and mink), and are the foundation of the recreational and commercial fishery.

Mangrove ecosystems are important habitat for at least 1,300 species of animals including 628 species of mammals, birds, reptiles, and amphibians (USFWS 1999). The mangrove forest provides habitats for resident, seasonal, and transient organisms from adjacent terrestrial and marine habitats. Many of the larger species are not restricted to mangroves, but are seasonal or opportunistic visitors; however, some resident vertebrate species are totally dependent on mangroves to survive and complete important life cycle functions. For example, some species of songbirds that occur only in this habitat include black-whiskered vireo, mangrove cuckoo, and Florida prairie warbler. In addition to these mangrove endemic species, a wide variety of wading birds utilize both mangrove forests and seagrass beds (USFWS 1999). These include roseate spoonbill, great egret, snowy egret, little blue heron, and tricolored heron, which

are listed as species of special concern. Other common wildlife include the rough green snake, the threatened Eastern indigo snake, the green anole, the yellow rat snake, the American alligator, and a few amphibians. The threatened loggerhead sea turtle and the endangered green sea turtle are also found in association with seagrass beds and mangrove-lined shorelines.

In estuarine and marine reaches, seagrasses and provide important habitat and nursery grounds for many fish species tolerant of variable and higher salinities in the estuary, some of which spend part or all of their life in the estuary, and some of which are migrant. Common recreational and commercial fish species include Florida gar (*Lepisosteus platyrhincus*), mutton snapper (*Lutjanus analis*), yellowtail snapper (*Ocyurus chrysurus*), lane snapper (*Lutjanus synagris*), yellowtail parrot fish (*Sparisoma rubripinne*), gag grouper (*Mycteroperca microlepis*), pinfish (*Lagodon rhomboids*), tarpon (*Megalops atlanticus*), common snook (*Centropomus undecimalus*), crevalle jack (*Cranx hippos*), spotted sea trout (*Cynoscion nebulosus*), redfish (*Sciaenops ocellatus*), sheepshead (*Archosargus probatocephalus*), mullet (*Mugil* spp.), threadfin shad (*Dorosoma petenense*), and gizzard shad (*Dorosoma cepedianum*) (USACE 1999).

C.1.11.1.3 Amphibians and Reptiles

The freshwater wetland complex supports a diverse assemblage of reptiles and amphibians. Common amphibians include the greater siren (*Siren lacertina*), Everglades dwarf siren (*Pseudobranchus striatus*), two-toed amphiuma (*Amphiuma means*), pig frog (*Rana grylio*), southern leopard frog (*Rana sphenocephala*), Florida cricket frog (*Acris gryllus*), southern chorus frog (Pseudacris nigrita), squirrel tree frog (*Hyla squirela*), and green tree frog (*Hyla cinerea*) (USACE 1999). Amphibians represent an important forage base for wading birds, alligators, and larger predatory fishes (USACE 1999).

Common reptiles of freshwater wetlands include the American alligator (*Alligator mississippiensis*), snapping turtle (*Chelydra serpentina*), striped mud turtle (*Kinosternon bauri*), mud turtle (*Kinosternon subrubrum*), cooter (*Chrysemys floridana*), Florida chicken turtle (*Deirochelys reticularia*), Florida softshell turtle (*Trionys ferox*), water snakes (*Nerodia* spp.), mud snake (*Francia abacura*), eastern ratsnake (*Pantherophis obsoletus*), and Florida cottonmouth (*Agkistrodon piscivorus*) (USACE 1999).

The eastern indigo snake (*Drymarchon corais couperi*) uses many watershed communities including year round habitation of moist areas of pine flatwoods due to the availability of a diet of amphibian and reptilian fauna. They also use the burrows of the gopher tortoise in the well- drained soil areas with open, herbaceous groundcover. The gopher tortoise forages on the grasses, herbs, fruits, and berries of the fire-maintained pine flatwoods. The gopher frog also uses gopher tortoise burrows and other animal burrows in mesic pine flatwoods. Gopher frogs find breeding habitat in shallow vegetated ephemeral ponds of the flatwoods adjacent to xeric scrub habitats.

C.1.11.1.4 Birds

Wading birds and marsh birds frequent depressional marshes and the littoral zones of ditches, canals, and stormwater detention ponds. Migratory birds move through this area of southeast Florida in the spring and fall, and some species may over-winter. Common wading birds include white ibis (*Eudocimus albus*), glossy ibis (*Plegadus falcenellus*), great egret (*Aredea albus*), snowy egret (*Egretta thula*), great blue heron (*Ardea herodias*), little blue heron (*Egretta caerulea*), tricolored heron (*Egretta tricolor*), green-backed heron (*Butorides virescens*), cattle egret (*Bubulcus ibis*), black-crowned night heron (*Nycticorax nycticorax*), yellow-crowned night heron (*Nycticorax violacea*), roseate spoonbill (*Platalea ajaja*), and wood stork (*Mycteria americana*) (USACE 1999). Common marsh birds include common gallinule

(*Gallinula galeata*), purple gallinule (*Porphyrio martinicus*), least bittern (*Ixobrychus exilis*), limpkin (*Aramus guarauna*), king rail (*Rallus elegans*) and black rail (*Laterallus jamaicensis*).

Bald eagles are commonly found in the watershed nesting near open water areas in large mature pine trees where they feed primarily on fish and water-dependent birds. Their distribution is influenced by the availability of suitable nest and perch sites near open water bodies, but eagles clearly adapt to a wide variety of habitat conditions and use most of the upland and wetland ecological communities in the watershed. Northern crested caracaras (*Caracara cheriway*) inhabit open pastures and prairies with cabbage palms that are suitable for nesting. Open-canopied mesic pine flatwoods adjacent to emergent wetlands and open water areas provide nesting and foraging habitat for sandhill cranes. The red-cockaded woodpecker has a small population in the J. W. Corbett WMA, where it nests preferably in mature longleaf pine.

C.1.11.1.4.1 Bald Eagle

USACE reviewed the known locations of bald eagle nests and will be cognizant of them during project design. As necessary, USACE will implement the National Bald Eagle Management Guidelines during construction (USFWS 2007).

The FWS published the final rule announcing the removal of the bald eagle from the federal list of endangered and threatened wildlife in the Federal Register on July 9, 2007, which became effective on August 8, 2007. Bald eagles remain protected under the Bald and Golden Eagle Protection Act and the Migratory Bird Treaty Act; therefore, bald eagles nests in the study area and within a three mile buffer of the study area were identified using the FWC Bald Eagle Nest Locator database (https://public.myfwc.com/FWRI/EagleNests/nestlocator.aspx). The database showed 15 nests in Martin County and 12 nests in Palm Beach County (**Table C.1-** and **Figure** C.1-22). The eagle nesting season occurs from October through May. Territories are used year after year, generally by the same pair.

Table C.1-5**. Bald eagle nest locations in Martin and Palm Beach counties.**

Nest ID	County	Latitude	Longitude	Last Known Active	Last Surveyed	Active 2017
MT001	Martin	27 00.33	80 08.09	2016	2016	Y
MT005	Martin	26 59.00	80 33.90	1997	2012	*
MT006	Martin	26 58.11	80 32.94	2016	2016	Y
MT007	Martin	27 00.30	80 33.40	2012	2016	-
MT008	Martin	26 58.84	80 34.68	2016	2016	Y
MT010	Martin	27 06.89	80 12.16	2012	2016	-
MT011	Martin	26 58.14	80 34.38	2016	2016	Y
MT014	Martin	27 01.30	80 22.00	2004	2012	*
MT016	Martin	26 57.51	80 33.99	2009	2016	-
MT017	Martin	26 57.63	80 34.53	2016	2016	Y
MT023	Martin	27 00.28	80 37.32	2009	2016	-
MT024	Martin	26 58.73	80 33.56	2009	2016	-
MT026	Martin	27 02.75	80 20.54	2016	2016	Y
MT028	Martin	27 08.41	80 10.08	2016	2016	Y

Nest ID	County	Latitude	Longitude	Last Known Active	Last Surveyed	Active 2017
MT030	Martin	27 00.28	80 34.95	2016	2016	Y
PB002	Palm Beach	26 56.92	80 33.42	1997	2014	*
PB004	Palm Beach	26 54.67	80 30.99	2015	2016	N
PB006	Palm Beach	26 47.65	80 10.17	2015	2015	*
PB007	Palm Beach	26 55.89	80 32.36	1999	2014	*
PB008	Palm Beach	26 52.39	80 23.89	2015	2016	N
PB009	Palm Beach	26 48.82	80 23.58	2001	2014	*
PB011	Palm Beach	26 52.08	80 27.73	2015	2016	N
PB016	Palm Beach	26 55.09	80 32.20	2016	2016	Y
PB017	Palm Beach	26 50.80	80 23.32	2016	2016	Y
PB020	Palm Beach	26 55.27	80 26.14	2015	2016	N
PB022	Palm Beach	26 53.15	80 05.91	2014	2014	*
PB025	Palm Beach	26 44.22	80 21.48	2015	2015	*

Source: FWC Bald Eagle Nest Locator database accessed 7/24/2018.

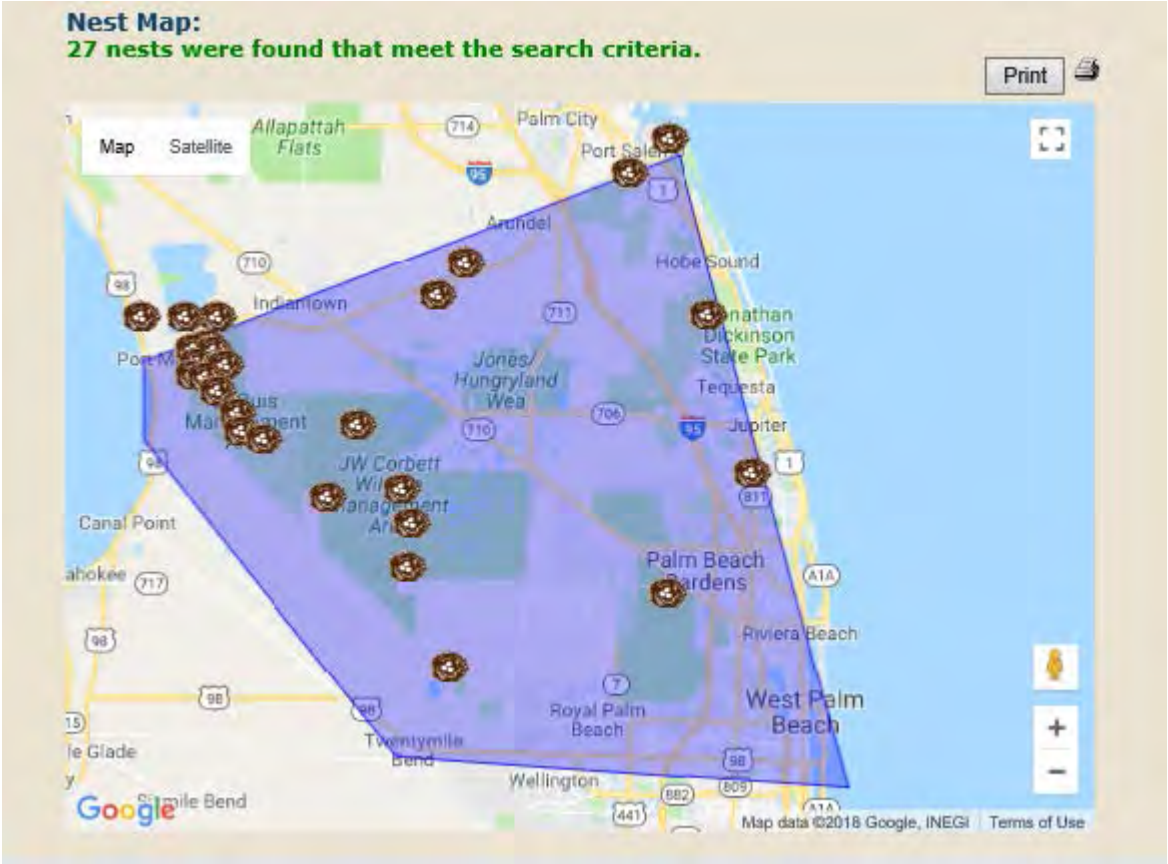

Figure C-1-22. Bald eagle nest locations within a three mile buffer of the LRWRP project area in Martin and Palm Beach counties.

In south Florida, nests are often in the ecotone between forest and marsh or water, and are constructed in dominant or codominant living pines (*Pinus spp*.) or bald cypress (*Taxodium distichum*) (McKewan and Hirth 1979). Approximately ten percent of eagle nests are located in dead pine trees, while two to three percent occur in other species, such as Australian pine (*Casuarina equisetifolia*) and live oak (*Quercus virginiana*). Suitable habitat for bald eagles is any forested area with potential nesting trees that are within 1.9 miles (3 kilometers) of large open water, such as borrow pits, lakes, rivers, and large canals.

C.1.11.1.5 Mammals

Mammals that are well-adapted to the mix of upland and wetland conditions throughout the area include the rice rat (*Oryzomys palustris natator*), round-tailed muskrat (*Neofiber alleni*), river otter (*Lontra canadensis*), marsh rabbits (Sylvilagus palustris), and raccoon (*Procyon lotor*). Other mammals with larger home ranges include the white-tailed deer (*Odocoileus virginianus*), black bear (Ursus floridanus), Florida panther (*Puma concolor coryi*; federally endangered), and bobcat (*Lynx rufus*). In the estuary and river, West Indian manatees (*Tricheus manatus*) occur seasonally. The Atlantic bottlenose dolphin (*Tursiops truncatus*) in the Loxahatchee estuary are part of the Indian River Lagoon estuarine system stock.

Upland habitats provide food, cover, roosting and nesting sites to a wide variety of wildlife. Hardwood mast (e.g., acorns, fruit, or nuts) makes the "island" hammocks attractive to birds and mammals, including a number of rare, threatened, and endangered plant and animal species. White-tailed deer and feral pigs are abundant in these hammocks. The Florida black bear ranges through large tracts of land that include cabbage palm and mixed hardwood hammocks, mesic pine flatwoods, in combination with other upland forested communities and major wetland systems, where they forage for berries, acorns, saw palmetto and cabbage palm. Sherman's fox squirrels inhabit open, fire-maintained longleaf pine, turkey oak, sandhills, and flatwoods (Florida Natural Areas Inventory 2010, http://myfwc.com/wildlifehabitats/imperiled/profiles/mammals/shermans-fox-squirrel/), where they forage on pine cones, acorns, cabbage palm fruits, bromeliad buds, and insects.

C.1.11.2 Future Without Project Conditions

The project area supports a variety of fish and wildlife resources. Disruption of the natural hydrology has resulted in aquatic vegetation community changes and a resultant disruption of aquatic productivity and function that has resulted repercussions through the food web, including effects on wading birds, larger predatory fishes, reptiles, and mammals. Under FWO conditions, a further reduction in habitat function is possible, albeit to a lesser rate than in the past. In this event, it would likely result in a decrease in the abundance and diversity of fish and wildlife resources on non-protected and unrestored lands.

Without the project, desired restoration of historic hydrology within LR watershed would not be accomplished. Unrestored wetlands would continue to have reduced functioning and not provide optimal fish and wildlife habitat. Vegetation communities would not include the species diversity and richness of naturally occurring communities. Seasonally depleted or lowered water levels would provide sub-optimal foraging opportunities for wading birds and other birds dependent on aquatic prey concentrated in short hydroperiod wetland habitats. During droughts, seasonally impaired flows would allow the salinity wedge creeping up the river to suppress tapegrass growth and further impair ecological condition.

Fish and wildlife resources would continue to be affected by annual variability in flows that would lead to salinity extremes outside the tolerance ranges of many fish and wildlife resources, resulting in decreased species diversity. Further declines in estuarine habitat (SAV and oysters) would continue to result in additional declines in the species that use these habitats. Seagrass communities within the estuary

provide critical refugia for juvenile fish. The long-term loss of nursery habitat will result in population declines for many species of estuarine and marine fishes and macroinvertebrates, including those whose young of the year use fresher habitats. Waterfowl and wading birds are also expected to decrease under FWO conditions as estuarine habitat quality continues to decline. Some level of improvement is expected to occur as a result of implementation of projects within the study area with the capability of improving the timing, quantity, and quality of freshwater flow to estuarine systems and coastal areas (i.e., C-43 West Basin Storage Reservoir Project (USACE 2010), Indian River Lagoon South Project (USACE 2004a) and the CEPP (USACE 2013)).

C.1.12 Hydrology

Historically, the Loxahatchee River watershed included an area of more than 216 square miles (560 square kilometers). The drainage basin was comprised primarily of pine flatwoods interspersed with cypress sloughs, hardwood swamps, marshes, and wet prairies. Rainfall was directed through natural topography into wetlands, treated by natural biological and chemical action, and slowly released to the Loxahatchee River and Estuary and the Indian River Lagoon (FDEP 2018).

C.1.12.1 Existing Conditions

Existing hydrological conditions are discussed briefly in the following sub-sections.

C.1.12.1.1 Flow-way 1

Flow-way 1 hydrology is strongly affected by the L-8, C-51, M Canal, M-O Canal, and other secondary drainage features. In addition, two major roads, Northlake Blvd., which crosses east-west along the north margin of GWP, and the Beeline Highway, which crosses diagonally from the southeast to the northwest along the southern margin of the Loxahatchee Slough Natural Area, block the flow of water from one area to the other. Hydrology in GWP South has been maintained relatively well by the city of West Palm Beach and inundation exceeds wetland community targets (indicator regions GWP 5-9). Hydrology in northern GWP (indicator regions GWP 1-4) has been more impacted and meets desired inundation criteria between 50 to 67% of the time. Loxahatchee Slough was drained significantly by the C-18 Canal before the G-160 control structure and associated operations with secondary drainage structures. The G-161 structure facilitates achieving the target stages in the GWP area while simultaneously sending excess water to G-160 and on to the NWFLR. Inundation duration was around 57% for Loxahatchee Slough. J.W. Corbett WMA is over-inundated along the L-8 Canal, under-inundated (33% of desired inundation duration) near the C-18W Canal and ITID.

C.1.12.1.2 Flow-way 2

In Flow-way 2, Hungryland Slough hydrology is negatively affected near the C-18W Canal, but is only slightly drained in the existing conditions. Flow-way 2 would transfer water from the C-18W Reservoir, and four ASR wells, through a pump station to overland flow northeastward across the Mecca natural storage area, through the improved Beeline culverts and bridge orifice, to the C-18E.

C.1.12.1.3 Flow-way 3

In Flow-way 3, many Pal-Mar indicator regions (1-2, Gulfstream West and East) are very drained (30-50% of desired inundation) due to numerous secondary canals, ditches, and berms. Other indicator regions in Pal-Mar to the west (PM 4-9) are in better condition and range from 67 to 85% of expected hydrologic

inundation duration. Tributary areas like Moonshine Creek, Cypress Creek, and Kitching Creek are severely drained due to drainage ditches, where hydrology ranges from 10 to 60% of desired targets.

C.1.12.2 Future Without Project Condition

Under the FWO scenario, it is forseeable that existing canals and drainage features would continue to operate as under existing conditions, and that additional development would be proposed variously throughout the project area, leading to constraints in future restoration of natural habitats because of flood control requirements.

C.1.13 Surface Water Quality

The LRWRP project impact on water quality will be evaluated by flow-way. The project is divided into three principal flow-ways and the Loxahatchee River and Estuary. The flow-ways and components are:

a. Flow-way 1: L-8 Canal, M Canal, GWP, Loxahatchee Slough

b. Flow-way 2: C-18 basin, C-18 Canal, G-46

c. Flow-way 3: Pal-Mar, Nine Gems, Cypress Creek, Hobe Grove Ditch

d. Loxahatchee River, and Estuary

C.1.14.1 Existing Conditions Existing conditions for the LRWRP project area focus on the current impact from phosphorus, nitrogen mercury, and chloride on the system. Nutrient conditions are the biggest contributor to degradation currently on the system. Flow-way 3 and Flow-way 1 have the elevated levels of Total Phosphorus (TP) and Total Nitrogen (TN) well above current levels to cause nuisance algal growths (**Table C.1-6**). Mercury data is limited in the project area. Primary source of the mercury is air disposition and therefore likely consistent through the project area. Chlorides are a larger issue for Flow-way 1, specifically the L-8 Canal and further evaluated below.

Table C.1-6. Historical and existing total phosphorus and total nitrogen concentrations inflows and outflows to LRWRP area.

-	-	Inflow			Outflow		
Flowway	Basin/area	Volume (ac-ft)	TP (mgL-1)	TN (mgL-1)	Volume (ac-ft)	TP (mg L-1)	TN (mg L-1)
3	PalMar	NM	NM	NM	NM	NM	NM
3	Cypress Creek	NM	0.079	1.11	20,886	0.053	<1.54
3	Hobe-St. Lucie	NM	0.110	1.26	3,759	0.071	<1.54
3	Kitching Creek	NM	0.079	1.32	10,534	0.075	1.893
2	C-18 Basin	27,804	0.017	1	44,594	0.017	0.98
2	C-18 Basin	16,790	0.016	1.225	44,594	0.017	1.037
2	Lox Slough	20,639	0.015	1.011	34,081	0.017	0.81
1	Lake Okeechobee	57,503	0.185	2.45	0	0	0
1	L-8+Lake	117,925	0.143	2.3	117,925	0.123	1.636

-	-	Inflow			Outflow		
1	ITID	27,804	0.039	1.352	27,804	0.039	1.352
1	GWP	13,442	0.01	0.839	2,977	0.01	0.839
1	GWP	13,442	0.01	0.839	17,660	0.013	1.011
River	Loxahatchee River NWF	85,039	0.055	1.02	0	0	0
River	Middle Estuary SWF	45,675	0.041	0.946	0	0	0

(Data sources: SFWMD, DbHydro, 2017; ITID; Loxahatchee River District (river keeper data)).

Mercury (Hg) in south Florida aquatic systems including Lake Okeechobee is 90-95% from eastern regional atmospheric deposition (SFWMD 2002, Burger et al 2004) as inorganic Hg. Significant local sources include coal-burning power plants, cement kilns, and incinerators (FDEP 2013). In the Everglades, the conversion of inorganic Hg to organic methylmercury ($MeHg^+$) is facilitated by naturally occurring reducing bacteria. This conversion of inorganic Hg to $MeHg^+$ is one of the important steps in the bioaccumulation of Hg as it greatly increases toxicity and potential for accumulation in aquatic biota.

Human exposure to Hg is primarily through the consumption of fish and shellfish containing $MeHg^+$. Human health risks from exposure to Hg includes neurodevelopmental delays in children. Environmental risk to wildlife exposure to $MeHg^+$ through the consumption of fish results in reproductive, neurological, and immune system problems (Fleming et al. 1995; Tchounwou et al. 2003). However, contaminated fish is not the only pathway for bioaccumulation of Hg.

The United States Environmental Protection Agency (USEPA) has determined that a concentration of Hg in fish tissue in excess of 0.3 mg/Kg is detrimental to human health. Water quality impairment for Hg is also measured by the incidence of game fish tissue with Hg in excess of 0.3 mg/Kg. Twenty species of Florida freshwater fish and over 60 species of marine fish are under consumptive advisory (FDOH 2012). Methylmercury also poses a threat to fish-eating wildlife and species that prey on them such as wading birds, ospreys, eagles, otters and panthers. The elevated concentrations of $MeHg^+$ in fish have been correlated with elevated concentrations in wildlife, including state and federally listed endangered species.

Largemouth bass collected at GWP outflow structure (GRL) from 2006 to 2012 had an average THg level of 0.521 mg/kg which exceeded USEPA 0.3 mg/kg standard for human health protection while bluegill had an average THg level of 0.133 mg/kg. L-8 FEB was a source of water to GWP. Largemouth bass and bluegill collected from the reservoir outflow from 2006 to 2012 contained an average THg of 0.196 mg/kg and 0.042 mg/kg which are all below the 0.3 mg/kg standard for human health protection. Ultimately, mercury will be considered as part of project implementation and monitoring following CERP Guidance Memorandum (CGM) 42 Screening Process for Mercury and Other Toxicants. It should be noted that mercury sample data within the project data is limited.

Chloride/ Specific Conductivity

There is a difference between Class I and Class III waters and the thresholds that have been adopted for chlorides, conductivity and total dissolved solids (TDS). The L-8 Canal is a Class III water body, however, as the L-8 Tieback Canal, becomes the M Canal downstream of the Control 2 Pump Station, it is

classified as a Class I waterbody. Standards for chlorides or TDS are not established for Class III waterbodies. Class I waterbodies have established standards for chlorides, conductivity, and dissolved solids. **Table C.1-7** summarizes the Class I and Class III water quality standards for chlorides, specific conductance, and TDS as outlined in Rule 62-302.530, F.A.C.

Table C.1-7. Surface Water Quality Criteria – for Classifications I & III.

Parameter	Units	Class I (Drinkable)	Class III (Fishable/ Swimmable)
(17) Chlorides	Milligrams/L	≤250	-
(22) Conductance, Specific	Micromhos/cm	Shall not be increased more than 50% above background or to 1275, whichever is greater	Shall not be increased more than 50% above background or to 1275, whichever is greater
(31) Dissolved solids	Milligrams/L	≤ 500 as a monthly avg., ≤ 1,000 max	-

Specific conductance (SC) is a measure of the electrical conductance (capability to pass electric flow) of water and is directly related to the concentration of ions in the water. The measurement of specific conductance can provide valuable information regarding high or low ionic content that may be associated with geologic processes, storm events, and wastewater releases. In recent studies SC has not been identified as a parameter of concern (Stoner et al. 2016, Northern Palm Beach County Improvement District 2017). However, SC impairment has been identified within the Everglades Agricultural Area (EAA) (Daroub et al. 2004, Chen et al. 2006). Some concern has been noted with respect to SC for the L-8 Flow Equalization Basin, which can contribute to waters within the LRWRP if the FEB facility is discharging, and the G-541 divide structure in the L-8 Canal is open. The annual mean SC values at L-8-FEB inflow structure G-538 and outflow structure G-539 for WY2017 were 802 µS/cm and 1,342 µS/cm, respectively. These structures remove water from or discharge water to the L-8 Canal, respectively. An evaluation study was implemented in January 2016 and since then, one exceedance has been observed in the M Canal at the L8.M CNL station. This exceedance was marginal in nature and the water was acceptable for water supply purposes. Surface water in the EAA that is high in SC is a naturally occurring phenomenon (Daroub et al. 2004). This was noted in early studies of the geological conditions in the EAA and is thought to be a result of ancient relic sea water. Only a fraction of the EAA (that portion located upstream of the S-76 structure on the L-8 Canal) discharges to the L-8 Canal. The remainder of the EAA that is within the Study Area boundary discharges south to the L-10/L-12 Canal (**Table C.1-8**).

Table C.1-8. Historical Source Water Conductance

Water Body or Source	Specific Conductance Level
Lake Okeechobee	550 Micromohs/cm
L-8	500 Micromohs/cm up to 1275 (limit to release)
ITID	550 Micromohs/cm
Loxahatchee River	Varied from 230 Micromohs/cm from Lainhart Dam to 550 Micromohs/cm at east of I-95

Loxahatchee River Watershed

Aquatic habitats within the LRWRP project area are very diverse and water quality conditions associated with those water bodies are correspondingly highly variable. Freshwater surface water systems within the project area include extensive wetland systems and both natural and man-made lakes. In addition to the relatively natural aquatic habitats, there are also extensive man-made canal networks and while these are considered freshwater surface waters, their physical and chemical characteristics often differ markedly from natural systems.

Variability in water quality mirrors the diversity in land uses. Within basins predominated by undeveloped lands that remain relatively pristine the water quality is characterized by low nutrient levels, variable but often elevated dissolved oxygen levels reflective of high biological productivity, and low concentrations of pollutants typically associated with land development (metals, petroleum hydrocarbons, other organics). For example, the interior of GWP is considered in near pristine condition, with observed total phosphorus (TP) concentrations of approximately 10 parts per billion (ppb). In contrast, the edges of GWP, along the M - and perimeter canals, are degraded by water with higher nutrient concentrations. Water quality degradation is found in basins with land cover dominated by urban and/or agricultural uses, where relative pollutant presence is inversely related to the level of success in the implementation of appropriate storm water best management practices. The eastern C-51 Basin is representative of the urbanized condition while the westernmost segment of the L-8 Basin is representative of areas where surface water quality is strongly influenced by localized agricultural operations.

Impaired Waters

The State of Florida has identified several waters bodies within the project area as being impaired. An Impaired Water is one that does not currently meet adopted water quality standards. The impaired water list was established to protective public health and the environment. Impaired waters are waters that need to be restored and further impacts to them are prohibited. See **Table C.1-9** for impaired waters list and reason for listing and see **Figure C.1-23** for impaired water body's map.

Table C.1-9. Impaired waters list.

WBID	Flow-way	Planning Unit Name	Water Segment Name	Waterbody Type	Parameters Assessed Using the Impaired Surface Waters Rule (IWR)	Criterion Concentration or Threshold Not Met	Summary Assessment Status	Parameter & Category
3224	3	Loxahatchee	Loxahatchee River (JDSP)	Estuary	Dissolved Oxygen (Percent Saturation)	≥ 42 %	Study List	Dissolved Oxygen (Percent Saturation) - category 4d
3224	3	Loxahatchee	Loxahatchee River (JDSP)	Estuary	Fecal Coliform	≤ 43 MPN / 100 mL	Impaired	Fecal Coliform - category 5
3224	3	Loxahatchee	Loxahatchee River (JDSP)	Estuary	Fecal Coliform (3)	≤ 14 MPN / 100 mL	Impaired	Fecal Coliform (3) - category 5
3230	2	Loxahatchee	Jupiter Farms	Stream	Nutrients (Algal Mats)	RPS ≤ 25%, or when between 20% - 25% Evaluation of Algal Autoecological Data Indicates No Imbalance	Impaired	Nutrients (Algal Mats) - category 5

WBID	Flow-way	Planning Unit Name	Water Segment Name	Waterbody Type	Parameters Assessed Using the Impaired Surface Waters Rule (IWR)	Criterion Concentration or Threshold Not Met	Summary Assessment Status	Parameter & Category
3230A1	2	Loxahatchee	Loxahatchee River (Northwest Fork)	Stream	Biology	Average score of at least two temporally independent SCI scores ≥ 40; or either of the two most recent SCI scores ≥ 35; or if there are only two SCI scores and there is less than or equal to a 20 point difference	Study List	Biology - category 4d
3233A	2	L-8	L-8	Stream	Nutrients (Chlorophyll-a)	≤ 20 µg/L	Impaired	Nutrients (Chlorophyll-a) - category 5
3233A	2	L-8	L-8	Stream	Turbidity	≤ 29 NTU + background	Impaired	Turbidity - category 5
3245C1	2	C-51	Lake Mangonia	Lake	Fecal Coliform	≤ 400 Counts / 100 mL	Impaired	Fecal Coliform - category 5

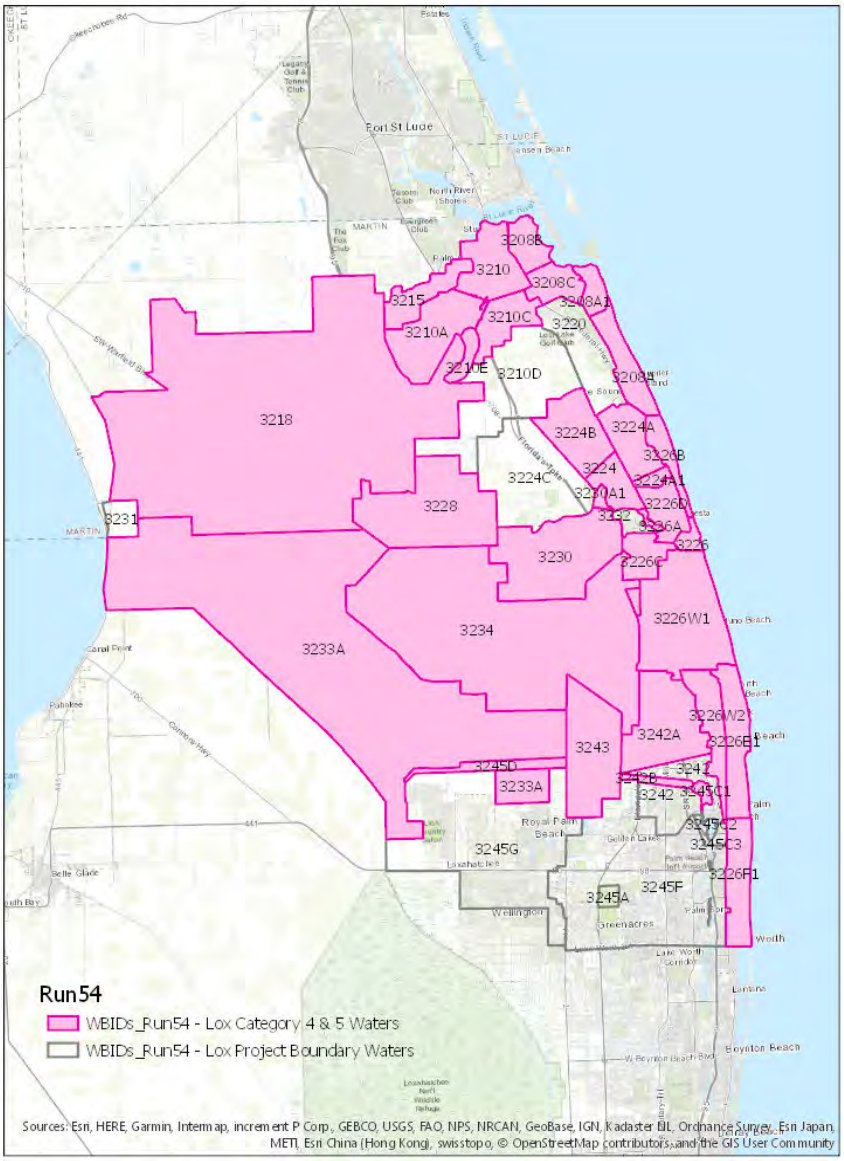

Figure C.2-23. Category 4 and 5 Impaired Waters and their ID within the project area.

Loxahatchee River Estuary

Estuarine water quality largely reflects the cumulative influence of freshwater interaction with the land as it moves downstream to the estuaries. Tidally-driven mixing of such freshwaters delivered to the estuary with seawater incursions through inlets generates the varied salinity regimes of these transitional habitats that are crucially important to the overall biological integrity of the estuaries and near-shore environments. In addition to salinity, which is perhaps the key water quality parameter to consider when addressing estuarine system conditions, the cumulative loading of other water quality constituents to the

estuaries strongly influences the nature and health of the estuaries. In the project area, the Loxahatchee River Estuary is the ultimate estuarine receiving water, and the existing water quality conditions generally reflect their watershed conditions and local physical, chemical and biological processes.

The Loxahatchee River Estuary has been greatly altered from its historical, pre-development condition due to the combination of watershed changes over time and the installation or stabilization of the Jupiter Inlet to the Atlantic Ocean. In the Loxahatchee River Estuary salinity stresses are correlated with proximity to locations of major pulsed inflow of stormwater during flood control operations. Evidence of salinity stress is present in the Southwest Fork of the River, fed primarily by C-18 Basin inflows passing through the S-46 Structure. Salinity in the Loxahatchee Estuary can rebound quickly as a result of greater tidal exchange. The historical stabilization of Jupiter Inlet has resulted in a greater salt water influence further upstream into the system contributing to the relatively favorable salinity regime in the existing central estuary. That inland salinity penetration has also been favored by reductions in dry season base flows. The net effect is that the mid to upper reaches of the NWFLR are now more saline than in the past, and the vegetative communities along certain river reaches reflect this changed surface water quality condition. Cypress and associated freshwater wetland communities have been variably replaced by mangroves reflecting this upstream movement of the estuarine water quality condition. This is viewed as a problem in that some of the last remaining "wild and scenic" habitats of this part of the river are threatened by this changed water quality condition.

The SFWMD, Loxahatchee River District, and others have conducted long term water quality monitoring studies within the Loxahatchee System, and have documented that ambient conditions generally do not suggest excessive eutrophication due to excessive nutrient loading. However, concerns do exist that continuing land development may contribute to increased nutrient loading (Stoner et al. 2016) that could ultimately catalyze algal blooms and/or fish kills. Further, as evidenced by the conditions in the St. Lucie Estuary to the north, concerns exist that water quality degradation due to modified upstream water management practices could inadvertently increase the chances of similar unacceptable estuarine water quality impacts.

Estuary-specific numeric interpretations of the narrative nutrient criterion in paragraph 62-302.530(47)(b), F.A.C., are outlined in the table below. The concentration-based estuary interpretations are open water, area-wide averages. Numeric values listed below, Table C.1-10, for nutrient and nutrient response values do not apply to wetlands or to tidal tributaries that fluctuate between predominantly marine and predominantly fresh waters during typical climatic and hydrologic conditions unless specifically provided by name. The interpretations expressed as load per million cubic meters of freshwater inflow are the total load of that nutrient to the estuary divided by the total volume of freshwater inflow to that estuary. The numeric values listed below will be superseded if, pursuant to subsection 62-302.531(2), F.A.C., a more recent numeric interpretation of the narrative nutrient criterion in paragraph 62-302.530(47)(b), F.A.C., such as a Level II Water Quality Based Effluent Limitation (WQBEL), Site Specific Alternative Criterion (SSAC), Total Maximum Daily Load (TMDL), or Reasonable Assurance Demonstration, is established by the Department.

Table C.1-10. Nutrient and Nutrient response Values by Estuary.

Estuary	Total Phosphorus	Total Nitrogen	Chlorophyll a
(q) Loxahatchee River Estuary	For estuary segments with criteria expressed as annual geometric means (AGM), the values shall	For estuary segments with criteria expressed as annual geometric means (AGM), the values shall	For estuary segments with criteria expressed as annual geometric means (AGM), the values shall

	not be exceeded more than once in a three year period. For all other estuary segments, the criteria shall not be exceeded in more than 10 percent of the measurements and shall be assessed over the most recent seven year period.	not be exceeded more than once in a three year period. For all other estuary segments, the criteria shall not be exceeded in more than 10 percent of the measurements and shall be assessed over the most recent seven year period.	not be exceeded more than once in a three year period. For all other estuary segments, the criteria shall not be exceeded in more than 10 percent of the measurements and shall be assessed over the most recent seven year period.
1. Lower Loxahatchee	0.032 mg/L as AGM	0.63 mg/L as AGM	1.8 µg/L as AGM
2. Middle Loxahatchee	0.030 mg/L as AGM	0.80 mg/L as AGM	4.0 µg/L as AGM
3. Upper Loxahatchee	0.075 mg/L as AGM	1.26 mg/L as AGM	5.5 µg/L as AGM
4. Loxahatchee River Estuary (Southwest Fork)	0.075 mg/L as AGM	1.26 mg/L as AGM	5.5 µg/L as AGM

Lake Okeechobee

One key factor in understanding the water quality of natural systems within the project area is the influence of Lake Okeechobee water releases. The primary issue is the mode of operation for Culvert 10A, the L-8 Basin water control structure located at the lake. Historically, Culvert 10A has been operated to allow water flows into Lake Okeechobee during flood control operations. However, during water supply operations and/or under lake stage management activities, this structure has been used to release lake water into the L-8 Canal for subsequent conveyance south to tide or to support the City of West Palm Beach water supply withdrawals. Therefore characterizations of L-8 Canal ambient water quality can be complex and vary substantially (**Figure C.1-24**) depending on whether Lake Okeechobee inflow is present and/or the length of time since the last discharge of Lake Okeechobee. During periods strongly influenced by lake inflow, which do not accurately reflect ambient L-8 Basin water quality, water quality constituent concentrations parallel those of Lake Okeechobee proper (elevated phosphorus and nitrogen concentrations). Conversely, during periods of little to no lake inflow into the L-8 Canal, ambient levels for these nutrients and other parameters are much lower. Thus, characterization of existing water quality conditions for this major portion of the project area needs to be put in the context of regional water management actions.

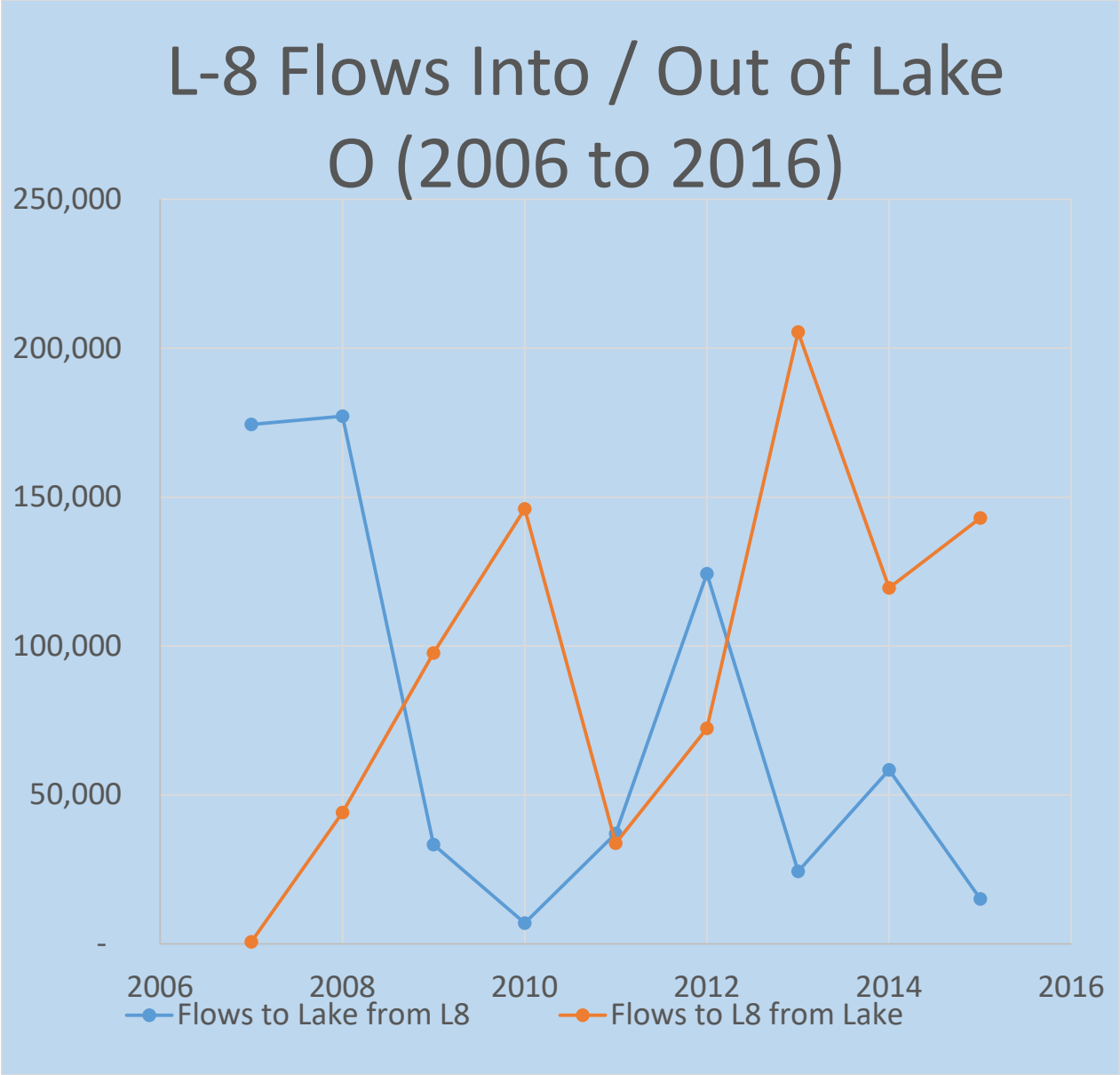

Figure C.1-24. L-8 Flows Into/Out of Lake Okeechobee.

Nutrient Standards

Phosphorus and nitrogen compounds are of concern to the ecosystems of the Loxahatchee River Watershed, including the Loxahatchee River and Slough, GWP, and the Loxahatchee Estuary, since they have the ability to negatively affect the flora and fauna of aquatic ecosystems. The Florida Department of Environmental Protection (FDEP) has established surface water quality numeric nutrient criteria for all Florida water bodies and has developed National Pollutant Discharge Elimination System (NPDES) Total Maximum Daily Loads (TMDLs) for many watersheds that have been determined to have excessive nutrient pollution. For example, a TMDL for phosphorus currently exists for Lake Okeechobee. Lake Okeechobee phosphorus TMDL is routinely exceeded by a factor of approximately 3-4 times. Additional

information on the status and implementation of TMDLs within the study area can be found at http://www.dep.state.fl.us/water/tmdl/.

For streams, if a site-specific interpretation pursuant to paragraph 62-302.531(2)(a) or (2)(b), Florida Administrative Code (F.A.C.), has not been established, biological information shall be used to interpret the narrative nutrient criterion in combination with Nutrient Thresholds. The narrative nutrient criterion in paragraph 62-302.530(47)(b), F.A.C., shall be interpreted as being achieved in a stream segment where information on chlorophyll *a* levels, algal mats or blooms, nuisance macrophyte growth, and changes in algal species composition indicates there are no imbalances in flora or fauna, and either:

1. The average score of at least two temporally independent stream condition indices (SCIs) performed at representative locations and times is 40 or higher, with neither of the two most recent SCI scores less than 35, or
2. The nutrient thresholds set forth in **Table C.1-11** are achieved.

Table C.1-11. Total Nutrient Threshold's by Florida geographic region.

Nutrient Watershed Region	Total Phosphorus Nutrient Threshold[1]	Total Nitrogen Nutrient Threshold[1]
Peninsular	0.12 mg -L	1.54 mg -L
South Florida	No numeric nutrient threshold. The narrative criterion in paragraph 62-302.530(47)(b), F.A.C., applies.	No numeric nutrient threshold. The narrative criterion in paragraph 62-302.530(47)(b), F.A.C., applies.

[1]These values are annual geometric mean concentrations not to be exceeded more than once in any three calendar year period.

Phosphorus is typically considered the limiting nutrient in many South Florida systems. Increased concentrations often correlate with increased algal development and can lead to an imbalance in animal and plant communities. The FDEP has developed water quality standards for phosphorus within the Everglades Protection Area (EPA) (FAC 2017), lakes, rivers and springs (FAC 2016b), and estuaries (FAC 2016a). The total phosphorus nutrient threshold (i.e. the annual geometric mean) for peninsular biological region is 0.12 mg L -1 (FAC 2016b), unless an estuary site-specific value has been established (FAC 2016a).

C.1.14.2 Future Without Conditions

Implementation of water quality total maximum daily loads (TMDLs) and any future associated basin management action plans (BMAPs) within the study area should result in improved water quality conditions. TMDLs and BMAPs have been developed for Lake Okeechobee. TMDLs are in the planning stage for other Loxahatchee river watershed area basins. Effects on water quality from agricultural activities should be reduced as land use near urban areas converts to residential and commercial development. Water quality in urban areas should improve somewhat as stormwater controls are implemented in areas that undergo redevelopment.

C.1.14 Air Quality

C.1.14.1 Existing Conditions

The project location is currently in attainment for air quality according to the most recent 2012 Florida Department of Environmental Protection Annual Air Monitoring Report. Attainment is a designation used

to identify air quality problem areas based six criteria pollutants (carbon monoxide, lead, nitrogen dioxide, ozone, sulfur dioxide, and particulate pollution). There are no exceedances in the project are for any of the criteria pollutants.

C.1.14.2 Future without Project Conditions

The long-term impact of the project neither improves nor degrades air quality. The short-term impact without project is a slight temporary decrease in emissions and particulates from construction.

C.1.15 Hazardous, Toxic, or Radioactive Wastes

The existing Hazardous, Toxic, Radiological, Waste (HTRW) conditions on the site are best summarized in Table C.1-12 Overview of Current HTRW Conditions in Project Area. The main take away point is that the SFWMD has either cleared the project footprint or is in the process of clearing the project footprint of any potential HTRW or residual agricultural chemical concern to the satisfaction of the appropriate authorities (FDEP waste cleanup section for HTRW and USFWS for ecorisk concerns associated with potential residual agricultural chemicals). Documentation that all sites within the project footprint have been satisfactorily cleared and the projects lands are acceptable for project use will be obtained from the USFWS and the FDEP waste cleanup section.

C.1.15.1 Existing Conditions

Current HTRW conditions are summarized in Table C.1-12.

Table C.1-12. Overview of Current HTRW Conditions in Project Area.

Location of HTRW Investigation	Overview of Existing HTRW Concerns
United Technologies Corporation – Pratt & Whitney Address: 17900 Beeline Highway	There are over 100 cleanup sites located on the Pratt & Whitney Property. The cleanup sites are located on the southwestern, south-central, and southeastern portions of the Pratt & Whitney Property. A total of 79 cleanup sites have received No Further Action (NFA) status, 14 cleanup sites have received NFA with conditions, 2 cleanup sites have received NFA under RCRA but require corrective actions for petroleum discharges, 2 have been proposed for NFA, 6 have been proposed for NFA with conditions, and 17 cleanup sites are actively being assessed and/or remediated. Institutional and engineering controls have been implemented for the cleanup sites that have received NFA with conditions. Soil and sediment impacts associated with these sites were remediated to levels that the Environmental Protection Agency (EPA) and FDEP found to be protective of human health and the environment. Corrective measures for contaminated soil have included the excavation of source material to reduce potential exposure by receptors. Other areas of contaminated soils are being managed in place. The controls implemented at these sites have included the maintenance of asphalt and/or concrete covers to reduce exposure and groundwater infiltration. Additionally, portions of the property have been deed restricted where source material with concentrations exceeding the FDEP Residential Direct Exposure soil cleanup target levels (SCTLs) has been left in place. Sediment caps have also been installed as part of corrective measures at some of the cleanup sites, which includes two canals.

Location of HTRW Investigation	Overview of Existing HTRW Concerns
	Of the 17 active cleanup sites, off-property contamination (J.W. Corbett WMA) has only been documented at one site (Study Area 2). Study Area 2 is located on the southeastern portion of the Pratt & Whitney Property. 1,4- Dioxane was noted above its groundwater cleanup target level (GCTL) (3.2 ug/L [micrograms per liter]) in two of the three groundwater samples collected from monitor wells along the southern property boundary during the most recent sampling event in October 2016. The concentrations were 16.1 ug/L, 11.6 ug/L, and 2.2 ug/L, respectively. A Phase I Ecological Risk Assessment (ERA), dated February 1999, determined that of all the media evaluated, only sediment and wetland soils posed a potential hazard to ecological receptors. A Phase II ERA, dated August 1999, evaluated sediment at the cleanup sites where the potential for ecological exposure existed. The Phase II ERA identified a total of 16 sites that had elevated ecological risks due to mercury and/or PCBs. Further assessment of those sites was recommended. According to a Phase III ERA, dated February 2000, indirect contact with site sediments through food chain exposure presented no appreciable hazards to populations of ecological receptors of concern in any of the ecological exposure units (EEUs). Direct exposure to maximum total PCB concentrations in sediments via ingestion resulted in risk levels above the acceptable benchmark in EEU5 and EEU6 for the raccoon and in EEU6 for the river otter. As a result, Medium Protection Standards of 251 milligrams per kilogram (mg/kg) and 48.9 mg/kg for PCBs were developed for EEU5 and EEU6, respectively. The Phase III ERA indicated those sediment PCB cleanup levels could be used as a foundation for determining the appropriate remedial measures to be taken in EEU5 and EEU6. No risks were noted from surface water ingestion, which was also evaluated in the Phase III ERA. Landfill: A closed landfill is located on the southeastern portion of the Pratt & Whitney Property. The landfill opened in the 1960s and has been closed since the late 1980s. Multiple cleanup sites, some of which are currently active, have been identified at the site in the vicinity of the landfill. Study Area 2, which was discussed above, includes the former landfill.
PAL-MAR Property Location:Portions of undeveloped land located southeast of Highway 76, west of Interstate 95, and northeast of Highway 710; Palm Beach and Martin Counties, Florida	A memorandum dated October 8, 1993, indicated Phase I ESA activities identified areas of solid waste dumping at the Pal-Mar Property in the vicinity of a borrow pit. Phase II ESA activities were performed “down gradient” of the debris and no impacts to the soil or groundwater were reported. An additional area of dumping was identified during the Phase II ESA. A memorandum dated March 2, 1994, stated that the previously identified solid waste at the site had been satisfactorily removed and no additional environmental concerns were identified in a 69-acre parcel addition. No additional assessment was recommended in the memorandum at that time. A memorandum dated November 18, 1996, stated that an additional Phase I ESA was completed in November 1996 on an 18,400-acre addition in the Pal-Mar project area. The Phase I ESA reported potential environmental impacts were limited to solid waste debris identified at the addition. The solid waste reportedly consisted of abandoned cars, car parts, household trash, rusted metal and plastic drums, appliances, tires, scrap metal, boat hull, and construction debris. Removal of the debris was recommended; however, no Phase II sampling was warranted at that time. No record of the removal of the solid waste identified in the 1996, 1997, and 2003 reports.

Location of HTRW Investigation	Overview of Existing HTRW Concerns
Mecca Farms Property (Portions of Flow-way 2) Location: Northeastern Corner of Seminole Pratt Whitney Road & 100th Lane North, Palm Beach County, Florida Facility IDs: COM_300436; 50/9809060; 50/9200303; 100015	According to a Phase II ESA dated September 24, 2012, performed by Professional Service Industries, Inc. (PSI), the Mecca Farms Property consists of approximately 1,916 acres and was historically utilized for citrus production. The proposed acquisition area was to be utilized for relatively low depth (less than three feet deep) water storage as part of the LRWRP. Palm Beach County previously performed a pre-acquisition Phase I/II ESA on the subject property when they acquired the land in 2004. The pre-acquisition Phase I/II ESA was conducted by URS Corporation (URS). The pre-acquisition Phase I ESA identified 16 areas of concern on the Mecca Farms Property which included the borrow pit, an equipment storage area and burn area, the maintenance area, 9 pump stations, canal sediments, and the cultivated area. All of the areas of concern were evaluated as part of the pre-acquisition Phase II ESA. URS evaluated the areas of concern and identified the presence of petroleum-impacted soils "requiring corrective action" at two pump stations as well as the presence of cadmium in the groundwater near a former shed in the staging area. URS also reported chlordane in the soils surrounding the maintenance shop at concentrations exceeding ecological risk thresholds and "low" concentrations of chlorinated solvents in the groundwater in the vicinity of the maintenance shop; however, they did not recommend any further assessment for these issues. URS recommended the removal of miscellaneous solid waste that was identified on the Mecca Farms Property, as well as abandonment of septic tanks, potable wells, and the residential structures on the Mecca Farms Property. The Phase II ESA performed by PSI in 2012 was performed to supplement and verify the previous assessments conducted by URS. The 2012 Phase II ESA confirmed petroleum contamination requiring remedial actions surrounding historic pump station IPS #2; identified concentrations of chromium, copper, and silver above regulatory action limits in the formerly cultivated areas; identified concentrations of arsenic, barium, chromium, and selenium in the borrow pit sediments above regulatory action limits; identified a large amount of solid waste, including construction materials; and identified a small quantity of asbestos-containing building materials in a residential structure located at the facility. Review letters from the Florida Department of Environmental Protection (FDEP) and the United States Fish and Wildlife Service (USFWS) agreed with the Phase II ESA recommendations to conduct source removal of the petroleum impacts identified, conduct surface water sampling in the borrow pit to determine if the metals concentrations are actively leaching into the surface waters, and to conduct surface water sampling as part of the startup activities during flooding operations. This property currently maintains one 12,000-gallon emergency generator diesel underground storage tank (UST), one 1,000-gallon "ammonia compound" aboveground storage tank (AST), one 16,000-gallon "other non-regulated" AST, and two 530-gallon generator/pump diesel ASTs. The most recent inspections for each storage tank facility available for review indicated the facilities were in compliance. The recommended surface water sampling and source removal activities should be completed prior to the implementation of watershed restoration activities at the Mecca Farms Property.
Loxahatchee River Flow-way 3 Project	Conditions with the potential to affect the project water quality were identified at the Mecca Farms Property. The recommended surface water sampling and source removal activities should be completed prior to the implementation of watershed restoration activities at the Mecca Farms Property.

Location of HTRW Investigation	Overview of Existing HTRW Concerns
Location: North of Indiantown Road; Martin County, Florida Facility ID: 43/8736022; COM_287105; COM_287110; COM_308099	The proposed Loxahatchee River Flow-way 3 project encompasses approximately 8,000 acres which consists of 12 parcels that were previously cultivated or undeveloped. The parcels are further identified as the Nine-Gems parcels, the Culpepper parcels, and the Sunrise Boys parcels (portions of which are also identified on Corps of Engineers figures as "Gulfstream East" and "Gulfstream West"). Most of the project area was historically undeveloped land with cattle grazing operations on portions of the Nine-Gems and Culpepper parcels. A small-scale dairy farm also operated on the Culpepper parcels. Historic use on the Sunrise Boys parcels included citrus and vegetable row crop agricultural operations as well as residential use. The 2012 report stated that previous assessment identified multiple environmental concerns at the Nine-Gems parcels; however, corrective actions were completed in 2007. The report indicated the corrective actions addressed all previously identified concerns at the Nine-Gems parcels. A review letter from the USFWS agreed with the completion of the corrective actions and concurred with the conclusion that the parcels were suitable for their intended use. A review letter from the FDEP noted that lead concentrations remained in the soils in the vicinity of the small arms firing range in excess of the sediment quality assessment guideline – toxic effect level in addition to "slightly impacted groundwater conditions"; however, the FDEP noted that given the intended use of the property, the residual contamination may not represent a significant risk. The FDEP also noted that agricultural areas of the property had been addressed in accordance with the "Protocol for Assessment, Remediation, and Post- Remediation Monitoring for Environmental Contaminants on Everglades Restoration Projects"; however, since the sampling density and subsequent cleanup did not follow protocols established in Rule 62- 780 Florida Administrative Code (FAC), FDEP would not be able to issue a Site Rehabilitation Completion Order (SRCO), as defined in the Risk Based Corrective Actions. It was further noted that this concurrence was applicable only to residual agricultural products and that the District should assess and remediate "point source" contamination in accordance with applicable FDEP statutes and rules, including 62-770 and 62-780 FAC. The report recommended no further sampling or potential corrective actions associated with the Nine-Gems parcels. The 2012 report stated that previous assessments of the Culpepper parcels identified multiple environmental concerns. Phase II assessment of the parcels identified "elevated nitrogen concentrations" in soil samples collected on the northern portion of the Dairy Waste Management Area and "elevated phosphorus" concentrations in soil samples collected in the northeastern area. No further assessment of this area was recommended. Soil and groundwater sampling conducted in the vicinity of the former UST and AST area revealed no concentrations of contaminants above their respective cleanup target levels. No further assessment was recommended; however, the completion of a Tank Closure Assessment Report for submittal to the FDEP was recommended. The report also identified concentrations of arsenic in the soil and groundwater in the vicinity of a cattle dipping vat identified on the property. No concentrations of organochlorine pesticides were detected above laboratory detection limits in the samples collected. Based on the soil data collected, URS estimated that up to 750 tons of arsenic impacted soil was present in the vicinity of the cattle dipping vat. No record of the completion of source removal activities was available for review. The Tetra Tech report recommended that a source removal be performed at the cattle dipping vat and that regulatory closure of the UST and AST in

Location of HTRW Investigation	Overview of Existing HTRW Concerns
	accordance with Chapter 62-770 FAC be performed. No record of the completion of these recommendations was provided for review. The 2012 report stated that previous assessments of the Sunrise Boys parcels identified multiple environmental concerns. According to the report, numerous impacts appear to remain at the Culpepper parcels (Table C.1-13) In addition to the SCTLs, soil contaminant concentrations at the Sunrise Boys parcels were compared to the SQAGs based on the projected land use for restoration of hydrologic flow. Phase III activities performed by URS in 2003 reported concentrations of contaminants detected in the citrus grove cultivated areas did not pose a significant risk to the projected land use of the site. No further sampling or corrective action was recommended in this area; however, it was recommended that concurrence with the recommendation by USFWS and the FDEP be obtained prior to flooding the area. The Phase III report also reported the contaminants reported in the pepper farm cultivated areas did not pose a significant risk to the projected land use for passive recreational purposes. The report recommended that in the event the area was to be inundated to restore hydrologic flow, further investigation into potential ecological receptors should be performed. Previous assessments also identified a cattle dipping vat on the Sunrise Boys parcels. In 2005, the vat was removed and impacted soils were excavated. Confirmation soil samples revealed a concentration of toxaphene was reported exceeding its SCTL. The approved work plan for removal of the vat required a 95 percent Upper Confidence Limit in the soils, which was achieved. Post active remedial monitoring of the groundwater was conducted until January 2008. Arsenic concentrations in the groundwater remained above the GCTL and restricted closure using an institutional control was recommended. A review letter by the USFWS, dated September 26, 2012, concurred with the recommendation of no further action warranted on the Nine-Gems parcels. The letter also indicated that, based on a 2006 Phase I/II ESA reviewed (not provided to Aerostar), that the Culpepper Parcels were also suitable for its intended use with no further sampling necessary. The letter concurred with the recommended actions at the Sunrise Boys parcels, and requested additional soil sampling in areas leased since the time of the initial Phase I/II ESA. This sampling was recommended in response to the use of chemicals at the parcels that are persistent in the environment and are on the USFWS's no application list which were discovered during best management practice inspections. The letter also recommended remedial action in areas with copper concentrations that exceed the USFWS's screening level, as well as areas with organochlorine pesticides that showed significant bioaccumulation. A review letter by the FDEP, dated August 16, 2012, concurred with the recommendation of no further action warranted on the Nine-Gems parcels. The letter also concurred with the recommended assessment and remedial actions recommended in the report at the Culpepper Parcels and the Sunrise Boys parcels. No additional actions were recommended by the FDEP.

Table C.1-13. HTRW concerns at Culpepper Farm.

Area of Concern	Soil Impacts	Groundwater Impacts	Sediment Impacts
Citrus Grove – Cultivated Areas	Copper	Boron (Note: Does not exceed present-day GCTL)	4,4'-DDE, copper, zinc
Citrus Grove – Maintenance Complex	Arsenic, barium, copper, lead, naphthalene	Boron, multiple petroleum hydrocarbons	None
Citrus Grove – Former Air Strip	Copper	None	None
Citrus Grove – Burn Area	Chlordane	Boron	None
Citrus Grove – Dump Area 1	Copper	None	None
Former Camp House/Former Storage Shed Area	Copper, chlordane	Lead	None
Pepper Farm – Cultivated Areas	Copper, dieldrin, total chlordane, 4,4'-DDE	Boron	Copper
Pepper Farm – Stake Area	Dieldrin	None	None
Pepper Farm – Maintenance Complex	Copper, lead, zinc	None	None
Cattle Dipping Vat	Toxaphene	Arsenic	None

C.1.15.2 Future without Project Conditions

The future without project has no relation to HTRW issues. Remediation may or may not commence without the project and it depended upon the responsible parties to ensure remediation.

C.1.16 Noise

Sound is a physical phenomenon consisting of pressure fluctuations that travel through a medium, such as air, and are sensed by the human ear, as well as fish and wildlife species. Noise is considered unwanted sound that can disturb routine activities (e.g., sleep, conversation, ambient environment, quality of life, location, and abundance of wildlife) and can cause annoyance. Ambient noise is generally higher in more urbanized areas and lower in suburban and rural areas. Concerns may be raised by residents/the public where there are project-related changes in ambient noise exposure, particularly in generally quiet rural undeveloped areas with low to moderate noise levels. There are also noise sensitivities with respect to certain resources such as national or local parks and wildlife refuges. Further, elevated noise levels may create unsuitable habitat conditions for fish and wildlife species.

Commonly used noise measures include the Leq, or equivalent level, which is a measure of the central tendency of the noise (total sound energy) over time, and the L10, which is the noise value exceeded 10% of the time. Leq is the preferred method to describe sound levels that vary over time, resulting in a single decibel value which takes into account the total sound energy over the period of time of interest. L10 is typically used for road traffic noise because it corresponds well with close proximity to busy roads as well as more rural situations. L10 noise levels should not exceed 50–75 dB, depending on whether they occur in residential, commercial, industrial, or natural areas. Vehicle speed and distance from source, and traffic volume, are the main influencing factors on the amount of traffic noise perceived by the receiver.

The study area for noise is the three dimensional geographic area with the potential to be impacted by noise from the proposed project. The steps generally required to describe the affected environment for noise and noise compatible land use for NEPA documents are: determine the study area for noise analysis; identify noise sensitive areas in the study area and pertinent land use information; and describe current noise conditions in the study area. This section describes the existing conditions and the future without project conditions.

C.1.16.1 Existing Conditions

The eastern side of the study area is characterized as a densely populated region that includes residential, recreational, commercial and industrial elements. The Florida Turnpike, a 4-lane highway, and I-95, a 6-lane highway, bisect the western side of the project area. The Bee-Line Highway, a 4-lane highway, cuts diagonally from southeast to northwest through the middle of the central study area. Vehicular traffic, commerce and industry all contribute to the background noise in the area. The western side of the study area consists of uninhabited natural areas, with occasional administration sites and scattered rural residential properties. The project area also lies under various approach vectors for aircraft landing at the nine airports (two public and seven private including two heliports) in Martin County and 41 airports (six public and 35 private including 27 heliports) in Palm Beach County.

Within the major natural areas of south Florida, external sources of noise are generally limited and of low occurrence. There are no significant noise generating land users within these areas. Existing sources of noise are limited to the vehicular traffic travelling on local roadways adjacent to and cutting through the project area, agricultural equipment (tractors, trucks, etc.), and pumping stations, boat engine and airboat traffic along the canals and in various management areas, small industry (i.e., produce processing and distribution), and urban activities in the few towns. Other sources of noise that may occur within natural areas include airboats, off road vehicles, swamp buggies, motor boats, and occasional aircraft traffic, particularly helicopter overflights for natural resource surveys. Sound levels along transportation arteries are typically in the range of 70 decibels (dB). Rural areas typically have noise levels of 35-55 dB and natural area ambient sound levels are also typically in the range of 35 dB; however, these quiet levels may be punctuated by sound levels that are typically in the range of 85 to 105 dB for motorboats and air boats, respectively. According to the FDOT State Environmental Management's Office, no known ambient noise monitoring has been conducted in the project area; consequently, no quantitative noise level data within the project area are available for analysis.

Martin County established a zoning Noise Compatibility Overlay based on Day-Night Average Noise Level (DNL) zones, focused on abating noise emanating from the Martin County Airport, in 2012. Two zones are defined: Zone A – 65 dB and Zone B – 60 dB (Martin County Ordinances https://www.martin.fl.us/martin-county-services/martin-county-code-ordinances). Landowners outside these zones are subject to noise control ordinances for various zoning categories. Palm Beach County similarly has airport noise abatement

ordinances (http://www.pbia.org/Airport/Noise/default.aspx) and noise control ordinances for various zoning categories.

C.1.16.2 Future Without Project Conditions

Sources of noise associated with surrounding land use are expected to be similar to those described in existing conditions. During the period between 2018 and the 50-year planning horizon of 2072, noise within the major natural areas of south Florida would continue to be limited and of low occurrence. Noise levels would be expected to change where land use is projected to change. For example, a proposed Olympic-quality shooting range in construction by FWC at the NW corner of the MECCA property (150 acres) would create localized elevated noise levels, depending on the design of the range and attenuation mitigation. Within rural municipalities and urban areas, sound levels would be expected to be of greater intensity, frequency, and duration as areas are further developed through 2072 from agricultural to residential/commercial due to increased noise from traffic, construction associated with development, and increased operations at commercial and industrial facilities.

C.1.17 Aesthetics

Visual aesthetics refers to the visual appearance of the project features within the surrounding landscape. Aesthetic effects refer generally to project-related impacts on the visual qualities of the environment.

C.1.17.1 Existing Conditions

The visual character of the LRWRP study area in southeast Florida is dominated by three land use categories: natural areas, agricultural lands, and urban areas. The natural areas consist of a mosaic of upland and wetland ecosystems. Uplands are dominated by expanses of slash pine forest or oak hammocks, including various sub-tropical and tropical hardwoods such as strangler fig and gumbo limbo. These areas are described in **Section C.1.1.1**. Overall, the land is extremely flat, with few natural elevated topographic features such as hills or other undulations. The transitional zone between uplands and wetlands may frequently be dominated by extensive expanses of Brazilian pepper, which obscures the visibility of the surrounding landscape, particularly in ruderal disturbed areas and along unmaintained canals and levees. Many of the visible features within the natural areas are man-made, including canals and levees, pump stations, water control structures, secondary and primary roads, highways, electrical wires, communication towers, occasional buildings, borrow pits and other features which may or may not detract from the regional aesthetic. Wetlands include features such as lakes, ponds, and vast expanses of marsh and wet prairie dominated by rushes, sedges, cattails, and broad-leaved wetland plants, or forested wetlands generally dominated by cypress. Because of the extensive area, flat landscape, and dense plant cover, most of the natural areas are not visible at long sight distances. From high positions, such as the view from a levee bank, perspectives of the surrounding landscape, and wildlife such as numerous wading birds or other wildlife species may be visible.

Agricultural lands are characterized by cattle grazing in open fields dotted with sabal palms and oak trees, cultivated row crops and citrus groves and have a semi-developed visual character. Residential and agricultural building developments with homes, garages, equipment sheds, and barns are prominently visible on these large landholdings.

Urban areas dominate the eastern side of the study area in both Martin and Palm Beach counties. The rural undeveloped lands on the western side of the study area transition through suburban housing developments to the dense residential areas in the central and eastern portions of the counties.

The upper end of the NWFLR lies within an undeveloped broad wooded floodplain; moving downstream towards the Jupiter Inlet; from about the mid-point of the Northwest Fork, as the channel widens, and the river leaves the JDSP, the river banks are densely developed with residences along both shorelines. The sinuosity of the river limits sight distance and views of the river in many areas.

C.1.17.2 Future without Project Conditions

The future without project condition of the study area is anticipated to have visual aesthetics similar to those described in existing conditions. Visual characteristics would be expected to change where land use is projected to change.

During the period between the present planning year 2018 and the 50-year planning horizon 2072 the visual environment within the major natural areas of south Florida is expected to decline as changes in the availability and distribution of freshwater would further exacerbate changes occurring in fish and wildlife resources and vegetative communities as described in **Sections C.1.2.1** and **C.1.2.2**.

Within suburban and urban areas, more infrastructure features would be expected to be visible as these areas are further developed from agricultural to residential/commercial during the planning horizon through 2072. Increased occurrence of visible topographic features (i.e. heavily used roads, highways, single-family homes, high rises, commercial and industrial facilities) would change the perception of the regional aesthetic, causing it to appear more densely developed. Conversely, if the 2014 Florida Land and Water Conservation Initiative, Amendment 1, receives more funding in the future, some lands may be purchased and added to the regional greenbelt areas, thus protecting them from future development.

Restoration of the LRWRP ecosystem is expected to result in hydrologic restoration of about 150,000 acres of depressional wetlands that are presently partially drained and about 5,000 acres of pastures (in the Nine Gems and Shiloh areas) and 2,490 acres of non-producing orange groves in the Gulfstream West (690 acres), Gulfstream East (420 acres), and Mecca (1,380) areas. The project would increase the flow of freshwater annually to the Loxahatchee River, in a seasonally appropriate pattern, thus reducing the upstream creep of the salinity wedge and ultimately shifting the existing mangrove community boundary further downstream by about two miles. Implementing the LRWRP Alt 5R features would have generally longterm regional effects, but the effects of individual features would be localized within the landscape and result in negligible and less than significant visual aesthetic effects. In the NWFLR, the action alternatives would increase the aesthetic value due to decreased high flow events and provide minor beneficial effects. Reductions in high volume discharges to the estuaries would result in lower suspended solids, increased water clarity and the correct salinity envelope that maintain healthy SAV beds. These benefits could also and lead to an increase in wildlife viewing opportunities (Orth et al. 2006).

Temporary, short-term major adverse impacts to aesthetic values will occur in the construction areas during construction. Long-term, major adverse impacts will occur at the reservoir and wetland enhancement features as the character of large surface areas are altered and changes in ground surface elevation are produced when levees are constructed. These elevational changes will interrupt existing lines of sight, although they will be generally grass covered to blend them into the existing landscape. Long-term moderate adverse visual impacts will occur as man-made features such as pump stations, ASR wells and maintenance roadways are constructed in the natural landscape. Long-term moderate impacts are predicted to occur to existing hydric to mesic pine flatwoods communities in the form of pine tree mortality as a result of improving hydroperiods – in some locations, because of the reduced hydroperiods since parcels were ditched and dewatered, pine trees have established lower on the landscape than the

positions they occupied historically and, as the water table comes up in the soil column and hydroperiods are extended, trees may die back, leaving variably-sized areas of dead trees, which will provide temporary beneficial effects as wildlife snags, particularly for species such as red-cockaded woodpecker and cavity roosting or nesting birds or bats.

All action alternatives show a significant increase in aesthetic value over the FWO due to restoration of wetlands in the Loxahatchee River watershed and provide a minor to major beneficial effect to the targeted habitats. The restoration of wetlands provides additional habitat for native plants and animals and opportunities for wildlife viewing. Alternative 5R will have the greatest increase in aesthetics due to the multiple wetland improvement features and the addition of wetland habitat within the storage reservoir footprint. The proposed wetland enhancement features will increase potential habitat for fish and wildlife that will enhance the area's visual aesthetics by providing an environment with greater ecological integrity that would support vigorous plant communities, larger fish and aquatic animal populations, large numbers of wading birds, alligators, and sustainable populations of wide-ranging mammals, in a natural setting, in perpetuity. Viewing wildlife, wetlands and open, relatively pristine spaces are highly valued by people, as supported by tourism statistics for south Florida.

C.1.18 Land Use

The LRWRP study area is located between the C-44 Canal at the north and the C-51 and L-8 Canal at the south. It is bounded by Lake Okeechobee to the west and the Atlantic Ocean to the east and encompasses approximately 480,000 acres in southern Martin and northern Palm Beach counties. An area of approximately 7,550 acres located between the L-8 and L-10/12 Canals at the eastern extent is also included in the study area.

C.1.18.1 Existing Conditions

Existing land use consists of a mixture of public and private ownership. Land use cover throughout the project area was determined using the SFWMD's Composite Land Use GIS coverage for 2014-2016. Most of land within the study area can be included in 3 broad land use categories: natural areas (including wetlands, forested and unforested uplands and open water), agricultural lands and urban (residential/commercial) space. Generally, the western and northwestern portions of the study area include large expanses of publicly owned natural lands (Dupuis Wildlife and Environmental Area, J.W. Corbett WMA alone encompass approximately 82,000 acres. These natural lands are former agricultural areas, primarily unimproved pasture, that have been acquired and established as wildlife management and recreational areas). East and north of J.W. Corbett WMA is the Pal-Mar area, which includes multiple tracts of public lands acquired with county funds alone, with state land acquisition programs such as Save Our Rivers and Florida Forever, or a combination of both. These publicly acquired lands are interspersed with numerous tracts that are privately owned.

Proceeding eastward, these lands ultimately give way to predominately agricultural lands in the mid-county region. Some of these agricultural lands (Nine Gems, Pal-Mar East, Culpepper and the Gulfstream and Shiloh Farms Properties) have been acquired in anticipation of this project. The eastern and southeastern portions of the study area are highly urbanized. The exception is JDSP located in Martin County, in the east central portion of the study area. JDSP encompasses approximately 11,500 acres. The area within the project boundary between the L-8 Canal and the L-10/L-12 canals is agricultural, interspersed with industrial (mining). The eastern portion of the study area also includes the Loxahatchee River/Lake Worth Creek Aquatic Preserve, as identified in **Figure C.1-25**. This 1,739-acre aquatic preserve

includes all forks of the Loxahatchee River (Northwest, Southwest, and North), as well as Lake Worth Creek, which connects with the northern reaches of the Lake Worth Lagoon.

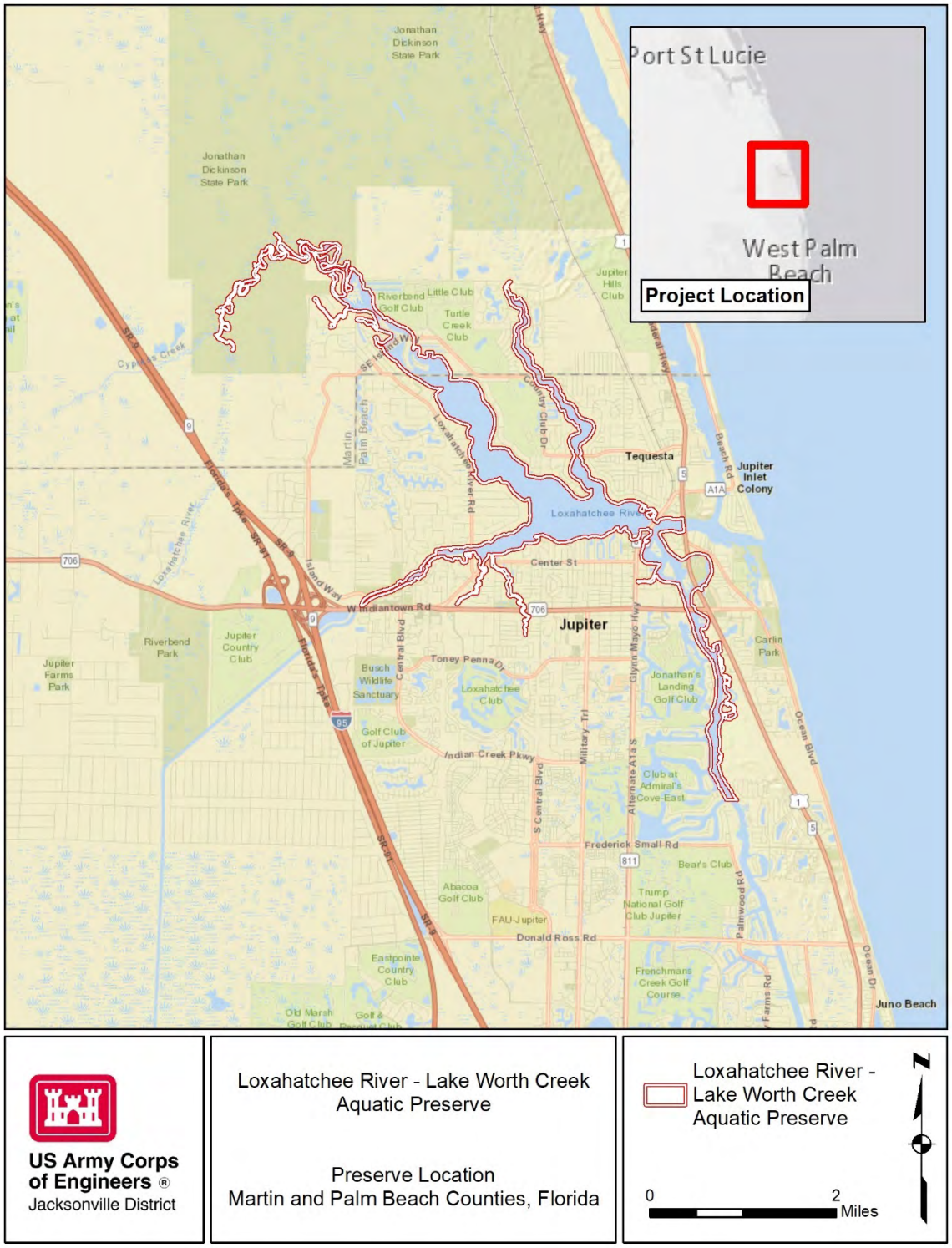

Figure C.1-25. Boundaries of the Loxahatchee River – Lake Worth Creek Aquatic Preserve.

As shown in **Table C.1-14** and **Figure C.1-26**, the existing regional land use configuration is a result of an increasing population, the demands of which have prompted planning efforts that will allow for balancing the resource needs of the counties while striving to protect the rural lifestyle and the natural areas of the region. Much of the eastern portions of the counties are built-up, necessitating western urbanization, which has consisted of a transition of agricultural lands to low-density residential and commercial development. Agricultural use types within the watershed consist primarily of sugarcane, pepper farming, nurseries for landscape vegetation and pasture land for cattle grazing. Previous agricultural areas included citrus cultivation, which has been heavily impacted due to canker and citrus greening. Many of these former citrus areas are now fallow.

Table C.1-14. Existing land use (SFWMD GIS coverage - 2014-2016).

Land Use Category	Acres	% of Total
1000 - Urban & Built Up	122,563	27.67
2000 - Agriculture	81,719	18.45
3000 - Upland, Non-forested	13,509	3.05
4000 - Upland, Forested	70,364	15.89
5000 - Water	13,425	3.03
6000 - Wetlands	125,672	28.38
7000 – Barren Lands	3,670	0.83
8000 – Transportation, Communication, & Utilities	11,962	2.70

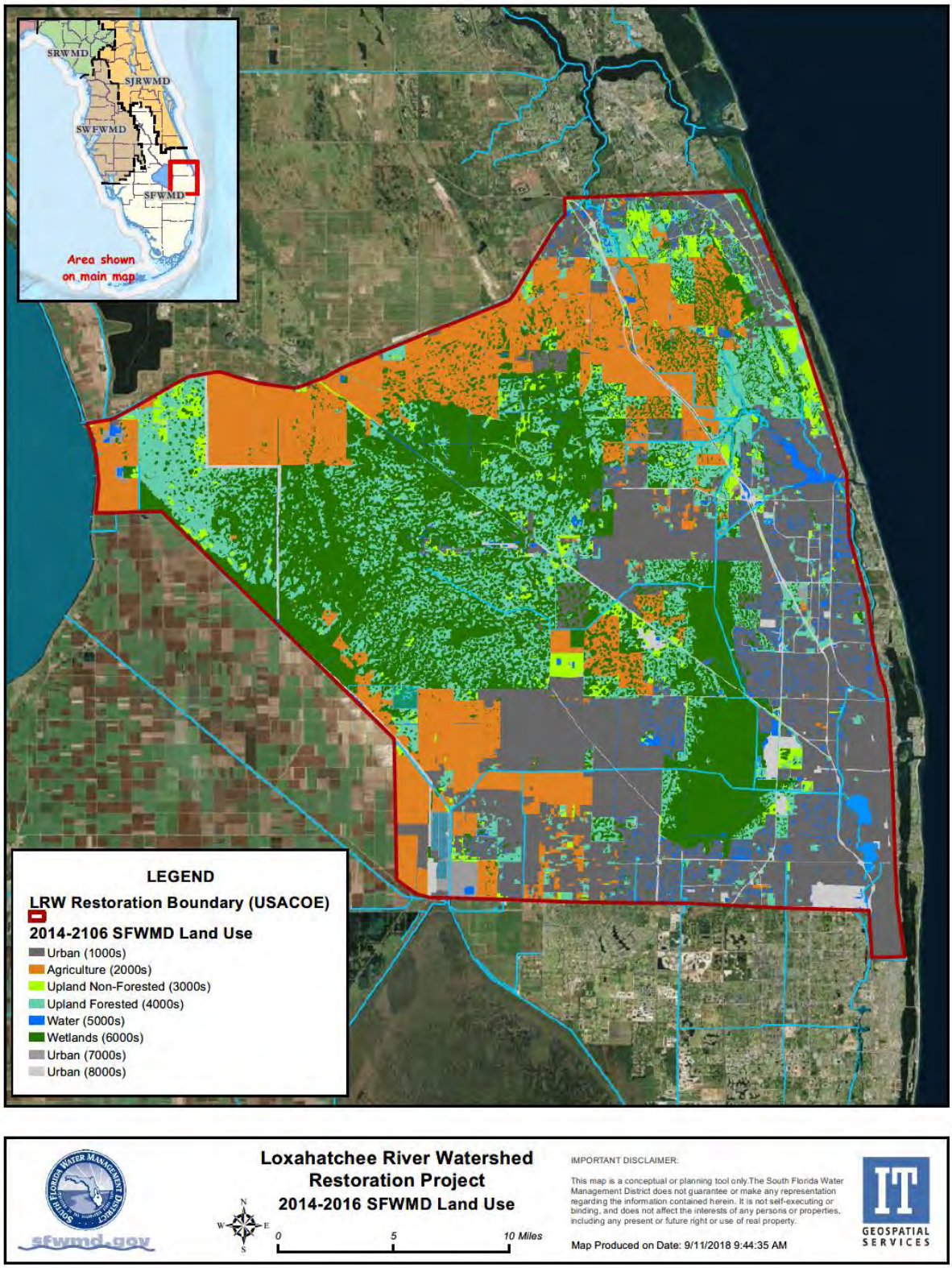

Figure C.1-26. Existing land use in the LRWRP planning area.

C.1.18.2 Future without Project Conditions

The future land use throughout the study area was examined using the SFWMD's 2050 Projected Composite Land Use, as shown in **Figure C.1-27**. The 2050 future land use coverage was analyzed by grouping similar Florida Land Use Cover and Classification System (FLUCCS) Level 1 Codes into general land use categories (urban areas (FLUUCS 100, 700, and 800), agricultural areas (FLUUCS 200), Wetlands (FLUUCS 600), upland forests and rangelands (FLUUCS 300 & 400) and water (FLUUCS 500). The resulting land use coverage demonstrates an overall general trend of upland forests, rangeland and agricultural land shifting to urban areas (**Table C.1-15**). Specifically, the 2050 scenario shows urban expansion in the northeastern, central and southern portions of the project area, where approximately 45,000 acres of agricultural and natural land will be lost. This is especially prevalent in southeastern Martin County. The existing conditions data characterized this area as predominantly agricultural, while the 2050 projects depict these same lands as urbanized, resulting in loss of both agricultural acreage and forested upland and wetland area. Martin County land use projections also show some conversion from agricultural to agricultural ranchette communities. The same shift also occurs in the middle of the project area due to increased industrialization around the United Technologies Pratt Whitney facilities.

Within the study area, many of the properties proposed have been acquired by state and/or local agencies with the expectation that they would be incorporated into the CERP/LRWRP. These include the Loxahatchee and Hungryland sloughs, some of the properties in the western Pal-Mar area, as well as the properties immediately upstream of the Cypress Creek and Moonshine Creek Tributaries (Pal-Mar East, Cypress Creek, Culpepper). The 2050 projection show these lands converting to more urban or ranchette estate condition. If not incorporated into the project, these properties would be subject to continual political pressure to be listed as surplus which would allow continued development within the watershed and the opportunity to improve the base flow and groundwater levels in direct proximity to the river would be lost.

Table C.1-15. Future without project land use projections (2050 SFWMD).

Land Use Category FWO*	Acres	% of Total	FWO-EC (Acres)
1000 - Urban & Built Up	185,656	37.43	43,138
2000 - Agriculture	70,865	17.02	-6,371
3000 - Upland, Non-forested	861	.12	-12,987
4000 - Upland, Forested	58,631	12.70	-14,148
5000 - Water	20,754	3.06	135
6000 - Wetlands	119,751	26.75	-7,268
7000 – Barren Lands	953	.19	-2,816
8000 – Transportation, Communication, & Utilities	12,835	2.73	101

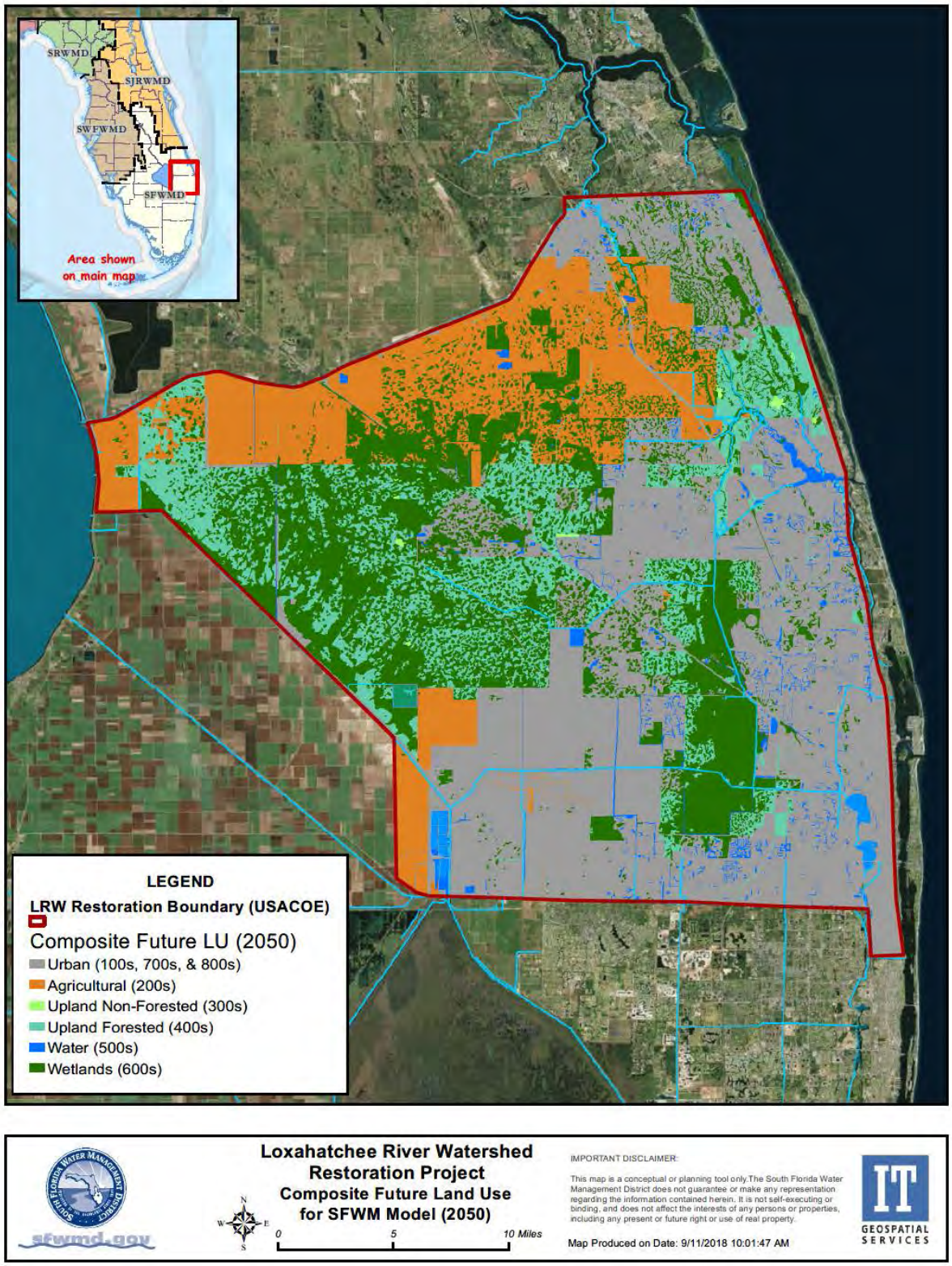

Figure C.1-27. Composite future land use (2050).

C.1.19 Recreation

There are many recreational opportunities throughout south Florida; however, with the dense urban surroundings demand often exceeds availability.

C.1.19.1 Existing Conditions

Existing recreational opportunities within the LRWRP two-county area are significant as much of the project area is in public ownership. These publicly owned areas include Palm Beach County's Cypress Creek, Pine Glades, Hungryland Slough, Pond Cypress, Sweetbay, Loxahatchee Slough Natural Areas, and Riverbend Park; the Florida Fish and Wildlife Conservation Commission's J.W. Corbett WMA and John C. and Mariana Jones Hungryland Wildlife and Environmental Area (Hungryland WEA); Martin County and SFWMD's, Pal-Mar East (also known as Nine Gems) and Loxahatchee River/Cypress Creek Management Area (Cypress Creek MA); and SFWMD's DuPuis Management Area; and JDSP, as well as the NWFLR and the Loxahatchee Estuary, which is currently a popular destination for paddlers. Current recreational access to the wild and scenic portion of the river is available only from Riverbend Park near the river's upstream origin and from JDSP at the downstream terminus of the Wild and Scenic designation.

Riverbend Park includes approximately 680 acres in northern Palm Beach County and serves as a starting point for six of Palm Beach County's Wildways Jesup Trail (Northern Everglades Natural Area, or NENA) recreational trails: four multi-use land trails, the Florida Trail Association's (FTA) Ocean to Lake (OTL) Hiking Trail, and the Loxahatchee Blueway paddling trail. The multi-use land trails are open to hiking, bicycling and horseback riding. Loxahatchee Blueway is non-motorized boat access to the Loxahatchee River. Road access to Riverbend Park is excellent.

The recreational potential of the 11,383-acre JDSP lies not only in the access it provides to the wild and scenic river, but in the extensive resource-based outdoor recreational opportunities offered within its boundaries and through programing provided at the Elsa Kimbell Environmental Education and Research Center. River access is provided by public boat ramps for launching private boats, a canoe/kayak rental concession, and a 44-passenger boat for tours upstream to Trapper Nelson's homestead. Recreation opportunities include picnicking, swimming, canoeing, fishing, biking, hiking, birding, camping (tent, recreational vehicle and cabin), nature study, and photography. Access to a section of the OTL Hiking Trail are provided by the park, including two primitive camping sites along that backpacking trail. Road access to JDSP and down to the river within the park, are excellent.

Substantial recreational opportunities such as hunting, horseback riding, cycling, camping, hiking, auto touring, and fishing are available in J.W. Corbett WMA (60,348 acres) and DuPuis (21,875 acres),

The 2013 State Comprehensive Outdoor Recreation Plan (SCORP) is a reliable source to determine if Florida residents and tourists need additional facilities to support outdoor recreation. Surveys determined the user rates for 26 different outdoor activities within 8 regions of Florida.

The SCORP divides all activities into either resource based or user based. Below is a table from Florida's 2013 SCORP showing each region and the level of service provided as either above or below the state average for surveyed activities (**Table C.1-16**). A close review of the table shows that canoeing and kayaking is not listed. The SCORP did survey this popular activity and found participation rates similar to motorized boating. The SCORP found the high user rates are where the available resource has been developed for this outdoor activity. SCORP did not assess the level of service due to the abundance of

available water but encourages the provision of facilities and designating canoe trails. These projects primarily provide opportunities for resource-based activities.

Table C.1-16. Regional levels of service for outdoor recreation 2013.

Comparing Regional Levels of Service to Statewide Median*

● Level of Service **Above** Statewide Median ○ Level of Service **Below** Statewide Median

Resource-Based Activities	Region							
	NW	NC	NE	CW	C	CE	SW	SE
Saltwater Beach Activities	●	○	●	○	NA	●	●	○
Freshwater Beach Activities	●	●	○	○	○	●	○	●
Saltwater Fishing Non-boat	●	○	○	○	NA	●	●	●
Freshwater Fishing Non-boat	○	●	○	●	●	○	●	○
Saltwater Boat Ramp	●	●	○	○	NA	●	●	○
Freshwater Boat Ramp	●	●	●	○	○	●	○	○
Bicycling Paved	○	●	○	●	○	●	●	○
Bicycling Unpaved	○	●	●	○	○	●	●	○
Hiking	●	●	○	○	○	●	●	○
Horseback Riding	○	●	●	○	○	●	●	○
Off-Highway Vehicle Driving	●	●	○	○	○	●	●	○
Nature Study	●	●	●	○	○	●	○	○
Picnicking	○	●	○	○	○	●	●	●
Visiting Historical or Archaeological Sites	○	●	●	○	○	●	●	○
Tent Camping	●	●	●	○	○	○	●	○
RV or Trailer Camping	○	●	○	●	○	●	●	○
Hunting	●	●	○	○	○	○	●	●

User-Oriented Activities	Region							
	NW	NC	NE	CW	C	CE	SW	SE
Swimming in Public Outdoor Pool	○	●	○	○	○	●	●	●
Baseball or Softball	●	●	●	○	○	●	○	○
Outdoor Basketball	○	●	●	●	○	●	○	○
Outdoor Tennis	○	●	○	○	○	●	●	●
Soccer	●	●	●	○	○	●	○	○
Football	●	●	●	○	○	●	○	○
Golf	○	○	●	○	○	●	●	●

*Table shows SCORP planning regions as either above or below the statewide median level of service, per activity. *See Appendix G for regional level of service calculations per activity.*

C.1.19.2 Future without Project Conditions

In general, the variety of recreational interests in the United States appears to be increasing along with recreational participation rates. As future recreation needs and interests develop, it is important to recognize that participation in specific types of recreational activities is often linked to demographic factors such as age and income. For example, participation in activities requiring vigorous exercise is considerably higher for young people than for senior citizens. However, the elderly population is increasing recreation participation because of the growing awareness of the importance of physical fitness. Participation in most activities is low for those with family incomes below $25,000 per year. Interestingly, participation is also low for those with family incomes greater than $100,000 per year. Most outdoor recreational activities appear to be enjoyed largely by the middle class, those with family incomes between $25,000 and $75,000 per year.

The 2013 State Comprehensive Outdoor Recreation Plan (SCORP) is a reliable source to determine if Florida residents and tourists need additional facilities to support outdoor recreation. Surveys determined the user rates for 26 different outdoor activities within 8 regions of Florida.

The map chart below (**Figure C.1-28**) from SCORP 2013 predicts population growth in all regions. All regions are expected to have significant increases in demands for the selected recreation activities with a commensurate need to increase development of the regions' recreation resources and facilities. The LRWRP area is encompassed within the CE and SE portions of the SCORP map, with an expectation of between 8 and 13 % growth in population.

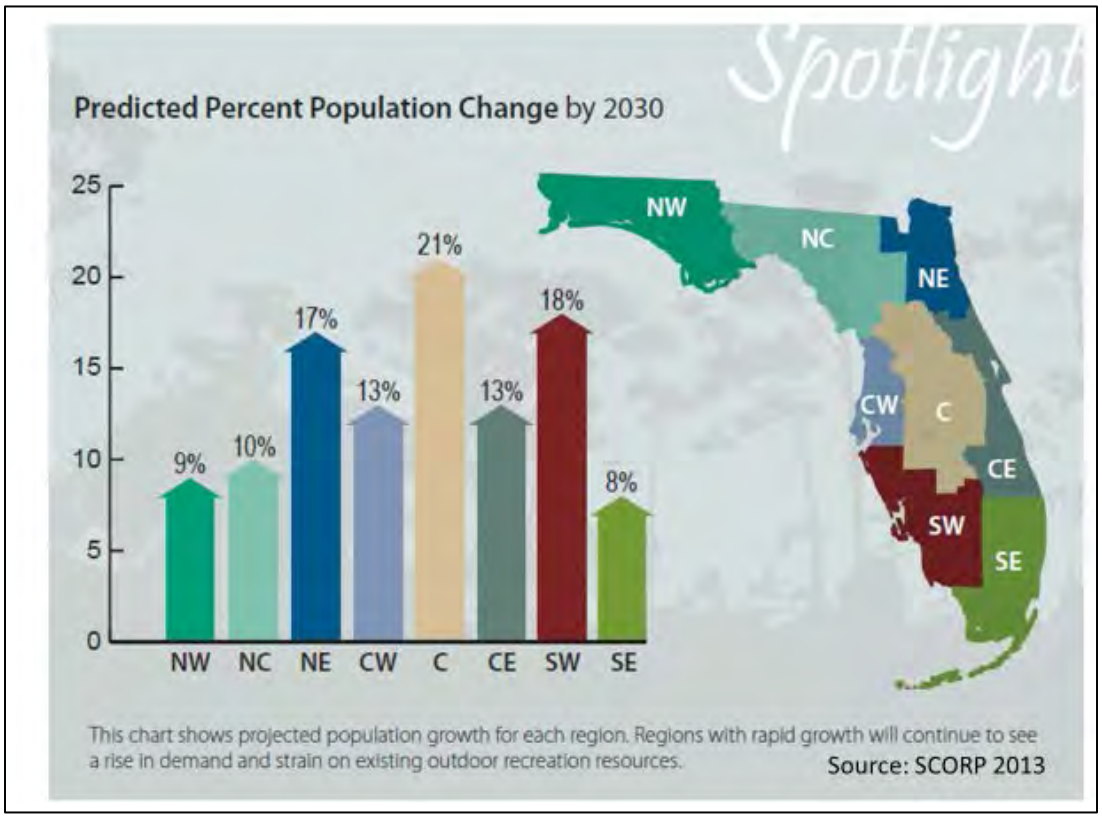

Figure C.1-28. Predicted percent population change by 2030.

C.1.20 Socioeconomics

The LRWRP study area is situated within Martin and Palm Beach counties. The socioeconomics section of this report provides background information on the population of the LRWRP study area and the economic activities that take place in the study area. Such information helps planners to understand what, if any, populations or economic activities might be impacted in the case of a Federal project in the LRWRP study area. For example, information on demographics helps inform whether Environmental Justice issues

are of concern[3], and population data together with information on land use[4] helps inform whether any of the proposed project features may impact the way land is used given future population growth. Socioeconomic information also allows those unfamiliar with the study area to gain background as to the social and economic environment surrounding the proposed project.

C.1.20.1 Existing Conditions

C.1.20.1.1 Population

The 2010 Census count of total population as reported by the United States Census Bureau is the basis for the 2017 population estimates by the University of Florida's Bureau of Economic and Business Research (BEBR 2017) (**Table C.1-17**). These estimates indicate that the populations of Martin and Palm Beach counties have increased since the 2010 census as has the state population. Although the percentage increase in the population of Palm Beach County was approximately two percent lower than that of Florida overall, the county is still the third most populous county in the state based on BEBR's 2017 estimates following only Miami-Dade and Broward counties. Martin County ranked 31st in population out of 67 counties total based on the same estimates.

Table C.1-17: Population estimates of Florida, Martin County, and Palm Beach County.

Geographic Area	2010 Census	2017 BEBR Estimates	Percentage Increase (2010 to 2017)
Florida	18,802,847	20,484,142	8.9%
Martin County	146,318	153,022	4.6%
Palm Beach County	1,320,134	1,414,144	7.1%

Source: 2017 BEBR Population Projections (04/01/2017).

C.1.20.1.2 Demographics

A summary of the racial and ethnic makeup of those living within the study area counties, the state, and the nation based on 2012–2016 ACS data is included in **Table C.1-18**. In general, the makeup of Palm Beach County is similar to that of the state of Florida overall, while Martin County has a relatively higher percentage of white residents and relatively lower percentage of other racial and ethnic groups.

Table C.1-18. Percentage population by race and ethnicity.

Geographic Area	White alone	Hispanic or Latino (of any race)	Black or African American alone	American Indian and Alaska Native alone	Asian alone	Some other race alone	Two or more races
Florida	55.6%	24.1%	15.4%	0.2%	2.6%	0.3%	1.7%

[3] See **C.1.21** for discussion of Environmental Justice (EJ).

[4] See **C.1.18** for discussion of land use.

Martin County	79.4%	12.9%	5.3%	0.2%	1.1%	0.1%	0.9%
Palm Beach County	56.9%	20.7%	17.8%	0.1%	2.5%	0.4%	1.5%

Note: Percentages by geographic area may not sum to 100% due to rounding.

Source: 2012-2016 American Community Survey 5-Year Estimates, U.S. Census Bureau, Demographic and Housing Estimates (DP05)

On the whole, the counties of Martin and Palm Beach have greater median household incomes than the state of Florida and lower percentages of households living below the poverty line than both the state of Florida and the U.S. (**Table C.1-19**). The poverty threshold for 2016 as released by the U.S. Census Bureau was approximately $25,000 per year for a family of four[5]. A few areas in which the percentage of families living below the poverty line are above the state and national levels do exist in the study area, including in the Riviera Beach area and dispersed intermittently in several of the study area's southeastern census tracts. **Figure C.1- 29** shows areas of relatively high poverty within or overlapping the study area.

Table C.1-19. ACS 5-year income and poverty estimates for U.S., Florida, and counties in study area (2012-2016).

Geographic Area	Median Household Income ($)	Families with Income Below the Poverty Line Over Last 12 Months
U.S.	$55,322	11.00%
Florida	$48,900	11.70%
Martin County	$52,622	7.30%
Palm Beach County	$55,277	9.90%

Source: 2012-2016 American Community Survey 5-Year Estimates, U.S. Census Bureau, Selected Economic Characteristics (DP03)

[5] Poverty thresholds for families of different sizes, ranging from one to nine or more people, are released by the U.S. Census Bureau each year.

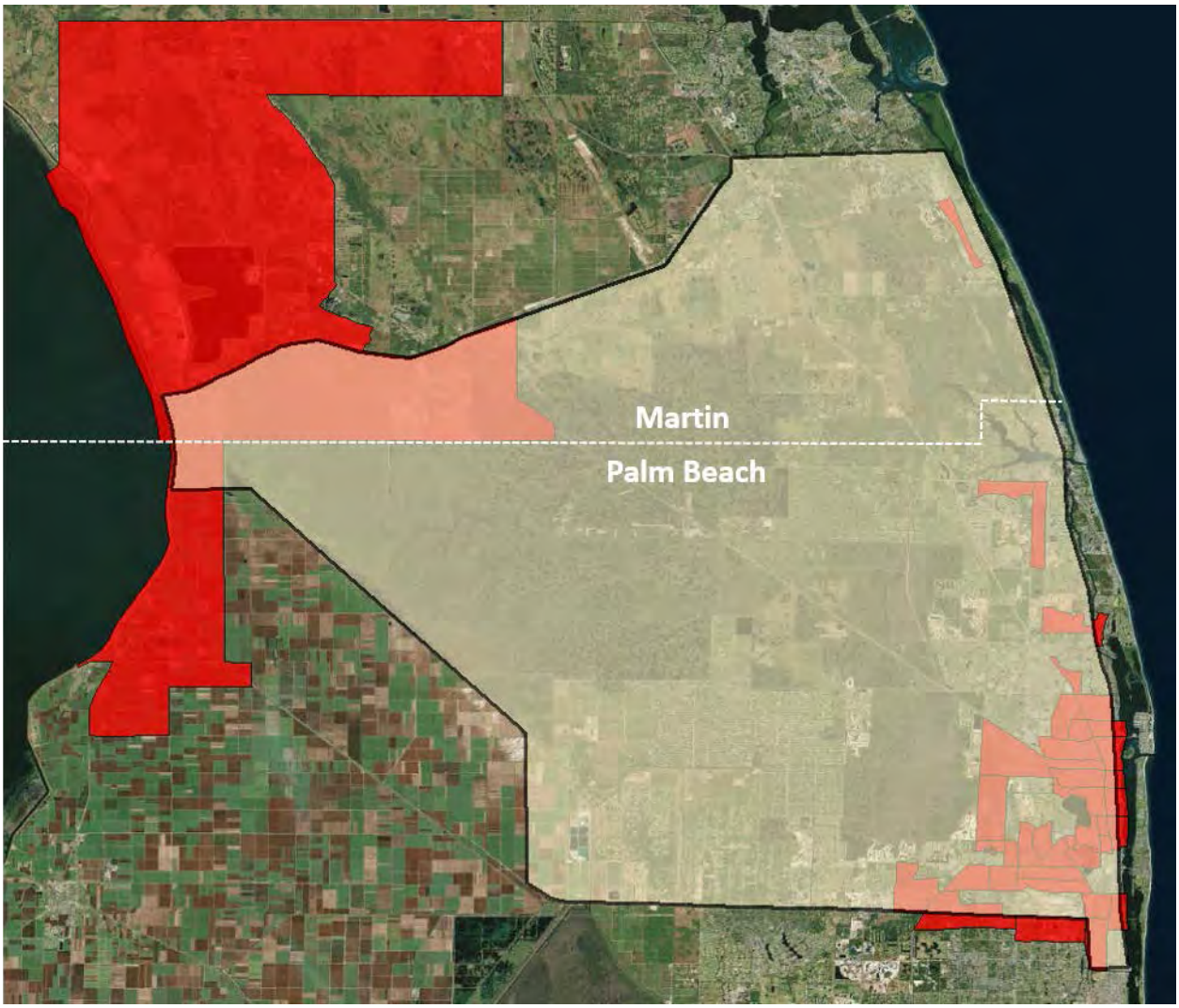

Figure C.1-29. LRWRP Study Area - Census tracts with poverty levels greater than 12 percent of families.

In **Figure C.1-29** above, the LRWRP study area is highlighted in tan. Census tracts fully within or overlapping the study area and having greater than 12% of families with incomes below the poverty line based on 2012-2016 ACS estimates are highlighted in red. The overlap between the study area and the aforementioned Census tracts appears pink/light red.

C.1.20.1.3 Economic Activities

The industries that employ the greatest percentage of residents in both Martin and Palm Beach Counties are (1) educational services and health care followed by (2) the professional, scientific, management, and administrative service industries. The retail and recreation/entertainment (including accommodation and food services) industries rank third or fourth in terms of the number of individuals employed in both counties. **Table C.1-Error! Reference source not found.** below outlines employment by industry and county based on U.S. Census Bureau's 2012-2016 American Community Survey (ACS) data.

Table C.1-20. Employment by industry in Martin and Palm Beach counties.

Industry	Martin	Palm Beach
Educational services, health care, social assistance	21.4%	20.7%
Professional, scientific, management, administrative, and waste management services	13.3%	15.1%
Arts, entertainment, recreation, accommodation, food services	11.6%	12.2%
Retail trade	11.3%	13.1%
Construction	8.8%	7.2%
Finance, insurance, real estate/rental/leasing	7.6%	8.1%
Other services, except public administration	5.9%	5.9%
Manufacturing	5.5%	4.4%
Transportation, warehousing, utilities	4.7%	4.1%
Public administration	3.6%	3.5%
Wholesale trade	2.7%	2.6%
Information	1.9%	2.0%
Agriculture, forestry, fishing and hunting, mining	1.7%	1.0%

Source: 2012-2016 American Community Survey 5-Year Estimates, U.S. Census Bureau, Selected Economic Characteristics (DP03)

As is suggested by the relatively large proportion of jobs attributable to the retail and recreation/entertainment (accommodation and food services) industries, tourism is a major source of economic activity in the area. According to the Official Tourism Marketing Corporation for Palm Beach County, an estimated 7.9 million people visited the county in 2017. [6] While much of the tourism is tied to the area beaches, which are not located directly in the study area, other tourism and recreation opportunities do exist within the bounds of the LRWRP study footprint. According to the 2017 Economic Impact of Outdoor Recreation Activities report completed by the Florida Department of Environmental Protection[7], visitors to Palm Beach County (non-Florida residents) reported participating in a variety of non-saltwater outdoor recreational activities including picnicking (43%), hiking (31%), walking/jogging (26%), outdoor swimming pool usage (26%), wildlife viewing (24%), visiting historical or archaeological sites (18%), golfing (18%), and nature study (19%), among others while visiting the county. The many natural areas, parks, and golf courses in the study area facilitate participation in these activities, thus contributing to the local economy.

6 Sorentrue J. 2018. Record-breaking 7.9 million tourists visited PBC in 2017. Palm Beach Post. <https://www.mypalmbeachpost.com/business/record-breaking-million-tourists-visited-pbc-2017/mS59E9dEP9bSUt6gDjES0L/>. Accessed August 31, 2018.

7 Florida Department of Environmental Protection [FDEP]. 2017. Economic Impact of Outdoor Recreation Activities, Appendix C Activities by County. <https://floridadep.gov/sites/default/files/Appendix%20C_0.pdf>. Accessed August 31, 2018.

C.1.20.2 Future without Project Conditions

Using the existing condition as a baseline, projections of future population, demographics, and economic activities in the study area are used to establish the future without project conditions. These projections from various sources are outlined in the following subsections.

C.1.20.2.1 Population

The Bureau of Economic and Business Research (BEBR) at University of Florida uses U.S. Census Bureau data to project future population at the state and county levels. The latest projections released by BEBR in January of 2018 for Martin and Palm Beach Counties, each of which is partially located within the LRWRP study area, cover the years 2020 through 2045 and are displayed in Table C.1-21. These county-level projections use the April 1, 2010 U.S. Census data as the basis for estimating the April 1, 2017 population. The 2017 population is then used as the starting point to which expected future population change is applied. The projections show consistent population growth in both Martin and Palm Beach Counties through 2045.

Table C.1-21. BEBR population projections for LRWRP planning area for 2010-2045.

Geographic Area		Census	Estimates	Projections					
-		2010	1-April-17	2020	2025	2030	2035	2040	2045
Martin County	Low	146,318	153,022	151,000	152,900	154,300	154,800	154,800	154,700
	Medium			158,400	165,800	171,700	176,700	181,200	185,700
	High			166,100	178,700	190,700	202,300	214,100	226,400
Palm Beach County	Low	1,320,134	1,414,144	1,403,800	1,434,500	1,464,500	1,484,900	1,493,300	1,493,000
	Medium			1,473,000	1,559,600	1,636,400	1,703,700	1,760,000	1,809,800
	High			1,543,400	1,676,400	1,810,200	1,937,500	2,058,200	2,174,900

Sources: Bureau of Economic and Business Research [BEBR]. 2018. Population Projections by Age, Sex, Race, and Hispanic Origin for Florida and Its Counties, 2020–2045, With Estimates for 2017. <https://www.bebr.ufl.edu/population>. Accessed 31 Aug 2018.

C.1.20.2.2 Demographics

In addition to projecting total population, BEBR also projects population by race and ethnicity. Based on the information displayed in Table C.1-22 below, the majority of the total population growth in Martin and Palm Beach counties over the period from 2010 through 2045 is projected to be attributable to growth in the Hispanic population. Approximately 56% and 62% of growth in population in Martin and Palm Beach counties, respectively, is projected to come from this group. This is consistent with the projected demographic trend in Florida overall.

Table C.1-22. BEBR population projections for LRWRP planning area by race and ethnicity.

Geographic Area	Race/ Ethnicity	Census	Estimates	Projections					
		2010	1-Apr-17	2020	2025	2030	2035	2040	2045
Martin	Non-Hispanic White	118,548	120,363	122,597	125,446	127,461	129,002	130,337	131,881

Geographic Area	Race/ Ethnicity	Census	Estimates	Projections					
		2010	1-Apr-17	2020	2025	2030	2035	2040	2045
	Non-Hispanic Black	7,858	8,411	8,827	9,444	9,967	10,372	10,726	11,056
	Hispanic	17,881	22,054	24,685	28,390	31,641	34,589	37,327	39,836
	Other	2,031	2,194	2,309	2,476	2,594	2,708	2,800	2,880
Palm Beach	Non-Hispanic White	804,488	807,564	809,141	810,625	812,247	813,704	814,960	816,065
	Non-Hispanic Black	228,326	253,954	272,351	299,639	324,058	345,296	363,096	378,495
	Hispanic	250,823	311,718	347,578	401,154	448,305	489,552	523,930	554,718
	Other	36,497	40,908	43,920	48,167	51,792	55,187	58,027	60,485

Sources: Bureau of Economic and Business Research [BEBR]. 2018. Population Projections by Age, Sex, Race, and Hispanic Origin for Florida and Its Counties, 2020–2045, With Estimates for 2017. <https://www.bebr.ufl.edu/population>. Accessed 31 Aug 2018.

C.1.20.2.3 Economic Activities

Employment estimates released by the Florida Department of Economic Opportunity (FDEO)[8] show that the industries projected to gain the most new jobs in Palm Beach County over the period from 2017 to 2025 are (1) Ambulatory Health Care Services; (2) Professional, Scientific, and Technical Services; and (3) Food Services and Drinking Places.[9] This is consistent with the industries employing the most individuals in the existing condition. Based on the estimates from the Florida Economic Estimating Conference held by the Florida Office of Economic and Demographic Research in July of 2018, growth in the annual number of tourists visiting the state is expected to continue throughout the forecasted period of 2018 through 2027[10] at annualized rates ranging from 3.0 to 5.5%. Such future growth projections are consistent with the importance of tourism to the study area economy in the existing condition.

C.1.21 Environmental Justice

The United States Environmental Protection Agency (EPA) defines Environmental Justice (EJ) as "the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies." In the above context, fair treatment means that "…no group of people should bear a

[8] These FDEO estimates are calculated using data from the Bureau of Labor Statistics (BLS) and U.S. Census Bureau.

[9] Florida Department of Economic Opportunity [FDEO]. 2018. Employment Projections. <http://www.floridajobs.org/labor-market-information/data-center/statistical-programs/employment-projections>. Accessed August 31, 2018.

[10] Florida Office of Economic and Demographic Research. 2018. Economic Estimating Conference Florida Economy – July 20, 2018 Long Run Conference Results. <http://edr.state.fl.us/Content/conferences/fleconomic/index.cfm>. Accessed August 31, 2018.

disproportionate share of the negative environmental consequences resulting from industrial, governmental, and commercial operations or policies."[11] To this end, the Executive Order 12898 on EJ (February 11, 1994) requires an analysis of environmental effects, including human health, economic and social effects, of Federal actions on minority and/or low-income communities.

C.1.21.1 Existing Conditions

See Section 0 for information on minority and low income populations found within the LRWRP study area in the existing condition.

C.1.21.2 Future without Project Conditions

See Section C.1.20.2.2 for information on minority populations in the future without project. The current study assumes that the presence and location of low income populations within the study area in the future without project condition will be similar to that of the existing condition.

C.1.22 Cultural Resources

The Florida Master Site File (FMSF) data from the Florida Division of Historical Resources lists 38 nationally registered sites, 114 archaeological sites, 18 historical resources groups, 7 cemeteries, 13 bridges, and 6,751 standing structures, within the LRWRP study area. Most of the 38 NRHP listed sites are found in the central to western side of the project area, many of which are prehistoric campsites and middens. There are multiple sites concentrated on the west side of the Loxahatchee River and along Loxahatchee Slough.

C.1.22.1 Future without Project Conditions

There are many previously identified archaeological sites within the region. Future population and associated economic growth may lead to an increase in the development and expansion of infrastructure including construction of roads, commercial businesses, and other facilities that have the potential to adversely impact cultural resources; however, all applicable state and federal regulations pertaining to their preservation would still apply.

C.1.22.2 Existing Conditions

Archaeological evidence indicates the earliest known prehistoric native peoples entered into Florida during the Paleoindian Period at least 12,000 years ago, inhabiting a landscape and environment considerably different from the present (Milanich 1994). At that time, the Florida peninsula was almost double the size of its current area, sea levels were 200 to 350 feet lower, fresh sources of water were limited, and Lake Okeechobee and the Everglades did not exist (Meltzer 1989; Milanich 1994). The interior of Florida was likely covered by extensive and moderately dry expanses of grasslands.

Intensive Paleoindian habitation was most likely restricted to Florida's coastline; however, remnants and other evidence of these coastal habitation sites are currently located offshore, progressively inundated by rising sea levels in the past. Paleo-Indian populations also inhabited interior regions extending

[11] Environmental justice and fair treatment definitions retrieved from https://www.epa.gov/environmentaljustice/learn-about-environmental-justice.

northward from Tampa into the Panhandle. These Tertiary Karst landscapes, are characterized by erosional features such as sinkholes, cave fissures, and deeply-incised stream channels. These features provided Paleoindians access to life-sustaining freshwater. They also provided a lithic source of naturally occurring chert, utilized for tool making, and recovered from exposed areas of the limestone formation (Dunbar and Waller 1983).

Paleoindian populations are characterized as consisting of highly mobile bands of large-game hunters. Projectile points during this period are lanceolates ranging from skillfully fluted (e.g. Clovis) to unfluted varieties (e.g. Suwanee-Simpson). These points, hafted to long stout spears, and propelled by the atlatl, suggest the existence of a subsistence strategy based primarily on hunting large mammals (Wilmsen 1970). In Southeast Florida, Paleoindians hunted mammoths, bison, and other types of megafauna in arid or semi-arid climatic conditions at first, adapting to a transitioning climate toward the end of the period coinciding with the new emerging wetlands, and subsistence strategies relying on marine life, gathering, and small game hunting. Few Paleoindian archaeological sites are recorded in Florida; however, several are identified by the Florida Master Site Files (FMSF) to occur within the LRWRP study area.

During the Archaic Period, lasting from 8500 – 500 BC, the environment and physiology of Florida transformed, undergoing a gradual warming trend, rising sea levels, a reduction in the area of the peninsula, and an increase in the proliferation of oak forests and hammocks within the interior of the state (Milanich 1994). Population increases and cultural changes begin to appear in the archaeological record. The Archaic period is divided into three subperiods –Early (8500 – 5000 BC), Middle (5000 – 3000 BC), and Late (3000 – 500 BC).

The Early Archaic archaeological sites in the study area are not well represented. Similar to the Paleoindian Period, an arid climate, limited freshwater sources, and scarce availability of raw lithic materials for tool-making, likely deterred Early Archaic settlement. During the Middle Archaic, coastal resources were exploited as the modern estuaries began to form resulting in a variety of new settlement and subsistence strategies adapted to local environments. All of the eastern Everglades Middle Archaic archaeological sites are identified as middens representing small habitation sites. With the beginning of the Late Archaic, exploitation of inland areas began, and tree islands are inhabited. Pre-ceramic tree-island middens in the Everglades are radiocarbon dated to around 2500 BC (Schwadron 2006). Importantly, the native peoples of Florida began to make the first pottery during this period.

In south Florida, two distinct Late Archaic cultures developed: the Orange culture and the Glades Archaic culture. Orange cultures sites are typically oyster and coquina shell middens along the coastline of Florida, and freshwater-pond snail middens along the inland rivers and streams. Glades Archaic culture sites are represented as non-ceramic bone middens occurring on interior tree islands in the marshes of south Florida. Faunal remains from Glades Archaic sites are mainly freshwater species, such as fish, turtle, and apple snail.

During the Glades Period (500 BC – AD 1513), cultures are adapting their lifeways regionally, allowing well-defined archaeological geographic cultural subdivisions to be established. The LRWRP area lies within the Glades archaeological region near its boundary with the Okeechobee Basin (or Belle Glade) region of south-central Florida. The Glades region includes all of the areas south of the Caloosahatchee, and south and east of the Okeechobee Basin (Milanich 1994). The area is often referred to as the East Okeechobee Area (Carr and Beriault 1984; Griffen 2002).

The cultural chronology of the Glades Period is founded in the seminal research of John Goggin (1947), who originally defined the Glades I, Glades II, and Glades III subperiods based on analysis of decorated pottery motifs. The early Glades I Period (500 BC – AD 200) is characterized by the presence of undecorated sand-tempered pottery. The undecorated pottery type continues to dominate the late Glades 1 Period; however, the decorated Fort Drum series, including punctated and incised varieties, begin to appear in the archaeological record. During the Glades III Period, newly introduced sand-tempered pottery types (e.g. Key Largo, Miami Incised, and Sanibel Incised) are identified in the archaeological record, allowing further subdivision of the period into the subperiods; Glades IIa, Glades IIb, and Glades IIc. By the Glades III Period (AD 1200 – 1513), decorated pots are almost entirely absent in the archaeological record (Griffen 1989); however, trade in exotic wares are evidenced by the presence of St. John's Checked-Stamped and Safety Harbor sherds recovered from prehistoric middens.

Glades culture sites in the LRWRP occurring near the coast are identified as substantial village settlements consisting of earth and shell mounds, linear canals, and circular embankments. Glades Period subsistence relied on the ample estuarine and tidal marsh resources, and settlements occurred primarily at the mouths of rivers (Milanich 1994). JDSP, located along the Loxahatchee River, presently contains many visible shell mounds. Burial mounds are increasingly common during this period, and archaeological sites containing dark black earth middens proliferate in the archaeological record (Griffen 1989). Temporary or seasonal camps occur inland on dry hammocks and other elevated areas in the sawgrass prairies.

During the early historic period, beginning with the first Spanish colonial period (1513 -1763), the Jaega, a native tribe, inhabited the region of present-day Palm Beach County, and further to the north, the Jobe tribe inhabited present-day Martin County. Their populations declined significantly, largely decimated by European-introduced illness, perilous migrations out of Florida, captivity, and warfare. Subsequently, during the 18th and 19th centuries, the Oconee, Creek, Miccosukee and other indigenous American groups migrated from Georgia, Alabama, and the Carolinas, establishing settlement in North Florida. The U.S. policy of continued Indian removal forced these groups further into south Florida. These groups were collectively referred to as the Spanish term *cimarrone*, meaning runaway, refusing domination by Europeans. The modern word *Seminole* is believed to be a derivative of this term.

The resistance of the Seminoles to the American thirst for new lands, resulted in three wars known as the Seminole Wars. The First Seminole War occurred from 1817 to 1818; the Second Seminole War from 1835 to 1842, and the Third Seminole War from 1855 to 1858. One major battle took place in the in the Palm Beach County area. Known as the Battle of Loxahatchee, and waged in 1838, the battle resulted in the defeat and surrender of a large group of Seminole Indians. As a result of such aggression and forced removal, many Seminole Indians now also live in Texas and Oklahoma. Of the less than 300 Seminoles who evaded capture or removal, the present-day Seminole Tribe of Florida and the Miccosukee Tribe of Indians of Florida are direct descendants.

The East Okeechobee area has been subjected to numerous cultural resources surveys. The major sites reveal evidence of occupation from the Paleoindian Period throughout the Glades Period (500 BC – AD 1763). The Florida Master Site File lists both prehistoric and historic archaeological sites located in the vicinity of the Loxahatchee River Watershed Restoration Project. Important prehistoric Native American sites located within the vicinity of the study area are the Loxahatchee River Complex, located a few miles west of Jupiter Inlet and the Riviera Complex, containing what is believed to be the main Jaega village. There are also shell and burial mounds and earthworks. The Big Mound City site, located ten miles east of Canal Point in the J.W. Corbett wildlife Management Area is the only Belle Glade site listed on the National Register of Historic Places. It represents an excellent example of a Calusa ceremonial complex with

occupation dated from as early as 500 BC to AD 1650. The Big Gopher archaeological site is a unique example of a well-preserved earthwork in the Lake Okeechobee Basin consisting of middens, mounds, crescents, and linear ridges. Historic sites include buildings, shipwrecks, cemeteries, roads, canals, and the Seaboard Air Line Railroad. The railroad, constructed in 1926, crosses a vast expanse of wetlands including the Loxahatchee Slough, and has been recently determined NRHP eligible by the State Historic Preservation Officer as of August 9, 2016.

After European contact, indigenous Native American populations in the region declined, and remained greatly diminished, until others supplanting them moved into southern Florida to escape the U.S. Army and U.S. Governments' forced relocation program to reservations and other areas in the western United States. At present, there are many archaeological sites associated with the Miccosukee Tribe of Indian of Florida and the Seminole Tribe of Florida identified throughout the region.

C.1.22.3 Exiting Conditions of Native Americans

The Miccosukee Tribe of Indians of Florida (MTIF) and the Seminole Tribe of Florida (STOF) are federally recognized tribes who inhabited the lands within the regional vicinity of the LRWRP. Both tribes have routinely utilized the area and share a cultural heritage that regards all indigenous aboriginal populations in Florida as ancestral to their own. These Native American groups (Miccosukee and Seminole) are separated by their languages, having migrated into Spanish Florida in the mid-1700s from Alabama, Georgia, and the Carolinas seeking their own claim to lands opened up by European colonization. The Miccosukee language derived from the Lower Creeks and the Seminole language arose from the Upper Creeks. The U.S. policy of persistent and continued Indian removal, forced these groups further into south Florida, culminating in several wars.

The First Seminole War occurred from 1817 to 1818, the Second Seminole War from 1835 to 1842, and the Third Seminole War from 1855 to 1858. One major battle took place in the within the LRWRP study area in Palm Beach County. Known as the Battle of Loxahatchee, and waged in 1838, the battle resulted in the defeat and surrender of a large group of Seminole Indians. As a result of such aggression and forced removal, many Seminole Indians and other Native American groups of the American Southeast presently reside on federal reservations in Oklahoma and Texas. Of the less than 300 Seminoles who evaded capture or removal by seeking safe-haven, engaging in guerilla warfare, and adapting to life in the Everglades; the present-day Seminole Tribe of Florida, the Miccosukee Tribe of Indians of Florida, and the Independent Seminole of Florida are direct descendants.

The Seminole Tribe of Florida received federal recognition as a sovereign nation in 1957. Other Native American groups, primarily located along Tamiami Trail, in an effort to maintain their own unique cultural identity, independence, and heritage, refused to join in tribal recognition with the STOF. Through their continued persistence and resistance to join, these groups held out to establish their own governance resulting in their federal recognition as the Miccosukee Tribe of Indian of Florida in 1962.

Today the homeland of the Miccosukee Tribe of Indians of Florida are on reservations occupying two counties of southern Florida. The Miccosukee Tribe of Indians of Florida has no land holdings within the LRWRP project area. The population primarily resides within the Tamiami Trail Reservation located 40 miles west of Miami, occupying a land area of 712.64 acres. The Miccosukee also maintain a perpetual lease within Water Conservation Area 3A on lands administered by the South Florida Water Management District. The tribe utilizes this lease to maintain their uniquely adapted Everglades traditional and cultural lifeways including subsistence agriculture, medicinal practices, ceremonial activities, hunting, and fishing.

Alligator Alley Reservation is the Miccosukee Tribe's largest reservation consisting of 74,812.37 acres, on the north and south sides of State Highway 84. Approximately 50,000 acres of this land is set aside for wetlands conservation, and the remaining is planned for development. Two additional smaller reservations are known as the Krome Avenue Reservations located at the intersection of Krome Avenue and Tamiami Trail. These smaller reservations contain the Miccosukee Indian Resort and Gaming operations and the Miccosukee Tobacco Shop.

The Seminole Tribal members reside on several reservations and properties with the largest being those of Big Cypress, Hollywood, and Brighton Reservations. The Seminole Tribe of Florida has no land holdings within the LRWRP project area. Hollywood is the headquarters location for the STOF and the smaller reservations are Tampa, Fort Pierce, and Immokalee. As with the Miccosukee Indians of Florida, the STOF practice traditional cultural activities uniquely adapted to the Everglades, including hunting fishing, agriculture, medicinal, and ceremonial activities. They also engage in modern entrepreneurship through various enterprises including cattle ranching, gaming, and businesses centering on tourism. The culture and traditional practices of both Tribes is closely aligned to the Everglades in such a way that careful consideration of effects is warranted.

C.1.22.4 Future without Project Conditions of Native Americans

The Seminole Tribe of Florida and the Miccosukee Tribe of Indians of Florida will continue to maintain their current and traditional cultural practices including medicinal, ceremonial, subsistence, cattle ranching, and other commercial activities in adaptive response to changes in the natural environment affecting the Everglades ecosystem. Changes in the existing environmental conditions are anticipated to occur as a result of further reductions in the availability and distribution of freshwater in addition to increase in the construction of modern infrastructure such as canals, levees, roads, and other commercial and non-commercial development. Climate change in the form of increased catastrophic or adverse weather events are anticipated in the future. Consequently, these Tribal communities have the potential to be affected by changes in the Everglades that will impact their modern and traditional lifeways.

C.1.23 Invasive Species

Executive Order (E.O.) 13112, entitled Invasive Species, states an "invasive species means an alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health." Alien species (exotic) means, with respect to a particular ecosystem, any species, including its seeds, eggs, spores or other biological material capable of propagating that species and is not native to that ecosystem. Invasive species are broadly defined and can be a plant, animal, fungus, plant disease, livestock disease or other organism. A native species is defined as a species that historically occurred or currently occurs in a particular ecosystem and is not the result of an introduction.

C.1.23.1 Existing Conditions

Significant scientific evidence and research documents that invasive non-native plants are degrading and damaging south Florida natural ecosystems (Doren and Ferriter 2001). Many species are causing significant ecological impacts by crowding out and displacing native plants, altering soil types and soil/water chemistry, altering ecosystem functions such as carbon sequestration, nutrient cycling and fire regimes, and reducing gene pools and genetic diversity. Non-native invasive animal distribution, extent and impacts are not well understood, however implications of invasive animals are apparent in south Florida. In addition to environmental impacts, invasive species impact human health, reduce agricultural production and property values, degrade aesthetic quality, decrease recreational opportunities and

threaten the integrity of human infrastructure such as waterways/navigation channels, locks, levees, dams and water control structures.

Florida is particularly vulnerable to the introduction, invasion, and naturalization of non-native species. This is due to several factors, including a subtropical climate, dense human population centers, major ports of entry, and the pet, aquarium, and ornamental plant industries. Major disturbance to the landscape has also increased Florida's vulnerability to invasive species. Alteration of the landscape for urban development, flood control and agricultural uses has exacerbated non-native plant and animal invasions. On average, 10 new organisms per year are introduced into Florida that are capable of establishing and becoming invasive and causing environmental harm. Approximately 90% of the plants and animals that enter the continental United States enter through the port of Miami (Cuda 2009a). Stein, Kutner and Adams (2000) estimated that over 32,000 exotic species (25,000 plants and 7,000 animals) have been introduced into Florida. There are approximately 4,000-5000 native species of plants and animals in Florida. The number of non-native species that have been introduced is eight times the total number of native species in the entire state.

The Guide to the Vascular Plants of Florida (Wunderlin 1998) documented 3,834 plant species in Florida. Of these, 1,180 were considered non-native and were naturalized (freely reproducing) populations. The Florida Exotic Pest Plant Council (FLEPPC) identifies 81 of the 1,180 species of non-native plants as Category I species and 87 as Category II species in the 2017 Invasive Plant List. Searches through existing data and resources indicate 110 non-native plant species have been documented to occur within the project area (See **Annex F, Table 1**). Other non-native species are probably present; however, documented citations could not be located. Of the 110 species of plants documented to occur within the project area, there are 59 FLEPPC Category I species, 39 FLEPPC Category II species and 22 Florida Noxious Weed species.

Plants that are widely established within the project area include Australian pine (*Casuarina equisetifolia*), Old World climbing fern (*Lygodium microphyllum)*, melaleuca (*Melaleuca quinquenervia),* Brazilian pepper (*Schinus terebinthifolius),* cogon grass (*Imperata cylindrical)*, torpedo grass (*Panicum repens),* creeping water-primrose (*Ludwigia spp.),* downy rose myrtle *(Rhodomyrtus tomentosa),* shoe button ardisia *(Ardisia crenata),* water hyacinth (*Eichhornia crassipes*) and water lettuce (*Pistia stratiotes*). There are 19 species of plants that are considered localized/Early Detection Rapid Response (EDRR) species (See Annex F). Other non-native plant species of concern that are managed for containment or eradication include tropical American water grass (*Luziola subintegra*), exotic black mangrove (*Lumnitzera racemosa*), mile-a-minute (*Mikania micrantha*) and Wright's nutrush (*Scleria lacustris*).

A primary native nuisance species within the project area is cattail (*Typha* spp). Many areas within the project area have been invaded by cattails. This is attributed to water with increased phosphorus being delivered to these areas which began in the late 1950s. Areas where water control structures, conveyance features, and levees exist provide a suitable habitat for invasion and expansion of cattail.

Searches through existing data and resources indicate 65 animal species have been documented to occur within the project area (See **Annex F**). Other non-native animal species are probably present, however, documented citations could not be located. Information regarding species presence and distribution is largely incomplete for most taxonomic groups of animals. Not all of the 65 non-native animal species identified and documented to occur in the LRWRP area will have a significant impact on the ecosystem.

Key species of carnivorous reptiles, such as the Burmese python (*Python molurus bivittatus*), Nile monitor (*Varanus niloticus*) and Argentine black and white tegu (*Salvator merianae*), have been located within the project area. As of 2018, these occurrences have been isolated but there is concern regarding further spread of these species from south of the project area. The 3 species along with the North African python are considered EDRR species for the project area. These species have potential to cause significant impacts to the ecosystem and are among south Florida's most threatening invasive animals. These species are considered top predators and increase additional pressures on native wildlife populations, particularly threatened and endangered species (SFER 2013). Other species of concern are addressed in Annex F.

C.1.23.2 Future without Project Conditions

Since the climate of south Florida is subtropical it presents a hospitable environment for non-native species to establish, inhabit, and become invasive. Currently, many non-native invasive species are thriving and negatively affecting the ecology throughout the project area. During the period between present and 2050, it is expected that anthropogenic effects will continue to negatively impact the project area therefore it is expected new invasions and expansion of current invasive species will continue in the future. Many factors affect the future expansion and reduction of invasive species currently present within the project area. In addition, there are numerous factors that affect new introductions of invasive species. This constrains the ability to predict the populations, new introductions and expansion and reduction of invasive species. Each species has a diverse and intricate biological heritage which influences their ability to inhabit and thrive in areas outside of their native range. Factors that affect invasive species introductions are presented below.

Canals within the project area provide deep-water refugia for species of tropical fish and serve as pathways for invasive species to travel, spread and expand into previously uninhabited areas. Currently, drier conditions within the project area are being experienced due to compartmentalization and diversion of water. The historically wetter areas that are now experiencing drier conditions will continue to shift in vegetation composition. Woody shrubs such as willow and invasive species such as melaleuca will continue to expand in these areas. Continued deliveries of nutrient rich water to the project area will further promote the expansion of cattail. Sea level rise is expected in the future which will allow saltwater species to invade further inland.

Environmental manipulation and construction activities, urban development, and agriculture will continue to provide disturbance within south Florida. Natural weather events, such as floods, droughts and hurricanes, will also provide disturbance and avenues for invasive species introduction and expansion. Disturbance of any type promotes the establishment and expansion of invasive species.

Management of invasive species within the project area is conducted by several agencies. The magnitude of the control programs within the project area is dependent upon the level of funding available. Portions of allocated funding for these programs have been and potentially will be redirected to other programs in the future. Management activities vary in effectiveness which also influences species control and spread within the project area. Management components will be incorporated into CERP projects which will reduce some species within those projects. This will reduce sources for invasions into other areas. Little is known about control and management measures for the majority of species already present, therefore these species will perpetuate and spread to other areas.

The large aquarium, pet, and ornamental plant industries import new non-native species into Florida on a regular basis. Therefore, new invasive species introductions will continue to occur. On average, each

year 10 new non-native organisms are introduced into Florida that are capable of establishing, becoming invasive, and causing environmental harm. New imported non-native species introductions will occur through intentional and unintentional releases. Educational efforts may slightly reduce the number of intentional releases.

The deeper navigation channels and expansion of ports in Florida, such as Miami and Port Everglades, will provide new trade opportunities for the state. Deeper channels will allow larger container cargo vessels to enter the ports. As a result, it is expected the Port of Miami will double its cargo traffic over the next several years. With the completion of the projects and as cargo traffic increases, it is expected the number of non-native species introductions into Florida will likely increase. The ships, barges, and goods coming into these ports come from all over the world. Ports are known points for species to be introduced from native to non-native locations.

C.1.24 Airport-Wildlife Hazard Assessment

Aircraft-wildlife strikes pose risks to safe aviation and wildlife conservation. The 2003 Memorandum of Agreement (MOA) (FAA 2003) between the Federal Aviation Administration (FAA), the U.S. Air Force, USACE, EPA, USFWS, and the U.S. Department of Agriculture - Wildlife Services (WS) established procedures necessary to coordinate their agency missions to more effectively address existing and future environmental conditions contributing to aircraft-wildlife strikes throughout the United States. The MOA applies to National Plan of Integrated Airport Systems (NPIAS) airports. These efforts are intended to minimize wildlife risks to aviation and human safety, while protecting the Nation's valuable environmental resources. The NPIAS encompasses approximately 3,400 airports in the national network of airports and the national airport plan, which identifies existing and proposed new airports to serve commercial and general aviation needs. The NPIAS contains all commercial service airports, all reliever airports, and selected general aviation airports. Specific criteria were established to meet national aviation needs at a reasonable cost. These criteria considered the number of based aircraft and annual operations, scheduled air carrier service, and proximity to other airports in the national plan. Airports that met special needs, such as access to remote populations, could also be included.

One of the three major activities of most concern identified in the MOA, "development of conservation/mitigation habitats or other land uses that could attract hazardous wildlife to airports or nearby areas" is relevant to the LRWRP, as the project purpose involves restoration of habitats used by numerous wildlife species including federally-endangered or threatened species. The agencies agreed that "information and analyses relating to mitigation that could cause or contribute to aircraft-wildlife strikes should, whenever possible, be included in documents prepared to satisfy the National Environmental Policy Act (NEPA). This should be done in coordination with appropriate signatory agencies to inform the public and Federal decision makers about important ecological factors that may affect aviation. This concurrent review of environmental issues will promote the streamlining of the NEPA review process."

The MOA recommends an analysis of project effects within the separation distances of 5,000 feet (airports serving piston-powered, e.g., propeller aircraft), 10,000 feet (airports selling Jet-A fuel, e.g., serving turbine-powered aircraft), and 5 miles (airspace surrounding airport). The FAA recommends a separation distance of 5 statute miles between the farthest edge of the airport's airport operations area (AOA) and a hazardous wildlife attractant if the attractant could cause hazardous wildlife movement into or across the approach or departure airspace. The basis for the separation criteria is found in existing FAA regulations. The separation distances are based on (1) flight patterns of piston-powered aircraft and turbine-powered aircraft, (2) the altitude at which most strikes happen (78 percent occur under 1,000

feet and 90 percent occur under 3,000 feet above ground level), and (3) National Transportation Safety Board (NTSB) recommendations (FAA 2007, AC150/5200-33B). The following discussion provides an analysis of TSP existing conditions and future without project conditions.

C.1.24.1 Existing Conditions

Five airports are located within the LRWRP project area (**Table C.1-23**, **Figure C.1-30**,). Of these, the Palm Beach International (KPBI), with an average of 384 aircraft operations/day and North Palm Beach County Airport (F45), with an average of 267 aircraft operations/day, are NPIAS airports. The other three airports, William P. Gwinn Airport (FAA ID 06FA), Tailwinds Airport (FAA ID FD15), and Br Ranch Airport (FAA ID 82FL) are not in the NPIAS system and, therefore, pursuant to the MOA, NEPA analysis is not provided.

Table C.1-23. NPIAS and other airports within the LRWRP project area.

County	Airport Type	FAA ID	Airport Name	Aircraft based on the field	Single engine airplanes	Multi engine	Jet airplanes	Heli-copters	Ultra-lights	Military
Martin	Private	06FA	William P. Gwinn	30				30		
Martin	Private	FD15	Tailwinds Airport	38	25	8	1	2	2	
Martin	Private	82FL	Br Ranch Airport	2	1			1		
Palm Beach	NPIAS	F45	North Palm Beach County General Aviation Airport	293	160	39	3	41		50
Palm Beach	NPIAS	KPBI	Palm Beach International	167	6	5	141	15		

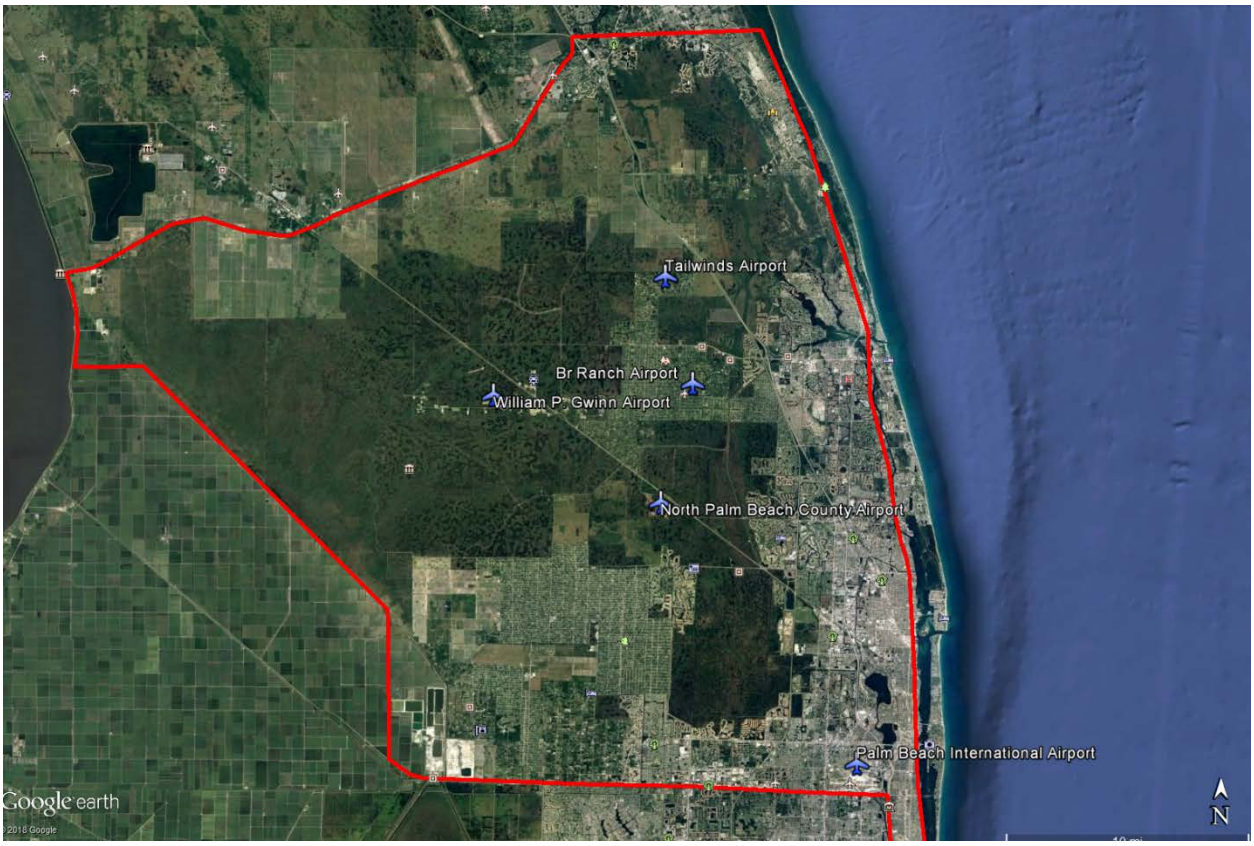

Figure C.1-30. Map of airports in the LRWRP project area.

