COMPREHENSIVE EVERGLADES RESTORATION PLAN

LOXAHATCHEE RIVER WATERSHED RESTORATION PROJECT

FINAL INTEGRATED PROJECT IMPLEMENTATION REPORT AND ENVIRONMENTAL IMPACT STATEMENT

January 2020

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Cover Sheet

FINAL INTEGRATED PROJECT IMPLEMENTATION REPORT AND ENVIRONMENTAL IMPACT STATEMENT
Loxahatchee River Watershed Restoration Project
Martin and Palm Beach counties, Florida

Lead Agency: Department of Army

U.S. Army Corps of Engineers, Jacksonville District

Abstract:

The purpose of the Loxahatchee River Watershed Restoration Project (LRWRP) is to improve the quantity, quality, timing, and distribution of water flows to the Northwest Fork of the Loxahatchee River, a National Wild and Scenic River, and restore hydrologic conditions and connectivity of wetlands and watersheds that form the historic headwaters of the river.

The Recommended Plan would restore volume and seasonal timing of flows by using a 9,500 acre-foot reservoir, a 4-well aquifer storage and recovery system, and associated small pump stations, canals, and water control structures in the watershed to capture and store water that is currently discharged away from the Northwest Fork of the Loxahatchee River, and then release the water to the river with a natural seasonal timing. Wet season flows would be 98% and dry season flows would be 91% of the restoration targets, versus 78% and 65% for the future without the project. The Recommended Plan would restore 27,000 acres of disturbed wetlands in the watershed. A former citrus grove will be restored to a flow-through wetland and would capture and moderate the peak pulse discharges from an upstream agricultural area to the river while also providing on-site wetland benefits. The restored wetlands and flows to the river will improve habitat connectivity and function for several threatened and endangered species including but not limited to the Everglade snail kite, wood stork, and Florida manatee. The Recommended Plan would remove drainage pipes and canals that overdrain disturbed wetlands. Replacing fixed water control structures with operational structures will further allow restoration of seasonal levels in the wetlands, while also maintaining levels of flood protection and water supply in the urban and agricultural areas. The LRWRP Recommended Plan was chosen based upon detailed estimates of hydrology across the 41-year period of record (January 1965 – December 2005) generated by the Lower East Coast Subregional Model - North Palm version (LECSR-NP). The estimated first cost (October 2019 price level) of the Recommended Plan is $740,760,000.

Send your comments
by: **March 9, 2020**

For further information on this statement, please contact

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REPORT FORMAT

The recommended format of an EIS is outlined within 40 CFR 1502.10 and has been integrated into this Feasibility Report. The table below lists the required information for an EIS and the location of that information within this integrated document.

EIS REQUIREMENT	LOCATION WITHIN THIS DOCUMENT
Cover sheet	Behind front cover page
Summary	Executive Summary
Table of Contents	Individual for each Section (detailed)
Purpose of and Need for Action	Section 1 (Introduction)
Alternatives including Proposed Action	Section 3 (Formulation), Section 5 (Effects of the Alternatives), and Section 6 (Recommended Plan)
Affected Environment	Section 2 (Existing and Future Conditions)
Environmental Consequences	Section 2 (Existing and Future Conditions) and Section 4, 5, and 6 (Evaluation and Comparison of Alternative Plans, Effects of Alternatives, and The Recommended Plan)
List of Preparers	Section 9 (List of Preparers)
List of agencies, organizations, and persons to whom copies of the statement are sent	Section 7 (Environmental Compliance) and Appendix C (Environmental and Cultural Resources Information)
Index	End of Main Report
Appendices and Annexes	As listed in the Table of Contents

Section 1: Introduction
Section 2: Existing and Future Without Project Conditions
Section 3: Formulation of Alternative Plans
Section 4: Plan Evaluation
Section 5: Effects of the Final Array of Alternatives and the Recommended Plan
Section 6: Recommended Plan
Section 7: Environmental Compliance
Section 8: District Engineer's Recommendations
Section 9: List of Preparers
Section 10: Glossary and Acronyms
Section 11: References
Section 12: Index
Appendix A: Engineering
Appendix B: Cost Estimates
Appendix C: Environmental and Cultural Resources Information
Appendix D: Real Estate
Appendix E: Plan Formulation
Appendix F: Recreation Resources
Appendix G: Environmental Benefits Model
Appendix H: Climate Change
Annex A: Fish and Wildlife Coordination and Endangered Species Act Compliance
Annex B: Analysis Required by WRDA 2000 and State Law
Annex C: Draft Project Operating Manual
Annex D: Adaptive Management and Monitoring Plans
Annex E: RECOVER System-wide Evaluation
Annex F: Invasive and Nuisance Species Management Plan

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TABLE OF CONTENTS *

Items with "*" indicate information from the integrated report that fulfill the National Environmental Policy Act requirements for an environmental impact statement.

