COMPREHENSIVE EVERGLADES RESTORATION PLAN

LOXAHATCHEE RIVER WATERSHED RESTORATION PROJECT

DRAFT INTEGRATED PROJECT IMPLEMENTATION REPORT AND ENVIRONMENTAL IMPACT STATEMENT

March 2019

Annex E

ANNEX E

REPORTS PROVIDED BY RECOVER

TO SUPPORT THE

LOXAHATCHEE RIVER WATERSHED RESTORATION PROJECT

PROJECT IMPLEMENTATION REPORT

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EXECUTIVE SUMMARY

Annex E contains documentation of four reviews performed by the interagency REstoration COordination and VERification team (RECOVER) system-wide science team, per CERP Programmatic Regulations guidance. The reviews were:

- RECOVER System-Wide Evaluation: Loxahatchee River Watershed Restoration Project (LRWRP)
- RECOVER Consistency Review: Loxahatchee River Watershed Restoration Project (LRWRP) Project Goals and Objectives and Performance Measures
- RECOVER Consistency Review: Loxahatchee River Watershed Restoration Project (LRWRP) Adaptive Management Plan
- RECOVER Review of the Loxahatchee River Watershed Restoration Project (LRWRP) Draft Project Operating Manual (DPOM)

RECOVER SYSTEM-WIDE EVALUATION: LOXAHATCHEE RIVER WATERSHED RESTORATION PROJECT (LRWRP)

The REstoration COordination and VERification team (RECOVER) system-wide evaluation of Loxahatchee River Watershed Restoration Project (LRWRP) performance provides the evaluation required for all Comprehensive Everglades Restoration Plan (CERP) projects under the 2003 programmatic regulations. This report is a broad-scale evaluation of ecological effects of the LRWRP alternatives on the Northwest Fork of the Loxahatchee River and Estuary, the Loxahatchee Watershed, and Lake Okeechobee lake stage. The scope of the review covers all areas expected to be improved by LRWRP including areas outside of the LRWRP project boundary which fall within the overall CERP program area. The review includes the use of a broad range of evaluation tools, performance measures, and best professional judgment that reach beyond the tools and expertise of the traditional USACE planning process. The purpose of the review is three-fold: (1) to provide insight into whether some alternatives performed better ecologically than others; (2) to indicate whether alternatives may lead to unintended ecological conditions; and (3) to investigate the effects of LRWRP alternatives that could potentially conflict with the goals of CERP on a regional scale. The following key findings are provided:

System-wide Performance: All areas affected by LRWRP can be improved by the proposed alternatives. These areas include the Northwest Fork of the Loxahatchee River and Estuary within the Northern Estuaries, the Loxahatchee Watershed which bridges the Northern Estuaries, Lake Okeechobee, and the Greater Everglades (indirectly via natural resource use), while not impacting lake stage levels in Lake Okeechobee. Performance of alternatives regarding the Northwest Fork of the Loxahatchee River works disparately with performance of LRWRP alternatives regarding the Loxahatchee Watershed, most likely due to whether increased freshwater flow is reaching the Northwest Fork or is distributed within the watershed. ALT10 performs best for the Northwest Fork and worst for the Loxahatchee Watershed. ALT13 performs best for the Loxahatchee Watershed and worst for the Northwest Fork. ALT5R is the second best performing alternative for both the Northwest Fork and Loxahatchee Watershed (ALT2 is third best for both). Despite this observation all alternatives improve ecological and hydrological conditions in both the Northwest Fork and Loxahatchee Watershed.

Adaptive Management: There was a determination that proceeding with an adaptive management approach can further increase the benefits of LRWRP and positively influence the implementation of LRWRP. Adaptive management provides a means to learn during implementation and operations through monitoring and assessment in order to ensure restoration performance, while minimizing impacts and reducing risk overall. RECOVER will continue to participate in the drafting of the LRWRP Adaptive Management and Monitoring Plans and provide a consistency review upon finalization.

Full CERP Implementation Consistency: Because modeling resources and capability did not allow for full system-wide CERP runs, RECOVER was unable to provide a complete understanding of how LRWRP would function as part of full CERP implementation. LRWRP project features formulated to achieve incremental system-wide restoration benefits in the near-term may not function as well once all of CERP is implemented as envisioned in the Water Resource Development Act of 2000. This may require adapting project features to achieve the full set of restoration benefits stated under CERP as additional CERP projects are implemented. Nevertheless, the LRWRP project represents an important near term-incremental step towards restoration of the south Florida Everglades ecosystem.

Future CERP Increments: Future increments of CERP, as it relates to the restoration of the Loxahatchee River and Watershed, should focus on the need for more storage and connectivity to meet full CERP restoration goals for water quantity, quality, timing, and distribution to the river and throughout the watershed and associated Everglades regions discussed in this review.

Climate Change: The need for more reliable sources of storage may become more apparent as a result of anticipated changes in climate. The National Climate Assessment and Development Advisory Committee's National Climate Assessment 2014 final report identifies sea level rise, increasing temperatures resulting in an increase in frequency, intensity, and duration of extreme heat events, and decreased water availability as key messages regarding climate change in the southeast United States and Caribbean. These factors may lead to increased evapotranspiration rates, changes in rainfall intensity, seasonal timing, and amounts. Atlantic cyclone activity is also anticipated to increase. Future planning efforts should evaluate scenarios of these climatic drivers and regional stressors to determine plans that are robust enough to address climate variation. In addition, scientists and managers should continue monitoring and associated analyses to understand the effects of climate change on system-wide indicators that are envisioned to be restored under CERP.

Northwest Fork of the Loxahatchee River and Estuary: Modeling of the hydrology, salinity, and associated ecology of the Northwest Fork of the Loxahatchee River and associated Loxahatchee Estuary, showed an increase in freshwater flow throughout the Northwest Fork of the Loxahatchee River during both the wet and dry seasons. The increase in dry season freshwater flows ranged from 15% to 30% while the increase of wet season freshwater flows ranged from 20% to 22% across the LRWRP alternatives. Modeling also showed that the increase of freshwater flow throughout the Northwest Fork of the Loxahatchee River and Estuary had a notable positive influence in the "Flood Plain Swamp and Hydric Hammock in the Freshwater Riverine Flood Plain" Valued Ecosystem Component (VEC) while showing only modest improvements in the "Tape Grass, *Vallisneria americana*" VEC, "Fish Larvae in the Oligohaline Zone" VEC, and "Oysters in the Mesohaline Zone" VEC. Virtually no difference between the future without modeling scenario and project alternatives were noted in the modeling results for the "Flood Plain Swamp in the Tidal Flood Plain" VEC and "Seagrasses in the Polyhaline Zone" VEC (7 acre difference between FWO [727 acres] and worst performing alternative [ALT10 = 720 acres) for the Polyhaline Zone. Overall, ALT10 provides the

most improvement in freshwater flow and the most enhancement of salinity conditions throughout the VECs, as a whole, within the Northwest Fork of the Loxahatchee River and Estuary.

Loxahatchee Watershed: General improvement in watershed hydrology was observed in Flow Way 3 (3% - 30%) and Flow Way 1 (15% - 16%). Minimal improvement in watershed hydrology was observed in Flow Way 2 (1% - 3%). Model results indicated alternative performance for the Loxahatchee Watershed was opposite of alternative performance for the Northwest Fork of the Loxahatchee River and Estuary. Alternative 13 made the most improvement of LRWRP alternatives in the hydrology of the Loxahatchee Watershed outperforming the future without modeling scenario by 30% in Flow Way 1, 3% in Flow Way 2, and 15% in Flow Way 3. Where ALT10 performed best in the Northwest Fork, it performed the worst of all alternatives in regards to hydrology in the Loxahatchee Watershed, improving hydrology by 3% in Flow Way 1, 15% in Flow Way 2, and 1% in Flow Way 3. Connectivity within the Loxahatchee Watershed was improved by all LRWRP alternatives, ranging from scores of 0.46 (ALT10) to 0.83 (ALT13) compared to 0 for the FWO scenario.

Lake Okeechobee Lake Stage: LRWRP ALT10 includes construction of deep reservoir associated with C-51. This feature would reduce water deliveries, via the L-8 canal, from Lake Okeechobee to the LRWRP area. Analysis of outflows through the C-10A culvert into the L-8 canal were analyzed for their impact on Lake Okeechobee lake stage as if the discharges did not occur. The additional water volume in Lake Okeechobee resulting from the lack of discharge through the C-10A culvert into the L-8 canal scenario showed virtually no increase in Lake Okeechobee lake stage. The largest monthly average release (October 2013) in the past 10 years was 394.5 cfs which was equivalent to an average of 782.4 acre feet per day (24,254 acre feet per month). None of the other LRWRP alternatives in the final array contain features that would impact Lake Okeechobee lake stage.

RECOVER CONSISTENCY REVIEW: PROJECT GOALS AND OBJECTIVES AND PERFORMANCE MEASURES

The RECOVER team consistency review of the project goals and objectives and performance measures for LRWRP fulfilled three requirements as described by the 2003 programmatic regulations. Those requirements were: (1) ensure the project is consistent with CERP's goals and objectives; (2) document consistency of the project performance measures with RECOVER's system-wide performance measures; and (3) suggest improvements to the project performance measures with the intent of improving target or evaluation methods to better evaluate project alternative plans that, if pursued, would contribute to selecting a tentative plan with the best performance by the project in achieving ecosystem restoration goals. To address these requirements, the RECOVER consistency review team reviewed the project summary report and performance measures considered for utilization in LRWRP plan formulation. RECOVER determined the goals and objectives of LRWRP are consistent with the goals and objectives of CERP which are: (1) enhance ecological values and (2) enhance economic values and social well-being. The RECOVER consistency review team noted how up-to-date each performance measure was, how frequent each performance measure is used, and if it was a RECOVER approved performance measure. The performance measures utilized by LRWRP for plan formulation and assessment of LRWRP alternative plans were found to be appropriate tools for assessing project alternatives and for achieving project success.

RECOVER CONSISTENCY REVIEW: ADAPTIVE MANAGEMENT PLAN

In accordance with CERP Guidance Memorandum 40.02 and other relevant guidance (e.g., CERP Guidance Letter 12/06), RECOVER must review the Loxahatchee River Watershed Restoration Project (LRWRP) project level monitoring plan(s) in regards to consistency with the existing Monitoring and Assessment Plan (MAP 2009) to prevent duplication of monitoring activities. Additionally, in this review, RECOVER evaluates the need for project-level monitoring to fill temporal or spatial gaps for parameters monitored in the MAP 2009 in order to evaluate project-level effects. As projects are typically not at the construction stage when this Review is prepared, and that a variety of changes may occur between now and operational readiness of the Project, this review, when completed, should be considered an interim document. Future developments may require modification of monitoring plans and/or revision of this Review. This document provides RECOVER's comments and recommendations to the Project PDT regarding incorporation of proposed monitoring into the project.

This statement documents recognition that the LRWRP Adaptive Management Plan and Monitoring Plans are in draft and will undergo updates in the future. It is recommended that a detailed review of the Adaptive Management Plan and Monitoring Plans be performed by RECOVER, when these documents are finalized, in order to gain input from scientists who possess most current system-wide scientific knowledge. RECOVER will continue coordination with the U.S. Army Corps of Engineers and the South Florida Water Management District as requested.

RECOVER REVIEW OF THE LOXAHATCHEE RIVER WATERSHED RESTORATION PROJECT (LRWRP) DRAFT PROJECT OPERATING MANUAL (DPOM)

The 2003 CERP Programmatic Regulations (33 CFR Part 385.26(c)) provides for, but does not require, a RECOVER review of the Project Operating Manual. This statement documents recognition that the LRWRP operating manual is in draft and will undergo updates in the future. It is recommended that a detailed review of the DPOM be performed by RECOVER near the end of the project design phase, in order to gain input from scientists who possess most current system-wide scientific knowledge. RECOVER will continue coordination with the U.S. Army Corps of Engineers and the South Florida Water Management District during future LRWRP project operations manual updates as requested.

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TRANSMITTAL LETTER FOR RECOVER SYSTEM-WIDE EVALUATION OF LOXAHATCHEE RIVER WATERSHED RESTORATION PROJECT (LRWRP)

REstoration COordination and VERification (RECOVER) Evaluation Team, Regional Evaluation Report

Date: August 10, 2018

To: Project Managers and Planning Technical Leads
Loxahatchee River Watershed Restoration Project
Comprehensive Everglades Restoration Plan

Dear Project Team Managers and Planning Technical Leads,

RECOVER has completed its regional evaluation of the Loxahatchee River Watershed Restoration Project (LRWRP) alternative plans and our final report is attached.

RECOVER's evaluation of project alternatives fulfills the following requirements as required by the 2003 CERP Programmatic Regulations 33 CFR Part 385.26(c):

1. Support project teams to achieve consistency with the Comprehensive Everglades Restoration Plan's (CERP) goals and objectives;
2. Document the performance of the project alternative plans using RECOVER approved system-wide performance measures, project performance measures (when appropriate), and best professional judgment. RECOVER determines the ability of each alternative plan to meet the targets established for each performance measure and describes the resulting effects upon the natural system. When appropriate, RECOVER evaluations include a qualitative analysis on how the project fulfills CERP goals and objectives;
3. Suggest improvements to the project, which if pursued could improve project performance or enhance benefits to the natural system;
4. Provide insight, if possible, and alert the project teams of any inconsistent modeling assumptions for the project as originally modeled in the CERP.

Recommendations discussed within the RECOVER regional evaluation report generally fall into one of three categories:

1. Recommendations that can easily be incorporated into the plan formulation process;
2. Recommendations that are more conceptual in nature, which the Project Team may select to incorporate into preliminary designs to improve project performance; and
3. Recommendations that are crucial to the project, but cannot be addressed prior to the TSP Milestone meeting.

Concerning the latter category, RECOVER provided its regional evaluation to satisfy the need for timely reporting, while bringing forward as much science as possible. As a result, this report may not constitute

the entirety of RECOVER's review as specified in the Programmatic Regulations. Therefore, RECOVER may provide additional information supporting and refining the original regional evaluation, with the expectation that those additional evaluation comments be considered by the project team.

Best Regards,

RECOVER Executive Committee

(Patti Gorman, Donna George, Fred Sklar, Agnes McLean, Gretchen Ehlinger, Laura Brandt)

E INTRODUCTION

E.1 Background and Purpose

This report documents the REstoration COordination and VERification (RECOVER) team system-wide/regional evaluation of the Loxahatchee River Watershed Restoration Project (LRWRP) required by the Comprehensive Everglades Restoration Plan (CERP) programmatic regulations 33 Code of Federal Regulations 385.20(e)(2). RECOVER is an independent (from the project delivery team [PDT]), interagency, and interdisciplinary team made-up of scientists charged with helping PDTs ensure their project's plans, designs, and performance are fully linked to the goals and objectives of CERP. The purpose of system-wide evaluations are to: (1) inform the PDT of the compatibility of proposed project alternative plans with regional CERP restoration goals and performance expectations; (2) determine the performance of each alternative plan toward meeting system-wide goals and objectives through the use of system-wide performance measures, project performance measures, and best professional judgment; (3) identify improvements for project performance that would improve system-wide performance; and (4) provide decision-makers required information regarding system-wide performance expectations of specific projects. This report documents the performance of the project alternatives in accordance with these four (4) tenets and, also, highlights the ability of each alternative to meet RECOVER system-wide/regional performance targets and documents expected effects on the natural system.

E.2 LRWRP Goals and Objectives

The purpose of CERP is to modify structural and operational components of the Central and Southern Florida (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. The sixty-eight (68) components of CERP will work together to benefit the ecological structure and function of the south Florida ecosystem by improving and/or restoring the proper quantity, quality, timing, and distribution of water in the natural system.

Table E-1: CERP Goals and Objectives

Goal & Objective Ids.	Goal and Objective Description
1	**Enhance ecological values.**
A	Increase the total spatial extent of natural areas.
B	Improve habitat and functional quality.
C	Improve native plant and animal species diversity.
2	**Enhance economic values and social well-being.**
A	Increase availability of fresh water (agricultural/municipal and industrial).
B	Reduce flood damages (agricultural/urban).
C	Provide recreational opportunities.
D	Protect cultural and archaeological resources and values.

LRWRP is composed of increments of project components that were identified in CERP. The term "increment" is used to underscore that this study will formulate portions (scales) of individual components of CERP. It is envisioned that later studies will investigate additional scales of components of CERP to

expand upon this initial "increment" to achieve the level of restoration envisioned for CERP. Portions of three (3) of the 68 components of CERP are being evaluated within LRWRP.

Table E- 2: LRWRP Goals and Objectives

CERP Objective	LRWRP Objective
Enhance Ecological Values - Increase the total spatial extent of natural areas	Objective 3: Increase natural area extent of wetlands.
Enhance Ecological Values - Improve habitat and functional quality	Objective 1: Restore wet and dry season flows of water to the National Wild and Scenic Northwest Fork of the Loxahatchee River and the river floodplain. Objective 2: Restore oysters, seagrass and other estuarine communities in the Loxahatchee River Estuary. Objective 4: Restore connections between Corbett WMA, Pal-Mar/Cypress Creek basin, Loxahatchee Slough, Grass Waters Preserve and Loxahatchee River to improve hydrology, sheetflow, hydroperiods, natural storage, and vegetation communities.
Enhance Ecological Values - Improve native plant and animal species abundance and diversity	Objective 5: Restore native plant and animal species abundance and diversity in Loxahatchee River watershed natural areas, river, and estuary.
Enhance Economic Values and Social Well Being - Increase availability of fresh water (agricultural/municipal & industrial)	No corresponding objective. Potential incidental benefit to increase availability of water supply.
Enhance Economic Values and Social Well Being - Reduce flood damages (agricultural/urban)	No corresponding objective. Potential incidental benefit.
Enhance Economic Values and Social Well Being - Provide recreational and navigation opportunities	No corresponding objective, but project will provide recreational opportunities consistent with ecosystem restoration.
Enhance Economic Values and Social Well Being - Protect cultural and archeological resources and values	No corresponding objective, but project will protect cultural and archeological resources and values.

LRWRP goals and objectives are consistent with those of CERP, as described in ***Table E.1- 1*** and ***Table E.1-2***. LRWRP focuses primarily on the restoration of water connectivity which will lead to: (1) the achievement of natural community restoration, resulting in (2) the increase in species abundance and diversity. LRWRP restoration fulfills CERP's goal to enhance ecological values while concurrently improving the recreational opportunity and experience associated with the "National Wild and Scenic" Northwest Fork of the Loxahatchee River and Estuary, partially satisfying CERP's second goal to "enhance economic values and social well-being." Improvements to connectivity, flow, and species composition should positively influence the health of the system as well.

E.2.1 Model Assumptions and Project Alternatives

As part of the RECOVER regional evaluation, the "future without project" (FWO) alternative was compared to four "with project" alternatives (ALTs) aimed at restoring and sustaining the overall quantity, quality

timing, and distribution of freshwater to the federally designated "National Wild and Scenic River" Northwest Fork of the Loxahatchee River (NWFLR) for current and future generations and restoring, sustaining, and reconnecting the area's wetlands and watersheds that form the historic headwaters for the river as proposed in the following CERP components:

- Pal Mar and J.W. Corbett WMA Hydropattern Restoration (OPE)
- WPAs/L-8 Basin (K)
- WPAs/L-8 Basin (GGG)

E.2.1.1 Model Assumptions Regarding the FWO

- Project Location: The active model boundary covers the entire LRWRP area, which stretches from Lake Okeechobee on the west to the Intracoastal Waterway on the east, from the C-44 canal on the north to the C-51 and the L-10/L-12 canals on the south. The 41-year period of simulation is from 1965 through 2005.
- Regional System: The Lower East Coast sub-Region North Palm Beach model (LECsR-NP) does not simulate regional water management and relies on the Regional 2x2 South Florida Water Management Model (SFWMM) for internal boundary conditions for the L-8, C-51 and C-44 canal stages, as well as flows from the regional system to the M-Canal to supply the City of West Palm Beach. Regional system flows through the M-Canal Control 2 pump station supplied by the SFWMM are reduced by seven (7) percent to account for seepage losses between Control 2 and Control 3 on the M-Canal because the model places this water directly into the M-Canal in the Grassy Water Preserve (GWP).
- L-8 Basin and/or C-51 Storage: Runoff available in the L-8 Basin is calculated for the West Corbett, Dupuis, Cypress Groves, and adjacent agricultural areas including the northwestern portion of the EAA from the ET-Recharge program. Additional inflow to the basin occurs, utilizing the reinjection drainflow (RDF) package, for the drainage canals located parallel to the L-8 Canal on the western and southern side of Dupuis and Corbett areas. Additional water is available as seepage into the L-8 Canal itself which is simulated as a river and obtains its daily stage from the SFWMM run. Some of the runoff is lost from the basin to provide irrigation to the eastern portion of the EAA and the agricultural areas in the Indian Trail Improvement District (ITID) area.
    - L-8 FEB: Simulation of stages within the L-8 FEB are obtained from the Restoration Strategies DMSTA 2012 Project modeling. Water levels within the facility can vary from approximately 13 feet NGVD to -40 feet NGVD.
    - C-51 Reservoir Phase 1: The C-51 Reservoir Phase 1 is simulated as an active, fully mined site.
    - C-51 Reservoir Phase II: The C-51 Reservoir Phase II storage is simulated as a partially mined site.
- M-Canal Conveyance
    - Control 2 Pump Station (WPB #2): The new 300 cfs pump station is completed but is restricted to a maximum rate of 225 cfs because of canal limitations. Flows through Control 2 are derived from the SFWMM run and simulated in the model using the diversion package.

- Grassy Waters Preserve (WPB Catchment Area) Deliveries: The M-Canal is maintained at a maximum stage of 18.9 feet NGVD. Regional system inflows are not provided to the M-Canal when stages are above 18.9 feet NGVD, in GWP, using the diversion package. Water supply for the City of West Palm Beach out of the M-Canal is simulated using the well package with withdrawal points along the M-Canal within GWP.
- Loxahatchee Slough Area:
    - Northlake Bridge: If stages in northern GWP are greater than 19.2 feet NGVD, water is diverted north across Northlake Blvd. using the diversion package.
    - Beeline Hwy Bridge: The Beeline Highway Bridge is indirectly modeled by allowing runoff west of the bridge to pass into the southern portion of the slough without restrictions.
- C-18W Storage:
    - East Corbett Weir: The weir is simulated at an elevation of 21.5 feet NGVD. The Corbett Weir is a sheet pile weir located in a heavily vegetated area which restricts flow. For simplification purposes, maximum flow over the weir is restricted to 50 cfs. It is simulated with the RDF package and discharges into the C-18 canal upstream of the C-18 weir. Water flows over the weir, across a road and into a ditch which connects the extreme western end of the C-18W canal.
    - Vavrus/Avenir: The Vavrus/Avenir property is assumed to be developed based upon existing plans. It is simulated as five distinct basins. The northern basin is a wetland restoration area with a control elevation of 20.5 feet NGVD and the existing agricultural ditches are filled. This northern wetland basin discharges to the C-18 canal upstream of the weir. The northeast corner of the property is a separate wetland restoration basin and is smaller than the northern wetland basin with a control elevation of 18.5 feet NGVD. It discharges east underneath the Beeline Highway into the Lox Slough and the southern C-18 canal leg. The southwest basin, Basin 3, is a wetland urban mix with a general control elevation of 20.0 feet NGVD. This basin discharges into Basin 1. Basin 1 is located in the south east corner of the property and is urban with a control elevation of 18.0 feet NGVD. This basin discharges into the smaller northeastern wetland basin. Basin 2 is an urban basin located in the middle of the property immediately south of the main wetland restoration basin. It has a control elevation of 18.5 feet NGVD and discharges northward into the main wetland restoration area.
    - NPBC Airport: Runoff from the airport drains east towards the southern leg of the C-18 Canal using the diversion package.
- C-18 Weir, G-92, and Lainhart Dam:
    - C-18 Weir: Flows over the C-18 weir are governed by the weir equation at steps of approximately 0.2 feet intervals using the RDF package. Flows into the west leg of the C-18 canal occur as runoff or base flow from eastern Corbett, Hungryland, Pratt and Whitney, Mecca and Avenir using a combination of the RDF and diversion packages.
    - C-18 Canal operations: The C-18 canal operations are simulated as follows: S-46 discharges in excess of 2000 cfs, depending upon slough water levels and runoff volumes when C-18 water levels exceed 14.9 feet NGVD. Flows through G-92 to the Loxahatchee

River are simulated using the RDF package and are head dependent. In general, up to approximately 30 cfs passes when the C-18 canal stage is above 12.5 feet. Up to approximately 60 cfs passes when the C-18 canal stage is above 13.5 feet. When it rises to above 14.0 feet, approximately 90 cfs occurs. Once it exceeds 14.5 feet, a volume up to 200 cfs is allowed to pass over the G-92 structure. Reverse flow is uncommon and is not simulated.

- South Indian River Water Control District (SIRWCD) and Jupiter Farms: Jupiter Farms is simulated as distinct basins. The north-western most portion is simulated using the RDF package at 15.5 feet. The western basin and central basins are simulated using the RDF package with controls of 15.0, 14.5 feet respectively. The eastern portion of Canal 2 and Section 18 are simulated using the RDF package at 13.0 feet. The basin, which is their C-14 canal and feeder canals receives the runoff and base flows from the other three basins and discharges over Lainhart Dam using the drain package at an elevation of approximately 10.7 feet NGVD. The basin is located east of the C-18 Canal and discharges downstream of the S-46 structure using the drain package with control elevation of 14.0 feet. Runoff from the basin, using the ET-recharge program is directly put into the basin at the RDF cells using the diversion package.
- Loxahatchee Tributaries (Kitching, Wilson and the North Fork): Flows into Kitching Creek occur as runoff from the northern urban and agricultural operations using the diversion package. Kitching Creek proper is simulated with the drain package in the non-tidal reaches and with the river package for the tidal areas. Wilson Creek and the North Fork are also simulated using a combination of the river, drain and general head boundaries.
- Southern Martin County Properties:
    - Hobe St. Lucie Conservancy District (HSLCD): HSLCD is simulated using the drain package The: Unit 1 South Fork Structure is outside the area of concern, Unit 2 Cypress Creek structure is simulated at 2.0 ft. NGVD and Unit 3 Hobe Grove Ditch Structure at 11.0 ft. NGVD. Individual canal and farm operations within this area are discussed in the individual project descriptions.
    - Cypress Creek Canal: Cypress Creek Canal upstream of the dilapidated control structure is maintained at an elevation of 2.0 feet NGVD from the structure located just west of the Turnpike westward to the Culpepper property using the drain package for the canal itself. Runoff from the urban basins, the western Grove, Pal Mar, Unit 2, Nine Gems, Thomas Farms and the Cypress Creek natural area are simulated using the diversion package with flows determined from the ET-Recharge program.
    - Nine Gems (Pal Mar East) Properties: The entire Pal Mar property including the primary southern canal and the laterals are all controlled at 16.0 feet NGVD and simulated as a drain. Runoff from the basin is calculated using the ET-Recharge program and introduced back into the model using the diversion package.
    - Pal Mar West of Pratt Whitney Road: Runoff from the Pal Mar area, calculated from the ET-Recharge program are simulated using the diversion package and is assumed to discharge into the Cypress Creek Canal in the general area of the twin 84 inch culverts and other culverts in the area. The Pine Glades area east of Pratt Whitney Road also discharges to the Cypress Creek Canal using the diversion package and also has a seepage barrier simulated along the southeastern portion.

- Thomas Farms (TF): Thomas Farms drains in two directions the northern area is simulated with drains at a control elevation of 12.0 feet NGVD and is considered part of HSLCD Unit 2. The southern area is controlled at 16.0 feet NGVD and is also simulated as drains and discharges southeastward into the Nine Gems property. Runoff from the property is introduced back into the model using the diversion package.
- Hobe St. Lucie Conservancy District Unit 2: Unit 2 is simulated with a control elevation of 12.0 feet NGVD using the drain package. Runoff from the property drains directly into the Cypress Creek canal using the diversion package.
- Gulfstream West Property: Gulfstream West is controlled at an elevation of 8.0 feet NGVD using the drain package. Runoff drains directly into the Cypress Creek Canal via the diversion package.
- Moonshine Creek and Eastern Gulfstream Property: Hobe Grove Ditch structure is controlled at 2.0 feet NGVD from the Eastern Gulfstream property to where it intersects the Loxahatchee River proper. The Eastern Gulfstream property is simulated using the drain package with elevation ranging from 12 NGVD for the perimeter canal to 6.0 feet NGVD in the agricultural areas. Runoff, using the ET-Recharge program is discharged to the southern end of the Unit 3 canal which then discharges directly into the Hobe-Grove Ditch.
- Culpepper Property: The Culpepper culverts are simulated as follows. Because of the size of the model grid the twin 84 inch culverts and WCS-2 are simulated at 17.6 feet NGVD. WCS-3 is simulated separately but also at 17.6 feet NGVD. The Jupiter grade culvert is also simulated in the model at 18.5 feet NGVD.
- Cypress Creek and Shiloh Farms Property: Small culverts underneath Gulfstream Road are not directly simulated in the model. The model assumes overland flow across the road. Improvements to this area are not included in the existing conditions.
- Ranch Colony and other Development Communities: The control elevations for these small parcels are simulated in the model using the drain package at the elevations specified.

- Indian Trail Improvement District (ITID) M-1 Basins:
  - Maximum discharge from ITID is limited to 750 cfs for the upper and lower basins using the RDF package. Flow in the south portion of ITID, south of the lower basin, is simulated using the drain package.
  - ITID flows head south to the C-51 canal.
  - Control elevations in the upper and lower basins of ITID are controlled using the RDF package at the elevations specified for each basin.
- Other Related Project Structures (outside LECsR-NP model boundary):
  - Stages at S-155 and S-155A are boundary conditions along the southern edge of the model. Stages for these canals are obtained from the SFWMM run.
  - STA-1E and STA-1W are outside the active model domain and are not simulated.
- Pumping and Water Restriction Areas:

- Public Water Supply (PWS) wellfield withdrawals from the surficial aquifer system (SAS) are simulated using the permitted allocations. In the case of West Palm Beach, the city's surface water withdrawals are represented in the model as SAS withdrawals from the M-Canal within the Grassy Waters area.
- Coastal well triggers are used to simulate water shortages when the potential for salt water intrusion exists into localized areas. Due to recent modifications made by the utilities several now partially rely upon the Floridan aquifer to meet their demands. This results a significant reduction in the threat of localized salt water intrusion in a number of coastal areas of the model domain and was implemented through the South Florida Water Management District (SFWMD) permitting process. However, the Palm Beach County area still undergoes water shortage restrictions when the SFWMD regional system is threatened due to low Lake Okeechobee stages. Lake Okeechobee lake triggers are obtained from the SFWMM model and occurred in Nov. 1972; Nov. 1976; Nov. 1977; Nov. & Dec. 1981; Jan. & Feb. 1982; Dec. 1989; Feb. 1990; Dec. 1990; Jan. 1991; Dec. 2000; and Jan. and Feb. 2001. When a water shortage is triggered it generally stays into effect through the dry season.

E.2.1.2 Flow Ways

Flow ways (FWs) are defined as general locations within the LRWRP project area based on existing natural areas, topography, and associated canals. FWs are generally separated by developed lands. Within the LRWRP there are three defined FWs, simply referred to as FW1, FW2, and FW3 (***Figure E.1- 1***).

Figure E-1: Orientation of Three Flow Ways within the Loxahatchee Watershed.

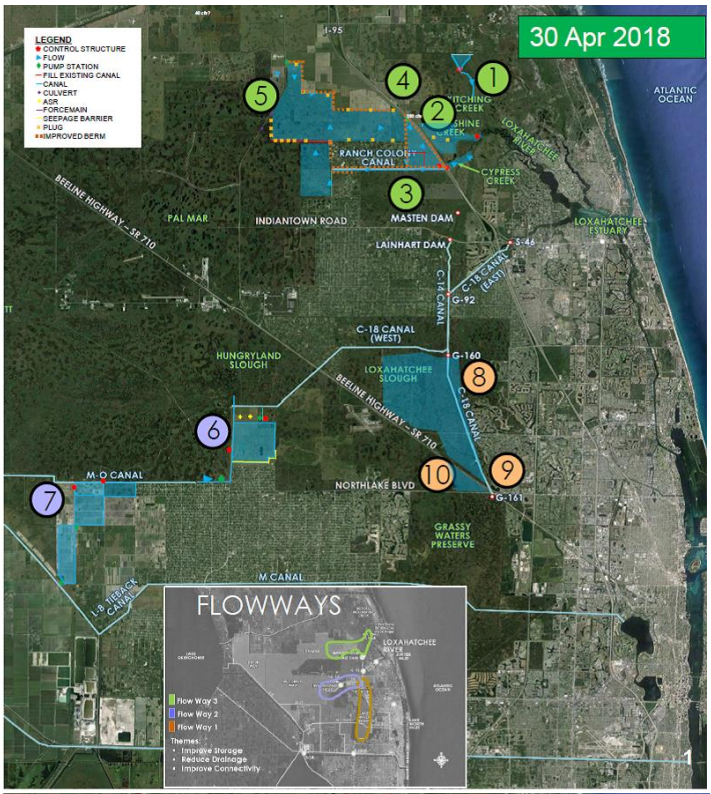
E.2.1.3 Project Alternatives

The PDT initially developed a list of 98 management measures for LRWRP which included: spreader canals, pump stations, conveyance canals, weirs, backfill/plugging of canals, removal of levees and berms, bridges and culverts, storage features, seepage barriers, operational changes (and other non-structural solutions), vegetation management measures, and adaptation planning measures. These 98 measures were initially screened to 85. The remaining measures were then combined into components and screened down to 21 components. These 21 components were further combined into "options" based on their location (flow way). Each option only exists in one FW (***Figure E.1- 1***). FW1 had 7 options. FW2 had 7 options and FW3 had 6 options. The options under each FW underwent additional screening.

To achieve restoration flows to the NWFLR, contributions are needed from all three FWs. Initial alternatives were generated by combining one option from each FW, generating 8 alternatives. Two alternatives were proposed by local governments. Three alternatives were developed to improve initial alternatives and two alternatives were added to address questions about specific structures. In total, 15 alternatives made up the initial array of alternatives. In March 2016, the PDT implemented a scoring method for the 15 alternatives in the initial array. Six (6) alternatives were screened out based on scoring leaving nine (9) alternatives. The remaining nine (9) alternatives were then compared to one another for similarity. Four (4) alternatives were screened out due to their similarity with other remaining alternatives (the highest similar alternative was retained). The five (5) remaining alternatives were reduced to four (4) for the final array of alternatives (***Figure E.1- 2*** and ***Figure E.1- 3***) with the elimination of Alternative 12 during the Alternatives Milestone Meeting.

ALTERNATIVE 2

1. Kitching Creek (Hydration) Spreader canal; weir/plug (Jenkins Ditch)
2. Moonshine Creek (MC) & Gulfstream East (GE) (Restoration): Connect HSLCD ditch to MC; clear MC vegetation; weir in Hobe Grove Ditch; regrade adjacent area to historic topography
3. Cypress Creek Canal (CCC) (Reduce Over-drainage): Replace CCC weir to raise control elevation, raise berm at Ranch Colony; automate twin 84" culverts;
4. Gulfstream West (Restoration & Reduce over-drainage): Partial backfill & relocate southern end of HSLCD canal; small pump, construct flow through marsh to attenuate flows
5. Palmar East (Restoration & Connectivity) Plug ditches; remove pipes; improve northern berm; construct western berm; improve eastern berm; pumps at Thomas Farm to redirect drainage to GW flow- through marsh via north Nine Gems canal
6. C-18W Reservoir (7,200 ac/ft & 2 ASR wells): Above-ground reservoir; inflow pump; discharge structure; seepage control; M-O Canal connector and pump
7. L-8 Basin Shallow Storage (4,300 ac/ft; includes pumps & channels)
8. G-160 Structure (Reduce Over-drainage): improve hydroperiod in Loxahatchee Slough
9. G-161 Structure (Connectivity): GWP water to Loxahatchee Slough
10. GWP Triangle (Connectivity)



ALTERNATIVE 5

1. Kitching Creek (Hydration): Spreader canal; weir/plug (Jenkins Ditch)
2. Moonshine Creek (MC) & Gulfstream East (GE) (Restoration): Connect HSLCD ditch to MC; clear MC vegetation; weir in Hobe Grove Ditch; regrade adjacent area to historic topography
3. Cypress Creek Canal (CCC) (Reduce Over-drainage): Replace CCC weir to raise control elevation; raise berm at Ranch Colony; automate twin 84" culverts;
4. Gulfstream West (Restoration & Reduce Over-drainage): Partial backfill & relocate southern end of HSLCD canal; small pump; construct flow through marsh to attenuate flow
5. Palmar East (Restoration & Connectivity) Plug ditches; remove pipes; improve northern berm; construct western berm; improve eastern berm; pumps at Thomas Farm; redirect drainage to GW flow-through marsh via north Nine Gems canal
6. C-18W Reservoir (9,500 ac/ft & 4 ASR Wells): Above-ground reservoir; inflow pump; discharge structure; seepage control; M-O Canal Connector and pump
7. G-160 Structure (Reduce Over-drainage): Improve hydroperiod in Loxahatchee Slough
8. G-161 Structure (Connectivity): GWP water to Loxahatchee Slough
9. GWP Triangle (Connectivity)
10. M-1 Pump Station (Conveyance): Deliver Lower M-1 Basin water to M-Canal, GWP, and G-161

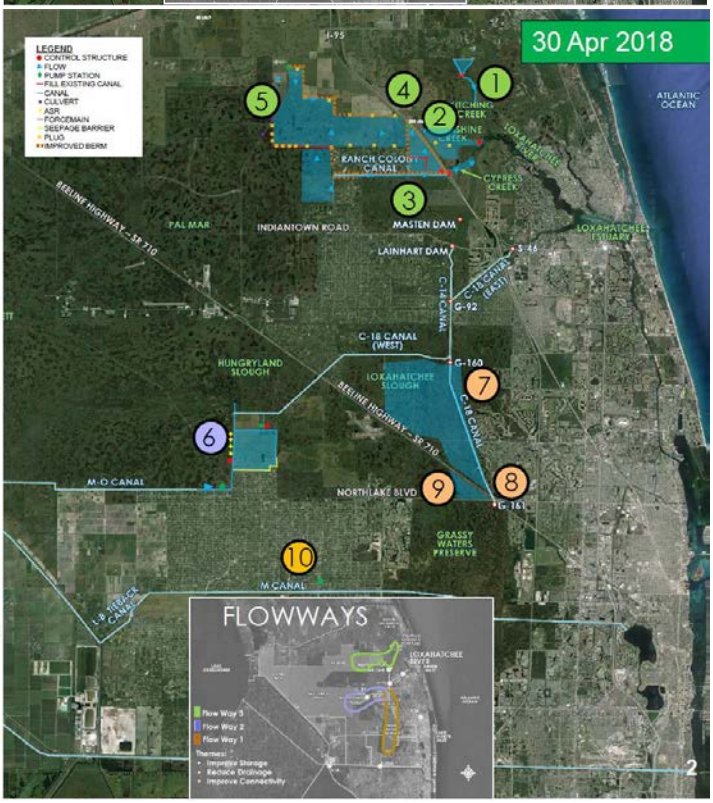
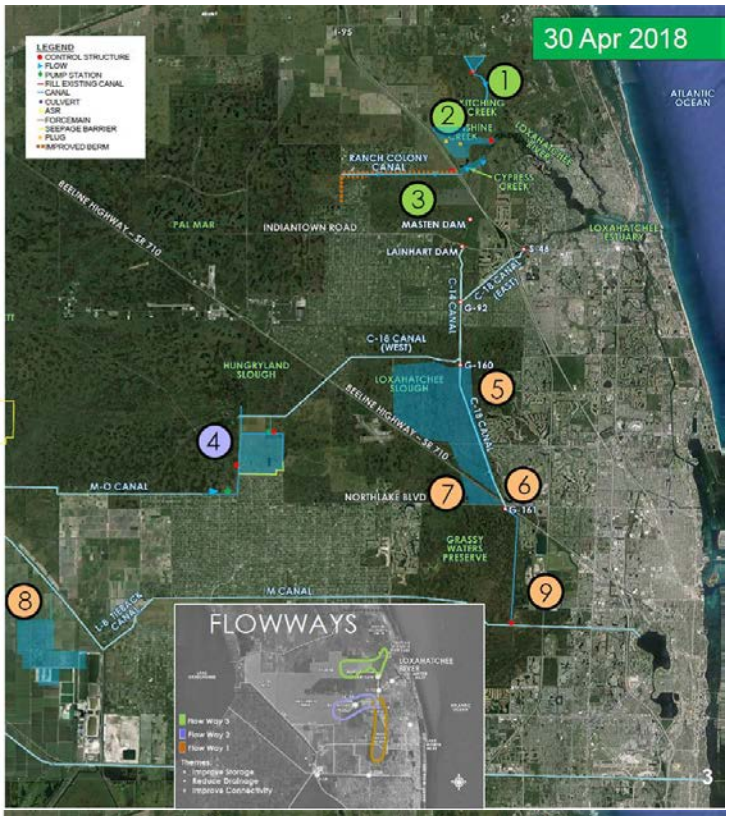


Figure E-2: LRWRP Alternatives 2 and 5.

ALTERNATIVE 10

1. Kitching Creek (Hydration): Spreader canal; weir/plug (Jenkins Ditch)
2. Moonshine Creek (MC) & Gulfstream East (GE) (Restoration): Connect HSLCD ditch to MC; clear MC vegetation; weir in Hobe Grove Ditch; regrade adjacent area to historic topography
3. Cypress Creek Canal (CCC) (Reduce Over-drainage): Replace CCC weir; raise berm at Ranch Colony; automate twin 84" Culverts
4. C-18W Reservoir (7,200 ac/ft): Above-ground reservoir; inflow pump; discharge structure; seepage control; M-O Canal Connector and pump
5. G-160 Structure (Reduce Over-drainage): improve hydroperiod in Loxahatchee Slough
6. G-161 Structure (Connectivity): GWP water to Loxahatchee Slough
7. GWP Triangle (Connectivity)
8. C-51 Deep Reservoir (Storage): 44,000 ac/ft; includes pump & channels
9. Force Main (Conveyance): Pump and pipeline through Grassy Waters Preserve to connect M-Canal to G-161



ALTERNATIVE 13

1. Kitching Creek (Hydration): Spreader canal; weir/plug (Jenkins Ditch)
2. Moonshine Creek (MC) & Gulfstream East (GE) (Restoration): Connect HSLCD ditch to MC; clear MC vegetation; weir in Hobe Grove Ditch; regrade adjacent area to historic topography
3. Cypress Creek Canal (CCC) (Reduce Over-drainage): Replace CCC weir; raise berm at Ranch Colony; automate twin 84" culverts; pump and spreader swale; regrade CC southern forks
4. Gulfstream West (Restoration & Reduce Over-drainage): Partial backfill & relocate southern end of HSLCD canal; small pump; construct flow through marsh to attenuate flow
5. Palmar East (Restoration & Connectivity): Plug ditches; remove pipes; improve northern berm; construct western berm; improve eastern berm; pumps at Thomas Farm to redirect drainage to GW flow through marsh via north Nine Gems canal
6. Natural Storage C-18W (Basin Restoration): Restore natural topography; seepage barriers; culverts for Beeline Hwy; backfill interior canals south of C-18W Canal; pump station at Mecca; flow-paths through Mecca & Avenir; M-O Canal connector & pump
7. L-8 Basin Shallow Storage (6,500 ac/ft & 4 ASR wells): includes pumps & channels
8. G-160 Structure (Reduce Over-drainage): improve Hydroperiod in Loxahatchee Slough
9. G-161 Structure (Connectivity): GWP water to Loxahatchee Slough
10. GWP Triangle (Connectivity)

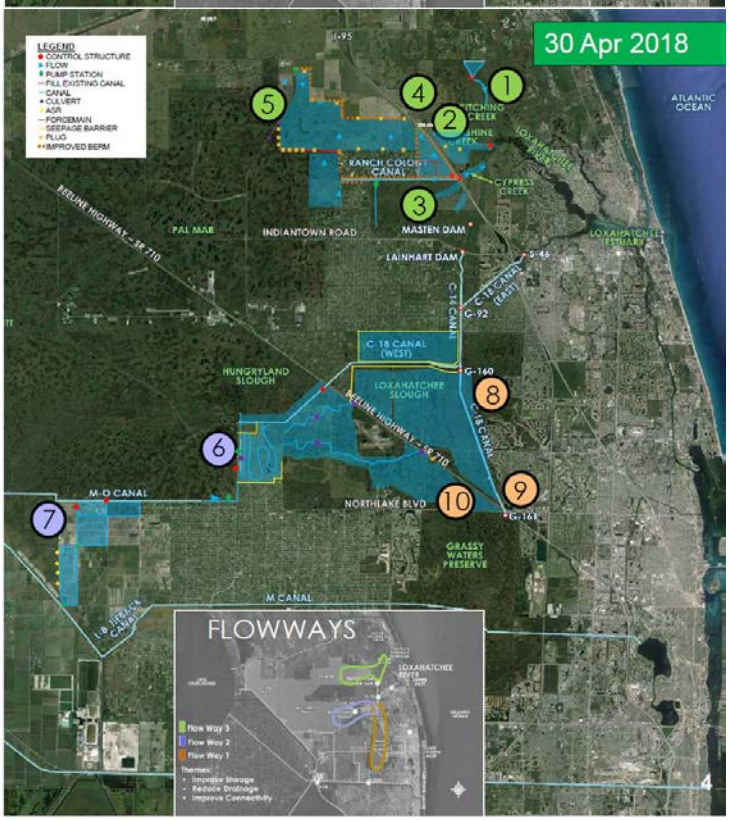


Figure E-3: LRWRP Alternatives 10 and 13.

E.2.1.4 Project Alternative 5R

Model results for the LRWRP ALTs were complete and posted for review on April 13, 2018. After the completion of the modeling results, the LRWRP PDT updated Alternative 5, in June 2018, to include a pump station and a spreader channel near Mack Dairy Road [from Alternative 13 (ALT13)] in FW3 after seeing the modeled benefits of these two features (***Figure E.1- 4***). This change to Alternative 5 (ALT5) to Alternative 5R (ALT5R) did not result in additional modeling runs. Modeling data for FW3 in the new ALT5R exists in the modeling data for FW3 in ALT13 from modeling completed on April 13, 2018. ALT5 is no longer a consideration as a project alternative for LRWRP. With an addition of 1,383 wetland habitat units (performance measure #4 [PM4]), ALT5R replaced ALT5, and along with Alternative 2 (ALT2), Alternative 10 (ALT10), ALT13, and FWO make up the final array of alternatives for LRWRP as of this evaluation.