C.1.24.1.1 NPIAS Airports

The North Palm Beach County General Aviation Airport, built c. 1994, is a general aviation airport with multiple 4,000-foot asphalt or turf runways lying generally southwest of Flow-way 2, 12 miles northwest of West Palm Beach FL. The airport is set in a vast landscape of wetlands dominated by depressional marsh and drainage canals, and has more than 30 acres of vegetated stormwater detention basins within the AOA. Operational notes acknowledge the presence of ongoing bird activity in the vicinity of the airport. Three strikes have been reported to the FAA Strike Database (**Table C.1-24**).

Table C.1-24. FAA Wildlife Strike Database reports for North Palm Beach County General Aviation Airport.

INCIDENT DATE	ATYPE	SPECIES	TIME	RUNWAY NO.	HEIGHT (ft)	SPEED (mph)	PHASE OF FLIGHT
3/13/2018	PA-34 SENECA	Turkey vulture	0200	32	400	100	Climb
4/4/2014	ROBINSON R22	Turkey vulture	1430	13	700	65	Climb
4/23/2008	PA-32	Unknown bird - large	1600		1200	110	Descent

The Palm Beach International Airport, built c. 1970, is a Part 139 certificated commercial airport with multiple 10,000 foot, 6,000 foot and 4,000 foot asphalt runways lying generally southeast of Flow-way 2,

3 miles west of West Palm Beach. The airport is set within the heavily urbanized Palm Beach Lakes area of northeast Palm Beach County, about 1.5 miles west of the Lake Worth Lagoon, immediately north of Lake Lytal Park and Trump International Golf Club, and about 1.5 miles south of Bear Lake Country Club, Lake Magonia, and Clear Lake. More than 30 acres of vegetated stormwater detention basins and rim canals are distributed within the AOA. Operational notes acknowledge the presence of ongoing bird activity in the vicinity of the airport. Of the 346 bird strikes reported to the FAA Strike Database, >57% were due to unknown birds. Migratory barn swallows, black and turkey vultures, gulls and wadingbirds accounted for 1-3% of the other reports (**Table C.1-25**).

Table C.1-25. FAA Wildlife Strike Database reports for Palm Beach International Airport 1990–2018.

Species	# of Reported Strikes
American kestrel Count	5
American robin Count	1
Barn swallow Count	21
Black vulture Count	1
Blackbirds Count	3
Brown pelican Count	2
Burrowing owl Count	2
Cattle egret Count	4
Cliff swallow Count	1
Common grackle Count	1
Common gray fox Count	1
Crows Count	1
Double-crested cormorant Count	1
Doves Count	5
Ducks Count	1
Egrets Count	10
European starling Count	8
Gray catbird Count	1
Gulls Count	17
Hawks Count	1
Horned lark Count	1
Killdeer Count	6
Merlin Count	1

Species	# of Reported Strikes
Mourning dove Count	5
New World Vultures Count	8
Nightjars Count	1
Osprey Count	2
Perching birds (y) Count	3
Peregrine falcon Count	2
Rock pigeon Count	2
Sandhill crane Count	1
Shorebirds Count	1
Sparrows Count	6
Swallows Count	6
Turkey vulture Count	14
Unknown bird Count	43
Unknown bird - large Count	18
Unknown bird - medium Count	61
Unknown bird - small Count	74
Unknown bird or bat Count	2
Veery Count	1
Wood thrush Count	1
Grand Count	346

C.1.24.1.2 Non-NPIAS Airports

Non-NPIAS airports are general aviation airports or civilian airports that do not serve scheduled passenger service and usually serve private aircraft and small aircraft charter operations. William P. Gwinn Airport is a private 7,000-foot asphalt runway lying west of SR 710 (Beeline Highway) and the Pratt-Whitney facility,

24 miles south of Jupiter. Tailwinds Airport is a private 2,700-foot asphalt runway within an airpark neighborhood, lying north of the Ranch Colony Canal, southeast of the Nine Gems parcel, and west of Moonshine Creek and Cypress Creek, five miles northwest of Jupiter. Br Ranch Airport is a private short-runway airport within a densely developed residential area, lying west of the C-14 Canal and north of the C-18 Canal, six miles southwest of Jupiter. No strikes have been reported to the FAA Strike Database for these three airports.

C.1.24.2 Future without Project Conditions

The Palm Beach International Airport and North Palm Beach County General Aviation Airport are anticipated to continue operations and air traffic similar to current operations.

C.1.24.2.1 NPIAS Airports

Future airport expansion of Palm Beach International Airport described in the airport master plan, and is restricted by existing highways and surrounding development, while expansion at North Palm Beach Airport is restricted by the proximity to the Beeline Highway on the east, and surrounding wetlands around the rest of the airport. North Palm Beach Airport recently expanded with a 22,000-square-foot, two-story building joined with a 30,000-square-foot hangar, two flight simulators, and an aircraft testing lab and machine shop connected to the hangar, and has future expansion plans.

C.1.24.2.2 Non-NPIAS Airports

The private airports are anticipated to continue operations, with air traffic similar to current operations. Future airport expansion is restricted by the residential areas surrounding the Tailwinds and Br Ranch airports, and by expansive wetlands surrounding William P. Gwinn Airport.

C.1.25 Water Supply and Groundwater Resources

Groundwater resource availability is defined under two separate water supply plans by the SFWMD. Martin County resources are evaluated within the Upper East Coast (UEC) water supply plan (SFWMD, 2016). Palm Beach County water resources are evaluated within the Lower East Coast (LEC) water supply plan (SFWMD 2013). Groundwater resources are used for drinking water, industrial, and agricultural irrigation water supply, obtained primarily from the surficial aquifer system (SAS) and the Floridan Aquifer System (FAS).

In the UEC planning area, the SAS supplies approximately 40 percent of the public water supply (drinking water, industrial water), and the FAS (primarily the Upper Floridan Aquifer, UFA) supplies the remaining 60 percent (SFWMD, 2016). Irrigation water is supplied through a combination of surface water, SAS groundwater, and reclaimed water.

In the LEC planning area, the SAS supplies approximately 94 percent of the public water supply (SFWMD 2013). The high proportion of source groundwater is due to the use of the Biscayne Aquifer of Broward and Miami-Dade Counties. Closer to the LRWRP project area, the coastal utilities (Seacoast Utility Authority, Jupiter, and Tequesta) rely on SAS and FAS for the public water supply, similar to those in the UEC (**Figure C.1-**). Elsewhere near the project area, the City of West Palm Beach Public Utilities Department use surface water conveyed via canals from Lake Okeechobee eastward through the GWP, Clear Lake, and Lake Mangonia for public water supply. In addition to surface water, SAS groundwater commonly is used for urban and agricultural water supply in the project area.

C.1.25.1 Existing Conditions

In Martin County (UEC planning area), the unconfined SAS serves as the primary source of potable water for drinking water and landscape irrigation water supply, but the county is also developing alternative water sources in the FAS. SAS and FAS wellfields for public water supply are located along the coast at Tequesta and South Martin Regional Utility (Hobe Sound). Martin County Water Utilities also supplies potable water to unincorporated areas, using the SAS at the southeastern and southwestern wellfields. The most primary producing zone of the SAS in Martin County is a marine sand, shell with thin lenses of sandstone and limestone, buried at depths of 20 ft to 50 ft beneath the surficial sand. The average thickness of the SAS primary producing zone is 130 ft to 150 ft on average (SFWMD, 2016). The SAS is recharge by rainfall infiltration, or by bank infiltration from canals and surface water bodies. Groundwater quality in the SAS at the coastal wellfields of Martin County is fresh, with chloride concentrations less than the drinking water MCL of 250 mg/L (SFWMD, 2016).

In order to meet or exceed current water supply demands and to maintain sufficient SAS groundwater for environmental restoration, most coastal communities are developing alternative water supplies in the FAS (primarily the UFA). However, groundwater quality in the UFA is brackish. Chloride concentrations range between 440 mg/L and 1,050 mg/L, and total dissolved solids (TDS) concentrations range between 1,200 and 2,150 mg/L in UFA wells throughout Martin County. Use of the UFA for water supply requires treatment by reverse osmosis (RO) to remove salinity and hardness. The RO-treated groundwater is then blended with treated SAS water for subsequent distribution. Current (2015) consumptive use permit allocations using the SAS and UFA at all Martin County and Palm Beach County water utilities is shown in **Figure C.1-31**.

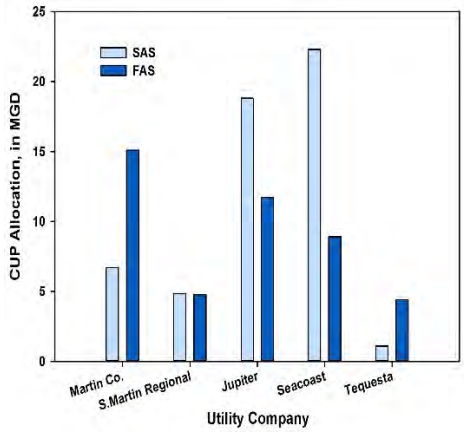

Figure C.1-31. Bar graph showing 2015 consumptive use permit allocations (in million gallons per day) in coastal Martin and Palm Beach counties. Data from SFWMD (2016).

Groundwater quality in UFA samples from wells in eastern Palm Beach County (SCU-MZU) and Martin County (MF-35B) is brackish. Chloride concentrations in both wells range between 3,400 mg/L and 4,600 mg/L; TDS concentrations range between 3,600 mg/L and 5,100 mg/L. Closer to the coast, chloride concentrations in the town of Jupiter reverse osmosis wells RO-5 and RO6. Groundwater quality in the UFA of central and eastern Palm Beach County is brackish, and so would require RO treatment prior to blending with fresh SAS groundwater.

The Avon Park Permeable Zone (APPZ) is a thick, transmissive aquifer that occurs below the UFA throughout south Florida (Reese and Richardson, 2008). Groundwater quality characteristics of the APPZ are defined in monitor wells SCU-MZL and JUP-RO4. Native groundwater quality is similar in the UFA and APPZ in eastern Palm Beach County. Chloride concentration measured in SCU-MZL_is 6,700 mg/L; ; TDS concentrationis 13,100 mg/L. Chloride concentrations in JUP-RO4range between 1,500 mg/L and 2,000mg/L, and at the time of well construction, chloride concentrations were lower in the APPZ compared to the overlying UFA.

C.1.25.2 Future without Project Conditions

Total water demands are expected to increase in both Martin County and Palm Beach County in the future. In Martin County, population is expected to increase by 22 percent in 2040, and public water supply demands will increase from 47.6 MGD to 73.2 MGD (SFWMD, 2016). It is unlikely that the increased demand can be met by increasing consumptive use permit allocations in the SAS without depleting the aquifer, and reducing groundwater seepage to the Loxahatchee River. In addition, Martin County is within the "Artesian Pressure Protection Area" so that additional pumping from the UFA cannot reduce artesian flow by more than 10 percent. The demand will be met by a combination of LRWRP features,

In Palm Beach County, population is expected to increase by 25 percent in 2030, and total water supply demand will increase by 20 percent to 1,008 MGD (SFWMD, 2013). Most of the increased demand is in public water supply. It is likely that Palm Beach County will meet the increased water demand by diversifying water supply sources and developing alternative water supplies such as brackish water RO, reclaimed water, and ASR and in-ground reservoirs for storage.

C.1.26 References

Abrahamson, W.G. and D.C. Hartnett. 1990. Flatwoods and dry prairies. Pp. 103-149 in R.L. Myers and J.J. Ewel, eds., Ecosystems of Florida. University of Central Florida Press, Orlando.

Anderson, S., 2008. Hydrogeologic Investigation of the Floridan Aquifer System at L-8 (PBF-15), Palm Beach County, FL. Technical publication WS-25, South Florida Water Management District, 136 p.

Arcadis Design and & Consultancy, 2016. Mecca Impoundment, Palm Beach County, Florida. Work Order No. 4600003011-WO01. Final Design Documentation Report.

Bent, A.C. 1926. Life histories of North American marsh birds. U.S. Natl. Mus. Bull. 135.

Breininger, D.R., M.R. Bolt, M.L. Legare, J.H. Drese, and E.D. Stolen. 2011. Factors influencing home-range sizes of eastern indigo snakes in central Florida. Journal of Herpetology 45:484–490.

Breininger, D. R.; Mazerolle, Marc J.; Bolt, M. R.; Legare, M. L.; Drese, J. H.; and Hines, J. E. 2012. Habitat fragmentation effects on annual survival of the federally protected eastern indigo snake. NASA Publications. 106.http://digitalcommons.unl.edu/nasapub/106.

Carr, R.S. and J.G. Beriault 1984. Prehistoric Man in South Florida. In Environments of South Florida: Present and Past. (2nd ed.), edited by P.J. Gleason, pp. 1-14. Miami Geological Society Memoir 2. Miami.

Christensen, R.F. 1965. An ichthyological survey of Jupiter Inlet and Loxahatchee River, Florida. Ph.D. Dissertation, Florida State University, Tallahassee, Florida.

C & N Environmental Consultants, Inc. 2002. Cypress Creek/Pal-Mar and the Groves Basins Study: 2.1.1. Wetland System Assessment.

Coulter, M.C. 1987. Foraging and breeding ecology of wood storks in East-Central Georgia. Pages 21-27, *in* Proceedings of the Third Southeastern Nongame and Endangered Wildlife Symposium, R.R. Odom, K.A. Riddleberger, and J.C. Ozier (Eds.). Georgia Department of Natural Resources, Game and Fish Division.

Coulter, M.C. and A.L. Bryan, Jr. 1993. Foraging ecology of wood storks (*Mycteria americana*) in east central Georgia: Characteristics of foraging sites. Colonial Waterbirds 16:59-70.

Cuda, J.P. 2009a. Invasive Species: A Florida Perspective. Entomology and Nematology Department, University of Florida, Institute of Food and Agricultural Sciences.

Dahl, T. E. 1990. Wetlands losses in the United States 1780s to 1980s. U. S. Department of the Interior, U. S. Fish and Wildlife Service, Washington, D. C.

Doren, R.F., A.P. Ferriter, and H. Hastings (Eds.). 2001. Weeds Won't Wait!: The Strategic Plan for Managing Florida's Invasive Exotic Plants, Part One: An Assessment of Invasive Plants in Florida. A Report to the South Florida Ecosystem Restoration Task Force and Working Group, FL. 273 pp.

Dunbar, J.S. and B. Waller 1983. A Distribution Analysis of the Clovis/Suwanee Paleo-Indian Sites of Florida – A Geographic Approach. The Florida Anthropologist, Vol. 36, Nos. 1-2, March-June.

Ecology and Environment, Inc. 2009. Nine Gems Restoration: Field Studies and Recommendations Report. Report prepared for SFWMD dated February 2009, 29 p.

Ecology and Environment, Inc. 2010. Comprehensive Everglades Restoration Plan, North Palm Beach County – Part I Project, draft Alternatives Formulation Briefing. Report prepared for USACE and SFWMD dated August 2010, variously paginated.

Executive Order Number 13112 64 F.R. 6183 (February 8, 1999).

Florida Atlantic University (FAU) CUES. 2007. Palm Beach County Manatee Protection Plan. Ecological Associates, Inc. July 2007.

Florida Department of Environmental Protection (FDEP). 2002. Loxahatchee River Watershed Action Plan. Loxahatchee River Watershed Management.

Florida Department of Environmental Protection [FDEP]. 2018. Coral Reef Conservation Program. https://floridadep.gov/rcp/rcp/content/floridas-coral-reefs.

Florida Exotic Pest Plant Council (FLEPPC). 2017. List of Invasive Plant Species. Florida Exotic Pest Plant Council. Internet: www.fleppc.org

Florida Fish and Wildlife Conservation Commission (FWC). 2016. Florida's Imperiled Species Management Plan. Tallahassee, Florida.

Florida Fish and Wildlife Conservation Commission (FWC). 2017. Annual report on the research and management of Florida panthers: 2016-2017. Fish and Wildlife Research Institute & Division of Habitat and Species Conservation, Naples, Florida, USA.

Florida Natural Areas Inventory (FNAI). 2010. Guide to the natural communities of Florida: 2010 edition. Florida Natural Areas Inventory, Tallahassee, Florida.

Gannett Fleming, Inc., 2016. Final Geotechnical Data Report for the J.W. Corbett Wildlife Management Area Hydrologic Assessment. Report prepared for South Florida Engineering and Consulting, LLC, dated 28 January 2016, 71 p.

Gawlik, D.E. 2002. The Effects of Prey Availability on the Numerical Response of Wading Birds. *Ecological Monographs*, 72(3), 2002, pp. 329-346. Ecological Society of America.

Gawlik, D.E., Crozier, G., and Tarboton, K. H. 2004. Wading Bird Habitat Suitability Index. Pages 111-127. In *Habitat Suitability Indices for Evaluation Water Management Alternatives*, K.C. Tarboton, M. M. Irizarry-Ortiz, D. P. Loucks, S. M. Davis, and J. T. Obeysekera.. Technical Report, South Florida Water Management District, West Palm Beach, Florida, USA.

Geraghty & Miller, 1986. Well construction report for the ENCON injection well (PB-1170). Data available on DBHydro at http://my.sfwmd.gov/dbhydroplsql/show_multimedia.display_list?p_station=PB-1170

Goggin, J.M. 1947. A Preliminary Definition of Archaeological Areas and Periods in Florida. American Antiquity 13:114-127.

Griffen, J.W. 1989. The Archeology of Everglades National Park: A Synthesis. National Park Service Southeastern Archaeological Center, Tallahassee.

Griffen, J.W. 2002. The Archaeology of Everglades. University Press of Florida, Gainesville.

Hefner, J. M., B. O. Wilen, T. E. Dahl, and W. E. Frayer. 1994. Southeast wetlands: status and trends, mid-1970s to mid-1980s. U.S. Fish and Wildlife Service, Region 4, Atlanta, GA, USA.

Herring, G. and D. E. Gawlik. 2007. Multiple nest-tending behavior in an adult female white ibis. Waterbirds 30:150-151.

Howell, A.H. 1932. Florida bird life. Coward-McCann, Inc.; New York, New York.

Humphrey, S.R. and J.L. Morrison. 1997. Habitat associations, reproduction and foraging ecology of the Audubon's crested caracara in south-central Florida. Final report to Florida Game and Fresh Water Fish Commission for Project No. NG91-007. Florida Game and Fresh Water Fish Commission; Tallahassee, Florida.

Kautz, R., R. Kawula, T. Hoctor, J. Comiskey, D. Jansen, D. Jennings, J. Kasbohm, F. Mazzotti, R. McBride, L. Richardson, and K. Root. 2006. How Much Is Enough? Landscape-scale Conservation for the Florida Panther. Biological Conservation.

Kendrick, M. M., and M. T. Mengak. 2010. Eastern Indigo Snake (Drymarchon couperi). Retrieved May 23, 2011, from The Warnell School of Forestry and Natural Resources: http://www.forestry.uga.edu/outreach/pubs/pdf/NHS10-12.pdf.

Kuniansky, E.L., Bellino, J.C., and Dixon, J.F., 2012. Transmissivity of the Upper Floridan Aquifer in Florida and parts of Georgia, South Carolina, and Alabama. US Geological Survey Scientific Investigations Map 3204, 1 sheet, scale 1:1,000,000 available at https://pubs.usgs.gov/sim/3204/

Marks, C. S., and G. E. Marks. 2006. Bats of Florida. University Press of Florida. Gainesville, Florida.

Meltzer, D.J. 1989. Why don't we know when the when the first people came to North America? *American Antiquity* 54(3): 471-490

Milanich, J.T. 1994. Archaeology of Precolumbian Florida. University Press of Florida.

Miller, J.A., 1986. Hydrogeologic framework of the Floridan Aquifer System in Florida and in parts of Georgia, Alabama, and South Carolina. US Geological Survey Professional Paper 1403-B, 87 p. plus plates. Accessed at https://sofia.usgs.gov/publications/papers/pp1403b/pp1403-b_mag/index.html

Mitsch, W.J. and J.G. Gosselink. 2015. Wetlands, 5th Edition. John Wiley & Sons, Inc.

Moler, P.E. 1992. Eastern indigo snake. Pages 181-186 in P.E. Moler, ed. Rare and endangered biota of Florida, volume III, Amphibians and Reptiles. University Press of Florida; Gainesville, Florida.

Morrison, J.L. 1998. Effects of double brooding on productivity of Crested Caracaras. Auk 115(4):979-987.

Morrison, J.L. and S.R. Humphrey. 2001. Conservation value of private lands for Crested Caracaras in Florida. Conservation Biology 15:675-684.

Morrison, J.L. and J.F. Dwyer. 2012. Crested Caracara (Caracara cheriway), version 2.0. In The Birds of North America (A. F. Poole, Editor). Cornell Lab of Ornithology, Ithaca, NY, USA. https://doi.org/10.2173/bna.249.

Myers, R. L. and J. J. Ewel. 1990. Ecosystems of Florida. University of Central Florida Press, Orlando, Florida.

National Marine Fisheries Service. 2001. Fisheries of the United State, 2000. Fisheries Statistics and Economics Division, Office of Science and Technology, National Marine Fisheries Service, Silver Spring, MD.

NRCS (Natural Resources Conservation Service), 2018. Soil Maps of Flow-ways 2 and 3 defined using the Web Soil Survey App accessed at https://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx on 1 and 4 July 2018.

Ogden, J.C., J.A. Kushlan, and J.T. Tilmant. 1976. Prey selectivity by the wood stork. Condor 78(3):324 330.

Ogden, J.C., Davis, S.M., Barnes, T.K., Jacobs, K.J., & Fling, H.E. 2005. The Use of Conceptual Ecological Models to Guide Ecosystem Restoration in South Florida. The Journal of the Society of Wetland Scientists. Vol. 25, No. 4, December 2005, pp. 795-809.

Orth, R. J., T. J. B. Carruthers, W. C. Dennison, C. M. Duarte, J. W. Fourqurean, K. L. Heck Jr., A. R. Hughes, G. A. Kendrick, W. Judson Kenworthy, S. Olyarnik, F. T. Short, M. Waycott, and S. L. Williams. A Global Crisis for Seagrass Ecosystems. BioScience 56(12): 987-996.

Oberholser, H. C. 1938. Bird life of Louisiana. Louisiana Department of Conservation Bull. 28:1-834.

Reese, R.S., and Richardson, E., 2008. Synthesis of the hydrogeologic framework of the Floridan Aquifer System and delineation of a major Avon Park Permeable Zone in central and southern Florida. US Geological Survey Scientific Investigations Report 2007-5207, 60 p. plus plates. Available at https://pubs.usgs.gov/sir/2007/5207/

Reese, R.S., and Wacker, M.A., 2009. Hydrogeologic and hydraulic characterization of the surficial aquifer system, and origin of the high salinity groundwater, Palm Beach County, Florida. US Geological Survey Scientific Investigations Report 2009-5113, 83 pp. plus appendices.

Reese, R.S., 2014. Hydrogeologic framework and geologic structure of the Floridan Aquifer System and Intermediate Confining Unit in the Lake Okeechobee Area, Florida. US Geological Survey Scientific Investigations Map 3288, 12 p. plus appendices and plates. Available at https://pubs.usgs.gov/sim/3288/

Schwadron, M. 2006. Everglades Tree Islands Prehistory: Archaeological Evidence for Regional Holocene Variability and Early Human Settlement. *Antiquity* 80(310). Electronic document, http://antiquity.ac.uk?ProjGall/schwadron/index.html.

SFWMD. 2002b. Northern Palm Beach County comprehensive water management plan. Planning Document, Volume 1. South Florida Water Management District, West Palm Beach, FL, USA.

SFWMD. 2006. Restoration Plan for the Northwest Fork of the Loxahatchee. South Florida Water Management District, West Palm Beach, FL; Florida Department of Environmental Protection Florida Park Service, District 5, Hobe Sound, FL; Loxahatchee River District, Jupiter, FL; and Loxahatchee River Interagency Team. April 12, 2006. Also published as Appendix 12-2 in 2007 South Florida Environmental Report – Volume I, South Florida Water Management District, West Palm Beach, FL.

SFWMD. 2012. Addendum to the Restoration Plan for the Northwest Fork of the Loxahatchee River. Feb. 2012. South Florida Water Management District, West Palm Beach, FL; Florida Department of Environmental Protection Florida Park Service, District 5, Hobe Sound, FL; Loxahatchee River District, Jupiter, FL.

South Florida Environmental Report (SFWMD). 2013. Chapter 7: Status of Nonindigenous Species. South Florida Water Management District.

SFWMD, 2018. Lithologic logs for well PB-1613 on DBHydro database. Data accessed on 13 July 2018.

Stein, B.A., L.S. Kutner, and J.S. Adams (Eds.). 2000. Precious Heritage: The Status of Biodiversity in the United States. Oxford University Press, Oxford, England.

TCRPC. 1999. Loxahatchee River basin wetland planning project for Palm Beach County. Treasure Coast Regional Planning Council, Final Report to United States Environmental Protection Agency, Atlanta, GA, USA.

Tierra, Inc., 2004. Preliminary Geotechnical Engineering Services Report for the Palm Beach County Biotechnology Research Park, Palm Beach County, Florida. Report prepared for Miller, Legg and Associates, Inc., dated August 2, 2004, 23 p.

URS Corporation, 2008. Geotechnical Investigation & Soils Evaluation, Mecca Farms Flow Way, Palm Beach County, Florida. Report prepared for RCT Engineering dated January 15, 2008, 64 p.

USACE and SFWMD, 2015. Aquifer Storage and Recovery Regional Study. Report prepared by USACE and SFWMD dated May 2015, 237 p.

U.S. Fish and Wildlife Service (USFWS). 1999. South Florida Multi-Species Recovery Plan. Southeast Region, Atlanta, Georgia, USA.

U.S. Fish and Wildlife Service (USFWS). 2007. West Indian manatee (*Trichechus manatus*):5 Year Review: Summary and Evaluation. Southeast Region, Atlanta, Georgia, USA.

U.S. Fish and Wildlife Service (USFWS). 2007. West Indian manatee (*Trichechus manatus*):5 Year Review: Summary and Evaluation. Southeast Region, Atlanta, Georgia, USA.

U.S. Fish and Wildlife Service (USFWS). 2019. Species profile for Red-cockaded woodpecker. https://ecos.fws.gov/ecp0/profile/speciesProfile?spcode=B04F.

Van Arman, J., G.A. Graves, and Fike, D. 2005. Loxahatchee Watershed Conceptual Ecological Model. The Journal of the Society of Wetland Scientists 25(4): 926-942.

Wayne, A.T. 1910. Birds of South Carolina. Contributions to the Charleston Museum No. 1.

Walters, T.W., D.S. Decker-Walters, and S. Katz. 1992. Seeking the elusive Okeechobee gourd. Fairchild Tropical Garden Bulletin 47(1)23-30.

Walters, T.W. and D.S. Decker-Walters. 1993. Systematics of the endangered Okeechobee gourd, C. okeechobeensis (Cucurbitaceae). Systematic Botany 18(2):175-187.

Williams, L.J. and Kuniansky, E.I., 2016. Revised hydrogeologic framework of the Floridan aquifer system in Florida and parts of Georgia, Alabama and South Carolina (ver 1.1, March 2016); US Geological Survey Professional Paper 1807, 140 p. plus 23 plates. Available for download at https://pubs.usgs.gov/pp/1807/index.html .

Wilmsen, E.N. 1970. Lithic Analysis and Cultural Inferences: A Paleoindian Case. Anthropological Papers of the University of Arizona No. 6. University of Arizona Press, Tuscon.

Wunderlin, R. P. 1998. Guide to the vascular plants of Florida. University Press of Florida, Gainesville, Florida, USA.

APPENDIX C.2

EFFECTS OF THE ALTERNATIVES AND TENTATIVELY SELECTED PLAN

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C.2 Effects of the Final Array of Alternatives and the Tentatively Selected Plan

This section provides a discussion of the potential environmental effects, which can be either positive or negative, that could result from implementation of the LRWRP alternatives. The evaluation of the effects was based on results of modeling simulations, current information including scientific literature, direct observation, project design reports, reasonable scientific judgment, the NEPA scoping processes, and information contained within other EIS documents for similar projects. The no-action alternative is always considered and carried forward as a requirement of NEPA and it forms the basis of comparison and evaluation of alternatives. The NEPA No Action Alternative (referred to as the FWO) considers the environmental conditions in the affected project area(s) without the proposed action.

Environmental impacts include both direct and indirect effects. Under the Council on Environmental Quality (CEQ) regulations, direct effects are "caused by the action and occur at the same time and place," while indirect effects are "caused by the action and are later in time or farther removed in distance, but are still reasonably foreseeable. Indirect effects may include growth inducing effects and other effects related to induced changes in the pattern of land use, population density or growth rate, and related effects on air and water and other natural systems, including ecosystems" (40 CFR 1508.8). Under NEPA, one purpose is to identify at an early stage the significant environmental issues deserving of study and deemphasizing insignificant issues, narrowing the scope of the environmental impact statement accordingly (40 CFR Sec 1501.1).

The Corps evaluated multiple resource conditions: climate, physical landscape, geology, soils, vegetation, federally-listed threatened and endangered species, state-listed threatened and endangered species, wildlife, essential fish habitat, hydrology, water quality, air quality, hazardous, toxic and radioactive waste (HTRW), noise, aesthetics, land use, agriculture, socioeconomics, environmental justice, flood control, recreation, cultural resources, invasive species, and aircraft-wildlife strike hazards.

C.2.1 Overview

The future without project (FWO) conditions are contrasted with the expected conditions resulting from the four alternatives. The TSP is referenced throughout the document as Alternative 5R (Alt 5R). The features of the TSP are described in **Section 6** with specific features located in **Figure 6-1**. The TSP will improve the quantity, timing, and distribution of water entering the Loxahatchee River watershed and NWFLR and floodplain, reduce undesirable releases to the Loxahatchee estuary, and restore portions of several wetland parcels. Improving the return frequency, volume, and duration of discharges to the estuary will improve salinity conditions and benefit seagrass beds and the animals that inhabit them. Various features would create emergent wetland habitat, resulting in improved connectivity across the landscape, more natural hydrologic conditions, and improved habitat for fish and wildlife resources.

C.2.2 Climate

The USACE Civil Works Program and its water resources infrastructure represent a tremendous federal investment that supports public health and safety, regional and national economic development, and national ecosystem restoration goals.

The hydrologic and coastal processes underlying water resources management infrastructure have the potential to be sensitive to changes in climate and weather. Therefore, USACE has a compelling need to understand and adapt to climate change and variability while continuing to provide authorized

performance despite changing conditions. The objective of USACE climate preparedness and resilience is to mainstream climate change adaptation in all activities to help enhance the resilience of USACE-built and natural water resource infrastructure, reducing its potential vulnerabilities to the effects of climate change and variability.

The USACE Civil Works Program has developed tools to analyze the potential uncertainties of climate change and sea level change relative to USACE infrastructure. For this analysis, there are two main assessments that are applied: potential impacts from future sea level change, and trends and projected future for hydrology.

The effects of sea level rise were analyzed per EC 1165-2-212, with final results pending. Sea levels relative to the Loxahatchee River and Estuary could rise 0.4 to 2.4 ft. over the next 50 years depending on the sea level rise scenario. The future conditions could ultimately effect the salinity levels within the river and estuary depending on the rate of sea level rise and the future with-project conditions, including the amount of freshwater inflow conveyed from project features.

The preceding analysis shows that, for the high SLC scenario of approximately 2.36 feet (computed using the relative difference between the 2020 baseline MSL of -0.671 ft. and the 2070 high curvature value of 1.686 ft) of rise by the year 2070, the current threshold for structure invert elevations may be impacted by MSL values and by EWL. This could lead to either increased or decreased discharge capabilities at these structures, depending on the phase of the tidal signal and the magnitude of the upstream freshwater inflow. These changes would be incorporated into future LRWRP analyses which could, in part, affect the operations of the LRWRP Recommended Plan. From a purely hydraulic perspective, it appears likely that the USACE could maintain the overall capacity of the Lainhart and Masten dams as well as the proposed structures except under extreme water levels closer to the 2070 planning horizon. Once the CH3D sea level change model simulations are complete, the TSP will be analyzed to determine how sensitive the estuary and river are to SLR and what design or operational modifications could be implemented in the future for robustness.

Although impacts to the project due to sea level rise have not been fully analyzed, preliminary analysis indicates that the average annual net project benefits are likely to be reduced in comparison to the projected average annual net project benefits estimated assuming no sea level rise.

Portions of the Loxahatchee River and Loxahatchee River Estuary are subject to tidal influences through the direct connection to the Atlantic Ocean from the Jupiter Inlet. The historic rise of sea level has likely increased the range of tidal influence in estuaries in the project area. If future sea level rise occurs as predicted, it is foreseeable that the tidal influence will move further upstream along with the sea level rise, causing potential impacts to the proposed project benefits.

The impact of sea level change on project benefits is assessed in **Appendix H** for the FWO and with project conditions per USACE guidance ER 1110-2-8162.

Implementation of any of the alternatives would have a short-term, regionally negligible, and less than significant effect on climate within the action area. Negligible to minor, localized effects to microclimate may occur under all action alternatives as a result of redistribution of water and shifts in vegetation. Potential effects may include increases in evapotranspiration, increases in localized rainfall, and temperature changes.

C.2.3 Physical Landscape

Throughout the study area, constructed drainage features altered the pre-development landscape. Under the FWO condition, these drained lands within the project area would remain over-drained. In the northwestern and western parcels, for example, drainage shifted the landscape previously occupied by cypress swamps, hydric pine flatwoods, and wet prairies to younger (less than 30 years) slash pines and invasive species such as the Old World climbing fern (*Lygodium microphyllum*), Brazilian pepper (*Schinus terebinthifolius*), and melaleuca (*Melaleuca quinquenervia)*, with oxidation of organic-rich hydric soils resulting from hydroperiods reduced in duration.

Changes that occur to the physical landscape without project implementation focus primarily on the conversion of undeveloped or former agricultural lands to residential and commercial development. In the project area, large properties have been acquired by state and/or local agencies with the expectation that these areas would be available for ecosystem restoration. State and local-owned tracts include the former Pal-Mar, Nine Gems, Mecca Farms property, J.W. Corbett WMA, Hungryland Slough, tracts of the Loxahatchee Slough, Gulfstream West and properties adjacent to Cypress Creek and Moonshine Creek. If not incorporated into the project, these properties would be subject to continual political pressure to be listed as surplus, which would allow continued development within the watershed and the opportunity to improve the base flow and groundwater levels in direct proximity to the river would be lost. Some improvement in the wetland functioning may occur as a result of the proposed mitigation related to the Avenir project.

Changes that would occur to the physical landscape with project implementation involve installing ditch blocks, grading to restore hydrologic patterns, swales, and structures to store and direct water flow (**Table C.2-1**). Construction of ASR systems would have a negligible effect on the physical landscape due to the limited area that these features occupy at any given site. Properties included in Alt 10 that were not included in the Nine Gems and Gulfstream West restoration and flow-through marsh would be subject to continual political pressure to be listed as surplus, which would allow continued development within the watershed and the opportunity to improve the base flow and groundwater levels in direct proximity to the river would be lost.

Elements of the LRWRP project landscape are bounded by topographic highs that are relict sand ridges. To the east is the extensively developed Atlantic Coastal Ridge. To the west is the subtle topography of the Orlando Ridge (Lichtler 1960). These two ridges bound the low-lying Allapattah Flats and Loxahatchee and Hungryland Sloughs. Pre-development, the Loxahatchee Slough drained bi-directionally depending on stage, either into the Loxahatchee River to the northeast, or to the northern Everglades to the southwest.

Table C.2-1. Comparison of landscape elements for the FWO and Alternatives.

Landscape Element	FWO	Alt 2	Alt 5R	Alt 10	Alt 13
Depressional Wetlands	Most of the depressional wetland acreage is under state ownership. Future development of	A primary objective of LRWRP will to increase acreage of depressional wetlands,	A primary objective of LRWRP will to increase acreage of depressional wetlands,	Acreage of depressional wetlands will not substantially increase.	A primary objective of LRWRP will to increase acreage of depressional wetlands,

Landscape Element	FWO	Alt 2	Alt 5R	Alt 10	Alt 13
	intervening former agricultural lands would further disconnect existing western depressional wetlands from those located closer to Loxahatchee Slough.	primarily in Pal-Mar and Nine Gems.	primarily in Pal-Mar and Nine Gems.		primarily in Pal-Mar and Nine Gems. Creation of natural storage from C-18W Reservoir to the Loxahatchee Slough will increase the acreage of depressional wetlands in Flow-way 2.
Sloughs	Undeveloped poorly drained sloughs (such as Loxahatchee and Hungryland Sloughs) are likely to remain under state ownership. However, increased development of adjacent former agricultural lands will further disconnect existing western depressional wetlands from those located closer to Loxahatchee Slough and also Kitching and Moonshine Creeks.	Increased flows in FW 2 will improve the Loxahatchee Slough landscape. Increased flows from Pal-Mar and Nine Gems will allow development of a flow way across Gulfstream West, and Kitching and Moonshine Creeks.	Increased flows in Flow-way 2 will improve the Loxahatchee Slough landscape. Increased flows from Pal-Mar and Nine Gems will allow development of a flow way across Gulfstream West, and Kitching and Moonshine Creeks.	Increased flows in Flow-way 2 will improve the Loxahatchee Slough landscape. Increased flows will occur along Cypress Moonshine and Kitching Creeks.	Increased flows in Flow-way 2 will improve the Loxahatchee Slough landscape. Increased flows from Pal-Mar and Nine Gems will allow development of a flow way across Gulfstream West, and Kitching and Moonshine Creeks.
Hydric Flatwoods	Hydric flatwoods such as Pal-Mar, Nine Gems and former agricultural lands at Gulfstream West are likely to remain under state ownership, but will remain over-drained.	The quality of the hydric flatwoods in the Nine Gems area will improve as a result of increased flows from the west.	The quality of the hydric flatwoods in the Nine Gems area will improve as a result of increased flows from the west.	Acreage of hydric flatwoods will not substantially increase.	The quality of the hydric flatwoods in the Nine Gems area will improve as a result of increased flows from the west.

C.2.4 Geology

Geologic changes would be unlikely in the FWO or LRWRP action alternatives as project features are generally surficial. No active mining operations occur in the LRWRP project area. Active and proposed limestone mines are located west of the project area in the L-8 Basin between the L-8 and C-51 canals. Expansion of the lime rock mining footprint is likely to continue into the future. Lime rock mines are converted to in-ground reservoirs when the maximum depth of the operation is reached.

C.2.5 Soils

Soils within the project area are primarily sands in the upland dry prairies, and fine sands and silt in the alluvial floodplain and depressional wetland areas. In the FWO, the landscape and soils are likely to remain over-drained until converted from ranch and agricultural lands to developed areas. In the alternative scenarios, as formerly hydric soils are re-hydrated, the acreage of hydric soils would increase (**Figure C.2-1, Table C.2-2**). Hydric soil changes are associated with the changes in vegetative communities, discussed in **Section 2.5**. Wetland soil indicators frequently may be visible as rapidly as 18-36 months after re-establishment of a functional wetland hydrological regime.

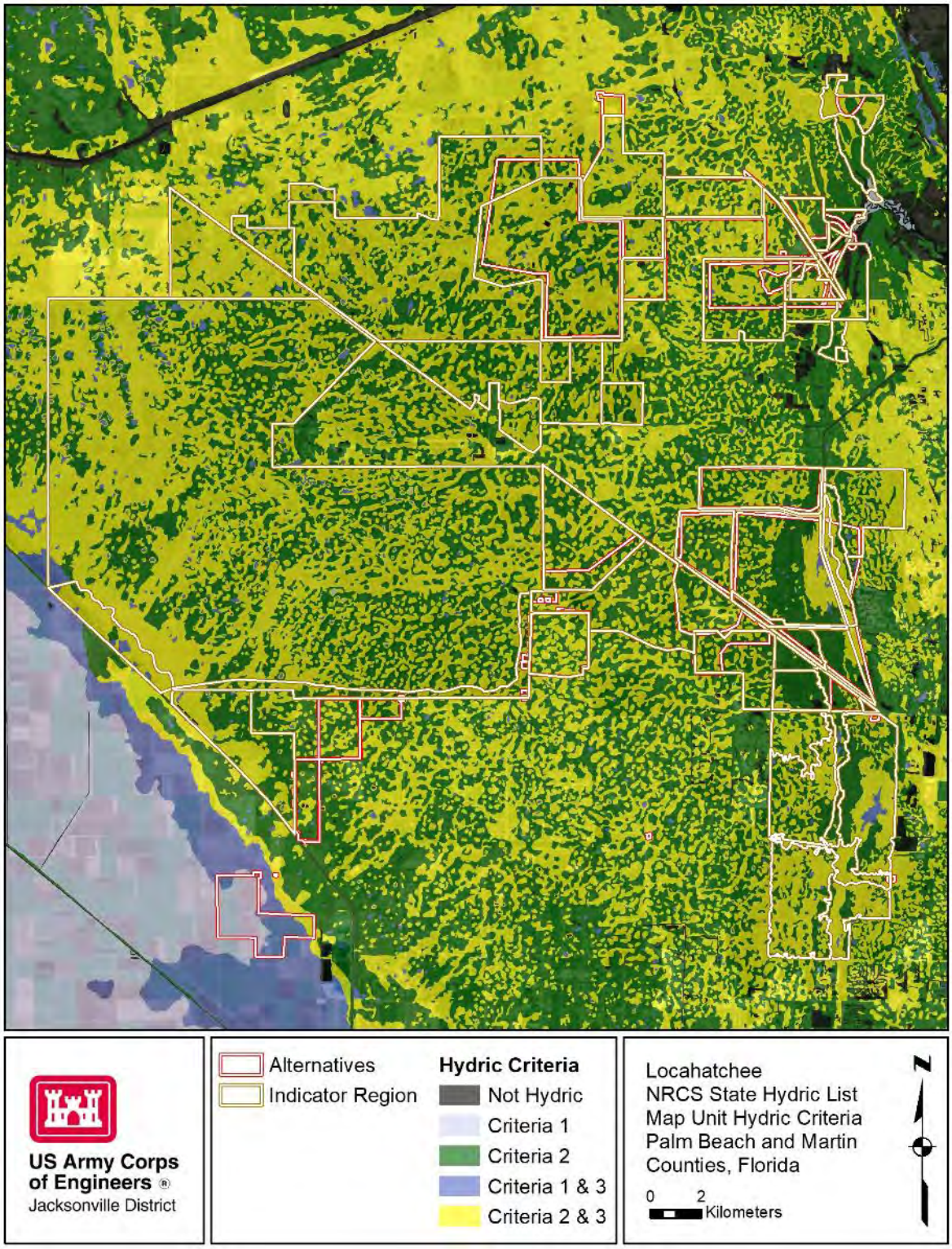


Figure C.2-1. Hydric soils in the LRWRP project area.

Table C.2-2. Comparison of FWO and alternatives: acres of hydric soils in Indicator Regions.

Summary	Alt 2	Alt 5R	Alt 10	Alt 13
Hydric map unit (MU) Acreage (total)	16460.41	22570.88	10259.95	24282.11
Hydric Indicator Region	13652.39	21474.04	8146.935	21232.1
Indicator Region	**Alt 2**	**Alt 5R**	**Alt 10**	**Alt 13**
CM	1379.21	1374.759	1376.193	4426.059
J.W. Corbett WMA	27.06511	47.28119	15.65469	47.13205
Cypress Creek	1508.645	3200.588	853.48	1508.645
Grassy Waters Preserve	310.222	310.222	316.3139	310.222
Hungryland Slough	0	0	0	665.1284
Kitching Creek	153.006	153.006	153.006	153.006
Loxahatchee Slough	5417.351	5417.351	5417.351	9265.016
Northwest Fork Loxahatchee River	9.790247	14.73346	9.790247	9.790247
Pal-Mar	4847.098	10956.1	5.146534	4847.098
Total Hydric soils in Indicator Regions, by Alternative	13652.39	21474.04	8146.935	21232.1

C.2.6 Aquifers

Groundwater resource availability is defined under two separate water supply plans by the SFWMD. Martin County resources are evaluated within the Upper East Coast (UEC) water supply plan (SFWMD, 2016). Palm Beach County water resources are evaluated within the Lower East Coast (LEC) water supply plan (SFWMD, 2018). Groundwater resources are used for drinking water, industrial, and agricultural irrigation water supply, obtained primarily from the surficial aquifer system (SAS) and the Floridan Aquifer System (FAS). (**Table C.2-36**) shows the effects of the alternatives on the three aquifers.

In the UEC planning area, the SAS supplies approximately 40 percent of the public water supply (drinking water, industrial water), and the FAS (primarily the Upper Floridan Aquifer, UFA) supplies the remaining 60 percent (SFWMD, 2016). Irrigation water is supplied through a combination of surface water, SAS groundwater, and reclaimed water.

In the LEC planning area, the SAS supplies approximately 94 percent of the public water supply (SFWMD, 2013). The high proportion of source groundwater is due to the use of the Biscayne Aquifer of Broward and Miami-Dade Counties. Closer to the LRWRP project area, the coastal utilities (Seacoast Utility Authority, Jupiter, and Tequesta, Riviera Beach) rely on SAS and FAS for the public water supply, similar to those in the UEC (SFWMD, 2016). Elsewhere near the project area, Palm Beach County, the city of West Palm Beach, and the towns of Palm Beach and South Palm Beach use surface water conveyed via canals from Lake Okeechobee eastward through the Grassy Waters Preserve, Clear Lake, and Lake Mangonia for public water supply. SAS groundwater commonly is used for nursery and agricultural water supply in the project area.

TableC.2-3. Groundwater resources for the Final Array of Alternatives and the TSP.

Aquifer	FWO	Alt 2	Alt 5R	Alt 10	Alt 13
Surficial Aquifer	Total water demand is expected to	Increased flows in the M-O canal from the L-8	No significant changes in FW1. When the C-	No significant changes in FW1.	Increased flows in the M-O canal from the

Aquifer	FWO	Alt 2	Alt 5R	Alt 10	Alt 13
System (SAS)	increase in both Martin County and Palm Beach County. Population is expected to increase by 22 to 25 percent in 2040, and public water supply demand will increase from 47.6 MGD to 73.2 MGD (Martin Co.) and up to 1,008 MGD (Palm Beach Co.). It is unlikely that increasing consumptive use permits in the SAS will meet those demands. Instead, alternative water supplies will be required to meet needs.	shallow storage will provide increased water for rehydration in FW1. When the C-18W reservoir is complete, rehydration of the SAS will occur in Loxahatchee Slough and along C-18W Canal of FW2. Higher stages are likely in the canal, which can directly recharge the SAS during the dry season. Increased groundwater levels will occur in FW3 and Kitching Creek as a result of wetland rehydration.	18W reservoir is complete, rehydration of the SAS will occur in Loxahatchee Slough and along C-18W Canal of FW2. Higher stages are likely in the canal, which can directly recharge the SAS during the dry season. Increased groundwater levels will occur in FW3 and Kitching Creek as a result of wetland rehydration.	Additional rehydration of the SAS will occur along the C-18W canal of FW2. Higher stages are likely in the canal, which can directly recharge the SAS during the dry season. Increased groundwater levels will occur in Kitching Creek as a result of wetland rehydration.	L-8 shallow storage will provide increased water for rehydration in FW1. Rehydration of all undeveloped lands between Corbett and Loxahatchee slough due to natural restored FW2. Increased groundwater levels will occur in FW3 and Kitching Creek as a result of wetland rehydration.
Upper Floridan Aquifer (UFA)	Estimated future demands on UFA groundwater are likely to increase, even though groundwater quality may be affected by salt water intrusion. Many coastal communities are relocating their UFA wellfields to the western areas of the county, and also building reverse osmosis systems to treat slightly saline water for public water supply.	Construction of 2 ASR wells at C-18W reservoir will augment storage capacity of reservoir and allow for flexible recharge (into aquifer) or recovery (out of aquifer) of stored groundwater to augment surface water storage and deliveries.	Construction of 4 ASR wells at C-18W reservoir will augment storage capacity of reservoir and allow for flexible recharge (into aquifer) or recovery (out of aquifer) of stored groundwater to augment surface water storage and deliveries.	No effect on the UFA	No effect on the UFA

Aquifer	FWO	Alt 2	Alt 5R	Alt 10	Alt 13
Avon Park Permeable Zone (APPZ)	The APPZ is not a water supply source due to greater salinity compared to the UFA, and greater depth. It is unlikely that the APPZ will provide significant public supplies in the future.	It may be that ASR wells will be constructed in the APPZ, depending on hydrologic testing performed during PED. This will augment storage in this deeper transmissive aquifer.	It may be that ASR wells will be constructed in the APPZ, depending on hydrologic testing performed during PED. This will augment storage in this deeper transmissive aquifer.	No effect on the APPZ	No effect on the APPZ.

C.2.7 Vegetative Communities

Of the more than 700 square miles in the study area, most of land within the study area can be included in three broad land use categories: natural areas (including wetlands, forested and unforested uplands, and open water), agricultural lands, and urban (residential/commercial) space. Approximately 351 square miles (224,600 acres; 51%) are comprised of natural communities. Each ecosystem includes an inter-related group of plant communities. Project study area ecosystems are grouped into three categories: upland ecosystems (forested, scrub-shrub, and herbaceous), freshwater wetlands (palustrine, riverine), and estuarine ecosystems (**Table C.2-3**). This classification represents the major plant communities and associated fauna found in the project study area, and is adapted from the Florida Natural Area Inventory (FNAI) and Florida Department of Natural Resources (FDNR 1990).

Under the FWO condition, lands within the project area would be developed consistent with surrounding land use patterns and local growth management plans, which indicates extensive residential development in the central/southern study area adjacent to existing residential areas. Continued drainage would facilitate further changes in plant communities, as has been observed in the northwestern western area where a community consisting of younger (less than 30 years) slash pines and invasive species such as the Old World climbing fern (*Lygodium microphyllum*), Brazilian pepper (*Schinus terebinthifolius*), and melaleuca (*Melaleuca quinquenervia)* now occupy the landscape previously occupied by cypress swamps, hydric pine flatwoods, and wet prairies. The oxidation of organic-rich hydric soils also has occurred as hydroperiods are reduced in duration. Without the project, hydrologic restoration would not occur for wetlands in multiple parcels where ditch blocking, grading, and connectivity improvement is planned and those plant communities would continue to decline, and be susceptible to invasive exotic plant colonization.

Under the alternative scenarios, final designs will determine the area of the upland and wetland plant communities that would ultimately develop within each of the restored parcels. Expected greater flow volume and desirable seasonal delivery patterns to NWFLR would be long-term major changes to improve ecosystem integrity. Pine flatwoods, freshwater marsh, wet prairie, and strand swamp would be most affected by any of the alternatives, due to their community dominance in the landscape. The C-18W Reservoir interior would have a minimal littoral zone because the reservoir would be designed with steep slopes to maximize water storage capacity. The perimeter canals, however, may be designed with littoral zones. Exotic plant species are expected to be controlled under any of the alternative scenarios, via

appropriate construction and maintenance procedures that would be established to deter and control exotic establishment at the project site, and implementation of the post-construction Invasive Species Management Plan.

Table C.2-4. Relative coverage of major plant communities within the project area [*adapted from the AFB document].*

Landscape Position	Natural Community Type	Relative Coverage (%)	FNAI Description
Upland	Pine Flatwoods	40.0	Mesic Flatwoods (G4/S4) –flatland with sand substrate; mesic; statewide except extreme southern peninsula and Keys; frequent fire (2-4 years); open pine canopy with a layer of low shrubs and herbs; longleaf pine and/or slash pine, saw palmetto, gallberry, dwarf live oak, wiregrass.
Upland	Dry Prairie	0.1	Dry Prairie (G2/S2)– flatland with sand soils over an organic or clay hardpan; mesic-xeric; central peninsula; annual or frequent fire (1-2 years); treeless with a low cover of shrubs and herbs; wiregrass, dwarf live oak, stunted saw palmetto, bottlebrush threeawn, broomsedge bluestem.
Upland	Sandhill	0.1	Sandhill (G3/S2) –upland with deep sand substrate; xeric; Panhandle to central peninsula; frequent fire (1-3 years); savanna of widely spaced longleaf pine and/or turkey oak with wiregrass understory.
Upland	Scrub	0.5	Scrub (G2/S2) – upland with deep sand substrate; xeric; statewide except extreme southern peninsula and Keys, mainly coastal in Panhandle; occasional or rare fire (usually 5-20 years); open or dense shrubs with or without pine canopy; sand pine and/or scrub oaks and/or Florida rosemary.
Upland	Hammock	1.8	Mesic Hammock (G3/S3?) –flatland with sand/organic soil; mesic; primarily central peninsula; occasional or rare fire; closed evergreen canopy; live oak, cabbage palm, southern magnolia, pignut hickory, saw palmetto.
Wetland	Hammock	0.1	Hydric Hammock (G4/S4)– lowland with sand/clay/organic soil over limestone or with high shell content; mesic-hydric; primarily eastern Panhandle and central peninsula; occasional to rare fire;

Landscape Position	Natural Community Type	Relative Coverage (%)	FNAI Description
			diamond-leaved oak, live oak, cabbage palm, red cedar, and mixed hardwoods.
Wetland	Pine Flatwoods	1.0	Wet Flatwoods (G4/S4)– flatland with sand substrate; seasonally inundated; statewide except extreme southern peninsula and Keys; frequent fire (2-4 years for grassy wet flatwoods, 5-10 years for shrubby wet flatwoods); closed to open pine canopy with grassy or shrubby understory; slash pine, pond pine, large gallberry, fetterbush, sweetbay, cabbage palm, wiregrass, toothache grass.
Wetland	Freshwater Marsh	21.7	Depression Marsh (G4/S4) –small, isolated, often rounded depression in sand substrate with peat accumulating toward center; surrounded by fire-maintained community; seasonally inundated; still water; statewide excluding Keys; frequent or occasional fire; largely herbaceous; maidencane, sawgrass, pickerelweed, longleaf threeawn, sand cordgrass, peelbark St. John's-wort.
Wetland	Inland Pond and Slough	4.0	Slough (G3/S3) – broad, shallow channel with peat; inundated except during droughts; flowing water; statewide excluding Keys; rare fire; sparsely canopied or with emergent or floating plants; alligator flag, American white waterlily.
Wetland	Wet Prairie	13.4	Wet Prairie(G2/S2)– flatland with sand or clayey sand substrate; usually saturated but only occasionally inundated; statewide excluding extreme southern peninsula; frequent fire (2-3 years); treeless, dense herbaceous community with few shrubs; wiregrass, blue maidencane, cutthroat grass, wiry beak sedges, flattened pipewort, toothache grass, pitcher plants, coastal plain yellow-eyed grass.
Wetland	Strand Swamp	10.1	Strand Swamp(G2/S2) –broad, shallow channel with peat over mineral substrate; situated in limestone troughs; seasonally inundated; slow flowing water; vicinity of Lake Okeechobee and southward; occasional or rare fire; closed canopy of cypress and mixed hardwoods; cypress, pond apple, strangler fig, willow, abundant epiphytes.
Wetland	Floodplain Swamp	0.5	Floodplain Swamp (G4/S4) – along or near rivers and streams with organic/alluvial

Landscape Position	Natural Community Type	Relative Coverage (%)	FNAI Description
			substrate; usually inundated; Panhandle to central peninsula; rare or no fire; closed canopy dominated by cypress, tupelo, and/or black gum.
Wetland	Dome Swamp	4.5	Dome Swamp (G4/S4)–small or large and shallow isolated depression in sand/marl/limestone substrate with peat accumulating toward center; occurring within a fire-maintained community; seasonally inundated; still water; statewide excluding Keys; occasional or rare fire; forested, canopy often tallest in center; pond cypress, swamp tupelo.
Wetland	Mangrove Swamp	0.3	Mangrove Swamp (G5/S4) – estuarine wetland on muck/sand/or limestone substrate; inundated with saltwater by daily tides; central peninsula and Keys; no fire; dominated by mangrove and mangrove associate species; red mangrove, black mangrove, white mangrove, buttonwood.
Exotic/Invasive	Exotic/Invasive	1.9	Plant communities overgrown by invasive exotic plant species, or 'nuisance' plants typically controlled to maintain a desired plant community.
--	Total	100.0	--

C.2.7.1 Northwest Fork Loxahatchee River

There are two control structures located on the federally designated "Wild and Scenic" Northwest Fork of the Loxahatchee River (NWFLR). These two structures, known colloquially as the Lainhart and Masten Dams, are technically weirs that were initially installed by adjacent landowners in the 1930s. The original structures were replaced in the mid-1980s and were recently reconstructed in 2017 to offset seepage issues. Lainhart and Masten Dams control and regulate upstream stages to maintain the hydrology of the river ecosystem and therefore serve a crucial role in protecting the cypress swamp floodplain. Modeling has shown that without the two dams in place, water levels within the river would be nearly 1.5 feet lower, draining the freshwater swamp and encouraging continued saltwater intrusion, further exacerbating an already low flow condition. The ecological health of the riverine floodplain is largely determined by regional hydrologic conditions and by how much flow is delivered to the river over Lainhart Dam, which in turn impacts the hydrologic factors that influence the integrity of the vegetative community types that exist in the riverine floodplain. These factors are the maximum dry season water elevations within the river channel, the minimum wet season water elevations in the floodplain, the durations of each and the water stages over the floodplain during transitions period. The restoration flow target is a variable dry season flow between 50 and 110 cfs, with a mean monthly flow of 69 cfs over Lainhart Dam. To simplify the analysis, the PDT used a rolling 30-day average of >68 cfs to determine how well the dry season target was met. Additionally, to maintain the appropriate wet season water elevations in the flood plain, the wet season target was a minimum of 110 cfs for 120 or more days in the wet season. Wet season

analysis was pass/fail (that is, if there was a flow of greater than 110 cfs for 120 days or more in a given year, the target was met, otherwise it was not).

Three distinct reaches (riverine, lower tidal and upper tidal) and four major forest community types (swamp, bottomland hardwood, hydric hammock and upland) are identified on the floodplain of the NWFLR. **Table C.2-5** summarizes hydrologic conditions and dominant canopy species of the floodplain forest and upper tidal communities.

Table C.2-5. Summary of hydrologic conditions and dominant riverine and upper tidal canopy species.

Forest Type	Typical Hydrologic Condition	Dominant Canopy species
Mesic Hammock	Rarely inundated, sandy soils elevate and dry quickly after flood waters recede	*Quercus virginiana* (live oak)
Hydric Hammock	Flooded average 2 months annually	*Sabal palmetto* (sabal palm)
Riverine 1	Flooded average of once every 3 years, sometimes for durations of 1-2 months or more, sandy soils dry quickly	*Quercus laurifolia* (laurel oak), *Chrysanobalanus icaco* (cocoplum), *Ilex cassine* (Dahoon holly), *Carya aquatica* (water hickory), *Persea borbonia* (red bay)
Riverine 2	Flooded average 1 month every year, loamy, clay soils remain saturated for a month or so following	*Acer rubrum* (red maple), *Cephalanthus occidentalis* (button bush), *Persea palustris* (swamp bay), *Salix caroliniana* (coastal plain willow)
Riverine 3	Flooded average 4-7 months each year, mucky, clay soils remain saturated another 5 months	*Taxodium distichum* (bald cypress) *Fraxinus caroliniana* (water ash)
Riverine 4	Flooded 2- 3 months every year, generally sandy soils	*Taxodium distichum* (bald cypress) *Sabal palmetto* (sabal palm)
Upper Tidal 1	Flooded 2-3 months every year, loamy muck and sandy soils dry quickly in some areas and remain saturated in others	*Laguncularia racemosa* (white mangrove), *Annona glabra* (pond apple), *Acer rubrum* (red maple), *Salix caroliniana* (coastal plain willow), *Cephalanthus occidentalis* (button bush), *Taxodium distichum* (bald cypress)
Upper Tidal 2	Flooded monthly by high tides or high river flows, or flooded daily by high tides from 9-11 months of the year with soils continuously saturated	*Fraxinus caroliniana* (water ash), *Rhizophora mangle* (red mangrove), *Laguncularia racemosa* (white mangrove), *Annona glabra* (pond apple)

Source: Restoration Plan for the NW Fork of the Loxahatchee River (2006) and USGS (2002).

All alternatives were conceptualized to deliver restoration flows that best balance these hydrologic factors, measured as flow over Lainhart Dam, by capturing and attenuating discharges that would otherwise be sent to tide, and then using that water to deliver flows as the river requires. For all alternatives, above ground (or in the case of Alt 10, below ground) storage features of variable size were considered. Three of the alternatives (2, 5 and 13) also augmented this aboveground storage with Aquifer

Storage and Recovery (ASR) wells. All of the impoundments/reservoirs are situated on land that was formerly cultivated for agriculture (citrus groves or, in the case of the C-51 Phase II site, sugar cane). For Alts 2, 5 and 10, an above ground impoundment of variable depth would be constructed in the Western C-18 Basin, adjacent to the J.W. Corbett WMA. In Alt 10, an additional below ground storage facility is proposed south of the L-8 Canal. The ability of each alternative to deliver flows to meet the restoration flow targets was assessed. All alternatives performed well (met the target 98% of the time or better) in the wet season. River performance was maximized in Alt 10, meeting the dry season target 95% of the time. Alts 2, 5, and 13 met the dry season targets 91%, 87%, and 80% of the time, respectively.

In the Restoration Plan for the Northwest Fork of the Loxahatchee River (Restoration Plan) (SFWMD et al. 2006) and the addendum (SFWMD et al. 2012), the Northwest Fork ecosystem was partitioned into the following five regions, each with its own specific valued ecosystem components (VECs) to evaluate the biological effects of each restoration flow alternative. Under the recommended variable flow scenarios, which include both seasonal and short-term (daily to monthly) variation, it was determined that the five desired habitat zones and their associated VECs would be established in the following areas of the river (**Figure C.2-2**):

1. Floodplain swamp and hydric hammock in the freshwater riverine floodplain – 0 practical salinity units (psu) (RM 16 to RM 9.5)
2. Floodplain swamp in the tidal floodplain – < 2 psu (RM 9.5 to RM 7.2)
3. Tapegrass (*Vallisneria americana*) – < 5 psu (RM 10.5 to RM 6.5)
4. Fish larvae in the oligohaline zone – preferred salinity range of 2 to 8 psu (RM 10 to RM 5.5)
5. Oysters in the mesohaline zone – preferred salinity range of 10 to 20 psu (RM 6.0 to RM 3.5)
6. Seagrasses in the polyhaline zone – preferred salinity range of > 20 psu (RM 4.0 to RM 0.0)

In addition to the riverine and tidal zones outlined above, several estuarine valued ecosystem component zones are present for the Loxahatchee River. These include *Vallisneria* (freshwater submerged aquatic vegetation), oligohaline (low salinity, larval and juvenile fish), mesohaline (oysters) and polyhaline (seagrass). The Loxahatchee Estuary is a species rich system that is influenced by its proximity to the western edge of the Florida current and adjacent tropical marine ecosystems. Dissolved nutrients and detritus, along with optimal temperature and salinity within the oligohaline zone provide the appropriate conditions for larval invertebrate and juvenile fish development. Low salinity and detritus associated with freshwater inputs contribute to productivity in this zone and might also provide protection against predation. The mesohaline zone is transitional between freshwater and seawater with a salinity averaging between 10 and 20 ppt. (Woodward-Clyde 1998) and is especially conducive to oyster production. Changes in freshwater runoff in the Loxahatchee can alter the salinity gradient and affect the location of oysters within the estuary. The polyhaline zone supports seagrass communities, which in turn support diversity and biological productivity in the estuary. Most commercial and recreational fish spend at least some time of their life history in seagrass beds. Seagrass species include shoal grass (*Halodule wrightii*), manatee grass (*Syringodium filiforme*), turtle grass (*Thalassia testudinum*), and Johnson's seagrass (*Halophila johnsonii*) (**Figures C.2-2, C.2-3, C.2-4**).

Flows in the wet season are designed to achieve 120 days of inundation of the freshwater riverine floodplain. Wet season (June–November) mean daily flows of 115 cfs with a range of 110 to 130 cfs and mean monthly flows of 110 to 300 cfs at Lainhart Dam with a mean monthly flow of 110 cfs for 120 days.

In the dry season, supplemental flows are needed to maintain a mean monthly flow of 69 to 90 cfs at Lainhart Dam. Daily dry season flow at Lainhart Dam should not be less than 50 cubic feet per second (cfs). Mean monthly flows over Lainhart Dam should not exceed 95 cfs, except under severe storm rainfall conditions.

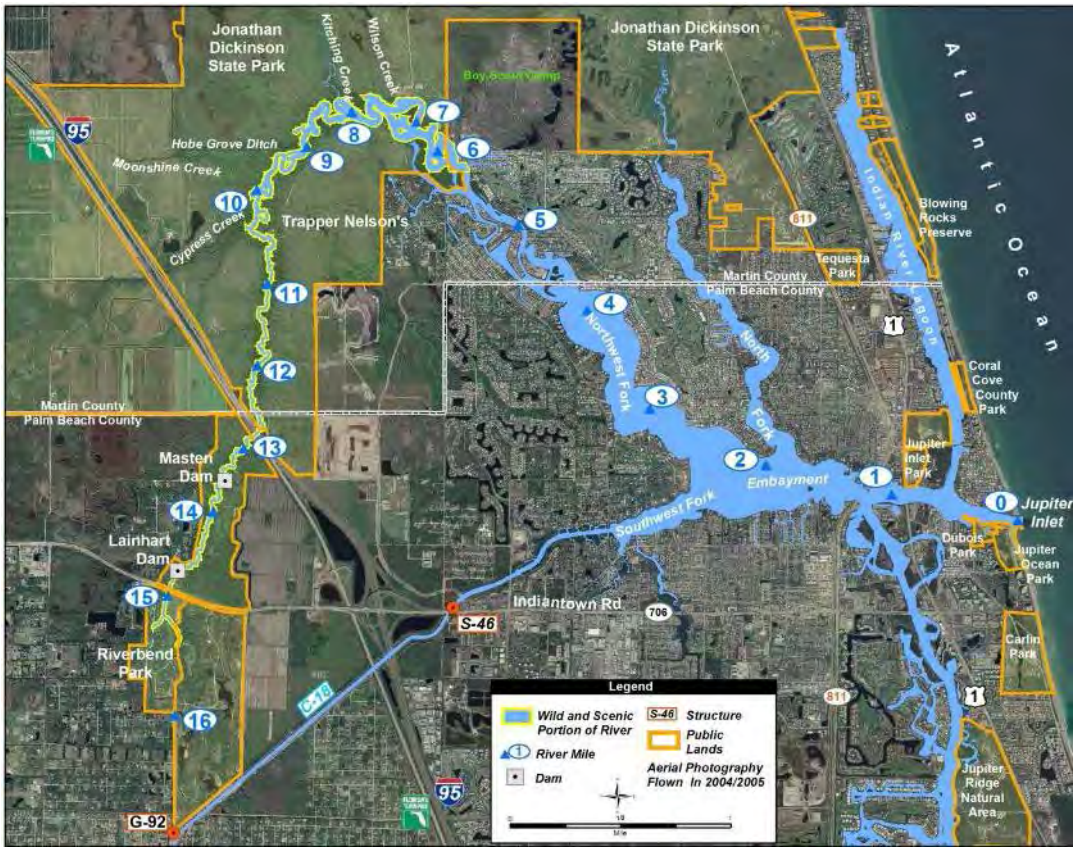


Figure C.2-2. Map of Loxahatchee River miles.

Flows over Lainhart Dam were used as an indicator of each habitat zone downstream based on the dry season performance measure criteria in the Restoration Plan of mean monthly flow of 69 cfs or greater. Alt 10 provides the most storage overall and scored a 0.95, followed by Alt 5R scoring a 0.91 and thus have the largest amount of storage closest to the river. Alt 2 followed right behind with a score of 0.87, where the additional shallow L-8 storage and smaller C-18 west storage did not perform as well in meeting river targets. Alt 13 performed the worst in meeting river targets with a 0.80 score likely due to much of the L-8 shallow storage not making its way to the river.

Salinity modeling using the CH3D model and hydrologic output from the Lower East Coast Sub-Regional Model (LECSR) model was also used to better understand potential effects on salinity downstream to infer ecological response. The modeling did not show much change from the base conditions for the tidal salinity zone, nor much change between alternatives. However, salinity modeling did reflect an improvement in salinity conditions for Alt 5R, 10, Alt 2 and to a lesser degree Alt 13 over the FWO for *Valisneria*, the oligohaline zone, and mesohaline zones. *Valisneria* potential habitat increased downstream between River Mile 10.5 to 6.5 as shown in **Figure C.2-3** with more area shaded pink (80-100 % suitable) and purple (60-80% suitable). Oligohaline habitat improved for fish as illustrated in **Figure C.2-4** with an increase from light blue (0-20% suitable) to blue or dark blue ranging from (21-60% suitable) at river mile 10 to 5.5. Mesohaline habitat that is suitable for oysters and some types of seagrass increased

in **Figure C.2-5** from river mile 6.0 to 3.5 and 0-60% suitable to 20-80% suitable over a larger area. Very little change was seen in the polyhaline habitat that is important for seagrasses that is largely tidally influenced.

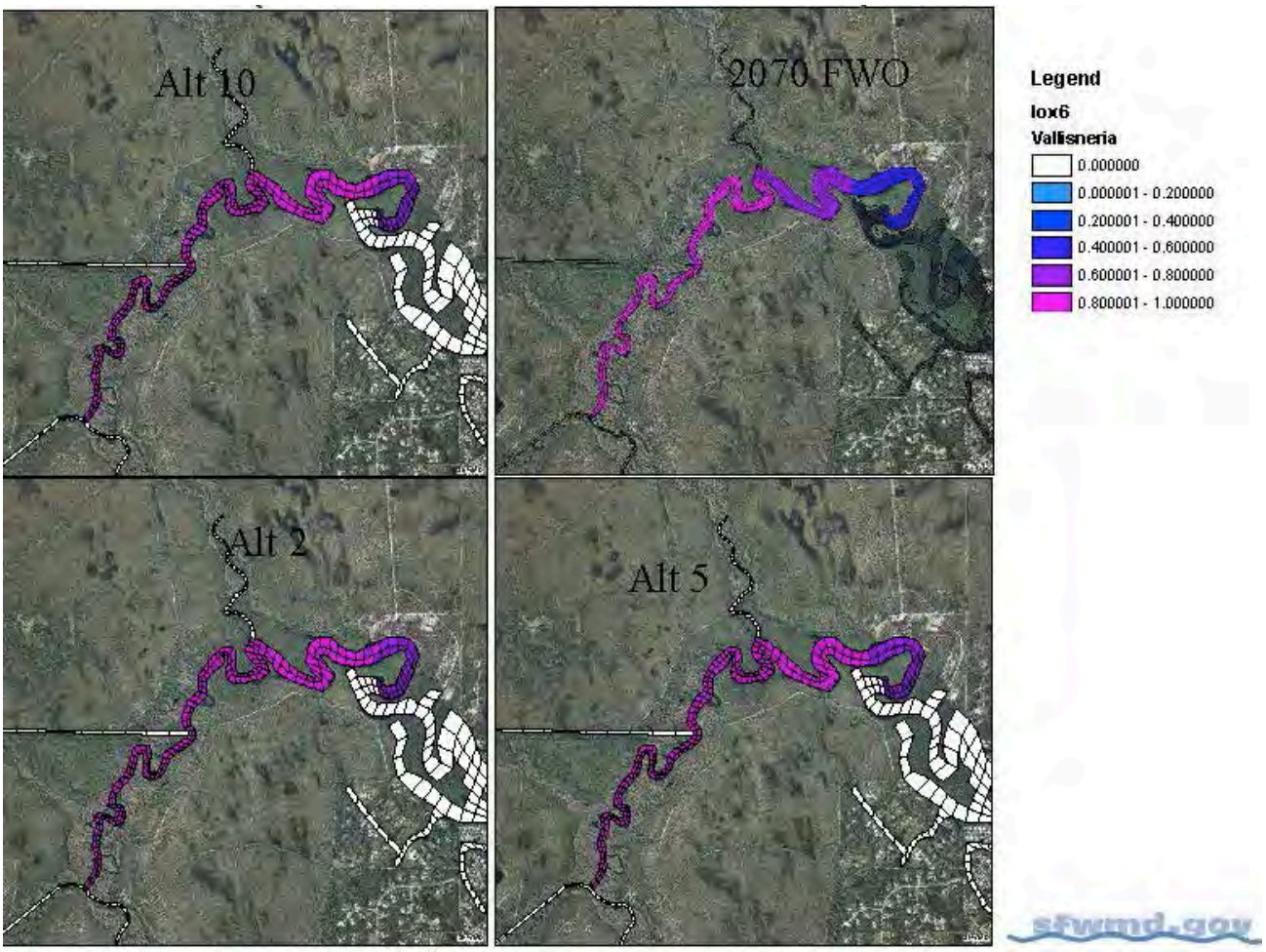


Figure C.2-3. Percentage of time meeting salinity criteria for *Valisneria*.

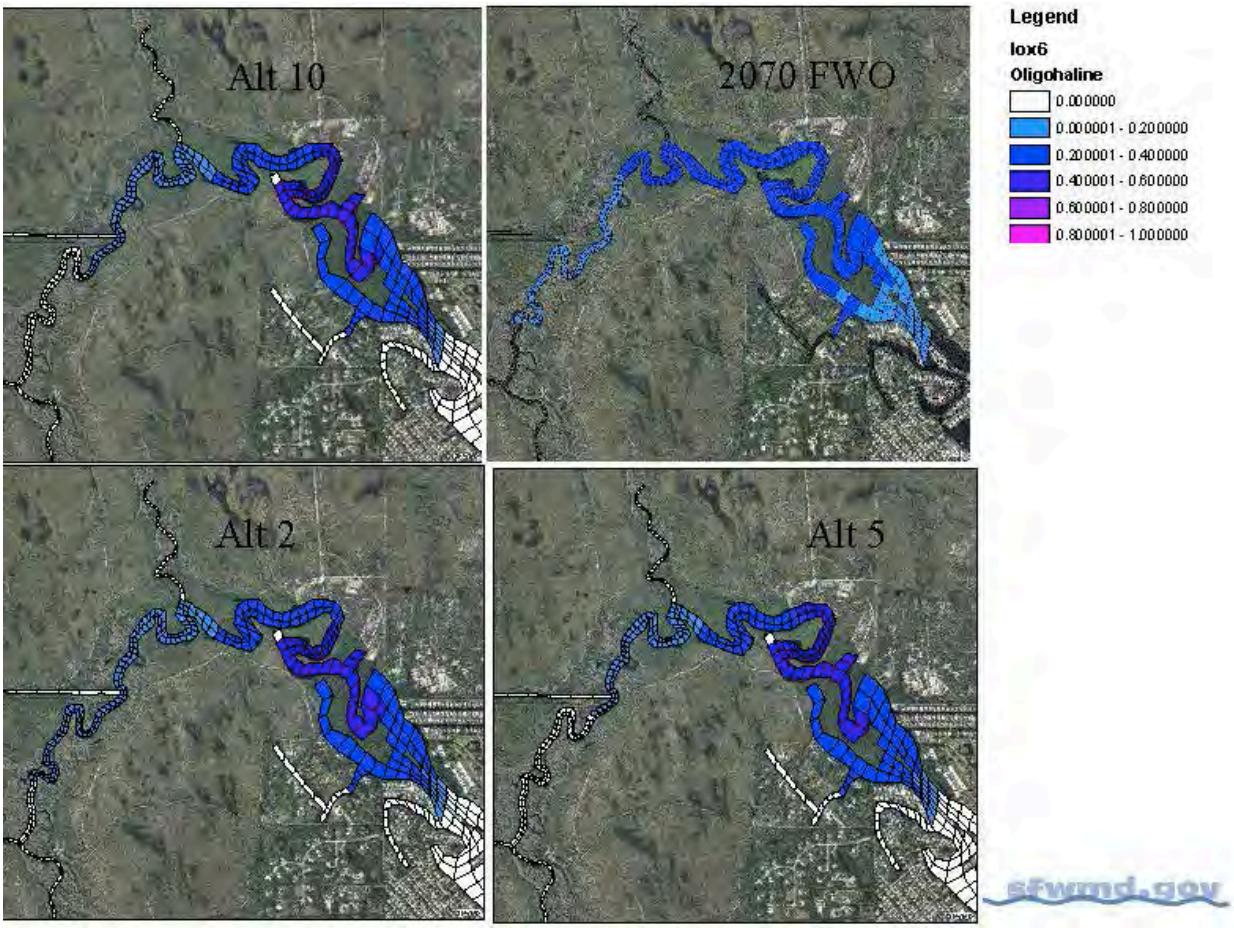


Figure C.2-4. Percentage of time meeting salinity criteria for the oligohaline zone.

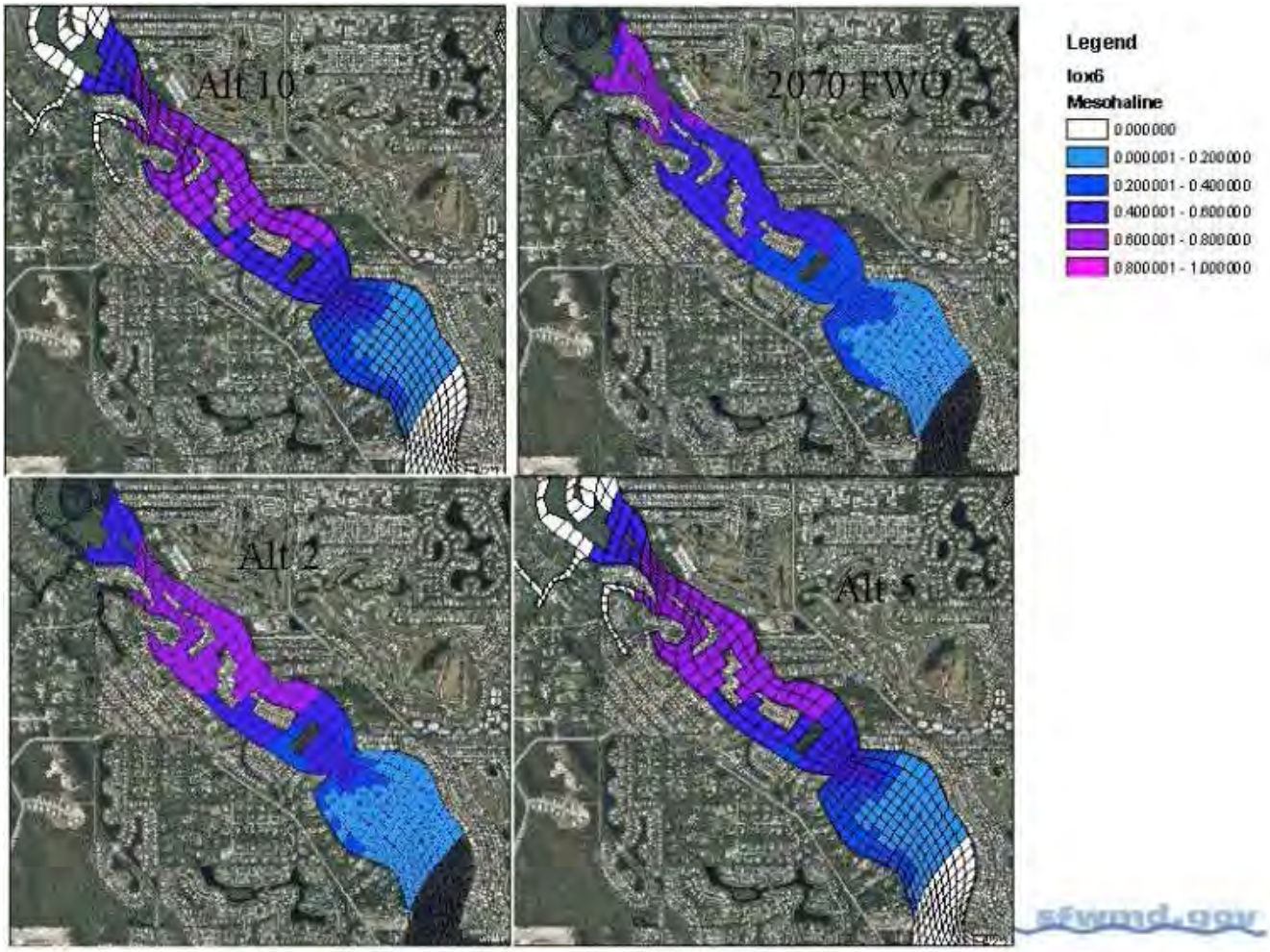


Figure C.2-5. Percentage of time meeting salinity criteria for mesohaline zone

C.2.7.2 Loxahatchee River Watershed

Due to changes in the quantity, quality, distribution, and timing of water in the Loxahatchee watershed, moderate and significant improvements to the wetland hydrology and vegetation would occur to various degrees under each alternative. The primary factors influencing the distribution of dominant freshwater wetland plant species in the watershed are soil type, soil depth, and hydrological regime (FWS 1999). Major wetland types and their appropriate inundation periods are shown in **Table C.2-**.

Table C.2-5. Loxahatchee River watershed wetland types and desired inundation period.

Plant Community	Desired Inundation (days)	Primary Plant Species
Mesic Flatwood (MF)	< or = 30	S. Florida slash pine, fetterbush, stagger bush, saw palmetto, gallberry, wiregrass, shiny blueberry
Mesic (Oak) Hammock (MH)	0-60	Live oak and associated hardwoods
Hydric Flatwood (HF)	30-60	S. Florida slash pine, mid-story vegetation is relatively absent but may include red or loblolly bay, dahoon

Plant Community	Desired Inundation (days)	Primary Plant Species
		holly and pond cypress, gallberry, sweet pepper bush, blue maindencane, toothache grass redroot
Hydric Hammock (HH)	30-60	Evergreen hardwood and/or palm forest with an understory of palms and ferns
Depression Marsh (DM)	180-300	Edges are yellow eyed grass, beak sedges, St. John's wort, blue maidencane, with deep zones including duckweed, spikerush, pickerelweed, water lilies, occasionally sawgrass and coastal plains willow
Wet Prairie (WP)	60-180	Meadow beauty, nutrush, beak sedges, yellow eyed grass, corkwood, sundews
Strand Swamp (SS)	210-300	Bald cypress, coastal plain willow, pond apple, red maple
Dome Swamp (DS)	210-300	Pond cypress, sweet bay, swamp bay, fetter bush, Virginia willow, buttonbush, royal and cinnamon fern, redroot, lizard's tail

For the analysis, areas within the watershed were parsed into indicator regions for which specific wetland types were most prevalent. These indicator regions are associated with the flow-way concept and were used to help determine project benefits and are shown in **Figure C.2-6**. **Table C.2-** provides a summary of hydrologic improvement in inundation duration over the future without project alternative using hydrology targets over the period of record for the dominant vegetation type in each indicator region. **Table C.2-** presents the performance measures (PM) scaled scores by alternative.

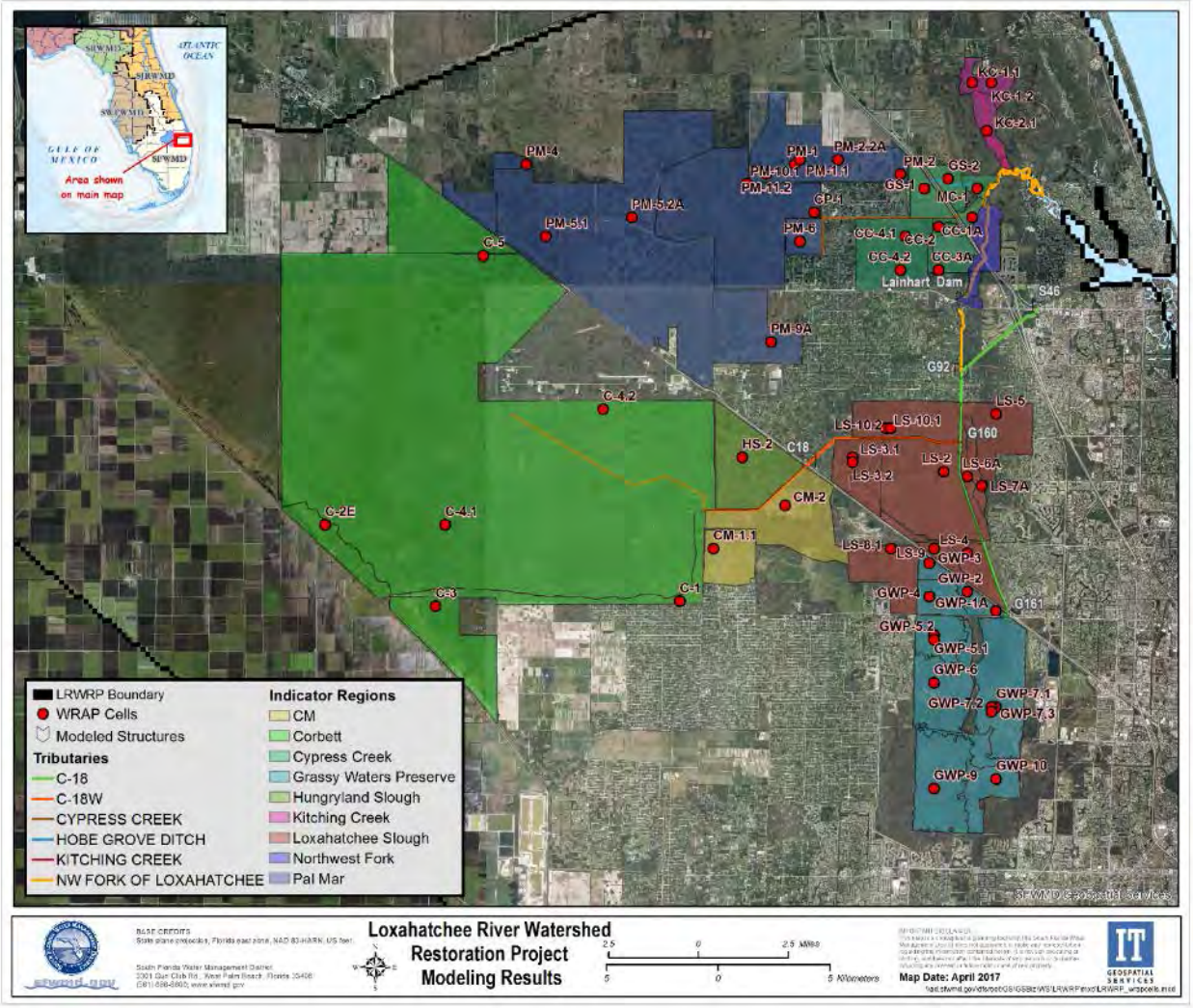


Figure C.2-6. Map of indicator regions used to evaluate project effects on dominant wetland community types. Red dots reflects areas assessed in field using WRAP procedure and site of model cell used for evaluation.

Table C.2-6. Summary of alternative plan hydrologic improvements in inundation duration days over the period of record by indicator region.

Indicator Region	Key Natural Area	Site	Acreage	Dominant Community Types*	Flow-way Designation	Alt 2	Alt 5R	Alt 10	Alt 13
C-1	J.W. Corbett WMA	Edge effect along the M-0 Canal	1,642	DM; WP	FW2	92	97	31	55
C-2	J.W. Corbett WMA	Edge effect along the L-8 Canal	1,226	DM; DS; WP; HF/MF; HH	FW2	0	0	0	0

Indicator Region	Key Natural Area	Site	Acreage	Dominant Community Types*	Flow-way Designation	Alt 2	Alt 5R	Alt 10	Alt 13
C-3	J.W. Corbett WMA	Moss Property	2,806	DS; FM; WP; HF	FW2	293	0	0	256
C-4	J.W. Corbett WMA	Unimpacted areas	25,500	DM; WP; DS; SS	FW2	-1	-1	-1	-1
C-5	J.W. Corbett WMA	3000-Acre triangle	3,170	DM; WP; DS; SS; HF	FW2	0	0	0	0
CC-1	Cypress Creek	Transect 5	202	FS	FW3	1	1	0	1
CC-2	Cypress Creek	West of Gulf Stream Citrus	207	FS	FW3	556	556	158	556
CC-3	Cypress Creek	Lox River Natural Area/Gauge 2	394	WP; DS	FW3	3	107	2	107
CC-4	Cypress Creek	Renaissance Village Wetland	2,542	DM; WP; SS; HF	FW3	86	1365	64	1365
CM-1	Corbett Management Area	C-18 West Impoundment	1,381	n/a	FW2	0	0	0	1229
Cm-2	Corbett Management Area	Avenir	3,191	n/a	FW2	-127	-104	-121	-410
GS-1	Gulf Stream east	Gulfstream Citrus	543	n/a	FW3	6	6	0	6
GS-2	Gulf Stream west	Gulfstream Citrus	737	n/a	FW3	543	543	0	543
GWP-10	Grassy Waters Preserve	Southeast corner	1,107	DS; DM; WP;SS; DS	FW1	248	248	0	248
GWP-1	Grassy Waters Preserve	G-161 triangle	42	DS; DM; WP;SS; DS	FW1	0	-54	44	0
GWP-2	Grassy Waters Preserve	West of G-161 triangle including Hog Island	397	DS; DM; WP;SS; DS; HF	FW1	-2	-2	-1	-2
GWP-3	Grassy Waters Preserve	Upper triangle-south of beeline and north of berm	308	DS; DM; WP;SS; DS; HF	FW1	123	123	122	116
GWP-4	Grassy Waters Preserve	South of the berm and west of Hog Island	755	DS; DM; WP;SS; DS; HF; MF	FW1	-4	-4	-3	-6

Indicator Region	Key Natural Area	Site	Acreage	Dominant Community Types*	Flow-way Designation	Alt 2	Alt 5R	Alt 10	Alt 13
GWP-5	Grassy Waters Preserve	Northwest corner (willow area; ~1500 acres)	977	DS; DM; WP;SS; DS; HF	FW1	-19	-19	-13	-50
GWP-6	Grassy Waters Preserve	South of willow area & north of M-Canal	2,134	DS; DM; WP;SS; DS; HF	FW1	-10	0	-344	-4
GWP-7	Grassy Waters Preserve	North of M-Canal east of Hog Island	2,992	DS; DM; WP;SS; DS; HF	FW1	0	-13	143	0
GWP-8	Grassy Waters Preserve	M-Canal edge effects	594	DM; SS	FW1	-2	-61	311	-3
GWP-9	Grassy Waters Preserve	South of M-Canal and west of Hog Island	2,518	DS; DM; WP;SS; DS; HF	FW1	0	-80	215	-1
HS-2	Hungryland Slough	Palm Beach County Natural Area	2,867	-	FW2	0	0	0	0
KC-1	Kitching Creek	Headwaters	656	FS; HH	FW3	124	124	124	124
KC-1.1	Kitching Creek	-	658	FS; HH	FW3	433	433	433	433
KC-2	Kitching Creek	Mid-portion	584	FS; HH	FW3	5	5	3	5
LS-10	Loxahatchee Slough	Site 7	1,891	DM; WP; SS	FW1	380	385	381	376
LS-2	Loxahatchee Slough	West of C-18 Canal	3,849	DM; WP; SS	FW1	199	199	199	199
LS-3	Loxahatchee Slough	Sandhill Crane	1,451	WP; DM	FW2	2	3	3	383
LS-4	Loxahatchee Slough	Roma Parcel	772	WP	FW1	50	46	18	33
LS-5	Loxahatchee Slough	East of C-18	1,782	DM; WP; SS	FW1	13	15	16	14
LS-6	Loxahatchee Slough	Melaleuca site south	405	DM; WP; SS	FW1	394	394	383	394
LS-7	Loxahatchee Slough	Site adj to melaleuca (SE)	426	SS	FW1	364	371	394	363
LS-8	Loxahatchee Slough	Southwest slough	1,666	-	FW2	-10	-10	-8	-51
LS-9	Loxahatchee Slough	-	576	-	FW2	-13	-14	-16	-43

Indicator Region	Key Natural Area	Site	Acreage	Dominant Community Types*	Flow-way Designation	Alt 2	Alt 5R	Alt 10	Alt 13
MC-1	Moonshine Creek	Moonshine Creek/Hobe Grove Ditch	266	FS	FW3	0	0	0	0
PM-1	Pal Mar (Martin Co.)	Unimproved Nine Gems Parcel	2,177	DM; WP	FW3	608	608	0	603
PM-10	Pal Mar (Martin Co.)	Part of Pal Mar 5	7,181	DM; WP	FW3	3143	3143	-1	3143
PM-2	Pal Mar (Martin Co.)	Improved Nine Gems Parcel	1,452	DM; WP	FW3	456	456	372	456
PM-3	Pal Mar (Martin Co.)	Area 3	709	DM; WP	FW3	390	390	0	390
PM-4	Pal Mar (Martin Co.)	Area 2	284	DM; WP	FW3	0	0	0	0
PM-5	Pal Mar (Martin Co.)	Unimpacted Pal-Mar	19,672	DM; WP	FW3	0	0	0	0
PM-6	Pal Mar (Martin Co.)	Culpepper Ranch	636	DM; WP	FW3	2	2	0	2
PM-9	Pal Mar (PBC)	Impacted site	2577	DM; WP	FW3	0	0	0	0

Table C.2-7. Performance Measure (PM) Scaled Score by Alternative.

Alternative:	2014B	2070B	ALT2	ALT5	ALT10	ALT13
PM-4 WRAP	0.37	0.36	0.46	0.46	0.39	0.49
PM-9	0.00	0.00	0.67	0.67	0.46	0.83
Total Watershed	0.33	0.32	0.48	0.48	0.39	0.53

For all alternatives, above ground features with associated seepage canals and embankments would be constructed and wetland communities would be restored as a result of modifying existing drainage features. Flow-way 3, where ground water levels have been significantly depressed as a result of relatively large drainage features with limited or no control structures, has some of the largest impact to the tributaries to the NWFLR as well as to the adjacent wetland communities. All alternatives, except for Alt 10, include the construction of a flow-through marsh in Flow-way 3, and the full removal of berms and ditches between Pal-Mar west and east (Nine Gems and Gulfstream). This marsh will attenuate flows from an adjacent agricultural area and, combined with a proposed control structure in the Cypress Creek Canal, will have a positive impact on improving overall groundwater levels throughout the area. Improving groundwater conditions in this area results in a positive impact on more than 12,000 acres, improving hydroperiods. Increasing groundwater levels in near proximity to the Cypress and Moonshine Creek tributaries and the NWFLR will also improve baseflow conditions throughout the area, and reduce flashy discharges to the tributaries. All four action alternatives improved hydroperiods and sheet flow in the Flow-way 3 area (Palmar East, Cypress Creek, Kitching Creek and Moonshine Creek) as compared with the FWO, however, the scope of changes proposed in this area are less comprehensive for Alt 10, resulting in less wetland vegetation improvement in Flow-way 3 for Alt 10. The Mack Dairy Spreader Canal in Alts 5R and 13 provides more lift to Cypress Creek Natural Area compared to Alts 2 and 10. Increased flows from Lainhart dam.

Alt 13 performed the best for wetland improvement overall due to the extensive natural storage area proposed in Flow-way 2, which extended into the western portion of the Loxahatchee Slough and Northern GWP. The primary purpose of the impoundments as defined above is storage to augment flow to the river to meet restoration targets; however, some marginal habitat quality may be realized with the impoundments. Groundwater improvements that provide hydroperiod improvement to adjacent areas such as the Moss property in J.W. Corbett WMA, located adjacent to the L-8 Canal, are realized in Alts 2 and 13 as a benefit associated with the L-8 Shallow Impoundment included in those alternatives.

All four action alternatives provide improvements in hydroperiods in Flow-way 1 due to the G-160 and G-161 structures improving hydroperiods for dominant vegetation communities particularly in the eastern portions of the Loxahatchee Slough adjacent to the C-18 Canal. The modeling shows moderate improvements and does not reflect the total improvement from these structures that were already constructed as part of the SFWMD acceler8 program to get early restoration benefits due to operational changes in the future without project. Alt 10 appears to improve hydrology in Grassy Waters Preserve by reducing over-inundation based on dominant plant community targets from the higher regulation schedule implemented in the existing conditions. However, a site visit was conducted to assess effects on wetland plant communities from the higher schedule and determined that vegetation did not show signs of stress.

C.2.8 Threatened and Endangered Species

The U.S. Fish and Wildlife Service (USFWS), National Marine Fisheries Service (NMFS), and State of Florida Fish and Wildlife Conservation Commission (FWC) have designated certain species of fish, amphibians, reptiles, birds, mammals, gastropods, and plants in the project area in Martin and Palm Beach counties as threatened or endangered. Federally and state listed threatened, endangered, and candidate species have been observed or may occur within the study area (**Table C.2-**). The LRWRP Biological Assessment (BA) includes life history information and the Corps' determinations of TSP project effects (**Annex A). Appendix C.1.8** presents a discussion of existing and FWO project effects on the species included on **Table C-2.8**. The appendix includes brief life histories of these species, so those are not repeated here. The Corps

consulted with NOAA NMFS via the CERP Programmatic Biological Opinion and has applied it to marine species under the purview of NMFS.

The overall objective of LRWRP is to increase water storage capacity in the watershed, improve the quantity and timing of discharges to the Loxahatchee estuary, and restore wetlands. This section compares the effects of the FWO and alternatives. Under the FWO scenario, habitat availability would be dependent on future land use, and an assumption is that the natural areas would continue to be managed according to present management plans or future modifications to those plans.

Table C.2-8. ESA-listed species for LRWRP project area.

Group	Common Name	Federal Status	USACE Determination	FWO	Alt 2	Alt 5R	Alt 10	Alt 13
Mammals	Florida Manatee	Threatened	MANLAA	Population would continue to access the river and estuary	+ -Beneficial on population	+ -Beneficial on population	+ -Beneficial on population	+ -Beneficial on population
Mammals	Florida Manatee	Critical Habitat	MANLAA	Designated critical habitat not affected by project construction; no beneficial effects with improved riverine hydrology	+ -Beneficial on population	+ - Beneficial effect on habitat	+ -Beneficial on population	+ -Beneficial on population
Mammals	Florida panther	Endangered	NE	Project area is not within the primary or secondary concentration areas	Project area lands would be conserved	Project area lands would be conserved	Project area lands would be conserved	Project area lands would be conserved

Group	Common Name	Federal Status	USACE Determination	FWO	Alt 2	Alt 5R	Alt 10	Alt 13
Mammals	Florida bonneted bat	Endangered	NE	Colonial. Roosts in cliff crevices, tree cavities and buildings. Future development could affect roosting/colony habitat availability	Possible insignificant effects per USFWS; tree removal could reduce roosting habitat; restoration of hydrologic patterns to freshwater wetlands could improve insect population and foraging opportunities; pre-construction surveys to avoid construction-related impacts would be conducted	Possible insignificant effects per USFWS; tree removal could reduce roosting habitat; restoration of hydrologic patterns to freshwater wetlands could improve insect population and foraging opportunities; pre-construction surveys to avoid construction-related impacts would be conducted	Possible insignificant effects per USFWS; tree removal could reduce roosting habitat; restoration of hydrologic patterns to freshwater wetlands could improve insect population and foraging opportunities; pre-construction surveys to avoid construction-related impacts would be conducted	Possible insignificant effects per USFWS; tree removal could reduce roosting habitat; restoration of hydrologic patterns to freshwater wetlands could improve insect population and foraging opportunities; pre-construction surveys to avoid construction-related impacts would be conducted

Group	Common Name	Federal Status	USACE Determination	FWO	Alt 2	Alt 5R	Alt 10	Alt 13
Birds	Audubon's crested caracara	Threatened	MA	Ubiquitous in project area; future land use changes and development could affect habitat availability and populations	Restoration of hydrologic patterns to freshwater wetlands could result in habitat conversion or reduction; C18-W Reservoir and L-18 Shallow Impoundment would decrease foraging habitat; pre-construction surveys will be conducted to identify nest trees; ongoing surveys as needed during construction	Restoration of hydrologic patterns to freshwater wetlands could result in habitat conversion or reduction; C18-W Reservoir would decrease foraging habitat; pre-construction surveys will be conducted to identify nest trees; ongoing surveys as needed during construction	Restoration of hydrologic patterns to freshwater wetlands could result in habitat conversion or reduction; C18-W Reservoir would decrease foraging habitat; pre-construction surveys will be conducted to identify nest trees; ongoing surveys as needed during construction	Restoration of hydrologic patterns to freshwater wetlands could result in habitat conversion or reduction; L-8 Basin Shallow Storage would decrease foraging habitat; pre-construction surveys will be conducted to identify nest trees; ongoing surveys as needed during construction

Group	Common Name	Federal Status	USACE Determination	FWO	Alt 2	Alt 5R	Alt 10	Alt 13
Birds	Everglade snail kite	Endangered	MANLAA	Localized nesting within project area; future land use changes and development could affect habitat availability and populations	Restoration of hydrologic patterns to freshwater wetlands; increased foraging area in Loxahatchee Slough and Pal-Mar, additional water from 161 through GWP to river not expected to alter hydroperiods; improved foraging opportunities	Restoration of hydrologic patterns to freshwater wetlands; increased foraging area in Loxahatchee Slough and Pal-Mar, additional water from 161 through GWP to river not expected to alter hydroperiods; improved foraging opportunities	Restoration of hydrologic patterns to freshwater wetlands; increased foraging area in Loxahatchee Slough and Pal-Mar, additional water from 161 through GWP to river not expected to alter hydroperiods; improved foraging opportunities	Restoration of hydrologic patterns to freshwater wetlands; increased foraging area in Loxahatchee Slough and Pal-Mar, additional water from 161 through GWP to river not expected to alter hydroperiods; improved foraging opportunities
Birds	Everglade snail kite	Critical Habitat	NE	Outside Final Critical Habitat	Outside Final Critical Habitat	Outside Final Critical Habitat	Outside Final Critical Habitat	Outside Final Critical Habitat

Group	Common Name	Federal Status	USACE Determination	FWO	Alt 2	Alt 5R	Alt 10	Alt 13
Birds	Wood stork	Threatened	MANLAA	core foraging area overlaps much of project area; future land use changes and development could affect habitat availability and populations	Restoration of hydrologic patterns to freshwater wetlands; consistent with natural flow regimes (Lox Slough, 9 Gems); no adverse effects to recession rates; increase in freshwater piscine populations; improved foraging opportunities; crayfish eversion of contaminated soils will be avoided by maintaining impoundment water depth of ≥6 inches to prevent stork bioaccumulation of contaminants	Restoration of hydrologic patterns to freshwater wetlands; consistent with natural flow regimes (Lox Slough, 9 Gems); no adverse effects to recession rates; Alt 5R does not change Culvert 10-A conditions; increase in freshwater piscine populations; improved foraging opportunities; crayfish eversion of contaminated soils will be avoided by maintaining impoundment water depth of ≥6 inches to prevent	Restoration of hydrologic patterns to freshwater wetlands; consistent with natural flow regimes (Lox Slough, 9 Gems); no adverse effects to recession rates; increase in freshwater piscine populations; improved foraging opportunities; crayfish eversion of contaminated soils will be avoided by maintaining impoundment water depth of ≥6 inches to prevent stork bioaccumulation of contaminants	Restoration of hydrologic patterns to freshwater wetlands; consistent with natural flow regimes (Lox Slough, 9 Gems); no adverse effects to recession rates; increase in freshwater piscine populations; improved foraging opportunities; crayfish eversion of contaminated soils will be avoided by maintaining impoundment water depth of ≥6 inches to prevent stork bioaccumulation of contaminants

Group	Common Name	Federal Status	USACE Determination	FWO	Alt 2	Alt 5R	Alt 10	Alt 13
					; volitional avoidance	stork bioaccumulation of contaminants ; volitional avoidance	; volitional avoidance	; volitional avoidance
Birds	**Red-cockaded woodpecker**	Endangered	NE	Population would continue to occupy present habitat and/or expand	Existing habitat would be unaffected	Existing habitat would be unaffected	Existing habitat would be unaffected	Existing habitat would be unaffected

Group	Common Name	Federal Status	USACE Determination	FWO	Alt 2	Alt 5R	Alt 10	Alt 13
Reptiles	Eastern indigo snake	Threatened	MA	Ubiquitous in project area; future land use changes and development could affect habitat availability and populations	Restoration of hydrologic patterns to freshwater wetlands (primarily seasonal depression marsh); increased area of freshwater marsh edges (foraging habitat); habitat loss from C18-W Reservoir and L-18 Shallow Impoundment; standard protection and conservation measures will be implemented during construction	Restoration of hydrologic patterns to freshwater wetlands (primarily seasonal depression marsh); increased area of freshwater marsh edges (foraging habitat); habitat loss from C18-W Reservoir; standard protection and conservation measures will be implemented during construction	Restoration of hydrologic patterns to freshwater wetlands (primarily seasonal depression marsh); increased area of freshwater marsh edges (foraging habitat); habitat loss from C18-W Reservoir; standard protection and conservation measures will be implemented during construction	Restoration of hydrologic patterns to freshwater wetlands (primarily seasonal depression marsh); increased area of freshwater marsh edges (foraging habitat); habitat loss from L-8 Basin Shallow Storage; Standard protection and conservation measures will be implemented during construction
Flowering Plants	Okeechobee gourd	Endangered	NE	Typical habitat not present; no reported populations	Typical habitat not present; no reported populations	Typical habitat not present; no reported populations	Typical habitat not present; no reported populations	Typical habitat not present; no reported populations

Group	Common Name	Federal Status	USACE Determination	FWO	Alt 2	Alt 5R	Alt 10	Alt 13
				in project area	in project area	in project area	in project area	in project area

Notes: FWS determinations cited in letter re Loxahatchee River Watershed Restoration Project, April 20, 2017; *Marine species regulated by NMFS; ** Indicates critical habitat for the designated species is not within the action study area. E: Endangered, T: Threatened, SC: Species of Special Concern, SA: Similarity of Appearance, CH: Critical Habitat; Pr E: Proposed Endangered; Pr CH: Proposed Critical Habitat.

In the following table, watershed feature effects to Okeechobee gourd, bonneted bat and panther are not included because they would not be affected by the project. The gourd is not known to occur in the project area, the current bonneted bat consultation area does not currently overlap the project area, and the panther primary and secondary consultation areas do not overlap the project area. If required, pre-construction surveys will be conducted for these species. Manatees will be benefited by improved flow quantities and timing to the NWFLR and estuary, where habitat availability and SAV forage would be improved. Manatees are generally precluded from accessing the upper river because the Masten dam forms a fixed impediment to manatee movement upstream, except under extreme high water conditions. Further, a manatee movement barrier would be installed as necessary for the duration of project construction to prevent access. Caracara, snail kites, wood storks, and eastern indigo snakes will be directly benefited, although variously by species, by wetland restoration features of all alternatives. The relative habitat benefits resulting from wetland restoration are shown in **Table C.2-9** (also refer to **Table C.2-19**, which shows wetlands land use changes).

Table C.2-9. Alternatives effects on habitat availability.

Feature	FWO	Alt 2	Alt 5R	Alt 10	Alt 13	Caracara	Snail Kite	Wood Stork	E. indigo snake	Panther	bonneted bat	Project Feature Purpose and Effect
Nine Gems (Pal-Mar East) – ditch plugs, grading	-	✓	✓		✓	Less forest 0	+	+	+	-	'	Hydrologic restoration; surface water; vegetation
Gulfstream West – Flow-through marsh	-	✓	✓		✓	0	+	+	+	-	'	Hydrologic restoration; surface water; vegetation
Gulfstream East and Moonshine Creek – grading, connectivity	-	✓	✓	✓	✓	0	+	+	+	-	'	Hydrologic restoration; surface water; vegetation
Kitching Creek – weir and spreader swale	-	✓	✓	✓	✓	0	+	+	+	-	'	Hydrologic restoration; surface water; vegetation

Feature	FWO	Alt 2	Alt 5R	Alt 10	Alt 13	Caracara	Snail Kite	Wood Stork	E. indigo snake	Panther	bonneted bat	Project Feature Purpose and Effect
Cypress Creek, water control structure	-	✓	✓	✓	✓	0	+	+	+	-	'	Hydrologic restoration; surface water; vegetation
Cypress Creek, spreader swale and pump station, Shiloh flow paths	-	✓	✓		✓	0	+	+	+	-	'	Hydrologic restoration
Grassy Waters Preserve triangle – grading, connectivity	-	✓	✓	✓	✓	0	+	+	+	-	'	Hydrologic restoration; surface water; vegetation
Grassy Waters Preserve with G-161, operation change for water deliveries to NWFLR	-	✓	✓	✓	✓	0	+	+	+	-	'	Continued operations; no hydrologic change
Grassy Waters Preserve – operational changes associated with deep storage reservoir	-			✓		0	+	+	+	-	'	Minor hydroperiod change

Feature	FWO	Alt 2	Alt 5R	Alt 10	Alt 13	Caracara	Snail Kite	Wood Stork	E. indigo snake	Panther	bonneted bat	Project Feature Purpose and Effect
Loxahatchee Slough Natural Area – hydrology changes associated G-160 and G-161	-	✓	✓	✓	✓	0	+	+	+	-	'	Surface water; vegetation, hydroperiod improvement
Beeline culverts – new structures	-				✓	0	+	+	+	-	'	Surface water drainage; connectivity
ASR well clusters co-located with C-18 W	-		✓			0	0	0	0	-	¦	Water storage, and delivery to NWFLR
ASR Well Clusters co-located with L-8 Shallow Impoundment	-	✓			✓	0	0	0	0	-	'	Water storage and delivery to NWFLR
C-18W Reservoir and associated infrastructure east boundary	-	✓	✓	✓		Habitat loss	+	+	+	-	'	Water body – large reservoir
C-18W Natural Storage, including western Loxahatchee Slough	-				✓	+	+	+	+	-	'	Hydrologic restoration and connectivity

Feature	FWO	Alt 2	Alt 5R	Alt 10	Alt 13	Caracara	Snail Kite	Wood Stork	E. indigo snake	Panther	bonneted bat	Project Feature Purpose and Effect
L-8 Shallow Impoundment	-	✓			✓	+	+	+	-	-	'	Shallow water storage
C-51 Ph. II Deep Storage	-			✓		0	0	0	0	-	'	Deep, in-ground water storage

Notes: 0 = neutral effect to species; + = beneficial effect to species; - = negative effect to species.

C.2.8.1 Florida Bonneted Bat

The project area does not include the current Florida bonneted bat consultation area and focal area (FWS 2017). (**Figure C.2-**). Given the ongoing studies of bat distribution, in the future they may be found in the project area. Bats are insectivorous and are nocturnal foragers while flying over water and marshes so all of the alternatives would provide benefits of increased wetlands for foraging. Bats require roost sites, commonly uplands that may contain roosting trees. The current survey approach is to conduct acoustic surveys to detect bats prior to construction so that if bats are encountered, the USACE will coordinate measures with FWS to minimize or avoid potentially adverse effects.

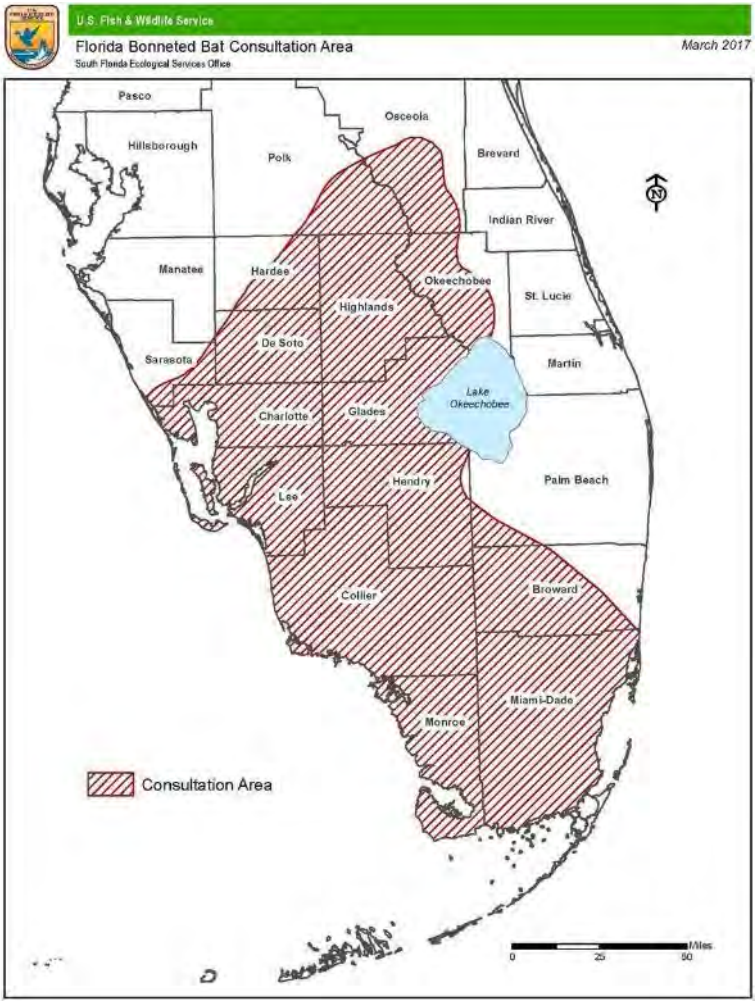


Figure C.2-7. 2017 Florida Bonneted Bat (FBB) Consultation and Focal Area (USFWS 2017).

C.2.8.2 Northern Crested Caracara

Numerous observations of caracara in the project area indicates that they are commonly present (**Figure C.2-7**). Since eBird records are general observations and do not cover all selected project features, surveys to protocol for caracara nest sites would be conducted during the PED stage or as a requirement of construction contracts. The direct effect of habitat loss on caracaras from any with-action alternative would be proportional to the acres of suitable habitat, generally pastures, affected by the alternative. ASRs generally have smaller surface footprints, so adverse effects of ASR construction and operation on caracaras would be trivial. A follow-up assessment will be needed once specific ASR sites are selected. Wetlands and pasture conversion may displace caracaras, but conversion to short-hydroperiod wetlands may not. Additionally, the anticipated increase in wetland-based prey items associated with restored wetlands is likely to increase foraging opportunities and may benefit the caracara. Caracaras may forage along future storage feature levees and seepage control features. The Corps includes survey requirements in construction contracts to assure caracara nests are identified during construction, and to define the magnitude of adverse and potentially beneficial effects. A biological opinion providing for some quantity

of incidental take of caracaras in the form of nest tree removal and/or construction-related incidental disturbance of foraging and roosting birds will likely be needed for any with-action alternative.

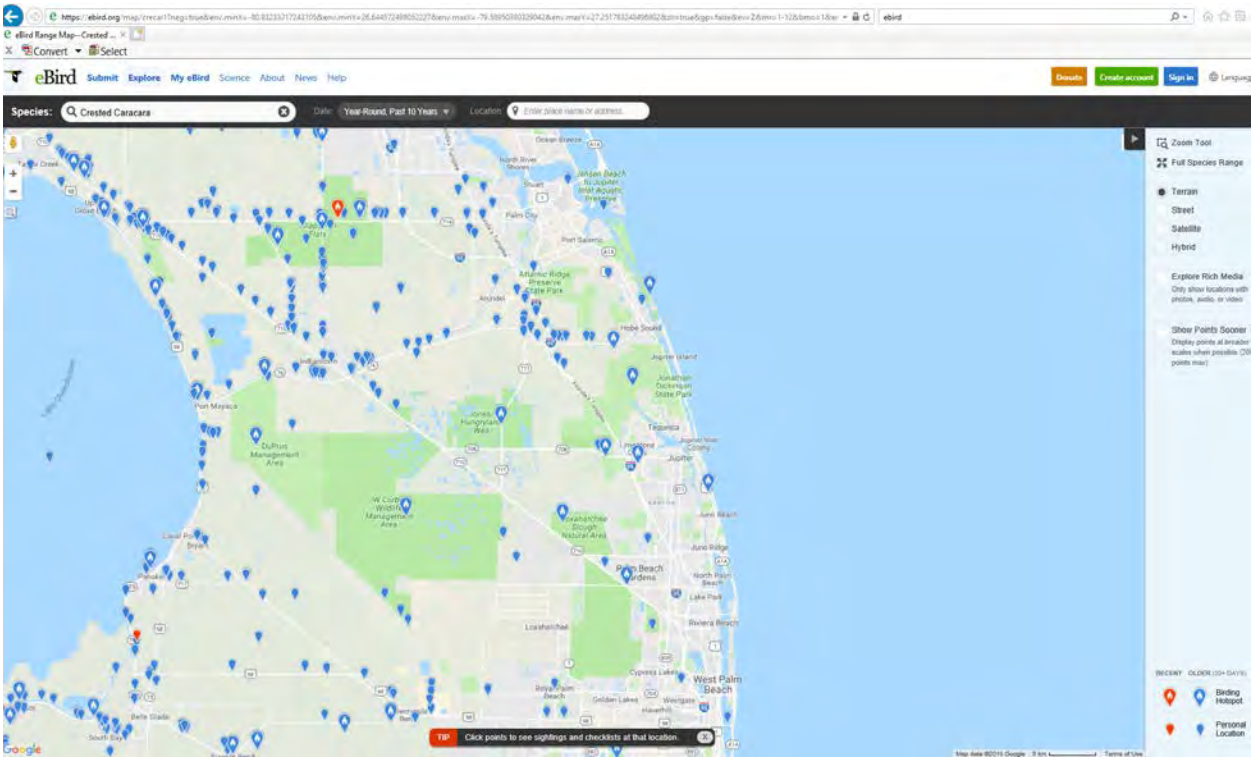


Figure C.2-8. Caracara observations (eBird database observations from 2008 to 2018).

C.2.8.3 Everglades Snail Kite

Numerous observations indicate that snail kites are frequently seen in the project area (**Figure C.2-8**). Surveys to protocol for snail kite nest sites would be conducted in affected areas during the PED stage or as a requirement of construction contracts. The direct effect of habitat loss on snail kites from any with-action alternative would be proportional to the acres of suitable habitat, generally emergent marsh supporting apple snails, affected by the alternative. Wetlands restoration to short-hydroperiod wetlands with moderate depths to support emergent vegetation will be beneficial through increased production of apple snails and increased foraging opportunities. The Corps includes survey requirements in construction contracts to assure snail kite nests are identified during construction, and to define the magnitude of adverse and potentially beneficial effects. A biological opinion exempting incidental take of snail kites will likely be needed for any with-action alternative.

Snail kites are known to nest in Hungryland Slough, Grassy Waters Preserve, Loxahatchee Slough, and possibly elsewhere in the project area depending on the annual water conditions. Between 2003 and 2018, snail kite nesting effort ranged from 0 to 11 nests, with two nests in 2018 in Grassy Waters Preserve, and 0 to 11 nests between 2012 and 2018, with 1 nest in 2018 in Hungryland (Tyler Dean, FWC, personal communication, June 19, 2018). In recent years, the introduction and expansion of the exotic apple snail (*Pomacea maculata*) population has, in turn, expanded both the areas in which snail kites may forage and nest as well as prolonged the nesting season in some years from the spring later into the summer and

sometimes fall. All alternatives that either restore or increase the spatial extent of wetlands could benefit the snail kite if apple snails and/or nesting substrate become present in those wetlands.

GWP stages are managed to hold water longer for water supply purposes and the inundation durations are longer for most of the indicator regions. For the most part, Alt 5R does not alter this pattern, Alt 2 and 13 only slightly decrease inundation duration, whereas Alt 10 approaches a more rainfall driven operation because the city relies on their water supply more from C-51 Phase II than from GWP it allows for a change in operational changes in the marsh. They do not have to hold as much water in the marsh so it can recede more. If this is a natural drawdown this would coincide with the SNKI nesting season. This was realistic because the city was on board with this operational scenario. When the plan before included the L-8 reservoir the city did follow a rainfall driven pattern. In 2013 they changed the operations from 18.2 to 18.8 to 19.2 to hold water as a hedge against drought. Operations decreases inundation in GWP to more closely match the target inundation of 70%. In GWP-5, the FWO hydrology is already at the target of 70% inundation which is maintained by Alt 5R, 2, and 13. Alt 10 decreases the inundation to 57%. GWP-6 FWO hydrology is at 97% and is maintained by Alt 5R, 2, and 13, but Alt 10 produces a target inundation of 90% inundation duration. GWP-7 hydrology in the FWO is around 89%. This hydrology is maintained in Alt 5R, decreased slightly to 85% in Alt 2 and 13, and decreased greatly to 60% in Alt 10, which is below the target of 70%. GWP-9 hydrology in the FWO is approximately 93% and is maintained in Alt 5R. Alt 2 and 13 decrease the inundation slightly to 90%, while Alt 10 decreases inundation to the target of 70%. GWP-10 hydrology in the FWO is around 97% and is maintained in Alt 5R. Alt 2 and 13 decrease inundation slightly to 93% and Alt 10 decreases moderately to 87%, towards the target inundation of 70% (**Figure C.2.34**).

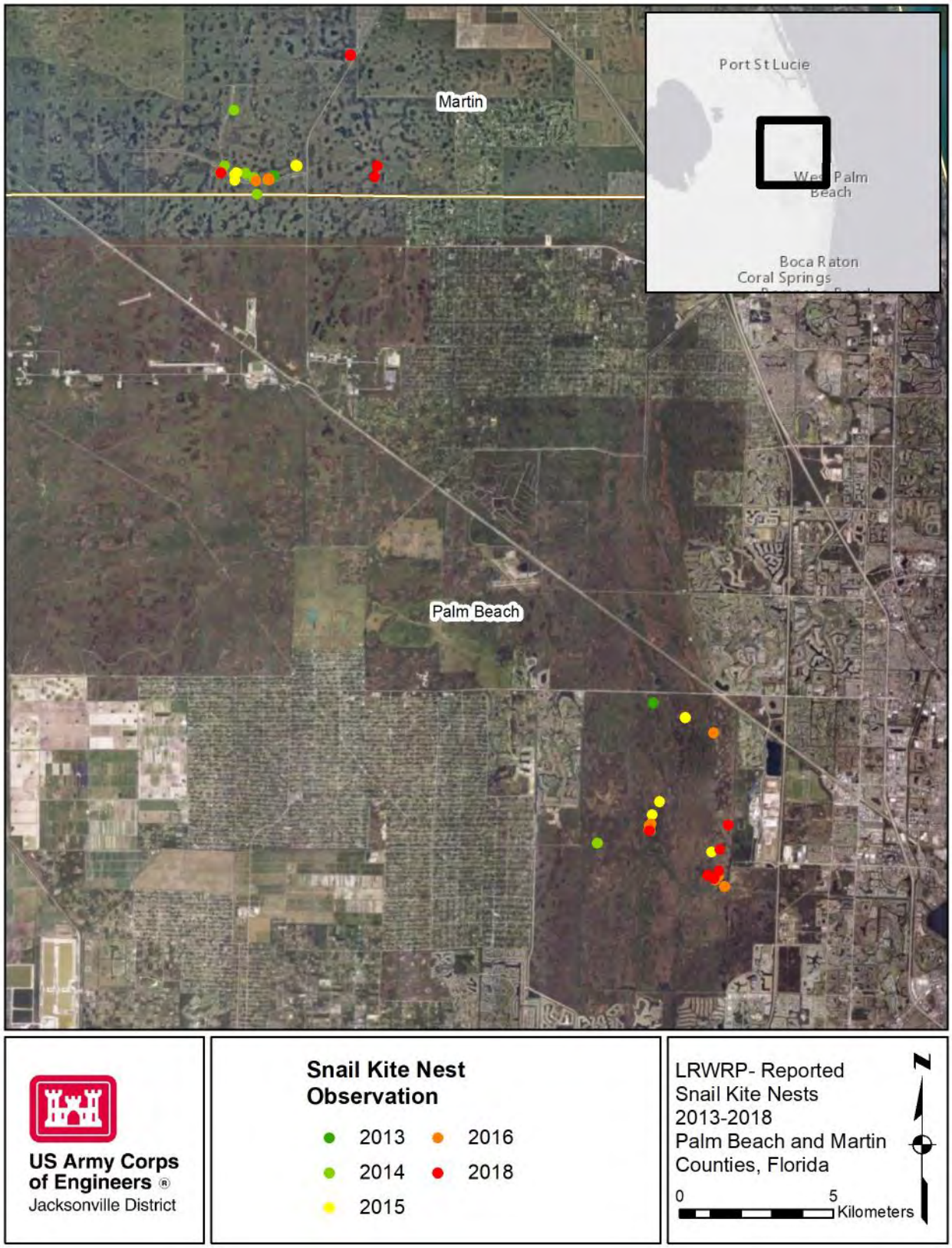


Figure C.2-9. Everglade snail kite nesting observations (USFWS database observations from 2013 to 2018).

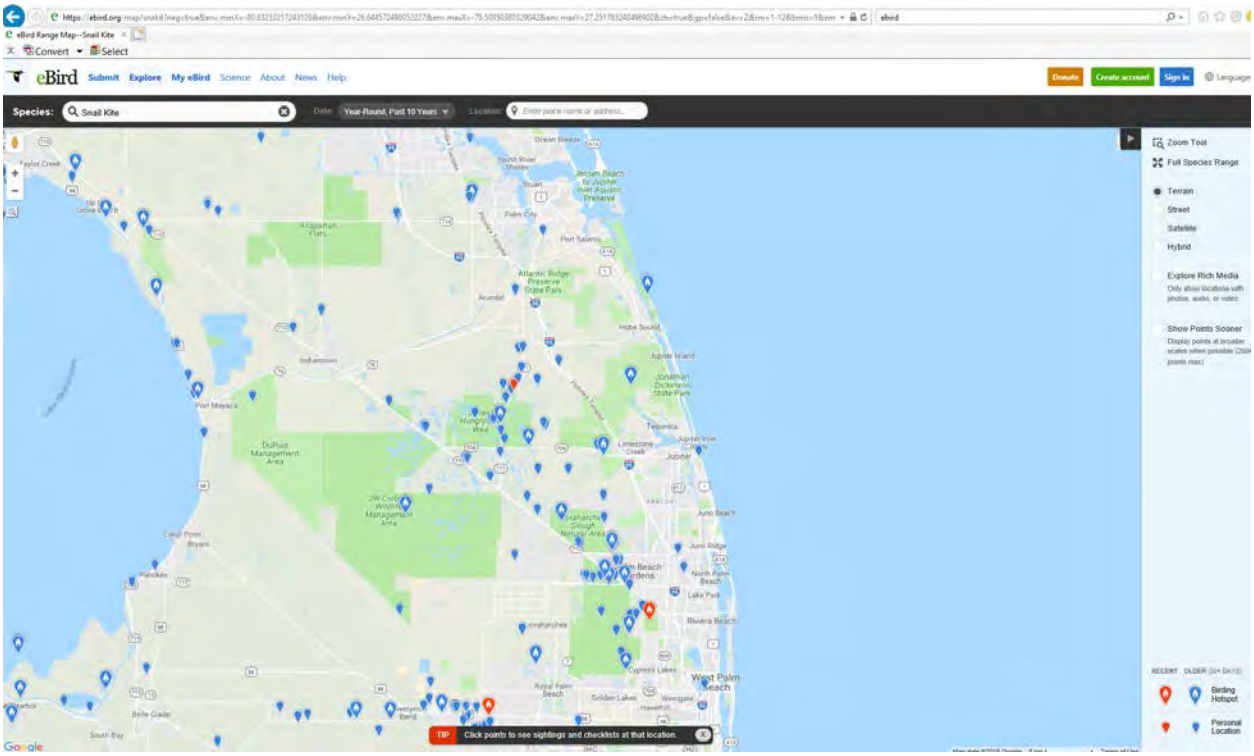


Figure C.2-10. Everglade snail kite observations from 2008-2018.

C.2.8.4 Everglades Snail Kite Critical Habitat

The project area is not within designated snail kite critical habitat.

C.2.8.5 Wood Stork

Numerous observations indicate that wood storks are frequently seen in the project area (**Figure C.2-9**). Two wood stork colonies occur within the study area, and wood stork core foraging areas overlap most of the project area (**Figure C.2-9**). In comparison to FWO, implementation of all action alternatives would be expected to improve conditions for wood storks throughout much of the project area. Restored wetland hydroperiods would increase the spatial extent of suitable foraging opportunities for wood storks providing a moderate long-term beneficial effect.

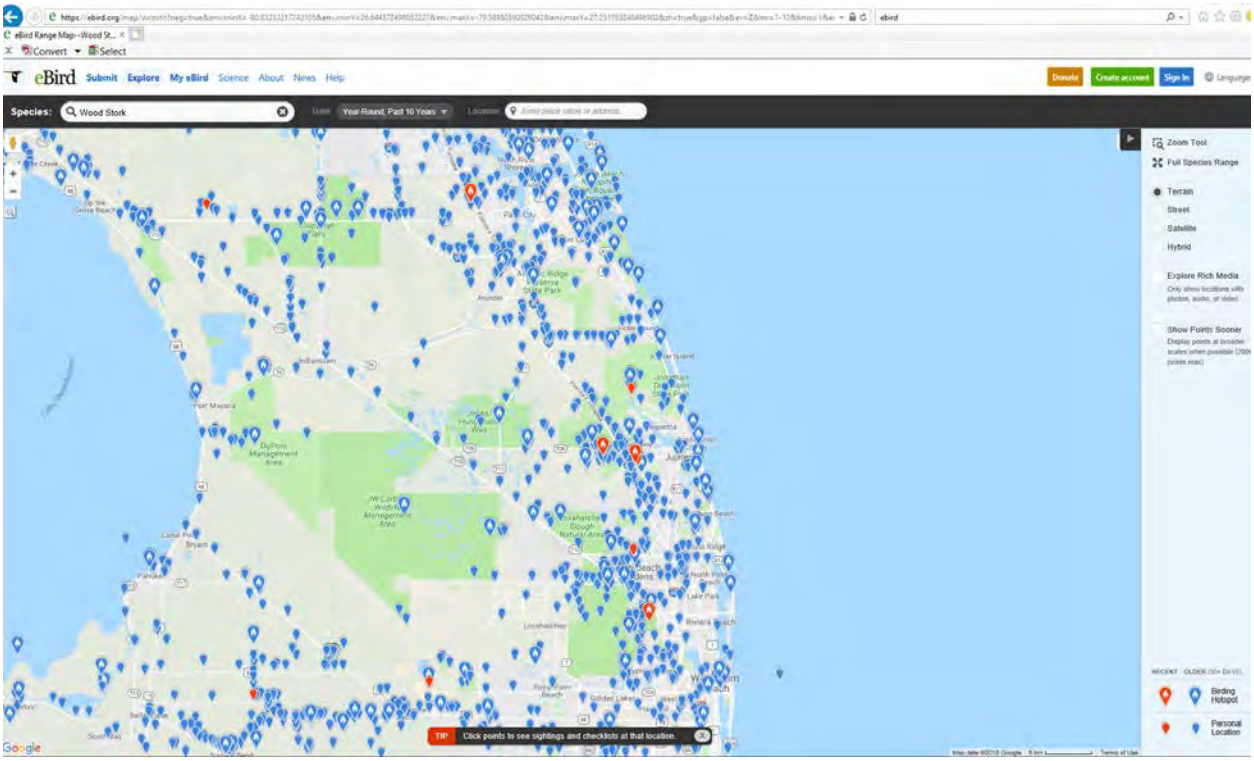


Figure C.2-11. Wood stork observations 2008-2018.

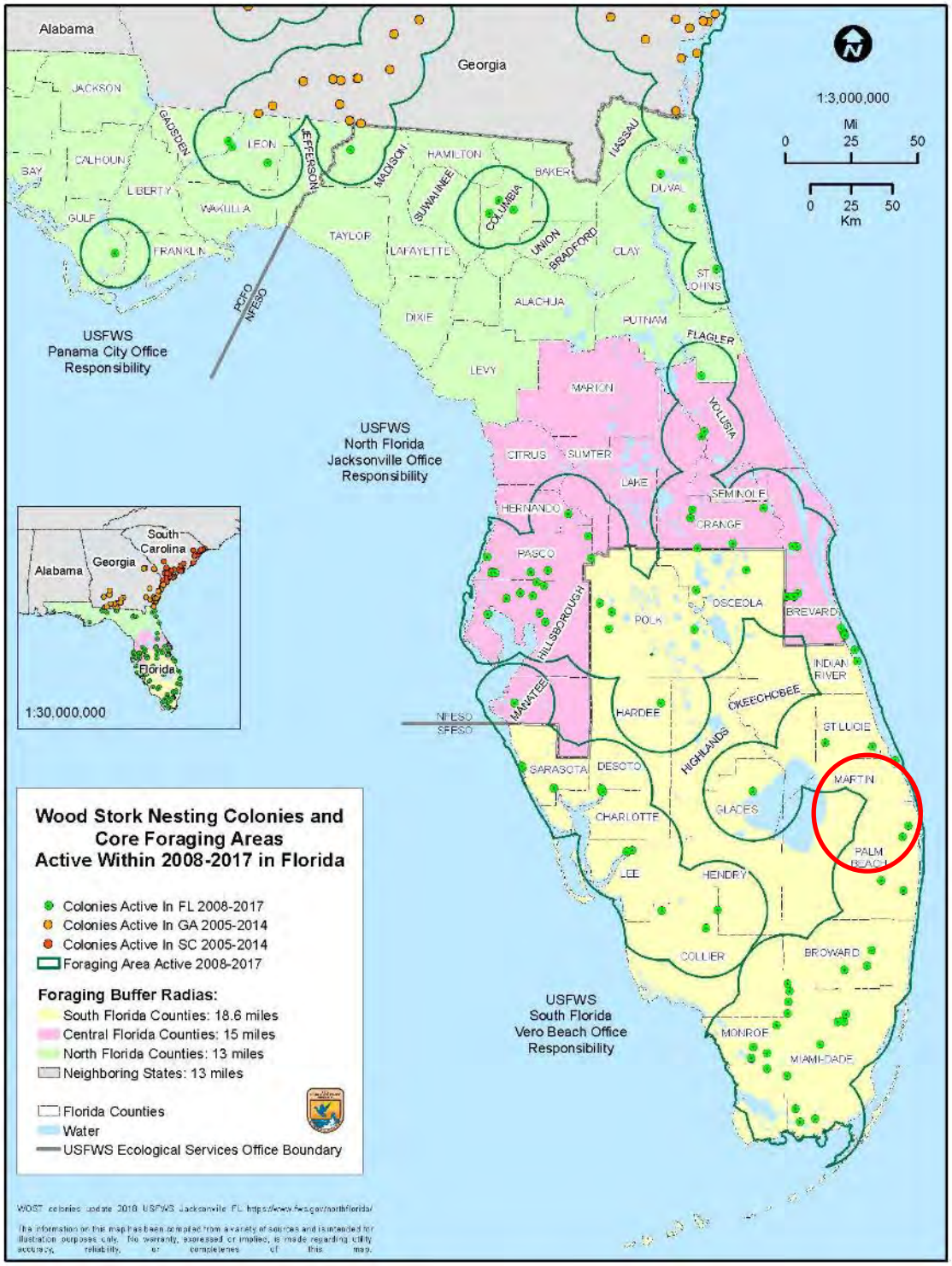


Figure C.2-12. Wood stork colony sites and core foraging areas.

C.2.8.6 Eastern Indigo Snake

Eastern indigo snakes have a high probability of occurrence within all proposed wetland restoration footprints because they are widely distributed in the matrix of uplands and wetlands throughout the project area. The FWO scenario involves lands that could be developed in the future, depending on market conditions. All LRWRP alternatives include various drained wetlands and uplands that would be transitioned to restored wetlands, and involve surficial water storage features that would not be occupied by snakes. Eastern indigo snakes have a high probability of occurrence within all proposed storage and wetland restoration footprints based on the acreage of the potential project component and the available potential snake habitat. All alternatives are likely to have unavoidable adverse effects on eastern indigo snakes. The USACE will utilize Standard Protection Measures for eastern Indigo snakes throughout project design and construction in order to minimize any potential adverse effects to the extent practicable.

C.2.8.7 Florida Manatee

The Florida manatee occurs in freshwater, brackish, and marine habitats, and can move freely between salinity extremes. The FWO will not improve habitat availability (water quantity or quality) in NWFLR and the estuary, whereas any of the “with-action” alternatives would improve seasonally beneficial flows and SAV distribution in the river and estuary, thus increasing foraging opportunities for manatees and providing a moderate beneficial effect. The TSP would provide the greatest per cent improvement to overall manatee foraging habitat within the estuary. Standard manatee protection guidelines will be used during construction along canals/rivers accessible to manatees to avoid effects.

C.2.8.8 Florida Manatee Critical Habitat

Critical habitat for the Florida manatee was designated in 1976 [50 Code of Federal Regulations [CFR] §17.95(a)]. No specific primary or secondary constituent elements were included in the critical habitat designation. However, experts agree essential habitat features for the manatee include SAV or seagrasses for foraging, shallow areas for resting and calving, channels for travel and migration, warm-water refuges during cold weather, and fresh water for drinking (Service 2001). Designated critical habitat includes … all U.S. territorial waters adjoining the coast and islands and all connected bays, estuaries , and rivers from Gordon's Pass, near Naples, Collier County, southward to and including Whitewater Bay, Martin and West Palm Beach Counties; that section of the intracoastal waterway from the town of Seawalls Point, Martin County to Jupiter Inlet, Palm Beach County; the entire inland section of water known as the Indian River, from its northernmost point immediately south of the intersection of U.S. Highway I and Florida State Highway 3, Volusia County, southward to its southernmost point near the town of Sewall’s Point, Martin County. Based on the hydrologic analysis (Section C.2.10), the TSP would provide the greatest per cent benefit of the alternatives to spatial extent of manatee habitat and improve SAV distribution for foraging habitat by reducing extreme drought and variable salinity events.

C.2.8.9 Florida Panther

The project is not within Florida panther critical habitat. One radio-collared individual was reported north of the C-44 reservoir area and it is likely that individuals roam occasionally in the LRWRP project area. Under the FWO scenario, increased development pressures and continued habitat fragmentation would reduce available panther habitat and impede nomadism. Under any of the alternatives, the proposed increased spatial extent of wetlands, with proportional increases by the proposed alternatives, may increase the potential prey base for panthers.

C.2.9 Essential Fish Habitat

Magnuson-Stevens Fishery Conservation and Management Act, 16USC 1801 et seq., Public Law 104-208, reflects the Secretary of Commerce and Fishery Management Council authority and responsibilities for the protection of essential fish habitat (EFH). Federal agencies that fund, permit, or carry out activities that may adversely impact EFH are required to consult with the National Marine Fisheries Service (NMFS) regarding the potential effects of their actions on EFH. The Corps consulted with NMFS regarding Essential Fish Habitat and species managed by NMFS. NMFS provided a Programmatic NMFS ESA Biological Opinion for CERP projects. The consultation revolved around potential impacts to living marine resources, including mangroves, seagrasses, live bottom communities, and the marine/estuarine water column that may be impacted by activities or operations of the project action alternatives. Generally, NMFS has indicated that beneficial effects to fish resources and EFH may occur as a result of CERP projects.

The project area encompasses the Loxahatchee river and estuary to Jupiter Inlet, and portions of the adjacent Indian River Lagoon. The on-shore project area is within the jurisdiction of the South Atlantic Fishery Management Council (SAFMC). The state of Florida recognized the important habitats in the area by designating the Loxahatchee River Lake Worth Creek Aquatic Preserve, which encompasses all forks of the river. As described in Appendix C.1.9, EFH is mapped within the Loxahatchee River, Jupiter Inlet, Indian River Lagoon, and waters immediately offshore for five management groups (National Marine Fisheries Service [NMFS] 2000): snapper-grouper complex (e.g., grouper (*Epinephelus* spp.), gray snapper (*Lutjanus griseus*), white grunt (*Haemulon plumieri*), red porgy (*Pagrus pagrus*)), spiny lobster (*Panulirus argus*), coral, coral reefs, and live/hard bottom habitats of the South Atlantic Region (Ahermatypic stony corals, Black corals, Hermatypic stony corals, Octocorals, Pennatulacea), coastal migratory pelagics of the gulf of Mexico and South Atlantic (cobia, king mackerel, Spanish mackerel) and several highly migratory species. The golden crab fishery of the South Atlantic region occurs offshore and a figure depicting its range is not provided in this discussion. Effects of the FWO and alternatives on fisheries management groups are shown in **Table C.2-10**.

The USACE acknowledges the potential existence of federally listed threatened and endangered species under NMFS purview within the boundaries of the LRWRP study area. Johnson's seagrass occurs within the Loxahatchee estuary and may be benefited by the project. The green sea turtle, hawksbill sea turtle, leatherback sea turtle, Kemp's ridley sea turtle, and the loggerhead sea turtle are known to potentially exist within close proximity of the project area, and any project related impacts through restoration efforts will ultimately benefit estuarine and nearshore communities and associated biota. Based on available information, it is evident that the Gulf sturgeon and smalltooth sawfish occur within the study area and could be benefited by LRWRP implementation. Elkhorn and staghorn stony corals occur offshore and outside project area or effect. The USACE has determined that the proposed project would enhance estuarine nursery conditions but would be unlikely to affect species outside the estuary where estuarine discharge is rapidly blended with the Atlantic ocean waters.

Table C.2-10. Effects of FWO and Alternatives on fisheries management groups.

Alternative	Snapper-grouper complex	Spiny lobster	Coral	Coastal migratory pelagics	Highly migratory species
FWO	Wet season flows meet 78% of target, and dry season flows meet between 57% and 65% of targets measure at Lainhart Dam. Tributary creeks will continue to be drained with limited groundwater contribution during dry season and flashy flows during the wet season. Downstream salinities will continue to be altered and with gradual sea-level rise, salinities will continue to increase up the northwest fork impacting tape grass, oligohaline, and tidal/freshwater riverine cypress forest zones.				
Effect	Degradation of Loxahatchee river branches & estuary	Degradation of Loxahatchee river branches & estuary	Offshore resources	Degradation of Loxahatchee river branches & estuary	Degradation of Loxahatchee river branches & estuary
All Alts	Increased wet season flows up to 98% of target. All alternatives improve Moonshine Creek hydrology with Gulfstream East features. Alt 10 increases dry season Lainhart flows to 95% and improves timing of Kitching Creek flows and to a lesser extent Moonshine and Cypress Creek flows.				
Effect	Improve nursery and adult habitat	Improve nursery and adult habitat	Offshore resources	Improve nursery habitat	Improve nursery habitat

Relative effects of the FWO and alternatives on Essential Fish Habitat are shown in **Table C.2-11**. Both Alt 5R and Alt 10 accrue greater benefits than Alt 2 or Alt 13.

Table C.2-11. Relative effects of FWO and alternatives to essential fish habitat.