COVER SHEET and ABSTRACT * i

REPORT FORMAT iv

EXECUTIVE SUMMARY xvii

1 INTRODUCTION * 1-1

1.1 Central and Southern Florida Project 1-1

1.2 Comprehensive Everglades Restoration Plan 1-2

1.3 Project Purpose and Need * 1-3

1.4 Scope of Study 1-4

1.5 Project and Study Area 1-5

1.6 Problems and Opportunities 1-10

1.6.1 Watershed Hydrological and Ecological Problems 1-10

1.6.2 Opportunities 1-11

1.7 Objectives and Constraints 1-12

1.7.1 LRWRP Planning Objectives 1-12

1.7.2 CERP and LRWRP goals and objectives 1-13

1.7.3 LRWRP Planning Constraints 1-14

1.8 Report Authority 1-15

2 EXISTING AND FUTURE WITHOUT PROJECT CONDITIONS * 2-1

2.1 "With" and "Without" Comparisons 2-1

2.2 Planning Horizon 2-1

2.3 Existing Ecological Description/Setting 2-2

2.4 Comparison of Existing and Future Without Project Conditions 2-7

2.5 Structural and Operational Assumptions for Future Without Project Conditions 2-18

2.5.1 Structures G-160 and G-161 in the C-18 Canal 2-18

2.5.2 Additional Structures 2-18

2.5.3 Other CERP Projects 2-19
2.6 Related Restoration Projects by Non-federal Agencies 2-20
2.7 Related Studies 2-20
2.7.1 L-8 Basin General Reevaluation Report (GRR) (2001) 2-21
2.7.2 Cypress Creek/Pal-Mar and the Groves Basin Study (2002) 2-21
2.7.3 Northern Palm Beach County Comprehensive Water Management Plan (2002) 2-21
2.7.4 The Loxahatchee River Watershed Action Plan (2002) 2-21
2.7.5 Loxahatchee River Minimum Flows and Minimum Water Levels (MFLs) (2002) 2-22
2.7.6 Restoration Plan for the Northwest Fork of the Loxahatchee River (2006) 2-22
2.7.7 CERP Project - North Palm Beach County Part 1 Plan Formulation 2-22
2.7.8 Restoration Strategies 2-23
2.8 Native Americans 2-23
3 PLAN FORMULATION * 3-1
3.1 Plan Formulation Concepts 3-1
3.2 CERP Components 3-2
3.3 Management Measures 3-5
3.3.1 Identify Management Measures 3-5
3.3.2 Management Measure Screening 3-6
3.3.3 Components 3-7
3.4 Options – Combinations of Components Within Flow-ways 3-9
3.4.1 Identify Options 3-9
3.4.2 Screen Options 3-11
3.4.3 Summary of Screening Decisions of Options 3-14
3.5 Initial Alternatives 3-15
3.5.1 Developing Alternatives from Options 3-15
3.5.2 Alternative 10 is the CERP Alternative 3-16
3.6 Screening Initial Alternatives 3-18
3.7 Alternatives Carried Forward 3-20
4 PLAN EVALUATION * 4-1