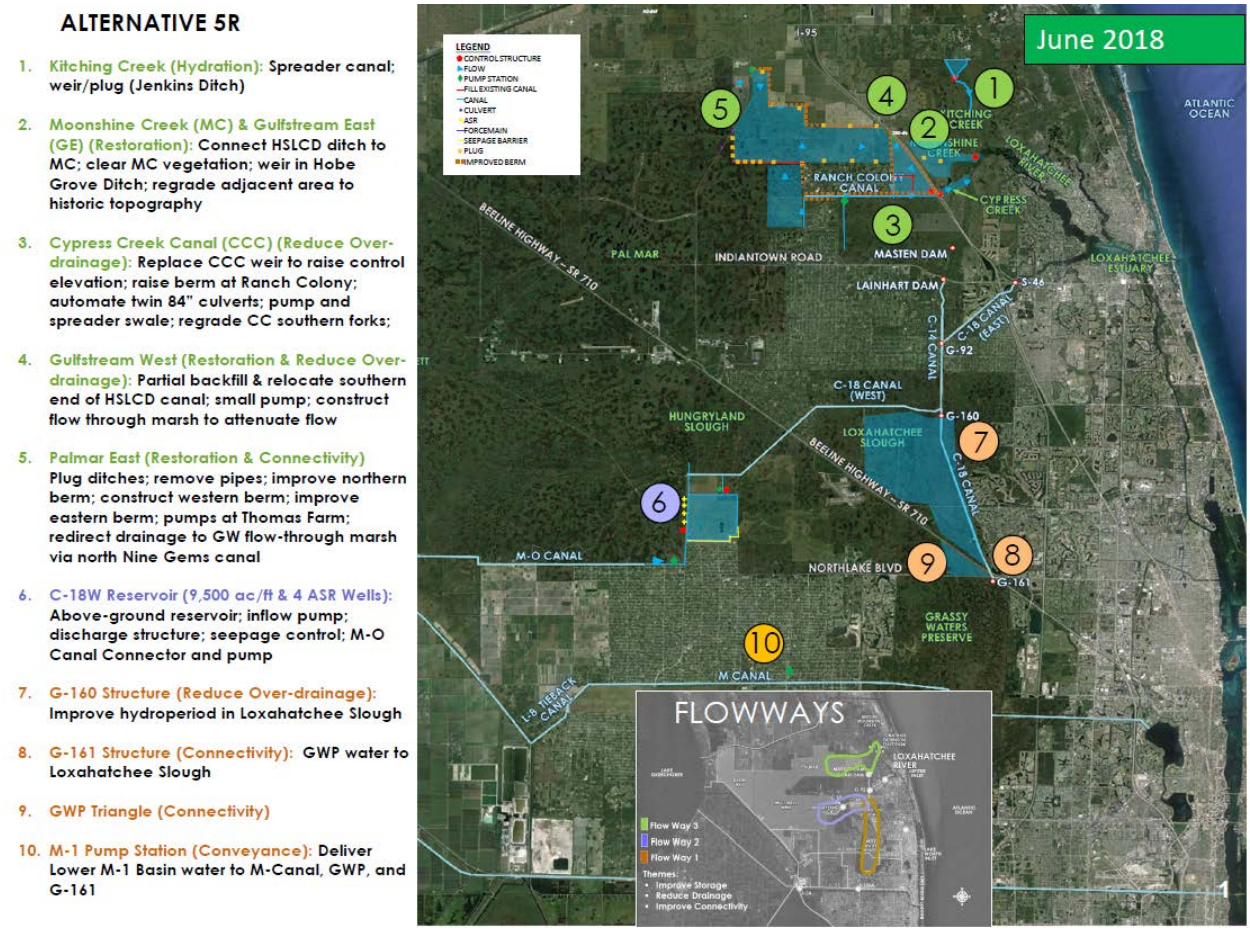


Figure E-4: LRWRP Alternative 5R (Revision of LRWRP ALT5).

E.2.2 Performance Measures

The performance measures (PM) used to define restoration targets and evaluation methodology were developed by the LRWRP PDT. As such, these are not RECOVER performance measures. However, each LRWRP performance measure, listed below, was reviewed by RECOVER as part of the LRWRP RECOVER Consistency Review. After evaluating each performance measure, RECOVER made comments and

suggestions to the LRWRP PDT resulting in final versions based on the most up-to-date science, knowledge, and methodology. The performance measures used in the evaluation of the LRWRP were:

- LRWRP Performance Measure 1 (PM1): Seasonal Flows to Manage Salinity and Floodplain Hydroperiod in the Northwest Fork of the Loxahatchee River
- LRWRP Performance Measure 4 (PM4): Hydrologic Regimes of Major Plant Communities in the Loxahatchee Watershed and Adjacent Wetlands
- LRWRP Performance Measure 9 (PM9): Hydrologic/Spatial Connectivity

PM1 evaluates restoration of the Northwest Fork of the Loxahatchee River and Estuary.

PM4 and PM9, in combination, evaluate the total Loxahatchee Watershed.

E.2.3 Uncertainty

Model uncertainty can be characterized in several forms (RECOVER 2002), but generally they fall into two categories: knowledge uncertainty or natural variability uncertainty. Knowledge uncertainty relates to errors in how a particular species or parameter will respond to various environmental and habitat conditions. Knowledge uncertainty can be measured using calibration statistics for the hydrologic models which can be propagated to the ecological models that use hydrologic output. The limits of a model's representation of actual factors or conditions can be described in model documentation reports. Natural variability relates to the temporal and spatial uncertainty with each input and output in the model and is further complicated by climate change nonstationarity. The significance of both types of model uncertainty is that it can pose a risk to identifying and implementing the best project plan to achieve restoration goals and objectives. Scenario analysis can be used to evaluate variations of an alternative which is more robust (perform better under a range of future conditions) to help minimize the risk associated with natural variability uncertainty. Adaptive management is another tool that can help reduce uncertainty associated with implementing the best alternative plan and operations to meet restoration performance goals.

E.2.3.1 Knowledge-based Uncertainty

Planning Uncertainty

The RECOVER regional evaluation made use of plan formulation assumptions for structure operations, structure maintenance, drainage, flow direction, flow rate, discharges, and land development within the LRWRP boundary (Section 1.3.1). If any of these assumptions are altered or not implemented, the results for each alternative could change.

Model Uncertainty

The hydrologic models used for evaluating the LRWRP is the Lower East Coast sub-Regional (LECsR) North Palm Beach (LECsR-NP) and the Regional 2x2 South Florida Water Management Model (SFWMM). The LECsR-NP is sub-regional version of the LECsR, which encompasses 5100 square miles over six sub-regions (North Palm Beach, South Palm Beach, Broward, Martin, North Miami-Dade and South Miami-Dade) and includes the Everglades Agricultural Area (EAA), Everglades National Park (ENP), and sections of Monroe and Collier counties. The LECsR model (including sub-regional models) is designed to assess differences

in groundwater flow, as well as, water supply and management. The model has a number of assessment module tools including: recharge, evapotranspiration (ET), river, drain, redirected flow, lake, operations, wetland, well, trigger, and reinjection drainflow. The current version of the LECsR also incorporates a weather module and ET-recharge and surface water management modules. The LECsR is compatible with and incorporates data from the SFWMM which assesses the relationship between water supply and demand in Palm Beach, Broward, Dade, and portions of seven other south Florida counties. The LECsR-NP model does have limitations and constraints which lead to model uncertainty. The "Model Calibration update of the Northern Palm Beach County Version of the Lower East Coast Subregional Model (LECsR-NP)" draft report states, "the model assumes constant fluid density, no transport, and no hydraulic routing. The model lacks canal-sizing capabilities and assumes canals have the capacity to route flows" (SFWMD 2017). There is limitation with the "Wetland Package (module)," which was designed to route overland flows but not to route open channel flows (SFWMD 2017). The LCEsR-NP is challenged to accurately simulate over land flow (including runoff and recharge) as it uses the year 2013 only to assess land use, which has changed over time due to urbanization and ongoing restoration projects (SFWMD 2017). The 2017 report also recommends review of rainfall and flow data, improvement of modeling software with less manual development, improvement to model packages for simulation of water delivery and canal routing process which will improve accuracy, and use multiple years of land use data during calibration.

Performance Measure and Ecological Planning Tool Uncertainty

The LRWRP regional evaluation is based on technical evaluation by RECOVER. This evaluation is performed using project-developed PMs (Appendix G) that have not gone through RECOVER scientific review and approval processes. RECOVER PMs typically describe performance measure uncertainty in the RECOVER documentation sheets for each PM. The project-developed PMs do not include information regarding uncertainty and how it might be addressed. Uncertainty exists with use/assessment associated with the ecological planning tool, PM1 Salinity Regression Tool, due to LECsR-NP errors and deficiencies in the model output that goes into the Salinity Regression Tool. The Salinity Regression Tool uses flow input to model salinity in the Northwest Fork of the Loxahatchee River (NWFLR). Model output from the LECsR-NP was in essence the same for tributary flow, which increased the uncertainty with output from the Salinity Regression Tool.

Knowledge Uncertainty

Performance measures and ecological planning tools are simplifications of the real relationships between hydrology and a particular ecological indicator of interest. Errors can result based on known and unknown responses of species and habitats (communities) to various environmental and other habitat conditions. This type of uncertainty is inherent with any ecosystem restoration project and is minimized by using the best available science to develop and interpret model results. In addition, uncertainty is addressed by proceeding with project implementation through an adaptive management approach that tests hypotheses about the best project design and operations to achieve desired results.

ASR Uncertainty

While a number of sources for uncertainty exist within LRWRP, the use of the small number of ASR wells at the scale envisioned for this project is not a significant source of uncertainty. The CERP ASR pilot projects and ASR Regional Study provided a substantial reduction in the degree of uncertainty regarding

regional implementation of the technology. The CERP ASR reports were reviewed in 2015 by the National Research Council of the National Academies' Committee on Independent Scientific Review of Everglades Restoration Progress (CISRERP). Although some additional follow-up studies were suggested, the CISRERP concluded that they could be accomplished through phased implementation and construction of ASR multi-well clusters (NRC 2015). RECOVER recommends the project pursue ecotoxicological testing of ASR technology to address the uncertainty associated with LRWRP's use of ASR that was identified as part of the CISRERP report on Everglades restoration progress.

E.2.3.2 Natural Variability-based Uncertainty

Climate Change Uncertainty

The LECsR-NP model uses a historic 41 year period of record (1965-2005) of rainfall and hydrology to simulate interaction of surface water/groundwater, evapotranspiration, and water management (movement of water through canals, structures, seepage, overland flow or estuarine flow) to estimate the flow, water depths and durations, and salinities in the estuaries. Project infrastructure (e.g., canals, water control structures) and operations are portrayed in abstraction that generally mimic the intent of the project features while not matching the exact mechanisms by which these operations would be achieved in the actual conditions. Climate change nonstationarity means that the past climatic conditions (41 year period of record for the hydrologic models) are not indicative of future climatic conditions. Uncertainty exists due to the inability to predict/forecast swings in rainfall from extreme storm events to extreme drought, rising temperatures, salt water intrusion, extent of sea level rise and the impacts resulting from these climate changes.

Sea Level Rise and Tidal Push

Historically, Jupiter Inlet went through periods of being open and closed (Hu 2002, Palm Beach County 2016). Sediment transport along with storm events most likely influenced the natural opening and closing, as well as migration of Jupiter Inlet. Dredging and stabilization of Jupiter Inlet increased hydraulic conveyance of the inlet and increased the tidal influence into the Loxahatchee River and Estuarine System (Hu 2002). Tidal influence is further exacerbated by an average sea level increase of 3.70 +/- 0.58 mm/yr at Lake Worth Pier, approximately 23 miles south-southeast of Jupiter Inlet (***Figure E.1- 5***) (NOAA). Ever rising sea levels increase the tidal reach further upstream of inlet associated rivers and tributaries resulting in salt water intrusion further upstream. Uncertainty exists in the predictability of salinity and tide regimes due to the unpredictability of future sea level rise.

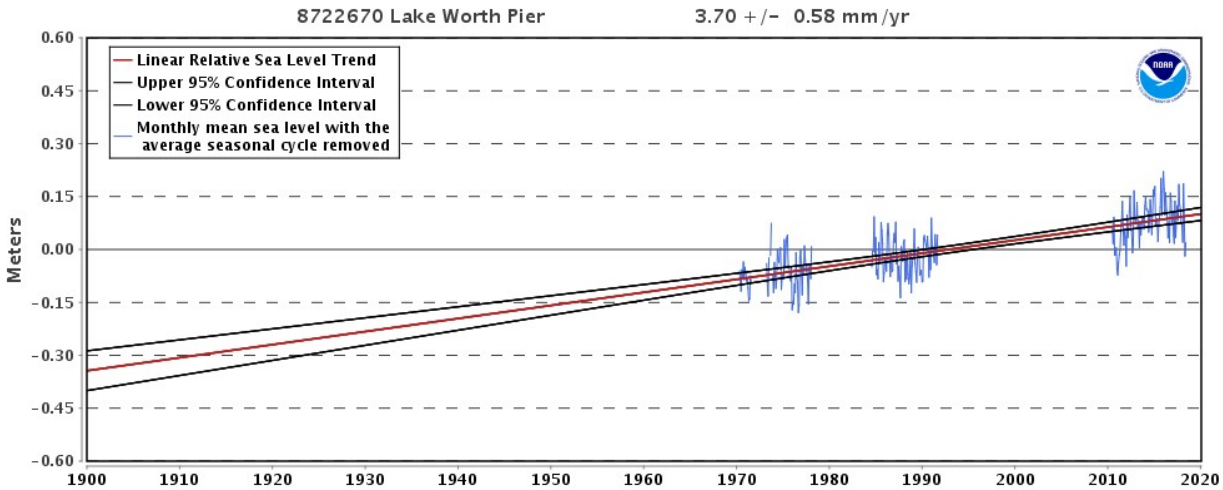


Figure E-5: Sea Level Trends at Lake Worth Pier since 1900 (NOAA).

Hurricane Frequency and Intensity

Hurricanes create an unpredictable setting when they near land. Hurricanes may affect the ecology within the boundary of the LRWRP via high shifting winds, storm surge, tidal push (saltwater intrusion), erosion, and high rainfall amounts. A study titled, "Effects of Two Hurricanes on *Syringodium filiforme*, Manatee Grass, Within the Loxahatchee River Estuary, Southeast Florida," revealed devastating effects of Hurricane Frances and Hurricane Jeanne in September 2004 to the ecology within the Loxahatchee River Estuary (Ridler et al. 2006). Effects of these two hurricanes included ecological damage (thinning) due to hurricane force winds in the estuary, increased rainfall (610 mm during September 2004 compared to 25 year average of 230 mm for September), increased discharge rates through the northwest and southwest forks of the Loxahatchee River (36.8 cubic meters per second monthly average for September 2004 [with a peak of 113.3 cubic meters per second] compared to 10.9 cubic meters per second monthly average for September over a 25 year period) (Ridler et al. 2006). This example shows the impacts hurricanes can have, regardless of strength. Increases in sea water temperatures associated with climate change may increase storm frequency and strength which adds a measure of unpredictability (uncertainty) regarding impacts of hurricanes on the LRWRP.

E.2.4 Evaluation Process and Organization

A RECOVER team (***Table E.6- 1***), consisting of members representing the RECOVER regions of Lake Okeechobee (LO), Northern Estuaries (NE), Greater Everglades (GE), and the Southern Coastal Systems (SCS), evaluated LRWRP ALTs using approved project PMs, best available scientific information, and best professional judgment. This evaluation was performed, utilizing the knowledge and expertise representative of the system as a whole, to help in understanding the regional hydrological and ecological performance of each alternative. This RECOVER system-wide (regional) evaluation report is organized by three impact areas associated with LRWRP: (1) Northwest Fork of the Loxahatchee River and Estuary, (2) Loxahatchee Watershed, and (3) Lake Okeechobee lake stage. Impacts to the RECOVER Module "Southern Coastal Systems," are not anticipated as a result of LRWRP. A summary of this RECOVER regional evaluation and recommendations are included in the executive summary, found in Annex E of the LRWRP Project Implementation Report/Environmental Impact Statement (PIR/EIS). Background information on

LRWRP goals, objectives, assumptions, and alternatives is included in this section. The following sections describe the evaluation process used to assess each impact area.

E.3 NORTHWEST FORK OF THE LOXAHATCHEE RIVER AND ESTUARY

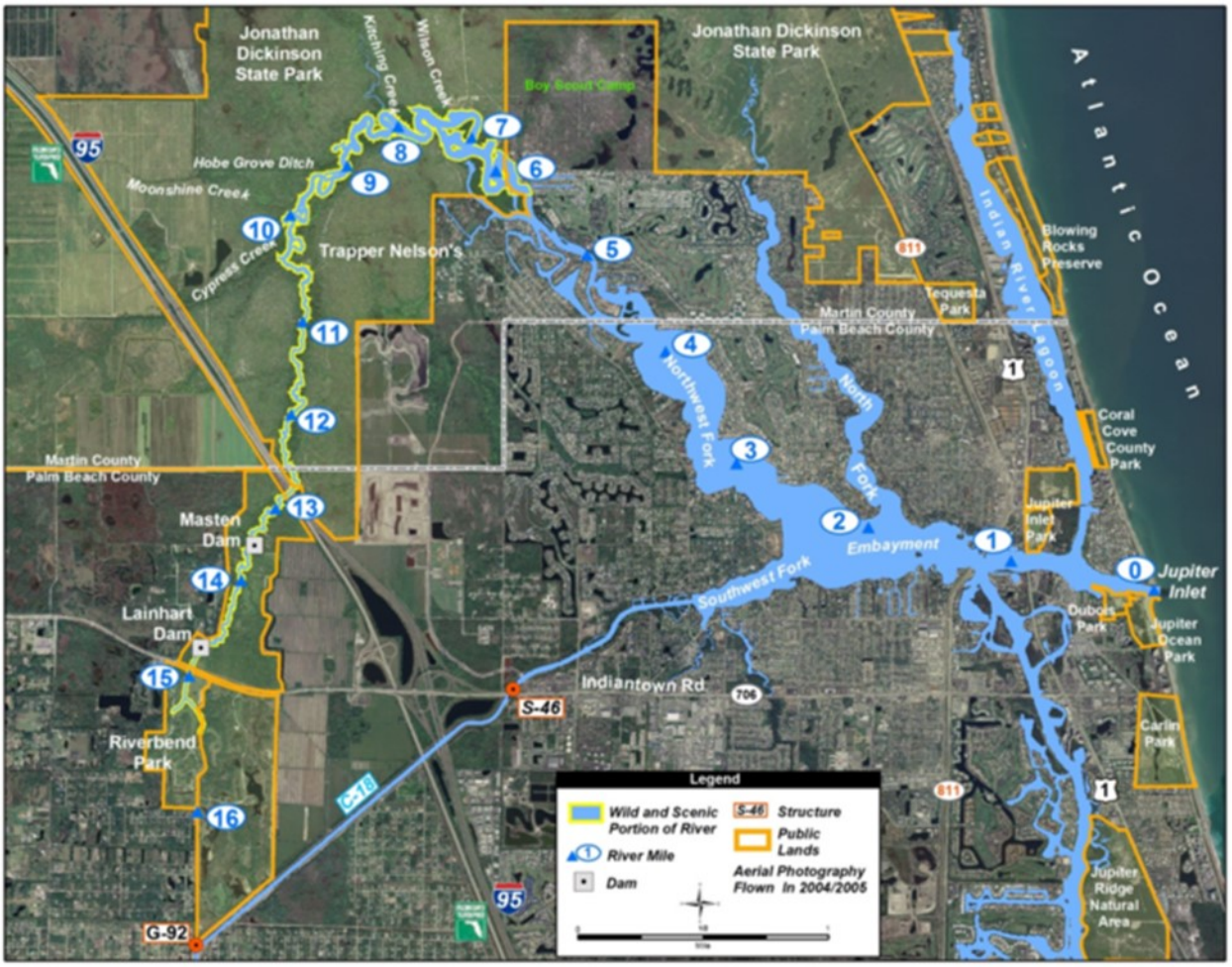


Figure E.2- 1: Map of the Loxahatchee River and Estuary.

E.3.1 Introduction

Designated in 1985 as a "National Wild and Scenic River," the NWFLR is one of only two rivers in Florida to have that distinction. The NWFLR is one of three forks, along with the north fork and southwest fork, which flows into a central embayment to form the Loxahatchee River and Estuary (***Figure E.2- 1***). Historically, the Loxahatchee River has drained the approximately 218 square mile Loxahatchee River Watershed, until the early to mid-1900s when water control was implemented to support land development, navigation, and agricultural practices (VanArman et al. 2005). This resulted in the creation of hydrologic units within and adjacent to the historic watershed resulting in the current drainage of approximately 240 square miles (SFWMD et al. 2010). In the 1930s, Lainhart (***Figure E.2- 2***) and Masten (***Figure E.2- 3***) dams were constructed which reduced freshwater flow to the NWFLR resulting in improved conditions for the freshwater floodplain surrounding the upper NWFLR. In 1948, Jupiter Inlet was

permanently opened and stabilized which increased tidal exchange allowing for salt water intrusion directly from the Atlantic Ocean to infiltrate farther upstream in the NWFLR. Prior to 1948, Jupiter Inlet had a history of naturally opening and closing over time, as well as, anthropogenic manipulation (Palm Beach County 2016) with the earliest documented opening occurring 1837. In 1958, the C-18 canal was constructed which drained the Loxahatchee Watershed. The implementation of the C-18 canal diverted the majority of freshwater flow into the central embayment via the Southwest Fork, effectively cutting off one of the major sources of water to the NFLWR in the Loxahatchee Slough. In 1975, the G-92 structure was constructed to redirect some flow back to the NWFLR. In 2018, the South Florida Water Management District (SFWMD) completed the "Lainhart and Masten Dams Maintenance Repair Project," which included seepage correction, erosion control, bank repair and stabilization, structural repairs, and portages corrections (SFWMD 2015). Today, half of the freshwater flow to the NWFLR comes via the Lainhart Dam. Other sources of freshwater to the NWFLR are groundwater seepage and other tributaries (Cypress Creek, Hobe Grove Ditch, and Kitching Creek) (***Figure E.2- 1***).

Figure E.2- 2: Lainhart Dam at 15 cfs (pre-2018).

Figure E.2- 3: Masten Dam during higher flows (pre-2018).

Due to the intrusion of salt water as a result of reduced freshwater flows and the creation of a direct source of tidal oceanic salt water, the ecology of the NWFLR has not only been subject to degradation but has resulted in ecological regime shifts further upstream from the Loxahatchee Estuary. To address these issues, the purposes of LRWRP include: (Goal 1) 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, and (Goal 3) restore and sustain salinity conditions in the Loxahatchee River Estuary (***Table E.1- 2***).

E.3.2 Performance Measures and Evaluation Approach

To assess the effects of the LRWRP, model output from four (4) project alternatives is contrasted and compared against targets and two different "base" conditions: the Existing Condition Baseline (ECB) and the Future Without Project (FWO). The ECB (2014B) represents the present configuration and operation of the water management system. The FWO (2070FWO) simulates a future configuration of the water management system without LRWRP but with future, additional restoration, and structural and operational components described in Section **E.1.3.1**.

The analysis for the NWFLR was completed using modeling data and results provided by the PDT for project-level evaluation PM1, "Seasonal Flows to Manage Salinity and Floodplain Hydroperiod in the Northwest Fork of the Loxahatchee River." PM1 was developed by the LRWRP PDT as an evaluation tool to assess the ability of project alternatives to achieve certain LRWRP objectives pertinent to the NWFLR by measuring wet and dry season flows to improve salinity and floodplain hydroperiods in the NWFLR (Objective 1 – ***Table E.1- 2***). PM1 uses regression equations that link flows to salinities downstream of Lainhart Dam and into the various salinity zones throughout the NWFLR (Objective 2- ***Table E.1- 2***). PM1 is based upon targets for seasonal flows and hydroperiods using a Valued Ecosystem Component (VEC) approach (USEPA 1987). VECs are species or communities that convey a complex message of ecological community composition and health in a simplified and useful manner (USEPA 1987). For LRWRP, the VECs are associated with characteristic salinity and hydrologic regimes at desired locations, with which project alternative scenarios are compared. There is some overlap in the VEC regimes, with their desired locations defined by river mile (RM) (***Figure E.2- 1***) in PM1:

1. Flood Plain Swamp and Hydric Hammock in the Freshwater **Riverine Flood Plain**: RM 16 to RM 9.5
2. Flood Plain Swamp in the **Tidal Flood Plain**: RM 9.5 to RM 8.0
3. Tape grass, ***Vallisneria*** *americana*: RM 10.5 to RM 6.5
4. Fish Larvae in the **Oligohaline Zone**: RM 10 to RM 5.5
5. Oysters in the **Mesohaline Zone**: RM 6.0 to RM 3.5
6. Seagrasses in the **Polyhaline Zone**: RM 4.0 to RM 0.0

A significant stressor for the VEC regimes is the alteration of salinity throughout the NWFLR. Species composition throughout the ecological communities associated with these VECs has shifted since the permanent opening and stabilization of Jupiter Inlet due to saltwater intrusion. Conceptually, altered hydrology in the form of reduced flows (stressor) coupled with altered salinity (ecological effect) and saltwater intrusion (ecological effect) have resulted in saltwater intrusion further upstream and a shift in the location/boundaries of salinity zones throughout the NWFLR. In order to restore the VEC regimes mentioned above, salinity targets for each VEC were developed. The salinity targets associated with each of these six (6) VECs are:

1. **Riverine Flood Plain**: 0 psu (practical salinity unit)
2. **Tidal Flood Plain**: < 2 psu
3. ***Vallisneria***: < 5 psu
4. **Oligohaline Zone**: 2 – 8 psu
5. **Mesohaline Zone**: 10 – 20 psu
6. **Polyhaline Zone**: > 20 psu

Despite some overlap in VECs, each are evaluated individually in this analysis.

E.3.3 Evaluation

All graphics utilized to evaluate the performance of LRWRP ALTs for restoration of the NWFLR contain the modeling results for ALT5 which was replaced in the final array of ALTs by ALT5R. The NWFLR lies in FW3 (***Figure E.1- 1***). ALT5R and ALT13 have the exact suite of project features for FW3 (***Figure E.1- 3*** and ***Figure E.1- 4***). For ALT5R, modeling data for FW1 and FW2 is the same as ALT5 and the same as ALT13 for FW3. Therefore, the modeling results for the tributaries of the NWFLR (Cypress Creek, Hobe Grove Ditch, and Kitching Creek) are the same for ALT5R and ALT13. Flow into the NWFLR via the Lainhart Dam for ALT5R is the same as ALT5, as the flow source is not in FW3.

E.3.3.1 Objective 1: Restore Wet and Dry Season Flows

Freshwater flow to the NWFLR from the Loxahatchee Watershed via the Loxahatchee Slough (Lainhart Dam) and tributaries (Cypress Creek, Hobe Grove Ditch, and Kitching Creek) is vital to the overall health and ecological maintenance of the NWFLR. The 2006 Restoration Plan for the Northwest Fork of the Loxahatchee River determined the restoration targets for flow during the wet season and dry season (SFWMD and FDEP). The wet season flow restoration target is to achieve flows greater than 110 cfs for a minimum of 120 days between August and November (SFWMD and DEP 2006). The dry season restoration flow restoration target is to have variable flows between 50 and 110 cfs, with a mean monthly flow of 69 cfs over Lainhart Dam, and an additional 30 cfs from downstream tributaries when needed (SFWMD and FDEP 2006). LRWRP alternatives were assessed on how often they achieved (% of years within the POR) the restoration targets during the wet season and dry season throughout the POR (1965-2005) (***Table E.2- 1***).

Table E.2- 1: Success of LRWRP Alternatives Achieving Flow Restoration Targets for the Wet Season and Dry Season to the NWFLR.

Flows	ECB	FWO	ALT2	ALT5R	ALT10	ALT13
Wet Season*	76%	78%	98%	98%	100%	98%
Dry Season**	65%	65%	87%	91%	95%	80%

*Wet Season (August – November): flows of greater than 110 cfs for a minimum of 120 days.
**Variable Dry Season Flow: flows between 50 and 110 cfs, with a mean monthly flow of 69 cfs over Lainhart Dam, and an additional 30 cfs from downstream tributaries when needed.

Compared to the FWO, all LRWRP ALTs greatly improved freshwater flow to the NWFLR (***Table E.2- 1***) via the Lainhart Dam. Regarding wet season freshwater flow, improvements ranged from 20% (ALT2, ALT5R, and ALT13) to 22% (ALT10). There was little separation among the ALTs, however, ALT10 did outperform all other ALTs by 2%. Disparity in alternative success is more evident in the assessment of dry season flows to the NWFLR. Improvement of dry season flows from the FWO ranged from 15% (ALT13) to 30% (ALT10), with ALT2 and ALT5R in the middle (22% and 26% improvement from FWO respectively).

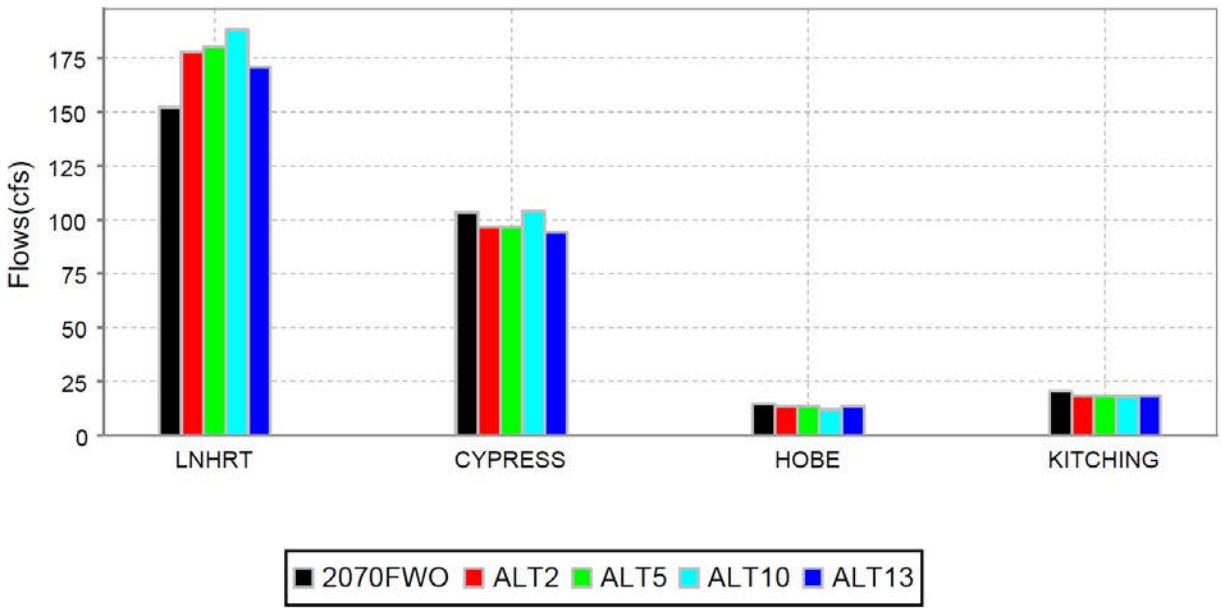


Figure E.2- 4: Contribution of Average Daily Tributary Flows to the NWFLR for the 41 POR (1965-2005).

Historically, surface water reaching the NWFLR entered via Lainhart Dam, Cypress Creek, Hobe Grove Ditch, and Kitching Creek (***Figure E.2- 1***). Approximately 50% of freshwater flow in the NWFLR arrived via Lainhart Dam with 32%, 5%, and 13% of freshwater flows entering via Cypress Creek, Hobe Grove Ditch, and Kitching Creek respectively. Estimations of flow to the NWFLR were made utilizing data from ***Figure E.2- 4***.

Table E.2- 2: Average Daily Flow to the NWFLR (cfs) Regardless of Season.

Flow Source	FWO	ALT2	ALT5R	ALT10	ALT13
Lainhart Dam	150	177	180	188	171
Cypress Creek	102	98	96	103	96
Hobe Grove Ditch	13	12	12	10	12

Flow Source	FWO	ALT2	ALT5R	ALT10	ALT13
Kitching Creek	20	19	19	19	19
Total	285	306	307	320	298

Table E.2- 3: Percentage of Flow to the NWFLR Based on Average Daily Flows (Regardless of Season).

Flow Source	FWO	ALT2	ALT5R	ALT10	ALT13	Historic
Lainhart Dam	52.6%	57.8%	58.6%	58.8%	57.4%	50%
Cypress Creek	35.8%	32.1%	31.3%	32.2%	32.2%	32%
Hobe Grove Ditch	4.6%	3.9%	3.9%	3.1%	4.0%	5%
Kitching Creek	7.0%	6.2%	6.2%	5.9%	6.4%	13%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100%

Table E.2- 2 and ***Table E.2- 3*** represent the average daily tributary freshwater flow, regardless of season, per year throughout the POR for each alternative. For perspective, tributary freshwater flows were analyzed by season. Average daily freshwater flow entering the NWFLR via all tributaries combined increases from +13 cfs (ALT13) to +35 cfs (ALT10) (***Table E.2- 2***). Compared to the FWO, much of the improvement of freshwater flow to the NFLWR is through Lainhart Dam (ALT10 +6.2%, ALT5R +6.0%, ALT2 +5.2%, ALT13 +4.8%) (***Table E.2- 3***). All alternatives have reduced tributary contributions from Cypress Creek, Hobe Grove Ditch, and Kitching Creek compared to the FWO.

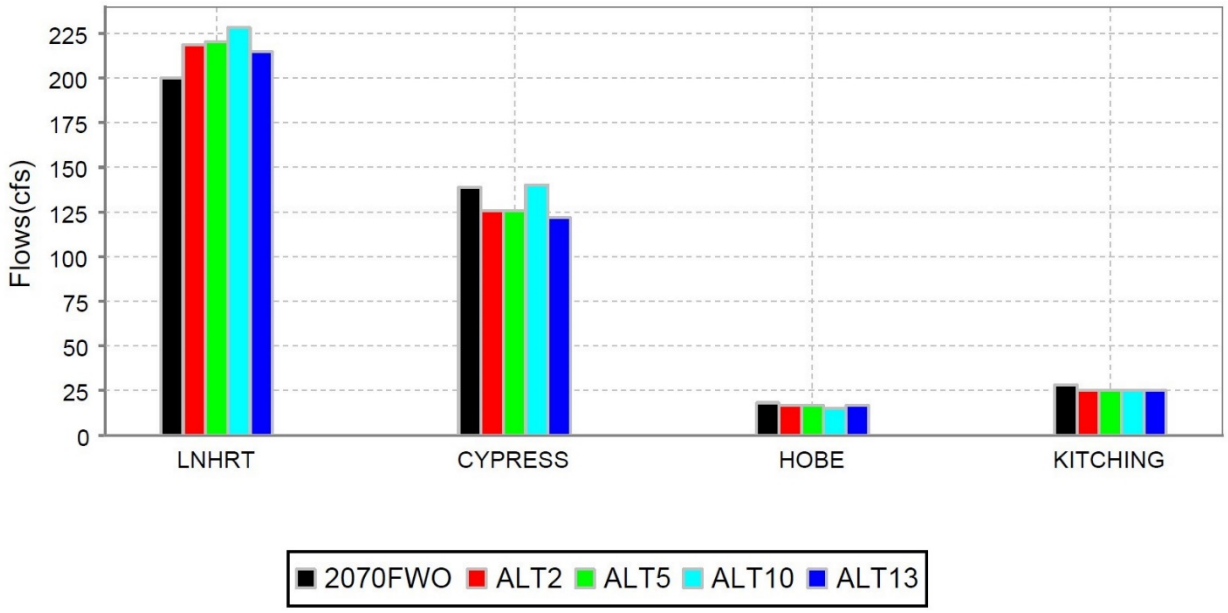


Figure E.2- 5: Wet Season Contribution of Average Daily Tributary Flows to the NWFLR (1965-2005).

Table E.2- 4: Wet Season Average Daily Flow to the NWFLR (cfs).

Flow Source	**FWO**	**ALT2**	**ALT5R**	**ALT10**	**ALT13**
Lainhart Dam	200	219	221	228	214
Cypress Creek	139	125	122	139	122
Hobe Grove Ditch	17	14	14	11	14
Kitching Creek	28	25	25	25	25
Total	384	383	382	403	375

Table E.2- 5: Percentage of Flow to the NWFLR Based on Wet Season Average Daily Flows.

	Percentage of Flow to NW Fork of Loxahatchee River (based on Wet Season AVG Daily Flows)				
Flow Source	**FWO**	**ALT2**	**ALT5R**	**ALT10**	**ALT13**
Lainhart Dam	52.1%	57.2%	57.9%	56.6%	57.1%
Cypress Creek	36.2%	32.6%	31.9%	34.5%	32.5%
Hobe Grove Ditch	4.4%	3.7%	3.7%	2.7%	3.7%
Kitching Creek	7.3%	6.5%	6.5%	6.2%	6.7%
Total	100%	100%	100%	100%	100%

Alternative performance for the average daily freshwater flow to the NWFLR during the wet season (***Figure E.2- 5***) differs from that of the average daily freshwater flow to the NWFLR regardless of season (***Figure E.2- 4***). ALT10 is the only alternative that increases freshwater flow (+19 cfs) to the NWFLR during the wet season compared to the FWO (***Table E.2- 4***). ALT2 has a slight decrease (-1 cfs) in total flow to the NWFLR during the wet season compared to the FWO, as does ALT5R (-2 cfs) and ALT13 (-9 cfs) (***Table E.2- 4***).

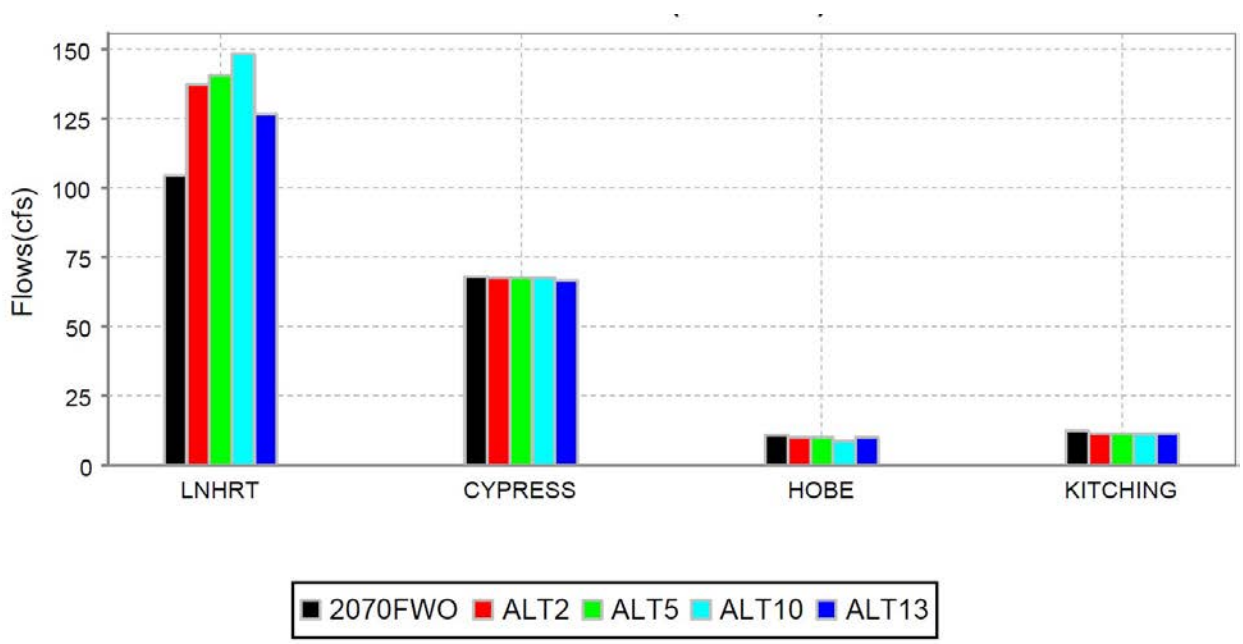


Figure E.2- 6: Dry Season Contribution of Average Daily Tributary Flows to the NWFLR (1965-2005).

As expected the average daily freshwater flow to the NWFLR during the dry season (***Figure E.2- 6***) are reduced compared to those of the wet season (***Figure E.2- 5***). Increases in freshwater flow to the NWFLR during the dry season via all tributaries ranged from +16 cfs (ALT13) to +36 (ALT10). Contributions of freshwater flow to the NWFLR during the dry season relies more heavily on flow through the Lainhart Dam compared to the tributaries for all alternatives and the FWO (***Table E.2- 6***).

Table E.2- 6: Dry Season Average Daily Flow to the NWFLR (cfs).

Flow Source	FWO	ALT2	ALT5R	ALT10	ALT13
Lainhart Dam	106	138	143	148	127
Cypress Creek	69	68	67	68	67
Hobe Grove Ditch	12	10	10	8	10
Kitching Creek	13	12	12	12	12
Total	200	228	232	236	216

Table E.2- 7: Percentage of Flow to the NWFLR Based on Dry Season Average Daily Flows.

Flow Source	FWO	ALT2	ALT5R	ALT10	ALT13
Lainhart Dam	53.0%	60.5%	61.6%	62.7%	58.8%
Cypress Creek	34.5%	29.8%	28.9%	28.8%	31.0%
Hobe Grove Ditch	6.0%	4.4%	4.3%	3.4%	4.6%
Kitching Creek	6.5%	5.3%	5.2%	5.1%	5.6%
Total	100%	100%	100%	100%	100%

Analysis from the 2006 Northwest Fork of the Loxahatchee River Restoration Plan states that the total volume of freshwater entering the system is the most important aspect of flow entering the Northwest Fork and not the amount entering through individual tributaries (SFWMD and FDEP). Therefore, the key performance metric regarding the restoration of freshwater flow to the NWFLR is average daily total flow. ALT10 increases freshwater flow to the NWFLR in both the wet and dry seasons compared to the FWO. All other alternatives (ALT2, ALT5R, ALT13) only increase freshwater flows, compared to the FWO, during the dry season. However, the increase in freshwater flows during the dry season overcomes the reduction in wet season daily freshwater flow rates for ALT2 (+28 cfs overall), ALT5R (+30 cfs overall), and ALT13 (+7 cfs overall) (***Table E.2- 4*** and ***Table E.2- 6***).

Of note are the freshwater flow rates at Kitching Creek. As the most downstream tributary to the NWFLR, Kitching Creek flows into the NWFLR between RM8 and RM9 (***Figure E.2- 1***). Tidal push of salinity upstream during high tides results in a "mixing" zone at the confluence of Kitching Creek with the NWFLR (SFWMD and FDEP 2006). High tide pushes the freshwater entering the NWFLR from Kitching Creek upstream. Increased volume of freshwater through Lainhart Dam compensates for the flow reduction via Kitching Creek in all project alternatives (compared to the FWO). Therefore, the reduction of freshwater flow from Kitching Creek is not significant.

E.2.3.2 Objective 2: Restore Oysters, Seagrass, and Other Estuarine Communities

The 2006 Northwest Fork of the Loxahatchee River Restoration Plan states that field data analysis of the Loxahatchee River demonstrated a correlation between salinity throughout the NWFLR and the total amount of freshwater entering the NWFLR (***Figure E.2- 7***) (SFWMD and FDEP). Due to strong tidal mixing near the confluence with Kitching Creek, the source of freshwater flow entering the NWFLR is not an important factor for salinity regime. However, the total volume of freshwater flow entering the NWFLR is an important factor for salinity regime throughout the NWFLR.

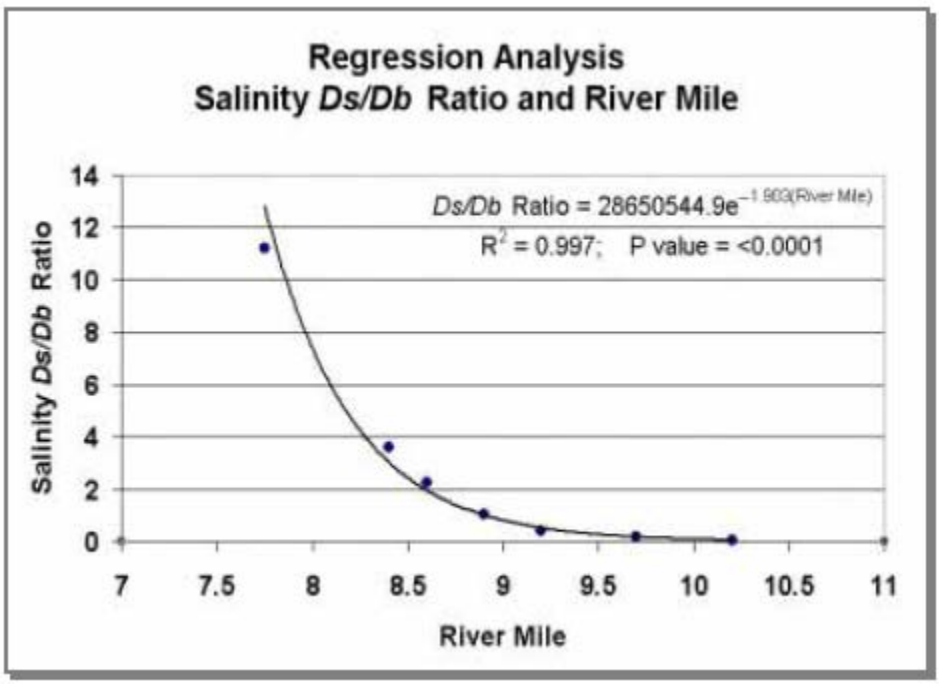


Figure E.2- 7: Correlation between Salinity Event Ratio Ds/Db (>1 ppt) and River Mile

(SFWMD and FDEP 2006). Ds is duration of all salinity events. Db is the duration between salinity events over time. Ds/Db is the salinity regime ratio of duration of all salinity events to the duration between these salinity events over time. (1 ppt, or psu is the threshold for inclusion).

Modeling data regarding salinity in the NWFLR for LRWRP alternatives has all freshwater flow to the NWFLR entering via the Lainhart Dam at approximately RM 14.5 (***Figure E.2- 1***), which represents freshwater flow input via the historic headwaters (Loxahatchee Slough) of the NWFLR. As previously

discussed, the source of freshwater flow to the NWFLR is not as important as the total amount of freshwater flow to the NWFLR (Section 2.3.1).

Evaluation of the modeling results for Objective 2 uses modeling data from ALT5 (formerly in the final array) and ALT13 to formulate the results for ALT5R (which was added to the final array in place of ALT5, but was not modeled) (Section E.1.3.4). As stated in Section E.2.3, analysis regarding any data influenced by Lainhart Dam utilizes modeling data from ALT5 and data related to the tributaries (Cypress Creek, Hobe Grove Ditch, and Kitching Creek) utilizes modeling data from ALT13. In this section, data for the Riverine Flood Plain VEC for ALT5R uses modeling results for ALT5. All other ALT5R VEC data uses ALT13 data. This is due to the downstream position of Riverine Flood Plain VEC in relation to all of the tributaries. Due to ALT5R having more total freshwater flow compared to ALT13 (Table E.2-2), the ecological and hydrological benefits in the objective 2 analysis for ALT5R are slightly underestimated.

Table E.2- 8: Salinity Performance Results from Performance Measure 1.