Impact of Alternatives to Essential Fish Habitat (as a result of degradation or improvement of Loxahatchee River branches and estuary)						
Alternative	**% target flows to NWFLR met dry/wet season**	**Snapper-grouper complex**	**Spiny lobster**	**Coral (offshore)**	**Coastal migratory pelagics**	**Highly migratory species**
FWO	65/78	(-)	(-)	N/A	(-)	(-)
Alt 2	87/98	+	No effect	N/A	+	No effect
Alt 5R	91/98	++	No effect	N/A	++	No effect
Alt 10	95/100	++	No effect	N/A	++	No effect
Alt 13	80/98	+	No effect	N/A	+	No effect
(+) = positive impact to class (-) = negative impact to class						

The Loxahatchee estuary and Jupiter Inlet receive seasonally and inter-annually variable discharges from the watershed, which will be modulated and improved by the TSP, particularly improving insufficient flows in the annual dry season and in dry years. Restoration goals for the Loxahatchee estuary include maintaining a more naturally variable salinity range that will stabilize fish, benthic invertebrates, oyster, and SAV populations and distributions.

C.2.10 State-listed Species

The LRWRP project area contains habitat suitable for the presence, nesting, and/or foraging of 12 state-listed threatened species (plus 1 threatened by similarity of appearance), and 1 species of special concern (**Table C.2-12**). Effects of project activities are not likely to adversely affect state protected species. Impacts to state-listed wading bird species will be similar to those described for the federally endangered wood stork. Modifications to the existing C&SF / LRWRP project are designed to improve hydrologic conditions for wading birds through increasing foraging opportunities within the project, thereby directly benefitting these species within the LRWRP study area.

Table C.2-12. State-listed threatened and endangered species potentially affected by LRWRP.

Group	Common Name	Scientific Name	State Status	Project Effects
Mammals	Sherman's fox squirrel	*Sciurus niger shermani*	FWC - SSC	Minimal disturbance of preferred habitats (longleaf pine (*Pinus palustris*) forests, mixed pine-hardwood forests, pineland, sandhill, and scrub)
Birds	American oystercatcher	*Haematopus palliatus*	FWC - ST	Project will not affect coastal areas
Birds	Black skimmers	*Rychops niger*	FWC - ST	Project will not affect coastal areas
Birds	Florida burrowing owl	*Athene cunicularia*	FWC - ST	Restoration of agricultural area historic hydrologic patterns to freshwater wetlands (primarily seasonal depression marsh) may diminish available habitat; Each work area will be re-surveyed before construction begins;
Birds	Florida sandhill crane	*Antigone canadensis pratensis*	FWC - ST	Restoration of agricultural area historic hydrologic patterns to freshwater wetlands (primarily seasonal depression marsh); post-construction beneficial effects; volitional avoidance
Birds	least tern	*Sternula antillarum*	FWC - ST	Project will not affect coastal areas
Birds	Little blue heron	*Egretta caerulea*	FWC - ST	Restoration of hydrologic patterns to freshwater wetlands (primarily seasonal depression marsh); post-construction

Group	Common Name	Scientific Name	State Status	Project Effects
				beneficial effects; volitional avoidance
Birds	Tricolored heron	*Egretta tricolor*	FWC - ST	Restoration of hydrologic patterns to freshwater wetlands (primarily seasonal depression marsh); post-construction beneficial effects; volitional avoidance
Birds	Reddish egret	*Egretta rufescens*	FWC - ST	Project should benefit estuarine salinity balance and foraging
Birds	Roseate spoonbill	*Platalea ajaja*	FWC - ST	Project should benefit estuarine salinity balance and foraging
Birds	southeastern American kestrel	*Falco sparverius paulus*	FWC - ST	Project area does not include KMUs, project will not affect typical southeastern sandhill ecosystem habitat, will modify some abandoned orange groves; volitional avoidance.
Reptiles	Florida pine snake	*Pituophis melanoleucus mugitus*	FWC - ST	Well-drained sandy soils with a moderate to open canopy
Reptiles	American alligator	*Alligator mississippiensis*	FWC – FT(S/A)	Volitional avoidance; pre-construction surveys; individuals will be excluded from work areas during construction; beneficial effects post-construction
Reptiles	Gopher tortoise	*Gopherus polyphemus*	FWC - ST	Restoration of agricultural area historic hydrologic patterns to freshwater wetlands (primarily seasonal depression marsh) may diminish available habitat; Each work area will be re-surveyed before construction begins; Standard protection and conservation measures will be implemented during construction;

Notes: E: Endangered, T: Threatened, SC: Species of Special Concern, SA: Similarity of Appearance, CH: Critical Habitat; Pr E: Proposed Endangered; Pr CH: Proposed Critical Habitat.

C.2.10.1 State-listed beach-nesting birds (American oystercatcher, black skimmer, least tern)

The state listed beach-nesting birds include the American oystercatcher, black skimmer and least tern. These species nest directly in sand, shell, or small gravel in coastal areas, in shallow scrapes in sand, shell, or gravel along the coast, near bodies of fresh water and occasionally on flat, gravel-covered rooftops. They will also rarely nest in large construction areas with suitable habitat. Threats to these species include

habitat loss and degradation, largely due to coastal development and incompatible recreational use, disturbance during breeding, causing nest failure and resulting in loss of eggs and/or chicks, changes to water quality that impact bivalves (e.g., turbidity, depth, and temperature) and predation that is magnified by human disturbance. All LRWRP action alternatives would likely benefit the bivalves, small fish and other prey items within the estuary.

C.2.10.2 Burrowing Owl

The burrowing owl occurs throughout the state although its distribution is considered spotty. The presence of burrowing owls is primarily dependent upon habitat. Burrowing owls inhabit open native prairies and cleared areas that offer short groundcover including pastures, agricultural fields, golf courses, airports, and vacant lots in residential areas. All LRWRP alternatives include storage features that will convert uplands to wetland habitat and wetland restoration sites that will convert uplands to wetlands. Florida burrowing owls have a high probability of occurrence within all proposed storage features and wetland restoration footprints and as a result of construction are likely to be displaced. The USACE will coordinate with Florida Fish and Wildlife Conservation Commission (FWC) on appropriate burrowing owl impact avoidance, minimization, and/or mitigation measures. Prior to construction, burrowing owl surveys will be conducted and if burrows are found will be relocated to minimize the impact of the project. All action alternatives may have an unavoidable adverse effect.

C.2.10.3 Florida Sandhill Crane

Florida sandhill cranes are non-migratory and inhabit prairies, improved pastures, and freshwater marshes. They occur throughout peninsular Florida north to the Okefenokee Swamp in southern Georgia. Degradation or direct loss of habitat due to wetland drainage or conversion of prairie for development or agricultural use is the primary threat that they face. All LRWRP alternatives include storage features that will convert uplands to wetland habitat and wetland restoration sites that will convert uplands to wetlands. Florida sandhill cranes may occur within all proposed storage features and wetland restoration footprints and as a result of construction may be displaced from storage features and to a lesser extent from wetlands. All alternatives provide a benefit to the Florida sandhill crane. Prior to construction, Florida sandhill crane surveys will be conducted. As needed, the USACE will coordinate with the FWC on appropriate Florida sandhill crane impact avoidance, minimization, and/or mitigation measures.

C.2.10.4 State-listed Wading Birds (reddish egret, little blue heron, roseate spoonbill, tricolored heron)

The state-listed wading bird species in the project area include the reddish egret, little blue heron, roseate spoonbill, and tricolored heron. The project would have no effect on reddish egret (Ricardo Zambrano, FWC, personal communication, June DD, 2018). As compared with FWO, all action alternatives would be expected to significantly improve foraging conditions for wading birds throughout much of the project area. Wetland restoration is anticipated to increase the spatial extent of suitable foraging opportunities for wading birds and therefore provides a moderate beneficial effect.

C.2.10.5 Southeastern American Kestrel

The southeastern American kestrel is a non-migratory subspecies of the American kestrel closely tied to sandhills in the southeastern U.S with preferred habitat consisting of open fields, grasslands, savannahs, or other habitats that contain widely scattered trees or similar perches. Population declines of southeastern American kestrels in Florida have been largely attributed to clearing of older pine forests

and conversion of sandhill and other upland habitats for agriculture and urban development. Kestrels are secondary cavity nesters, and suitable nest sites can be a limiting factor for kestrel populations (Smallwood and Collopy 2009). All alternatives include storage features that will convert uplands to wetland habitat and wetland restoration sites that will convert uplands to wetlands. Southeastern American kestrels have a high probability of occurrence within all proposed storage feature and wetland restoration footprints and as a result of construction are likely to be displaced and nesting sites lost. As needed, the USACE will coordinate with the FWC on appropriate southeastern American kestrel impact avoidance, minimization, and/or mitigation measures.

C.2.10.6 Florida Pine Snake

The Florida pine snake is found in the project area and prefers habitats with well-drained, sandy soils and moderate to open canopy cover (Franz 1992, Ernst and Ernst 2003). The most common natural habitat of pine snakes in Florida is sandhill, but they also are found in scrub, xeric hammock, scrubby flatwoods, and mesic pine flatwoods and dry prairie with dry soils (Allen and Neill 1952, Enge 1997, Franz 2005). Florida pine snakes are fossorial, spending ca. 80% of their time in underground retreats, primarily burrows of the southeastern pocket gopher (*Geomys pinetis)* (Franz 2005, Miller 2008) as well as other retreats such as stumpholes, mole runs, and burrows of gopher tortoises (*Gopherus polyphemus*), nine banded armadillos (*Dasypus novemcinctus*), and mice (Franz 2005, Miller 2008). All alternatives include storage features that will convert uplands to wetland habitat and wetland restoration sites that will convert uplands to wetlands. As needed, the USACE will coordinate with the FWC on appropriate Florida pine snake impact avoidance, minimization, and/or mitigation measures.

C.2.10.7 Sherman's Fox Squirrel

Sherman's fox squirrel is a species of special concern and are large tree squirrels that inhabit mature, open, fire-maintained longleaf pine (*Pinus palustrus*) - turkey oak (*Quercus laevis*) sandhills and flatwoods. To accommodate the large home ranges and fluctuating food resources, suitable habitat also includes more productive lower slopes of sandhills (Kantola 1992). This species also inhabits mixed hardwood pine, mature pine forests, cypress domes, pastures, the ecotone between bayheads and pine flatwoods, and other open habitats with pines and oaks (summarized in Endries et al. 2009; Florida Natural Areas Inventory 2001). All alternatives include storage features that will convert uplands to wetland restoration sites that will convert uplands to wetlands. Sherman's fox squirrel may occur within all proposed storage feature and wetland restoration footprints and as a result of construction are likely to be displaced. Prior to construction, Sherman's fox squirrel surveys will be conducted. As needed, the USACE will coordinate with the FWC on appropriate Sherman's fox squirrel impact avoidance, minimization, and/or mitigation measures.

C.2.10.8 American Alligator

The American alligator inhabits freshwater lakes, slow moving rivers, and brackish water habitats in Florida. The alligator can be found from southeast Oklahoma and east Texas, east to North Carolina, and down Florida (Florida distribution map data from: Krysko et al. 2011). Alligators are distributed ubiquitously throughout the project features. The American alligator is Federally protected by the Endangered Species Act as a Threatened species, due to their similarity of appearance to the American crocodile, and as a Federally-designated Threatened species by Florida's Endangered and Threatened Species Rule. Alligators would be managed as required by federal and/or state regulation during project development.

C.2.10.9 Gopher Tortoise

Gopher tortoises are found in the southeastern Coastal Plain, from southern South Carolina, southwest to extreme southeastern Louisiana (Florida Natural Areas Inventory 2001). In Florida, tortoises occur in parts of all 67 counties, but prefer high, dry sandy habitats such as longleaf pine-xeric oak sandhills. They also may be found in scrub, dry hammocks, pine flatwoods, dry prairies, coastal grasslands and dunes, mixed hardwood-pine communities, and a variety of disturbed habitats, such as pastures.The gopher tortoise is protected as a State-designated Threatened species by Florida's Endangered and Threatened Species Rule. Gopher tortoises must be relocated before any land clearing or development takes place, and property owners must obtain permits from FWC before they can move them. The U.S. Fish & Wildlife Service lists the gopher tortoise as a Candidate species for protection under the Federal Endangered Species Act. The gopher tortoise has been regulated in Florida since 1972 and has been fully protected since 1988. Despite the afforded protection, many gopher tortoise populations in Florida continue to decline. Project features would be surveyed in the PED stage and again pre- and during construction as necessary to avoid harm to gopher tortoises.

C.2.11 Fish and Wildlife

The LRWRP potential effects on wildlife of the FWO and action alternatives within the LRWRP action area are summarized below. Implementation of LRWRP action alternatives would have beneficial effects for most fish and wildlife resources within the LRWRP project area (**Table C.2-13**).

Table C.2-13. LRWRP FWO and effects of alternatives to wildlife taxa.

Impact of Alternatives to Wildlife (as a result of degradation or improvement of Loxahatchee watershed, river branches and estuary)						
Alternative	**% target flows to NWFLR met dry/wet season**	**Aquatic invertebrates**	**Fish**	**Reptiles and Amphibians**	**Birds**	**Mammals**
FWO	65/78	(-)	(-)	(-)	(-)	(-)
Alt 2	87/98	+	++	++	+	+
Alt 5R	91/98	++	++	++	++	+
Alt 10	95/100	++	++	++	++	+
Alt 13	80/98	+	++	++	+	+

(+) = positive impact to class

(-) = negative impact to class

C.2.11.1 Invertebrates

With implementation of any LRWRP action alternative within the LR watershed and restored wetlands, aquatic invertebrates would rapidly colonize restored or created aquatic habitat directly benefitting invertebrates within the action area resulting in a moderate beneficial effect. Increases in stages and hydroperiods within the restored wetlands would promote wetland vegetation transition through expansion of several wetland types, which provides substrate and/or forage for many aquatic invertebrates.

C.2.11.2 Fish

With implementation of any LRWRP action alternative within the LR watershed and restored wetlands, fish in wetlands would be benefited by improved hydroperiods and riverine fish would be benefited by improved water quantity, quality, and expansion of the wetted perimeter encompassing a greater area of the riparian fringe. Greater connectivity between project features would increase and provide more diverse aquatic habitat in a matrix of storage features, canals, and overland sheet flow. The large reservoir will have limited benefit as fishery habitat since it is being designed as a deep storage facility and will not have a littoral zone. Operation of pumps would be likely to cause some entrainment and impingement of fish and other aquatic organisms. Species that will likely inhabit project waters include a variety of warmwater forage and game fish: largemouth bass, black crappie, gar, red ear sunfish, bluegill, and mosquitofish, among others, including exotic species such as armored catfish and cichlids.

C.2.11.3 Reptiles and Amphibians

Reptiles and amphibians, including alligators, snakes, turtles, and frogs, use a variety of habitats depending on their life history stage and habitat availability. Aquatic invertebrate and fish populations would increase, resulting in increased foraging opportunities for the variety of species that forage on aquatic prey. All alternatives would result generally in moderate to major beneficial effects for reptiles and amphibians as parcels are committed to the project, reducing the risk of future development and assuring longterm habitat availability. Aquatic reptiles and amphibians would benefit from the increased spatial extent of suitable habitat resulting from wetland rehydration within previously ditched and drained areas within the watershed. Increased aquatic prey availability (e.g., crayfish and other invertebrates, fish) would also directly benefit reptile and amphibian species. A loss of terrestrial habitat for upland herptiles (e.g., toads, various snakes, and box turtle) would result from the conversion of agricultural lands to reservoir.

C.2.11.4 Birds

Current eBird reports indicate 304 and 396 resident and migratory bird species observed in Martin and Palm Beach counties, respectively. Project implementation would benefit all bird species by committing lands to the project instead of the uncertainty of future development. Project features that are also top birding hot spots in Marin County include JDSP (189 observed species), DePuis WEA (156 observed species), and Hungryland WEA (110 observed species) (eBird https://ebird.org/region/US-FL-085?yr=all&m=&rank=mrec, accessed September 26, 2018). Project features that are also top birding hot spots in Palm Beach County include Loxahatchee National Wildlife Refuge (244 observed species), Loxahatchee Slough (168 observed species), J. W. Corbett WMA (167 observed species), and Grassy Waters Nature Preserve (127 observed species) (eBird https://ebird.org/region/US-FL-099?yr=all&m=&rank=mrec, accessed September 26, 2018). Restoring wetlands across the project area would have moderate to major beneficial effects for numerous species. Aquatic invertebrate and fish

populations would increase, resulting in increased foraging opportunities for the variety of species that forage on aquatic prey. Wading birds would be benefited by increased foraging habitat dispersed across the landscape. Increased wetland acreage would produce moderate to major long-term benefits for the variety of raptors, including osprey, bald eagle, and snail kites, plus cormorants, anhingas, and other birds that forage on aquatic invertebrates, fish, and herptiles. Waterfowl would likely be attracted to the reservoir, although its productivity would be limited since a broad littoral zone of emergent vegetation is not planned for the reservoir perimeter. Forested or upland bird species (turkey, bobwhite quail, and songbirds) may lose habitat within areas that shift from mesic to hydric flatwoods. The conversion of uplands, such as fallow citrus groves, to wetlands or agriculture to water storage features would reduce available habitat for some insectivorous or frugivorous birds such as mourning and ground doves, and sparrows that forage in these habitats.

C.2.11.4.1 Bald Eagle

Bald eagles are protected pursuant to the Bald and Golden Eagle Protection Act USACE reviewed the known locations of bald eagle nests and will be cognizant of them during project design. As necessary, USACE will implement the National Bald Eagle Management Guidelines during construction (USFWS 2007).

The FWS published the final rule announcing the removal of the bald eagle from the federal list of endangered and threatened wildlife in the Federal Register on July 9, 2007, which became effective on August 8, 2007. Bald eagles remain protected under the Bald and Golden Eagle Protection Act and the Migratory Bird Treaty Act; therefore, bald eagles nests in the study area and within a three mile buffer of the study area were identified using the FWC Bald Eagle Nest Locator database (https://public.myfwc.com/FWRI/EagleNests/nestlocator.aspx). The database showed 15 nests in Martin County and 12 nests in Palm Beach County (**Table** and **Figure C.2-10**). The eagle nesting season occurs from October through May. Territories are used year after year, generally by the same pair.

Table C.2-14. Bald eagle nest locations in Martin and Palm Beach counties.

Nest ID	County	Latitude	Longitude	Last Known Active	Last Surveyed	Active 2017
MT001	Martin	27 00.33	80 08.09	2016	2016	Y
MT005	Martin	26 59.00	80 33.90	1997	2012	*
MT006	Martin	26 58.11	80 32.94	2016	2016	Y
MT007	Martin	27 00.30	80 33.40	2012	2016	-
MT008	Martin	26 58.84	80 34.68	2016	2016	Y
MT010	Martin	27 06.89	80 12.16	2012	2016	-
MT011	Martin	26 58.14	80 34.38	2016	2016	Y
MT014	Martin	27 01.30	80 22.00	2004	2012	*
MT016	Martin	26 57.51	80 33.99	2009	2016	-
MT017	Martin	26 57.63	80 34.53	2016	2016	Y
MT023	Martin	27 00.28	80 37.32	2009	2016	-
MT024	Martin	26 58.73	80 33.56	2009	2016	-
MT026	Martin	27 02.75	80 20.54	2016	2016	Y
MT028	Martin	27 08.41	80 10.08	2016	2016	Y

Nest ID	County	Latitude	Longitude	Last Known Active	Last Surveyed	Active 2017
MT030	Martin	27 00.28	80 34.95	2016	2016	Y
PB002	Palm Beach	26 56.92	80 33.42	1997	2014	*
PB004	Palm Beach	26 54.67	80 30.99	2015	2016	N
PB006	Palm Beach	26 47.65	80 10.17	2015	2015	*
PB007	Palm Beach	26 55.89	80 32.36	1999	2014	*
PB008	Palm Beach	26 52.39	80 23.89	2015	2016	N
PB009	Palm Beach	26 48.82	80 23.58	2001	2014	*
PB011	Palm Beach	26 52.08	80 27.73	2015	2016	N
PB016	Palm Beach	26 55.09	80 32.20	2016	2016	Y
PB017	Palm Beach	26 50.80	80 23.32	2016	2016	Y
PB020	Palm Beach	26 55.27	80 26.14	2015	2016	N
PB022	Palm Beach	26 53.15	80 05.91	2014	2014	*
PB025	Palm Beach	26 44.22	80 21.48	2015	2015	*

Source: FWC Bald Eagle Nest Locator database accessed 7/24/2018; nests within 3 mile buffer of project area.

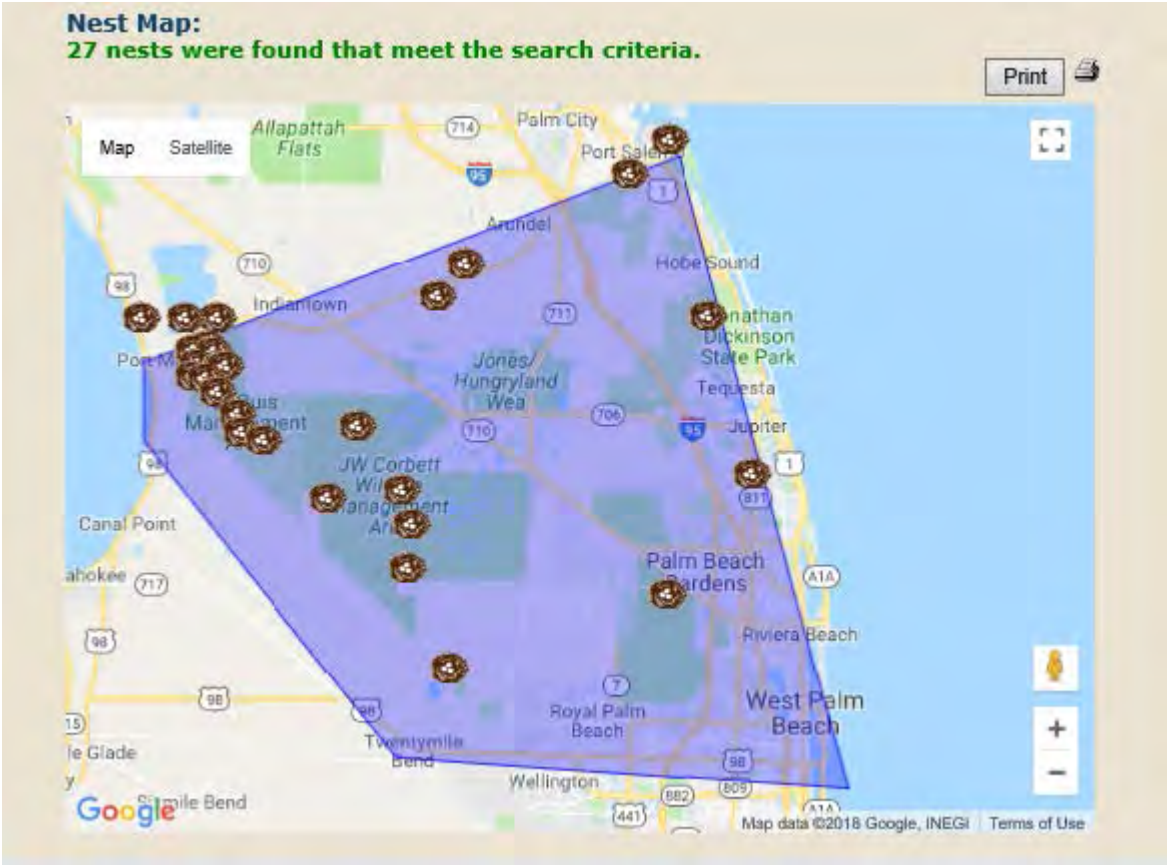


Figure C.2-7. Bald eagle nest locations within a three mile buffer of the LRWRP project area in Martin and Palm Beach counties.

In south Florida, nests are often in the ecotone between forest and marsh or water, and are constructed in dominant or co-dominant living pines (*Pinus spp*.) or bald cypress (*Taxodium distichum*) (McKewan and Hirth 1979). Approximately ten percent of eagle nests are located in dead pine trees, while two to three percent occur in other species, such as Australian pine (*Casuarina equisetifolia*) and live oak (*Quercus virginiana*). Suitable habitat for bald eagles generally is any forested area with potential nesting trees that are within 1.9 miles (3 kilometers) of large open water, such as borrow pits, lakes, rivers, and large canals.

C.2.11.5 Mammals

As compared with FWO, potential minor to major long-term beneficial effects for mammals within the action area are anticipated with implementation of any action alternative. Piscivorous mammals, such as raccoons and river otters, would benefit from increased small prey fish biomass in rehydrated wetlands with longer hydroperiods. In comparison to the FWO, where development pressure could result in land use changes, lands committed to the project would continue to provide a landscape matrix of wetland and upland habitats that would be generally beneficial to terrestrial mammals. Some stands of pines are predicted to become too wet to survive and would be habitable snags for arboreal mammals as long as they were standing.

C.2.12 Hydrology

Hydrologic modeling simulations of the existing condition baseline (ECB) and the LRWRP future without project condition (FWO) were developed with the Lower East Coast Sub-Regional modeling tool for North-Palm (LECSR-NP), to provide baseline conditions for plan formulation, the assessment of LRWRP project benefits (comparisons against FWO), and the assessment of LRWRP alternative performance for the level-of-service for flood protection and water supply (comparisons against ECB). The ECB was developed to represent the system-wide infrastructure and operations that were in place at the time LRWRP plan formulation. The FWO for LRWRP assumes the construction and implementation of currently authorized CERP and non-CERP projects, and other Federal, state or local projects constructed or approved under existing governmental authorities that occur in the LRWRP study area. Features simulated in the existing condition base include the recent modifications to the G-92 structure, the North Lake Boulevard weir, wetland improvement areas constructed by Palm Beach County, regional system deliveries to the City of West Palm Beach, the east Corbett weir and the existing canal operations for the SFWMD canals, water control districts (298 Districts) and local developments. The main change from existing conditions not presently observed is the Public Water Supply Utility demands which are based upon the SFWMD permitted allocation and not upon recently observed usage. The future without project base includes all the existing condition base assumptions, except it is assumed that the L-8 Flow Equalization Basin is operational and is receiving water from outside of the L-8 Basin. In addition, the future without project base includes the recent proposal for the Avenir property which creates two wetland areas on the northern portion of the property and an urban development at the southern section of the property. All alternatives include the components of the future without project base assumptions unless otherwise specified (Giddings et al. 2018).

Selection of the TSP is conducted based on comparisons between the LRWRP action alternatives and the LRWRP FWO. The reader should refer to **Section 2** of the LRWRP PIR main report and **Appendix A** for additional documentation of the ECB and FWO conditions. All alternatives improve wet season and dry season flows to the Loxahatchee River, above that of the FWO condition, by capturing excess freshwater previously lost to tide and sending flows to meet the wet and dry season flow targets. The timing of tributary creek flow and ground water is improved with alternatives to various degrees. This results in

improvements to downstream freshwater river and estuarine salinity conditions important to various habitat zones and flora/fauna species. Restoration alternatives improve watershed hydrology by decreasing excess drainage through implementation of water storage features and control structures, removal of berms, filling of ditches, hydrologic connection between natural areas which are currently cut off, introducing sheetflow and rehydration of areas with spreader canals and natural flow-ways. A summary of the anticipated hydrologic effects of the alternative actions, which were described in **Section 3**, is presented in **Table C.2-15.**

Table C.2-15. Effects of FWO and alternatives on hydrology.

Geographic Region	Alt	Hydrologic Effects
NWFLR	FWO	Wet season flows meet 78% of target, and dry season flows meet 65% of targets measure at Lainhart Dam. Tributary creeks will continue to be over-drained with limited groundwater contribution during the dry season and high (sometimes excessive) discharges during the wet season. Lack of storage in those tributary basins will results in periods of excessive freshwater inflow, followed by periods of insufficient freshwater inflow into the estuary. Downstream salinities will continue to be altered and with gradual sea-level rise, salinities will continue to increase up the northwest fork impacting *Valisneria*, oligohaline, and tidal/freshwater riverine Cypress forest zones.
	All Alts	All alternatives showed an increase in percentage of time the wet and dry season targets were met. Increased wet season flows up to 98% of target for Alts 2 and 5, 100% for Alt 10 and 93% for Alt 13. Additionally, dry season targets were met at or greater than 75% of the POR, with Alt 5R and 10 producing the greatest percentage at 91% and 95%, respectively. The tributary, Cypress Creek showed hydrologic improvement in Alts 2, 5, and 13 over that of alt 10 by both improving the timing and distribution of peak flow volumes. Hobe and Kitching Creek preformed similarly among the alternatives, improving the hydroperiod while simultaneously decreasing the flashiness of the tributaries.
FW1	FWO	Grassy Waters Preserve south of North Lake Boulevard hydrology remains in good condition. The FWO condition shows higher water levels than ECB due to the redirection of the discharge from the proposed Avenir property and therefore the FWO hydrology is dependent upon the construction of Avenir.
	All Alts	G-160 and G-161 improve Loxahatchee Slough hydroperiods in all alternatives. Minor changes to hydrology in GWP south of north lake boulevard for Alts 2, 5R, and 13, and more moderate decreased stages in GWP with Alt 10. Alt 5R introduces additional volume through the M-canal, which, depending on operations, may be used for make-up water for the City of West Palm Beach or may be sent through G-161 to the Loxahatchee

Geographic Region	Alt	Hydrologic Effects
		River. Improved stages and hydroperiods in GWP North of North Lake Blvd from the triangle gradation in all alternatives.
FW2	FWO	Restoration of hydrology would occur in the C-18 West area from a mitigation area on the Avenir property. However, J.W. Corbett WMA and Hungryland Slough remain slightly drained.
	All Alts	Alts 2 and 13 have the largest improvements to hydrology near the proposed site due to improvements in both groundwater and surface water levels from the shallow L-8 impoundment, which under the ECB and FWO is used for agricultural purposes. Additionally the shallow storage provides an additional volume of water that may be sent to meet the targets at Lainhart. All alternatives show improvements in the hydroperiod of the J.W. Corbett WMA. Alt 13 shows an improvement in the hydroperiod for the C-18 natural storage component. The C-18 Reservoir, proposed in Alts 2, 5R, and 10 will capture excess flow and disperse it in a hydrologically improved (lower peak flows, volume available during dry periods) to the River.
FW3	FWO	Large amounts of agricultural lands remained drained in Pal Mar, Cypress Creek, Moonshine Creek and Kitching creek.
	All Alts	Alt 10 improves hydrology modestly in cypress creek natural area, followed by slightly more improvements from Alt 2, and large improvements in stage and duration in Alt 13 and 5R. All alternatives improve Moonshine Creek hydrology with gulf stream East features. The Gulf Stream West flow-way aids in improving groundwater levels w is slightly over inundated from historic targets in Alts 2,5R, and 13, but is key to providing flow from Pal-mar to Moonshine Creek. Kitching Creek hydroperiods improve with the spreader canal and plugging of Jenkin's ditch in all alts. Pal-Mar hydrology is greatly improved in Alts. 2, 5R, and 13.

Loxahatchee River and Estuary

The construction of the Lainhart and Masten dams in the 1930s has slowed the flow through the upper Northwest Fork and helped maintain the floodplain by providing additional lift (**Figure C.2-11**). Today the reconstructed dam and its recently completed repairs over the years have resulted in an average of 50% of the total flows to the Northwest Fork coming from Lainhart Dam. The restoration target is based on total inflows to the Northwest Fork. Measured data over the last 10 to 15 years indicates that Cypress Creek at RM 10.3 provides a considerable volume of surface water flow—on average 26% to 32% (**Figure C.2-11**). Hobe Grove Ditch, which enters the river at RM 9.07 flows ~5% and Kitching Creek at RM 8.13 contributes 11% to 13%. As a result of the reduced freshwater inflows and the influx of saline waters into what were formerly freshwater river reaches, mangroves have replaced cypress and other freshwater

native vegetation in some river reaches. Currently, freshwater cypress and hardwood communities share the floodplain with saltwater tolerant mangroves from RM 8.6 to RM 10. Mangroves are the dominant shoreline vegetation downstream of RM 8.2 (SFWMD et al. 2006, SFWMD et al. 2012).

The modeling result of hydrologic flows are summarized in **Table C.2.16** and **Figure C.2.12**. The modeled results of the dry season flows for the future without project and existing conditions are artificially higher than what was observed prior to G-160 and G-161 being installed as part of the SFWMD acceler8 projects. The model removes the two structures from the FWO and ECB, but was unable to remove the regional operations of structures inside and flowing into Loxahatchee Slough. Prior to these changes, the flows across Lainhart Dam met targets about 57%. The modeling reflects the ECB as 63% and FWO meeting 65% of target flows. All alternatives increase flows measured at Lainhart Dam to the NWFLR. Alt 10 contained the most storage volume and increased the flows the most to 95% of dry season flows. Alt 5R provided the most efficient storage with co-located ASR wells and meets the target 91% of the time. Alt 2 had the second largest amount of storage but only met the dry season target 87% of the time. Alt 13 had the least amount of storage and met the target 80% of the time.

Table C.2.16. Percentage wet and dry season targets met.

Flows	ECB	FWO	ALt2	Alt5	ALt10	ALt13
Wet Season	76%	78%	98%	98%	100%	98%
Dry Season	63%	65%	87%	91%	95%	80%
# of year Dry Season Met	-	17%	51%	56%	71%	41%

The percent of time the hydrologic target was met for the simulated conditions and alternatives, and the years when the target was not met are shown in Table C.2.17.

Table C.2-17. Percent hydrologic target met and years when not met for the simulated conditions and alternatives.

Category	2014B	2070FWO	ALT2	ALT5	ALT10	ALT13
Percent Met	76%	78%	98%	98%	100%	98%
Years when target was not met	1977, 1979-1980, 1987-1989, 2000, 202-2004	1977, 1980, 1987-1989, 2000, 2002-2004	2000	2000	Not applicable	2000

Figure C.2.14. Dry season performance by year based on flows over Lainhart Dam.

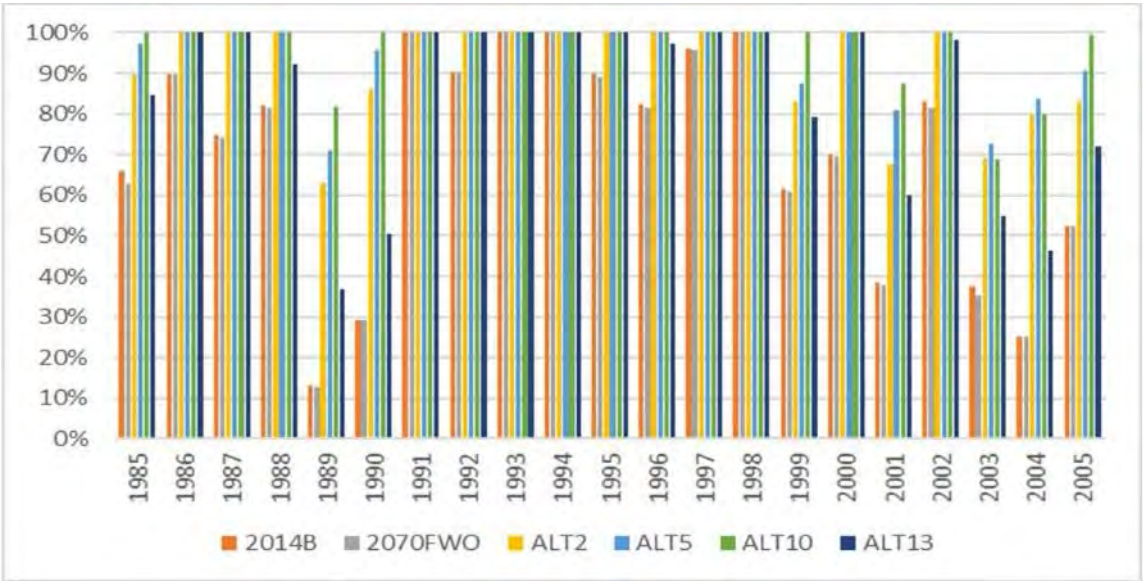


Figure C.2.15. Years wet seasons flows not met.

The modeling of tributary hydrologic changes did not reveal many changes, see **Figure C.2-14**. It is expected that the weir at Hobe Grove ditch should aid in redirecting flow from the ditch to the historic Moonshine Creek, which is currently too dry, while helping to improve the timing of discharges to the NW fork, which can be flashy during storms. Replacement of the Cypress Creek control structure with a controlled weir should also improve the timing of discharge at Cypress Creek, while aiding in improving the surrounding groundwater (and surface water) elevations for a greater duration of time within the Cypress Creek natural area and in portions of Palmar East. The Gulfstream East parcel land smoothing and Kitching Creek watershed both experience an increase in the depth and duration of inundation

compared to the FWO project conditions with the implementation of the proposed project features. The weir and plug at Jenkins ditch should also improve the timing and quantity of discharges into Kitching Creek.

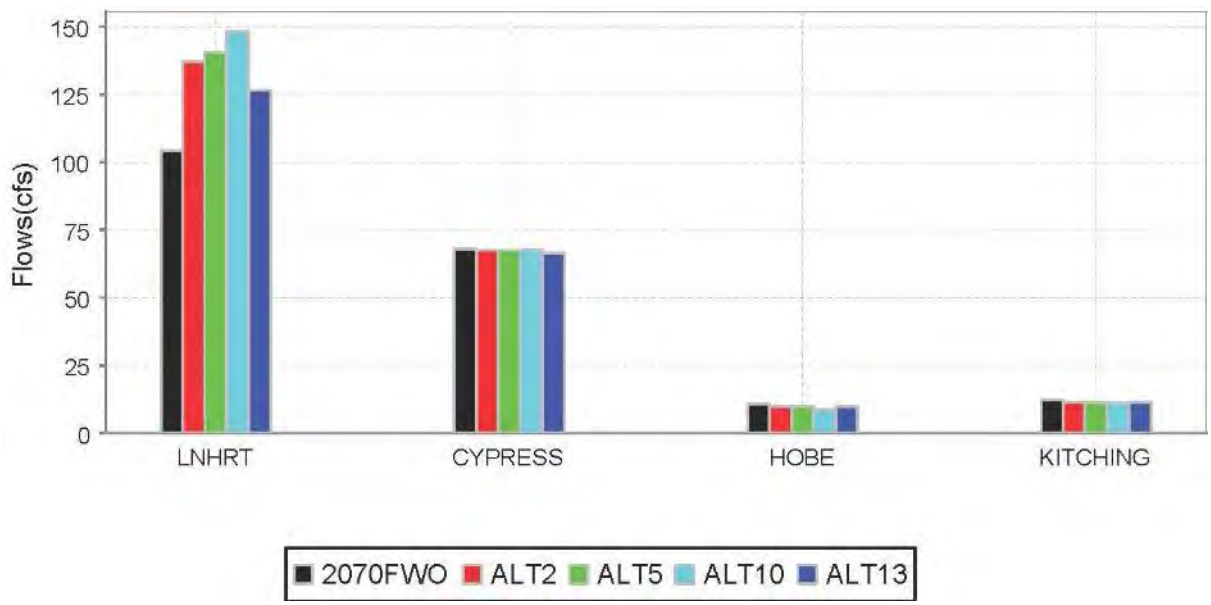


Figure C.2-16. Dry season contribution of average daily tributary flows to northwest fork of Loxahatchee River from Lainhart and tributaries.

C.2.12.1 Loxahatchee River Watershed

The management measures proposed in LRWRP will improve hydrology in the watershed. The hydroperiods improvements in the watershed is covered in the vegetation section of **C.2.5**. This section covers key hydrograph changes in the watershed due to the restoration alternatives.

In flow-way 3, there were three different combination of management measures. All alternatives contained the Kitching Creek spreader and plug, which led to improved hydroperiods and stages in part of Johnathan Dickinson State Park, see **Figure C.2.15**.

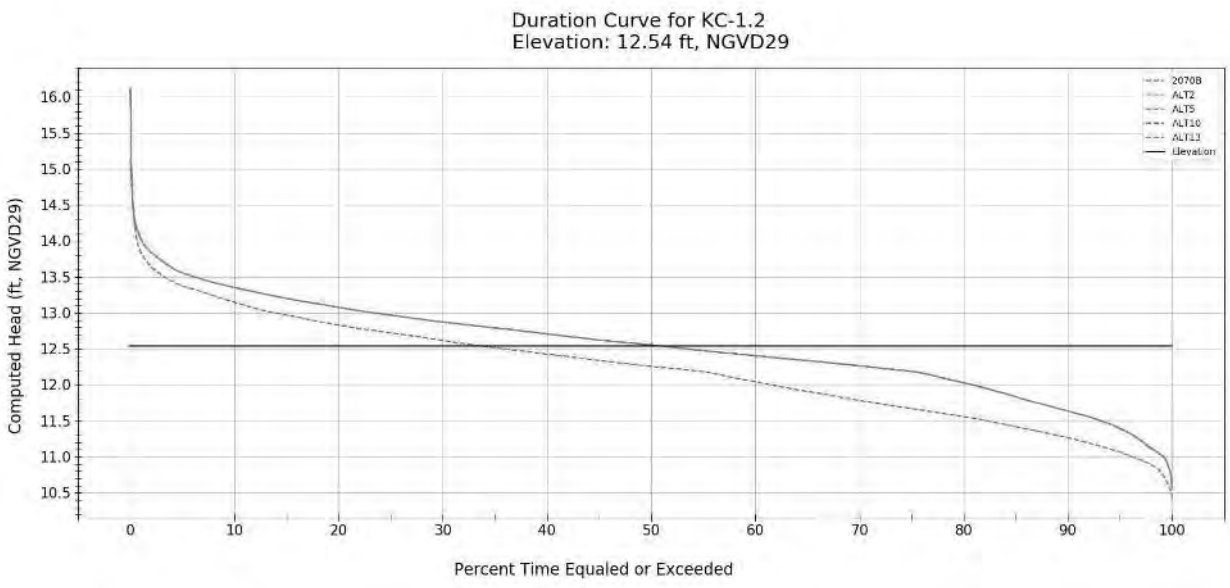


Figure C.2.17 – Stage Duration Curve for Kitching Creek Indicator Region 1.2

All of the alternatives include connection of Hobe St. Lucie Control District ditch to Moonshine Creek, clearing Moonshine Creek vegetation and regrading of the citrus farm on Gulf Stream East, and installation of a weir at Hobe Grove Ditch. These features increase the groundwater storage in the Moonshine Creek area compared to the future without, see **Figure C.2.16**. The ground elevation for this model cell was rather high at 12.5 ft, whereas, the FWO hydrograph was flat at 2.0 ft. All alternatives raised groundwater to an average of 5.5 to 6.0 feet.

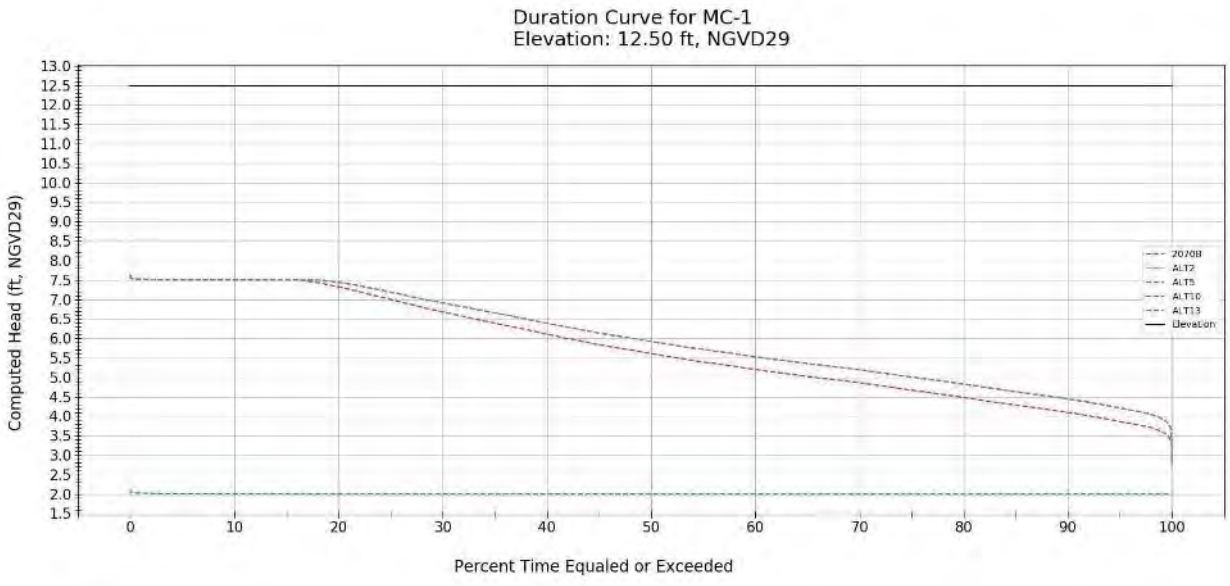


Figure C.2.18. Stage Duration Curve for Moonshine Creek Gulf Stream East Indicator Region 1.

In Pal Mar, Alts 2, 5R, and 13 contain the same features of removing berms, plugging ditches, and rerouting flow from Thomas Pepper farms for hydrologic re-connection of Palmar East parcels. Alt 10 does not include this version of full flow-way 3 restoration features. Consequently, hydrology is greatly improved

for Pal-mar indicator regions 1, 2, 10.1, 11.2 in Alts 2, 5R, and 13, but not in 10, see **Figures C.2.17**, **C.2.18**, **C.2.19.**

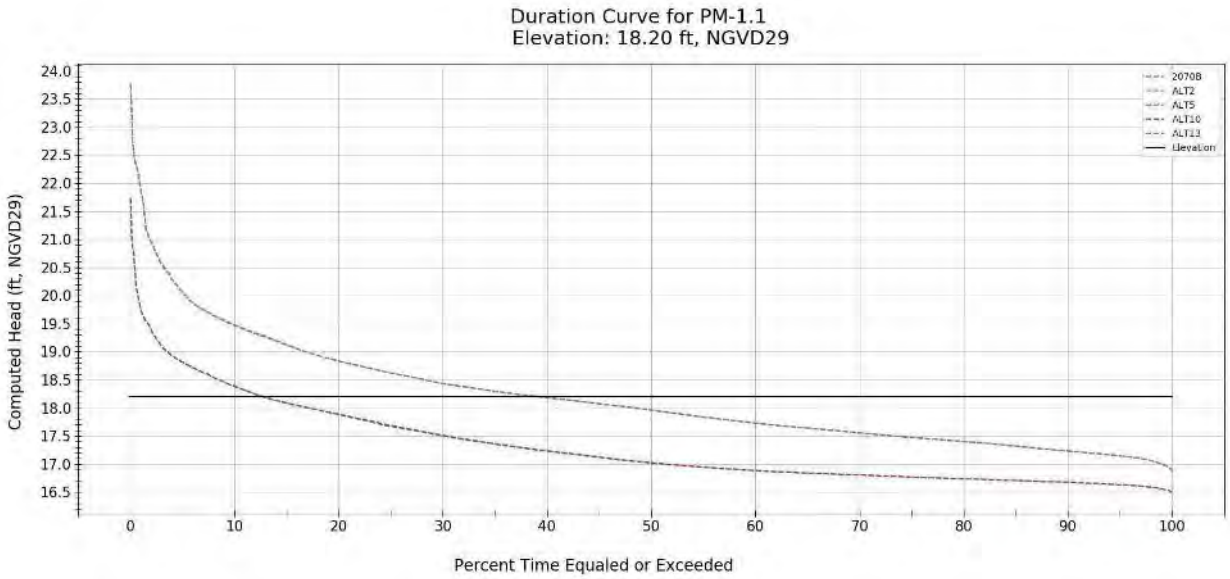


Figure C.2.19. Stage duration curve for Pal-Mar indicator region 1.

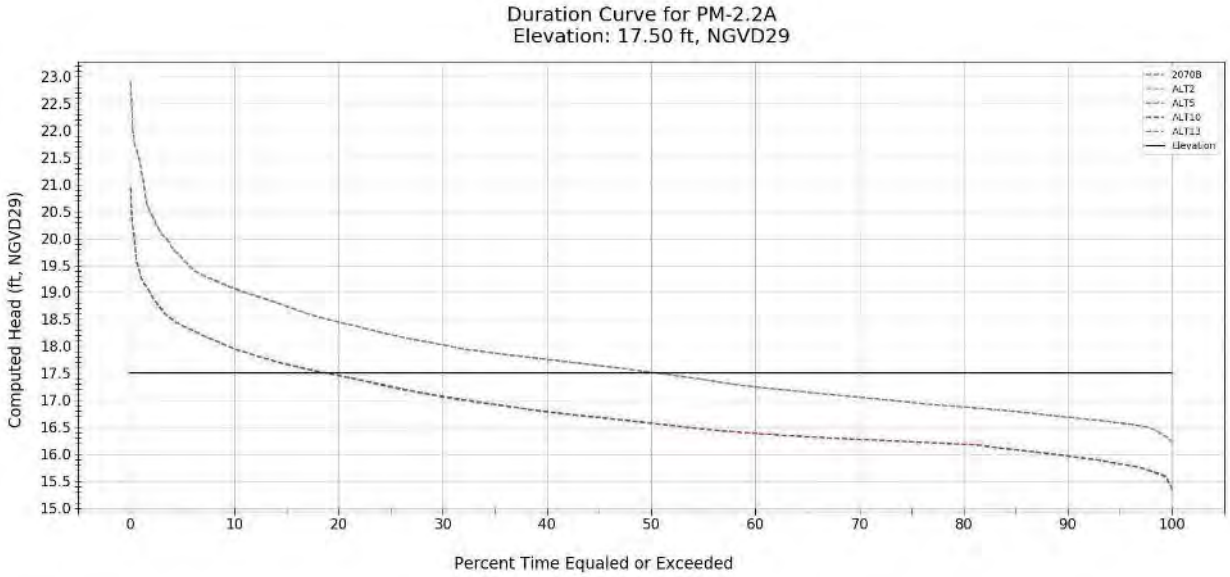
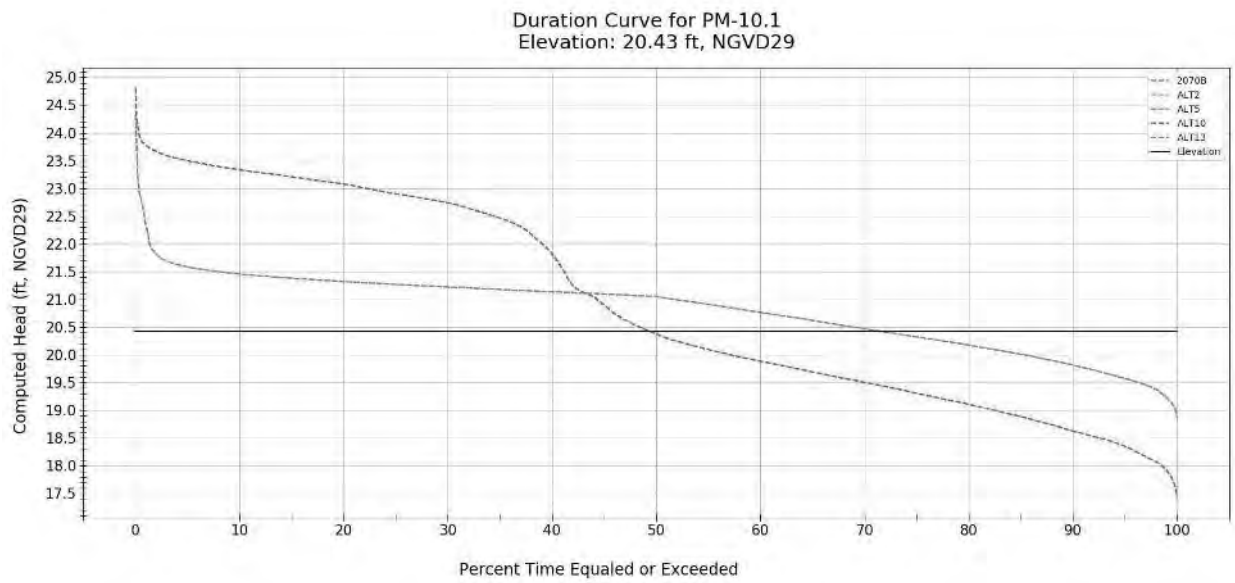


Figure C.2.20. Stage duration curve for Pal-Mar indicator region 2.



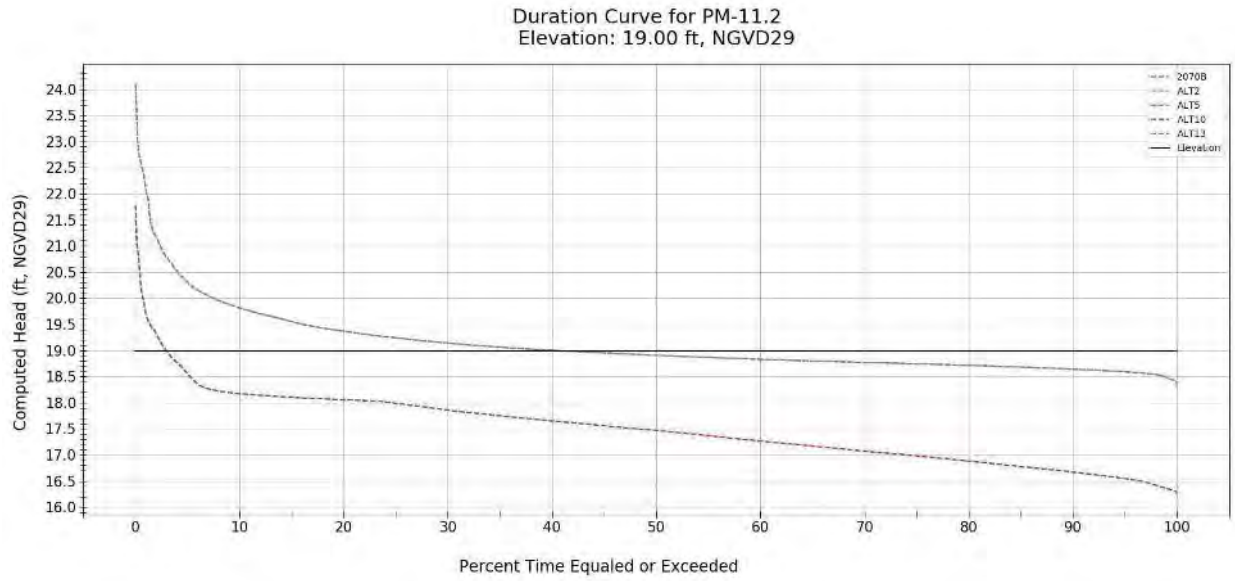
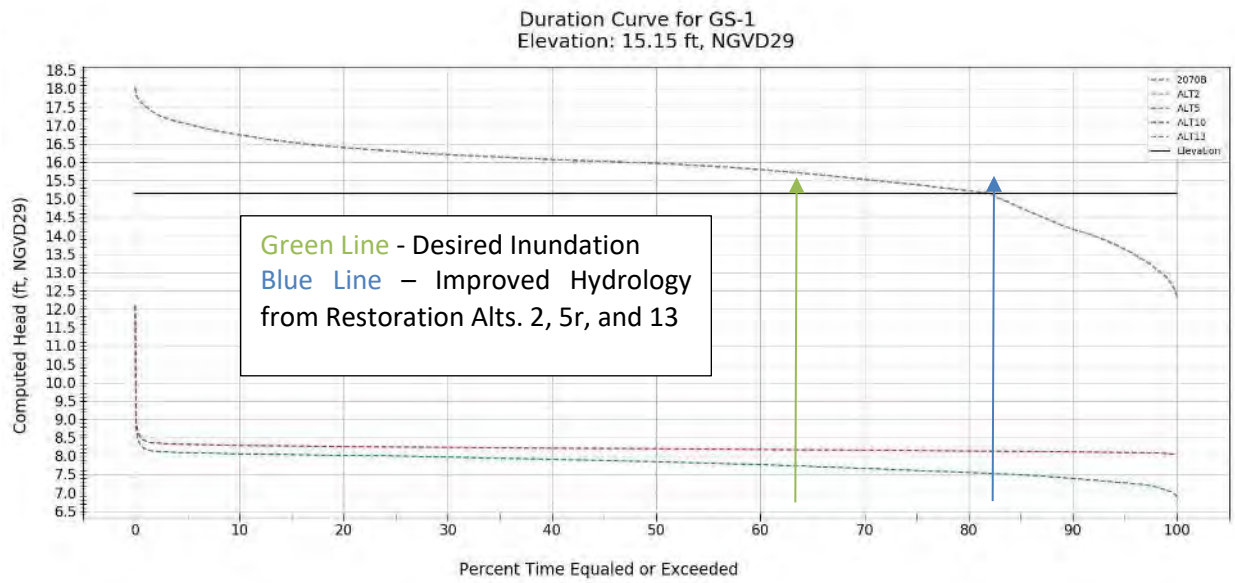


Figure C.2.21. Stage duration curve for Pal-Mar indicator region 10 and region 11.

Alts 2, 5R, and 13 contain the Gulfstream West flow-way that aids in rehydrating the existing overly drained agricultural land and assists in reducing peak flows from HSCLD drainage canal. This feature improves hydrology over the FWO, but creates water depths and durations greater than the original target of a depression marsh, see **Figure C.2.20**. The increased depth and duration would reflect wetland community type of a deep slough, which is still consistent with the type of wetland communities in this system.

Figure C.2.22. Stage Duration Curve for flow-through marsh in GulfStream West Indicator Region 1.



Cypress creek natural area showed great improvement in hydrology from the Mac Dairy spreader canal and grading of Shiloh pepper farm represented in Alt 13 and 5R. Alt 2 provides some improvement to the Cypress Creek hydrology from the flow through marsh and cypress creek weir. Alt 10 provided the least amount of performance to this areas from the cypress creek weir, see **Figures C.2.21, C.2.22**. Please note that Alt 5 is represented in the model output that does not include the Mac Dairy Spreader and is different than Alt 5R output which would match Alt 13 in flow-way 3.

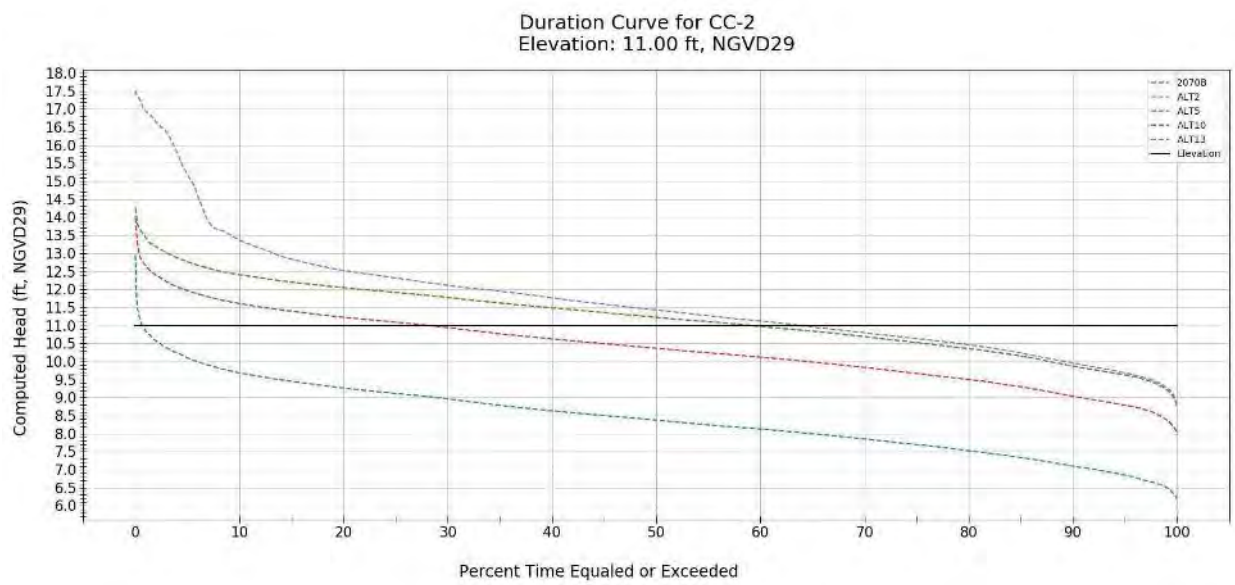


Figure C.2.23. Stage hydrograph of Cypress Creek indicator region 2 (south of flowthrough marsh).

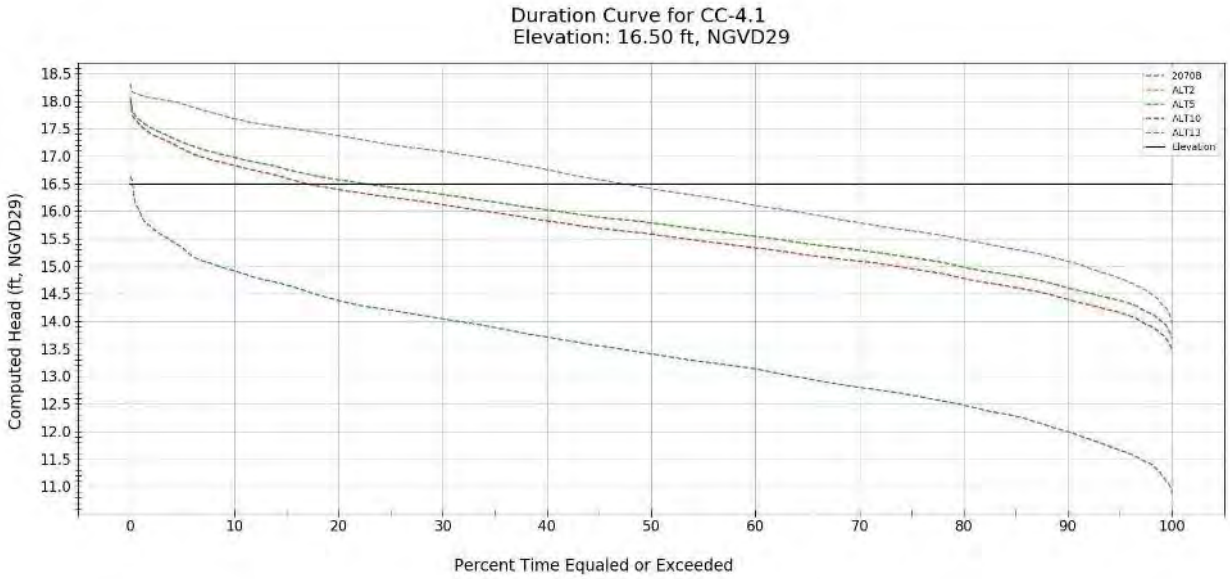


Figure C.2.24. Stage hydrograph of Cypress Creek indicator region 4 (east of Mac Dairy Spreader)

Hydrology results are available for the rest of Pal Mar indicator regions west of the project area, which include PM-4, 5, 6, and 9 (see **Figure C.2.23**). As expected, they do not illustrate any change from any of the project features over the future without project, except for a slight increase in stage and duration at PM 6 (Culpepper) due to flow improvements towards Cypress Creek from the Ranch Colony Canal improvements.

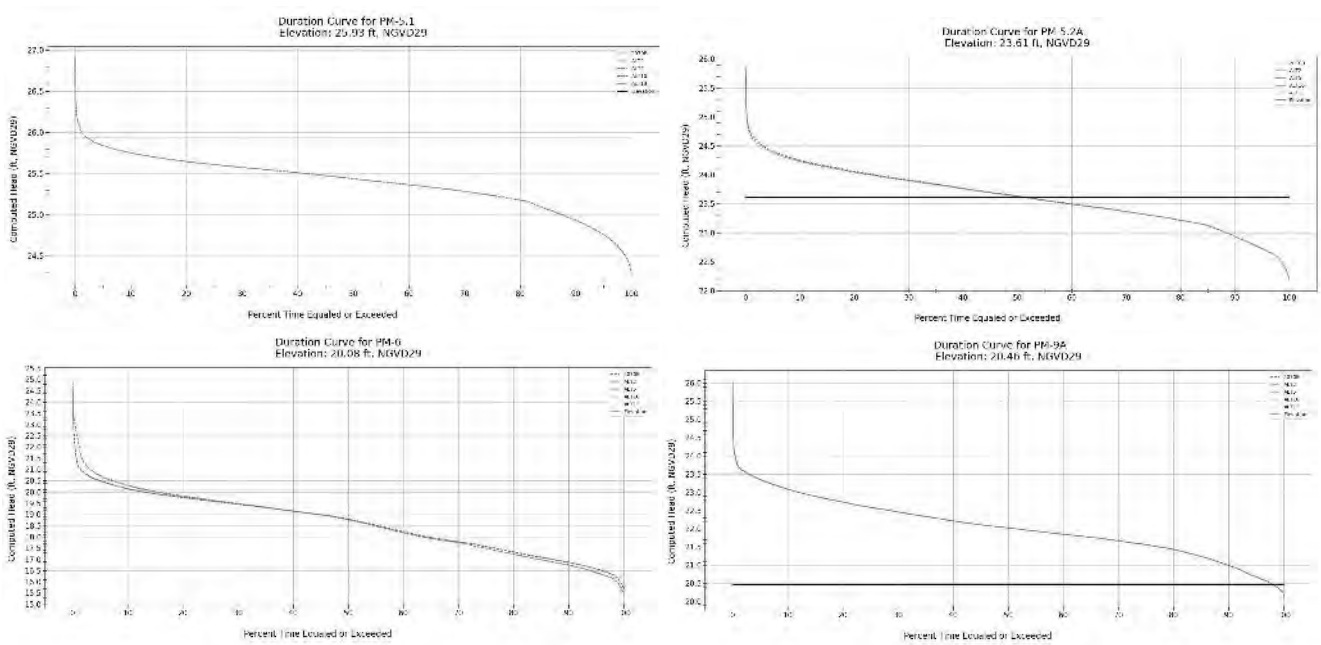


Figure C.2.25. Stage hydrograph of Cypress Creek indicator region 4 (east of Mac Dairy Spreader).

In flow-way 2, there are four different versions of storage features in indicator region CM-1. Alt 5 has the deeper storage reservoir, followed by Alt 2 and Alt 10, then Alt 13. **Figure C.2.24** indicates that Alt 5 average depth would be around 4.5 feet, followed by 4.0 feet for Alt 2, and 2.5 feet for Alt 2 and 13. However, the storage feature in Alt 10 is only hydrated 65% of the time compared to 85 to 90% in the other alternatives. The natural storage feature in Alt 13 has the longest period of inundation and average depth of 2.0 ft. None of the alternatives reflect hydrology completely consistent with restored historic condition of depression marsh (65% inundation duration and depths 1-2 feet). However, the natural storage feature comes the closest to meeting depth with an increased duration of 90%. The hydrology within the impoundments of Alt 5R, 2, and 10 will likely be too deep to support historical vegetation of the area.

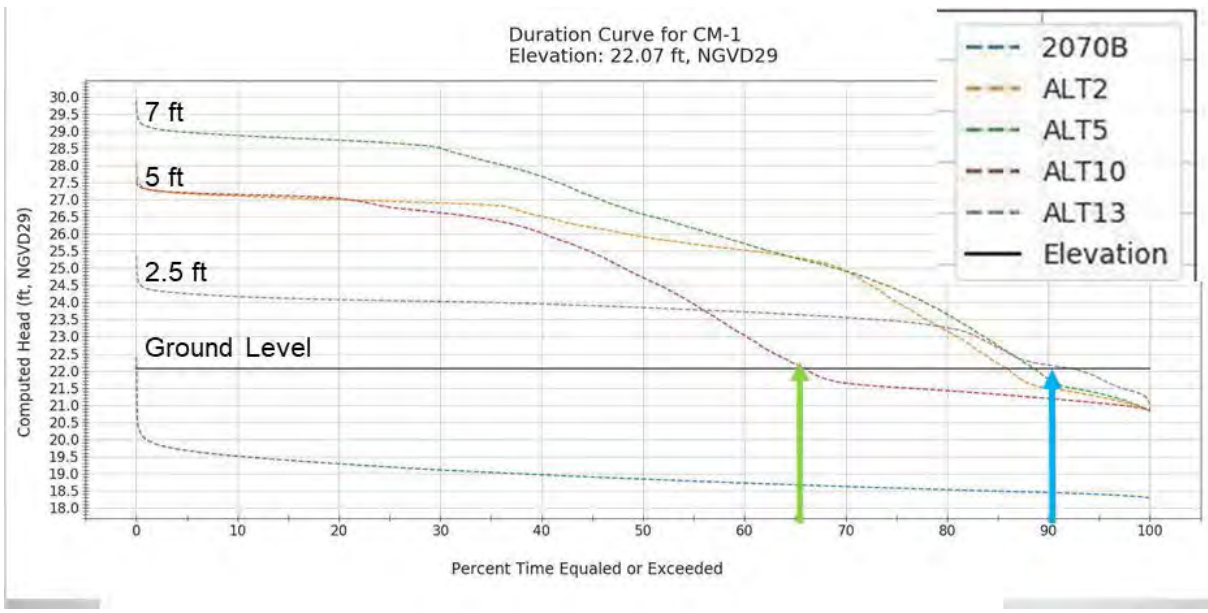


Figure C.2.26. Stage hydrograph of C-18 West storage indicator CM-1.

The eastern and southern portion of Corbett Wildlife Management Area is affected to a degree by the several restoration alternatives. There is a very small increase in inundation duration from the restoration alternatives ranging from an increase of 2 to 6 % in Corbett indicator region 1 that is immediately next to the C-18 impoundment. Unexpectedly, the water depth does not change much in this area given that the excess water is one source for filling the impoundments, see **Figure C.2.25**. Corbett indicator region 3 (Moss Property) reveals a moderate increase in stage and inundation duration by 20% to 33% due to seepage from the shallow L-8 reservoir in Alt 2, and 13, see **Figure C.2.26**. While the hydrologic improvements are notable, it would not achieve the 70% inundation duration target for a Dome Swamp. No changes in depth or duration are experienced in the rest of Corbett indicator regions 2, 4, and 5 see **Figure C.2.27**.

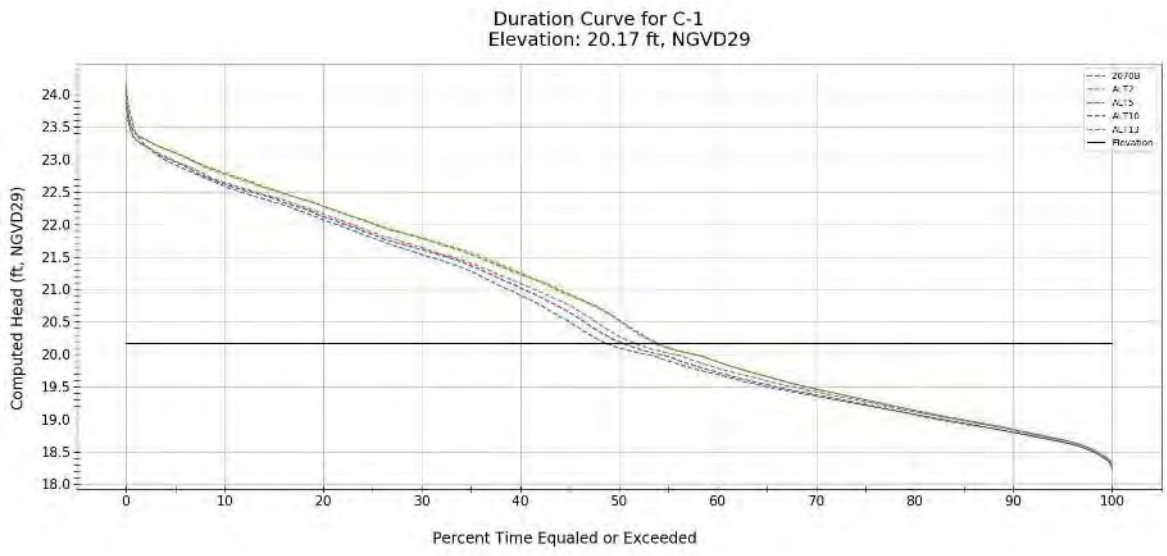


Figure C.2.27. Stage hydrograph of Corbett indicator region 1 (C-1).

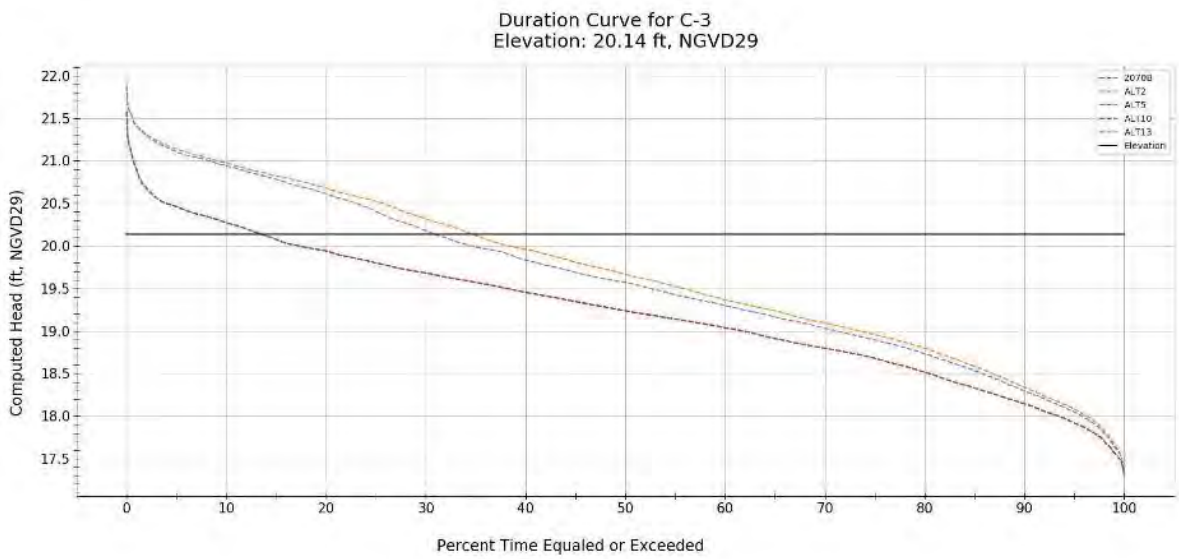
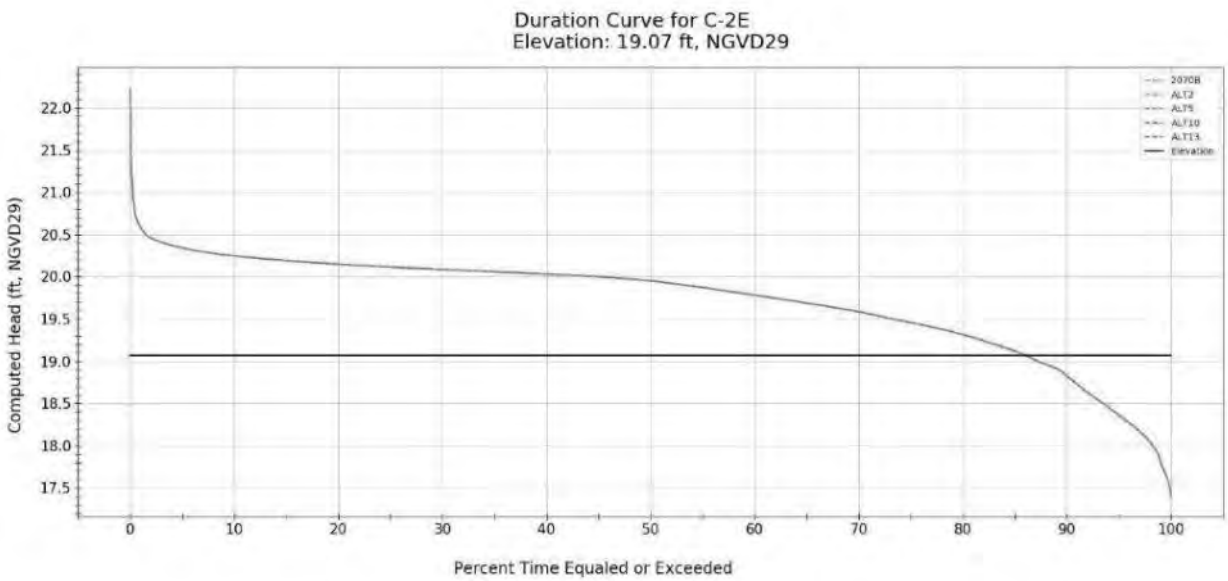
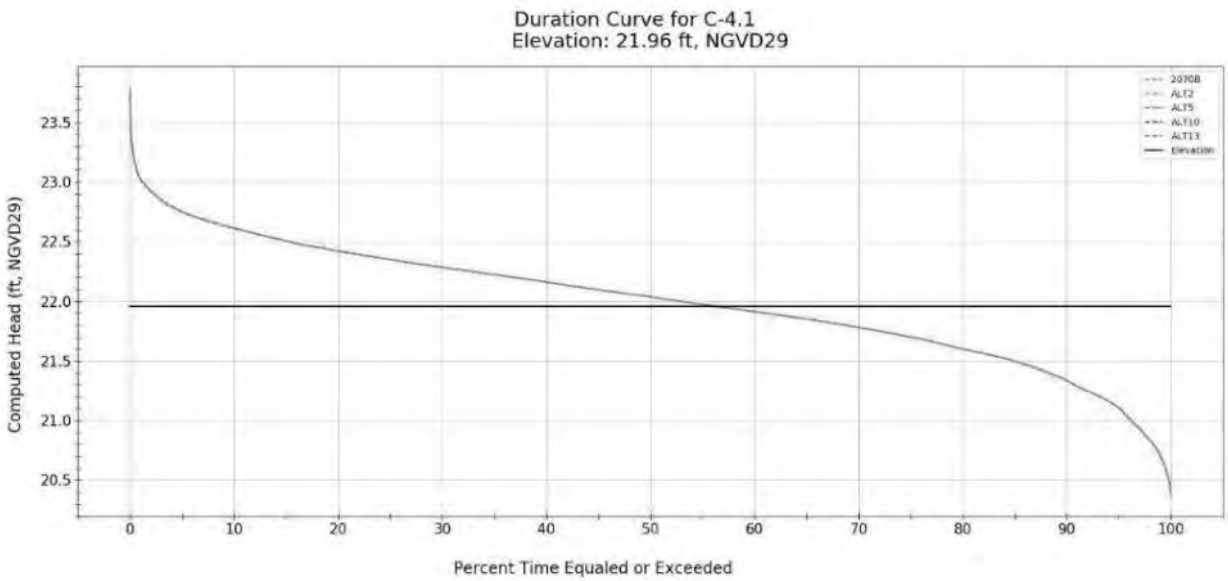


Figure C.2.28. Stage Hydrograph of Corbett Indicator Region 3 (C-3).


Duration Curve for C-2E
Elevation: 19.07 ft, NGVD29
2070B
ALT2
ALT5
ALT10
ALT13
Elevation
Computed Head (ft, NGVD29)
22.0
21.5
21.0
20.5
20.0
19.5
19.0
18.5
18.0
17.5
0
10
20
30
40
50
60
70
80
90
100
Percent Time Equaled or Exceeded


Duration Curve for C-4.1
Elevation: 21.96 ft, NGVD29
2070B
ALT2
ALT5
ALT10
ALT13
Elevation
Computed Head (ft, NGVD29)
23.5
23.0
22.5
22.0
21.5
21.0
20.5
0
10
20
30
40
50
60
70
80
90
100
Percent Time Equaled or Exceeded

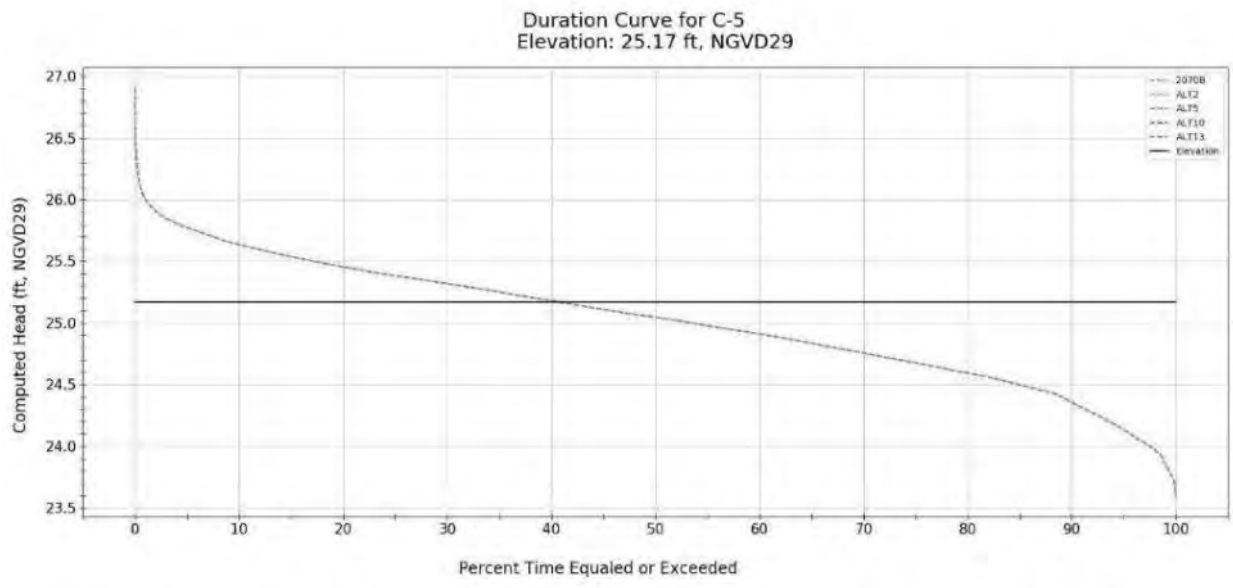


Figure C.2.29. Stage hydrograph of Corbett indicator regions 2, 4, and 5 (no change).

Flow-way 1 experiences a wide variety of hydrologic changes in Loxahatchee Slough (LS) and Grassy Waters Preserve (GWP) depending on the restoration alternative. Loxahatchee Slough indicator region LS-2 experiences a modest increase over the Future without conditions by 10% from 63% to 73% due primarily to G-160 and a lesser degree from G-161, which is in all the alternatives, see **Figure C.2.28**.

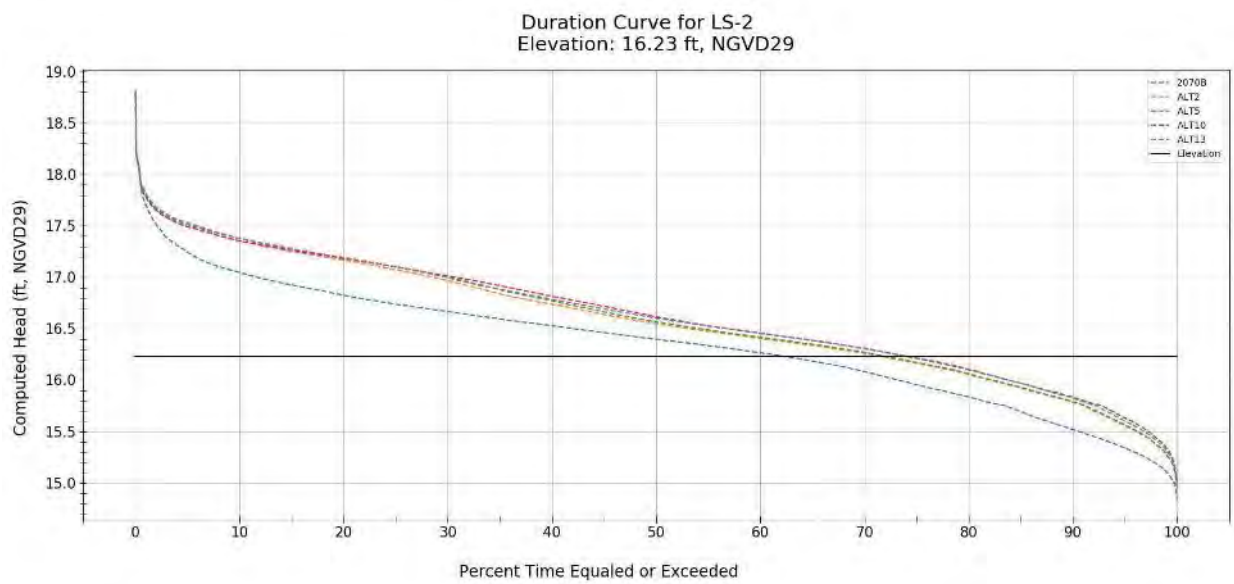


Figure C.2.30. Stage Hydrograph of Loxahatchee Slough Indicator Region 2 (LS-2).

All alternatives greatly improve hydrology in indicator regions LS-6 and 7. Inundation duration increases from between 16-18% to 65 to 70% and depth on average from 0.25 to 0.5 ft below ground to 0.1 to 0.5 ft above ground for all alternatives, **see Figure C.2.29**. Alt 10 increases inundation duration even longer

to 85% likely from additional flow from the forcemain from the M-Canal directly to G-161 to the C-18 canal.

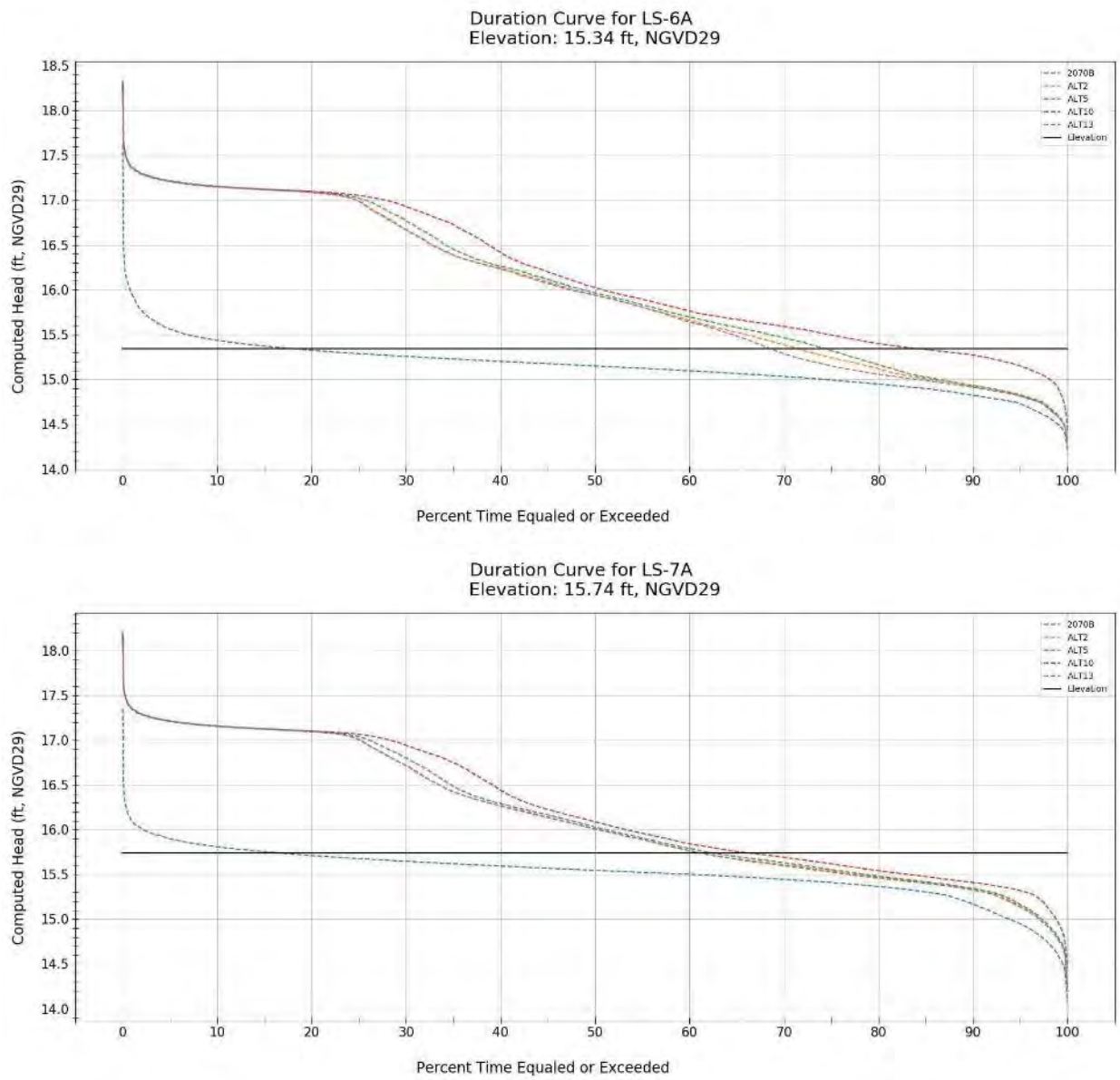


Figure C.2.31. Stage hydrograph of Loxahatchee Slough indicator regions 6 and 7 (LS-6 and 7).

LS-4, located within the southern portion of the Loxahatahcee Slough, also indicates a dramatic improvement in hydrology from 57% to 90% inundation and increased depth from on average 0.25 ft to almost 1.0 ft in all restoration alternatives. This change is likely due to improvements from G-160, G-161, and potentially the GWP triangle scrape down allowing more flow towards Loxahatchee Slough, **see Figure C.2.30**.

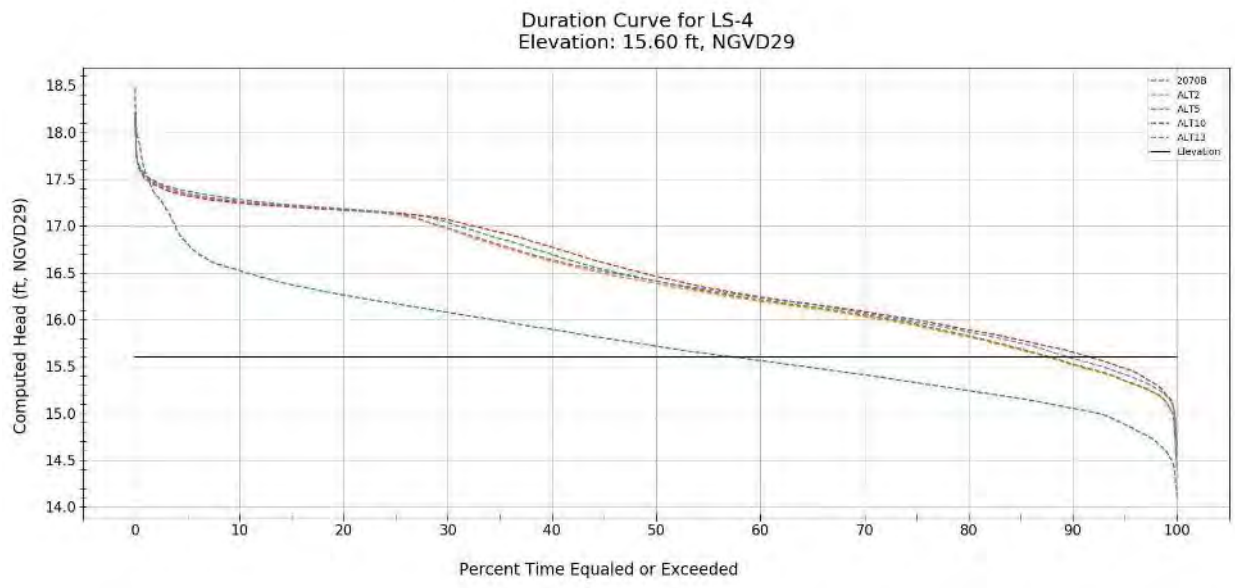
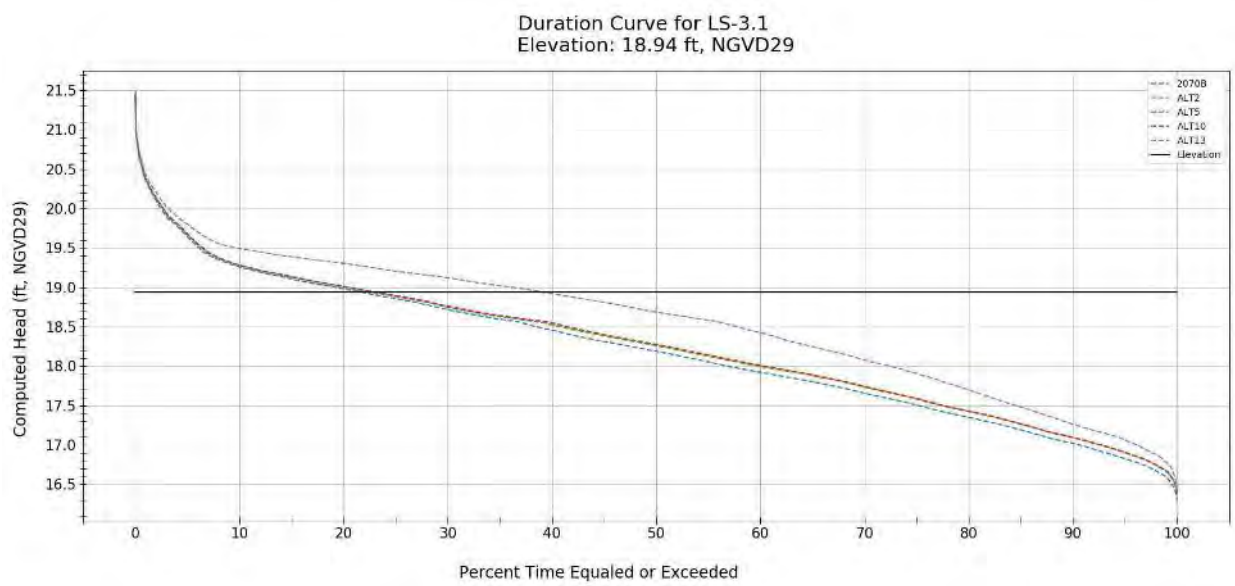


Figure C.2.32. Stage Hydrograph of Loxahatchee Slough Indicator Region 4 (LS-4).

Alt 13 increases inundation duration in LS-3 and LS-8 due to a pumped connection between the C-18 natural flow-way, via culverts under the beeline highway to these sites. LS-3 inundation duration is improved from 30% to 60%, almost achieving the target of 65%. LS-8 hydrologic increase is slight moving from 95% to 98% inundation. None of the other alternatives change hydrology in these areas, see **Figure C.2.32**.



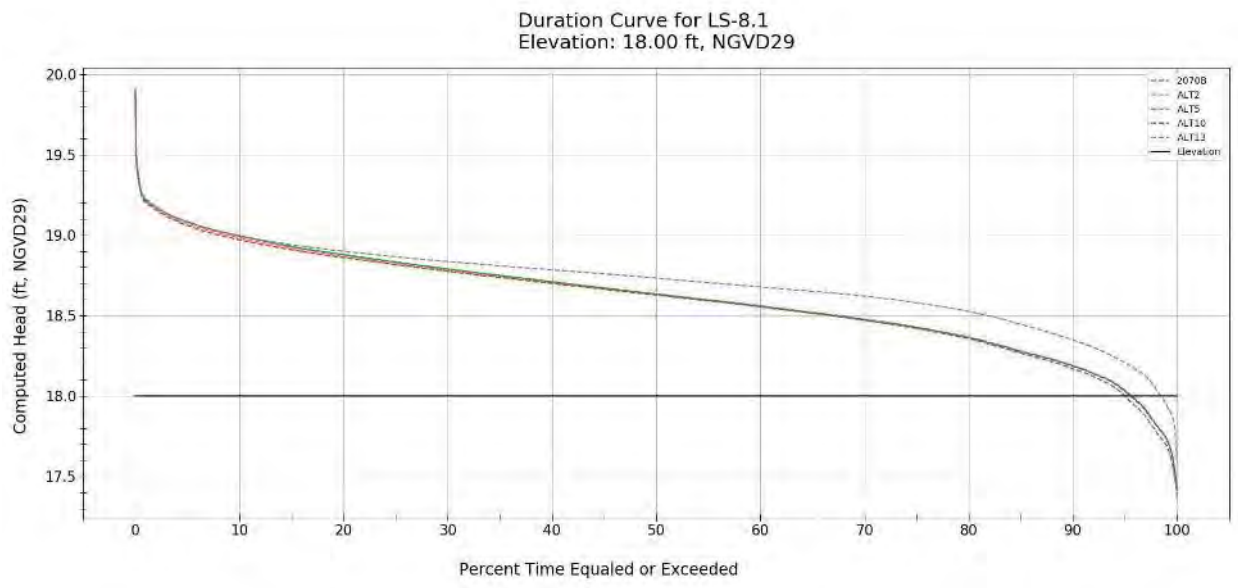


Figure C.2.33. Stage Hydrograph of Loxahatchee Slough Indicator Regions 3 and 8 (LS-3 and 8).

Indicator Region LS-9 receives modest increases in hydrology varying from an increase from 75% inundation duration to 84% (Alt2, Alt5, and Alt10) and 89% (Alt13). Indicator Region LS-5 did not show any changes in hydrology, as it is north of all project features (**Figure C.2.33)**.

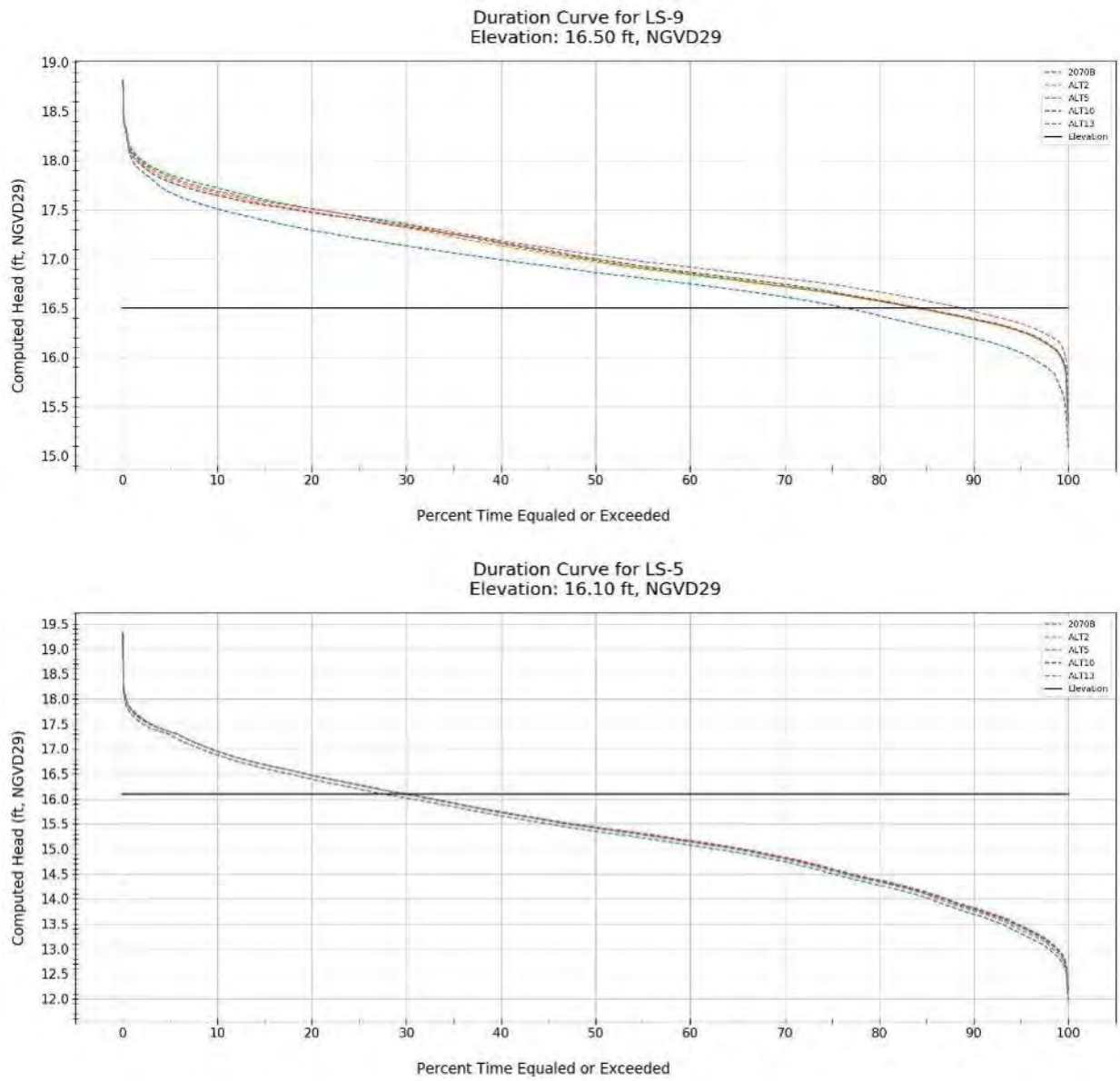


Figure C.2.34. Stage hydrograph of Loxahatchee Slough indicator regions 9 and 5 (LS-9 and 5).

Grassy Waters Preserve experiences different degrees of hydrologic changes depending on the area and alternative restoration plan. Indicator regions 1, 2, 3, 4 are north of lake boulevard road, within the GWP triangle area. Indicator region 2 shows a large amount of hydrologic improvement from the GWP triangle scraping and likely the increase in flow from the G-161 structure, see **Figure C.2.33.**

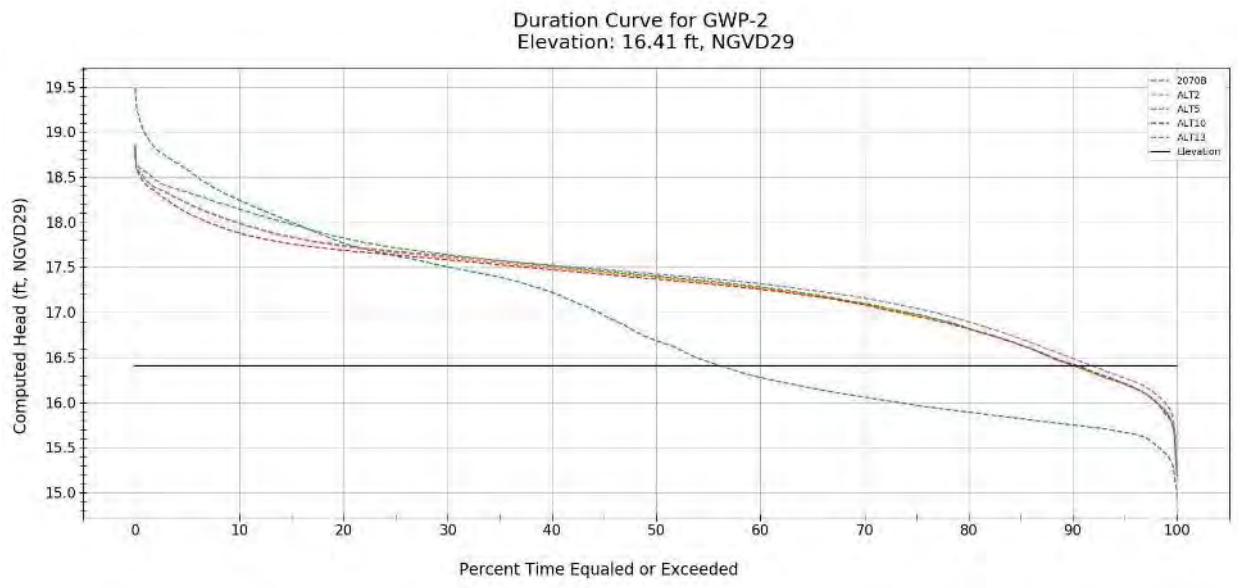


Figure C.2.35. Stage Hydrograph of Loxahatchee Slough Indicator Region 2 (LS-2).

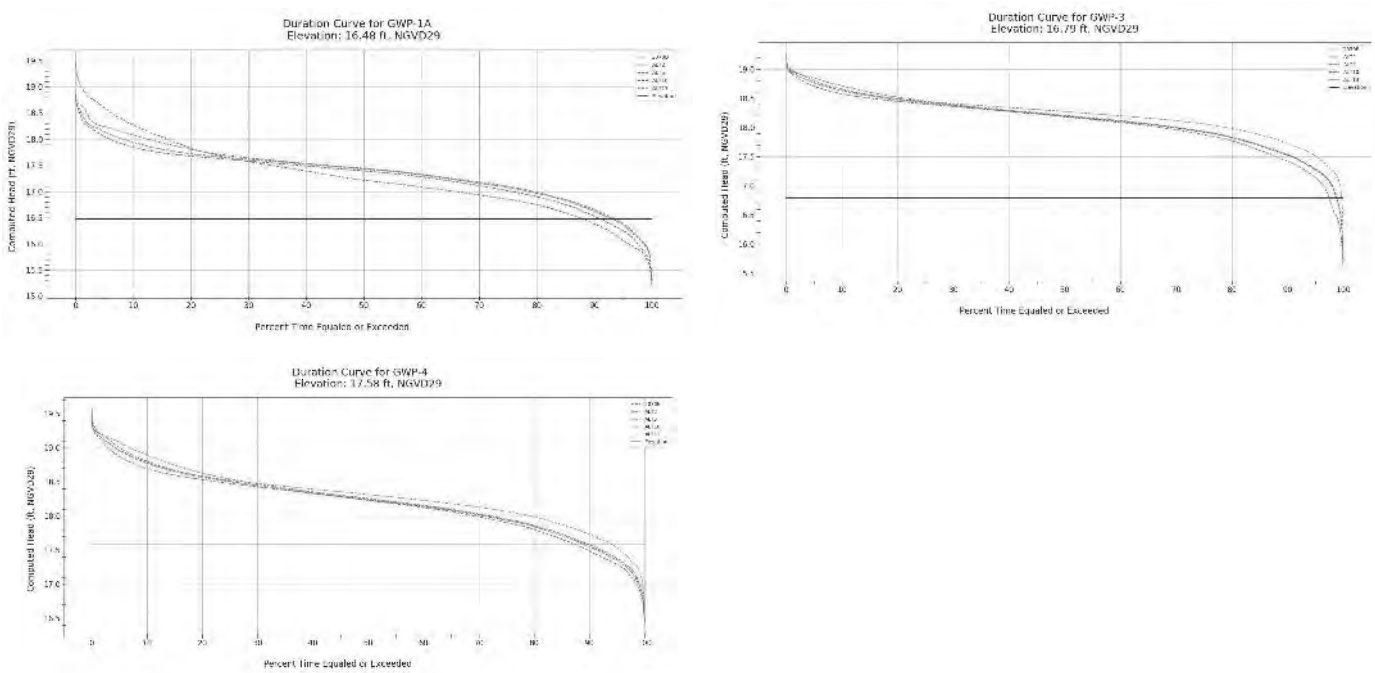


Figure C.2-36. Stage hydrograph of Grassy Waters Preserve indicator regions 1, 3, 4.

The main area of GWP managed by the city of West Palm Beach includes indicators regions GWP 5, 6, 7, 8, and 9. GWP stages are managed to hold water longer for water supply purposes and the inundation durations are longer for most of the indicator regions. For the most part, Alt 5R does not alter this pattern, Alt 2 and 13 only slightly decrease inundation duration, whereas Alt 10 decreases inundation in GWP to more closely match the target inundation of 70%. In GWP-5, the FWO hydrology is already at the target of 70% inundation which is maintained by Alt 5R, 2, and 13. Alt 10 decreases the inundation to 57%.

GWP-6 FWO hydrology is at 97% and is maintained by Alt 5R, 2, and 13, but Alt 10 produces a target inundation of 90% inundation duration. GWP-7 hydrology in the FWO is around 89%. This hydrology is maintained in Alt 5R, decreased slightly to 85% in Alt 2 and 13, and decreased greatly to 60% in Alt 10, which is below the target of 70%. GWP-9 hydrology in the FWO is approximately 93% and is maintained in Alt 5R. Alt 2 and 13 decrease the inundation slightly to 90%, while Alt 10 decreases inundation to the target of 70%. GWP-10 hydrology in the FWO is around 97% and is maintained in Alt 5R. Alt 2 and 13 decrease inundation slightly to 93% and Alt 10 decreases moderately to 87%, towards the target inundation of 70% (**Figure C.2.34**).

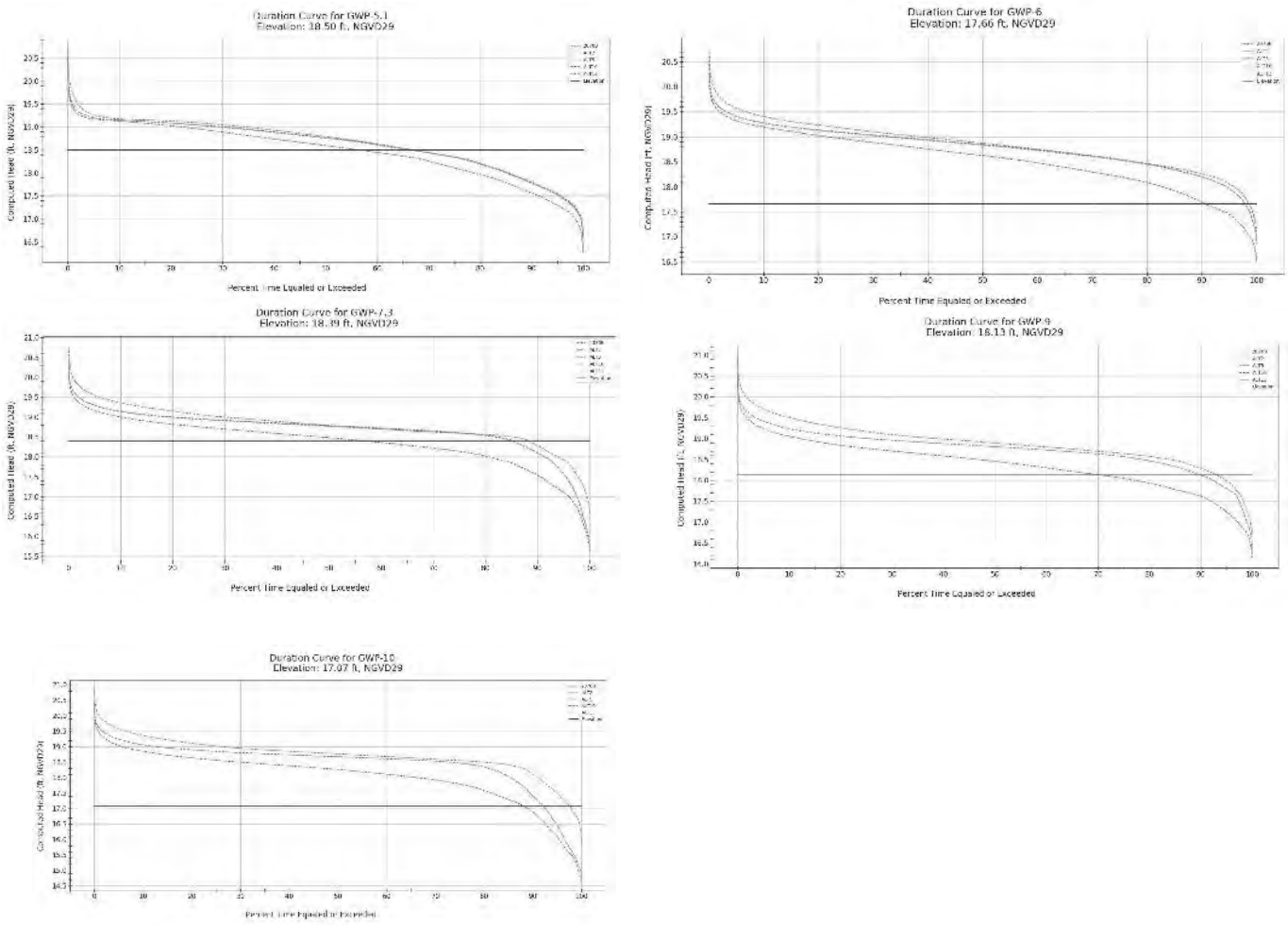


Figure C.2-37. Stage hydrograph of Grassy Waters Preserve.

C.2.13 Water Quality

The LRWRP project was evaluated in accordance to CERP Guidance Memorandum #23 (CGM 23). This guidance outlines three possible classifications for CERP projects. The possible classifications are:

- Components that include water quality improvement features
- Components that do not contain water quality improvement features but are designed to achieve water quality improvement

- Components for which the Comp Plan does not include Water Quality (WQ) improvement features or specifically reference water quality improvement to be addressed during design.

CGM 23 classification of the LRWRP is a Category B project as hydrologic restoration and features will likely benefit WQ but at a minimum will not degrade WQ conditions.

The SFWMD developed a water quality WQ spreadsheet tool that takes existing conditions for existing sources of water and modifies volumes of water using hydrologic input from the Lower East Coast Subregional North Palm LECSR-NP Model. The Total Phosophorus (TP) and Total Nitrogen (TN) concentrations and loads are calculated based on estimated concentration of each water input source and adjusted based on assumptions for project features that are known to have water quality improvements (deep storage vs. shallow storage reservoirs). The assumptions made for the water quality evaluation tool are as follows:

- A literature based assumption that reservoirs have a concentration treatment reduction of 15%.
- Shallow impoundment has a concentration treatment reduction of 20% for TP and 5% for TN. (Based on literature)
- Shallow storage has a 20% concentration reduction for TP and 5% for TN.
- 7% seepage loss in M-Canal reach
- Runoff coefficient is 0.2.
- Calculated concentrations of a water body are equal to the annual flow weighted mean of source concentrations.
- Aquifer Storage Recovery (ASR) has 40% for TP removal and 10% TN removal.

The LECSR model used has been calibrated and evaluated and found to meet criteria for flow prediction. There is some uncertainty with the model that is different with the various monitoring stations. The greatest percent deviation in volume of discharged water was 9+/-% error.

Table C.2-18. Summary for TP concentrations and loads from LECSR-NP Modeling.

Site	ECB TP (ppb)	ECB Load (kg)	FWO TP (ppb)	FWO Loads (kg)	Alt 2 TP (ppb)	Alt 2 Load (kg)	Alt 5R TP (ppb)	Alt 5R Loads (kg)	Alt 10 Loads (ppb)	Alt 10 loads (kg)	Alt 13 TP (ppb)	Alt 13 Load (kg)
CS3	92	6,428	92	6,430	92	6,494	76	6,415	35	1,764	92	6,502
C-18W	41	2,226	41	2,264	34	2,276	28	2,279	31	2,621	25	1,742
G-161	10	0	10	0	10	12	10	34	35	463	10	13
G-92	41	3,502	41	3,517	24	2,636	21	2,265	22	2,521	19	1,885
Lainhart	43	5,674	43	5,688	31	4,805	28	4,432	28	4,676	27	4,075
S-46	41	2,326	41	2,326	24	1,093	21	1,006	22	1,017	19	858
LR_NWF	50*	12,695	50*	12,709	41	10,980	39*	10,607	39*	11,080	39*	10,142
Net	268	32851	268	32934	256	28296	184	27038	173	24142	192	25217
Comparsion to ECB	---	---	---	---	-12	-4555	-84	-5813	-95	-8709	-76	-7634
Comparsion to FWO	---	---	---	---	-12	-4638	-84	-5896	-95	-8792	-76	-7717

*Target 54 ppb

Table C.2-19. Summary for TN Concentrations and Load from LECSR-NP Modeling.

Site	ECB TN (mg/L)	ECB Loads (tons)	FWO TN (mg/L)	FWO Loads (tons)	Alt 2 TN (mg/L)	Alt 2 Load (tons)	Alt 5R TN (mg/L)	Alt 5R Loads (tons)	Alt 10 TN (mg/L)	Alt 10 Loads (tons)	Alt 13 TN (mg/L)	Alt 13 Loads (tons)
G-92	0.92	78	0.92	78	0.87	94	0.87	96	0.87	102	0.87	88
S-46	0.95	53	0.95	53	0.90	40	0.90	44	0.90	42	0.90	41
LR_NWF	1.17*	297	1.17*	297	1.11*	297	1.11*	299	1.12*	314	1.12*	289

*Target 1.20 mg/L

WQ parameters were identified and are specific to water body type as different types of water bodies have different water quality concerns. **Table C.2-20** highlights WQ evaluation criteria selected by water body.

Table C.2-20 LRWRP WQ evaluation criteria and key areas.

Area/Parameter	Total Phosphorus (µg/L)	P Load (kg)	Total Nitrogen (mg/L)	N Load	Specific Conductance (Micromohs/cm)
Grassy Waters Preserve: Control 2, Control 3, Control 4 – Water Supply Utilities	X	X	-	-	X
Loxahatchee Slough: C-18 West, G-161, and G-160	X	X	-	-	-
Loxahatchee River: G-92 and Lainhart Dam	X	X	X	X	-
Loxahatchee Estuary: S-46 to lower estuary, Loxahatchee River (see above) and tributaries (Cypress, Moonshine, Kitching Creek) and qualitative analysis as what gets delivered to middle estuary	X	X	X	X	-

The 62-302.531 (2) (c) 2 FAC establishes nutrient thresholds by watershed region in Florida. The Loxahatchee Basin (**Figure C.2.35**) is considered part of the Peninsula Biological Region but closely borders and could drain into the Everglades/South Florida Biological region. For water quality purposes the LRWRP will be evaluated as a Peninsular as the footprint of the project is within the Peninsular Region. The 62-302.531 (2)(c) 2 FAC geometric mean concentrations (not to be exceeded more than once in any three year period) for peninsular region for Total Phosphorus Nutrient Threshold is 0.12 mg/L and Total Nitrogen Nutrient Threshold of 1.54 mg/L.

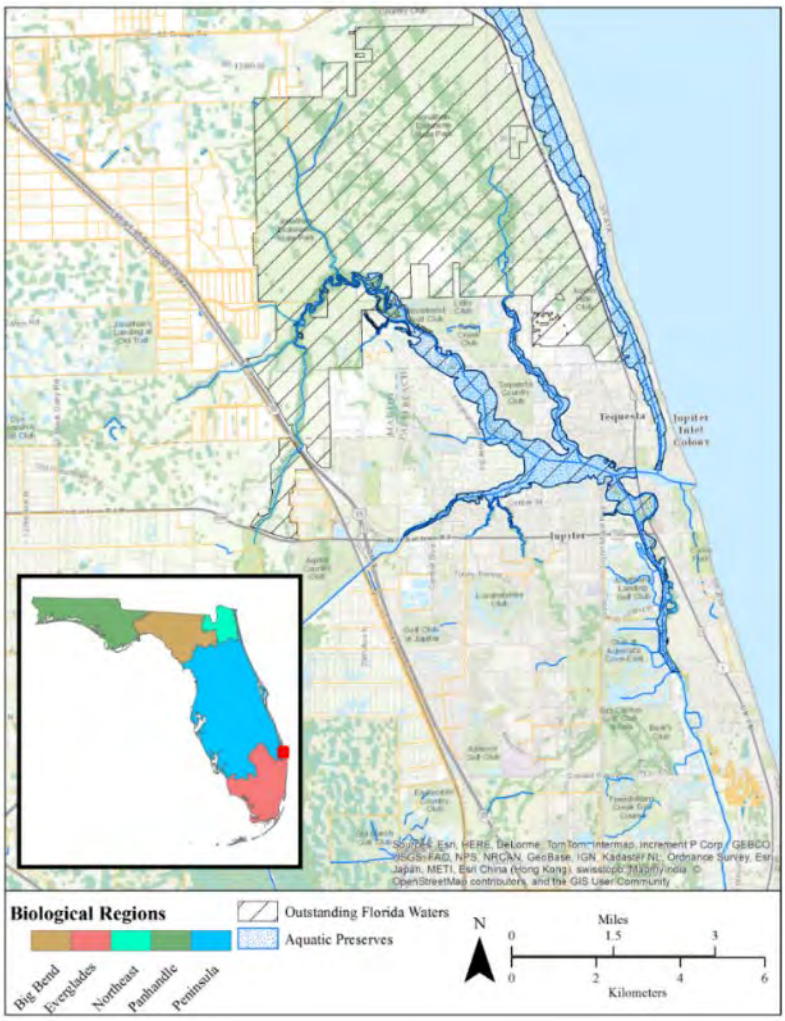


Figure C.2.38. Florida Biological Regions and Outstanding Florida Waters of project location.

The water quality analysis results from the spreadsheet tool are presented by alternative. Alt 2 Water Quality Evaluation is summarized below in **Table C.2-21** and **Table C.2-22** is the comparison between Alt 2 and the future without (FWO).

Table C.2-21. Alternative 2 Water Quality Evaluation.

Flow-way	Basin/Natural Area	Inflow			Outflow			
		Volume (ac-ft)	TP (mg/L)	TN (mg/L)	Volume (ac-ft)	TP (mg/L)	TN (mg/L)	Data Source
3	PalMar	Not measured	Not measured	Not measured	Not measured	Not measured	Not measured	N/A
3	Cypress Creek	Not measured	0.079	1.11	68,380	0.05	<1.54	LRD 2016

Flow-way	Basin/Natural Area	Inflow			Outflow			Data Source
		Volume (ac-ft)	TP (mg/L)	TN (mg/L)	Volume (ac-ft)	TP (mg/L)	TN (mg/L)	
3	Hobe-St. Lucie	Not measured	0.11	1.26	9,455	0.071	<1.54	LRD 2016
3	Kitching Creek	Not measured	0.079	1.32	12,906	0.068	1.363	LRD 2016
2	C-18 Basin	5,800	0.017	1	44,594	0.034	0.985	LRD 2016
2	C-18 Basin	16,790	0.0147	1.225	65,570	0.034	0.985	SFWMD DBHYDRO 2017
2	Lox Slough	13,814	0.011	1.011	54,773	0.013	0.81	Mock Roos 2017
1	Lake Okeechobee C10A	0	0	2.45				
1	L-8+Lake to C51	129,211	0.185	2.3	129,211	0.123	1.636	Julian 2016
1	ITID	16,518	0.039	1.352	16,518	0.039	1.352	IDIT personal communication and SFWMD DBHYDRO 2017
1	Grassy Water Preserve	57,240	0.01	0.839	2,977	0.01	0.839	SFWMD DBHYDRO 2017
1	Grassy Water Preserve	57,240	0.01	0.839	17,660	0.013	1.011	SFWMD DBHYDRO 2017
River	Loxahatchee River NWF	216,608	0.041	1.11				Julian 2016
River	Middle Estuary (S/W Fork)	36,193	0.024	0.899				LRD 2016

Table C.2-22. Alternative 2: Comparison to FWO water quality analysis results.

		Inflow				Outflow			
Flow way	Basin/ Natural Area	TP (mg/L)	TP Difference To FWO (Alt 2-FWO)	TN (mg/L)	TN Difference To FWO (Alt 2-FWO)	TP (mg/L)	TP Difference To FWO (Alt 2-FWO)	TN (mg/L)	TN Difference To FWO (Alt 2-FWO)
3	PalMar	N/M		N/M		N/M		N/M	
3	Cypress Creek	0.079	0	1.11	0	0.05	-0.003	<1.54	0
3	Hobe-St. Lucie	0.11	0	1.26	0	0.071	0	<1.54	0
3	Kitching Creek	0.079	0	1.32	0	0.068	-0.007	1.363	0
2	C-18 Basin	0.017	0	1	0	0.034	0.017	0.985	0.005
2	C-18 Basin	0.0147	-0.0283	1.225	0.121	0.034	0.005	0.985	-0.052
2	Lox Slough	0.011	-0.004	1.011	0	0.013	-0.016	0.81	0
1	Lake Okeechobee C10A	0	-0.185	2.45	0		0		0
1	L-8+Lake to C51	0.185	0.062	2.3	0	0.123	0.123	1.636	1.636
1	ITID	0.039	0	1.352	0	0.039	0	1.352	0
1	Grassy Water Preserve	0.01	0	0.839	0	0.01	0	0.839	0
1	Grassy Water Preserve	0.01	0	0.839	0	0.013	0	1.011	0
River	Loxahatchee River NWF	0.041	-0.009	1.11	-0.06				0
River	Middle Estuary (S/W Fork)	0.024	-0.017	0.899	-0.047				0

Alt 2 water quality effect is limited at most points where assessed by the model. Total Phosphorus (TP) and Total Nitrogen (TN) inflows are not significantly different. Outflows are similar with exception of L-8+Lake to C51 being 1.636 higher for TN. This is a result of increased flows as part of the increased spreader canal and is similar to other alternatives with the same feature. See **Figures C.2.36** and **C.2.37** for TP flows. There are no negative impacts associated with this alternative.

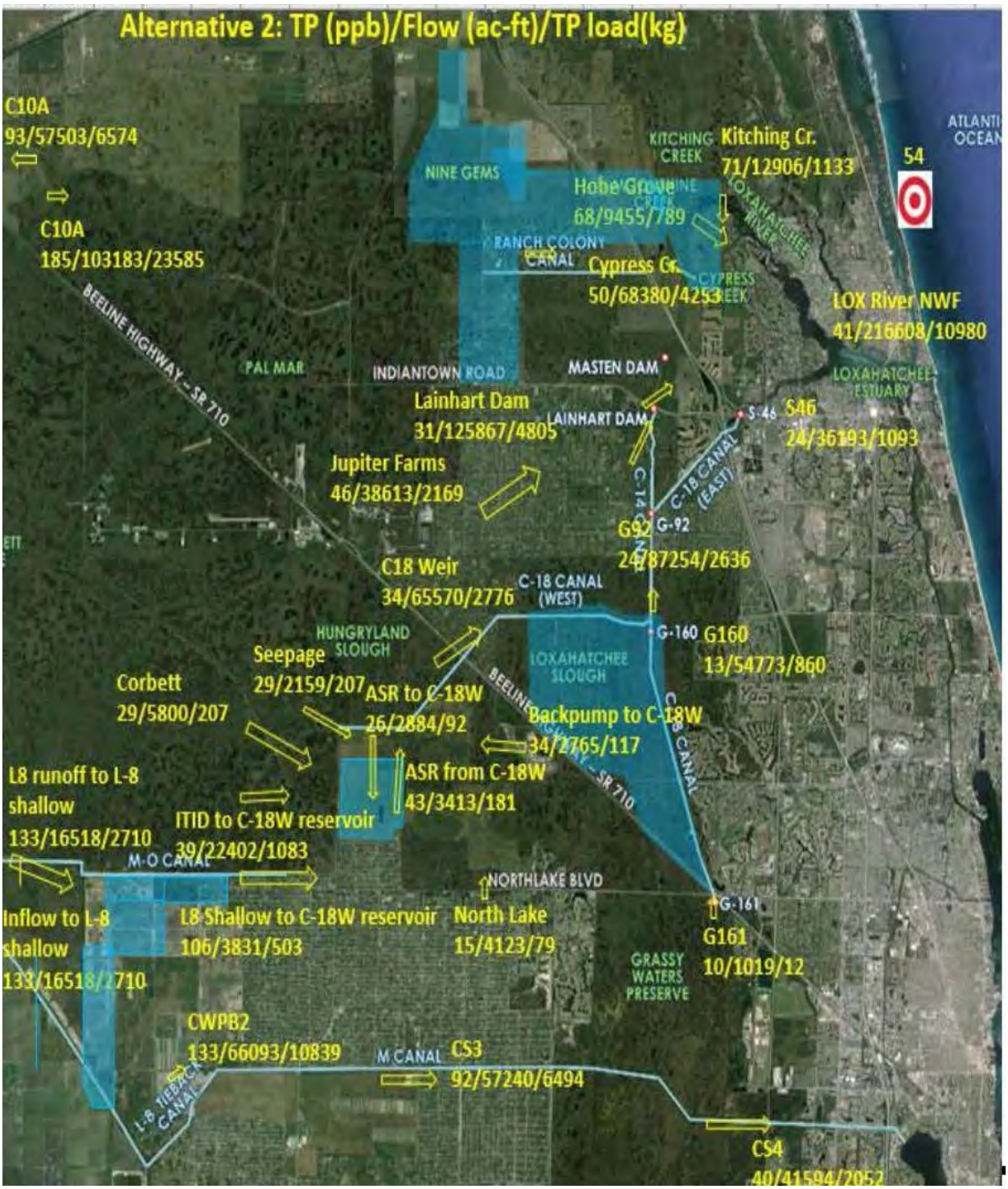


Figure C.2-39 Alternative 2 total phosphorous (TP) flow map.

Figure C.2-40: Alternative 2 Total Phosphorous flow map and structures.

Alt 5R Water Quality Evaluation is summarized below in Table **C.2-23** and Table **C.2-24** is the comparison between Alt 5R and the future without (FWO).

Table C.2-23. Alternative 5R Water Quality Evaluation.

Flow-way	Basin/Natural Area	Inflow			Outflow			Data Source
		Volume (ac-ft)	TP (mg/L)	TN (mg/L)	Volume (ac-ft)	TP (mg/L)	TN (mg/L)	
3	PalMar	N/M	N/M	N/M	N/M	N/M	N/M	N/A
3	Cypress Creek	N/M	0.05	1.11	68,380	0.05	<1.54	LRD 2016
3	Hobe-St. Lucie	N/M	0.11	1.26	9,455	0.068	<1.54	LRD 2016
3	Kitching Creek	N/M	0.079	1.32	12,900	0.071	1.363	LRD 2016
2	C-18 Basin	6,214	0.029	1	66,888	0.028	0.985	LRD 2016
2	C-18 Basin	2,988	0.029	1.225	66,888	0.028	0.985	SFWMD DBHYDRO 2017
2	Lox Slough	9,634	0.014	1.011	59,334	0.013	0.81	Mock Roos 2017
1	Lake Okeechobee C10A	103,183	0.185	2.45				
1	L-8+Lake to C51	203,864	0.133	2.3	203,864	0.123	1.636	Julian 2016
1	ITID	27,639	0.039	1.352	27,639	0.039	1.352	IDIT personal communication and SFWMD DBHYDRO 2017
1	Grassey Water Preserve	68,134	0.01	0.839	9,872	0.01	0.839	SFWMD DBHYDRO 2017
1	Grassey Water Preserve	38,134	0.01	0.839	6,834	0.02	1.011	SFWMD DBHYDRO 2017
River	Loxahatchee River NWF	218,363	0.039	1.11				Julian 2016
River	Middle Estuary (S/W Fork)	39,561	0.021	0.899				LRD 2016

Table C.2-24. Alternative 5R Comparison to FWO Table.

Flow way	Basin/Natural Area	Inflow				Outflow			
		TP (mg/L)	TP Diff. To FWO (Alt-FWO)	TN (mg/L)	TN Diff. To FWO (Alt-FWO)	TP (mg/L)	Diff. To FWO (Alt - FWO)	TN (mg/L)	Diff. TN To FWO (Alt-FWO)
3	PalMar	N/M		N/M		N/M		N/M	
3	Cypress Creek	0.05	-0.029	1.11	0	0.05	-0.003	<1.54	0
3	Hobe-St. Lucie	0.11	0	1.26	0	0.068	-0.003	<1.54	0
3	Kitching Creek	0.079	0	1.32	0	0.071	-0.004	1.363	0
2	C-18 Basin	0.029	0.012	1	0	0.028	0.011	0.985	0.005
2	C-18 Basin	0.029	-0.014	1.225	0.121	0.028	-0.001	0.985	-0.052
2	Lox Slough	0.014	-0.001	1.011	0	0.013	-0.016	0.81	0
1	Lake Okeechobee C10A	0.185	0	2.45	0		0		0
1	L-8+Lake to C51	0.133	0.01	2.3	0	0.123	0.123	1.636	1.636
1	ITID	0.039	0	1.352	0	0.039	0	1.352	0
1	Grassey Water Preserve	0.01	0	0.839	0	0.01	0	0.839	0
1	Grassey Water Preserve	0.01	0	0.839	0	0.02	0.007	1.011	0
River	Loxahatchee River NWF	0.039	-0.011	1.11	-0.06		0		0
River	Middle Estuary (S/W Fork)	0.021	-0.02	0.899	-0.047		0		0

Alt 5R TP and TN inflows are not significantly different from FWO. Outflows are similar to for TP and TN with notable exception of L-8+Lake to C51, similar to Alt 2. There is an increase of 1.636 mg/L of TN as compared to the FWO. This is reflective of increased flow as a result of the spreader canal. There are no negative impacts of this alternative in regards to water quality, See **Figures C.2.38** and **C.2.39**.

Figure C.2-48: Alternative 5R total phosphorous (TP) flow map.

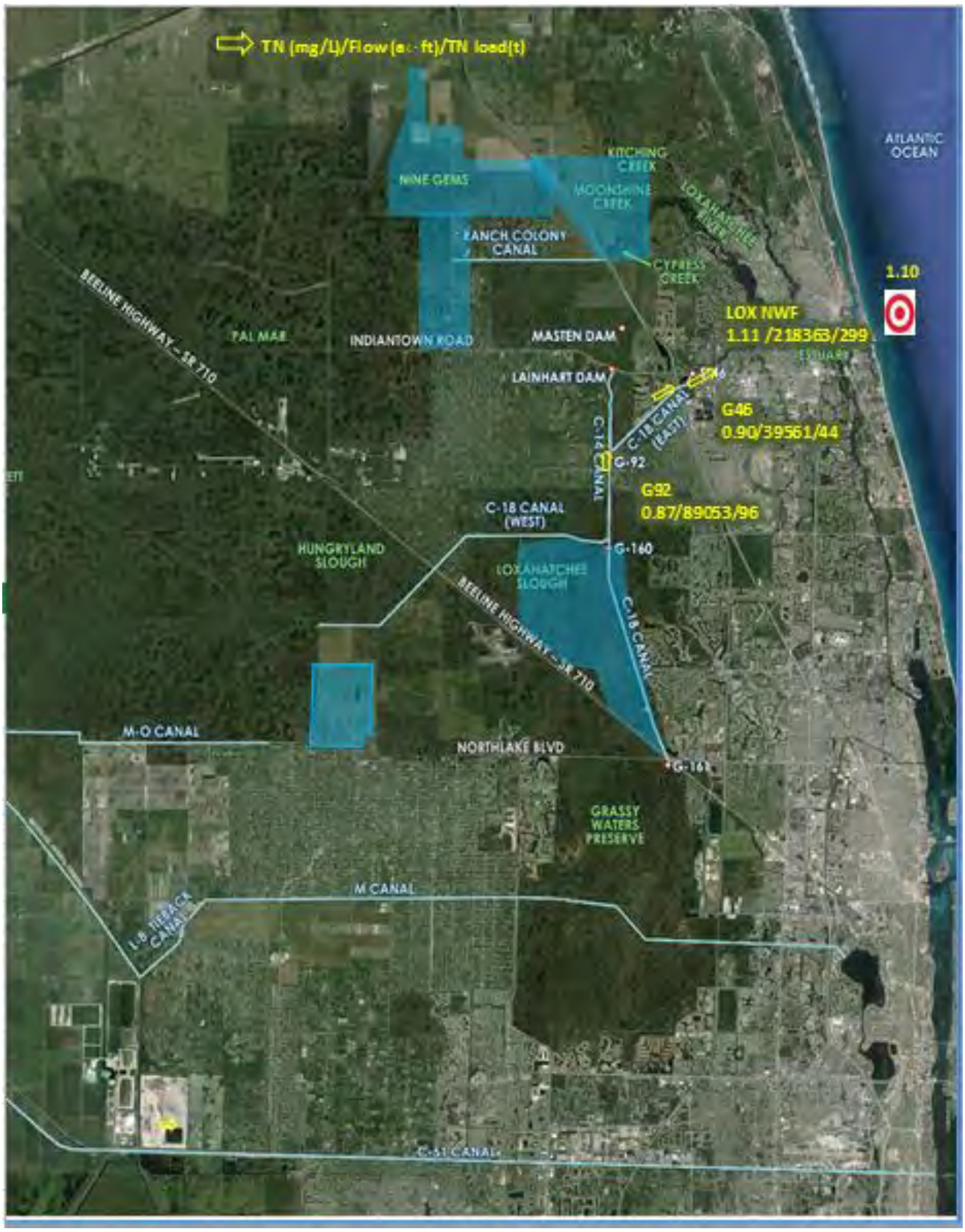


Figure C.2-42: Alternative 5R total nitrogen (TN) flow map.

Alt 10 Water Quality Evaluation is summarized below in Table **C.2-25** and Table **C.2-26** is the comparison between Alt 10 and the future without (FWO).

Table C.2-25. Alternative 10 water quality evaluation.

Flow way	Basin/ Natural Area	Inflow			Outflow			Data Source
		Volume (ac-ft)	TP (mg/L)	TN (mg/L)	Volume (ac-ft)	TP (mg/L)	TN (mg/L)	
3	PalMar	N/M	N/M	N/M	N/M	N/M	N/M	N/A
3	Cypress Creek	N/M	0.079	1.11	73,586	0.05	<1.54	LRD 2016
3	Hobe-St. Lucie	N/M	0.11	1.26	8,390	0.068	<1.54	LRD 2016
3	Kitching Creek	N/M	0.079	1.32	12,833	0.071	1.363	LRD 2016
2	C-18 Basin	5,212	0.017	1	68,544	0.031	0.985	LRD 2016
2	C-18 Basin	0	0	1.225	68,544	0.031	0.985	SFWMD DBHYDRO 2017
2	Lox Slough	13,409	0.031	1.011	73,308	0.013	0.81	Mock Roos 2017
1	Lake Okeechobee C10A	103,183	0.185	2.45				
1	L-8+Lake to C51	0	0	2.3	43,590	0.123	1.636	Julian 2016
1	ITID	97,974	0.039	1.352	87,974	0.039	1.352	IDIT personal communication and SFWMD DBHYDRO 2017
1	Grassey Water Preserve	40,538	0.01	0.839	10,633	0.01	0.839	SFWMD DBHYDRO 2017
1	Grassey Water Preserve	40,538	0.01	0.839	2,776	0.0154385	1.011	SFWMD DBHYDRO 2017
River	Loxahatchee River NWF	227,979	0.039	1.12				Julian 2016
River	Middle Estuary (S/W Fork)	38,228	0.022	0.899				LRD 2016

Table C.2-26. Alternative 10 Comparison to FWO Table.

Flow way	Basin/Natural Area	Inflow				Outflow			
		TP (mg/L)	Diff. To FWO (Alt-FWO)	TN (mg/L)	Diff. To FWO (Alt-FWO)	TP (mg/L)	Diff. To FWO (Alt -FWO)	TN (mg/L)	Diff. To FWO (Alt-FWO)
3	PalMar	N/M		N/M		N/M		N/M	
3	Cypress Creek	0.079	0	1.11	0	0.05	-0.003	<1.54	0
3	Hobe-St. Lucie	0.11	0	1.26	0	0.068	-0.003	<1.54	0
3	Kitching Creek	0.079	0	1.32	0	0.071	-0.004	1.363	0
2	C-18 Basin	0.017	0	1	0	0.031	0.014	0.985	0.005
2	C-18 Basin	0	-0.043	1.225	0.121	0.031	0.002	0.985	-0.052
2	Lox Slough	0.031	0.016	1.011	0	0.013	-0.016	0.81	0
1	Lake Okeechobee C10A	0.185	0	2.45	0		0		0
1	L-8+Lake to C51	0	-0.123	2.3	0	0.123	0.123	1.636	1.636
1	ITID	0.039	0	1.352	0	0.039	0	1.352	0
1	Grassey Water Preserve	0.01	0	0.839	0	0.01	0	0.839	0
1	Grassey Water Preserve	0.01	0	0.839	0	0.01544	0.002439	1.011	0
River	Loxahatchee River NWF	0.039	-0.011	1.12	-0.05		0		0
River	Middle Estuary (S/W Fork)	0.022	-0.019	0.899	-0.047		0		0

Alt 10 inflows show no significant change between Alt 10 and FWO. As with Alt 2 and 5R there is an increase of TN at L-8+Lake to C51 of 1.636. This is a result of increased flow to the spreader canal as the other alternatives. There are no significant impacts to water quality associated with this alternative, See **Figure C.2.40** and **C.2.41**.

Figure C.2-43: Alternative 10 total phosphorous (TP) flow map.

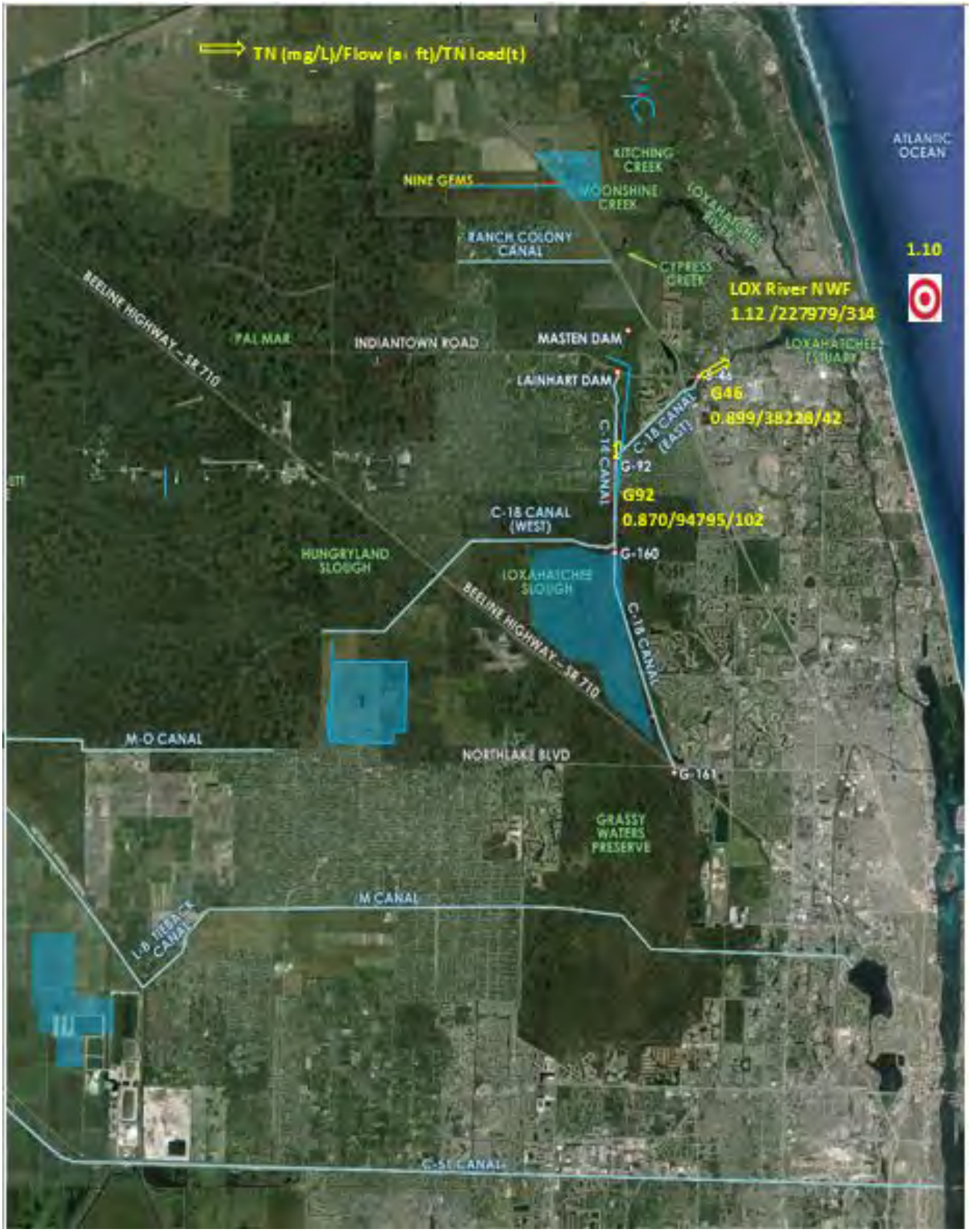


Figure C.2-44: Alternative 10 total nitrogen (TN) flow map.

C.2.13.1 Conductivity

Conductivity (chlorides) was only a major concern in Flow-way 1 and primarily Alt 10. The formula that is used to determine conductivity and its relationship with TDS is 0.6*conductivity=TDS (NOTE: Patrick Painter will provide supporting documentation). To meet the TDS criteria the conductivity for class I waters needs to be below 800 µS/cm. Once it hits the 800 threshold there is a human health concern, and the chlorides would get harder to dilute. The conductivity levels will be evaluated at Control 2 for flow-way 1. Alt 10 is the primary alternative needed for this evaluation. Monitoring and modelling of chlorides in this system would need to be put in place to inform operations given the seasonal nature of rainfall and water levels in deep reservoirs for to minimize risk of moving high chlorides downstream. To analyze effects of different water sources chlorides the following Table **C.2-27** lists assumptions for conductivity levels, as source water will effect analysis:

Table C.2-27. Historical Source Water Conductance.