4.1 Effectiveness 4-2
4.2 Efficiency Analysis: Environmental Benefits and Costs of Alternative Plans 4-4
4.2.1 Costs of Final Array of Alternative Plans 4-5
4.2.2 Average Annual Costs 4-6
4.2.3 Ecological Benefits Evaluation 4-7
4.2.4 Cost Effectiveness and Incremental Cost Analysis 4-13
4.2.5 Efficiency Conclusion 4-18
4.3 Completeness 4-18
4.4 Acceptability 4-19
4.5 Summary of Principles and Guidelines Evaluation Criteria 4-20
4.6 Refined Alternatives and the Tentatively Selected Plan 4-20
4.6.1 Costs and Benefits of the Revised Alternatives 4-21
4.6.2 CE/ICA for River, Estuary, and Floodplain Benefits 4-21
4.6.3 CE/ICA for Watershed Benefits 4-22
4.6.4 Discussion of Revised Alternatives 4-23
4.6.5 Sea Level Rise Considerations for Alt 5R 4-24
4.6.6 The Recommended Plan is Alt 5R 4-25
4.7 RECOVER System-wide Evaluation 4-25
4.8 TSP and RECOVER Consistency 4-27
5 EFFECTS OF THE FINAL ARRAY OF ALTERNATIVES AND THE TENTATIVELY SELECTED PLAN * 5-1
5.1 Climate 5-1
5.2 Physical Landscape 5-3
5.3 Vegetative Communities 5-3
5.3.1 Northwest Fork Loxahatchee River 5-3
5.3.2 Loxahatchee River Estuary 5-5
5.3.3 Loxahatchee River Watershed 5-5
5.4 Threatened and Endangered Species 5-11
5.5 State Listed Species 5-13
5.6 Wildlife 5-13

5.6.1 Invertebrates 5-14
5.6.2 Fish 5-14
5.6.3 Amphibians and Reptiles 5-14
5.6.4 Birds 5-15
5.6.5 Mammals 5-15
5.7 Essential Fish Habitat 5-15
5.8 Hydrology 5-16
5.9 Water Quality 5-17
5.10 Air Quality 5-19
5.11 Hazardous, Toxic and Radioactive Waste 5-19
5.12 Noise 5-19
5.13 Aesthetics 5-19
5.14 Land Use 5-20
5.14.1 Wetlands 5-20
5.14.2 Agriculture 5-22
5.15 Socioeconomics 5-22
5.15.1 Population 5-22
5.15.2 Economic Activities 5-22
5.15.3 Socioeconomics: Water Supply and Flood Control 5-23
5.15.4 Recreation 5-24
5.16 Environmental Justice 5-25
5.17 Cultural Resources 5-25
5.18 Effects on Native Americans 5-27
5.19 Invasive Species 5-28
6 RECOMMENDED PLAN * 6-1
6.1 Plan Components 6-1
6.1.1 Features 6-1
6.1.2 Lands and Interests in Lands 6-10
6.1.3 Project Operations Manual 6-14

6.1.4 Adaptive Management and Monitoring Plan 6-15
6.1.5 Invasive and Nuisance Species Management Plan 6-17
6.1.6 Recreation Plan Features 6-17
6.2 Plan Accomplishments 6-18
6.2.1 Ecological Benefits 6-18
6.2.2 Significance of Ecosystem Benefits 6-18
6.2.3 Progress toward Interim Goals and Interim Targets 6-21
6.2.4 Ecosystem Services 6-23
6.3 Environmental Considerations 6-24
6.3.1 Cumulative Impacts 6-24
6.3.2 Incomplete or Unavailable Information 6-27
6.3.3 Unavoidable Adverse Environmental Effects 6-28
6.3.4 Irreversible and Irretrievable Commitment of Resources 6-30
6.3.5 Environmental Operating Principles 6-31
6.4 Cost Estimates of Restoration Elements 6-31
6.4.1 Construction 6-32
6.4.2 Real Estate 6-33
6.4.3 Operations, Maintenance, Repair, Replacement, and Rehabilitation 6-36
6.4.4 Monitoring and Adaptive Management 6-36
6.4.5 Invasive Species Management 6-38
6.4.6 Cultural Resources Preservation Costs 6-38
6.5 Cost Estimate for Recreation Elements 6-39
6.6 Cost Sharing 6-40
6.6.1 Cost Sharing of Construction and Real Estate 6-41
6.6.2 Cost Sharing of OMRR&R 6-41
6.6.3 Cost Sharing of Monitoring 6-41
6.6.4 Cost Sharing of Cultural Resources Preservation 6-42
6.6.5 Non-Federal Sponsor Work-in-Kind for Construction 6-42
6.7 Plan Implementation 6-42