Obj.2 restore river, flood plain, estuary		Salinity Tool Performance Habitat Units (Acres)						Salinity Tool Performance %					
VECs	Total Area (Acres)*	ECB	FWO	ALT2	ALT5R	ALT10	ALT13	ECB	FWO	ALT2	ALT5R	ALT10	ALT13
Riverine Flood Plain**	483	314	314	420	440	459	386	65%	65%	87%	91%	95%	80%
Tidal Flood Plain	18	18	18	18	18	18	18	100%	100%	100%	100%	100%	100%
Valisneria	93	72	72	74	73	75	73	78%	78%	80%	79%	81%	79%
Oligohaline	161	35	34	38	37	39	37	22%	21%	23%	23%	24%	23%
Mesohaline	303	121	119	137	131	139	131	40%	39%	45%	43%	46%	43%
Polyhaline	731	675	673	671	672	667	672	92%	92%	92%	92%	91%	92%

**Flood Plain Acres and corresponding calculations are based on 30 day rolling average of dry season flows over 68 cfs (see Table E.2-9).

Table E.2- 9: Riverine Flood Plain Scoring Using 30 Day Rolling Average (Dry Season).

Scenario	30D Rolling Avg. Flow > 68cfs	Acreage of River Flood Plain	River Floodplain Restored Acres Per Alternative
ECB	0.65	483	313.95
FWO	0.65	483	313.95
ALT2	0.87	483	420.21
ALT5R	0.91	483	439.53
ALT10	0.95	483	458.85
ALT13	0.80	483	386.40

The **Riverine Flood Plain** (RM 16 to RM 9.5) still incurs a small amount of salinity mixing on the downstream end of the VEC where the target salinity is 0 practical salinity units (psu). The amount of salinity mixing on the downstream end (RM 9.5) of the **Riverine Flood Plain** VEC is markedly improved by all the LRWRP alternatives compared to the FWO (***Table E.2- 8***). ALT10 makes the most significant

improvement in the reduction of salinity mixing in the Riverine Flood Plain VEC, meeting the target of 0 psu for 95% of the riverine flood plain area (acreage) compared to just 65% of the riverine flood plain acreage for the FWO (***Table E.2- 8***). ALT13 meet 0 psu for only 80% of the riverine flood plain acreage which is still 15% higher than the FWO.

The **Tidal Flood Plain** (VEC (RM 9.5 to RM 8.1) has a salinity target of less than 2 psu. This target is met for 100% of the tidal flood plain acreage in all alternatives, as well as the ECB and FWO (***Table E.2- 8*** and ***Table E.2- 11***). This is not surprising giving the tidal mixing that occurs in this region. The confluence of Kitching Creek also occurs on the downstream end of this VEC. Freshwater entering the NWFLR is pushed upstream during high tides, keeping the salinity regime within the target range (< 2 psu). Thus, the **Tidal Flood Plain** VEC is not a factor in assessing LRWRP alternative performance.

To better understand the impacts of LRWRP alternatives on the NWFLR, data was parsed out by season (wet and dry) to provide insight into seasonal effects of LRWRP.

Table E.2- 10: Habitat Units (Acres) for Each VEC where Salinity Restoration Targets Were Met.

	POLYHALINE		Total Acres: 731	**MESOHALINE**		Total Acres: 303	**OLIGOHALINE**		Total Acres: 161	**VALLISNERIA**		Total Acres: 93	**TIDAL FLOOD PLAIN**		Total Acres: 18
Scenario	Dry	Wet	**Avg**	Dry	Wet	**Avg**	Dry	Wet	**Avg**	Dry	Wet	**Avg**	Dry	Wet	**Avg**
2014B	727	624	**675**	102	140	**121**	33	36	**35**	69	75	**72**	18	18	**18**
2070FWO	727	619	**673**	101	137	**119**	32	36	**34**	69	75	**72**	18	18	**18**
ALT2	722	619	**671**	128	145	**137**	39	36	**38**	73	75	**74**	18	18	**18**
ALT5R	724	620	**672**	118	145	**131**	37	37	**37**	71	75	**73**	18	18	**18**
ALT10	720	613	**667**	128	149	**139**	42	36	**39**	75	75	**75**	18	18	**18**
ALT13	724	620	**672**	118	145	**131**	37	37	**37**	71	75	**73**	18	18	**18**

Table E.2- 11: Percentage of VEC Acreage where Salinity Restoration Targets Were Met.

	Dry					Wet					Overall				
Scenario	P	M	O	V	T	P	M	O	V	T	P	M	O	V	T
2014B	99%	34%	20%	74%	100%	85%	46%	22%	80%	100%	92%	40%	21%	77%	100%
2070FWO	99%	33%	20%	74%	100%	85%	45%	22%	80%	100%	92%	39%	21%	77%	100%
ALT2	99%	42%	24%	79%	100%	85%	48%	23%	80%	100%	92%	45%	23%	80%	100%
ALT5R	99%	39%	23%	77%	100%	85%	48%	23%	80%	100%	92%	43%	23%	79%	100%
ALT10	98%	42%	26%	80%	100%	84%	49%	22%	80%	100%	91%	46%	24%	80%	100%
ALT13	99%	39%	23%	77%	100%	85%	48%	23%	80%	100%	92%	43%	23%	79%	100%

The ***Vallisneria*** VEC demonstrates no discernable difference among alternatives during the wet season (***Table E.2- 10*** and ***Table E.2- 11***). Thus, any difference between alternative performance is solely based on dry season flows. ALT10 outperforms the FWO and all other alternatives in meeting the salinity target of "less than 5 psu" from RM 10.5 to RM 6.5 (***Table E.2- 10*** and ***Table E.2- 11***).

The **Oligohaline Zone** VEC (RM 10 to RM 5.5) overlaps the ***Vallisneria*** VEC for 3.5 miles (RM 10 to RM 6.5). This overlap is important to the interpretation of model results for the **Oligohaline Zone**, as all project alternative and baseline scenarios (ECB and FWO) perform poorly for the restoration of acres within the 2 to 8 psu salinity range (***Table E.2- 10***). Restoration percentage within this overlap section of the NWFLR are high (79% to 80%) for the ***Vallisneria*** VEC (salinity < 5 psu) but low (23% to 24%) for the **Oligohaline**

Zone VEC (salinity between 2 and 8 psu). This suggests the salinity on the upstream side of the **Oligohaline Zone** VEC tends towards the lower salinity range (< 2 psu) (***Figure E.8- 2*** through ***Figure E.8- 4*** and ***Figure E.8- 7*** through ***Figure E.8- 9***). If salinity was between 2 psu and 5 psu on the upstream side, the restoration percentage would be high for both ***Vallisneria*** and **Oligohaline Zone** VECs. If salinity tended to be above 5 psu, restoration percentage would be higher for the **Oligohaline Zone** and low for the ***Vallisneria*** VEC in the overlap area. With modeling data revealing low percentages of restored acres (23% to 24%) in the **Oligohaline Zone** VEC (salinity 2 to 8 psu) combined with the high percentage of restored acres (79% to 80%) in the ***Vallisneria*** VEC (salinity < 2 psu), interpretation suggests that salinity tends towards the lower **Oligohaline Zone** threshold of 2 psu between RM 10 and RM 6.5.

LRWRP alternatives do not perform particularly well in the **Mesohaline Zone** VEC in meeting the salinity target of 10 to 20 psu. However, all alternatives outperform the FWO. All alternatives perform better in the wet season compared to the dry season, with much of the improvement in meeting the salinity target range is in the dry season (***Table E.2- 11***). Overall ALT10 meets the salinity target over 15% more acreage (20 acres) than the FWO and performs slightly better than all other alternatives overall. ALT2 achieves the salinity restoration target on 13% more acreage (18 acres) than the FWO. ALT5R and ALT13 achieve the salinity restoration target on 10% more acreage (12 acres) compared to the FWO.

All alternatives perform on par with the FWO, regardless of season, in the **Polyhaline Zone** VEC (RM 4 to RM 0) with FWO performing the best, meeting the target over 673 acres, and ALT10 performing the worst with the target met on 667 acres. All alternatives and the FWO meet the salinity target of greater than 20 psu over 90% of acreage in the **Polyhaline Zone** VEC (***Table E.2- 11***).

Modeling results for all ALTs, ECB, and FWO regarding the achievement of salinity restoration targets in each VEC is included in Section 8 (**pg. 56**).

E.2.4 Compatibility with RECOVER Northern Estuaries Goals and Targets

LRWRP is consistent with the ecological restoration targets established throughout the Northern Estuaries (NE) PMs. However, one structure, S-46, can have an impact on the salinity ranges found within the Loxahatchee Estuary. The S-46 structure discharges into the southwest fork of the Loxahatchee River and ultimately into the Loxahatchee Estuary. Most of LRWRP alternatives reduce average wet season flows through the S-46 structure (reduction of 1,520 ac-ft (ALT2), 140 ac-ft (ALT10), and 350 ac-ft (ALT13) compared to the FWO. However, ALT5R increases average wet season flow by 700 ac-ft compared to the FWO. The magnitude of these changes, increases or decreases, are considerably small. While most of the alternatives provide less wet season flows to the estuary which could result in decreased salinity, the magnitude of these changes are minimal (**Figure E.2- 8**). The same is true for the slight increase in wet season flow in ALT5R (**Figure E.2- 8**)

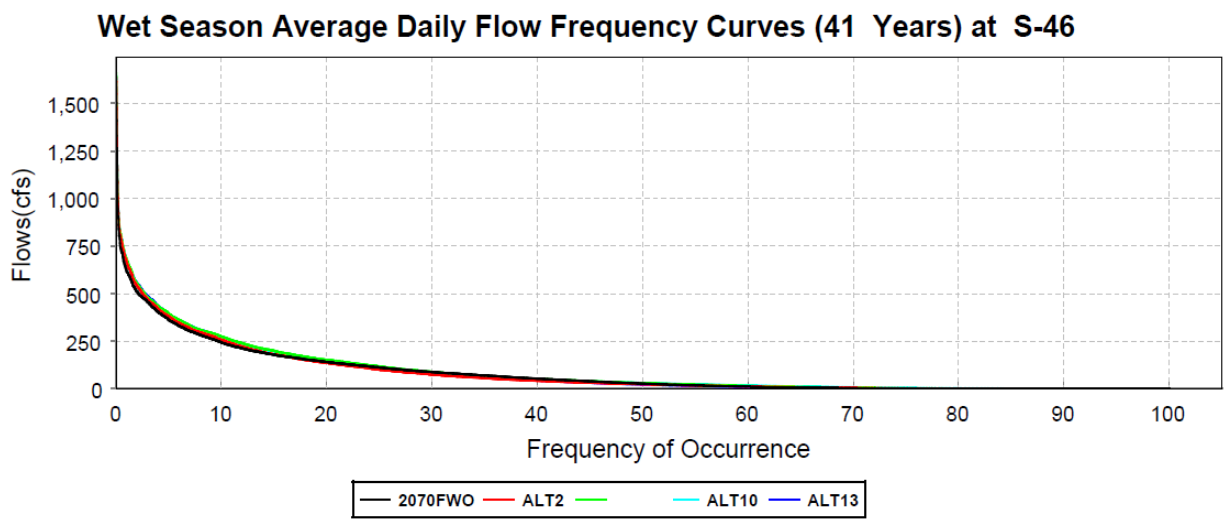


Figure E.2- 8: Comparison of LRWRP alternative wet season average daily flow compared to the FWO.

All of the LRWRP alternatives increase dry season flow through the S-46 structure improving dry season salinity conditions for flora and fauna utilizing the Loxahatchee Estuary. Dry season flow increases from 1,400 ac-ft (ALT2) to 2,520 ac-ft (ALT5R) compared to the FWO. Again, the magnitude of improvement is considerably small (**Figure E.2- 9**). Ultimately, salinity in the Loxahatchee Estuary will be influenced by S-46 flow as well as restored flows through the Northwest Fork of the Loxahatchee River.

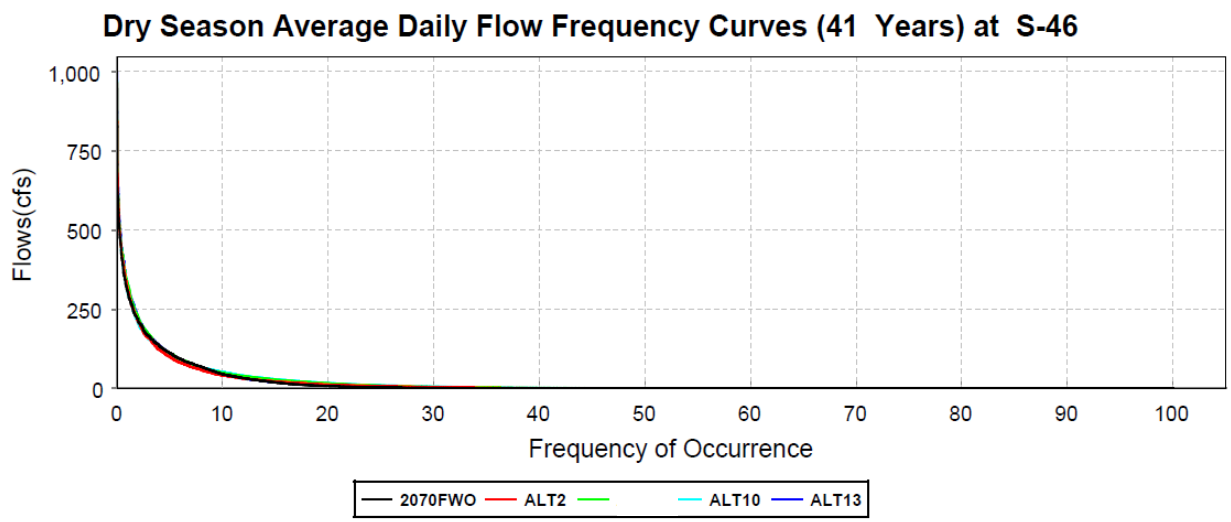


Figure E.2- 9: Comparison of LRWRP alternative average dry season daily flow compared to the FWO.

E.3.4 Summary and Conclusions

Objective 1 of the LRWRP is to "restore wet and dry season flows of water to the National Wild and Scenic Northwest Fork of the Loxahatchee River and the river floodplain." Scoring for objective 1 is based on the 30 day rolling average flow > 68 cfs (***Table E.2- 9***) as there was little separation in the performance of alternatives for the wet season. ALT10 outperformed all other alternatives in the restoration of dry season

flow to the NWFLR (***Table E.2- 1***). Of note, ALT10 performed the best of all alternatives in restoring wet season flow to the NWFLR as well (***Table E.2- 1***).

Table E-12: PM1 Scoring Rubric for Objective 2 (USACE and SFWMD 2015).

Score	Tidal floodplain	*Vallisneria Americana* (Manatee Grass)	Oligohaline Zone (Juvenile Fish)	Mesohaline Zone (Oysters)	Polyhaline Zone (Seagrass)
1	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	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
0.5	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
0.25	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	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

Table E.2- 12 shows the scoring rubric for LRWRP objective 2, "restore oysters, seagrass, and other estuarine communities in the Loxahatchee River Estuary" (USACE and SFWMD 2015). The scoring rubric (***Table E.2- 12***) from PM1 was used to analyze the performance of each LRWRP alternative. Scores for each alternative were calculated by matching the VEC restoration percentage (***Table E.2- 8***) to the correct range for that VEC in the rubric and then averaging the rubric scores (column 1 above) for all the 5 VECs used in Objective 2 (Riverine Flood Plain restoration was Objective 1). If a restoration percentage score, i.e. 80%, fell in two separate rubric scoring categories, an average of the two rubric scores was used. For example, if the Oligohaline score was 80%, which falls in the rubric score categories of 1 and 0.75, the average score used is 0.875. For Objective 2, ALT2 and ALT10 equally outperformed ALT5R and ALT13 (***Table E.2- 13***). The RECOVER evaluation team conducting this review recommends the scoring methodology for PM1 be reevaluated and edited. The scoring ranges in the rubric are too wide resulting

in less discernible results. RECOVER recommends forgoing a scoring rubric and using percentage scores (which range from 0 to 1) as the scoring methodology for Objective 2 of PM1.

Overall, analysis of restoration alternatives for the LRWRP with respect to the NWFLR has shown that all project alternatives improve freshwater inputs for both wet and dry seasons compared to the FWO. In turn, the restoration of wet and dry season flows also show that all project alternatives improve the salinity conditions for most of the VECs within the Northwest Fork of the Loxahatchee River and Estuary when compared to the FWO. Of the project alternatives, ALT10 performs the best of the final array of alternatives in regards to the restoration of the NWFLR (PM1) for LRWRP (***Table E.2- 13***). Again, it is important to note that due to lack of modeling for ALT5R, the data used for scoring of ecological and hydrological improvements are underestimated for ALT5R in this analysis.

Table E.2- 13: Ranking of LRWRP ALTs Performance for PM1.

Restoration Alternative	Ranking for Objective 1	Ranking for Objective 2	Overall Ranking
FWO	0.65 (5)	0.65 (5)	0.65 (5)
ALT2	0.87 (3)	0.73 (1.5)	0.80 (3)
ALT5R	0.91 (2)	0.70 (3.5)	0.81 (2)
ALT10	0.95 (1)	0.73 (1.5)	0.84 (1)
ALT13	0.80 (4)	0.70 (3.5)	0.75 (4)

( ) denotes alternative ranking

E.4 LOXAHATCHEE WATERSHED

E.4.1 Introduction

This section evaluates Lower East Coast Sub-Regional Model (LECsR) predictions of the overall quantity, quality, timing, and distribution of freshwater for the Loxahatchee River watershed and adjacent wetlands associated with the Loxahatchee River Watershed Restoration Project (LRWRP) (***Figure E.3- 1***). This report also aims to provide a better understanding of the LRWRP's role in Everglades restoration as a whole.

Historically, the Loxahatchee River watershed included and drained more than 218 square miles 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 (***Figure E.3- 2***). 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. Early accounts report plentiful game including deer, bear, panther, and wading birds (McVoy et al. 2011).

Today, the Loxahatchee River Watershed is hydrologically disconnected from the Everglades. Approximately 168 square miles of the original watershed drains to the Atlantic Ocean through Jupiter Inlet. During the past sixty years, significant portions of the watershed have been converted from upland forests and wetlands to urban, residential and agricultural development (VanArman et al. 2005).

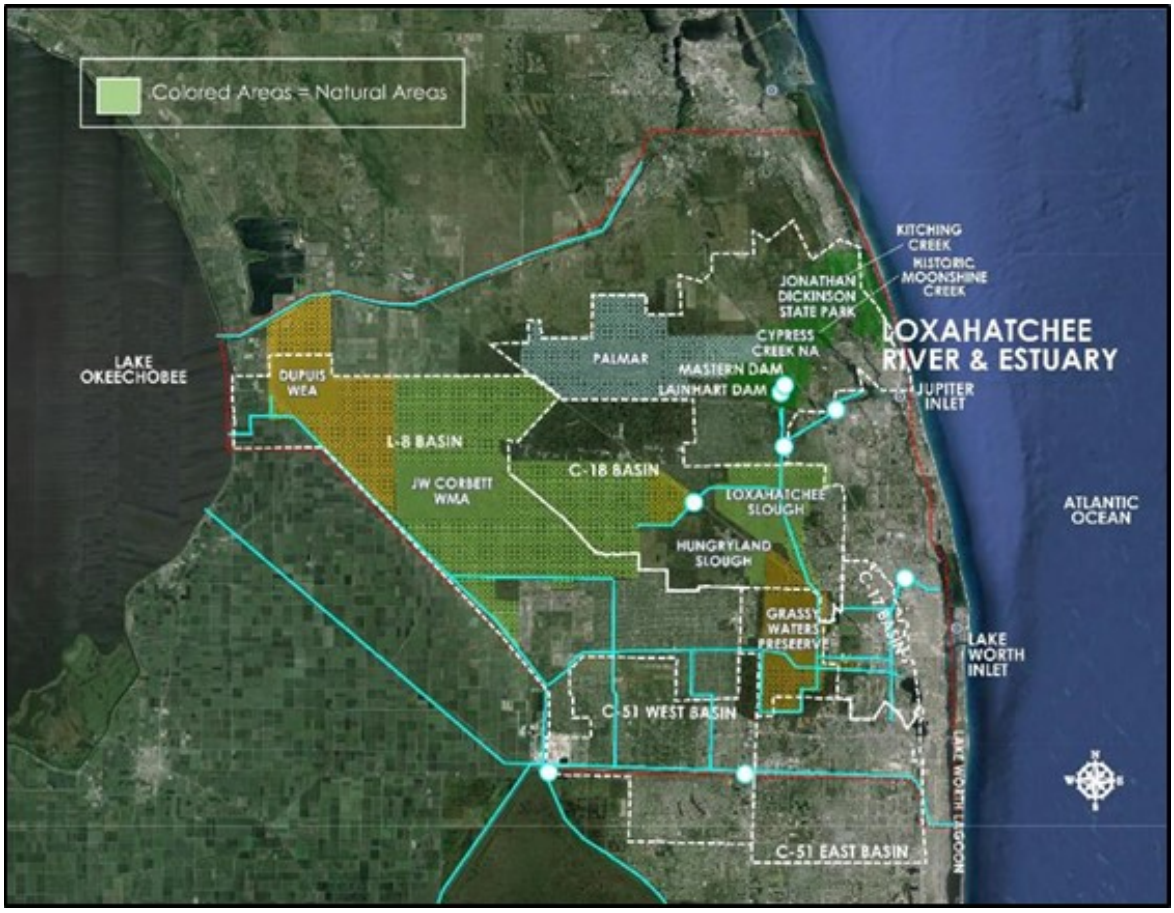


Figure E.3- 1: The LRWRP Project Area.

The study area is approximately 480,000 acres and includes the Loxahatchee River watershed and limited portions of the St. Lucie River watershed and Lake Worth Lagoon watershed.

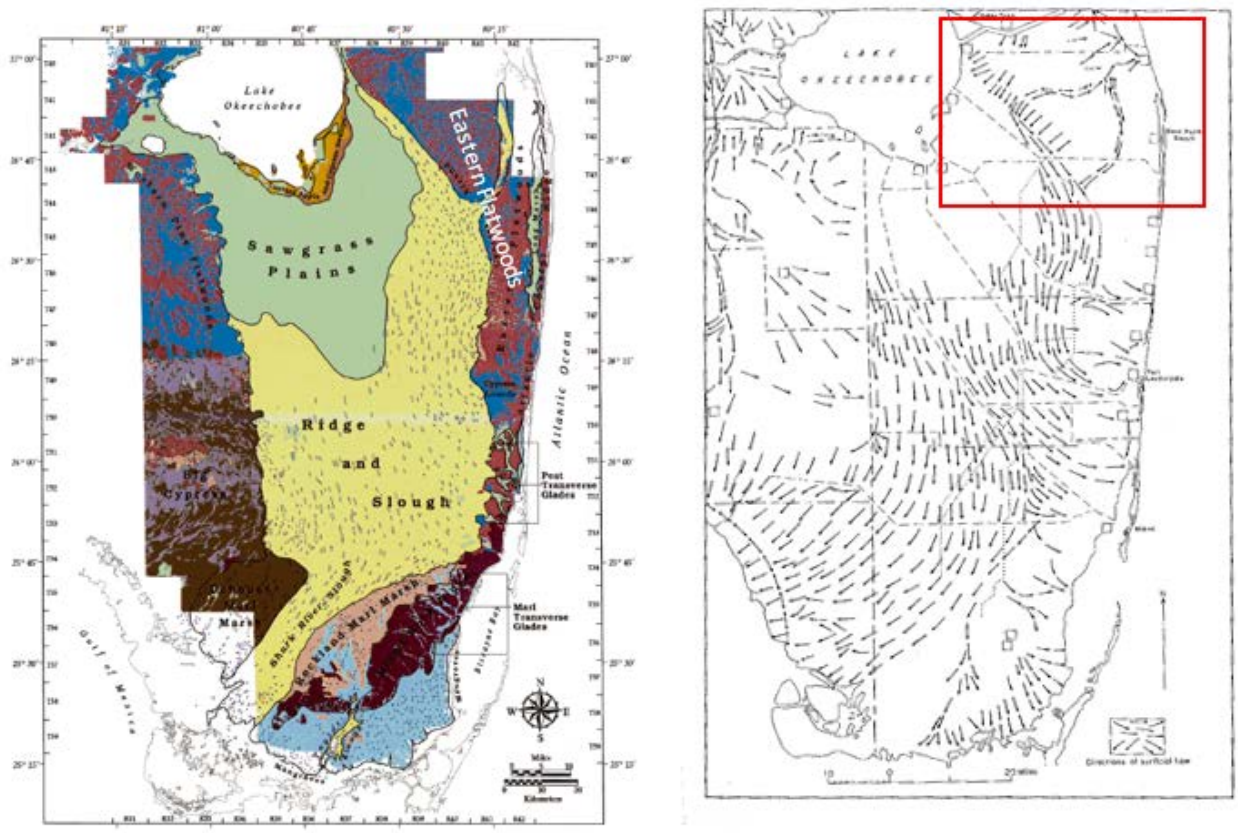


Figure E.3- 2: The map on the left shows the landscapes of the predrainage Everglades and bordering areas. The map on the right shows the directions of surface water flow under predrainage conditions. The red box indicates areas relevant to the LRWRP. Maps are modified from McVoy et al. 2011.

The LRWRP objectives include increasing natural area extent of wetlands in the watershed, restoring connections between natural areas, and restoring native plant and animal species abundance and diversity. The LRWRP objectives align with CERP goals, which include increasing the total spatial extent of natural areas, improving habitat and functional quality, and improving native plant and animal species abundance and diversity.

To assess the effects of the LRWRP, output from six modeling scenarios were compared. Modeling scenarios included ALT2, ALT5R, ALT10, and ALT13 (collectively referred to as ALTs), ECB, and FWO. The ECB represents the present configuration and operation of the water management system. The FWO scenario simulates a future configuration of the water management system without the LRWRP, but with other CERP projects that should benefit the overall system.

Two LRWRP PMs were used in the LRWRP plan formulation and evaluation, one is based on hydrologic targets, including duration of inundation, and the other is based on hydrologic and spatial connectivity. The two PMs are:

1. Hydrologic Regimes of Major Plant Communities in the Loxahatchee Watershed and Adjacent Wetlands (Watershed Hydrology)

2. Hydrologic/Spatial Connectivity (Connectivity)

E.4.2 Performance Measures and Evaluation Approach

E.4.2.1 Watershed Hydrology (PM 4)

One of the goals of the LRWRP is to improve vegetation communities and restore native plant and animal species abundance and diversity by achieving appropriate depth, duration and frequency targets in the Loxahatchee Watershed wetlands (USACE and SFWMD, 2014). Available data shows fifteen naturally-occurring vegetation communities are found within the Loxahatchee River watershed, including Jonathan Dickinson State Park (FNAI 1990, Roberts et al. 2006). Dominant communities include mesic and wet flatwoods, wet prairie, floodplain and dome swamp, depression marsh and mesic and hydric hammock. The species composition and distribution of plant communities in a given locale is a function of hydrologic regimes (depth of water table, length and frequency of inundation) as well as soil type, frequency of fire, and climate. Hydrologic restoration targets for each community type were determined by using data from literature supplemented by model output from unimpacted areas (including predevelopment and existing conditions).

The Watershed Hydrology performance measure determines the acres of restored wetlands from urban and agricultural land use to assess the increase in extent of natural areas (objective 3 – ***Table E.1- 2***). Measurements are based on hydrologic regimes of major plant communities in the Loxahatchee Watershed and adjacent wetlands based on inundation durations. The proportion of days inundated out of the target number of days inundated yields the inundation duration score for each plant community. This was assessed for various indicator regions throughout the Watershed (***Figure E.3- 3***). The PM also uses Wetland Rapid Assessment Procedure (WRAP) Assessments, which produces a rating index for wetland sites that have been created, enhanced, preserved, or restored through the regulatory process. The WRAP rating index establishes a numerical ranking for individual ecological and anthropogenic factors (variables) that can influence the functionality of a natural system and the overall success of environmental projects. The final WRAP score is a numerical value between 0 and 1. 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. The PM scores are determined by multiplying the inundation duration score and the functional scaling scare (WRAP score) by the total number of possible acres. A proportion of restored acres is used as the PM score for each alternative and flow way. Restoration of wetland hydrology will support restoration of fish and wildlife populations and diversity (objective 5 – ***Table E.1- 2***). Grassy Water Preserve was not included in PM calculations since hydrology is a result of operations managed by the City of West Palm Beach.

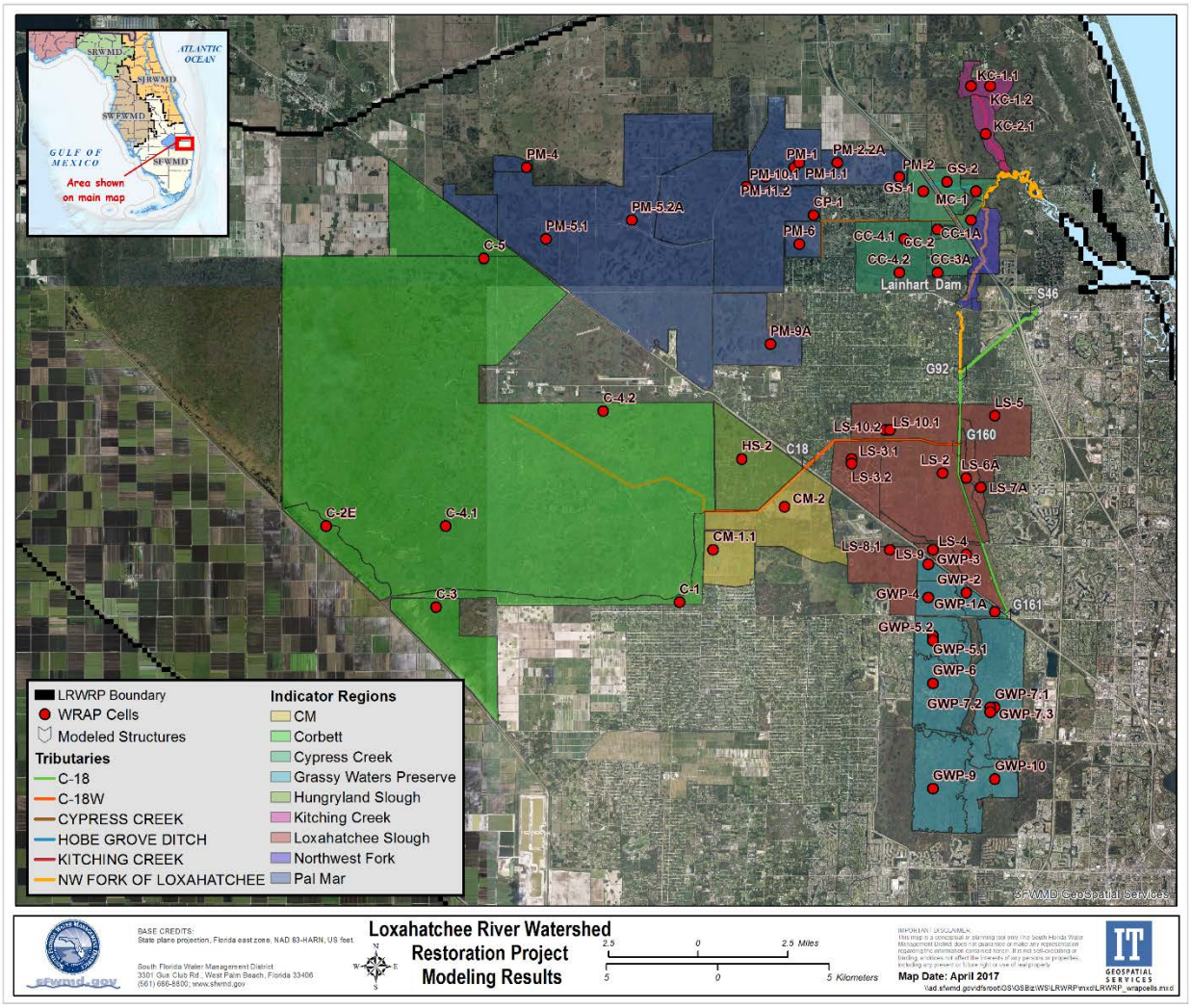


Figure E.3- 3: Indicator regions within the Loxahatchee River Watershed.

E.4.2.2 Connectivity (PM 9)

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). Establishment of new hydrologic connections in the landscape and restoration of connectivity in highly modified human-dominated landscapes can have species- to ecosystem-level effects (Pringle, 2003). Increasing the spatial extent of natural areas within the project study area, one of the three (3) major goals of the CERP (USACE and SFWMD 1999), will help to maintain and promote biodiversity by increasing available resources and habitat. Similarly, population and system dynamics would benefit from the hydrologic/spatial connectivity between protected lands by alleviating obstacles in the spread of native flora and wildlife movement between natural areas. Flora and faunal species would experience a spatial increase in suitable habitat and movement corridors and potentially, a larger reproductive gene pool due to the expansion of protected natural areas.

The Connectivity performance measure assesses 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) (Objective 4). GIS layers were updated to add more quantitative information to support the overall qualitative approach to evaluating connectivity performance.

E.4.3 Evaluation

E.4.3.1 Watershed Hydrology

Compared to the FWO, most improvement was observed in FW3, except in ALT10, where most improvement occurred in FW1 (***Figure E.3- 4*** and ***Figure E.3- 5***). Improvements in FW3 ranged from a 3% improvement in ALT10 to a 30% improvement in ALT13. FW1 also improved over all ALTs, increasing inundation duration and functionality of wetlands by 15% in ALT2, ALT10, and ALT13, to 16% in ALT5R. Across all alternatives, FW2 showed the least improvement compared to the FWO, decreasing performance of inundation duration and functionality of wetlands by 1% in ALT10 to increasing performance by 3% in ALT13 and ALT5R. Stage duration curves for indicator regions (IRs) in western FW2 showed stages consistently lower than targets, even with top-performing alternatives (***Figure E.3- 6***).

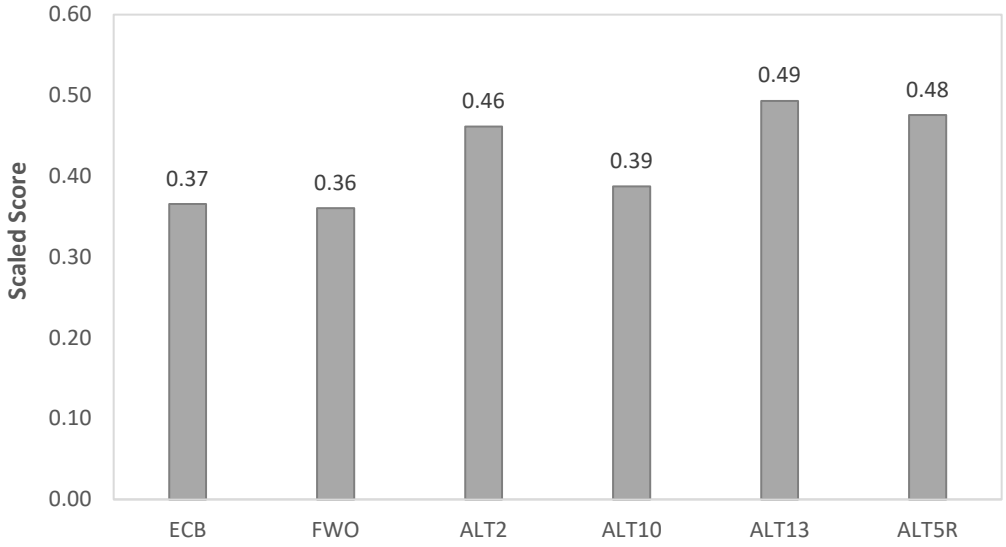


Figure E.3- 4: Scores for Watershed Hydrology PM.

A score of 0 is the worst score. A score of 1.0 the best score).

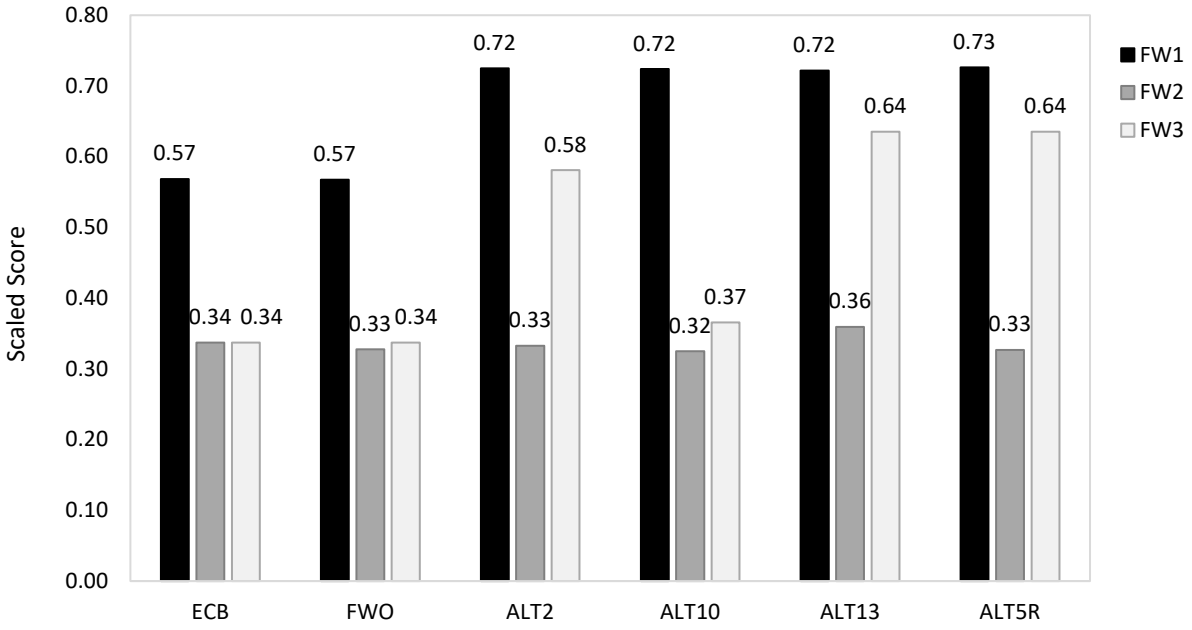


Figure E.3- 5: Scores for Watershed Hydrology PM by flow way.

A score of 0 is the worst score. A score of 1.0 is the best score.

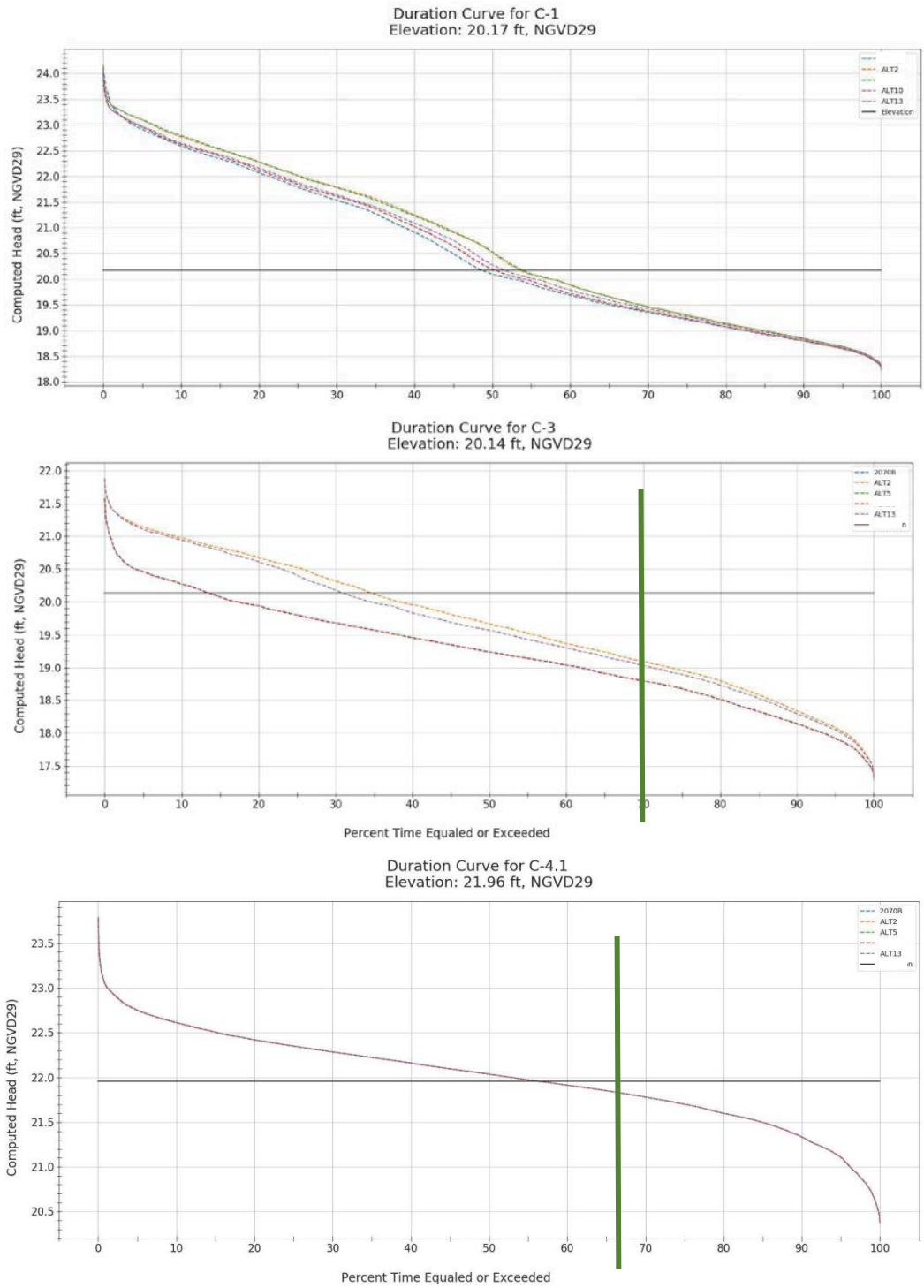


Figure E.3- 6: Stage Duration Curves for Indicator Regions in Western FW2.

The black line indicates the ground elevation. The target is indicated by the green vertical line. Best performance is indicated by above-ground water levels meeting target inundation duration. C-1 (top) is

considered to be a depression marsh with a target inundation of 66%. All ALTs fall below target, but perform better than the FWO. C-3 (middle) is considered to be a dome swamp with a target inundation of 70%. All ALTs fall below target. C-4.1 (bottom) is considered a depression marsh with a target inundation of 66%. All ALTs fall below target.

E.4.3.2 Connectivity

ALT13 improved the most above the FWO, while ALT 10 improved the least (***Figure E.3- 7***). ALT13 also showed the most improvement in all four criteria for connectivity. Greenway connectivity received the highest score, followed by water quality and fish and wildlife, and then hydrology (***Figure E.3- 8***). FW2 scores in ALT13 consistently performed the best, likely because of the C-18W Natural Storage feature (***Figure E.3- 9***). ALT13 results in a longer inundation duration than the target at indicator region CM-1, which has an inundation duration target intended to support vegetation for depression marsh. However, the range of water levels in ALT13 is more suitable for sawgrass, which is the community that commonly dominates depression marshes near the coast or where limestone is near the surface (FNAI 2010). ALT10 meets the target inundation for depression marshes, however water levels fluctuate between 5ft to 1ft below ground, which is not suitable for supporting sawgrass communities that commonly dominate depression marshes (***Figure E.3- 10***).

Fish and wildlife benefits may be underestimated in FW1 by the LRWRP team, considering the proximity of the area to wading bird colonies in northern Water Conservation Area 1. Additionally, Everglade snail kites consistently use the Grassy Water Preserve area for nesting and are likely foraging in the area. Consideration of this information would not change ranking of the ALTs, however.

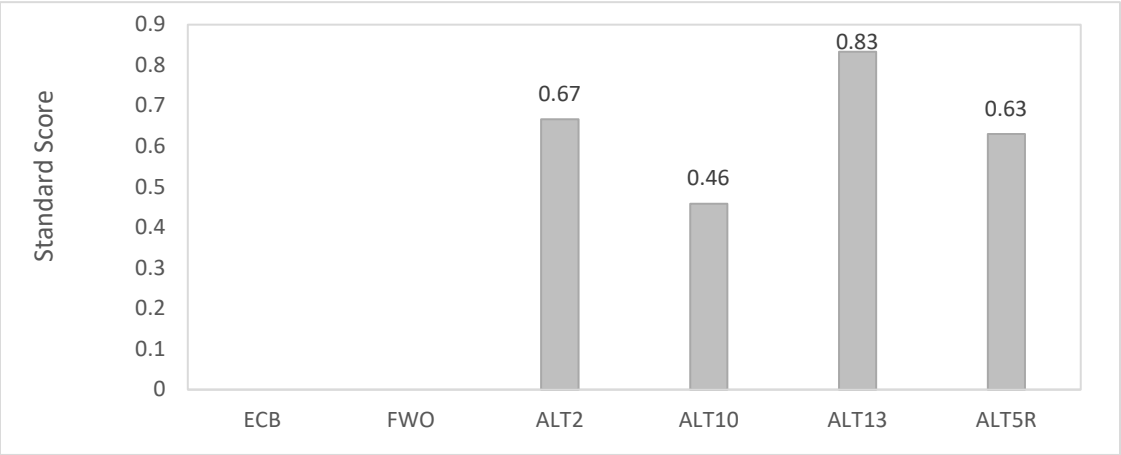


Figure E.3- 7: Scores for Connectivity PM.

A score of 0 is the worst score and a score of 1.0 is the best. Connectivity scores for the ECB and FWO are zero since connectivity is assumed to be the increment above the base condition.

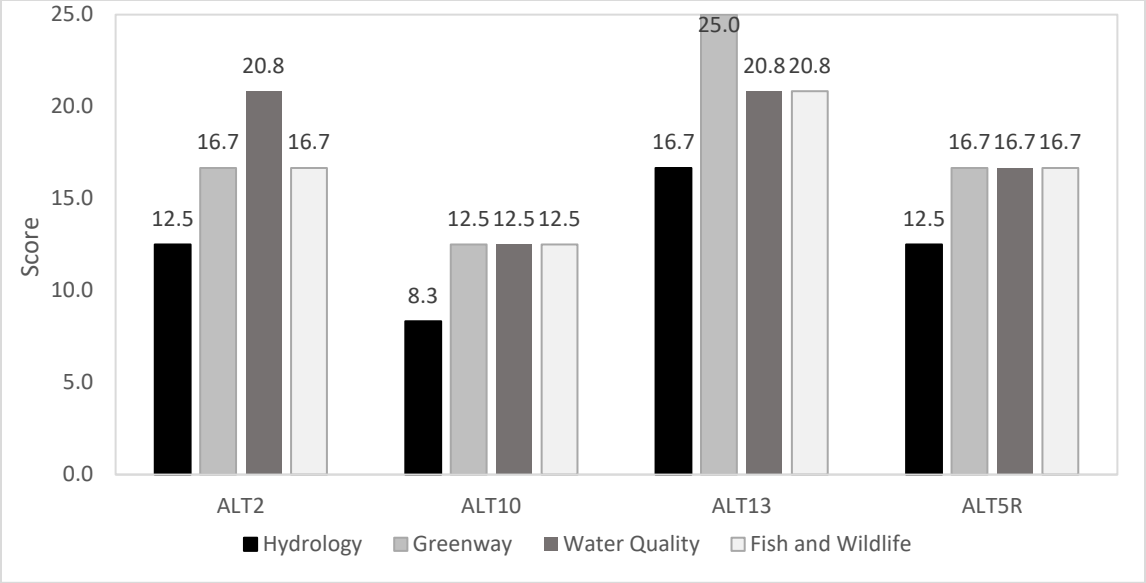


Figure E.3- 8: Scores for Each Criterion for Each Alternative.