Water Body or Source	Specific Conductance Level
Lake Okeechobee	550 Micromohs/cm
L-8	500 Micromohs/cm up to 1275 (limit to release)
ITID	550
Loxahatchee River	Varied from 230 Micromohs/cm from Lainhart Dam to 550 Micromohs/cm at east of I-95

Modeling based on spreadsheet analysis of existing conductance conditions and flow volumes from the LECSR model is presented in **Figure C.2.42** and **Table C.2.28**. Conductivity increases from ECB (used for FWO assumption) of 548 µS/cm at Control 2 structure to 758 µS/cm. This is a significant increase by 38% but is below the threshold of concern 800 µS/cm identified by the City of West Palm Beach for water supply purposes. If this alternative were to be selected, there is an assumption that limiting the depth of the reservoir would avoid high chlorides. Pre-L-8 Flow Equalization Basin construction revealed high chlorides in the L-8 area. To ensure lower risk of chlorides (which cause heavy water to sink to bottom), releases should not be made below a certain water levels in the reservoir. L-8 data would need to be reviewed to determine exact threshold of reservoir stage to higher chloride incidence, if this alternative were selected.

Figure C.2-45: Alternative 10 Conductivity Flow Map

Table C.2-28: Alternative 10 Summary Table Conductivity Analysis.

	Alt 10 Max	Alt 10 Expected	ECB
C-51 Area (acres)	1,600		-
C-51 Volume (ac-ft)	44,000		-
C-51 Depth (ft)	27.5		-
Seepage rate (in/day)	0.33[1]	0.25[2]	
Annual seepage Qseep (ac-ft)	16,060	12,034	-
% of Seepage (Qseep/Qtotal)	26%	19%	-
Seepage Specific Conductance (µS/cm)	3,220[3]	3,220	-
Specific Conductance of C-51 Reservoir (µS/cm)	1,053	936	-
Specific Conductance of C-51 Reservoir at CS2 (µS/cm)	758[4]	709	548
Seepage Specific Conductance (µS/cm) for 800 (µS/cm) target at CS2	3,700	4,565	-

Alt 13 Water Quality Evaluation is summarized below in Table **C.2-29** and Table **C.2-30** is the comparison between Alt 10 and the future without (FWO).

Table C.2-29. Alternative 13 Water Quality Evaluation.

Flow way	Basin/ Natural Area	Inflow			Outflow			Data Source
		Volume (ac-ft)	TP (mg/L)	TN (mg/L)	Volume (ac-ft)	TP (mg/L)	TN (mg/L)	
3	PalMar	N/M	N/M	N/M	N/M	N/M	N/M	N/A
3	Cypress Creek	N/M	0.079	1.11	66,636	0.05	<1.54	LRD 2016
3	Hobe-St. Lucie	N/M	0.11	1.26	9,459	0.071	<1.54	LRD 2016
3	Kitching Creek	N/M	0.079	1.32	12,906	0.071	1.363	LRD 2016
2	C-18 Basin	4,598	0.029	1	57,494	0.025	0.985	LRD 2016
2	C-18 Basin	0	0	1.225	10,613	0.025	0.985	SFWMD DBHYDRO 2017
2	Lox Slough	10,787	0.023	1.011	56,946	0.013	0.81	Mock Roos 2017
1	Lake Okeechobee C10A	0	0	2.45				
1	L-8+Lake to C51	0	0	2.3	61,613	0.031	1.636	Julian 2016
1	ITID	33,071	0.039	1.352	33,071	0.039	1.352	IDIT personal communication and

Flow way	Basin/ Natural Area	Inflow			Outflow			Data Source
		Volume (ac-ft)	TP (mg/L)	TN (mg/L)	Volume (ac-ft)	TP (mg/L)	TN (mg/L)	
								SFWMD DBHYDRO 2017
1	Grassey Water Preserve	57,300	0.01	0.839	9,862	0.01	0.839	SFWMD DBHYDRO 2017
1	Grassey Water Preserve	57,300	0.01	0.839	4,133	0.015	1.011	SFWMD DBHYDRO 2017
River	Loxahatchee River NWF	209,823	0.039	1.116				Julian 2016
River	Middle Estuary (S/W Fork)	37,235	0.019	0.8987				LRD 2016

Table C.2-30. Alternative 13 Comparison to FWO.

Flow way	Basin/ Natural Area	Inflow				Outflow			
		TP (mg/L)	Diff. To FWO (Alt-FWO)	TN (mg/L)	Diff. To FWO (Alt-FWO)	TP (mg/L)	Diff. To FWO (Alt - FWO)	TN (mg/L)	Diff. To FWO (Alt-FWO)
3	PalMar	N/M		N/M		N/M		N/M	
3	Cypress Creek	0.079	0	1.11	0	0.05	-0.003	<1.54	0
3	Hobe-St. Lucie	0.11	0	1.26	0	0.071	0	<1.54	0
3	Kitching Creek	0.079	0	1.32	0	0.071	-0.004	1.363	0
2	C-18 Basin	0.029	0.012	1	0	0.025	0.008	0.985	0.005
2	C-18 Basin	0	-0.043	1.225	0.121	0.025	-0.004	0.985	-0.052
2	Lox Slough	0.023	0.008	1.011	0	0.013	-0.016	0.81	0
1	Lake Okeechobee C10A	0	-0.185	2.45	0		0		0

Flow way	Basin/ Natural Area	Inflow				Outflow			
		TP (mg/L)	Diff. To FWO (Alt-FWO)	TN (mg/L)	Diff. To FWO (Alt-FWO)	TP (mg/L)	Diff. To FWO (Alt - FWO)	TN (mg/L)	Diff. To FWO (Alt-FWO)
1	L-8+Lake to C51	0	-0.123	2.3	0	0.031	0.031	1.636	1.636
1	ITID	0.039	0	1.352	0	0.039	0	1.352	0
1	Grassey Water Preserve	0.01	0	0.839	0	0.01	0	0.839	0
1	Grassey Water Preserve	0.01	0	0.839	0	0.015	0.002	1.011	0
River	Loxahatchee River NWF	0.039	-0.011	1.116	-0.054		0		0
River	Middle Estuary (S/W Fork)	0.019	-0.022	0.8987	-0.0473		0		0

Alt 13 inflows show no significant change between Alt 13 and FWO. As with other alternatives there is an increase of TN at L-8+Lake to C51 of 1.636. This is a result of increased flow to the spreader canal. There are no significant impacts to water quality associated with this alternative, see **Figure C.2.43** and **C.2.44**.

Figure C.2-46: Alternative 13 Total Phosphorous (TP) Flow Map.

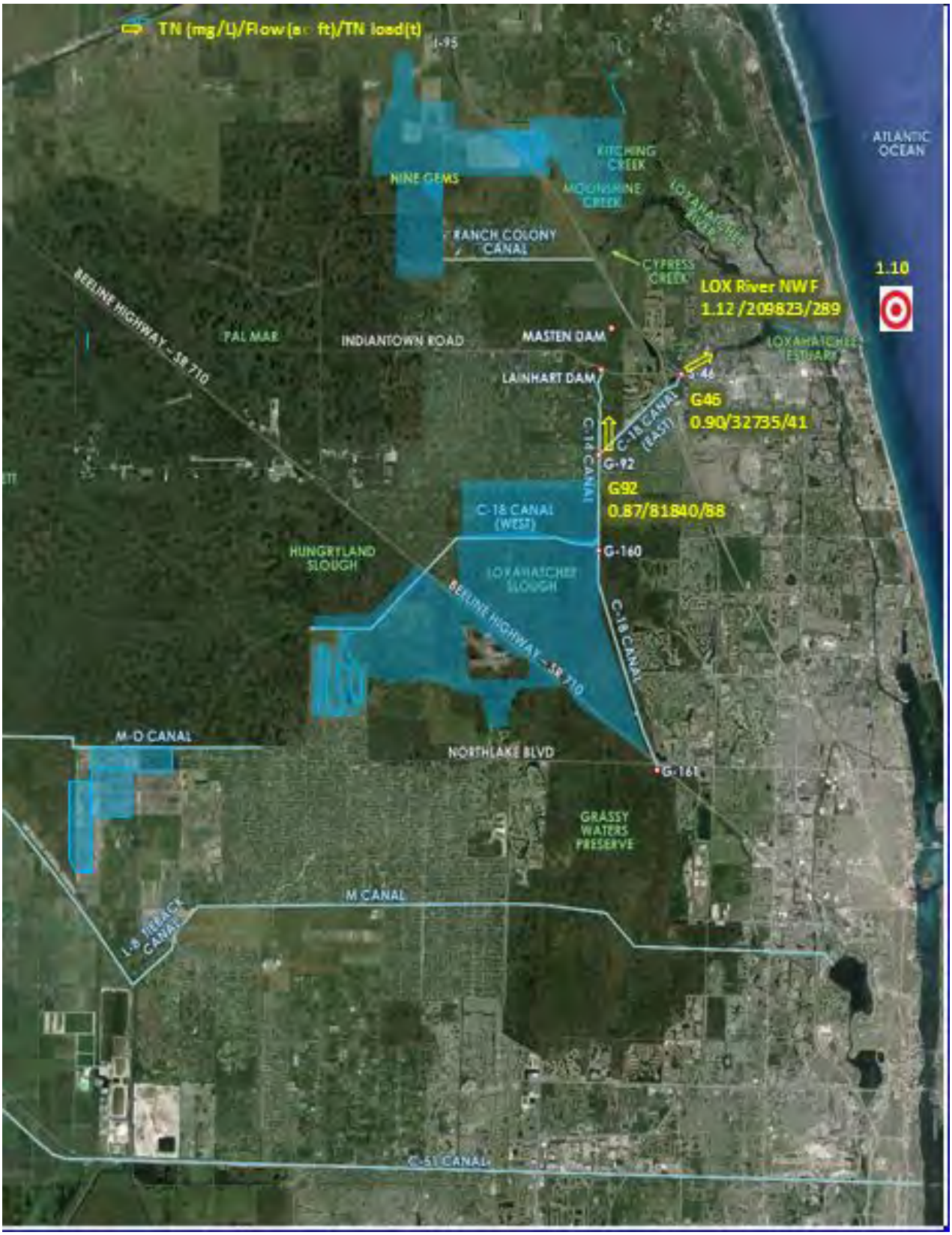


Figure C.2-47: Alternative 13 Total Nitrogen (TN) Flow Map.

C.2.14 Air Quality

The FWO long term impact of the project neither improves nor degrades air quality. The short term impact without project is a slight temporary decrease in emissions and particulates from construction. The alternatives all have short-term impact from emissions by the construction equipment associated with the project but will not significantly impact air quality. Exhaust emissions of the construction equipment would have a temporary effect on the air quality, but no permanent impacts are expected. The temporary effects from construction are not expected to cause a non-attainment for air quality. There will be no long-term impacts to air quality from any alternative as all structures are either unpowered and the only powered feature, the ASR well pumps, will be electric.

C.2.15 Hazardous, Toxic, and Radioactive Waste

The FWO project has no relation to HTRW issues. Remediation may or may not commence without the project and it depended upon the responsible parties to ensure remediation. The main areas that would require potential assessment and remediation vary by the area affected by alternative features during construction or hydration. Table **C.2-31** summarizes whether further HTRW assessment and clearance would be needed if implemented, based on the summary from the ECB/FWO write-up.

Table C.2-31. Summary of Alternatives – HTRW assessment and clearance requirements.

Area\Alternatives	Alt 2	Alt 5R	Alt 10	Alt 13
Mecca Property	Yes, Impoundment Flow-way 2	Yes, Impoundment Flow-way 2	Yes, Impoundment Flow-way 2	Yes, Construction of flow-ways in Flow-way 2
Nine Gems and Culpepper	Yes, Flow-way 3	Yes, Flow-way 3	No	Yes, Flow-way 3
Gulfstream West and East Citrus Farms	Yes, Flow-way 3	Yes, Flow-way 3	Yes, Flow-way 3	Yes, Flow-way 3
Shiloh Farms	No	Yes, Flow-way 3	No	Yes, Flow-way 3

For all alternatives remediation must take place to allow project implementation, the lands must be cleared of HTRW/residual agricultural chemical concerns within the project footprint at 100% nonfederal sponsor cost. Maintenance areas. During the construction of project features, it is possible that undiscovered HTRW contamination will be found. Per EC 1165-2-132, the non-federal sponsor will be required to remediate these sites at their sole expense. There is also the potential for HTRW release associated with the operation of project pump stations; however, with modern facilities and best management practices, this presents a minor risk to the environment.

The issues and further investigations by the non-federal sponsor continue and are advancing towards completion and remediation. The non-federal sponsor will provide all lands free and clear of any and all environmental issues and the property will have no limitations that will prevent the selected remedy from achieving goals. The local sponsor will obtain the necessary written concurrence that the project sites are acceptable for project purposes from the appropriate agencies. USFWS is the responsible authority to address endangered species issue relative to contaminant levels. FDEP is the responsible authority to address human health issues relative to contaminant levels.

C.2.16 Noise

The FWO would result in additional ambient noise related to future development not associated with the proposed project. All alternatives would have minor short-term, construction related increases in noise. During ASR well construction (duration approximately 1 month per well) a drill rig would cause some noise during the day. All action alternatives include additional pump stations which would result in long-term, localized increases in noise. Effects of alternatives would vary with number of pump stations with fewer pump stations having lesser effects. Pumps associated with ASR wells would also result in long-term localized increases in noise. ASR pumps are electric, which run much quieter than diesel powered engines. The turbines are submerged to a depth of 30 ft. below the surface, so sound is damped. Compressors for the airburst system (to clean intake screen) runs infrequently for 5 minutes. Hospital-grade mufflers will be included in design.

C.2.17 Aesthetics

Aesthetic effects refer generally to impacts on the visual qualities of the environment. Restoration of the Loxahatchee watershed ecosystem is expected to result in a more hydrologically balanced environment that would support vigorous native plant communities; larger fish and aquatic animal populations; large numbers of charismatic wildlife species such as wading birds; alligators; and sustainable populations of wide-ranging mammals, in a natural landscape setting, for the duration of the project. The public values viewing wildlife, wetlands, and open, relatively pristine spaces, as supported by tourism statistics for south Florida. During construction of all features there will be a temporary short-term moderate localized impacts to aesthetic values in the construction areas. All action alternatives show a significant increase in aesthetic value over the FWO due to restoration of wetlands in the Loxahatchee watershed and provide a minor to major beneficial effect, depending on the feature. Restored wetlands provide natural habitat for native plants and animals and increased opportunities for wildlife viewing. For the reservoirs and wetland attenuation feature there will be a long-term, major adverse impact in reservoir areas due to levees in line of sight. An earthen dam will be visible on the rise, but covered in grass or other vegetation to minimize the aesthetics impact. There will be a moderate adverse impact with the addition of a pump stations, ASR wells, and reservoirs by adding man-made features in the natural landscape. Improved flows to NWFLR and the estuary would provide negligible to moderate beneficial effects as scenic and recreational settings improved. These benefits could also lead to an increase in wildlife viewing opportunities (Orth et al. 2006).

C.2.18 Land Use

The LOWRP project area consists of a mixture of private and public land ownership. The public lands belong to the South Florida Water Management District (SFWMD) and the State of Florida. Publicly owned lands include state parks, wildlife and ecological management areas, and various infrastructure.

The LRWRP project area includes lands for project physical features (such as impoundments), as well as C.2-102hydroperiod restoration for areas such as Flow-way 3 (Pal-Mar East aka Nine Gems, Cypress Creek) and the Loxahatchee Slough. Most of the properties that will have improved hydroperiods, or that are proposed for the physical features such as impoundments, are already within public ownership, though some minor acquisitions may be necessary to finalize project footprints and prevent impacts to private lands. The TSP (Alt 5R) has one impoundment (C-18W) that is to be located on the former Mecca Farms property in the western C-18 basin. This property is a former citrus grove that is now fallow. Another feature in the TSP that could mimic an impoundment is the Gulfstream West Flow-through marsh. This

feature will be located on the former Gulfstream Citrus property, a fallow citrus grove located west of I-95 and Florida's turnpike in Martin County. These properties have both been acquired in support of this project and will be certified to the project prior to construction. As such, they will be protected from surplus and from further urbanization.

C.2.18.1 Agriculture

Modest reduction in overall agricultural acreage is expected in the study area within FWO as compared to the existing condition. Agricultural acreage is expected to decline slightly in both Martin and Palm Beach counties, primarily due to urbanization. The number of acres cultivated in any given year is driven by market forces and cultivation practices such as rotating crops (SFWMD Draft LEC Water Supply Plan, 2013). For the LRWRP, the properties proposed for reservoir or wetland features are fallow citrus or pasture lands that have already been acquired. The exception is the proposed shallow impoundment in Alt 2 and Alt 13, which is located on active row crop agricultural land. Impact to agriculture is minor**.**

All alternatives include above ground storage features and wetland restoration components. One alternative (Alt 10) includes both a below-ground and an aboveground storage component and has lesser effect with respect to improved wetlands than the remaining alternatives. Alt 13 has greater positive wetland effects and a more limited impoundment feature. For all alternatives, storage features have been conceptualized on existing or former agricultural lands (primarily fallow citrus groves) to minimize impacts to wetlands. The below-ground storage component in Alt 10 would use a site that is currently proposed for mining. The L-8 shallow impoundment (in Alts 2 and 13) would be situated on an existing row-crop agricultural area. For the alternatives not selected, approximately 50% of the land required to complete the storage facilities has been acquired (C-18 W Impoundment) while the remaining properties would need to be acquired (C-51 Phase II, L-8 Shallow) had they been components of the Selected Plan. Alt 13 considered substantial wetland improvements on former ranchlands and citrus groves and would have provided a relatively unbroken hydrologic connection between Corbett and the Loxahatchee Slough. A relatively large portion of the unacquired land for the wetland restoration component of Alt 13 is proposed as mitigation for a planned development to be located west of Beeline Highway and north of Northlake Blvd. All the land required for the proposed C-18W impoundment in the TSP (Alt 5R) has been acquired.

All alternatives propose improvements to groundwater stages in near proximity to the NWFLR, and consequently improve wetland hydroperiods throughout the project area, particularly in Flow-way 3. Most of the properties in this area are former ranch lands or fallow citrus groves that are in public ownership, having been acquired in anticipation of this project. Many are currently leased for cattle grazing. Estimated impacts to agricultural lands are outlined in **Table C.2-32**. If these lands were not included in the project, there is high likelihood that they would be listed for surplus. If that occurs, the opportunity for restoration of baseflow to the NWFLR would become increasingly difficult.

Table C.2-32. Agricultural Impacts from the project.

Feature	Acres	Current Agricultural Use	FWO Use	Alt 2	Alt 5R	Alt 10	Alt 13
C-18 W Impoundment	~1,800	SFWMD owned, Fallow citrus	Potential grazing or other ag use	✓	✓	✓	

Feature	Acres	Current Agricultural Use	FWO Use	Alt 2	Alt 5R	Alt 10	Alt 13
L-8 Shallow Impoundment	~1,500	Row crop	Row crop, potential for development	✓	N/A	N/A	✓
C-51 Phase II Impoundment	~1,000	Sugar cane	Mined	N/A	N/A	✓	N/A
Gulfstream West Flow through Marsh	~750	SFWMD owned. Fallow citrus leased for cattle	Potential surplus, cattle or row crop	✓	✓	N/A	✓
Gulfstream East (wetland restoration)	~450	SFWMD owned. Fallow citrus	Potential surplus, cattle or row crop	✓	✓	✓	✓
Cypress Creek (wetland restoration, hydroperiod improvement)	~1,200 (2,400 for Alt 5R & 13)	SFWMD, Martin County and Palm Beach County owned. Conservation	Conservation	✓	✓	✓	✓
Shiloh Farms	300	SFWMD owned. Row crop, pepper	Potential surplus. Row crop, pepper	N/A	✓	N/A	✓
Pal-Mar East (Nine Gems, Culpepper)	~4,500	Conservation (former unimproved pasture)	Potential surplus cattle grazing, development	✓	✓	N/A	✓

Table C.2-33 summarizes agricultural impacts by Alt from the proposed project.

Table C.2-33. Agricultural Impacts by alternative from the project.

Impacts to Agriculture for each Alternative	Alt 2	Alt5R (TSP)	Alt 10	Alt 13
C-18W	Impoundment (impacts ~1,800 acres (fallow citrus)	Impoundment (impacts ~1,800 acres (fallow citrus)	Impoundment (impacts ~1,800 acres (fallow citrus)	Wetland restoration and flow paths – impacts ~ 2,000 acres Improved/unimproved Pasture and 1,800 acres fallow citrus
C-51 Phase II Reservoir	N/A	N/A	N/A	N/A

Impacts to Agriculture for each Alternative	Alt 2	Alt5R (TSP)	Alt 10	Alt 13
L-8 Shallow	Impoundment, (impacts ~1,500 acres - row crop)	N/A	N/A	Impoundment (impacts ~1,500 acres - row crop)
Gulfstream West Flow through Marsh	750 acres (fallow citrus), leased for cattle	750 acres (fallow citrus)	N/A	750 acres (fallow citrus)
Gulfstream East	450 acres (fallow citrus)	450 acres (fallow citrus)	450 acres (fallow citrus)	450 acres (fallow citrus)
Cypress Creek	~1,200 acres (mixed pasture and forested wetland)	~2,400 acres (mixed pasture and forested wetland) ~300 acres row crop (pepper)	N/A	~2,400 acres (mixed pasture and forested wetland) ~300 acres row crop – pepper)
Pal-Mar East (Nine Gems, Culpepper)	~ 4,500 acres Unimproved Pasture, forested and unforested upland/wetland	~ 4,500 acres Unimproved Pasture, forested and unforested upland/wetland	N/A	~ 4,500 acres Unimproved Pasture, forested and unforested upland/wetland

C.2.18.2 Wetlands

All alternatives propose improvements to wetlands. Most of the wetland improvements for the project will occur in Loxahatchee Slough (due to the G-160 structure and concurrent modification to the operation of the project culvert control elevations) and in Flow-way 3 on the Pal-mar East (aka Nine Gems and Culpepper properties). Three of the four alternatives (Alt 2, Alt 5R and Alt 13) recommend connecting the Culpepper property and portions of Pal-mar to the Nine Gems property through the removal of sections of the canal and berm that separate these parcels. This will facilitate sheet flow and reconnect flow-ways that have been cut off by drainage canals and associated berms. **Figure C.2.45** shows the wetland character of Flow-way 3 (Nine Gems and Pal-Mar) in 1958 prior to the construction of the canals and berms. **Figure C.2-22** shows the locations where water tends to impound, adjacent to the western canal and berm that separates the Nine Gems property from Pal-Mar.

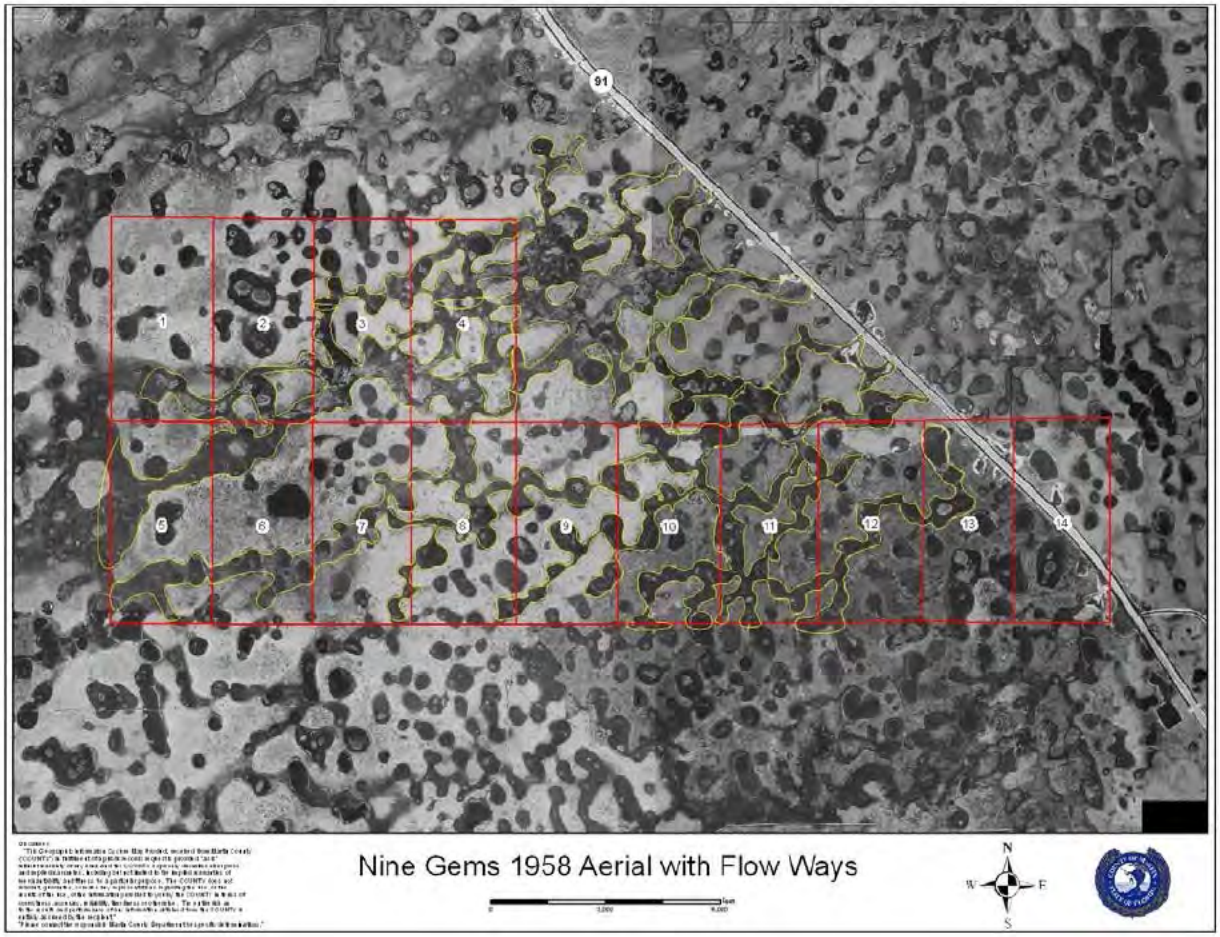


Figure C.2-48: 1958 aerial of Nine Gems and surrounding areas.

Figure C.2-49: Aerial contrasting Nine Gems and Pal-Mar (photo is oriented with north on the bottom).

Effects on wetlands and uplands are summarized for the final array of alternatives in Appendix G (**Table C.2-34**). The action alternatives show a major beneficial and significant effect with an increase in wetland/upland habitat and wetland function over the FWO with some differences between alternatives. The differences stem from different project features (location and degree of backfilling; whether or not spreader swales are proposed, and hydrological changes proposed). For example, Alt 10 does not include ditch filling and berms on the Pal-Mar East properties, while the other alternatives do include these activities. Although impacts to wetlands are expected in the FWO condition because of increased development pressure, these losses would, for the most part, be offset by mitigation requirements and thus there would minimal loss of wetlands. For the alternatives, there is expected to be improvement to wetland hydroperiods as ditches are filled and areas are reconnected. This is especially true in the Flow-way 3 area, where substantial improvement in wetland hydroperiods are expected. Also in Flow-way 3, there are several areas that will be graded to more natural topography (Shiloh, Gulfstream East) that can be considered as gains in wetland acreage.

Table C.2-34. Effects of alternatives on wetlands (acres).

Project Area	FWO Acres of Wetland Gain (Loss)	Alt 2 Acres of Wetland Improvement (impact)	Alt 5 Acres of Wetland Improvement (Impact)	Alt 10 Acres of Wetland Improvement (impact)	Alt 13 Acres of Wetland Improvement (impact)
Flow-way 1	(10)	1522	1532	1511	1493
Flow-way 2	(395)	215	(51)	(128)	1362
Flow-way 3	0	6173	7551	723	7551
Total Net Change	**(405)**	**7910**	**9032**	**2106**	**10,406**

C.2.18.3 Utility and Transportation Corridors

There is an extensive network of utility and transportation infrastructure throughout the project area. These improvements have facilitated land development and other economic activities, which result in a need for additional infrastructure, and a rather continuous need for upgrading and adding new roads and utilities. There are, as a result, environmental consequences that include fragmentation of natural areas, and disruption of sheet flow.

Within the project area, the most relevant transportation features include Interstate 95, Florida's Turnpike, the CSX Railroad, Beeline Highway (SR 710) and State Road 7. Other significant transportation corridors include Seminole Pratt Whitney Road (in Palm Beach County), Indiantown Road, PGA Boulevard, Northlake Boulevard and SR 711 (aka Pratt Whitney Road) in Martin County. Most of these corridors traverse areas that were once wetlands or sloughs, or other types of natural lands. These corridors, along with the land improvements they facilitate, are physical barriers to wildlife and in many cases, redirect or constrain natural flow, resulting in the loss of wetland habitat and the degradation of natural areas downstream. Roadway elevations can also act as constraints that limit the amount of water that can be stored in adjacent wetlands as high water levels can cause impacts to roadways.

The project alternatives do not propose modifications to existing transportation and utility corridors.

C.2.19 Recreation

There will be no impacts to recreational navigation with this project. The TSP alternative would provide enhanced fishing, boating, and wildlife observation opportunities due to better salinity conditions in the Loxahatchee estuary. A Recreation Plan is included in **Appendix F**.

C.2.20 Socioeconomics

Neither population projections nor the overall economic activities of the study area are anticipated to differ between the FWO and alternative conditions. However, there are a few spatially limited impacts of

the different alternatives on isolated economic activities, mainly tied to changes in land use, which are outlined below:

- State-owned land in the Shiloh farms area is currently leased for use in agriculture. In Alt5, Alt5R, and Alt13, this land would be utilized as part of the project and thus would no longer be used for agricultural purposes.
- Avenir, a mixed-use development including commercial and residential structures, is currently planned in Palm Beach Gardens. The location of this future development is on lands which are included in Alt13. Thus, the development and associated economic activities could not go forward in this location with the implementation of Alt13.
- The proposed site of the shallow storage in L-8 Basin (south of the M-0 canal) in Alt2 and Alt13 is currently farmland. Building a reservoir there would prevent agriculture on this land in the future.

C.2.21 Environmental Justice

The following sections outline the EJ analysis completed for the LRWRP, including information on low income and minority populations in the study area and/or located in close proximity to specific project features. Note that at the time of this report information on the real estate footprint is still being refined but, as stated in the Real Estate Appendix C, no opposition by landowners to acquisition of lands needed to implement the tentatively selected alternative, 5R, is anticipated. The EJ assessment will be updated to incorporate any relevant real estate information once available.

C.2.21.1 Area of Analysis

Data on (1) income and (2) race and ethnicity of residents from all 2017 census tracts overlapping spatially with the LRWRP study area was obtained to identify which portions of the study area and consequently which project features may need to be analyzed in greater detail for potential Environmental Justice issues.[1] Based on this initial analysis, the Census tracts that were determined to have >= 12% of families below the poverty line, which is greater than the national, Florida, Martin County, and Palm Beach County poverty levels of 11.0%, 11.7%, 7.3%, and 9.9%, respectively, were noted as areas that should be considered when looking at potential EJ concerns. Census tracts in which the combined percentage of residents belonging to minority (non-white) populations is greater than 50% were also noted for consideration in assessing possible EJ concerns.

C.2.21.2 Alternative Comparison

In general, the LRWRP alternatives (Alt2, Alt5, Alt10, and Alt13) are not expected to present impacts that are high, adverse and disproportionate to low income or minority populations. The alternatives do not (a) exclude persons from participation in, (b) deny persons the benefits of, or (c) subject persons to

[1] See Section 5-15, Socioeconomics, for additional information on poverty levels and racial and ethnic makeup of the study area.

discrimination because of their race, color, or national origin. Public scoping efforts did not identify environmental justice concerns attributable to the proposed project alternatives.

Once Alt 5R was identified as the TSP, a more detailed analysis was completed in which construction features associated with the proposed project were delineated spatially and overlaid on the Census tracts above to determine whether any overlap exists between the proposed project's footprint and the relatively high poverty and/or minority communities identified previously.

C.2.21.3 Environmental Justice Assessment Based on Poverty Levels - TSP

Figure C.2-50 shows a 2-mile radius around features proposed to be constructed as part of Alt 5R. Bright yellow areas indicate a Census tract with relatively high poverty levels (≥ 12% of families below the poverty line as defined above). Red and orange lines and polygons represent the spatial location of the proposed project's construction features. The green areas indicate a two-mile buffer around a proposed construction feature. Note that only one very small overlap occurs between these buffer areas and the yellow Census tracts within the study footprint. This happens where the G-161 floodway control and diversion structure is within a 2-mile radius of the very northern point of Census Tract 10.02 in Palm Beach County, where 15.1% percent of families were estimated to be below the poverty line based on 2012-2016 5-Year ACS estimates.

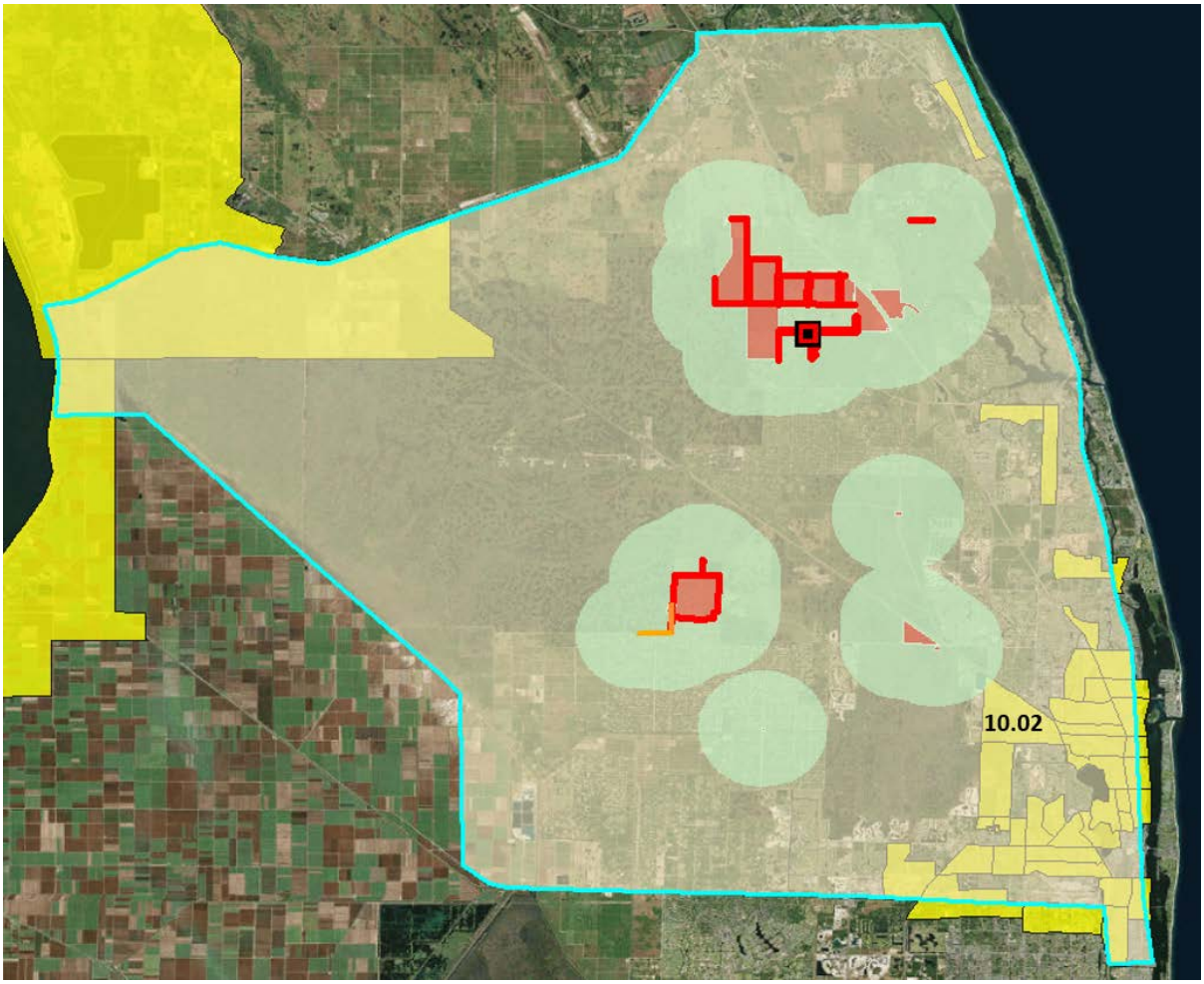


Figure C.2-50. Above-average poverty levels within 2-mile radius of 5R construction features.

C.2.21.4 Environmental Justice Assessment Based on Race and Ethnicity - TSP

Similar to the assessment based on poverty levels, only Census Tract 10.02 in Palm Beach County within the two-mile radius of construction features proposed as part of the TSP (Alt 5R) was identified as having minority (non-white) populations of 50% or greater. All other Census tracts overlapping with the areas directly surrounding proposed project features were less than 50% minority. Error! Reference source not found. below shows the racial and ethnic make-up of this Census tract based on 2016 ACS 5-year estimates.

Table C.2-35. Greater than 50% minority population by census tract.

Census Tract	White only, non-Hispanic	Hispanic and Latino	Black & African American only, non-Hispanic	All other
10.02 Palm Beach County	13.1%	11.6%	67.1%	8.2%

C.2.21.5 Environmental Justice Conclusions

As outlined above, only one potential environmental justice population was identified within a 2-mile buffer of the TSP project features just East of Grassy Waters Preserve (GWP). This minority and low-income population would not be affected by the project because the project overall doesn't result in increased risk of flooding or water supply associated with features affecting GWP.

C.2.22 Cultural Resources

The LRWRP study area encompasses approximately 480,000 acres (753 square miles) and includes all of the Loxahatchee River watershed and limited portions of the St. Lucie River watershed within Martin and Palm Beach Counties. Several natural areas including Kitching Creek; Moonshine Creek; Cypress Creek; Lainhart Dam; Pal Mar; Hungryland Slough; J.W. Corbett Wildlife Management Area (WMA); Dupuis Management Area; Loxahatchee Slough; and Grassy Waters Preserve are located within the study area. The project seeks to restore these areas to their historic functionality via wetlands restoration and watershed connectivity, and rejuvenate the historic headwater of the river.

The LRWRP study areas have been impacted by anthropogenic changes in the landscape for over 120 years. The changes are largely a result of state, federal, and commercial infrastructure projects, agricultural features and practices, and other development within the watershed that have lowered groundwater levels, and altered flow regimes and drainage patterns within these natural areas and other less developed areas. A review of the Florida Master Site File (FMSF) indicates that there are previously recorded archaeological sites and resource groups located within the LRWRP study area. Many of these sites are evaluated as potentially eligible for inclusion in the National Register of Historic Places (NRHP).

Throughout the planning process for LRWRP, project archaeologists, engineers, and plan formulators have sought to avoid adverse effects to cultural resources. They have worked collaboratively to formulate alternatives and features of alternatives that reduce or eliminate impacts to cultural resources, prioritized by their relative significance. Pursuant to 36 CFR 800.1, where possible, the project design will be modified to avoid impacting significant historic properties and culturally significant sites. Where avoidance is not possible, minimization and/or mitigation measures will be considered, which could include but are not limited to data recovery excavations. The mitigation measures will be developed in consultation with the

SHPO, the appropriate federally-recognized tribes, and other interested parties as established in implementing regulations for Section 106 of the NHPA.

In accordance with the National Historic Preservation Act (NHPA), consultation was initiated with the Seminole Tribe of Florida's Tribal Historic Preservation Office (THPO); the Miccosukee Tribe of Indians of Florida's Native American Graves Protection and Repatriation Act (NAGPRA) Representative; the SHPO; and the Palm Beach County Archaeologist. During formal consultations, several survey areas were evaluated in regard to the LRWRP's potential effects on cultural resources. These areas are identified as Grassy Waters Preserve, Loxahatchee Slough, Kitching Creek, J.W. Corbett WMA, Mecca, and Pal Mar. Eighteen cultural resources surveys were previously conducted within a half-mile buffer zone of these areas. Based on analyses of these surveys, it was determined that additional cultural resources surveys were needed to identify the types and nature of sites within these specific areas of potential effect for the feasibility study. It was also decided that additional surveys may be needed during the Pre-construction, Engineering, and Design (PED) phase.

Due to the large area considered in the alternative actions, the USACE will employ a phased process in the identification and evaluation of historic properties and an assessment of effects. Consistent with Section 106 of the NHPA (36 CFR § 800.4[b][2]), this approach has been coordinated with the Florida SHPO and the appropriate federally-recognized tribes and is documented in the ROD in lieu of a programmatic agreement. Engineering Regulation (ER) 1105-2-100 Appendix C, paragraph C-4(d)(6)(a) states that results of cultural resources investigations conducted during the feasibility phase and if needed, the PED phase will "serve as the basis for formulation of plans for management of historic properties prior to or during the construction and operational stages of projects". At which time, as required under ER 1105-2-100 Appendix C, paragraph C-4 (d)(6)(b) the PED phase will be utilized to complete historic property inventories, seek determinations of eligibility for the NRHP, determine effects of the project to historic properties, determine the need to mitigate adverse project effects on National Register and eligible properties, develop plans and cost estimates for such mitigation, and serve as the basis for negotiation of a Memorandum of Agreement with the appropriate parties specifying actions which will be taken by the USACE prior to or during the project construction period to mitigate adverse effects on National Register and eligible properties.

Post project authorization, each suite of features in the TSP will be subject to separate consultation and consideration of effects during PED as the APE may be subject to change based on final designs or modifications of project features. Supplementary cultural resources assessments will be conducted in areas that have not been previously surveyed. During PED and prior to construction, these surveys and a final determination of effects for any historic properties within the APE will be coordinated with the appropriate interested parties. Pursuant to Section 106 of the National Historic Preservation Act (54 U.S.C. 306108), the project design would be modified to avoid impacting significant historic properties and culturally significant sites where possible. Where avoidance is not possible, other mitigation measures would be considered, which could include, but are not limited to, data recovery excavations. Mitigation measures would be developed in consultation with the SHPO, the Advisory Council on Historic Preservation (ACHP), the appropriate federally recognized tribes, and other interested parties as established in implementing regulations for Section 106 of the NHPA (36 CFR 800). This PIR/EIS meets cultural resources requirements as specified under NEPA. The LOWRP will remain in compliance with the National Historic Preservation Act (NHPA) pre and post construction.

C.2.22.1 Area of Potential Effect

The area of potential effect (APE) for cultural resources differs greatly from the overall LRWRP study area. For this project, the APE for cultural resources covers many of the same features in each alternative. Two alternatives (5R and 2), are very similar sharing project features affecting the Kitching Creek, Moonshine Creek, Cypress Creek, Gulfstream West, and Palmar East areas; the major difference being that Alt 2 incorporates the additional 4,300-acre L-8 shallow storage basin including pumps and channels. Alt 13 has the largest potential to effect cultural resources with increased hydrologic connectivity and restoration in the Hungryland Slough, Loxahatchee Slough, and Grassy Waters Preserve Areas. Alt 10 has the least potential to effect cultural resources, virtually eliminating project features and hydration in the Palmar East area, and greatly reducing hydrologic restoration in the Loxahatchee Slough, Hungryland Slough, and Grassy Waters Preserve areas. However, unlike the other alternatives, Alt 10 incorporates a 44,000-acre deep storage reservoir southwest of the L-8 Tieback Canal. The location of the APE will continue to be refined during PED.

C.2.22.2 Evaluation Criteria Specific to Cultural Resources

Impacts to cultural resources vary by individual components within the alternatives. Therefore, impact evaluations were based on a review of the individual components of each alternative to determine if actions would potentially result in impacts to significant cultural resources (which include sites eligible or potentially eligible for listing in the NRHP) described below. Throughout the development and selection of the components, measures to eliminate or lessen adverse cultural resource effects were utilized.

The following significance thresholds have been used in determining whether components proposed for each alternative would result in a significant impact to cultural resources. The use of the term cultural resources includes historic properties eligible or potentially eligible for listing in the NRHP and culturally significant sites. A cultural resource impact is considered significant if implementation of a component of an alternative would result in any of the following when compared to Future Without Conditions (FWO):

- Result in a change in the significance or NRHP eligibility of a historic property, including but not limited to any contributing elements.
- Disturb any human remains, including but not limited to those outside of formal cemeteries.*
- Disturb memorials determined to hold public significance regardless of age.
- Result in adverse changes to sites identified through consultation with Native American Tribes as having cultural significance.

* The Jacksonville District has implemented a Burial Resources Agreement (BRA) with the Seminole Tribe of Florida which serves as the basis for consultation regarding the presence of burial resources and sets forth procedures that will ensure the culturally sensitive treatment of burial resources pursuant to the USACE Trust Responsibility. The 2008 CERP Policy on Human Remains also applies to the current study and is only superseded by the BRA for consultation regarding burial resources with the Seminole Tribe of Florida.

C.2.22.3 Comparison of Proposed Alternatives and Future without Conditions

The project schedule (Section 6.7 and 6.11.2.3) allows for a phased approach to Section 106 compliance, in that each suite of features will be evaluated and consulted on as they are designed. This will ensure that the most up to date information will be considered in determinations of effect to historic properties.

Also, based on final designs or modifications of the project features, additional work may be required for compliance with the NHPA. While the USACE is currently in compliance with the procedural requirements of the NHPA, the USACE recognizes that additional cultural resource surveys, NRHP evaluations, and determination of effects made in consultation with the SHPO, appropriate federally-recognized tribes, and other interested parties will be required in PED.

Consultation is currently ongoing with regards to the determination of effects and potential mitigation of effects listed below, and therefore should be considered preliminary. The effects associated with each alternative have been preliminarily considered for this feasibility study. A final identification, evaluation of historic properties, and determination of effects, as required under Section 106 of the NHPA, will not be made until the project is authorized and project features are sited during the subsequent PED phase.

For each component discussion below, the environmental effect is determined when compared to the future without conditions. For this document, the use of the term cultural resources includes significant historic properties that are determined eligible or potentially eligible for NRHP listing and culturally significant sites. See **Section 10** in the Main Document for definitions of terms.

C.2.22.4 Existing Archaeological Sites and Resources

The Florida Master Site File (FMSF) data from the Florida Division of Historical Resources lists 38 nationally registered sites, 114 archaeological sites, 18 historical resources groups, 7 cemeteries, 13 bridges, and 6,751 standing structures, within the LRWRP study area. Most of the 38 NRHP listed sites are found in the central to western side of the project area, many of which are prehistoric campsites and middens. There are multiple sites concentrated on the west side of the Loxahatchee River and along Loxahatchee Slough.

Prior to designing and implementing cultural resources field investigations for the LRWRP feasibility study, consultation with the Seminole Tribe of Florida Tribal Historic Preservation Office (STOF-THPO) was coordinated and each of the alternatives were evaluated for their potential to effect existing cultural resources by areas of potential impact including construction, impoundment, and restoration. Error! Reference source not found.**35** presents a summary of archeological sites and historic resources identified during consultation, and updated as the alternatives were further refined during the planning phase of the study.

Table C.2-36. Existing Cultural Resources potentially affected by the alternatives (construction, impoundment, and restoration).

Alternative 2 & 5r - Construction	Archaeological Sites Impacted	Description	SHPO Evaluation	FMSF Survey Number
	MT0517 – Linear Resource	Florida Turnpike Kitching Canal	Ineligible for NRHP	16754
	MT01600 – Linear Resource	Florida Turnpike (1950 – Present)	Ineligible for NRHP	19799
	MT01520	Mack Dairy – Farm/Building	Ineligible for NRHP	16754
	MT01516 – Linear Resource	Mack Dairy – Culpepper Road (unimproved)	Ineligible for NRHP	16754

Alternative 2 & 5r - Construction	Archaeological Sites Impacted	Description	SHPO Evaluation	FMSF Survey Number
	MT01453 – Linear Resource	Jupiter Road Late 19th Century Road	Insufficient Information	16754
Alternative 2 & 5R - Impoundment	None	N/A	N/A	N/A
Alternative 2 & 5R - Restoration	MT01344 – Homestead – Trapper Nelson's Pineapple Patch	20th Century	Eligible for NRHP	9019
	MT01348 – Trapper Nelson's Cabin and Zoo	20th Century	Not evaluated by SHPO	N/A
	MT01449 – Trapper Nelson Zoo Historic District	Cert. Date – 20061003	National Register Listed	Ref. Number 06000918
	MT01323 – Structure Resource Museum/Art Gallery/Planetarium/Residence	Year built c. 1938	Not Evaluated by SHPO	N/A
	MT0517 – Linear Resource	Florida Turnpike Kitching Canal	Ineligible for NRHP	16754
	MT01600 – Linear Resource	Florida Turnpike (1950 – Present)	Ineligible for NRHP	19799
	MT01516 – Linear Resource	Mack Dairy – Culpepper Road (unimproved)	Ineligible for NRHP	16754
	MT01453 – Linear Resource	Jupiter Road Late 19th Century Road	Insufficient Information	16754
	MT01284 (not impacted – 650 ft. from restoration APE) – Kitching Creek #3	Glades Ia prehistoric midden	Not Evaluated by SHPO	5412
	MT01518 – South Cypress Creek Canal – Linear Resource	20th Century	Ineligible for NRHP	16754
	MT01519 – Cecil Johnson Road – Linear Resource	20th Century	Ineligible for NRHP	16754
	MT01515 – Cecil Johnson Homestead	20th Century	Ineligible for NRHP	16754
Alternative 10 - Construction	Same as Alts 2 & 5 absent impacts to Mack Dairy, Jupiter Road, Kitching Canal, and FL Turnpike			
Alternative 10 - Impoundment	None	N/A	N/A	N/A
Alternative 10 – Restoration	Same as Alts 2 and 5 absent impacts to Mack Dairy, Jupiter Road,	N/A	N/A	N/A

Alternative 2 & 5r - Construction	Archaeological Sites Impacted	Description	SHPO Evaluation	FMSF Survey Number
	Kitching Canal, and FL Turnpike			
Alternative 13 – Construction	Same as Alts 2 and 5	N/A	N/A	N/A
Alternative 13 – Impoundment	None	N/A	N/A	N/A
Alternative 13 – Restoration	Same as Alts 2 and 5 including:	N/A	N/A	N/A
	PB6294 – Hungryland Prehistoric Midden	Glades, 1000 B.C. – A.D. 1700	Not Evaluated by SHPO	20976
	PB13929 – Boar Hammock Prehistoric Midden	Glades I, 1000 B.C. – A.D. 1700	Not Evaluated by SHPO	20976
	PB11489 – Vavrus Prehistoric Campsite	Not specified	Potentially Eligible	12752
	PB14419 – Lox Slough 1	Prehistoric with pottery	Not Evaluated by SHPO	Not specified

C.2.22.5 Kitching Creek (Hydration) Spreader Canal and Weir/Plug

The Kitching hydration project area measures 192.33 acres and is located in Jonathan Dickinson State Park approximately 2.5 miles southwest of Hobe Sound in Martin County. This component of the LRWRP involves the construction of several water control features including a spreader canal, weir, and plug at Jenkins Ditch. All Alts (2, 5R, 10, and 13) incorporate theses ground-disturbing features resulting in the hydration of Kitching Creek.

Only one previously conducted cultural resources survey (FMSF Survey #2114) has been completed in the vicinity of the Kitching Creek (Ballo and Hardin 1989). Piper Archaeological Research, Inc. conducted this reconnaissance cultural resources survey with limited shovel testing to investigate a large parcel located approximately 350 feet west of the proposed LRWRP Kitching Creek hydration area, and did not identify any historic properties. In 1989, the Florida SHPO concurred with their findings and recommendations for this nearby property, concluding that the project activities would have no effect on any archaeological or historic sites or properties listed, or eligible for listing in the NRHP or otherwise of national, state, regional or local significance (Division of Historic Resources Project File No. 892649).

In June 1998, the Archaeological and Historical Conservancy, Inc. (ACH) conducted an archaeological survey (Survey #5412) of the upper drainage basin of the Northwest Fork of the Loxahatchee River (Pepe and Steele 1998). This cultural resources survey included portions of Jonathon Dickinson State Park, all of Palm Beach County's Riverbend Park, and portions of Jupiter Farms, an unincorporated area of private residences west and southwest of Riverbend Park. ACH identified an archaeological site (8MT1284) as a temporary prehistoric camp site consisting of 8 sand-tempered pottery sherds recovered in a single shovel test within the LRWRP Kitching Creek hydration area. The site was reported to be located 10 feet above the western bank of Kitching Creek. ACH evaluated the site as potentially eligible for inclusion in the National Register of Historic Places and recommended further archaeological testing.

In support of present feasibility study, a reconnaissance-level cultural resources assessment survey of the APE for the Kitching Creek hydration area was completed for the USACE in 2016. The purpose of the survey was to identify historic and cultural sites on lands within Jonathon Dickinson State Park potentially affected by the construction of the spreader canal, weir, and plug and associated terrestrial hydration (Carlson and Sypniewski 2017). Pursuant to

the BRA, the cultural resource survey methodology/approach was coordinated with the Seminole Tribe of Florida on August 4, 2016. Other than 8MT1284, no previously recorded historic structures, bridges, cemeteries, or districts were identified within a half-mile radius of the Kitching Creek hydration area. During the investigations the mapped location of 8MT1284 recorded at the FMSF was revisited; however shovel testing in the recorded area of the site indicated no additional cultural materials. As a result of this survey, the USACE determined 8MT1284 to be ineligible for inclusion in the NRHP. Moreover, the survey did not identify any archaeological sites within the Kitching Creek hydration area.

Based on the survey results, the USACE determined project activities involving ground disturbance or inundation occurring within these surveyed areas will pose no effect to historic properties eligible for inclusion in the NRHP. Inundation of the Kitching Creek Hydration Area will not exceed historic pre-drainage patterns or velocities. The Florida SHPO concurred with this determination of effect by letter dated April 5, 2017 (DHR Project File No.: 2015-0187-B). Mr. Fred Dayhoff, Section 106 Miccosukee Tribal Representative, also concurred with this determination (Personal Communication, March 9, 2017). The Seminole Tribe of Florida THPO concurred with this determination; however, in regard to 8MT1284, indicated that enough ambiguity concerning the site's location exists to warrant additional archaeological monitoring in the mapped vicinity of the site in advance of any ground-disturbing activities. The USACE determined that if ground-disturbing construction activities occur within the vicinity of 8MT1284, a Secretary of the Interior (SOI) qualified archaeologist will be required to monitor the area. Consultation with the Florida SHPO and federally-recognized tribes will be completed pursuant to Section 106 of the NHPA and the Jacksonville District's Federal Trust Responsibility to Native American Tribes.

C.2.22.6 Moonshine Creek and Gulfstream East Restoration

Ground disturbance activities associated with the Moonshine Creek (MC) and Gulfstream East (GE) restoration area involve connecting the Hobe-St. Lucie Conservancy District ditch to Moonshine Creek, placing a weir in the Hobe Grove ditch, and contouring adjacent areas to return the landscape to its historic topography. All Alts (2, 5R, 10, and 13) incorporate theses ground-disturbing features

South Arc, Inc. conducted a cultural resources reconnaissance survey (Survey #16754) for the South Florida Water Management District during April 2009 in advance of restoring the historic hydrologic connectivity and functionality within portions of the Cypress Creek watershed (Torres et. al. 2009). This survey included portions of three tracts of land identified as the Culpepper, Cypress Creek, and Sunrise Boys tracts. The investigations within the Sunrise Boys tract covered a significant geographic portion of the MC and GE restoration area. These investigations identified no prehistoric archaeological sites within the MC and GE project area; however, the survey identified a historic canal (8MT1517) that was probably associated with aiding in drainage for the construction of the Florida Turnpike during the late 1950s. The Florida SHPO evaluated the canal as not meeting National Register significance criteria and determined it to be ineligible for inclusion in the NRHP (DHR Project File No. 2009-4127). During consultation, the Seminole Tribe of Florida THPO expressed concern that the 2009 reconnaissance investigation did not adequately investigate an area identified as having the highest probability for containing the site of the Seminole Wars' Battle of Loxahatchee, noting an absence of subsurface shovel testing in this area. The Seminole Tribe of Florida THPO recommended a pedestrian survey of the area to identify non-inundated areas as probable candidates for future subsurface investigations and remote-sensing surveys.

Another earlier survey (Pepe and Steele 1998), conducted by AHC for the Jonathon Dickinson State Park, covered a portion of the MC and GE restoration and did not identify any archaeological sites. In June 2003, AHC conducted an archaeological and historical survey of the Trapper Nelson site resulting in the documentation of archaeological and historical elements associated with Trapper Nelson's Cabin and Zoo (8MT1045) and Trapper Nelson's Pineapple Patch (8MT1344) located in Jonathan Dickinson State Park (Lance and Carr 2003). These historic twentieth century sites, eligible for inclusion or listed as a district on the NRHP, are situated in close proximity to the MC and GE restoration area; however, they are not likely impacted by the project activities. For the current feasibility study, no cultural resources investigations were conducted in the MC and GE restoration area. Restorative inundation of the MC and GE area will not exceed historic pre-drainage patterns or velocities. During consultation and discussions of survey methodologies and approaches, the Seminole Tribe of Florida THPO, Miccosukee tribal representative, and

USACE acknowledged that further investigations of these areas would be required during PED because of the age, limited nature, and geographic coverage of previous cultural resources reconnaissance investigations. Based on information gathered from the reconnaissance there is a low probability of adverse effects to cultural resources within the MC and GE restoration area; however, adverse impacts to archaeological sites 8MT1045 and 8MT1344 should be considered and avoided by ground disturbance. Additionally, updated cultural resources surveys, monitoring, and further consultation with the Florida SHPO and federally recognized tribes will be necessary, specifically during the detailed design phase for construction, when feature designs are sited, finalized, and construction staging areas and access routes are determined. Identification of historic properties, evaluations, and determination of effects in consultation with the appropriate parties will be complete prior to construction.

C.2.22.7 Cypress Creek Canal (Reduce Over-drainage)

Project features associated with reducing over-drainage at the Cypress Creek Canal include replacement of the weir to control water elevations, raising the berm at Ranch Colony, automating the twin 84 inch culverts, constructing a pump and spreader swale, and re-grading the Cypress Creek southern forks.

Portions of these features are covered by the previously aforementioned cultural resources reconnaissance survey for the South Florida Water Management District conducted during April 2009 in advance of restoring the historic hydrologic connectivity and functionality within portions of the Cypress Creek watershed (Torres et. al. 2009). Alts 5R and 13 include all of these components. Alts 2 and 10 do not include the pump and spreader swale and will not re-grade the southern forks of Cypress Creek. During consultation and discussions of survey methodologies and approaches, The Seminole Tribe of Florida THPO, Miccosukee Tribal Representative, and USACE acknowledged that further investigations of this area would likely be required during PED because of the age, limited nature, and insufficient coverage of previous reconnaissance investigation. Additionally, updated cultural resources surveys, monitoring, and further consultation with the Florida SHPO and appropriate parties will be necessary, specifically during the detailed design phase for construction, when feature designs are sited, finalized, and construction staging areas determined. Identification of historic properties, evaluations, and determination of effects in consultation with the appropriate parties will be complete prior to construction.

C.2.22.8 Gulfstream West (Restoration and Reduce Over-drainage)

The Gulfstream West (Restoration and Over-drainage) involves partially backfilling and relocating the southern end of the Hobe St. Lucie Conservancy District Canal, the addition of a small pump, and construction of a flow through marsh to attenuate flows. Only Alts 2, 5R, and 13 are included in the Gulfstream West restoration, sharing all of these features. Restorative inundation of the Gulfstream West area will not exceed historic pre-drainage patterns or velocities.

As with the Moonshine Creek & Gulfstream East and Cypress Creek Canal areas of the LRWRP, the Gulfstream West restoration features are covered by the previous reconnaissance cultural resources survey conducted for the South Florida Water Management District during April 2009 in advance of restoring the historic hydrologic connectivity and functionality within portions of the Cypress Creek watershed (Torres et. al. 2009). During consultation and discussions of survey methodologies and approaches, The Seminole Tribe of Florida THPO, Miccosukee Tribal Representative, and USACE acknowledged that further investigations of this area would likely be required during PED because of the age, limited nature, and insufficient geographic coverage of the previous reconnaissance investigation. Additional updated cultural resources surveys, monitoring, and further consultation with the Florida SHPO and federally recognized tribes will be necessary, specifically during the detailed design phase for construction, when feature designs are sited, finalized, and construction staging areas determined. Identification of historic properties, evaluations, and determination of effects in consultation with the appropriate parties will be complete prior to construction.

C.2.22.9 Palmar East (Restoration and Connectivity)

Palmar comprises more than 37,000 acres in northern Palm Beach and southern Martin counties. Over 90 percent of this area has been converted to agricultural use as a result of wetlands having been transformed into uplands suitable for farming. LRWRP construction activities proposed for Palmar include plugging ditches; removing irrigation pipes, improving the northern and eastern berms; constructing the western berm; and installing pump stations at Thomas Farm to redirect drainage to the Gulfstream West flow-through marsh via the north Nine Gems canal. Only Alts 2, 5R, and 13 are included in the Palmar East restoration and connectivity, sharing all of these components. Restorative inundation of the Palmar East area will not exceed historic pre-drainage patterns or velocities.

Previous cultural resources reconnaissance survey (Austin 2009) of the Palmar East Restoration Area (Survey #16596) identified three subareas as containing a high probability of cultural resources based on background research, pedestrian survey, and limited shovel testing. The remaining medium and low probability areas were recommended as not requiring additional fieldwork. The Florida SHPO also concurred with this recommendation on June 8, 2009 (DHR Project File No.: 2009-02584-B). In support of the present feasibility study, the USACE contracted SEARCH, Inc. to conduct an intensive cultural resources assessment survey of these three high probability subareas designated Palmar Boxes 1, 2, and 3; however, no cultural resources were identified. As a result of this investigation, existing archaeological sites Mack Dairy Farms (8MT01520) and Mack Dairy – Culpepper Road (8MT01546) have been determined ineligible for inclusion in the NRHP by the Florida SHPO. Jupiter Road is identified as an historic linear resource; however, insufficient information has been obtained for the Florida SHPO to evaluate its eligibility for inclusion in the NRHP. Based on this investigation, the Corps has determined that adverse impacts to Jupiter Road (8MT01453) should be minimized or avoided. Additional updated cultural resources surveys, monitoring, and further consultation with the Florida SHPO and federally recognized tribes may be necessary, specifically during the detailed design phase for construction, when feature designs are sited, finalized, and construction staging areas determined. Identification of historic properties, evaluations, and determination of effects in consultation with the appropriate parties will be complete prior to construction.

C.2.22.10 Natural Storage C-18W (Basin Restoration)

Alt 13 incorporates the most project features within the C-18W Natural Storage designed to restore the flow-way by restoring the natural topography; establishing seepage barriers; constructing culverts for Beeline Highway; backfilling interior canals south of C-18W Canal; constructing a pump station at Mecca; creating flow paths through Mecca and Avenir; and constructing a M – O connector and pump. Alts 2, 5R and 10 will utilize Mecca for an above-ground reservoir with an inflow pump; discharge structure; seepage control; and M – O connector and pump. Restorative inundation of the basin will not exceed historic pre-drainage patterns or velocities.

There have been many cultural resources surveys conducted in the vicinity of this basin. In 2004 AHC conducted a reconnaissance survey (Survey #9896) for the proposed Biotechnology Research Park development within the Mecca parcel (Carr and Mankowski 2004); however, during this survey no subsurface testing was carried out and no historic properties were identified. Another survey (Survey #15143) was conducted in 2008 for two proposed powerline corridors (Ambrosino 2008) near the western border of the Mecca parcel also identifying no archaeological sites. Three additional large-scale surveys conducted by AHC abut the east and north boundaries of Mecca parcel (Carr and Longo 2005; Carr et al. 2005; Beriault and Mankowski 2008). These surveys identified three small prehistoric sites (8PB6294, 8PB11489, and 8PB13929).

For the present feasibility study, a reconnaissance level cultural resources assessment survey of the Mecca parcel was conducted in October through December 2016 (Carlson and Sypniewski 2016). The Mecca parcel measures 1,876.75 acres and is eight miles west of Palm Beach Gardens in Palm Beach County. This parcel once served as a citrus grove, and was almost developed into a biotechnical research facility, before being resold in 2013 to the South Florida Water Management District. These investigations identified no cultural resources eligible for inclusion in the NRHP. Any ground-disturbing activities or inundation occurring within the Mecca Parcel will pose no effect on

cultural resources eligible for inclusion in the NRHP. The Florida SHPO concurred with this determination of effect by letter dated April 5, 2017 (DHR Project File No.: 2015-0187-B). Mr. Fred Dayhoff, Section 106 Miccosukee Tribal Representative, also concurred with this determination (Personal Communication, March 9, 2017). The Seminole Tribe of Florida concurred by letter dated April 24, 2017 (THPO No.: 000029049). Adverse impacts from ground disturbing activities should be designed to avoid PB06294, PB13929, and PB11489.

C.2.22.11 L-8 Basin Shallow Storage

The L-8 Shallow Storage area is designed to increase water supply availability and improve flood protection to the L-8 Basin; provide flows to enhance hydroperiods and aid the restoration of J.W. Corbett WMA, Dupuis Reserve, and Loxahatchee Slough; increase base flows to the Northwest Fork of the Loxahatchee River; and reduce high discharges to Lake Worth Lagoon. Components include a 48,000 acre-foot above ground/in ground reservoir with pumps and embankment with slurry wall; Aquifer Storage and Recovery (ASR) located along the City of West Palm Beach Lake Mangonia (water supply lake); M Canal improvements including increasing the pump capacity in the L-8 Tieback Canal to 300 cfs; new structures in the south leg of C-18 canal just south of the west leg; a 50 cfs pump for water supply deliveries to utilities; and recharge canal for coastal wellfields. Only Alts 2 and 13 contain the L-8 shall basin storage components; these are absent in Alts 10 and 5R.

In 2006, AHC conducted a cultural resources survey of the Indian Trails parcel (Mueller 2006), which covers all of the area of potential effect for the present feasibility study with the exception of a portion of the J. W. Corbett WMA. This large scale survey covered 4,957 acres and included subsurface archaeological shovel testing. The parcel at that time had been entirely cleared, drainage ditches/canals excavated, and planted in citrus trees. The survey identified no archaeological sites. As a result, AHC recommended no further cultural resources investigations. The Florida SHPO concurred that the project would have no effect on cultural resources listed or eligible for listing in the NRHP by letter dated April 7, 2007 (DHR Project File No.: 2007-01994).

For the present feasibility study, a reconnaissance level cultural resources assessment survey of the LRWRP APE within the J.W. Corbett WMA was conducted in October through December 2016 (Carlson and Sypniewski 2016). The Corbett parcel measures 319.71 acres and is located approximately 12 miles west of Palm Beach Gardens in Palm Beach County. As a result of these investigations, no cultural resources were identified and no further archaeological investigations were recommended. Thus, the USACE determined the project construction and inundation occurring within the J.W. Corbett WMA portion of the APE for the L-8 shallow basin storage poses no effect to cultural resources eligible for inclusion in the NRHP. Ground-disturbing activities or inundation occurring within the surveyed portion of the J.W. Corbett parcel within the L-8 Basin Shallow Storage will pose no effect on cultural resources eligible for inclusion in the NRHP. The Florida SHPO concurred with this determination of effect by letter dated April 5, 2017 (DHR Project File No.: 2015-0187-B). Mr. Fred Dayhoff, Section 106 Miccosukee Tribal Representative, also concurred with this determination (Personal Communication, March 9, 2017). The Seminole Tribe of Florida concurred by letter dated April 24, 2017 (THPO No.: 000029049). Moreover, based on the results and disturbed nature of the previous 2006 cultural resources survey conducted by AHC in 2006 for the Indian Trails parcel (Mueller 2006), the USACE has determined that there would be no effect to cultural resources eligible for inclusion in the NRHP for the alternatives incorporating the L-8 shallow shallow storage. Identification of historic properties, evaluations, and determination of effects in consultation with the appropriate parties will be complete prior to construction.

C.2.22.12 C-51 Deep Reservoir (Storage)

Alt 10 is the only alternative that incorporates the C-51 deep storage reservoir comprising a 44,000 acre-foot in-ground deep storage reservoir including a pump station and channels. The proposed placement of these components would be within an existing rock mine. For all alternatives there would be no potential to effect historic properties eligible for inclusion in the NRHP based on the disturbed nature of the area.

C.2.22.13 G-160 Structure (Reduce Over-drainage) and G-161 Structure (Connectivity)

The G-160 Structure is designed to improve hydroperiod in the Loxahatchee Slough and the G-161 Structure will deliver Grassy Waters Preserve water to the slough. All of the alternatives (2, 5R, 10, and 13) incorporate these structures. Only one existing archaeological site (8PB14419) is recorded at the FMSF as within the Loxahatchee Slough restoration area. As part of the present feasibility study, a reconnaissance level cultural resources assessment survey of the LRWRP APE within Loxahatchee Slough was conducted in October through December 2016 (Carlson and Sypniewski 2016). Specifically the Lucky Tract parcel measuring 1,914.85 acres was investigated; however, no archaeological sites were identified during these investigations. As a result of this survey, USACE has determined any ground-disturbing activities or inundation occurring within the surveyed Lucky Tract parcel in Loxahatchee Slough will pose no effect on cultural resources eligible for inclusion in the NRHP. The Florida SHPO concurred with this determination of effect by letter dated April 5, 2017 (DHR Project File No.: 2015-0187-B). Mr. Fred Dayhoff, Section 106 Miccosukee Tribal Representative, also concurred with this determination (Personal Communication, March 9, 2017). The Seminole Tribe of Florida concurred by letter dated April 24, 2017 (THPO No.: 000029049). Adverse impacts from ground disturbing activities should be designed to avoid 8PB14419. Restorative hydration of the basin will not exceed historic pre-drainage patterns or velocities; therefore, there would be no effect to cultural resources eligible for inclusion in the NRHP for all alternatives.

C.2.22.14 Grassy Waters Preserve Triangle (Connectivity)

The southern half of the historical Loxahatchee Slough has been impounded to form the Grassy Waters Preserve (GWP). The GWP is a managed wetland ecosystem spanning 12,800 acres, which is owned and operated by the City of West Palm Beach. GWP serves as a surface water catchment, groundwater recharge and storage system for public water supply. All alternatives (2, 5R, 10, and 13) incorporate the Grassy Waters Triangle to improve hydrologic connectivity. Restoration of the GWP will not exceed historic pre-drainage patterns or velocities. Alt 10 is the only alternative that will incorporate force main conveyance with a pump and pipeline through the GWP to connect the M-Canal to Structure G-161.

For the present feasibility study, a reconnaissance level cultural resources assessment survey of the LRWRP APE covering a 300.48 acre parcel within the GWP and the force main conveyance feature was conducted in October through December 2016 (Carlson and Sypniewski 2016) identifying no archaeological sites within the parcel. As a result of this survey, USACE has determined any ground-disturbing activities or inundation occurring within the surveyed parcel of the GWP will pose no effect on cultural resources eligible for inclusion in the NRHP. The Florida SHPO concurred with this determination of effect by letter dated April 5, 2017 (DHR Project File No.: 2015-0187-B). Mr. Fred Dayhoff, Section 106 Miccosukee Tribal Representative, also concurred with this determination (Personal Communication, March 9, 2017). The Seminole Tribe of Florida concurred by letter dated April 24, 2017 (THPO No.: 000029049).

C.2.22.15 M -1 Pump Station (Conveyance)

The M-1 Pump Station is designed to deliver Lower M-1 Basin water to the M-Canal, Grass Waters Preserve and the G-162 Structure. Alt 5R is the only alternative that will utilize this pump station. No cultural resources survey was conducted for this pump station. Based on the previous cultural resources surveys conducted in the vicinity of the M-1 Pump Station, the probability of identifying historic properties is low. Additionally, updated cultural resources surveys, monitoring, and further consultation with the Florida SHPO and appropriate parties will be necessary, specifically during the detailed design phase for construction, when feature designs are sited, finalized, and construction staging areas determined. Identification of historic properties, evaluations, and determination of effects in consultation with the appropriate parties will be complete prior to construction.

In summary, during this feasibility study, 5,042.62 acres of the TSP (Alt 5R) were surveyed for cultural resources. Based on final designs or modifications of the project features, additional work may be required for compliance with the NHPA. While the USACE is currently in compliance with the procedural requirements of the NHPA, the USACE

recognizes that additional cultural resource surveys, NRHP evaluations, and determination of effects made in consultation with the SHPO, appropriate federally-recognized tribes, and other interested parties will be required in PED. Consultation is currently ongoing with regards to the determination of effects and potential mitigation of effects, and therefore should be considered preliminary. The effects associated with each alternative have been preliminarily considered for this feasibility study. A final identification, evaluation of historic properties, and determination of effects, as required under Section 106 of the NHPA, will not be made until the project is authorized and project features are sited during the subsequent PED phase.

C.2.23 Invasive and Exotic Species

All of the alternatives have the potential and likelihood for establishment and spread of non-native invasive and native nuisance species (**Table C.2-37)**. Proposed restoration activities may affect ecosystem drivers that directly or indirectly influence the invasiveness of non-native species. These factors may affect invasive species positively or negatively, depending on the unique characteristics of individual species and the environmental conditions for a given biological invasion (Doren et al. 2009). For example, shortened surface water drawdowns may reduce the recolonization rates of melaleuca in marshes while increasing habitat suitability for Old World climbing fern in other areas. Many of the areas where features are proposed are currently inhabited by non-native invasive and native nuisance species. Construction of the proposed features has the potential to spread the existing non-native invasive and native nuisance species on site as well as introduce new invasive species via contaminated equipment. Disturbed areas resulting from construction are likely to become established with non-native invasive and native nuisance species. New flows created by operations of the proposed features may serve as vectors to spread invasive and native nuisance species into new areas. The large number of existing and potential invasive plant and animal species and the often-incomplete knowledge of invasive mechanisms for each species create moderate to high uncertainty in this evaluation. Long-term monitoring in an adaptive management framework is critical to ensure efficient management of the most threatening non-native invasive species in the restoration footprint.

Table C.2-37. Invasive species management effects assessment for FWO and Alternatives.

Feature	Future With Out Project (No Action Alternative)	Alternative 2	Alternative 5R	Alternative 10	Alternative 13
Invasive Species					
Flow Way 1					
G-160 Structure	Water releases will continue to spread invasive species.	Existing water control structure, therefore operation of structure expected to minimally impact invasive or native nuisance species. Water releases will spread invasive species.			
G-161 Structure	Water releases will continue to spread of invasive species.	Existing water control structure, therefore operation of structure expected to minimally impact invasive or native nuisance species. Water releases will spread invasive species.		Same as FWO.	Same as Alt 2 & 5r.
GWP Triangle	Invasive and nuisance species will continue to persist and expand.	Effects to invasive species would be similar for all alternatives. Recruitment of terrestrial invasive species potentially reduced with additional water flow. Expansion emergent and floating aquatic invasive species will likely occur. Spreader canal will require continual maintenance and the area below the spreader canal may require maintenance to allow water flow. Diligent monitoring and control efforts required.			
C-51 Deep Reservoir		Same as FWO.		Terrestrial invasive species will be removed. Establishment of invasive SAV & FAV such as hydrilla & water hyacinth will occur. Potential for establishment of emergent invasive vegetation. Invasive fish & snail species will invade & persist.	Same as FWO.

<table>
<tr><th>Feature</th><th>Future With Out Project (No Action Alternative)</th><th>Alternative 2</th><th>Alternative 5R</th><th>Alternative 10</th><th>Alternative 13</th></tr>
<tr><td colspan="6">Invasive Species</td></tr>
<tr><td>Force Main</td><td rowspan="2"></td><td colspan="2">Same as FWO.</td><td>Invasive aquatic species will persist and expand. Potential to introduce new invasive plants and fish species due to connection.</td><td>Same as FWO.</td></tr>
<tr><td>M-1 Pump Station</td><td>Same as FWO.</td><td>Invasive aquatic species will persist & expand. Potential to introduce new invasive aquatic plants and fish species due to connection.</td><td colspan="2">Same as FWO.</td></tr>
<tr><td colspan="6">Flow Way 2</td></tr>
<tr><td>CW-18 Reservoir</td><td rowspan="3">Invasive and nuisance species will continue to persist and expand.</td><td colspan="3">Terrestrial invasive species will be removed. Establishment of invasive SAV and FAV such as hydrilla and water hyacinth will occur. Potential for establishment of emergent invasive vegetation. Invasive fish and snail species will invade and persist.</td><td>Same as FWO.</td></tr>
<tr><td>CW-18 Natural Storage</td><td colspan="3">Same as FWO.</td><td>Recruitment of terrestrial invasive species potentially reduced with additional water flow. Expansion of invasive EAV & FAV will likely occur. Seepage management area will require regular maintenance. Diligent surveillance and control efforts will be required.</td></tr>
<tr><td>ASR's</td><td colspan="2">Invasive species will be removed & vegetation will be maintained.</td><td>Same as FWO.</td><td>Same as Alternative 2 & 5r.</td></tr>
</table>

Feature	Future With Out Project (No Action Alternative)	Alternative 2	Alternative 5R	Alternative 10	Alternative 13
Invasive Species					
M-O Connector	Invasive and nuisance species will continue to persist and expand.	Terrestrial invasive species will be removed. Establishment of invasive SAV & FAV such as hydrilla and water hyacinth will occur. Potential for establishment of emergent invasive vegetation. Invasive fish & snail species will invade & persist.	Same as FWO.		
L-8 Shallow Storage			Same as FWO.	Same as FWO.	Same as alternative 2.
Flow Way 3					
Palmar East	Invasive and nuisance species will continue to persist and expand.	Terrestrial invasive species will be removed in the backfill areas. Establishment of terrestrial and wetland invasive vegetation in backfill areas will occur and require routine maintenance.		Same as FWO.	Same as Alternative 2 & 5r.
Thomas Pepper Farm		Terrestrial invasive species will be removed in the backfill areas. Establishment of terrestrial and wetland invasive vegetation in backfill areas will occur and require routine maintenance.	Same as FWO.		

Feature	Future With Out Project (No Action Alternative)	Alternative 2	Alternative 5R	Alternative 10	Alternative 13
Invasive Species					
Ranch Colony Canal		Increased floating and SAV invasive vegetation will occur. Terrestrial invasive species will be removed during canal expansion; new recruitment will occur with ground disturbance.	Same as FWO.		
Gulf Stream West		Recruitment of terrestrial invasive species will likely be reduced with additional water flow. Expansion of emergent and floating aquatic invasive species will likely occur. Diligent monitoring and control efforts required.		Same as FWO.	Same as Alternative 2 & 5r.
Gulf Stream East & Moonshine		Effects to invasive species would be similar for all alternatives. Recruitment of terrestrial invasive species will likely be reduced with additional water flow. Expansion of emergent and floating aquatic invasive species will occur due to major disturbance from grading. Diligent surveillance and control efforts required.			
Kitching Creek		Effects to invasive species would be similar for all alternatives. Recruitment of terrestrial invasive species will likely be reduced with additional water flow. Expansion of emergent and floating aquatic invasive species will likely occur. Likely to introduce new invasive species to the area. The spreader swale area will require maintenance. Diligent surveillance and control efforts will be required.			
Mack Dairy Spreader Canal					
Shiloh Farm		Effects to invasive species would be similar for all alternatives. Recruitment of terrestrial invasive species will likely be reduced with additional water flow. Expansion of invasive EAV and FAVis likely to occur. Diligent surveillance and control efforts required.			
Cypress Creek Natural Area					

Feature	Future With Out Project (No Action Alternative)	Alternative 2	Alternative 5R	Alternative 10	Alternative 13
Invasive Species					
Cypress Creek Canal		Increased floating and SAV invasive vegetation likely will occur. Terrestrial invasive species will be removed during canal expansion; new recruitment will occur with ground disturbance along the canal. Diligent surveillance and control efforts will be required.			

C.2.24 Airport-Wildlife Hazard Assessment

The 2003 Memorandum of Agreement (MOA) between the Federal Aviation Administration (FAA), the U.S. Air Force, USACE, EPA, USFWS, and the U.S. Department of Agriculture - Wildlife Services (WS) established procedures necessary to coordinate their agency missions to more effectively address existing and future environmental conditions contributing to aircraft-wildlife strikes throughout the United States. The MOA applies to airports in the National Plan of Integrated Airport Systems (NPIAS).

C.2.24.1 NPIAS Airports

None of the key project features of the TSP alternative occurred within the five-mile separation distance of Palm Beach International Airport, therefore, strike risks would not be projected to change (**Figure C.2-25**, **Table C.2-38**). Key TSP alternative project features occurring within the five-mile separation distance (red circles around airports) of the North Palm Beach County Airport are shown in **Figure C.2-51**.

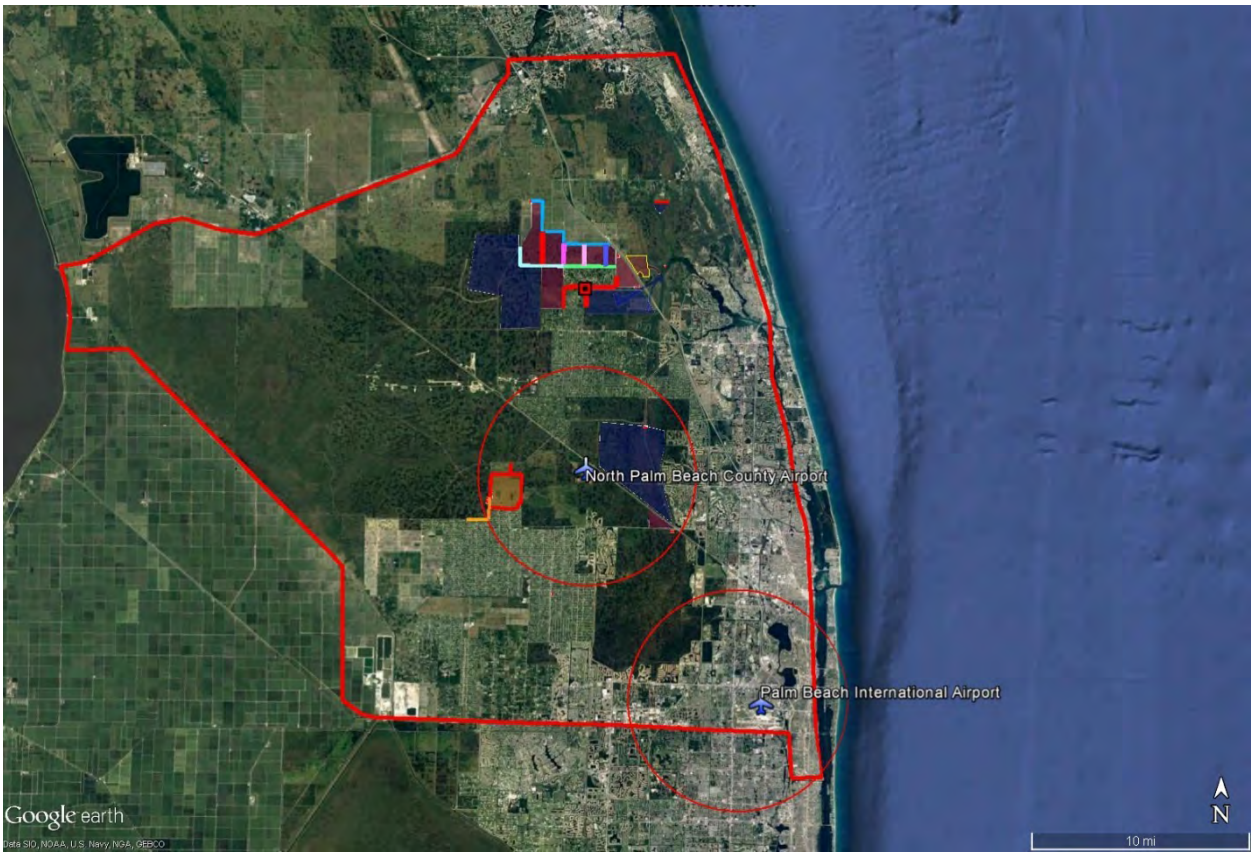


Figure C.2-51: LRWRP features within the 5-mile separation distance from North Palm Beach County Airport and Palm Beach International Airport.

In the FWO scenario, none of the project features would be constructed or operative (**Table C.2-34**). Many features lie beyond the 5-mile separation distance. Of the features around the 10,000 ft separation distance, Grassy Waters Preserve and Loxahatchee Slough proposed operational changes are included in all alternatives, and the C-18W reservoir, has the most potential to attract many species of birds and other wildlife, perhaps more so than the shallow impoundment or natural storage features.

Table C.2-38. Airport – wildlife hazard assessment for FWO and alternatives assessment relative to North Palm Beach Airport.

Feature	FWO	Alt 2	Alt 5R	Alt 10	Alt 13	Distance to airport AOA	Project Feature Purpose and Effect
Nine Gems (Pal-Mar East) – ditch plugs, grading	—	✓	✓	—	✓	>5 miles	Hydrologic restoration; surface water; vegetation – outside 5 mile separation distance
Gulfstream West – Flow-through marsh	—	✓	✓	—	✓	>5 miles	Hydrologic restoration; surface water; vegetation – outside 5 mile separation distance
Gulfstream East and Moonshine Creek – grading, connectivity	—	✓	✓	✓	✓	>5 miles	Hydrologic restoration; surface water; vegetation – outside 5 mile separation distance
Kitching Creek – weir and spreader swale	—	✓	✓	✓	✓	>5 miles	Hydrologic restoration; surface water; vegetation – outside 5 mile separation distance
Cypress Creek, water control structure	—	✓	✓	✓	✓	>5 miles	Hydrologic restoration; surface water; vegetation – outside 5 mile separation distance
Cypress Creek, spreader swale and pump station, Shiloh flow paths	—	✓	✓	—	✓	>5 miles	Hydrologic restoration – outside 5 mile separation distance
Grassy Waters Preserve triangle – grading, connectivity	—	✓	✓	✓	✓	2.56 mi NW	Hydrologic restoration; surface water; vegetation – negligible land use change, no substantial difference to wildlife attraction
Grassy Waters Preserve with G-161, operation change for water deliveries to NWFLR	—	✓	✓	✓	✓	2.18 mi N	Continued operations; no hydrologic change – no substantial difference to wildlife attraction t
Grassy Waters Preserve – operational changes associated with deep storage reservoir	—	—	—	✓	—	1.46 mi NW	Minor hydroperiod change – no substantial difference to wildlife attraction t
Loxahatchee Slough Natural Area – hydrology changes associated G-160 and G-161	—	✓	✓	✓	✓	0.1 mi E	Surface water; vegetation, hydroperiod improvements - no substantial difference to wildlife attraction
Beeline culverts – new structures	—	—	—	—	✓	0.68 mi N	Surface water drainage; connectivity – negligible attractant
ASR well clusters co-located with C-18 W	—	—	✓	—	—	3.66 mi W	Water storage, and delivery to NWFLR; non-attractant; these sites will negligibly change the existing ruderal herbaceous habitat conditions

Feature	FWO	Alt 2	Alt 5R	Alt 10	Alt 13	Distance to airport AOA	Project Feature Purpose and Effect
ASR Well Clusters co-located with L-8 Shallow Impoundment	—	✓	—	—	✓	>5 miles	Water storage and delivery to NWFLR – non-attractant; these sites will negligibly change the existing ruderal herbaceous habitat conditions
C-18W Reservoir and associated infrastructure east boundary	—	✓	✓	✓	—	2.50 mi E	Water body – large reservoir; major attractant
C-18W Natural Storage, including western Loxahatchee Slough	—	—	—	—	✓	0.1 mile	Hydrologic restoration and connectivity – would increase wildlife attraction as compared with FWO
L-8 Shallow Impoundment	—	✓	—	—	✓	>5 miles	Shallow water storage, outside 5-mile separation distance
C-51 Ph. II Deep Storage	—	—	—	✓	—	>5 miles	Deep, in-ground water storage – outside 5-mile separation distance

C.2.24.2 Non-NPIAS Airports

Analysis of the three non-NPIAS airports is not required per the MOA.

C.2.25 Water Supply and Groundwater Resources

Groundwater resource availability is defined under two separate water supply plans by the SFWMD. Martin County resources are evaluated within the Upper East Coast (UEC) water supply plan (SFWMD, 2016). Palm Beach County water resources are evaluated within the Lower East Coast (LEC) water supply plan (SFWMD, 2013). Groundwater resources are used for drinking water, industrial, and agricultural irrigation water supply, obtained primarily from the surficial aquifer system (SAS) and the Floridan Aquifer System (FAS).

In the UEC planning area, the SAS supplies approximately 40 percent of the public water supply (drinking water, industrial water), and the FAS (primarily the Upper Floridan Aquifer, UFA) supplies the remaining 60 percent (SFWMD, 2016). Irrigation water is supplied through a combination of surface water, SAS groundwater, and reclaimed water.

In the LEC planning area, the SAS supplies approximately 94 percent of the public water supply (SFWMD, 2013). The high proportion of source groundwater is due to the use of the Biscayne Aquifer of Broward and Miami-Dade Counties. Closer to the LRWRP project area, the coastal utilities (Seacoast Utility Authority, Jupiter, and Tequesta, Riviera Beach) rely on SAS and FAS for the public water supply, similar to those in the UEC). Elsewhere near the project area, Palm Beach County, the city of West Palm Beach, and the towns of Palm Beach and South Palm Beach use surface water conveyed via canals from Lake Okeechobee eastward through the Grassy Waters Preserve, Clear Lake, and Lake Mangonia for public water supply. SAS groundwater commonly is used for nursery and agricultural water supply in the project area.

The project area has two Water Restriction Areas (WRA). WRA 1 is the Martin County portion of the study area; WRA 2 is the Palm Beach County portion of the study area, from the Martin County line south to the C-51 Canal. To determine if an elimination or transfer of existing legal sources of water occurred, an analysis was done using the frequency, duration, and severity of water use cutbacks during water shortages during periods of deficient rainfall using the LECSR-NP results. The LECSR-NP trigger package emulates the SFWMD water shortage policy by reducing water withdrawals when groundwater stages below designated levels in pre-identified trigger cells.

Although the LECSR-NP model predicts the absolute number of water supply cutback events and the corresponding frequency of occurrence have a high degree of uncertainty, relative comparisons between the ECB, FWO and TSP provide a meaningful comparison to quantify potential effects of the project. In WRA 1, the frequency, duration and severity of water restrictions (water use cutbacks) triggered by dry conditions including droughts are identical between the ECB, FWO and the TSP. Locally triggered events in WRA 1 are not influenced by the TSP. The same months and the same level of cutbacks were triggered in the ECB, FWO and the TSP (Alt 5R). Additionally, the TSP does not change either the frequency or severity water use cutbacks relative to the ECB and FWO in WRA 2.

Additional information regarding the water supply analysis can be found in Annex B.

C.2.26 Flood Protection

All proposed alternatives were conceptualized to ensure that the levels of service for flood protection were not be reduced by implementation of the project. Therefore, the project components are to be designed to either maintain or, if appropriate, provide additional flood protection. The LECSR-NP model was used as a tool to indicate a potential change in flood risk through analysis of the stage-duration curves at various locations of interest, including residential and agricultural areas. The stage-duration curves were reviewed to ensure that any increases in water surface elevations remained below the ground surface elevation or were only increased in expected areas. Expected areas include the proposed C-18W reservoir and areas where rehydration was preferred and necessary to achieve the project objectives. Overall, the LECSR-NP results indicate that implementation of both the TSP and other alternatives will not reduce the levels of service for flood protection within the areas affected by the project. Additional details regarding flood protection analysis can be found in Annex B, which addresses the Savings Clause requirements and Project-Specific Assurances as required by WRDA 2000.

While there are limitations to the LECSR-NP model (e.g., no canal conveyance capabilities, limited ability to handle complex water management operations), it provides reasonably good estimates of water stages and flows over/through structures over a period of record. The LECSR-NP model has no capability to directly measure flood control at a resolution finer than the LECSR-NP grid cell or during relatively short events storm. Therefore, the Hydrologic Engineering Center River Analysis System (HEC-RAS) modeling platform is to be used for informing the design and operations of key project features. A description of the HEC-RAS modeling effort and how it may be implemented in future efforts can be found in Appendix A.

C.2.27 Cumulative Effects

Cumulative effects are defined in 40 CFR 1508.7 as those effects that result from:

> *"the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-*

Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time."

Cumulative effects for the proposed action were assessed in accordance with guidance provided by the President's Council on Environmental Quality (CEQ). The primary goal of cumulative effects analysis is to determine the magnitude and significance of the environmental consequences of the proposed action in the context of the cumulative effects of other past, present, and future actions. The following summarizes past, present, and projected USACE efforts that cumulatively affect the regional environment of Martin and Palm Beach counties in south Florida. In addition, numerous efforts are underway by other federal, state, and local agencies, as well as non-governmental organizations, working towards similar restoration goals. **Table C.2-39** shows the net cumulative effects of the various resources which are directly or indirectly impacted. LRWRP is expected to contribute to a net beneficial cumulative impact on the regional ecosystem.

C.2.27.1 Past, Present, and Reasonably Foreseeable Actions Affecting Resources within the Project Area.

In addition to CERP and non-CERP projects, multiple local initiatives would contribute to cumulative effects in the LRWRP project area. Future without project conditions include continued implementation of the congressionally authorized purposes of the C&SF Flood Control project.

Table C.2-39. Past, Present, and Reasonably Foreseeable Actions and Plans Affecting the Action Area.

Action	Past Actions/Authorized Plans	Current Actions and Operating Plans	Reasonably Foreseeable Future Actions and Plans
Non-CERP Projects	C&SF Project (1948) ENP Protection and Expansion Act (1989)?	C&SF C-51 West End Flood Control Project	SFWMD Restoration Strategies Project
Local Initiatives	Multiple local initiatives	Multiple local initiatives	Multiple local initiatives
CERP Projects		Congressional Authorization Received: Broward County Water Preserve Areas Project Congressional Authorization Received and Construction in Progress: Indian River Lagoon-South Project	Loxahatchee River Watershed Restoration Project

The CERP identifies storage north, south, east, and west of Lake Okeechobee that work together to achieve beneficial ecological effects. These complete storage components are critical to the overall success of the CERP and other CERP components. The combination of these storage features with other CERP components provide synergy in achieving Loxahatchee watershed restoration. The previously authorized projects are components that were identified in the CERP and are being implemented incrementally over time consistent with the Integrated Delivery Schedule, reducing the risks and uncertainties associated with project planning and implementation.

For the LRWRP FWO condition, other CERP and non-CERP projects that improve the condition of the watershed that have been authorized, are under construction, or are completed, are assumed to be in place. This combination of the authorized projects and the LRWRP TSP would be a significant accomplishment in re-regulating the volume of discharges to the estuary (**Table C.2-40**).

Table C.2-40. Summary of Cumulative Effects.

Hydrology	
Past Actions	Flood and water control projects have greatly altered the natural hydrology.
Present Actions	Federal and state agencies are coordinating on and implementing projects to improve hydrology.
Proposed Action	Improvement in the quantity, timing and distributions of flows into the NWFLR watershed wetlands and additional flow to the NWFLR would be realized by the TSP compared to the FWO. Significant beneficial hydrologic effects are anticipated within the NWFLR watershed wetlands through rehydration of previously drained areas.
Future Actions	Additional CERP projects propose to restore hydrology to more natural conditions (example – Western Everglades Restoration Project (WERP) and Lake Okeechobee Watershed Restoration Project (LOWRP)), SFWMD Restoration Strategies Project, multiple local initiatives.
Cumulative Effect	Improved hydrology, but less than full restoration of natural hydrologic conditions to pre-drainage conditions. CERP/LRWRP is expected to improve the quantity, quality, timing and distribution of freshwater flow to NWFLR.
Threatened and Endangered Species	
Past Actions	Water management practices and urbanization have resulted in the degradation of existing habitat function and direct habitat loss leading to declining population trends for some threatened and endangered species.
Present Actions	Ongoing efforts by federal and state agencies to implement projects to improve hydrology within the project area and manage lands for wildlife conservation.
Proposed Action	Federal determinations: may affect the northern crested caracara, eastern indigo snake, and wood stork, MANLAA for Everglade snail kite, Florida manatee, Florida manatee critical habitat; no effect to Florida panther, Everglade snail kite critical habitat, Okeechobee gourd, Florida bonneted bat (See Annex A). State T&E species would be managed as required by state guidance.
Future Actions	Ongoing projects would be implemented to maintain threatened and endangered species within the project area.
Cumulative Effect	Habitat improvement, monitoring and management of threatened and endangered species would maintain or enhance populations. Restoration and enhancement of suitable habitat through efforts to restore more natural hydrologic conditions within the project area would increase populations and distribution of species.
Fish and Wildlife Resources	
Past Actions	Water management practices, habitat fragmentation, and urbanization have resulted in the degradation of existing habitat function and direct habitat loss leading to declining population trends for some wildlife species. North Palm Beach GA Airport built within vast matrix of wetlands; >30 acres uncovered stormwater management system existing on airport

Present Actions	Ongoing efforts by federal and state agencies to implement projects to manage lands for wildlife conservation and improve hydrology within the project area. >30 acres uncovered stormwater management system wildlife attractant existing on airport
Proposed Action	Would provide additional management of conservation lands, and improve hydrologic conditions of drained wetland systems; reservoir construction would result in loss of agricultural land by conversion to a steep-sided reservoir. Proposed project features would have negligible to minor effects as wildlife attractants and would cause a minor increase in wildlife strike risk; C-18W reservoir not proposed to have a littoral zone but would attract waterfowl, particularly over-wintering waterfowl.
Future Actions	Variable improvement to fish and wildlife resources is expected to occur as a result of implementation of projects with the capability of improving the timing, quantity, quality and distribution of freshwater flow to the study area. Hydrologic restoration planned as part of CERP would further improve fish and wildlife habitat. Airport master plan indicates some planned expansion; development could occur on surrounding parcels dependent on market conditions
Cumulative Effect	Habitat improvement efforts are anticipated to benefit fish and wildlife resources. Airport is situated in a vast expanse of existing wetlands; some project features would result in local increase in wildlife attraction
Vegetation and Wetlands	
Past Actions	Drainage of Florida's interior wetlands, conversion of wetlands to agriculture, and urban development has reduced the spatial extent and quality of wetland resources.
Present Actions	Ongoing efforts by federal and state regulatory agencies to reduce wetland losses.
Proposed Action	Implementation would result in restoration of various wetland habitat types resulting in significant beneficial effects within the watershed.
Future Actions	Some level of improvement to vegetative communities is expected to occur as a result of implementation of projects with the capability of improving the timing, quantity, quality and distribution of freshwater flow to the study area. More natural hydrology as part of the CERP would assist in restoring natural plant communities.
Cumulative Effect	While the spatial extent of natural plant communities would not be restored to historic extent, the quality of vegetative communities would be improved.
Cultural Resources	
Past Actions	Flood and water control projects, conversion of wetlands into agriculture and urban development have had adverse unmitigated effects to cultural resources either directly or indirectly.
Present Actions	Ongoing efforts have been made by Federal and state agencies to implement projects to improve hydrology within the project area, which are known to have a high potential for cultural resources.
Proposed Action	While effects of the proposed action have been evaluated, a final determination of effects on cultural resources is not complete. Each suite of features will be subject to separate consultation and consideration of effects during PED as the APE may be subject to change based on final designs or modifications of project features. Consultation with stakeholders, including the State Historic Preservation Office, Advisory Council on Historic Preservation, Seminole Tribe of Florida and the Miccosukee Tribe of Indians of Florida is currently ongoing.

Future Actions	Continued improvement to hydroperiods could stabilize the environment and prevent impacts to cultural resources within the wetland restoration areas.
Cumulative Effect	Cumulative effects to historic properties and culturally significant sites will potentially be long-term adverse effects if not avoided. Mitigation measures for effects to historic properties could potentially reduce the cumulative effect to minor long-term adverse effects. Mitigation measures for culturally significant sites is unknown.
Water Quality	
Past Actions	Water quality has been degraded from urban, suburban, commercial, industrial, recreational and agricultural development.
Present Actions	Efforts to improve water quality discharges from agricultural areas are ongoing. Federal and state projects can temporarily elevate localized levels of suspended solids and turbidity.
Proposed Action	Implementation of the project is not expected to significantly affect the water quality of NWFLR, there will be minor improvements to water quality.
Future Actions	Actions by the State of Florida's Restoration Strategies will decrease nutrient concentration and loadings to the project area
Cumulative Effect	While anthropogenic effects on water quality are unlikely to be eliminated, water quality is expected to slowly improve over existing and recent past conditions. During detailed planning and design, the USACE and SFWMD are committed to ensuring that project feature implementation will not result in violations of water quality standards.
Water Supply/Flood Control	
Past Actions	Water supply and flood control for agricultural and urban users has benefited from construction and operation of the C&SF project. To be edited.
Present Actions	*To be inserted*
Proposed Action	*To be inserted*
Future Actions	Future supplies would not change unless additional CERP storage features are implemented to increase water availability. To be edited.
Cumulative Effect	*To be inserted*

Historically, high and consistent dynamic storage capacity existed in the project study area because of shallow elevation gradients, large expanses of wetlands, and extensive wet pine flatwoods and sloughs. As water progressed down slope, as occurred in the western portions of the project study area in what are now the L-8 and Pal-Mar Basins, the slow movement of water led to storage within wetland systems at a rate that made water available for use for many seasons. It is believed that water residence times varied from a few months to several years. Throughout the system, groundwater seepage, driven by hydraulic gradients, provided the base flow of creeks and of the Loxahatchee River (SFWMD & USACE – Restudy 1999).

The extended hydroperiods of the natural system depended more on the large dynamic storage capacity and slow flow of water, than on the immediate effects of rainfall. Wet season rainfall kept the wetlands flooded and maintained freshwater flow throughout the year. The seasonal "carry-over" effect of the dynamic storage capacity of the natural system was so prominent that a year of high rainfall could sustain

surface water in wetlands and freshwater flow to estuaries into one or more subsequent drought years (Walters et al., 1992; Fennema et al., 1994; Browder, 1976). Dynamic storage made wetlands and estuaries less vulnerable to South Florida's spatially and temporally variable rainfall, which resulted in hydration of the natural systems throughout the year (SFWMD & USACE – Indian River Lagoon Study, 2002).

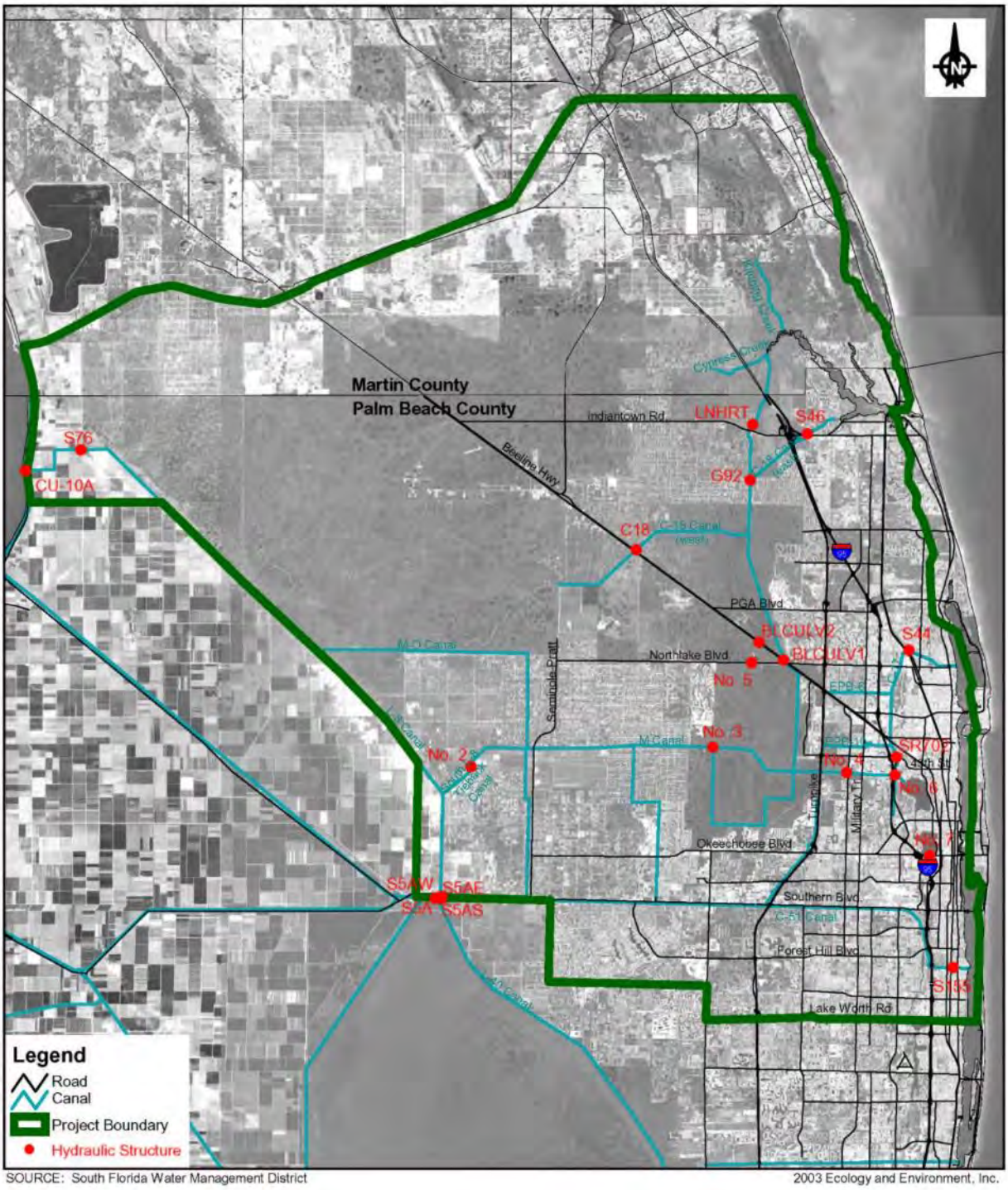
The NWFLR once provided the outlet for the majority of the Loxahatchee River Watershed. The headwaters to the river began in the Hungryland and Loxahatchee Sloughs, which extended south into the area that is now designated as Grassy Waters Preserve. Cypress Creek extended east from Palmar, through what is now the Links development and the Cypress Creek Preserve, discharging into the NWFLR. Increased urban and agricultural development over the past 100 years or so has altered the natural system. Navigation and drainage activities have significantly altered the volume, timing and distribution of freshwater flow throughout the system.

Stormwater runoff in the project area is now drained via canals and rivers to the Southwest Fork of the Loxahatchee River, the St. Lucie River and the Lake Worth Lagoon. There are several special districts (Chapter 298 District) that own, maintain and operate a number of non-CS&F canals throughout the watershed. For example, the SIRWCD (until 1975 referred to as South Indian River Drainage District) was formed in July 1923, under Chapter 298, Florida Statutes. The initial works of this special District were comprised of primary drainage canals, mainly used for agricultural purposes. This included the C-14 Canal, which currently runs parallel to the C-18 Canal until C-18 turns to the east toward the S-46 structure. C-14 continues north to connect with the NWFLR. G-92 discharges into C-14, upstream of Lainhart Dam.

Much of the reduction in flow can be attributed to the construction of the C&SF System, and especially the C-18 canal and S-46 structure, which were constructed between 1957 and 1958 and which diverted flows away from the NWFLR to tide via S-46 to the Southwest Fork. As noted in the previous paragraph, some of this water is diverted to the NWFLR for environmental water supply purposes through the G-92 structure, which was constructed by the SFWMD in the mid-1970s.

Presently, a better understanding of the importance of wetlands and surface waters to the health of the environment has also guided the decision to decrease the volume of water expeditiously drained off the land. Attempts to balance flood control, water supply demands, and ecological needs have resulted in this complex system of water management facilities within the project area.

In addition to the G-92 and S-46 structures, there are nineteen primary control structures within the project area. These allow water managers to control stages and discharges in and out of the basins to the ultimate receiving waters (**Figure C.2.48**). The most notable flood control canals and structures include the C-51 Canal, C-18 Canal, C-17 Canal, L-8 Canal, C44 Canal, and the S-155 Structure.



SOURCE: South Florida Water Management District

2003 Ecology and Environment, Inc.

Figure C.2.52:. Project area primary canals and hydraulic structures.

The C-44 Canal and the C-51 Canal (to a lesser extent) are used as drainage outlets for Lake Okeechobee when lake levels are too high. The L-8 Canal is also used to help lower lake levels but the capacity of the L-8 is substantially less than either the C-51 or C-44. Other important canals and structures in the project area include the M-Canal and the G-92 structure. Unlike the C-44 Canal and the C-51 Canal which are primarily flood control canals, the M-Canal is used exclusively for municipal water supply and is connected to the L-8 Canal. During dry periods, water from Lake Okeechobee can be routed via the L-8 Canal to the M-Canal and on to Grassy Waters Preserve (GWP), Lake Mangonia and Clear Lake where it is held until needed. The G-92 structure is located at the intersection of the C-14 Canal and the C-18 Canal. The structure regulates the amount of water northward to the NWFLR and eastward to the S-46 for discharge to tide.

During the dry season, gated control structures located near the coast (i.e., S-155, S-46) are typically closed to maintain adequate water levels in the canals, recharge the groundwater and prevent saltwater intrusion. In some cases, the canals help recharge wellfields and thus it is important that adequate water is available. Currently, operations during the wet season pass excess stormwater through the canals and out to tide, rather than storing it for use during the next dry season. The SFWMD maintains stage and flow recording gauges at each of the primary structures within the project area.

The management of surface water is generally considered on a watershed level and in the project area, three watersheds have been delineated; the St. Lucie River Watershed, the Loxahatchee River Watershed, and the Lake Worth Lagoon Watershed (Figure 2-5). Within the St. Lucie Watershed, some portions of the C-44 Basin and the south St. Lucie Basin are within the project area. All of the Loxahatchee River Watershed is within the project area and includes the following six basins: Kitching Creek, the Grove, Cypress Creek/Pal-Mar, Wild & Scenic River/Jupiter Farms, Loxahatchee Estuary, and the C-18/J.W. Corbett Wildlife Management Area (WMA). The L-8 Basin, C-17 Basin, the GWP Basin, and the C-51 Basin are part of the Lake Worth Lagoon Watershed and all fall within the project boundary. While the St. Lucie River and Lake Worth Lagoon Watersheds are technically part of the project area, the focus of the LRWRP project is the Loxahatchee River watershed.

C.2.28 References

Ambrosino, M. L. 2008. An Archaeological and Historical Survey of the Seminole Pratt Whitney Road Project Area in Palm Beach County, Florida. Panamerican Consultants, Inc., Tampa Florida Master Site File Survey No. 15143. On file, Florida Division of Historical Resources, Tallahassee.

Austin, R.J. 2009. Cultural Resource Reconnaissance Survey of Palmar East Property, Martin County, Florida. Prepared for South Florida Water Management District, West Palm Beach, Florida.

Ballo, J.R. and K.W. Hardin 1989. Cultural Resource Assessment Survey of the Proposed Hobe Sound Plantation Development Site, Martin County, Florida. Piper Archaeological Research, Inc., St. Petersburg, Florida.

Beriault, J.G. and J. Monkowski 2008. Cultural Resource3 Survey of the Hungryland Slough Natural Area, Palm Beach County, Florida. Archaeological and Historical Conservancy, Inc. Florida Master Site File Survey No. 20976. On file, Florida division of Historical Resources, Tallahassee.

Carlson, L. and C. Sypniewski 2016. Phase 1 Cultural Resource Survey for the Loxahatchee River Watershed Restoration Project, Martin and Palm Beach Counties, Florida. Prepared for U.S. Army Corps of Engineers, Jacksonville District.

Carr, R.S., and V. Longo 2005. A phase 1 Archaeological Survey of the Vavrus South Parcel, Palm Beach County, Florida. Archaeological and Historical Conservancy, Inc., Davie. Florida Master Site File Survey No. 12730. On file, Florida Division of Historical Resources, Tallahassee.

Carr, R.S. and J.F. Mankowski 2004. An Archaeological and Historical Assessment of the Palm Beach County Biotechnology Research Park Parcel, Palm Beach County, Florida. Prepared for Kilday & Associates, Inc. Technical Report #483.

Cornell University. eBird: https://ebird.org/region/US-FL-099?yr=all&m=&rank=mrec, accessed September 26, 2018.

Dean, T. June 19, 2018. FWC, personal communication.

Doren, R.F., J.C. Volin and J.H. Richards. 2009. Invasive exotic plant indicators for ecosystem restoration: An example from the Everglades Restoration Program. *Ecological Indicators*, 1634 9S:S29-S36.

Florida Natural Areas Inventory (FNAI). 2010. Guide to the natural communities of Florida: 2010 edition. Florida Natural Areas Inventory, Tallahassee, Florida.

FWC. 2019. Bald Eagle Nest Locator database https://public.myfwc.com/FWRI/EagleNests/nestlocator.aspx.

Lance, M. and R.S. Carr 2003. An archaeological Survey of the Trapper Nelson Site, Jonathan Dickinson State Park, Martin County, Florida. Archaeological and Historical Conservancy for Leslie Divoll, Inc., Technical Report #440.

Lichtler, W.F., 1960. Geology and Groundwater Resources of Martin County Florida. Florida Geological Survey Report of Investigations No. 23, 149 p.

Mueller, B. M. 2006. A Phase 1 Cultural Resources Assessment Survey of the Indian Trails Parcel, Palm Beach County, Florida. Archaeological and Historical Conservancy, Ind., Davie. Florida Master Site File Survey No. 13968. On file, Florida Division of Historical Resources, Tallahassee.

Pepe, J. and W.S. Steele 1998. An Archaeological Survey of the Upper Loxahatchee River, Martin and Palm Beach Counties, Florida. Conducted under the direction of Robert S. Carr, Archaeological and Historical Conversancy, Inc., Technical Report #218.

SFWMD. 2006. Restoration Plan for the Northwest Fork of the Loxahatchee. South Florida Water Management District, West Palm Beach, FL; Florida Department of Environmental Protection Florida Park Service, District 5, Hobe Sound, FL; Loxahatchee River District, Jupiter, FL; and Loxahatchee River Interagency Team. April 12, 2006. Also published as Appendix 12-2 in 2007 South Florida Environmental Report – Volume I, South Florida Water Management District, West Palm Beach, FL.

SFWMD. 2012. Addendum to the Restoration Plan for the Northwest Fork of the Loxahatchee River. Feb. 2012. South Florida Water Management District, West Palm Beach, FL; Florida Department of Environmental Protection Florida Park Service, District 5, Hobe Sound, FL; Loxahatchee River District, Jupiter, FL.

SFWMD 2016. Upper East Coast Water Supply Plan Update – Planning Document. Accessed at https://www.sfwmd.gov/sites/default/files/documents/uec_2016_plan_planning_document.pdf on 12 March 2019.

SFWMD 2018. Lower East Coast Water Supply Plan Update – Planning Document. Accessed at https://www.sfwmd.gov/sites/default/files/documents/2018_lec_plan_planning_doc.pdf on 12 March 2019.

Torres, J.M., A.I. Batun-Alpuche, L.B. Wayne, and M.F. Dickinson 2009. Cultural Resources Reconnaissance Survey, Cypress Creek Properties, Martin County. Prepared for South Florida Water Management District, Pot St. Lucie, Florida.

Zambrano, R. June 2018. FWC, personal communication.

APPENDIX C.3
PERTINENT CORRESPONDENCE INFORMATION

C.3.1 National Environmental Policy Act (NEPA) Scoping
C.3.2 Agency Coordination and Public Involvement
C.3.3 Draft Project Implementation Report (PIR) and Environmental Impact Statement (EIS) Notice of Availability

C.3.1 NEPA SCOPING

A NEPA scoping letter dated January 6, 2015 was mailed to stakeholders soliciting comments for this action. The scoping letter was used to invite comments from Federal, State, and local agencies, affected Indian Tribes, and other interested private organizations and individuals. Comments were accepted through February 8, 2015. Public scoping meetings were held January 12, 2015 in Stuart, Florida. A Notice of Intent (NOI) to prepare the Environmental Impact Statement (EIS) for the LRWRP was published in the Federal Register (80 FR Volume 5) January 8, 2015. NEPA Scoping comments and responses are summarized in Table C.3-1.

Table C.3- 1. LRWRP NEPA Scoping Comments Response Matrix.

LETTER ID Number	AGENCY/PUBLIC COMMENT	CORPS RESPONSE
State Governments		
Loxahatchee River Management Coordinating Council (LRMCC)		
LRMCC-1	Strongly recommend that PDT carefully consider the information, particularly the performance measures and restoration targets, provided in the following documents: 1. 2006 Restoration Plan for the Northwest Fork of the Loxahatchee river; 2. 2010 Loxahatchee Wild and Scenic River Management Plan; 3. 2009 Loxahatchee River Science Plan; and 4. 2012 Addendum to the Restoration Plan for the Northwest Fork of the Loxahatchee River	The PDT will use the Restoration Plan for the Northwest Fork of the Loxahatchee River, Science Plan, and Addendum to support plan formulation of potential restoration management measures to consider, as well as updating restoration performance measures used to evaluate LRWRP project alternatives. Specifically, the restoration flow targets are being used to update performance measures.
LRMCC-2	Critical to complete this effort … [the Loxahatchee River Watershed Restoration Plan (LRWRP)] and move towards project authorization. In light of the continued degradation of the ecosystem due to insufficient freshwater flows, and additional urgency from climate change and sea level rise, it is essential to make meaningful restoration progress for the Loxahatchee River and watershed. Please proceed as expeditiously as possible through the planning phase to complete the PIR and recommend the plan for project authorization.	The rescoped LRWRP project will move forward using the updated USACE SMART Planning Process. This process emphasizes moving forward at a faster pace (no more than 3 years) to complete the decision document for Congress to consider in future authorizations.
LRMCC-3	On behalf of our members and interested stakeholders, the Loxahatchee River Management Coordinating Council strongly supports the efforts of the PDT and CERP as we continue to focus on preserving and restoring the unique and ecologically significant nationally designated Wild and Scenic Loxahatchee River and its watershed.	Thank you, we appreciate the support from partners in seeing the LRWRP project through to completion.

LETTER ID Number	AGENCY/PUBLIC COMMENT	CORPS RESPONSE
State of Florida - 1	Based on the information contained in the scoping notice and comments provided by our reviewing agencies, at this stage, the state has no objections to the proposed federal activities. To ensure the project's consistency with the Florida Coastal Management Program (FCMP), the concerns identified by the state must be addressed prior to project implementation. The state's final concurrence of the project's consistency with the FCMP will be determined during the environmental permitting process, in accordance with Section 373.428, Florida Statutes.	The USACE is aware of the state of Florida Coastal Management Program consistency review process and looks forward to continued collaboration with the state of Florida to ensure the project's recommended plan contains the necessary measures to meet consistency review standards through feedback in PDT meetings and draft NEPA document reviews.
FDACS - 1	FDACS staff notes that the reinitiation the North Palm Beach County - Part 1 Project (NPBC - Part 1) as the LRWRP should retain all of the CERP goals and objectives for both restoration and other water related needs.	The LRWRP project is a rescoped version of the NPBC – Part 1 project to be able to meet new Federal planning requirements that shortened the time and constrained over all study budgets. In order to meet the new time and budget requirements, the focus of the LRWRP project is ecosystem restoration, which is consistent with CERP goals and objectives. Other water related needs will be evaluated during the study. In addition, formulation of restoration plans must be consistent with future water supply plans developed by the state in partnership with other stakeholders.
FDACS - 2	The NPBC - Part 1 Project included CERP conceptual components in all or portions of the following basins: C-51 East and West Basins, C-18 Basin, L-8 Basin, C-17 Basin, City of West Palm Beach Grassy Waters Preserve, South Indian River Water Control District (SIRWCD), and the Intracoastal Basin. The NPBC - Part 1 Project incorporated the CERP goals and objectives for these components and intended that upon implementation it would provide for urban, agricultural, and environmental water supply needs, flood attenuation and some water quality improvement for north Palm Beach County. The NPBC - Part 1 Project also addressed	The project has been rescoped to focus on ecosystem restoration goals and objectives. Components considered in the NPBC – Part 1 from the Yellow Book component X (C-17 Backpumping and Treatment) and Y (C-51 Backpumping and Treatment) were screened out. In some cases, best professional judgment was used to eliminate measures, particularly those that exhibited fatal flaws. For example, all the measures that made up the C-51 and C-17 backpumping components (in essence both of those components) were eliminated since the stormwater treatment areas were not big enough to handle the projected flows and one of the STAs was proposed to be placed in a high

LETTER ID Number	AGENCY/PUBLIC COMMENT	CORPS RESPONSE
	many of the features and goals identified in the Northern Palm Beach County Comprehensive Water Management Plan (NPBCCWMP) as described in the NPBC - Part 1 Project Management Plan (PMP) with stated goals to increase the storage and conveyance of surface water within and between the respective basins, provide adequate present and future water supplies, protect water quality, provide flood protection for urban and agricultural lands and protect and enhance important environmental resources.	quality wetland. Given flow and other constraints, neither of these components was deemed to be effective in providing water to the NWFLR when it was needed most. The new rescoped LRWRP project is focusing on Pal-Mar J.W. Corbett WMA Hydropattern Restoration (OPE), and the Water Protection Areas/L-8 Basin (K & GGG). In addition to these components, some of the ASR components in the CERP will be considered.
FDACS - 3	While providing restoration benefits for the Loxahatchee River Watershed, the LRWRP should formulate alternatives consistent with the goals and objectives of CERP and the former NPBC - Part 1 Project for both restoration and other water related needs.	While related, NPBC- Part 1 and LRWRP are different projects. NPBC – Part 1 was a multipurpose project. The goals and objectives of LRWRP are for ecosystem restoration. There may be ancillary benefits to water supply and flood damage risk reduction that will be evaluated along with restoration. Other water related issues that were considered in the NPBC-Part 1 will need to be reconsidered as part of a separate planning effort.
Florida Fish and Wildlife Conservation Commission (FWC)	Within the restoration areas, the FWC manages J.W. Corbett Wildlife Management Area and DuPuis Wildlife and Environmental Area (in cooperation with South Florida Water Management District) and coordination with our staff will be crucial to maintain public access and hunting in these areas. FWC staff participation throughout the project planning and permitting phases will be essential to protecting Florida's fish, wildlife, and habitat resources.	The LRWRP will form a recreation subteam to consider and evaluate maintaining existing and potentially enhancing public access and other recreation activities in natural areas affected by this project. We encourage active participation from FWC as part of PDT and the recreation subteam.
FDOT - 1	FDOT District 4 staff is actively participating in the Loxahatchee River Watershed Restoration Project. The team member is Ms. Ann Broadwell, District Environmental Administrator. She will be sharing District 4's Work Program with the team and identifying watershed restoration components that have been added to upcoming transportation	The USACE appreciates having Ms. Broadwell represent FDOT interests on the PDT and ensuring consistency between restoration and transportation goals in the project area.

LETTER ID Number	AGENCY/PUBLIC COMMENT	CORPS RESPONSE
	improvement projects within the Loxahatchee River basin.	
FDEP - 1	The DEP is fully supportive of reinitiating the CERP planning efforts for the LRWRP, and believes that it is necessary to narrow the scope of the original proposed project (North Palm Beach - Part 1 CERP Project) in order to complete the project planning phase for the PIR within a reasonable budget and time-period.	The USACE agrees that in order to complete the LRWRP project under the new SMART planning guidance (3 years and under 3 million dollars) the project must focus on ecosystem restoration. Focusing plan formulation on additional mission areas (water supply and flood damage risk reduction) would require additional analyses, modeling, formulation process, review and lengthen the schedule and cost for planning. Please refer to FDACS-1 Response regarding water supply and flood damage risk reduction goals.
FDEP - 2	As noted in DEP's 2002 comments for the Scoping Letter for North Palm Beach - Part 1 CERP Project (now the LRWRP), this project is important to the DEP because the objectives will provide supplemental flows to help restore the Loxahatchee River. The Northwest Fork of the Loxahatchee River is the only federally designated Wild and Scenic River within the greater Everglades ecosystem.	The objectives of LRWRP include providing restoration flows to restore the federally designated Wild and Scenic Northwest Fork of the Loxahatchee River consistent with the Loxahatchee River Restoration Plan.
FDEP - 3	The DEP, which includes the Florida Park Service – Jonathan Dickinson State Park, and the SFWMD worked together to develop a restoration vision and a detailed Restoration Plan for the Northwest Fork of the Loxahatchee River (original Plan published 2006, and updated in 2012). The restoration plan identified a preferred restoration flow rates scenario that provides for specific flow targets for both the dry season and wet season, and also provided salinity targets in the downstream estuarine areas. The DEP recommends using the restoration plan targets in the 2006 Plan as the basis for performance measures and guiding the plan formulation efforts.	Concur. Please see response to LRMCC-1 comment.

LETTER ID Number	AGENCY/PUBLIC COMMENT	CORPS RESPONSE
FDEP - 4	Since this project has completed significant planning efforts as part of CERP from 2002 through 2011, it is important to build on the previous efforts and utilize the modeling/analysis if project conditions or proposed management measures remain the same. The Department recommends using the previous information as the base for the new plan formulation. The previous model runs should be utilized for screening analysis and development of final alternatives.	Concur. The LRWRP team intends to use as much as possible the analyses and modeling performed during 2002 through 2011.
FDEP - 5	Previous planning efforts evaluated restoring flows over Lainhart Dam through the referenced Flow-way 1 and Flow-way 2, and by providing additional flows through the other downstream tributaries, including Kitching Creek, Hobe Grove Ditch and Cypress Creek, through Flow-way 3. The Flow-way 3 alternative development and optimization was completed separately from the regional hydrodynamic modeling analysis of the larger study area (LECSR model area). The Flow-way 3 alternative development and optimization utilized a separate modeling tool that provided a finer level of detail for the natural areas within this flow way (a finer scale watershed model by Tomasello). The Department recommends using as much of the previous modeling efforts as possible to support selection of a restoration plan for the downstream tributaries.	Concur. The LRWRP team will look closely at the prior analysis of Flow-way 3. We anticipate that Flow-way 3 will require fewer modifications than the Flow-way 1 and Flow-way 2 options from the prior study. Some additional analysis may be required for Flow-way 3 to ensure we have identified the appropriate management measures to support meeting restoration goals and objectives.
FDEP - 6	There may be opportunity to further explore additional management measures within the Cypress Creek and Moonshine Creek Basins that could improve both quantity and quality of the deliveries down the Cypress Creek Canal. It may be possible that the optimization of the Flow-way 3 components can be completed through an adaptive management plan, with minimal additional modeling requirements.	The USACE encourages all PDT members to identify potential additional management measures support restoration of tributary flow from Cypress Creek. Depending on the nature of the management measures to what has already been modeled, they may easily be incorporated into the plan formulation. If there is uncertainty on whether they are needed as indicated by modeling or other studies, then they may be relevant for consideration in an adaptive management plan.

LETTER ID Number	AGENCY/PUBLIC COMMENT	CORPS RESPONSE
FDEP - 7	As part of re-initiating planning, the Department recommends focusing the planning efforts on the C-18 Basin to develop storage options to replace the previously identified L-8 Reservoir, which was repurposed to serve as a Flow Equalization Basin (FEB) identified for the State Restoration Strategies Regional Water Quality Plan.	Concur. The LRWRP team will consider multiple types, locations, and volumes of water storage within the C-18 Basin.
FDEP - 8	The Department requests that the USACE focus its planning efforts for storage and treatment projects on SFWMD/ publically owned lands. The rationale for such limitations should be detailed in the PIR/EIS. This focus would be in the best interest of public, as it will provide multiple benefits, including: elimination of evaluation of multiple footprints on lands not in public ownership, expediting the federal planning process and utilizing these significant investments.	The LRWRP team will consider multiple locations for storage, both public and not public lands. There is much publicly owned land in the project area. The ecological performance and cost of storage locations will be combined with the rationale in your comment when the team analyzes storage locations.
FDEP - 9	The previously planned L-8 Reservoir provided flood control storage for the L-8 basin runoff, including improved flood control for Indian Trail Improvement District, water supply storage for both the City of West Palm Beach and the Seacoast Utilities. The L-8 Reservoir also provided environmental water supply storage for Grassy Waters Preserve, Loxahatchee Slough, and flows to the Loxahatchee River through Flow-way 1 and Flow-way 2. The L-8 Reservoir provided 45,000 acre-foot of storage, but was unable to meet the natural systems' demands during extreme dry conditions, in part because the reservoir water had to meet not only the river demands but also domestic water supply demands and the flood control needs.	We are looking at alternative storage to help meet restoration flow needs for the Loxahatchee River.
FDEP - 10	The original Project Management Plan (PMP) identified the original time schedule for completing the PIR as 2007 and it was expected that project construction would be complete by 2014. The planning process for this project was	USACE will coordinate with the USACE vertical chain of command to get concurrence on prior USACE Headquarters decision to include constructed features (G-160 and G-161) in the with project alternatives and exclude from the

LETTER ID Number	AGENCY/PUBLIC COMMENT	CORPS RESPONSE
	not completed. SFWMD acquired lands, constructed project features (such as the G-160 and G-161 structures in Flow-way 1) and implemented improvements to gain benefits on some of the acquired lands. The early work has been beneficial for increased environmental benefits gained and gaining significant information on managing the operations of the Flow-way 1 structures. The Department recommends following the guidance provided in the previous planning efforts and not including these features in the current and future without project conditions; however, the Department recommends including the features in the future with project conditions. Inclusion of these structures with the LRWRP is critical to ensure that operational protocols for environmental deliveries are developed and agreed upon.	future without project. These project features are consistent with the CERP plan approved by Congress in 2000.
FDEP - 11	In regards to water quality, it is critical to develop a plan that prevents degradation of Grassy Waters Preserve and the Loxahatchee River, which are Outstanding Florida Waters.	The USACE will work with FDEP, the state, and other interested PDT members to ensure water quality considerations are factored into the planning, evaluation, and implementation of this project. A water quality subteam has been established to address water quality issues. We look forward to FDEP's continued participation on the PDT and water quality subteam.
FDEP - 12	During the course of previous plan formulation, the Department and multiple stakeholders and environmental group representatives expressed concern that the transfer of stormwater from the L-8 to C-18 Basins through the Grassy Waters Preserve has the potential to cause water quality degradation that could negatively affect the wetland communities in this area. A water quality model was developed to evaluate the effects of this proposed alternative flow way. The analysis illustrated that water quality impacts would occur if a flow of more than 50 cubic feet per second (cfs) was directed northward within the flow path from the M-Canal through the Grassy Waters Preserve toward the flow way connections to	The LRWRP water quality subteam has recommended using prior water quality analysis and new information on the water quality of potential sources of water for restoration.

LETTER ID Number	AGENCY/PUBLIC COMMENT	CORPS RESPONSE
	Loxahatchee Slough (G-161 and/or the new bridge connection under Northlake Boulevard).	
FDEP - 13	The Department recommends that the previous water quality modeling should be utilized for screening purposes, confirming that alternatives developed do not degrade the water quality within the natural wetlands of the Grassy Waters Preserve.	The USACE in coordination with other agencies as part of the water quality subteam will examine the criteria and prior modeling to inform the restoration plan screening process.
FDEP - 14	Through operating G-160 and G-161, improvements have been observed to the Loxahatchee Slough hydroperiods and dry season flows to the Loxahatchee River. Information has been gained to determine that seepage losses are higher than predicted by the models. During dry time periods it is critical to have water and storage in the C-18 basin near the River and not rely on flows from the M-Canal/Grassy Waters system, as the seepage losses are very high.	Groundtruthing seepage analysis is being done to better examine seepage losses in this part of the system and this information will be incorporated into the planning process. The results will be factored into restoration alternatives that bring additional water into and out of Grassy Waters Preserve to support meeting Loxahatchee River restoration flows while maintaining water supply.
FDEP - 15	Additionally, the water supply demands to the City of West Palm Beach compete with the objective of providing water for the River. Limiting testing of the G-161 delivering base flows at the end of the wet season has demonstrated that it is feasible to deliver very low flows through G-161 (15-35 cfs) to the Loxahatchee River, which has assisted in meeting the established Minimum Flow and Level (MFL) for the river. The Department recommends retaining the Flow-way 1 option, if in the near future an agreement can be reached with the City of West Palm Beach for an operations agreement and a flowage easement.	The USACE will consider this information in restoration planning and evaluating the water supply savings clause for both humans and the natural system. The LRWRP team anticipates developing Flow-way 1 options to incorporate into restoration alternatives for further evaluation.
FDEP - 16	Early project guidance will be required to determine what the project assumptions should be as it pertains to the features that were	Concur. Refer to response to comment FDEP-10

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	implemented by the local sponsor (G-160, G-161 and possibly the Northlake Bridge).	
FDEP - 17	The S-46 discharges are variable, ranging from a low flow of near zero cfs to a high flow of 4,000 cfs and disrupt the ecosystem of the Loxahatchee Estuary. If storage was provided within the C-18 basin, portions of this discharge volume could be stored and provided to the Loxahatchee River.	Concur. Storage and operational changes upstream of S-46 may reduce discharges through S-46.
FDEP - 18	A storage reservoir at the Mecca site should be considered, together with other storage options such as storage in natural areas, Aquifer Storage and Recovery (ASR) and dynamic storage in areas near the Loxahatchee River. The dynamic storage includes canals and lakes that feed the Loxahatchee River at Riverbend Park and/or lakes within the adjacent Cypress Creek restoration Areas.	Concur. The LRWRP storage analysis will consider Mecca, ASR, and dynamic storage on the landscape.
FDEP - 19	An evaluation may be needed to import water from the adjacent basin areas such as Corbett/L-8 basin, Indian Trail Improvement District and Grassy Waters. If water is imported from the L-8, additional management measures for stormwater treatment for water quality measures may be required. Based on previous Stormwater Treatment Analysis, this option may not be cost effective.	Concur. The PDT will need to analyze the potential water quality of source water to support hydrologic restoration for the Loxahatchee River.
FDEP - 20	It is also important to recognize that some of the elements of the plan may not be effective in achieving the overall restoration goals. A comprehensive adaptive management plan should be developed that integrates monitoring and optimization of the recommended plan to ensure that the project components are effectively achieving the overall objectives.	An adaptive management and monitoring plan will be developed to address key areas of uncertainty in achieving restoration success.

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FDEP - 21	The Department is an active participant on the Loxahatchee River Management Coordination Council (LRMCC), applauds the USACE for assertive outreach associated with this project and encourages the USACE to continue to provide periodic progress updates to the Council.	The USACE and SFWMD will provide periodic updates to the LRMCC.
FDEP - 22	The Department recommends the completion of the planning phase for this project so the needed restoration work can be completed.	Concur.
DOS - 1	A review of the Florida Master Site file data indicates that the proposed location contains multiple historical and archaeological resources. Due to the size and scope of the proposed project area and potential for direct and indirect adverse effects on historic properties, DOS staff recommends that a professional cultural resource management consultant be retained to identify known cultural resources and sensitivity areas, and develop a plan for the protection of historic properties that may be identified. The resultant report must conform to the provisions of Chapter 1A-46, F.A.C., and be forwarded to DOS staff to complete the review process.	Concur, cultural resources surveys will be completed before construction and coordinated with the Florida State Historic Preservation Officer and appropriate federally recognized Native American Tribes.
DOS - 2	The American Cultural Resources Association (ACRA) maintains a listing of professional consultants at www.acra-crm.org. In addition, the Register of Professional Archaeologists (RPA) maintains a membership directory that may be useful in locating professional archaeologists and other professional preservation consultants in your area (www.rpanet.org).	Concur.
DOS - 3	Many qualified historic preservation professionals are not members of these organizations, and omission from the directories does not imply that someone does not meet the Secretary's Standards or that the resultant work would not be acceptable. Conversely, inclusion	Concur.

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	on the list is no guarantee that an archaeologist's work will automatically be acceptable. As with any contractor references and recent work history should be requested.	
TCRPC - 1	In 1999, at the request of Palm Beach County and the U.S. Environmental Protection Agency, the TCRPC prepared the Loxahatchee River Basin Wetland Planning Project for Palm Beach County. This report, which can be found on the TCRPC's website (http://www.tcrpc.org/special_projects/Loxahatchee_River_Basin_Wetland_Planning_Project.pdf), contains twenty two conclusions and recommendations that discuss a broad range of issues related to the restoration of the Loxahatchee River. This report, and a similar report prepared by Martin County for the Martin County portion of the Loxahatchee River watershed, contain historic information that may be relevant to the proposed project.	Thank you for the link to the report. We will review the information and the report's recommendations will be considered in the planning process.
TCRPC - 2	The proposed project is consistent with the Strategic Regional Policy Plan. The Loxahatchee River Watershed Restoration Project has the potential to help achieve ecosystem restoration, increased water supplies, improved water quality, and the maintenance of flood protection. This project represents an opportunity to accomplish these goals and balance the need to provide water for natural systems and urban and agricultural uses.	Please see response to FDACs-3 comment.
Town of Jupiter - 1	The Town of Jupiter is deeply concerned that the current watershed has inadequate supply and storage to provide both minimum and restorative flows to the naturally designated "wild and scenic" Loxahatchee River. As a result, the Town has the expectation that the primary goal and objective of the project will be to increase availability of high quality water to the river.	Analysis of water budgets in the basin will aid in determining the amount of water available to support meeting LRWRP objectives. The study will evaluate the supply of water for the river and consider constructing new storage options. The study will also consider the quality of the water delivered to the river, as well as ensuring water supply will not be impacted.

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Town of Jupiter - 2	Secondarily, the Town also owns and operates a regional water utility serving nearly 80,000 people in Palm Beach and Martin Counties. The Town's utility is fully reliant on two local aquifer systems for its raw water supply, the Surficial Aquifer and the Floridan Aquifer. CERP's longstanding objectives have included additional fresh water supply to Jupiter's wellfields (25 cfs) to provide ground water recharge, minimize seepage losses, minimize the risk of salt water infusion, prevent wetland drawdowns during drought and to support the long-term sustainability of aquifer resources. As such, it is imperative the ongoing scope of work provide continued emphasis on achieving this long standing goal of delivering at least 25 cfs to Jupiter's wellfields.	Please see response to FDACs-1 Comment.
Town of Jupiter - 3	Lastly, we would ask that your office clearly acknowledge the Town's reservation in the use of aquifer storage and recovery (ASR) within the Floridan Aquifer near Jupiter. As mentioned previously, the Town is reliant on the Floridan Aquifer for water supply through brackish water RO desalination. Any introduction of water from outside source into this aquifer system may cause degradation of the supply rendering it untreatable.	ASR will be carefully evaluated as an option for storage in meeting Loxahatchee River restoration goals. Lessons learned from recent ASR pilots and regional ASR studies will be used. The quality of source water will be evaluated as well as water that is obtained from ASR.
Town of Jupiter - 4	I've been authorized to represent the Town of Jupiter tonight. A concern -- and I was a critic of the initial PIR planning process when it first came out and felt that it lacked the focus and the direction in keeping the eye on the ball that is needed for water resource projects. That being said, a lot of really good work was done in the PIR process and my concern is you've had a process and while Congress might have authorized the yellow book in 2000, the planning process went back into the early '90s so we've been working on this project for 25 years. We know an awful lot about this watershed. And my concern is the pendulum has	The USACE and SFWMD will be relying on the past plan formulation and study as a strong basis for moving forward with viable alternatives to support restoration of the Loxahatchee River and Watershed ecosystem. The past planning revealed that the scoped needed to be changed and focused on ecosystem restoration to successfully complete a plan to send to Congress for authorization. Other objectives, water supply and flood damage risk reduction will be considered where compatible with restoration. The basin has already been comprehensively reviewed as part of the L-8 General Reevalation Report (2001), Cypress Creek/Pal-Mar and

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	swung so far in the other direction. Say you've got three years and $3 million, what are we going to jam into this process that I wanted to be – I want this to be a comprehensive review of the Loxahatchee Basin.	Groves Basin Study (2002), North Palm Beach County Comprehensive Water Management Plan, Loxahatchee River Watershed Action Plan (2002), Loxahatchee River Minimum Flows and Levels (2002), Restoraiton Plan for the Northwest Fork of the Loxahatchee River (2006) and Addendum (2012), Draft North Palm Beach County Part 1 Alternative Formulation Briefing Document (2010), and Restoration Strategies analysis (2012).
Town of Jupiter - 5	And as Michelle said, the role Grassy Water plays and the Lake Worth Lagoon, the Indian River, I want this to be more than just a Mecca project and really looking at the entire L-8 Basin.	The scope of this study is ecosystem restoration of the Loxahatchee River watershed. It will include more than the Mecca site.
Town of Jupiter - 6	I was very intrigued by your comments about Lake Okeechobee. The one thing I think everybody in the Jupiter area is in agreement, and I've got to admit my thinking has changed on this, but I used to say, you know, the Water Management District and Corps will do the right thing, but thank God we don't have a connection with C-18, S-46 and Lake Okeechobee because I'm convinced that the same damages that occurred in the St. Lucie Estuary would have happened in the Loxahatchee River if there would have been that direct discharge. And from the Culvert 10 structures into L-8, you can get water into the North Fork – or into the system, especially if there's an extension of C-18 Canal. So keeping Lake Okeechobee water out of Loxahatchee water basin is a top priority	The study team intends to accomplish restoration using water in the watershed. The team does not intend to propose additional connections to Lake Okeechobee or to use more water from Lake Okeechobee beyond current regulatory releases from the Lake.
Town of Jupiter - 7	There's a concern. The Town of Jupiter has made a huge investment in brackish water desalination, it has some ASR projects. One of the mysteries of water resources in South Florida has been changing of the upper Florida and finding out that the quality and the source water changes and its had a -- it used to be back in the '80s an unlimited potential for the upper Florida. Now we're finding out that it does have limits. And as you put in -- if you were to put in	Please see response to Town of Jupiter comment 3.

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	systems, clearly the existing users have concerns about what impact that might have on the investment Jupiter has made with their groundwater system.	
Town of Jupiter - 8	So these are all things -- and my concern is you're on this fast track. The PIR process is way too slow, way too ambiguous, way too big. Now you've kind of got your .30-06 and you're saying full speed ahead, we're going to hit this target out there. And I think it's going to end up somewhere in between those two extremes. But let's not throw out all the good work that had been done in looking for a comprehensive standpoint of what needs to be done with the Loxahatchee Basin. It is a complex area and it's a very special place and this could be that blueprint for how we manage water resources in the future of the county in the north end, but it's got to be done right.	The study team intends to learn from and re-use much of the analysis completed during the earlier study of the area.
MC - 1	Martin County has active projects going on in the Kitching Creek area. We have an active project ongoing and I'd be happy to take any of you out there to see it in progress to build a stormwater treatment area to clean the water before it reaches into Kitching Creek which is one of the main headwaters of the – that restores the river. So we're looking at maintaining dry season flows for the Loxahatchee with that project.	Thank you.
MC-2	We are also, our Board of County Commissioners voted last year to set aside a million dollars of land acquisition money to continue land acquisition to try to get a more active program back in acquiring the Pal Mar area which is in your project area as well to see what we can do to get some of those important wetland areas under public ownership. And we've got a number of other projects going on in Cypress Creek. So we've tried to step out and we've taken some leadership and building some new structures in that watershed up along the	Thank you. We will be requesting additional details of Martin County's actions in the study area so that we may correctly incorporate them into the study.