6.7.1 Implementation and Construction Sequencing 6-42
6.7.2 Pre-construction Engineering and Design 6-47
6.7.3 Construction 6-47
6.7.4 Operational Testing and Monitoring Period 6-48
6.7.5 Floodplain Management and Flood Insurance Programs Compliance 6-48
6.7.6 Environmental Commitments 6-49
6.8 Project Assurances and Savings Clause Summary 6-50
6.8.1 Level of Service for Flood Protection 6-50
6.8.2 Effects on Water Supply for Existing Legal Sources 6-52
6.8.3 Water Restriction Area 1 (WRA 1) (Southern Martin County) 6-52
6.8.4 Water Restriction Area 2 (WRA 2) (North Palm Beach County) 6-55
6.8.5 Effects on Tribal Compact 6-57
6.8.6 Identification of Water Made Available for the Natural System and Other Water Related Needs 6-58
6.9 Project Concerns 6-59
6.10 Risk and Uncertainty 6-60
6.10.1 Planning 6-60
6.10.2 Design and Construction 6-61
7 ENVIRONMENTAL COMPLIANCE 7-1
7.1 Public Involvement * 7-1
7.1.1 Scoping 7-1
7.1.2 Agency Coordination and Public Involvement 7-1
7.1.3 Draft Project Implementation Report and Environmental Impact Statement 7-2
7.1.4 Comments and Responses 7-2
7.1.5 Statement Recipients * 7-2
7.2 Compliance with Environmental Laws, Statutes, and Executive Orders 7-2
7.3 Compliance with USACE CERP Agricultural Chemical Policy 7-11
7.4 Compliance with Florida Statutes 7-12
7.4.1 Permits, Entitlements and Certifications 7-12

7.4.2 Compliance with Applicable Water Quality Standards and Permitting Requirements .. 7-13

8 DISTRICT ENGINEER'S RECOMMENDATIONS 8-1

8.1 Items of Local Cooperation 8-2

8.2 Recommendation for Congressional Authorization 8-7

9 LIST OF REPORT PREPARERS * 9-1

10 GLOSSARY OF ACRONYMS AND TERMS 10-1

10.1 List of Acronyms 10-1

10.2 Glossary of Terms 10-6

10.3 List of Scientific Names 10-18

11 REFERENCES 11-1

12 INDEX * 12-1

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EXECUTIVE SUMMARY

The United States Army Corps of Engineers (USACE), Jacksonville District, in partnership with the South Florida Water Management District (SFWMD), prepared the Final Integrated Project Implementation Report (PIR) and Environmental Impact Statement (EIS) to evaluate the federal and non-federal interest in implementing the Loxahatchee River Watershed Restoration Project (LRWRP). This project is a component of the Comprehensive Everglades Restoration Plan (CERP). Congress approved CERP in the Water Resources Development Act of 2000 as a framework for restoring the South Florida ecosystem while providing for other water-related needs of the region. The LRWRP Final integrated PIR and EIS presents a description of existing and expected future conditions in the ecosystem; formulation and evaluation of plans considered to address ecosystem restoration needs in the region; analysis of environmental effects of the Recommended Plan; project costs; and considerations for implementation.

PURPOSE AND NEED

Loxahatchee Slough was once connected to the Everglades and contained both sawgrass and ridge and slough habitats characteristic of the Greater Everglades. The Central and Southern Florida (C&SF) Project was authorized in 1948 for various purposes, including flood control, navigation, water conservation (agricultural, municipal, industrial, Everglades National Park), preservation of fish and wildlife, prevention of salt water intrusion, recreation, and groundwater recharge. Between 1957 and 1958, USACE constructed three C&SF features (C-18 Canal, C-18W Canal, and S-46 Structure) which cut off the Northwest Fork of the Loxahatchee River from Loxahatchee Slough and the rest of its watershed, and channelized the Southwest Fork of the Loxahatchee River. The flood control improvements resulted in reduced flows to the Northwest Fork by diverting freshwater that formerly flowed naturally to the Northwest Fork into the Southwest Fork. Urban and agricultural development that followed implementation of the C&SF project features further severed the connections of the watershed to the Loxahatchee River. The construction of canals, channelization of natural waterways, and barriers to flow also degraded wetland structure and function throughout the watershed. These drained wetlands cannot store water as effectively as they once did, which results in periods of excessive and insufficient freshwater inflow to the Loxahatchee River and Estuary.