Scores are averaged across flow-ways for each alternative. A score of 0 is the worst score and 25 is the best score.

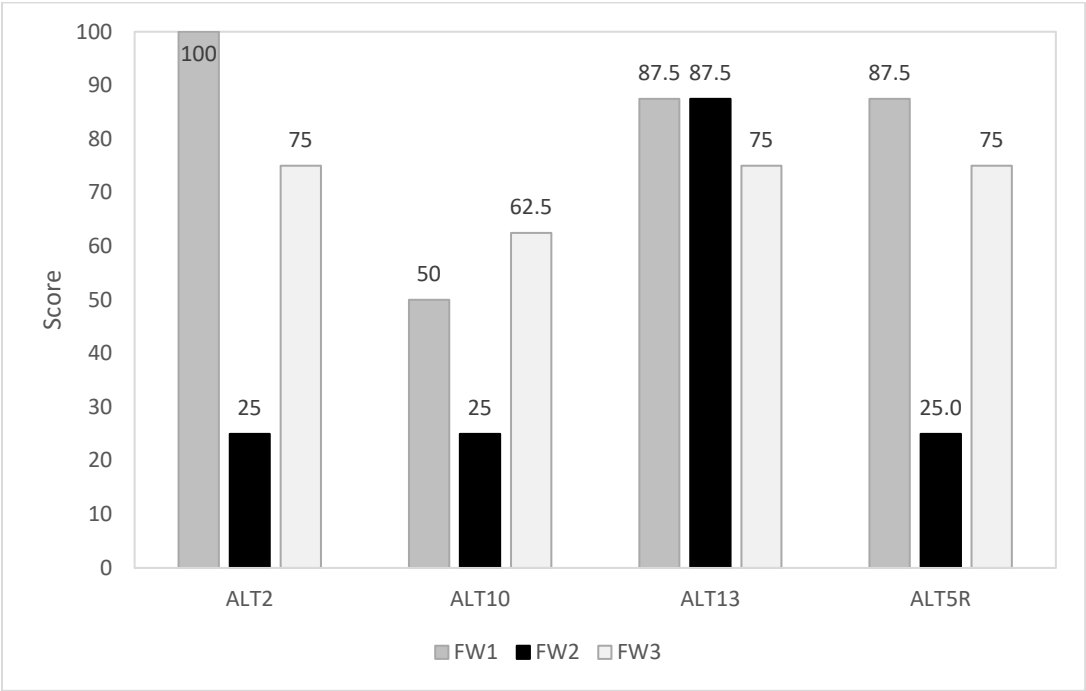


Figure E.3- 9: Criteria Combined by Flow Way.

A score of 0 is the worst score and 100 is the best score.

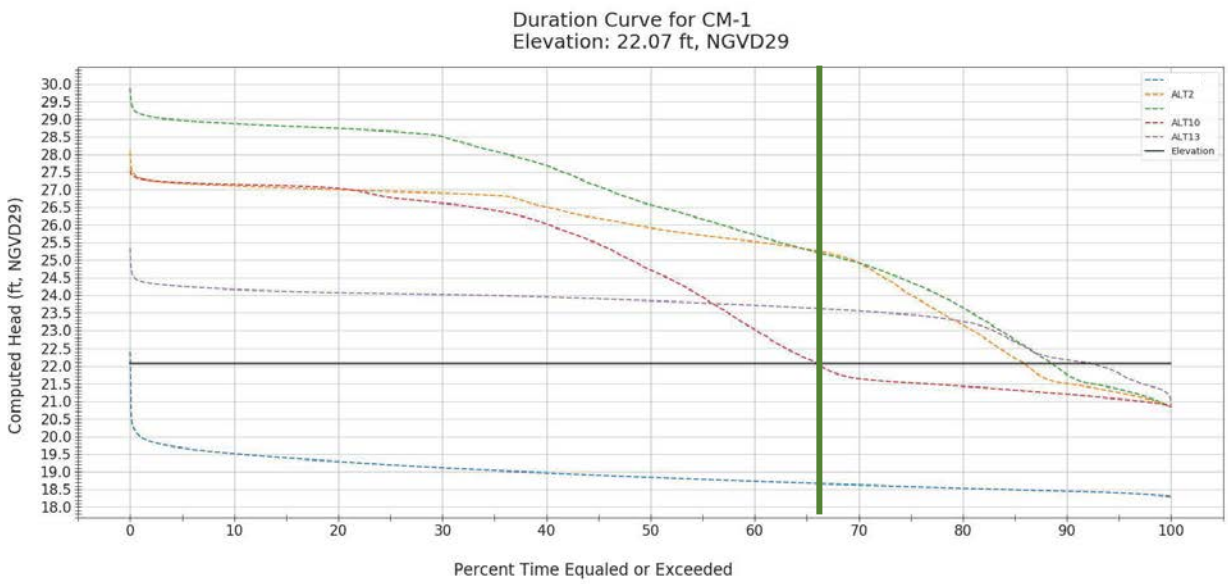


Figure E.3- 10: Stage Duration Curve for Indicator Region CM-1.

The black line indicates the ground elevation. The target is indicated by the green vertical line. Best performance is indicated by above-ground water levels meeting target inundation duration. CM-1 is considered to be a depression marsh with a target inundation of 66%.

E.4.3.3 Watershed Hydrology and Connectivity PM Scores Combined

The combined score for the Loxahatchee River watershed was highest for ALT13, followed by comparable scores for ALT5R and ALT2. ALT10 performed the worst. All projects ALTs improved watershed hydrology and connectivity compared to the FWO (***Figure E.3- 11***).

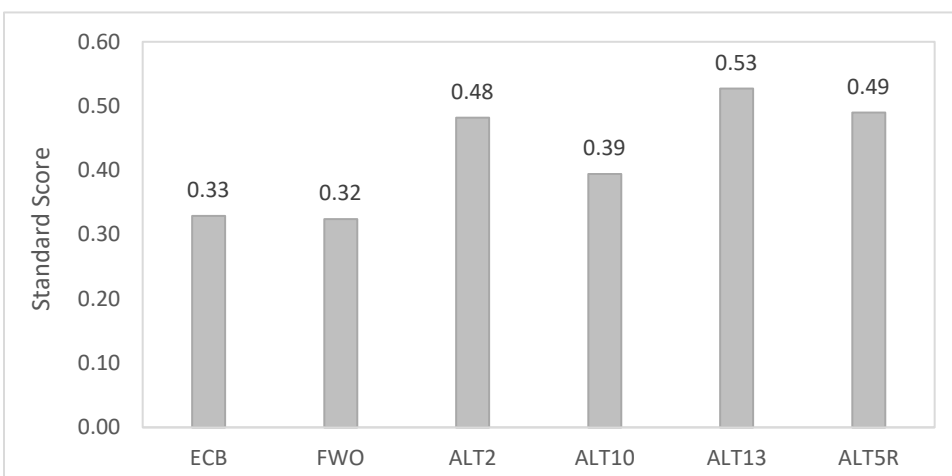


Figure E.3- 11: Scores for the Total Watershed.

A score of 0 is the worst score. A score of 1.0 is the best score. Scores from the watershed hydrology and connectivity PMs were combined and weighted 90% and 10%, respectively, to obtain the score for the total watershed.

E.3.4 Watershed Restoration and Connectivity to the Everglades

Though the historical hydrological connection between the Loxahatchee River and Everglades cannot be fully restored, restoration to the Loxahatchee River Watershed can still improve connectivity to the Everglades. Increasing the extent and quality of wetlands can also allow for progress towards restoration goals.

Defining characteristics are major ecological components that describe the pre-altered Everglades basin at large system-wide scales and collectively define the Greater Everglades ecosystem. Defining characteristics include 1) abundant large vertebrates and aquatic prey bases and 2) animals with large spatial requirements (Ogden et al. 2005). Species that exemplify defining characteristics, and use the LRWRP area, include wading birds (i.e. white ibis and wood stork), the Everglade snail kite, marsh fishes and crayfish (collectively referred to as aquatic fauna), and apple snails. (***Figure E.3- 12***).

Many of the species described below compose a suite of indicators that help to inform restoration progress. "Interim goals" for each indicator were developed to provide incremental goals which are expected to be met as restoration occurs. Species of concern in the LRWRP area are also discussed.

E.3.4.1 Wading Birds

Data for wading bird nesting and foraging locations were provided by the U.S. Fish and Wildlife Service (USFWS) (***Figure E.3- 11***) and informed by the 2018 South Florida Wading Bird Report (Cook and Baranski 2018). Several colonies within and around the project area were identified as colonies potentially impacted by the LRWRP. Colonies included Ballen Isles, Wakodahatchee Wetlands, Palm Beach Natural Areas, and Water Conservation Area (WCA) 1. Improved hydrological conditions and quality of foraging area within the LRWRP boundary can provide nearby colonies with food resources needed to initiate and sustain reproductive processes (Frederick and Collopy 1989, Frederick and Spalding 1994). Wood storks (*Mycteria americana*) will forage up to 50 km (Herring and Gawlik 2011), while small herons forage up to 30 km (Strong et al. 1997) from their colonies. Considering their foraging distances, much of the LRWRP area is available to these birds. Interim goals for wading birds, relevant to the LRWRP, consider system-wide patterns of nesting, including measurements of number of breeding pairs, timing of wood stork breeding, and frequency of "super colonies".

E.3.4.2 Everglade Snail Kite (*Rostrhamus sociabilis plumbeus*)

The snail kite is an endangered species characteristic of the Everglades, living in wet prairie habitats with tree islands. It has experienced dramatic population changes over the past 20 years. Three features that remain consistent within the selected habitats are the presence of apple snails, sparsely distributed emergent vegetation, and suitable nesting substrates. The USFWS has identified recovery criteria related to population size, population growth rate, and extent of foraging habitat (Fletcher et al. 2018). The Everglade snail kite has also been documented within and around the LRWRP area (***Figure E.3- 12***).

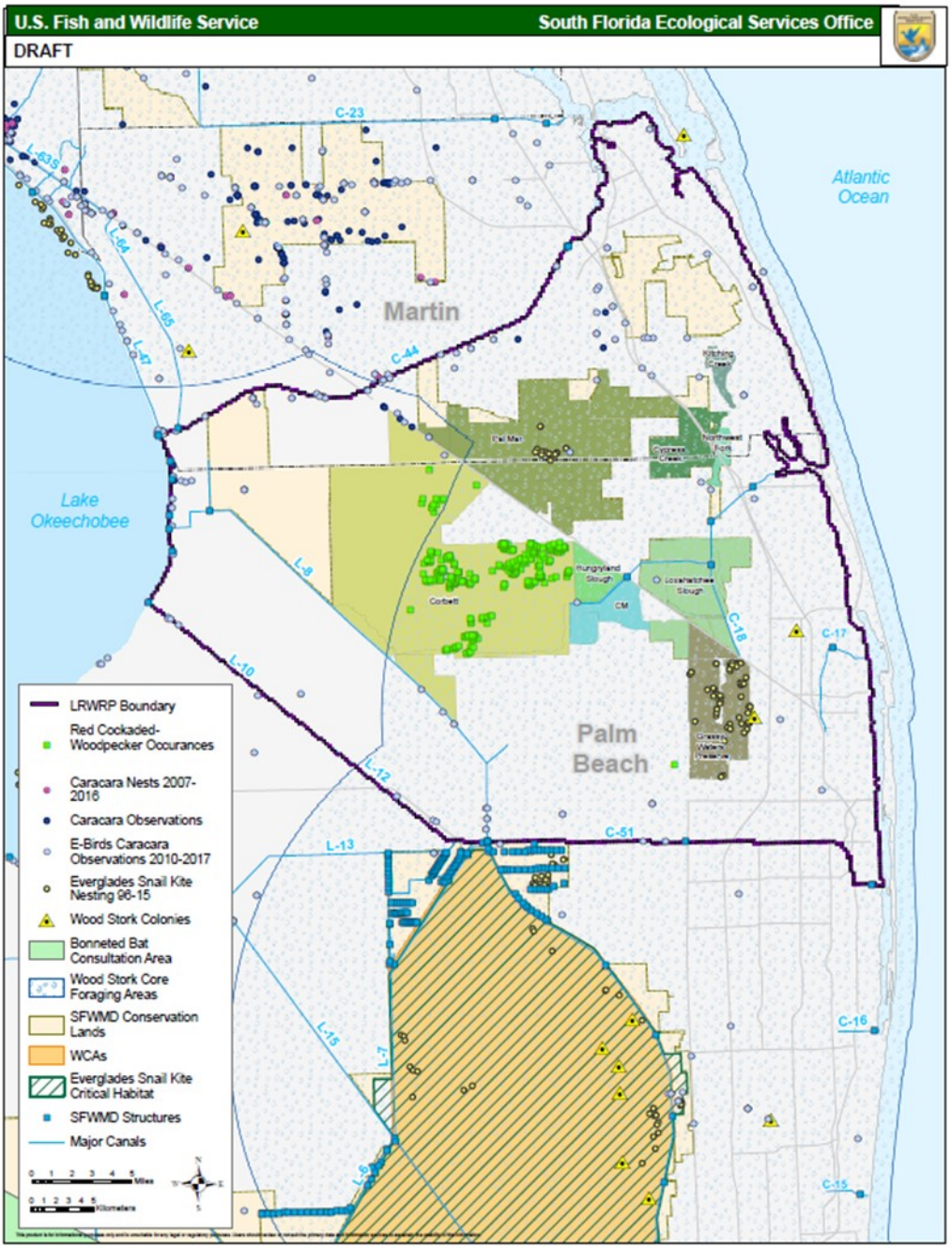


Figure E.3- 12: Species Occurrence within the LRWRP and Adjacent Areas.

E.3.4.3 Red-Cockaded Woodpecker (*Leuconotopicus borealis*)

The red-cockaded woodpecker is an endangered species found in the longleaf pine ecosystem. Recovery criteria are related to increased population sizes and potential breeding groups (USFWS 1985). Several observations have been documented in the Corbett Wildlife Management Area. Improved habitat and re-

establishment of historical vegetation as a result of LRWRP may be able to facilitate the success of potential breeding groups as the extent of favorable groundcover increases (***Figure E.3- 12***).

E.3.4.4 Crested Caracara (*Caracara cheriway*)

The caracara is a threatened species found in open prairie, pastures, or open rangeland, preferably with cabbage palmettos for roosting. The main threat to caracara is habitat loss. Prey species can include small mammals, amphibians, reptiles, fish crabs, invertebrates, and young birds. Restoration as a result of the LRWRP can improve habitat quality, particularly for aquatic prey species, for the caracara and facilitate expansion into areas that become more suitable. Several observations of caracara have been documented around and within the LRWRP area (***Figure E.3- 12***).

E.3.4.5 Aquatic Fauna

Fish and freshwater crustacean community structure are very sensitive to hydrological conditions. Research has linked three key aspects of Everglades' ecology to this indicator: (1) top predators, such as wading birds, are directly dependent on prey density, especially fish and crustaceans; (2) prey population structure, standing crop, and density are directly dependent on periphyton biomass, water depth, quality and distribution, the timing of seasonal concentrations, and duration of drought conditions; (3) prey availability is directly dependent on prey density, water depth, timing of seasonal concentrations and duration of drought conditions (Trexler and Goss 2009).

Data for aquatic fauna from 2005 to 2006 were provided by RECOVER. Monitoring sites were located within the Pal Mar area (***Figure E.3- 13***). Pal Mar contributed a relatively large percent (30%) of mollusks, non-fish vertebrates, and other invertebrates (mostly dragonfly nymphs) to the average standing crop. Notably, this area had high densities of crayfish (***Figure E.3- 14***).

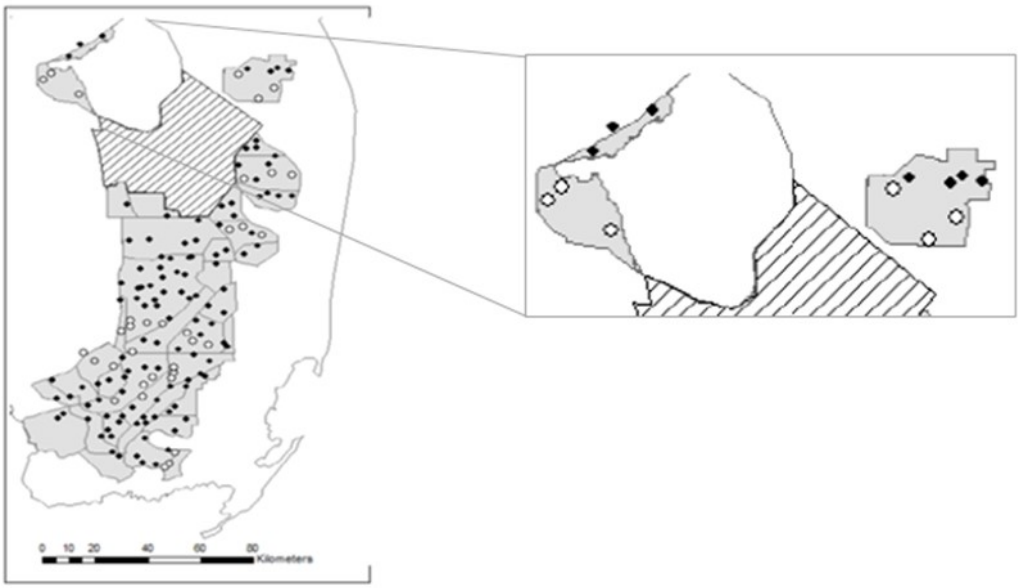


Figure E.3- 13: Sampling Locations for Aquatic Fauna in the Everglades and Adjacent Areas from 2005-2006.

Dark circles are sites sampled only during the wet season. White circles are sites sampled during both wet and dry seasons.

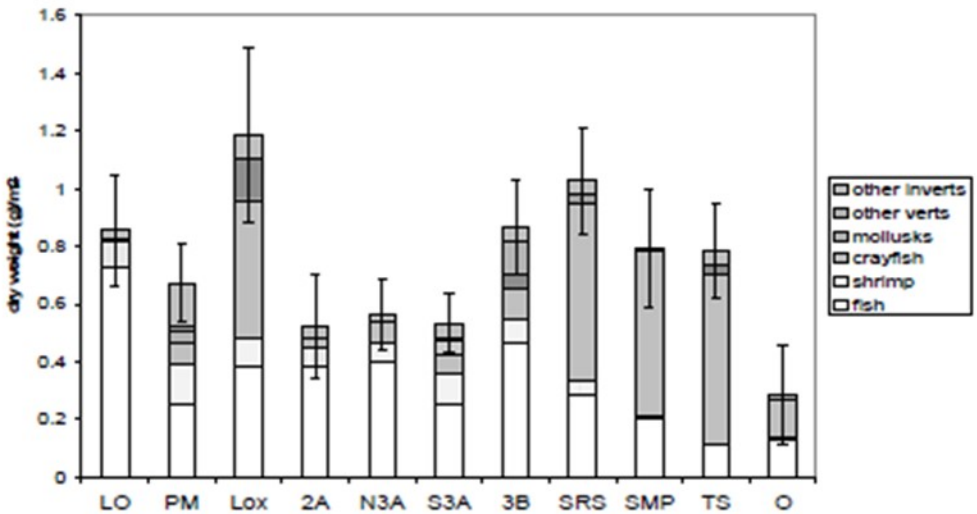


Figure E.3- 14: Average Standing Crop per Region of Aquatic Fauna Prey Population during the 2005 Late Wet Season, Broken Down by Taxonomic Category (Trexler and Robertson 2006).

Error bars are one standard error of the mean of the standing crop for each region. Location Abbreviations: LO- Lake Okeechobee; PM-Pal Mar; 2A- WCA 2A; 3B – WCA 3B; SRS- Shark River Slough; SMP-Southern Marl Prairies; TS- Taylor Slough; O – Ochopee Marl Prairie. Pal Mar is the only sampling location within the LRWRP area (Trexler and Robertson 2006).

The diversity of habitats and prey in this area may provide alternative foraging habitats when conditions are less favorable in the WCAs. During periods of high rainfall, the higher ground elevations in the LRWRP area may allow for suitable depths for foraging species when water levels in the WCAs are too deep. Additionally, in some years, areas within the LRWRP provide higher prey biomass per m^2 than WCA 2 and 3 (***Figure E.3- 14***). Over the past several years, monitoring has suggested the number of small herons is severely declining in the Everglades (Cook and Baranski 2018). Differences among regions in biomass are probably the result of interaction of recent hydrological history (time since the most recent drying event and spatial pattern of drying in the region relative to sampling site placement) long-term management history (frequency of drying events over the past several years), biogeochemical status of the area and access to permanent aquatic refuges such as canals. Improved habitat as a result of the LRWRP may provide sufficient food resources and improve nesting numbers since the area offers a diverse array of prey species, which small herons have been documented to consume (Klassen et al. 2016).

E.4.4 Summary and Conclusions

For the watershed hydrology and connectivity PMs, ALT10 performed noticeably worse than other LRWRP ALTs, most likely due to performance in the Cypress Creek and Pal Mar indicator regions (***Table E.3- 1***). Low scores may be a result of the exclusion of the Gulfstream West and Pal Mar East features in this ALT. High performance of ALT13 was attributed to consistently higher FW2 scores, which may be a result of hydrological improvements associated with the C-18W Natural Storage feature (***Figure E.3- 5***). Stage duration curves for indicator regions in western FW2 showed stage duration consistently lower than

targets, even with top-performing alternatives. However, LRWRP ALTs showed improvement over the FWO. Fish and wildlife benefits may be underestimated in FW1 by the LRWRP team, considering the proximity of FW1 to wading bird colonies in northern Water Conservation Area 1 and the consistency of snail kite nesting within the Grassy Water Preserve area. However, this would not affect the ranking of alternatives. These species along with aquatic fauna in the regions may provide benefits to the Everglades restoration by providing improved habitat for species and may result in further movement towards restoration interim goals.

Though the historical hydrological connection between the Loxahatchee River and Everglades cannot be fully restored, restoration to the Loxahatchee River Watershed can still improve connectivity to the Everglades. Increasing the extent and quality of wetlands can allow for progress towards restoration goals. The LRWRP is expected to improve conditions for a number of indicators (wading birds, marsh fish, and snail kite) and listed species residing within and near the project area. Increased extent and quality of foraging conditions for ecological indicators can also support progress towards meeting interim goals.

Table E.3- 1: Ranking of LRWRP ALTs Performance for PMs 4 and 9.

Performance Metric	FWO	ALT2	ALT5R	ALT10	ALT13
PM-4 Watershed Hydrology	0.36 (5)	0.46 (3)	0.48 (2)	0.39 (4)	0.49 (1)
PM-9 Connectivity	0* (5)	0.67 (2)	0.63 (3)	0.46 (4)	0.83 (1)
Total Watershed	0.32 (5)	0.48 (3)	0.49 (2)	0.39 (4)	0.53 (1)

*****Connectivity scores for FWO are zero since connectivity is assumed to be the increment above the base condition
( ) denotes alternative ranking

E.5 LAKE OKEECHOBEE LAKE STAGE

E.5.1 Introduction

ALT 10 includes construction of the C-51 deep reservoir feature, which would reduce water deliveries, via the L-8 canal, from Lake Okeechobee to the project area. This would incrementally reduce the discharge opportunities from Lake Okeechobee and the Herbert Hoover Dike. The L-8 canal is a relatively small canal used primarily for water supply (SFWMD 2010). The Lake Okeechobee section evaluates the potential effects of ALT10 on lake stages and the ecology of the Lake Okeechobee system. Other LRWRP alternatives are not considered in the analysis since they are not expected to affect water deliveries or lake stage because they do not include the C-51 deep reservoir feature.

A wide body of published research (summarized in Havens 2002) documents the ecological benefits of seasonally variable water levels within the range of 12.0 feet (ft) NGVD, in June and July, and 15.0 ft, from November to January. Falling water levels in late winter to spring benefit wading birds by concentrating prey resources in the littoral zone where those birds forage (Smith et al. 1995), water levels near 12.0 ft benefit submerged plants and bulrush by providing optimal light levels for photosynthesis in the summer months (Havens et al. 2004), and variation in the prescribed range results in annual flooding and drying

of upland areas of the littoral zone, which favors development of a diverse emergent plant community (Richardson et al. 1995, Keddy and Frazer 2000). However, periodic low stage events (11 ft NGVD) occurred approximately once per decade at a duration of roughly three months in the 1950s to 1970s (prior to implementation of high stage regulation schedules), and are considered beneficial to the littoral zone because they allow for periodic exposure of seed banks, oxidation of accumulated organic material, and fires that are important to maintaining species diversity in the littoral zone.

E.4.2 Performance Measures and Evaluation Approach

There were no performance measures developed to assess the effects of LRWRP on Lake Okeechobee. Instead, monthly average outflow data from the C-10A culvert were evaluated. The C-10A culvert releases water into the L-8 canal. Monthly outflow rates were converted to acre-feet to describe the volume of water released from the lake. One acre-foot of water is equivalent to 43,560 cubic feet A flow rate of one cubic foot per second (cfs) over one day will result in 1.98 acre feet per day.**E.4.3 Evaluation**

Flow data from the last ten years were evaluated to determine the effects on lake stage if flow was reduced from the C-10A culvert into the L-8 canal. The average monthly flow and volume of water conveyed through the C-10A culvert is presented in ***Table E.4- 1*** and ***Table E.4- 2***, respectively.

Table E.4- 1: Outflows (cfs) through the C-10A Culvert into the L-8 Canal over the Past Ten Years.

Values of 0 indicate months that no releases into the L-8 canal occurred.

Months / Year	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
1	0	270.419	96.061	105.997	219.935	392.935	243.968	357	130.116	248.59	146.496
2	0	213.571	39.496	135.75	118.552	330.929	205.911	367.519	20.13	189.996	257.214
3	0	101.787	133.774	90.065	80.423	320.645	220.355	306.2	170.981	126.703	282.935
4	0	8.19	313.1	59.7	29.038	267	70.103	250.267	198.393	0	157.637
5	0.207	0	363.613	46.956	0	145.419	0	199.355	250.581	0	0
6	0	0	273.1	12.043	0	0	0	7.83	277.6	0	0
7	0	0	259.968	0	0	0	0	0	380.194	0	0
8	0	131.839	197.435	0	625.581	485.29	316.129	0	181.178	0	0
9	46.9	195.367	104.4	0	112.356	306.733	183.393	0	122.362	0	0
10	79.548	254.71	164.742	0	112.356	394.452	117.032	288.839	95.509	0	0
11	349.667	238.137	164.847	0	218.067	374.333	196.933	218.967	256.067	6.594	0
12	312.824	121.748	183.903	88.103	373.387	304.839	282.355	207.258	327.174	1.271	0

Table E.4- 2: Additional Volume (Acre-Feet) of Water in Lake Okeechobee if Outflows through the C-10A Culvert into the L-8 Canal Did Not Occur.

Values of 0 indicate months that no releases into the L-8 canal occurred.

Months	Years										
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
1	0.0	536.4	190.5	210.2	436.2	779.4	483.9	708.1	258.1	493.1	290.6
2	0.0	423.6	78.3	269.3	235.1	656.4	408.4	729.0	39.9	376.9	510.2
3	0.0	201.9	265.3	178.6	159.5	636.0	437.1	607.3	339.1	251.3	561.2
4	0.0	16.2	621.0	118.4	57.6	529.6	139.0	496.4	393.5	0.0	312.7
5	0.4	0.0	721.2	93.1	0.0	288.4	0.0	395.4	497.0	0.0	0.0
6	0.0	0.0	541.7	23.9	0.0	0.0	0.0	15.5	550.6	0.0	0.0
7	0.0	0.0	515.6	0.0	0.0	0.0	0.0	0.0	754.1	0.0	0.0
8	0.0	261.5	391.6	0.0	1240.8	962.6	627.0	0.0	359.4	0.0	0.0
9	93.0	387.5	207.1	0.0	222.9	608.4	363.8	0.0	242.7	0.0	0.0
10	157.8	505.2	326.8	0.0	222.9	782.4	232.1	572.9	189.4	0.0	0.0
11	693.6	472.3	327.0	0.0	432.5	742.5	390.6	434.3	507.9	13.1	0.0
12	620.5	241.5	364.8	174.7	740.6	604.6	560.0	411.1	648.9	2.5	0.0

Monthly average releases were 138.2 cfs, which is equivalent to an average of 274.0 acre feet per day, or an average of 8,190 acre feet per month. The largest monthly average release occurred in October 2013 and was 394.5 cfs, which is equivalent to an average of 782.4 acre feet per day or an average of 24,254 acre feet per month. The L-8 is primarily used for water supply. October 2013 was considered the third driest October on record for areas near West Palm Beach (LRWRP area). High outflows may have been a result of increased needs for water during dry conditions (***Figure E.4- 1***).

Presently, Lake Okeechobee itself is approximately 445,000 acres (Havens and Gawlik 2005). Given the relatively small volume of water being released from the C-10A culvert, on average, halting flows into the L-8 canal from Lake Okeechobee will not result in considerable increases in lake stage. This is not surprising considering the small size of the canal.

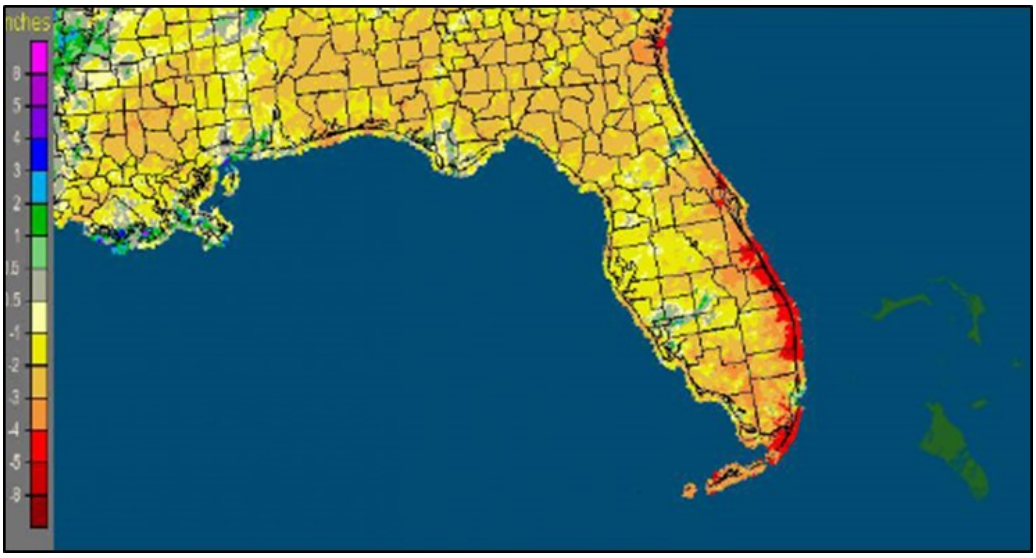


Figure E.4- 1: October 2013 Monthly Departure from Normal Precipitation (Griffin and Zierden 2013).

E.5.2 Summary and Conclusions

ALT10 is not expected to have significant impacts on Lake Okeechobee.

E.6 Overall Rankings of LRWRP Alternatives

The RECOVER Regional Evaluation Team (***Table E.6- 1***) reviewed the performance of the final array of alternatives for effects on the NWFLR (PM1), Loxahatchee Watershed (PM4), connectivity (PM9), and Lake Okeechobee lake stage (no PM). Conclusions concerning these effects can be found at the end of each related section above. Overall, regarding ecological and hydrological performance, the alternatives in the final array for the LRWRP were ranked on the basis that LRWRP restoration regarding the NWFLR (PM1) and the total Loxahatchee Watershed (PM4 + PM9) have equal weight (***Table E.5- 1***). All of the project alternatives improve performance when compared to the FWO. ALT5R was the best performing alternative, on average, of the final array for LRWRP from an ecological and hydrological perspective in meeting the goals and objectives of LRWRP.

Table E.5- 1: Overall Ranking of LRWRP Alternatives Based on Performance.

Metric	Ranking for ALT2	Ranking for ALT5R	Ranking for ALT10	Ranking for ALT13
NWFLR (PM1)	3	2	1	4
Total Watershed (PM4 + PM9)	3	2	4	1
AVG	3	2	2.5	2.5
Overall Ranking	**4**	**1**	**2.5**	**2.5**

*1 represents the best performing ALT while 4 represents the worst performing ALT.

E.7 RECOVER EVALUATION

E.7.1 RECOVER Regional Evaluation Team

Table E.6- 1: RECOVER Regional Evaluation Team

Member Name	Agency
Michael Simmons	USACE
Jenna May	USACE
Miles Meyer	USFWS
Phyllis Klarmann	SFWMD
Andy Rodusky	SFWMD

E.7.2 RECOVER Executive Committee Review

This RECOVER regional evaluation was reviewed by members of the RECOVER Executive Committee (REC) in ***Table E.6- 2***.

Table E.6- 2: Members of the REC who Reviewed this RECOVER Regional Evaluation.

REC Member	Agency
Gretchen Ehlinger	USACE
Fred Sklar	SFWMD
Agnes McLean	NPS
Laura Brandt	USFWS

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E.9 SUPPLEMENTAL INFORMATION

E.9.1 Dry Season Scoring Maps for VEC Zones (excluding Riverine Flood Plain)

Dry season score (or percentage of time meet the criteria) for five VEC zones: Tidal Flood Plain (***Figure E.8- 1***), Vallisneria (***Figure E.8- 2***), Oligohaline (***Figure E.8- 3***), Mesohaline (***Figure E.8- 4***), and Polyhaline (***Figure E.8- 5***) for ECB (top left), FWO (top right), ALT2 (mid left), ALT5 (mid right), ALT10 (bottom left), and ALT13 (bottom right).

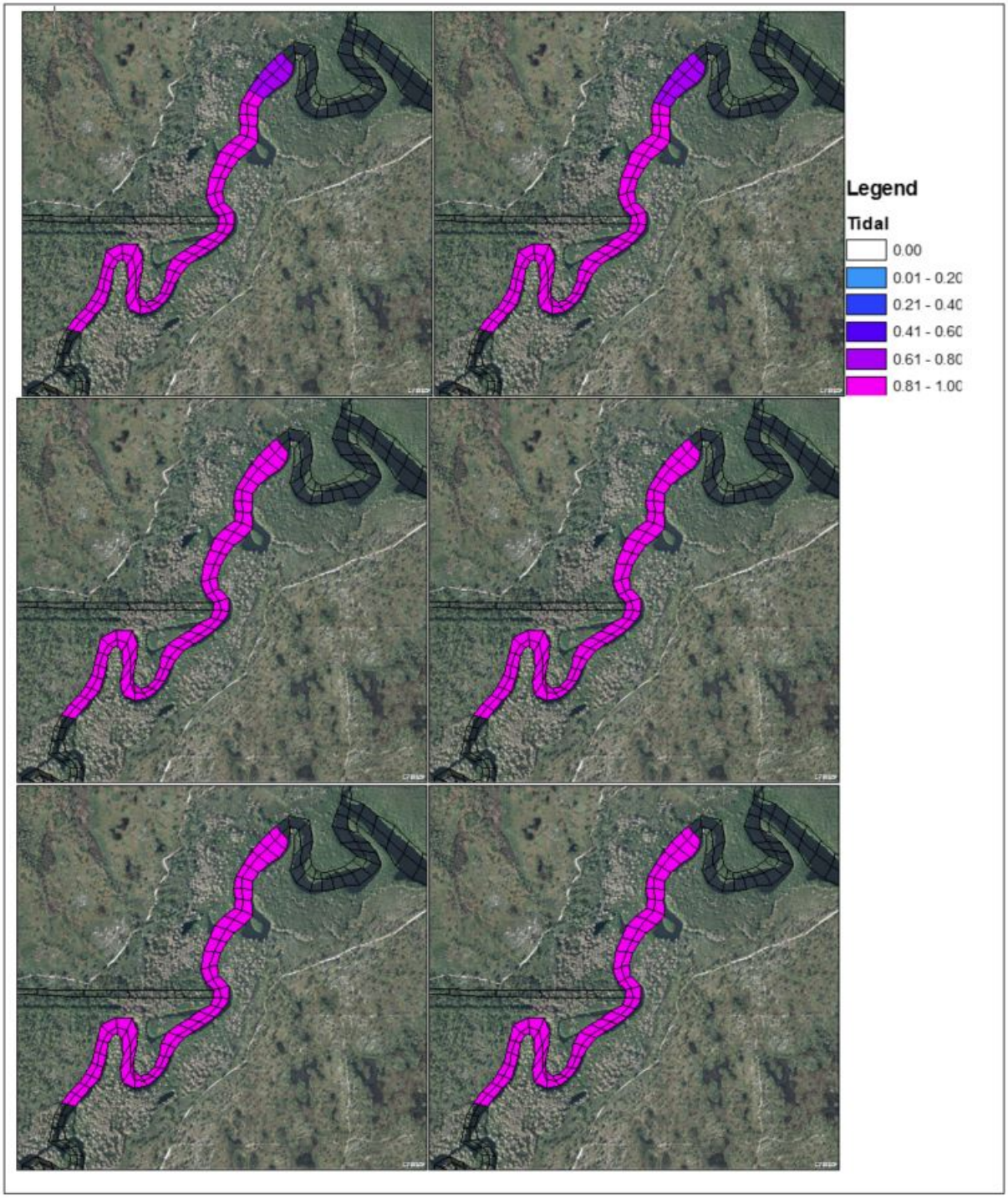

Figure E.8- 1: Map of Dry Season Scoring of LRWRP Alternatives in the Tidal Flood Plain VEC.

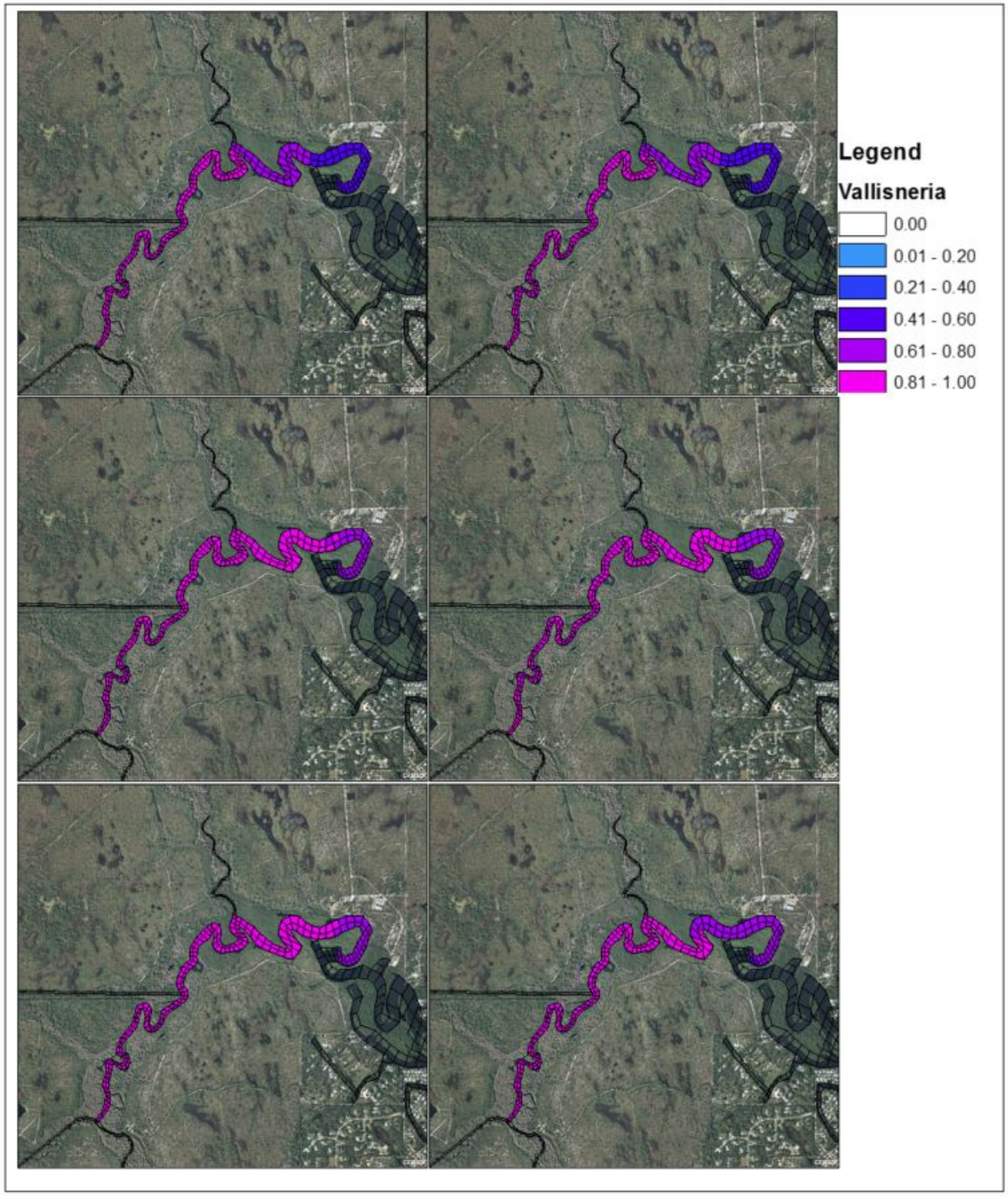

Figure E.8- 2: Map of Dry Season Scoring for LRWRP Alternatives for the Vallisneria VEC.

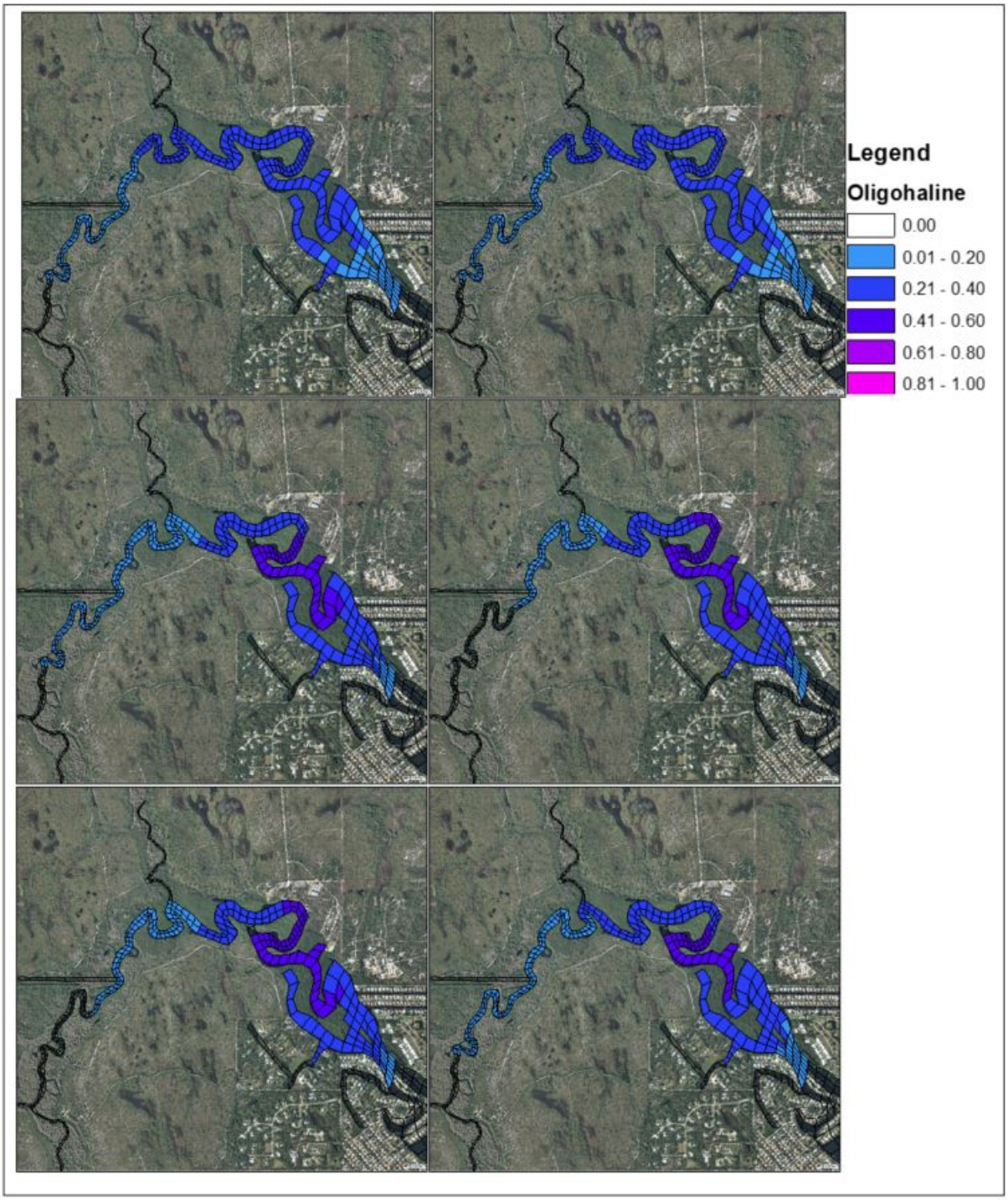

Figure E.8- 3: Map of Dry Season Scoring for the Oligohaline Zone VEC.