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	Ranch Colony Canal. We replaced the 28 storm structures recently. And the operations of the area, the complexity of the operations can't be underestimated so we would just ask you to take that into consideration as we move forward.	
MC-3	We did proceed through the Loxahatchee River Preservation initiative asking for some design in planning, funding. And if we're successful in getting funding from the legislature this year, we can move on planning and design of infrastructure along the Ranch Colony Canal that will help the Loxahatchee River in some very significant way. But we are looking for partners for constructing that structure and we look to you for consideration as we move forward in this process.	There are a couple avenues for partnering with the USACE on restoration project features in this project area. 1) Martin County partnering with the SFWMD as the entity that would support planning and design of Ranch Colony canal infrastructure, or 2) Martin County partnering with the USACE on that specific structure and meeting the requirements for partnering with the USACE. Ultimately, the project features identified by the Martin County effort would need to also be part of the tentatively selected plan and approved plan for the LRWRP for the USACE to partner in constructing any of these features.
MC-4	We will be at the table, we will be active. Please let us know if there's anything we could do to assist.	Thank you, and will be asking for your expertise and capability as the study progresses.
ITID -1	IT ID is in full support with the entire project	Thank you. We appreciate your support
WPB - 1	Grassy Waters Preserve is part of the City's natural system but also a major part of the City's water supply system and as such we would just want to make sure that a study of that part of the system is still a focus and goal of this project.	GWP will be incorporated into the analysis and evaluation of restoration benefits for LRWRP. Evaluation criteria will be developed to address water supply and other water related needs.
WPB -2	The City system which has come to be known as Flow-way 1, that really grew out of the original planning out here back in the late 19s and early 2000s, so we became a part of the flow way system from then and have been functioning as such. There are waters flowing through our system today and actually monies that the City has spent as a part of this kind of history of the North Palm Beach project that's now the Loxahatchee Watershed Project and shouldn't be part of the existing conditions baseline.	The USACE would appreciate further input from the city of west palm beach to best describe planning assumptions for existing conditions and future without project conditions.

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WPB -3	And then the City's very happy to be a part of an environmental restoration partner on that, but you have to realize, also, we want to make sure it's a part of the study that water quality and water quantity impacts occur to the City's water supply system as a result of using Grassy Waters Preserve as part of Flow-way 1 and that restoration of connection. So it's kind of a multi-purpose project for the City while being a restoration benefit for the Loxahatchee River Slough system absolutely, but we just want to have the water quality aspect considered as part of this project.	Potential water quality effects will be analyzed as part of the project formulation to avoid additional water quality degradation as a result of this project.
WPB -4	The flowage easement and analysis is needed so that as water flows through our system and it's pulled for restoration purposes, we want to make sure that doesn't negatively impact the utility which also relies on that shame shared system. It's actually a very beneficial shared system like much of the Everglades has become over time.	As the project progresses, the PDT will examine the existing real estate interests held by the State, local public interests, and other public entities as well as the SFWMD. The PDT will also examine the current uses of each interest held and the reasons they were acquired. The PDT will conduct an estate analysis to determine what real estate interest would be required to implement the plan and whether it is compatible with the current uses. It would be the intent that the plan does not impact the current uses of public utilities such as municipal water supply. The PDT will work with the City.
WPB -5	Loxahatchee system, we want to make sure that the lake lagoon that flows through the lagoon that comes to the City of West Palm Beach are not forgotten as part of this. I see that the lake lagoon is still listed, I'm not sure where it will fit into your scoping process and your study of alternatives. So we just want to make sure that bigger projects as we participated previously isn't lost. I know you're trying to go with a similar, more specific focus thing here, but there are some very key pieces there that the City of West Palm Beach was a historic partner on and would like to remain on a partner on those issues.	The focus of this Loxahatchee River Watershed Restoration Plan is narrower than the prior study, which considered the entire northern part of Palm Beach County. This study cannot address all the water-related problems and opportunities.

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Ms. Diffender fer	So you had that the L-8 Reservoir was removed and I sort of heard that you were talking about ASR as being one of the potential surface water storage options. Is there an actual reservoir, though, that's being looked at?	We repurposed the L-8 Reservoir which was in the former plan to meet the water quality requirements that were required to send water to the south to the Everglades. In repurposing that reservoir, the volume of water that was in the L-8 Reservoir was moved to another project so that storage that's in the ground today will not be available for this project. We are considering new options for storage (above ground storage and aquifer storage and recovery). This project will be looking at both of those as management measures or project components to store water when it's available and deliver it to the river when it's not. From an aboveground impoundment standpoint, the SFWMD has identified a replacement project for the L-8 Reservoir and that's the acquisition that we made with Palm Beach County for the Mecca location, which is in the western leg of the C-18. We are examining those lands that are in public ownership to build storage features aboveground that could be used or co-located with ASR technology to provide storage to the Northwest Fork of the river. Part 2, there's a second flow path that's owned and operated by the City of West Palm Beach known as Flow-way 1. The city has a very large 20-square mile natural area known as Grassy Waters Preserve and that natural system is connected to the regional system. This area is potentially another mechanism to improve hydro- periods in the natural system and see if there are opportunities to move water to restore flows to the river without adversely affecting the higher periods and grassy waters.
Albrey Arrington	Verbal at Scoping Meeting - We have an abbreviated time schedule, a 3x3x3. What's the date of the first draft of the reports or documentation that you'll be presenting or putting forth? And specifically where I'm going,	The public will be able to participate in discussing various drafts of the plan as part of Project Delivery Team (PDT) meetings that can be found on the following website - http://www.bit.ly/LRWRP_CERP

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	you showed a map with some generic symbols on it, but you said, "Well, we haven't done anything with any of these yet." And so the spirit of my question is when do you start and when do you start showing that to the public, and then how many days following when you first show that to the public do you actually start presenting the draft to – up the chain?	Alternative plans will be developed by May 2015 and presented at PDT meetings. The draft Project Implementation Report and Environmental Impact Statement (EIS) will be available summer of 2016 for public review and comment. As part of the review of the Draft EIS, we'll have another public meeting for comments.
?	Verbal at Scoping meeting - Water for the whole project is the Loxahatchee River Watershed Area and possibly Lake Okeechobee water? you have too many variables here, especially when you consider that Orlando wants to capture the Kissimmee River Watershed, some of that water for their aquifer re-nourishment and future growth when you have the others that are variables. You have too many variables and I don't know how you, you know, how you build the equations to tie up all the variables. I'm told the equation. If you ask, they say all water should go south. If all the water went south, how do we address all the freshwater about the growth and the people moving to the area and so forth?	No changes to the Lake Okeechobee Regulation Schedule are being considered, nor is Lake Okeechobee water being considered to meet Loxahatchee River restoration flows. Projects are analyzed as part of the regional modeling system that includes assumptions for how each of the multiple projects and variables functions, and metrics to measure each purpose of the project (water supply, flood control, restoration)

Appendix C.3.2 Agency Coordination and Public Involvement

Agency Coordination and Public Involvement Summary
Agency and Public Involvement Comment Response Matrix
Agency and Public Letters
Agency/Tribe Coordination Letters

C.3.2 Agency Coordination and Public Involvement

Agency coordination and public involvement has taken place throughout the LRWRP planning process. Project Delivery Team (PDT) and public involvement has been a critical component of the development of this PIR. **Table C.3-2** provides a list of interagency coordination and public presentations conducted throughout the planning process for LRWRP. Further information on meetings agendas, read-aheads and minutes can be found at: http://www.saj.usace.army.mil/Missions/Environmental/Ecosystem-Restoration/Loxahatchee-River-Watershed-Restoration-Project/

Table C.3- 2. Agency Coordination and Public Involvement Summary.

Action	Location	Date
Scoping	Stuart	January 12, 2015
Project Delivery Team	Jupiter	December 14, 2014
	Hobe Sound	January 30, 2015
	Hobe Sound	March 19, 2015
	Webmeeting	January 21, 2016
	Hobe Sound	March 30, 2016
	Webmeeting	April 5, 2016
	Webmeeting	December 14, 2016
	Webmeeting	April 26, 2017
	Hobe Sound	May 31, 2017
	Webmeeting	December 13, 2017
	Webmeeting	March 20, 2018
	Webmeeting	April 19, 2018
	Hobe Sound	May 9, 2018
Seminole Tribe of Florida	Big Cypress Reservation	February 23, 2016
	Big Cypress Reservation	June 30, 2016
	Big Cypress Reservation	August 4, 2016
Environmental Protection Agency	Webmeeting	January 15, 2015

Appendix C.3.3 Draft Project Implementation Report (PIR) and Environmental Impact Statement (EIS)
Notice of Availability

Statement of Recipients

Draft PIR and EIS Notice of Availability (NOA)

C.3.3 Draft PIR/EIS Notice of Availability

The Notice of Availability (NOA) was published in the Federal Register and mailed to interested stakeholders March 22, 2019, to begin the 45 day review period. The Draft EIS was filed in accordance with ER-FRL-8994-7, Amended Environmental Impact Statement Filing System Guidance for Implementing 40 CFR 1506.9 and 1506.10 of the Council on Environmental Quality's Regulations Implementing the National Environmental Policy Act and made available for public and agency review.

The draft EIS was published on the following websites:

http://www.saj.usace.army.mil/Missions/Environmental/Ecosystem-Restoration/Loxahatchee-River-Watershed-Restoration-Project/

and

http://www.saj.usace.army.mil/About/DivisionsOffices/Planning/EnvironmentalBranch/EnvironmentalDocuments.aspx#Multiple_Counties

A comment response matrix will be included in the Final EIS detailing comments received on the Draft EIS with USACE responses.

APPENDIX C.4

ENVIRONMENTAL COMPLIANCE INFORMATION

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C.4 Compliance with Environmental Laws, Statutes, and Executive Orders

The following sections provide a summary of environmental compliance with each Act, Executive Order, or other applicable environmental or cultural protection law.

C.4.1 Anadromous Fish Conservation Act, Pub. L. No. 89-304

The Anadromous Fish Conservation Act, Pub. L. No. 89-304, conserves fish that live in the ocean and enter fresh water to spawn. Anadromous fish species would likely not be affected by the proposed project. NMFS provided a Programmatic Biological Opinion for the Comprehensive Everglades Restoration Plan (CERP) to the USACE on December 17, 2013, and it is incorporated by reference to the LRWRP, a component of CERP.

C.4.2 Archaeological Resources Protection Act of 1979

This Act works to protect and preserve historical and cultural resources of federal lands, including Indian lands, through a permit system authorizing scholarly study and excavation of cultural properties, as well as provide sanctions for unauthorized use, removal, or damage to any archaeological resource 16 U.S.C. §§432-33 and 36 CFR Part 296. The term resource includes human remains, pottery, basketry, bottles, weapon projectiles, rock carvings and paintings, tools, structures or portions thereof, graves, skeletal remains 16 U.S.C. § 470bb(1). Resources of 'recent' origin (less than 100 years) are not protected by ARPA. U.S. v. Shivers, 96 F.3d 120. LRWRP is in compliance with this act and will continue to comply throughout construction and operation.

C.4.3 Bald and Golden Eagle Protection Act of 1940

The Bald and Golden Eagle Protection Act 16 U.S.C. §668 *et. seq*., prohibits anyone, without a permit issued by the Secretary of the Interior, from "taking" bald eagles, including their parts, nests, or eggs. Bald eagle nests would be avoided during construction. While areas of foraging habitat used by bald eagle may be within the project area, impacts to these areas are not likely to adversely affect this protected species. The project will incorporate conservation measures to maintain compliance with this Act during construction.

C.4.4 Clean Air Act

The existing air quality within South Florida is considered good. Section 176 (c) of the Clean Air Act requires that federal agencies assure that their activities are in conformance with the federally-approved Clean Air Act state implementation plans for geographical areas designated as "non-attainment" and "maintenance" areas under the Act. The proposed project is not located within a "non-attainment" area since there are none in southeast Florida. The only new potential sources of air pollution as a result of this project would be from temporary discharges from machinery during construction and construction and the operation of pump station(s). Pursuant to rule 62-210.300(3)(a)(21)(b), operations staff would be required to determine if stations would be exempt from air permitting or if an air general permit would be required. Upon such determinations, the project will be in compliance with this Act.

C.4.5 Clean Water Act of 1972

Full compliance would be achieved with issuance of a Section 401 Water Quality Certification (WQC) from Florida. A Section 404 (b)(1) evaluation is included in **Appendix C.4.39**. The project may require dewatering permits and National Pollutant Discharge Elimination System (NPDES) permits, depending on means and methods of construction. The project would obtain Water Quality Certification (WQC) from Florida and any required NPDES permits and would update the 404(b)(1) analysis prior to construction. All required permits would be obtained prior to construction activities. All state water quality standards would be met. Water quality is expected to improve with the proposed project. The project will be in compliance with this Act.

C.4.6 Coastal Barrier Resources Act and Coastal Barrier Improvement Act of 1990

The official Coastal Barrier Resources System (CBRS) maps were reviewed and the LRWRP project does not fall into any designated CBRS areas. There are no designated coastal barrier resources in the project area that would be affected by the proposed project. These Acts are not applicable to this project.

C.4.7 Coastal Zone Management Act of 1972

A federal consistency determination has been prepared in accordance with the provisions of 15 CFR 930 (**Appendix C.4.40)**. The USACE has considered the enforceable policies of the State of Florida's management program as requirements to be adhered to in addition to existing federal agency statutory mandates. The proposed project would be consistent to the maximum extent practicable with the enforceable policies of Florida's approved Coastal Zone Management program. This project will be in compliance upon review of this document by the State of Florida and issuance of Water Quality Certification.

C.4.8 Endangered Species Act of 1973

The proposed project has been coordinated with the USFWS and National Marine Fisheries Service (NMFS). The USACE requested concurrence from the USFWS on federally listed species and critical habitat that may be present in the project area in a letter dated March 16, 2017. The USFWS provided concurrence on the species list on April 20, 2017. The USACE provided a BA to USFWS in March 2019 to initiate consultation with the USFWS (**Annex A – Biological Assessment**).

The USACE proposed "no effect" determinations for Florida panther, Everglade snail kite designated critical habitat, red-cockaded woodpecker, and Okeechobee gourd; "may affect" determinations for Everglade snail kite, wood stork, Audubon's crested caracara, eastern indigo snake, Florida bonneted bat; and "may affect not likely to adversely affect" determinations for West Indian manatee and its critical habitat. The USACE will consult with and request USFWS to concur with these determinations of project effects to the threatened or endangered species that are found in the action area.

A programmatic Endangered Species Act Section 7 consultation for the Comprehensive Everglades Restoration Plan (CERP) was prepared on March 15, 2013 to evaluate potential effects of CERP, including the proposed LRWRP, on listed species and designated critical habitat under the NMFS' purview. The USACE provided a Programmatic Biological Assessment for the Comprehensive Everglades Restoration Plan to NMFS on 2 July 2013. NMFS provided a Programmatic Biological Opinion for the Comprehensive Everglades Restoration Plan to the USACE on 17 December 2013 that includes LRWRP. This project would

be in compliance with this Act and ongoing consultation would be conducted throughout the PED and construction phase as appropriate.

C.4.9 Estuary Protection Act of 1968

The proposed project would provide opportunities to redirect water that is currently discharged through various canal systems for flood control purposes to NWFLR, which would foster ecological improvement of the Loxahatchee River / Jupiter Inlet estuary and associated estuarine resources, including oysters and seagrass, that are important for providing water quality, habitat functions, and a robust food web, and improvement of EFH for fisheries populations such as seatrout, and snapper-grouper complex. The project is in compliance with this Act.

C.4.10 Farmland Protection Policy Act of 1981

USACE initiated coordination with the United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) to meet the requirements of the Farmland Protection Policy Act (FPPA), 7 U.S.C. § 4201 et seq., on October 10, 2018 and received a Form AD 1006 evaluation on November 15, 2018. The evaluation indicated that, with the exception of reservoir features, the project would not affect prime or unique farmland or potentially remove land from agricultural production. Projects are subject to FPPA requirements if they may irreversibly convert farmland (directly or indirectly) to nonagricultural use and are completed by a federal agency or with assistance from an agency.

FPPA farmland includes prime farmland, unique farmland, and land of statewide or local importance. Prime farmland is land that has the best combination of physical and chemical characteristics for producing food, feed, forage, fiber, and oilseed crops and is also available for these uses. It has the soil quality, growing season, and moisture supply needed to produce economically sustained high yields of crops when treated and managed according to acceptable farming methods, including water management. In general, prime farmlands have an adequate and dependable water supply from precipitation or irrigation, a favorable temperature and growing season, acceptable acidity or alkalinity, acceptable salt and sodium content, and few or no rocks. They are permeable to water and air. Prime farmlands are not excessively erodible or saturated with water for a long period of time, and they either do not flood frequently or are protected from flooding [SSM, USDA Handbook No. 18, October 1993]. Unique farmland is land other than prime farmland that is used for the production of specific high value food and fiber crops (7 CFR 657.5). These lands are not used in producing feed, food, fiber, forage, and/or oilseed crops. Almost all land in central and southern Florida used for agricultural production has been designated unique farmland. The USACE will be in full compliance with the Act at the time of construction.

C.4.11 Federal Water Project Recreation Act of 1965, As Amended

The effects of the proposed action on outdoor recreation have been considered and are presented in **Appendix F**. The LRWRP recreation plan identifies, evaluates, and addresses the impacts of LRWRP implementation on existing recreational use within the South Florida ecosystem and identifies and evaluates potential new recreation, public use, and public educational opportunities. Continued recreation planning would be performed during detailed project engineering and design. This project would not adversely affect existing recreational opportunities. This project is in compliance with this Act.

C.4.12 Fish and Wildlife Coordination Act of 1958, As Amended

The Fish and Wildlife Coordination Act provides guidance for equal consideration of wildlife resources during project planning. The USFWS was involved as a PDT member in project planning, development, and evaluation of project effects to fish and wildlife resources and natural wildlife management areas. USFWS provided a draft Fish and Wildlife Coordination Act Report (CAR) to USACE in March 2019 (**Annex A)**. The USACE's responses to the CAR recommendations are included in **Annex A.3 - Recommendations and Responses under the Fish and Wildlife Coordination Act Report**. The project is in compliance with this Act.

C.4.13 Magnuson-Stevens Fishery Conservation and Management Act

The Magnuson-Stevens Fishery Conservation and Management Act, 16 U.S.C. 1801 *et seq*. Pub. L. 104-208 reflects the Secretary of Commerce and Fishery Management Council authority and responsibilities for the protection of Essential Fish Habitat (EFH). Federal agencies that fund, permit, or carry out activities that may adversely impact EFH are required to consult with the NMFS regarding the potential effects of their actions on EFH. An Essential Fish Habitat (EFH) assessment was covered by the Programmatic NMFS NEPA consultation (Appendix C.2.7). To document NEPA compliance, the USACE provided a letter that includes the EFH assessment to NMFS with the Notice of Availability of the DEIS. USACE will implement relevant recommendations of the programmatic consultation; therefore, USACE is in compliance with this Act.

C.4.14 Marine Mammal Protection Act of 1972

West Indian manatees inhabit the coastal and major inland waters of south Florida including C&SF Project canals. Manatees are not expected to be adversely affected by the proposed project as the project features to be constructed will be isolated from manatee access during construction. Incorporation of the Standard Manatee Construction Conditions would be used as necessary to protect threatened and endangered manatees during construction and operation of the project. USACE made a determination of may affect not likely to adversely affect manatees and requested concurrence in the USFWS Biological Opinion (**Annex A – Biological Opinion**). The USACE is in compliance and will be in full compliance with the Act at the time of construction.

C.4.15 Marine Protection, Research and Sanctuaries Act

Ocean disposal of dredged material is not proposed as a part of the recommended plan. This Act is not applicable.

C.4.16 Migratory Bird Treaty Act of 1918, 16 U.S.C. §703 *et seq*.

This Act makes it illegal to take, possess, import, export, transport, sell, purchase, barter, or offer for sale, purchase, or barter, any migratory bird, or the parts, nests, or eggs of such a bird except under the terms of a valid federal permit. Under the Migratory Bird Treaty Act, "migratory birds" include all birds native to the United States and the Act pertains to any time of the year, not just during migration (50 CFR 10.13). The USACE has incorporated compliance with this Act in project planning and will be in full compliance with the Act at the time of construction.

C.4.17 National Environmental Policy Act of 1969

This Act encourages public participation and comment on federal projects, and requires agencies to cooperate with other federal agencies and state and local governments, and to involve public stakeholders.

A National Environmental Policy Act (NEPA) scoping letter dated January 6, 2015 was used to invite comments from federal, state, and local agencies, affected Indian tribes, and other interested private organizations and individuals. Scoping comments were accepted through February 8, 2015. A Notice of Intent (NOI) to prepare an Environmental Impact Statement (EIS) for the LRWRP was published in the Federal Register (FR Volume 80, Number 5) January 8, 2015. Public scoping meetings were held January 12, 2015 in Stuart, Florida. A copy of the scoping letter, NOI, scoping letters received and a comment response matrix are located in **Appendix C.3**. Twelve Project Delivery Team meetings that were open to the public were held to get feedback on project scope, plan formulation including identification of the final array of alternatives, and input on the evaluation and selection of a tentative restoration plan.

The Notice of Availability (NOA) of the Draft Project Implementation Report and Environmental Impact Statement was published in the Federal Register on March 22, 2019 and mailed to interested stakeholders to begin a 45-day review period. Two NEPA Draft PIR/EIS Public Meetings will be held in 2019 in south Florida locations. The USACE is complying with the NEPA process and will be in full compliance with the Act at the time of construction. The USACE will update NEPA documentation as appropriate.

C.4.18 National Historic Preservation Act of 1966 (Inter alia)

The proposed project is in compliance with the National Historic Preservation Act, as amended (Pub. L. 89-665). As part of the requirements and consultation process contained within the National Historic Preservation Act implementing regulations of 36 CFR 800, this project is also in compliance through ongoing consultation with the Archaeological and Historic Preservation Act, as amended (Pub. L. 93-291), Archeological Resources Protection Act (Pub. L. 96-95), American Indian Religious Freedom Act (Pub. L. 95-341), Executive Orders 11593, 13007, and 13175, the Presidential Memo of 1994 on Government to Government Relations and appropriate Florida Statutes. Consultation with the Florida State Historic Preservation Officer (SHPO), appropriate federally recognized tribes, and other interested parties was initiated January 8, 2015 and is ongoing. See **Appendix C.5** for details of the ongoing consultation. USACE is currently coordinating a Programmatic Agreement with Florida SHPO and the advisory Council on Historic Preservation (ACHP) to conduct a phased identification and evaluation of historic properties during the project's design phase. Dependent on further consultation with the Florida SHPO and the results of Phase I cultural resources investigations, project design modification may be necessary to avoid or minimize impact to historic properties. Phase II NRHP eligibility testing or mitigation may be required if impacts cannot be avoided.

C.4.19 Native American Graves Protection and Repatriation Act, as Amended

Federal agencies must make an inventory of all Indian human remains and funerary objects in its possession and control, attempt to identify the affiliated tribe, and repatriate the items to the appropriate group. This Act also applies to inadvertent discoveries, in that there is a required delay in the disturbance of a site containing human remains until consultation with affiliated tribes is accomplished. The proposed project is in compliance.

C.4.20 Resource Conservation and Recovery Act, As Amended By the Hazardous and Soils Waste Amendments of 1984, CERCLA As Amended by the Superfund Amendments and Reauthorization Act of 1966, Toxic Substances Control Act of 1976

Hazardous, toxic and radioactive waste surveys would be conducted as required. While the proposed action would involve ground disturbances, it is not expected to result in the discovery or generation of HTRW materials. The USACE is currently in compliance and will continue to meet the requirements of this act throughout construction and operation.

C.4.20.1 USACE – Comprehensive Everglades Restoration Policy – Residual Agricultural Chemicals, USACE-ASA-CW Policy, September 2011.

To address the issues presented by low-level residual agricultural chemicals present on CERP project lands, the Assistant Secretary of Army for Civil Works provided a policy memorandum on September 14, 2011. The policy has been incorporated into the formulation of the proposed project. The project will meet the requirements of this policy throughout construction and operation.

C.4.21 Rivers and Harbors Act of 1899

The proposed project would not obstruct navigable waters of the United States. The project has been subject to public notice and other evaluations normally conducted for activities subject to the Act. The proposed project is in compliance with this Act.

C.4.22 Submerged Lands Act of 1953

The proposed project would improve the quantity and seasonal availability of freshwater flows to the Loxahatchee River Estuary and Jupiter Inlet, and provide freshwater overland flow across various parcels that will ultimately benefit the ecological habitats that occur on emergent and submerged lands of the State of Florida. No construction is expected on submerged lands; therefore, the project is in compliance with this Act.

C.4.23 Wild and Scenic Rivers Act of 1968, As Amended

The NWFLR is a 10.3 mile reach designated as a wild and scenic river within the project area that would be beneficially affected by project-related activities. The proposed project is in compliance with this Act.

C.4.24 E.O. 11514, Protection of the Environment

E.O. 11514 directs federal agencies to “initiate measures needed to direct their policies, plans, and programs so as to meet national environmental goals.” The objectives of the project are focused on environmental protection. The project is in compliance with the goals of this E.O.

C.4.25 E.O. 11593, Protection and Enhancement of the Cultural Environment

E.O. 11593 directs federal agencies to provide leadership in preserving, restoring and maintaining the historical and cultural environment of the Nation. Agencies of the executive branch of the Government (hereinafter referred to as "Federal agencies") shall (1) administer the cultural properties under their control in a spirit of stewardship and trusteeship for future generations, (2) initiate measures necessary to direct their policies, plans and programs in such a way that federally owned sites, structures, and

objects of historical, architectural or archaeological significance are preserved, restored, and maintained for the inspiration and benefit of the people, and (3), in consultation with the Advisory Council on Historic Preservation (16 U.S.C. 470i), institute procedures to assure that Federal plans and programs contribute to the preservation and enhancement of non-federally owned sites, structures and objects of historical, architectural or archaeological significance. The project is in compliance with this E.O. through ongoing and continued consultation with the federally-recognized tribes and the Florida State Historic Preservation Office throughout planning, design, and implementation. Pursuant to Section 106 of the National Historical Preservation Act (16 USC 470), obligation regarding USACE Trust Responsibilities to federally-recognized Native American Tribes, and in consideration of the Burial Resources Agreement between USACE and the Seminole Tribe of Florida, consultation on the project will continue to be coordinated with the appropriate federally-recognized tribes, SHPO, and interested parties; and through measures including avoidance, minimization, or mitigation will be completed prior to project implementation.

C.4.26 E.O. 11988, Flood Plain Management

E.O. 11988 directs federal agencies to avoid siting projects in floodplains and to avoid inducing further development of flood-prone areas. The project is a restoration action; therefore, commitment of lands to project restoration would preclude other floodplain development. The proposed action would help restore and preserve the natural and beneficial uses of the floodplain. The project would be operated in a manner that would not increase flooding of private property. The project is in compliance with the goals of this E.O.

C.4.27 E.O. 11990, Protection of Wetlands

E.O. 11990 directs federal agencies to avoid developing and locating projects in wetlands. The proposed project area is located within a landscape matrix of freshwater wetlands. The nature of this project is that it involves operations in wetlands, and no other practicable alternative to locating this project and to avoidance of wetlands exists. The objectives of the project are focused on environmental restoration. A net functional benefit to wetlands within and adjacent to the project area is expected. The project is in compliance with the goals of this E.O.

C.4.28 E.O. 12962, Recreational Fisheries

E.O. 12962 requires the evaluation of federally funded, permitted, or authorized actions on aquatic systems and recreational fisheries. Overall, project effects to recreational fisheries would be beneficial because seasonally appropriate increased freshwater flows will be delivered to the NWFLR. The Recreation Plan (Appendix F) describes recreational improvements associated with the project. Implementation of LRWRP is predicted to improve EFH and, thus, recreational fish stocks using the Loxahatchee Estuary and Jupiter Inlet habitats. This project is in compliance with the goals of this E.O.

C.4.29 E.O. 12898, Environmental Justice

E.O. 12898 directs federal agencies to provide full participation of minorities and low-income populations in the federal decision-making process, and further directs agencies to fully disclose any adverse effects of plans and proposals on minority and low-income populations. The scoping effort communicated the proposed project to the public. During scoping and subsequent public meetings no subjects or issues were presented as possible environmental impacts that may disproportionately affect minority and or low income populations. The objectives of the project are focused on environmental restoration.

Implementation of the project would benefit all population groups by providing restoration of wetlands and other natural resources within the project area. LRWRP would provide benefits to quality of life by improving the estuarine environment and contribute to hydrological and water quality improvements in the historic NWFLR. The project would improve the quality of human life by providing improved estuarine conditions for fish and wildlife. It would translate into aesthetic and economic benefits for sport fishing and other recreational communities. No homeowners would be displaced by the project. The project would not result in adverse human health or environmental effects. The project would not disproportionately adversely affect any minority or low-income population.

Executive Order 12898 environmental justice guidance from EPA was followed to identify potential EJ populations. Only one population was identified with in a 2-mile buffer of the project just east of Grassy Waters Preserve (GWP). This minority population would not be affected by the project, because the project overall does not result in increased risk of flooding or water supply associated with features affecting GWP. The proposed activity would not (a) exclude persons from participation in, (b) deny persons the benefits of, or (c) subject persons to discrimination because of their race, color, or national origin, nor would the proposed action adversely impact "subsistence consumption of fish and wildlife." Therefore, the project is in compliance with this E. O.

C.4.30 E.O. 13045 Protection of Children

E.O. 13045, requires each federal agency to “identify and assess environmental risks and safety risks [that] may disproportionately affect children and ensure that its “policies, programs, activities, and standards address disproportionate risks to children that results from environmental health risks or safety risks.” The proposed project will not result in environmental health risks or safety risks that may have a disproportionate effect on children. Children will not be in the vicinity of any of the construction operations and activities should not have an impact on children. The project is in compliance with this E.O.

C.4.31 E.O. 13089 Coral Reef Protection

There are no hard bottom or coral reef communities located within the proposed project site or the nearshore waters affected by the project. The project is not expected to adversely impact coral reefs or coral reef resources. This E.O. is not applicable.

C.4.32 E.O. 13122 Invasive Species

The proposed project has the potential to allow expansion of exotic and/or invasive species, due to construction and operational changes within the LR watershed. Construction measures to reduce the spread of exotic and/or invasive species would be included in the contract specifications. An Invasive Species Management Plan is included in **Annex F**. The objectives of the plan are to prevent and/or reduce the establishment of non-native species within the project area. The project is in compliance with the goals of this E.O.

C.4.33 E.O. 13175, Consultation and Coordination with Indian Tribal Governments

E.O. 13175 sets forth fundamental principles to guide agencies in formulating and implementing policies that have tribal implications. The E.O. goes on to set forth policymaking criteria to which agencies must adhere to the extent permitted by law. These principles an policymaking criteria apply to an agency’s “regulations, legislative comments or proposed legislation, and other policy statements or actions” that

have "substantial direct effects on one or more Indian tribes, on the relationship between the Federal Government and Indian tribes, or on the distribution of power and responsibilities between the Federal Government and Indian tribes" (Sec.1(a)). See **Appendix C.3** and **Appendix C.5** for further details. The project is in compliance with this E.O.

C.4.34 E.O. 13186, Responsibilities of Federal Agencies to Protect Migratory Birds

Migratory and resident bird species have been observed within the project area and are likely to use available habitat for foraging, nesting, and breeding. The proposed project is not expected to destroy migratory birds, their active nests, their eggs, or their hatchlings. The proposed project is expected to benefit migratory birds by improving habitat and increasing availability of forage species (amphibians, fish, aquatic and invertebrates) for wading birds, raptors, passerines, and other groups. Consistent with the Migratory Bird Treaty Act, migratory bird surveys will be conducted prior and during construction to provide measures to avoid impacts to migratory birds nesting or foraging near project construction sites. The project is in compliance with the goals of this E.O.

C.4.35 Memorandum on Government-to-Government Relations with Native American Tribal Governments 1994

This Presidential Memorandum directs the federal government to operate within a government-to-government relationship with federally recognized Native American tribes. The head of each executive department and agency shall be responsible for ensuring that the department or agency operates within a government-to-government relationship with federally recognized tribal governments. Each executive department and agency shall apply the requirements of the E.O. 12875 ("Enhancing the Intergovernmental Partnership") and E.O. 12866 ("Regulatory Planning and Review") to design solutions and tailor federal programs, in appropriate circumstances, to address specific or unique needs of tribal communities. The USACE has consulted with the Miccosukee Tribe of Indians of Florida and the Seminole Tribe of Florida during the NEPA process and during planning efforts for the LRWRP. This project is in compliance with the goals of this memorandum. Coordination letters are included in **Appendix C.3** and **Appendix C.5**.

C.4.36 Seminole Indian Lands Claim Settlement Act of 1987

The Florida Indian (Seminole) Land Claims Settlement Act of 1987 directed the SFWMD, the State of Florida, and the Seminole Tribe of Florida to execute an agreement for the purposes of resolving tribal land claims and settling the lawsuit filed by the Seminole Tribe of Florida, which involved certain land claims within the State. Agreements to resolve tribal land claims were executed between the three parties, which included conveyance of land and payment of consideration to the tribe, and implementing legislation by the Congress of the United States and Legislature of the State of Florida. An agreement known as the Water Rights Compact (Compact) was executed between the State of Florida, the District, and the Seminole Tribe of Florida. The Compact specifically defined tribal water rights. This Compact was adopted into federal and state law. It includes a series of provisions establishing the Tribe's rights and creating several '"entitlements" to water for each of the Tribe's reservations. This project is in compliance with this Act.

C.4.37 Compliance with Florida Statutes

The State of Florida has enacted several laws pertaining to implementation of CERP projects. These include amendments to Section 373.026 (8), Florida Statute (F.S.), which establish a requirement for the

SFWMD to submit a report for review and approval by the Florida Department of Environmental Protection (FDEP) prior to formal submission of a request for authorization from Congress and prior to receiving an appropriation of state funds for construction and other implementation activities (except the purchase of lands from willing sellers); the enactment of Section 373.1501 F.S., which establishes the intent of the Florida Legislature with respect to CERP and the criteria for FDEP approval and the procedures to be followed by the SFWMD and FDEP for submitting and reviewing requests for approval; the enactment of Section 373.1502 F.S., which establishes permitting requirements and a process for the submittal, review, and issuance of certain regulatory permits for CERP projects; and the enactment of Section 373.470 F.S. and Section 373.472 F.S., establishing the "Save Our Everglades Trust Fund," funding and reporting requirements, and procedures for distributions from the trust fund.

The SFWMD's State Compliance Report addressing the criteria for approval listed in Section 373.1501 F.S. is included in **Annex B**. In addition to the above-described statutory requirements, other sections of Chapters 373 (Water Resources) and 403 (Environmental Control) of the Florida Statutes include requirements that may apply to various aspects of CERP project planning and implementation. In particular, Chapter 403 F.S. and the administrative laws adopted in accordance with Chapters 373 and 403 F.S., contain the requirements for facilities that involve the discharge or potential discharge of pollutants to surface and ground waters, and the discharge of air pollutants, including facilities regulated under the federal Clean Water and Safe Drinking Water Acts and the federal Clean Air Act. Based on the information contained in this PIR, the recommended plan complies with the applicable provisions of the Florida Statutes. A detailed explanation of how the project complies with the applicable requirements for CERP projects contained in the Florida Statutes can be found in **Annex B**.

C.4.38 Memorandum of Agreement to Address Aircraft-Wildlife Strikes

The 2003 Memorandum of Agreement (MOA) between the Federal Aviation Administration (FAA), the U.S. Air Force, USACE, EPA, USFWS, and the U.S. Department of Agriculture - Wildlife Services (WS) established procedures necessary to coordinate their agency missions to more effectively address existing and future environmental conditions contributing to aircraft-wildlife strikes throughout the United States. These efforts are intended to minimize wildlife risks to aviation and human safety, while protecting the Nation's valuable environmental resources (FAA 2003). The National Plan of Integrated Airport Systems (NPIAS) contains all commercial service airports, all reliever airports, and selected general aviation airports. Palm Beach International Airport and North Palm Beach GA Airport are NPIAS airports. The proposed action includes "the development of conservation/mitigation habitats or other land uses that could attract hazardous wildlife to airports or nearby areas", and is relevant to the LRWRP, as the project purpose involves restoration of habitats used by numerous wildlife species including federally endangered or threatened species. USACE evaluated the distance of key project features that could contribute to aircraft-wildlife strikes from the two NPIAS airports and determined that the proposed land use or land management changes would not cause significant change to already existing wildlife use patterns throughout Martin and Palm Beach counties. By inclusion of this analysis in the NEPA document USACE is in compliance with this MOU.

C.4.39 CLEAN WATER ACT SECTION 404(B) (1) EVALUATION

This section provides a programmatic Section 404(b) (1) evaluation for the LRWRP PIR/EIS. It generally addresses the potential environmental effects of the wetland and aquatic ecosystem alterations expected from the construction of the structural components of the recommended plan and associated dredge and fill activities. Subsequent site-specific Section 404(b)(1) evaluations would be completed for individual

project components, or groups thereof, in sufficient detail for final decision making and to provide full compliance with the Section 404(b)(1) Guidelines and National Environmental Policy Act requirements. This 404 (b)(1) evaluation should be sufficient to qualify for and, in the event that subsequent decisions render the project in compliance with, coverage under Section 404(r) of the Clean Water Act and exempt state and tribal water quality certification.

C.4.39.1 Location

The study area for the LRWRP encompasses multiple parcels in Martin and Palm Beach Counties (see Project Description in Section 1, and **Figure C.4-1**). The TSP includes multiple features to restore historic hydrology to various parcels, improve connectivity and conveyance between parcels, and deliver seasonally appropriate flow volumes to drained palustrine wetlands and eventually to the riverine floodplain wetlands of the NWFLR and downstream estuary **(Figure C.4-2).**

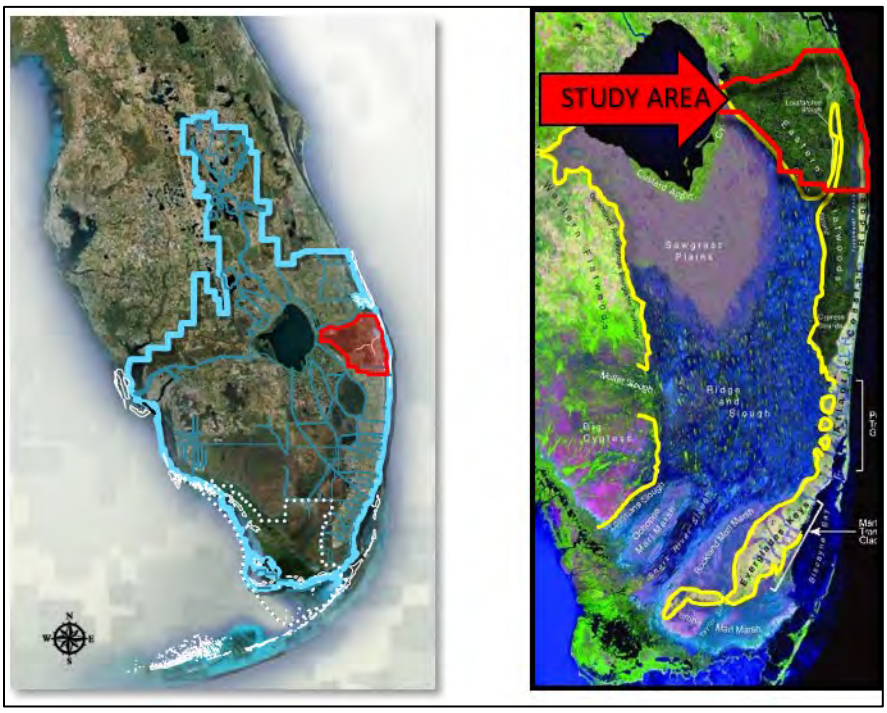

Figure C.4-1. Project area map.

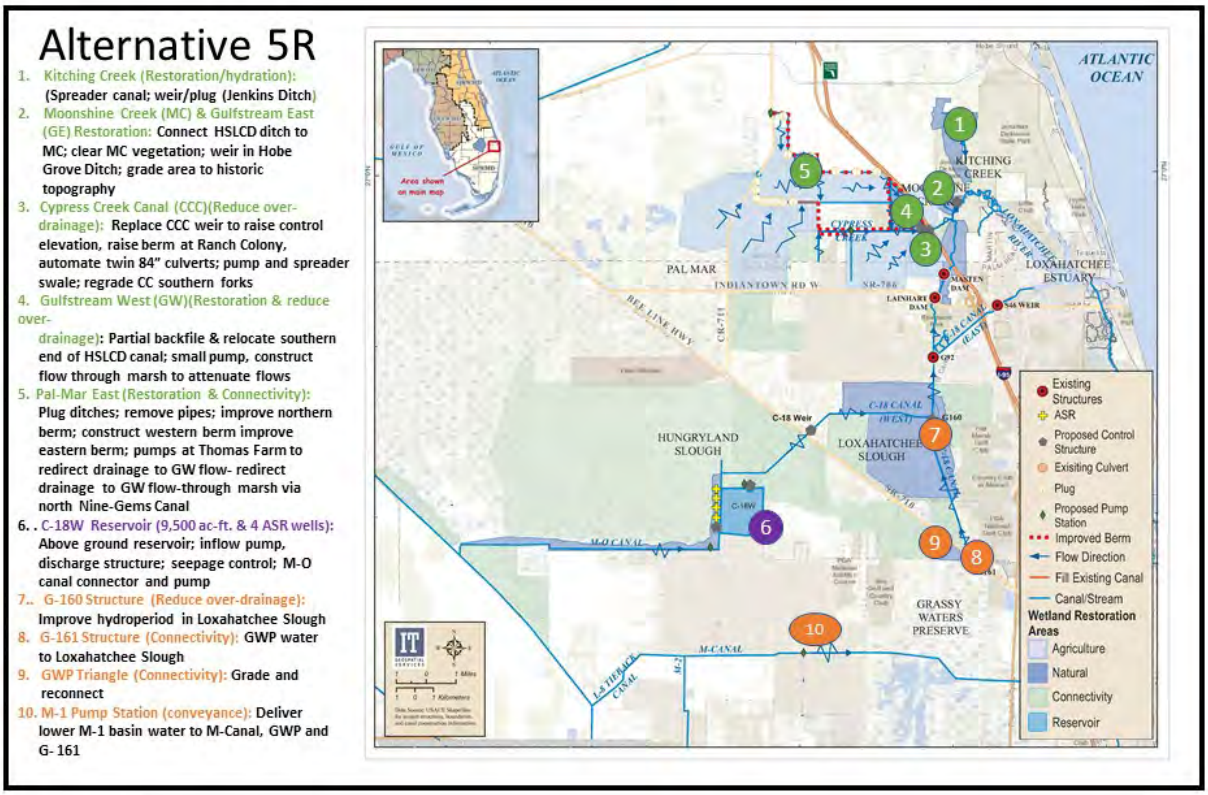

Figure C.4-2. LRWRP Alternative 5R (Revision of LRWRP ALT5R).

C.4.39.2 Project Description

The LRWRP TSP, Alt 5R, will increase flows to the NWFLR, achieving 91% of the dry season restoration target flows and 98% of the wet season restoration target flows. The Plan will do this by collect water that currently flows rapidly away from the Loxahatchee watershed, eventually into the C-51 Canal. The TSP will either immediately deliver that water to the Northwest Fork or store the water in a surface reservoir or in aquifer storage and recovery wells for delivery at more natural times. The TSP will restore 17,000 acres of former wetlands that had been converted to agriculture and an additional 10,000 acres of existing but disturbed wetlands in the Corbett Wildlife Management Area, Loxahatchee Slough, Cypress Creek Natural Area, and Kitching Creek. These restored wetlands will connect with 51,000 acres of other wetland communities in the area, resulting in 78,000 acres of connected habitat.

C.4.39.3 Plan Features

The components of the TSP are described in **Table C.4-1** and in Section 6. Additional information, details of features, and documentation of assumptions are found in **Appendix A (Engineering)**.

Table C.4-1. Key features of LRWRP TSP Alt 5R.

Feature	Project Feature Purpose
Nine Gems (Pal-Mar East) – ditch plugs, grading	Hydrologic restoration; surface water; vegetation
Gulfstream West – Flow-through marsh	Hydrologic restoration; surface water; vegetation
Gulfstream East and Moonshine Creek – grading, connectivity	Hydrologic restoration; surface water; vegetation
Kitching Creek – weir and spreader swale	Hydrologic restoration; surface water; vegetation
Cypress Creek, water control structure,	Hydrologic restoration; surface water; vegetation
Cypress Creek, spreader swale and pump station, Shiloh flow paths	Hydrologic restoration
Grassy Waters Preserve Triangle – grading, connectivity	Hydrologic restoration; surface water; vegetation
Grassy Waters Preserve with G-161, operation change for water deliveries to NWFLR	Continued operations; no hydrologic change
Loxahatchee Slough Natural Area – hydrology changes associated G-160 and G-161	Surface water; vegetation, hydroperiod improvements
ASR well clusters co-located with C-18 W	Water storage, and delivery to NWFLR
C-18W Reservoir and associated infrastructure east boundary	Water body – large reservoir

C.4.39.4 Authority and Purpose

The WRDA of 2000 approved the CERP as a framework for modifications to the C&SF Project in Section 601(b) (1) (A). The PIR will be submitted in compliance with Section 601(d) of WRDA 2000, titled "Authorization of Future Projects."

The Central and Southern Florida (C&SF) Flood Control Project, as constructed, had unintended adverse impacts to the Greater Everglades including the Loxahatchee River watershed. Historically, freshwater flowed towards the river from surface (through wetlands and drainage features such as sloughs, strands, creeks, and overland across the low topography) and groundwater sources and resulted in a mosaic of vegetative communities as well as a salinity plume positioned much lower in the Loxahatchee estuary than presently. While historic hydrologic conditions sustained extensive ecological communities (ridge and slough, wet prairies, tree islands, sawgrass prairies, mangrove communities and seagrass beds) these communities have been degraded under the managed system. The purpose of LRWRP is to improve the quantity, quality, timing, and distribution of water flows to the NWFLR.

C.4.39.5 General Description of Dredged or Fill Material

Construction of several project features are expected to involve the discharge of dredged or fill material into wetlands or other aquatic resources such as portions of existing canals or excavation in wetlands for conveyance purposes; however, feature-specific designs are unavailable at this time. Additional 404(b) (1) documents would be prepared for individual features when actual fill material needs are identified. The specific characteristics (general characteristics discussed below), quantities, and sources of dredged or fill material would be determined during planning and design activities for each component.

C.4.39.5.1 General Characteristics of Material

The shallow subsurface soils consists of Holocene sands, silts and freshwater muck soils that developed on marine sand, silt, and shell parent material deposited during Quaternary high sea level stands. Surface soils in the area of flow-way 3 consist primarily of Wabasso sand, and Pineda and Riviera fine sands, which are classified as SP-SM and SP, respectively (NRCS 2018; **Section C.1.5 – Soils).** Surface soils in the area of flow-way 2 are finer grained than those in flow-way 3, and consist primarily of drained and ponded Riviera fine sands, which are classified as SP-SM (NRCS 2018; Tierra, Inc. 2004**; Section C.1.5 – Soils**).

The material may be reused or would be disposed of offsite in a Class 1 landfill. Soil testing would be conducted to better define the soil characteristics and, as a result of that soil testing, other disposal options may be determined.

C.4.39.5.2 Quantity of Material (cubic yards)

Quantities of material would be determined during the PED phase of project design. Wherever possible, topsoils would be conserved per NRCS guidelines and would be cleanly stockpiled, and used as topsoil on constructed features.

C.4.39.5.3 Source of Material

The material would consists of various quantities of various soils, depending on final feature design.

C.4.39.6 Description of the Proposed Discharge Site

The proposed discharge site(s) will be selected during PED when a refined project can be analyzed.

C.4.39.6.1 Location

Previously excavated material in existing berms, levees, and other deposited materials would be replaced into excavated areas. Soil testing would be performed prior to construction of each component. As a result of soil testing, other disposal options may be pursued for placing clean dredged or excavated material including placement at project features, in which case the specific soil characteristics would be evaluated for discharge impacts.

C.4.39.6.2 Size

It is anticipated that LRWRP would be constructed in stages as described within the Implementation Plan (refer to **Section 5**) and that, due to construction sequencing, several potential interim staging, stockpile, or temporary disposal sites may be required.

C.4.39.6.3 Site

Excavated material will be replaced into various project sites, depending on the final project design. The material would be deposited in compliance with the Clean Water Act.

C.4.39.6.4 Habitat

Excavated material would be placed according to final project design and would not adversely affect habitats. Excavated material of good quality would also be used to augment materials at select project features.

C.4.39.6.5 Timing and Duration of Discharge

Installation timing of the project features would be determined during the PED phase of design. The time and duration of discharge would be further defined during the detailed design phase.

C.4.39.7 Description of Disposal Method

Excavated material, if the excavated material is used as fill, it would be hauled by truck to placement or staging stockpile areas.

C.4.39.8 Factual Determinations (Section 230.11)

The determinations of effects of each proposed discharge shall include the following: (a) physical substrate determinations, (b) water circulation, fluctuation, and salinity determinations, (c) suspended particulate/turbidity determinations, (d) contaminant determinations, (e) aquatic ecosystem and organism determinations, (f) proposed disposal site determinations, (g) determination of cumulative effects on the aquatic ecosystem, and (h) determination of secondary effects on the aquatic ecosystem.

C.4.39.8.1.1 Substrate Elevation and Type

The natural topography of the area is nearly flat with slopes generally less than 2%, with the exception of the unnatural features (e.g., canals and levees.).

C.4.39.8.1.2 Sediment Type

The shallow subsurface soils consists of Holocene sands, silts and freshwater muck soils that developed on marine sand, silt, and shell parent material deposited during Quaternary high sea level stands. Surface soils in the area of Flow-way 3 consist primarily of Wabasso sand, and Pineda and Riviera fine sands, which are classified as SP-SM and SP, respectively (NRCS 2018; **Section C.1.5 – Soils**). Surface soils in the area of flow-way 2 are finer grained than those in Flow-way 3, and consist primarily of drained and ponded Riviera fine sands, which are classified as SP-SM (NRCS 2018; Tierra, Inc. 2004**; Section C.1.5 – Soils**).

C.4.39.8.1.3 Dredge/Fill Material Movement

Material will be excavated and or replaced as determined by the PED design for each feature. Best management practices would be employed during construction to control movement of sediment into undisturbed areas and areas outside the construction footprint. USACE will develop Environmental Compliance Plans and obtain appropriate permits.

C.4.39.8.1.4 Physical Effects on Benthos

No adverse impacts to benthic organisms are anticipated other than displacement of those organisms in the construction footprint of the proposed project. These highly prolific organisms are expected to quickly re-establish in the natural wetlands restored through improved hydrology.

C.4.39.8.2 Water Circulation, Fluctuation, and Salinity Determination

An ecological monitoring plan has been developed to monitor hydrology, water quality, and associated changes within the project area (**Annex D**).

C.4.39.8.3 Suspended Particulate/Turbidity Determinations

During project construction, a temporary short-term increase in suspended particulates may occur in the canals and ponded areas associated with wetland restoration, levee or canal bank alteration, and land re-grading. Best management practices would be used to minimize the suspension and transport of soils, levee materials, and roadway materials into water adjacent to or downstream of the construction area including use of sediment controls, turbidity screens, or sediment blockages for adjacent wetlands.

In general, any short-term impacts to water quality associated with construction of the project would be ameliorated by construction sequencing, best management practices for erosion and sedimentation control, and monitoring during construction. Longer-term impacts to water quality not associated with fill and associated with the operation of project features would be addressed through operational monitoring and adaptive management actions, if potentially adverse effects are observed or predicted.

C.4.39.8.3.1 Expected Changes in Suspended Particulates and Turbidity Levels in the Vicinity of the Disposal Site

Although site-specific information is unknown at this time, temporary localized increases in suspended particulates and turbidity levels can be expected during construction of some of project features. Such increases are generally short term and insignificant. All appropriate measures to reduce and contain turbidity would be employed so State Water Quality Standards would not be violated.

C.4.39.8.3.2 Effects on Chemical and Physical Properties of the Water Column

Chemical and physical properties of the water column are characterized by light penetration, dissolved oxygen, toxic metals, organics, and pathogens, and aesthetics of the water column.

C.4.39.8.3.2.1 Light Penetration

During construction operations there would be a temporary insignificant reduction in light penetration in the canals in the immediate vicinity of the activity. Once construction is complete, light penetration is expected to return to pre-construction levels.

C.4.39.8.3.2.2 Dissolved Oxygen

During construction operations there would be a temporary reduction in the dissolved oxygen content in the water column due to organic sediment oxygen demand from the disturbed soils in the immediate

vicinity of the activity. Once construction is complete, dissolved oxygen is expected to return to pre-construction levels.

C.4.39.8.3.2.3 Toxic Metals, Organics, and Pathogens

Generally no toxic metals, anthropogenic organics, or pathogens are anticipated to be released by project construction. Additional discussion on these items would be provided during further planning and design on project components.

C.4.39.8.3.2.4 Aesthetics of the Water Column

During construction, visual aesthetics would be temporarily, locally affected. After completion, aesthetics would improve due to landscaping with native plants around constructed features, and control of invasive exotic plant species via implementation of the ISMP.

C.4.39.8.3.3 Effects on Biota

Effects on biota include three taxonomic groups.

C.4.39.8.3.3.1 Primary Productivity and Photosynthesis

Disposal of excavated materials would adversely affect wetlands in the immediate vicinity of construction by destroying vegetation and smothering biota. However, project operation would improve the primary productivity and photosynthesis due to an increase in quantity and quality of wetland habitat.

C.4.39.8.3.3.2 Suspension/Filter Feeders

During construction operations there would be a temporary increase in turbidity and possibly a decrease in suspension/filter feeders due to construction activities. This temporary increase in turbidity would be short-term and should not have any long-term negative impact on these highly fecund organisms. The implantation of the project should benefit these organisms by creating a better quality wetland habitat.

C.4.39.8.3.3.3 Sight Feeders

During construction operations there would be a temporary increase in turbidity and possibly a decrease in sight feeders due to construction activities. No significant impacts on these organisms are expected as the majority of sight feeders are highly mobile and can move outside the affected area. When the project is operational, sight feeders would benefit from the better quality wetland habitat.

C.4.39.8.4 Contamination Determinations

A HTRW evaluation was conducted for Alt 5R parcels (**Appendix C.1.16**). Site-specific evaluations will be conducted as necessary during the PED phase.

C.4.39.8.5 Aquatic Ecosystem and Organism Determinations

No long-term adverse impacts on aquatic organisms are anticipated. Wetland and estuarine ecosystems are expected to greatly improve because of implementation of Alt 5R. The proposed project is not expected to cause or contribute to violations of state water quality standards, jeopardize the existence of

any federally endangered or threatened species, nor impact a marine sanctuary. No significant degradation is expected and all appropriate and practicable steps would be taken to minimize impacts. Improvements to upland and wetland habitats are predicted with the construction of Alt 5R.

C.4.39.8.5.1 Effects on Plankton

No adverse impacts to plankton are anticipated.

C.4.39.8.5.2 Effects on Benthos

No adverse impacts to benthic organisms are anticipated other than displacement of those organisms in the construction footprint of the proposed project. Improvement of freshwater flows to the Loxahatchee River Estuary would provide improved habitat for the benthos.

C.4.39.8.5.3 Effects on Nekton

No adverse impacts to benthic organisms are anticipated other than displacement of those organisms in the construction footprint of the proposed project. Improvement of freshwater flows to the Loxahatchee River Estuary would provide improved habitat for the benthos.

More than 250 species of fish representing 78 families have been identified within the Loxahatchee River and its estuary (Christensen 1965). Estuarine fish species most likely to occur in the areas include the small forage species such as killifish (both *Cyprinodon* spp. and *Fundulus* spp.), mosquito fish, juvenile sciaenids, silversides and mullets. Larger secondary consumers include gray snapper, tarpon, snook, red drum and spotted seatrout. Aquatic macro invertebrates such as crayfish (*Procambarus alleni*), riverine grass shrimp (*Palaemonetes paludosus*), amphipods (*Hyallela aztecus*), Florida apple snail (*Pomacea aludosa*), Seminole ramshorn (*Planorbella duryi*), Atlantic Rangia (*Rangia cuneata*), and numerous species of aquatic insects, form a vital link between the algal and detrital food web base of freshwater wetlands and the fishes, amphibians, reptiles, and wading birds that feed upon them (USACE 1999). Freshwater deliveries to NWFLR would provide improved habitat and nursery opportunities for fishes.

C.4.39.8.5.4 Effects on Aquatic Food Web

Periphyton forms the base of the food web within the project area. Implementation of the project is expected to increase periphyton biomass and productivity throughout the site as well as freshwater diatoms. No adverse impacts to the aquatic food web are anticipated, other than minor temporary impacts within the construction footprint of various features.

C.4.39.8.5.5 Effects on Special Aquatic Sites

The designation special aquatic sites includes sanctuaries and refuges, wetlands, mudflats, vegetated shallows, coral reefs, and riffle and pool complexes. They are geographic areas, large or small, possessing special ecological characteristics of productivity, habitat, wildlife protection, or other important and easily disrupted ecological values. These areas are generally recognized as significantly influencing or positively contributing to the general overall environmental health or vitality of the entire ecosystem of a region.

C.4.39.8.5.5.1 Sanctuaries and Refuges

The project will benefit NWFLR, a federally designated National Wild and Scenic River. State refuges, recreation areas, and aquatic preserves are discussed in Section C.4.41.

C.4.39.8.5.5.2 Wetlands

The project is classed as a wetland restoration project, and the project area parcels are dominated by palustrine forested, scrub-shrub, and emergent wetlands communities (mesic and wet flatwoods, wet prairie, floodplain and dome swamp, depression marsh and mesic and hydric hammock).

Historically, the Loxahatchee River watershed included and drained more than 565 km^2 of inland sloughs and wetlands. The drainage basin was comprised primarily of pine flatwoods interspersed with cypress sloughs, hardwood swamps, marshes, and wet prairies. Rainfall in the basin was directed through natural topography into the wetlands, treated by natural biological and chemical action, and slowly released to receiving water bodies (VanArman et al. 2005). The watershed was considered to fall within the Eastern Flatwoods landscape, which bordered the eastern side of the Everglades, from Lake Okeechobee to the New River. The Eastern Flatwoods landscape was only slightly elevated above the Everglades, and the Loxahatchee Slough served as a wetland connection between the Everglades and NWFLR. The Loxahatchee Slough may have historically provided water flow into, or received outflow from, the Everglades depending on local rainfall. However, landscape patterns suggest the volumes were small. While not a principal outflow, the Loxahatchee Slough does appear to have provided a continuous aquatic connection between the northeastern Everglades and the Loxahatchee River.

Estuarine habitats (mangroves, oysters, seagrass) replace palustrine wetlands midway along the NWFLR where salinity increases sufficient to support halophytic vegetation (FDEP/FCO 2018). Project designs will be developed in the PED phase including calculation of wetland impacts. Generally, project features include ditch filling, regrading previously ditched areas to re-connect them to the surrounding landscape, improving existing connectivity, installing ditch plugs, weirs, and spreader canal features that will re-distribute water across existing lands that were historically classified as wetlands. Some portion of the projected wetland impacts will be permittable via the Nationwide Permit program. The C-18W Reservoir will eliminate some palustrine wetlands and permitting will be obtained as necessary. The proposed project is anticipated to provide positive ecological benefits, including improving hydroperiods and hydropatterns, by improving the quantity, timing, and distribution of water delivered to the NWFLR.

C.4.39.8.5.5.3 Mud Flats

Mud flats have not been mapped at project-specific detail and will be investigated during the PED phase. Mud flats will be generally avoided from construction disturbance.

C.4.39.8.5.5.4 Vegetated Shallows

Submerged aquatic vegetation (SAV) is present. Tapegrass and widgeon grass occur in freshwater zones of NWFLR. Johnson's seagrass, turtle grass, manatee grass, and shoal grass occur in zones with higher salinities and are likely stressed by salinities less than 15 parts per thousand (ppt), which occurs when flow through the S-46 flood control structure is greater than 600 cfs within the Loxahatchee River system, so a longer duration lower-flow release will be beneficial compared to pulsed flows (LRD 2013). Improvement of freshwater flows to the estuary would provide improvements to SAV vigor and distribution.

C.4.39.8.5.5.5 Hardground and Coral Reef Communities

There are no hard bottom or coral reef communities located within the proposed project site or the nearshore waters affected by the project. Corals found offshore of Jupiter Inlet are outside of the area of potential effect.

C.4.39.8.5.5.6 Riffle and Pool Complexes

There are no riffle or pool complexes within the project footprint, therefore, none should be impacted by the proposed project.

C.4.39.8.5.6 Threatened and Endangered Species

Eight federally listed threatened and endangered species are present potentially in the project area. The USACE is consulting with USFWS on effects determinations for these federally listed species within the project area. A Biological Assessment is included to document potential effects to threatened and endangered species **(Annex A)**. A USFWS Biological Opinion on the effect of implementation of the proposed project on any endangered and/or threatened species would be determined and included in **Annex A** of the Final PIR/EIS.

C.4.39.8.6 Proposed Disposal Site Determinations

Disposal site determinations would be made during site-specific design. The project would not result in long-term adverse impacts to the project area resources as a result of placement of discharged material.

C.4.39.8.6.1 Mixing Zone Determination

Where material is placed to backfill existing canals or other excavated areas, discharged material would not cause unacceptable changes in the mixing zone water quality requirements as specified by the State of Florida's Water Quality Certification permit procedures. No adverse impacts related to depth, current velocity, direction and variability, degree of turbulence, stratification, or ambient concentrations of constituents are expected from implementation of the project.

C.4.39.8.6.2 Determination of Compliance with Applicable Water Quality Standards

LRWRP complies with water quality standards applicable to the project and adjacent waters. Proposed features are located in and adjacent to waters designated as Class III by the State of Florida. In accordance with Florida Administrative Code (F.A.C.) Rule 62-302 ("Surface Water Quality Standards"), the use classification of Class III waters is "Recreation, Propagation, and Maintenance of a Healthy, Well-Balanced Population of Fish and Wildlife." In addition to the minimum and general criteria for surface waters found in Section 62-302.500(1) F.A.C., there are numerous water quality criteria for specific parameters for Class III waters listed in Section 62-302.530, F.A.C. Although the proposed plan is not expected to affect most of the parameters listed in this rule, certain parameters (e.g., turbidity, dissolved oxygen and nutrients) listed in the criteria may be affected by construction and operations activities. The construction and operation of the proposed project components would comply with federal and state water quality standards.

C.4.39.8.7 Potential Effects on Human Use Characteristics

These evaluations address municipal and private water supply, recreational and commercial fisheries, water related recreation, aesthetics, parks and preserves.

C.4.39.8.7.1 Municipal and Private Water Supply

No municipal or private water supplies would be adversely impacted by the implementation of the project. Refer to **Section 4** for additional information pertaining to CERP LRWRP water supply analyses.

C.4.39.8.7.2 Recreational and Commercial Fisheries

The Recreation Plan details proposed features to provide recreational fishing opportunities. The proposed project would benefit recreational and commercial fisheries through salinity improvements within the Loxahatchee River estuary.

C.4.39.8.7.3 Water Related Recreation

Water related recreation may be reduced by some project features and improved by other project features. Further detail is included in **Appendix F**.

C.4.39.8.7.4 Aesthetics

Project feature construction and land alterations to restore sheet flow to the Loxahatchee watershed and NWFLR would enhance the overall aesthetics of the project area. Invasive exotic plant control may enhance the aesthetics of the area.

C.4.39.8.7.5 Parks, National and Historical Monuments, National Seashores, Wilderness Areas, Research Sites, and Similar Preserves

The project would enhance environmental conditions at these types of sites within the project area. For more information refer to **C.4.39.8.5.5.1 Sanctuaries and Refuges**.

C.4.39.8.8 Essential Fish Habitat

The Magnuson-Stevens Fishery Conservation and Management Act, Congress define Essential Fish Habitat (EFH) as "*...those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity*." Essential fish habitat includes all types of aquatic habitat—wetlands, coral reefs, seagrasses, and mangroves—where fish spawn, breed, feed, or grow to maturity. Three fishery management councils (FMC)—the Gulf of Mexico, South Atlantic, and U.S. Caribbean—are responsible for identifying EFH for federally managed species in the southeast United States. The definition of EFH may include habitat for an individual species or an assemblage of species, whichever is appropriate within each FMP. Also, highly migratory species, such as tunas, billfish, and sharks, are managed by NMFS and have EFH designations in these areas of the Southeast as well.

C.4.39.8.8.1 Essential Fish Habitat in the Area

The project area includes EFH within the Loxahatchee river system and estuary. EFH habitats include oyster reefs, SAV, and mangrove ecosystems. The on-shore project area is within the jurisdiction of the

South Atlantic Fishery Management Council (SAFMC). EFH is mapped within the Loxahatchee River, Jupiter Inlet, Indian River Lagoon, and waters immediately offshore for five management groups (National Marine Fisheries Service [NMFS] 2000): snapper-grouper complex (e.g., grouper, gray snapper, white grunt, red porgy), spiny lobster, coral, coral reefs, and live/hard bottom habitats of the South Atlantic Region (Ahermatypic stony corals, Black corals, Hermatypic stony corals, Octocorals, Pennatulacea), coastal migratory pelagics of the gulf of Mexico and South Atlantic (cobia, king mackerel, Spanish mackerel) and several highly migratory species.

C.4.39.8.8.2 Assessment of Effects on Hard bottom and Coral Reef Communities

This project is not expected to have an effect on coral reef or hard bottom communities in the project area. Coral reefs and hard bottom communities are located offshore of waters affected by the project.

C.4.39.8.8.3 Assessment of Effects on Sanctuaries and Refuges

The proposed project is intended to improve the quantity, timing, and distribution of water delivered to NWFLR and the Loxahatchee River estuary.

C.4.39.8.8.4 Assessment of Effects on Wetlands

Project specific assessment of effects on wetlands will be conducted during the PED phase to obtain accurate delineations of wetland impacts.

C.4.39.8.8.5 Assessment of Effects on Mud Flats

Project specific assessment of effects on mud flats will be conducted during the PED phase to obtain accurate delineations of special aquatic site impacts.

C.4.39.8.8.6 Assessment of Effects on Vegetated Shallows

SAV is present in the riverine system to nearshore waters. The typical species progression from the shoreline to the deeper waters: widgeon grass, turtle grass, manatee grass, shoal grass and Johnson's seagrass. Increase of freshwater flows to NWFLR would provide improvements to SAV, and the project is not anticipated to have any deleterious effects on SAV.

C.4.39.8.8.7 Assessment of Effects on Riffle and Pool Complexes

There are no riffle or pool complexes within the project footprint and none should be impacted by the project.

C.4.39.8.9 Assessment of Effects on Plankton

No adverse impacts to plankton are anticipated.

C.4.39.8.10 Assessment of Effects on Benthos

No adverse impacts to benthic organisms are anticipated other than displacement of those organisms in the construction footprint of the project.

C.4.39.8.11 Assessment of Effects on Nekton

There should be no adverse impacts to freshwater swimming aquatic organisms including fishes during construction. Estuarine fish species most likely to occur in these areas include the small forage species such as killifish (*Cyprinodon* spp. and *Fundulus* spp.), mosquito fish, juvenile sciaenids, silversides and mullets. Larger secondary consumers include gray snapper, tarpon, snook, red drum, and spotted seatrout. Freshwater deliveries through NWFLR would provide improved habitat and nursery opportunities for fishes in the estuary.

C.4.39.8.12 Determination of Effects on Essential Fish Habitat

The overall benefit to regional EFH is expected to be far greater than the localized adverse effects. The restoration of hydrology of the NWFLR within the Greater Everglades ecosystem and the increase in spatial extent of restored wetland acreage in the region would produce extensive cumulative beneficial effects. These beneficial effects are expected to substantially outweigh the cumulative adverse effects produced by the aquatic ecosystem alterations that may be necessary to construct some of the project components.

C.4.39.9 Determination of Cumulative Effects on the Aquatic Ecosystem

The overall benefit to the regional system is expected to be far greater than the localized adverse effects. The hydrologic restoration of the LRWRP within the Greater Everglades ecosystem and the increase in spatial extent of restored wetland acreage in the region would produce extensive cumulative beneficial effects. These beneficial effects are expected to substantially outweigh the cumulative adverse effects produced by the aquatic ecosystem alterations that may be necessary to construct some of the project features.

C.4.39.10 Determination of Secondary Effects on the Aquatic Ecosystem

No adverse secondary impacts on the aquatic ecosystem would occur as a result of the construction. During construction the sites would be contained with sedimentation barriers. Erosion would be controlled by appropriate erosion control techniques. Sedimentation would be controlled during construction. An ecological and water quality monitoring plan would be implemented during and after construction and specific environmental commitments, engineering and design commitments, and operational commitments would be incorporated to avoid, minimize, and/or mitigate for adverse effects.

C.4.39.11 Findings of Compliance or Non-compliance with the Restrictions on Discharge

No significant adaptations of the guidelines were made relative to this evaluation.

At the time of the project planning phase, no practicable alternatives exist which meet the study objectives involving discharge of some small fill into waters of the United States.

At this time, no practicable alternatives exist which have less adverse impact on the aquatic ecosystem without presenting other significant adverse environmental consequences. The alternatives all have overwhelming beneficial impacts.

The discharge of fill materials is not anticipated to cause or contribute to violations of any applicable state water quality standards for Class III waters or Outstanding Florida Waters where applicable. The discharge operation is not anticipated to violate the Toxic Effluent Standards of Section 307 of the Clean Water Act.

The placement of fill materials in the project area is not anticipated to jeopardize the continued existence of any species listed as threatened and endangered or result in the likelihood of destruction or adverse modification of any critical habitat as specified by the Endangered Species Act of 1973, as amended.

The placement of fill material is not anticipated to result in significant adverse effects on human health and welfare, including municipal and private water supplies, recreational and commercial fishing, plankton, fish, shellfish, wildlife, and special aquatic sites. The life stages of aquatic species and other wildlife is not anticipated to be adversely affected. Significant adverse effects on aquatic ecosystem diversity, productivity and stability, and recreational, aesthetic, and economic values are not anticipated.

Based on the guidelines, the proposed discharge site for the discharge of fill and/or dredged material is specified as complying with the requirements of these guidelines.

C.4.40 Public Interest Review

While USACE does not process and issue permits for its own activities, pursuant to 33 CFR 336.1, USACE authorizes its own discharges of dredged or fill material by applying all applicable substantive legal requirements, including public notice, opportunity for public hearing, and application of the section 404(b)(1) guidelines. As part of its review, the Corps evaluates the probable impacts, including cumulative impacts, of the proposed activity and its intended use on the public interest. All factors which may be relevant to the proposal must be considered including the cumulative effects thereof. These factors may include:

- Conservation
- Economics
- Aesthetic.
- General Environmental Concerns
- Wetlands
- Historic Properties
- Fish and Wildlife Values
- Flood Hazards
- Flood Plain Values
- Land Use
- Navigation
- Shore Erosion and Accretion
- Recreation
- Water Supply and Conservation
- Water Quality
- Energy Needs
- Safety
- Food and Fiber Production
- Mineral Needs
- Consideration of Property Ownership
- Needs and Welfare of the People

Finding: Based on the following public interest review (**Table C.4-2**), the USACE made a determination that the proposed activity is within the public interest.

Table C.4-2. Public Interest Review.

Factor	Analysis
Conservation	**Anadromous Fish Conservation Act**: The proposed action would not adversely affect anadromous fish species. **Clean Air Act of 1972**: The proposed action could cause temporary air quality impacts associated with construction emissions and dust. Contractors will implement BMPs to limit temporary impacts. **Resource Conservation and Recovery Act, as Amended by the Hazardous and Soils Waste Amendments of 1984; CERCLA as Amended by the 5.26.21 Superfund Amendments and Reauthorization Act of 1996; Toxic Substances Control Act of 1976**: FDEP is the responsible authority, delegated by EPA, for human health issues related to soil and water contamination. The SFWMD will obtain concurrence from the FDEP waste cleanup group that any remediation activity has been satisfactorily completed. USFWS is the authority with regards to ecological risk with regards to soil and water conditions. The SFWMD will also obtain concurrence from the USFWS that the project lands are suitable for intended use. The concurrence from these two agencies will constitute documentation that the project lands are suitable for intended use. **Estuary Protection Act of 1968:** The proposed action provides the opportunity to redirect water that is currently discharged via the SFWMD canal infrastructure to improve the quantity and seasonal timing to the NWFLR, thus reducing salinity in the river reach, increasing the distribution and quantity of tapegrass, improving floodplain hydrology, increasing the area of available manatee habitat, and expanding suitable oyster and sea grass habitat that benefit water quality and habitat functions within the Loxahatchee estuary. Other benefits also accrue. **E.O. 11514 Protection of the Environment**: The objectives of the proposed action are focused on environmental protection **E.O. 13089 Coral Reef Protection**: Coral reefs are not affected.
Economics	The proposed action would result in long-term economic benefits to the region through ecological restoration of impaired ecosystems, resulting in recreational and commercial fisheries resources benefits; enhanced terrestrial and aquatic recreational benefits; and surety in future land management scenarios.
Aesthetics	The proposed action would have temporary, local, short-term effects on the regional landscape and long-term effects would be beneficial in terms of restored wetlands functioning and appearance, and enhanced ecological communities.
General Environmental Concerns	**National Environmental Policy Act of 1969:** Initial public coordination for this project began with the distribution of a scoping letter dated January 6, 2015 announcing the preparation of the Draft EIS and inviting public and agency comment (Appendix C.3). A NOI to prepare an EIS was published in the Federal Register (FR Volume 80, Number 5) on January 8, 2016. Public scoping meetings were held on January 12, 2015.. The NOA of the LRWRP Draft PIR/EIS was published in the Federal Register on February 22, 2019 and mailed to interested stakeholders to begin the 45-day review period. Two NEPA Draft PIR/EIS public meetings are planned to be held in March, 2019. **Submerged Lands of 1953:** The proposed project would increase freshwater flows to the Loxahatchee Estuary and provide freshwater overland flow to Loxahatchee River that will ultimately benefit the ecological habitats that occur on submerged lands of

Factor	Analysis
	the State of Florida. The proposed project does not occur on submerged lands and no construction is expected on submerged lands.
Wetlands	**E.O. 11990 Protection of Wetlands:** The objectives of the proposed action are focused on environmental protection and, as required, will "minimize the destruction, loss or degradation of wetlands, and preserve and enhance the natural and beneficial values of wetlands."
Historic Properties	**Archaeological Resources Protection Act of 1979:** Further investigations may be needed within federally-owned lands (once the project is authorized and the Preconstruction, Engineering and Design (PED) phase has started. **National Historic Preservation Act of 1966:** Section 106 of the National Historic Preservation Act allows for a phased approach to compliance with this Act. Once the project is authorized and PED is implemented, further investigations and consultation will be conducted as necessary. Each suite of features will be consulted on as they arise to ensure that the most up to date information will be considered in the subsequent determination of effects. Consultation has been initiated and is ongoing with the Florida SHPO and the appropriate federally-recognized tribes pursuant to the Act. The Corps is currently coordinating a Programmatic Agreement with Florida SHPO and the Advisory Council on Historic Preservation to conduct a phased identification and evaluation of historic properties during the project's design phase and prior to conclusion of NEPA. Dependent on further consultation with the Florida SHPO and the results of Phase I cultural resources investigations, project design modification may be necessary to avoid or minimize impact to historic properties. Phase II National Register of Historic Places eligibility testing or mitigation may be required if impacts cannot be avoided. **Native American Graves Protection and Repatriation Act:** This Act applies to Federal owned lands, including Reservation lands. "Human remains and/or funerary objects were not recovered during excavations on Federally owned or managed lands during the course of this feasibility study. Should inadvertent discoveries occur within ENP during PED or construction phases of the LRWRP, procedures established by ENP will be followed. Ground disturbing activities will not occur on Reservation Lands." Neither human remains nor funerary objects were recovered during excavations on federally owned or managed lands during the course of this feasibility study. **E.O. 11593 Protection and Enhancement of the Cultural Environment:** The purpose of this E.O. has been incorporated in Section 110 of the National Historic Preservation Act. Consultation is ongoing to ensure compliance for this E.O. **E.O 13007 Indian Sacred Sites:** This E.O. is directed towards executive branch agencies with statutory or administrative responsibility for the management of federal lands. The proposed action would not affect lands owned by the Department of Defense or managed by the Corps of Engineers Natural Resource Management Program. **E.O. 13175 Consultation and Coordination with Indian Tribal Governments:** Consultation with members and representatives of the Seminole Tribe of Florida and the Miccosukee Tribe of Indians of Florida have been ongoing. See Appendix C.3 and Appendix C.5 for specifics. Pursuant to E.O. 13175, the Corps developed the November 01, 2012 Tribal Policy Memorandum, which dictates Federal responsibilities, including Trust Responsibilities, to federally recognized Tribes. **Memorandum on Government to Government Regulations with Native American Tribal Governments:** The USACE has consulted with the Miccosukee Tribe of Indians of Florida and Seminole Tribe of Florida throughout the LRWRP planning process (see Appendix C.3 and Appendix C.5).

Factor	Analysis
Fish and Wildlife Values	**Bald and Golden Eagle Protection Act:** The project will implement the National Bald Eagle Management Guidelines (2007) as applicable and the proposed action would not adversely affect the bald eagle (the resident eagle in Florida). **Endangered Species Act of 1973:** USACE submitted a Biological Assessment to USFWS in February, 2019 to initiate consultation for potential project effects to T&E species. The Corps requested formal consultation with USFWS on the Everglade snail kite, but not its designated critical habitat, West Indian manatee, and its designated critical habitat, wood stork, Audubon's crested caracara, red-cockaded woodpecker, Florida bonneted bat, Florida panther, eastern indigo snake, and Okeechobee gourd. The Corps' determination is that the proposed project is not likely to jeopardize the continued existence of the species listed above and is not likely to adversely modify critical habitat, where designated. A programmatic Endangered Species Act Section 7 consultation for the Comprehensive Everglades Restoration Plan (CERP) was prepared on March 15, 2013 to evaluate potential effects of CERP on listed species and designated critical habitat under the NMFS' purview. The Corps provided a Programmatic Biological Assessment for the Comprehensive Everglades Restoration Plan to NMFS on July 2, 2013. NMFS provided a Programmatic Biological Opinion for the Comprehensive Everglades Restoration Plan to the Corps on December 17, 2013. **Fish and Wildlife Coordination Act of 1958, as amended:** The USACE coordinated with USFWS, which participated on the PDT to provide information on fish and wildlife elements of the project. The USFWS provided a draft Fish and Wildlife Coordination Act (FWCA) Report on February 1, 2019 (Annex A). The Corps' responses to the FWCA Report recommendations will be included in the Final PIR/EIS in Annex A.3. **Magnuson-Stevens Fishery Conservation and Management Act:** An Essential Fish Habitat (EFH) assessment was covered by the Programmatic NMFS NEPA consultation (Appendix C.2.7). To document compliance, the USACE provided a letter that includes the EFH assessment to NMFS with the Notice of Availability of the DEIS. USACE will implement relevant recommendations of the programmatic consultation. **Marine Mammal Protection Act of 1972:** Project construction sites would be isolated from West Indian manatees to limit access and avoid incidental take of manatees. USACE will implement standard manatee construction conditions, where necessary, to protect manatees during construction. No take of manatees is anticipated. **E.O. 12962 Recreational Fisheries:** The proposed action would have a beneficial effect on recreational fisheries in Loxahatchee river and estuary. **E.O. 13122 Invasive Species:** A nuisance and exotic vegetation control plan has been prepared to prevent or reduce establishment of invasive and non-native species within the project area (Annex G). **E.O. 13186, Responsibilities of Federal Agencies to Protect Migratory Birds:** The proposed action would not adversely affect migratory bird species, and is expected to benefit species by improving habitat and increasing availability of foraging opportunities. **FAA Memorandum of Agreement – Aircraft – Wildlife Strike Hazards:** The USACE prepared an analysis of NPIAS airports relative to project features as required by the memorandum.
Flood Hazards	The proposed project will not increase the risk of flooding to existing properties.
Flood Plain Values	**Wild and Scenic River Act of 1968:** The NWFLR is a designated wild and scenic river and is the beneficiary of the project.

Factor	Analysis
	E.O. 11988 Flood Plain Management: The commitment of lands to restoration precludes development and discourages federally-induced development of floodplains.
Land Use	**Farmland Protection Policy Act of 1981:** USACE coordinated with USDA/NRCS to meet the requirements of the Farmland Protection Act and received a determination on 11/15/2018 from NRCS; the determination indicated that restoring wetlands will not affect acreages of agricultural land, particularly grazable pasture; only the reservoir will result in farmland loss. NRCS will update their determination of acres of unique farmland that would be affected by the project when detailed design information for each plan component is available.
Navigation	**Rivers and Harbors Act of 1899:** Proposed action would not obstruct navigable waters of the United States.
Shore Erosion and Accretion	**Coastal Barrier Resources Act of 1982 and Coastal Barrier Improvement Act of 1990:** The proposed project would not affect Otherwise Protected Area Jupiter Beach (CBRS Unit FL-16P), at the mouth of the Jupiter Inlet; therefore, there are no designated coastal barrier resources in the project area that would be affected by this project. **Coastal Zone Management Act of 1972:** Florida Coastal Zone Consistency Determination was prepared in accordance with the provisions of 15 CFR 930 and is located in Appendix C.4, Section C.4.32. The USACE has determined that the proposed action is consistent to the maximum extent practicable with the enforceable policies of Florida's approved Coastal Zone management program. Final Coastal Zone Management Act consistency will be provided by the State Water Quality Certification.
Recreation	**Federal Water Project Recreation Act/Land and Water Conservation Fund Act:** Effects of the proposed action on outdoor recreation were considered in Section 5.2.15.3 and Appendix C.2.15. Recreational opportunities have been considered and the proposed action would not adversely affect existing recreational opportunities.
Water Supply and Conservation	**Seminole Indian Claims Settlement Act of 1987:** This Act also involves an agreement known as the Water Rights Compact, which specifically defines tribal water rights. This Act is not applicable in this geographic area.
Water Quality	**Clean Water Act of 1972:** In accordance with the Clean Water Act, a Section 404(B)(1) Evaluation has been completed and is contained within Appendix C.4, Section C.4.32. Comprehensive Everglades Restoration Plan Regulation Act (CERPRA) permit would be sought from the State of Florida for Water Quality Certification.
Energy Needs	Fossil fuel energy sources will be required to construct the features comprising the proposed action, and to operate various facilities thereafter for the life of the project. The project is not proposed to be dependent on alternate energy sources such as solar, wind power, or nuclear energy production. This project does not involve the exploration; drilling or production of gas, oil or petroleum products.
.Safety	Construction and operation of the proposed project will comply with federal safety standards. Proposed features have been designed to meet currently approved infrastructure safety standards.
Food and Fiber Production	**Farmland Protection Policy Act of 1981:** USACE coordinated with USDA/NRCS to meet the requirements of the Farmland Protection Act and received a determination on 11/15/2018 from NRCS; the determination indicated that restoring wetlands will not affect acreages of agricultural land, particularly grazable pasture; only the reservoir will result in farmland loss. NRCS will update their determination of acres of unique farmland that would be affected by the project when detailed design information for each plan component is available.

Factor	Analysis
Mineral Needs	The proposed project would not adversely affect existing mining operations; mining operations would be ongoing until the life of the mine was expended.
Consideration of Property Ownership	A complete analysis of real estate interests was conducted. Real estate interests would be acquired as necessary to complete the project.
Needs and Welfare of the People	**American Indian Religious Freedom Act:** The policy of the U.S. on and after August 11, 1978, is to protect and preserve for American Indians, Alaska Native Groups (Eskimo, Aleut), and Native Hawaiians, their inherent right of freedom to believe, express, and exercise traditional religions, including but not limited to access to sites, use and possession of sacred objects, and the freedom to worship through ceremonials and traditional rites. (Pub. L. 95–341, § 1, Aug. 11, 1978, 92 Stat. 469.) **E.O. 12898 Environmental Justice:** LRWRP does not present any environmental impacts that are high, adverse, and disproportionate to low income, or minority populations. Sufficient scoping and public participation ensured potential impacts were understood by the public. No comments were presented as possible environmental impacts that may be disproportionate to low income or minority populations. **E.O. 13045 Protection of Children:** Proposed action is not expected to have environmental or safety risks that may disproportionately affect children.

C.4.41 Coastal Zone Management Act Consistency Statement

FLORIDA COASTAL MANAGEMENT PROGRAM

FEDERAL CONSISTENCY EVALUATION PROCEDURES

Loxahatchee River Watershed Restoration Project

Martin and Palm Beach, Counties

Enforceable Policy. Florida State Statues considered "enforceable policy" under the Coastal Zone Management Act (www.dep.state.fl.us/cmp/federal/24_statutes.htm).

Applicability of the Coastal Zone Management Act.

Table C.4- summarizes the process and procedures under the Coastal Zone Management Act for Federal Actions and for non-Federal Applicants*.

Table C.4-3. Coastal Zone Management Act processes and procedures.

Item	Non-Federal Applicant (15 CFR 930, subpart D)	Federal Action (15 CFR 930, subpart C)
Enforceable Policies	Reviewed and approved by NOAA (in FL www.dep.state.fl.us/cmp/federal/24_statutes.htm)	Same
Effects Test	Direct, Indirect (cumulative, secondary), adverse or beneficial	Same
Review Time	6 months from state receipt of Consistency Certification (30-days for completeness notice) Can be altered by written agreement between State and applicant	60 Days, extendable (or contractible) by mutual agreement
Consistency	Must be Fully Consistent	To Maximum Extent Practicable**
Procedure Initiation	Applicant provides Consistency Certification to State	Federal Agency provides "Consistency Statement" to State
Appealable	Yes, applicant can appeal to Secretary (NOAA)	No (NOAA can "mediate")
Activities	Listed activities with their geographic location (State can request additional listing within 30 days)	Listed or Unlisted Activities in State Program
Activities in Another State	Must have approval for interstate reviews from NOAA	Interstate review approval NOT required
Activities in Federal Waters	Yes, if activity affects state waters	Same

* There are separate requirements for activities on the Outer Continental Shelf (subpart E) and for "assistance to an applicant agency" (subpart F).
** Must be fully consistent except for items prohibited by applicable law (generally does not count lack of funding as prohibited by law, 15 CFR 930.32).

Coastal Zone Consistency Statement by Statute/Enforceable Policy

CHAPTER 161, F.S., BEACH AND SHORE PRESERVATION

Coastal areas are among the state's most valuable natural, aesthetic, and economic resources; and they provide habitat for a variety of plant and animal life. The state is required to protect coastal areas from imprudent activities that could jeopardize the stability of the beach-dune system, accelerate erosion, provide inadequate protection to upland structures, endanger adjacent properties, or interfere with public beach access. Coastal areas used, or likely to be used, by sea turtles are designated for nesting, and the removal of vegetative cover that binds sand is prohibited. This statute provides policy for the regulation of construction, reconstruction, and other physical activities related to the beaches and shores of the state. Additionally, this statute requires the restoration and maintenance of critically eroding beaches.

Response: The proposed plans and information would be submitted to the state in compliance with this chapter. No work is proposed seaward of the mean high water line and would not affect shorelines or shoreline processes.

CHAPTER 163, PART II, F.S., INTERGOVERNMENTAL PROGRAMS: GROWTH POLICY, COUNTY AND MUNICIPAL PLANNING: LAND DEVELOPMENT REGULATION

The purpose of this statute is to provide for the implementation of comprehensive planning programs to guide and control future development in the state. The comprehensive planning process encourages units of local government to preserve, promote, protect, and improve the public health, safety, comfort, good order, appearance, convenience, law enforcement and fire prevention, and general welfare; prevent the overcrowding of land and avoid undue concentration of population; facilitate the adequate and efficient provision of public facilities and services; and conserve, develop, utilize, and protect natural resources within their jurisdictions.

Chapter 163, Part II Intergovernmental Programs: Growth Policy; County and Municipal Planning; Land Development Regulation

Enforceable policy includes only:

Sections 163.3164 Local Government Comprehensive Planning and Land Development Regulation Act; definitions;

.3177(6)(a) requiring a future land use plan element designating proposed future general distribution, location, and extent of the uses of land for residential uses, commercial uses, industry, agriculture, recreation, conservation, education, public buildings and grounds, other public facilities, and other categories of the public and private uses of land.

(10)(h). public facilities and services needed to support development shall be available concurrent with the impacts of such development in accordance with s. 163.3180. [see .3180(2)(a-c), (5)(a&c), (6), and (8); below].

(10)(l). consider land use compatibility issues in the vicinity of all airports in coordination with the Department of Transportation and adjacent to or in close proximity to all military installations in coordination with the Department of Defense.

(11)(a). innovative approaches to development which may better serve to protect environmentally sensitive areas, maintain the economic viability of agricultural and other predominantly rural land uses, and provide for the cost-efficient delivery of public facilities and services.

(11)(c). maximize the use of existing facilities and services through redevelopment, urban infill development, and other strategies for urban revitalization.

.3178(1) local government comprehensive plans restrict development activities where such activities would damage or destroy coastal resources, and that such plans protect human life and limit public expenditures in areas that are subject to destruction by natural disaster.

(2)(d-j); studies, surveys, and data; be consistent with coastal resource plans prepared and adopted pursuant to general or special law; and contain:

(d) A component which outlines principles for hazard mitigation and protection of human life against the effects of natural disaster, including population evacuation, which take into consideration the capability to safely evacuate the density of coastal population proposed in the future land use plan element in the event of an impending natural disaster. The Division of Emergency Management shall manage the update of the regional hurricane evacuation studies, ensure such studies are done in a consistent manner, and ensure that the methodology used for modeling storm surge is that used by the National Hurricane Center.

(e) A component which outlines principles for protecting existing beach and dune systems from human-induced erosion and for restoring altered beach and dune systems.

(f) A redevelopment component which outlines the principles which shall be used to eliminate inappropriate and unsafe development in the coastal areas when opportunities arise.

(g) A shoreline use component that identifies public access to beach and shoreline areas and addresses the need for water-dependent and water-related facilities, including marinas, along shoreline areas. Such component must include the strategies that will be used to preserve recreational and commercial working waterfronts as defined in s. 342.07.

(h) Designation of coastal high-hazard areas and the criteria for mitigation for a comprehensive plan amendment in a coastal high-hazard area as defined in subsection (9). The coastal high-hazard area is the area below the elevation of the category 1 storm surge line as established by a Sea, Lake, and Overland Surges from Hurricanes (SLOSH) computerized storm surge model. Application of mitigation and the application of development and redevelopment policies, pursuant to s. 380.27(2), and any rules adopted thereunder, shall be at the discretion of local government.

(i) A component which outlines principles for providing that financial assurances are made that required public facilities will be in place to meet the demand imposed by the completed development or redevelopment. Such public facilities will be scheduled for phased completion to coincide with demands generated by the development or redevelopment.

(j) An identification of regulatory and management techniques that the local government plans to adopt or has adopted in order to mitigate the threat to human life and to control proposed development and redevelopment in order to protect the coastal environment and give consideration to cumulative impacts.

.3180(2)(a-c), (a) Consistent with public health and safety, sanitary sewer, solid waste, drainage, adequate water supplies, and potable water facilities shall be in place and available to serve new development no later than the issuance by the local government of a certificate of occupancy or its functional equivalent. Prior to approval of a building permit or its functional equivalent, the local government shall consult with the applicable water supplier to determine whether adequate water supplies to serve the new development will be available no later than the anticipated date of issuance by the local government of a certificate of occupancy or its functional equivalent. A local government may meet the concurrency requirement for sanitary sewer through the use of onsite sewage treatment and disposal systems approved by the Department of Health to serve new development.

(b) Consistent with the public welfare, and except as otherwise provided in this section, parks and recreation facilities to serve new development shall be in place or under actual construction no later than 1 year after issuance by the local government of a certificate of occupancy or its functional equivalent. However, the acreage for such facilities shall be dedicated or be acquired by the local government prior to issuance by the local government of a certificate of occupancy or its functional equivalent, or funds in the amount of the developer's fair share shall be committed no later than the local government's approval to commence construction.

(c) Consistent with the public welfare, and except as otherwise provided in this section, transportation facilities needed to serve new development shall be in place or under actual construction within 3 years after the local government approves a building permit or its functional equivalent that results in traffic generation.

(5)(a) & (c),

(a) … planning and public policy goals may come into conflict with the requirement that adequate public transportation facilities and services be available concurrent with the impacts of such development. … in urban centers transportation cannot be effectively managed and mobility cannot be improved solely through the expansion of roadway capacity, that the expansion of roadway capacity is not always physically or financially possible, and that a range of transportation alternatives is essential to satisfy mobility needs, reduce congestion, and achieve healthy, vibrant centers.

(c) … developments located within urban infill, urban redevelopment, urban service, or downtown revitalization areas or areas designated as urban infill and redevelopment areas under s. 163.2517, which pose only special part-time demands on the transportation system, are exempt from the concurrency requirement for transportation facilities. A special part-time demand is one that does not have more than 200 scheduled events during any calendar year and does not affect the 100 highest traffic volume hours.

(6) a *de minimis* impact [on a transportation facility] is consistent with this part.

(8) When assessing the transportation impacts of proposed urban redevelopment within an established existing urban service area, 110 percent of the actual transportation impact caused by the previously existing development must be reserved for the redevelopment…

.3194(1)(a); After a comprehensive plan, or element or portion thereof, has been adopted in conformity with this act, all development undertaken by, and all actions taken in regard to development orders by, governmental agencies in regard to land covered by such plan or element shall be consistent with such plan or element as adopted.

.3202(2)(a-h); Local land development regulations shall contain specific and detailed provisions necessary or desirable to implement the adopted comprehensive plan and shall as a minimum:

(a) Regulate the subdivision of land.

(b) Regulate the use of land and water for those land use categories included in the land use element and ensure the compatibility of adjacent uses and provide for open space.

(c) Provide for protection of potable water wellfields.

(d) Regulate areas subject to seasonal and periodic flooding and provide for drainage and stormwater management.

(e) Ensure the protection of environmentally sensitive lands designated in the comprehensive plan.

(f) Regulate signage.

(g) Provide that public facilities and services meet or exceed the standards established in the capital improvements element required by s. 163.3177 and are available when needed for the development, or that development orders and permits are conditioned on the availability of these public facilities and services necessary to serve the proposed development. Not later than 1 year after its due date established by the state land planning agency's rule for submission of local comprehensive plans pursuant to s. 163.3167(2), a local government shall not issue a development order or permit which results in a reduction in the level of services for the affected public facilities below the level of services provided in the comprehensive plan of the local government.

(h) Ensure safe and convenient onsite traffic flow, considering needed vehicle parking.

.3220(2) & (3).

(2) (a) The lack of certainty in the approval of development can result in a waste of economic and land resources, discourage sound capital improvement planning and financing, escalate the cost of housing and development, and discourage commitment to comprehensive planning.

(b) Assurance to a developer that upon receipt of his or her development permit or brownfield designation he or she may proceed in accordance with existing laws and policies, subject to the conditions of a development agreement, strengthens the public planning process, encourages sound capital improvement planning and financing, assists in assuring there are adequate capital facilities for the development, encourages private participation in comprehensive planning, and reduces the economic costs of development.

(3) In conformity with, in furtherance of, and to implement the Local Government Comprehensive Planning and Land Development Regulation Act and the Florida State Comprehensive Planning Act of 1972, it is the intent of the Legislature to encourage a stronger commitment to comprehensive and capital facilities planning, ensure the provision of adequate public facilities for development, encourage the efficient use of resources, and reduce the economic cost of development.

Response: The proposed project has been coordinated with various federal, state and local agencies during the planning process. The project meets the primary goal of the State Comprehensive Plan through preservation and protection of the environment.

CHAPTER 186, F.S., STATE AND REGIONAL PLANNING

The state comprehensive plan provides basic policy direction to all levels of government regarding the orderly social, economic, and physical growth of the state. The goals, objectives, and policies of the state comprehensive plan are statewide in scope and are consistent and compatible with each other. The statute provides direction for the delivery of governmental services, a means for defining and achieving the specific goals of the state, and a method for evaluating the accomplishment of those goals.

Response: The proposed project has been coordinated with various federal, state and local agencies during the planning process. The project meets the primary goal of the State Comprehensive Plan through preservation and protection of the environment.

CHAPTER 252, F.S., EMERGENCY MANAGEMENT

The state of Florida is vulnerable to a wide range of emergencies, including natural, technological, and manmade disasters and this vulnerability is exacerbated by the tremendous growth in the state's population, especially the growth in the number of persons residing in coastal areas, in the elderly population, in the number of seasonal vacationers, and in the number of persons with special needs. This statute directs the state to reduce the vulnerability of its people and property to natural and manmade disasters; prepare for, respond to and reduce the impacts of disasters; and decrease the time and resources needed to recover from disasters. Disaster mitigation is necessary to ensure the common defense of Floridians' lives and to protect the public peace, health, and safety. The policies provide the means to assist in the prevention or mitigation of emergencies that may be caused or aggravated by the inadequate planning or regulation of facilities and land uses. State agencies are directed to keep land uses and facility construction under continuing study and identify areas that are particularly susceptible to natural or manmade catastrophic occurrences.

Response: This project is a restoration project and provides increased ability to store water in the natural system during hurricanes or floods. All structures will be built to federal and state standards. This project would be consistent with the efforts of the Division of Emergency Management.

CHAPTER 253, F.S., STATE LANDS

The Board of Trustees of the Internal Improvement Trust Fund (Trustees) is vested and charged with the acquisition, administration, management, control, supervision, conservation, protection, and disposition of all lands owned by the state. Lands acquired for preservation, conservation and recreation serve the public interest by contributing to the public health, welfare, and economy. In carrying out the requirements of this statute, the Trustees are directed to take necessary action to fully: conserve and protect state lands; maintain natural conditions; protect and enhance natural areas and ecosystems; prevent damage and depredation; and preserve archaeological and historical resources. All submerged lands are considered single-use lands to be maintained in natural condition for the propagation of fish and wildlife and public recreation. Where multiple-uses are permitted, ecosystem integrity, recreational benefits, and wildlife values are conserved and protected.

Chapter 253 State Lands

No lease of the type covered by this law shall be granted, sold, or executed south of 26° north latitude off Florida's west coast and south of 27° north latitude off Florida's east coast…. After July 31, 1990, no oil or natural gas lease shall be granted, sold, or executed covering lands located north of 26°00'00" north latitude off Florida's west coast to the western boundary of the state bordering Alabama … or located north of 27°00'00" north latitude off Florida's east coast to the northern boundary of the state bordering Georgia ….

Response: The proposed project would conserve, protect, restore and enhance natural conditions within state lands. This project would make a positive contribution to preserving water, fish and wildlife, cultural, and wetland resources within the State of Florida and therefore, complies with the intent of this chapter.

CHAPTER 258, F.S., STATE PARKS AND PRESERVES

The statute addresses the state's administration of state parks, aquatic preserves, and recreation areas, which are acquired to emblemize the state's natural values and to ensure that these values are conserved for all time. Parks and preserves are managed for the non-depleting use, enjoyment, and benefit of Floridians and visitors and to contribute to the state's tourist appeal. Aquatic Preserves are recognized as having exceptional biological, aesthetic, and scientific value and are set aside for the benefit of future generations. Disruptive physical activities and polluting discharges are highly restricted in aquatic preserves. State managed wild and scenic rivers possess exceptionally remarkable and unique ecological, fish and wildlife, and recreational values and are designated for permanent preservation and enhancement for both the present and future.

Response: The proposed project would help enhance environmental conditions at state parks, recreation areas, and aquatic preserves in the region. The proposed project would comply with the intent of this chapter.

State Parks: JDSP is a 11,500-acre park supporting rare environments such as costal sand hills, upland lakes, and scrub forests as well as the pristine Loxahatchee River. DePuis Reserve: John G. and Susan H. DuPuis, Jr. Wildlife and Environmental Area (WEA) consists of nearly 22,000 acres in northwestern Palm Beach and southwestern Martin counties and adjoins the J.W. Corbett Wildlife Management Area to the east.

Aquatic Preserve: The Loxahatchee River/ Lake Worth Creek Aquatic Preserve, a state aquatic preserve and part of Florida's "Save Our Rivers" program, encompasses the upper NWFLR, approximately 10.3 miles of which is designated as a "Wild and Scenic River", located in Martin and Palm Beach counties, and lies between the town of Jupiter and village of Tequesta. The Lake Worth Creek section connects south to the Lake Worth Lagoon. The Jupiter Inlet and central embayment open easterly to the Indian River Lagoon and the Atlantic Ocean. The remaining sections consist of three major tributaries, the North Fork, Northwest Fork, and Southwest Fork (C-18 canal) (DEP & SFWMD, 2010; DEP, n.d.-c). The proposed project would improve freshwater delivery to NWFLR and associated floodplain wetlands and Loxahatchee estuary, which would be beneficial for EFH and key nongame and recreational fish species, and change the salinity profile in the estuary to improve water quality for cypress-dominated floodplain wetlands.

Recreation Areas: J. W. Corbett Wildlife Management Area comprises 60,348 acres of wildlife-rich habitats open to a wide range of recreation. The John C. and Mariana Jones/Hungryland WEA comprises more than 16,600 acres in Martin and Palm Beach counties, 7 miles west of Jupiter, and includes a portion of the Great Florida Birding Trail. The Palm Beach County Solid Waste Authority (SWA) Greenway Trail System includes 300 acres of natural area designated during the development of the SWA landfill and waste-to-energy facility to serve as a conservation area. Tucked away in the SWA conservation area is a large rookery that harbors thousands of native birds, including two endangered species, the Everglade snail kite and the wood stork. Project actions will complement existing projects to improve local hydrology on these areas.

CHAPTERS 259, F.S., LAND ACQUISITION FOR CONSERVATION OR RECREATION

The statute addresses public ownership of natural areas for purposes of maintaining the state's unique natural resources; protecting air, land, and water quality; promoting water resource development to meet the needs of natural systems and citizens of this state; promoting restoration activities on public lands; and providing lands for natural resource based recreation. Lands are managed to protect or restore their natural resource values, and provide the greatest benefit, including public access, to the citizens of this state.

Response: The potentially affected property is currently in public ownership. These chapters do not apply.

CHAPTERS 260, F.S., FLORIDA GREENWAYS AND TRAILS ACT

A statewide system of greenways and trails is established in order to conserve, develop, and use the natural resources of Florida for healthful and recreational purposes. These greenways and trails provide open space benefiting environmentally sensitive lands and wildlife and provide people with access to healthful outdoor activities. The greenways and trails serve to implement the concepts of ecosystem management while providing, where appropriate, recreational opportunities such as horseback riding, hiking, bicycling, canoeing, jogging, and historical and archaeological interpretation.

Response: The potentially affected property is currently in public ownership. This project is in compliance with the intent of this chapter.

CHAPTER 267, F.S., HISTORICAL RESOURCES

The management and preservation of the state's archaeological and historical resources are addressed by this statute. This statute recognizes the state's rich and unique heritage of historical resources and directs the state to locate, acquire, protect, preserve, operate, and interpret historical and archeological resources for the benefit of current and future generations of Floridians. Objects or artifacts with intrinsic historical or archeological value located on, or abandoned on, state-owned lands or state-owned submerged lands belong to the citizens of the state. The state historic preservation program operates in conjunction with the National Historic Preservation Act of 1966 to require state and federal agencies to consider the effect of their direct or indirect actions on [significant] historical and archeological resources. These resources cannot be destroyed or altered unless no prudent alternative exists. Unavoidable impacts must be mitigated.

Response: The U.S. Army Corps of Engineers has initiated consultation under Section 106 of the National Historic Preservation Act with the State Historic Preservation Officer, the Miccosukee Tribe of Indians of Florida, and the Seminole Tribe of Florida and would meet all responsibilities under Chapter 267.

CHAPTER 288, F.S., COMMERCIAL DEVELOPMENT AND CAPITAL IMPROVEMENTS

The framework to promote and develop general business, trade, and tourism components of the state economy are established in this statute. The statute includes requirements to protect and promote the natural, coastal, historical, and cultural tourism assets of the state; foster the development of nature-based tourism and recreation; and upgrade the image of Florida as a quality destination. Natural resource-based tourism and recreational activities are critical sectors of Florida's economy. The needs of the environment must be balanced with the need for growth and economic development.

Response: The proposed project would be compatible with tourism for this area and therefore, is consistent with the goals of this chapter.

CHAPTER 334, F.S., TRANSPORTATION ADMINISTRATION

The statute addresses the state's policy concerning transportation administration. It establishes the responsibilities of the state, the counties, and the municipalities in the planning and development of the transportation systems serving the people of the state and to assure the development of an integrated, balanced statewide transportation system. This is necessary for the protection of public safety and general welfare and for the preservation of all transportation facilities in the state.

Response: No public transportation systems would be impacted by this project.

CHAPTER 339, F.S., TRANSPORTATION FINANCE AND PLANNING

The statute addresses the finance and planning needs of the state's transportation system.

Response: No public transportation systems would be impacted by this project.

CHAPTER 370, F.S., SALTWATER LIVING RESOURCES

This chapter directs the state to preserve, manage and protect the marine, crustacean, shell and anadromous fishery resources in state waters; to protect and enhance the marine and estuarine environment; to regulate fishermen and vessels of the state engaged in the taking of such resources within or without state waters; to issue licenses for the taking and processing products of fisheries; to secure and maintain statistical records of the catch of each such species; and to conduct scientific, economic, and other studies and research.

Response: The proposed project would help improve ecological conditions in the Loxahatchee Estuary and Jupiter Inlet. Implementation of the project would provide direct positive impacts on saltwater resources within the Loxahatchee Estuary and Jupiter Inlet by improving the seasonal frequency and volume of reduced flows to NWFLR, and improve the salinity balance in branches of the Loxahatchee River. This will benefit seagrass, oysters, fish, and wildlife. Implementation of the proposed project would provide direct positive impacts on saltwater resources within Loxahatchee Estuary by enhancing freshwater runoff from the watershed to provide a more natural and historic overland flow through strands, wetlands, creeks, and existing drainages that will reduce the extent of the salinity wedge in the

river and improve the overall salinity balance. This water quality improvement would provide benefits for fisheries and wildlife, including key species such as seatrout, baitfish, and snapper-grouper complex as well as seagrass. Based on the overall effects, the project is consistent with the goals of this chapter.

CHAPTER 372, F.S., LIVING LAND AND FRESHWATER RESOURCES

This chapter establishes the Game and Freshwater Fish Commission (now called the Florida Fish and Wildlife Conservation Commission) and directs it to manage freshwater aquatic life and wild animal life and their habitat to perpetuate a diversity of species with densities and distributions that provide sustained ecological, recreational, scientific, educational, aesthetic, and economic benefits.

Response: The proposed project would have a long-term beneficial effect on freshwater aquatic life and wildlife. The proposed project would increase the foraging opportunities for wading birds and other wildlife. The proposed project is consistent with the intent of this chapter.

CHAPTER 373, F.S., WATER RESOURCES

The waters in the state of Florida are managed and protected to conserve and preserve water resources, water quality, and environmental quality. This statute addresses sustainable water management; the conservation of surface and ground waters for full beneficial use; the preservation of natural resources, fish, and wildlife; protecting public land; and promoting the health and general welfare of Floridians. The state manages and conserves water and related natural resources by determining whether activities will unreasonably consume water; degrade water quality; or adversely affect environmental values such as protected species habitat, recreational pursuits, and marine productivity.

Specifically, under Part IV of Chapter 373, the Department of Environmental Protection, water management districts, and delegated local governments review and take agency action on wetland resource, environmental resource, and stormwater permit applications, which address the construction, alteration, operation, maintenance, abandonment, and removal of any stormwater management system, dam, impoundment, reservoir, or appurtenant work or works, including dredging, filling and construction activities in, on, and over wetlands and other surface waters.

Response: The proposed project incorporates restoration components primarily intended to benefit freshwater wetlands and estuarine resources by distributing freshwater flows through the Loxahatchee riverine and estuarine systems. The goals and objectives of this project are to improve habitat conditions for native wildlife species. Impacts of this project have been detailed within an Environmental Impact Statement and in the Section 404(b)(1) Clean Water Act Evaluation (Appendix C.4.38). This project is in compliance with the intent of this chapter.

The non-federal sponsor for this project is the SFWMD, which is the state agency responsible for implementing this statute. The USACE and the SFWMD have coordinated planning efforts to ensure compatibility with established policies. The project is consistent with the goals of this chapter.

CHAPTER 375, F.S., OUTDOOR RECREATION AND CONSERVATION LANDS

The statute addresses the development of a comprehensive multipurpose outdoor recreation plan. The purpose of the plan is to document recreational supply and demand, describe current recreational opportunities, estimate the need for additional recreational opportunities, and propose the means to meet the identified needs.

Response: The potentially affected property is currently in public ownership. This project is in compliance with the intent of this chapter.

CHAPTER 376, F.S., POLLUTANT DISCHARGE PREVENTION AND REMOVAL

Regulating the transfer, storage, and transportation of pollutants, and the cleanup of pollutant discharges is essential for maintaining the coastal waters, estuaries, tidal flats, beaches, and public lands adjoining the seacoast in as close to a pristine condition as possible. The preservation of the seacoast as a source of public and private recreation and the preservation of water and certain lands are matters of the highest urgency and priority. This statute provides a framework for the protection of the state's coastline from spills, discharges, and releases of pollutants as a result of the transfer, storage, and transportation of such products. The discharge of pollutants into or upon any coastal waters, estuaries, tidal flats, beaches, and lands adjoining the seacoast of the state is prohibited. The statute provides for hazards and threats of danger and damages resulting from any pollutant discharge to be evaluated; requires the prompt containment and removal of pollution; provides penalties for violations; and ensures the prompt payment of reasonable damages from a discharge. Portions of Chapter 376, F.S., serve as a complement to the national contingency plan portions of the federal Water Pollution Control Act.

Response: The contract specifications would prohibit the contractor from dumping oil, fuel, or hazardous wastes in the work area and would require that the contractor adopt safe and sanitary measures for the disposal of solid wastes. A spill prevention plan would be required.

CHAPTER 377, F.S., ENERGY RESOURCES

The statute addresses the regulation, planning, and development of the energy resources of the state. The statute provides policy to conserve and control the oil and gas resources in the state, including products made therefrom and to safeguard the health, property, and welfare of Floridians. The Department of Environmental Protection (DEP) is authorized to regulate all phases of exploration, drilling, and production of oil, gas, and other petroleum products in the state. The statute describes the permitting requirements and criteria necessary to drill and develop for oil and gas. DEP rules ensure that all precautions are taken to prevent the spillage of oil or any other pollutant in all phases of extraction and transportation. The state explicitly prohibits pollution resulting from drilling and production activities. No person drilling for or producing oil, gas, or other petroleum products may pollute land or water; damage aquatic or marine life, wildlife, birds, or public or private property; or allow any extraneous matter to enter or damage any mineral or freshwater-bearing formation. Penalties for violations of any provisions of this chapter are detailed.

Chapter 377 Energy Resources

Not approved as enforceable policy: Sections 377.06, .24(9), and .242(1)(a)5. All deal with regulation of oil and gas resources.

Response: This project does not involve the exploration; drilling or production of gas, oil or petroleum product and therefore, this chapter does not apply.

CHAPTER 379, F.S., FISH AND WILDLIFE CONSERVATION

The framework for the management and protection of the state of Florida's wide diversity of fish and wildlife resources are established in this statute. It is the policy of the state to conserve and wisely manage

these resources. Particular attention is given to those species defined as being endangered or threatened. This includes the acquisition or management of lands important to the conservation of fish and wildlife. This statute contains specific provisions for the conservation and management of marine fisheries resources. These conservation and management measures permit reasonable means and quantities of annual harvest, consistent with maximum practicable sustainable stock abundance, as well as ensure the proper quality control of marine resources that enter commerce.

Additionally, this statute supports and promotes hunting, fishing, and the taking of game opportunities in the State. Hunting, fishing, and the taking of game are considered an important part in the state's economy and in the conservation, preservation, and management of the state's natural areas and resources.

Chapter 379 Fish and Wildlife Conservation.

Not approved as enforceable policy: Sections 379.2551 and .362.

379.2511 Lease of state-owned water bottoms for growing oysters and clams.

379.362 Wholesale and retail saltwater products dealers; regulation.

Response: The goals and objectives of this project are to improve habitat conditions for native fish and wildlife species. This project is in compliance with the intent of this chapter.

CHAPTER 380, F.S., LAND AND WATER MANAGEMENT

Land and water management policies are established to protect natural resources and the environment; and to guide and coordinate local decisions relating to growth and development. The statute provides that state land and water management policies, to the maximum possible extent, be implemented by local governments through existing processes for the guidance of growth and development and that all the existing rights of private property be preserved in accord with constitutions of this state and of the United States. The chapter establishes the Areas of Critical State Concern designation, the Florida Communities Trust as well as the Florida Coastal Management Act. The Florida Coastal Management Act provides the basis for the Florida Coastal Management Program which seeks to protect the natural, commercial, recreational, ecological, industrial, and aesthetic resources of Florida's coast.

Chapter 380 Land and Water Management

Not approved as enforceable policy: Section 380.23(3)(d). [Consistency review of] federal activities within the territorial limits of neighboring states when the Governor and the department determine that significant individual or cumulative impact to the land or water resources of the state would result from the activities.

Response: The proposed project incorporates restoration components primarily intended to benefit freshwater wetlands and estuarine resources by distributing freshwater flows through various parcels to the NWFLR and Loxahatchee estuary. This includes the installation/construction of features shown in Table C.4-1***. The goals and objectives of this project are to improve habitat conditions for native fish and wildlife species. Impacts of this project have been detailed within an Environmental Impact Statement. This project is in compliance with the intent of this chapter***.

CHAPTER 381, F.S., PUBLIC HEALTH: GENERAL PROVISIONS

The statute establishes public policy concerning the state's public health system, which is designated to promote, protect, and improve the health of all people in the state.

Chapter 381 Public Health: General Provisions

Enforceable policy includes only Sections 381.001, .0011, .0012, .006, 0061, .0065, .0066, and .0067.

381.001 Legislative intent; public health system.

381.0011 Duties and powers of the Department of Health.

381.0012 Enforcement authority.

381.006 Environmental health.

381.0061 Administrative fines.

381.0065 Onsite sewage treatment and disposal systems; regulation.

381.0066 Onsite sewage treatment and disposal systems; fees.

381.0067 Corrective orders; private and certain public water systems and onsite sewage treatment and disposal systems.

Response: This project would not affect the state's public health system and, therefore, this chapter is not applicable.

CHAPTER 388, F.S., MOSQUITO CONTROL

Mosquito control efforts of the state are to achieve and maintain such levels of arthropod control as will protect human health and safety and foster the quality of life of the people, promote the economic development of the state, and facilitate the enjoyment of its natural attractions by reducing the number of pestiferous and disease-carrying arthropods. It is the policy of the state to conduct arthropod control in a manner consistent with protection of the environmental and ecological integrity of all lands and waters throughout the state.

Response: The proposed project would not further the propagation of mosquitoes or other pest arthropods and, with the restoration of sheetflow, standing water would be reduced, thus potentially reducing the propagation of mosquitoes. This project is in compliance with the intent of this chapter.

CHAPTER 403, F.S., ENVIRONMENTAL CONTROL

Environmental control policies conserve state waters; protect and improve water quality for consumption and for the propagation of fish and wildlife; and maintain air quality to protect human health and plant and animal life. This statute provides wide-ranging authority to address various environmental control concerns, including air and water pollution; electrical power plant and transmission line siting; the Interstate Environmental Control Compact; resource recovery and management; solid and hazardous

waste management; drinking water protection; pollution prevention; ecosystem management; and natural gas transmission pipeline siting.

Chapter 403 Environmental Control

Not approved as enforceable policy: Section 403.7125(2) and (3).

(2) The owner or operator of a landfill …shall establish a fee, or a surcharge on existing fees or other appropriate revenue-producing mechanism, to ensure the availability of financial resources for the proper closure of the landfill.

(3) An owner or operator of a landfill … may provide financial assurance to the department in lieu of the requirements of subsection (2).

Response: A draft Environmental Impact Statement addressing project impacts has been prepared and would be reviewed by the appropriate resource agencies including the Florida Department of Environmental Protection. Environmental protection measures would be implemented to ensure that no lasting adverse effects on water quality, air quality, or other environmental resources would occur. The project complies with the intent of this chapter.

CHAPTER 553, F.S., BUILDING AND CONSTRUCTION STANDARDS

The statute addresses building construction standards and provides for a unified Florida Building Code.

Chapter 553 Building and Construction Standards.

Enforceable policy includes only Sections 553.73 and .79.

553.73 Florida Building Code.

553.79 Permits; applications; issuance; inspections.

Response: A draft Environmental Impact Statement addressing project impacts has been prepared and would be reviewed by the appropriate resource agencies including the Florida Department of Environmental Protection. Environmental protection measures would be implemented to ensure that no lasting adverse effects on water quality, air quality, or other environmental resources would occur. Water Quality Certification would be sought from the State prior to construction. The project complies with the intent of this chapter.

CHAPTER 582, F.S., SOIL AND WATER CONSERVATION

It is the state's policy to preserve natural resources; control and prevent soil erosion, prevent floodwater and sediment damages and to further the conservation, development and use of soil and water resources, and the disposal of water. Farm, forest, and grazing lands are among the basic assets of the state; and the preservation of these lands is necessary to protect and promote the health, safety, and general welfare of its people. These measures help to preserve state and private lands, control floods, maintain water quality, prevent impairment of dams and reservoirs, assist in maintaining the navigability of rivers and harbors, preserve wildlife and protect wildlife habitat, protect the tax base, protect public lands, and protect and promote the health, safety, and general welfare of the people of this state.

Response: Project construction and implementation would include appropriate erosion control plans and measures to ensure compliance with the intent of the Chapter.

CHAPTER 597, F.S., AQUACULTURE

The statute establishes public policy concerning the cultivation of aquatic organisms in the state. The intent is to enhance the growth of aquaculture, while protecting Florida's environment. This includes a requirement for a state aquaculture plan which provides for the coordination and prioritization of state aquaculture efforts, the conservation and enhancement of aquatic resources and which provides mechanisms for increasing aquaculture production for the creation of new industries, job opportunities, income for aquaculturists, and other benefits to the state.

Response: The proposed project does not include aquaculture activities and, therefore, this chapter does not apply.

APPENDIX C.5

CULTURAL RESOURCES LETTERS

This entire appendix includes correspondence to and from federal, state, and tribal government agencies regarding the project to obtain comments and identify any concerns they may have.

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT CORPS OF ENGINEERS
P.O. BOX 4970
JACKSONVILLE, FLORIDA 32232-0019

REPLY TO
ATTENTION OF

Planning Division
Environmental Branch

TO WHOM IT MAY CONCERN:

The Jacksonville District, U.S. Army Corps of Engineers (Corps) is beginning preparation of a National Environmental Policy Act (NEPA) assessment for the Loxahatchee River Watershed Restoration Project (LRWRP) (Figure 1). In 2000, the U.S. Congress authorized the Federal government, in partnership with the State of Florida, to embark upon a multi-decade, multi-billion dollar Comprehensive Everglades Restoration Plan (CERP) to further protect and restore the remaining Everglades ecosystem while providing for other water-related needs of the region. CERP involves modification of the existing network of drainage canals and levees that make up the Central and Southern Florida Flood Control Project. The LRWRP was originally entitled the North Palm Beach County Part 1 Project and included six individual project components outlined in CERP. During the course of the previous study effort, several of the original project components were eliminated or repurposed for other uses. These changes have resulted in the need to reexamine project objectives and identify additional alternatives to achieve restoration within the Loxahatchee River Watershed, River, and Estuary.

The renewed purpose of LRWRP is to restore and sustain the overall quantity, quality, timing, and distribution of freshwaters to the federally designated "National Wild and Scenic" Northwest Fork of the Loxahatchee River for current and future generations. This project also seeks to restore, sustain, and reconnect the area's wetlands and watersheds that form the historic headwaters for the river. These areas include Jonathan Dickinson State Park, Pal Mar East/Cypress Creek, Dupuis Wildlife and Environmental Management Areas, J.W. Corbett Wildlife Management Area, Grassy Waters Preserve, Loxahatchee Slough, the last remaining riverine cypress stands in Southeast Florida in the Loxahatchee River floodplain and the Loxahatchee River Estuary.

The LRWRP seeks to address these goals by developing a series of alternatives that will capture, store and redistribute water currently lost to tide; rehydrate natural areas that have been hydrologically impacted by excessive draining, water diversions, and structural features, such as, roadways; reduce discharges to the project's estuarine systems; improve timing and distribution of water from the upstream watershed to increase the resiliency of freshwater riverine habitats to future sea-level changes; and reestablish connections among natural areas. In addition, improvements to water supply and flood damage risk reduction may occur as a result of the LRWRP.

We invite the participation of Federal and state agencies, Native American tribes, local agencies, and interested parties and individuals in providing comments and identifying any issues or concerns. Please participate in the NEPA Scoping meeting being held on January 12, 2015, from 6:00 to 8:00 pm, at: Indian River State College, Chastain Campus, 2400 Southeast Salerno Road, Stuart, Fl, 34997. Please share this notice with any interested party not included on the address list, and send any comments you may have to the attention of Mr. Andrew LoSchiavo at the letter head address or email Andrew.J.LoSchiavo@usace.army.mil no later than 30 days from the date of this letter. All individuals who respond with comments will be included in future mailings. Others may be included by making a written request in writing (postcard) to the same address or by email.

Sincerely,

Kenneth R Duggan

for Eric Summa
Chief, Environmental Branch

Enclosure

Allen/CESAJ-PD-PX1619
LoSchiavo/CESAJ-PD-ES
Ralph/CESAJ-PD-ES
Summa/CESAJ-PD-E

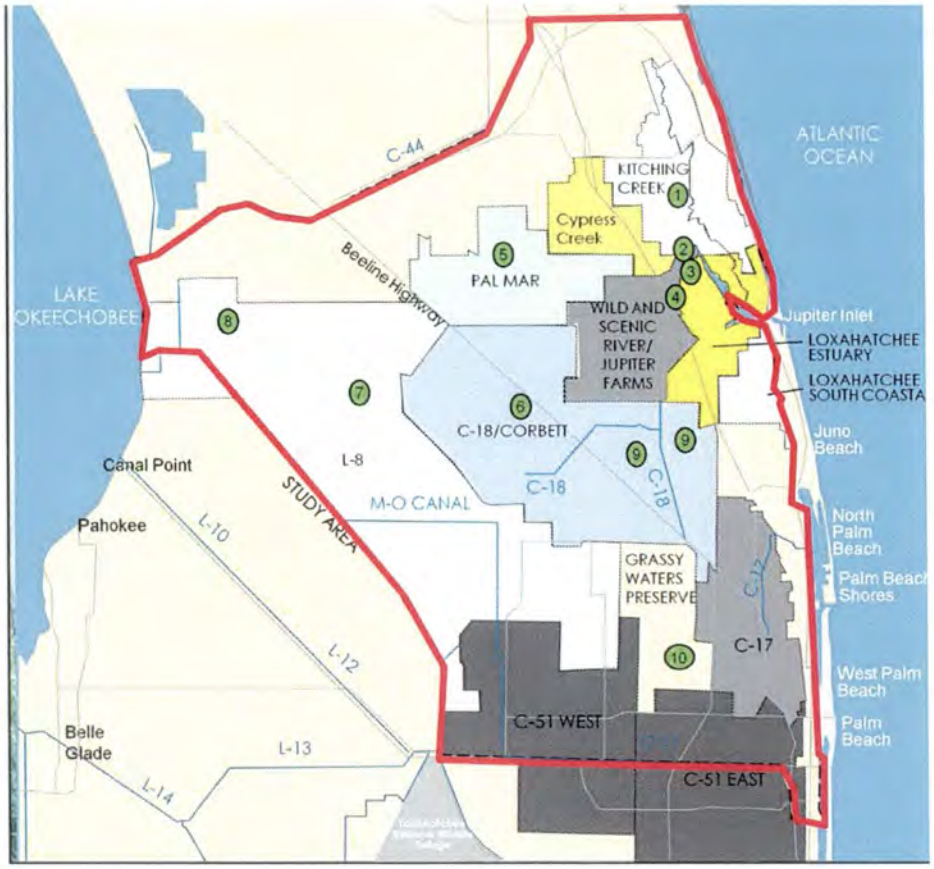

Figure 1. Loxahatchee River Watershed Restoration Project Study Area Map and Natural Areas, Basins, and Water Management Features.

Loxahatchee National Wild and Scenic River Features

1. Kitching Creek
2. Moonshine Creek
3. Cypress Creek
4. Lainhart Dam

Loxahatchee River Watershed Natural Areas

5. Pal Mar Wildlife Management Area
6. Hungryland Slough
7. J.W. Corbett Wildlife Management Area
8. Dupuis Management Area
9. Loxahatchee Slough
10. Grassy Waters Preserve

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT CORPS OF ENGINEERS
P.O. BOX 4970
JACKSONVILLE, FLORIDA 32232-0019

REPLY TO
ATTENTION OF

FEB 23 2015

Planning and Policy Division
Environmental Branch

Mr. Fred Dayhoff, Tribal Representative
NAGPRA, Section 106
Miccosukee Tribe of Indians of Florida
Post Office Box 440021
Tamiami Station
Miami, Florida 33144

Transmittal Memo for the Loxahatchee River Watershed Restoration Plan

Dear Mr. Dayhoff:

I would like to inform you of the upcoming Loxahatchee River Watershed Restoration Plan project. I have enclosed a copy of the scoping letter and Federal Register notice for your records. This project consists of restoration and maintenance of the overall quantity, quality, timing, and distribution of freshwaters to the federally designated "National Wild and Scenic" Northwest Fork of the Loxahatchee River for current and future generations.

This project also seeks to restore, sustain, and reconnect the area's wetlands and watersheds that form the historic headwaters for the river. These areas include Jonathan Dickinson State Park, Pal Mar East/Cypress Creek, Dupuis Wildlife and Environmental Management Areas, J.W. Corbett Wildlife Management Area, Grassy Waters Preserve, Loxahatchee Slough, the last remaining riverine cypress stands in Southeast Florida in the Loxahatchee River, and the Loxahatchee River Estuary.

Planning efforts for the project were put on hold in 2011 and have now been restarted. Currently, the project is being re-scoped and existing plan formulation data and analysis will be used in the development of a final plan, known as a Project Implementation Report and Environmental Impact Statement, to prepare for congressional authorization. The current, tentative schedule for this project is as follows:

- April/May 2015 - choosing the alternative plans
- Summer 2015 - modeling of the project features completed
- December 2015/January 2016 - modeling of the hydroperiods of the alternatives completed
- March/April 2016 - choosing the tentatively selected plan (TSP)

I would like to get together with you in the near future and go over the plans and get your input regarding the cultural resources aspect of this project. I will forward more information to you as I receive it. The following website also contains information (http://www.saj.usace.army.mil/Missions/Environmental/EcosystemRestoration/LoxahatcheeRiverWatershedRestorationProject.aspx). Please feel free to call me if you have any questions (904-232-2137). I look forward to working with you on this project.

Sincerely,

Wendy

Wendy Weaver,
Archeologist, Environmental Branch

• *OMB:* Office of Management and Budget, New Executive Office Building, Room 10235, Washington, DC 20503 or fax to (202) 395–5806. Mailed or faxed comments to OMB should be to the attention of the OMB Desk Officer for the Bureau of Consumer Financial Protection. *Please note that comments submitted after the comment period will not be accepted.* In general, all comments received will become public records, including any personal information provided. Sensitive personal information, such as account numbers or social security numbers, should not be included.

FOR FURTHER INFORMATION CONTACT: Documentation prepared in support of this information collection request is available at *www.reginfo.gov* (this link active on the day following publication of this notice). Select "information Collection Review," under "Currently under review, use the dropdown menu "Select Agency" and select "Consumer Financial Protection Bureau" (recent submissions to OMB will be at the top of the list). The same documentation is also available at *http://www.regulations.gov.* Requests for additional information should be directed to the Consumer Financial Protection Bureau, (Attention: PRA Office), 1700 G Street NW., Washington, DC 20552, (202) 435–9575, or email: *PRA@cfpb.gov. Please do not submit comments to this email box.*

SUPPLEMENTARY INFORMATION:

Title of Collection: Bridges to Financial Security: A Multi-site Demonstration Project.

OMB Control Number: 3170–XXXX.

Type of Review: New collection (Request for a new OMB control number).

Affected Public: Individuals or households.

Estimated Number of Respondents: 15,120.

Estimated Total Annual Burden Hours: 42,488.

Abstract: The Consumer Financial Protect Bureau (CFPB), beginning in the winter of 2015, will launch a multi-site financial education demonstration project to provide one-on-one and group financial counseling/coaching services to individuals with disabilities transitioning into the workplace or already employed. The goal is twofold: (1) To improve the financial skills of approximately 15,000 individuals across the spectrum of disability to effectively navigate the financial marketplace, resulting in improved credit, reduced debt, and increased savings; and (2) to build the capacity of diverse multi-sector systems (non-disability and disability) in up to 14 cities to unite around the common purpose of building financial security for individuals with disabilities. CFPB envisions the need to collect a combination of client personally identifiable information (PII), including direct-identifying PII (*i.e.*, basic contact and demographic information), performance metrics (outputs), as well as other relevant organization-level outcomes. Monthly qualitative reports and quantitative aggregated individual data will be collected from participating sites to document the design, growth and impact of up to 14 integrated diverse delivery models serving primarily low-income populations with disabilities.

Request for Comments: The Bureau issued a 60-day **Federal Register** notice on October 17, 2014, 79 FR 62420. Comments were solicited and continue to be invited on: (a) Whether the collection of information is necessary for the proper performance of the functions of the Bureau, including whether the information will have practical utility; (b) The accuracy of the Bureau's estimate of the burden of the collection of information, including the validity of the methods and the assumptions used; (c) Ways to enhance the quality, utility, and clarity of the information to be collected; and (d) Ways to minimize the burden of the collection of information on respondents, including through the use of automated collection techniques or other forms of information technology. Comments submitted in response to this notice will be summarized and/or included in the request for Office of Management and Budget (OMB) approval. All comments will become a matter of public record.

Dated: December 23, 2014.

Ashwin Vasan,

Chief Information Officer, Bureau of Consumer Financial Protection.

[FR Doc. 2015–00104 Filed 1–7–15; 8:45 am]

BILLING CODE 4810–AM–P

DEPARTMENT OF DEFENSE

Department of the Army, Corps of Engineers

Revised Notice of Intent and Scoping Meeting for Loxahatchee River Watershed Restoration Project (Formerly Called North Palm Beach County Part 1) Associated With Prior Notice of Intent To Develop a Draft Environmental Impact Statement Issued October 16th, 2002

AGENCY: Department of the Army, U.S. Army Corps of Engineers, DoD.

ACTION: Revised notice of intent.

SUMMARY: The U.S. Army Corps of Engineers (Corps) Jacksonville District intends to prepare a National Environmental Policy Act (NEPA) assessment to restore and sustain the overall quantity, quality, timing, and distribution of freshwaters to the federally designated "National Wild and Scenic" Northwest Fork of the Loxahatchee River for current and future generations in Martin and Palm Beach Counties of Florida.

FOR FURTHER INFORMATION CONTACT: Mr. Andrew J. LoSchiavo, U.S. Army Corps of Engineers, Planning Division, Environmental Branch, P.O. Box 4970, Jacksonville, FL 32232–0019, by email *Andrew.J.LoSchiavo@usace.army.mil,* or by telephone at 904–232–2077.

SUPPLEMENTARY INFORMATION:

a. *Project Background and Authorization.* This notice is in regards to a re-scoping of a Comprehensive Everglades Restoration Plan (CERP) feasibility study originally entitled North Palm Beach County Part 1 and renamed the Loxahatchee River Watershed Restoration Project (LRWRP). The LRWRP contains several of the 68 restoration project components envisioned as part of the Comprehensive Everglades Restoration Plan authorized by the U.S. Congress in section 601 of the 2000 Water Resources Development Act. The LRWRP Project Delivery Team (PDT) identified a Tentatively Selected Plan (TSP) in August 2010. Prior to the approval of the TSP, a select component of the plan was repurposed to accomplish specific state water quality objectives and it was determined this component would not be available to achieve water quantity, timing, and distribution goals of the project. This resulted in the need to rescope project objectives and identify additional alternatives through the U.S. Army Corps of Engineers (Corps) SMART Planning process. This study will use the best available science to develop an array of project alternatives and select a recommended plan to achieve restoration within the Loxahatchee River Watershed and provide restoration flows to the Loxahatchee River Northwest Fork and estuary.

b. *Need or Purpose.* This NEPA Assessment will evaluate the potential benefits and impacts of restoring and sustaining the overall quantity, quality, timing, and distribution of freshwaters to the federally designated "National Wild and Scenic" Northwest Fork of the Loxahatchee River for current and future generations. This project also seeks to restore, sustain, and reconnect

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT CORPS OF ENGINEERS
701 San Marco Boulevard
JACKSONVILLE, FLORIDA 32207-8175

REPLY TO
ATTENTION OF

Planning and Policy Division
Environmental Branch

SEP 09 2016

Dr. Paul Backhouse, THPO
Seminole Tribe of Florida
Tribe Historic Preservation Office
30290 Josie Billie Highway
PMP 1004
Clewiston, FL 33440

Re: Loxahatchee River Watershed Restoration Project Alternatives

Dear Dr. Backhouse:

The U.S. Army Corps of Engineers, Jacksonville District (Corps) would like to extend our appreciation to the Seminole Tribe of Florida's Historic Preservation Office for meeting with us August 4, 2016 to discuss potential management measures associated with the Loxahatchee River Watershed Restoration Project. The purpose of Loxahatchee River Watershed Restoration Project is to restore and sustain the overall quantity, quality, timing, and distribution of freshwaters to the federally designated "National Wild and Scenic" Northwest Fork of the Loxahatchee River for current and future generations. This project also seeks to restore, sustain, and reconnect the area's wetlands and watersheds that form the historic headwaters for the river.

At our August 4, 2015 meeting, the Corps presented a focused array of five alternatives and the area of potential effect (APE) for each alternative (**Exhibit A**). The five alternatives are described in **Table 1** and illustrated in **Figures 1** through **Figure 5**. The Corps utilized the construction footprints, degree of impoundment, and best professional judgment on hydrologic restoration benefits to define the APEs for each alternative. The Corps recognizes that the construction, operation, or modifications of project features, and resultant changes in hydrologic conditions, may have the potential to adversely affect historic properties.

In an email dated August 10, 2016 (**Exhibit B**), the Seminole Tribe of Florida's Historic Preservation Office concurred with the cultural resources survey areas and methodology for identification of burial resources officially documenting the initiation of Step 1 of the Burial Resources Agreement pursuant to the Trust Agreement between the Corps and the Seminole Tribe of Florida regarding proposed actions that may adversely affect American Indian burial resources.

The survey areas are detailed in the performance work statement (PWS) in **Exhibit C**. This PWS is not available for public dissemination due to contracting laws. Once the contract is awarded and the results of the surveys are received, continued consultation with the Seminole Tribe of Florida's Historic Preservation Office will identify potential treatment alternatives (e.g. avoidance, minimization, and mitigation) for identified burial resources, and initiate the development of the proposed consultation schedule moving forward with the Loxahatchee River Watershed Restoration Project. Step 1 of the Burial Resources Agreement will not be completed until after these remaining tasks are accomplished, and the MFR No. 1 has been circulated to all consulting parties for a 30 calendar day review and commenting period.

Pursuant to Section 106 of the National Historic Preservation Act (16 USC 470), as amended and its implementing regulations (36 CFR 800), and in consideration of the Corps' Trust Responsibilities and the Burial Resources Agreement with the Seminole Tribe of Florida, the Corps respectfully requests your input and comments on the focused array of five alternatives. The Corps looks forward to continued coordination and consultation on the Loxahatchee River Watershed Restoration Project. We request your input on the focused array of five alternatives in writing to the letterhead address above or by email at Marc.A.Tiemann@usace.army.mil within 30 days of receipt of this letter.

Sincerely,

Gina Paduano Ralph, Ph.D.
Chief, Environmental Branch

Enclosures

cc:
Anne Mullins, Deputy Tribal Historic Preservation Officer, Seminole Tribe of Florida, 30290 Josie Billie Highway, PMP 1004, Clewiston, Florida 33440
Bradley Mueller, Compliance Review, Seminole Tribe of Florida, 30290 Josie Billie Highway, PMP 1004, Clewiston, Florida, 33440

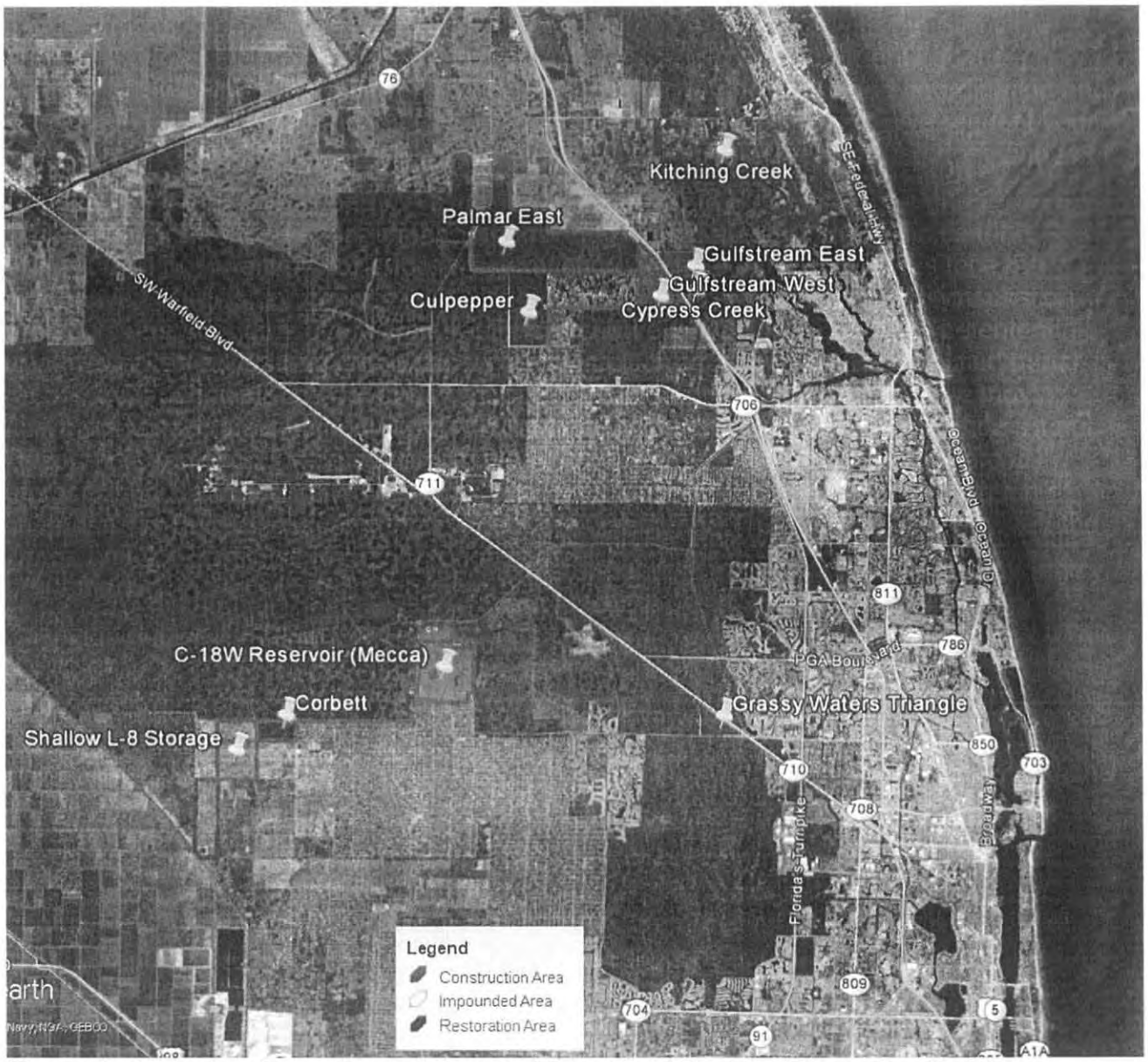

Figure 1. Map showing estimated Areas of Potential Effect for Alternative 2 of the Loxahatchee River Watershed Restoration Project.

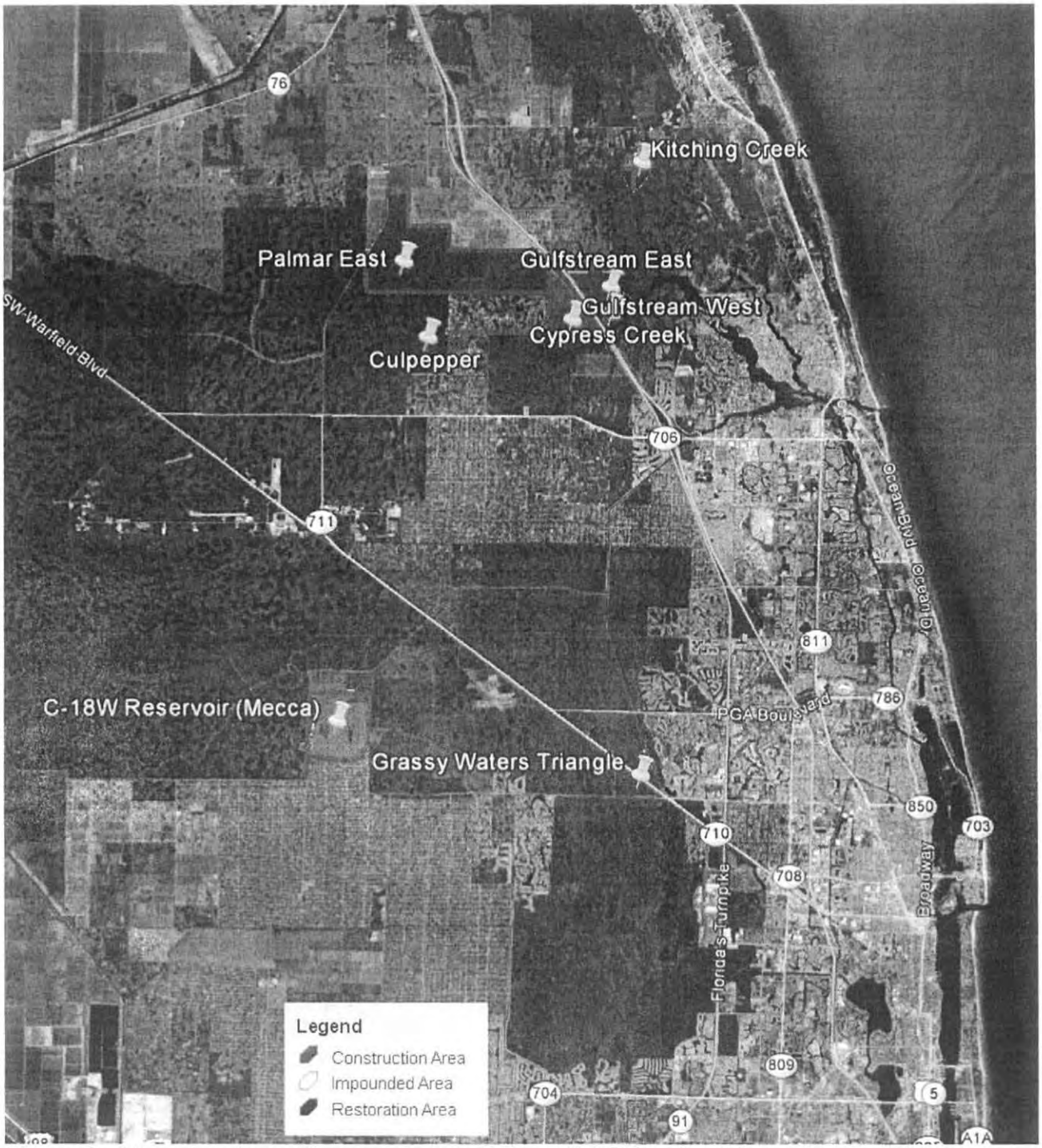

Figure 2. Map showing estimated Areas of Potential Effect for Alternative 5 of the Loxahatchee River Watershed Restoration Project.