The purposes of the LRWRP are to restore and sustain the flow of freshwater to the federally designated "National Wild and Scenic" Northwest Fork of the Loxahatchee River, to increase connectivity of hydrology, flora, and fauna between natural areas, and to improve seasonal timing and distribution of water to restore drained wetlands that form the historic headwaters for the river.

PROJECT AREA

The LRWRP study area is approximately 480,000 acres (~750 square miles) located in southern Martin County and northern Palm Beach County (**Figure ES- 1**). The study area is characterized as highly urbanized in the eastern portion, and transitions to extensive natural areas to the west and north. The Loxahatchee River Watershed drains an area of approximately 154,000 acres (240 square miles) within the study area. Nearly half of the drainage basin is comprised of wetlands. Agricultural and forested uplands in the northern area of the basin comprise one quarter of the watershed. The remaining quarter is developed urban areas.

AUTHORITY

The LRWRP study is being conducted under the authority provided by Section 601(d)(2)(b) of the Water Resources Development Act (WRDA) of 2000, which requires preparation of a PIR to implement components of the CERP. Upon approval of the PIR by the Governing Board of the SFWMD and the Assistant Secretary of the Army for Civil Works, the PIR will be submitted to Congress for authorization.

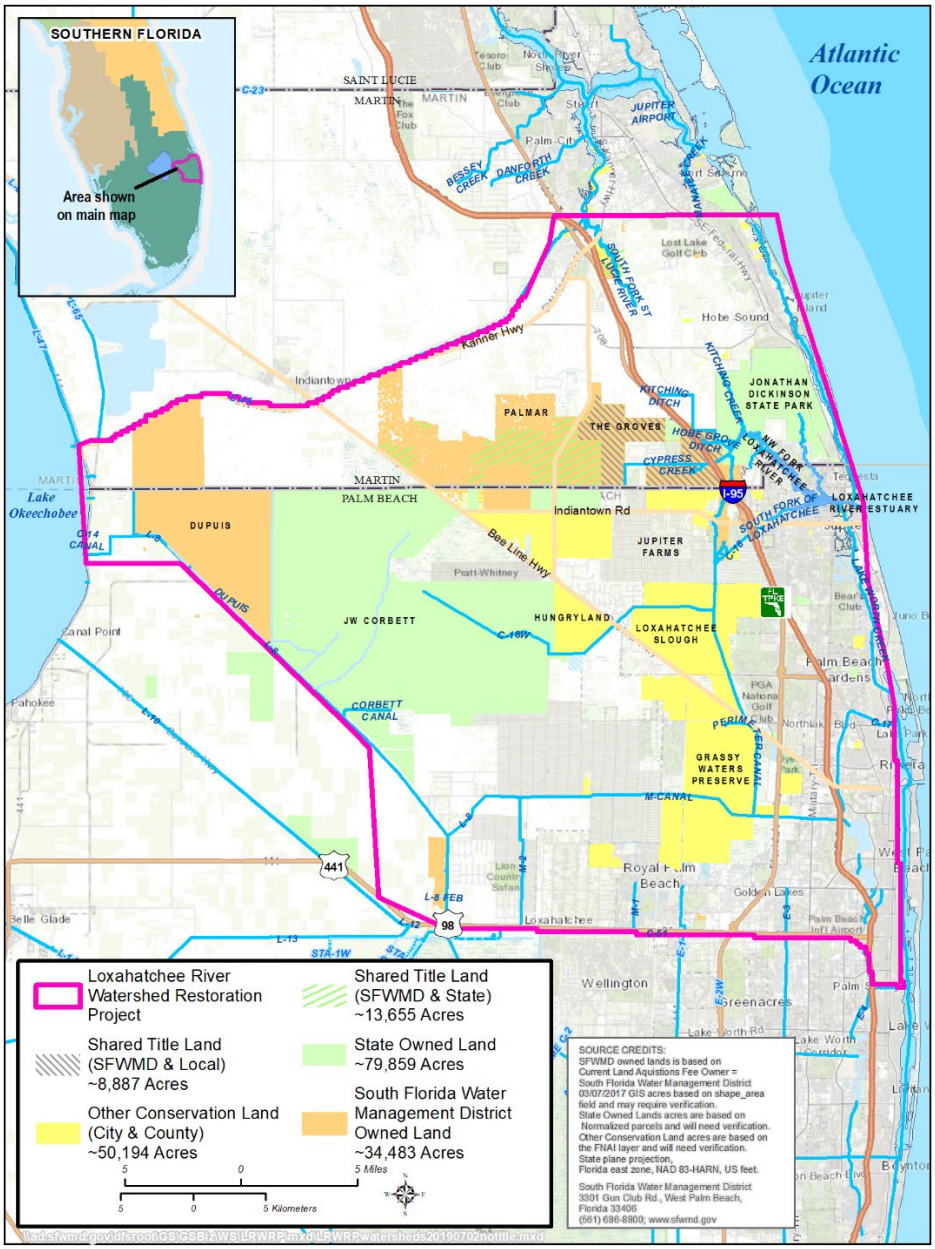

Figure ES- 1. Map of study area.

ALTERNATIVE PLANS AND THE RECOMMENDED PLAN

The LRWRP seeks to achieve restoration by developing alternatives that will capture, store, and redistribute water currently lost to tide; rehydrate headwater natural areas that have been hydrologically impacted by excessive draining and water diversions; reduce peak discharges to the project's estuarine systems; improve timing and distribution of water from the upstream watershed to increase the resiliency of freshwater riverine habitats to future sea-level changes; and re-establish connections among natural areas that have become spatially and/or hydrologically fragmented.