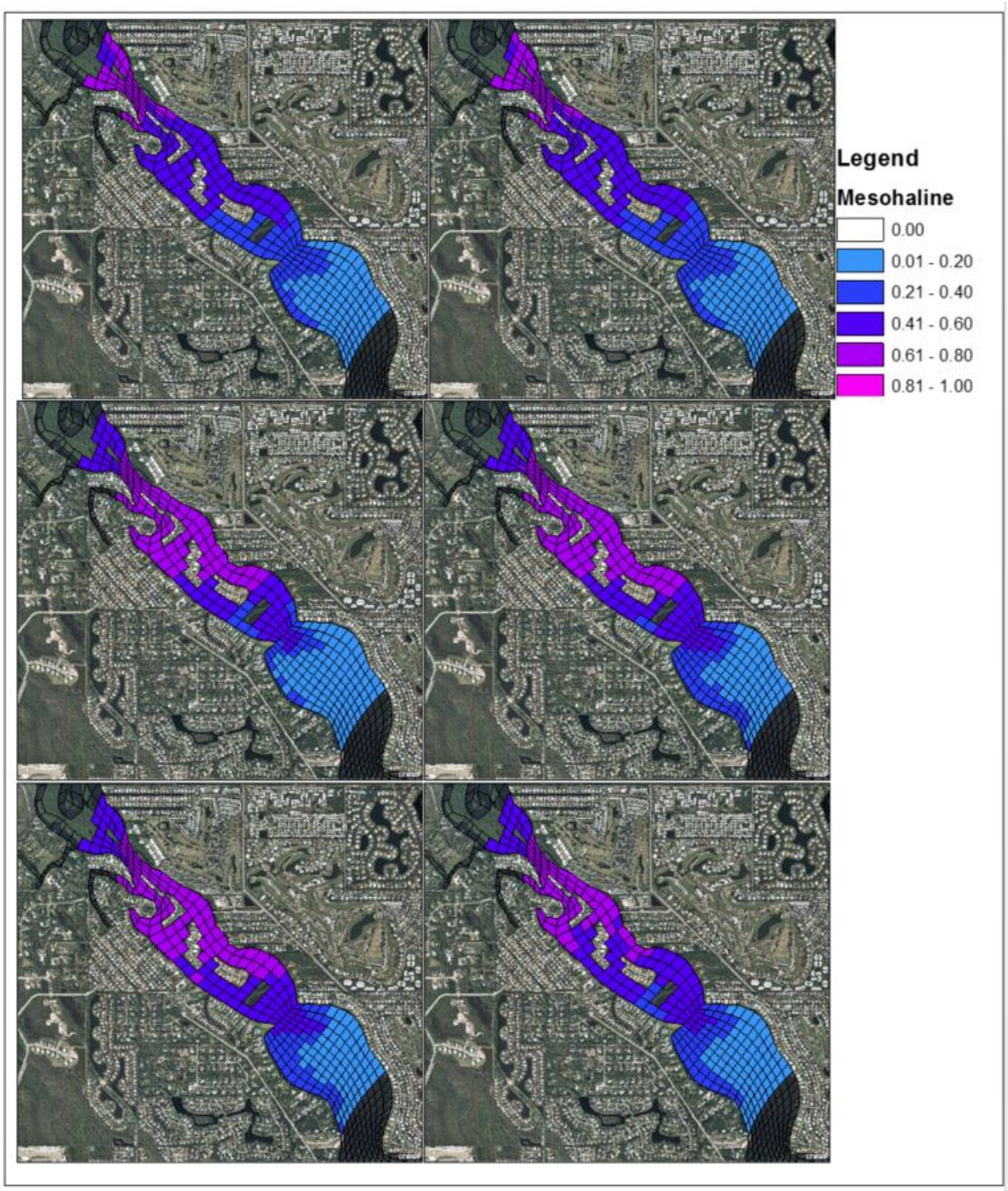

Figure E.8- 4: Map of Dry Season Scoring for the Mesohaline Zone VEC.

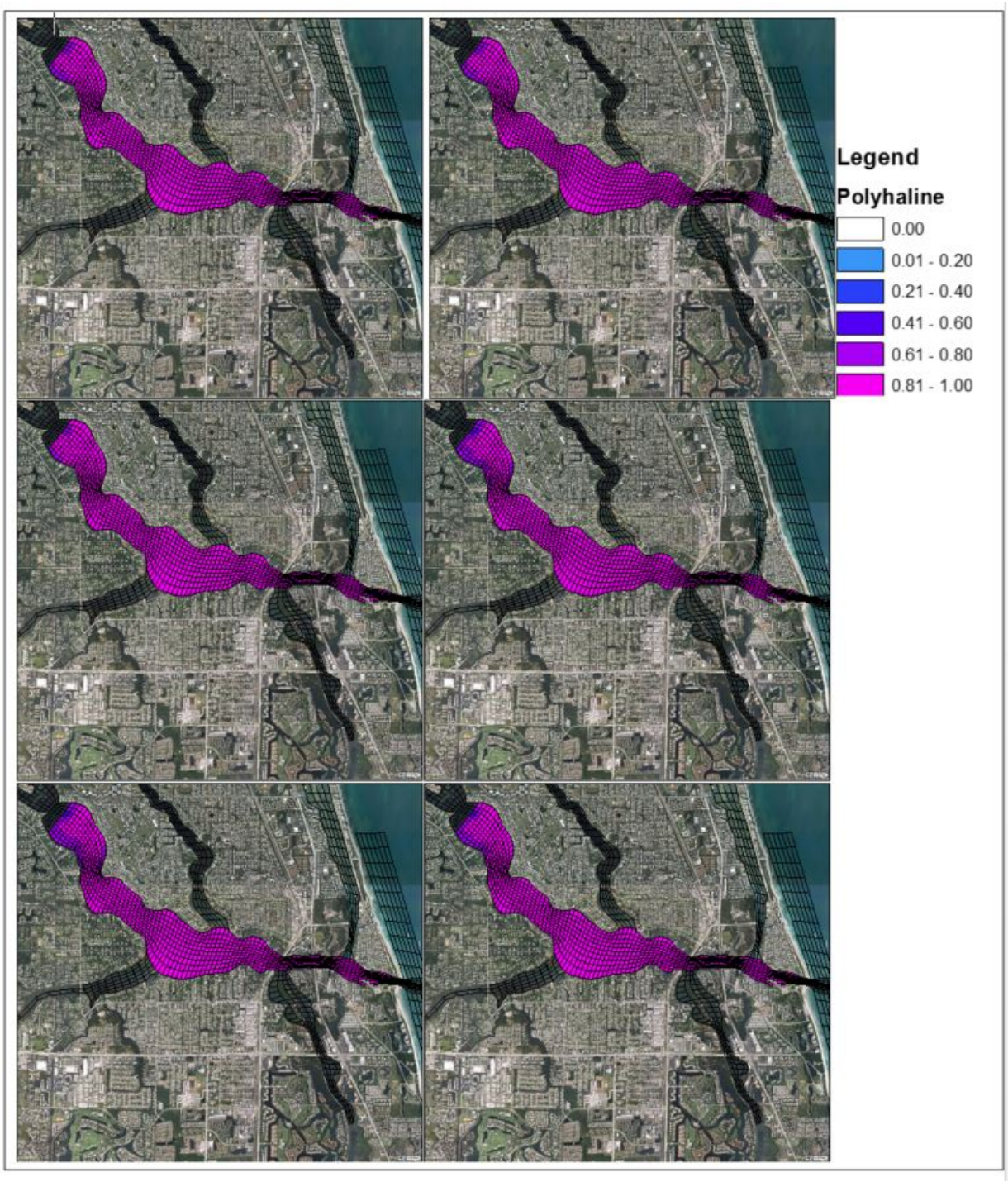

Figure E.8- 5: Map of Dry Season Scoring for the Polyhaline Zone VEC.

Wet Season Scoring Maps for VEC Zones (Excluding Riverine Flood Plain)

Wet season score (or percentage of time meet the criteria) for five VEC zones: Tidal Flood Plain (***Figure E.8- 6***), Vallisneria (***Figure E.8- 7***), Oligohaline (***Figure E.8- 8***), Mesohaline (***Figure E.8- 9***), and Polyhaline

(***Figure E.8- 10***) for ECB (top left), FWO (top right), ALT2 (mid left), ALT5 (mid right), ALT10 (bottom left), and ALT13 (bottom right).

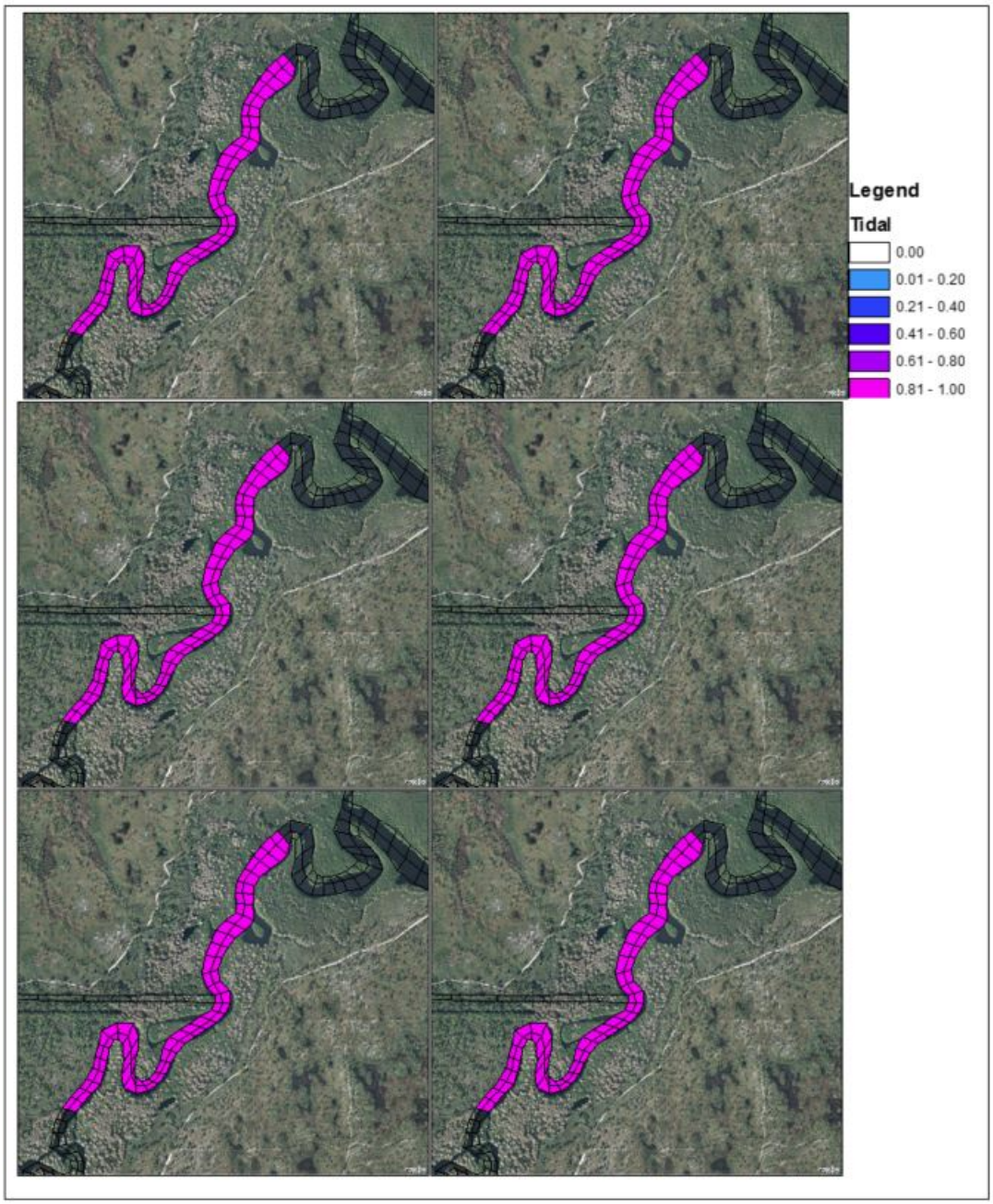

Figure E.8- 6: Map of Wet Season Scoring for the Tidal Flood Plain VEC.

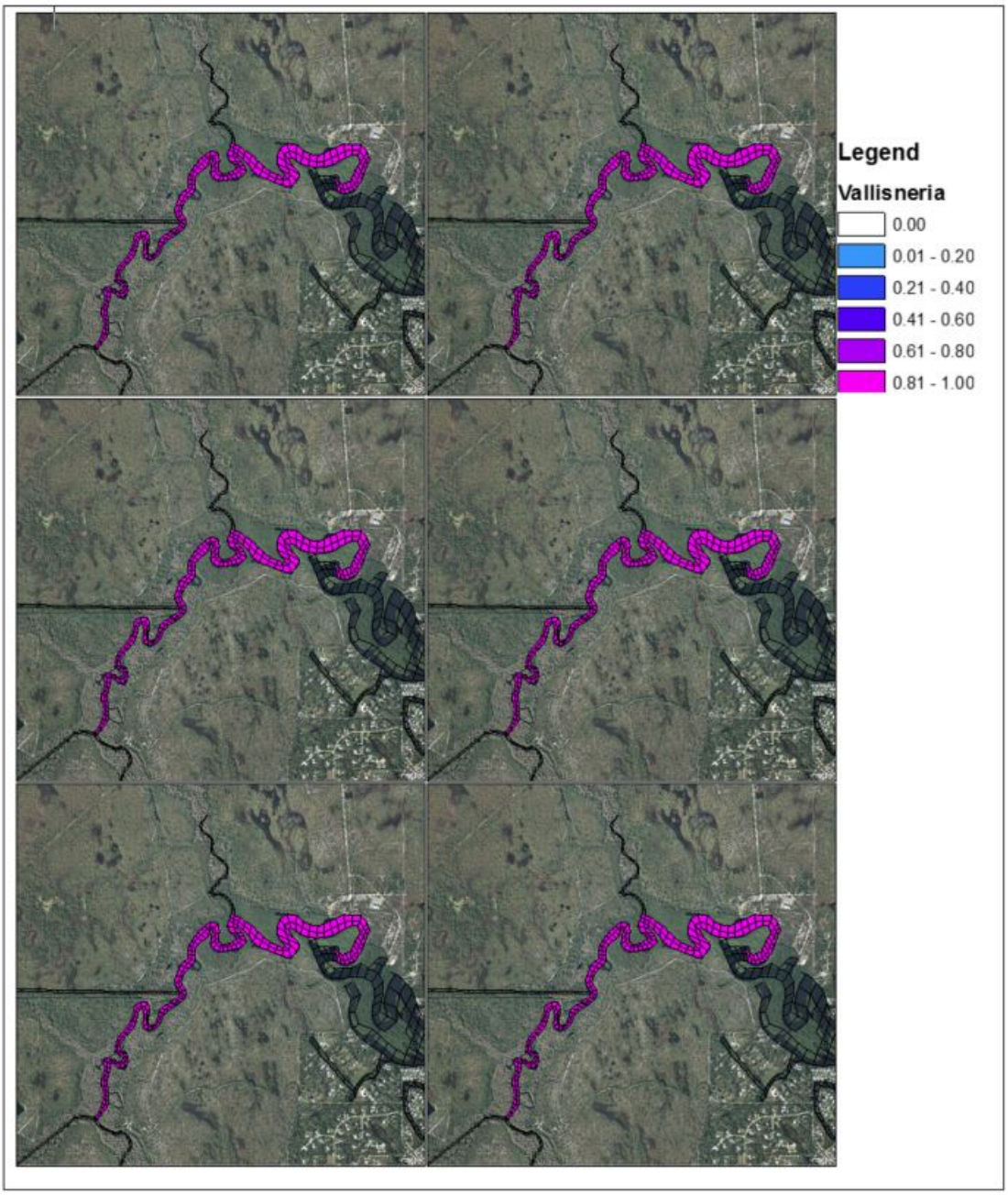

Figure E.8- 7: Map of Wet Season Scoring for the Vallisneria VEC.

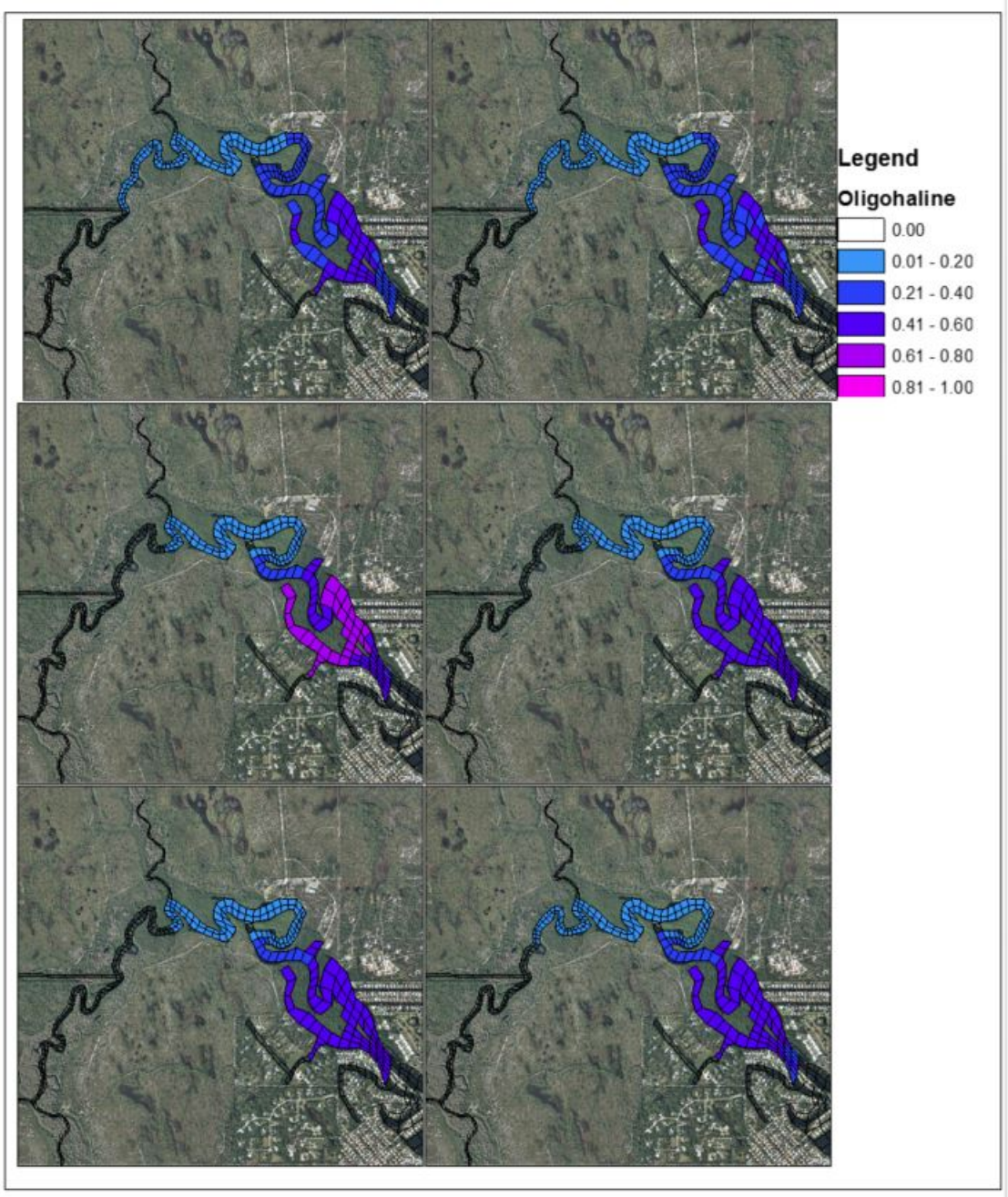

Figure E.8- 8: Map of Wet Season Scoring for the Oligohaline Zone VEC.

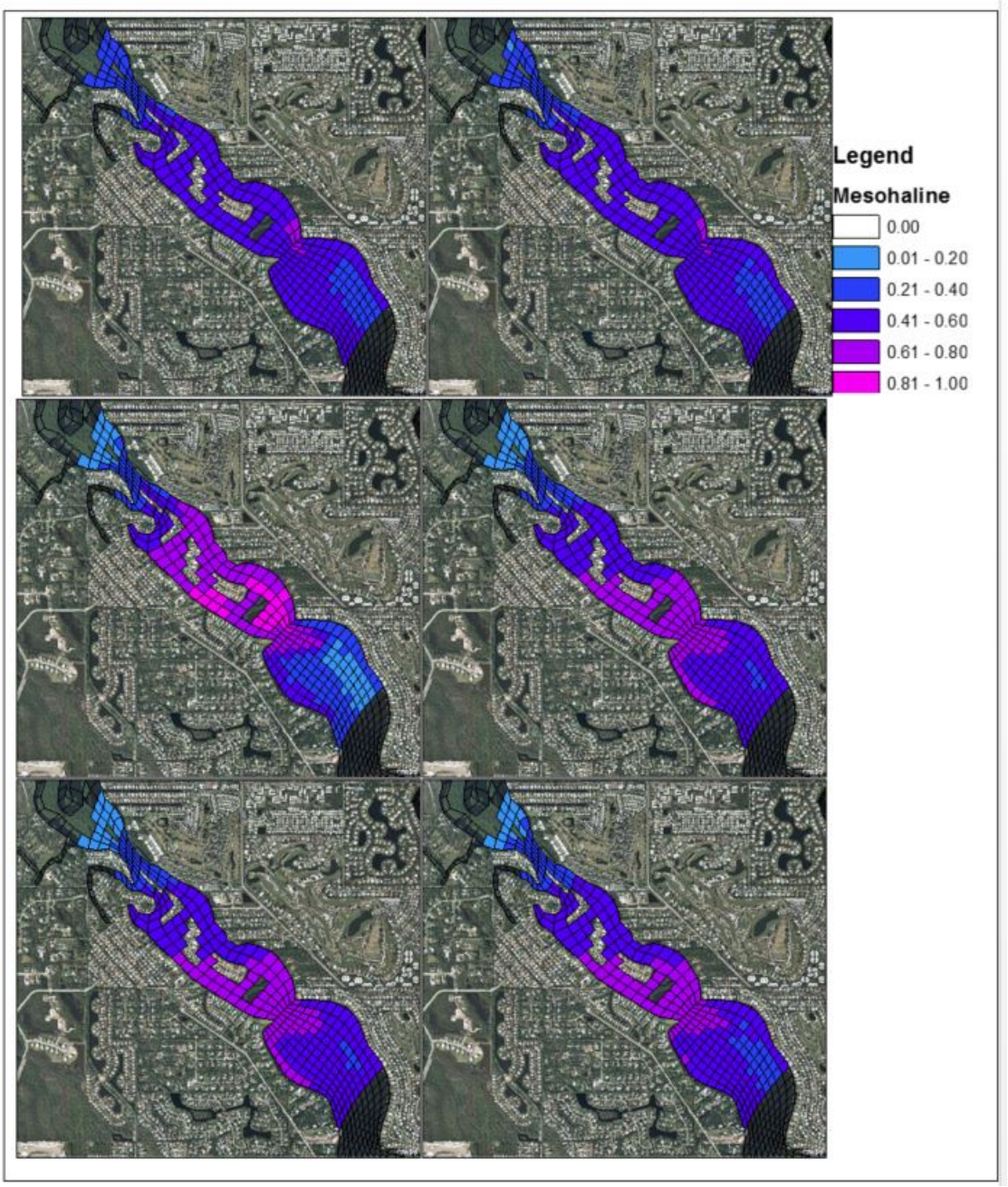

Figure E.8- 9: Map of Wet Season Scoring for the Mesohaline Zone VEC.

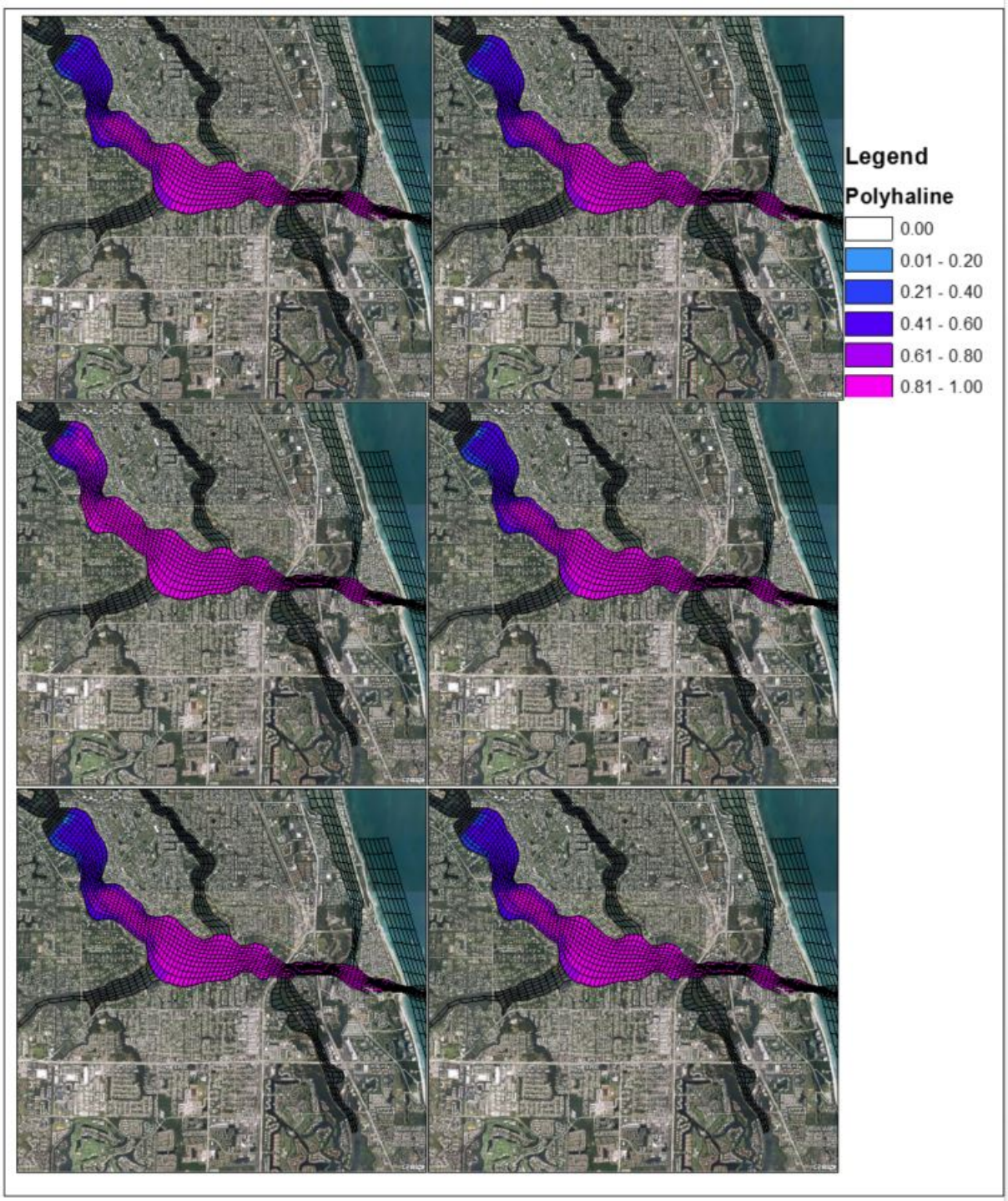

Figure E.8- 10: Map of Wet Season Scoring for the Polyhaline Zone VEC.

E.10 RECOVER CONSISTENCY REVIEW: LRWRP PROJECT GOALS AND OBJECTIVES AND PERFORMANCE MEASURES

E.10.1 RECOVER Consistency Review

Loxahatchee River Watershed Restoration Project (LRWRP)

RECOVER Consistency Review of Project Goals and Objectives and Performance Measures

Reviewers: Peter Doering, SFWMD, Tom Dreschel, SFWMD, Gretchen Ehlinger, USACE, Amanda McDonald, SFWMD, Agnes McLean, NPS, Steve Traxler, FWS

Coordinator: Kelly Keefe, USACE

Date: May 15, 2015

Introduction

The following document summarizes a few members of the RECOVER review of LRWRP project goals and objectives and performance measures as they related to CERP goals and objectives and RECOVER system-wide/regional performance measures. The review was conducted using the following documents:

1. LRWRP Report Synopsis (includes goals and objectives and background on project)
2. Performance Measure 1 - Northwest Fork Salinity
3. Performance Measure 4 - Plant Community Hydrology
4. Performance measure 9 - Connectivity
5. LRWRP Virtual Tour Presentation and Project Delivery Team PM presentation

General Comments

<u>Goals and Objectives Consistency</u>

1. LRWRP goals and objectives are consistent with CERP goals and objectives described in the yellow-book Table E.2-3-1. The overall goal 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 and flows and salinity conditions in the Loxahatchee River Estuary. While the LRWRP Objectives are clearly listed, a crosswalk table with the CERP Goals and Objectives would be useful. The table below is our attempt at that table.

Table E10-1. Yellow Book Goals and Objectives.

Yellow-Book Goal and Objective	LRWRP Objective
Enhance Ecological Values - Increase the total spatial extent of natural areas	Objective 3: Increase natural area extent of wetlands
Enhance Ecological Values - Improve habitat and functional quality	Objective 1: Restore wet and dry season flows of water to the National Wild and Scenic Northwest Fork of the Loxahatchee River and the river floodplain Objective 4: Restore connections between Corbett Wildlife Management Area, Pal-Mar/Cypress Creek basin, Loxahatchee Slough, Grass Waters Preserve and Loxahatchee River to improve hydrology, sheetflow, hydroperiods, natural storage, and vegetation communities
Enhance Ecological Values - Improve native plant and animal species abundance and diversity	Objective 2: Restore oysters, seagrass and other estuarine communities in the Loxahatchee River Estuary by reducing excess wet season high flows to Loxahatchee River Estuary through South Fork at the coastal control structure S-46 Objective 5: Restore native plant and animal species abundance and diversity in Loxahatchee River watershed natural areas, river, and estuary
Enhance Economic Values and Social Well Being - Increase availability of fresh water (agricultural/municipal & industrial)	Objective 7: Increase availability of water supply
Enhance Economic Values and Social Well Being - Reduce flood damages (agricultural/urban)	No corresponding LRWRP objective
Enhance Economic Values and Social Well Being - Provide recreational and navigation opportunities	Objective 6: Provide recreational opportunities
Enhance Economic Values and Social Well Being - Protect cultural and archeological resources and values	No corresponding LRWRP objective

2. LRWRP planning objective 2 states that estuary salinity benefits will be measured based on the percent reduction in frequency and duration of S-46 structure peak flow discharges that relate to salinity threshold criteria for seagrasses. Are the threshold discharges going to be compared to oyster

thresholds as well? The actual objective lists oysters, seagrass and other estuarine communities and PM1 uses tape grass, fish larvae, oysters and seagrass to calculate benefits.

3. Section 10: In the hydrology section it states that the primary focuses of the LRWRP project are the Loxahatchee River and the LWL watersheds. Where are the PMs for LWL?

4. The report seems organized according to a prescribed format and this makes it hard to follow at times and also seems to have caused considerable redundancy. For example, problems associated with altered hydrology are summarized in slightly different ways on pages 5 (under Section 5), 11 (under Section 6.2 project area) 14, and 15 (under section 8.1 Hydrological/ Ecological Problems).

5. There should be more explicit emphasis on restoration of flows (hydroperiod/depth) to the floodplain of the Loxahatchee River. This goal is really not explicitly stated until page 17 of the report. "Restore wet and dry season flows of water to the National Wild and Scenic Northwest Fork of the Loxahatchee River and the river floodplain. " The restoration goal of floodplain hydroperiod should be identified early on in the report. This is particularly important as the floodplain inundation targets established in the Restoration Plan for the Northwest Fork of the Loxahatchee River is the metric used to measure restoration.

6. Is Lake Worth Lagoon included in this study? On page 21 the report states that the primary focuses of the LRWRP project are the Loxahatchee and Lake Worth Lagoon watersheds. Yet the primary goal is to restore freshwater flow to the "National Wild and Scenic" Northwest Fork of the Loxahatchee River (see page 16).

Performance Measure Consistency

Performance Measure #1 – Seasonal Flows to Manage Salinity and Floodplain Hydroperiod in the Northwest Fork of the Loxahatchee River

Justification Section:

1. This section is confusing. What is supposed to be justified here? Is it the LRWRP itself, the VEC or the flow target from the Restoration Plan?

2. Suggest that this section reiterate the goals of the LRWRP as stated in the project synopsis report, identify which goal (s) this PM addresses and concentrate on why the VEC, salinity envelopes and flow targets are appropriate for measuring progress towards these goals.

3. Paragraph 2 on page 2 needs a bit of rewording. In its present form it seems to indicate that opening of the inlet was a structural alteration that lead to reduced freshwater inflow. One approach would be to re-write the paragraph to emphasize how structural alterations have led to saltwater intrusion.

4. On pages 2 and 3, the discussion of the VECs, their location and their salinity envelopes could be improved by providing a more detailed description of how they were chosen and the relationships between location, salinity and the target flow scenario. For example, were the locations of the VEC

chosen because this is where the flow target produced favorable salinity or does this reflect their present distribution in the river estuary?

CERP Evaluation Target

1. The preferred restoration flow scenarios describe the LV90TV60, but later compare it to LV90TV90 and LV90TV120. The later scenarios are not explained and are very confusing. Suggest that a table that explains the scenarios be added or an explanation of the scenarios added. Include the table from the Restoration Plan since it is a key factor in the performance measure. The Floodplain Targets reference Figure E.2-2 for LV90TV60, but there is no Figure E.2-2 in the PM doc sheet.

2. Page 10: The document states that a conservative target of 1 psu was set in the Restoration plan for the freshwater tidal community upstream of RM 8.2. In Table E.1-1 the target for the Upper Tidal Flood Plain is <2 psu. Why the difference? Are these two criteria considered compatible?

Evaluation Protocol

1. The target locations given in Table E.1-1 do not entirely correspond to the locations given in the list of VECs in the Justification section.

2. Locations of VEC overlap. This not necessarily a problem but it might affect scoring in some unforeseen way.

3. The protocol used to score the Riverine Floodplain VEC is pretty straight forward. However, as formulated the procedure might not be sensitive enough to distinguish between alternatives. For the two areas in the example given on page 11, an alternative that produced 5 months and 2 months of inundation would also yield 328 habitat units. It might be better to have a more defined target inundation period of say 6 months. Anything with at least 6 months of inundation gets a 1. Five months gets (5/6=) 0.83, 4 months gets (4/6=) 0.66 etc.

4. Riverine Floodplain: Is there an upper limit to inundation period. Would, for example, 10 months be too long and hence detrimental. Should a scoring protocol be developed for this eventuality?

5. Other VECs: No example is given. However, the scoring of habitat units for these would be likely based on the some measure of time that the salinity is within the preferred range at the preferred location(s). Compute mean monthly salinity in each 1 km segment from RM0 to RM16 for the period of record. Establish a target number of months each year that salinity should be in the preferred range for each VEC. For *Vallisneria* this would be 12 months each year. For fish larvae it may be only each month from March-June. For each segment within the spatial range of a VEC, compute the number of months during the relevant time of year that salinity is within the preferred range. For each segment, divide the observed number of months by the target number of months with the desired salinity range and multiply by the number of acres in the segment. Sum acres across segments within the desired spatial range for each VEC to calculate habitat units.

6. How do you score the salinity targets? If the salinity is out of the range for the entire POR then it would score a 0, if it is in the range for the entire POR then it would score a 1. How does it score for being in range for part of the POR? Is it always 0.5 if it is one day less the than target?

7. It looks like the actual goal is to restore flows at Lainhart Dam and the salinity targets are based on flows. I would try to state that clearly at the start of the PM doc sheet, since flows are really the only thing the project is going to affect. Flows are the target, salinities result from the flows and the targets are based on salinities of the VECs.

8. Please give an example using one of the VECs, not just the riverine floodplain example. The VECs use the other models and are not just based on output from the hydrological model.

9. Scoring system is not very sensitive, 1 month and 5 month meeting of the salinity score the same (0.5). There is a big ecological difference between meeting the target 1% of the time versus 99% of the time, but as it is written, both would receive a score of 0.5. There needs to be greater sensitivity in the scoring rubric.

Performance Measure #4 – Hydrologic Regimes of Major Plant Communities in the Loxahatchee Watershed and Adjacent Wetlands

Justification Section:

1. The document states that a separate performance measure has been established for Grassy Waters Preserve. Is that performance measure being used for this project? Where is that PM doc sheet?

Evaluation Protocol

1. When were the WRAP assessments completed? It reads as if they were done in 2004. If they are being used for the evaluation, should they be updated to assess current conditions?

2. Using the WRAP from 2004 makes the assumption that the 2004 assessment is the existing condition. If this is the case, this needs to be explained in the document.

Performance Measure #9- Hydrologic/Spatial Connectivity

CERP Evaluation Target

1. The target is the highest % increase in connectivity. What is the CERP target? 100%, 90%, what are we shooting for? I can see evaluating and comparing the alternatives based on the highest % connectivity, but what is the end goal? What are we ultimately trying to achieve?

Evaluation Protocol

1. There is currently some connection to the NW Fork of the Loxahatchee, how would it score using your criterion rubric?

2. If Existing condition is considered a zero, is future without project considered a zero as well? Could connectivity get worse than it is now?

3. Scoring system is not very sensitive, partial connectivity always scores a 12.5. There is a big ecological difference between a 1% connectivity and a 99% connectivity, but as it is written, both would receive a score of 12.5. There needs to be greater sensitivity in the scoring rubric.

4. How is this PM used to calculate habitat units? You get a score from the criterion rubric, but what is done with it from there?

E.10.2 LRWRP Eco-subteam Response to RECOVER Consistency Review

Loxahatchee River Watershed Restoration Project (LRWRP) Ecosubteam Response to Comments from:

RECOVER Consistency Review of Project Goals and Objectives and Performance Measures
Ecosubteam Responders: Andy LoSchiavo, Patti Gorman

Date: June 4, 2015

Introduction

The following document summarizes the LRWRP ecosubteam responses to RECOVER comments on the LRWRP project goals and objectives and performance measures. A subset of the full ecosubteam reviewed the comments and provided responses to address comments and suggestions to improve the statements of LRWRP goals and objectives and how they will be measured with the performance measures. The ecosubteam appreciates this independent review by Everglades science experts and believe the updates that will be made to performance measure documentation will improve their validity and clarity to a variety of audiences. We have responded to comments by providing a name and response after each comment provided using the original RECOVER response document format.

Review Comments and LRWRP Ecosubteam Responses

<u>Review Part 1 and 2: Goals and Objectives Consistency with CERP</u>

1. LRWRP goals and objectives are consistent with CERP goals and objectives described in the yellow-book table 5-1. The overall goal 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 and flows and salinity conditions in the Loxahatchee River Estuary. While the LRWRP Objectives are clearly listed, a crosswalk table with the CERP Goals and Objectives would be useful. The table below is our attempt at that table.

Table E10-2. Yellow Book Goals and Objectives Consistency with LRWRP Objectives.

Yellow-Book Goal and Objective	LRWRP Objective
Enhance Ecological Values - Increase the total spatial extent of natural areas	Objective 3: Increase natural area extent of wetlands
Enhance Ecological Values - Improve habitat and functional quality	Objective 1: Restore wet and dry season flows of water to the National Wild and Scenic Northwest Fork of the Loxahatchee River and the river floodplain. Objective 4: Restore connections between Corbett Wildlife Management Area, Pal-Mar/Cypress Creek basin, Loxahatchee Slough, Grass Waters Preserve and Loxahatchee River to improve hydrology, sheetflow, hydroperiods, natural storage, and vegetation communities
Enhance Ecological Values - Improve native plant and animal species abundance and diversity	Objective 2: Restore oysters, seagrass and other estuarine communities in the Loxahatchee River Estuary through South Fork at the coastal structure S-46. Objective 5: Restore native plant and animal species abundance and diversity in Loxahatchee River watershed natural areas, river, and estuary
Enhance Economic Values and Social Well Being - Increase availability of fresh water (agricultural/municipal & industrial)	Objective 7: Increase availability of water supply
Enhance Economic Values and Social Well Being - Reduce flood damages (agricultural/urban)	No corresponding LRWRP objective
Enhance Economic Values and Social Well Being - Provide recreational and navigation opportunities	Objective 6: Provide recreational opportunities
Enhance Economic Values and Social Well Being - Protect cultural and archeological resources and values	No corresponding LRWRP objective

Subteam Leads: Andy LoSchiavo and Patti Gorman

Response: We will include a cross walk table of LRWRP and CERP goals and objectives in future updates to the report synopsis which will become a draft project implementation report (PIR) and environmental impact statement (EIS).

Status: Resolved upon revisions to the document.

2. LRWRP planning objective 2 states that estuary salinity benefits will be measured based on the percent reduction in frequency and duration of S-46 structure peak flow discharges that relate to salinity threshold criteria for seagrasses. Are the threshold discharges going to be compared to oyster thresholds as well? The actual objective lists oysters, seagrass and other estuarine communities and PM1 uses tape grass, fish larvae, oysters and seagrass to calculate benefits.

Response: The changes in flows to the estuary from all sources (e.g., Lainhart dam, S-46, and tributaries) provided by the array of alternatives will be input into a salinity regression tool. This tool will provide an estimate of salinity envelops for the entire river and estuary from Lainhart dam to the inlet. The effects on the estuarine indicators described in PM1 will then be evaluated for each alternative as well as the FWO and ECB in order to determine the lift provided by a given plan. The areas of improved habitat will then be turned into habitat units (HUs) by multiplying by the acreage of improvements along the river/estuary gradient. The LRWRP team will make sure the report language is up to date and consistent with current project expectations. Subteam Leads: Patti Gorman and Andy LoSchiavo

Status: Resolved on agreement to make sure the report language is up to date and consistent with current project expectations.

3. Section 10: In the hydrology section it states that the primary focuses of the LRWRP project are the Loxahatchee River and the LWL watersheds. Where are the PMs for LWL? Also in section 10: there is a statement that "Based on assumptions used for future forecasting, there is little reason to believe that hydrologic conditions in the LRWRP would be substantially different between 2050 and 2072". Given the current rate and projected rate of SLR, can this statement be supported? Are there any projections as to whether/how much restoration of the cypress regions could be expected with improved freshwater flows?

Response: Lake Worth Lagoon (LWL): Unlike NPB Part 1 this projects focus is on the NW Fork and the contributing watersheds including C-18, but is not formulated to achieve benefits in LWL. Therefore there are no LWL PMs this time. The watersheds and sub-basins are highly managed. Water that would route to the LWL can also be diverted towards the Loxahatchee river through flow-way 1 going through Grassy Waters Preserve.

Sea-Level Rise (SLR): The project will analyze sea-level rise effects on restoration benefits. At this time we have not yet done an analysis of much benefits that project will achieve vs. how much will be lost due to SLR. The planning assumption is that SLR in 22 years on the low and medium SLR curves will not be greater than 4-6 inches, and will not be a significant impact on restoration benefit lift compared to the future without project. SLR effects will not be large in the years specified in the planning of the project. SLR analysis will be done. Ecosubteam believes they do not need to adjust formulation based on this. Subteam Leads: Andy LoSchiavo and Patti Gorman

Status: Resolved on agreement to make changes and clarifications in the report.

4. The report seems organized according to a prescribed format and this makes it hard to follow at times and also seems to have caused considerable redundancy. For example, problems associated with altered hydrology are summarized in slightly different ways on pages 5 (under Section 5), 11 (under Section 6.2 project area) 14, and 15 (under section 8.1 Hydrological/ Ecological Problems).

Response: All new and rescoped USACE civil works projects must first develop a report synopsis that follows a standard template. Pg. 5 is as statement of Federal Interest that is intended to be short and concise (high level). Section 6.2 gives the reader more insight into each area of the project, where as section 8.1 is a more detailed description of problems and opportunities to be addressed by the project. Subteam Leads: Andy LoSchiavo and Patti Gorman

Status: Resolved

5. There should be more explicit emphasis on restoration of flows (hydroperiod/depth) to the floodplain of the Loxahatchee River. This goal is really not explicitly stated until page 17 of the report. "Restore wet and dry season flows of water to the National Wild and Scenic Northwest Fork of the Loxahatchee River and the river floodplain. " The restoration goal of floodplain hydroperiod should be identified early on in the report. This is particularly important as the floodplain inundation targets established in the Restoration Plan for the Northwest Fork of the Loxahatchee River is the metric used to measure restoration.

Response: Agree, there is a lot of information from the 2006 and 2011 NW Fork Restoration Plans that can be used and/or referenced, as discussed on pg. 13, bullet 6. We will update the report to ensure restoration of floodplain hydroperiods is captured in the project background, existing and future conditions, and statement of problems and objectives. Subteam Leads: Patti Gorman and Andy LoSchiavo

Status: Resolved upon revisions to the document.

6. Is Lake Worth Lagoon included in this study? On page 21 the report states that the primary focuses of the LRWRP project are the Loxahatchee and Lake Worth Lagoon watersheds. Yet the primary goal is to restore freshwater flow to the "National Wild and Scenic" Northwest Fork of the Loxahatchee River (see page 16).

Response: No LWL is not included. The watersheds and subbasins are highly managed. Water that would route to the LWL can also be diverted towards the Loxahatchee river through flow-way 1 going through Grassy Waters Preserve. Understanding the three watersheds is necessary to understanding opportunities for bringing additional flow to restore the Loxahatchee river. Prior North Palm Beach County Part 1 planning efforts indicated that the Lake Worth Lagoon should be a separate CERP project. Subteam Leads: Andy LoSchiavo and Patti Gorman

Status: Resolved upon revisions to the document.

7. How to combine the evaluation protocols of the 3 PMs is not defined. This will probably be completed at a later date, but the earlier this process can be reviewed the better. Developing a measureable evaluation protocol that is sensitive to the alternatives has proven to be difficult in CERP.

Response: We are still developing the evaluation protocol of how the 3 PMs will be combined. We will be leveraging similar approaches used for Biscayne Bay Coastal Wetlands and Indian River Lagoon-South. The goal is to ensure that the smaller acreage restoration benefit lift in the Loxahatchee River freshwater floodplain, tidal floodplain, oligohaline, mesohaline, and estuarine areas are not valued less than the larger acreage upstream watershed. This RECOVER review was focused on the performance measures that will be used and not the habitat units methodology, which is a separate project task.

Subteam Leads: Andy LoSchiavo and Patti Gorman

Status: Resolved

8. The number of PMs does not appear to cover all of the project objectives. There are no PMs for Oyster, seagrass, or connectivity. If the formulation possibly can, it would be good to have a PM link to each objective and then the monitoring plan could link to each PM. That way the project could be evaluated and assessed on the same parameters.

Response: Oysters and SAV are a part of PM1 and there is a connectivity PM - #9. We will add a table that links objectives to performance measures, and ultimately attributes being measured that can then be monitored as part of the monitoring and adaptive management plan. Subteam Leads: Patti Gorman and Andy LoSchiavo

Status: Resolved upon revisions to the document.

9. Include a section discussing the shift from mangroves back to the freshwater community and if the loss of mangroves will be a permitting issue.

Response: This can be added to PM#1, but there is no expectation that the mangroves will die off and be replaced by freshwater floodplain vegetation. Once established, mangroves have no problem living in freshwater. The only way to facilitate that shift back to a more historic vegetative community would be to actively remove the mangroves and plant freshwater species. That is not anticipated as part of this project. Prior planning coordination with FDEP indicated that changing conditions favorable to mangroves to restored condition favorable to Cypress floodplain would not be an issue. We are ultimately restoring unique plant community types that will improve overall system function and diversity in southeast Florida. Subteam Leads: Patti Gorman and Andy LoSchiavo

Status: Resolved upon revisions to the document.

10. Climate change is only mentioned 3 times in the document and sea level rise just once. A section discussing sea level rise and precipitation changes and how they will affect the future without and the alternatives is needed. Promoting resilience to climate change is a major white house priority

(Presidents Priority Agenda: Enhancing the Climate resilience of America's natural resources, October 2014).