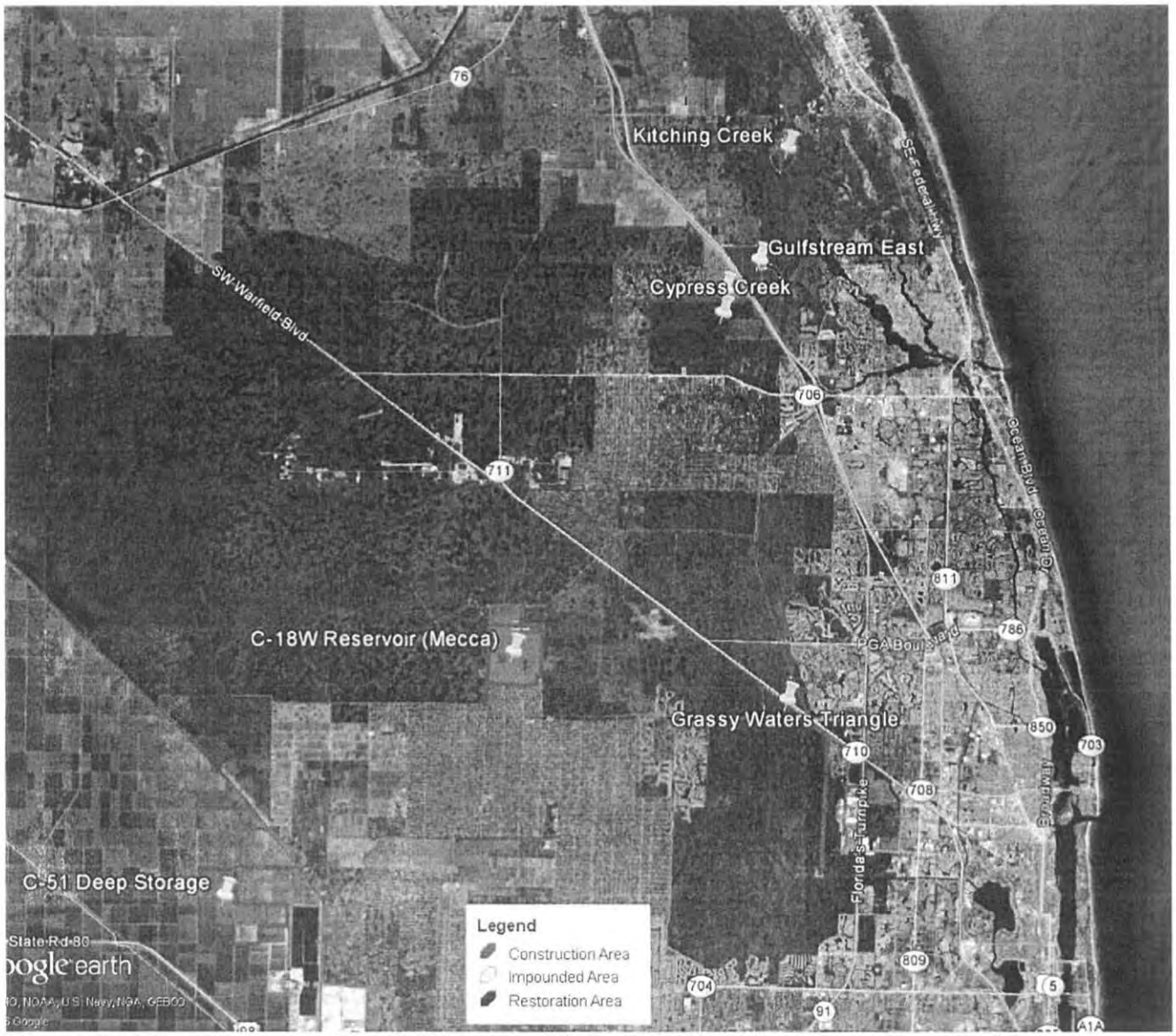

Figure 3. Map showing estimated Areas of Potential Effect for Alternative 10 of the Loxahatchee River Watershed Restoration Project.

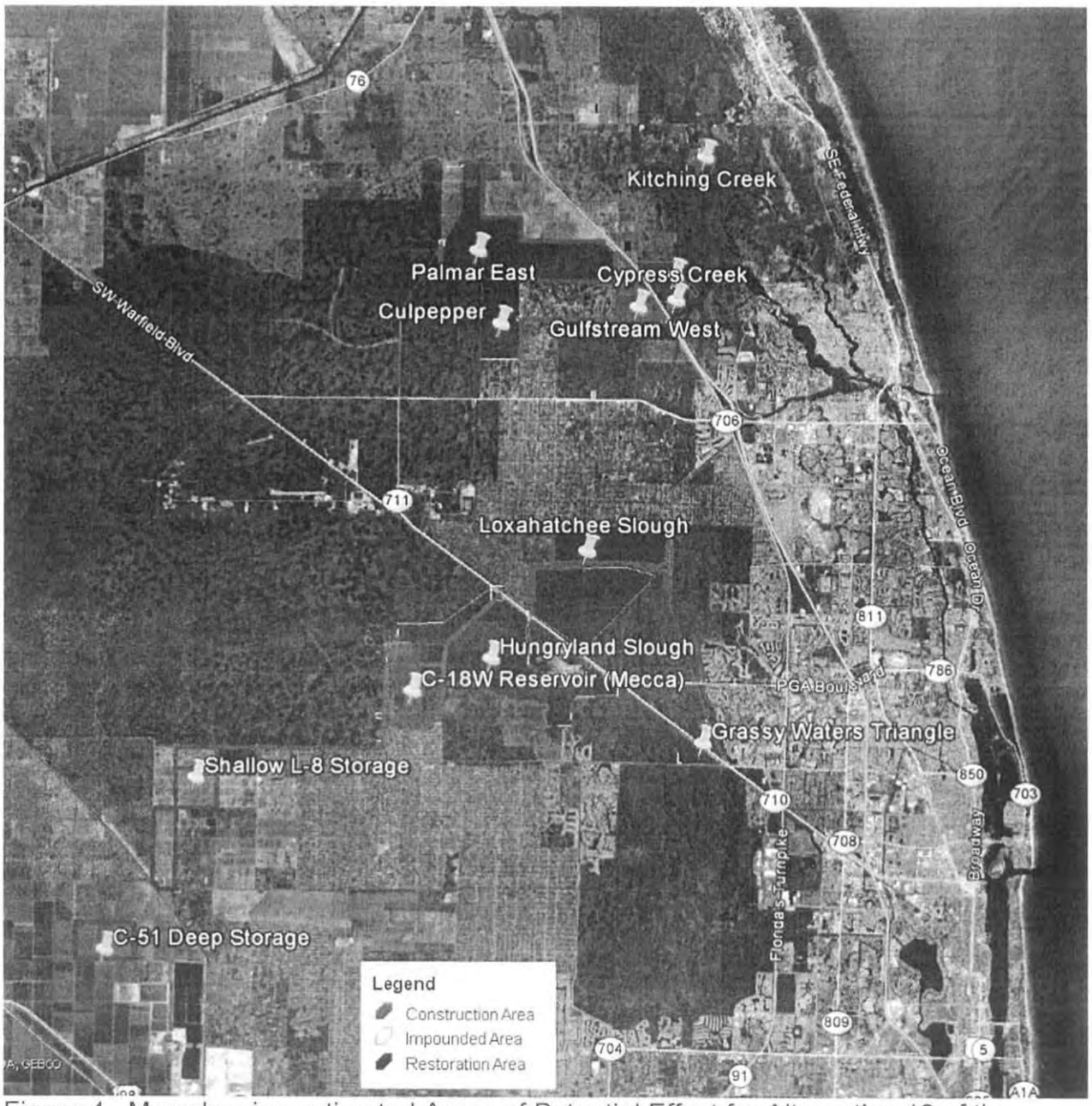

Figure 4. Map showing estimated Areas of Potential Effect for Alternative 12 of the Loxahatchee River Watershed Restoration Project.

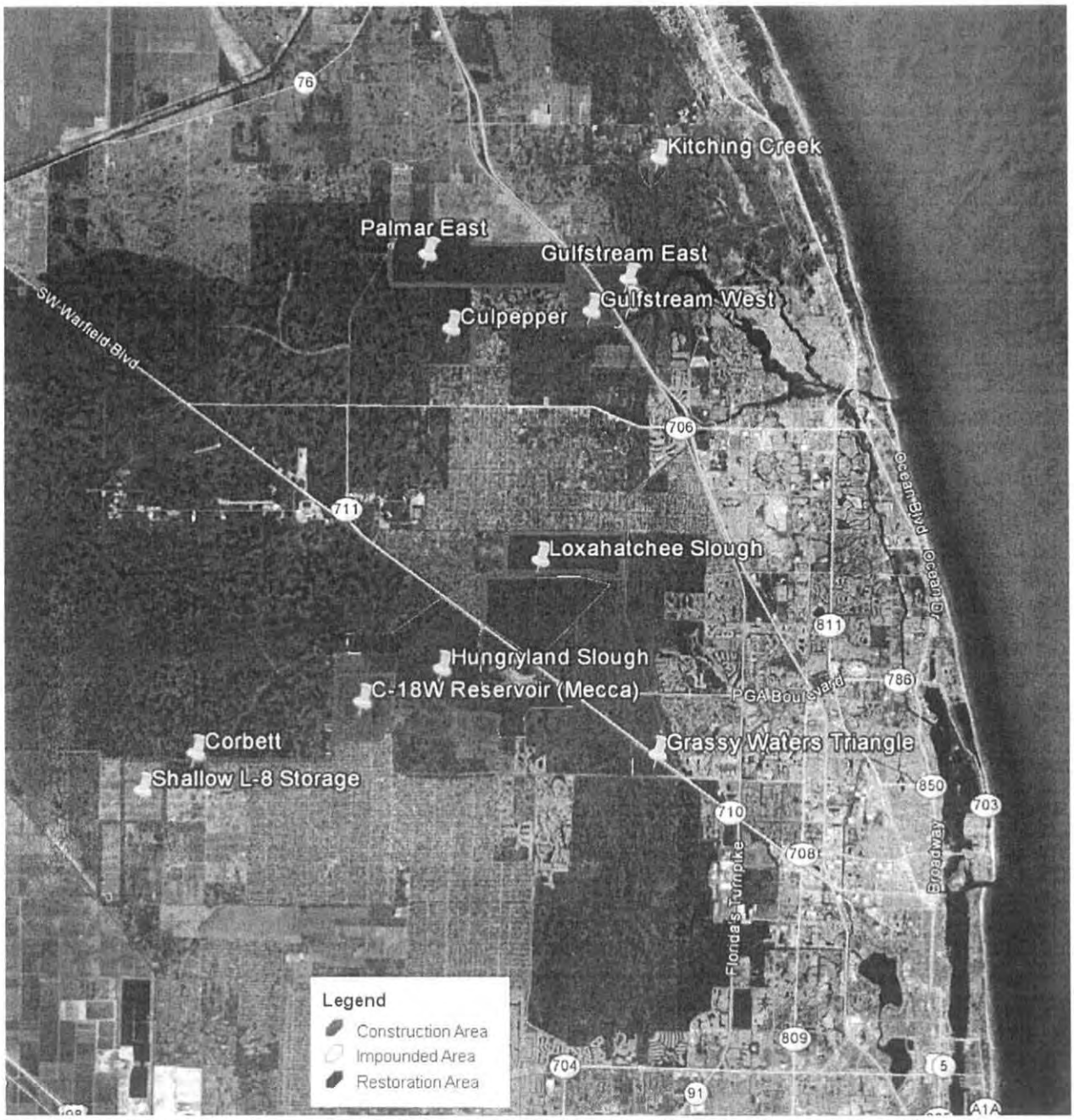

Figure 5. Map showing estimated Areas of Potential Effect for Alternative 13 of the Loxahatchee River Watershed Restoration Project.

Alternative 2		
3E	Kitching Creek Hydration	Spreader Canal at Jenkins Ditch at JDSP northern boundary Weir or plug on Jenkins ditch near connection with Kitching Creek
	Moonshine Creek & Gulfstream East	Connect HSLCD ditch to Moonshine Cr; Clear veg in Moonshine Cr; Fill Gulfstream Ditch; Regrade to historic topography
	Cypress Creek Canal	Replace Cypress Creek Canal Weir Raise Northern Berm at Ranch Colony Automate twin 84
	Restore Gulfstream West as a Flow through Marsh	Partial backfill & relocate southern end of HSLCD canal; Small pump; Flow through marsh; Discharge structure
	Connect PalMar	Plug N-S ditches; Remove pipes; Improve northern berm; Construct western berm; Improve eastern berm; Backfill northern canal;
2B	C-18 W storage reservoir	Above ground reservoir, Inflow pump, Discharge structure, Seepage ctrl (7,200 ac-ft)
	ASR at C-18 W storage	2 wells, supplement volume of the reservoir
1F	Shallow L-8 Basin storage (10,000 ac-ft)	10,000 ac-ft Shallow Storage Includes Pump & Channels
	G-160	Restore hydroperiod in Lox Slough
	G-161	GWP water to Lox Slough
	GWP triangle	Improve Connectivity

Alternative 5		
3E	Kitching Creek Hydration	Spreader Canal at Jenkins Ditch at JDSP northern boundary Weir or plug on Jenkins ditch near connection with Kitching Creek
	Moonshine Creek & Gulfstream East	Connect HSLCD ditch to Moonshine Cr; Clear veg in Moonshine Cr; Fill Gulfstream Ditch; Regrade to historic topography
	Cypress Creek Canal	Replace Cypress Creek Canal Weir Raise Northern Berm at Ranch Colony Automate twin 84
	Restore Gulfstream West as a Flow through Marsh	Partial backfill & relocate southern end of HSLCD canal; Small pump; Flow through marsh; Discharge structure
	Connect PalMar	Plug N-S ditches; Remove pipes; Improve northern berm; Construct western berm; Improve eastern berm; Backfill northern canal;
2B+	C-18 W storage reservoir	Above ground reservoir, Inflow pump, Discharge structure, Seepage ctrl (9,500 ac-ft)
	ASR at C-18 W storage	4 wells, supplement volume of the reservoir
1A	G-160	Restore hydroperiod in Lox Slough
	G-161	GWP water to Lox Slough
	GWP triangle	Improve Connectivity

Alternative 12		
3E	Kitching Creek Hydration	Spreader Canal at Jenkins Ditch at JDSP northern boundary Weir or plug on Jenkins ditch near connection with Kitching Creek
	Moonshine Creek & Gulfstream East	Connect HSLCD ditch to Moonshine Cr; Clear veg in Moonshine Cr; Fill Gulfstream Ditch; Regrade to historic topography
	Cypress Creek Canal	Replace Cypress Creek Canal Weir Raise Northern Berm at Ranch Colony Automate twin 84
	Restore Gulfstream West as a Flow through Marsh	Partial backfill & relocate southern end of HSLCD canal; Small pump; Flow through marsh; Discharge structure
	Connect PalMar	Plug N-S ditches; Remove pipes; Improve northern berm; Construct western berm;
2H	Natural storage on Mecca	Restore Natural Topography; Bridge/Culverts for Beeline; Backfill Interior Canals in Corbett; Pump to protect Caloosa
1F	Shallow L-8 Basin storage (10,000 ac-ft)	10,000 ac-ft Shallow Storage Includes Pump & Channels
	G-160	Restore hydroperiod in Lox Slough
	G-161	GWP water to Lox Slough
	GWP triangle	Improve Connectivity
	C-51 Storage	Deep Storage Includes Pump & Channels

Alternative 13		
3E	Kitching Creek Hydration	Spreader Canal at Jenkins Ditch at JDSP northern boundary Weir or plug on Jenkins ditch near connection with Kitching Creek
	Moonshine Creek & Gulfstream East	Connect HSLCD ditch to Moonshine Cr; Clear veg in Moonshine Cr; Fill Gulfstream Ditch; Regrade to historic topography
	Cypress Creek Canal	Replace Cypress Creek Canal Weir Raise Northern Berm at Ranch Colony Automate twin 84
	Restore Gulfstream West as a Flow through Marsh	Partial backfill & relocate southern end of HSLCD canal; Small pump; Flow through marsh; Discharge structure
	Connect PalMar	Plug N-S ditches; Remove pipes; Improve northern berm; Construct western berm;
2H	Natural storage on Mecca	Restore Natural Topography; Bridge/Culverts for Beeline; Backfill Interior Canals in Corbett; Pump to protect Caloosa
1F+	Shallow L-8 Basin storage (10,000 ac-ft)	10,000 ac-ft Shallow Storage Includes Pump & Channels
	G-160	Restore hydroperiod in Lox Slough
	G-161	GWP water to Lox Slough
	GWP triangle	Improve Connectivity
	ASR at L8	2 wells, supplement volume of the reservior

Alternative 10		
3B	Kitching Creek Hydration	Spreader Canal at Jenkins Ditch at JDSP northern boundary Weir or plug on Jenkins ditch near connection with Kitching Creek
	Moonshine Creek & Gulfstream East	Connect HSLCD ditch to Moonshine Cr; Clear veg in Moonshine Cr; Fill Gulfstream Ditch; Regrade to historic topography
	Cypress Creek Canal	Replace Cypress Creek Canal Weir Raise Northern Berm at Ranch Colony Automate twin 84
LOCAL PREFERRED OPTION		

Table 1. Descriptions of the Focused Array of Five Alternatives.

Exhibit A

MEMORANDUM for RECORD **8 August 2016**

SUBJECT: Meeting with Seminole Tribe on 04 August 2016

PARTICIPANTS: THPO office: Brad Mueller, Lacee Cofer; Jacksonville District: Marc Tiemann, Brad Foster.

PURPOSE: Jacksonville District staff met with the Seminole Tribe's Tribal Historic Preservation Officer (THPO) and staff to discuss the Loxahatchee River Watershed Restoration Project. The meeting was a follow-up to the 30 June 2016 meeting with the goal of seeking additional input on the focused array of five alternatives as it relates to cultural resources and the evaluation of submitted KMZ/shape files. The meeting occurred on 04 August 2016, from 10:00 to 12:00 PM, at office of the Seminole Tribe's Tribal Historic Preservation Officer (THPO) on the Big Cypress Reservation.

SUMMARY: An agenda and table of potentially impacted archaeological sites based on the Florida Master Site File were emailed in advance of the meeting. The table listed archaeological sites that could be potentially impacted by the focused array of five alternatives. Hardcopies of cultural resources survey reports specifically targeting Loxahatchee River Watershed Restoration areas of potential impact were distributed at the opening of the meeting as an aid in guiding discussion.

1. Both reconnaissance and systematic intensive pedestrian surveys were recommended by the THPO staff, following standard Division of Historical Resources Module 3 Archaeological Guidelines.
2. Areas requiring intensive pedestrian archaeological survey at 25 meter intervals were: Palmar East Property (3 project areas identified by Southeastern Archaeological Research, Inc.) in survey report.
3. Areas identified by the Seminole Tribe of Florida as needing reconnaissance investigations, if not adequately covered by previous surveys were:
4. Kitching Creek (construction and restoration) area, including a literature review and revisit to Archaeological Site 8MT01284 with subsurface shovel testing investigations (no previous survey coverage).
5. Gulf Stream West (check previous survey coverage).
6. Gulf Stream East (includes recommended metal detector survey for Loxahatchee Battle Site) in area recommended by South Arc, Inc. (check previous survey coverage).
7. Culpepper area (check previous survey coverage).
8. Cypress Creek (check previous survey coverage).
9. Lucky Tract - Loxahatchee Slough (no previous survey coverage).
10. Mecca (previous survey coverage was inadequate); possibly include reconnaissance survey of the MO Canal if ownership is not private.

11. Grassy Waters Triangle (includes pipeline construction southward; no previous survey coverage).Corbett Property (no previous survey coverage).

THPO staff indicated that they need the contract to include a literature review of Archaeological Sites 8PB06294, 8PB13929, and 8PB11489 in the Hungryland Slough restoration area. THPO Staff will investigate if there are any tribal concerns with Archaeological Site 8MT01515 (Cecil Johnson Homestead) and Archaeological Site 8MT01449 (Trapper Nelson's Site) in Cypress Creek restoration area. The C-51 reservoir area and the Shallow L8 area are privately owned, and will be addressed if needed in following year.

Actions:

1. Jacksonville: evaluate survey coverage in reports, and coordinate with the Seminole Tribe of Florida for contracting.
2. THPO office: evaluate survey coverage in reports, and verify with Seminole Tribe any connections to the Cecil Johnson Homestead and Trapper Nelson's Site.

Exhibit B

From: Bradley Mueller
To: Tiemann, Marc A SAJ
Subject: [EXTERNAL] RE: Loxahatachee River WRP Cultural Resource Investigations
Date: Wednesday, August 10, 2016 1:39:08 PM
Attachments: image001.jpg

Good Afternoon Marc,

Yes, that is an accurate summery of our discussions and what we decided.
Regards,

Bradley M.

Mueller, MA

Compliance

Supervisor

Tribal Historic Preservation Office
Seminole Tribe of Florida

30290 Josie Billie Highway, PMB 1004

Clewiston, FL 33440

Tel: 863-983-6549 ext 12245

Fax: 863-902-1117

Email: bradleymueller@semtribe.com
Web: Blockedwww.stofthpo.com

-----Original Message-----
From: Tiemann, Marc A SAJ
[mailto:Marc.A.Tiemann@usace.army.mil] Sent:
Tuesday, August 09, 2016 11:35 AM
To: Bradley Mueller
Subject: RE: Loxahatachee River WRP Cultural Resource Investigations

Brad,

As discussed via phone today, do you concur that for this year's cultural resources contract of the Loxahatchee River Watershed Restoration Project, we will not include the Culpepper area, the Gulf Stream West area, the Gulf Stream East area, and the Cypress Creek area, and the MO Canal leading from the Mecca area to the Corbett area?

The areas we concur will need cultural resources investigations are the 3 areas of systematic intensive 25-meter gridded surveys in the Palmar East property, and reconnaissance cultural resources investigations following Module 3 state guidelines in the following areas:

Kitching Creek area (including a literature review and site revisit with shovel testing to investigate Archaeological Site PB14419, the Lucky tract, the Grassy Waters Triangle including linear pipeline construction southward, and the Corbett property.

We will also include a literature review of Archaeological Sites PB06294, PB13929, and PB11489 in Hungryland Slough for this year's contract.

Respectfully,

Marc

Marc A. Tiemann, M.A., RPA

Archaeologist

Planning Division,

Environmental Branch USACE,

Jacksonville District

701 San Marco Blvd.

Jacksonville, FL 32207

Phone: 904-232-1557

Email: marc.a.tiemann@usace.army.mil <mailto:marc.a.tiemann@usace.army.mil>

-----Original Message-----

From: Bradley Mueller [mailto:bradleymueller@semtribe.com

<mailto:bradleymueller@semtribe.com>] Sent: Tuesday, August 09, 2016

10:11 AM

To: Tiemann, Marc A SAJ <Marc.A.Tiemann@usace.army.mil

<mailto:Marc.A.Tiemann@usace.army.mil> > Subject: [EXTERNAL]

Loxahatachee River WRP Cultural Resource Investigations

Marc,

While the 2009 report helps clarify several issues I still have the following concern:

1. While much of the Gulf Stream East (GSE) tract appears to have been surveyed it is unclear from Figure 16 of the 2009 report whether there was adequate field investigations in the general vicinity of the possible battle site shown on the STOF-THPO Loxahatchee River WRP Project map. I recommend additional field investigations in the curvilinear area that extends eastward from the GSE tract and is aligned generally NW to SE (see attached figure). This is as close as we can get to the possible battle site and remain within the APE. South Arc does not appear to have done any shovel testing or metal detecting in this area. At a minimum the area should be walked to assess the possibility of doing either ST's or metal detecting. It may turn out to be too wet but I think the effort should be made.

Respectfully,

Bradley M. Mueller, MA
Compliance Supervisor
Tribal Historic Preservation Office
Seminole Tribe of Florida

30290 Josie Billie Highway, PMB 1004

Clewiston, FL 33440
Tel: 863-983-6549 ext 12245
Fax: 863-902-1117

Email: bradleymueller@semtribe.com
<mailto:bradleymueller@semtribe.com>

<mailto:bradleymueller@semtribe.com > >
Web: BlockedBlockedwww.stofthpo.com
<BlockedBlockedhttp://www.stofthpo.com>

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT CORPS OF ENGINEERS
701 San Marco Boulevard
JACKSONVILLE, FLORIDA 32207-8175

REPLY TO
ATTENTION OF

Planning and Policy Division
Environmental Branch

MAR 0 3 2017

Tim Parsons, Ph.D.
State Historic Preservation Officer
Division of Historical Resources
500 South Bronough Street
Tallahassee, Florida 32399-0250

Re: Loxahatchee River Watershed Restoration Project, Palm Beach and Martin Counties, Florida

Dear Dr. Parsons:

The U.S. Army Corps of Engineers, Jacksonville District (Corps), is studying the environmental effects associated with five proposed alternatives incorporating potential management measures formulated to improve the quantity, quality, timing, and distribution of freshwater deliveries from the Loxahatchee River Watershed to the Loxahatchee River and Estuary. In addition, the project will focus on improving hydrologic connections between the protected natural areas that are the headwaters to the "National Wild and Scenic Loxahatchee River Northwest Fork" and its tributaries.

The Corps contracted Southeastern Archaeological Research Inc. (SEARCH) to conduct reconnaissance-level cultural resources investigation of six survey areas within the watershed identified as Corbett, Loxahatchee Slough, Kitching Creek, Mecca, Grassy Waters Triangle, and Grassy Waters Preserve Linear Feature in Palm Beach and Martin Counties, Florida. Additionally, an intensive-level Phase 1 cultural resources investigation of three survey areas identified as Palmar East Boxes 1, 2, and 3 was also conducted. Their resulting draft report entitled: *Phase 1 Cultural Resources Survey for the Loxahatchee River Watershed Restoration Project, Martin and Palm Beach Counties, Florida* documenting these investigations is enclosed with this letter. No archaeological sites, isolated archaeological occurrences, or historic structures were identified as a result of SEARCH's investigations. One historic canal (8PB17040) was recorded as a result of this survey; however, based on SEARCH's evaluation, the canal does not meet the Florida Division of Historic Resources' guidelines to be considered significant, and is recommended ineligible for inclusion in the National Register of Historic Places (NRHP). In addition, SEARCH attempted to relocate previously recorded archaeological site 8MT1284. SEARCH conducted intensive shovel testing at the mapped location of the site; however, no cultural materials were recovered. Based on the negative results of this intensive shovel testing, SEARCH recommended archaeological site 8MT1284 as ineligible for inclusion in the NRHP.

Based on this information, the Corps has determined project activities involving ground disturbance or inundation occurring within these surveyed areas will pose no effect to historic properties eligible for inclusion in the NRHP. Pursuant to Section 106 of the National Historic Preservation Act (16 USC 470) and it's implementing regulations (36 CFR 800), I request your comments on the determination of 8PB17040 and 8MT1284 as ineligible for inclusion in the NRHP, on the overall determination of no effect for project activities within the surveyed areas, and your comments on the draft report. If there are any questions, please contact Mr. Marc Tiemann at 904-232-1557 or e-mail at Marc.A.Tiemann@usace.army.mil.

Sincerely,

Gina Paduano Ralph, Ph.D.
Chief, Environmental Branch

Enclosure

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT CORPS OF ENGINEERS
701 San Marco Boulevard
JACKSONVILLE, FLORIDA 32207-8175

REPLY TO
ATTENTION OF

Planning and Policy Division
Environmental Branch

MAR 0 3 2017

Mr. Fred Dayhoff, Tribal Representative
NAGPRA, Section 106
Miccosukee Tribe of Indians of Florida
HC 61
SR 68
Ochopee, Florida 34141

Re: Loxahatchee River Watershed Restoration Project, Palm Beach and Martin Counties, Florida:

Dear Mr. Dayhoff:

The U.S. Army Corps of Engineers, Jacksonville District (Corps), is studying the environmental effects associated with five proposed alternatives incorporating potential management measures formulated to improve the quantity, quality, timing, and distribution of freshwater deliveries from the Loxahatchee River Watershed to the Loxahatchee River and Estuary. In addition, the project will focus on improving hydrologic connections between the protected natural areas that are the headwaters to the "National Wild and Scenic Loxahatchee River Northwest Fork" and its tributaries.

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Based on this information, the Corps has determined project activities involving ground disturbance or inundation occurring within these surveyed areas will pose no effect to historic properties eligible for inclusion in the NRHP. Pursuant to Section 106 of the National Historic Preservation Act (16 USC 470) and it's implementing regulations (36 CFR 800), and in consideration of the Corps' Trust Responsibilities to the Miccosukee Tribe of Indians of Florida, I request your comments on the determination of 8PB17040 and 8MT1284 as ineligible for inclusion in the NRHP, on the overall determination of no effect for project activities within the surveyed areas, and your comments on the draft report. If there are any questions, please contact Mr. Marc Tiemann at 904-232-1557 or e-mail at Marc.A.Tiemann@usace.army.mil.

Sincerely,

Gina Paduano Ralph, Ph.D.
Chief, Environmental Branch

Enclosure

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT CORPS OF ENGINEERS
701 San Marco Boulevard
JACKSONVILLE, FLORIDA 32207-8175

REPLY TO
ATTENTION OF

Planning and Policy Division
Environmental Branch

MAR 0 3 2017

Dr. Paul Backhouse, THPO
Seminole Tribe of Florida
Tribe Historic Preservation Office
30290 Josie Billie Highway
PMP 1004
Clewiston, FL 33440

Re: Loxahatchee River Watershed Restoration Project, Palm Beach and Martin Counties, Florida:

Dear Dr. Backhouse:

The U.S. Army Corps of Engineers, Jacksonville District (Corps), is studying the environmental effects associated with five proposed alternatives incorporating potential management measures formulated to improve the quantity, quality, timing, and distribution of freshwater deliveries from the Loxahatchee River Watershed to the Loxahatchee River and Estuary. In addition, the project will focus on improving hydrologic connections between the protected natural areas that are the headwaters to the "National Wild and Scenic Loxahatchee River Northwest Fork" and its tributaries.

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SEARCH conducted intensive shovel testing at the mapped location of the site; however, no cultural materials were recovered. Based on this information, the Corps has determined project activities involving ground disturbance or inundation occurring within these surveyed areas will pose no effect to historic properties eligible for inclusion in the NRHP. Pursuant to Section 106 of the National Historic Preservation Act (16 USC 470) and it's implementing regulations (36 CFR 800), and in consideration of the Corps' Trust Responsibilities and the Burial Resources Agreement with the Seminole Tribe of Florida, I request your comments on the determination of 8PB17040 and 8MT1284 as ineligible for inclusion in the NRHP, on the overall determination of no effect for project activities within the surveyed areas, and your comments on the draft report. If there are any questions, please contact Mr. Marc Tiemann at 904-232-1557 or e-mail at Marc.A.Tiemann@usace.army.mil.

Sincerely,

Gina Paduano Ralph, Ph.D.
Chief, Environmental Branch

Enclosure

FLORIDA DEPARTMENT of STATE

RICK SCOTT
Governor

KEN DETZNER
Secretary of State

Dr. Gina Paduano Ralph
Chief, Environmental Branch, Planning and Policy Division
Jacksonville District Corps of Engineers
701 San Marco Boulevard
Jacksonville, Florida 32207-8175

April 5, 2017

RE: DHR Project File No.: 2015-0187-B, Received by DHR: March 6, 2017
DRAFT REPORT: Phase I Cultural Resource Survey for the Loxahatchee River Watershed Restoration Project, Martin and Palm Beach Counties, Florida

Dear Dr. Paduano Ralph:

Our office received and reviewed the above referenced report for possible effects on historic properties listed, or eligible for listing, on the *National Register of Historic Places.* The review was conducted in accordance with Section 106 of the *National Historic Preservation Act of 1966*, as amended, and its implementing regulations in *36 CFR Part 800: Protection of Historic Properties.*

From October to December 2016, Southeastern Archaeological Research (SEARCH) conducted a reconnaissance survey of six (6) parcels totaling approximately 4,672 acres and a Phase I cultural resource assessment survey of three (3) parcels totaling approximately 371 acres at the request of the U.S. Army Corps of Engineers (USACE). The multiple methodology approach for the areas of potential effect (APE) was agreed upon by USACE and SEARCH prior to the fieldwork. SEARCH recorded one (1) new linear resource during the investigation, historic canal 8PB17040, and attempted to locate previously recorded archaeological site 8MT1284. Site 8MT1284 was unable to be relocated despite rigorous testing. SEARCH determined that historic canal 8PB17040 is ineligible for NRHP listing due to its common design and engineering, and site 8MT1284 is ineligible due to the limited nature of the site. Additionally, previously recorded NRHP-eligible railroad 8PB12917 borders one of the APE, and previously recorded NRHP-ineligible canals 8PB14880 and 8PB15976 border or cross another APE. The proposed project will have no effect on historic properties listed or eligible for listing on the NRHP. SEARCH recommends no further cultural resource work within the nine (9) surveyed APEs. The USACE concurs with SEARCH's determinations and recommendations.

Based on the information provided, including the justification for the multi-level survey approach and thoroughness of both the recon and intensive surveys, our office concurs with these determinations and finds the submitted report complete and sufficient in accordance with Chapter 1A-46, *Florida Administrative Code*. If I can be of any further help, or if you have any questions about this letter, please feel free to contact Lindsay Rothrock at *Lindsay.Rothrock@dos.myflorida.com*.

Sincerely,

Jason Aldridge
For

Timothy A. Parsons, Ph.D.
Director, Division of Historical Resources and State Historic Preservation Officer

From: Bradley Mueller
To: Ralph, Gina P CIV USARMY CESAJ (US)
Cc: Tiemann, Marc Auguste CIV USARMY CESAJ (US)
Subject: [Non-DoD Source] Loxahatchee River Watershed Restoration Project Phase I CRAS Review
Date: Monday, April 24, 2017 10:38:15 AM
Attachments: image005.png

SEMINOLE TRIBE OF FLORIDA
TRIBAL HISTORIC PRESERVATION OFFICE
AH-TAH-THI-KI MUSEUM

TRIBAL HISTORIC PRESERVATION OFFICE

SEMINOLE TRIBE OF FLORIDA
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FAX: (863) 902-1117

THPO WEBSITE: WWW.STOFTHPO.COM
MUSEUM WEBSITE: WWW.AHTAHTHIKI.COM

TRIBAL OFFICERS

MARCELLUS W. OSCEOLA JR.
CHAIRMAN

MITCHELL CYPRESS
VICE CHAIRMAN

LAVONNE ROSE
SECRETARY

PETER A. HAHN
TREASURER

April 24, 2017

Ms. Gina Paduano Ralph, Ph.D.
Environmental Branch Chief, Planning Division
Department of the Army
Jacksonville District Corps of Engineers
P.O. Box 4970
Jacksonville, FL 322322-0019

Subject: Loxahatchee River Watershed Restoration Project, Palm Beach and Martin Counties, Florida
THPO #: 000029049

Dear Ms. Ralph,

Thank you for contacting the Seminole Tribe of Florida – Tribal Historic Preservation Office (STOF-THPO) regarding the Loxahatchee River Watershed Restoration Project, Palm Beach and Martin Counties, Florida. The proposed undertaking does fall within the STOF Area of Interest. We have reviewed the Phase I Cultural Resource Survey report you provided and completed our assessment pursuant to Section 106 of the National Historic Preservation Act and its implementing authority, 36 CFR 800. We concur with the recommendations of the report with the exception of the recommendation regarding previously recorded archaeological site 8MT1284. Although the cultural resource consultants we unable to re-locate the site, there appears to be enough ambiguity concerning the sites location that we respectfully recommend that if the proposed undertaking will result in any ground disturbing activities in the general vicinity of the recorded site location then a Secretary of the Interior qualified archaeological monitor should be present in the event cultural materials are discovered. Our only other comment is that the number of shovel tests excavated within the low probability areas of the six "reconnaissance-level" parcels are less that the Florida Division of Historic Resources Module Three guidelines recommends. We are not asking for any additional shovel testing however, we suggest in the future that consultants be given more direction in the number of shovel tests expected within low probability zones. Thank you and feel free to contact us with any questions or concerns.

Respectfully,

Bradley M. Mueller

Bradley M. Mueller, MA, Compliance Supervisor
STOF-THPO, Compliance Review Section
30290 Josie Billie Hwy, PMB 1004
Clewiston, FL 33440

Office: 863-983-6549 ext 12245
Fax: 863-902-1117
Email: bradleymueller@semtribe.com
Web: Blockedwww.stofthpo.com

COMPREHENSIVE EVERGLADES RESTORATION PLAN

LOXAHATCHEE RIVER WATERSHED RESTORATION PROJECT

DRAFT INTEGRATED PROJECT IMPLEMENTATION REPORT AND ENVIRONMENTAL IMPACT STATEMENT

March 2019

Appendix D

APPENDIX D

REAL ESTATE

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LOXAHATCHEE RIVER WATERSHED RESTORATION PROJECT

Palm Beach and Martin Counties

Project Implementation Report and Environmental Impact Statement

REAL ESTATE PLAN

D. STATEMENT OF PURPOSE

The purpose of this Real Estate Plan is to identify and describe the real estate to support Loxahatchee River Watershed Restoration Project (LRWRP). The LRWRP is included in the Comprehensive Everglades Restoration Plan (CERP). The CERP, as documented in the 1999 Central and Southern Florida (C&SF) Project Comprehensive Review Study Final Integrated Feasibility Report and Programmatic Environmental Impact Statement (Yellow Book), consists of 68 different components. The purpose of the CERP is to modify structural and operational components of the C&SF Project to achieve restoration of the Everglades and the south Florida ecosystem, while providing for other water related needs such as urban and agricultural water supply and flood protection. LRWRP contains 3 of the 68 total CERP components.

The purpose of LRWRP is to restore and sustain the overall quantity, quality, timing, and distribution of freshwaters to the federally designated "National Wild and Scenic" Northwest Fork of the Loxahatchee River (NWFLR) for current and future generations. This project also seeks to restore, sustain, and reconnect the area's wetlands and watersheds that form the historic headwaters for the river. These areas include Jonathan Dickinson State Park (JDSP), Pal Mar East/Cypress Creek, Dupuis Wildlife and Environmental Management Areas, J.W. Corbett Wildlife Management Area (WMA), Grassy Waters Preserve (GWP), Loxahatchee Slough, the last remaining riverine cypress stands in Southeast Florida in the Loxahatchee River, and the Loxahatchee River Estuary.

The Real Estate Plan is tentative in nature; it is for planning purposes only and both the final real estate cost estimates provided are subject to change even after approval of the Loxahatchee River Watershed Restoration Project Implementation Report.

D.1 PROJECT AND STUDY AUTHORIZATION

The Water Resources Development Act of 2000 (WRDA, 2000) (Public Law No. 106-541, of the 106th Congress), Title VI, Section 601 provides for and guides modifications to the Central and Southern Florida (C&SF) project and describes authorizations specific to the Comprehensive Everglades Restoration Plan (CERP). Section 601(b)(A) of the Act, "Comprehensive Everglades Restoration Plan Approval," provides authority for CERP. Section 601(d) "Authorization of Future Projects" provides the authority for the preparation of Project Implementation Reports.

D.2 PROJECT LOCATION AND STUDY AREA

D.2.1 Location

The project is generally located in South Florida within the vicinity of Martin and Palm Beach Counties (**Figure D-1.**).

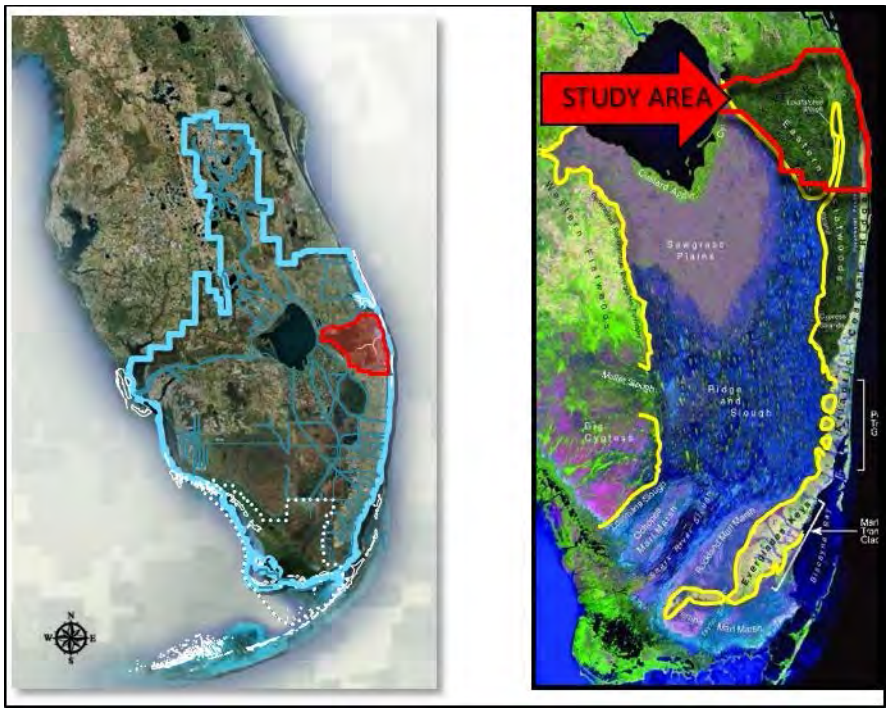

Figure D-1. Project Location.

D.2.2 Study Area

The LRWRP study area is approximately 480,000 acres (750 square miles) and is located in northern Palm Beach County and southern Martin County. The study area is characterized as highly urbanized in the eastern portion, and transitions to extensive natural areas to the west and north. The study area is bounded on the north by the C-44 Canal, on the south by the C-51 Canal, on the west by the L-8 Canal and Lake Okeechobee, and on the east by the Loxahatchee River Estuary and Lake Worth Lagoon. The project area includes all of the Loxahatchee River watershed and limited portions of the St. Lucie River watershed. Central and Southern Florida Project features within the study area include the L-8 Canal, the east and west legs of the C-18 Canal, and the C-51 Canal. Transportation infrastructure within the project area includes the Florida Turnpike and Interstate 95, as well as several major east/west county and state roadways (Indiantown Road [SR 706], PGA Boulevard [SR 708], Beeline Highway [SR 710], and Northlake Boulevard). This infrastructure and other development within the watershed have resulted in lowered groundwater levels and altered drainage patterns and flow regimes within the natural and less developed areas.

The LRWRP study includes eight major named natural areas under state, county, and city ownership. See **Table D-D-1** for descriptions and Figure D-2 for the location of these natural areas. Figure D-3 shows the major drainage basins and structures within the study area. Each of these areas have experienced some level of impacts from the drainage, water supply, and flood protection afforded by C&SF Project and the agricultural and urban development that followed.

Table D-D-1. Description of the LRWRP natural areas.

Natural Area	Description
Jonathan Dickinson State Park	Jonathan Dickinson State Park (JDSP) is located in the northeast section of the project area within Martin and Palm Beach Counties and is comprised of 11,471 acres. The park contains portions of several branches of the Loxahatchee River and its upstream tributaries (Northwest Fork, upper reaches of the North Fork, Cypress Creek, Moonshine Creek, Hobe Grove Ditch, Wilson's Creek, and Kitching Creek.
Northwest Fork of the Loxahatchee River (NWFLR)	The Northwest Fork of the Loxahatchee River (NWFLR), one of Florida's two federally designated National Wild and Scenic Rivers, is a natural river channel that originates in the Loxahatchee and Hungryland Sloughs. Downstream from these sloughs, the NWFLR receives additional input from the other major tributaries of the Loxahatchee River: Cypress Creek/Ranch Colony Canal, Hobe Grove Ditch, and Kitching Creek. A cypress river swamp community historically dominated the floodplain of the Loxahatchee River with freshwater stream swamps and Cypress communities present upstream from river mile 6.5 and dominant within the floodplain above river mile 8.0.
Loxahatchee River Estuary	The Loxahatchee River Estuary is downstream from the designated National Wild and Scenic River. Salt water from the Atlantic Ocean flows through Jupiter Inlet, merging with the freshwater that flows in from the north, northwest and southwest forks of the river, forming the estuary. This shallow embayment has an average depth of 3.5 feet, a maximum depth of 15 feet and covers an area of approximately 380 acres.
Pal-Mar	Pal-Mar comprises more than 37,000 acres in southern Martin and northern Palm Beach counties. Pal-Mar forms a linkage between J.W. Corbett WMA and JDSP. Prior to development, much of the Pal-Mar area drained toward Cypress Creek. Due to the transformation of the historic creek into the Cypress Creek Canal and the diversion of water from the historic creek into the Ranch Colony Canal, flows into the creek have been greatly altered and it is no longer a receiving body of Pal-Mar surface water. Western Pal-Mar is primarily a natural area and occurs as a mosaic of wetland/upland communities including depression marsh, wet prairie, dome and strand swamps, pine flatwoods and sloughs. The northern and eastern portions of Pal-Mar have been converted to agricultural usage and have undergone significant hydrological changes.
J.W. Corbett Wildlife Management Area	J.W. Corbett WMA encompasses approximately 62,000 acres in the northwest section of the project area. It contains extensive hydric/mesic flatwoods, depression marshes, wet prairies, strand and dome swamps and hydric/mesic hammocks. An intact Everglades sawgrass marsh ecosystem, considered a remnant of the Greater Everglades ecosystem, occurs along the southern boundary of J.W. Corbett WMA.
Loxahatchee Slough	Loxahatchee Slough was historically one of the most prominent flow ways in the study area and contained a large portion of the historic headwaters of the Northwest and Southwest Forks of the Loxahatchee River. The 12,000 acre site is the single most ecologically-diverse tract of protected land in Palm Beach County, including nine distinct community types. The slough used to extend all the way to what now is the Loxahatchee National Wildlife Refuge, but has been cut off by the levees that surround the Refuge, by the C-51 and C-18 canals, and by several highways that traverse the project area. These features have altered historic drainage patterns in this area and have allowed for extensive invasions by melaleuca.

Natural Area	Description
Grassy Waters Preserve	The southern half of the historical Loxahatchee Slough has been impounded to form the GWP. The GWP is a managed wetland ecosystem, approximately 12,800 acres (20 square miles), which is owned and operated by the City of West Palm Beach. GWP serves as a surface water catchment, groundwater recharge and storage system for public water supply. GWP is also known as the West Palm Beach Water Catchment Area. The City's management of the GWP as an element of the water supply system has protected and sustained most of this system in a high quality wetland condition. The wetlands within this catchment area include wet prairies (sawgrass and spikerush), sloughs and cypress and other tree islands configured in a remarkably natural mosaic.
Dupuis WEA	The Dupuis Wildlife and Environmental Area includes 21,875 acres located in the westernmost section of the study area, between Corbett WMA and Lake Okeechobee. Once part of the Everglades ecosystem, the hydrology of the area was altered through drainage. Habitats on the property include ponds, wet prairies, cypress domes, pine flatwoods, and remnant Everglades marsh.

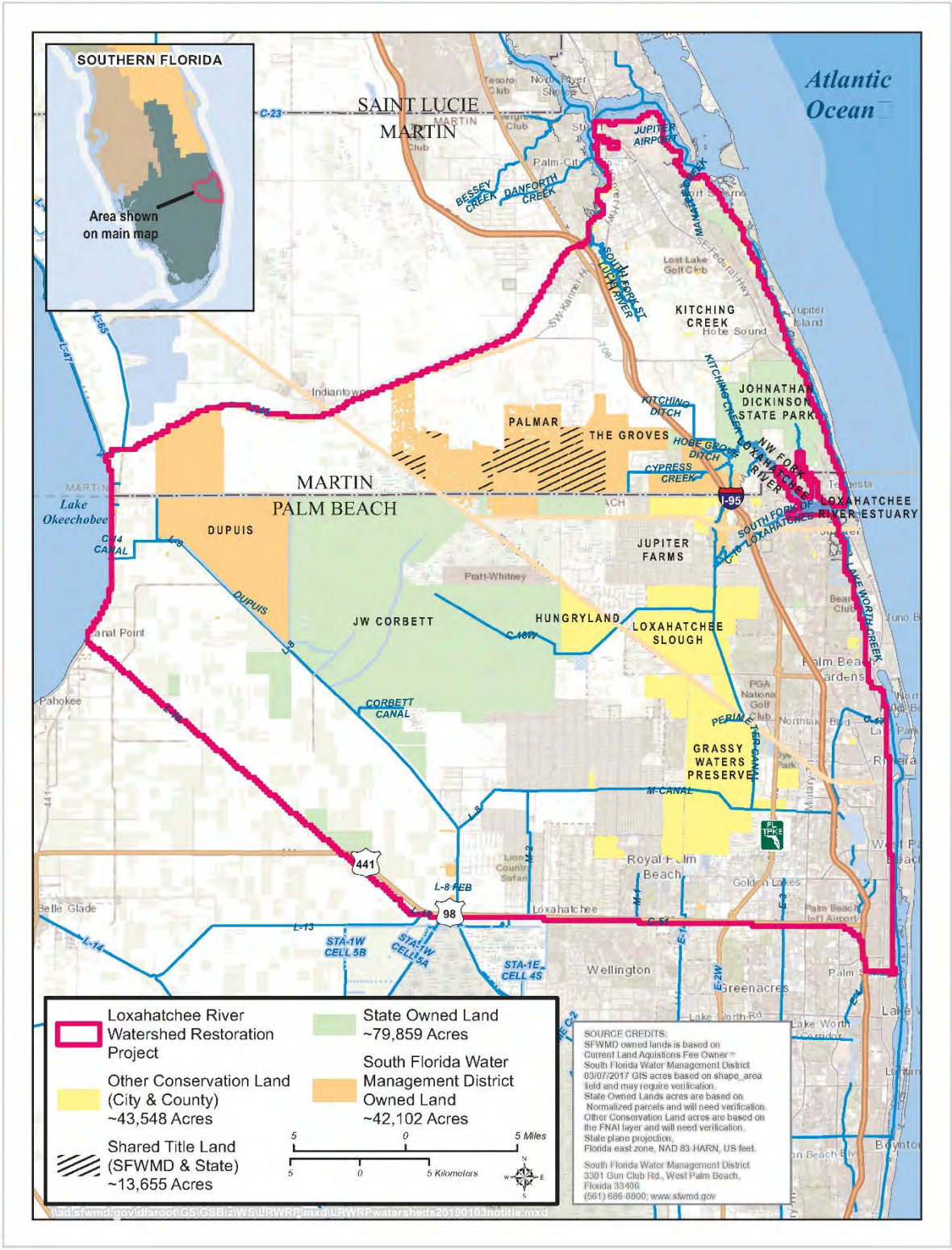

Figure D-2. Major canals and natural areas within the study area.

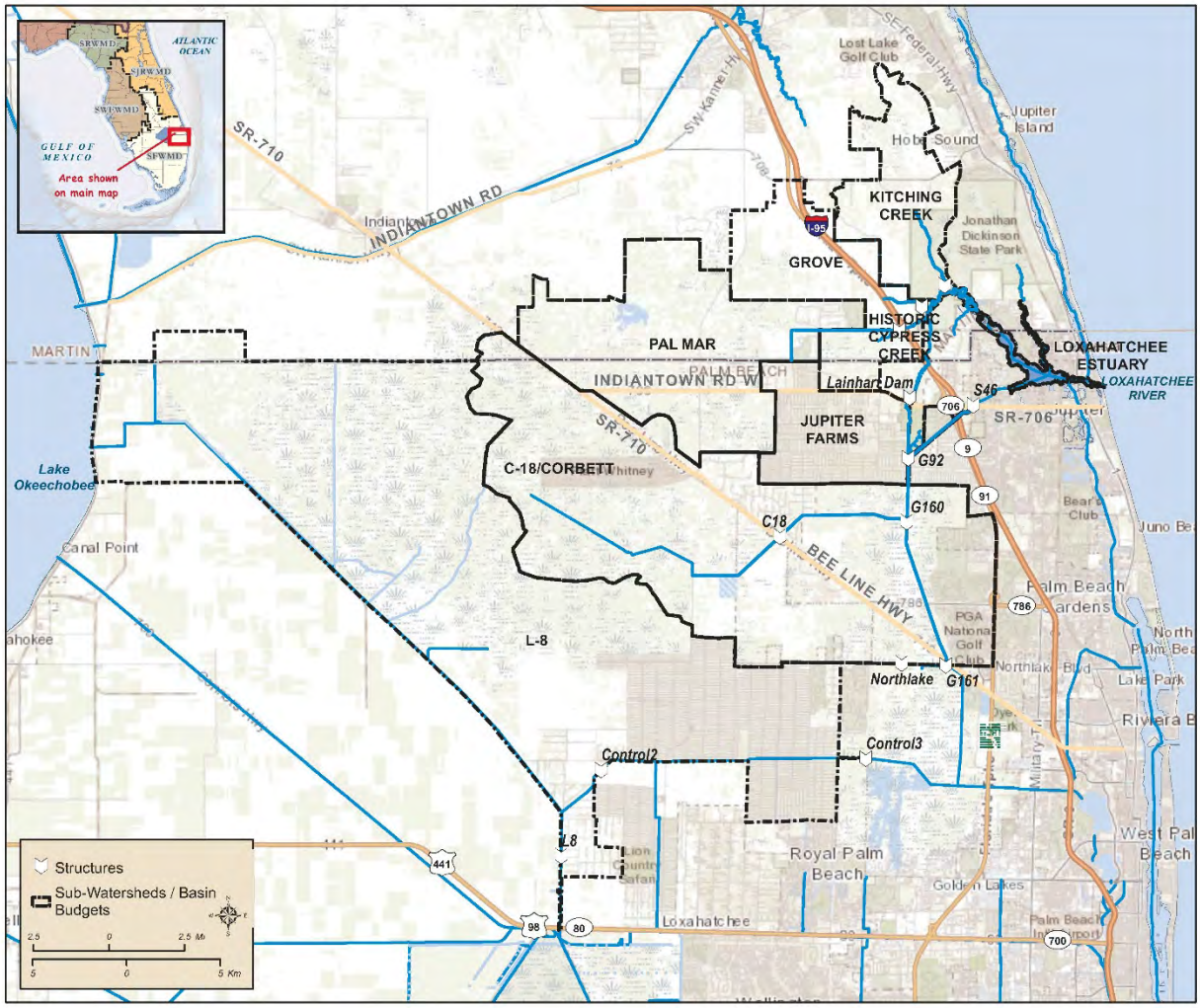

Figure D-3. Sub-watersheds, canals, features within the study area.

D.3 PROJECT DESCRIPTION

The project area is a subset of the study area. It is located primarily in the central and north central portions of the study area. The components of the Tentatively Selected Plan (TSP), Alternative (Alt) 5R, are organized into three geographic areas or flow-ways: Flow-way 1, Flow-way 2, and Flow-way 3. There is some overlap between Flow-ways 1 and 2. The TSP, Alt 5R, includes spillways, multi-purpose features such as conveyance channels and culvert barrels, swales, pump stations, a reservoir, culvert structures, Aquifer Storage and Recovery (ASR) wells, canals, drainage fills and backfills, berm improvements, a levee, and weirs.

Table D-2 highlights the key features proposed in the TSP. The subsequent sections define each proposed feature of the selected plan for each flow-way. The Project Delivery Team (PDT) agreed that the

preliminary design of features may be optimized during the preconstruction engineering and design phase (PED) at the discretion of the team.

Table D-2. Design features proposed for the TSP.

Project Feature	Feature Type	Purpose
Flow-way 1 - G-160	Structure	Water control/hydroperiod improvement, quantity and timing of flows to the river
Flow-way 1 - G-161	Structure	Water control/hydroperiod improvement, quantity and timing of flows to the river
Flow-way 1 - Grassy Waters Preserve Triangle	Earthwork	Conveyance, storage, hydroperiod improvement
Flow-way 1 - M-1 Lower Pump Station	Pump Station	Conveyance
Flow-way 2 - C-18W Reservoir	Impoundment	Storage, quantity and timing of flows to the river
Flow-way 2 - Aquifer Storage & Recovery (ASR)	Wells	Conveyance to storage
Flow-way 2 - M-O Canal Connector	Pump, Canal	Conveyance to storage
Flow-way 3 - Pal-Mar East	Earthwork	Hydrologic restoration and natural storage
Flow-way 3 - Thomas Pepper Farm	Drainage modifications	Maintain existing drainage
Flow-way 3 - Pal-Mar East (Nine-Gems) northern canal	Drainage modifications, berm improvements	Accommodate additional drainage from pepper farm, prevent wetland overflow
Flow-way 3 - Cypress Creek Canal	Structure, canal improvements	Water control, conveyance, discharge attenuation
Flow-way 3 - Gulfstream West Flow through Marsh	Impoundment	Discharge attenuation
Flow-way 3 - Gulfstream East, Moonshine Creek	Earthwork, weir	Hydrologic restoration, natural storage
Flow-way 3 - Kitching Creek	Earthwork, weir	Hydrologic restoration
Flow-way 3 - Mack Dairy Spreader Swale	Earthwork, pump	Hydrologic restoration, natural storage, timing and distribution to Cypress Creek

D.3.1 Flow-Way 1

Flow-way 1 is located in the southernmost portion of the project area, bounded by M Canal in the south and the G-92 spillway in the north. This flow-way uses the M Canal and C-18 Canal to route water from upstream project area basins to the Loxahatchee River. Flow-way 1 features include the M-1 pump station, M Canal, GWP, G-161 water control structure, GWP Triangle, the C-18 Canal, and G-160 spillway, as shown in **Figure D-4**. Only the M-1 pump station, GWP Triangle, G-161, and G-160 required a design analysis for the TSP.

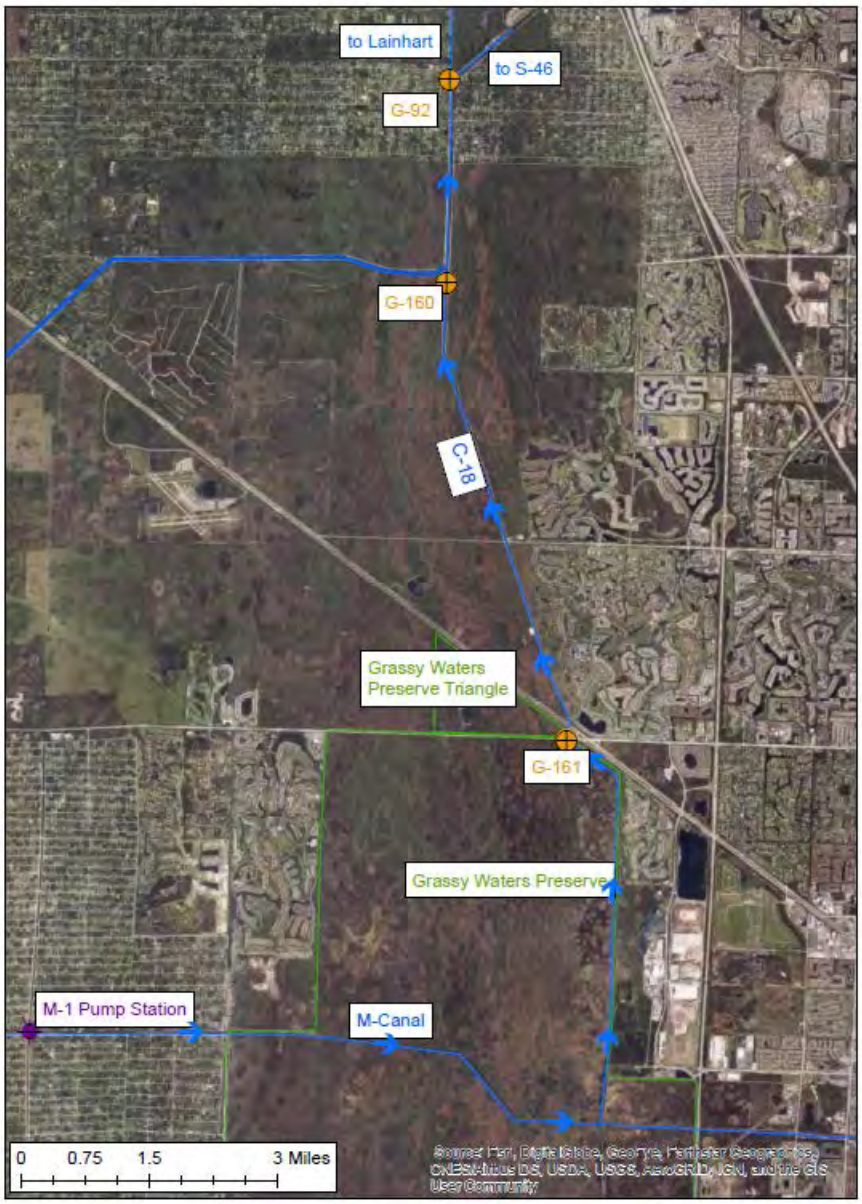

Figure D-4. Location Map of Major Features in Flow-way 1

D.3.1.1 M-1 Lower Pump Station

A pump station will deliver up to 75 cfs to the M Canal from Indian Trails Improvement District (ITID) lower M-1 Basin when canal stage conditions allow. Operations of the M-1 Basin allow for water to be pumped to the M Canal when stages are above 17.0 ft NGVD29 (15.5 NAVD88) in the dry season and 15.0 ft NGVD29 (13.5 NAVD88) in the wet season. The inflow pumping location within the M Canal will be either at or downstream of the area within the M Canal that has been widened.

D.3.1.2 M-Canal

The M Canal is an existing feature that provides a hydraulic connection between the L-8 Canal, via the L-8 Tieback Canal to the City of West Palm Beach. The M Canal flows through the GWP east to Lake Mangonia and Clear Lake. The West Palm Beach (WPB) water treatment plant is located on the northeast shore of Clear Lake where it takes its water.

D.3.1.3 GWP Triangle

The GWP Triangle is located northwest of the intersection of Beeline highway (SR-710) and Northlake Boulevard. Since the construction of Northlake Boulevard, this portion of GWP has experienced hydrologic separation from the rest of the GWP area. Hydrologic restoration of this area will be accomplished through earth work and strategic construction of a natural conveyance feature (shallow, with gentle slopes) that runs in an east to west direction. The conveyance will allow a hydrologic connection between the eastern and western portions of the triangle. When water levels are high in the western triangle (or vice versa) this will facilitate connectivity and equalization of the triangle hydrology, enabling storage and hydroperiod improvement.

D.3.1.4 G-161

The G-161 structure will act as the gateway through which water will be transported from GWP through the system to the Northwest Fork of the Loxahatchee River. The G-161 structure is a multi-purpose feature that will facilitate hydroperiod restoration of GWP, maintain existing flood protection, and provide improved conveyance for the regional water system. The water transfer from the G-161 structure will occur just west of the intersection of the Beeline Highway and Northlake Boulevard. Water will flow from GWP into the northern GWP Triangle area, north of Northlake Boulevard. A circuitous conveyance channel will carry the flow through the GWP Triangle between the G-161 structure and an existing culvert beneath the Beeline highway that connects GWP to the C-18 Canal. The conveyance channel also transverses under an existing railroad bridge. Flow will then pass through G-160 to the G-92 structure and on to the Northwest Fork. The design allows for variable flow rates between 0 and 150 cfs, adjustable as needed for conservation or flood risk management purposes. The structure will consist of two 60-in diameter culvert barrels with a total length of 240 ft. The barrels will be controlled by slide gates and have a flow line elevation of 11.1 ft NGVD29 (9.6 ft NAVD88).

D.3.1.5 C-18 Canal

The C-18 Canal was constructed in the 1950s by the USACE, as part of the C&SF, for the purpose of removing runoff from the adjacent lands, northward through S-46 structure, to the Southwest Fork of the Loxahatchee River. Surface water flows within the canal flow from south to north /northeast direction. The S-46 structure was constructed for flood control purposes, causing diversion of freshwater that flowed naturally to the Northwest Fork, away to the Southwest Fork. The G-92 structure, which was constructed in 1975 by the SFWMD, is located upstream of S-46 and diverts water from the C-18 Canal northward to the NWFLR. The east branch, containing the S-46 Structure, plus the main canal extends from the southwest fork of the Loxahatchee River, west of the low flat divide and west of the Atlantic Intracoastal Waterway (AIWW) (Mile 288.3), and then south, for approximately 10 miles to its intersection with Beeline Highway. The project will connect is to the historical NWFLR headwaters upstream of G-161. The C-18 Canal also has a west leg, approximately 7.9 miles long with headwaters consisting of the C-18/J.W. Corbett WMA. Water surface elevations in the portion of the C-18W Canal that is west of Beeline Highway are controlled by the C-18 Weir, which maintains water surface elevations at 17.6 ft, National Geodetic Vertical Datum (NGVD). Water elevations in the C-18 West leg east of Beeline Highway are controlled by the elevation at S-46.

D.3.1.6 G-160

The proposed G-160 structure is a reinforced concrete spillway designed to enhance delivery of the restoration flows to the Northwest Fork of the Loxahatchee River while maintaining water elevations within the Loxahatchee Slough and conserving optimum upstream water control stages in Canal 18 (C-18). Construction of the G-160 structure should achieve the following: (1) preserve sensitive wetlands in the Loxahatchee slough, (2) maintain the existing flooding level of service, and (3) provide water to the Northwest Fork of the Loxahatchee River. G-160 will increase stages in the Loxahatchee Slough, improving hydroperiods that have been adversely impacted by the construction and historic operations of the C&SF Project, specifically the C-18 Canal and Structure 46 (S-46). With increased stages in the slough, and deliveries through G-161, G-160 can deliver additional flow to the Loxahatchee River as needed. Discharges from G-160 are controlled by two stem -operated vertical lift gates. The design discharge rate, to maintain flood control capability, will be approximately 2000 cfs via two spillway bays, each 25 ft in length. The structure is operable to allow for the dual purposes of flood risk management and environmental restoration. The operable gates allow for management of upstream stages to mimic natural slough recession and ascension in water depth between the wet and dry seasons.

D.3.2 Flow-Way 2

Flow-way 2 is in the central portion of the project area. Its primary canal conveyances are the M-O Canal and C-18W Canal. The areas that will contribute to these canals include the ITID basin via the M-O Canal, J.W. Corbett WMA, Hungryland Slough, “Mecca” property (area of proposed C-18W Reservoir), and the natural area east of the North Palm Beach County Airport via the C-18W Canal. Note existing structures of regional importance: G-92, S-46, Lainhart Dam, and Masten Dam. **Figure D-5.** shows the proposed features of the TSP in Flow-way 2 and contributing areas.

Figure D-5. Location of Project Features for Flow-way 2.

D.3.2.1 C-18W Reservoir

The only reservoir proposed in the TSP is the C-18W Reservoir. The proposed reservoir is a 9,500 ac-ft above-ground volume that will provide pumped diversion and storage of excess flows from the adjacent C-18W Canal, J.W. Corbett WMA, and from ITID upper basin via the M-O Canal. The reservoir will release water back to the C-18W Canal as needed and available during low-flow periods, for delivery to Lainhart Dam and the Loxahatchee River downstream. The purposes of the reservoir are (1) capture excess flows from J.W. Corbett WMA, ITID and the C-18W basin and, 2) deliver water to meet the target restoration flows for the National Wild and Scenic Northwest Fork of the Loxahatchee River (NWFLR), and 3) change the timing of flow distribution and reduce waste to tide. The C-18W Reservoir site is approximately 1,920

acres of former citrus grove, located on the east side of Seminole-Pratt Whitney Road approximately 0.5 mile north of Northlake Boulevard in northern Palm Beach County, Florida.

There will be two main outflow structures at the reservoir: 1) a gated culvert discharge structure for normal operations; and 2) an emergency overflow spillway. The gated culvert structure will be located along the northern embankment of the reservoir, closely situated to the inflow pump station. The design is for a dual 48-in diameter culvert that can discharge 300+ cfs, depending on the stages within the reservoir. The proposed overflow spillway design is a 50 ft wide concrete spillway crest at an elevation lower than the embankment design elevation. It will be located adjacent to the culvert discharge structure and discharge into the C-18W Canal. The overflow spillway is designed to convey excess flood water to the C-18W Canal and away from the residential areas on the south side of the impoundment. The proposed overflow spillway crest elevation is set to provide 1 foot of freeboard above the normal pool elevation (27.5 feet NAVD88).

The seepage management system design will vary depending on location. Adjacent to the residential community to the south, Avenir property to the east, and a proposed shooting range to the north-west, a seepage cut-off wall will be installed. Total length will be approximately 2.5 miles for all segments. The seepage cut-off wall will consist of approximately 30-ft deep by 18-in wide soil-bentonite slurry mix. A seepage barrier conducted along the L-31 Canal, adjacent to Everglades National Park, serves as the basis of design during the feasibility phase (Amec Foster Wheeler Environment & Infrastructure, 2016). Other areas adjacent to the reservoir will maintain seepage through the use of seepage collection canals. The seepage canal collection system on the western perimeter of the reservoir will be managed by the 250 cfs pump station mentioned in previous paragraphs. These seepage collection canals were initially designed with 3 horizontal to 1 vertical (3H:1V) side slopes, with a depth and bottom width of 10 ft.

The main components of the reservoir design were the embankment design, erosion protection, and borrow material. Initial estimates for the embankment geometry were based on standard design requirements from DCM-2 for wind setup and wave run-up over that of the normal pool elevations. Additional requirements for freeboard included the potential probable maximum flood inflow volume (direct rainfall on site). These design considerations resulted in an embankment height approximately 18.5 ft above natural ground elevation with a normal design pool depth of approximately 7.5 ft or a normal pool elevation of 27.5 ft NAVD88. The embankment crest will be 14 ft wide and the exterior and interior slopes of the basin from the toe to crest are 3H:1V. It was estimated that all of fill material for the embankment will likely come from on-site through a combination of on-site grading, and the construction of borrow and seepage canals. Riprap lining of the intake/discharge structures and along the embankment side slope was included to help with erosion control either due to higher velocities near the structures or wave action for the interior side slopes.

D.3.2.2 Four-Well Aquifer Storage and Recovery System

An Aquifer Storage and Recovery (ASR) system will be constructed at the C-18W Reservoir to augment surface storage capacity and provide greater flexibility in reservoir operations. The ASR system consists of four ASR wells open to permeable zones of the Floridan Aquifer System.

D.3.2.3 M-O Canal Connector

This canal will be between the existing M-O Canal and the area upstream of the planned Seminole-Pratt Whitney Road Culverts and C-18W Reservoir. The purpose of the M-O Canal Connector is to transfer excess water from the ITID upper basin to C-18W Reservoir.

D.3.2.4 M-O Canal Connector Pump Station

This pump station will be located at the eastern terminus of the M-O Canal. As a result of the topography of the connector canal area, a pump station is required to pump water from the M-O Canal to the connector canal for delivery to the C-18W Reservoir

D.3.3 Flow-Way 3

Flow-way 3 is located within southern Martin County and a portion northern Palm Beach County north of Indiantown Road. This area contributes to the northwest fork of the Loxahatchee River via the Cypress Creek Canal and Cypress Creek, Moonshine Creek, Hobe Grove Ditch, and Kitching Creek tributaries. The project features for Pal-Mar East, Ranch Colony Canal, Gulfstream West, Gulfstream East, Moonshine Creek, and Kitching Creek are described below. An additional spreader swale feature, the Mack Dairy Spreader, was incorporated into the TSP due to public input and a cost/benefit analysis. **Figure D-6.** and **Figure D-7**, below, illustrate the western and eastern project areas and features of Flow-way 3, respectively.

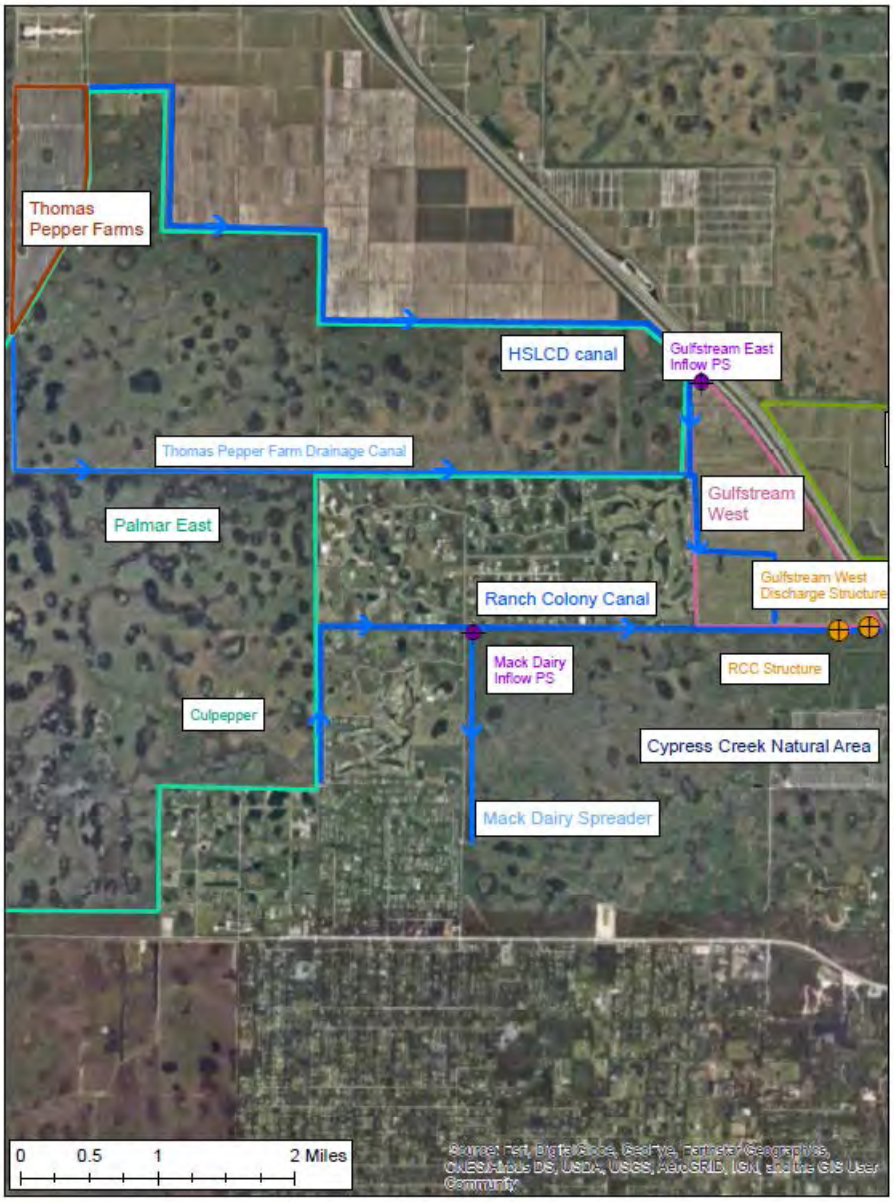

Figure D-6. Location of western Project features of Flow-way 3.

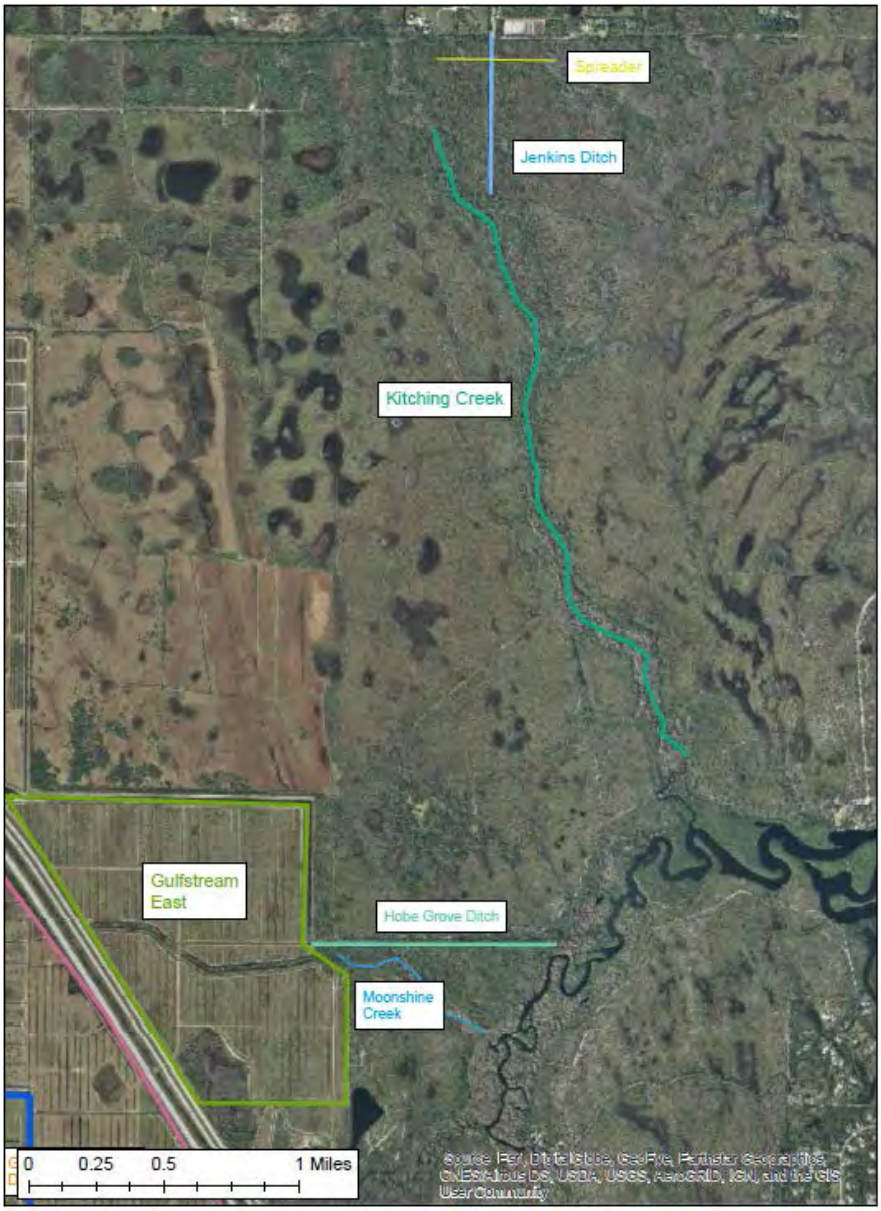

Figure D-7. Location of eastern Project features of Flow-way 3

D.3.3.1 Pal-Mar East (Nine Gems)

Multiple features within the Pal-Mar East property are proposed to improve hydroperiods and ecology within the area. The first component is to fill the internal drainage canals within Pal-Mar East to help reduce run-off from the site. Additionally, the small drainage pipes and culverts that are located along the northern boundary will be removed and backfilled to further reduce the drainage from the site. Minor improvements along the adjacent berm will be necessary at irregular intervals along the Pal-Mar East northern and eastern border to ensure water is held on site during larger storm events.

D.3.3.2 Thomas Pepper Farms

The Thomas Pepper Farms is located to the west of the Pal-Mar East Property and Pratt Whitney Road (SR-711). Currently, the farm drains to the south through a culvert under the road, and then through a canal that bisects the Pal-Mar East property. This canal is owned and operated by the Hobe St. Lucie Conservancy District (HSLCD). It continues east and south to eventually discharge into the Cypress Creek Canal and ultimately to the NWFLR via Cypress Creek. The canal through which the Thomas Pepper Farms currently drains causes a disruption in sheet flow from the southern portion of Pal-Mar East flowing in a northerly direction. Due to the topography, the northwest corner of southern portion of Pal-Mar East (south of this canal and to the east of Pratt Whitney Road (SR 711) may have periods of over-inundation due to the small berm that separates the natural area of Pal-Mar East from the Thomas Pepper drainage canal. The proposed design is to backfill the existing HSLCD canal that provides drainage to Thomas Pepper Farms and then smooth the existing berms to promote sheet flow from southern Pal-Mar East to the north/eastern portions of the property. The new drainage pattern would divert water from the Thomas Pepper Farms to another existing HSLCD canal located along the northern border of Pal-Mar East, between Pal-Mar East and the HSLCD agricultural land. This will require modification of a drainage ditch that currently exists along the northern boundary of Pal-Mar. The existing ditch shall be widened and deepened to handle the additional outflow from Thomas Pepper Farms. Additionally, a new culvert and pump will be required to re-route the Farm's drainage under Pratt Whitney road and into the newly constructed drainage canal.

D.3.3.3 Cypress Creek Canal

The south eastern portion of Pal-Mar East (also known as "Culpepper") currently drains through four water control structures into the Ranch Colony Canal. The Ranch Colony Canal begins at the south-eastern corner of Pal-Mar East, extending north and east between residential communities (The Links and Ranch Colony). Additionally, as noted above, the HSLCD drainage canal discharges into the downstream portion of the Cypress Creek Canal. The combined flow discharges uncontrolled under I-95 and the Florida Turnpike into Cypress Creek eventually reaching the NWFLR, downstream of Lainhart Dam. The system experiences periods of high discharge during wet periods or large rain events, causing scour and erosion both within the canal and downstream. Additionally, during drier periods, the canal continues to intercept adjacent groundwater seepage due to the canal's low bottom elevation. Modifications to the Culpepper control structures and to the Ranch Colony Canal are proposed for reducing the flashy nature of the system. Higher inlet control elevations as well as modifications to make the structures operable are proposed to help maintain more water on the Pal-Mar East property. This modification will help achieve a more desirable hydroperiod within the Culpepper property, while simultaneously reducing discharges into the Ranch Colony Canal.

The purpose of the proposed new control structure within the Ranch Colony Canal is to improve management of water elevations within the canal during the wet and dry season. The proposed structure is a two-bay concrete ogee spillway with telemetry operated vertical lift gates. Each bay will be 10 ft wide with a crest elevation at approximately 9 ft NAVD88. This design will allow for flexibility during the wet

and dry season. During the dry season, the gates can help hold additional water in the canal, assisting in the improvement of groundwater levels by reducing groundwater draw down. The structure will be designed and operated to control discharge velocities associated with wet season releases that may cause downstream erosion. The design will maintain or improve the current flood protection for the surrounding developments. The structure location, downstream of the Cypress Creek discharge location into Ranch Colony Canal, will provide additional hydrologic improvements to the currently over-drained Cypress Creek Natural Area.

Additional modifications to ensure flood protection is maintained include the proposed berm improvements along the Ranch Colony Canal and along the eastern border of Pal-Mar East (western boarder of the Ranch Colony Community). Existing berm elevations vary and contain low spots that may be susceptible to flooding during extreme events. The berm improvements along the Ranch Colony Canal will provide a uniform berm protection elevation for the neighborhoods and account for the proposed modification to the inlet control elevations of the four water control structures, which will cause higher stages within the Culpepper property. .

D.3.3.4 Gulfstream West

The Gulfstream West parcel is bordered by the Florida Turnpike to the east, Cypress Creek Canal to the south, and Pal-Mar East/Old Trail neighborhood to the west. The land was historically a citrus grove but is currently being used for cattle grazing. The HSLCD drainage canal extends along the western perimeter of the Gulfstream West property before turning east, cutting through a portion of the property and then south again to connect with and discharge to the Cypress Creel Canal. The Gulfstream West area has been excessively drained due to the drainage canals and ditches from agricultural use as well as the low stages within the Ranch Colony Canal, to which the HSLCD canal drains.

The main feature proposed for the Gulfstream West property is to construct a flow-through marsh. This feature will provide multiple benefits:

1. The flow-through marsh will source water from the HSLCD drainage canal, thereby helping control discharge rates and attenuate flow. This canal provides drainage for HSLCD Unit 2, an agricultural area located to the immediate north, as well as excess water from Pal-Mar East.

2. A flow through marsh will provide ecosystem benefits and water quality improvements.

3. Potential reduction in stages within the HSLCD drainage canal and Ranch Colony Canal as the flow through marsh provides additional storage and can re-route water from the HSLCD canal to downstream of the newly proposed structure within Cypress Creek Canal.

The flow-through marsh feature will pump water from the existing HSLCD drainage canal into a series of collection ditches and spreader berms that will promote sheet flow and re-hydration of the site. The design will require extensive earthwork, including the construction of a levee to ensure water is maintained and held on-site. The site will be graded and existing drainage ditches will be removed to

provide a more uniform topography and slight gradient to promote flow in a southerly direction. Approximately three to four collection ditches with spreader berms will be installed perpendicular to flow. This will help reduce preferential flow path development, while controlling discharge velocities for ecological benefits. The runoff from Thomas Pepper Farms, HSLCD Unit 2 and Pal-Mar East is discharged into the flow through marsh at the northern end of the property via a 250 cfs pump station. If runoff exceeds 250 cfs the by-pass canal (existing HSLCD canal) is used to route the excess runoff directly to the Ranch Colony Canal. The "dog-leg" at the southern end of the existing HSLCD canal is removed and the newly constructed portion of canal will continue north-south, along the west side of the property, with an open connection at the Ranch Colony Canal. Inflow pumping will stop when water elevations within the flow through marsh exceed 17.75 ft-NGVD29 (16.25 NAVD88) (avg. depth of 3'). The outflow structure will be a notched weir and is designed to discharge a variable rate depending on the marsh depth, with discharges reaching over 250 cfs when water depth within the marsh exceeds 3 feet. At 1.75 feet of depth the discharge will be approximately 30 cfs as baseflow to the Loxahatchee River. All discharge from the flow-through marsh is downstream of the new Ranch Colony Canal structure.

D.3.3.5 Gulfstream East and Moonshine Creek

The Gulfstream East property is approximately 450 acres of fallow citrus grove located to the east of the Florida Turnpike. Historically, the run-off of this property would flow east to the Moonshine Creek and ultimately to the Northwest Fork of the Loxahatchee River. Restoration of the Gulfstream East and Moonshine Creek is proposed. The existing drainage ditches will be filled and the site will be re-graded to the historical topography. To the east of the Gulfstream East property is the HSLCD Unit 3 control structure, which discharges into the Hobe Grove Ditch. The Hobe Grove Ditch, also a HSLCD facility, ultimately discharges into the NWFLR downstream of the historical Moonshine Creek channel. Approximately 250 ft downstream of the HSLCD Unit 3 structure the Hobe Grove Ditch and Moonshine Creek are partially separated due to heavy vegetation and sediment. The proposed feature will remove much of this sediment and vegetation to connect the Hobe Grove Ditch and Moonshine Creek. Additionally, a new weir will be installed at the eastern extent of the Hobe Grove Ditch to help hold additional water within the ditch, improving the groundwater levels while helping to promote additional flow down the historic Moonshine Creek. The proposed weir elevation is at 7.5 ft NGVD29 (6 ft NAVD88).

D.3.3.6 Kitching Creek

Kitching Creek discharges from the north into the north-west fork of the Loxahatchee River. Currently, Jenkins Ditch discharges flow from the northern portion of Kitching Creek via the Kitching Creek Preserve. The ditch also helps convey local runoff from surrounding residential properties. The natural area of Kitching Creek, just south of the residential areas, receives discharge from the ditch. The ditch has caused higher flow rates and a less natural run-off pattern to occur than historically observed. The proposed spreader swale is to be constructed to the east and west from Jenkins Ditch at the north end of the Jonathan Dickinson State Park. This swale will help distribute flows to historic Kitching Creek channels instead of directly down the ditch. This distribution is meant to mimic historical conditions by reducing peak discharge rates and creating a more natural flow pattern, aiding in the overall rehydration of the

area. A sheet pile weir is proposed to be constructed in the ditch upstream of the main Kitching Creek channel at elevation 12.0 ft NGVD to aid in the dispersion of water into the spreader system.

D.3.3.7 Mack Dairy Spreader Swale

The proposed Mack Dairy Spreader Swale will be located south of the Ranch Colony Canal, parallel to Mack Dairy Road. The purpose of the spreader swale is to help rehydrate the Cypress Creek Natural Area by pumping excess water from the Ranch Colony Canal to the spreader swale, located along the western-most extent of the Cypress Creek Natural Area. This spreader swale will assist in distributing water in a southerly direction while the natural topography will cause the water to flow east. This design for the distribution of water was to mimic historical flow patterns from the west (Culpepper area) that have been interrupted due to urban development. The natural discharge location of Cypress Creek is located just upstream of the proposed Ranch Colony Canal control structure. This control structure will also help stages, and associated ecological benefits, within the natural Cypress Creek Natural Area.

The spreader swale pump station capacity is designed to send up to 50 cfs from the Ranch Colony Canal into the spreader swale. The swale will extend for approximately 3,500 feet, with an average depth of 3 feet, bottom width of 5 feet, and 3H:1V side slopes. The spoil material will be placed along the western edge of the swale as a small berm. This will assist in promoting an easterly flow direction while helping provide additional flood protection to Mack Dairy Road. To further improve the hydroperiod and flow conditions in the Cypress Creek Natural Area, re-grading of the easterly forks of Cypress Creek are proposed. This is to help maintain lower flow velocities, reduce scour, and promote natural vegetative growth and improved ecological conditions in the area.

D.4 REAL ESTATE REQUIREMENTS

Approximately 81 parcels of land will be impacted by the project. See Exhibit A, Real Estate Maps, page 8 of 8 for the list of impacted parcels. The following real estate interests identified below for each project feature are required for the construction and operations, maintenance, repair, replacement, and rehabilitation (OMRR&R) of LRWRP. These are further delineated in Table D-3.

D.4.1 Flow-Way 1

<u>M-1 Lower Pump Station</u>

Fee is required for this feature; construction of this feature is within the M-Canal. The M Canal is owned in fee by the Indian Trail Improvement District and West Palm Beach County. In the event that neither can convey fee title to the SFWMD, than they can execute a Supplemental Agreement to provide the required lands pursuant to the terms and conditions of the CERP Master Agreement ARTICLE III - LANDS, EASEMENTS, RIGHTS-OF-WAY, RELOCATIONS AND COMPLIANCE WITH PUBLIC LAW 91-646, AS AMENDED of the MASTER AGREEMENT BETWEEN THE DEPARTMENT OF THE ARMY AND SOUTH FLORIDA WATER MANAGEMENT DISTRICT FOR COOPERATION IN CONSTRUCTING AND OPERATING, MAINTAINING, REPAIRING, REPLACING AND REHABILITATING AUTHORIZED PROJECTS UNDER THE COMPREHENSIVE EVERGLADES RESTORATION PLAN, entered into on August 13, 2009, subparagraph E. provides: The Government recognizes that the Non-Federal Sponsor in limited circumstances will be entering into supplemental agreements with the State of Florida or another Florida governmental entity whereby (1)

the State of Florida or another Florida governmental entity, rather than the Non-Federal Sponsor, has acquired or will acquire required lands, easements, and rights-of-way, and (2) the State of Florida or another Florida governmental entity will dedicate the land interests it owns to the *authorized CERP Project* and ensure that such lands, easements, and rights-of-way are retained in public ownership for uses compatible with the purposes of the *authorized CERP Project* and shall not be conveyed, transferred, altered, or otherwise encumbered without the advance written consent of the Non-Federal Sponsor and the Government. These supplemental agreements shall be limited in effect to the signatory parties and shall not reduce or alter in any way the requirements of this Master Agreement and any *PPA* that makes the Non-Federal Sponsor solely responsible for providing lands, easements, and rights-of-way that are required for the construction, operation, maintenance, repair, replacement, and rehabilitation of the *authorized CERP Project.*

D.4.1.1 M Canal

A perpetual channel easement is required for this existing canal. The M Canal is owned in fee by the Indian Trail Improvement District and West Palm Beach. In the event that neither cannot convey fee title to the SFWMD, than they can execute a Supplemental Agreement to provide the required lands pursuant to the terms and conditions of the CERP Master Agreement ARTICLE III.

D.4.1.2 Grassy Waters Preserve Triangle

Fee is required for earthwork and strategic construction of a swale. The Grassy Waters Preserve Area is owned in fee by the City of West Palm Beach. In the event that the City of West Palm Beach cannot convey fee title to the SFWMD, than they can execute a Supplemental Agreement to provide the required lands pursuant to the terms and conditions of the CERP Master Agreement ARTICLE III.

D.4.1.3 G-161

Fee is required for the G-161 feature. Any potential work required to allow for proper flow through the conveyance channel to include flows under both the Bee Line Highway and Northlake Blvd that connect the GWP to the C-18 Canal and under an existing railroad bridge, temporary construction easements and perpetual channel easements are required. The SFWMD owns fee to this area.

D.4.1.4 G-160

Fee is required for the G-160 feature. Construction of this feature will be within the C-18 Canal. C-18 Canal is a Central and South Florida Flood Control Project feature, and SFWMD holds a permanent easement for canal operations. Underlying fee ownership is public, owned by Palm Beach County. Palm Beach County owns fee title to this area and the SFWMD owns a Conservation Easement. The Conservation Easement does not give the SFWMD the right to flow water across the property nor the right to retain water on the properties. In the event that the Palm Beach cannot convey fee title to the SFWMD, than they can execute a Supplemental Agreement to provide the required lands pursuant to the terms and conditions of the CERP Master Agreement ARTICLE III.

D.4.1.5 Loxahatchee Slough

Palm Beach County owns fee title to this area and the SFWMD owns a Conservation Easement. The Conservation Easement does not give the SFWMD the right to flow water across the property nor the right to retain water on the properties. In the event that the Palm Beach County cannot convey fee title to the SFWMD, than they can execute a Supplemental Agreement to provide the required lands pursuant to the terms and conditions of the CERP Master Agreement ARTICLE III.

D.4.2 Flow-Way 2

D.4.2.1 C-18W Reservoir

C-18W Reservoir: above ground reservoir, Estate Required Fee, 1 Parcel, Sponsor Owned, SFWMD, owns fee to the approximately 1,650 acres is needed for the reservoir.

D.4.2.2 Four Well Aquifer Storage and Recovery System

The real estate requirement for this feature is within the lands required for the C-18W Reservoir; Fee is required. SFWMD, owns fee to these lands.

D.4.2.3 M-O Canal Connector

A perpetual channel easement is required for the M-O Canal Connector. SFWMD has acquired easements along the north side of the M-O Canal, as well as along the west side of the proposed C-18W Reservoir. During PED, the project will determine if these easements are adequate for the project or if additional area is required.

D.4.2.4 M-O Canal Connector Pump Station

Fee title is required for this feature. This land is owned in fee by the Florida Fish and Wildlife Commission. In the event that the Florida Fish and Wildlife Commission cannot convey the existing easements to the SFWMD, than they can execute a Supplemental Agreement to provide the required lands pursuant to the terms and conditions of the CERP Master Agreement ARTICLE III.

M-O Canal: existing feature already constructed, though some improvement may be necessary to ensure appropriate conveyance capacity. The underlying fee ownership is by private individual owners, subject to an Easement to the Indian Trail Improvement District for road and drainage purposes. Perpetual Channel Easement for Public Right-of-way is required. During PED, the project will determine if these easements are adequate for the project or if additional area is required. In the event that the Indian Trail Improvement District cannot convey the existing easements to the SFWMD, than they can execute a Supplemental Agreement to provide the required lands pursuant to the terms and conditions of the CERP Master Agreement ARTICLE III.

D.4.3 Flow-Way 3

D.4.3.1 Pal-Mar East (Nine Gems)

Pal-Mar East (Nine Gems): filling or plugging of existing north to shout drainage canals, internal grading, small drainage pipes and culverts will be removed and backfilled, minor berm improvements. The SFWMD has acquired the Pal-Mar East properties, except for approximately 235 acres on the western boundary between the property and Pratt Whitney Road (SR 711) and 60 acres on the north east corner. The planning models showed these areas to be unimpacted by the restoration, however, this will need to be confirmed with the detailed, event-based modeling during PED. If the properties are affected they will either need to be acquired in Fee, or protected with a seepage barrier or other physical structure. Additionally, the four (4) drainage ditches that traverse the property from north to south remain in ownership of the Hobe St. Lucie Conservancy District (HSLCD) and will need to be acquired in Fee. This

will be treated as a facility/utility relocation. A temporary easement will be required to complete the minor berm work and removal of small drainage pipe along the northern boundary of the property.

Thomas Pepper Farm

The project feature is the backfill of the existing Thomas Pepper farms drainage canal, rehabilitate the existing berms, construction of a new culvert and pump; and reroute the farm drainage to the HSLCD canal on the north side of the Pal-Mar East (Nine-Gems) property. Estate required is Fee. This will be treated as a facility/utility relocation.

D.4.3.2 Cypress Creek Canal:

Temporary easements are required for the construction of the two-bay concrete ogee spillway, and berm improvements. The portion of the canal where the structure will be constructed is owned by the SFWMD, shared title with Martin County. The portion of the canal adjacent to the residential communities is privately owned. Martin County has an easement to operate and maintain the canal.

D.4.3.3 Gulfstream West

A real estate interest of Fee is required for the flow-through marsh, extensive earthwork, the levee and the collection ditches with spreader berms. The SFWMD has acquired the property necessary to complete the construction of the flow through marsh, with the exception of the canal that transects the property.

D.4.3.4 Gulfstream East and Moonshine Creek

A real estate interest of Fee is required for the weir and for the restoration work that may affect the Hobe Grove drainage ditch, which are owned by HSLCD. The SFWMD has acquired the parcels necessary to complete the hydro-period restoration work.

D.4.3.5 Kitching Creek

A real estate interest of Fee is required for the proposed project features of a spreader swale and sheet pile weir. The proposed improvements are within Jonathan Dickenson State Park (JDSP). The State of Florida, Trustees of the Internal Improvement Trust Fund owns fee title to these lands and cannot convey fee title. A Supplemental Agreement to provide the required lands pursuant to the terms and conditions of the CERP Master Agreement ARTICLE III.

D.4.3.6 Mack Dairy Spreader Swale

A real estate interest of Fee is required to construct the swale on the southern portion of the area, these properties are owned by Palm Beach County. The SFWMD has a conservation easement over most of the property needed to increase water levels and complete the hydro-period restoration. The Conservation Easement does not give the SFWMD the right to flow water across the property nor the right to retain water on the properties. In the event that the Palm Beach County cannot convey fee title to the SFWMD, than they can execute a Supplemental Agreement to provide the required lands pursuant to the terms and conditions of the CERP Master Agreement ARTICLE III.

D.4.4 Staging and Access

Staging areas will be within the project footprint and identified during preconstruction, engineering and design (PED) of this project. Access areas will be by public roads and non-federal sponsor owned lands situated within the project area other access areas will be identified during PED for this project. A temporary work area easement will be required for areas identified for access outside the project area.

D.5 NON-FEDERALLY OWNED LANDS

The non-federal sponsor owns much of the lands required for the project in fee. Property was acquired using either SFWMD or State of Florida funds, no Federal funds. The total real estate required for the project includes 26,235 acres for hydroperiod improvement and approximately 1,650 acres for construction of a reservoir (C-18W iReservoir), associated infrastructure, and other miscellaneous pump stations and structures. The non-federal sponsor has acquired the majority of the lands required for the project, either in fee, or with conservation easements as shown in Table D-3.

Table D-3. Real Estate Requirements for Project Feature.

Feature	Feature Type	Required Estate	Estimated Acreage	Current Sponsor Estate
Flow-way 1 - G-160	Structure	Fee	2.5	Canal Easement
Flow-way 1 - G-161	Structure	Fee	3.0	Easement
Flow-way 1 - Grassy Waters Preserve Triangle	Earthwork	Fee	397	Unacquired
Flow-way 1 - M-1 Lower Pump Station	Pump Station	Fee	2.0	Unacquired
Flow-way 1 - Loxahatchee Slough	Operational changes, hydroperiod improvement	Fee or Conservation Easement	6,661	Acquired Palm Beach County, Fee, SFWMD Conservation Easement on ~ 12,000 acres which provides a buffer of ~ 2,500 yds east and west of the central restoration area
Flow-way 2 - C-18W Reservoir	Impoundment	Fee	~1,650	Fee
Aquifer Storage & Recovery (ASR)	Wells	Fee	Within C-18W footprint	Fee
Flow-way 2 - M-O Canal Connector	Pump, Canal	Fee	~100	Perpetual Easements
Flow-way 2 - J. W. Corbett Wildlife	Operational modification	Fee	1,642	Unacquired
Flow-way 3 - Pal-Mar East	Earthwork, wetland restoration	Fee	11,519	Various, mostly acquired, some existing easements to be acquired, some private parcels to be determined during PED

Feature	Feature Type	Required Estate	Estimated Acreage	Current Sponsor Estate
Flow-way 3 - Thomas Pepper Farm	Drainage modifications	Fee	TBD	Unacquired
Flow-way 3 - Pal-Mar East (Nine-Gems) northern canal	Drainage modifications, berm improvements	Fee	~60	Unacquired
Flow-way 3 - Cypress Creek Canal	Structure, canal improvements	Fee for structure, Temporary easement for canal	TBD	Fee acquired
Flow-way 3 - Cypress Creek Restoration	Mack Dairy Spreader, hydroperiod improvement	Fee, Perpetual Conservation Easement	3,493	Fee and conservation easement acquired
Flow-way 3 - Gulfstream West Flow through Marsh	Impoundment	Fee	750	Fee acquired, existing easement encumbrance to transfer
Flow-way 3 - Gulfstream East, Moonshine Creek	Earthwork, weir	Fee, easement for weir	650	Fee Acquired, easement needed
Flow-way 3 - Kitching Creek	Earthwork, weir	Fee	1243	TIITF (JDSP)
Flow-way 3 - River Floodplain	Increased flows to provide floodplain hydration and increase riverine connectivity	Perpetual Easement	~460	Fee

D.6 STANDARD ESTATES

The following estates are required:

FEE

The fee simple title to (the land described in _____ Schedule A) (Tracts Nos._____, _____ and _____), Subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

D.6.1 TEMPORARY WORK AREA EASEMENT

A temporary easement and right of way in, on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____ and _____), for a period not to exceed _____, beginning with date possession of the land is granted to the United States, for use by the United States, its representatives, agents, and contractors as a (borrow area) (work area), including the right to (borrow and/or deposit fill,

spoil and waste material thereon) (move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of the _____ Project, together with the right to trim, cut, fell and remove therefrom all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right of way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

D.6.2 FLOWAGE EASEMENT

The perpetual right, power, privilege and easement in, upon, over and across (the land described in Schedule "A") (Tracts Nos.____, ____ and ____ for the purposes set forth below:

a. Permanently to overflow, flood and submerge the land lying below elevation _____ (and to maintain mosquito control,) in connection with the operation and maintenance of the project for the purposes as authorized by the Act of Congress approved _____, together with all right, title and interest in and to the timber and the continuing right to clear and remove any brush, debris and natural obstructions which, in the opinion of the representative of the United States in charge of the project may be detrimental to the project.

b. b. Occasionally to overflow, flood and submerge the land lying above elevation (and to maintain mosquito control,) in connection with the operation and maintenance of said project.

Together with all right, title and interest in and to the structures and improvements now situate on the land, except fencing above elevation _____ (and also excepting _____, (here identify those structures not designed for human habitation which the District Engineer determines may remain on the land)) provided that no structures for human habitation shall be constructed or maintained on the land , that no other structures shall be constructed or maintained on the land except as may be approved in writing by the representative of the United States in charge of the project, and that no excavation shall be conducted and no landfill placed on the land without such approval as to the location and method of excavation and/or placement of landfill; the above estate is taken subject to existing easements for public roads and highways, public utilities, railroads and pipelines; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used and enjoyed without interfering with the use of the project for the purposes authorized by Congress or abridging the rights and easement hereby acquired; provided further that any use of the land shall be subject to Federal and State laws with respect to pollution.

D.6.3 CHANNEL IMPROVEMENT EASEMENT

A perpetual and assignable right and easement to construct, operate, and maintain channel improvement works on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____ and _____) for the purposes as authorized by the Act of Congress approved_____, including the right to clear, cut, fell, remove and dispose of any and all timber, trees, underbrush, buildings, improvements and/or other obstructions therefrom; to excavate: dredge, cut away, and remove any or all of said land and to place thereon dredge or spoil material; and for such other purposes as may be required in connection with said work of improvement; reserving, however, to the owners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement

hereby acquired; subject, however, to existing easements far public roads and highways, public utilities, railroads and pipelines.

D.6.4 THESE ESTATES CAN BE PROVIDED BY SUPPLEMENTAL AGREEMENT

In accordance with the terms of ARTICLE III - LANDS, EASEMENTS, RIGHTS-OF-WAY, RELOCATIONS AND COMPLIANCE WITH PUBLIC LAW 91-646, AS AMENDED of the MASTER AGREEMENT BETWEEN THE DEPARTMENT OF THE ARMY AND SOUTH FLORIDA WATER MANAGEMENT DISTRICT FOR COOPERATION IN CONSTRUCTING AND OPERATING, MAINTAINING, REPAIRING, REPLACING AND REHABILITATING AUTHORIZED PROJECTS UNDER THE COMPREHENSIVE EVERGLADES RESTORATION PLAN, entered into on August 13, 2009 subparagraph E. provides: The Government recognizes that the Non-Federal Sponsor in limited circumstances will be entering into supplemental agreements with the State of Florida or another Florida governmental entity whereby (1) the State of Florida or another Florida governmental entity, rather than the Non-Federal Sponsor, has acquired or will acquire required lands, easements, and rights-of-way, and (2) the State of Florida or another Florida governmental entity will dedicate the land interests it owns to the *authorized CERP Project* and ensure that such lands, easements, and rights-of-way are retained in public ownership for uses compatible with the purposes of the *authorized CERP Project* and shall not be conveyed, transferred, altered, or otherwise encumbered without the advance written consent of the Non-Federal Sponsor and the Government. These supplemental agreements shall be limited in effect to the signatory parties and shall not reduce or alter in any way the requirements of this Master Agreement and any *PPA* that makes the Non-Federal Sponsor solely responsible for providing lands, easements, and rights-of-way that are required for the construction, operation, maintenance, repair, replacement, and rehabilitation of the *authorized CERP Project.*

Use of Supplemental Agreements between the SFWMD as non-Federal Sponsor and the State of Florida or another Florida governmental entity whereby (1) the State of Florida or another Florida governmental entity, rather than the Non-Federal Sponsor have been approved in the following CERP Projects: Biscayne Bay Coastal Wetland, C-111 West Spreader Canal, and Broward County Water Preserve Areas.

D.7 EXISTING FEDERAL PROJECTS

The Central and Southern Florida Flood Control Canal 18 will be partially impacted. The Canal 18 (C-18) was constructed as part of the Central and South Florida Flood Control Project. The South Florida Water Management District is the owner of the lands that were certified. Lands are sufficient and available for the LRWRP. The non-federal sponsor will not receive credit for the value of LER, including incidental costs for lands acquired as part of the CS&F, C-18 project.

D.8 FEDERALLY OWNED LANDS

There are no known federally owned lands within the project area.

D.9 NAVIGATION SERVITUDE

The navigation servitude is not applicable to this project.

D.10 REAL ESTATE MAPS

The real estate planning map depicts the project area. See Exhibit A

D.11 INDUCED FLOODING

Preliminary analysis indicate there will be no flooding outside the lands identified as required for the Project, induced by the construction or the operation and maintenance of the project. However, a Taking/Savings Analysis has not been completed to determine if the current level of service will be maintained. Either prior to completion of the Final PIR or during PED, additional modeling will be completed to determine if there is a violation of the Savings Clause related to the maintenance of the level of service of flood protection. If it is determined that induced flooding is anticipated a Takings Analysis/Savings Clause will be prepared to determine if the expected induced flooding would rise to the level that would require additional real estate for the project. If it is determined that additional real estate is required; the additional lands impacted by induced flooding will be authorized to be acquired as part of this real estate plan for the LRWRP.

D.12 MITIGATION

Preliminary cultural resources surveys have identified impacts to cultural resources on lands within the project area. Additional cultural resource surveys will be necessary to identify, evaluate, and avoid impacting historic properties within the project area. Measures to mitigate, avoid, or minimize these impacts will be determined during PED of this project.

D.13 RELOCATION ASSISTANCE (PUBLIC LAW 91-646)

It is anticipated that relocation assistance benefits will not be required for this project.

D.14 MINERALS

Preliminary assessment indicates no known present or anticipated mineral or sub-surface mineral extraction activities within the vicinity of the proposed area which may affect construction, operation, or maintenance of the project.

D.15 NON-FEDERAL SPONSOR'S AUTHORITY TO PARTICIPATE IN PROJECT

The South Florida Water Management District (SFWMD) is the non-federal sponsor for this project. The SFWMD is empowered and authorized to acquire the LER for the construction, operation, and maintenance of the project. The capability assessment of SFWMD's real estate acquisition capability is attached as Exhibit "B" of this real estate plan. The SFWMD is familiar with P.L. 91-646 requirements and the requirements for documenting expenses for credit purposes.

D.16 ZONING ORDINANCES

Preliminary investigations indicates that no enactments of zoning ordinances are proposed in lieu of, or to facilitate, acquisition in connection with the project.

D.17 REAL ESTATE ACQUISITION SCHEDULE

No real estate acquisition scheduled has been developed; coordination with the SFWMD will take place to develop a schedule of all land acquisition milestones, including LER certification. Also, the SFWMD will be advised by letter of the risks associated with land acquisition prior to the execution of the Project

Partnership Agreement (PPA) or prior to the Government's formal notice to proceed with the acquisition. A draft copy of the Risk Letter is attached as Exhibit "C" of this real estate plan.

D.18 RELOCATIONS, ALTERATIONS, VACATIONS, AND ABANDONMENTS (UTILITIES, STRUCTURES AND FACILITIES, CEMETERIES, AND TOWNS).

Only one relocation, alteration, vacation, and abandonment is expected for this project.

The Thomas Pepper farm is located to the west of the Pal-Mar East Property and Pratt Whitney Road (SR-711). Currently, the farm drains to the south through a culvert under the road, and then through a canal that bisects the Pal-Mar East property. This canal is owned and operated by the Hobe St. Lucie Conservancy District (HSLCD). It continues east and south to eventually discharge into the Cypress Creek Canal and ultimately to the NWFLR via Cypress Creek. The canal through which the Thomas Pepper farms currently drains causes a disruption in sheet flow from the southern portion of Pal-Mar East flowing in a northerly direction. Due to the topography, the northwest corner of southern portion of Pal-Mar East (south of this canal and to the east of Pratt Whitney Road (SR 711) may have periods of over-inundation due to the small berm that separates the natural area of Pal-Mar East from the Thomas Pepper drainage canal. The proposed design is to backfill the existing HSLCD canal that provides drainage to Thomas Pepper farms and then smooth the existing berms to promote sheet flow from southern Pal-Mar East to the north/eastern portions of the property. The new drainage pattern would divert water from the Thomas Pepper Farm to another existing HSLCD canal located along the northern border of Pal-Mar East, between Pal-Mar East and the HSLCD agricultural land. This will require modification of a drainage ditch that currently exists along the northern boundary of Pal-Mar. The existing ditch shall be widened and deepened to handle the additional outflow from Thomas Pepper Farms. Additionally, a new culvert and pump will be required to re-route the Farm's drainage under Pratt Whitney road and into the newly constructed drainage canal. Because the Hobe-St. Lucie Conservancy District is a water control district codified by House Bill No. 1433 of Ch. 2005-339, in accordance with section 298.001, Florida Statutes acquisition of the drainage ditches owned by the HSLCD and improvement of the other drainage ditches owned by the HSLCD will be a utility/facility relocation. A Preliminary Attorney's Opinion of Compensability is not required under Chapter 12 of ER 404-1-12 or Real Estate Policy Letter 31, dated January 11, 2019.

Further assessments will be conducted during PED phase of the project to determine if any of the utilities listed below will have to be relocated.

The following utility lines have been identified as potentially being within the project footprint.

D.18.1 Loxahatchee Flow Way 1:

Easement in favor of Florida Power & Light Company by virtue of that certain Easement as recorded in Official Records Book 3008, page 81, public records of Martin County, Florida. (Section 28, Township 41 South, Range 42 East).

Easement in favor of Florida Power & Light Company by virtue of that certain Easement as recorded in Deed Book 1014, page 518, public records of Palm Beach County, Florida. (Section 32, Township 42 South, Range 42 East).

Easement in favor of Florida Power & Light Company by virtue of that certain Easement as recorded in Official Records Book 1446, page 252, public records Palm Beach County, Florida. (Section 36, Township 42 South, Range 39 East).

Easement in favor of Florida Power & Light Company by virtue of that certain Easement as recorded in Official Records Book 1601, page 296, public records of Palm Beach County, Florida. (Sections 3 and 4, Township 43 South, Range 40 East).

Easement in favor of Florida Power & Light Company by virtue of that certain Easement as recorded in Official Records Book 1601, page 298, public records of Palm Beach County, Florida. **(Sections 3 and 4, Township 43 South, Range 40 East).**

Easement in favor of Florida Power & Light Company by virtue of that certain Easement as recorded in Official Records Book 1619, page 586, public records of Palm Beach County, Florida. **(Sections 3 and 4, Township 43 South, Range 40 East).**

Seacoast Utility Authority's interest as shown by virtue of that certain Notice of Lien Rights as recorded in Official Records Book 22953, page 1631 and that certain Notice oflnterest as recorded in Official Records Book 26779, page 403, public records of Palm Beach County, Florida. **(Various Sections in Townships 41 and 42, Range 42 East).**

Easement in favor of Florida Power & Light Company by virtue of that certain Easement as recorded in Official Records Book 3008, page 81, public records of Palm Beach County, Florida. **(Section 28, Township 41 South, Range 42 East).**

Easement in favor of Seacoast Utility Authority by virtue of that certain Utility Easement as recorded in Official Records Book 10264, page 1783, public records of Palm Beach County, Florida. **(Section 28, Township 41 South, Range 42 East).**

Easement in favor of Florida Power & Light Company by virtue of that certain Order of Taking as recorded in Official Records Book 6873, page 1317, as modified by that certain Partial Release of Easement as recorded in Official Records Book 12426, page 484, public records of Palm Beach County, Florida. **(Sections 28, 29 and 32, Township 41 South, Range 42 East and Section 5, Township 42 South, Range 42 East).**
Utility Easement as shown on the Plat of Mirasol Plat Five as recorded in Plat Book 98, page 73, public record of Palm Beach County, Florida. **(Section 32, Township 41 South, Range 42 East and Section 5, Township 42 South, Range 42 East).**

Memorandum of Right of Way Consent Agreement between TWC/Golf Digest and Florida Power & Light Company as recorded in Official Records Book 11988, page 1069, public records of Palm Beach County, Florida. **(Section 32, Township 41 South, Range 42 East and Section 5, Township 42 South, Range 42 East).**

Easement in favor of the Seacoast Utility Authority by virtue of that certain Non-Exclusive Utility Easement as recorded in Official Records Book 13195, page 1896, public records of Palm Beach County, Florida. **(Section 5, Township 42 South, Range 42 East).**

Easement in favor of Florida Power & Light Company by virtue of that certain Easement as recorded in Official Records Book 13632, page 1462, public records of Palm Beach County, Florida. (Section 5, Township 42 South, Range 42 East).

Easement in favor of Seacoast Utility Authority by virtue of that certain Utility Easement as recorded in Official Records Book 6476, page 1920, public records of Palm Beach County, Florida. **(Section 6, Township 42 South, Range 42 East).**

Memorandum of Nonexclusive Permanent Underground Occupancy Agreement between CSX Transportation, Inc. and Florida Power & Light Company as recorded in Official Records Book 25775, page 1185, public records of Palm Beach County, Florida. **(Sections 7, 8, 16, 17 and 21, Township 42 South, Range 42 East).**

Easement in favor of Florida Power & Light Company by virtue of that certain Easement as recorded in Official Records Book 23334, page 1158, public records of Palm Beach County, Florida. **(Section 7, Township 42 South, Range 42 East).**

Right of Way Occupancy Agreement between CSX Transportation, Inc. and MCI Telecommunications Corporation as recorded in Official Records Book 5769, page 517, public records of Palm Beach County, Florida. **(Sections 7, 8, 16, 17 and 21, Township 42 South, Range 42 East).**

Easement in favor of Florida Power & Light Company by virtue of that certain Easement as recorded in Official Records Book 9491, page 509, public records of Palm Beach County, Florida. **(Section 17, Township 42 South, Range 42 East).**

Easement in favor of Seacoast Utility Authority by virtue of that certain Easement Deed as recorded in Official Records Book 17267, page 174, public records of Palm Beach County, Florida. **(Section 18, Township 42 South, Range 42 East).**

Easement in favor of Seacoast Utility Authority by virtue of that certain Memorandum of Developer Agreement as recorded in Official Records Book 18411, page 1962, public records of Palm Beach County, Florida. **(Section 18, Township 42 South, Range 42 East).**

Easement in favor of Florida Power & Light Company by virtue of that certain Easement as recorded in Official Records Book 9204, page 821, public records of Palm Beach County, Florida. **(Section 20, Township 42 South, Range 42 East).**

Easement in favor of Florida Power & Light Company by vi1iue of that certain Order of Taking as recorded in Official Records Book 7393, page 1811, public records of Palm Beach County, Florida. **(Section 19, Township 43 South, Range 40 East).**

Easement in favor of Florida Power & Light Company and Southern Bell Telephone and Telegraph Company by virtue of that certain Easement as recorded in Official Records Book 1137, page 344, public records of Palm Beach County, Florida. **(Sections 5 and 6, Township 42 South, Range 42 East).**

D.18.2 Loxahatchee Flow Way 2:

Memorandum of Nonexclusive Permanent Underground Occupancy Agreement between CSX Transportation, Inc. and Florida Power & Light Company as recorded in Official Records Book 25775, page 1185, public records of Palm Beach County, Florida. **(Sections 28, 34 and 35, Township 41 South, Range 41 East).**

Right of Way Occupancy Agreement between CSX Transportation, Inc. and MCI Telecommunications Corporation as recorded in Official Records Book 5769, page 517, public records of Palm Beach County, Florida. **(Sections 28, 34 and 35, Township 41 South, Range 41 East).**

Easement in favor of Florida Power & Light Company as reserved in that certain Special Warranty Deed as recorded in Official Records Book 10328, page 1142, public records of Palm Beach County, Florida. **(Section 34, Township 41 South, Range 41 East).**

Permit Agreement between Palm Beach County and Florida Power & Light Company as recorded in Official Records Book 9690, page 1475, public records of Palm Beach County, Florida. **(Sections 34 and 35, Township 41 South, Range 41 East).**

Easement in favor of Florida Power & Light Company by virtue of that certain Easement as recorded in Official Records Book 6688, page 387, public records of Palm Beach County, Florida. **(Section 34, Township 41 South, Range 41 East).**

Easement in favor of Florida Power & Light Company by virtue of that certain Easement as recorded in Official Records Book 6682, page 1577, public records of Palm Beach County, Florida. **(Section 28, Township 41 South, Range 41 East).**

Easement in favor of Florida Power & Light Company by virtue of that certain Easement as recorded in Official Records Book 6633, page 1635, public records of Palm Beach County, Florida. **(Section 28, Township 41 South, Range 41 East).**

Declaration of Easement in favor of Palm Beach County as recorded in Official Records Book 21666, page 904, public records of Palm Beach County, Florida. **(Sections 5 and 8, Township 42 South, Range 41 East).**

Declaration of Easement in favor of Palm Beach County as recorded in Official Records Book 26494, page 1068, public records of Palm Beach County, Florida. **(Section 8, Township 42 South, Range 41 East).**

Easement in favor of Florida Power & Light Company by virtue of that certain Easement as recorded in Official Records Book 11426, page 87, public records of Palm Beach County, Florida. **(Section 7, Township 41 South, Range 41 East).**

Utility Easements shown on the Plat of Palm Beach County Biotechnology Research Park as recorded in Plat Book 103, page 108, public records of Palm Beach County, Florida. **(Sections 5, 6, 7 and 8, Township 42 South, Range 41 East).**

Utility Easement as shown in those certain Easement, Assignment and Assumption of Easement and Amendment Number 1 to FWC Easement Number 13510 as recorded in Official Records Book 19023, page 1733, Official Records Book 26517, page 907 and Official Records Book 27184, page 1749, public records of Palm Beach County, Florida. **(Sections 12 and 13, Township 42 South, Range 40 East).**

Easement in favor of Florida Power & Light Company by vi1iue of that certain Easement as recorded in Official Records Book 23200, page 1491, public records of Palm Beach County, Florida. **(Section 1, Township 42 South, Range 40 East).**

Easement in favor of Florida Power & Light Company by vi1iue of that certain Easement as recorded in Official Records Book 1231, page 475, public records of Palm Beach County, Florida. **(Sections 28, 32 and 33, Township 41 South, Range 41 East).**

Easement in favor of Florida Power & Light Company by virtue of that certain Right of Way Agreement as recorded in Official Records Book 749, page 698, public records of Palm Beach County, Florida. **(Sections 1, 2, 11 and 12, Township 42 South, Range 40 East and Section 35, Township 41 South, Range 40 East).**

Easement in favor of Florida Power & Light Company by virtue of that certain Easement as recorded in Official Records Book 1658, page 1602, public records of Palm Beach County, Florida. **(Section 36, Township 41 South, Range 40 East and Section 1, Township 42 South, Range 40 East).**

Easement in favor of Florida Power & Light Company by virtue of that ce1ain Easement as recorded in Official Records Book 765, page 68, public records of Palm Beach County, Florida. **(Sections 1, 2 and 12, Township 42 South, Range 40 East and Section 35, Township 41 South, Range 40 East).**

Easement in favor of Florida Power & Light Company by virtue of that certain Easement as recorded in Official Records Book 1802, page 1226, public records of Palm Beach County, Florida. **(Section 1, Township 42 South, Range 40 East).**

D.18.3 Loxahatchee Flow Way 3:

Easement in favor of Florida Gas Transmission Company by virtue of that certain Sovereign Submerged Lands Easement as recorded in Official Records Book 1105, page 2493, public records of Martin County, Florida. **(Section 13, Township 40 South, Range 41 East and Sections 18, 19, 29 and 30, Township 40 South, Range 42 East).**

Easement in favor of Florida Power & Light Company by virtue of that certain Easement as recorded in Official Records Book 17435, page 243, public records of Palm Beach County, Florida. **(Sections 31 and 32, Township 40 South, Range 41 East).**

Easement in favor of Florida Gas Transmission Company by virtue of that certain Natural Gas Pipeline Easement Agreement as recorded in Official Records Book 2768, page 1471 (Martin County) and Official Records Book 27363, page 1648 (Palm Beach County) and that certain First Amendment to Natural Gas Pipeline Easement Agreement as recorded in Official Records Book 2768, page 2439 (Martin County) and Official Records Book 27368, page 1832 (Palm Beach County), public records of

Martin and Palm Beach Counties, Florida. **(Section 13, Township 40 South, Range 41 East, Sections 13, 18, 19, 29 and 30, Township 40 South, Range 42 East, Martin County and Section 32, Township 40 South, Range 42 East, Palm Beach County).**

Easement in favor of Florida Power & Light Company by virtue of that certain Easement as recorded in Official Records Book 179, page 283, public records of Martin County, Florida. **(Section 32, Township 39 South, Range 42 East).**

Easement in favor of Florida Power & Light Company by virtue of that certain Easement as recorded in Official Records Book 186, page 133, public records of Martin County, Florida. **(Sections 32 and 33, Township 39 South, Range 42 East).**

Easement in favor of Florida Power & Light Company by virtue of that certain Easement as recorded in Official Records Book 188, page 396, public records of Martin County, Florida. **(Section 32, Township 39 South, Range 42 East).**

Easement in favor of Florida Power & Light Company by virtue of that certain Easement as recorded in Official Records Book 188, page 405, public records of Martin County, Florida. **(Section 32, Township 39 South, Range 42 East).**

Easement in favor of Florida Power & Light Company by virtue of that certain Easement as recorded in Official Records Book 313, page 94, public records of Martin County, Florida. **(Section 32, Township 39 South, Range 42 East).**

Easement in favor of Florida Power & Light Company by virtue of that certain Right of Way Agreement as recorded in Deed Book 9, page 571, public records of Martin County, Florida. **(Section 32, Township 39 South, Range 42 East).**

Right of Way Agreement between Florida State Turnpike Authority and the American Telephone and Telegraph Company as recorded in Official Records Book 160, page 283, public records of Martin County, Florida. **(Section 13, Township 40 South, Range 41 East and Sections 18, 19, 29 and 30, Township 40 South, Range 42 East).**

Easement in favor of Florida Power & Light Company by virtue of that certain Easement as recorded in Official Records Book 128, page 29, public records of Martin County, Florida. **(Section 19, Township 40 South, Range 42 East).**

Easement in favor of Florida Power & Light Company by virtue of that certain Easement as recorded in Official Records Book 136, page 392, public records of Martin County, Florida. **(Section 19, Township 40 South, Range 42 East).**

Easement in favor of Florida Power & Light Company by virtue of that certain Easement as recorded in Deed Book 92, page 574, public records of Martin County, Florida. **(Section 32, Township 39 South, Range 42 East).**

Easement and Right of Way Agreement between Florida State Turnpike Authority and Florida Gas Transmission Company as recorded in Official Records Book 215, page 538, public records of Martin County, Florida. **(Section 13, Township 40 South, Range 41 East and Sections 18, 19, 29 and 30, Township 40 South, Range 42 East).**

Easement in favor of Florida Power & Light Company by virtue of that certain Easement as recorded in Official Records Book 508, page 1676, public records of Martin County, Florida. **(Section 26, Township 40 South, Range 41 East).**

Preliminary Attorney's Opinions of Compensability were not prepared, the Government will make a final determination if survey during PED identifies relocations, alterations, vacations, and/or abandonments are required, a Final Attorney's Opinion of Compensability will be prepared in writing for each proposed relocation, alteration, vacation, and/or abandonment.

"ANY CONCLUSION OR CATEGORIZATION CONTAINED IN THIS REPORT THAT AN ITEM IS A UTILITY OR FACILITY RELOCATION TO BE PERFORMED BY THE NON-FEDERAL SPONSOR AS PART OF ITS LERRD RESPONSIBILITIES IS PRELIMINARY ONLY. THE GOVERNMENT WILL MAKE A FINAL DETERMINATION OF THE RELOCATIONS NECESSARY FOR THE CONSTRUCTION, OPERATION, OR MAINTENANCE OF THE PROJECT AFTER FURTHER ANALYSIS AND COMPLETION AND APPROVAL OF FINAL ATTORNEY'S OPINIONS OF COMPENSABILITY FOR EACH OF THE IMPACTED UTILITIES AND FACILITIES."

D.19 HAZARDOUS, TOXIC, AND RADIOACTIVE WASTE (HTRW)

Currently there are no impacts to the real estate acquisition process and LER value estimate due to HTRW contaminants within the project area. The environmental site assessment process will identify and provide for resolution of any HTRW sites prior to certification of LER for project construction. Should remediation of HTRW contamination be required; it will be the responsibility of the SFWMD, the non-federal sponsor at their sole expense. In the event that HTRW contaminants are identified and are under the Comprehensive Environmental Response, Compensation and Liability Act, as amended, (CERCLA); for crediting purposes shall follow policy per ER 405-1-12, "12-37. Special Considerations, c.(3)g.

D.20 ATTITUDE OF LANDOWNERS

No opposition anticipated by landowners in the project area.

D.21 REAL ESTATE ACQUISTION/INCIDENTAL COSTS

(This section will be updated after completion of the gross appraisal)

The real estate cost estimate for the TSP is approximately $103,765,959.00. A 30% contingency is added in the amount of $31,129,791.00 to the overall real estate estimate for the project. The real estate cost estimate of lands required for the construction, operation, and maintenance to include the contingency is approximately $134,896,000.00 (Rounded up).

The estimate of the Federal real estate incidental acquisition cost including a contingency is $1,053,000.00. This cost includes project real estate planning, mapping, review, oversight, monitoring, administrative and legal costs, crediting review costs, certification of lands required for project purposes,

real estate analysis or other requirements that may be necessary during Planning, Engineering and Design (PED). The estimate of the non-federal sponsor incidental costs associated with the acquisition including a contingency is $1,579,500.00.

The total real estate cost estimate including contingencies to implement this project is approximately $137,528,260.00. The non-Federal sponsor will receive credit towards its share of real estate project costs incurred for certification of lands to include incidental costs.

D.22 SUMMARY OF PROJECT REAL ESTATE COSTS

The following cost figures (**Table** D-4. 4) are subject to change prior to construction.

Table D-4. Baseline cost estimate for real estate.

Real Estate Cost Category	Cost Estimate (current dollar)
Lands & Damages	$103,765,969
Lands & Damages – Contingency (30%)	$31,129,791
Subtotal for Lands & Damages	**$134,895,760**
Federal Review of Non-Federal Sponsor	$810,000
Federal Review of Non-Federal Sponsor– Contingency (30%)	$243.000
Subtotal for Federal Review of Non-Federal Sponsor	**$1,053,000**
Non-Federal Sponsor Administrative Costs	$1,215,000
Non-Federal Sponsor Administrative Costs – Contingency (30%)	$364,500
Subtotal for Non-Federal Sponsor Administrative Costs	**$1,579,500**
TOTAL Real Estate Cost Estimate	$137,528,260

D.23 REAL ESTATE CHART OF ACCOUNTS

Table D-5. summarizes the chart of accounts for the project.

Table D-5. Chart of accounts for the TSP.

Code - Description	Federal Cost Estimate	Non-Federal Cost Estimate	Totals
01B20 - Acquisition by Sponsor	$0	$1,215,000	$1,215,000
01B40 - Review of Project Sponsor	$810,000	$0	$810,000
01C20 - Condemnations by Project Sponsor	$0	$0	$0
01C40 - Review of Project Sponsor	$0	$0	$0
01F20 - PL 91-646 Relocation Assistance by Project Sponsor	$0	$0	$0
01F40 - Review of Project Sponsor	$0	$0	$0
01R1 - Land Payments	$0	$103,765,969	$103,765,969
Total Real Estate Cost Estimates Excluding Contingency	**$810,000**	**$104,980,969**	**$105,790,969**
Total Real Estate Contingency Estimates	**$243,000**	**$31,494,291**	**$31,737,291**
Total Project Real Estate Cost Estimates	**$1,053,000**	**$136,475,260**	**$137,528,260**

Note: The contingency is based on real estate incremental costs.