Response: Agreed. Climate change is one of the moderate risks identified in the LRWRP risk register. A climate change analysis will be done to address SLR and whether precipitation changes are likely to be important factors affecting restoration performance. The effects of climate change will be measured using primarily PM 1. Climate change considerations will also be factored into the formulation of project alternatives with respect to storage. In addition, some management measures such as adjustable tide barriers strategically placed in the estuary are being considered during management measure development. The Climate change analysis will be a discrete section of the draft PIR and EIS. Subteam Leads: Andy LoSchiavo and Patti Gorman

Status: Resolved upon revisions to the document.

11. PM 1 mentions that "one of the guiding principles of the restoration plan is that one part of the watershed will not be sacrificed to benefit another part. It was essential to the restoration plan that ecological benefits were achieved system wide." Yet, many of the objectives state restore the various habitats and species as well as increase water supply. This does not seem possible with future population growth projections and climate change threats. A trade-off analysis that includes a water budget for the project area should to be performed.

Response: The discussion of restoration objectives related to water supply is summarized in the following excerpt from pg.18 of the Report Synopsis: "Ecosystem restoration is the primary goal, and formulation will first address ecosystem restoration objectives. Then, water supply benefits will be evaluated in reference to modeled operations of the recommended plan to optimize water supply performance, including increasing the amount of water made available by the project for consumptive use allocation in Lower East Coast Service Area without reducing the beneficial effects on the natural system." Subteam Leads: Patti Gorman and Andy LoSchiavo

Status: RECOVER scientists satisfied that the team will fully coordinate this with the USACE Vertical Team.

Review Part 3: Performance Measure Consistency with CERP

Performance Measure #1 – Seasonal Flows to Manage Salinity and Floodplain Hydroperiod in the Northwest Fork of the Loxahatchee River

Justification Section:

1. This section is confusing. What is supposed to be justified here? Is it the LRWRP itself, the VEC or the flow target from the Restoration Plan?

Response: All of the above, it sets the stage by discussing the historical, man-made changes that have caused damage. Then discusses the targets and selected VEC's. This section has been slightly rewritten to provide a clearer narrative on what and why we are measuring salinity related to VECs. Lead: Patti Gorman

Status: Resolved

2. Suggest that this section reiterate the goals of the LRWRP as stated in the project synopsis report, identify which goal (s) this PM addresses and concentrate on why the VEC, salinity envelopes and flow targets are appropriate for measuring progress towards these goals.

Response: We have added a written statement of LRWRP goals, objectives that relate to this performance measure that links the importance of flow and salinity to VECs in measuring the project goals. In addition, the VECs are consistent with the Loxahatchee River and Estuary CEM's ecological attributes. Lead: Patti Gorman

Status: Resolved

3. Paragraph 2 on page 2 needs a bit of rewording. In its present form it seems to indicate that opening of the inlet was a structural alteration that led to reduced freshwater inflow. One approach would be to re-write the paragraph to emphasize how structural alterations have led to saltwater intrusion.

Response: Paragraph rewritten to emphasize changes to the system that have led to saltwater intrusion. Lead: Patti Gorman

Status: Resolved

4. On pages 2 and 3, the discussion of the VECs, their location and their salinity envelopes could be improved by providing a more detailed description of how they were chosen and the relationships between location, salinity and the target flow scenario. For example, were the locations of the VEC chosen because this is where the flow target produced favorable salinity or does this reflect their present distribution in the river estuary?

Response: Language has been added to explain why VECs were chosen as good indicators of ecological community composition and health for the Loxahatchee River and Estuary and how they are consistent with ecological attributes described in the CEM for the Loxahatchee. Lead: Patti Gorman

Status: Resolved

5. Saltwater intrusion is not mentioned until the Evaluation target section and is only related to flow not water level. Was analysis performed to determine a minimum water level needed to correspond with the flow, or was it just assumed that the flow would provide the needed water levels?

Response: The restoration flows produce the right level of inundation in the Fresh water floodplain, but no analysis was done in the restoration plan to take into account a detailed analysis of how SLR will affect the water levels in the downstream portion of the floodplain. As part of the planning process, a SLR analysis will be done based on the USACE newest guidance. Lead: Patti Gorman

Status: Resolved

CERP Evaluation Target

1. The preferred restoration flow scenarios describe the LV90TV60, but later compare it to LV90TV90 and LV90TV120. The later scenarios are not explained and are very confusing. Suggest that a table that explains the scenarios be added or an explanation of the scenarios added. Include the table from the Restoration Plan since it is a key factor in the performance measure. The Floodplain Targets reference Figure 7 for LV90TV60, but there is no Figure 7 in the PM doc sheet.

Response: Label of Figure 7 has been changed to Figure 4. The performance measure figures will be edited and formatted consistently with the order they are introduced in the text. More information will be included on the three scenarios to simplify and clarify the modeling methods. Lead: Patti Gorman

Status: Resolved

2. Page 10: The document states that a conservative target of 1 psu was set in the Restoration plan for the freshwater tidal community upstream of RM 8.2. In Table 1 the target for the Upper Tidal Flood Plain is <2 psu. Why the difference? Are these two criteria considered compatible?

Response: Changed to <2psu

Status: Resolved

Evaluation Protocol

1. The target locations given in Table 1 do not entirely correspond to the locations given in the list of VECs in the Justification section.

Response: Good catch. The targets in the table will be matched up with the justification section. Lead: Patti Gorman

Status: Resolved

2. Locations of VEC overlap. This not necessarily a problem but it might affect scoring in some unforeseen way.

Response: We will index the scores for VECs where they overlap in area. The flood plain is separate from the river itself, so there is no overlap between riverine and upper tidal. *Valisneria* and fish larvae overlap from 10-6.5, so each would be ½ the score in that area. Fish larvae and oysters overlap for .5 miles, and oysters/seagrass for .5 miles. Lead: Patti Gorman

Status: Resolved. Updated description will be provided to RECOVER for courtesy review, ideally before project's model review takes place.

3. The protocol used to score the Riverine Floodplain VEC is pretty straight forward. However, as formulated the procedure might not be sensitive enough to distinguish between alternatives. For the two areas in the example given on page 11, an alternative that produced 5 months and 2 months

of inundation would also yield 328 habitat units. It might be better to have a more defined target inundation period of say 6 months. Anything with at least 6 months of inundation gets a 1. Five months gets (5/6=) 0.83, 4 months gets (4/6=) 0.66 etc.

Response: This is a good idea. We are pursuing a slightly different approach in making it more sensitive that brings in different time ranges for inundation and different scores that can be 1, .75, .5, and .25.

Lead: Patti Gorman

Status: Resolved

4. Riverine Floodplain: Is there an upper limit to inundation period. Would, for example, 10 months be too long and hence detrimental. Should a scoring protocol be developed for this eventuality?

Response: Yes, we looked into the detrimental duration anything longer than 8 months will start getting reduced scores that related to 1 additional month (9 months = .75), 2 additional months (10 months=.5), 11-12 months = .25, and anything greater is 0. Lead: Patti Gorman

Status: Resolved

5. Other VECs: No example is given. However, the scoring of habitat units for these would be likely based on the some measure of time that the salinity is within the preferred range at the preferred location(s). Compute mean monthly salinity in each 1 km segment from RM0 to RM16 for the period of record. Establish a target number of months each year that salinity should be in the preferred range for each VEC. For *Vallisneria* this would be 12 months each year. For fish larvae it may be only each month from March-June. For each segment within the spatial range of a VEC, compute the number of months during the relevant time of year that salinity is within the preferred range. For each segment, divide the observed number of months by the target number of months with the desired salinity range and multiply by the number of acres in the segment. Sum acres across segments within the desired spatial range for each VEC to calculate habitat units.

Response: Great idea. The Eco-subteam will coordinate with the reviewer (Peter Doering) to make revisions. Lead: Patti Gorman

Status: Resolved

6. How do you score the salinity targets? If the salinity is out of the range for the entire POR then it would score a 0, if it is in the range for the entire POR then it would score a 1. How does it score for being in range for part of the POR? Is it always 0.5 if it is one day less the than target?

Response: The team will further develop the degree of reduced scoring, either .5 or .25 increments, as is suggested for the inundation portion of the metric. Output will be focused on monthly averages, so 1 day less than target won't affect the score. However, a larger deviation from the salinity over a certain portion of time (7 to 15 days) could affect the monthly average and then the resulting score for an

alterantive. Subteam Leads: Patti Gorman

Status: Resolved

7. It looks like the actual goal is to restore flows at Lainhart Dam and the salinity targets are based on flows. I would try to state that clearly at the start of the PM doc sheet, since flows are really the only thing the project is going to affect. Flows are the target, salinities result from the flows and the targets are based on salinities of the VECs.

Response: Text has been added to explain the link between flows at Lainhart Dam and other NW Fork Tributaries and downstream salinity, as well as inundation depth and duration in the river floodplain. Lead: Patti Gorman

Status: Resolved

8. Please give an example using one of the VECs, not just the riverine floodplain example. The VECs use the other models and are not just based on output from the hydrological model.

Response: Oysters have also been added as an example of using the salinity PM to measure performance for this VEC. Lead: Patti Gorman

Status: Resolved

9. Scoring system is not very sensitive, 1 month and 5 month meeting of the salinity score the same (0.5). There is a big ecological difference between meeting the target 1% of the time versus 99% of the time, but as it is written, both would receive a score of 0.5. There needs to be greater sensitivity in the scoring rubric.

Response: The team is currently considering how best of include additional increments of scoring related to salinity duration in months and area in which salinity ranges occur to provided scores of 0, .25, .5, .75, and 1. Lead: Patti Gorman

Status: Resolved

10. The LSMM was mentioned in 2 sentences with the second stating "This model can also simulate system operation rules and calculate the amount of freshwater demand for salinity management". There should be a description as to how this modeling tool will be used in the PM and the Evaluation methodology.

Response: This statement has been removed and replaced with an overview of the models being used and how they relate to model output specific to salinity and the VECs being evaluated. Lead: Patti Gorman

Status: Resolved

Performance Measure #4 – Hydrologic Regimes of Major Plant Communities in the Loxahatchee Watershed and Adjacent Wetlands

Justification Section:

1. The document states that a separate performance measure has been established for Grassy Waters Preserve. Is that performance measure being used for this project? Where is that PM doc sheet?

Response: We are correcting the statement to read: In addition, a separate evaluation criteria has been established for Grassy Waters Preserve (GWP) that accounts for Snail Kite use and water supply in addition to freshwater wetland plant communities. GWP is still evaluated as part of this PM for wetland plant community hydrology benefits. But, a separate evaluation criteria that looks at constraints related to the endangered Everglades Snail Kite habitat and use of GWP, as well as water supply benefits obtained from GWP. Subteam Lead: Andy LoSchiavo

Status: Resolved. Revisions will be sent to RECOVER.

Evaluation Protocol

1. When were the WRAP assessments completed? It reads as if they were done in 2004. If they are being used for the evaluation, should they be updated to assess current conditions?

Response: They were completed in 2004. We are making the assumption that the changes experienced in all sites will show some improvements and some degradation but will not be significant enough to affect the overall planning decision. There will only be a few site assessment updates to be able to understand the magnitude of these changes to provide data to substantiate the assumption. Subteam Lead: Andy LoSchiavo

Status: Resolved upon coordination with USACE vertical chain

2. Using the WRAP from 2004 makes the assumption that the 2004 assessment is the existing condition. If this is the case, this needs to be explained in the document.

Response: We will add this explanation to the document. See response above. Subteam Lead: Andy LoSchiavo

Status: Resolved

3. The Lower East Coast Sub-Regional Model (LECsR) was modified for this project study area and field measurements were used to confirm and update the current model. A brief overview of this activity and the effectiveness of the model/updates are needed here. The description of how the model will be used to predict and/or evaluate the success of the project is confusing. There seems to be a significant amount of data manipulation for the comparisons. Will the results be field verified?

Response: We will add more language on what model updates were made specifically. One key update was the elevation based on laser level measurements in the field when conducting WRAP assessments. This corrected the elevations used by the model. Subteam Leads: Andy LoSchiavo with Beth Kacvinsky and Boyd Gunsalus

Status: Resolved. Leads will make sure language is clear in the document and provide for courtesy review by RECOVER reviewers

4. How to use the WRAP analysis for alternatives was not well defined. The WRAP score is made up of 6 parameters: Wildlife utilization; Wetland overstory /shrub canopy; Wetland vegetative ground cover; Adjacent upland/wetland buffer; Field indicators of wetland hydrology; and Water quality input and treatment systems. The evaluation appears to focus on using a model for the field indicator of wetland hydrology and none of the other scores are described as to how they will be modeled. The WRAP procedure is probably not the best methodology to use for future without condition and the alternative evaluation due to it being primarily a field tool. Some sort of expert elicitation and models would be needed to use this tool for alternatives.

Response: Correct. WRAP is used for an initial assessment of the baseline conditions. In order to standardize the calculation of model derived WRAP scores from field assessed scores, LECsR model results for the existing conditions base were scaled to the Eco-Subteam's field scores for the hydrology component only. Alternatives and future without project predictions only compare hydrologic changes caused by the project and non-project actions. Hydrology is the dominant variable being affected by restoration alternatives, as well as the main limiting variable within the natural areas that will be restored and reconnected. Subteam Leads: Andy LoSchiavo, Boyd Gunsalus, and Inger Hansen

Status: Resolved. Revisions will be sent to RECOVER.

5. Table 11 for Pal Mar and Cypress Creek depict no difference among alternatives for the wet prairie. There may be a better community to use.

Response: The Table 11 comparing Pal Mar and Cypress Creek was used to illustrate how there are differences in inundation for several vegetation communities relative to hydroperiods targets. This table is now called Figure 4 in the revised performance measure documentation sheet. Based on the WRAP assessments and the Existing Conditions Base, the dominant vegetation community type will be used as the target to compared alternatives against. The assumption that as hydrology improves for the dominant vegetation (depression marsh for the Pal Mar and Cypress Creek sites), other vegetation community types are likely to either benefit or not get worse. If an evaluation area existing conditions hydrology already meets the target for the dominant vegetation (what we see with wet prairie in this example, but it isn't the dominant vegetation), then we shouldn't see any further improvement and wouldn't claim in restoration benefits. Subteam Leads: Andy LoSchiavo, Inger Hansen

Status: Resolved. Revisions will be sent to RECOVER.

Performance Measure #9 – Hydrologic/Spatial Connectivity

<u>CERP Evaluation Target</u>

1. The target is the highest % increase in connectivity. What is the CERP target? 100%, 90%, what are we shooting for? I can see evaluating and comparing the alternatives based on the highest % connectivity, but what is the end goal? What are we ultimately trying to achieve?

Response: There was not a CERP target evaluated for Loxahatchee with respect to connectivity. CERP looked at amount of canals and levees removed compared to each other over the current condition of 330 miles of canals and 400 miles of levees in the Everglades protection area. We are looking at connectivity relative to four criteria and maximizing the benefits of connectivity for natural area connection, hydrologic connection, water quality improvements, and endangered-threatened species improvement. We will clarify that the target for this performance measure is the first column of the Hydrologic/Spatial Connectivity Matrix: Target – 1. Connect hydrology between natural areas that promote additional flow to the Loxahatchee River; 2. Restoration actions promote connectivity (flow and land) consistent with an existing or proposed greenway corridor; 3. Connectivity actions promote flow of water only through natural overland flow; and 4. Connectivity contributes to expanded native habitats and support of wildlife populations by improving foraging range, territory, or migration path of listed or rare endemic species. Subteam Lead: Andy LoSchiavo, and PM9 team

Status: Resolved.

<u>Evaluation Protocol</u>

1. There is currently some connection to the NW Fork of the Loxahatchee, how would it score using your criterion rubric?

Response: Yes, there is some connectivity. From the standpoint of evaluating relative improvement among alternatives, the existing conditions will be used to represent a zero score, which is similar to how CERP evaluated connectivity in the Everglades Protection Area. We'll add this assumption to the documentation sheet. Subteam Leads: Andy LoSchiavo, Jerilyn Ashworth, and Delta Harris

Status: Resolved. Revisions will be sent to RECOVER.

2. If Existing condition is considered a zero, is future without project considered a zero as well? Could connectivity get worse than it is now?

Response: Yes, the future without is likely to be zero or slightly better. Connectivity realistically would only get worse if new roads, developments, levees were constructed in the publically owned lands. This is likely not going to happen in public lands. Connectivity could get better based on partners taking actions to restore connectivity. We are still in the process of reviewing future without assumptions and accounting for what projects are planned in the foreseeable future, and then accounting for their ability to provide more connections between natural areas. Subteam Leads: Andy LoSchiavo, Inger Hansen

Status: Resolved.

3. Scoring system is not very sensitive, partial connectivity always scores a 12.5. There is a big ecological difference between a 1% connectivity and a 99% connectivity, but as it is written, both would receive

a score of 12.5. There needs to be greater sensitivity in the scoring rubric.

Response: The commenter is correct that there are some varying degrees of measuring partial connectivity. The purely quantitative approach would calculate the mileage of canals and levees and then measure the amount of levees/canals removed. This approach would not accurately calculate the benefits of connectivity, when only a portion of the canals and levees really need to be opened up to achieve the benefits of connectivity. Where and how much of the total number of levee/canal removal is necessary to achieve full benefits for hydrology, greenway, water quality, and threatened/rare species is difficult to precisely determine. We opted for a more qualitative approach using best professional judgment and a standardized set of qualitative criteria supported by GIS results and various agency reports and scientific literature supporting each criteria. The approach allows for ratings of the four criteria (hydrology, greenway/blueway, water quality, and Threatened/rare species) that are split into thirds (0, 12.5, and 25). Theoretically, alternatives could have any variety of total scores (sum of all four criteria) ranging in 12.5 increments from 0-100. Subteam Leads: Jerilyn Ashworth and Andy LoSchiavo

Status: Resolved. Revisions will be sent to RECOVER.

4. How is this PM used to calculate habitat units? You get a score from the criterion rubric, but what is done with it from there?

Response: The team is still developing the benefits model. The approach used last time was to have the connectivity score be an index multiplied by the acreage of the natural areas where connectivity was improved by an alternative. The acreage was then further weighted to represent 10% of the total habitat units for the watershed, while PM 4 would represent 90% of the total habitat unit score for the watershed. We will likely use a similar approach but have not confirmed the portion PM9 will represent, whether 10% or up to 33%.

Status: Resolved. Revisions sent to RECOVER. Team will provide courtesy review to RECOVER for further input as team progresses.

5. The figures 3 and 4 have issues and especially the "Rare Species Potential Habitat" map is not helpful, impossible to sort out with background colors.

Response: We have updated these figures and will include the updates in the revised performance measure. Subteam Leads: Delta Harris and Marissa Krueger

Status: Resolved. Revisions will be sent to RECOVER.

6. It is unclear what would be done to establish the connectivity. Will properties be bought and converted to natural areas? Where and how much? Will canals be filled in? Will new canals/swales be constructed? Can the current topography be used to reestablish the connections?

Response: All of the above. A number of properties have been purchased already in public ownership. Primarily, the alternatives will focus on reconnecting and restoring some portion of those lands in public ownership. Ditches and canals will be plugged or filled. Berms and levees will be degraded in some areas to promote sheetflow/connectivity and reinforced in others to address flooding constraints. Some areas may be regraded. Other areas may include culverts and spreader canal to not only connect areas hydrologically, but to facilitated water movement across the landscape in a sheet flow form, while improving the timing and distribution of natural storage and flow to the river. Subteam Leads: Andy LoSchiavo

Status: Resolved.

7. It is also unclear how the connectivity is calculated. Mention of the alternatives such as "Future Without Project" imply that model output will be used. However, the descriptions are all of GIS layers and seem to only include potential land acquisitions or land type changes making it only a mapping exercise. If this is the case, the discussion of water quality (implied benefit of potential sheetflow) and flora and fauna seems misleading.

Response: It is a GIS based exercise. There are benefits of both hydrologic and land connectivity to reduce fragmentation for fish and wildlife. We will be more clear on what species will benefit from this type of connectivity. With respect to water quality, if connectivity brings water from natural area to other natural area, rather than natural area, to canal, to natural area, there will be more nutrient removal (wetland biogeochemical removal of excess nutrients because of more contact with vegetation) and less nutrient concentration (canal affects during dry season) (RECOVER, 2007). With respect to flora and fauna, benefits range from additional foraging area, breeding opportunities, increased genetic health/diversity, and additional habitat area for shelter and growth to adult (Smith, et al., 1996; Beier and Noss, 1998; Bond, 2003; Hoctor, et al., 2007). Subteam Lead: Inger Hansen

Status: Resolved.

E.11 RECOVER CONSISTENCY REVIEW: LRWRP ADAPTIVE MANAGEMENT AND MONITORING PLANS

In accordance with CERP Guidance Memorandum 40.02 and other relevant guidance (e.g., CERP Guidance Letter 12/06), RECOVER must review the Loxahatchee River Watershed Restoration Project (LRWRP) project level monitoring plan(s) in regards to consistency with the existing Monitoring and Assessment Plan (MAP 2009) to prevent duplication of monitoring activities. Additionally, in this review, RECOVER evaluates the need for project-level monitoring to fill temporal or spatial gaps for parameters monitored in the MAP 2009 in order to evaluate project-level effects. As projects are typically not at the construction stage when this Review is prepared, and that a variety of changes may occur between now and operational readiness of the Project, this review, when completed, should be considered an interim document. Future developments may require modification of monitoring plans and/or revision of this Review. This document provides RECOVER's comments and recommendations to the Project PDT regarding incorporation of proposed monitoring into the project.

As of the date of completion of this Annex, the Adaptive Management Plan and associated Monitoring Plans for LRWRP were not available for RECOVER review. This statement documents recognition that the

LRWRP Adaptive Management Plan and Monitoring Plans are in draft and will undergo updates in the future. It is recommended that a detailed review of the Adaptive Management Plan and Monitoring Plans be performed by RECOVER, when these documents are finalized, in order to gain input from scientists who possess most current system-wide scientific knowledge. RECOVER will continue coordination with the U.S. Army Corps of Engineers and the South Florida Water Management District as requested.

E.12 RECOVER REVIEW OF THE LRWRP DRAFT PROJECT OPERATING MANUAL (DPOM)

The 2003 CERP Programmatic Regulations (33 CFR Part 385.26(c)) provides for, but does not require, a RECOVER review of the Project Operating Manual. This statement documents recognition that the LRWRP operating manual is in draft and will undergo updates in the future. It is recommended that a detailed review of the DPOM be performed by RECOVER near the end of the project design phase, in order to gain input from scientists who possess most current system-wide scientific knowledge. RECOVER will continue coordination with the U.S. Army Corps of Engineers and the South Florida Water Management District during future LRWRP project operations manual updates as requested.

COMPREHENSIVE EVERGLADES RESTORATION PLAN

LOXAHATCHEE RIVER WATERSHED RESTORATION PROJECT

DRAFT INTEGRATED PROJECT IMPLEMENTATION REPORT AND ENVIRONMENTAL IMPACT STATEMENT

March 2019

Annex F

ANNEX F

INVASIVE AND NUISANCE SPECIES MANAGEMENT PLAN

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F INVASIVE AND NUISANCE SPECIES MANAGEMENT PLAN

In accordance with the Comprehensive Everglades Restoration Plan (CERP) Guidance Memorandum 062.00 (CGM62), Invasive Species, the LRWRP will incorporate invasive and nuisance species assessments and management of those species into pertinent planning documents and phases of the project. The Invasive and Nuisance Species Management Plan (INSMP) is a living document and will be updated throughout the Design, Construction and Operations, Maintenance, Repair, Replacement, and Rehabilitation (OMRR&R) phases.

The Project Partnership Agreement (PPA) and the Construction Phasing, Transfer, and Warranty (CPTW) Plan are developed and agreed to prior to construction. The documents outline the responsibilities of the federal and non-federal sponsor during the construction phase, the operational testing and monitoring period, and the OMRR&R phase, and will include the cost estimates associated with this INSMP. This INSMP must be included with the CPTW Plan.

F.1 Introduction

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 into the Atlantic Ocean near the town of Jupiter, Florida. The Northwest Fork of the Loxahatchee River (NWFLR), a federally designated National Wild and Scenic River, is a natural river channel that originates in the Loxahatchee and Hungryland Sloughs. Downstream from these sloughs, the NWFLR receives additional inflow from other major tributaries of the Loxahatchee River that includes 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” 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.

Nationally, more than 50,000 species of introduced plants, animals, and microbes cause more than $120 billion in economic damages and control costs each year (Pimentel et al. 2005). Not all introduced species become invasive species. According to the U. S. Congress, Office of Technology Assessment “Harmful Non-indigenous Species in the United States” report, approximately 10 to 15% of introduced species will become established and 10% of the established species may become invasive.

Executive Order (E.O.) 13112, entitled Invasive Species, signed February 3, 1999, 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 means, with respect to a particular ecosystem, any species, including its seeds, eggs, spores, or other biological material capable of propagating that species, that 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. The terms ‘alien’ and ‘exotic’ also refer to non-native species. 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.

Invasive non-native species decrease biodiversity, displace native plant and animal communities, reduce wildlife habitat and forage opportunities, alter the rates of soil erosion and accretion, alter fire regimes, upset predator/prey relationships, alter hydrology, degrade environmental quality and spread diseases to native plants, animals and other organisms. Furthermore, invasive species are the second largest threat

to biodiversity following only habitat destruction (Wilcove et al. 1998); invasive species are second in destructive nature only to human development. In the United States, invasive species directly contributed to the decline of 49% of the T&E species (Wilcove et al. 1998). 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. Florida is listed as one of the states with the largest number of invasive species. This list also includes Hawaii, California, and Louisiana. 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 4,000-5,000 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.

Significant scientific evidence and research document 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. It has been documented there are 14 non-native species that are causing direct impacts to threatened and endangered species and rare habitats. Holm et al. (1977) documented that 19 species within Florida are among the world's worst weeds. It is estimated that federal, state, and county agencies in Florida spend between $94 million and $127 million each year in an effort to manage invasive non-native plants (GAO 2000).

Invasive species are a major threat to the success of CERP. "The intent of CERP is to restore, preserve, and protect the south Florida ecosystem while providing for other water-related needs of the region. CERP focuses on hydrologic restoration to improve degraded natural habitat in the south Florida ecosystem. Hydrologic restoration alone cannot ensure habitat restoration" (USACE and SFWMD 2010). In order to restore the Everglades and ensure south Florida's natural ecosystems are preserved and remain intact, invasive species must be comprehensively addressed (Doren and Ferriter 2001). The lack of management will allow invasive non-native species to flourish and to continue to out-compete native species.

F.2 Status of Priority Species and Their Impacts

Information regarding both plants and animals is presented below in three categories: widely established within the project area, localized/potential early detection rapid response (EDRR) species, and other species of concern.

F.2.1 Plants

The Guide to the Vascular Plants of Florida (Wunderlin 1998) documented 3,834 plant species in Florida. Of the 3,834 plant species, 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 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 (Table F 1: Invasive Plant Species Documented in the Project Area). 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.

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.

F.2.1.1 Widely Established Species

Plants that are widely established within the project area that are managed for long term suppression 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*).

Summaries on the distribution and impacts of these widely established species are included below. Other non-native plant species with limited or localized distributions or which have a high potential to spread into the project area are also discussed.

F.2.1.2 Australian pine

Australian pine is an evergreen tree that can grow to 150 feet tall. It has inconspicuous flowers and produces tiny fruit, a 1-seeded, winged nutlet that is formed in a woody cone-like cluster. Australian pine is a prolific seed producer and seeds are dispersed by birds, wind and water flow. It is native to Australia, the south Pacific Islands, and Southeast Asia. Australian pine was introduced in the late 1800s and was planted extensively in south Florida as windbreaks and shade trees. It inhabits sandy shores and pinelands and is salt tolerant. It also invades disturbed sites such as filled wetlands, roadsides, cleared undeveloped land, canal banks, and levees. Australian pine grows rapidly, shading out native species. It produces dense litter accumulation, causes beach erosion, and produces an allelopathic agent that inhibits growth of other species. It also interferes with nesting of sea turtles and the American crocodile (Langeland and Burks 1998).

F.2.1.3 Brazilian pepper

Brazilian pepper is an evergreen shrub or tree that can grow up to 40 feet tall. It forms dense thickets and is a prolific seed producer. It produces a small bright red fruit in the form of a spherical drupe. Brazilian pepper is native to Brazil, Argentina, and Paraguay and was imported in the 1840s as an ornamental plant (Langeland and Burks 1998) Brazilian pepper inhabits natural areas such as pinelands, hardwood

hammocks and mangrove forests. It is an aggressive pioneer species that quickly colonizes and thrives in disturbed areas (Francis n.d.) such as fallow farmland, fence lines, right-of-ways, roadsides, canal banks, and levees. Seeds are spread primarily by birds and mammals through consumption and deposition of the fruit. Seeds are also spread by flowing water (Langeland and Burks 1998). Brazilian pepper seedlings will not tolerate inundation and are quickly killed; however large plants can withstand 6 months of flooding (Francis n.d.) with several feet of inundation. Brazilian pepper forms dense monocultures and completely shades out, crowds and displaces native vegetation. It also produces allelopathic agents that possibly suppress the growth of other plants. Brazilian pepper is a member of the family Anacardiaceae which includes plants such as poison ivy, poison oak, and poison sumac. The leaves, flowers, and fruits of Brazilian pepper produce a chemical that can irritate and form a rash on human skin and cause respiratory problems (Langland and Burks 1998).

F.2.1.4 Melaleuca

Melaleuca is an evergreen tree that can grow up to 100 feet tall. It has white flowers that form spikes often referred to as a “bottle brush.” The fruit is a round woody capsule in clusters along the stem; each capsule can contain 200-330 tiny seeds. It is native to Australia and was introduced to Florida in 1906 as an ornamental plant and in the 1930s it was scattered over the Everglades in order to create forests (Langeland and Burks1998). Melaleuca inhabits natural areas such as pine flatwoods, hardwood bottomlands, cypress forests, freshwater marshes, sawgrass prairies, and mangrove forests. It also infests disturbed sites such as improved pasture, natural rangeland, idle farmland, canal and levee banks and urban areas. It prefers sites that are seasonally wet. Melaleuca also flourishes in areas with standing water and persists in well-drained upland sites (Langeland and Burks 1998). Melaleuca displaces native plant species, reduces quality of wildlife habitat, alters fire regimes, and potentially alters wetland hydrology (Mazotti, Center, Dray, and Thayer 2008).

F.2.1.5 Old World Climbing Fern

Old World climbing fern (*Lygodium microphyllum*), is a plant that has long fronds that can grow up to 90 feet. The fronds grow along the ground, over shrubs or climb by twisting and winding around trees, vines and other structures. The rhizomes and rachis are wiry and they are brown to black in color. The leafy branches that form along the rachis are 2 to 5 inches in length and have many pairs of leaflets. It produces spores that are dispersed by the wind. In south Florida, the plant produces spores throughout the year. Each fertile leaflet of Old World climbing fern can produce up to 28,600 spores. Old World climbing fern is native to Africa, Asia, and Australia and the first record of it being found in Florida was in 1958. It was collected from a Delray Beach plant nursery where it was being cultivated (Langeland and Hutchinson 2005). Old World climbing fern has been documented to occur in hardwood hammocks, mesic flatwoods, forested swamps, wet flatwoods, hydric hammocks, floodplain forests, and strand swamps. It can completely overgrow the vegetation in these areas which allows the plant to compete with canopy trees and understory vegetation for light. The growth in the tree canopy provides an avenue for fire spread into the canopy which damages or even kills the trees. Over time, rhizomes accumulate in mats 3 feet or more thick on top of the soil (Langeland et al. 2008) which can prevent new growth of native plants. This plant is a threat to many areas within the project site (Ferriter et al. 2005) and disturbed sites.

F.2.1.6 Shoebutton ardesia

Shoebutton ardisia (*Ardisia elliptica*) is an evergreen, glabrous shrub or small tree approximately 17 feet tall. It was imported as an ornamental shrub as early as 1900 (Gordon and Thomas 1997). It invades

understories of hammocks, tree islands, disturbed wetlands and cypress and mangrove areas. This species often forms monocultures resulting in local displacement of native plant species. There is a tendency for reinvasion by shoebutton ardisia or other exotic plants following removal of dense thickets of this species. New infestations may go undetected due the physical similarity to the common native marlberry (*Ardisia escallonioides*).

F.2.1.7 Water hyacinth

Water hyacinth (*Eichhornia crassipes*) is a floating aquatic plant native to tropical South America that was introduced in Florida in 1884. The plant reproduces extremely quickly, it grows at explosive rates that exceed any other tested vascular plant (Wolverton and McDonald 1979). Vegetative reproduction occurs rapidly except in the coolest months. It forms large floating mats that block navigation, impact water control structures, degrade water quality, and dramatically alter native plant and animal communities (Gowanlock 1944, Penfound and Earle 1948). New plants are produced vegetatively and from seed, which germinate abundantly on exposed moist soils (Perez 2011). Water hyacinth has low nutrient needs and wide tolerance for water conditions that enables it to persistence and spread.

F.2.1.8 Water Lettuce

Water lettuce (*Pistia stratiotes*) is a floating aquatic plant native to South America. The plant reproduces extremely quickly except in the coolest months. It reproduces both vegetatively and from seed which are found to be up to 80% viable (Dray and Center 1989). Water lettuce was reported as early as 1765 by William Bartram as forming dense mats on the St. Johns River. It forms large floating mats that block navigation, impact water control structures, degrade water quality, and dramatically alter native plant and animal communities.

F.2.1.9 Torpedograss

Torpedograss (*Panicum repens*) is a perennial grass that can grow up to 3 feet tall. It has extended rhizomes that can be rooted or floating. It has a panicle-type inflorescence that is 3-9 inches long. It flowers nearly year round. Torpedo grass reproduces primarily through rhizome extension and fragmentation. It is native to Africa and Asia and was introduced into the Gulf Coast of the United States before 1876. Torpedo grass seed was introduced as a forage crop in the south and was planted in almost every southern Florida County by 1950. It is drought tolerant and grows in upland areas but thrives in areas with moist to wet sandy or organic soil. It inhabits scrub, coastal flatwoods, upper tidal marshes, mesic flatwoods, herbaceous wetlands, wet prairies, swales, lakeshores, canals, and other disturbed sites. Torpedo grass can quickly form a monoculture and displace native vegetation. In 1992, it was present in approximately 70% of the public waters in Florida. The largest population of torpedo grass was present in Lake Okeechobee. Approximately 14,000 acres of torpedo grass displaced native plants in Lake Okeechobee's marsh (Langeland et al. 2008). Torpedo grass is present in agricultural and water conveyance canals throughout the project area and has potential to spread into areas with the removal of levees and backfilling canals.

F.2.1.10 Cogongrass

Cogongrass (*Imperata cylindrica*) is a perennial grass that grows in compact bunches and produces extensive rhizomes. The leaf blades are erect and narrow with a whitish midvein off center and leaves can be one to four feet in length. The inflorescence is narrow, white, and plume-like. Cogongrass flowers in the spring, fall, and sometimes year round. It produces seeds that are spread by wind, animals, and

equipment. Cogongrass is native to Southeast Asia and was introduced into Florida in the 1930s and 1940s for forage and soil stabilization in Gainesville, Brooksville and Withlacoochee. More than 1,000 acres of cogongrass was established in central and northwest Florida by 1949. Cogongrass inhabits dry to moist sites and has been documented to occur in xeric hammocks, mesic flatwoods, herbaceous marshes, and floodplain forests (Langeland et al. 2008). It has extensively invaded disturbed areas such as fallow pastures (FDEP n.d.) and is commonly found along transportation and utility corridors (Langeland et al. 2008). Cogongrass forms dense stands which results in almost complete displacement of native plants. Dense stands of cogongrass also create a severe fire hazard, especially when mixed with other volatile fuels (FDEP n.d.).

F.2.1.11 Cattail

Cattails (*Typha spp.*) are native to Florida and occur in wetlands, lakes, rivers, canals, storm water treatment areas and other disturbed sites. Cattails grow up to 12 feet tall and have strap-like leaf blades. The inflorescence is spike-like with very tiny flowers. This plant is a primary native nuisance species within the project area. 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 (Holmes et al. 2002). Areas where water control structures, conveyance features, and levees exist provide a suitable habitat for invasion and expansion of cattail.

F.2.1.12 Localized or Potential EDRR Species

The Treasure Coast Cooperative Invasive Species Management Area, which includes Indian River, St. Lucie, Martin, and portions of Palm Beach County, has identified 19 species of plants as EDRR species: feathered mosquito-fern (*Azolla pinnata),* Antilles calophyllum (*Calophyllum antillanum),* day jessamine (*Cestrum diurnum),* camphortree (*Cinnamomum camphora),* deeprooted sedge *(Cyperus entrerianus),* aroma sickle pod *(Dichrostachys cinerea subsp. Africana)*, grand eucalyptus (*Eucalyptus grandis),* Gold Coast jasmine (*Jasminum dichotomum),* jazmin de trapo (*Jasminum fluminense),* glossy privet (*Ligustrum lucidum),* Japanese climbing fern *(Lygodium japonicum),* monkey's apple (*Mimusops coriacea),* Eurasian water-milfoil *(Myriophyllum spicatum),* burmareed (*Neyraudia reynaudiana),* skunk-vine (*Paederia foetida),* flamevine (*Pyrostegia venusta),* Russian thistle (*Salsola kali),* Chinese tallowtree *(Triadica sebifera) and* Oriental tremis (*Trema orientalis).*

F.2.1.13 Other Species of Concern (Containment and Eradication)

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*).

F.2.1.13.1 Tropical American Watergrass

Tropical American watergrass (*Luziola subintegra)* is a perennial grass that is usually rooted but sometimes grows in floating mats. This plant can also grow in terrestrial sites. It produces a panicle type inflorescence. Tropical American watergrass spreads vegetatively and by seed. It is an aggressive grass that competes with both native and non-native invasive plants. It is native to Mexico, Central America, the Caribbean Basin with its range extending south through South America to Argentina (Krunzer and Bodle 2008). The first record of occurrence was in Lake Okeechobee in 2007 when two large mats of tropical American watergrass (approximately two and eighty hectares each) were found near Harney Pond Canal in Fisheating Bay at Lake Okeechobee. From the initial population identified, this plant quickly spread and

by July 2009 more than 2,000 acres of the plant were treated in the lake. The plant was also found at the mouth of Fisheating Creek in both emergent and terrestrial forms. Since Fisheating Creek is the only unregulated flow into Lake Okeechobee, it is thought this area was the point of introduction. Since the initial sighting of tropical American watergrass in December 2007, other populations have been found in the Cody's Cove-Eagle Bay area, near Observation Shoal and inside Lake Okeechobee near the S-77 Structure and downstream in the Caloosahatchee River, C-43 canal. The majority of the populations of plants have occurred in areas that receive water flow from Fisheating Bay, however, one terrestrial population (in two small areas) was identified in the 8.5 Square Mile Area (SMA) adjacent to ENP. Through EDRR procedures, this plant was treated and appears to be eradicated in the 8.5 SMA. The source for the introduction of tropical American watergrass into 8.5 SMA is not known at this time, although contaminated equipment is highly suspected.

F.2.1.13.2 Exotic Black Mangrove

Exotic black mangrove (*Lumnitzera racemosa*), also known as kripa, is native to Asia and Australia. It escaped cultivation from Fairchild Tropical Botanic Garden and was found to be rapidly proliferating in neighboring Matheson Hammock Preserve in 2008. Exotic black mangrove aggressively out-competes Florida's native mangroves. The impacts of a major invasion of this species on Florida mangrove swamp diversity and function are not fully understood and are difficult to predict. Given the important contributions of mangroves to marine productivity and the economy of South Florida, regional invasive species biologists launched a rapid response effort immediately after the plant invasion was detected. Exotic black mangrove has only been found in Florida in and around Fairchild Tropical Botanic Garden in Miami-Dade County (SFER 2018).

F.2.1.13.3 Mile-a-minute

Mile-a-minute (*Mikania micrantha*) is a federally listed noxious weed that recently appeared in south Florida. This vine has turned into a serious weed where it was introduced in Asia, Australia, and Africa (Holm et al. 1977, Zhang et al. 2004). Mile-a-minute was found near Homestead in 2008. An aggressive reconnaissance and eradication effort was launched immediately following the discovery of the plant. Controlling the plant is challenging due in part to plant populations on private lands (Dozier 2012), although the threat of FDACS quarantine is an incentive for nursery owners to eliminate the weed. Eradication from Florida seems unlikely but containment and suppression remains a priority to prevent it from colonizing large natural areas like the South Dade Wetlands and ENP (SFER 2018).

F.2.1.13.4 Wright's Nutrush

Wright's nutrush (*Scleria lacustris*) is a sedge native to seasonal wetlands of Africa, Central and South America, and the Caribbean. It has a robust, three-sided stem, with a side width up to 2.5 cm, and leaf length up to 30 cm. A red coloration can be seen at the base of the plant's stems. It was first recorded in Florida in 1988 in Jane Green Swamp, a marsh in the Upper St. Johns River Basin (UF/IFAS 2017). After range expansion, the current distribution of this species in Florida extends to more than twenty natural areas in seven counties (Brevard, Hendry, Indian River, Lee, Osceola, Okeechobee and Polk). In 2009, the Florida Exotic Pest Plant Council listed this plant as a Category I invasive species when recognition was made of its ability to alter the composition and structure of native wetland communities (UF/IFAS 2017).

F.2.2 Animals

Searches through existing data and resources indicate 65 animal species have been documented to occur within the project area (**Table 1**). 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.

F.2.2.1 Widely Established Species

Species that are well established and are known or presumed to exert significant negative impacts on Florida ecosystems include the island applesnail (*Pomacea* maculata), purple swamphen (*Porphyrio porphyrio)*, feral pig (*Sus scrofa*) Cuban tree frog, Asian swamp eel, and redbay ambrosia beetle (*Xyleborus glabratus)* and associated fungus (*Raffaelea lauricola).*

F.2.2.1.1 Redbay Ambrosia Beetle (laurel wilt)

Laurel wilt is a lethal disease of redbay (*Persea borbonia*) and other members of the Laurel family (*Lauraceae*). The disease is caused by a fungus (*Raffaelea lauricola*) that is introduced into trees by the wood-boring redbay ambrosia beetle (*Xyleborus glabratus*) (FDACS 2011). *Xyleborus glabratus* is the twelfth species of non-native ambrosia beetle known to have become established in the U. S. since 1990. All are suspected to have been introduced in solid wood packing materials, such as crates and pallets (Haack 2003). Most native ambrosia beetles attack stressed, dead or dying woody plants, but *X. glabratus* attacks healthy Florida trees. Once infected, susceptible trees rapidly succumb to the pathogen and die. Besides redbay, it impacts other native and non-native members of the Lauraceae (Hanula et al. 2008) including swamp bay (*P. palustris*), an important species of many Everglades plant communities. Since its arrival in 2002, the red bay ambrosia beetle and laurel wilt have spread quickly throughout the southeastern U.S. In March 2010, the beetle was found in Miami-Dade County. Laurel wilt disease was subsequently confirmed on nearby swamp bay trees in February 2011. Aerial reconnaissance identified symptomatic swamp bay trees scattered throughout the Bird Drive Basin, northward into the Pennsuco Wetland area, and westward into ENP and WCA 3B. In February 2012, laurel wilt was also confirmed in the LNWR. There is currently no feasible method for controlling this pest or associated disease in natural areas. A systemic fungicide (propiconazole) can protect individual trees for up to one year, but widespread utilization in natural areas is impractical (Mayfield et al. 2009). State and federal agencies are monitoring the spread of laurel wilt disease and the red bay ambrosia beetle through the Cooperative Agricultural Pest Survey (CAPS) program. There is little to no research underway to assess the ecological impacts of laurel wilt disease. Interagency coordination is limited to the exchange of reporting information and some coordinated research. The red bay ambrosia beetle is considered a plant pest, so screening for additional introductions is carried out but is inadequate. Critical research areas include: (1) evaluating Persea resistance, (2) Persea seed/genetic conservation efforts, (3) potential chemical or biological control tools, (4) impacts on native plant communities, and (5) impacts on the Palamedes swallowtail butterfly (*Papilio palamedes*) and other host-specific herbivores.

F.2.2.1.2 Asian Swamp Eel

The Asian swamp eel (*Monopterus albus*) is a versatile animal, capable of living in extremely shallow water, traveling over land when necessary, and burrowing into mud to survive periods of drought (Shafland et al. 2010). This species is a generalist predator with a voracious appetite for invertebrates, frogs, and fishes (Hill and Watson 2007; Shafland et al. 2010). Wild populations in Florida originated as escapes or releases

associated with aquaculture, the pet trade, or live food markets. Regional biologists are concerned that this species may become widely established, since the diverse wetland habitats of the Greater Everglades may be suitable for the species. Additionally, Asian swamp eels have a broad salinity tolerance giving concern that this species could also establish populations in estuaries (Schofield and Nico 2009). There are at least four reproducing populations of Asian swamp eels in Florida: North Miami canals, canal networks near Homestead adjacent to the ENP, eastern ENP, and in water bodies near Tampa (Collins et al. 2002; Nico et al 2011, USGS, personal communication, 2012; Jeff Kline, USNPS, personal communication, 2012). The impact of Asian swamp eels to Everglades fauna is undocumented and management options are currently limited to monitoring and electrofishing in canals. The species' generalist diet and adaptations to low water events suggests that native fishes, aquatic invertebrates, and frogs could be threatened. Nico et al. (2011) also report high parasitism rates in wild caught Asian swamp eels in Florida, raising concern that the species could be a vector for macroparasites to native fishes.

F.2.2.1.3 Cuban Treefrog

The Cuban treefrog is the largest species of treefrog in Florida and range from 1-4 inches in length. The Cuban treefrog has expanded pads on the ends of their toes which are exceptionally larger than toepads of Florida's native treefrogs. Cuban treefrogs have large eyes and usually have rough somewhat warty skin. Sometimes Cuban treefrogs have a pattern of large wavy marks or blotches on their back and have stripes or bands on their legs. The color of the treefrogs varies from creamy white to light brown but Cuban treefrogs can be green, beige, yellow, dark brown or combination thereof. It is native to Cuba, the Cayman Islands, and the Bahamas. It was first reported in Florida in the 1920s in the Florida Keys, and was likely transported in cargo or ornamental plant shipments. Cuban treefrogs inhabit natural areas such as pine forests, hardwood hammocks and swamps. They also inhabit disturbed sites such as urban and suburban developments, agricultural areas such as orange groves and plant nurseries (Johnson 2007). Cuban treefrogs inhabit areas throughout most of the CERP area. These treefrogs are introduced to new areas as stowaways on cars, trucks, boat trailers and through shipment of ornamental plants and trees. Cuban treefrogs consume a variety of invertebrates and native treefrog species (Maskell et al. 2003). Native green and squirrel treefrogs (*Hyla cinerea* and *H. squirella)* are less likely to be found when Cuban treefrogs are present (Waddle et al. 2010), and when Cuban treefrogs are removed from an area, the abundance of native treefrogs increases (Rice et al. 2011). In addition, tadpoles of Cuban treefrogs are fierce competitors and can inhibit the growth and development of two species of native treefrogs (Johnson 2007). Effects of CERP projects on the distribution and abundance of Cuban treefrogs should be assessed given the Cuban treefrog's wide distribution and habitat tolerances, mounting evidence of direct impacts to native anuran species, and the lack of regional monitoring and control programs.

F.2.2.1.4 Feral Hog

Feral hogs (*Sus scrofa*), also known as wild pigs, have existed on the Florida landscape since their introduction four centuries ago. They are reported in all 67 Florida counties within a wide variety of habitats, but prefer oak-cabbage palm hammocks, freshwater marshes and sloughs and pine flatwoods. Although they do not favor marshes with deep water, during the dry season they make extensive use of partially dried out wetlands. Feral hog populations are particularly high in the counties immediately north and west of Lake Okeechobee, and in the Big Cypress and East Coast Regions. Hogs commonly grow 5-6 feet long with weights over 150 pounds. With a keen sense of smell and a powerful snout, they can detect and root up buried food. The diet of feral hogs includes vegetation, earthworms, insects, reptiles, frogs, bird eggs, rodents, small mammals, and carrion (Laycock 1966, Baber and Coblentz 1987). This invasive mammal is also known to prey on sea turtles, gopher tortoises, and other at-risk wildlife (Singer 2005). No animal native to North America creates the kind of disturbance when feeding that hogs do (Baber and

Coblentz 1986). Rooting by feral hogs can convert native grassland and other low vegetation to what looks like plowed fields. Hog rooting may facilitate establishment of invasive plant species because invasive exotics typically favor disturbed areas and colonize more quickly than many native plants (Belden and Pelton 1975, Duever et al. 1986). Feral hogs are unusually prolific for large mammals. This is because they reach sexual maturity at an early age (6-10 months) (Barrett 1978), can farrow more than once a year (Springer 1977; Taylor et al. 1998), have large litters (4-8) (Sweeny et al. 2003), and often experience low natural mortality rates (Bieber and Ruf 2005). Recreational hunting is often a major source of mortality (Barrett and Pine 1980). In favorable habitat, however, hog populations are typically not greatly reduced by hunting (Bieber and Ruf 2005). There is no regional, coordinated monitoring program for the ubiquitous feral hog. Monitoring is limited to efforts associated with trapping programs and game management. Numerical monitoring of hogs present challenges because they are wary and adaptable animals that change their activity patterns and feeding areas in response to changing needs and threats from humans (Hughs 1985, Sweeny et al. 2003).

F.2.2.1.5 Green Iguana

The green iguana (*Iguana iguana*) is a large lizard native to Central and South America, extending to the eastern Caribbean (FWC 2018). Green iguanas can be found on the ground, in shrubs or in trees in a variety of habitats, from agricultural and natural areas to suburban developments. They are excellent swimmers, and are often found near canals and waterways. Male green iguanas can reach lengths of 1.5 meters, and can feed on a variety of vegetation, fruits, bird eggs, and dead animals. This species is characterized by its green coloration, a row of spikes down the center of the neck, back and upper section of the tail, which is banded with dark rings. Mature male iguanas display heavy jowls and a large throat fan, used both for sexual selection and self-defense. Green iguanas were first reported in Florida in the 1960s in Hialeah, Coral Gables and Key Biscayne along Miami-Dade's southeastern coast (FWC 2018). Breeding populations now extend along the Atlantic Coast in Collier and Lee Counties, and reports have been made as far north as Alachua, Highlands, Hillsborough, Indian River and St. Lucie Counties (FWC 2018). Those reported in more northern counties are likely individual pet releases, however, as green iguanas are not cold resistant, and will, therefore, be unlikely to establish breeding populations in these locations. In cleared habitats such as canal banks and vacant lots, green iguanas reside in burrows, culverts, drainage pipes and rock or debris piles. South Florida's extensive man-made canals serve as "ideal dispersal corridors to further allow iguanas to colonize new areas" (FWC 2018). Green iguanas cause damage to residential and commercial landscape foliage, and are often considered a nuisance by landowners. Some iguanas may even cause damage to infrastructure by digging burrows that erode and collapse sidewalks, foundations, seawalls, berms, levees and canal banks (FWC 2018). It is vital that this species be actively managed throughout South Florida to prevent further damage to infrastructure and native vegetation.

F.2.2.1.6 Purple Swamphen

The purple swamphen (*Porphyrio porphyrio*) is a member of the rail family native to Australia, Europe, Africa, and Asia. It is noticeably larger than its Florida native relatives, the American coot (*Fulica americana*), the common moorhen (*Gallinula chloropus*), and the purple gallinule (*Porphyrio martinica).* The swamphen and the gallinule both have purple plumage and red bills, but the face shield above the bill is red and the legs are pink in the swamphen while the face shield is pale blue, the legs are yellow and the bill has a yellow tip in the gallinule. Introduction of the swamphen was likely due to escapes from the Miami zoo and private aviculturists in Broward County. The purple swamphen feeds on shoots and reeds, invertebrates, small mollusks, fish, snakes, and the eggs and young of waterfowl (Pranty et al. 2000). Nests are typically large mounds of vegetation in wetlands. Known to be highly aggressive and territorial, the

purple swamphen could negatively affect native water birds through competition for food and space and through direct predation. Rapid response efforts between 2006 and 2009 did not successfully reduce the abundance or distribution of this species. The management goal for the species has shifted from eradication to suppression (Jenny Ketterlin Eckles, FWC, personal communication, 2012). Efforts to remove birds by hunting did not significantly deplete the population. No other control tools are currently developed for this species. In recent years, purple swamphens have been sighted in the WCAs, ENP, Big Cypress National Preserve, Lake Okeechobee, and in all Everglades stormwater treatment areas. The FWC is currently conducting prey and habitat analyses to support a risk assessment, which will guide future management strategies (Jenny Ketterlin Eckles, FWC, personal communication, 2012). There are currently no coordinated monitoring efforts for purple swamphens.

F.2.2.1.7 Island Applesnail

The island applesnail (*Pomacea maculata*) is a large South American freshwater mollusk that is established throughout Florida. It was intentionally introduced through releases from aquaria and as a food crop. Potential impacts to the environment include destruction of native vegetation, competition with native fauna, and disease transmission. There is concern the island applesnail may out-compete the native applesnail, *P. paludosa* which is the primary food source of the endangered Everglade snail kite. In addition a newly described cyanobacterium (*Aetokthonos hydrillicola*) found in the Kissimmee Chain of Lakes is associated with a lethal neurologic disease, avian vacuolar myelinopathy (AVM), which affects avifauna in the southeastern United States (Wilde et al. 2005). Research has confirmed that bioaccumulation of a neurotoxin produced by *A. hydrillicola* in the island applesnail and birds fed with affected snail incur 100 percent development of AVM in laboratory birds (Dodd et al. 2016), suggesting a significant risk to the snail kite and other avifauna.

F.2.2.2 Localized/Early Detection Rapid Response Species

Of the species identified, there are four key carnivorous reptiles that are currently present within or in close proximity to the project area and have potential to cause significant ecological impacts. These include the Argentine black and white tegu, the Burmese python, northern African python, and the Nile monitor. At present time, these occurrences have been isolated but there is concern regarding further spread of these species from the southern portion of the project area. These reptiles are among south Florida's most threatening invasive animals. The species are considered top predators and increase additional pressures on native wildlife populations, particularly threatened and endangered species (SFER 2013). Other species considered EDRR include Oustalet's chameleon (*Furcifer oustaleti*), spectacled caiman (*Caiman crocodilus fuscus*), veiled chameleon (*Chamaeleon calyptratus*) and the giant African land snail.

F.2.2.2.1 Northern African Python

Since 2001, over 40 northern African pythons (*Python sebae*) have been found in western Miami-Dade County (Jacob Kline, FWC, personal communication). This giant constrictor's natural history traits are similar to the Burmese python and is considered a high risk for establishment and expansion throughout South Florida (Reed and Rodda 2009). Rapid response efforts to eradicate this population are now of highest priority. The SFWMD, Miccosukee Tribe of Indians, and Miami-Dade County, the primary landowners within the Bird Drive Basin, are working closely with FWC and other agencies to address this threat.

F.2.2.2.2 Burmese Python

Burmese pythons are large (up to 5.5 meters) constrictors that are native to Southeast Asia (Dorcas et al. 2012) and are top predators (SFER 2013). For 20 years prior to being considered established, python sightings occurred intermittently in south Florida. In 2000, the Burmese python was considered established in south Florida and since that time, the population has increased significantly in abundance and geographic range (Dorcas et al. 2012). The Burmese python is found throughout the southern Everglades, particularly in ENP and adjacent lands including the East Coast Buffer lands and the northern ENP boundary along Tamiami Trail. Sightings have also been documented in the Key Largo region (SFER 2013). Pythons consume a wide variety of mammals and birds. More than 100 species have been identified as a food source and these include the endangered Key Largo woodrat (*Neotoma floridana smalli*) and the wood stork (*Mycteria americana*). In addition, American alligators (*Alligator mississippiensis*) are infrequently preyed upon by the python. Little is known about the impacts of predation by pythons on native species; however a recent study by Dorcas et al. indicates there has been a dramatic decline in mammal populations that coincides with the increase of pythons in ENP. The increase in the population size of pythons has been linked to a regional decline in small and medium mammals, but has not been distinguished from possible effects of changes in habitats and hydrology on mammal populations that also occurred during this time period (Dorcas et al. 2012).

F.2.2.2.3 Argentine Black and White Tegu

The Argentine black and white tegu is a large South American lizard that can reach 1.5 meters in length in the wild. Tegus seem to prefer savannas and other grassy open areas in its native range (SFER 2013). In Florida, tegus seem to prefer disturbed upland areas adjacent to wetlands or permanent bodies of water. These types of habitats are frequently found adjacent to canals and rock pits and occur throughout the South Florida landscape. Tegus are generalist predators with a diet that includes a variety of fruits, vertebrates, invertebrates and eggs. Because the tegu is a predator of eggs, it threatens native ground nesting birds and reptiles which includes threatened and endangered species such as the American crocodile (*Crocodylus acutus*) and Cape Sable seaside sparrow (*Ammodramus maritimus mirabilis*). Endangered snail species such as *Liguus fasciatus* are also potential prey. There are two known established populations in Florida, one in Hillsborough and Polk counties and one in southern Miami-Dade County. The population in Miami-Dade County seems to be increasing and expanding its range both to the west towards ENP and east toward Turkey Point. Both areas are home to endangered wildlife that may be threatened by tegus. Continued monitoring and removal efforts are needed to prevent the expansion into natural areas and control the population. Recently, there has been an increase in sightings near ENP which suggests the population is expanding. Systematic surveys of the species are needed to validate the population is expanding near ENP (SFER 2011), and to provide early detection of possible range expansion to new areas.

F.2.2.2.4 Nile Monitor

The Nile monitor (*Varanus niloticus*) is a large, carnivorous lizard from sub-Saharan Africa that is capable of reaching 2.4 meters (FWC bioprofile). It is a generalist feeder and an egg specialist in its native range (SFER 2013) that will feed on a wide variety of invertebrates and vertebrates it acquires by either predation or scavenging (FWC bioprofile). As such, the Nile monitor could impact a variety of native and threatened species in Florida through both competition and predation. The Nile monitor may pose a serious threat to a number of wading birds, marsh birds, gopher tortoises (*Gopherus polyphemus*), burrowing owls (*Athene spp*.), Florida gopher frogs (*Lithobates capito*), sea turtles and other ground

nesting species. They may negatively impact populations of American alligators and American crocodiles via egg predation and competition (FWC bioprofile). The Nile monitor has been well established in the Cape Coral area since the 1990s. There is also a small breeding population near Homestead Air Force base in Miami Dade County (SFER 2011). More recently, a breeding population of Nile monitors has been discovered in Palm Beach County and numerous reports of the species throughout Broward County also suggest a breeding population. Because of their threat to our native wildlife, this species has potential to impact restoration efforts.

F.2.2.2.5 Oustalet's Chameleon

The Oustalet's chameleon (*Furcifer oustaleti*) is a large chameleon native to Madagascar where it utilizes a wide variety of habitats, including human altered environments (D'Cruze et al. 2007). Diet analysis indicates that this species preys on a variety of anole and insect species, particularly moth larvae (Krysko et al. 2012). Florida populations of this species are suspected to have been established through intentional releases by reptile enthusiasts. A population of the Oustalet's chameleon was discovered in rural Miami-Dade County in early 2010. This species does not appear to be spreading without human assistance and the number of chameleons per survey has decreased, indicating eradication may be possible if regular surveys resume. (SFER 2018)

F.2.2.2.6 Veiled Chameleon

The veiled chameleon (*Chamaeleo calyptratus*) naturally occurs in mountain and coastal regions of the Arabian Peninsula, although it is also known to utilize a wide range of habitats. Florida populations of this species are suspected to have been established through intentional releases by reptile enthusiasts. Breeding populations of the veiled chameleon are now documented in the Lee County (northwest estuaries), Miami-Dade County (one population near ENP a second adjacent to BCNP), Broward County, and Palm Beach County near the southern tip of LNWR (FWC 2013). In addition, reports of veiled chameleons are now common from Buckingham, Alva, Cape Coral, Marco Island, and Lutz, Florida. If chameleons continue to demonstrate the ability to spread from suburban and agricultural land and build populations in native Florida habitats, then the argument for an aggressive eradication program will be strong. (SFER 2018)

F.2.2.2.7 Spectacled Caiman

The spectacled caiman (*Caiman crocodilus fuscus*) naturally occurs throughout Central and South America, and can reach sizes of about 2.4 meters. They are easily distinguished from native crocodilians not only by their smaller adult size, but by the characteristic vertical dark bands that can be found on their tails. In Florida, spectacled caiman are commonly encountered in ditches, canals, and disturbed wetlands but are occasionally found in relatively undisturbed marshes. This species was first reported within canals at the Homestead Air Force Base as early as 1960 (Ellis 1980). It feeds primarily on fish, mammals, waterbirds, and snails in its native range (Thorbjarnarson 1993). Breeding populations are documented in localized areas of Miami-Dade and Broward counties. Given its intolerance of cold temperatures, breeding populations will remain limited to southern Florida. (SFER 2018)

F.2.2.2.8 Giant African Land Snail

The Giant African land snail (*Lissachatina fulica*) is a large snail native to Africa, but was discovered in Miami in 2011 (USDA 2013). It is known to eat a variety of vegetation, namely crop plants, horticultural plants and environmentally valuable plants. This species of snail is an intermediate host of the rat

lungworm (*Angiostrongylus cantonensis*), which can spread meningitis to humans (Cowie 2013). This lungworm was undetected in Florida prior to the Giant African land snail's introduction. A previous infestation of this snail occurred in Miami in 1966, and the State of Florida spent $1 million and 10 years of effort on eradication (USDA 2013). The Giant African land snail is known to occur in developed areas of Broward and Miami-Dade counties, from Davie south to Homestead. As of July 2017, researchers have identified 31 population cores in Miami-Dade County and a single core in southern Broward County. There are indications that control efforts are having an effect, as fewer large snails are being reported, and local eradications of the snail are being observed in some of the population cores (Roda et al. 2016).

F.3 Introduction to Invasive Species Management

Invasive species management includes prevention, monitoring, education and public awareness, EDRR, control and management as well as adaptive management. In addition to these components, it is important to understand the risks and uncertainties associated with invasive species in order to effectively implement control/management measures and to adaptively manage.

F.3.1 Prevention

Prevention is the first-line of defense and the most efficient and cost effective approach to reduce the threat of invasive non-native species. Successful prevention will reduce the rate of introduction and establishment and thereby reduce the impacts of invasive species. One essential element to prevention is identifying the high risk pathways that facilitate introductions and implementing actions to impede those introductions. Other critical elements include using effective management tools to reduce unintentional introductions and using risk assessment for both intentional and accidental introductions of non-native species. Baseline data and monitoring systems are required in order to evaluate the success of preventative measures.

F.3.2 Education and Public Awareness

A key to addressing problems caused by invasive species is to increase public awareness of their impacts and providing information about how individuals can help prevent the introduction and spread. However, reaching each person whose activities may affect our natural environment is a daunting task. Collaboration, cooperation and coordination across federal and state agencies, local governments, tribal entities, and the public and private sectors is required to facilitate this effort.

F.3.3 Monitoring

Natural resource managers need spatial data on invasive species populations to develop management strategies for established populations, direct rapid response efforts for new introductions, and evaluate the success of control efforts (Myers et al. 2000; Dewey and Andersen 2004; Barnett et al. 2007). Several approaches may be taken to document the spatial distribution and population trends of invasive species. Each method has strengths and weaknesses and should be utilized according to specific management objectives. Monitoring is the collection and analysis of population measurements in order to determine changes in population status and progress towards meeting a management objective (Elzinga et al. 1998). This type of monitoring is usually intended to detect relatively small changes in populations over time and often utilize small scale plots and/or transects. Invasive species surveys and inventories may be preferred when the objective is to detect populations and describe their spatial distributions over large landscapes, especially when early detection of new populations is desired (see EDRR discussion below).

Optimally invasive plant mapping methods have high positional accuracy, high species detection accuracy (particularly for low-density infestations), rapid turnaround time, relatively low cost, and the ability to quantify the degree of infestation (USDA 2012). Ground-based surveys can provide high positional accuracy and species detection, but can be time consuming and logistically unrealistic for large landscapes (Rew et al. 2005). Stratified subsampling approaches to ground surveys can mitigate some of these limitations but probabilistic mapping may be ineffective for early detection needs of land managers (Barnett et al. 2007) and may not provide sufficient fine scale information over large areas.

Developments in remote sensing technology have greatly improved opportunities for rapidly obtaining spatially precise data on invasive plant populations, particularly for large areas (Lass et al. 2005). However, the ability to detect target species using remote sensing is still limited to conditions where the species has a unique spectral signature or is a dominant canopy species and is often ineffective at detecting target species at low densities (Shafii et al. 2003). This inability to detect target species at low densities is a significant limitation for land managers focused on containment of expanding populations and detection of new invasions. Visual surveys from aircraft have been effectively used to map invasive plant distributions in the Everglades since 2008 (Rodgers et al. 2014). While visual aerial surveys may provide cost-effective information on landscape distributions of targeted plants, it has limited value for long-term change detection or fine scale assessments of abundance. This method may also lack sufficient detection precision for small plant species or species that occupy understories. Use of UAVs may also provide relatively inexpensive invasive plant monitoring data and video documentation provides a permanent record of conditions. However, detection accuracy may be less than that of visual surveys, especially at low densities or new species introductions.

F.3.4 Early Detection and Rapid Response

Once a species becomes widespread, the cost to control it will more than likely require significant and sustained funding. EDRR may be a cost-effective strategy to locate, contain, and eradicate invasive species early in the invasion process in order to minimize ecological and economic impacts of non-indigenous species (Rejmanek and Pitcairn 2002).

The three components of EDRR are *Early Detection*, *Rapid Assessment*, and *Rapid Response*. Early detection is defined as a comprehensive and integrated system of active or passive surveys to locate, identify, and report new invasive species as quickly as possible in order to implement procedures when it is feasible and less costly. Rapid Assessment includes the actions necessary to determine the appropriate response. This assessment identifies the current and potential range of the infestation, an analysis of the risks associated with the invasion, and timing and overall strategy for the appropriate actions. Rapid response is defined as a systematic approach to control, contain, or eradicate these species while the infestation is still contained in a particular area. Based on the results of the rapid assessment, a rapid response may be implemented to address new introductions or isolated infestations of a previously established species invading a new site (i.e., containment strategy).

Another critical element to rapid response is having the infrastructure in place to quickly implement management actions while new invasions can still be eradicated or contained. Effectively implementing EDRR will require coordination and collaboration among federal, tribal, state, local governments, nongovernment organizations (NGOs) and the private sector (National Invasive Species Council 2008).

F.3.5 Control and Management

Integrated Pest Management (IPM) is an effective approach to manage invasive species. IPM is the coordinated use of the most appropriate strategy to prevent or reduce unacceptable levels of invasive species and their damage by utilizing the most economical means, and with the least possible hazard to people, property and the environment. Physical, mechanical, chemical and biological control methods are utilized in IPM.

Physical control, sometimes referred to as cultural control, is the physical manipulation of an invasive species or their habitat. A number of techniques are used for physical control. These include manual removal, installing barriers and environmental alterations such as water level manipulation, prescribed fire, and light attenuation.

Mechanical control refers to the use of machinery designed to cut, shear, shred, uproot, grind, transport and remove invasive species. Equipment used to complete mechanical control may include but is not limited to heavy equipment such as an excavator or front-end loader (with a root rake, grinding heads or other attachments), cutter boats, dredges and mechanical harvesters (Haller 2009).

Chemical control is the use of a specially formulated pesticide to control an invasive species. The United States Environmental Protection Agency defines a pesticide as “a substance or mixture of substances intended for the prevention, destruction, repulsion, or mitigation of any pest”. The term pesticide encompasses a broad range of substances including herbicides, insecticides, fungicides etc. Pesticides are applied through ground and aerial applications.

Biological control, also known as bio-control, is the planned use of one organism to suppress the growth of another. Biological control is primarily the search for and purposeful introduction of species-specific organisms that selectively attack a single target species. Organisms such as insects, animals, or pathogens that cause plant diseases are used as biological controls (Cuda 2009).

Objectives of management can include complete eradication within a given area, population suppression, limiting spread and reducing effects of invasive species. Once an invasive species becomes widely established complete eradication is usually not feasible. The most effective action for managing widely spread invasive species is often preventing the spread and reducing the impacts by implementing control measures. This concept is known as maintenance control. Maintenance control is defined as controlling an invasive species in order to maintain the population at the lowest feasible level.

F.3.6 Risk and Uncertainties Related to Invasive Species

As with most land management activities, there are a number of risks and uncertainties associated with invasive species management. The use of an adaptive management approach will help develop and prioritize invasive species control strategies. As restoration proceeds, invasive species may establish and/or spread as a direct result or independently of restoration activities. In the context of LRWRP and the long-term management of the natural resources within the study area, risks include but are not limited to:

- Introduction of new invasive species which are difficult to control and/or new species for which techniques are unknown or haven't been developed. Restoration activities which unintentionally facilitate the spread of invasive species via contaminated earth moving equipment.

- Undetected spread of invasive species into new areas, making containment of populations more costly and less likely to succeed.
- Uncontrolled invasive species which create disturbances or alter ecosystems such that desired restoration outcomes are not achieved.
- Failure to secure necessary funding to control invasive species.
- Undesirable impacts on non-target species and ecosystem functions resulting from invasive species control efforts.
- Not taking action to manage a species due to inaccurate assessments of the species impact on restoration activities.

The major uncertainty is that in most cases we do not have necessary information for detailed, specific pre-project evaluations of the need for management activities to control invasive species. With the exception of a few well-established and well-studied species (e.g., melaleuca), there is an information deficit on the status, potential impact, and effective control techniques for priority species. This is particularly true for non-indigenous animals. Current knowledge on invasion mechanisms suggests that some restoration activities may facilitate the spread of certain priority species. For example, partial removal of canals and levees could encourage spread of or provide sites for colonization by numerous invasive species, including Brazilian pepper, Old World climbing fern, Nile monitors, pythons, and Cuban treefrogs. However, there remains considerable uncertainty regarding the degree to which different species will respond, if at all, to restoration activities and how these responses will impact achievement of restoration goals.

Given the high degree of uncertainty, the most effective and lowest cost management option is early detection and rapid removal of invasive species during and post project. Central to this strategy is the implementation of a rigorous monitoring program (discussed below).

Several specific uncertainties have been identified in the initial analysis of the selected plan. They are listed here to provide a starting point for developing monitoring, control and BMP strategies for the construction and operations phases of the restoration. Specific uncertainties addressed by the LRWRP Adaptive Management Plan as well as uncertainties addressed in this plan are listed below.

- Will increased flow result in increased nutrient loading thereby increasing spread of invasive and/or nuisance plants (e.g., torpedograss, cattail)?
- Will non-native fish species spread into new areas as a result of hydrologic connection?
- Will there be secured and available funding for management and control of invasive species? Will other priorities outcompete for funds?
- How will the lack of biological information for new introduced species affect invasive species management?
- Will changes in hydrology facilitate the spread of invasive plant species? (AM uncertainty #14)
- How will new invasive faunal species affect the restoration? (AM uncertainty #15)
- How will new invasive plant species affect the restoration? (AM uncertainty #16)
- Is there a potential for the project to transfer/expand invasive plants to other areas? (AM uncertainty #18)

- How will invasive species that are not managed on private property affect the restoration? (AM uncertainty #19)

F.4 Existing Management Programs

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.

F.4.1 South Florida Water Management District

The SFWMD manages invasive exotic aquatic and terrestrial plants in canals and on levees within the project area, interim project lands, and on public conservation lands. Most of the vegetation management is outsourced through the Vegetation Management Division and includes herbicide application contractors, mechanical removal contractors, and use of biological controls such as plant specific insects and herbivorous fish. The Melaleuca Control Program is a major focus for the SFWMD, but other priority plant species are controlled within the CEPP study area as funding resources allow.

F.4.2 US Army Corps of Engineers

The USACE also conducts treatments of priority species on the Herbert Hoover Dike. In addition to the operations and maintenance program on Lake Okeechobee, the USACE conducts treatments of vegetation during the construction & OMRRR phase for CERP projects. Vegetation treated includes FLEPPC Category I and II species, as well as native nuisance species.

F.4.3 U.S. Department of Agriculture / University of Florida

The SFWMD, USACE, NPS, USFWS, FWC, and other agencies provide financial support to the U.S. Department of Agriculture – Agricultural Research Service (USDA-ARS) and the University of Florida (UF) for the development of invasive plant biological controls. Efforts to identify safe and effective biological controls have led to important advancements in the integrative management of several invaders, including melaleuca, Old World climbing fern, water hyacinth, and alligator weed. The *CERP Melaleuca Eradication and Other Exotic Plants – Implement Biological Controls Project* is dedicated to the implementation of biological control agents once overseas surveys and quarantine testing has developed agents deemed safe for release in Florida. The project includes a mass rearing annex to the existing USDA-ARS biological control facility in Davie, Florida, in support of implementing the mass rearing, field release, establishment, and field monitoring of approved biological control agents for melaleuca and other invasive nonindigenous species.

F.4.4 Florida Fish and Wildlife Conservation Commission

The FWC's Invasive Plant Management Section is the designated lead entity in Florida responsible for coordinating and funding the statewide control of invasive aquatic and upland plants in public waterways and on public conservation land. In addition to funding the SFWMD melaleuca control program, FWC annually awards funding for individual invasive plant management projects in the Everglades region. Allocation of control funding is determined by an interagency regional working group.

F.4.5 Invasive Animals

Efforts to develop control tools and management strategies for several priority species are underway for a few priority animal species. These include the Burmese python and other giant constrictors, the Nile monitor, and the Argentine black and white tegu. Control tools are very limited for free-ranging reptiles, and the application of developed methods is often impracticable in sensitive environments where impacts to non-target species are unacceptable. Available tools for removing large constrictor snakes and lizards currently include trapping, detection dogs, and visual searching. Potential tools include the use of toxicants, introduced predators, and pheromone attractants, but these have not been fully explored to date

Regional biologists have developed a conceptual response framework for established priority invasive animals in south Florida. Objectives within this framework are classified into three main categories—containment (slow the spread), eradicating incipient populations (remove outliers), and suppression (reduce impact in established areas). The resources to implement this strategic framework remain insufficient, but close collaboration between agencies has allowed for some coordinated efforts. Currently, FWC, NPS, UF, and SFWMD are conducting trapping and visual searching for Burmese pythons, northern African pythons, Argentine black and white tegus, spectacled caimans, and Nile monitors.

F.5 Existing Monitoring Programs

Since 2008, the SFWMD and USNPS, along with other partner agencies, have utilized digital aerial sketch mapping (DASM) for a region-wide mapping program over 728,000 ha in the Everglades. DASM is a method for mapping plant infestations “on-the-fly” using GPS-linked computers and trained biologists. Visual surveys allow an observer to learn to recognize targeted species, sometimes at low densities, under a range of environmental and phenological conditions. Visual aerial surveys also may provide data more rapidly than other methods, which is important when rapid responses to newly established threats are expected. The primary objective of the DASM inventory program is to determine the distributions of four priority invasive plant species on managed conservation lands in the region. These are Australian pine, Brazilian pepper, melaleuca, and Old World climbing fern. A secondary objective of the program is to detect new plant species invasions in remote areas to facilitate rapid response efforts. This data is currently collected on a two year cycle.

Since 2010, the SFWMD has been collaborating with UF, FWC, USGS, NPS and FWS on the Everglades Invasive Reptile, Amphibian, and Mammal Monitoring Program (EIRAMMP). The purpose of the project is to develop an early detection, rapid response, removal and monitoring program for invasive reptiles and amphibians within Greater Everglades ecosystems. Specifically, the program seeks to (1) determine the status and spread of existing populations and the occurrence of new populations of invasive reptiles and amphibians, (2) provide additional EDRR capability for removal of invasive reptiles and amphibians, and (3) evaluate the status and trends of populations in native reptiles, amphibians, and mammals. The monitoring program involves visual searches for targeted invasive species on fixed routes along levees and roads within LNWR, WCA-2, WCA-3, Big Cypress National Preserve (BCNP), Southern Glades Wildlife Management Area, ENP, Corkscrew Swamp Sanctuary, and other areas such as the C-51 canal, US Highway 1, and Card Sound Road. Visual searches and call surveys are conducted to monitor invasive species and their potential prey species. Twenty-one routes have been established, and seven are active. The encounter rates for Burmese pythons ranged from 0.0014 to 0.0035 observations per kilometer. To date, a total of 105 Burmese pythons have been detected during these visual surveys. In 2018, EIRAMMP will increase focus on removal of this priority species.

F.6 Management Strategy and Plan

Many of the new features of the water management system, as well as construction and operations and maintenance activities, have the potential to spread and promote establishment of non-native invasive and native nuisance species. 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). 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. Monitoring is a critical component of the management strategy. Information on distribution and restoration responses of invasive species should be used to inform decisions on control strategies Invasive species surveillance, monitoring, and control should be carried out within the construction footprints, as well as impacted areas. Species of non-native vegetation to be treated include, but are not limited to, species listed in the current version of the FLEPPC invasive plant lists and the Florida Department of Environmental Protection prohibited plant list. The priorities for managing vegetation include FLEPPC category I and II species, new invasive plant introductions, native nuisance species and plants that impact project operations. Management of animal species will include surveillance, control, and monitoring.

The strategy for managing invasive species will be to utilize an IPM approach. Objectives of management will include complete eradication, population suppression, limiting spread and reducing effects of invasive species. Eradication will be the objective for new established species that are localized. The objective for wide spread invasive species will be to implement control measures to suppress and prevent the spread of identified priority invasive species.

F.6.1 Surveillance – Early Detection and Rapid Response

EDRR should be implemented during every phase, for the life of a project. EDRR is an effective management measure to controlling and containing invasive species that were not previously within the project area. EDRR minimizes the negative impacts the invasive species has on the ecosystem and economy, and reduces future treatment and management costs. It is very difficult to predict when and where an invasive species may appear. As such, estimating a needed budget is near impossible. However, to assist managers, a priority list of species to immediately respond to under EDRR management strategy has been developed (refer to **Error! Reference source not found.**).

A framework for establishing an EDRR program in the Everglades was recently drafted by an interagency team of invasive species experts and land managers (see ECISMA EDRR Plan at http://www.evergladescisma.org/ECISMA_EDRRPlan_2009-2011.pdf). As discussed above (Section F.3.4 Early Detection and Rapid Response), EDRR includes three strategy elements: 1) early detection, 2) rapid assessment, and 3) rapid response.

1.) Early Detection: This plan proposes implementation of routine surveillance in the project area in order to minimize the time between initial introduction and detection of a new species. Strategic surveillance by trained biologists in proximity to the CEPP project elements should greatly increase the probability of

detection of new species. In many cases, existing programs could be expanded to include focused monitoring in the CEPP footprint. For example, the EIRAMMP is well suited for enhanced surveillance for numerous invasive animal species (see Section F.4 Existing Management Programs).

2.) Rapid Assessment: Following the detection of new invasions (or expansion of formerly contained invasions), it is important to gather and process available information to determine the potential risk and control options in the face of high uncertainty. Critical questions must be answered in a relatively short period of time. Example questions include:

- What is the spatial extent and abundance of the invasive non-native species?
- What is the likelihood that the species will impact native species, ecosystem function, operations infrastructure, or human health?
- What are the management options for containment or eradication?

Numerous tools are available to assist natural resource managers with the assessment phase of EDRR, though none of them is likely to be 100% accurate in assessing the risk of a species. This plan proposes utilization of the IFAS Assessment of Non-native plants in Florida's Natural Areas, the Florida Exotic Pest Plant Council's Invasive Species List, the FWC Non-native Animal Bioprofile protocol, and the ECISMA Rapid Response Plan for assessing the risks of non-indigenous species in the CEPP footprint. These assessments should be conducted with CEPP biologists, subject matter experts, and stakeholders.

3.) Rapid Response: This is the "risk management" component of EDRR. Once a species is determined to have a high probability of ecological impact and control options are available, rapid response strategies aimed at containment, and ultimately eradication, can be formulated and implemented. To be effective, rapid response programs must have built in procedural, financial and logistical capacity to respond quickly to newly established threats. Since it is not possible to accurately predict the number and severity of new invasions during the project, this plan proposes contingency funding for rapid response activities in the event new, high-priority species establish in the project area. During the pre-construction phase, protocols for implementing rapid response should be developed.

F.6.2 Control

A combination of biological, physical, mechanical, and chemical control methods will be utilized to manage invasive species.

Biological control agents will be used to decrease the targeted invasive species competitive advantages over native species and to weaken the invading population by increasing leaf mortality, decreasing plant size, reducing flower and seed production, and/or limiting population expansion. Biological control agents will be acquired through the “Melaleuca Eradication and Other Exotic Plants – Implement Biological Controls” project, which is a component of CERP. One element of this CERP component includes the implementation of biological control agents which involves mass rearing, field release, establishment and monitoring of approved biological controls in south Florida and the Everglades. The four main invasive plant species targeted for control through this component include melaleuca, Australian pine, Brazilian pepper and Old World climbing fern.

It is anticipated that physical control methods will be limited. Prescribed burns will be conducted in order to promote native plant growth and should be planned, if possible, to target invasive species when they are most susceptible to fire. Hand pulling of melaleuca and other non-native plant species will occur when

it is feasible. Weed/debris barriers will be placed at water control structures when it is required to minimize dispersal of floating vegetation. Physical control measures will be utilized for invasive animal control. Examples of these measures include trapping of feral hogs, controlled harvest/overfishing (nets, fishing tournaments specific to invasive fish species) and compliance with FWC Fishing Regulation release/movement of fish (no return to water/used as bait).

Mechanical control will be implemented to remove non-native plant species when the construction of project features requires such removal. Heavy equipment such as bulldozers, front-end loaders and excavators (with or without grinding heads) will be utilized to uproot, grind and/or clear and grub. It is expected this type of control method will be utilized during levee degrades, canal backfilling and during construction of new project features such as water control structures.

Chemical control will be utilized to treat aquatic and terrestrial invasive plants. Methods for treatment will include hack-n-squirt, basal bark, cut-stump, foliar and aerial application. EPA approved herbicides will be utilized to control invasive plants. Chemical control will be utilized to treat invasive plants in canals, along levees, in wetland/natural areas as well as the Wetland Attenuation Feature (WAF), etc.

F.6.3 Monitoring

Monitoring of invasive species populations will be conducted through DASM, Unmanned Aircraft System (UAS) surveys, electrofishing and EIRAMMP. Invasive species will also be identified through monitoring for the Adaptive Management Plan. This information will be provided to invasive species managers to ensure appropriate management measures are implemented.

F.6.4 Pre-construction Phase

Baseline conditions need to be established prior to the construction phase. Existing monitoring programs should be used as much as possible to establish baseline conditions prior to construction activities beginning. Although there are no system-wide monitoring programs for invasive species in the Everglades region, several individual agencies collect data. Data mining will be the primary resource to obtain baseline data via collaboration with the individual agencies. In areas with data gaps, surveys will need to be accomplished by the most cost-effective method (e.g. ground survey, Unmanned Aircraft Systems survey, DASM).

Existing monitoring and management programs should continue to be implemented. The existing programs help maintain invasive and nuisance species at a controlled level.

A significant length of time lapses from the time a project is planned to when it receives congressional authorization and appropriations, and ultimately goes to construction. As property (lands and structures) sit with no activity, vegetation, and wildlife changes can occur. Unmanaged areas become inhabited by many species of flora and fauna, native and non-native. Older growth vegetation is more difficult and more costly to treat / remove versus lands that are managed along the way. As these lands become established with invasive species, there is an increased risk of spreading the invasive species to neighboring lands. Therefore, it is beneficial, ecologically and economically, to manage the lands early on. Managing invasive vegetation throughout the interim phase reduces construction costs since mowing is much less costly than clearing/grubbing and treating, and rapid response of new infestations helps reduce spread into environmentally sensitive areas. Site 1 Impoundment is an excellent example. $2.9M is estimated to manage invasive species during construction and until turnover to the local sponsor. The property's prior use included plant nurseries and pasture. Once project lands were acquired by the

sponsor, the land sat unused until the Site 1 project was ready to begin construction. By this time, the project lands became highly vegetated, primarily by invasive species. It would have been significantly less expensive to have maintained the lands until the time of construction versus waiting until construction started.

F.6.5 Design and Construction Phases

The best method of controlling invasive and nuisance species is to prevent non-native species from being introduced and established to begin with. Incorporation of invasive species prevention and control into project designs, alternatives analysis, and operational plans has the potential to save significant resources during the long-term. The plans and specifications phase should simply design "with the end in mind." When the end goal is ecosystem restoration, the designers should periodically obtain input from invasive species experts to identify design features and operation strategies that could potentially favor the establishment and spread of invasive species. An example of design influences on invasive species is levee removal without backfill of canals. Without canal backfilling, deep water refuges for non-native fishes and invertebrates (from both seasonal cold temperatures and seasonal drying) are maintained, and barriers to dispersal from canal waters to marsh habitats are removed. Design alternatives should be explored that would allow seasonal cooling of water in the canals. Cooler water temperatures will reduce the refuge capacity for cold temperature sensitive non-native fishes. In some cases, such as the coastal canals, aquatic barrier technologies could be used to mitigate the spread of non-native aquatic species.

Below are examples of cost-saving measures to consider during design and construction.

- Include invasive species management staff from the Corps, SFWMD, and other partner agencies throughout the design and construction phases.
- Work with subject matter experts to identify design features that may create habitat or entry points for invaders. Evaluate design alternatives to mitigate potential design vulnerabilities.
- Design to promote the establishment of native species.
- Use construction methods that minimize ground disturbance whenever possible.
- Contain mobilized nutrients resulting from soil disturbances.
- Require all construction contractors to follow vehicle and equipment decontamination protocols prior to deployment. Coordinate with invasive species specialists for decontamination protocol specifications.
- Evaluate cost/benefit ratios for treating invasive/nuisance species prior to construction activities. In some cases, pre-construction removal of a species may significantly reduce its spread.
- Implement a monitoring and rapid response protocol aimed at detecting and controlling new invasions early.
- Manage and control invasive/nuisance species during the entire construction phase.
- When native planting is specified in the plans, use plant material from regional sources that are weed and pathogen free.

Construction will be the responsibility of either the Corps or the SFWMD. This will be determined at a future time. Regardless of which agency will be responsible, both agencies commit to requiring the construction contractor to implement preventive measures and best management practices that will

minimize the potential introduction and spread of invasive and nuisance species due to construction equipment (including personal protective equipment) and activities. This commitment is also included in the Project Implementation Report/Environmental Impact Assessment (Section 5.2.5 Environmental Commitments).

The Corps currently includes the following language in all of their specifications (Specification # 01 57 20 Environmental Protection, "Prevention of Invasive and Nuisance Species Transfer"):

> The Contractor shall thoroughly clean equipment prior to and following work on the project site to ensure that items/materials including, but not limited to, soil, vegetative debris, eggs, mollusk larvae, seeds, and vegetative propagules are not transported from a previous work location to this project site, nor transported from this project site to another location. Prevention protocols require cleaning all equipment surfaces, including but not limited to, undercarriages, tires, and sheet metal. All equipment, including but not limited to, heavy equipment, vehicles, trailers, ATV's, and chippers must be cleaned. Smaller equipment, including, but not limited to, chainsaws, loppers, shovels, and backpack sprayers, must be cleaned and inspected to ensure they are free of eggs, vegetative debris, vegetative propagules, etc. The Contractor may utilize any method accepted by the Government; common accepted methods include pressure washing and steam cleaning/washing equipment. Prevention protocols should also address clothing and personal protective equipment.
>
> Prior to the commencement of work, the Contractor shall complete and provide an invasive and nuisance species transfer prevention plan to the Corps for approval. This plan shall be part of the Environmental Protection Plan as defined in subparagraph "Environmental Protection Plan" of paragraph SUBMITTALS (Part 1.5) above. The invasive and nuisance species transfer prevention plan shall identify specific transfer prevention procedures and designated cleaning sites/locations. Prevention protocols may vary depending upon the nature of the project site. It will be the responsibility of the Contractor to ensure all equipment coming onto and leaving the project site is inspected and not harboring materials that would spread, or potentially spread, invasive and nuisance species onto or off the project site. The Contractor shall provide a report verifying equipment brought on site was cleaned and shall provide a report verifying equipment was cleaned prior to removal from the project site.

F.6.6 Operational Testing and Monitoring Period

The operational testing and monitoring period is the timeframe from the end of construction until the project is transferred and accepted by the local sponsor. EDRR is very critical and the most cost-effective management measure during this period. Disturbed areas, such as areas impacted from construction activities, are prone to the establishment of invasive and nuisance species. Early detection of invasive and nuisance species and immediate treatment/control measures prevent these species from establishing and becoming long-term problems, ecologically and economically.

F.6.7 OMRR&R Phase

"Prevention of Invasive and Nuisance Species Transfer" language applies not only to the construction phase, but also to the OMRR&R phase. The preventive measure applies to contractors and government employees. Maintenance equipment and rental equipment are often used at multiple locations. As equipment is moved from one location to another, this potential spread vector can easily be reduced / prevented simply by ensuring the equipment is clean prior to arrival on site and prior to leaving the site.

In addition, numerous operational aspects of the restoration can influence mechanisms of invasion. For example, many non-indigenous species become more invasive in environments with elevated nutrient availability. With large pulses of only slightly elevated phosphorus levels, some invasive plant species could establish and spread.

F.6.8 Specific Control by Project Feature – Construction Phase

Surveillance and management of invasive species may begin as early as 2 years prior to actual construction of the project features. This will be in effort to minimize spread of priority species during the construction phase. Various management measures will be implemented in order to reduce colonization and spread of invasive plant and animal species.

F.6.8.1 Flow-way 1, M1 Pump Station Installation & Connectivity Improvements to GWP Triangle and G-161

Surveys of the pump station installation area should be completed prior to construction to identify invasive and non-native plant and animal species that may be spread by construction activities. These species should be treated prior to construction. Monitoring and treatment of submersed and floating plant species that could impact construction should occur throughout the construction phase. Surveys of the affected area of the GWP footprint should be completed prior to pump station construction to identify invasive and non-native species that may be spread to the footprint from the M-1 basin during construction activities. The discharge site into GWP from the outlet structure should be closely monitored to reduce the spread of invasive and non-native species. Priority plant species in the GWP should be treated during the construction phase. Connectivity improvements may also cause the spread of invasive and non-native species, and these areas should be closely monitored throughout the duration of the project.

F.6.8.2 Flow-way 2

F.6.8.2.1 C-18W Above-Ground Reservoir & Canal Connector Installation

Surveys of the projected reservoir area should be completed prior to construction to identify priority invasive and non-native species that may be spread to C-18 or other discharge canals during construction activities. Such species should be treated prior to the beginning of construction. Coordination with other agencies should be conducted to determine the appropriate measures to be implemented to address the high priority non-native invasive fish and plant species.

F.6.8.2.2 C-18W Inflow Pump Installation

Surveys of the pump installation area should be completed prior to construction to identify priority invasive and non-native plant and animal species that may be spread by construction activities. These

species should be treated prior to construction. Monitoring and treatment of submersed and floating plant species that could impact construction should occur throughout the construction phase. Surveys of the affected area of the Hungryland Slough footprint and other nearby discharge areas should be completed prior to pump station construction to identify priority invasive and non-native species that may be spread to the footprint from the C-18W basin during construction activities. The discharge site from the outlet structure should be closely monitored to reduce the spread of invasive and non-native species. Priority plant species in these areas should be treated.

F.6.8.3 Wetland Restoration Sites

F.6.8.3.1 Kitching Creek Hydration – Spreader Canal and Weir/Plug Installation

Surveys of Kitching Creek should be completed prior to construction to identify invasive and non-native species that may be spread by construction activities. Such species should be treated prior to the beginning of construction. Periodic surveys of the areas adjacent to the new weir/plug and spreader canal structures should be conducted throughout the construction phase to identify growth of invasive and non-native species. Water diverted by the weir into the Jenkins Ditch may result in the spread of invasive and non-native species, and should thereby be closely monitored. Priority plant species in these areas should be treated.

F.6.8.3.2 Moonshine Creek (MC) & Gulfstream East (GE) Restoration - Weir Installation, Vegetation clear, Canal Connections & Historic Topography Re-grade

Surveys of MC and GE should be completed prior to construction to identify invasive and non-native species that may be propagated or spread by construction activities. Such species should be treated prior to the beginning of construction. Periodic surveys of the areas adjacent to the Hobe Grove Ditch weir installation should be conducted throughout the construction phase to identify growth of invasive and non-native species. Equipment used for the clearing of vegetation should be thoroughly cleaned and inspected for invasive and non-native plant materials before leaving the project area in order to prevent the spread of invasive plant species. Water flowing into the HSLCD ditch from MC may result in the spread of priority species, and should thereby be closely monitored during this phase. Priority plant species in these areas should be treated. Any land that is graded must be surveyed for invasive and non-native plant species prior to and upon completion of grading.

F.6.8.3.3 Cypress Creek Canal (CCC) Over-drainage Reduction – Weir Replacement, Berm Improvement, Spreader Swale Installation & Southern Fork Re-grade

Surveys of CCC should be completed prior to construction to identify invasive and non-native species that may be propagated or spread by construction activities. Such species should be treated prior to the beginning of construction. Periodic surveys of the areas adjacent to the replacement weir should be conducted throughout the construction phase to identify growth of invasive and non-native species. Material to be used to raise the berm structure should be inspected for signs of invasive and non-native plant species prior to use, and periodically surveyed once material is in place. Any land that is graded must be surveyed for invasive and non-native plant species prior to and upon completion of grading. Water being transported via spreader swale must be surveyed prior to and upon installation; to ensure no non-native or invasive species are propagated throughout the area. The area to which water will be delivered via spreader swale will be hydrologically altered, and must therefore be closely monitored for new invasive and non-native growth.