Exhibit "A"

Real Estate Maps

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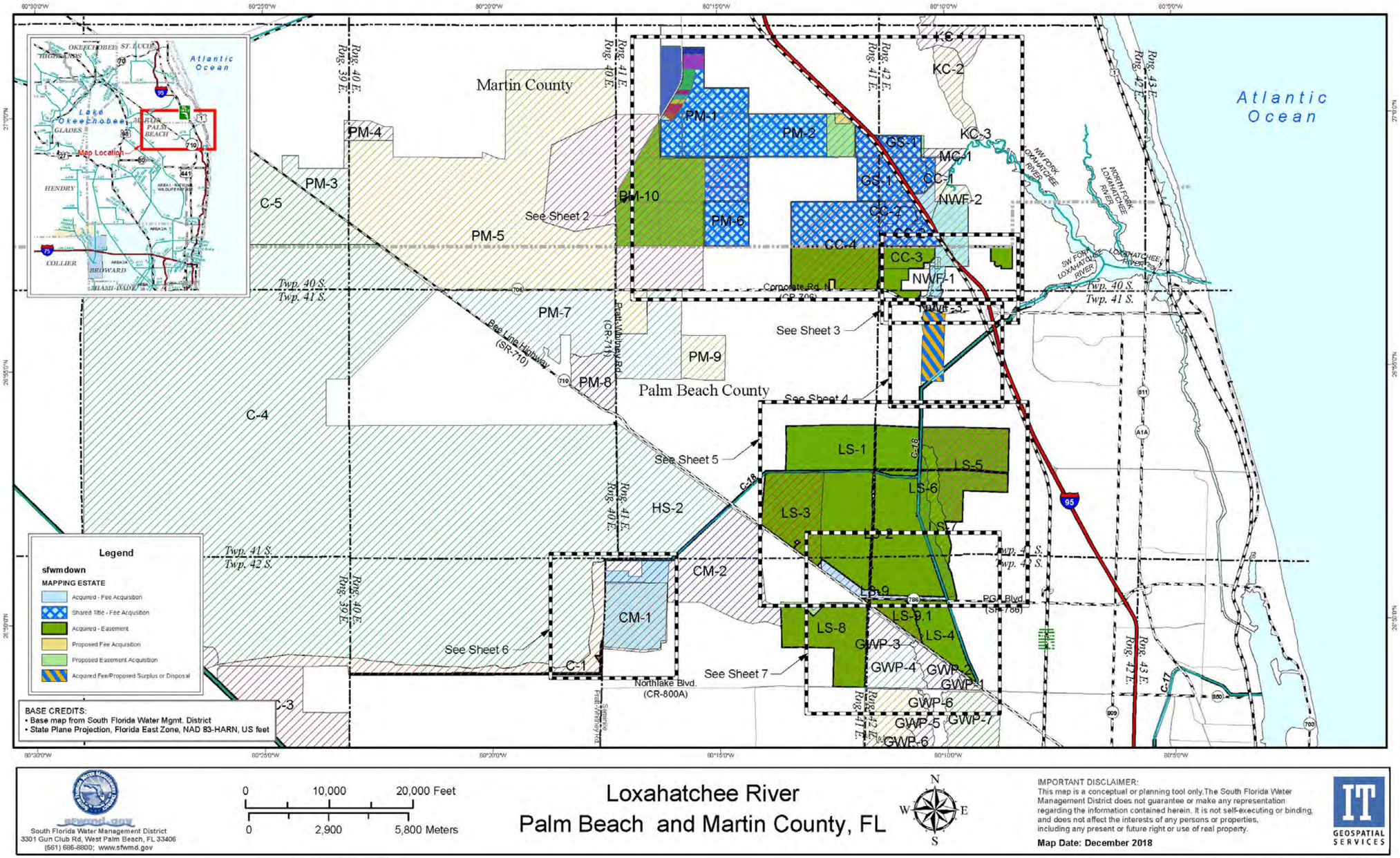
Atlantic Ocean
Martin County
Palm Beach County
Map Location
See Sheet 2
See Sheet 3
See Sheet 4
See Sheet 5
See Sheet 6
See Sheet 7
Twp. 40 S.
Twp. 41 S.
Twp. 42 S.
Rng. 39 E.
Rng. 40 E.
Rng. 41 E.
Rng. 42 E.
Rng. 43 E.
Bee Line Highway (SR-710)
Prat-Whitney Rd (CR-711)
Corporate Rd. N. (CR-709)
PGA Blvd (SR-786)
Northlake Blvd. (CR-800A)
NW FORK LOXAHATCHEE RIVER
NORTH FORK LOXAHATCHEE RIVER
SW FORK LOXAHATCHEE RIVER
LOXAHATCHEE RIVER
PM-1
PM-2
PM-3
PM-4
PM-5
PM-6
PM-7
PM-8
PM-9
PM-10
C-5
C-4
C-3
C-1
C-18
C-17
KC-2
KC-3
MC-1
GS-1
CC-1
CC-2
CC-3
CC-4
NWF-1
NWF-2
HS-2
CM-1
CM-2
LS-1
LS-2
LS-3
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LS-5
LS-6
LS-8
LS-9
LS-9.1
GWP-1
GWP-2
GWP-3
GWP-4
GWP-5
GWP-6
GWP-7
Legend
sfwmdown
MAPPING ESTATE
Acquired - Fee Acquisition
Shared Title - Fee Acquisition
Acquired - Easement
Proposed Fee Acquisition
Proposed Easement Acquisition
Acquired Fee/Proposed Surplus or Disposal
BASE CREDITS:
• Base map from South Florida Water Mgmt. District
• State Plane Projection, Florida East Zone, NAD 83-HARN, US feet
South Florida Water Management District
3301 Gun Club Rd, West Palm Beach, FL 33406
(561) 686-8800; www.sfwmd.gov
0 10,000 20,000 Feet
0 2,900 5,800 Meters
Loxahatchee River
Palm Beach and Martin County, FL
IMPORTANT DISCLAIMER:
This map is a conceptual or planning tool only.The South Florida Water Management District does not guarantee or make any representation regarding the information contained herein. It is not self-executing or binding, and does not affect the interests of any persons or properties, including any present or future right or use of real property.
Map Date: December 2018
GEOSPATIAL SERVICES
Sheet 1 of 8
User Name:rschaff
Remedy: ____
Map Produced on Date: 1/4/2019
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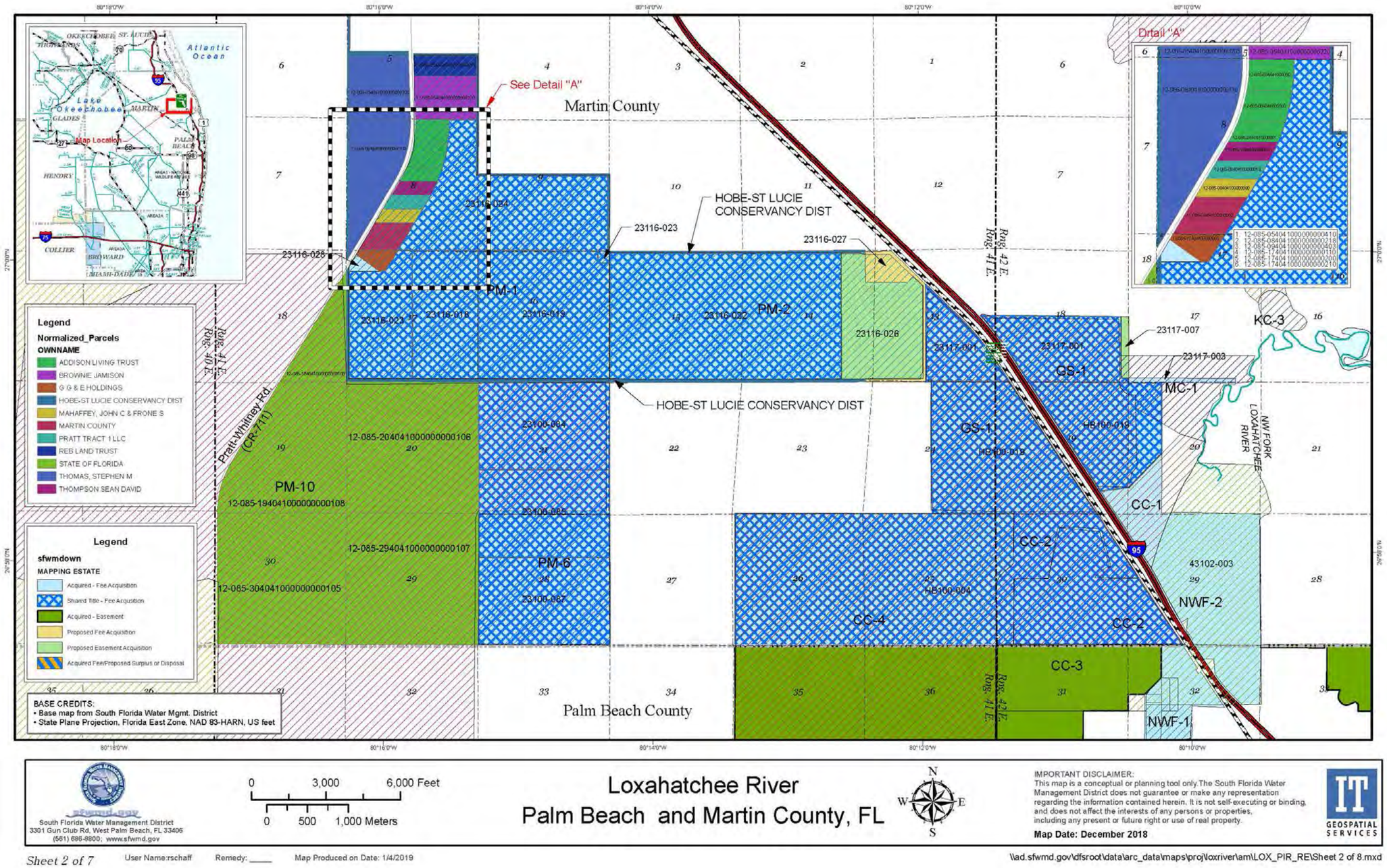
Atlantic Ocean
Lake Okeechobee
Map Location
Martin County
See Detail "A"
Detail "A"
HOBE-ST LUCIE CONSERVANCY DIST
23116-023
23116-027
23116-028
23116-024
23116-026
23116-022
23116-018
23116-019
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PM-2
PM-6
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GS-1
MC-1
KC-3
HB100-019
HB100-018
HB100-004
CC-1
CC-2
CC-3
CC-4
43102-003
NWF-2
NWF-1
NW FORK LOXAHATCHEE RIVER
Pratt-Whitney Rd. (CR-711)
Palm Beach County
Legend
Normalized_Parcels
OWNNAME
ADDISON LIVING TRUST
BROWNIE JAMISON
G G & E HOLDINGS
HOBE-ST LUCIE CONSERVANCY DIST
MAHAFFEY, JOHN C & FRONE S
MARTIN COUNTY
PRATT TRACT 1 LLC
REB LAND TRUST
STATE OF FLORIDA
THOMAS, STEPHEN M
THOMPSON SEAN DAVID
Legend
sfwmdown
MAPPING ESTATE
Acquired - Fee Acquisition
Shared Title - Fee Acquisition
Acquired - Easement
Proposed Fee Acquisition
Proposed Easement Acquisition
Acquired Fee/Proposed Surplus or Disposal
BASE CREDITS:
• Base map from South Florida Water Mgmt. District
• State Plane Projection, Florida East Zone, NAD 83-HARN, US feet
South Florida Water Management District
3301 Gun Club Rd, West Palm Beach, FL 33406
(561) 686-8800; www.sfwmd.gov
0 3,000 6,000 Feet
0 500 1,000 Meters
Loxahatchee River
Palm Beach and Martin County, FL
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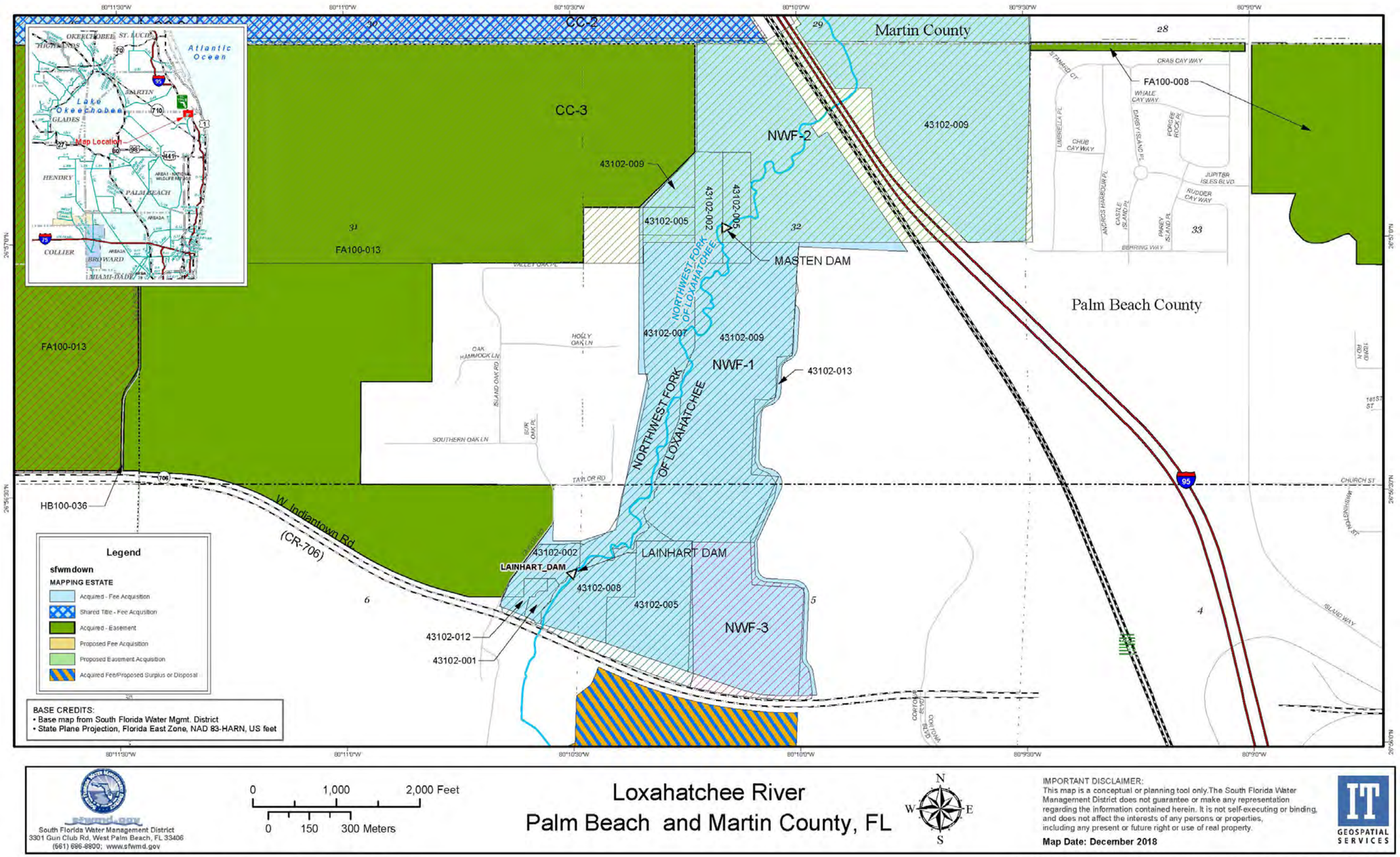
IMPORTANT DISCLAIMER:
This map is a conceptual or planning tool only. The South Florida Water Management District does not guarantee or make any representation regarding the information contained herein. It is not self-executing or binding, and does not affect the interests of any persons or properties, including any present or future right or use of real property.
Map Date: December 2018
GEOSPATIAL SERVICES
Sheet 2 of 7
User Name:rschaff
Remedy: ____
Map Produced on Date: 1/4/2019
\\ad.sfwmd.gov\dfsroot\data\arc_data\maps\proj\loxriver\am\LOX_PIR_RE\Sheet 2 of 8.mxd


Martin County
Palm Beach County
CC-2
CC-3
FA100-013
FA100-008
HB100-036
NWF-1
NWF-2
NWF-3
43102-009
43102-005
43102-002
43102-007
43102-013
43102-008
43102-012
43102-001
MASTEN DAM
LAINHART DAM
NORTHWEST FORK OF LOXAHATCHEE
W. Indiantown Rd (CR-706)
Atlantic Ocean
Lake Okeechobee
Map Location
Legend
sfwmdown
MAPPING ESTATE
Acquired - Fee Acquisition
Shared Title - Fee Acquisition
Acquired - Easement
Proposed Fee Acquisition
Proposed Easement Acquisition
Acquired Fee/Proposed Surplus or Disposal
BASE CREDITS:
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• State Plane Projection, Florida East Zone, NAD 83-HARN, US feet
0 1,000 2,000 Feet
0 150 300 Meters
Loxahatchee River
Palm Beach and Martin County, FL
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(561) 686-8800; www.sfwmd.gov
GEOSPATIAL SERVICES
Sheet 3 of 8
User Name:rschaff
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Palm Beach County
Atlantic Ocean
Lake Okeechobee
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Shared Title - Fee Acquisition
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Acquired Fee/Proposed Surplus or Disposal
BASE CREDITS:
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• State Plane Projection, Florida East Zone, NAD 83-HARN, US feet
South Florida Water Management District
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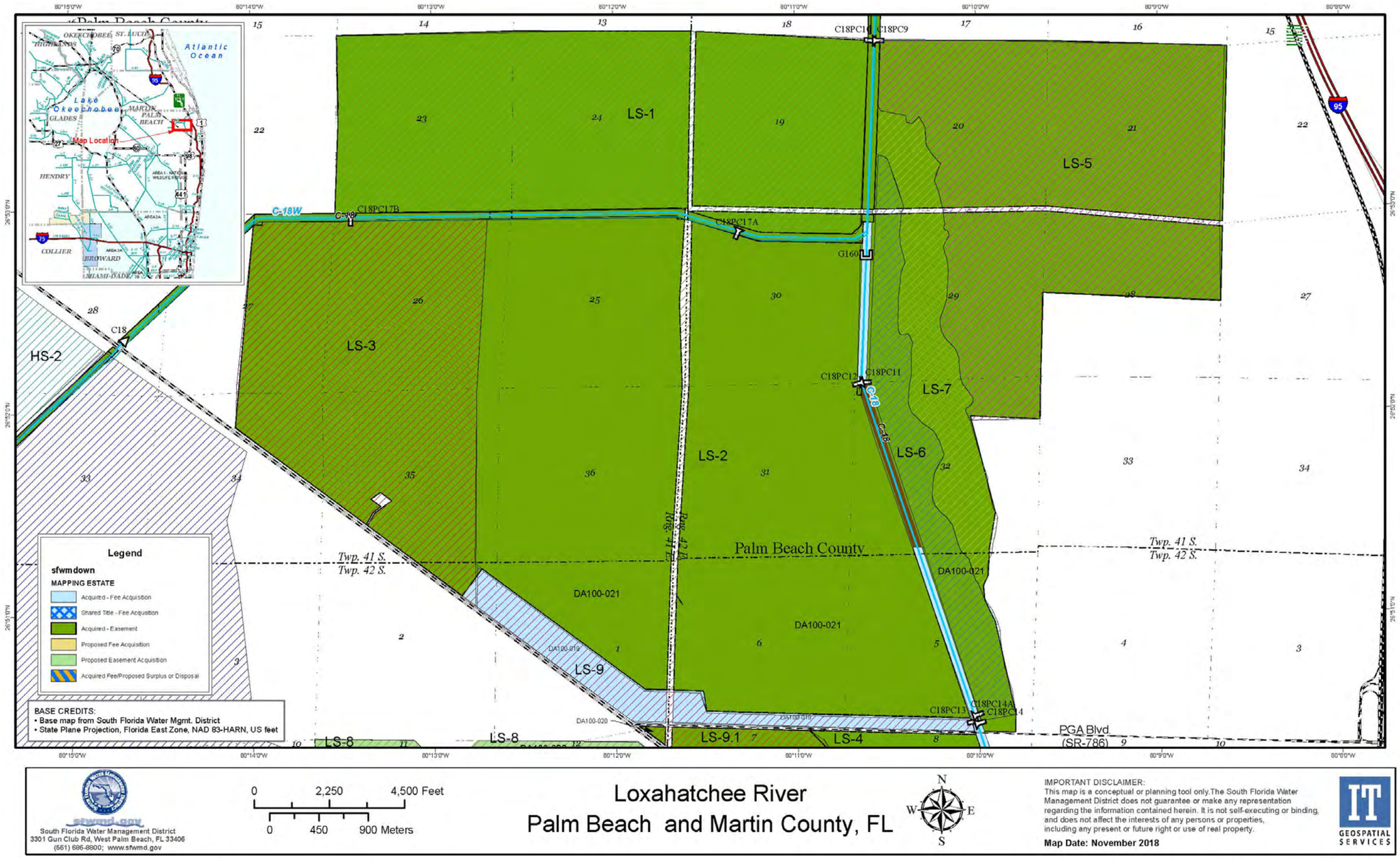
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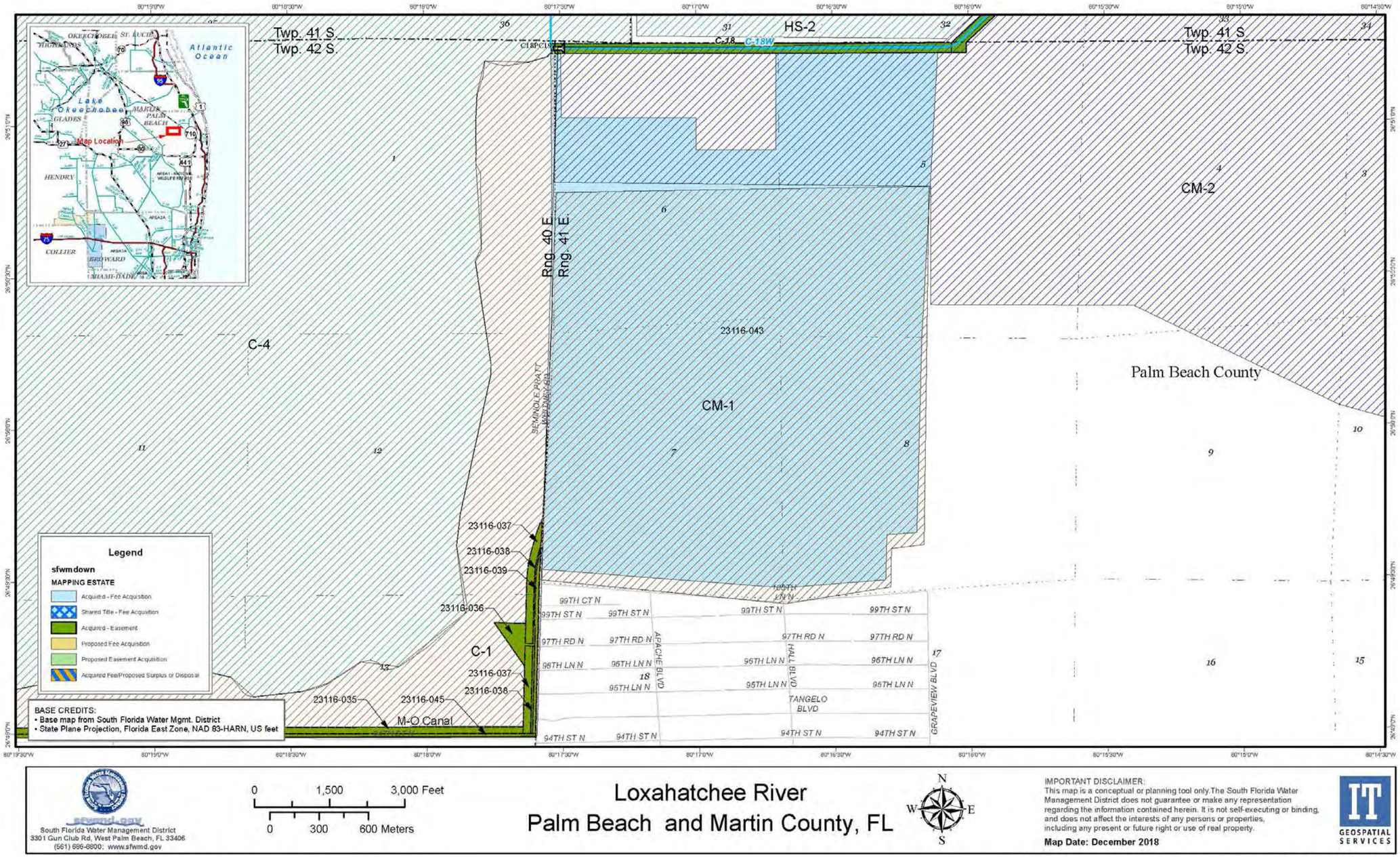
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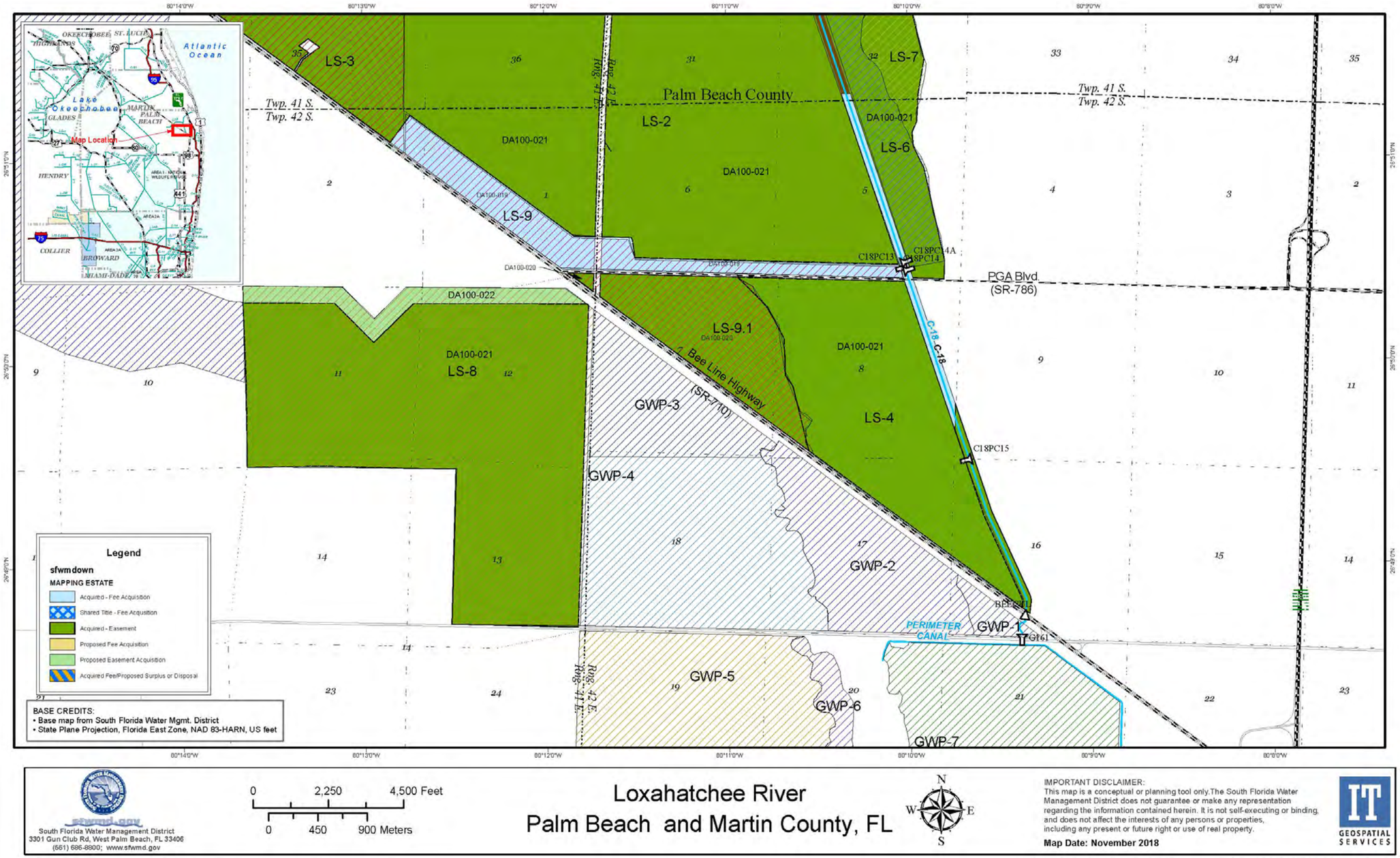
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DA100-022
DA100-020
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(SR-786)
Bee Line Highway
(SR-710)
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C18PC13
C18PC14A
C18PC14
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TRACT ID	ACREAGE	ACREAGE SRCE	MAPPING ESTATE	WORK STATUS	COMPONENT	PROJECT	PARCEL_NO	FEE_OWNER	PROJ_TYPE
23100-084	427.54	Deed	Shared Title-Fee	Shared Title	Palmar and JW Corbett WMA Hydropattern Restoration LRWRP Flowway 3	Loxahatchee River Watershed Restoration Project	21404100000000104	South Florida Water Management District	CERP
23100-085	427.54	Deed	Shared Title-Fee	Shared Title	Palmar and JW Corbett WMA Hydropattern Restoration LRWRP Flowway 3	Loxahatchee River Watershed Restoration Project	21404100000000110 28404100000000110	South Florida Water Management District	CERP
23100-087	427.53	Deed	Shared Title-Fee	Shared Title	Palmar and JW Corbett WMA Hydropattern Restoration LRWRP Flowway 3	Loxahatchee River Watershed Restoration Project	28404100000000109	South Florida Water Management District	CERP
23116-018	314.67	Legal Desc	Shared Title-Fee	Shared Title	Palmar and JW Corbett WMA Hydropattern Restoration LRWRP Flowway 3	Loxahatchee River Watershed Restoration Project	17404100000000102	South Florida Water Management District	CERP
23116-019	621.74	Legal Desc	Shared Title-Fee	Shared Title	Palmar and JW Corbett WMA Hydropattern Restoration LRWRP Flowway 3	Loxahatchee River Watershed Restoration Project	16404100000000104	South Florida Water Management District	CERP
23116-022	1086.30	Survey	Shared Title-Fee	Shared Title	Palmar and JW Corbett WMA Hydropattern Restoration LRWRP Flowway 3	Loxahatchee River Watershed Restoration Project	15404100000000106 14404100000000109	South Florida Water Management District	CERP
23116-023	274.04	Legal Desc	Shared Title-Fee	Shared Title	Palmar and JW Corbett WMA Hydropattern Restoration LRWRP Flowway 3	Loxahatchee River Watershed Restoration Project	16404100000000210 17404100000000120 17404100000000130	South Florida Water Management District	CERP
23116-024	589.74	Survey	Shared Title-Fee	Shared Title	Palmar and JW Corbett WMA Hydropattern Restoration LRWRP Flowway 3	Loxahatchee River Watershed Restoration Project	08404100000000101 09404100000000207	South Florida Water Management District	CERP
23116-028	10.00	Survey	Fee	Acquired	Palmar and JW Corbett WMA Hydropattern Restoration LRWRP Flowway 3	Loxahatchee River Watershed Restoration Project	17404100000000000	South Florida Water Management District	CERP
23116-031	329.52	Calculations	PropFee	Acq Not Initiated	Palmar - Remaining	Palmar	05404100000000205 08404100000000110 17404100000000110	Thomas, Stephen M.	SOR
23116-032	24.00	Calculations	PropFee	Acq Not Initiated	Palmar - Remaining	Palmar	05404100000000410 08404100000000209 17404100000000200	Hobe-St. Lucie Conservancy District	SOR
23116-036	6.37	Deed	Esmt	Acquired	L-8 Basin, LRWRP Flowway 2 Storage	Loxahatchee River Watershed Restoration Project	00404213000001000	Florida Fish and Wildlife Conservation Commission	CERP
23116-037	13.92	Deed	Esmt	Acquired	L-8 Basin, LRWRP Flowway 2 Storage	Loxahatchee River Watershed Restoration Project	00404212000009000 00404213000001000	Florida Fish and Wildlife Conservation Commission	CERP
23116-038	2.91	Deed	Esmt	Acquired	L-8 Basin, LRWRP Flowway 2 Storage	Loxahatchee River Watershed Restoration Project	00404212000009000 00404213000001000	Florida Fish and Wildlife Conservation Commission	CERP
23116-039	6.80	Deed	Esmt	Acquired	L-8 Basin, LRWRP Flowway 2 Storage	Loxahatchee River Watershed Restoration Project	00404212000009000	Florida Fish and Wildlife Conservation Commission	CERP
23116-040	2.19	Calculations	PropEsmt	Acq Not Initiated	L-8 Basin, LRWRP Flowway 2 Storage	Loxahatchee River Watershed Restoration Project	00414205010010000	Palm Beach County	CERP
23116-043	1647.76	Calculations	Fee	Acquired	L-8 Basin, LRWRP Flowway 2 Storage	Loxahatchee River Watershed Restoration Project	00414205010010000	South Florida Water Management District	CERP
23117-001	414.10	Tax Roll	Shared Title-Fee	Shared Title	Palmar and JW Corbett WMA Hydropattern Restoration LRWRP Flowway 3	Loxahatchee River Watershed Restoration Project	13404100000000209 13404100000000405 18404200000000206 18404200000000215	South Florida Water Management District	CERP
43100-005	0.02	Survey	PropEsmt	Acq Not Initiated	Loxahatchee River	Loxahatchee River	30424105000001030	IHP INVESTMENT FUND III LP	SOR
43100-010	18.00	Calculations	PropFee	Acq Not Initiated	Loxahatchee River	Loxahatchee River	00424106000005050	Hatcher, Walter & joyce	SOR
43102-001	2.71	Calculations	Fee	Acquired	Loxahatchee River	Loxahatchee River	30424106000001000	South Florida Water Management District	SOR
43102-002	17.98	Calculations	Fee	Acquired	Loxahatchee River	Loxahatchee River	00424032000003040	South Florida Water Management District	SOR
43102-003	581.52	Calculations	Fee	Acquired	Loxahatchee River	Loxahatchee River	19404200000000115	South Florida Water Management District	SOR
43102-004	2.16	Survey	Esmt	Acquired	Loxahatchee River	Loxahatchee River	00424032000003050 00424032000003040 00424032000007010 30424106000001040	Florida Department of Environmental Protection (TIITF)	SOR
43102-005	41.87	Deed	Fee	Acquired	Loxahatchee River	Loxahatchee River	00424032000003020 00424032000003050 00424105000003080	South Florida Water Management District	SOR
43102-007	42.90	Calculations	Fee	Acquired	Loxahatchee River	Loxahatchee River	00424032000003070	South Florida Water Management District	SOR
43102-008	19.00	Deed	Fee	Acquired	Loxahatchee River	Loxahatchee River	30424105000005040 30424106000001040	South Florida Water Management District	SOR
43102-009	321.65	Deed	Fee	Acquired	Loxahatchee River	Loxahatchee River	00424032000001010 00424105000003050 00424032000007010 00424105000003020 00424105000003110 00424032000003080 00424032000003090	South Florida Water Management District	SOR
43102-012	2.45	Calculations	Fee	Acquired	Loxahatchee River	Loxahatchee River	30424106000001080	South Florida Water Management District	SOR
43102-013	9.86	Tax Roll	Fee	Acquired	Loxahatchee River	Loxahatchee River	00424032000007030 00424105000001010	South Florida Water Management District	SOR
43102-014	492.79	Deed	Fee/PropFee Surplus	Acquired	Loxahatchee River	Loxahatchee River	00424105000007010 00424105000007020 00424105000003070 00424106000005020 00424105000003100 00424108000003020 00424108000003000 00424108000007020	South Florida Water Management District	SOR
43102-015	1.04	Legal Desc	Fee/PropFee Disposal	Acquired	Loxahatchee River	Loxahatchee River	00424106000005020	South Florida Water Management District	SOR
DA100-019	256.94	Deed	Fee	Acquired	L-8 Basin, LRWRP Flowway 1 Storage	Loxahatchee River Watershed Restoration Project	52414201000003010 52414202000001010 52424205000005030 52424206000005010	South Florida Water Management District	CERP
DA100-020	334.63	Tax Roll	Esmt	Acquired	L-8 Basin, LRWRP Flowway 1 Storage	Loxahatchee River Watershed Restoration Project	52414201000003010 52414207000001010 52414208000003010	GB Ranch, LLC	CERP
HB100-004	1987.17	Tax Roll	Shared Title-Fee	Shared Title	Palmar and JW Corbett WMA Hydropattern Restoration LRWRP Flowway 3	Loxahatchee River Watershed Restoration Project	26404100102500001 25404100100100004 29404200000000114 30404200000000103	South Florida Water Management District	CERP
HB100-019	961.21	Tax Roll	Shared Title-Fee	Shared Title	Palmar and JW Corbett WMA Hydropattern Restoration LRWRP Flowway 3	Loxahatchee River Watershed Restoration Project	19404200000000106 19404200000000204 20244200000000408 24404100000000117	South Florida Water Management District	CERP

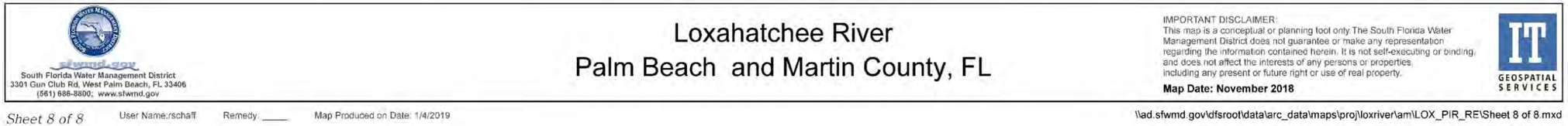

Exhibit "B"

Assessment of Non-Federal Sponsor's

Real Estate Acquisition Capability

ASSESSMENT OF NON-FEDERAL SPONSOR'S
REAL ESTATE ACQUISITION CAPABILITY

I. Legal Authority:

a. Does the sponsor have legal authority to acquire and hold title to real property for project purposes? (yes/no)

Yes, per Section 373.139(2), Florida Statutes

"The governing board of the district is empowered and authorized to acquire in fee or less than fee title to real property, easements and other interests or rights therein, by purchase, gift, devise, lease, eminent domain, or otherwise for flood control, water storage, water management, conservation and protection of water resources, aquifer recharge, water resource and water supply development, and preservation of wetlands, streams, and lakes. Eminent domain powers may be used only for acquiring real property for flood control and water storage or for curing title defects or encumbrances to real property owned by the district or to be acquired by the district from a willing seller."

b. Does the sponsor have the power of eminent domain for this project? (yes/no)

Yes, per Section 373.139(2), Florida Statutes, as stated above. Section 373.1501, Florida Statutes, South Florida Water Management District as local sponsor gives authority to act as local sponsor on Federal projects.

c. Does the sponsor have "quick-take" authority for this project? (yes/no)

Yes, if a "quick take" as opposed to a "slow take" is the method by which the District pursues the condemnation, it takes approximately six months to a year depending on the county.

d. Are any of the lands/interests in land required for the project located outside the sponsor's political boundary? (yes/no)

No.

e. Are any of the lands/interests in land required for the project owned by an entity whose property the sponsor cannot condemn? (yes/no)

No.

II. Human Resource Requirements:

a. Will the sponsor's in-house staff require training to become familiar with the real estate requirements of Federal projects including P.L. 91-646, as amended? (yes/no)

No.

b. If the answer to II.a. is "yes," has a reasonable plan been developed to provide such training? (yes/no)

c. Does the sponsor's in-house staff have sufficient real estate acquisition experience to meet its responsibilities for the project?

(yes/no)

Yes. SFWMD Real Estate staff have successfully acquired many acres of land for Federal CERP projects and pre-CERP projects.

d. Is the sponsor's projected in-house staffing level sufficient considering its other work load, if any, and the project schedule? (yes/no)

Yes. However, the current workload is high and SFWMD needs to review the project acquisition schedule once it is developed.

e. Can the sponsor obtain contractor support, if required in a timely fashion? (yes/no)

Yes, if a contractor is needed we can hire.

f. Will the sponsor likely request USACE assistance in acquiring real estate? (yes/no) (If "yes," provide description)

No but coordination with USACE during the process will be key.

III. Other Project Variables:

a. Will the sponsor's staff be located within reasonable proximity to the project site? (yes/no)

Yes.

b. Has the sponsor approved the project/real estate schedule/milestones? (yes/no)

No. SFWMD will review the schedule once it has been developed.

IV. Overall Assessment:

a. Has the sponsor performed satisfactorily on other USACE projects? (yes/no/not applicable)

Yes. Examples include Kissimmee River Restoration, C-111, C-44, Broward County Water Preserve Areas.

b. With regard to this project, the sponsor is anticipated to be: highly capable/fully capable/moderately capable/marginally capable/ insufficiently capable. (If sponsor is believed to be "insufficiently capable," provide explanation)

Highly Capable.

V. Coordination:

a. Has this assessment been coordinated with the sponsor? (yes/no)

Yes.

b. Does the sponsor concur with this assessment? (yes/no) (If "no," provide explanation

Yes.

Prepared by:

FREEMAN.EMMANUEL.JOSEPH.1068891813

Emmanuel Freeman
Realty Specialist

Reviewed by:

BEALYER.HANSLER.AMOS.1230707436

Hansler A. Bealyer
Chief, Acquisition Branch

Reviewed and approved by:

MCQUILLEN.TIMOTHY.HART.1050583305

Timothy H. McQuillen
Chief, Real Estate Division

Exhibit "C"

Draft Risk Letter

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT CORPS OF ENGINEERS
701 San Marco Boulevard
JACKSONVILLE, FLORIDA 32207-8175

REPLY TO
ATTENTION OF

Real Estate Division

Subject: NAME OF PROJECT

NAME
POSTION/TITLE
AGENCY
ADDRESS
CITY/STATE/ZIP

Dear LAST NAME:

The intent of this letter is to formally advise the NON-FEDERAL SPONSOR for the project, of the risks associated with land acquisition prior to the execution of the Project Partnership Agreement (PPA) or prior to the Government's formal notice to proceed with acquisition. If a non-Federal sponsor deems it necessary to commence acquisition prior to an executed PPA for whatever reason, the non-Federal sponsor assumes full and sole responsibility for any and all costs, responsibility, or liability arising out of the acquisition effort.

Generally, these risks include, but may not be limited to, the following:

a. Congress may not appropriate funds to construct the proposed project;

b. The proposed project may otherwise not be funded or approved for construction;

c. A PPA mutually agreeable to the non-Federal sponsor and the Government may not be executed and implemented;

d. The non-Federal sponsor may incur liability and expense by virtue of its ownership of contaminated lands, or interests therein, whether such liability should arise out of local, state, or Federal laws or regulations including liability arising out of CERCLA, as amended;

e. The non-Federal sponsor may acquire interests or estates that are later determined by the Government to be inappropriate, insufficient, or otherwise not required for the project;

f. The non-Federal sponsor may initially acquire insufficient or excessive real property acreage which may result in additional negotiations and/or benefit payments under P.L. 91-646 as well as the payment of additional fair market value to affected landowners which could have been avoided by delaying acquisition until after PPA

-2-

execution and the Government's notice to commence acquisition and performance of LERRD; and

g. The non-Federal sponsor may incur costs or expenses in connection with its decision to acquire or perform LERRD in advance of the executed PPA and the Government's notice to proceed which may not be creditable under the provisions of Public Law 99-662 or the PPA.

We appreciate your participation in this project. Should you have questions or concerns pertaining to this letter please feel free to contact Emmanuel Freeman at (904) 232-1636.

Sincerely,

Timothy H. McQuillen
Chief, Real Estate Division

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COMPREHENSIVE EVERGLADES RESTORATION PLAN

LOXAHATCHEE RIVER WATERSHED RESTORATION PROJECT

DRAFT INTEGRATED PROJECT IMPLEMENTATION REPORT AND ENVIRONMENTAL IMPACT STATEMENT

March 2019

Appendix E

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APPENDIX E

PLAN FORMULATION

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Table E-1. Results of screening management measures. E-2

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Figure E-1. Overview of plan formulation steps. E-1

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E INTRODUCTION

This plan formulation appendix is a supplement to Section 3 of the main report. The primary contents of this appendix are a large table with details of initial evaluation and screening of management measures. This table is too large to include in the main report.

Figure E-1. Overview of plan formulation steps.

E.1 Management Measures and Screening

Table E-1 shows the management measures considered and the results of screening. A management measure had to meet at least one project objective and not violate any of the project constraints for the measure to be retained. A management measure also had to meet three additional criteria: be acceptable, not create significant adverse environmental effects, and not be cost prohibitive.

Twelve of the 98 measures were assigned an "N" (no) for one or more of the four criteria, and were eliminated from further analysis. One measure was initially screened but the decision was reversed and the measure was retained. Seventy-four measures were retained for further analysis and potential inclusion in project alternatives. Eleven measures had too much uncertainty to make a clear decision to retain or eliminate. These 11 measures were tentatively kept until additional information was developed. Results of screening decisions for each of the 98 management measures are shown in **Table E-1**. This table shades each "Y" green, each "?" yellow, and each "N" red in the columns for the four criteria.

Additional notes to help understand this table:

- ASR stands for Aquifer Storage and Recovery;
- GWP stands for Grassy Waters Preserve;
- J.W. Corbett WMA for J.W. Corbett Wildlife Management Area;
- ITID stands for Indian Trail Improvement District;
- SIRWCD stands for South Indian River Water Control District;
- FWC stands for Florida Fish and Wildlife Conservation Commission;
- C-18W Reservoir, Mecca Reservoir, and reservoir at the Mecca site are the same feature.

Table E-1. Results of screening management measures.

Unique ID	Measure Name	Measure Type	Purpose & Notes	Obj 1: Restore Wet & Dry Season Flow	Obj 2: Restore Estuary	Obj 3: Increase Spatial Extent	Obj 4: Restore Connections	Obj 5: Restore Species Abundance & Diversity	Constraint: Do Not Reduce Flood Protection	Constraint: Do Not Reduce Water Supply	Constraint: Do Not Reduce Water Quality	Acceptable (by state & local entities)?	Meet an objective & avoid constraints	Not create sig adverse env effects	Not cost prohibitive	Management Measure Screening Result
1.1.c	Increase Conveyance of M Canal	Pump Station/ Conveyance	Control 2 pump station improvements already done by City of West Palm Beach; M Canal Improvements to include muck removal, selective widening/removal of bottlenecks. Improve connectivity with historic river headwater (increase flow capability from 165 cfs to 300 cfs) to offset discharges to G-161 is to offset water discharged from G-161 to the river at the appropriate ratio to not impact water supply) operationally, must be connected with G-161. Improve M Canal to accommodate increased flows from Control 2 pump station.	Y	N	N	N	N	Y	Y	Y	Y	Y	?	?	Retained.
1.12.a	ASR at L8 Shallow Storage	Storage	ASR on Flow-way 1/2: Couple ASR with ITID impoundment. Requires connection to C-18W basin in Flow-way2. Provide storage of L-8 basin water between Flow-ways 1 and 2. ASR would increase storage of ITID impoundment, for dry season deliveries along a modified M-O canal to Mecca Reservoir.	N	N	Y	N	N	Y	?	Y	?	Y	Y	Y	Retained.
1.13.a	PC-10 Pump Station	Pump station/conveyance	Small (25 cfs) pump station at PC-10 ditch berm. Capture dry season discharges before they move east to SIRWCD structure/deliver to G-92 via C-18 Canal (requires engineering review regarding availability. SIRWCD would have to approve location and operational criteria.	Y	N	N	N	N	Y	Y	Y	?	Y	Y	Y	Retained. May consider once a TSP is identified. Management measure provides limited benefits. Benefits are extremely localized.

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1.14.a	C-51 Storage Reservoir	Storage	Phase II, Deepwater storage in L-8 basin. Provide storage of L-8 basin water between Flow-ways 1 and 2 at Moss Area.	Y	N	N	N	N	Y	Y	?	N	Y	Y	?	Initially screened out for acceptability, but the initial decision was reversed and the measure was retained. Risks include potential conflict with water supply, and restoration strategies state program objectives, complex negotiations regarding use of water will be required. Based on previous cost for L-8 reservoir cost could be prohibitive, difficultly in determining/valuing below ground storage.
1.16.a	Flow-way1 Water Quality Feature	Water Quality	Allow treatment of L-8 water moving through Flow-way1, or finding a way to move cleaner water (i.e. CWMA western runoff, C-51 Reservoir operations, Pump Station/gravity into L-8 Tieback Canal, Control 2 Pump Station).	N	N	N	N	N	Y	Y	Y	Y	N	Y	Y	Screened out. Does not meet project goals and objectives by itself. Consider WQ with focused array.
1.18.a	Shallow L-8 Storage	Storage	Shallow storage reservoir in L-8 basin to capture water. US Sugar parcel land next to L-8 Canal. Shallow storage reservoir in L-8 basin to capture and treat water. US Sugar parcel land next to L-8 Canal. Note: Acquiring large parcels of land is not the most appealing option to the project sponsor.	Y	N	N	N	Y	Y	Y	Y	?	Y	Y	Y	Retained.
1.18.a.i	Shallow L-8 Storage Features	Pump Station / Conveyance Canal	Inflow pump station, conveyance canal, outflow structure for shallow L-8 Storage.	Y	N	N	N	Y	Y	Y	Y	?	Y	Y	Y	Retained.

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1.2	G-161 Water Control Structure	Control structure/Conveyance	Connect GWP (historical headwater) with C-18 Canal and Loxahatchee Slough. Provide flows to Loxahatchee River.	Y	N	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Retained.
1.3.a	Northlake Blvd Bridge/Weir	Conveyance Connectivity	Improve connectivity with historic river headwater, bridge to restore flows to the north as part of restoring the GWP flow-way and allow for higher elevations in the Loxahatchee Slough by operations of the G-160 and G-161 structures.	Y	N	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Retained.
1.3.a.i	Northlake Blvd Bridge/Weir: 38 cfs (avg. annual)	Operational	Associated with supplemental flow through G-161. Improve connectivity with historic river headwater, bridge to restore flows to the north as part of restoring the GWP flow-way and allow for higher elevations in the Loxahatchee Slough by operations of the G-160 and G-161 structures.	Y	N	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Retained.
1.3.a.ii	Northlake Blvd Bridge/Weir: 28 cfs (avg. annual)(25% reduction)	Operational	Associated with supplemental flow through G-161. Improve connectivity with historic river headwater, bridge to restore flows to the north as part of restoring the GWP flow-way and allow for higher elevations in the Loxahatchee Slough by operations of the G-160 and G-161 structures.	Y	N	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Retained.
1.3.a.iii	Northlake Blvd Bridge/Weir: 19 cfs (avg. annual)(50% reduction)	Operational	Associated with supplemental flow through G-161. Improve connectivity with historic river headwater, bridge to restore flows to the north as part of restoring the GWP flow-way and allow for higher elevations in the Loxahatchee Slough by operations of the G-160 and G-161 structures.	Y	N	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Retained.

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1.3.a.iv	Northlake Blvd Bridge/Weir: 5 cfs (avg. annual)(90 % reduction)	Opera-tional	Associated with supplemental flow through G-161. Improve connectivity with historic river headwater, bridge to restore flows to the north as part of restor-ing the GWP flow-way and allow for higher elevations in the Loxahatchee Slough by operations of the G-160 and G-161 structures.	Y	N	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Retained.
1.4.a	G-160 Water Control Structure	Control Structure	In C-18E Canal, upstream of C-18W Canal. Provides hydroperiod improvements to Loxahatchee Slough (through ability to raise stages in C-18W Canal up-stream of the structure). Allows for some flows to Lox-ahatchee River.	Y	N	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Retained.
1.5.a	ITID connec-tion to M Ca-nal	Connection	Small pump station (<100 cfs) used to connect ITID to M Canal, requires inter-local agreement (West Palm Beach, ITID), deliveries for environmental water supply to GWP and Loxahatchee River (M Canal connection).	Y	N	N	Y	N	Y	Y	Y	Y	Y	Y	Y	Retained.
1.6.a	GWP Scrapedown	Natural Area Res-toration	GWP eutrophic willow area scrape-down (760 acres with 1'-1.5' storage) 759.12 acres of degraded eu-trophic lands with accumulated nutrient rich muck and unnatural plants in NW portions of Grassy Waters can be restored to open marsh areas by reestablishing wetland grade and more natural soil conditions (cost $33,000 per acre based on works already done in adja-cent areas). This would allow for both wetland resto-ration/habitat improvements, reestablish wetland con-nectivity and increased storage.	Y	N	Y	N	Y	Y	Y	Y	?	Y	Y	?	Retained. Note that cost of scrape down can be costly, ~ $25M to gain 1,138 acre-feet (as compared to storage on Mecca which is ~ $80 million for 7200 acre-feet. Habitat gain is inherent to this alterna-tive as well.

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1.7.a	Change GWTA Storage Connectivity	Conveyance	Grassy Waters Triangle Area (GWTA) storage hydrologic connectivity. Portions of the lands within the triangle area is at higher elevations separating the G-161 flow way areas from the Grassy Waters Flow-way which flows north connecting to Loxahatchee Slough. Excavation of a linear conveyance slough just south of the railroad line would allow for connection of the two flow-ways.	N	N	N	Y	N	Y	Y	Y	Y	Y	Y	Y	Retained.
1.8.a	PGA Blvd Bridge Improvements	Conveyance, Operational Modifications	PGA Blvd bridge is planned for construction by FDOT to allow for higher elevations in the Loxahatchee Slough by operations of the G-160 and G-161 structures. (Approximately 100 feet wide allowing for flows to the north and includes wildlife crossings).	Y	N	N	Y	N	Y	Y	Y	Y	Y	Y	Y	Retained.
1.9.a	Moss Property Restoration: Relocate ITID Discharge	Control Structure	Relocate ITID Discharge from impoundment and Cypress Grove drainage and irrigation canal to eastern boundary. Keeps ITID and CG 'whole', allows relocation of Moss canals to assist in restoration and connectivity. This concept takes water from ITID to Moss, relocates discharges and could be acceptable if associated with approved restoration plan by FWC, but FWC could object (relocation of ITID discharge might not be acceptable to FWC).	N	N	Y	Y	Y	Y	Y	Y	?	Y	Y	?	Retained.
1.9.b	Moss Property Restoration: Reconnect J.W. Corbett WMA	Natural Area Restoration	Connect J.W. Corbett WMA to Moss (via culvert under ITID Canal or other means that do not impact ITID drainage. Fill existing ITID Discharge Canal and Cypress Grove Canal. Facilitates restoration of the property and eliminates 'severing' from J.W. Corbett WMA.	N	N	Y	Y	Y	Y	Y	Y	?	Y	Y	?	Retained.

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1.9.c	Moss Property Restoration: Construct Weirs	Control Structure	Allows overflow of ITID stormwater to facility hydroperiod enhancement on Moss on west and south ITID impoundment berms (connect ITID impoundment to Moss).	N	N	Y	Y	Y	Y	Y	Y	?	Y	Y	?	Retained.
1.9.d	Moss Property Restoration: Discharge to L-8 Canal	Control Structure	In compliance with proposed stage elevations to support hydroperiod restoration as determined in the development of a restoration plan from Moss Property (install or improve a series of culverts at L-8). RISK: requires coordination and agreement and easements with FPL to facilitate restoration, may require berm to separate FPL from Moss.	N	N	Y	Y	Y	Y	Y	Y	?	Y	Y	?	Retained.
2.1.a	C-18W Storage Reservoir	Storage	7,200 acre - feet above ground reservoir 4.5' depth.	Y	N	Y	N	N	Y	Y	Y	Y	Y	Y	Y	Retained.
2.1.b	C-18W Storage Reservoir	Storage	9,500 acre - feet above ground reservoir 6' depth.	Y	N	Y	N	N	Y	Y	Y	Y	Y	Y	Y	Retained.
2.1.c	C-18W Storage Reservoir	Storage	12,700 acre - feet above ground reservoir 8' depth.	Y	N	Y	N	N	Y	Y	Y	Y	Y	Y	Y	Retained.
2.1.d	C-18W Storage Reservoir	Storage	16,700 acre - feet above ground reservoir 10.5' depth.	Y	N	Y	N	N	Y	Y	Y	Y	Y	Y	Y	Retained.
2.10.a.i	Natural Storage at C-18W: Scrape-down	Scrape-down	Scrape down ground to match natural surrounding area elevation and increase natural storage to facilitate sheetflow.	Y	N	Y	Y	Y	Y	Y	Y	?	Y	Y	?	Retained.

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2.10.a.ii	Natural Storage at C-18W Canal: Backfill	Natural Area Restoration	Backfill C-18W Canal (west of SR 710) to facilitate sheetflow. Filling C-18W Canal could compromise flood control for private property, if property is proposed to be acquired to effect the measures, then cost could increase substantially.	Y	N	Y	Y	Y	Y	Y	Y	?	Y	Y	?	Retained.
2.10.a.iii	Natural Storage at C-18W: ASR Supplement	Storage	ASR adjacent to C-18 Canal (south of G-160 and PGA Park) to maximize use of clean water into ASR storage during wet season, and pull out during dry season. In dry season, water may not be available to send to the NW Fork, ASR proposed to offset flow deficit.	Y	N	Y	Y	Y	Y	Y	Y	N	Y	Y	?	Screened out. Determined in subsequent engineering meetings that ASR would not be feasible without a storage reservoir or a large canal in the vicinity.
2.14.a	Riverbend Park Pump Station	Pump Station/ Conveyance	Approximately 40 cfs pump to Riverbend Park. Make use of dynamic storage in the wetlands of the park. Limited storage capability in RB however direct connection to NW Fork, timing of the pump operations needs to coordinates to not compete with MFL and water supply demands.	Y	N	N	N	N	Y	Y	Y	?	Y	Y	Y	Retained. May consider only once a TSP is identified. Management measure provides limited benefits. Benefits are extremely localized. RE constraints.
2.2.a.i	C-18W Storage Reservoir: ASR Supplement	Storage	ASR Wells (8 mgd, 40 cfs pumped 120 days). Various flow capability - the wells placed in combination with C-18W, along north side of M-O canal to capture excess J.W. Corbett WMA water or north of GWP or a mixture. Quantity of ASR will be driven by the design limitations on the reservoir with respect to storage needed and delivery of dry season flows to the NW Fork.	Y	N	N	N	N	Y	Y	Y	?	Y	Y	?	Retained.

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2.2.a.ii	C-18W Storage Reservoir: ASR Supplement	Storage	5 wells @ 8 cfs ea. = 9,500 ac-ft. Various flow capability - Wells placed in combination with C-18W, along north side of M-O canal to capture excess J.W. Corbett WMA water or north of GWP or a mixture. Quantity of ASR will be driven by the design limitations on the reservoir with respect to storage needed and delivery of dry season flows to the NW Fork.	Y	N	N	N	N	Y	Y	Y	?	Y	Y	?	Retained.
2.2.a.iii	C-18W Storage Reservoir: ASR Supplement	Storage	8 wells @ 8 cfs ea. = 15,600 ac-ft. Various flow capability - Wells placed in combination with C-18W, along north side of M-O canal to capture excess J.W. Corbett WMA water or north of GWP or a mixture. Quantity of ASR will be driven by the design limitations on the reservoir with respect to storage needed and delivery of dry season flows to the NW Fork.	Y	N	N	N	N	Y	Y	Y	?	Y	Y	?	Retained.
2.2.a.iv	C-18W Storage Reservoir: ASR Supplement	Storage	15 wells @ 8 cfs ea. = 28,500 ac-ft. - Various flow capability - Wells placed in combination with C-18W, along north side of M-O canal to capture excess J.W. Corbett WMA water or north of GWP or a mixture. Quantity of ASR will be driven by the design limitations on the reservoir with respect to storage needed and delivery of dry season flows to the NW Fork.	Y	N	N	N	N	Y	Y	Y	?	Y	Y	?	Retained.
2.3.a	M-O Connection to Mecca via Canal	Connection	New Canal to Connect western M-O Canal with Mecca. Allows delivery of storage or ASR captured water to Mecca Reservoir and River. Easements are acquired, increases flexibility.	Y	N	N	N	N	Y	Y	Y	Y	Y	Y	Y	Retained.

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2.3.a.i	M-O Connection to Mecca via Shallow Flow-way	Natural Area Restoration	Shallow wide flow-way connecting C-18 Reservoir and M-O Canals. 200 cfs delivery. Flowage easement relies upon agreement with private property owner, may be impacted by ability of development to acquire approval.	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Retained.
2.3.b	Pump Station to move water from M-O to Mecca	Pump Station	Pump station (200 cfs) to move water from M-O to Mecca or C-18.	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Retained.
2.4.a.i	Luckey Tract Seepage Barrier	Natural Area Restoration	Seepage barrier along natural storage to prevent water from groundwater seepage to northern areas. 3.0 miles long along southern margin.	Y	N	N	N	N	Y	Y	Y	Y	Y	Y	?	Retained.
2.4.a.ii	New Control Structure in C-18W	Control Structure	West of confluence with C-18 Canal. Increase in stage in western C-18 basin (east of weir) to reduce seepage into C-18 Canal from the Lucky Tract (north) and Lox. Slough/Sandhill (south) RISK: Design must accommodate flood control discharges for Caloosa and Wind in the Pines developments.	Y	N	N	N	N	Y	Y	Y	Y	Y	Y	Y	Retained.
2.5.a	C-18 Weir Pump Station	Control Structure/Pump Station	To provide water from east of weir to reservoir for storage. RISK - could reduce wet season flows to the river. Allows for additional water to be captured by C-18W reservoir, dependent upon water availability analysis.	Y	N	N	N	N	Y	Y	Y	Y	Y	Y	Y	Retained.
2.6.a	Relocate C-18 Weir	Control Structure Modification	Relocate C-18 Weir and Modify elevation west of Beeline. Allows increased stages for Hungryland Slough, western J.W. Corbett WMA. Improves hydrological conditions. Cost of relocating the weir may not be efficient.	Y	N	N	N	N	Y	Y	Y	Y	Y	Y	?	Retained.

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2.7.a	Beeline Bridge	Connection	New bridge in Beeline highway to allow water to flow water from Hungryland to Loxahatchee slough. RISK: Potential issue with CSX railroad that runs parallel to highway.	Y	N	Y	Y	Y	Y	Y	Y	?	Y	Y	?	Retained. With concerns with railroad.
2.8.a	Beeline Culverts	Conveyance	Install culverts under Beeline (north of Pratt-Whitney). Allows connectivity between east and west Hungryland Slough. RISK - needs review of # and location of culverts under FEC Railroad. Not cost prohibitive if done with proposed Beeline improvements.	Y	N	N	Y	N	Y	Y	Y	Y	Y	Y	?	Retained.
2.9.a	Backfill Interior Canals in J.W. Corbett WMA	Natural Area Restoration	Backfill interior canals in J.W. Corbett WMA and maximize water levels.	N	N	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Retained.
3.1	Restore Nine Gems (Palmar East) Properties	Natural Area Restoration	Increase wetland upland mosaic/increase connectivity to Cypress Creek Head Waters. Increase groundwater levels and restore wetland function to improve base flow to NW Fork.	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Retained.
3.1.a.i	Construct Southern and Western Berm Along Nine Gems	Berm	Construct berm along Southern and Western boundaries of Nine Gems. Allow ground water levels and wetlands to be restored without impacting adjacent parcels.	N	N	N	N	N	Y	Y	Y	Y	Y	Y	Y	Retained.
3.1.a.iii	Backfill N/S Drainage Ditches in Nine Gems.	Natural Area Restoration	To restore sheet flow. Restores more natural hydropattern to Cypress Creek, reduces competition for Nine Gems water. Requires acquisition of easements from HSLCD.	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Retained.

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3.1.b	Remove drainage pipes along the northern Nine Gems boundary	Natural Area Restoration	Allows recovery of wetland stages within the Nine Gems property. Assume 20 pipes, shallow excavation for removal. Must be done in conjunction with improvements to HSLCD Berm.	N	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Retained.
3.1.b.i	Improve HSLCD Berm Along Northern Nine Gems Boundary	Improve Berm	Prevent rehydrated wetlands from overtopping berm. Allow wetland restoration and maintenance of natural groundwater table. Approximately 23,000 feet long. Berm elevation should be to 20' NGVD on the east to offset expected wetland elevations.	Y	N	Y	N	N	Y	Y	Y	Y	Y	Y	Y	Retained.
3.1.c	Nine Gems: Fill Southern HSLCD Canal	Connection	Allows sheet flow from Culpepper to Nine Gems. Reduces ponding in northern Culpepper. Improves wetland function.	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Retained.
3.1.c.i	Nine Gems: Reroute Thomas Farms Drainage & Pump Station	Conveyance/ Pump Station	Reroute Thomas Farms (pepper farm) drainage to North HSLCD Ditch (new canal). Relocation, offsets, drainage impacts of filling the ditch in MM 3.1.c. Pump station needed.	N	N	N	N	N	Y	Y	Y	Y	Y	Y	Y	Retained.
3.1.c.ii	Nine Gems: Degrade Access Road	Connection	Fill and degrade access road (also acquire rights from HSLD). Facilitates sheet flow from Culpepper to Nine Gems.	N	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Retained.
3.1.c.iii	Nine Gems: HSLCD Canal Improvements	Conveyance	Generic improvement of HSLCD Canal on North Side of Nine Gems. Relocation, facilitates additional flow from new drainage ditch and pump station, ensures existing level of service.	N	N	N	N	N	Y	Y	Y	Y	Y	Y	Y	Retained.

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3.1.c.iv	Nine-Gems: In-line Culverts	Connection/ Conveyance	Located in the canal in the south and west of Nine Gems. Connects Culpepper and Pal-Mar to Nine Gems. Maintains drainage for Thomas Farms.	N	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Retained.
3.10	Saltwater Attenuation Structure	Control Structure	Construct at approximate RM 6.2 (Florida Power and Light) easement between Camp Tanah Keeta and JDSP boat ramp. Structure would dynamically respond to mean high tidal encroachment into proposed tidal forested wetland sections located upstream of RM 6.2 Structure would utilized floating activated gates that would throttle upward movement. Structure could be controversial.	Y	N	Y	N	Y	Y	Y	Y	?	Y	Y	Y	Retained. Consider only once TSP is selected with climate change and sea level rise analysis.
3.11	V-Notch for Navigation	Control Structure	By river mile 6.2 install weirs on either side of FPL right of way that have floatation devices, v-notch for navigation, to maintain pool upstream of 6.2. Keep freshwater in as opposed to saltwater out. 1b (for salinity improvement) Use of these types of structures, particularly in Wild & Scenic, is controversial.	Y	N	N	N	N	Y	Y	Y	?	Y	Y	Y	Retained. Consider only once TSP is selected with climate change and sea level rise analysis.
3.12	Replace A1A Oyster Bar	Oyster Replacement	(Circa 1961). Follow permit criteria to ensure that navigability is not impacted. Complements potential of oyster bed location further downstream when freshwater flows are being increased Objective 1b (for salinity improvement). Reduces soil pore salinity levels in flood plain portions.	Y	N	N	N	Y	Y	Y	Y	Y	Y	Y	Y	Retained. Consider only once TSP is selected with climate change and sea level rise analysis.

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3.13	Backfill Palmar Ditches	Backfill and Scrape	Backfill ditches and scrape down berms to restore wetland function. Will potentially require acquisition of parcels not already in public ownership within Palmar. Examine potential to raise culverts in SR 711 (Beeline) to move water east. Requires downstream components to implement this MM. Allows additional connectivity with Palmar to Culpepper to Nine Gems to Cypress Creek.	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Retained. May consider only once a TSP is identified due to RE constraints and minimal benefits.
3.14	Culverts under SR710	Conveyance	Install culverts under SR 710 (Beeline) north of SR 710 (Pratt-Whitney) east of Pratt, to facilitate moving water north across Indiantown road; may require acquisition of parcels in Palmar. Allows additional connectivity. Could be costly if not done in concert with road upgrades/improvements.	Y	N	N	Y	N	Y	Y	Y	Y	Y	Y	?	Retained. May consider only once a TSP is identified due to RE constraints and minimal benefits.
3.2	Restore Gulfstream Property (1,411 acre Citrus Groves Adjacent to I-95)	Natural Area Restoration	Increase wetland upland mosaic/increase connectivity to Cypress Creek Head Waters.	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Retained.
3.2.a	Gulfstream West: Shallow Flow-way	Flow-way	Flow through marsh discharge structure between gulfstream and Shiloh Farms. Construct shallow flow-way on Gulfstream Property West of I-95/Turnpike to include accommodation for HSLCD Unit II Drainage.	Y	N	Y	N	N	Y	Y	Y	Y	Y	Y	Y	Retained.
3.2.a.i	Gulfstream West: Inflow Pump Station	Pump Station	To attenuate flows to Cypress Creek while providing for existing level of service for HLSCD drainage.	N	Y	N	Y	N	Y	Y	Y	Y	Y	Y	Y	Retained.

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3.2.a.ii	Gulfstream West: Fill Existing HSLCD Drainage Ditch	Connection	Straighten southern end of Hobe (HSLCD) drainage ditch to the western side of the Gulfstream West property; continue to connect to Cypress Creek Canal. Allows construction of flow-way through Gulfstream West. Requires agreement with HSLCD, and potentially operation costs.	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Retained.
3.2.a.iii	Gulfstream West: Southern Outflow Structure	Conveyance	Outflow structure allows discharge from flow through marsh to Cypress Creek.	N	N	N	Y	N	Y	Y	Y	Y	Y	Y	Y	Retained.
3.2.b	Gulfstream West: Eastern Outflow Structure	Conveyance	Alternative outlet to east side of I-95 to facilitate groundwater and wetland conditions and maintain base flow to Moonshine Creek and NW Fork.	N	N	N	Y	N	Y	Y	Y	Y	Y	Y	Y	Retained.
3.2.c	Gulfstream West: Reroute HSLDC Canal to Align with the Turnpike (relocation)	Conveyance	Allows existing canal to be filled to facilitate storage on gulfstream properties. Could be a workable solution, other alternatives may provide more benefits. Includes building a new bridge over the Becker Grove Ditch for access to culverts.	Y	N	N	N	N	Y	Y	Y	Y	Y	Y	?	Retained.
3.2.c.i	Gulfstream West: Sediment Trap	Control Structure/ Conveyance	Construct sediment trap on realigned canal prior to discharge into Cypress Creek Canal. Slows flows released to Cypress Creek Canal and to Cypress Creek, reducing further channel incision.	Y	N	N	N	N	Y	Y	Y	Y	Y	Y	Y	Retained.
3.2.c.ii	Gulfstream West: Weir Structure	Control Structure/ Conveyance	Provide weir structure to discharge from sediment trap to Cypress Creek Canal Completes HSLCD system. Provides control to HSLCD for mgmt. of their flows.	Y	N	N	N	N	Y	Y	Y	Y	Y	Y	Y	Retained.

Unique ID	Measure Name	Measure Type	Purpose & Notes	Obj 1: Restore Wet & Dry Season Flow	Obj 2: Restore Estuary	Obj 3: Increase Spatial Extent	Obj 4: Restore Connections	Obj 5: Restore Species Abundance & Diversity	Constraint: Do Not Reduce Flood Protection	Constraint: Do Not Reduce Water Supply	Constraint: Do Not Reduce Water Quality	Acceptable (by state & local entities)?	Meet an objective & avoid constraints	Not create sig adverse env effects	Not cost prohibitive	Management Measure Screening Result
3.2.d	Gulfstream West: Re-route HSLDC Canal to align to western side of Gulf-stream West	Convey-ance	Allows southern portion only of existing canal to be filled to facilitate storage on gulfstream properties.	Y	N	N	N	N	Y	Y	Y	Y	Y	Y	Y	Retained.
3.3	Replace Cy-press Creek Canal Outfall Weir	Control Structure	Replace Cypress Creek Canal Outfall Weir.	N	Y	Y	N	N	Y	Y	Y	Y	Y	Y	Y	Retained.
3.3.a	Raise North-ern Berm on Ranch Col-ony Canal	Berm Im-prove-ments	For flood risk. This may be necessary depending upon strategies proposed for the Canal in order to ensure that there is not overflow to adjacent communities. Could include strategic increases in population (reloca-tion).	N	N	N	N	N	Y	Y	Y	Y	Y	Y	Y	Retained.
3.4	Restore Cul-pepper Ranch Prop-erties (1,280 acres)	Natural Area Res-toration	Increase wetland upland mosaic/increase connectivity to Cypress Creek Head Waters.	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Retained.
3.4.a	Automate Twin 84s	Operations	Automate operation of modified Control Structure on Twin 84" Culverts and southern Culpepper culverts. Increase storage elevation on Culpepper property, po-tential improvement to Ranch Colony Flood control. Will need concurrence from SFWMD Operations and developed operational guidelines.	Y	N	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Retained.

Unique ID	Measure Name	Measure Type	Purpose & Notes	Obj 1: Restore Wet & Dry Season Flow	Obj 2: Restore Estuary	Obj 3: Increase Spatial Extent	Obj 4: Restore Connections	Obj 5: Restore Species Abundance & Diversity	Constraint: Do Not Reduce Flood Protection	Constraint: Do Not Reduce Water Supply	Constraint: Do Not Reduce Water Quality	Acceptable (by state & local entities)?	Meet an objective & avoid constraints	Not create sig adverse env effects	Not cost prohibitive	Management Measure Screening Result
3.4.b	Raise Berm West of Ranch Colony	Berm Improvements	For flood risk. Protects ranch colony from increase stage west, reduces peak flows in early wet season to allow Ranch Colony and Old Trail to discharge to Cypress Creek Canal, connected with putting control on Culpepper culverts; berm needed to protect RC when water levels are increased.	N	N	N	N	N	Y	Y	Y	Y	Y	Y	Y	Retained.
3.5	Sag Culverts to Connect Culpepper and Nine Gems	Culvert/ Conveyance	Provide sag culverts to connect Culpepper with Nine Gems to encourage Sheet Flow; Memorandum of Agreement with HSLCD (temp construction); fill lateral ditches. Connectivity between Palmar and Palmar East/encourage sheet flow.	N	N	N	Y	Y	Y	Y	Y	Y	N	Y	Y	Screened out. Determined in subsequent engineering meetings that hydrology would not favor sag culverts to connect Culpepper and Nine Gems.
3.6	Cypress Creek and Shiloh Farms Property Improvements	Natural Area Restoration	Habitat and hydrologic lift, tributary connectivity, restoration of wetlands (ditch fills, culvert control, remove exotics (Approximate total acres = 8,000).	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Retained.
3.6.a	Spreader Swale at Cypress Creek	Spreader Swale	Spreader swale at west end of cypress creek natural area. East of Mack Dairy road Spreader Swale.	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Retained.
3.6.b	Pump Station at Cypress Creek	Pump Station	Pulls water from canal to redistribute to spreader swale at Cypress Creek.	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Retained.
3.6.c	Slow Flow in Cypress Creek	Dam	Provide natural structural features (logs or rip rap) to slow flow and encourage sedimentation to offset scouring in Cypress Creek Tributary Channel. Allow sediment buildup to restore channel cross section, and allow floodplain inundation.	N	N	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Retained.

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3.6.d	R&A Farms Flow Through Marsh	Flow-way	Reconnect southern prong of Cypress Creek with Lox - Reconstruct old creek/tributary channel.	Y	N	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Retained.
3.7	Links Development Flow-way	Natural Area Restoration	Involves reconfiguration of an existing development to allow flow through slough in a golf course.	N	N	N	N	N	Y	Y	Y	N	Y	Y	N	Screened out for acceptability and cost prohibitive. Risks include potential conflict with private development, and O&M of golf course.
3.8.a	Reconnect Moonshine Creek	Control Structure	Connect HSLCD with Moonshine creek. Allows restored hydrology to Moonshine Creek Channel, reduces direct flow to Lox NW Fork via Hobe Grove Ditch.	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Retained.
3.8.a.i	Clear Moonshine Creek	Flow-way	Moonshine creek flow through marsh. Proposes using already acquired ag land, need to ensure flood control and agreement with HSLCD.	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Retained.
3.8.a.ii	Hobe Grove Ditch Weir	Control Structure	Moonshine Creek install weir at bottom of Hobe Grove Ditch to back up water to reduce flashiness and recharge groundwater. Remove exotics to promote a redirected sheetflow. Allows restored hydrology to Moonshine Creek Channel, reduces direct flow to Lox NW Fork via Hobe Grove Ditch.	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Retained.
3.8.b	Gulfstream East Restoration	Natural Area Restoration	Fill gulf stream ditch and regrade property to historic topography.	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Retained.
3.8.c	Flow Through Marsh at Gulfstream East	Flow-way	Construct flow through marsh at Gulfstream East and connect to flow through marsh on west side of highway using existing drainage ditch (convert to swale).	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Retained.

Unique ID	Measure Name	Measure Type	Purpose & Notes	Obj 1: Restore Wet & Dry Season Flow	Obj 2: Restore Estuary	Obj 3: Increase Spatial Extent	Obj 4: Restore Connections	Obj 5: Restore Species Abundance & Diversity	Constraint: Do Not Reduce Flood Protection	Constraint: Do Not Reduce Water Supply	Constraint: Do Not Reduce Water Quality	Acceptable (by state & local entities)?	Meet an objective & avoid constraints	Not create sig adverse env effects	Not cost prohibitive	Management Measure Screening Result
3.9.a	Kitching Creek Hydration: Atlantic Ridge Flow-way	Flow-way	Could augment Kitching Creek by moving water from Bridge Road through private lands to eastern fork of Kitching creek. Culvert under bridge road and control structure to stop discharges down Jenkins Ditch. To restore the slough area at the eastern fork of Kitching Creek.	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Retained. May consider only for TSP. Feature is too far east of the NW Fork. Benefits will not contribute to our target flows at the NW Fork.
3.9.b	Kitching Creek Hydration: Spreader Canal at Jenkins Ditch.	Control Structure	Western side of Jenkins Ditch. Existing 72 inch culverts to bring water into a spreader canal that is needed. Need to plug Jenkins canal. Two spreaders proposed. Must still maintain flood control.	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Retained.
3.9.b.i	Kitching Creek Hydration: Weir at Jenkins Ditch	Control Structure	Increase ground water level within northern park, pushes water back into spreader to rehydrate west branch of Kitching Creek.	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Retained.
3.9.c	North Fork Ditch Control Structure	Control structure	North fork ditch drains over 2000 acres. Control structure would reduce flows out of North fork ditch to benefit wetland area while maintaining drainage Hobe Hills. Could provide GW improvement and hold back freshwater that is currently going to tide through the north fork (not NW fork).	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Retained. May consider only for TSP. Feature is too far east of the NW Fork. Benefits will not contribute to our target flows at the NW Fork.
No ID assigned	Modification/automation of S-76 in L-8 Canal	Operational Changes	Provides WQ improvement by allowing ag. Lands to drain to Lake, and natural lands to L-8 Canal.	N	N	N	N	N	Y	Y	Y	Y	N	Y	Y	Screened out. Does not meet project goals and objectives by itself. Consider WQ with focused array.

Unique ID	Measure Name	Measure Type	Purpose & Notes	Obj 1: Restore Wet & Dry Season Flow	Obj 2: Restore Estuary	Obj 3: Increase Spatial Extent	Obj 4: Restore Connections	Obj 5: Restore Species Abundance & Diversity	Constraint: Do Not Reduce Flood Protection	Constraint: Do Not Reduce Water Supply	Constraint: Do Not Reduce Water Quality	Acceptable (by state & local entities)?	Meet an objective & avoid constraints	Not create sig adverse env effects	Not cost prohibitive	Management Measure Screening Result
No ID assigned	Storage in Moss - Impoundment	Storage	Provide storage of L-8 basin water between Flow-ways 1 and 2 at Moss Area.	Y	N	N	N	N	Y	Y	Y	N	Y	Y	Y	Screened out. Flowage easement criteria does not allow use of Moss as stormwater treatment area or impoundment, restoration only, not acceptable to FWC.
No ID assigned	Dredge M Canal to allow more conveyance of L-8 basin waters.	Canal Dredge	Dredge M Canal to allow more conveyance of L-8 basin waters.	N	N	N	N	N	Y	Y	Y	Y	N	Y	?	Screened out. Dredging canal does not meet project objectives.
No ID assigned	Add Rock Ballast Along M Canal	Water Quality	Potentially limestone to help with treatment. Improve Water Quality in M Canal.	N	N	N	N	N	Y	Y	Y	Y	N	Y	?	Screened out. No project objective met by this measure, may be reconsidered if needed to avoid violating constraints. May be needed as part of deliveries to replace water in GWP released through G-161.
No ID assigned	Apoxee Flow Equalization Basin	Storage	With inflow/outflow structures for storage (Use Apoxee [1400 acres/stressed wetland], 4-48" culverts to hydrate, used to hydrate AWT, have a pump station Apoxee to Control 4, would remove concerns on poor water quality water, essentially and stormwater treatement area for the Lakes). Water storage in Apoxee will serve as replacement for restoration flows diverted from GWP through G-161.	N	N	N	N	N	Y	Y	Y	Y	N	Y	?	Screened out. No project objective met by this measure, may be reconsidered if needed to avoid violating constraints.

Unique ID	Measure Name	Measure Type	Purpose & Notes	Obj 1: Restore Wet & Dry Season Flow	Obj 2: Restore Estuary	Obj 3: Increase Spatial Extent	Obj 4: Restore Connections	Obj 5: Restore Species Abundance & Diversity	Constraint: Do Not Reduce Flood Protection	Constraint: Do Not Reduce Water Supply	Constraint: Do Not Reduce Water Quality	Acceptable (by state & local entities)?	Meet an objective & avoid constraints	Not create sig adverse env effects	Not cost prohibitive	Management Measure Screening Result
No ID assigned	Capture M Canal Seepage	Seepage Management	Improve flows to GWP and river. Between control structure 2 and 3 to improve flows to GWP and river.	N	N	N	N	N	Y	Y	Y	Y	N	Y	?	Screened out. No project objective met by this measure, may be reconsidered if needed to avoid violating constraints.
No ID assigned	Operational changes in L-8 Canal northwest of G-541 and downstream of S-76	Storage	Raise stage and increase canal storage and retain water in J.W. Corbett WMA.	N	N	N	N	N	Y	Y	Y	Y	N	Y	?	Screened out. No project objective met by this measure, may be reconsidered if needed to avoid violating constraints.
No ID assigned	Moss Property as STA using C-51 Phase II	STA	Increase drainage and treatment.	N	N	N	N	N	Y	Y	Y	N	Y	Y	?	Screened out. Flowage easement criteria does not allow use of Moss as STA or impoundment, restoration only, not acceptable to FWC.

COMPREHENSIVE EVERGLADES RESTORATION PLAN

LOXAHATCHEE RIVER WATERSHED RESTORATION PROJECT

DRAFT INTEGRATED PROJECT IMPLEMENTATION REPORT AND ENVIRONMENTAL IMPACT STATEMENT

March 2019

Appendix F

APPENDIX F

RECREATION ANALYSIS OF THE LOXAHATCHEE RIVER WATERSHED RESTORATION PROJECT

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F ECONOMIC AND SOCIAL CONSIDERATIONS

F.1 Authorization

On Dec 11, 2000 the Water Resources Development Act of 2000 (WRDA, 2000) was signed into law by the President of the United States (Public Law No. 106-541, of the 106th Congress). Title VI, Section 601 of the Act provides for and guides modifications to Central and Southern Florida project and describes authorizations specific to the CERP. Section 601(b)(A) "Comprehensive Everglades Restoration Plan Approval" provides authority for CERP as stated below.

(b) Comprehensive Everglades Restoration Plan –

(1) Approval-

(A) IN GENERAL. – Except as modified by this section, the Plan is approved as a framework for modifications and operational changes to the Central and Southern Florida Project that are needed to restore, preserve, and protect the South Florida ecosystem while providing for other water-related needs of the region, including water supply and flood protection. The Plan shall be implemented to ensure the protection of water quality in, the reduction of the loss of fresh water from, and the improvement of the environment of the South Florida ecosystem and to achieve and maintain the benefits to the natural system and human environment described in the Plan, and required pursuant to this section, for as long as the project is authorized.

F.2 Introduction

F.2.1 Proposed Recreation Overview

The recreation appendix for the Loxahatchee River Watershed Restoration Project contains a description of the conceptual plan that is being proposed for recreation purposes. Recreation features are being planned in the Loxahatchee River Watershed Restoration Project as an incidental project benefit. These recreation benefits will not be used in the justification of the recommended plan. Order of magnitude costs have been included as provided by the South Florida Water Management District (SFWMD), gleaned from other approved reports and recent construction. Costs have updated in consultation with the Jacksonville District Cost Engineers, using Palm Beach County water preserve area (WPA) recreation and MCASES costs. A determination of recreation facility design standards to meet Corps and local building code requirements is under way. SFWMD will be operating and maintaining the Loxahatchee River Watershed Restoration Project recreational features. The cost for proposed recreation features would be $1,300,000 (FY18 dollars). Including an additional ten percent for planning, engineering and design (PED), and eight percent for construction supervision and administration (S/A) brings the estimated total costs for recreation to $1,534,000. To ensure that the developed costs comply with USACE cost estimating policy, a 25 percent contingency cost has been applied to the total cost, resulting in a total estimated cost of $1,918,000. (See **Table F-9** for details.)

It is assumed that all the proposed recreational features will be located on project fee title lands, and thus no additional real estate would be required. The real estate appendix will verify this within the Draft Real Estate Plan for the Draft PIR. All proposed features are compatible with the environmental purposes of the plan and will not detract from the environmental or socioeconomic benefits being generated by the project.

The recreation facilities proposed for the Loxahatchee River Watershed Restoration Project will create additional opportunities for biking, hiking, nature study, horseback riding, freshwater fishing non-boating, canoeing/kayaking, and wildlife viewing which will fit with the project purposes as managed by the SFWMD.

F.2.2 Conceptual Recreation Plan

Planning the recreation for the Loxahatchee River Watershed Restoration Project has been somewhat different than has been the planning of previous federal projects for which the SFWMD is the non-federal sponsor (NFS). Typically, a project will have an area bounded by a levee with a public access area into the water for boating within the project and access to the levees to be used as trails.

This recreation plan is primarily a trail-oriented plan which follows the flow ways toward the Loxahatchee River. Large tracts of public land within the watershed offers several possible flow ways to the Loxahatchee River. While the project will connect and enhance the flow ways for providing water to the Loxahatchee River with water control structures and storage areas; the recreation features will enhance trail connections with portages and bridges. Recreational users will seamlessly cross lands owned by various public entities as they progress towards the Loxahatchee River and join it, whether by boat or on trails. The bridges and portages together form a continuous trail of greater value to the user than separate disconnected segments. Project features built for the flow ways will be enhanced as possible with portages to also function as bridges, and fishing locations. Two storage areas will utilize public access sites that will also act as trailheads for the public to follow the flow ways to the Loxahatchee River. Staging areas for construction will be reviewed for the possibility of leaving in place to be enhanced as parking areas. The locations and designs of recreation facilities will change as necessary when the project features locations change as needed by the project.

F.3 Recreation Facilities Management Overview

The SFWMD will be responsible for 100% of the recreation operations, maintenance, repair, rehabilitation and replacement (OMRR&R) as outlined in ER 1105-2-100, Apr 2000, page E-286, the Agreement of May 2000 and the 29 Sept 2005 OMRR&R Corps Memorandum.

Through their rulemaking authority, the NFS, SFWMD, has established, in the Florida Administrative Code (F.A.C.) Chapter 40E-7 the ability to identify enforcement provisions which can be implemented by Florida Fish and Wildlife Conservation Commission (FWC) officers or other law enforcement officers. This rule has general language applicable to all SFWMD lands as well as specific provisions that are applicable to different types of land. Rules allow SFWMD to address hours of public access, the ability to allow or prohibit certain types of activities in different areas or at various times and the overall ability to close public access at any time in response to emergencies, pending storms or routine operations and management needs or ongoing protection of the land itself.

Chapter 40E-7.5384 F.A.C., Special Provisions for Impoundment Areas of the District Open to the Public, has further language that expressly applies to the operational specifications with respect to the use of boats within the impoundments. The rule allows SFWMD to specify which boat types, engine types and sizes, operating speeds and areas of operation are acceptable. Personal watercraft are specifically prohibited while air boats may be allowed if so designated. The rules can be adjusted through the posting of signs. This allows SFWMD to modify procedures as necessary to ensure that the projects' intended purposes are served, to manage conflicts between users, to adjust public use

in accordance with operational levels, or for various other factors. This set of rules allows SFWMD to adjust the boating controls at each impoundment so that the different character of each water body can be enjoyed in a proper manner by the public. The rules are posted on the SFWMD web site through this link:

https://www.sfwmd.gov/sites/default/files/documents/40e_7_511_rule_public_access.pdf

F.4 Benefit Categories

F.4.1 Study Area Recreation Background.

The study area for the recreation benefit analysis for this project includes northern Palm Beach County and southern Martin County; approximately the same geographical extent as Central East and South East Region of the 2013 Statewide Comprehensive Outdoor Recreation Plan (SCORP). The 2013 SCORP was utilized to identify the recreation baseline for CERP recreation planning. Recreation deficits identified by the SCORP for this region include: biking, hiking, nature study, horseback riding, freshwater fishing non-boating, canoeing/kayaking, and wildlife viewing. A statewide needs assessment through 2013 identifies these deficits and the unit need for each (miles of trail, campsites, etc.) is provided in SCORP 2013. The SCORP deficits for bicycle riding, hiking, freshwater fishing (non-boat), and hunting (managed) activities are considerations for the LRWRP proposal.

The population growth of south Florida will only add to the calculated existing recreation deficits. The proposed recreation study also typically considers outside study influences from surveys and other documented and respected sources. **Table F-1** presents projected county and State population growth per Census 2010.

Table F-1. Study Area Population and Annual Growth Rates Through Year 2070.

Census 2010 Counties Population & Annual Growth Rate for Years Specified	Census 2010	2020	2030	2040	2050	2060	2070	2010-2070 difference	% Change
Palm Beach County Population	1,320,134	1,463,900	1,615,100	1,736,500	1,891,244	2,037,322	2,177,401	857,267	65%
Palm Beach County Annual Growth Rate	---	1.09%	1.03%	0.75%	0.89%	0.77%	0.69%	---	N/A
Martin County Population	146,318	157,300	170,200	179,800	192,686	204,439	216,192	69,874	48%
Martin County Annual Growth Rate	---	0.75%	0.82%	0.56%	0.72%	0.61%	0.57%	---	N/A
Florida Population	18,801,332	21,235,400	23,872,500	26,081,400	28,728,603	31,225,215	33,721,828	14,920,496	79%
Florida Annual Growth Rate	---	1.29%	1.24%	0.93%	1.01%	0.87%	0.80%	---	N/A
Study Area % of Florida Population	7.80%	7.63%	7.48%	7.35%	7.25%	7.18%	7.10%	6.21%	N/A

Source: Bureau of Economic and Business Research (BEBR), UF, Florida Statistical Abstract 2017

F.4.2 Existing Recreation Resources

Existing recreational facilities within the SCORP Southeast and Central East Regions provide ideal recreational resources for linkages and bundling with the proposed LRWRP project. Recreation facilities within the LRWRP and two-county area include: Palm Beach County's Cypress Creek, Pine Glades, Hungryland Slough, Pond Cypress, Sweetbay, and Loxahatchee Slough Natural Areas, and Riverbend Park; the Florida Fish and Wildlife Conservation Commission's J.W. Corbett Wildlife Management Area (Corbett WMA) and John C. and Mariana Jones Hungryland Wildlife and Environmental Area (Hungryland WEA); Martin County and SFWMD's, Palmar East (also known as Nine Gems) and Loxahatchee River/Cypress Creek Management Area (Cypress Creek MA); and SFWMD's DuPuis Management Area; and Jonathan Dickinson State Park (JDSP). All of these properties lie within the historic watershed of the Loxahatchee River. The Northwest Fork of the Loxahatchee River (NWFLR), extends a distance of approximately 16 miles from Riverbend Park to Jupiter Inlet. The 7.6-mile upstream portion of the NWFLR is one of only two rivers in the State to be designated a National Wild and Scenic River. It is currently a popular destination for paddlers. Current recreational access to the wild and scenic portion of the river is available only from Riverbend Park near the river's upstream origin and from JDSP at the downstream terminus of the Wild and Scenic designation.

The recreational potential of the 680-acre Riverbend Park[1] lies not only in its ability to provide resource-based outdoor recreational opportunities, but because it serves as a hub for recreational access to many of the other recreation resources noted above. The Park provides an ideal setting for passive recreation such as picnicking, canoeing, fishing, biking, hiking, birding, camping, nature study, photography, and archeological cultural and historical interpretation. It also serves as a starting point for six of Palm Beach County's Wildways Jesup Trail (Northern Everglades Natural Area, or NENA) recreational trails: four multi-use land trails, the Florida Trail Association's (FTA) Ocean to Lake (OTL) Hiking Trail, and the Loxahatchee Blueway paddling trail. The multi-use land trails are open to hiking, bicycling, and horseback riding. Loxahatchee Blueway is non-motorized boat access to the Loxahatchee River. Road access to Riverbend Park is excellent.

The recreational potential of the 11,383-acre JDSP lies not only in the access it provides to the wild and scenic river, but in the extensive resource-based outdoor recreational opportunities offered within its boundaries and through programing provided at the Elsa Kimbell Environmental Education and Research Center. River access is provided by public boat ramps for launching private boats, a canoe/kayak rental concession, and a 44-passenger boat for tours upstream to Trapper Nelson's homestead. Recreation opportunities include picnicking, swimming, canoeing, fishing, biking, hiking, birding, camping (tent, recreational vehicle and cabin), nature study, and photography. Access to a section of the OTL Hiking Trail are provided by the park, including two primitive camping sites along that backpacking trail. Road access to JDSP and down to the river within the Park, are excellent.

[1] Riverbend Park and Loxahatchee River Battlefield Park for practical purposes are operated and maintained as a single regional park. Together, both properties total 674 acres (611 acres at Riverbend Park and 63 acres at Loxahatchee River Battlefield Park). Loxahatchee River Battlefield Park was originally part of Riverbend Park and was renamed in 2010. For purposes of describing the existing and FWO LRWRP conditions, both parks will be referred to as Riverbend Park.

While recreational facilities at both ends of the Loxahatchee River are well developed and easily accessed, minimal recreational facilities exist within the SFWMD/Martin County Loxahatchee River/Cypress Creek Management Area. Two ditches that empty into the Loxahatchee River, pass through this conservation property and are the subject of proposed modification in various LRWR Project Alternatives. The Wildway's Jesup Trail passes through this property. The management area offers natural surfaced trails for hiking, cycling and horseback riding, but no developed water access, camping or trail amenities. Road access is limited to permit only entry through a gate across a shell rock road leading to two grassed parking areas.

Palm Beach County's Wildways program interconnects most of the conservation lands lying within the LRWRP boundary. It includes the OTL Hiking Trail which is 63 miles long and offers a multi-day wilderness backpacking experience unmatched in the region. This trail exists primarily as a natural surface trail that utilizes some segments of the Wildway's Pântano and Jesup Trails. It is currently missing or requires improvements to the following sections, listed from west to east: Lake Okeechobee Scenic Trail (LOST) to DuPuis Management Area entry, Hungryland Slough to Sweetbay Natural Area, Sweetbay Natural Area to Loxahatchee Slough Natural Area, and the Hobe Grove ditch crossing. Four multi-use land trails: Bluegill, Pântano, Historic Jupiter-Indiantown and Jesup Trail serve hikers, bicycles and horseback riders. The amenities along these trails vary with the conservation land being crossed by them. The Loxahatchee Blueway includes the Loxahatchee Wild and Scenic River. The portion upstream of Trapper Nelson's is closed to motorized boating.

Each of the County natural areas, and the SFWMD and FWC management areas can be separately accessed by excellent to moderate quality roads. Each offers recreational opportunities within its boundaries.

F.5 Proposed Recreation

The majority of the Future Without Project (FWO) recreation facilities are proposed to be developed on the C-18 and C-18 West canals, and within the Loxahatchee Slough. Proposed public use facilities include a portion of the proposed Loxahatchee Blue-way, a canoe/kayak trail that is intended to link canoe trails in the City of West Palm Beach Grassy Waters Preserve, the Loxahatchee Slough Natural Area and the Loxahatchee River. There is water flow between Grassy Waters and the Loxahatchee Slough Natural Area under the CSX Railroad and SR 710 and under PGA Boulevard. However, the Loxahatchee Slough Natural Area is fragmented by the C-18W and C-18 canals. Proposed facilities to accommodate the Loxahatchee Blue-way include portages between the portion of the paddling trail in the slough to the C-18W Canal and from the C-18 into South Indian River Improvement District's Canal 14 which empties directly into the Loxahatchee River.

The FWO facilities for the Pond Cypress Natural Area at this time offer only walk-in access and no marked trails. Entrance to all of these facilities is free. While access gates are closed at night, the access is not monitored and data with respect to current use is unavailable. No parking is provided at this natural area. The recreation concept map is shown in **Figure F-1.**

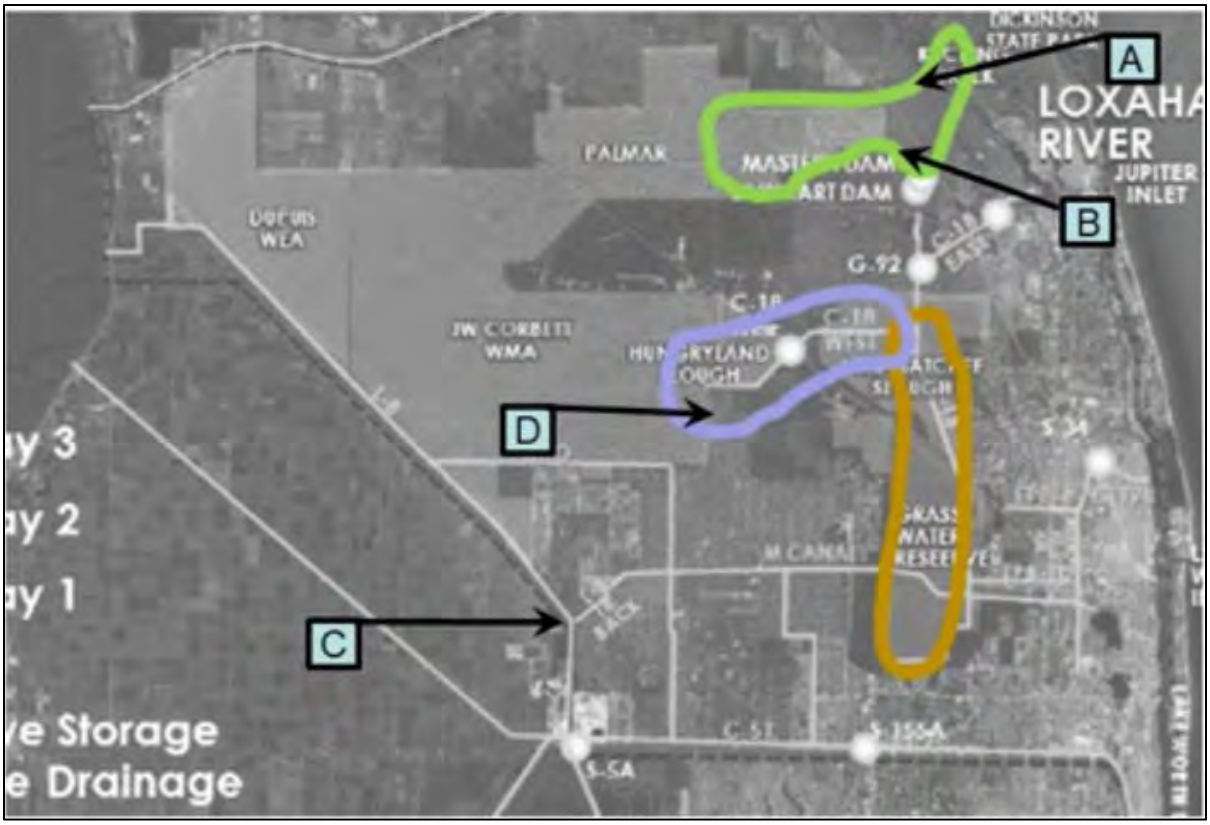

Figure F-1. Recreation Facilities.

F.5.1 'Site A' Ocean to Lake Trail Bridge to Jonathan Dickinson State Park Recreation Features

The OTL Trail meanders from the ocean through Jonathan Dickinson State Park to Lake Okeechobee. This trail currently has an existing wet crossing upon entering JDSP, in the Moonshine Creek area, shown as site A in **Figure F-2**. In this area, a project features include the design and construction of a weir within the existing Hobe Grove Ditch and scraping the adjacent area to reconnect and rehydrate the historic Moonshine Creek channel. This feature is expected to create a wider and deeper wet crossing. While this is a seasonal effect, the existing wet crossing is often not passable due to water depth. To ensure trail connectivity a dry crossing will be created using an individual feature or some combination of a bridge, boardwalk, or potentially the weir itself. Once design is initiated, the definitive location of the weir and the forecast stage and duration of the hydroperiod will be determined. With this more detailed information, the best combination of recreation features and alignment to maintain this trail connection can be determined. This location is not anticipated to provide parking or act as a trailhead but is likely to be a resting spot along the trail. Other features such as a trail shelter, picnic tables, and signboard are secondary to the function of a dry crossing.

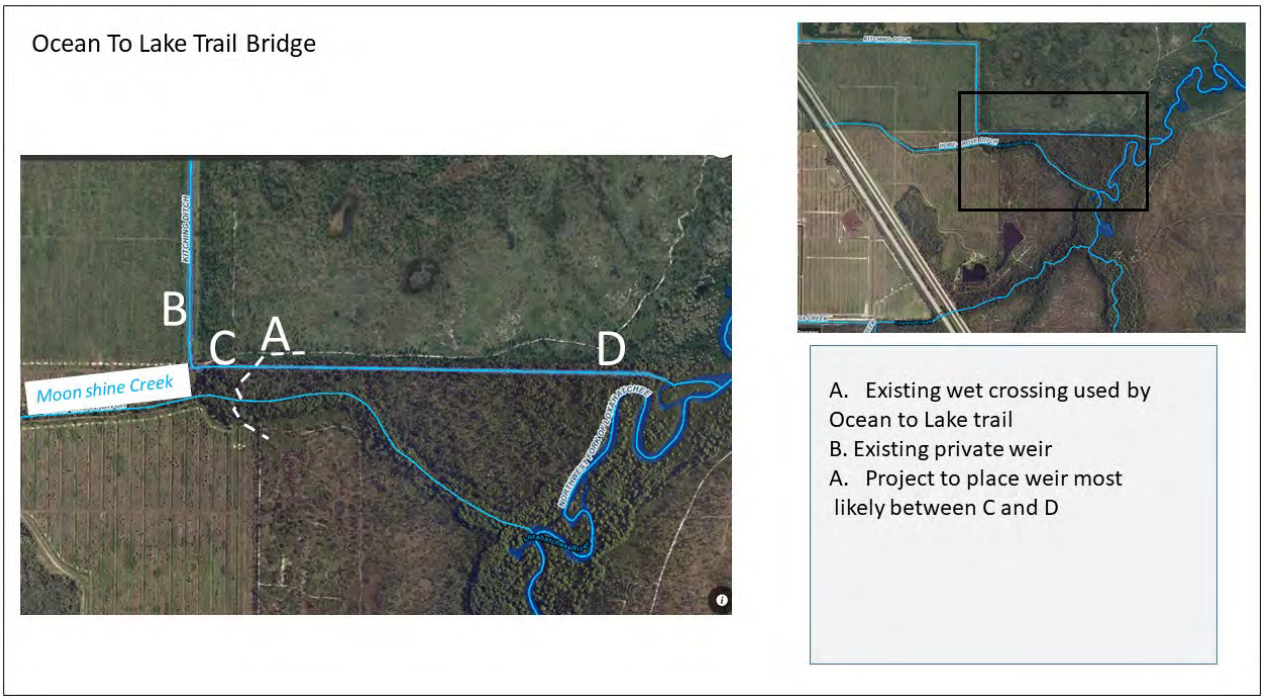

Figure F-2. Ocean to Lake Trail Bridge.

The cost to construct the OTL Trail Bridge and the surrounding recreation area is estimated at $434,000 as shown in **Table F-2**.

Table F-2. 'Site A' OTL Trail Bridge to JDSP Recreation Features.

Feature	Cost FY18 dollars
Bridge	$185,000
Foundation	$50,000
Delivery & install	$75,000
Board walk (100 ft. at $700 per foot)	$70,000
Signage with a roofed sign board	$2,000
Shelter 18x 24	$50,000
Picnic tables	$2,000
Total Cost Estimate	**$434,000**

F.5.2 'Site B' Cypress Creek Recreation Features

At this general location a project water control structure will be built to replace an existing and ineffectual weir in the Cypress Creek Canal (**Figure F-3**). The existing weir elevation is so low as to compromise groundwater levels throughout the area. The new structure will improve groundwater conditions and effect control of flows into Cypress Creek, which is tributary to the Loxahatchee River. Flow through the existing weir joins Cypress Creek near the east edge of this area.

This structure will be designed to function as a recreational feature that will allow its use as a fishing pier, trail footbridge and will incorporate a kayak launch. There are no salinity structures beyond this point and snook are known to approach the existing weir. A fishing platform across the width of the new structure is proposed. The SFWMD/Martin County Cypress Creek property is just south of this point and an existing trail crosses the canal west of the existing weir at a vehicular bridge. This trail would be re-routed to use the structure to cross the Cypress Creek Canal instead of the vehicle bridge. The outdoor trail experience would be enhanced, as hikers will travel through the adjacent southern wooded area and avoid the road. From this location the Cypress Creek enters JDSP and joins the Loxahatchee River 0.2 miles down-stream of Trapper Nelson's. The design and location of the structure will affect the design of the portage and launch facilities.

Access to this site is by hiking or biking and could be enhanced for vehicle use controlled by SFWMD Special Use licenses.

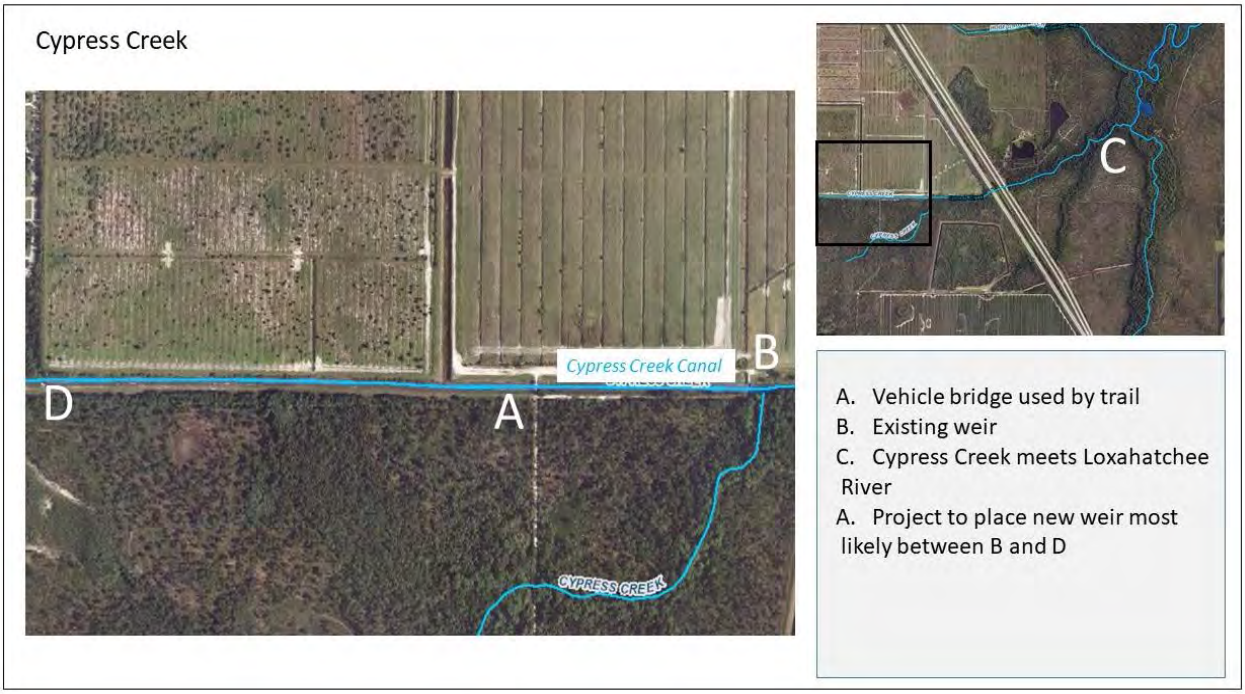

Figure F-3. Cypress Creek Recreation Features.

The location of the structure, east, or west of the existing bridge may make a difference as well. If west of the bridge the kayak launch facility would be built east of the bridge allowing launching down-stream of the bridge. Public and private lands upstream of this location could contribute kayak access to the upstream side of the weir. The hiking trail could be rerouted to the structure whether east or west of the bridge. **Table F-3** presents the cost to construct the Cypress Creek Recreation Features, which is estimated at $345,000.

Table F-3. 'Site B' Cypress Creek Recreation Features.

Feature	Cost FY18 dollars
Road improvements Parking area shell	$50,000
Fishing pier, may be a part of weir with concrete and railings or wood	$75,000
Kayak launch and portage around the weir	$100,000
Steep side and wood staircase	$0
Shelter 18 X 24	$50,000
Guard rail 100’	$20,000
Signage with a roofed sign board	$7,000
Board and post parking fence 200’	$3,600
Dry vault 2 gender toilet	$40,000
Total Summary	**$345,600**

F.5.3 ‘Site C’ L-8 Tie Back Bridge, OTL Connection to Loxahatchee National Wildlife Refuge and East Coast Protective Levees

At this location a footbridge across the L-8 Tie Back Canal would provide and fulfill trail connectivity between the Loxahatchee River via the OTL trail and the Arthur R. Marshall Loxahatchee NWR (**Figure F-4**). This trail connectivity is consistent with greenway trail plans formed by partnering agencies Palm Beach County and NWR. SFWMD is currently working with the NWR to further trail connections to the south of this area. The L-8 and other Federal Conservation levees form the eastern bounds of a series of adjoining public lands including the three Water Conservation Areas better known as the Arthur R. Marshal Loxahatchee National Wildlife Refuge, the Everglades and Francis S. Taylor Wildlife Management Area, and the Everglades National Park.

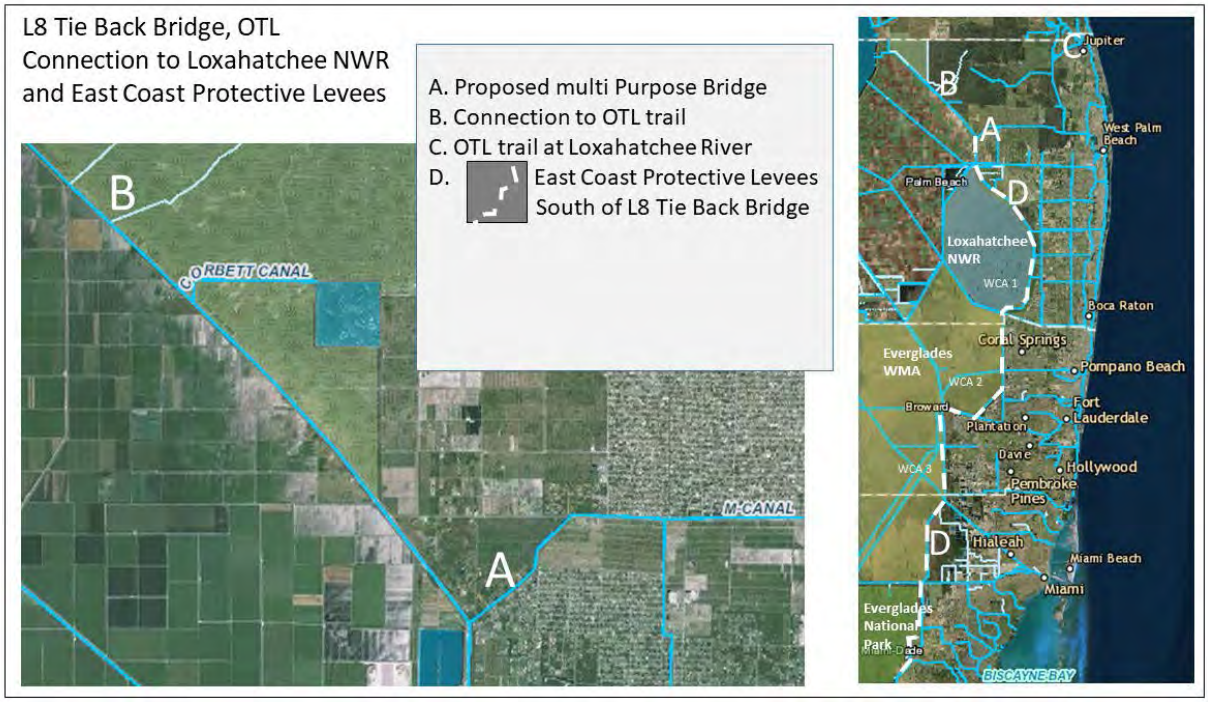

Figure F-4. L-8 Tie Back Bridge, OTL Connection to Loxahatchee NWR and East Coast Protective Levees Recreation Features.

As shown in **Table F-4**, the cost to construct the L-8 Tie Back Bridge, OTL Connection to Loxahatchee NWR and East Coast Protective Levees Recreation Features is estimated at $319,000.

Table F-4. 'Site C' L-8 Tie Back Bridge, OTL Connection to Loxahatchee NWR and East Coast Protective Levees Recreation Features.

Feature	Cost FY18 dollars
Bridge	$185,000
Foundation	$50,000
Delivery & install	$75,000
Signage with a roofed sign board	$7,000
Signage	$2,000
Total Cost Estimate	**$319,000**

F.5.4 'Site D' C-18W Reservoir

This site would have parking and access off Seminole Pratt Whitney Road into a parking area on the reservoir site (**Figure F-5**). The parking would allow non-motorized access onto the levee for hiking and biking and launching of non-trailered and non-motorized boats into the reservoir. The reservoir itself could serve as a center of activity for fishing and hunting as well as access around the levee. Access around the levee maybe also be used by the public as an exercise route due to proximity of residences.

For kayaks and other non-motorized boats in the reservoir and connection to the C-18W Canal on the discharge side or a portage across Palm Beach County land would allow a connection into the C-18W and C-18 Canals that then eventually connects to the Loxahatchee River through the River Bend Park and over the Lainhart and Masten dams.

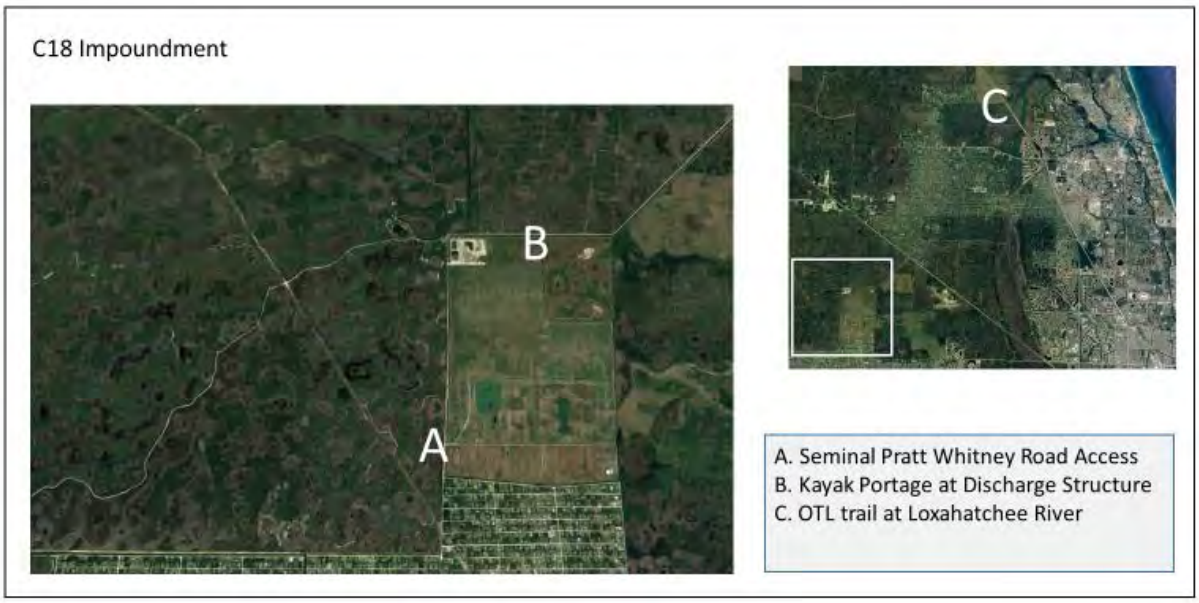

Figure F-5. C-18W Reservoir.

Table F-5 presents the cost to construct the C-18W Reservoir connections.

Table F-5. "Site D" C-18W Reservoir.

Feature	Cost FY18 dollars
Road improvements parking area shell	$50,000
Kayak launch and portage around discharge structure	$100,000
Shelter 18 X 24	$50,000
Signage with a roofed sign board	$7,000
Board and post parking fence 200'	$3,600
Dry Vault 2 gender toilet	$40,000
Total Cost Estimate	**$200,650**

F.5.5 Alternative Sites Considered

During the development of the recreation plan multiple recreation features were considered. Multiple sites along trails for shelters, camping areas, portages or crossings were evaluated. Most were eliminated due to difficulties associated with land ownership or because other similar features were near in proximity. The features chosen and outlined in the above sections do not compete with nearby features and contribute to the cohesiveness of recreation in the Loxahatchee Planning Area.

The bridges proposed at Sites A and C were located after evaluating alternative routes and bridge sites. These other sites were eliminated due to lack of land ownership rights or because wider canals would require a greater span along the route and would thus be more costly. The proposed Site A bridge is located on the existing OTL trail where a project feature will increase the depth and duration of water along the trail. This feature serves to remedy that and provide continued access. Site C bridge serves to connect north to south along the Federal Conservation Levee that leads to the Arthur R. Marshal Loxahatchee National Wildlife Refuge and ultimately the Everglades National Park. Site B and D are recreation features that focus on the opportunities created by project features (the C-18W Reservoir and the Cypress Creek Weir). The location of these proposed recreational features was driven by the location of project features themselves. Within the planning area the number and type of recreation features were screened and minimized to most efficiently support recreational opportunities.

F.6 Recreation Benefits

F.6.1 National Perspective

The national economic development (NED) benefit evaluation procedures contained in ER 1105-2-100 (22 Apr 00), Appendix E, Section VII, include three methods of evaluating the beneficial and adverse NED effects of project recreation: travel cost method (TCM), contingent valuation method (CVM), and unit day value (UDV) method.

The unit day value (UDV) method was selected for estimating recreation benefits associated with the creation of the Loxahatchee River Watershed Restoration Project. The UDV approach in recreation benefit analysis consists of two parts: determining value per visit based on a willingness to pay approximation and estimating visitation. The benefits of recreation features are measured through approximation of visitors' willingness to pay (WTP) for the recreation resource. Willingness-to-pay is assumed to represent the economic value, in dollars, that a visitor places on a recreation resource. Measuring the economic value of the recreation resource without a project, then again with the project in place, allows the calculation of net recreation benefits due to construction of the recreation alternative. The Unit Day Value (UDV) method was selected as the appropriate valuation method based on the characteristics of the LRWRP.

F.6.2 Determining Value per Visit

When the UDV method is used for economic evaluations, planners will select a specific value based on a series of criteria applied to the various recreation facilities and opportunities provided by the project. The criteria and point values for this analysis are derived from Economic Guidance Memorandum (EGM) 18-03, which is updated annually to reflect any increases or decreases in estimated willingness to pay for general recreation features. . Application of the selected value to estimate annual use over the project life, in the context of the with- and without-project framework of analysis, provides the estimate of recreation benefits.

The without project condition described site by site for this analysis have minimal recreation value as the proposed Loxahatchee River recreation facilities do not exist. It is presumed that the proposed facilities must be opened to the public in order to realize the recreation benefits being claimed. The with-project will be the expected value of recreational activity based on the UDV method.

Table F-6 illustrates the method of assigning a point rating to a particular general recreation activity. The table also shows the point values assigned based on measurement standards described for the five criteria: Recreation Experience, Availability of Opportunity, Carrying Capacity, Accessibility, and Environmental.

Table F-6. Guidelines for Assigning Points for General Recreation.

Criterion	Judgment factors				
Recreation experience Total Points: 30	Two general activities	Several general activities	Several general activities: one high-quality value activity3	Several general activities; more than one high-quality activity	Numerous high-quality value activities; some general activities
Point Value: 27	0-4	5-10	11-16	17-23	24-30
Availability of opportunity Total Points: 18	Several within 1 hr. travel time; a few within 30 min. travel time	Several within 1 hr. travel time; none within 30 min. travel time	One or two within 1 hr. travel time; none within 45 min. travel time	None within 1 hr. travel time	None within 2 hr. travel time
Point Value: 15	0-3	4-6	7-10	11-14	15-18
Carrying capacity5 Total Points: 14	Minimum facility for development for public health and safety	Basic facility to conduct activity(ies)	Adequate facilities to conduct without deterioration of the resource or activity experience	Optimum facilities to conduct activity at site potential	Ultimate facilities to achieve intent of selected alternative
Point Value: 7	0-2	3-5	6-8	9-11	12-14
Accessibility Total Points: 18	Limited access by any means to site or within site	Fair access, poor quality roads to site; limited access within site	Fair access, fair road to site; fair access, good roads within site	Good access, good roads to site; fair access, good roads within site	Good access, high standard road to site; good access within site
Point Value: 10	0-3	4-6	7-10	11-14	15-18
Environmental Total Points: 20	Low esthetic factors that significantly lower quality7	Average esthetic quality; factors exist that lower quality to minor degree	Above average esthetic quality; any limiting factors can be reasonably rectified	High esthetic quality; no factors exist that lower quality	Outstanding esthetic quality; no factors exist that lower quality
Point Value: 8	0-2	3-6	7-10	11-15	16-20

Point value assignments for **Table F-6** above are based on Economic Guidance Memorandum (EGM) 18-03: Unit Day Values for Recreation for Fiscal Year 2018. The Criteria and Judgment Factors for

General Recreation were specifically used as the basis of the estimated point values for the proposed recreation area. Judgment factors were reviewed after conducting site visits and coordination with local agencies. The following selection factors were used for the criteria outlined in **Table F-6**.

The Loxahatchee River Watershed Restoration Project proposed recreation resources would provide an area specific, unique recreation opportunity afforded by the project setting which includes over 165, 000 acres of public land, interconnecting trails and the presence of one of only two National Wild and Scenic Rivers in Florida. This creates opportunities for a high diversity of common activities (e.g., picnicking; camping; hiking; jogging; riding; cycling; kayaking/canoeing; and fishing, hunting, stargazing, wildlife viewing and photography of normal quality) as well as high quality, high value activities (e.g., kayaking/canoeing, endurance running/racing and high-quality hunting within two State WMAs). The site offers solitude and panoramic views outside a growing metropolitan region and would provide specific recreation amenities (as outlined) for expanding regional population. The point value rating is estimated at the high end of the scale because of the high-quality value activities and numerous general activities.

The availability of opportunity rating is based upon the presence of large conservation lands to both the north and south of the project that offer similar common activities but are not within the 30-minute time frame for the majority of the population. LRWRP offers three recreation activities that are rare in South Florida: the Ocean-to-Lake Hiking trail provides opportunity for wilderness backpacking not otherwise available except on the Florida National Scenic Trail; this is one of only two Wild and Scenic Rivers in Florida; and the rare species provide photographic opportunities that are hard to encounter. Alternative facilities do not exist for backpacking, and nothing provides the connectivity that the river provides. Scores for this judgment factor are therefore expected to be on high scale.

The proposed LRWRP recreation resources carrying capacity point values are estimated to improve with the recreation component construction. Currently some facilities experience heavy use and others very little; a situation that could be alleviated by development of new access facilities. Good water resources and access to them for non-boat fishing, multi-use trail and environmental observation comprise a balanced use of the proposed recreation resource use. Adequate facilities will be constructed to conduct these activities without deteriorating the resources or activity experience.

The accessibility rating is based upon the availability of local highways, roads and streets in good condition that would provide access to the proposed recreation facilitates. Direct routes from the east on paved roads provide good access.

The environmental quality rating is based upon the existing aesthetic values of the proposed Loxahatchee River Watershed Restoration Project recreation resource facilities and the ease of correcting any limiting aesthetic factors. The proposed site would possess panoramic views. The best aesthetics of the proposed project area are views from the Loxahatchee River Watershed Restoration Project to the west during a sunset.

The value of a day of general recreation at the proposed Loxahatchee River Watershed Restoration Project was determined for each project activity using the guidelines for Assigning Points for the General Recreation in **Table F-6**. The points were then converted to dollar values using conversion factors included in the Economic Guidance Memorandum 18-03, Unit Day Values for Recreation, 2018, which is based on ER 1105-2-100.

Table F-7 displays the point value conversion to a UDV FY2018 dollar amount. Using linear interpolation the total point value for the recreation sites was determined to be 67. The user day value conversion equivalent is $9.72. Estimation of the annual use over the project life is next.

Table F-7. Conversion of points to dollar values.

General Recreation Point Values	General Recreation Dollar Values
0	$4.05
10	$4.81
20	$5.32
30	$6.08
40	$7.59
50	$8.61
60	$9.37
70	$9.87
80	$10.89
90	$11.64
100	$12.15

F.6.3 Estimating Visitation

F.6.3.1 State of Florida Perspective

The State of Florida's Department of Environmental Protection (FDEP), Division of Recreation and Parks, developed the Florida Statewide Comprehensive Outdoor Recreation Plan (SCORP) for 2013. The SCORP was used to obtain state regional recreation participation rates. The SCORP also provides recreation user day guidelines for resource based outdoor recreation activities listed in **Table F-8**. These guidelines are based on maximum carrying capacity levels developed by FDEP. The LRWRP is a geographically large inland body of freshwater in an area of the state where state based recreation resources are mainly environmental/ecological or riverine in nature.

Using the guidelines available from the SCORP, reasonable user rate projections can be determined. Due to the LRWRP rural location and rustic/minimal recreation features planned, it was determined that a conservative usage rate would be used. The projected LRWRP recreation use rates referenced the resource needs and guidelines published by the SCORP, but use rates developed were substantially lower than the SCORP published rates.

In many areas, even where water bodies are accessible, they are unusable due to the lack of facilities. As previously noted, the regional-level needs assessments in this plan (SCORP) are not capable of identifying local needs. Nonetheless, it is well known that there is a need to fund development of access facilities such as boat ramps, canoe launches, docks, catwalks and piers, as well as support

facilities such as bathhouses, restrooms, and parking areas.[2] Federal, state and local governments should work together to fund construction of these facilities in all areas where there is sufficient access to water bodies suitable for recreation (SCORP, 2013).

F.6.3.2 Regional Perspective

The current SCORP indicates regional recreation demands not met for the year 2013 for seven activities associated with the proposed LRWRP recreation. In the current or FWO condition miles of biking, hiking, nature study, horseback riding, freshwater fishing non-boating, canoeing/kayaking, and wildlife viewing are needed to fill projected regional demand. Analysis of supply and demand within Southeast and Central East Regions indicate that FWO demand for equestrian trails will overcome supply.

The use guidelines for designated bicycle, hiking, and nature study trails were based on carrying capacity guidelines adopted by the SCORP and used by the state park system. Since SCORP provides no guidelines for bank fishing use, the SFWMD and Corps provided use rates of 5 per weekend day. There are roughly 33 miles of trail open to the public on canal or impoundment levees:

- City of West Palm Beach's Owahee Trail = 14.2 mi Grassy Waters Preserve impoundment levee
- City of West Palm Beach's Promontory Trail = 1 mi Grassy Waters Preserve levee
- Palm Beach County's Bluegill Trail = 7.5 mi C-18 levee
- Palm Beach County's Pântano Trail = 10.3 mi on C-18 & C-18W.

Almost all trails and canals were used to determine daily usage rates because it is expected that 33 miles are on canal levies to either side of the access point and parking will be used most often.

A balanced mix of ecosystem compatible recreation use and facilities are proposed for the LRWRP. The proposed recreation would help to fill existing and projected SCORP 2013 recreation deficits for Southeast and Central East Regions.

[2] Draft Caloosahatchee River (C-43) West Basin Storage Reservoir PIR and EIS, pg. H-13, April 2007

Table F-8. Most likely recreation participation user day projection scenario.

Activity	Units Provided	SCORP Maximum Area Requirements	SCORP Turnover Rates	SCORP Capacity Guidelines	SCORP Regions: Southeast and Central East Needs (2013) User Occasions	SCORP Regions: Southeast and Central East Needs (2013) Units	Loxahatchee (LRWRP) River Projected Users
Bicycling and Hiking	12 miles / 4 utilized	10-20 users Per Mile	4/day	40-80 users per mile per day	16,675,164	1,177 miles	10 each
Equestrian Trails	12 miles / 4 utilized	2-8 groups/ mile – 4/ group	3/day	24 – 96 equestrians/ trail mi/ day	204,592	0 miles	5
Canoeing / kayaking	12 miles of canals and Impoundment	1-2 users per canoe	2/day	1-2 canoes per acre or mile	N/A	N/A	10
Nature Study (Interpretative Signs)	12 miles / 4 utilized	5-20 groups per mile	4/day	40-160 users per mile of trail/day	3,073,615	56.80 miles	10
Bankfishing †	50 mi of canal & reservoir banks	1 fisherman/20 linear feet	2/day	528 users per mile/day	N/A	N/A	5 / day (wkday/wkend average)
Wildlife Viewing	2 – double-lane paved boat-ramp	N/A	2/day	I	N/A	4	10 / day (wkday/wkend average)
General Recreation Total	N/A	N/A	N/A	N/A	N/A	N/A	60 users per day

† signifies conservative user rates developed between by Corps and SFWMD recreation planning POCs after SCORP review. By utilizing SCORP methodology the capacity is more tremendous than what we use.

F.7 Economic Justification of Recreation

The justification of incurring additional costs for recreation features is derived by utilizing a benefit to cost ratio. The tangible economic justification of the proposed project can be ascertained by comparing the equivalent average annual charges with the estimate of the equivalent average annual benefits, which would be realized over the period of analysis. These average annual recreation benefits and costs are summarized in **Table F-9**.

Engineering Regulation 1105-2-100 (The Planning Guidance Notebook) provides economic evaluation procedures to be used in all Federal water resources planning studies. The guidelines specified in the ER 1105-2-100 dated 22 April 2000 were observed in preparing this cost analysis. The federally

mandated project evaluation interest rate of 2 3/4 percent, an economic period of analysis of 50 years and 2018 price levels were used to evaluate economic feasibility.

Table F-9. Summary of recreation costs and benefits.

Recreational Facility	Cost Estimate
Site A - OTL Trail Bridge to JDSP - Table Summary	$434,000
Site B - Cypress Creek - Table Summary	$346,000
Site C – L-8 Tie Back Canal, OTL Connection in Corbett -Table Summary	$319,000
Site D - C-18W Reservoir –Table Summary	$201,000

Table F-10. Recreation costs.

Cost Category	Cost Estimate (FY18 dollars)
Summary of Feature Costs	$1,300,000
PED & S/A (18%)	$234,000
Contingency (25%)	$384,000
Total Cost including Contingency	$1,918,000
Interest During Construction (12-month duration)	$24,000
Total Investment	$1,942,000
Amortized (50 year period of analysis)	$72,000
OMRR&R	$25,000
Average Annual Cost	$97,000
Unit Day Value[3]	$9.72
Daily Use (average number of users/ day)	60
Annual Use (60 users x 365 days)	22,000
Average Annual Benefit	$213,000
Benefit to Cost (average annual benefit / average annual cost)	2.20
Net Annual Benefits (average annual benefit – average annual cost)	$116,000

This analysis leads to the conclusion that there are 2.20 times the benefits than the costs. The benefit-to-cost ratio for the recreation features is 2.20-to-1, with net annual benefits of $116,000.

A sensitivity analysis was conducted to further reinforce expected benefits and provide additional justification for proposed recreation features. **Table F-11** includes a sensitivity analysis which contains the expected annual benefits from **Table F-9**, a worst-case scenario depicting the number of annual visitors required for benefits to equal cost, and a scenario in which SCORP guidelines are utilized as

[3] Unit Day Values are derived from EMG 18-03, Unit Day Values for Recreation

they are presented. As can be noted from this sensitivity analysis, a minimum average rate 31 users per day would be required to justify the proposed costs for recreation, and following the minimum guidelines from SCORP the expected minimum benefit from the site could be $4.8 million dollars. This economic analysis suggests there would be ample benefits to conservatively justify the proposed recreation facility construction for the Loxahatchee River Watershed Restoration project.

Table F-11. Sensitivity analysis using multiple scenarios.

Scenario	Annual Users	Average Daily Users	Annual Benefits
Worst Case Scenario	11,315	31	$110,000
Projected Scenario	22,000	60	$213,000
SCORP Guidelines	500,000	1,370	$4,860,000

NOTE: Annual Benefits were derived by multiplying Annual Users by $9.72 point value.

F.8 References

Bureau of Economic and Business Research (BEBR), UF, College of Liberal Arts and Sciences. Florida Statistical Abstract 2017.

Design Agreement Between The Department of the Army and South Florida Water Management District for the Design of Elements of the Comprehensive Plan for the Everglades and South Florida Ecosystem Restoration Project (12 May 2000).

Florida Fish and Wildlife Conservation Commission, "Boating Access to the South Region Counties", http://myfwc.com/boating/access/ramps/so-ramps.html#180> (12 Feb. 2007).

Florida Fish and Wildlife Conservation Commission, Boat Access Need Letter (23 Feb 2007).

Personal Communication: Jerry Krenz, Sr. Planner South Florida Water Management District.

Personal Communication: Sally Channon, Environmental Analyst, Palm Beach Department of Environmental Resources Management.

Personal Communication: Jean Matthews, Palm Beach County Parks & Recreation Dept.

Personal Communication: Steve Bergkamp, Palm Beach County Parks & Recreation Dept.

Personal Communication: Mark Kiser, Planning Consultant, Florida Department of Environmental Protection, Division of Recreation and Parks

Public Law (PL) 78–534. Flood Control Act of 1944, Washington, D.C.

PL 89-72. The Federal Water Project Recreation Act of 1965, Washington, D.C.

PL 99-662. Water Resources Development Act (WRDA) of 1986, Washington, D.C.

PL 104-303. Water Resources Development Act of 1996, Washington, D.C.

PL 106-541. Water Resources Development Act of 2000, Washington, D.C.

State of Florida, Department of Environmental Protection, Division of Recreation and Parks, Outdoor Recreation in Florida-2000: Florida's Statewide Comprehensive Outdoor Recreation Plan, Tallahassee, FL (SCORP, 2000).

State of Florida, Department of Environmental Protection, Division of Recreation and Parks, Recreational Boating Access in Florida State Parks, Tallahassee, FL (Jan 2006).

South Florida Water Management District (SFWMD), Public Access Rule 40E-7, Florida Administrative Code, Tallahassee, FL (Feb 2007).

U.S. Army Corps of Engineers, Central and Southern Florida Study (Yellow Book, 1999), Jacksonville District, Jacksonville, Florida.

U.S. Army Corps of Engineers, Final Site 1 Impoundment PIR and EA: Recreation Appendix H. Central and Southern Florida Project, CERP, Jacksonville, FL (April 2006).

U.S. Army Corps of Engineers, South Atlantic Division (CESAD-PDD-J). Multi-Purpose Project Memorandum, Atlanta, GA (15 Sep. 2004).

U.S. Army Corps of Engineers, South Atlantic Division (CESAD-PDD-J). OMRR&R Memorandum, Atlanta, GA (29 Sep 2005).

U.S. Army Corps of Engineers, South Atlantic Division (CESAD-PDD-J), Recreation Authority Memorandum, Atlanta, GA (26 Jan 2007).

U.S. Army Corps of Engineers, Civil Works, Water Resources Policies and Authorities (CECW-A), Economic Guidance Memorandum (EGM) 17-03, Unit Day Values for Recreation Fiscal Year 2017, Washington, D.C. (Oct. 2016).

U.S. Army Corps of Engineers, Ecosystem Restoration - Supporting Policy Information Engineer Pamphlet (EP) No. 1165-2-502, Washington, D.C. (Sep. 1999).

U.S. Army Corps of Engineers, Civil Works, Policy Division (CECW-AG), Policy Guidance Letter (PGL) No. 59, Recreation Development at Ecosystem Restoration Projects. Memorandum (June 1998).

U.S. Army Corps of Engineers, Planning Guidance Notebook, ER 1135-2-100 (APR 2000). Washington, D.C.

U.S. Army Corps of Engineers, Design of Recreation Areas and Facilities - Access and Circulation (DEC 1982). Washington, D.C.

USACE/SFWMD, Comprehensive Everglades Restoration Plan, Master Recreation Plan, Public Involvement Summary Report, (Jan 2007).

COMPREHENSIVE EVERGLADES RESTORATION PLAN

LOXAHATCHEE RIVER WATERSHED RESTORATION PROJECT

DRAFT INTEGRATED PROJECT IMPLEMENTATION REPORT AND ENVIRONMENTAL IMPACT STATEMENT

March 2019

Appendix G

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APPENDIX G

BENEFIT MODEL

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G MODEL DOCUMENTATION INTRODUCTION

The Department of the Army Engineer Regulation (ER) 1105-2-100 requires that ecosystem restoration planning contribute to national ecosystem restoration (NER), which is measured in terms of increases in the net quantity and/or quality of desired ecosystem resources. The United States Army Corps of Engineers (USACE) uses NER benefits as the basis to compare alternatives and select plans for ecosystem restoration projects. The following report documents the methodology that was used to quantify ecological benefits and support plan evaluation, comparison, and selection for the Loxahatchee River Watershed Restoration Project. The LRWRP Planning Model underwent peer review per Engineering Circular (EC) 1105-2-412, 31 May 2011 (Assuring Quality of Planning Models) and was recommended for single-use on LRWRP by the National Ecosystem Restoration Planning Center of Expertise (ECO-PCX) on 27-JUL-2016. The HQUSACE Model Certification Panel approved the LRWRP Planning Model on 16-AUG-2016.

G.1 Overview of LRWRP Planning Model

The LRWRP planning model was specifically developed to evaluate project alternative benefits within the LRWRP project domain. The primary areas to be evaluated in the project domain include the Loxahatchee river watershed, the freshwater and tidal flood plains of Northwest Fork of the Loxahatchee River (NWFLR), the freshwater river itself, and the downstream oligohaline, mesohaline, and polyhaline zones. The planning model was developed by the Jacksonville District with support from multiple Federal, state, and local agencies including the U.S. Fish and Wildlife Service, U.S. Environmental Protection Agency, National Marine Fisheries Service, South Florida Water Management District, Florida Fish and Wildlife Conservation Commission, Florida Department of Environmental Protection, Loxahatchee River District, Martin County, Palm Beach County, and City of West Palm Beach. Members of the project delivery team (PDT) include subject matter experts on Loxahatchee Watershed, River, and Estuary flora and fauna, with extensive experience working in south Florida and Everglades wetland systems in the fields of ecology, hydrology, engineering, and planning.

Performance measures were used to document the linkage between hydrologic output from models and ecosystem functions to evaluate the degree to which alternative plans met restoration objectives. Each of the performance measures were updated from the prior North Palm Beach County Part 1 project based on the availability of new tools, updated knowledge on the system from peer reviewed literature and technical reports, and RECOVER review comments. RECOVER is an interagency system-wide science team to support Comprehensive Everglades Restoration Plan (CERP) projects and is made up of Everglades scientists independent of the PDT. Each performance measure has a predictive target and process for how to measure predicted performance of alternatives. Targets were based on peer-reviewed relationships between hydrology and ecological species or communities, and technical synthesis reports of multiple data sources identifying restored conditions in the Loxahatchee River and Estuary. Performance measure scores were displayed as a function of restoration potential or achievement of the target. Habitat unit (HU) scores were produced by indexing the scores 0-1. The indexed scores were then multiplied by their proportion of the total index score for a given ecological zone (i.e., some performance measure outputs overlap in area) and then multiplied by the area to get the HUs. HUs were then evaluated for the Existing Condition Baseline (ECB), future without project (FWO) condition, and project alternatives, to identify the best performer for each zone and the whole Loxahatchee River watershed and estuarine system.

G.2 Description of Project Performance Measures

Three performance measures (PM) were developed to measure five restoration objectives (see **Table G-1**) for LRWRP within five ecological zones (see **Table G-2**):

1. **Flows to Manage Salinity and Floodplain Inundation PM 1** - Seasonal flows to manage salinity and floodplain hydroperiod in the NWFLR to benefit native flora and fauna.
2. **Watershed Hydrology PM 4** - Hydrologic regimes of major plant communities in the Loxahatchee watershed and adjacent wetlands based on inundation durations.
3. **Connectivity PM 9** - Measuring potential benefits of reconnecting natural areas specific to four criteria (1-Hydrologic flow; 2-Greenway; 3-Water Quality; and 4-Endangered and/or Rare Species).

Table G-1. LRWRP Project Objective linked to performance measures.

LRWRP Objective (Abbreviated)	PM 1 – Flow, Salinity, Floodplain	PM 4 – Watershed Hydrology	PM 9 - Connectivity
1. Restore wet and dry season flows to Northwest Fork of Loxahatchee River	√	Not Applicable	Not Applicable
2. Restore and/or maintain estuarine communities (oysters, fish, seagrass)	√	Not Applicable	Not Applicable
3. Increase natural area extent of wetlands	√	√	Not Applicable
4. Restore connections between natural areas	√	√	√
5. Restore native plant and animal species abundance and diversity	√	√	√

Table G-2. Ecosystem Zones linked to performance measures.

Ecosystem Zones	PM 1	PM 4	PM 9
Watershed Wetlands – Freshwater Flora and Fauna	Not Applicable	√	√
Cypress Swamp-River Floodplain - Freshwater Flora and Fauna	√	Not Applicable	√
Tidal River Floodplain -	√	Not Applicable	Not Applicable
Oligohaline with *Vallisneria americana* and Fish Larvae	√	Not Applicable	Not Applicable
Mesohaline - Oysters	√	Not Applicable	Not Applicable
Polyhaline - Seagrass	√	Not Applicable	Not Applicable

G.3 Hydrologic Models Used

Several hydrologic modeling tools were used to provide the output used in PMs 1 and 4. GIS data were used to analyze PM 9. **Figure G-1** provides an overview of models used to measure performance measure output for the seven habitat zones. Some of the zones overlap and the benefits model process describes later on in the document how the results were combined to avoid double counting.

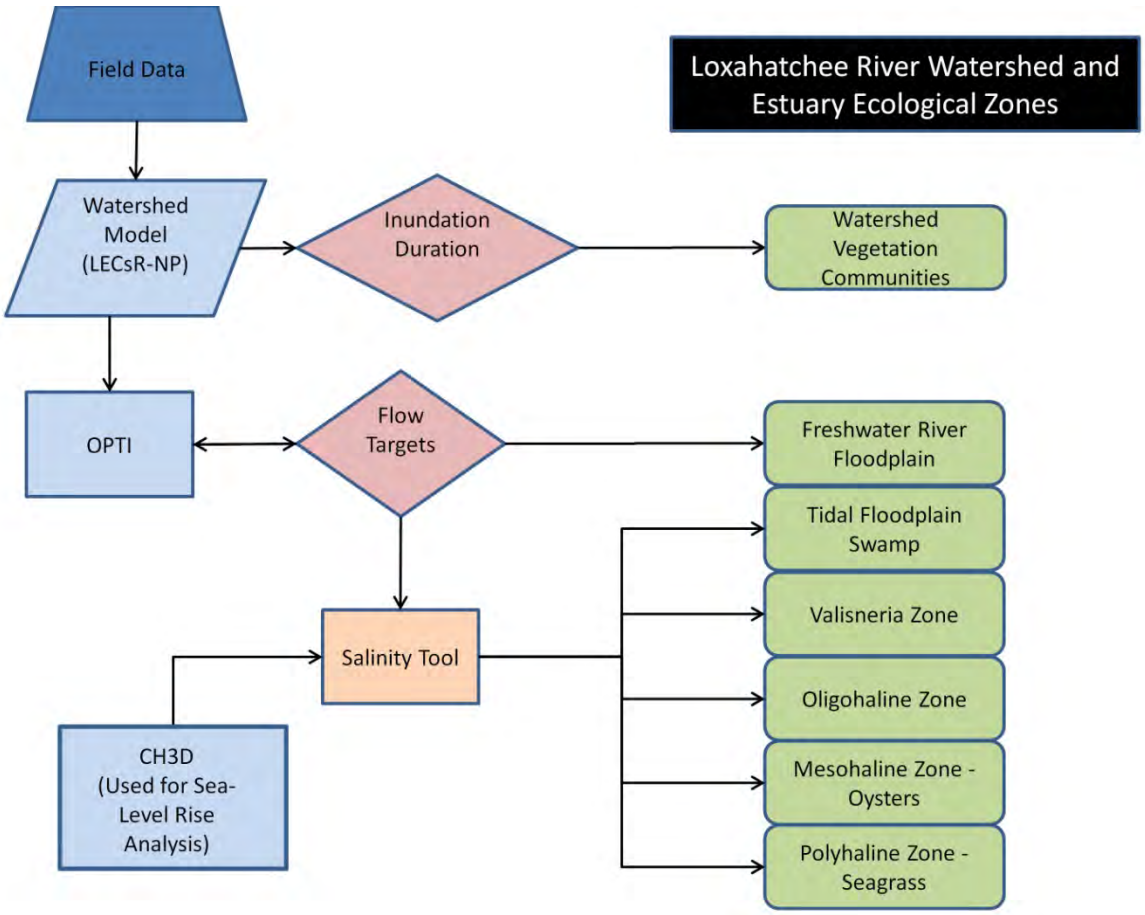

Figure G-1. Diagram of models used to measure performance in the Loxahatchee River, Watershed, and Estuary ecological zones.

G.3.1 Spatial Extent of Performance Measures.

The performance measures cover the Loxahatchee River Watershed depicted in **Figure G-2**. Performance measure 1 covers the riverine floodplain, river and downstream to the estuary (see **Figure G-2** [orange circle] and **Figure G-3**). Performance measure 4 covers the watershed vegetation communities. Performance measure 9 is mostly focused in the watershed leading into the river.

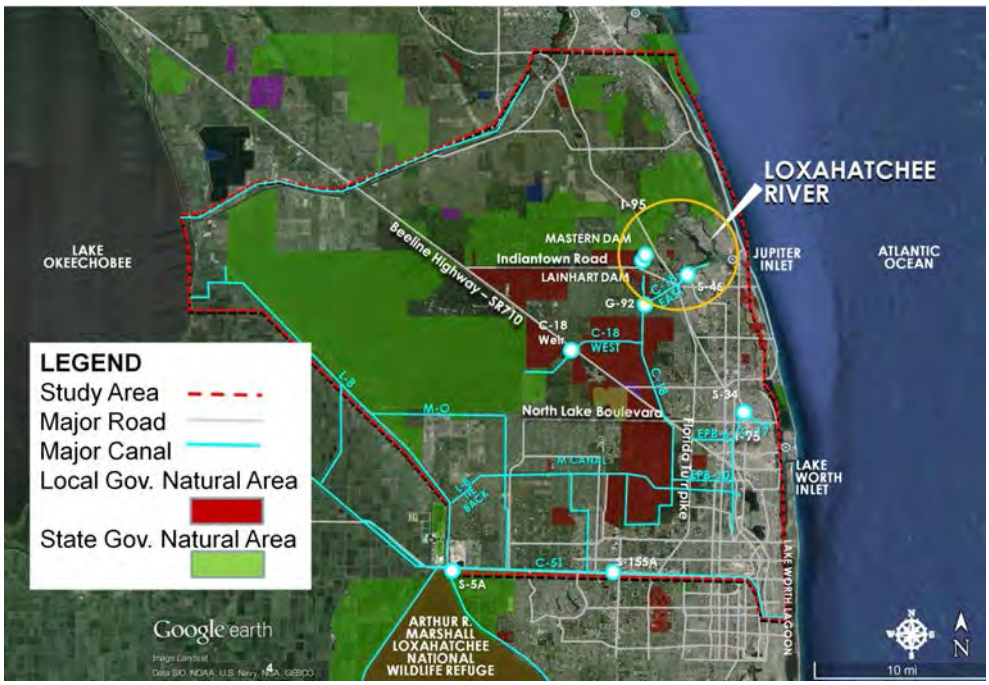

Figure G-2. Map of Loxahatchee River Watershed Project Area including river and estuary.

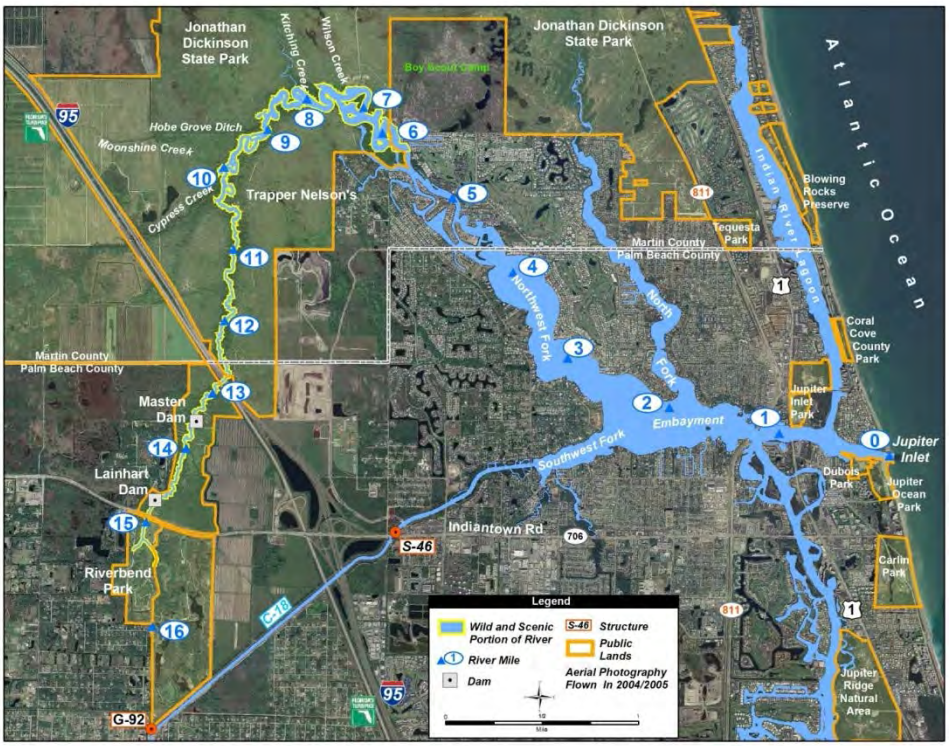

Figure G-3. Loxahatchee River close-up.

G.3.1.1 Performance Measures.

The following provides a brief description of the above performance measures including the performance measure target for each, and the applicable metrics for the target(s).

G.3.2 PM 1 – Flows to Manage Salinity and Floodplain Inundation

The purpose of LRWRP is to restore and sustain the overall quantity, quality, timing, and distribution of freshwaters to the federally designated "National Wild and Scenic" NWFLR for current and future generations. This performance measure concentrates on the restoration and preservation of key indicator species (Valued Ecosystem Components or VECs, USEPA 1987) from the farthest upstream freshwater section of the river to the outer estuary. Performance metrics representing characteristic regimes of hydrology or salinity at desired locations are identified for each of the VECs in order to evaluate alternative scenarios. The areas in the river and estuary designated in these targets have been determined based on mainly two factors, dynamic and static habitat. Dynamic habitat is then paired up with a location in the river or estuary where the static habitat is conducive to the health and survival of that VEC. For example, the preferred location for juvenile fish can be found where both the salinity is favorable and where there is floodplain and shoreline vegetation and SAV such as *Vallisneria* to provide refuge for small fish to hide from predators. Another example is the oyster which needs not only favorable salinity conditions but also hard bottom substrate for larvae (spat) to settle on.

In the Restoration Plan for the Northwest Fork of the Loxahatchee River (Restoration Plan) (SFWMD *et al*. 2006) and the addendum (SFWMD et al. 2012), the Northwest Fork ecosystem was partitioned into the following five habitat zones, each with its own specific valued ecosystem components (VECs) to evaluate the biological effects of each restoration flow alternative. For this study we added one more habitat zone and VEC, *Vallisneria americana*, which provides excellent structural habitat for small fish and invertebrates as well as food for such things as turtles and manatees. Under the recommended variable flow scenarios, which include both seasonal and short term (daily to monthly) variation, it was determined that the six desired habitat zones and their associated VECs would be established in the following areas of the river and have the associated salinity target ranges:

- Floodplain swamp and hydric hammock in the freshwater riverine floodplain – 0 practical salinity units (psu), 4 to 8 months inundation per year during the months of June–November (RM 16 to RM 9.5)
- Floodplain swamp in the tidal floodplain – < 2 psu (RM 9.5 to RM 8.1)
- *Vallisneria americana* – < 5 psu (RM 10.5 to RM 6.5)
- Fish larvae in the oligohaline zone – preferred salinity range of 2 to 8 psu (RM 10 to RM 5.5)
- Oysters in the mesohaline zone – preferred salinity range of 10 to 20 psu (RM 6.0 to RM 3.5)
- Seagrasses in the polyhaline zone – preferred salinity range of > 20 psu (RM 4.0 to RM 0.0)

The alternatives, which will include sets of management measures, will be compared against each other and the FWO by running the series of models outlined in **Figure G-1**. These models are linked together with the Northern Palm Beach County version of the Lower East Coast Sub-regional Model (LECSR-NP), providing output to the OPTI model, which optimizes operations of the alternative in order to best meet the flow and inundation targets. The optimized operation output flows are evaluated for the inundation duration targets for the freshwater floodplain and also fed into the salinity regression tool, which outputs

salinity zones in ½-mile increments throughout the entire river and estuary from the top of the river to the inlet.

G.3.3 PM 4 – Watershed Vegetation Community Hydrology

One of the goals of the Loxahatchee River Watershed Restoration Project (LRWRP) is to achieve appropriate depth, duration and frequency targets in the Loxahatchee watershed wetlands (USACE and SFWMD 2014). The draft Loxahatchee Watershed Conceptual Ecological Model (2004) states that general hydrologic requirements need to be defined for each of the major plant communities identified within the indicator regions. As described by the Florida Natural Areas Inventory (FNAI 1990), fifteen of these distinct plant communities are found within Jonathan Dickinson State Park (Roberts et al. 2006) and the Loxahatchee River watershed. The nine most dominant plant communities are mesic and wet flatwoods, wet prairie, floodplain, strand and dome swamp, depression marsh, and mesic and hydric hammock.

The performance measure target is as follows: seasonal hydrologic regimes to be within five % (plus or minus) of desired values for major wetland plant communities at specified indicator regions (See **Figure G-4**). Desired values were based on literature data, model outputs for pre-development conditions, and/or existing conditions in unimpacted areas based on field assessment data collected through the wetland rapid assessment procedure (WRAP, Miller and Gunsalus 1999). At minimum these literature based community hydrologic regimes will be used as targets for each major wetland plant community. However, they are subject to refinement based on comparison and validation of model outputs from Lower East Coast Sub-Regional Model (LECSR) to actual field conditions in unimpacted areas. Refinements would only be made if field conditions indicated the community was unimpacted and experiencing a different hydrologic regime than understood from published literature in **Table G-3**. (Sources: Drew and Schomer 1984; Duever et al 1984; Vince et al. 1989; Abrahamson and Harnett, 1990; Myers and Ewel 1990; Mitsch and Gosselink 1993; David 1996; FDEP 2003).

Table G-3. Annual average water depth and annual inundation for major wetland plant communities identified within the Loxahatchee watershed.

Plant Community Type	Annual Avg. Water Depth (inches)	Inundation Duration* (days/yr)	Target - Median Inundation Duration (days/yr)	Target Inundation Duration 36 Year Period of Record (POR)
Mesic Flatwood	Below ground	<30	15	540
Mesic (Oak) Hammock	Below ground	0-60	30	1080
Hydric Flatwood	0-6	30-60	45	1620
Hydric Hammock	0-6	30-60	45	1620
Depression Marsh	12-24	180-300	240	8640
Wet Prairie	6-16	60-180	120	4320
Strand Swamp	18-36	210-300	255	9180
Floodplain Swamp	12-30	120-240	180	6480
Dome Swamp	12-24	210-300	255	9180

Note: * Frequency of inundation duration days/yr coincides with wet weather patterns and existing groundwater conditions.

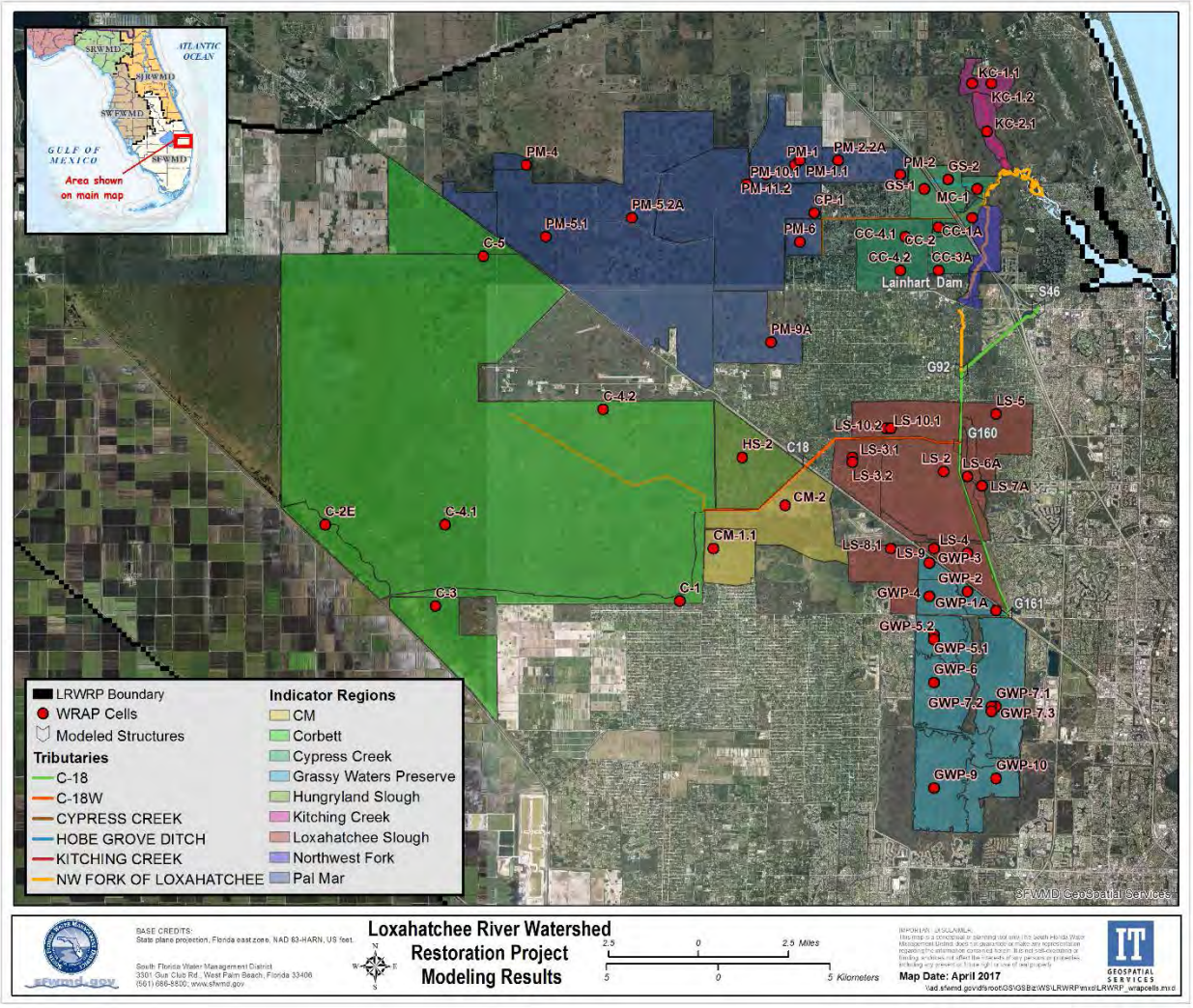

Figure G-4. Map of Indicator Regions.

G.3.4 PM 9 – Connectivity

Agricultural practices and urban development activities such as drainage systems, roadways, utility corridors, and housing have disrupted and impacted wetland communities by fragmenting the natural hydrologic landscape. Specifically, the continuity of pre-development surface water flow through wetland systems has been compromised, and the loss of continuity between and among greenway connections has resulted in the loss of wildlife habitat and functionality. Hydrologic connectivity is essential to the ecological integrity of the landscape, and reduction or alteration by anthropological processes can have major negative environmental effects (Pringle 2003).

Potential for hydrologic and spatial connectivity will be evaluated using the "Connectivity Matrix" (**Table G-4**) developed by the interagency team. The connectivity target is the highest % increase in connectivity

compared to the total maximum score achievable of 100% based on Hydrologic/Spatial Connectivity Matrix and Scoring Rubric (see **Table G-4**). CRITERION SCORING: **0**: No/Does not occur; **12.5:** Partially occurs; **25**: Yes/Definitely occurs. No specific targets were stated for CERP in the 1999 Comprehensive Plan or by RECOVER.

Table G-4. Hydrologic/Spatial Connectivity Matrix.

Hydrologic/Spatial Connectivity Matrix Target	Criterion Value based on Subteam Assessment (Example)	Maximum Score Possible
Downstream Hydrologic Linkage: Connection provides historic hydrologic linkage which contributes to the restoration of downstream areas and improved quantity, timing and distribution of water. Connections that are closer to the river (<10 miles) and are continuous based on GIS analysis will be scored higher than those further away.	12.5	**25**
Greenway Corridor: Connections cover majority area (>50%) of an existing or proposed greenway.	25	**25**
Water Quality: Connectivity promotes water quality improvements and protects water quality by allowing for only sheetflow across natural lands and natural flow ways.	12.5	**25**
Fish and Wildlife: Connectivity contributes to expanded native habitats and the support of wildlife populations by improving the following: 1) foraging range, 2) territory, or 3) migration path of listed or rare endemic species. Restoration actions address 2-3 of the criteria using maps of known species occurrences and potential habitats.	25	**25**
TOTAL SCORE	75	**100**

While a quantitative approach focused on counting the number of miles of levee, berms, canals, ditches removed could have been developed, it wouldn't necessarily be accurate with respect to more is better for connectivity. The team chose a qualitative approach focused on GIS analysis and best professional judgment to maximize the benefits of connectivity related to four ecologic, hydrologic and management criteria: Downstream Hydrologic Linkage; Greenway Corridor; Water Quality (RECOVER, 2007); and Fish and Wildlife (Smith, et al., 1996; Beier and Noss, 1998; Bond, 2003; Hoctor, et al., 2008). To avoid subjectivity, we standardized the approach to evaluate alternatives using a scoring rubric developed as a method of evaluating potential connectivity to meet ecosystem restoration objectives. Each alternative is evaluated to determine how well it meets each criterion by using a scoring rubric (**Table G-4**): not at all = 0; partially = 12.5; yes, completely = 25. There are four criteria resulting in a total possible score for any alternative of 100 with performance varying by 12.5 increments all the way to zero. The ECB is scored as a 0 from the standpoint of natural areas being disconnected with respect to hydrology and flow to the river, and natural areas allowing natural movement of physical and biological resources. The team assumes that connectivity will not get worse in publicly owned lands. The FWO condition will likely be slightly better given some restoration efforts that are likely to be implemented by partner agencies at the state, county, and city levels. All alternatives are then compared to FWO alternative score to estimate increased connectivity from actions to plug canals and ditches, flow-ways to improve hydrologic

connections, removal of levees/berms that are barriers to flow, and providing movement of water below roads and between natural areas.

G.4 Method: Calculation of Ecosystem Benefits

The calculation of ecosystem benefits (quantitative scoring) consisted of the following steps: 1) *Normalize Scores* - normalizing performance measures output to a common scale (0-1); 2) *Combine Scores and Calculate Habitat Units* - combine performance measures into aggregates scores for each habitat zone in the project area (i.e., watershed evaluation polygons, freshwater river floodplain, tidal river floodplain, *Vallisneria*, oligohaline, mesohaline, polyhaline) and multiply by acreages to get habitat units; and 3) *Compare Habitat Units* - Aggregate watershed habitat units and compare alternatives by habitat zones.

G.4.1 Step 1 – Normalize Performance Measure Scores to Common Scale

Performance measure scores were calculated for restoration alternatives and then scaled to 0-1 scale using the following processes for each performance measure.

G.4.1.1 Performance Measure 1 Normalization

The original approach to calculate ecosystem benefits for the river and estuary involved calculation of inundation frequencies (period of record annual averages in the freshwater floodplain (salinity < 0) using model output related to flow from the LECSR model. The frequency the floodplain was wet was compared to the target of 4-8 months in river mile 16.0 to 9.5. The salinity output from the CH3D salinity model tool would then be used to compare with target ranges for the other five VECs in the specified area of where they should occur in a restored condition. The output is normalized 0-1 using the following rubric (see **Table G-5**).

Table G-5. Scoring rubric to index PM 1 output for river and tidal floodplain, *Vallisneria*, oligohaline, mesohaline, and polyhaline zones.

Score	Riverine Floodplain	Tidal floodplain	*Vallisneria americana* (tapegrass)	Oligohaline Zone (Juvenile Fish)	Mesohaline Zone (Oysters)	Polyhaline Zone (Seagrass)
1	Inundation June-November for 4-8 months	Salinity target met in 80-100% of the specified area	Salinity target met in 80-100% of the specified area	Salinity target met in 80-100% of the specified area	Salinity target met in 80-100% of the specified area	Salinity target met in 80-100% of the specified area
0.75	Inundation June-February for 3-9 months	Salinity target met in 60-80% of the specified area	Salinity target met in 60-80% of the specified area	Salinity target met in 60-80% of the specified area	Salinity target met in 60-80% of the specified area	Salinity target met in 60-80% of the specified area
0.50	Inundation of < 3months and/or 9-10 months	Salinity target met in 40-60% of the specified area	Salinity target met in 40-60% of the specified area	Salinity target met in 40-60% of the specified area	Salinity target met in 40-60% of the specified area	Salinity target met in 40-60% of the specified area

Score	Riverine Floodplain	Tidal floodplain	*Vallisneria americana* (tapegrass)	Oligohaline Zone (Juvenile Fish)	Mesohaline Zone (Oysters)	Polyhaline Zone (Seagrass)
0.25	12 months of no inundation and/or 11-12 months of continual inundation	Salinity target met in 20-40% of the specified area	Salinity target met in 20-40% of the specified area	Salinity target met in 20-40% of the specified area	Salinity target met in 20-40% of the specified area	Salinity target met in 20-40% of the specified area
0.00	24 or more months of no inundation and/or constant inundation for >12 months	Salinity target met in <20% of the target area	Salinity target met in <20% of the target area	Salinity target met in <20% of the target area	Salinity target met in <20% of the target area	Salinity target met in <20% of the target area

However, the CH3D salinity model tool output was not sensitive to providing meaningful habitat units for the river and estuary. The tributary and groundwater flow did not represent meaningful differences among the future with and future without project flows going to the river/estuary down stream of Lainhart due to lack of calibration data, which fed into the CH3D salinity model tool. The salinity tool output is presented in Appendix C.2 to describe a representation of alternative effects on these several VECs, but the approach utilized in Table G-5 given small changes in tributary flow, didn't show much change between alternatives when combining salinity zones into habitat units. A different approach was used to provide more sensitive calculation of river and estuary benefits based on the original performance measure 1 using dry season flows across Lainhart dam and is further explained in section G.5.2

G.4.1.2 Performance Measure 4 Normalization

The ECB model derived score for hydrology was modified based on field assessment data derived from the WRAP field assessment scores (Miller and Gunsalus, 1999). The WRAP field assessment uses specific criteria to score hydrology criteria on a scale of 0-3 in 0.5 increments. The example indicator region LS-2 had a hydrology field score of 2. The field derived ECB score is then divided by 3 to calculate the normalized score 0-1 and multiplied by the target days for the dominant vegetation community to determine the number of days inundated over the period of record. For LS-2, the ECB score would be 2/3 or 0.67 multiplied by 8,640 target inundation days for 5,788 (number of days the model cell would need to be inundated to receive a field score of 2). The model (LECSR daily elevation data for each WRAP cell were then examined to find the corresponding elevation that resulted in the calculated number of inundation days (the calibration line) for all WRAP evaluation cells in each indicator region. For LS-2, a normalized scored of 0.67 and 5,788 inundation days would correspond to an elevation of 16.51 in the model (calibration line). The ECB score for LS-2 = 0.34 based on the WRAP assessment score of 2 divided by 3 for a score of 0.67 multiplied by a scaling factor of 0.5. The calibration line for the WRAP evaluation cell and LIDAR ground elevation of each indicator region was then used to compare FWO and project alternative to calculate inundation days. The inundation days model output (X_m) is divided by the target inundation days (X_t) for the dominant vegetation community in the indicator region to get a score ranging from 0-1. PM 4 Score = X_m/X_t, see **Example 1**.

Example 1 - FWO: Indicator Region LS-2, depression marsh is dominant vegetation community. X_m = 5,581, X_t = 8,640, PM4 score = 0.65.

The score is then rescaled to reflect the non-linear nature on wetland functional unit value compared to an index score (See **Table G-6**).

Table G-6. PM 4 WRAP Score Re-Scaling Table.

WRAP Score	Re-Scale Factor
1.00 – 0.85	1.00
0.84 – 0.70	0.75
0.69 – 0.55	0.50
0.54 – 0.40	0.25
<0.39	0.10

The scaling of the WRAP scores differentiates between those systems functioning at a very high level (1.00–0.85) to those systems exhibiting heavy impacts and functioning at a low level (<0.40). In addition to differentiating between severely degraded wetlands compared to those which are minimally impacted, the weighting factor also addresses the linearity associated with scoring the WRAP components. The linearity is unintentional and a consequence of scaling the scoring from 0 to 1. The LRWRP eco-subteam that developed the PMs recognized that restoration is not linear. For example, a 0.25 change in scoring from 0.25 to 0.50 is different than a 0.25 change in scoring from a 0.50 to 0.75, not only from a functionality standpoint, but mathematically. A 0.25 increase from 0.25 to 0.50 is a 100% increase, while a 0.25 increase from 0.50 to 0.75 is a 50% increase. As a general guideline, wetlands with WRAP scores ranging from 0.85 to 1.0 are high quality, 0.84-0.70 are medium high, 0.69-0.55 are medium, 0.54-0.40 are low quality and ≤0.39 are poor quality wetlands. Therefore, the 0.50 to 0.75 increase is likely more ecologically significant from an improved function standpoint than a 0.25 to 0.50 increase.

Using the example above, the LS-2 indicator regions had a score of 0.65 and would then be multiplied by 0.50 to get a final score of 0.33 for the FWO.

G.4.1.3 Performance Measure 9 Normalization

GIS data is used to evaluate project alternatives degree of connectivity using the four criteria and the scoring rubric methodology in **Table G-7**.

Table G-7. Scoring Criterion Rubric.

Criterion	No/Does not Occur = 0	Partially Occurs = 12.5	Yes/Definitely Occurs = 25
1.0 - Hydrologic Linkage to River	Restoration actions do not allow any additional water to flow to the Loxahatchee River;	Restoration actions improve wetland storage near Loxahatchee River that allows for groundwater recharge that is greater than 10 miles away from the river; or promotes additional flows of water to the river.	Restoration actions improve wetland storage near Loxahatchee River that allows for groundwater recharge, and/or promotes additional flows of water to the river and are closer than 10 miles to the river.

Criterion	No/Does not Occur = 0	Partially Occurs = 12.5	Yes/Definitely Occurs = 25
2.0 - Greenway Corridor	Restoration actions do not support hydrological restoration or additional connections to existing or proposed greenway corridors.	Restoration actions support hydrological restoration and/or greenway land connections in a portion of existing or proposed greenway corridors.	Restoration actions support hydrological restoration and/or greenway land connections along a majority of an existing or proposed greenway corridor.
3.0 - Water Quality Improvements	Connectivity and restoration actions do not provide additional water quality improvements.	Connectivity and restoration actions improves water quality by partially allowing for sheetflow across natural lands, natural flow ways providing some treatment, but also utilizing the canal system.	Connectivity and restoration actions improves water quality by allowing for only sheetflow across natural lands and natural flow ways.
4.0 - Flora and Fauna	Restoration actions do not lead to wildlife connectivity.	Restoration actions address 1 of 3 questions regarding flora and fauna benefits from connectivity	Restoration actions address 2-3 of the 3 questions regarding flora and fauna benefits from connectivity.

A derived score from combining the criterion values is then divided by 100 to get an index value of 0-1. For example, an alternative that scores a 62.5, divided by 100, would get a normalized score of 0.625.

G.4.2 Step 2 – Combine Performance Measure Scores into Habitat Zone Scores and Calculate Habitat Units

Performance measure output scores for PM4 and PM9 were combined for the Loxahatchee River indicator region and then multiplied by the indicator region acreage to get habitat units. The PM1 output score is used for the other habitat zones Loxahatchee river watershed, the freshwater and tidal flood plains of Northwest Fork of the Loxahatchee River, the freshwater river and the downstream oligohaline, mesohaline, and polyhaline zones, and is not combined with any other PM output. The PM1 scores are multiplied by the areas of the zones they represent to generate habitat units. The process is described in more detail below.

G.4.2.1 Loxahatchee River Watershed

The watershed habitat zone scores are made up of scores from PM 4 and PM 9. Because hydrology is the dominant driver of change related to restoration and based on more empirical data, PM 4 represents 90% of the combined score for each indicator region and PM 9 represents 10 % of the score. The combined score for an indicator region *i* (PC_i) is the indicator region PM 4 score ($PM4_i$) x 0.9 plus the PM 9 score ($PM9_i$) x 0.1

Equation: $PC_i = PM4_i * 0.9 + PM9_i \times 0.1$

For example, using LS-2 indicator region, the FWO PC_i score is based on PM4 score is 0.34 and the PM9 score is 0. The combined watershed performance score for the LS-2 (PCi) would be 0.31 = 0.34(0.9) + 0(0.1).

The combined watershed performance score for LS-2 is then multiplied by the indicator region area of 3,849 acres to calculate habitat units of 1,193 for the future without project condition.

Indicator region habitat unit scores are then combined to get the total habitat units for the watershed zone for the FWO and project alternatives. See **Table G-8** for FWO total habitat unit score for the Loxahatchee Watershed Zone.

Table G-8. Example watershed zone performance measure output and calculation of habitat units.

Indicator Region	Acres	Dominant Vegetation	Target Inundation	FWO Inundation	PM 4 Initial Score	PM 4 Function Scale Factor	PM 4 Function Scaled Score	PM 9 Score	PM 4 & 9 Combined	FWO HUs	Maximum HUs
C-1	1,642	DM	8,640	5,761	0.67	0.50	0.34	0.00	0.30	**495**	1,642
C-2E	1,226	DM	8,640	5,820	0.67	0.50	0.34	0.00	0.30	**370**	1,226
C-3	2,806	DS	9,180	3,035	0.33	0.10	0.03	0.00	0.03	**83**	2,806
C-4.1	54,871	DM	8,640	7,166	0.83	0.75	0.62	0.00	0.56	**30741**	54,871
C-5	3,170	DM	8,640	7,153	0.83	0.75	0.62	0.00	0.56	**1776**	3,170
CC-1	202	FS	1,800	591	0.33	0.10	0.03	0.00	0.03	**6**	202
CC-2	557	FS	1,800	135	0.08	0.10	0.01	0.00	0.01	**4**	557
CC-4.1	2,542	DM	2,400	1,353	0.56	0.50	0.28	0.00	0.25	**641**	2,542
GS-1	1,411	DM	2,400	403	0.17	0.10	0.02	0.00	0.02	**22**	1,411
GWP-10	1,107	DS	9,180	2,233	0.24	0.10	0.02	0.00	0.02	**24**	1,107
GWP-1A	42	DS	9,180	2,738	0.30	0.10	0.03	0.00	0.03	**1**	42
GWP-2	397	DS	9,180	4,237	0.46	0.25	0.12	0.00	0.10	**41**	397
GWP-3	308	DS	9,180	5,318	0.58	0.50	0.29	0.00	0.26	**80**	308
GWP-4	755	DS	9,180	8,497	0.93	1.00	0.93	0.00	0.84	**632**	755
GWP-5.1	977	DS	9,180	6,832	0.74	0.75	0.56	0.00	0.50	**488**	977
GWP-6	2,134	DS	9,180	5,836	0.64	0.50	0.32	0.00	0.29	**615**	2,134
GWP-7.1	2,992	DS	9,180	3,459	0.38	0.10	0.04	0.00	0.03	**102**	2,992
GWP-9	2,518	DS	9,180	4,953	0.54	0.25	0.14	0.00	0.12	**306**	2,518
LS-2	3,849	DM	8,640	5,581	0.65	0.50	0.33	0.00	0.29	**1126**	3,849
LS-3.1	1,451	DM	8,640	4,316	0.50	0.25	0.13	0.00	0.11	**163**	1,451
LS-4	772	DM	8,640	3,421	0.40	0.10	0.04	0.00	0.04	**28**	772
LS-5	1,782	DM	8,640	490	0.06	0.10	0.01	0.00	0.01	**10**	1,782
LS-6A	405	DM	8,640	2,819	0.33	0.10	0.03	0.00	0.03	**12**	405
LS-7A	426	SS	9,180	259	0.03	0.10	0.00	0.00	0.00	**1**	426
MC-1	266	FS	1,800	293	0.16	0.10	0.02	0.00	0.01	**4**	266
PM-1	2,177	DM	2,400	1,230	0.51	0.25	0.13	0.00	0.11	**250**	2,177
PM-2	1,452	DM	2,400	754	0.31	0.10	0.03	0.00	0.03	**41**	1,452

Indicator Region	Acres	Dominant Vegetation	Target Inundation	FWO Inundation	PM 4 Initial Score	PM 4 Function Scale Factor	PM 4 Function Scaled Score	PM 9 Score	PM 4 & 9 Combined	FWO HUs	Maximum HUs
PM-3	709	DM	2,400	1,952	0.81	0.75	0.61	0.00	0.55	**388**	709
PM-4	284	DM	2,400	1,999	0.83	0.75	0.62	0.00	0.56	**159**	284
PM-5.1	19,672	DM	2,400	1,994	0.83	0.75	0.62	0.00	0.56	**11021**	19,672
PM-6	636	DM	2,400	404	0.17	0.10	0.02	0.00	0.02	**10**	636
PM-7A	4,236	DM	2,400	1,567	0.65	0.50	0.33	0.00	0.29	**1239**	4,236
PM-8	671	DM	2,400	1,927	0.80	0.75	0.60	0.00	0.54	**362**	671
PM-9	637	DM	2,400	937	0.39	0.10	0.04	0.00	0.04	**22**	637
CG	2,700	DM	2,400	NA	0.17	0.10	0.02	0.00	0.02	**41**	2700
Totals	121,782	NA	NA	NA	NA	NA	NA	NA	NA	**51,304**	**121,782**

Loxahatchee River Freshwater Floodplain

The scores for the Loxahatchee Freshwater Floodplain are already normalized 0-1 using PM1 output. Scores are broken out by area as part of the PM 1 and need to be multiplied by the area to develop habitat units. See the following example for a hypothetical alternative.

The area of the river between RM 12.0 and 16.0 was inundated for 6 months during the preferred time frame of June – November giving that area a score of 1 and acreage size was 650 acres, but in the area between RM 9.5 and 12.0 the floodplain was only inundated for 3 months giving that portion of the river a score of 0.5 and acreage size was 300 acres. Therefore the habitat units for the Riverine Floodplain habitat zone 300 x 0.5 = 150 and 650 x 1.0 = 650, therefore 150 + 650 = 800 habitat units.

Loxahatchee River Tidal Floodplain, Vallisneria, Oligohaline, Mesohaline, and Polyhaline Zones

The Loxahatchee River Tidal Floodplain, Vallisneria, Oligohaline, Meshaline, and Polyhaline Zones scores and habitat units are all calculated in the same way. Model output scores are calculated and in some areas there is overlap of salinity ranges for the habitat zones. Where the overlap occurs between two habitat zones (e.g., oysters and SAV at river mile 4-3.5), the scores for both oysters and SAV are multiplied by 0.5. For example, salinity zone for oysters is met on annual average for the period of record ranging between 10 to 25 psu between river miles 6 to 4, and acreage of 250.

G.4.3 Step 3 - Compare Alternatives

Habitat units are used to compare project alternatives compared to the FWO for each habitat zone and for the total project area. The cost effectiveness and incremental cost analysis (CE/ICA) will identify the most cost effect alternative for each habitat zone, as well as the total project area. The results will be displayed in a table (see **Table G-9**) examining cost and habitat units over the FWO.

Table G-9. Example cost-effectiveness comparison table by habitat zone and total project area.

Project Alternative	Cost	Watershed	Freshwater Floodplain	Tidal Floodplain	Vallisneria	Oligohaline (Fish Larvae)	Mesohaline (Oysters)	Polyhaline (Seagrass)	Total Project Area
FWO	N/A	51,304	456	325	300	700	200	500	53,785
Alt. A	N/A	79000	600	400	450	1000	300	505	82,255
Alt. B	N/A	85000	750	480	500	1100	350	525	88,705
Alt. C	N/A	84000	850	600	500	1250	400	530	88,130
Alt. D	N/A	95000	950	650	500	1250	375	530	99,255
Alt. E	N/A	66000	950	625	500	1500	400	530	70,505

Ultimately, the best performance plan should be cost-effective for the most habitat zones to ensure restoration alternatives meet all project objectives.

G.5 Loxahatchee River Watershed Restoration Project Evaluation of Alternative Plan Benefits

Performance measures 4 (watershed plant community hydrology) and performance measure 9 (connectivity) were evaluated as described in the approved planning model and are presented below. Performance measure 1 output had to be modified to focus on the original performance measure output based on restoration flows to the northwest fork of the Loxahatchee River. The salinity modeling output was not reliable due to the fact that tributary flows did not show meaningful differences from the base conditions. This resulted in very few differences between alternatives compared to the base condition for the oligohaline and Vallisneria zones. This information is presented below when documenting river and estuarine benefits. The overall approach for evaluating river and estuarine benefits is consistent with the Loxahatchee River Restoration Plan.

G.5.1 Watershed Benefits

G.5.1.1 Performance Measure 4 Output

Alternative 13 performed the best due to the natural storage area in flow-way 2 with a PM 4 score of 0.49 (38,605 habitat units [HUs]). Alternative 5R followed with a close second having similar flow-way 1 and 3 features with a PM score of 0.48 (37,261 HUs). Alternative 2 followed with a PM score of 0.46 (36,138 Hus) habitat units with slightly more habitat units in flow-way 2 than alternative 5r due to seepage from the shallow L-8 Reservoir into Corbett Wildlife Management Area, but slightly less in flow-way 3 due to the lack of the mack dairy spreader canal in cypress creek. Alternative 10 performed the worst with a PM score of 0.39 (30, 335 Hus) mainly due to the smaller flow-way 3 features (**Table G-10**). Complete calculations for habitat units using PM4 are shown in **Table G-11**.

Table G-10. PM 4 scores for base conditions and project alternative and corresponding habitat units based on PM4 only.

Flowway	Area	ECB Habitat Units	FWO Habitat Units	ALT-2 Habitat Units	ALT-5R Habitat Units	ALT-10 Habitat Units	ALT-13 Habitat Units
FW1	9,654	5,487	5,477	6,999	7,009	6,988	6,970
FW2	43,373	14,615	14,220	14,435	14,169	14,092	15,582
FW3	25,312	8,532	8,532	14,705	16,083	9,255	16,083
Total	78,339	28,635	28,230	36,138	37,261	30,335	38,635
PM4 Score	N/A	0.37	0.36	0.46	0.48	0.39	0.49

Table G-11. Performance Measure 4 – Wetland Plant Community Hydrology Output – ECB and FWO.*

Indicator Region	WRAP Cell Name	Acres	Dominant Vegetation	Target Inundation	FW Designation	ECB WRAP Hydro score	WL Type Upper Range Ratio	ECB Inundation (est.)	2014 ECB (APR 2018)	PM 4 Initial Score	PM Functional Scaling Score	PM4 Score Scaled	ECB Habitat Units	2070FWO	2070 FWO (APR 2018)	PM 4 Initial Score	Revised PM4 Functional Scaling Score	PM4 Score Scaled	FWO Habitat Units
C-1	C-1	1,642	DM	9,840	FW2	2.00	1.25	6560	7296	0.74	0.75	0.56	913	6649	7296	0.74	0.75	0.56	913
C-2	C-2E	1,226	DM	9,840	FW2	2.00	1.25	13117	12879	1.31	0.73	0.96	1171	6633	12879	1.31	0.73	0.96	1171
C-3	C-3	2,806	DS	10,455	FW2	1.00	1.18	3485	2015	0.19	0.10	0.02	54	4117	2015	0.19	0.10	0.02	54
C-4	C-4.1	25,500	DM	9,840	FW2	2.50	1.25	8200	4805	0.49	0.25	0.12	3113	7198	4805	0.49	0.25	0.12	3113
C-4	C-4.2	–	–	–	–	–	–	8200	8397	0.00	0.10	0.00	0	7669	8397	0.00	0.10	0.00	0
C-5	C-5	3,170	DM	9,840	FW3	2.50	1.25	8200	6093	0.62	0.50	0.31	981	7912	6094	0.62	0.50	0.31	982
CC-1	CC-1A	202	FS	7,380	FW3	1.00	1.33	2460	108	0.01	0.10	0.00	0	1231	106	0.01	0.10	0.00	0
CC-2	CC-2	557	FS	7,380	FW3	0.50	1.33	1230	102	0.01	0.10	0.00	1	1956	102	0.01	0.10	0.00	1
CC-3	CC-3A	394	WP	4,920	FW3	2.50	1.50	4100	1213	0.25	0.10	0.02	10	353	1203	0.24	0.10	0.02	10
CC-4	CC-4.1	2,542	DM	9,840	FW3	1.50	1.25	4920	32	0.00	0.10	0.00	1	3461	32	0.00	0.10	0.00	1
CC-4	CC-4.2	–	–	–	FW3	–	–	4920	3241	0.00	0.10	0.00	0	5101	3241	0.00	0.10	0.00	0
CM-1	CM-1.1	1,381	DM	9,840	FW2	0.50	1.25	1640	3	0.00	0.10	0.00	0	1	3	0.00	0.10	0.00	0
CM-2	CM-2	3,191	DM	9,840	FW2	0.50	1.25	1640	11656	1.18	0.84	1.00	3191	3135	12802	1.30	0.74	0.96	3066
Pal-Mar	CP-1	642	DM	9,840	FW3	1.50	1.25	4920	1018	0.10	0.10	0.01	7	3541	1017	0.10	0.10	0.01	7
Pal-Mar	CP-2	642	DM	9,840	–	–	1.25	–	427	0.04	0.10	0.00	3	–	426	0.00	0.10	0.00	0
GS-1	GS-1	543	DM	9,840	FW3	0.50	1.25	1640	0	0.00	0.10	0.00	0	0	0	0.00	0.10	0.00	0
GS-2	GS-2	737	DM	9,840	FW3		1.25	1640	0	0.00	0.10	0.00	0	0	0	0.00	0.10	0.00	0
GWP-10	GWP-10	1,107	DS	10,455	–	3.00	1.18	10455	14436	1.38	0.62	0.85	943	12803	13813	1.32	0.67	0.89	986
GWP-1	GWP-1A	42	DS	10,455	FW1	1.50	1.18	5228	13305	1.27	0.73	0.92	39	5823	13161	1.26	0.74	0.93	39
GWP-2	GWP-2	397	DS	10,455	FW1	2.00	1.18	6970	7788	0.74	0.75	0.56	222	6762	8395	0.80	0.75	0.60	239
GWP-3	GWP-3	308	DS	10,455	FW2	2.00	1.18	6970	14227	1.36	0.64	0.86	266	9482	14595	1.40	0.60	0.84	260
GWP-4	GWP-4	755	DS	10,455	FW2	3.00	1.18	10455	12457	1.19	0.83	0.99	745	10288	13101	1.25	0.75	0.94	709
GWP-5	GWP-5.1	977	DS	10,455	–	2.50	1.18	8713	10244	0.98	1.00	0.98	957	9570	10033	0.96	1.00	0.96	938
GWP-5	GWP-5.2	–	–	–	–	–	–	–	9591	0.00	0.10	0.00	0	10454	9347	0.00	0.10	0.00	0
GWP-6	GWP-6	2,134	DS	10,455	–	3.00	1.18	10455	14762	1.41	0.59	0.83	1778	13383	14655	1.40	0.60	0.84	1791
GWP-7	GWP-7.1	2,992	DS	10,455	–	3.00	1.18	10455	13968	1.34	0.66	0.88	2635	11495	13726	1.31	0.68	0.90	2681
GWP-7	GWP-7.2	2,992	DS	10,455	–	–	1.18	10455	14182	1.36	0.64	0.87	2595	11551	13911	0.00	0.10	0.00	0
GWP-7	GWP-7.3	2,992	DS	10,455	–	–	1.18	10455	13077	1.25	0.75	0.94	2814	11632	12816	0.00	0.10	0.00	0

Indicator Region	WRAP Cell Name	Acres	Dominant Vegetation	Target Inundation	FW Designation	ECB WRAP Hydro score	WL Type Upper Range Ratio	ECB Inundation (est.)	2014 ECB (APR 2018)	PM 4 Initial Score	PM Functional Scaling Score	PM4 Score Scaled	ECB Habitat Units	2070FWO	2070 FWO (APR 2018)	PM 4 Initial Score	Revised PM4 Functional Scaling Score	PM4 Score Scaled	FWO Habitat Units
GWP-9	GWP-9	2,518	DS	10,455	–	3.00	1.18	10455	13738	1.31	0.68	0.90	2254	14566	13449	1.29	0.71	0.91	2303
HS-2	HS-2	2,867	DM	9,840	FW2	2.50	1.25	8200	11246	1.14	0.87	1.00	2867	2905	11305	1.15	0.87	1.00	2867
KC-1	KC-1.1	658	FS	7,380	FW3	1.50	1.33	3690	3817	0.52	0.25	0.13	85	0	3814	0.52	0.25	0.13	85
KC-1	KC-1.2	658	FS	7,380		1.50	1.33	3690	5068	0.69	0.50	0.34	226	0	5042	0.68	0.50	0.34	225
KC-2	KC-2.1	585	FS	7,380	FW3	2.00	1.33	4920	382	0.05	0.10	0.01	3	0	381	0.05	0.10	0.01	3
LS-10	LS-10.1	1,981	DM	9,840	FW1	–	1.25	–	6594	0.67	0.50	0.34	664	–	6616	0.67	0.50	0.34	666
LS-10	LS-10.2	1,981	DM	9,840	–	–	1.25	–	9060	0.92	1.00	0.92	1824	–	9077	0.00	0.10	0.00	0
LS-2	LS-2	3,849	DM	9,840	FW1	2.00	1.25	6560	8980	0.91	1.00	0.91	3513	5695	9330	0.95	1.00	0.95	3650
LS-3.1	LS-3.1	1,451	DM	9,840	FW2	1.50	1.25	4920	3288	0.33	0.10	0.03	48	4700	3230	0.33	0.10	0.03	48
LS-3.1	LS-3.2	1,451	DM	9,840	–	–	1.25	–	4574	0.46	0.25	0.12	169	5152	4538	0.00	0.10	0.00	0
LS-4	LS-4	772	DM	9,840	FW1	1.50	1.25	4920	8035	0.82	0.75	0.61	473	4231	8602	0.87	1.00	0.87	675
LS-5	LS-5	1,782	DM	9,840	FW1	1.50	1.25	4920	6090	0.62	0.50	0.31	551	4218	4133	0.42	0.25	0.11	187
LS-6	LS-6A	405	DM	9,840	FW1	2.00	1.25	6560	3205	0.33	0.10	0.03	13	6576	2735	0.28	0.10	0.03	11
LS-7	LS-7A	426	SS	10,455	FW1	2.00	1.18	6970	3074	0.29	0.10	0.03	13	6657	2473	0.24	0.10	0.02	10
LS-8	LS-8.1	1670	DM	9840	FW2	2	1.25	6560	12143	1.23	0.81	1.00	1670	6303	14222	1.45	0.60	0.86	1444
LS-9	LS-9	576	DM	9840	FW2	2	1.25	6560	10476	1.06	0.94	1.00	576	6736	11469	1.17	0.86	1.00	576
MC-1	MC-1	266	FS	7,380	FW3	0.50	1.33	1230	0	0.00	0.10	0.00	0	0	0	0.00	0.10	0.00	0
PM-1	PM-1	2,177	DM	9,840	–	1.50	1.25	4920	994	0.10	0.10	0.01	22	4618	994	0.00	0.10	0.00	0
PM-1	PM-1.1	2,177	DM	9,840	FW3	1.50	1.25	4920	1901	0.19	0.10	0.02	42	4644	1899	0.19	0.10	0.02	42
PM-10	PM-10.1	7,181	DM	9,840	FW3	2.50	1.25	8200	7378	0.75	0.75	0.56	4038	8710	7378	0.75	0.75	0.56	4038
PM-1	PM-11.2	2,181	DM	9,840	–	1.50	1.25	4920	446	0.05	0.10	0.00	10	5211	446	0.00	0.10	0.00	0
PM-2	PM-2	1,452	DM	9,840	FW3	1.00	1.25	3280	8210	0.83	0.75	0.63	909	3162	8211	0.83	0.75	0.63	909
PM-2	PM-2.2A	709	DM	9,840	FW3	2.50	1.25	3280	2798	0.28	0.10	0.03	20	3253	2796	0.28	0.10	0.03	20
PM-4	PM-4	284	DM	9,840	FW3	2.50	1.25	8200	9176	0.93	1.00	0.93	265	7801	9176	0.93	1.00	0.93	265
PM-5	PM-5.1	19,672	DM	9,840	–	2.50	1.25	8200	344	0.03	0.10	0.00	69	8438	344	0.00	0.10	0.00	0
PM-5	PM-5.2A	–	DM	9,840	–	2.50	1.25	8200	7745	0.79	0.75	0.59	0	8505	7744	0.00	0.10	0.00	0
PM-6	PM-6	636	DM	9,840	FW3	2.00	1.25	6560	1713	0.17	0.10	0.02	11	1803	1713	0.17	0.10	0.02	11
PM-9	PM-9A	2577	DM	9,840	FW3	2.00	1.25	6560	14677	1.49	0.56	0.84	2160	6619	14677	1.49	0.56	0.84	2160

Table G-12. Performance Measure 4 – Wetland Plant Community Hydrology Output – Alt 2, Alt 5R.

Indicator Region	WRAP Cell Name	Acres	Dominant Vegetation	Target Inundation	ALT 2 (APR 2018)	PM 4 Initial Score	PM Functional Scaling Score	PM4 Score Scaled	Alt 2 Habitat units	Alt 5R (APR 2018)	PM 4 Initial Score	PM Functional Scaling Score	PM4 Score Scaled	Alt 5r Habitat Units
C-1	C-1	1,642	DM	9,840	8029	0.82	0.75	0.61	1005	8074	0.82	0.75	0.62	1010
C-2	C-2E	1,226	DM	9,840	12880	1.31	0.73	0.95	1171	12880	1.31	0.73	0.95	1171
C-3	C-3	2,806	DS	10,455	5180	0.50	0.25	0.12	348	2014	0.19	0.10	0.02	54
C-4	C-4.1	25,500	DM	9,840	4803	0.49	0.25	0.12	3112	4803	0.49	0.25	0.12	3112
C-4	C-4.2	–	–	–	8403	0.00	0.10	0.00	0	8397	0.00	0.10	0.00	0
C-5	C-5	3,170	DM	9,840	6094	0.62	0.50	0.31	982	6093	0.62	0.50	0.31	981
CC-1	CC-1A	202	FS	7,380	308	0.04	0.10	0.00	1	308	0.04	0.10	0.00	1
CC-2	CC-2	557	FS	7,380	8829	1.20	0.84	1.00	557	8835	1.20	0.84	1.00	557
CC-3	CC-3A	394	WP	4,920	1608	0.33	0.10	0.03	13	1609	0.33	0.10	0.03	13
CC-4	CC-4.1	2,542	DM	9,840	3374	0.34	0.10	0.03	87	3374	0.34	0.10	0.03	87
CC-4	CC-4.2	–	–	–	3775	0.00	0.10	0.00	0	3775	0.00	0.10	0.00	0
CM-1	CM-1.1	1,381	DM	9,840	12867	1.31	0.73	0.96	0	13271	1.35	0.69	0.93	0
CM-2	CM-2	3,191	DM	9,840	13354	1.36	0.68	0.92	2939	13252	1.35	0.69	0.93	2962
Pal-Mar	CP-1	642	DM	9,840	1926	0.20	0.10	0.02	13	1926	0.20	0.10	0.02	13
Pal-Mar	CP-2	642	DM	9,840	729	0.00	0.10	0.00	–	732	0.00	0.10	0.00	0
GS-1	GS-1	543	DM	9,840	12288	1.25	0.80	1.00	543	12288	1.25	0.80	1.00	543
GS-2	GS-2	737	DM	9,840	6623	0.67	0.50	0.34	248	6623	0.67	0.50	0.34	248
GWP-10	GWP-10	1,107	DS	10,455	13816	1.32	0.67	0.89	986	14609	1.40	0.60	0.84	932
GWP-1	GWP-1A	42	DS	10,455	13942	1.33	0.66	0.88	37	13928	1.33	0.66	0.88	37
GWP-2	GWP-2	397	DS	10,455	13472	1.29	0.71	0.91	362	13483	1.29	0.71	0.91	362
GWP-3	GWP-3	308	DS	10,455	14798	1.42	0.59	0.83	256	14799	1.42	0.59	0.83	256
GWP-4	GWP-4	755	DS	10,455	13462	1.29	0.71	0.91	690	13468	1.29	0.71	0.91	690
GWP-5	GWP-5.1	977	DS	10,455	9930	0.95	1.00	0.95	928	10036	0.96	1.00	0.96	938
GWP-5	GWP-5.2	–	–	–	9179	0.00	0.10	0.00	0	9360	0.00	0.10	0.00	0
GWP-6	GWP-6	2,134	DS	10,455	14653	1.40	0.60	0.84	1791	14765	1.41	0.59	0.83	1778
GWP-7	GWP-7.1	2,992	DS	10,455	13737	1.31	0.68	0.90	2679	14046	1.34	0.65	0.88	2620
GWP-7	GWP-7.2	2,992	DS	10,455	13917	0.00	0.10	0.00	0	14256	0.00	0.10	0.00	0

GWP-7	**GWP-7.3**	2,992	DS	10,455	12783	0.00	0.10	0.00	0	13255	0.00	0.10	0.00	0
GWP-9	**GWP-9**	2,518	DS	10,455	13447	1.29	0.71	0.91	2303	13930	1.33	0.66	0.88	2223
HS-2	**HS-2**	2,867	DM	9,840	10505	1.07	0.94	1.00	2867	10481	1.07	0.94	1.00	2867
KC-1	**KC-1.1**	658	FS	7,380	4681	0.63	0.50	0.32	209	4681	0.63	0.50	0.32	209
KC-1	**KC-1.2**	658	FS	7,380	7624	1.03	0.97	1.00	658	7621	1.03	0.97	1.00	658
KC-2	**KC-2.1**	585	FS	7,380	1069	0.14	0.10	0.01	8	1069	0.14	0.10	0.01	8
LS-10	**LS-10.1**	1,981	DM	9,840	6930	0.70	0.75	0.53	1046	6963	0.71	0.75	0.53	1051
LS-10	**LS-10.2**	1,981	DM	9,840	9529	0.00	0.10	0.00	–	9541	0.00	0.10	0.00	0
LS-2	**LS-2**	3,849	DM	9,840	10715	1.09	0.92	1.00	3849	10789	1.10	0.91	1.00	3849
LS-3.1	**LS-3.1**	1,451	DM	9,840	3381	0.34	0.10	0.03	50	3411	0.35	0.10	0.03	50
LS-3.1	**LS-3.2**	1,451	DM	9,840	4690	0.00	0.10	0.00	0	4720	0.00	0.10	0.00	0
LS-4	**LS-4**	772	DM	9,840	13106	1.33	0.70	0.94	725	13166	1.34	0.70	0.93	721
LS-5	**LS-5**	1,782	DM	9,840	4425	0.45	0.25	0.11	200	4463	0.45	0.25	0.11	202
LS-6	**LS-6A**	405	DM	9,840	10708	1.09	0.92	1.00	405	11140	1.13	0.88	1.00	405
LS-7	**LS-7A**	426	SS	10,455	9176	0.88	1.00	0.88	374	9356	0.89	1.00	0.89	381
LS-8	**LS-8.1**	1670	DM	9840	14317	1.45	0.59	0.86	1435	14319	1.46	0.59	0.86	1435
LS-9	**LS-9**	576	DM	9840	12576	1.28	0.77	0.98	563	12596	1.28	0.76	0.98	562
MC-1	**MC-1**	266	FS	7,380	0	0.00	0.10	0.00	0	0	0.00	0.10	0.00	0
PM-1	**PM-1**	2,177	DM	9,840	3679	0.00	0.10	0.00	0	3680	0.00	0.10	0.00	0
PM-1	**PM-1.1**	2,177	DM	9,840	5876	0.60	0.50	0.30	650	5876	0.60	0.50	0.30	650
PM-10	**PM-10.1**	7,181	DM	9,840	10679	1.09	0.92	1.00	7181	10679	1.09	0.92	1.00	7181
PM-1	**PM-11.2**	2,181	DM	9,840	6022	0.00	0.10	0.00	0	6022	0.00	0.10	0.00	0
PM-2	**PM-2**	1,452	DM	9,840	13083	1.33	0.71	0.94	1365	13087	1.33	0.71	0.94	1365
PM-2	**PM-2.2A**	709	DM	9,840	7595	0.77	0.75	0.58	410	7593	0.77	0.75	0.58	410
PM-4	**PM-4**	284	DM	9,840	9176	0.93	1.00	0.93	265	9176	0.93	1.00	0.93	265
PM-5	**PM-5.1**	19,672	DM	9,840	341	0.00	0.10	0.00	0	341	0.00	0.10	0.00	0
PM-5	**PM-5.2A**	–	DM	9,840	7653	0.00	0.10	0.00	0	7653	0.00	0.10	0.00	0
PM-6	**PM-6**	636	DM	9,840	2015	0.20	0.10	0.02	13	2017	0.20	0.10	0.02	13
PM-9	**PM-9A**	2577	DM	9,840	14675	1.49	0.56	0.84	2160	14676	1.49	0.56	0.84	2160

Table G-13. Performance Measure 4 – Wetland Plant Community Hydrology Output – ALT 10, Alt 13.

Indicator Region	WRAP Cell Name	Acres	Dominant Vegetation	Target Inundation	Alt 10	ALT 10 (APR 2018)	PM 4 Initial Score	PM Functional Scaling Score	PM4 Score Scaled	Alt 10 habitat units	Alt 13	ALT 13 (APR 2018)	PM 4 Initial Score	PM Functional Scaling Score	PM4 Score Scaled	Alt 13 Habitat Units
C-1	C-1	1,642	DM	9,840	1461	7543	0.77	0.75	0.57	944	6420	7734	0.79	0.75	0.59	968
C-2	C-2E	1,226	DM	9,840	6590	12879	1.31	0.73	0.96	1171	6607	12879	1.31	0.73	0.96	1171
C-3	C-3	2,806	DS	10,455	4079	2013	0.19	0.10	0.02	54	4135	4619	0.44	0.25	0.11	310
C-4	C-4.1	25,500	DM	9,840	7201	4803	0.49	0.25	0.12	3112	7195	4803	0.49	0.25	0.12	3112
C-4	C-4.2	–	–	–	7667	8393	0.00	0.10	0.00	0	7668	8395	0.00	0.10	0.00	0
C-5	C-5	3,170	DM	9,840	7913	6094	0.62	0.50	0.31	982	7908	6094	0.62	0.50	0.31	982
CC-1	CC-1A	202	FS	7,380	1525	172	0.02	0.10	0.00	0	2513	493	0.07	0.10	0.01	1
CC-2	CC-2	557	FS	7,380	10578	4207	0.57	0.50	0.29	159	14505	9560	1.30	0.77	1.00	557
CC-3	CC-3A	394	WP	4,920	454	1461	0.30	0.10	0.03	12	1395	2914	0.59	0.50	0.30	117
CC-4	CC-4.1	2,542	DM	9,840	13027	2528	0.26	0.10	0.03	65	14650	7052	0.72	0.75	0.54	1366
CC-4	CC-4.2	–	–	–	5546	3706	0.00	0.10	0.00	0	7569	7607	0.00	0.10	0.00	0
CM-1	CM-1.1	1,381	DM	9,840	13868	9890	1.01	0.99	1.00	0	14974	13823	1.40	0.63	0.89	1229
CM-2	CM-2	3,191	DM	9,840	2964	13328	1.35	0.68	0.92	2945	4920	14778	1.50	0.55	0.83	2656
Pal-Mar	CP-1	642	DM	9,840	10444	1027	0.10	0.10	0.01	7	12407	1958	0.20	0.10	0.02	13
Pall-Mar	CP-2	642	DM	9,840	–	391	0.00	0.10	0.00	0	–	763	0.00	0.10	0.00	0
GS-1	GS-1	543	DM	9,840	0	0	0.00	0.10	0.00	0	14966	12292	1.25	0.80	1.00	543
GS-2	GS-2	737	DM	9,840	0	0	0.00	0.10	0.00	0	0	6624	0.67	0.50	0.34	248
GWP-10	GWP-10	1,107	DS	10,455	11524	13217	1.26	0.74	0.93	1030	13116	13820	1.32	0.67	0.89	985
GWP-1	GWP-1A	42	DS	10,455	6435	13627	1.30	0.69	0.90	38	6056	14013	1.34	0.65	0.88	37
GWP-2	GWP-2	397	DS	10,455	8222	13534	1.29	0.70	0.91	361	8320	13761	1.32	0.68	0.89	355
GWP-3	GWP-3	308	DS	10,455	9473	14793	1.41	0.59	0.83	256	10068	14927	1.43	0.58	0.82	254
GWP-4	GWP-4	755	DS	10,455	9603	13343	1.28	0.72	0.92	696	10311	14095	1.35	0.65	0.87	659
GWP-5	GWP-5.1	977	DS	10,455	8787	8472	0.81	0.75	0.61	594	9657	9986	0.96	1.00	0.96	933
GWP-5	GWP-5.2	–	–	–	9214	7431	0.00	0.10	0.00	0	10520	9209	0.00	0.10	0.00	0
GWP-6	GWP-6	2,134	DS	10,455	11795	13571	1.30	0.70	0.91	1934	13443	14658	1.40	0.60	0.84	1791
GWP-7	GWP-7.1	2,992	DS	10,455	9201	11848	1.13	0.88	1.00	2992	11540	13743	1.31	0.68	0.90	2678
GWP-7	GWP-7.2	2,992	DS	10,455	9265	12509	0.00	0.10	0.00	0	11656	13921	0.00	0.10	0.00	0
GWP-7	GWP-7.3	2,992	DS	10,455	9357	8617	0.00	0.10	0.00	0	11820	12790	0.00	0.10	0.00	0
GWP-9	GWP-9	2,518	DS	10,455	14055	10536	1.01	0.99	1.00	2518	14647	13457	1.29	0.71	0.91	2302
HS-2	HS-2	2,867	DM	9,840	2563	10801	1.00	1.00	1.00	2867	2215	10361	1.00	1.00	1.00	2867
KC-1	KC-1.1	658	FS	7,380	0	4683	0.63	0.50	0.32	209	0	4681	0.63	0.50	0.32	209
KC-1	KC-1.2	658	FS	7,380	0	7617	1.00	1.00	1.00	658	0	7618	1.00	1.00	1.00	658
KC-2	KC-2.1	585	FS	7,380	0	788	0.11	0.10	0.01	6	0	1070	0.14	0.10	0.01	8
LS-10	LS-10.1	1,981	DM	9,840	–	6932	0.70	0.75	0.53	1047	–	6902	0.70	0.75	0.53	1042
LS-10	LS-10.2	1,981	DM	9,840	–	9604	0.00	0.10	0.00	0	–	9466	0.00	0.10	0.00	0

Indicator Region	WRAP Cell Name	Acres	Dominant Vegetation	Target Inundation	Alt 10	ALT 10 (APR 2018)	PM 4 Initial Score	PM Functional Scaling Score	PM4 Score Scaled	Alt 10 habitat units	Alt 13	ALT 13 (APR 2018)	PM 4 Initial Score	PM Functional Scaling Score	PM4 Score Scaled	Alt 13 Habitat Units
LS-2	LS-2	3,849	DM	9,840	10420	11079	1.13	0.89	1.00	3849	10695	11106	1.13	0.89	1.00	3849
LS-3.1	LS-3.1	1,451	DM	9,840	5397	3463	0.35	0.10	0.04	51	6130	5844	0.59	0.50	0.30	431
LS-3.1	LS-3.2	1,451	DM	9,840	5729	4742	0.00	0.10	0.00	0	6312	8880	0.00	0.10	0.00	0
LS-4	LS-4	772	DM	9,840	10240	13714	1.39	0.64	0.90	692	10503	13409	1.36	0.67	0.92	708
LS-5	LS-5	1,782	DM	9,840	4863	4491	0.46	0.25	0.11	203	5291	4436	0.45	0.25	0.11	201
LS-6	LS-6A	405	DM	9,840	12565	12644	1.28	0.76	0.97	394	12423	10277	1.04	0.96	1.00	405
LS-7	LS-7A	426	SS	10,455	11574	9908	0.95	1.00	0.95	404	11484	9150	0.88	1.00	0.88	373
LS-8	LS-8.1	1670	DM	9840	6883	14305	1.45	0.59	0.86	1436	7375	14738	1.50	0.56	0.83	1394
LS-9	LS-9	576	DM	9840	8219	12645	1.29	0.76	0.97	560	8433	13299	1.35	0.68	0.92	533
MC-1	MC-1	266	FS	7,380	0	0	0.00	0.10	0.00	0	0	0	0.00	0.10	0.00	0
PM-1	PM-1	2,177	DM	9,840	4723	996	0.00	0.10	0.00	0	13220	3673	0.00	0.10	0.00	0
PM-1	PM-1.1	2,177	DM	9,840	4743	1911	0.19	0.10	0.02	42	13144	5835	0.59	0.50	0.30	645
PM-10	PM-10.1	7,181	DM	9,840	8686	7377	0.75	0.75	0.56	4038	14975	10678	1.09	0.92	1.00	7181
PM-1	PM-11.2	2,181	DM	9,840	5238	449	0.00	0.10	0.00	0	14975	6023	0.00	0.10	0.00	0
PM-2	PM-2	1,452	DM	9,840	4670	8676	0.88	1.00	0.88	1280	14383	13087	1.33	0.71	0.94	1365
PM-2	PM-2.2A	709	DM	9,840	3403	2825	0.29	0.10	0.03	20	7854	7581	0.77	0.75	0.58	410
PM-4	PM-4	284	DM	9,840	7801	9176	0.93	1.00	0.93	265	7798	9176	0.93	1.00	0.93	265
PM-5	PM-5.1	19,672	DM	9,840	8437	344	0.00	0.10	0.00	0	8438	341	0.00	0.10	0.00	0
PM-5	PM-5.2A	–	DM	9,840	8502	7745	0.00	0.10	0.00	0	8501	7653	0.00	0.10	0.00	0
PM-6	PM-6	636	DM	9,840	14975	1654	0.17	0.10	0.02	11	14975	2085	0.21	0.10	0.02	13
PM-9	PM-9A	2577	DM	9,840	6584	14676	1.49	0.56	0.84	2160	6554	14676	1.49	0.56	0.84	2160

*NOTES- Table color coding represents

Yellow	areas where we had to make adjustments to model output or topo	Orange/peach	consistent lack of results	Red	Data not used for habitat units calculation
Blue	scores have improved from 2005 to present due to local restoration efforts	Dark gray	extra model cell for indicator region to check on different hydrology questions. Not part of habitat units calculations	Dark Green	Model Output in inundation duration days used to ultimately calculate habitat units for the watershed

Please note that the Grassy Waters Preserve (GWP) main area performance was not factored into the habitat units for PM 4, because ultimately the stages in GWP are regulated by the City of West Palm Beach. The LRWRP does not incorporate changes in authority or responsibility for regulating water levels in GWP. The project coordinates flows to and from GWP in coordination with the City of West Palm Beach to provide additional flow for restoration of the Loxahatchee River.

G.5.1.2 Performance Measure 9 – Connectivity Output

Four criteria were used to score alternatives based on hydrology, water quality, greenway, and fish and wildlife criteria as explained in PM 9 documentation sheet. Alternative 13 scored the highest (0.83) because of increased hydrological, water quality, and fish and wildlife connectivity in flow-way 2 due to the natural storage area connecting with several other indicator regions (Avenir, Loxahatchee Slough west, and northern Grassy Water Preserve areas) that are not connected in any other alternative. Alternative 10 scored the worst (0.46) due to less connectivity from a hydrological and fish and wildlife perspective in flow-way 3 and has fewer natural area flow-ways than all the other alternatives in flow-way 1 from a water quality perspective. Alternative 2 and 5R were had similar scores of 0.67 and 0.63 due to similar features except for the Mack Dairy spreader canal which has a lower water quality score due to use of canal to natural area hydrologic connection. **Table G-14** provides a more detailed breakdown of scores by criteria and flow-way, followed by **Table G-15** that summarizes scores, and **Table G-16** that provides the habitat units based only on **PM 9**.

Table G-14. PM 9 connectivity output for alternatives.

Criteria and Flow-way	Alt 2 Score	Alt 5R Score	Alt 10 Score	Alt 13 Score	Alt 2 Description	Alt 5R Description	Alt 10 Description	Alt 13 Description
Hydrology 3	25	25	12.5	25	Complete	Complete	Partial - does not fully meet the wetland storage near Lox. River compared to other alternatives	Complete
Hydrology 2	0	0	0	12.5	0	0	0	Partial provides wetland storage and connectivity to provide flows to river.
Hydrology 1	12.5	12.5	12.5	12.5	Partial provides wetland storage and connectivity to provide flows to river.	Partial provides wetland storage and connectivity to provide flows to river.	Partial provides wetland storage and connectivity to provide flows to river.	Partial provides wetland storage and connectivity to provide flows to river.
Hydrology	12.5	12.5	8.3	16.7	NA	NA	NA	NA

Criteria and Flow-way	Alt 2 Score	Alt 5R Score	Alt 10 Score	Alt 13 Score	Alt 2 Description	Alt 5R Description	Alt 10 Description	Alt 13 Description
Greenway3	25	25	12.5	25	Restoration actions support hydrological restoration along a majority of an existing or proposed greenway corridor	Restoration actions support hydrological restoration along a majority of an existing or proposed greenway corridor	Restoration actions support hydrological restoration in a portion of existing or proposed greenway corridors.	Restoration actions support hydrological restoration along a majority of an existing or proposed greenway corridor
Greenway2	0	0	0	25	Restoration actions do not support hydrological restoration or additional connections existing or proposed greenway corridors.	Restoration actions do not support hydrological restoration or additional connections existing or proposed greenway corridors.	Restoration actions do not support hydrological restoration or additional connections existing or proposed greenway corridors.	Restoration actions support hydrological restoration along a majority of an existing or proposed greenway corridor
Greenway1	25	25	25	25	Restoration actions support hydrological restoration along a majority of an existing or proposed greenway corridor	Restoration actions support hydrological restoration along a majority of an existing or proposed greenway corridor	Restoration actions support hydrological restoration along a majority of an existing or proposed greenway corridor	Restoration actions support hydrological restoration along a majority of an existing or proposed greenway corridor
Greenway	16.7	16.7	12.5	25.0	NA	NA	NA	NA
Water Quality 3	25	12.5	12.5	12.5	Connectivity and restoration actions improves water quality by allowing for only sheetflow across natural lands and natural flow ways.	Connectivity and restoration actions improves water quality by allowing for only sheetflow across natural lands and natural flow ways.	Connectivity and restoration actions improves water quality by partially allowing for sheetflow across natural lands, natural flow ways providing some treatment, but also utilizing the canal system. Focused on pump stations, spreader canal.	Connectivity and restoration actions improves water quality by partially allowing for sheetflow across natural lands, natural flow ways providing some treatment, but also utilizing the canal system. Incorporates additional spreader canal

Criteria and Flow-way	Alt 2 Score	Alt 5R Score	Alt 10 Score	Alt 13 Score	Alt 2 Description	Alt 5R Description	Alt 10 Description	Alt 13 Description
Water Quality 2	12.5	12.5	12.5	25	Connectivity and restoration actions improves water quality by partially allowing for sheetflow across natural lands, natural flow ways providing some treatment, but also utilizing the canal system. Focused on pump stations, spreader canal.	Connectivity and restoration actions improves water quality by partially allowing for sheetflow across natural lands, natural flow ways providing some treatment, but also utilizing the canal system. Focused on pump stations, spreader canal.	Connectivity and restoration actions improves water quality by partially allowing for sheetflow across natural lands, natural flow ways providing some treatment, but also utilizing the canal system. Focused on pump stations, spreader canal.	Connectivity and restoration actions improves water quality by allowing for only sheetflow across natural lands and natural flow ways.
Water Quality 1	25	25	12.5	25	Connectivity and restoration actions improves water quality by allowing for only sheetflow across natural lands and natural flow ways.	Connectivity and restoration actions improves water quality by allowing for only sheetflow across natural lands and natural flow ways.	Connectivity and restoration actions improves water quality by partially allowing for sheetflow across natural lands, natural flow ways providing some treatment, but also utilizing the canal system. Force main.	Connectivity and restoration actions improves water quality by allowing for only sheetflow across natural lands and natural flow ways.
Water Quality	20.8	16.7	12.5	20.8	NA	NA	NA	NA
Fish and Wildlife 3	25	25	12.5	25	Restoration actions address 2-3 of the 3 questions regarding flora and fauna benefits from connectivity. Foraging, shelter, diversity	Restoration actions address 2-3 of the 3 questions regarding flora and fauna benefits from connectivity. Foraging, shelter, diversity	Restoration actions address 1 of 3 questions regarding flora and fauna benefits from connectivity. Foraging	Restoration actions address 2-3 of the 3 questions regarding flora and fauna benefits from connectivity. Foraging, shelter, diversity

Criteria and Flow-way	Alt 2 Score	Alt 5R Score	Alt 10 Score	Alt 13 Score	Alt 2 Description	Alt 5R Description	Alt 10 Description	Alt 13 Description
Fish and Wildlife 2	12.5	12.5	12.5	25	Restoration actions address 1 of 3 questions regarding flora and fauna benefits from connectivity. Foraging	Restoration actions address 1 of 3 questions regarding flora and fauna benefits from connectivity. Foraging	Restoration actions address 1 of 3 questions regarding flora and fauna benefits from connectivity. Foraging	Restoration actions address 2-3 of the 3 questions regarding flora and fauna benefits from connectivity. Foraging, shelter, diversity
Fish and Wildlife 1	12.5	12.5	12.5	12.5	Restoration actions address 1 of 3 questions regarding flora and fauna benefits from connectivity. Foraging	Restoration actions address 1 of 3 questions regarding flora and fauna benefits from connectivity. Foraging	Restoration actions address 1 of 3 questions regarding flora and fauna benefits from connectivity. Foraging	Restoration actions address 1 of 3 questions regarding flora and fauna benefits from connectivity. Foraging
Fish and Wildlife	16.7	16.7	12.5	20.8	NA	NA	NA	NA

Table G-15. Summary of PM9 Connectivity Scores.

Criteria	Alt 2	Alt 5R	Alt 10	Alt 13
Hydrology	12.5	12.5	8.3	16.7
Greenway	16.7	16.7	12.5	25.0
Water Quality	20.8	16.7	12.5	20.8
F&W	16.7	16.7	11.1	20.8
PM 9 Score	67	63	44	83

Table G-16. Alternative Plan Habitat Units based on Connectivity.

Alternative	Alt 2	Alt 5R	Alt 10	Alt 13
Total PM 9 Acres	52,226	48,962	35,905	65,283

G.5.1.3 Summary of Habitat Unit Output by Alternative Restoration Plan for the Watershed

Performance measure output was combined based on the planning model formulas where PM 4 represents 90% of the watershed score and PM 9 represents 10%. **Table G-17** provides a summary of the final watershed habitat units plus life over the future without project. Alternative 13 scores the highest with 41,300 habitat units, followed by alternative 5R with 38,401, alternative 2 with 37, 747 habitat units, and alternative 10 a distant fourth with 30,892 habitat units.

Table G-17. Total Watershed habitat units for each Loxahatchee River Watershed Restoration Project alternative.

Alternatives Performance							
	Flow-way	**2014B**	**2070B**	**ALT 2**	**ALT 5R**	**ALT 10**	**ALT 13**
PM4-WRAP (worth 90%)	FW1	5,487	5,477	6,999	7,009	6,988	6,970
	FW2	14,615	14,220	14,435	14,169	14,092	15,582
	FW3	8,532	8,532	14,705	16,083	9,255	16,083
	Subtotal	28,635	28,230	36,138	37,261	30,335	38,635
PM9 - Connectivity (worth 10%)	*Subtotal*	0	0	52,226	48,962	35,905	65,283
Watershed Habitat Units	**Total**	**25,771**	**25,407**	**37,747**	**38,431**	**30,892**	**41,300**
	LIFT VS 2070B	364	-	12,340	13,024	5,485	15,893
	% improvement	NA	NA	49%	51%	22%	63%

NOTE: Connectivity scores for 2014B and 2070B are zero since connectivity is assumed to be the increment above the base condition.
NOTE: Connectivity scores are not calculated by flow-way so only the total is shown.

G.5.2 Performance Measure 1 – River and Estuarine Performance

The performance measure (PM) 1 documentation sheet cites the restoration plan for the Northwest Fork of the Loxahatchee River to reference flow targets and how they correspond to desired salinity zones for five estuarine habitat zones (Tidal River, Vallisneria [Freshwater submerged aquatic vegetation], oligohaline [larval and juvenile fish], mesohaline [Oysters], and Polyhaline [Seagrass]. The original approach was to use the salinity model to provide salinity output related to downstream locations to measure performance. Unfortunately, the LECSR model output of tributary flows was not sensitive enough to detect changes between alternatives and base conditions due to small geographic scale of tributaries and narrowness of Northwest fork (see **Figure G-5**). The existing conditions appeared to be meeting targets for downstream for the Tidal and *Vallisneria* zones (see **Table G-18** and **Table G-19**). However, actual monitoring data indicates this is not the case for existing flows.

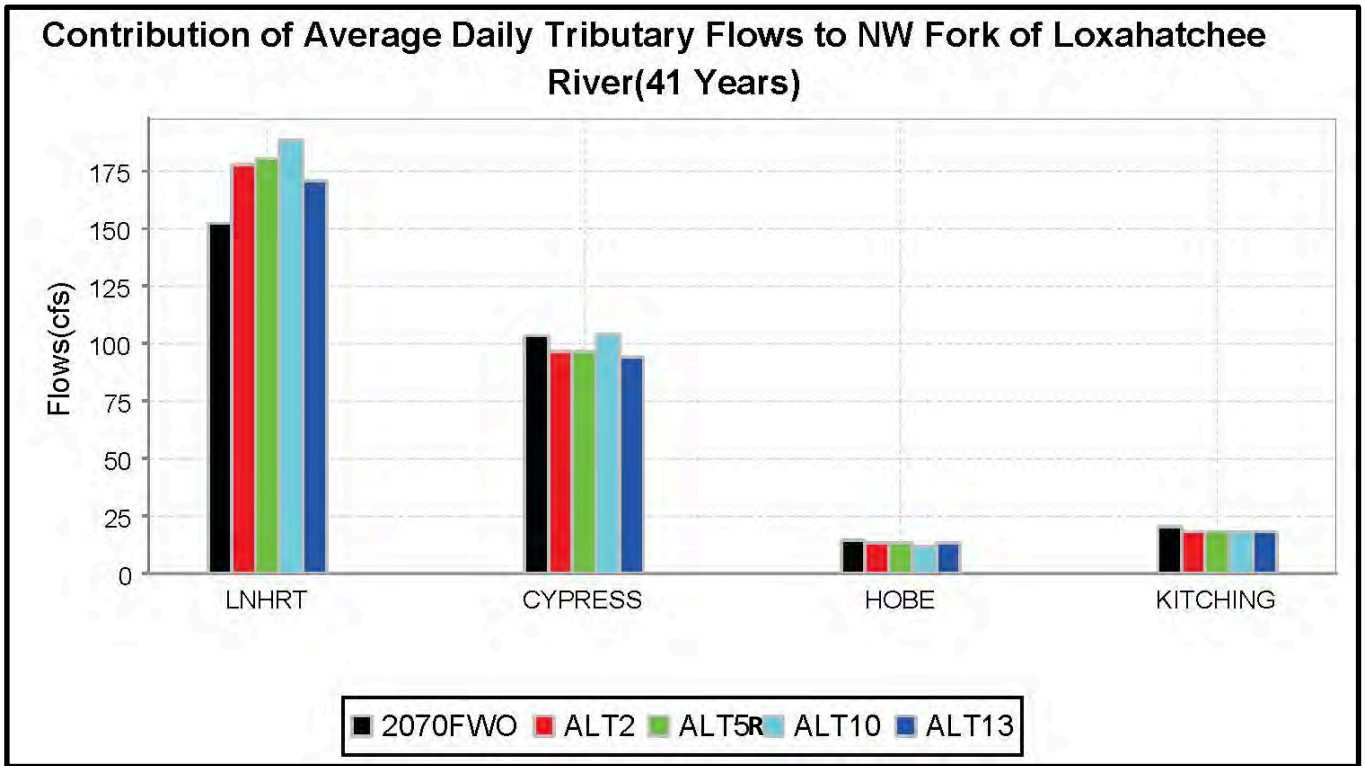

Figure G-5. Average daily flows from tributaries similarity with base conditions

Table G-18. Habitat units (in acre) computed using salinity tool during the wet seasons.

Scenario	Polyhaline	Mesohaline	Oligohaline	*Vallisneria*	*Tidal*	Total
2014B	624.22	139.75	36.18	74.79	17.69	788.63
2070FWO	619.32	137.27	36.05	74.79	17.69	782.50
ALT 2	619.21	145.20	36.35	74.79	17.69	792.23
ALT 5R	615.79	146.57	35.84	74.79	17.69	789.30
ALT 10	613.31	149.29	35.51	74.79	17.69	789.47

Scenario	Polyhaline	Mesohaline	Oligohaline	*Vallisneria*	*Tidal*	Total
ALT 13	619.70	144.55	36.65	74.79	17.69	791.29

Table G-19. Habitat units (in acres) computed using salinity tool during the dry seasons

Scenario	Polyhaline	Mesohaline	Oligohaline	*Vallisneria*	*Tidal*	Total
2014B	726.55	101.91	32.96	69.24	17.69	828.98
2070FWO	726.55	100.95	31.71	69.08	17.69	826.89
ALT 2	721.94	127.80	38.81	73.28	17.69	864.12
ALT 5R	720.96	128.36	38.55	74.23	17.69	866.35
ALT 10	719.87	128.49	41.79	74.61	17.69	865.96
ALT 13	723.65	118.31	36.51	71.34	17.69	850.15

The PDT recommended using the Lainhart Flows as an indicator of each habitat zone downstream based on the dry season performance measure criteria in the Restoration Plan of mean monthly flow of 69cfs or greater. A sliding scale scoring table was developed based on this criteria (see **Table G-20**). Habitat units were calculated for each alternative and base conditions based on 30-day monthly rolling averages for the model period of record with the maximum habitat units for these 6 habitat zones being 2067 habitat units (See **Table G-21**). Alternative 10 which provides the most storage overall scored a 0.95, followed by alternative 5R scoring a 0.91 and having the largest amount of storage closest to the river. Alternative 2 followed right behind with a score of 0.87, where the additional shallow L-8 storage and smaller C-18 west storage did not perform as well in meeting river targets. Alternative 13 performed the worst in meeting river targets with a 0.8 score likely due to much of the shallow L-8 storage not making its way to the river.

Table G-20. Dry season criteria sliding scale.

Daily Lainhart Flow	Daily Score
>= 69 cfs	1.0
>55 and <69 cfs	0.75
>45 and <= 55 cfs	0.50
>= 35 to <= 45 cfs	0.25
<35	0.00

Table G-21. Dry season performance and HUs.

Scenario	30Day Rolling Avg. Flow > 68cfs	Acreage of River, Floodplain and Estuary	Habitat Units Per Alternative	Habitat Unit Lift as compared to FWO
2070FWO	0.65	2067	1344	NA
2014B	0.65	2067	1344	NA
ALT 13	0.80	2067	1654	310
ALT 2	0.87	2067	1798	454
ALT 5R	0.91	2067	1881	537

Scenario	30Day Rolling Avg. Flow > 68cfs	Acreage of River, Floodplain and Estuary	Habitat Units Per Alternative	Habitat Unit Lift as compared to FWO
ALT 10	0.95	2067	1964	620

G.5.3 Loxahatchee River Watershed Restoration Project (LRWRP) Annualization of Benefits

G.5.3.1 Loxahatchee Watershed:

The ecological response time for the Loxahatchee river watershed was estimated based on the ability of LRWRP to improve conditions for aquatic and herbaceous, shrubby and forested vegetation communities, periphyton, piscivorous fish, aquatic prey organisms in the diverse headwater's watershed. The watershed includes major plant communities consisting of mesic and wet flatwoods, mesic and hydric hammocks, wet prairies, depression and slough marsh, and floodplain, strand, and dome swamps. The expected ecological response time is estimated to be 75-100 years until full impact would be realized with a large percentage of benefits accruing earlier once the desirable hydrological conditions have been restored. Vegetation changes and wetland function will begin 2 years into hydrologic restoration with the rate of response to full wetland restoration decreasing over time, as vegetation succession moves forward. **Table G-22** provides the timing estimate for benefit accrual.

Table G-22. Watershed benefits accrual.

0-2 Years	2-5 Years	5-10 Years	10-30 Years	30-50 Years	50-75 Years	75-100 Years
50%	60%	70%	75%	80%	95%	100%

G.5.3.2 Loxahatchee River Northwest Fork and Estuary:

An ecological response time for the river, floodplain, and estuary was estimated based on the ability of the alternatives to improve the various communities as compared to the future without (FWO). In the future if there is no CERP project, there is likely to be a continued degradation of the ecosystem due to climate change and potentially future land-use changes that restrict flows to the river. Because estimating this rate of degradation is difficult with the available tools, the future without was determined to be similar to the existing conditions. The LRWRP river and estuary covers several different zones and habitat types. Increased volumes and improved timing of flows into the North West Fork of the Loxahatchee River will have a positive impact on the vegetation within the river floodplain (**Table G-23**). It will also directly impact the river channel, especially with respect to improving conditions to support the growth of *Vallisneria americana,* a freshwater submerged aquatic vegetation community that provides habitat for many small larval and juvenile fish and invertebrate species in the riverine oligohaline zone. In the mesohaline zone oyster habitat may slightly shift to a more downstream location where historically oysters were more abundant. This could allow for some expansion of oyster beds in areas with the proper substrate for spat settlement. Seagrasses within polyhaline areas should remain healthy and abundant (**Table G-24**).

Table G-23. Floodplain benefits accrual (483 acres).

0-2 Years	2-5 Years	5-10 Years	10-30 Years	30-50 Years	50-75 Years	75-100 Years
0%	30%	50%	60%	75%	80%	100%

Table G-24. River and estuary benefits accrual (1583 acres).

0-2 Years	2-5 Years	5-20 Years	20-50 Years
20%	75%	100%	100%

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COMPREHENSIVE EVERGLADES RESTORATION PLAN

LOXAHATCHEE RIVER WATERSHED RESTORATION PROJECT

DRAFT INTEGRATED PROJECT IMPLEMENTATION REPORT AND ENVIRONMENTAL IMPACT STATEMENT

March 2019

Appendix H

APPENDIX H

CLIMATE CHANGE ASSESSMENT FOR LOXAHATCHEE RIVER WATERSHED RESTORATION PROJECT

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H IMPACTS OF SEA LEVEL AND CLIMATE CHANGE ON THE LOXAHATCHEE RIVER WATERSHED RESTORATION PROJECT

H.1 Introduction

The USACE Civil Works Program and its water resources infrastructure represent a tremendous federal investment that supports public health and safety, regional and national economic development, and national ecosystem restoration goals.

The hydrologic and coastal processes underlying water resources management infrastructure have the potential to be sensitive to changes in climate and weather. Therefore, USACE has a compelling need to understand and adapt to climate change and variability while continuing to provide authorized performance despite changing conditions. The objective of USACE climate preparedness and resilience is to mainstream climate change adaptation in all activities to help enhance the resilience of USACE-built and natural water resource infrastructure, reducing its potential vulnerabilities to the effects of climate change and variability.

The USACE Civil Works Program has developed tools to analyze the potential uncertainties of climate change and sea level change relative to USACE infrastructure. For this analysis, there are two main assessments that are applied: potential impacts from future sea level change, and trends and projected future for hydrology.

Sea level change and changes in storm and rainfall patterns associated with climate change could have a potentially dramatic impact on water resources infrastructure in the state of Florida, including the Loxahatchee River Watershed.

H.2 Project Description

The purpose of the Loxahatchee River Watershed Restoration Project is to improve the timing and distribution of wet and dry season flows to the Northwest Fork of the Loxahatchee River floodplain to help restore native plant and animal species abundance and diversity in Loxahatchee River watershed natural areas, river, and estuary. The features proposed in the Tentatively Selected Plan (TSP) include an above ground 9,500 ac-ft reservoir, 4 Aquifer Storage & Recovery (ASR) wells, an approximately 1500 ac-ft shallow flow-through marsh, and multiple pump stations and water control structures that will assist in achieving the project objectives, as seen in **Figure H-1**.

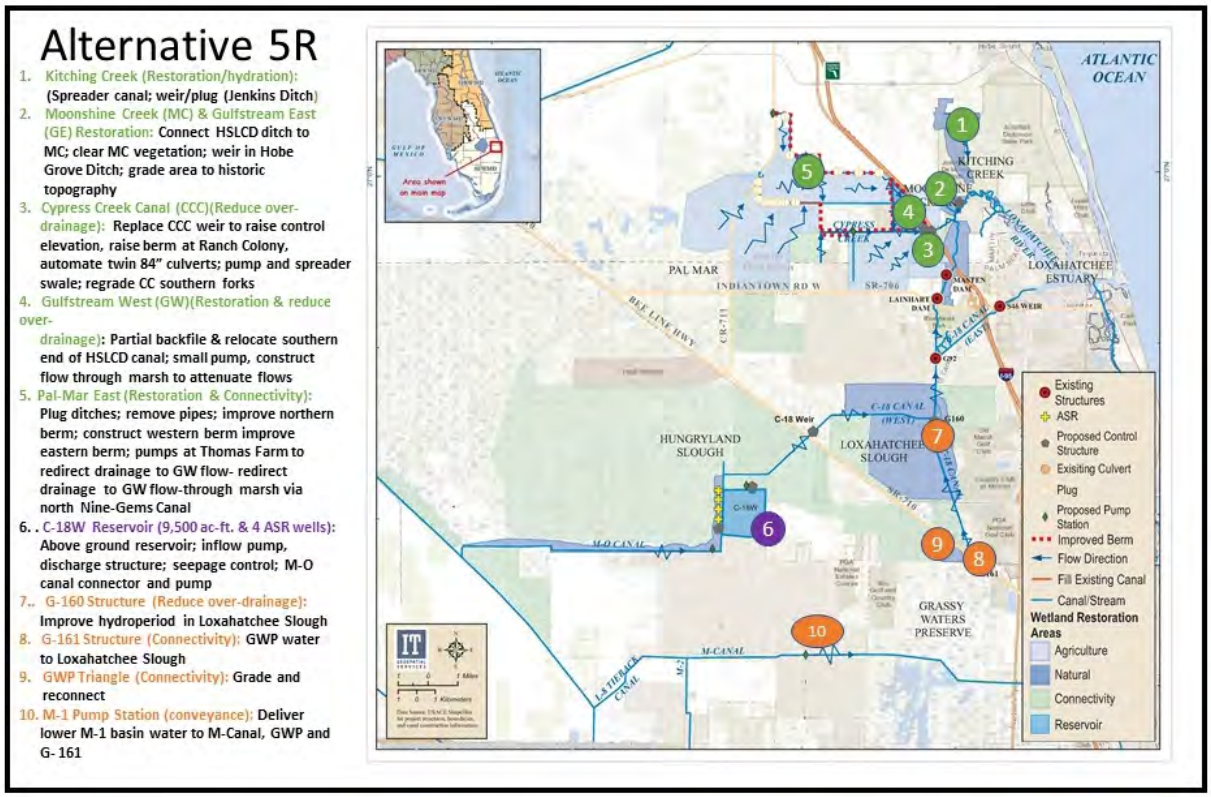

Figure H-1. Project Features Proposed in the TSP for the LRWRP.

H.3 Potential Impacts from Future Sea Level Change

Portions of the Loxahatchee River and Loxahatchee River Estuary are subject to tidal influences through the direct connection to the Atlantic Ocean from the Jupiter Inlet. The historic rise of sea level has likely increased the range of tidal influence in estuaries in the project area. If future sea level rise occurs as predicted, it is foreseeable that the tidal influence will move further upstream along with the sea level rise, causing potential impacts to the proposed project benefits.

H.3.1 Sea Level Rise Curves

To better understand the effects of projected future sea level change on design, construction, operation, and maintenance of Federal water resources projects, the USACE has provided guidance via ER 1100-2-8162 and ETL 1100-2-1. Three relative sea level change (RSLC) scenarios are detailed in this guidance:

- Baseline (or "low") estimate, which is based on historic sea level rise and represents the minimum expected sea level change.
- Intermediate estimate.
- High estimate, representing the maximum expected sea level change.

The closest compliant tidal gauge, Miami Beach, FL, was selected as the basis for the sea level rise analysis. The USACE Sea Level Change Curve Calculator, based on the guidance found in ER 1100-2-8162, was used to compute the potential high, intermediate, and low curves for sea level rise, as shown in **Figure H-2**. The

baseline Mean Sea Level condition for the Miami Beach, FL gauge in 1992 was -0.96 ft NAVD88, as illustrated in Figure H-3**.**

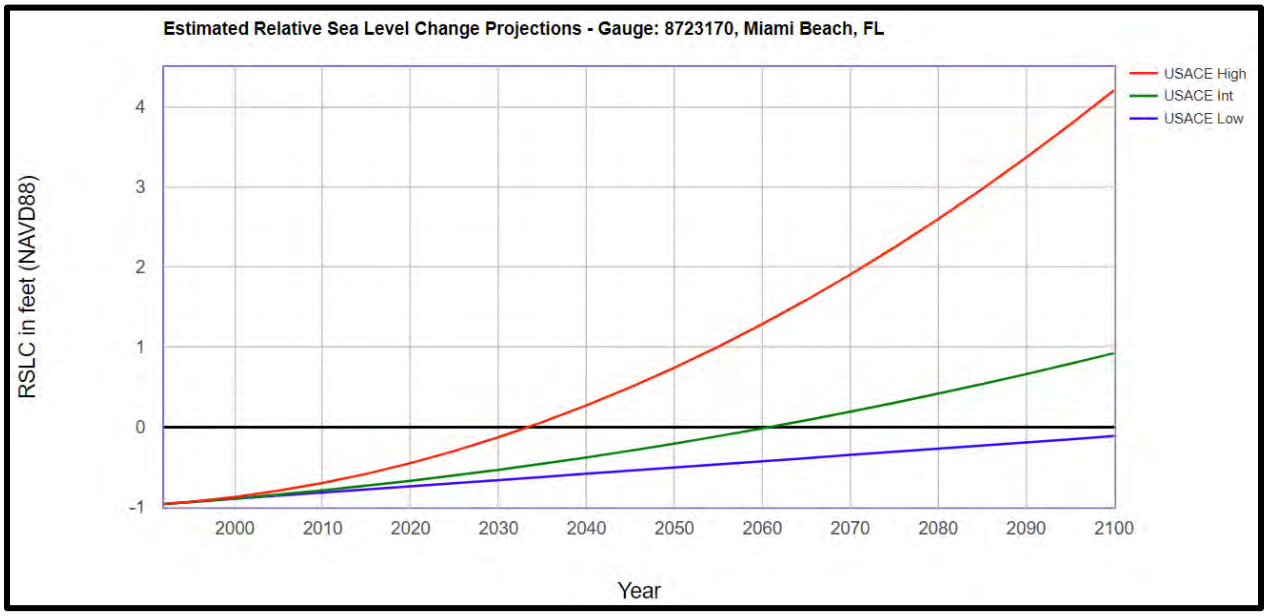

Figure H-2. Estimated Relative Sea Level Change Projections – Miami Beach FL Gauge.

Version of Data :	05/17/2017
ID:	8723170
Reference Datum:	NAVD88
Name:	Miami Beach, FL
HAT:	1.53 (ft)
MHHW:	0.33 (ft)
MHW:	0.25 (ft)
MSL:	-0.96 (ft)
MLW:	-2.20 (ft)
MLLW:	-2.37 (ft)
NAVD88:	0.00 (ft)
EWL Type:	NOAA GEV (NAVD88)
*100 Yr:	3.83 (ft)
50 Yr:	3.40 (ft)
20 Yr:	2.88 (ft)
10 Yr:	2.52 (ft)
5 Yr:	2.19 (ft)
2 Yr:	1.74 (ft)
Yearly:	1.14 (ft)
Monthly:	NaN (ft)
From:	1931
To:	1982
Years of Record:	51

Figure H-3. Tidal Datums – Miami Beach FL Gauge.

Following the intermediate curve, a new MSL baseline for the 2020 condition was defined as -0.671 ft NAVD88, as shown in **Figure H-4**. The intermediate curve was selected as the 2020 elevation based on the

observations of the historic trends in MSL for other gauges within the area that have a more recent period of record (POR), including Vaca Key, FL and Key West, FL. As can be seen in **Figure H-5** and **Figure H-6** the linear trend of MSL over the period of record shows that for 2020, the estimated MSL is either slightly above (Vaca Key, FL) or below (Key West, FL) the intermediate curve estimate, therefore it was assumed the intermediate curve would also be applicable for the Miami Beach, FL gauge.

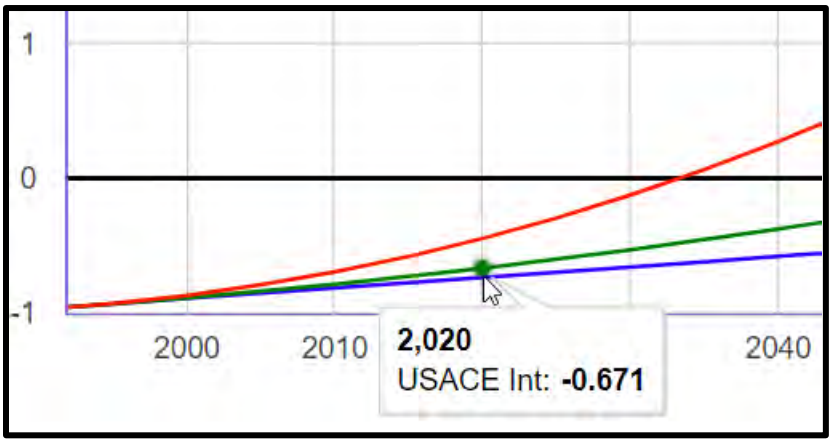

Figure H-4. Estimated Sea Level Change for Intermediate Curve at 2020.

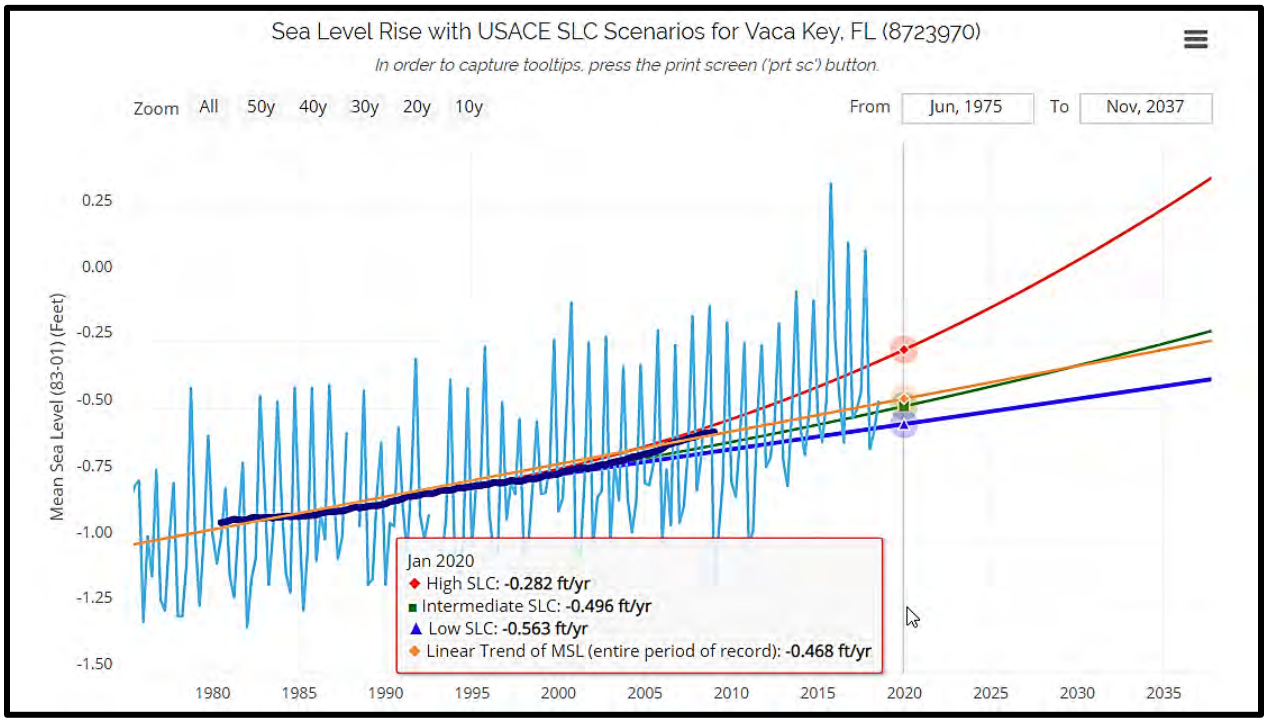

Figure H-5. SLR Estimate for Vaca Key, FL.

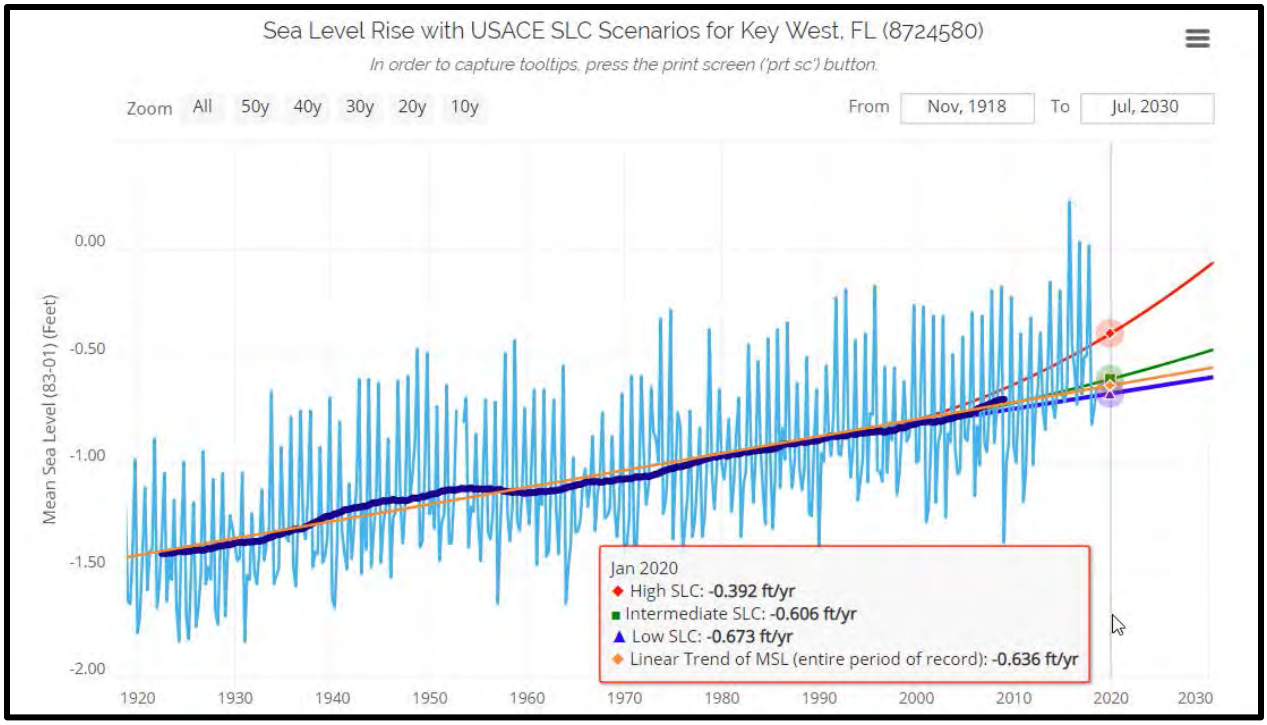

Figure H-6. SLR Estimate for Key West, FL.

The original high, intermediate, and low elevations based on the 1992 baseline year are shown in **Figure H-7**, below.

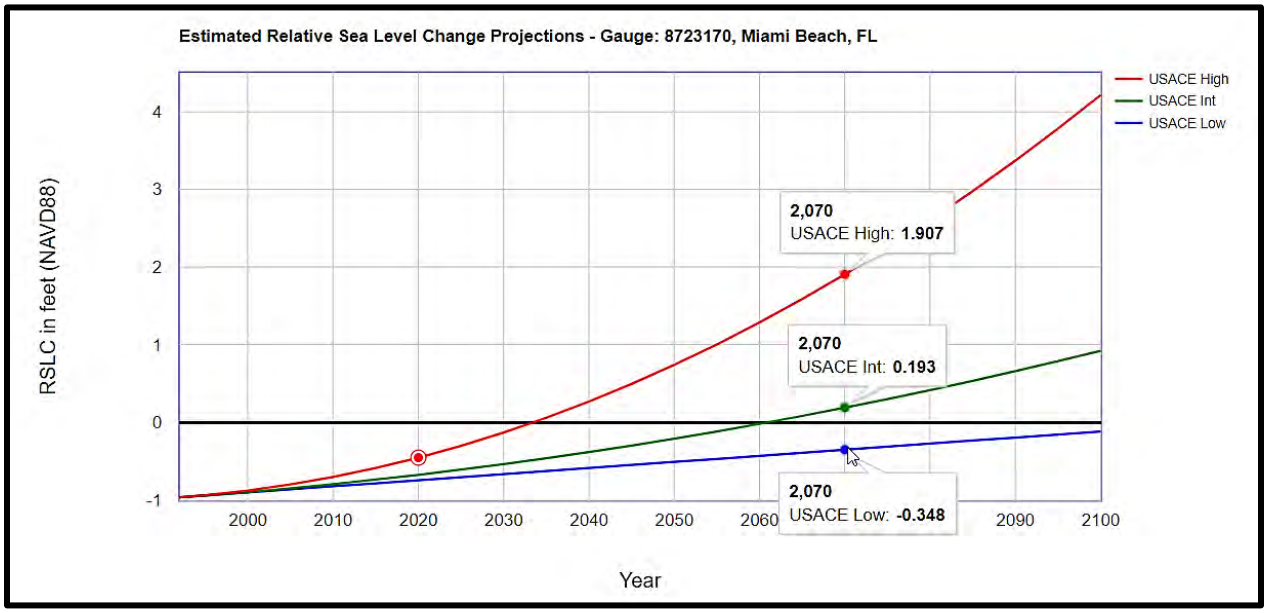

Figure H-7. 2070 SLR values for the low, intermediate, and high curves based on the 1992 start year.

The high and low curves were re-projected with the starting point at the previously identified 2020 project baseline (-0.671). The shape of the curve between 2020 and 2070 was maintained but was translated along the Y-axis as necessary for the re-established 2020 baseline elevation, as shown in Figure H-8, below.

The revised curves start at the new 2020 MSL base elevation and the high and low curves are offset from the original curves based on the difference between the 2020 intermediate elevation (new baseline) and 2020 high and low elevations. The original curves (beginning at 1992) were not translated across the X-axis to the new 2020 baseline condition as the approach utilized was more conservative.

The Low curve maintained the previously identified linear trend line but has a point of departure in 2020 of -0.671 ft. NAVD88, resulting in a 2070 elevation of -0.28. The intermediate curve was maintained, therefore the project 2070 condition will have a MSL at 0.193 ft NAVD88. The High curve maintained the trend from 2020 to 2070 but the starting point is the new 2020 baseline, resulting in a 2070 high elevation of 1.686 ft NAVD88. The dashed lines are the low and high curves adjusted for the 2020 baseline (**Figure H-8** and **Table H-1**).

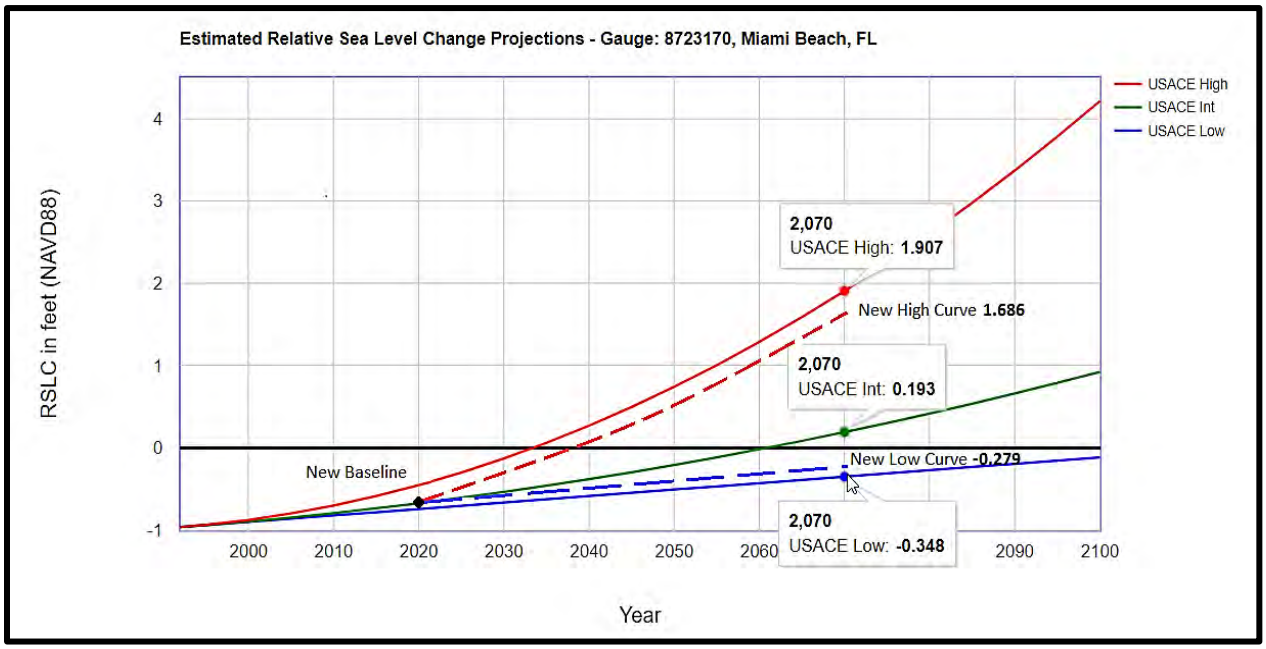

Figure H-8. Modified SLR curves based on a newly defined 2020 baseline condition.

Table H-1. Sea level change for the year 2070, Re-established using the 2020 baseline.

Baseline	2070 High Curve	2070 Intermediate Curve	2070 Low Curve
1992	1.907	0.193	-0.348
2020	1.686	0.193	-0.279
Note: All measurements are in ft., NAVD88.			

H.3.2 Evaluation of Sea Level Rise and Project Benefits

In order to evaluate the sea level rise (SLR) impact on the restoration project, a curvilinear three-dimensional hydrodynamic model CH3D (Sheng, 1986), was applied to the Northwest Fork of the Loxahatchee River and the Loxahatchee River Estuary. To incorporate projected SLR, the tidal boundary condition offshore of the Jupiter Inlet was developed by combining tidal components and projected mean sea level (MSL), including SLR, at Miami Beach. The SLR scenarios evaluated with CH3D were defined using the analysis described in H.3.1.

The CH3D model was initially calibrated/verified for a two-year period from 2003 to 2004 and applied in the Loxahatchee River to study the feasibility and effectiveness of saltwater barriers for the prevention of saltwater intrusion (Sun, 2004). The model was further validated for this restoration project for the period of 2005-2009. The CH3D model was run for a period of 41 years with a baseline condition starting at year 2020. The low, intermediate**,** and high projections for future SLR were incorporated into the boundary condition to provide a comparative framework between the three SLR scenarios. The tidal boundary conditions were computed by a tidal prediction program using known tidal harmonics at Jupiter Inlet.

Freshwater inflows (surface and groundwater) were prescribed at upstream boundaries including structures and major tributaries. The flows are output from the Lower East Coast Sub-regional Model – North Palm (LECSR-NP) hydrological model. Two alternatives were evaluated, the 2070 future without project (2070FWO) and the Tentatively Selected Plan. The existing condition baseline (ECB) was established starting at the year 2020, as it is the earliest year that the LRWRP can be incorporated into a Water Resource Development Act (WRDA). The future with-project condition baseline was selected at year 2070 as it both aligns with the hydrologic output from the LECSR-NP and provides sea level rise approximations for a 50-year planning horizon that can be compared to the FWO condition.

The two flow alternatives and three projected SLR conditions yield a combination of six scenarios or six model simulations. For each simulation, salinity and stage from the model results are to be evaluated based on the Valued Ecosystem Components (VECs) approach. For each VEC zone, a ranking score and the habitat volume will be calculated based on the criteria laid out in the performance measure (PM1, see main report for PIR). Therefore, SLR impact will be evaluated by comparing the ranking score and habitat volume at each VEC zone for the 2070FWO and TSP alternative.

In addition to ecosystem impacts, existing and proposed infrastructure within the LRWRP footprint are susceptible to sea level rise. Existing structures include the Lainhart Dam, Masten Dam, and S-46 within the Loxahatchee River. Lainhart and Masten Dams are passive weir structures, located approximately 0.1 mile and 1.2 miles, respectively, north of SR-706 along a 7.5-mile section of the Northwest Fork of the Loxahatchee River. SLR considerations may result in an impact to the hydraulic conditions for the tailwater of the Masten Dam. The current configuration for the Masten Dam includes two inset weirs, each about 12 feet wide and 1.5 feet deep below the upper weir crest at an elevation of 5.9 ft. NAVD88. The S-46 structure, a gated spillway with discharge controlled by three stem operated, vertical lift gates, discharges directly to the Loxahatchee Estuary. The crest of the spillway is at 5.2 ft. NAVD88 and is designed for a headwater elevation of 11.3 ft. NAVD88 and tailwater of 0.7 ft NAVD88.

In the TSP, there are proposed structures for the Ranch Colony Canal and Hobe Grove Ditch within tributaries to the Northwest Fork. Based on preliminary design, the Ranch Colony Canal and Hobe Grove Ditch water control structures have invert elevations at approximately 7.5 ft and 6 ft. NAVD88, respectively. Although the existing and proposed project features have invert elevations greater than 3.5

ft above the "high" curve planning horizon of 2070, the conditions within the estuary and river are highly dependent upon tidal conditions, storm severity, and timing and duration of runoff. Therefore, it is important to analyze the potential extreme water levels (EWL) to further understand the potential exceedance probability for water levels within the estuary. EWL are statistically derived probability of future storm events developed from recorded high water events. The NOAA EWLs are derived using the Generalized Extreme Value (GEV) probability distribution function whereas the USACE EWLs are derived using the Percentile function. Both EWL calculations can be applied to the sea level rise scenarios to understand the severity and frequency by which the project features may be impacted, as seen in **Figure H-9**.

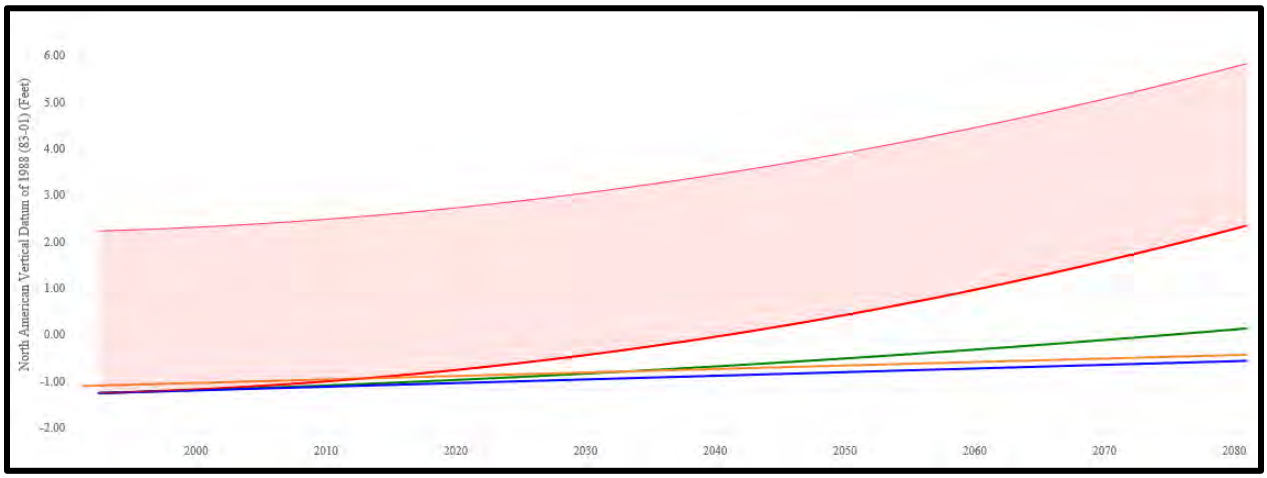

Figure H-9. SLR Graphic Illustrating a 10% Exceedance Probability for NOAA High EWL.

H.4 Hydrologic Analysis

The following sections present the literature review, and tools relevant to current climate and climate change for inland hydrology, ECB 2016-25.

H.4.1 Literature Review

The USACE Institute for Water Resources (IWR) has developed a series of 21 documents that summarize current climate change science with respect to current USACE missions for the 2-digit Hydrologic Unit Code (HUC) Water Resource regions. These documents assist USACE staff in meeting climate change adaptation policies set by the Assistant Secretary of the Army for Civil Works. Each report summarizes observed and projected climate and hydrological patterns cited in peer-reviewed literature, and characterizes climate threats to USACE business lines. The Loxahatchee River watershed is located in the South Atlantic-Gulf Region.

With respect to observed data, the IWR report for the South Atlantic-Gulf Region finds a mild ascending trend in temperature and a mild descending trend in stream flow, mainly since the 1970s. However, clear agreement does not exist for either variable among the literature. Studies on precipitation indicate diverse results but with more research exhibiting increasing annual and seasonal precipitation over the past 50–100 years.

With respect to climate predictions, reasonable consensus indicates that the intensity and frequency of extreme storm events will increase in the future for the South Atlantic-Gulf Region, which may lead to increased runoff. However, there is little agreement on the future trends for stream flow and annual/seasonal precipitation. A significant increase in temperature (4°F – 8°F) is predicted for the region by the end of the century. **Figure H-10** illustrates potential impacts to USACE business lines.

CLIMATE VARIABLE	VULNERABILITY
Increased Ambient Temperatures	Increased ambient air temperatures throughout the century, and over the next century are expected to create the following vulnerabilities on the business lines in the region: • Loss of vegetation from increased periods of drought and reduced streamflows may have impacts on vegetation within the region, which is important for sediment stabilization in the watershed. Loss of non-drought resistant vegetation may result in an increase in sediment loading, potentially causing geomorphic changes in the tributaries to the river system. • Decrease in flows may result from periods of drought and reduced streamflow has implications for maintain water levels in the rivers. • Risk of wildfires during hot and dry conditions may cause an increased risk of wildfires, especially in heavily forested and dry areas. Flora and fauna that are not drought resistant can also be impacted by longer drought conditions, which may reduce opportunities for recreational wildlife viewing. **BUSINESS LINES IMPACTED:**
Increased Maximum Temperatures	Air temperatures are expected to increase 2-4°C in the latter half of the 21st century, especially in the summer months. This is expected to create the following vulnerabilities on business lines in the region: • Increased water temperatures leading to water quality concerns, particularly for the dissolved oxygen (DO) levels, growth of nuisance algal blooms and influence wildlife and supporting food supplies. • Increased evapotranspiration. • Human health risk increases from extended heat waves, impacting recreational visitors and increasing the need for emergency management. **BUSINESS LINES IMPACTED:**
Increased Storm Intensity and Frequency	Extreme storm events may become more intense and frequent over the coming century which are expected to influence the following vulnerabilities on business lines in the region: • Increased flows and runoff, which may carry pollutants to receiving water bodies, decreasing water quality. • Increased erosion with subsequent changes in sediment accumulation rates and creating water quality concerns. • Increased groundwater recharge rates, as residence times are shortened within areas where evapotranspiration takes place during high intensity events. • Increased flooding, which may have negative consequences for all infrastructure, habitats, and people in the area. **BUSINESS LINES IMPACTED:**
Sea Level Rise	Sea level rise may exacerbate saltwater intrusion into fresh water supplies. **BUSINESS LINES IMPACTED:**

NOTE: The Regulatory and Military Program business lines may be impacted by all climate variables

= Navigation = Flood Risk Management = Ecosystem Restoration = Hydropower = Recreation = Water Supply = Emergency Management

Figure H-10. Summary of projected climate trends and impacts on USACE business lines.

H.4.2 Climate Hydrology Assessment Tool Observed Trends

A qualitative analysis was conducted using data from the Fisheating Creek gage (see **Figure H-11.** and **Figure H-12.**) and two methods from the Climate Hydrology Assessment Tool. This tool allows users to access both existing and projected climate data to support consistent analyses and to potentially develop reliable climate change projections for USACE projects. The first qualitative method involves performing a linear regression of the annual maximum daily discharge (**Figure H-13.**). The second method is similar to the first, but it uses the largest 3-day annual maximum discharge (**Figure H-14.**). Note that the p-value is equal to 0.09 and 0.10 in **Figure H-13.** and **Figure H-14.**, respectively. In both cases, although the slope is negative, the p-value is greater than 0.05, which indicates the data does not exhibit a statistically significant slope and no trends are apparent.

02256500 FISHEATING CREEK AT PALMDALE, FL

LOCATION - Lat 26°55'56", long 81°18'54" referenced to North American Datum of 1927, in SW 1/4 sec.03, T.41 S., R.30 E., Glades County, FL, Hydrologic Unit 03090103, near right bank on downstream side of southbound bridge on U.S. Highway 27, 1.0 mi south of Palmdale, and 16 mi upstream from Lake Okeechobee.

DRAINAGE AREA - 311 mi^2.

SURFACE-WATER RECORDS

PERIOD OF RECORD - April 1931 to current year.

REVISED RECORDS - WRD FL-66-2: Drainage area.

GAGE - Water-stage recorder and data-collection platform. Datum of gage is 27.19 ft above NGVD of 1929 and 25.91 ft below NAVD of 1988. Prior to Mar. 16, 1949, nonrecording gage and Mar. 16, 1949, to Jan. 23, 1956, water-stage recorder, at site 450 ft upstream at same datum.

COOPERATION - This gage is monitored in cooperation with the US Army Corps of Engineers Jacksonville District and the Florida Department of Agriculture and Consumer Services.

Figure H-11. Pertinent data for Fisheating Creek at Palmdale gage from USGS.

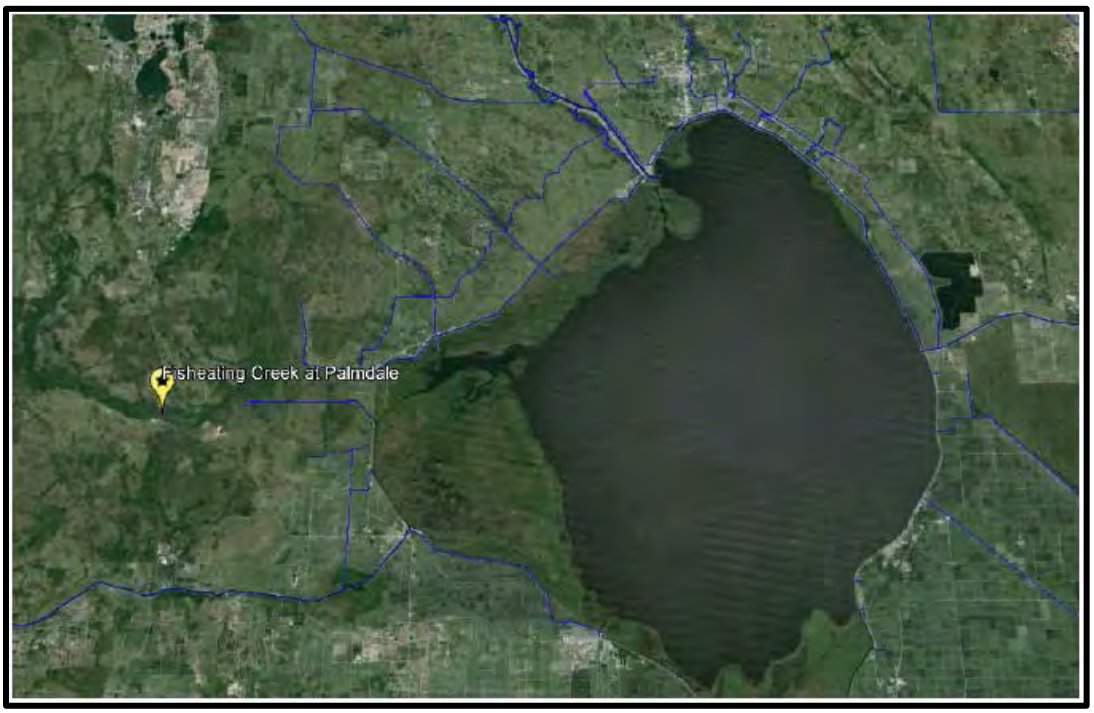

Figure H-12. Location of the Fisheating Creek at Palmdale gage.

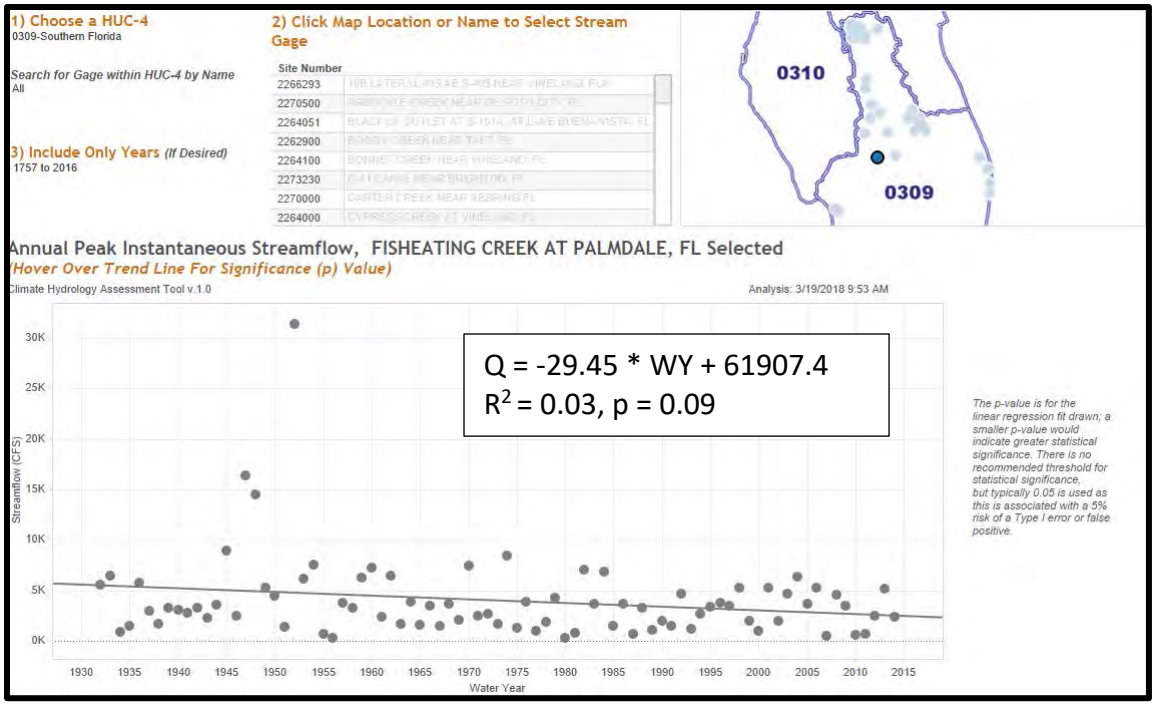

Figure H-13. Climate Hydrology Assessment Tool output showing annual maximum daily discharge at Fisheating Creek gage.

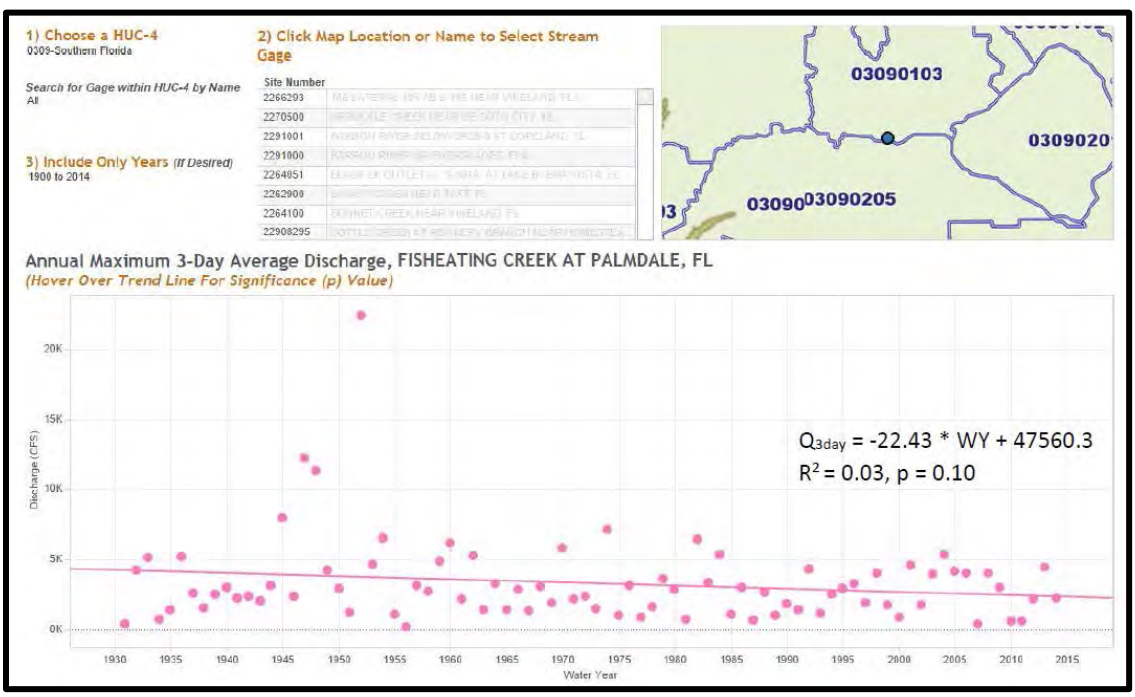

Figure H-14. Climate Hydrology Assessment Tool output showing annual maximum 3-day average discharge at Fisheating Creek gage.

H.4.3 Nonstationarity Detection Tool

The Nonstationarity Detection Tool was utilized for the Fisheating Creek at Palmdale gage in accordance with ECB 2016-25. The tool analyzes whether the assumption of stationarity, which is the assumption that statistical characteristics of time-series data are constant over the period of record, is valid for a given hydrologic time-series data set. The Fisheating Creek at Palmdale gage was chosen because it is the only gage within the Central and Southern Florida watershed included in the predetermined dataset queried by the Nonstationarity Detection Tool. **Figure H-15** shows the results from the tool.

The dark grey lines in **Figure H-15.** titled "Nonstationarities Detected using Maximum Annual Flow" indicate that the gage experienced abrupt nonstationarities twice: once in 1953 and again in 1963. The first was attributed to a change in mean flow and the second to a change in the distributional pattern of flow. Referring to the USGS website for gage USGS 02256500 FISHEATING CREEK AT PALMDALE, the annual peak stage for 1953 is noted as being "not the peak stage for the year." In addition, due to the occurrence of a significant flood event in 1952, the more typical flow experienced in 1953 would be such to result in a nonstationarity from the previous year. For the second nonstationarity in 1963, the data from the USGS is not flagged; therefore, the reason for the nonstationarity is not known. The remaining graphics in **Figure H-15.** illustrate that nonstationarities identified by the tool are not significant because only one method was capable of detecting the nonstationarity for each event. Results from the monotonic trend analysis also indicate there are no statistically significant trends for the gage analyzed (**Figure H-16.).**

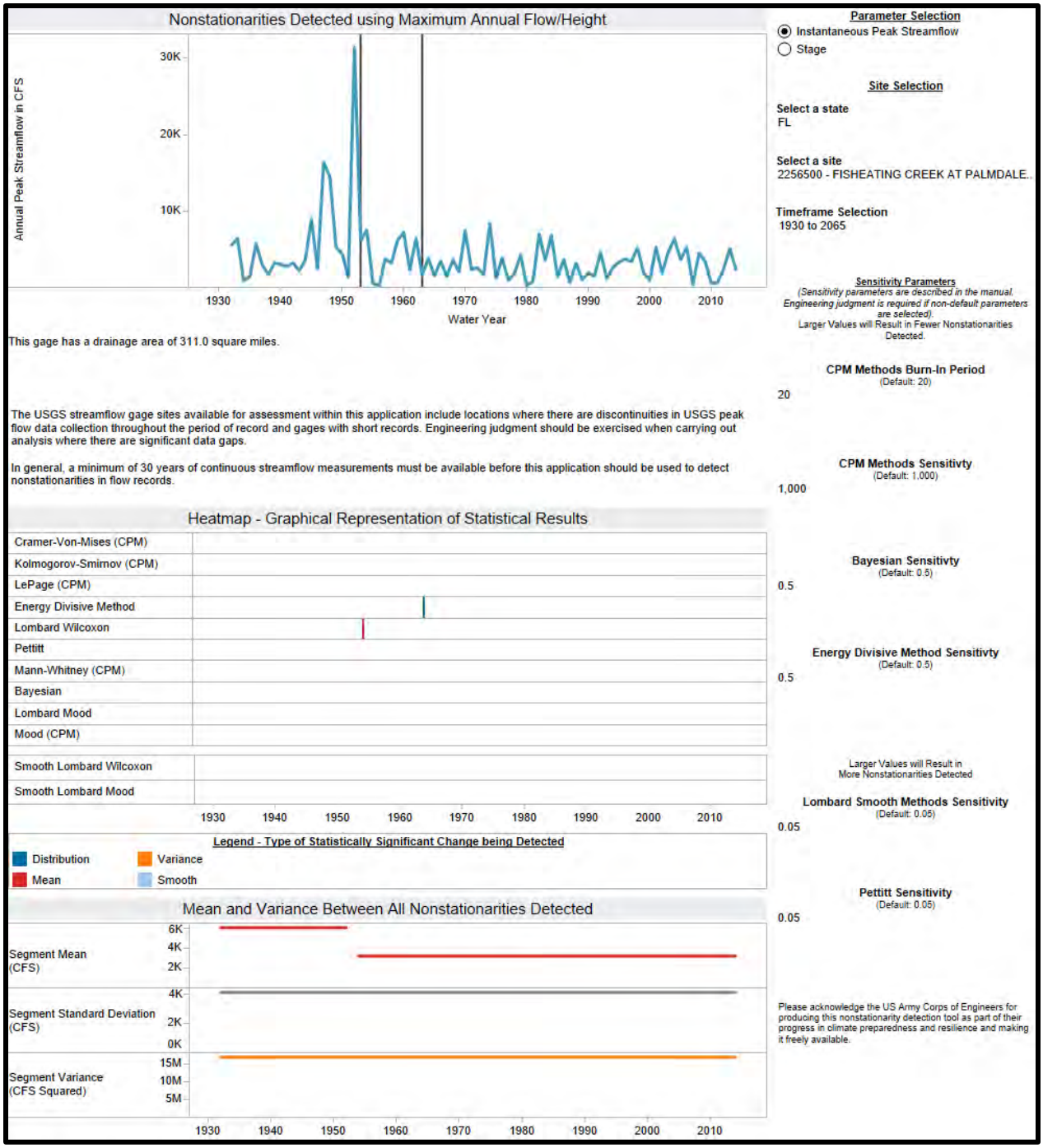

Figure H-15. Output from Nonstationarity Detection Tool (USACE).

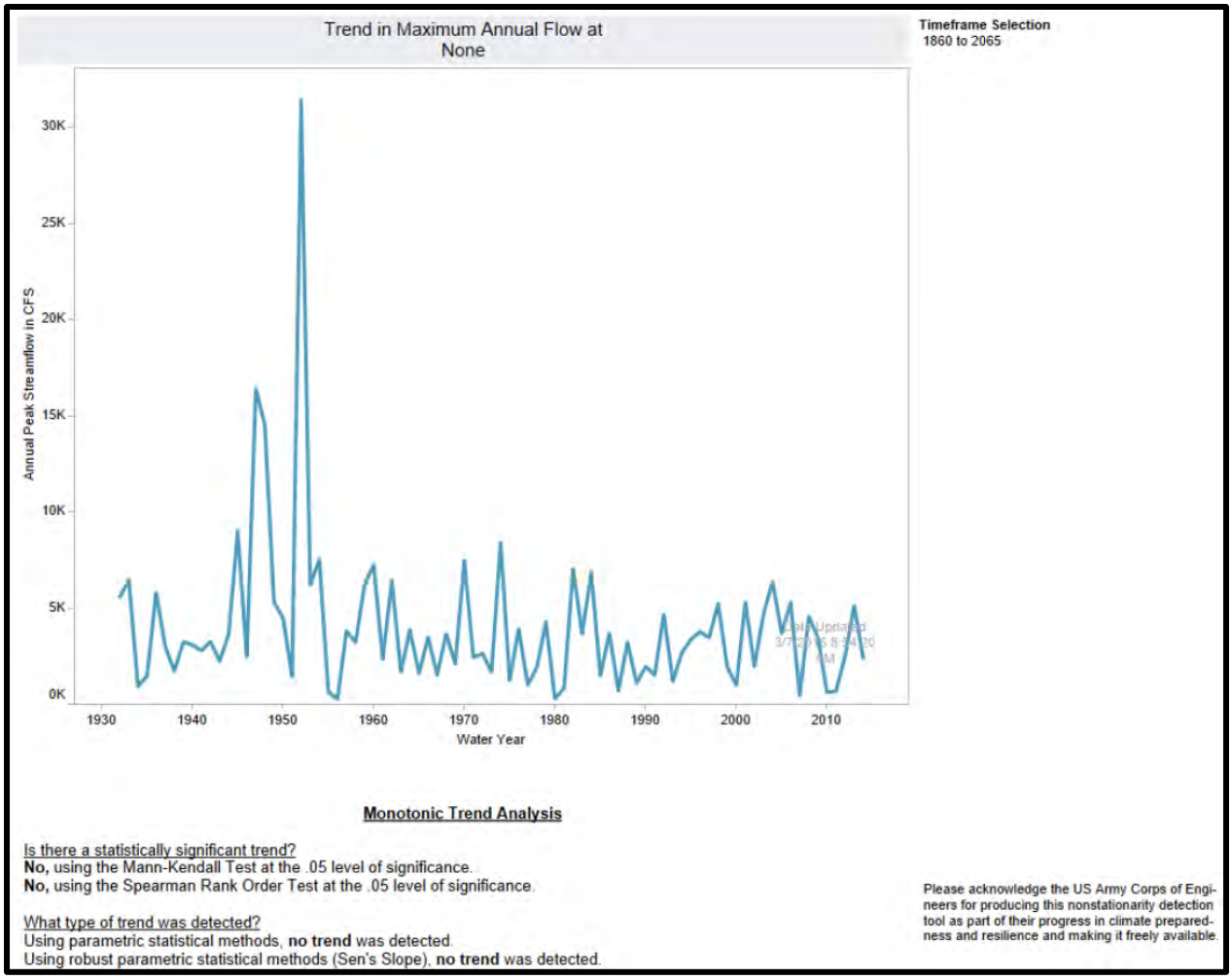

Figure H-16. Monotonic trend analysis results.

H.5 Projected Changes to Watershed Hydrology and Assessment of Vulnerability to Climate Change

The following sections present the tools for the projected changes to watershed hydrology and assessment of vulnerability to climate change.

H.5.1 The USACE Climate Hydrology Assessment Tool

Figure H-17 displays the range of forecast annual maximum monthly flows and the mean flow computed by 93 different hydrologic climate models for a period of 2000–2099 for the HUC-4 Basin 0309 – Southern Florida. These forecast flows display trends consistent with that of observed data as well as available literature. No substantial trend is visible within the projected flows.

An additional analysis was performed to provide first-order detection of any changes in floods for both the observed record and the projected future based on bias-corrected and spatially downscaled data from simulations developed for the Coupled Model Intercomparison Project Phase 5 (CMIP5), with hydrologic response simulated by the Variable Infiltration Capacity (VIC) model (Liang et al. 1994).

The first-order statistical analysis for the simulations for 1950 to 1999 indicates a statistically significant decreasing linear trend for potential realizations of runoff for the 20th century (**Figure H-18**). A statistical analysis of the projected hydrology for 2000–2099 indicates a statistically significant linear trend of increasing average annual maximum monthly flows (**Figure H-18**). These trends are consistent with the literature for both observed and projected discharge, respectively.

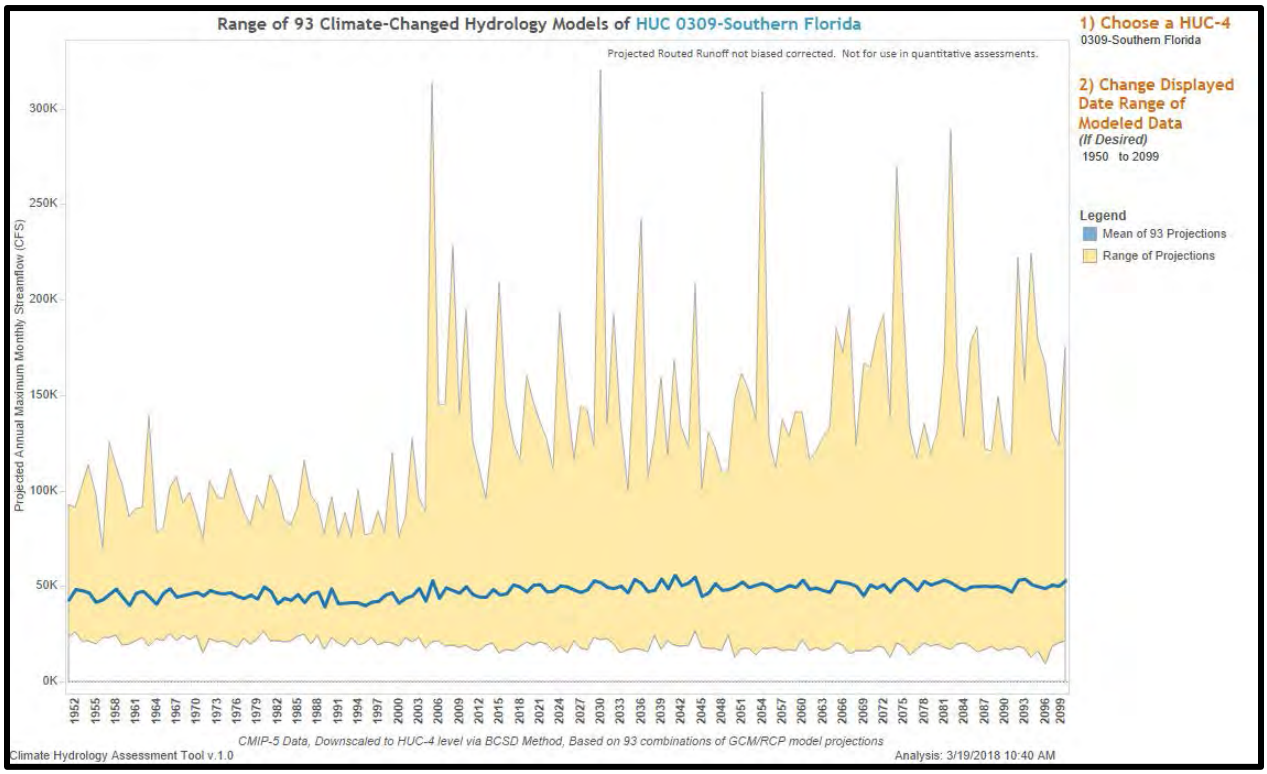

Figure H-17. Projected annual maximum monthly flow - HUC-4 309 (based on 93 combinations of climate change model projections).

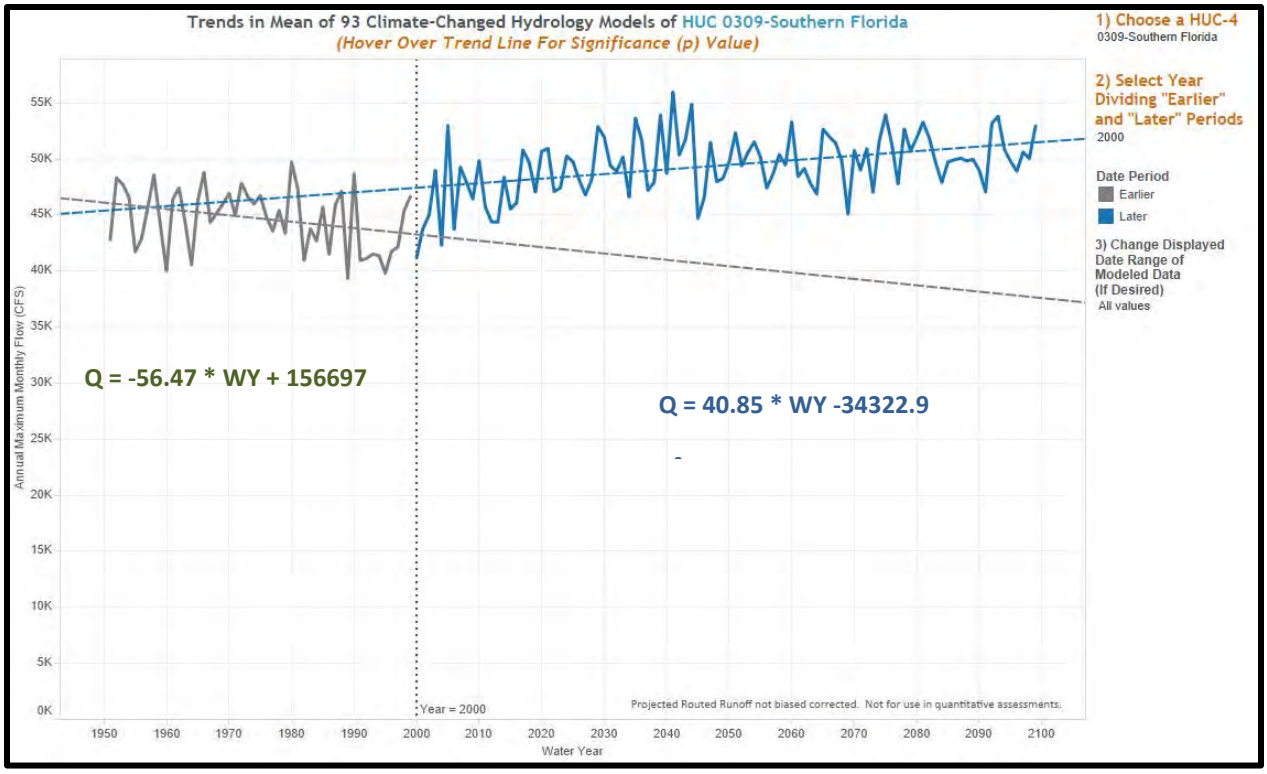

Figure H-18. Trends in historical & projected mean annual maximum monthly flow - HUC-4 0309.

The Watershed Vulnerability Assessment Tool was used to examine the vulnerability for the future flood-risk management business line. The LRWRP area is located within HUC 309. For the South Florida HUC 309 watershed, the dominant indicator is the urban 0.2% exceedance probability (500-year) floodplain for both the dry and wet scenarios and both 2050 and 2085 epochs. This shows that there is a potential higher vulnerability to the 0.2% exceedance probability (500-year) flood with respect to anticipated increases in the magnitude, extent, and depth of flooding in the watershed. However, there are minimal differences in the 0.2% exceedance probability (500-year) floodplain indicator across wet/dry scenarios and epochs as presented in Error! Reference source not found.**2** and **Figure H-19**.

Table H-2. Flood risk reduction HUC vulnerability percentage for wet and dry scenarios.

Scenario	Epoch Year 2050	Epoch Year 2085
Wet	56.78 %	57.54 %
Dry	60.55 %	61.48 %

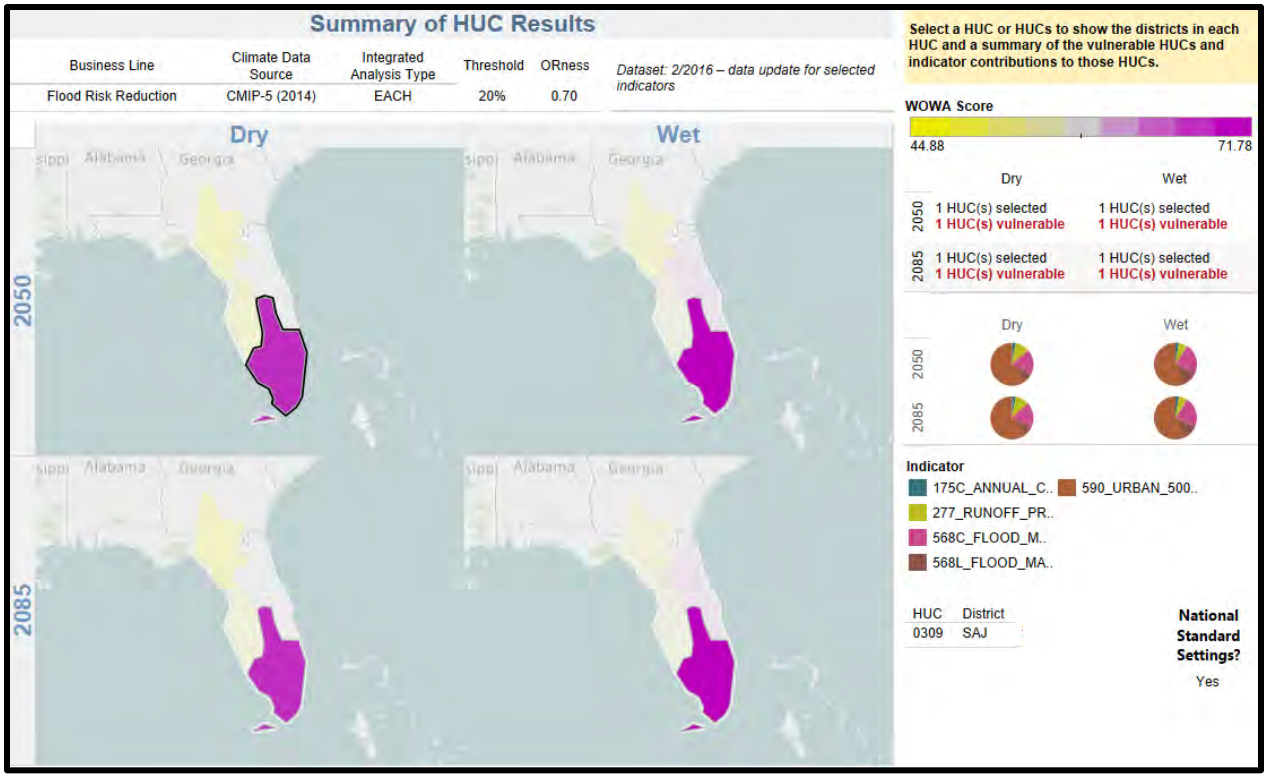

Figure H-19 Flood risk reduction HUC summary, wet and dry scenarios.

H.6 Conclusion

The effects of sea level rise were analyzed per EC 1165-2-212, with final results pending. Sea levels relative to the Loxahatchee River and Estuary could rise 0.4 to 2.4 ft. over the next 50 years depending on the sea level rise scenario. The future conditions could ultimately effect the salinity levels within the river and estuary depending on the rate of sea level rise and the future with-project conditions, including the amount of freshwater inflow conveyed from project features.

The preceding analysis shows that, for the high SLC scenario of approximately 2.36 feet (computed using the relative difference between the 2020 baseline MSL of -0.671 ft. and the 2070 high curvature value of 1.686 ft) of rise by the year 2070, the current threshold for structure invert elevations may be impacted by MSL values and by EWL. This could lead to either increased or decreased discharge capabilities at these structures, depending on the phase of the tidal signal and the magnitude of the upstream freshwater inflow. These changes would be incorporated into future LRWRP analyses which could, in part, affect the operations of the LRWRP Recommended Plan. From a purely hydraulic perspective, it appears likely that the USACE could maintain the overall capacity of the Lainhart and Masten dams as well as the proposed structures except under extreme water levels closer to the 2070 planning horizon. Once the CH3D sea level change model simulations are complete, the TSP will be analyzed to determine how sensitive the estuary and river are to SLR and what design or operational modifications could be implemented in the future for robustness.

Although impacts to the project due to sea level rise have not been fully analyzed, preliminary analysis indicates that the average annual net project benefits are likely to be reduced in comparison to the

projected average annual net project benefits estimated assuming no sea level rise. Further details will be provided during the next submittal.

The hydrologic analysis is an initial assessment on available historical data using a screening-level tool. There do not appear to be any statistically significant trends that will impact the overall hydrology that is used in the LRWRP preliminary TSP. In conclusion, the impacts of climate change on the LRWRP TSP in this DRAFT PIR will require additional study as climate change tools and techniques evolve and become more mature.

H.7 References

US Army Corps of Engineers, Engineering Construction Bulletin (ECB) 2016-25, Guidance for Incorporating Climate Change Impacts to Inland Hydrology in Civil Works Studies, Designs, and Projects (Climate Hydrology Assessment Tool), USACE, (September 2016).

USGS Circular 1331.

Carter, L. M., J. W. Jones, L. Berry, V. Burkett, J. F. Murley, J. Obeysekera, P. J. Schramm, and D. Wear. (2014). Ch. 17: Southeast and the Caribbean. Climate Change Impacts in the United States: The Third National Climate Assessment, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, 396–417.

EAA Reservoir, SB10, Impacts of Climate Change and Sea Level Change on EAA Reservoir, SFWMD and USACE, (March 2018).

Central Everglades Planning Project, Final Integrated Project Implementation Report and Environmental Impact Statement, SFWMD and USACE, (July 2014).

Central Everglades Planning Project, Post Authorization Change Report, Feasibility Study and Environmental Impact Statement, SFWMD, (February 2018)

Central & Southern Florida Project, *Herbert Hoover Dike Dam Safety Modification Report*, USACE (January 2016).

Friedman, D., J. Schechter, B. Baker, C. Mueller, G. Villarini, and K.D. White. (2016). *U.S. Army Corps of Engineers Nonstationarity Detection Tool User Guide*. U.S. Army Corps of Engineers: Washington DC.

Ingram, K., K. Dow, L. Carter, J. Anderson, eds. (2013). *Climate of the Southeast United States: Variability, Change, Impacts, and Vulnerability*. Washington DC: Island Press.

Liang, X., D.P. Lettenmaier, E.F. Wood, and S.J. Burges. (1994). "A simple hydrologically based model of land surface water and energy fluxes for GSMs." *Journal of Geophysical Research* 99(D7), 14, 415–428.

NOAA. 2013. *Regional Climate Trends and Scenarios for the U.S. National Climate Assessment*. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Environmental Satellite Data, and Information Service: Washington, DC. http://www.nesdis.noaa.gov/technical_reports/142_Climate_Scenarios.html

Olsen, J. Rolf, Julie Kiang and Reagan Waskom, (editors). (2010). *Workshop on Nonstationarity, Hydrologic Frequency Analysis, and Water Management*. Colorado Water Institute Information Series No. 109. http://www.cwi.colostate.edu

Sheng, Y. P., 1986. CH3D: a three-dimensional numerical model of coastal and estuarine circulation and transport in generalized curvilinear grids, Technical Report N0. 587, Aeronautical Research Associates of Princeton, Inc., New Jersey.

Sun, D. 2004. Modeling saltwater barrier in the Loxahatchee River. Project report, Coastal Technology Inc., Vero Beach.

United States Army Corps of Engineers. (2016). Engineering and Construction Bulletin No. 2016-25: *Guidance for Incorporating Climate Change Impacts to Inland Hydrology in Civil Works Studies, Designs, and Projects*. US Army Corps of Engineers: Washington DC.

White, K.D., J.R. Arnold. (2015). *Recent US Climate Change and Hydrology Literature Applicable to US Army Corps of Engineers Missions – South Atlantic-Gulf Region*. U.S. Army Corps of Engineers: Washington DC.