F.6.8.3.4 Gulfstream West Restoration – Backfill, Canal Relocation, Pump and Flow-through Marsh Installation

Any material to be used as backfill must be thoroughly inspected for signs of invasive and non-native plant species prior to installation. Relocating the southern end of the HSLCD canal may cause a spread of existing invasive and non-native plant and animal species. Surveys of Gulfstream West and HSLCD canal should be conducted both prior to and after relocation is complete. Priority plant species in these areas should be treated. Surveys of the pump installation area should be completed prior to construction to identify priority invasive and non-native plant and animal species that may be spread by construction activities. These species should be treated prior to construction. Monitoring and treatment of submersed and floating plant species that could impact construction should occur throughout the construction phase. Surveys of the affected area of Gulfstream West and other nearby discharge areas should be completed prior to pump station construction to identify priority invasive and non-native species that may be spread to the HSLCD canal from the Gulfstream West basin during construction activities. The discharge site from the outlet structure should be closely monitored to reduce the spread of invasive and non-native species. Priority plant species in these areas should be treated.

F.6.8.3.5 Palmar East Restoration and Connectivity – Plug, Berm and Pump Installation

Surveys of the Palmar East area should be completed prior to construction to identify invasive and non-native species that may be spread by construction activities. Such species should be treated prior to the beginning of construction. Periodic surveys of the areas adjacent to the new plug, berm, and pump structures should be conducted throughout the construction phase to identify growth of invasive and non-native species. Water diverted by the pump into GW may result in the spread of invasive and non-native species, and should thereby be closely monitored. Priority plant species in these areas should be treated. The discharge site from the outlet structure should be closely monitored to reduce the spread of invasive and non-native species. Material to be used to build the berm structure should be inspected for signs of invasive and non-native plant species prior to use, and periodically surveyed once material is in place.

F.6.9 Specific Control by Project Feature – OMRR&R Phase

Surveillance and management of invasive will occur throughout the OMRR&R phase. This will be in effort to minimize spread of priority species. Various management measures will be implemented in order to reduce colonization and spread of invasive plant and animal species.

F.6.9.1 Flow-way 1, M1 Pump Station and Connectivity Improvements to GWP Triangle and G-161

Surveys of the newly installed and improved features should be completed to identify invasive and non-native plant and animal species and these species should be treated/or removal procedures implemented during the OMRR&R Phase. Surveys of the affected area of the GWP footprint should be completed to identify invasive and non-native species that spread to the footprint from the M-1 basin. Regular surveillance should occur at the discharge site into GWP from the outlet structure, appropriate management measures shall be implemented in order to reduce the spread of invasive and non-native species. Priority plant species in the GWP should be treated. Connectivity improvements may also cause the spread of invasive and non-native species, these areas should be surveyed and management measures implemented throughout the duration of the project.

F.6.9.2 Flow-way 2

F.6.9.2.1 C-18W Above-Ground Reservoir & Canal Connector

Surveys of the reservoir, canal connector, C-18W and other discharge canals should be completed to identify priority invasive and non-native species. Treatments and/or appropriate management measures shall be implemented to control priority species. Coordination with other agencies should be conducted to determine the appropriate measures to be implemented to address the high priority non-native invasive fish and plant species.

F.6.9.2.2 C-18W Inflow Pump

Surveys should be completed at the C-18W Inflow Pump, in the Hungryland Slough footprint and nearby discharge areas to identify priority invasive and non-native plant and animal species. Treatments and/or appropriate management measures shall be implemented to control priority species. Regular surveillance should occur at the discharge site from the outlet structure an appropriate treatments shall be conducted to reduce the spread of invasive and non-native species. Priority plant species in these areas should be treated throughout the OMRR&R phase.

F.6.9.3 Wetland Restoration Sites

F.6.9.3.1 Kitching Creek Hydration – Spreader Canal and Weir/Plug

Surveys of Kitching Creek should be to identify invasive and non-native species and these species should be treated throughout the OMRR&R Phase. Periodic surveys of the areas adjacent to the new weir/plug and spreader canal structures should be conducted throughout the OMRR&R phase to identify growth of invasive and non-native species. Water diverted by the weir into the Jenkins Ditch may result in the spread of invasive and non-native species. Surveillance of this area should be conducted on a regular basis and priority plant species in these areas should be treated.

F.6.9.3.2 Moonshine Creek (MC) & Gulfstream East (GE) Restoration - Weir, Canal Connections & Historic Topography Re-grade

Surveys of MC, GE and Hobe Grove Ditch weir should be completed to identify invasive and non-native species and these species should be treated throughout the OMRR&R phase. Water flowing into the HSLCD ditch from MC may result in the spread of priority species, and thereby should receive periodic surveys to identify priority species. Priority plant species in these areas should be treated. Regular periodic inspections shall be conducted in areas where land is graded. Regular treatments shall be conducted to control invasive plants in the graded areas throughout the OMRR&R phase.

F.6.9.3.3 Cypress Creek Canal (CCC) Over-drainage Reduction – Weir, Berm, Spreader Swale & Southern Fork Re-grade

Surveys of the newly installed and improved features should be completed to identify invasive and non-native plant and animal species and these species should be treated/or removal procedures implemented during the OMRR&R Phase. Regular periodic inspections shall be conducted in areas where land is graded and in the spreader swale. Regular treatments shall be conducted to control invasive plants in these areas throughout the OMRR&R phase. The area to which water will be delivered via spreader swale will

experience hydrologic alteration, and must therefore be closely monitored for new invasive and non-native growth, management measures shall be implemented as appropriate.

F.6.9.3.4 Gulfstream West Restoration – Backfill, Canal, Pump and Flow-through Marsh

Surveys of the newly installed and improved features should be completed to identify invasive and non-native plant and animal species and these species should be treated/or removal procedures implemented during the OMRR&R Phase. Regular periodic surveys of Gulfstream West and other nearby discharge areas should be completed to identify priority invasive and non-native species and these species should be treated to prevent spread to the HSLCD canal from the Gulfstream West basin. The discharge site from the outlet structure should be closely monitored to reduce the spread of invasive and non-native species. Priority plant species in these areas should be treated.

F.6.8.3.5 Palmar East Restoration and Connectivity – Plug, Berm and Pump

Surveys of the newly installed and improved features should be completed to identify invasive and non-native plant and animal species and these species should be treated/or removal procedures implemented during the OMRR&R Phase. Water diverted by the pump into GW may result in the spread of invasive and non-native species, and should thereby be closely monitored. Priority plant species in these areas should be treated. The discharge site from the outlet structure should be closely monitored to reduce the spread of invasive and non-native species.

F.7 Education / Outreach Opportunities at Recreational Areas

Recreational opportunities will be created by the LRWRP. Recreation areas such as boat ramps, hiking trails, and hunting areas can serve as vectors and pathways for aquatic and terrestrial invasive species. For example, invasive species can be transferred from one area to another by hikers and by boats/trailers. Many recreational users are unaware of their role in the spread of unwanted species. Hence, educating the public on preventing the spread of invasive species can be a cost effective component of the overall management strategy. The recreation access points can be used to display educational information on invasive species identification, prevention/control measures, and awareness of the invasive species programs in the area, and how individuals can contribute to invasive species prevention. Educational kiosks are recommended and should include information on:

- Specific priority invasive species in the area
- Impacts and costs of invasive species on conservation, human health, and recreation
- Preventative measures, such as removing vegetation from boats/trailers before leaving the boat ramp or removing vegetation from shoes and clothing before leaving the area.
- Ways to report invasive species observations
- Programs that citizens can get involved with and learn more about invasive species
- Laws against the release of non-native wildlife

F.8 Costs

A summary of costs are below in **Table F-8.** Detailed costs can be found in Tables F-4 and F-5 (**Error! Reference source not found.** and

2 Year Pre-Construction	$2,559,070
1 Year Pre-Construction	$1,423,072
Construction Phase	$893,019
Operational Testing & Monitoring Phase	$508,551
1 Year OMRR&R Phase	$536,285
50-Year OMRR&R Phase (Includes Year 1)	$52,279,358
Total Management Cost	**$57,663,070**

Table F-9. LRWRP Invasive and Nuisance Total Monitoring Costs.

Category	Cost Estimate
Total Monitoring Cost	**$1,480,949**

). It was assumed that in the field baselines and potential invasive species treatments and management would need to occur starting about 2 years prior to the actual construction start date. Costs were estimated for the life of the project, assuming a 50-year life. However, due to size, the OMRR&R table only shows years 1 and the total 50 year cost estimate. Monitoring costs are provided as a total for 10 years during the OMRR&R phase.

Table F-1. Invasive Plant Species Documented in the Project Area

Common Name	*Scientific Name*	LO Region	NE Region	EAA Region	GE Region	FLEPPC Category
rosarypea	*Abrus precatorius* L.	x	x	x	x	---
earleaf acacia	*Acacia auriculiformis* A. Cunningham ex Benth.	x	x	x	x	I
sisal	*Agave sisalana* Perrine	x	x	x	x	II
mimosa	*Albizia julibrissin* Durazz.	x	x	x	x	I
woman's tongue tree	*Albizia lebbeck* (L.) Benth	x	x	x	x	I
deviltree	*Alstonia macrphylla*	x	x	x	x	II
alligatorweed	*Alternanthera philoxeroides* (Mart.) Griseb.	x	x	x	x	II
coral vine	*Antigonon leptopus* Hook. & Arn.	x	x	x	x	II
coral ardisia	*Ardisia crenata* Sims	x	x	x	x	I
shoebutton ardisia	*Ardisia elliptica* Thunb	x	x	x	x	I
Sprenger's asparagus fern	*Asparagus aethiopicus* L.	x	x	x	x	I
Chinese violet, Ganges primrose	*Asystasia gangetica* (L.) T. Anders	x	x	x	x	II
feathered mosquito fern	*Azolla pinnata pinnata*	x	x	x	x	---
mountain ebony	*Bauhinia variegata* L	x	x	x	x	I
Javanese bishopwood	*Bischofia javanica* Blume	x	x	x	x	I
bottlebrush	*Callistemon viminalis* (Gaertn.)G.Don ex Loudon	x	x	x	x	II
river sheoak	*Casuarina cunninghamiana* Miq.	x	x	x	x	II
Australian-pine	*Casuarina equisetifolia* L.	x	x	x	x	I
gray sheoak	*Casuarina glauca* Sieb. ex Spreng	x	x	x	x	I
Madagascar periwinkle	*Catharanthus roseus* (L.) G. Don	x	x	x	x	---
watersprite	*Ceratopteris thalictroides*	x	x	x	x	---
day jessamine	*Cestrum diurnum* L.	x	x	x	x	II
camphortree	*Cinnamomum camphora* (L.) J. Presl	x	x	x	x	I
coconut palm	*Cocos nucifera*	x	x	x	x	II
coco yam, wild taro	*Colocasia esculenta* (L.) Schott	x	x	x	x	I

Common Name	*Scientific Name*	LO Region	NE Region	EAA Region	GE Region	FLEPPC Category
Asian nakedwood	*Colubrina asiatica* (L.) Brongn.	x	x	x	x	I
smooth crotalaria	*Crotalaria pallida* Aiton	x	x	x	x	---
showy rattlebox	*Crotalaria spectabilis* Roth	x	x	x	x	---
carrotwood	*Cupaniopsis anacardioides* (A. Rich.) Radlk.	x	x	x	x	I
Cuban bulrush	*Cyperus blepharoleptos*	x	x	x	x	---
miniature flatsedge, dwarf papyrus	*Cyperus prolifer* Lam	x	x	x	x	II
crowfootgrass	*Dactyloctenium aegyptium* (L.) Willd	x	x	x	x	II
Indian rosewood	*Dalbergia sissoo* Roxb. ex DC.	x	x	x	x	II
winged yam	*Dioscorea alata* L.	x	x	x	x	I
air-potato	*Dioscorea bulbifera* L.	x	x	x	x	I
Brazilian waterweed	*Egeria densa*	x	x	x	x	---
waterhyacinth	*Eichhornia crassipes* (Mart.) Solms	x	x	x	x	I
centipede tongavine	*Epipremnum pinnatum* (L.) Engl	x	x	x	x	II
Surinam cherry	*Eugenia uniflora* L.	x	x	x	x	I
Eulophia ground orchid	*Eulophia graminea*	x	x	x	x	II
Chinese banyan	*Ficus microcarpa* L. f.	x	x	x	x	I
limpograss	*Hemarthria altissima* (Poir.) Stapf & C.E. Hubbard	x	x	x	x	II
hydrilla	*Hydrilla verticillata* (L. f.) Royle	x	x	x	x	I
miramar weed, green hygro, Indian swampweed	*Hygrophila polysperma* (Roxb.) T. Anders.	x	x		x	I
West Indian marsh grass	*Hymenachne amplexicaulis* (Rudge) Nees	x	x	x	x	I
jaraguagrass	*Hyparrhenia rufa* (Nees) Stapf	x	x		x	II
cogongrass	*Imperata cylindrica* (L.) Beauv.	x	x	x	x	I
hairy indigo	*Indigofera hirsuta* L.	x	x	x	x	---
Gold Coast jasmine	*Jasminum dichotomum* Vahl	x	x	x	x	I
Brazilian jasmine	*Jasminum fluminense* Vell.	x	x	x	x	I
cathedral bells	*Kalanchoe pinnata (Lam.) Pers.*	x	x	x	x	II

Common Name	*Scientific Name*	LO Region	NE Region	EAA Region	GE Region	FLEPPC Category
Lantana, shrub verbena	*Lantana camara*	x	x	x	x	I
white leadtree	*Leucaena leucocephala* (Lam.) de Wit	x	x	x	x	II
limnophila, Asian marshweed	*Limnophila sessiliflora* (Vahl) Blume	x	x	x	x	II
primrose-willow	*Ludwigia peruviana* (L.) Hara	x	x	x	x	I
Japanese climbing fern	*Lygodium japonicum* (Thunb. ex Murr.) Sw.	x	x	x	x	I
old world climbing fern	*Lygodium microphyllum* (Cav.) R. Br.	x	x	x	x	I
sapodilla	*Manilkara zapota* (L.) van Royen	x	x	x	x	I
guineagrass	*Megathyrsus maximus* (Jacq.) R. Webster	x	x	x	x	---
melaleuca	*Melaleuca quinquenervia* (Cav.) Blake	x	x	x	x	I
chinaberry	*Melia azedarach* L.	x	x	x	x	II
natalgrass	*Melinis repens* (Willd.) Zizka	x	x	x	x	I
catclaw mimosa	*Mimosa pigra*	x	x	x	x	I
balsamapple	*Momordica charantia* L.	x	x	x	x	II
parrot feather	*Myriophyllum aquaticum*	x	x	x	x	---
Asian swordfern	*Nephrolepis brownii* (Desv.) Hovenkamp & Miyam.	x	x	x	x	I
narrow swordfern	*Nephrolepis cordifolia* (L.) C. Presl	x	x	x	x	I
burmareed	*Neyraudia reynaudiana* (Kunth) Keng ex A.S. Hitchc.	x	x	x	x	I
cape blue waterlily	*Nymphaea capensis* var. zanzibariensis	x	x	x	x	---
crested floating heart	*Nymphoides cristata* (Roxb.) O. Ktze.	x	x	x	x	I
skunk-vine	*Paederia foetida*	x	x	x	x	I
torpedo grass	*Panicum repens*	x	x	x	x	I
mission grass	*Pennisetum polystachion* (Linnaeus) Schultes		x		x	II
elephant grass, Napier grass	*Pennisetum purpureum* Schumacher	x	x	x	x	I
Senegal date palm	*Phoenix reclinata*	x	x	x	x	II
golden bamboo	*Phyllostachys aurea* Carr. ex A.& C. Rivière	x	x		x	II

Common Name	*Scientific Name*	LO Region	NE Region	EAA Region	GE Region	FLEPPC Category
waterlettuce	*Pistia stratiotes*	x	x	x	x	I
strawberry guava	*Psidium cattleianum* Sabine	x	x	x	x	I
guava	*Psidium guajava* L.	x	x	x	x	I
ladder brake, Chinese brake fern	*Pteris vittata* L.	x	x	x	x	II
downy rose myrtle	*Rhodomyrtus tomentosa* (Ait.) Hassk.	x	x	x	x	I
largeflower Mexican clover	*Richardia grandiflora*	x	x	x	x	II
castorbean	*Ricinus communis* L.	x	x	x	x	II
roundleaf toothcup	*Rotala rotundifolia* (Buch.-Ham. ex Roxb.) Koehne	x	x	x	x	II
Britton's wild petunia	*Ruellia simplex* C. Wright	x	x	x	x	I
water fern	*Salvinia minima* Baker	x	x	x	x	I
iguanatail, bowstring hemp	*Sansevieria hyacinthoides* (L.) Druce	x	x	x	x	II
beach naupaka	*Scaevola taccada* Vahl	x	x	x	x	I
octopus tree, Queensland umbrella tree	*Schefflera actinophylla* (Endl.) H.A.T. Harms	x	x	x	x	I
Brazilian peppertree	*Schinus terebinthifolius* Raddi	x	x	x	x	I
climbing cassia, Christmas cassia	*Senna pendula var. glabrata*	x	x	x	x	I
red sesbania, purple sesban, rattlebox	*Sesbania punicea* (Cav.) Benth.	x	x	x	x	II
twoleaf nightshade	*Solanum diphyllum* L.	x	x	x	x	II
tropical soda apple	*Solanum viarum* Dunal	x	x	x	x	I
Bay Biscayne creeping-oxeye, wedelia	*Sphagneticola trilobata* (L.C. Rich.) Pruski	x	x	x	x	II
queen palm	*Syagrus romanzoffiana* (Cham.) Glassman	x	x	x	x	II
American evergreen, arrowhead vine	*Syngonium podophyllum* Schott	x	x	x	x	I
Java plum	*Syzygium cumini* (L.) Skeels	x	x	x	x	I
Malabar plum	*Syzygium jambos*	x	x	x	x	II

Common Name	*Scientific Name*	LO Region	NE Region	EAA Region	GE Region	FLEPPC Category
sea hibiscus	*Talipariti tiliaceum var. tiliaceum* L.	x	x	x	x	---
tropical almond	*Terminalia catappa* L.	x	x	x	x	II
Australian almond	*Terminalia muelleri*	x	x	x	x	II
portia tree, seaside mahoe	*Thespesia populnea* (L.) Soland. ex Correa	x	x	x	x	I
white-flowered spiderwort	*Tradescantia fluminensis* Vell.	x	x	x	x	I
boatlily, oyster plant	*Tradescantia spathacea* Sw.	x	x	x	x	II
Chinese tallowtree	*Triadica sebifera* (L.) Small	x	x		x	I
Jamaica feverplant, puncture vine, burr-nut	*Tribulus cistoides* L.	x	x	x	x	II
Caesarweed	*Urena lobata* L.	x	x	x	x	I
paragrass	*Urochloa mutica* (Forsk.) T.Q. Nguyen	x	x	x	x	I
simpleleaf chastetree	*Vitex trifolia* L.	x	x	x	x	II
coco yam, wild taro	*Colocasia esculenta* (L.) Schott	x	x	x	x	I
Asian nakedwood	*Colubrina asiatica* (L.) Brongn.	x	x	x	x	I
smooth crotalaria	*Crotalaria pallida* Aiton	x	x	x	x	---
showy rattlebox	*Crotalaria spectabilis* Roth	x	x	x	x	---
carrotwood	*Cupaniopsis anacardioides* (A. Rich.) Radlk.	x	x	x	x	I
Cuban bulrush	*Cyperus blepharoleptos*	x	x	x	x	
miniature flatsedge, dwarf papyrus	*Cyperus prolifer* Lam	x	x	x	x	II
crowfootgrass	*Dactyloctenium aegyptium* (L.) Willd	x	x	x	x	II
Indian rosewood	*Dalbergia sissoo* Roxb. ex DC.	x	x	x	x	II
winged yam	*Dioscorea alata* L.	x	x	x	x	I
air-potato	*Dioscorea bulbifera* L.	x	x	x	x	I
Brazilian waterweed	*Egeria densa*	x	x	x	x	
waterhyacinth	*Eichhornia crassipes* (Mart.) Solms	x	x	x	x	I
centipede tongavine	*Epipremnum pinnatum* (L.) Engl	x	x	x	x	II
Surinam cherry	*Eugenia uniflora* L.	x	x	x	x	I

Common Name	*Scientific Name*	LO Region	NE Region	EAA Region	GE Region	FLEPPC Category
Eulophia ground orchid	*Eulophia graminea*	x	x	x	x	II
Chinese banyan	*Ficus microcarpa* L. f.	x	x	x	x	I
limpograss	*Hemarthria altissima* (Poir.) Stapf & C.E. Hubbard	x	x	x	x	II
hydrilla	*Hydrilla verticillata* (L. f.) Royle	x	x	x	x	I
miramar weed, green hygro, Indian swampweed	*Hygrophila polysperma* (Roxb.) T. Anders.	x	x		x	I
West Indian marsh grass	*Hymenachne amplexicaulis* (Rudge) Nees	x	x	x	x	I
jaraguagrass	*Hyparrhenia rufa* (Nees) Stapf	x	x		x	II
cogongrass	*Imperata cylindrica* (L.) Beauv.	x	x	x	x	I
hairy indigo	*Indigofera hirsuta* L.	x	x	x	x	---
Gold Coast jasmine	*Jasminum dichotomum* Vahl	x	x	x	x	I
Brazilian jasmine	*Jasminum fluminense* Vell.	x	x	x	x	I
cathedral bells	*Kalanchoe pinnata (Lam.) Pers.*	x	x	x	x	II
Lantana, shrub verbena	*Lantana camara*	x	x	x	x	I
white leadtree	*Leucaena leucocephala* (Lam.) de Wit	x	x	x	x	II
limnophila, Asian marshweed	*Limnophila sessiliflora* (Vahl) Blume	x	x	x	x	II
primrose-willow	*Ludwigia peruviana* (L.) Hara	x	x	x	x	I
Japanese climbing fern	*Lygodium japonicum* (Thunb. ex Murr.) Sw.	x	x	x	x	I
old world climbing fern	*Lygodium microphyllum* (Cav.) R. Br.	x	x	x	x	I
sapodilla	*Manilkara zapota* (L.) van Royen	x	x	x	x	I
guineagrass	*Megathyrsus maximus* (Jacq.) R. Webster	x	x	x	x	---
melaleuca	*Melaleuca quinquenervia* (Cav.) Blake	x	x	x	x	I
chinaberry	*Melia azedarach* L.	x	x	x	x	II
natalgrass	*Melinis repens* (Willd.) Zizka	x	x	x	x	I
catclaw mimosa	*Mimosa pigra*	x	x	x	x	I
balsamapple	*Momordica charantia* L.	x	x	x	x	II
parrot feather	*Myriophyllum aquaticum*	x	x	x	x	---

Common Name	*Scientific Name*	LO Region	NE Region	EAA Region	GE Region	FLEPPC Category
Asian swordfern	*Nephrolepis brownii* (Desv.) Hovenkamp & Miyam.	x	x	x	x	I
narrow swordfern	*Nephrolepis cordifolia* (L.) C. Presl	x	x	x	x	I
burmareed	*Neyraudia reynaudiana* (Kunth) Keng ex A.S. Hitchc.	x	x	x	x	I
cape blue waterlily	*Nymphaea capensis* var. zanzibariensis	x	x	x	x	---
crested floating heart	*Nymphoides cristata* (Roxb.) O. Ktze.	x	x	x	x	I
skunk-vine	*Paederia foetida*	x	x	x	x	I
torpedo grass	*Panicum repens*	x	x	x	x	I
mission grass	*Pennisetum polystachion* (Linnaeus) Schultes		x		x	II
elephant grass, Napier grass	*Pennisetum purpureum* Schumacher	x	x	x	x	I
Senegal date palm	*Phoenix reclinata*	x	x	x	x	II
golden bamboo	*Phyllostachys aurea* Carr. ex A.& C. Rivière	x	x		x	II
waterlettuce	*Pistia stratiotes*	x	x	x	x	I
strawberry guava	*Psidium cattleianum* Sabine	x	x	x	x	I
guava	*Psidium guajava* L.	x	x	x	x	I
ladder brake, Chinese brake fern	*Pteris vittata* L.	x	x	x	x	II
downy rose myrtle	*Rhodomyrtus tomentosa* (Ait.) Hassk.	x	x	x	x	I
largeflower Mexican clover	*Richardia grandiflora*	x	x	x	x	II
castorbean	*Ricinus communis* L.	x	x	x	x	II
roundleaf toothcup	*Rotala rotundifolia* (Buch.-Ham. ex Roxb.) Koehne	x	x	x	x	II
Britton's wild petunia	*Ruellia simplex* C. Wright	x	x	x	x	I
water fern	*Salvinia minima* Baker	x	x	x	x	I
iguanatail, bowstring hemp	*Sansevieria hyacinthoides* (L.) Druce	x	x	x	x	II
beach naupaka	*Scaevola taccada* Vahl	x	x	x	x	I
octopus tree, Queensland umbrella tree	*Schefflera actinophylla* (Endl.) H.A.T. Harms	x	x	x	x	I

Common Name	*Scientific Name*	LO Region	NE Region	EAA Region	GE Region	FLEPPC Category
Brazilian peppertree	*Schinus terebinthifolius* Raddi	x	x	x	x	I
climbing cassia, Christmas cassia, Christmas senna	*Senna pendula var. glabrata*	x	x	x	x	I
red sesbania, purple sesban, rattlebox	*Sesbania punicea* (Cav.) Benth.	x	x	x	x	II
twoleaf nightshade	*Solanum diphyllum* L.	x	x	x	x	II
tropical soda apple	*Solanum viarum* Dunal	x	x	x	x	I
Bay Biscayne creeping-oxeye, wedelia	*Sphagneticola trilobata* (L.C. Rich.) Pruski	x	x	x	x	II
queen palm	*Syagrus romanzoffiana* (Cham.) Glassman	x	x	x	x	II
American evergreen, arrowhead vine	*Syngonium podophyllum* Schott	x	x	x	x	I
Java plum	*Syzygium cumini* (L.) Skeels	x	x	x	x	I
Malabar plum	*Syzygium jambos*	x	x	x	x	II
sea hibiscus	*Talipariti tiliaceum var. tiliaceum* L.	x	x	x	x	---
tropical almond	*Terminalia catappa* L.	x	x	x	x	II
Australian almond	*Terminalia muelleri*	x	x	x	x	II
portia tree, seaside mahoe	*Thespesia populnea* (L.) Soland. ex Correa	x	x	x	x	I
white-flowered spiderwort	*Tradescantia fluminensis* Vell.	x	x	x	x	I
boatlily, oyster plant	*Tradescantia spathacea* Sw.	x	x	x	x	II
Chinese tallowtree	*Triadica sebifera* (L.) Small	x	x		x	I
Jamaica feverplant, puncture vine, burr-nut	*Tribulus cistoides* L.	x	x	x	x	II
Caesarweed	*Urena lobata* L.	x	x	x	x	I
paragrass	*Urochloa mutica* (Forsk.) T.Q. Nguyen	x	x	x	x	I
simpleleaf chastetree	*Vitex trifolia* L.	x	x	x	x	II

Table F-2. Totals of Invasive Plant Species, by Categories, Documented in the Project Area.

Category	TOTALS
Non-native plants	*110*
FLEPPC Category I	*59*
FLEPPC Category II	*39*
Noxious Weeds	*22*
This list was compiled utilizing the 2017 Florida Exotic Pest Plant Council (FLEPPC) Category I and II species lists. It was cross-checked with species occurrences reported in EDDMapS (Early Detection and Distribution Mapping System) for Martin, Palm Beach, Hendry and surrounding counties. Any of the FLEPPC species that had not been recorded in these counties were removed from the list. The list also includes any species that are being actively managed in these areas by the US Army Corps of Engineers or the National Park Service (based on WEEDDAR (Weed Data and Reports) data).	

Table F-3. Invasive Animal Species –Birds- Documented in the Project Area.

Common Name	*Scientific Name*	LO Region	NE Region	EAA Region	GE Region
Muscovy Duck	*Cairina moschata*	x	x	x	x
Rock Dove	*Columba livia*	x	x	x	x
Spot-breasted Oriole	*Icterus pectoralis*	x	x	x	x
Budgerigar	*Melopsittacus undulatus*	x	x	---	x
Monk Parakeet	*Myiopsitta monachus*	x	x	x	x
House Sparrow	*Passer domesticus*	x	x	x	x
Purple Swamphen	*Porphyrio porphyrio*	x	x	x	x
Eurasian Collared-Dove	*Streptopelia decaocto*	x	x	x	x
European Starling	*Sturnus vulgaris*	x	x	x	x
White-winged Dove	*Zenaida asiatica*	x	x	x	x

Table F-4. Invasive Animal Species –Reptiles and Amphibians- Documented in the Project Area.

Common Name	*Scientific Name*	LO Region	NE Region	EAA Region	GE Region
African Redhead Agama	*Agama agama*	x	x	x	x
Largehead Anole	*Anolis cybotes*	x	x	---	---
Bark Anole	*Anolis distichus*	x	x	x	x
Knight Anole	*Anolis equestris equestris*	x	x	x	x
Cuban Green Anole	*Anolis porcatus*	---	---	---	x
Brown Anole	*Anolis sagrei*	x	x	---	---
Brown Basilisk	*Basiliscus vittatus*	x	x	x	x
Common Boa	*Boa constrictor*	x	x	x	x
Black Spinytail Iguana	*Ctenosaura similis*	x	x	---	x
Greenhouse Frog	*Eleutherodactylus planirostris*	---	x	---	---
Tokay Gecko	*Gekko gecko*	x	x	x	x
Common House Gecko	*Hemidactylus frenatus*	---	---	---	x
Indo-Pacific Gecko	*Hemidactylus garnotii*	---	x	---	x
Tropical House Gecko	*Hemidactylus mabouia*	x	x	x	x
Mediterranean Gecko	*Hemidactylus turcicus*	x	x	x	x
Green Iguana	*Iguana iguana*	x	x	x	x
Northern Curlytail Lizard	*Leiocephalus carinatus armouri*	x	x	x	x
Cuban Treefrog	*Osteopilus septentrionalis*	x	x	x	x
Texas Horned Lizard	*Phrynosoma cornutum*	x	x	x	x
Burmese Python	*Python molurus bivittatus*	x	x	x	x
Brahminy Blind Snake	*Ramphotyphlops braminus*	x	x	---	x
Giant Toad, Cane toad	*Rhinella marina*	x	x	x	x
Red-eared Slider	*Trachemys scripta elegans*	---	---	---	x
Black and white tegu	*Tupinambis merianae Linnaeus, 1758*	---	---	---	x
Nile Monitor	*Varanus niloticus*	x	x	x	x

Table F-5. Invasive Animal Species –Fish- Documented in the Project Area.

Common Name	*Scientific Name*	LO Region	NE Region	EAA Region	GE Region
Oscar	*Astronotus ocellatus*	x	x	x	x
Bullseye snakehead	*Channa marulius*	x	x	x	x
Clown knifefish	*Chitala ornata*	x	x	x	x
Butterfly peacock bass	*Cichla ocellaris*	---	---	---	x
Black acara	*Cichlasoma bimaculatum*	---	---	---	x
Mayan cichlid	*Cichlasoma urophthalmus*	---	---	---	x
Walking catfish	*Clarias batrachus*	---	---	---	x
African jewelfish	*Hemichromis letourneuxi*	x	x	x	x
Brown hoplo	*Hoplosternum littorale*	---	---	---	x
Suckermouth catfish	*Hypostomus sp.*	---	---	---	x
Silver dollar	*Metynnis hypsauchen*	x	---	---	---
Asian swamp eel	*Monopterus albus*	---	---	---	x
Blue tilapia	*Oreochromis aureus*	---	---	---	x
Nile tilapia	*Oreochromis niloticus*	x	x	x	x
Jaguar Guapote	*Parachromis managuensis*	x	x	x	x
lionfish	*Pterois volitans/miles*	x	x	x	x
Vermiculated sailfin catfish	*Pterygoplichthys disjunctivus*	---	---	---	---
Orinoco sailfin catfish	*Pterygoplichthys multiradiatus*	---	---	---	x
Jack Dempsey	*Rocio octofasciata*	x	x	x	x
Spotted tilapia	*Tilapia mariae*	x	x	x	x
Redhead Cichlid	*Vieja melanura*	x	x	x	x

Table F-6. Invasive Animal Species –Mammals- Documented in the Project Area.

Common Name	*Scientific Name*	LO Region	NE Region	EAA Region	GE Region
Black rat	*Rattus rattus*	---	---	---	x
Wild hog, feral pig	*Sus scrofa*	x	x	x	x

Table F-7. Invasive Animal Species –Others- Documented in the Project Area.

Common Name	*Scientific Name*	LO Region	NE Region	EAA Region	GE Region
Asian clam	*Corbicula fluminea*	x	x	x	x
Giant Ramshorn Snail	*Marisa cornuarietis*	x	x	x	x
Asian tiger shrimp	*Penaeus monodon*	x	x	x	x
Green mussel	*Perna viridis*	x	x	x	x
Spiketop applesnail	*Pomacea diffusa Blume, 1957*	x	x	x	x
Island applesnail	*Pomacea insularum (d'Orbigny, 1839)*	x	x	x	x
Giant applesnail	*Pomacea maculata*	x	x	x	x

Table F-8. LRWRP Invasive and Nuisance Species Management Costs.

Category	Cost Estimate
2 Year Pre-Construction	$2,559,070
1 Year Pre-Construction	$1,423,072
Construction Phase	$893,019
Operational Testing & Monitoring Phase	$508,551
1 Year OMRR&R Phase	$536,285
50-Year OMRR&R Phase (Includes Year 1)	$52,279,358
Total Management Cost	**$57,663,070**

Table F-9. LRWRP Invasive and Nuisance Total Monitoring Costs.

Category	Cost Estimate
Total Monitoring Cost	**$1,480,949**

Table F-10. Invasive and Nuisance Species Management Costs – Construction Phase

Flow-Way and Feature/Area	Management Activity	Pre-Construction 2yrs	Pre-Construction 1yr	Construction	OTM
Flow-way 1 - G-160 Structure	EDRR/Plant Surveillance	$1,016	$1,016	$1,016	$1,016
Flow-way 1 – G-160	Plant Control/Treatment	$0	$616	$616	$616
Flow-way 1 – G-160	Coordination/Inspections/Contract Implementation	$0	$245	$245	$245
Flow-way 1 - G-161 Structure	EDRR/Plant Surveillance	$1,016	$1,016	$1,016	$1,016
Flow-way 1 - G-161 Structure	Plant Control/Treatment	$0	$616	$616	$616
Flow-way 1 - G-161 Structure	Coordination/Inspections/Contract Implementation	$0	$245	$245	$245
Flow-way 1 - GWP Triangle (350ac)	EDRR/Plant Surveillance	$1,016	$1,016	$1,016	$1,016
Flow-way 1 - GWP Triangle (350ac)	Plant Control/Treatment	$176,400	$66,150	$23,625	$23,625
Flow-way 1 - GWP Triangle (350ac)	Coordination/Inspections/Contract Implementation	$26,612	$10,075	$3,696	$3,696
Flow-way 1 - M-1 Pump Station	EDRR/Plant Surveillance	$1,016	$1,016	$1,016	$1,016
Flow-way 1 - M-1 Pump Station	Plant Control/Treatment	$0	$616	$616	$616
Flow-way 1 - M-1 Pump Station	Coordination/Inspections/Contract Implementation	$0	$245	$245	$245
Flow-way 2 - CW-18 Reservoir (1920ac)	EDRR/Plant Surveillance	$3,048	$3,048	$2,032	$2,032
Flow-way 2 - CW-18 Reservoir (1920ac)	Plant Control/Treatment	$967,680	$362,880	$362,880	$147,840
Flow-way 2 - CW-18 Reservoir (1920ac)	Coordination/Inspections/Contract Implementation	$145,609	$54,889	$54,737	$22,481
Flow-way 2 - 4 ASR Wells	EDRR/Plant Surveillance	$1,016	$1,016	$1,016	$1,016

Flow-Way and Feature/Area	Management Activity	Pre-Construction 2yrs	Pre-Construction 1yr	Construction	OTM
Flow-way 2 - 4 ASR Wells	Plant Control/Treatment	$0	$1,008	$378	$378
Flow-way 2 - 4 ASR Wells	Coordination/Inspections/Contract Implementation	$0	$304	$209	$209
Flow-way 2 - M-O Canal Connector (3,500Lnft)	EDRR/Plant Surveillance	$1,016	$1,016	$1,016	$1,016
Flow-way 2 - M-O Canal Connector (3,500Lnft)	Plant Control/Treatment	$0	$1,512	$1,512	$462
Flow-way 2 - M-O Canal Connector (3,500Lnft)	Coordination/Inspections/Contract Implementation	$152	$379	$379	$222
Flow-way 3 - PalMar East (50ac)	EDRR/Plant Surveillance	$1,016	$1,016	$1,016	$1,016
Flow-way 3 - PalMar East (50ac)	Plant Control/Treatment	$0	$25,200	$9,450	$9,450
Flow-way 3 - PalMar East (50ac)	Coordination/Inspections/Contract Implementation	$152	$3,932	$1,570	$1,570
Flow-way 3 - Thomas Pepper Farm (31,190LNftx35w)	EDRR/Plant Surveillance	$1,016	$1,016	$1,016	$1,016
Flow-way 3 - Thomas Pepper Farm (31,190LNftx35w)	Plant Control/Treatment	$0	$12,600	$4,725	$4,725
Flow-way 3 - Thomas Pepper Farm (31,190LNftx35w)	Coordination/Inspections/Contract Implementation	$152	$2,042	$861	$861
Flow-way 3 - Ranch Colony Canal (19,215LNftx35w)	EDRR/Plant Surveillance	$1,016	$1,016	$1,016	$1,016
Flow-way 3 - Ranch Colony Canal (19,215LNftx35w)	Plant Control/Treatment	$0	$15,624	$5,859	$5,859
Flow-way 3 - Ranch Colony Canal (19,215LNftx35w)	Coordination/Inspections/Contract Implementation	$152	$2,496	$1,031	$1,031
Flow-way 3 - Gulfstream West (700ac)	EDRR/Plant Surveillance	$1,016	$1,016	$1,016	$1,016
Flow-way 3 - Gulfstream West (700ac)	Plant Control/Treatment	$352,800	$132,300	$66,150	$66,150

Flow-Way and Feature/Area	Management Activity	Pre-Construction 2yrs	Pre-Construction 1yr	Construction	OTM
Flow-way 3 - Gulfstream West (700ac)	Coordination/Inspections/Contract Implementation	$53,072	$19,997	$10,075	$10,075
Flow-way 3 - Gulfstream East & Moonshine(1410ac)	EDRR/Plant Surveillance	$3,048	$1,016	$1,016	$1,016
Flow-way 3 - Gulfstream East & Moonshine(1410ac)	Plant Control/Treatment	$710,640	$85,050	$42,525	$42,525
Flow-way 3 - Gulfstream East & Moonshine(1410ac)	Coordination/Inspections/Contract Implementation	$107,053	$12,910	$6,531	$6,531
Flow-way 3 - Kitching Creek (2,500LNftx35w)	EDRR/Plant Surveillance	$1,016	$1,016	$1,016	$1,016
Flow-way 3 - Kitching Creek (2,500LNftx35w)	Plant Control/Treatment	$0	$1,008	$378	$378
Flow-way 3 - Kitching Creek (2,500LNftx35w)	Coordination/Inspections/Contract Implementation	$152	$303	$209	$209
Flow-way 3 - Mack Dairy Spreader Swale (3,500LNft x 35w)	EDRR/Plant Surveillance	$1,016	$1,016	$1,016	$1,016
Flow-way 3 - Mack Dairy Spreader Swale (3,500LNft x 35w)	Plant Control/Treatment	$0	$1,512	$1,512	$462
Flow-way 3 - Mack Dairy Spreader Swale (3,500LNft x 35w)	Coordination/Inspections/Contract Implementation	$152	$379	$379	$222
Flow-way 3 - Shiloh Farm (500ac)	EDRR/Plant Surveillance	$0	$2,032	$2,032	$2,032
Flow-way 3 - Shiloh Farm (500ac)	Plant Control/Treatment	$0	$252,000	$94,500	$47,250
Flow-way 3 - Shiloh Farm (500ac)	Coordination/Inspections/Contract Implementation	$0	$38,105	$14,480	$7,392
Flow-way 3 - Cypress Creek Natural Area (1480a)	EDRR/Plant Surveillance	$0	$4,064	$4,064	$4,064
Flow-way 3 - Cypress Creek Natural Area (1480a)	Plant Control/Treatment	$0	$256,410	$139,860	$69,930

Flow-Way and Feature/Area	Management Activity	Pre-Construction 2yrs	Pre-Construction 1yr	Construction	OTM
Flow-way 3 - Cypress Creek Natural Area (1480a)	Coordination/Inspections/Contract Implementation	$0	$39,071	$21,589	$11,099
Totals	---	**$2,559,070**	**$1,423,072**	**$893,019**	**$508,551**
Construction Phase Total = $5,383,711					

Table F-11. Invasive and Nuisance Species Management Costs – OMRR&R Phase

Feature/Area	Management Activity	YR 1 OMRR&R	50 YR Total
Flow-way 1 - G-160 Structure	EDRR/Plant Surveillance	$1,016	$99,044
Flow-way 1 - G-160 Structure	Plant Control/Treatment	$616	$60,050
Flow-way 1 - G-160 Structure	Coordination/Inspections/Contract Implementation	$245	$23,864
Flow-way 1 - G-161 Structure	EDRR/Plant Surveillance	$1,016	$99,044
Flow-way 1 - G-161 Structure	Plant Control/Treatment	$616	$60,050
Flow-way 1 - G-161 Structure	Coordination/Inspections/Contract Implementation	$245	$23,864
Flow-way 1 - GWP Triangle (350ac)	EDRR/Plant Surveillance	$1,016	$99,044
Flow-way 1 - GWP Triangle (350ac)	Plant Control/Treatment	$37,800	$3,684,908
Flow-way 1 - GWP Triangle (350ac)	Coordination/Inspections/Contract Implementation	$5,822	$567,593
Flow-way 1 - M-1 Pump Station	EDRR/Plant Surveillance	$1,016	$99,044
Flow-way 1 - M-1 Pump Station	Plant Control/Treatment	$616	$60,050
Flow-way 1 - M-1 Pump Station	Coordination/Inspections/Contract Implementation	$245	$23,864
Flow-way 2 - CW-18 Reservoir (1920ac)	EDRR/Plant Surveillance	$3,048	$297,132
Flow-way 2 - CW-18 Reservoir (1920ac)	Plant Control/Treatment	$73,920	$7,206,043
Flow-way 2 - CW-18 Reservoir (1920ac)	Plant Control/Treatment - Submersed	$57,600	$5,615,098
Flow-way 2 - CW-18 Reservoir (1920ac)	Coordination/Inspections/Contract Implementation	$20,185	$1,967,741
Flow-way 2 - 4 ASR Wells	EDRR/Plant Surveillance	$1,016	$99,044
Flow-way 2 - 4 ASR Wells	Plant Control/Treatment	$378	$36,849

Feature/Area	Management Activity	YR 1 OMRR&R	50 YR Total
Flow-way 2 - 4 ASR Wells	Coordination/Inspections/Contract Implementation	$209	$20,384
Flow-way 2 - M-O Canal Connector (3,500LNFTx35w)	EDRR/Plant Surveillance	$1,016	$99,044
Flow-way 2 - M-O Canal Connector (3,500LNFTx35w)	Plant Control/Treatment	$462	$45,038
Flow-way 2 - M-O Canal Connector (3,500LNFTx35w)	Coordination/Inspections/Contract Implementation	$222	$21,612
Flow-way 3 - PalMar East (50ac)	EDRR/Plant Surveillance	$1,016	$99,044
Flow-way 3 - PalMar East (50ac)	Plant Control/Treatment	$9,450	$921,227
Flow-way 3 - PalMar East (50ac)	Coordination/Inspections/Contract Implementation	$1,570	$153,041
Flow-way 3 - Thomas Pepper Farm (31,190LNFTx35w)	EDRR/Plant Surveillance	$1,016	$99,044
Flow-way 3 - Thomas Pepper Farm (31,190LNFTx35w)	Plant Control/Treatment	$4,725	$460,614
Flow-way 3 - Thomas Pepper Farm (31,190LNFTx35w)	Coordination/Inspections/Contract Implementation	$388	$37,813
Flow-way 3 - Ranch Colony Canal (19,215LNftx35w)	EDRR/Plant Surveillance	$1,016	$99,044
Flow-way 3 - Ranch Colony Canal (19,215LNftx35w)	Plant Control/Treatment	$5,859	$571,161
Flow-way 3 - Ranch Colony Canal (19,215LNftx35w)	Coordination/Inspections/Contract Implementation	$1,031	$100,531
Flow-way 3 - Gulfstream West (700ac)	EDRR/Plant Surveillance	$2,032	$198,088
Flow-way 3 - Gulfstream West (700ac)	Plant Control/Treatment	$66,150	$6,448,590
Flow-way 3 - Gulfstream West (700ac)	Coordination/Inspections/Contract Implementation	$10,227	$997,002
Flow-way 3 - Gulfstream East & Moonshine(450ac)	EDRR/Plant Surveillance	$1,016	$99,044
Flow-way 3 - Gulfstream East & Moonshine(450ac)	Plant Control/Treatment	$18,900	$1,842,454
Flow-way 3 - Gulfstream East & Moonshine(450ac)	Coordination/Inspections/Contract Implementation	$2,987	$291,225
Flow-way 3 - Kitching Creek (2,500LNftx35w)	EDRR/Plant Surveillance	$1,016	$99,044
Flow-way 3 - Kitching Creek (2,500LNftx35w)	Plant Control/Treatment	$378.00	$36,849
Flow-way 3 - Kitching Creek (2,500LNftx35w)	Coordination/Inspections/Contract Implementation	$209.10	$20,384
Flow-way 3 - Mack Dairy Spreader Swale (3,500LNftx35w)	EDRR/Plant Surveillance	$1,016	$99,044
Flow-way 3 - Mack Dairy Spreader Swale (3,500LNftx35w)	Plant Control/Treatment	$462	$45,038

Feature/Area	Management Activity	YR 1 OMRR&R	50 YR Total
Flow-way 3 - Mack Dairy Spreader Swale (3,500LNftx35w)	Coordination/Inspections/Contract Implementation	$222	$21,612
Flow-way 3 - Shiloh Farm (500ac)	EDRR/Plant Surveillance	$2,032	$198,088
Flow-way 3 - Shiloh Farm (500ac)	Plant Control/Treatment	$94,500	$9,212,271
Flow-way 3 - Shiloh Farm (500ac)	Coordination/Inspections/Contract Implementation	$14,480	$1,411,554
Flow-way 3 - Cypress Creek Natural Area (1480a)	EDRR/Plant Surveillance	$5,080	$495,220
Flow-way 3 - Cypress Creek Natural Area (1480a)	Plant Control/Treatment	$69,930	$6,817,081
Flow-way 3 - Cypress Creek Natural Area (1480a)	Coordination/Inspections/Contract Implementation	$11,252	$1,096,845
Note: Year-1 OMRR&R is $536,285. The 50-yr total is $52,279,358			

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