To facilitate the evaluation of numerous possible combinations of management measures, screening criteria were developed to select the array of plans for detailed modeling and evaluation. Four alternative plans, Alternative 2, Alternative 5, Alternative 10, and Alternative 13, and the no action plan or future without project condition (FWO) were initially evaluated using hydrologic simulation model output, hydrologic performance, and ecological improvements. Performance measures were used to evaluate hydrologic simulation model output to assess hydrological and ecological performance. Planning-level cost estimates were developed for the four alternative plans, and ecosystem restoration benefits were calculated. Alternative 5 was preferred over the other three initial alternatives. After comparing these four initial alternatives, three of the initial alternatives were revised with the intent to achieve additional benefits. The revised Alternatives 10R and 13R were not cost effective compared to the initial Alternatives 10 and 13, while Alternative 5R proved to be cost effective, and it replaced Alternative 5 in the final analysis. The final alternatives (**Table ES-1**) were evaluated and compared using multiple selection criteria, including the USACE Principals and Guidelines Criteria (Efficiency, Effectiveness, Completeness, and Acceptability). Alternative 5R was identified as the National Ecosystem Restoration Plan and therefore the Recommended Plan. It is the plan that reasonably maximizes ecosystem restoration benefits in the Loxahatchee River and floodplain as well as the wetlands in the watershed, compared to costs.

Table ES- 1. Major features of the alternative plans.

Flow-way	Major Project Features	Feature Type	Alt 2	Alt 5R	Alt 10	Alt 13
1	G-160, G-161, GPW Triangle	Conveyance	Yes	Yes	Yes	Yes
1	M-1 Lower Pump Station	Conveyance	no	Yes	no	no
1	C-51 Phase II Reservoir, Pump Station & Pipeline at GWP	Storage	no	no	44k ac-ft	no
2	C-18W Reservoir	Storage	7.2k ac-ft	9.5k ac-ft	7.2k ac-ft	no
2	Aquifer Storage & Recovery	Storage	2 wells	4 wells	no	4 wells
2	M-O Canal Connector & Pump	Conveyance/Pump	Yes	Yes	Yes	Yes
2	L-8 Basin Shallow Storage	Storage	4.3k ac-ft	no	no	6.5k ac-ft
2	C-18W Natural Storage	Storage	no	no	no	Yes
3	Pal-Mar East Restoration, Pepper Farm Drainage	Conveyance/Storage	Yes	Yes	no	Yes
3	Gulfstream West Flow-through Marsh	Conveyance/Storage	Yes	Yes	no	Yes
3	Ranch Colony Canal Structure	Conveyance/Storage	Yes	Yes	Yes	Yes
3	Gulfstream East, Moonshine Creek, and Kitching Creek	Conveyance/Storage	Yes	Yes	Yes	Yes
3	Mack Dairy Road Pump & Spreader Swale	Conveyance	no	Yes	no	Yes

THE RECOMMENDED PLAN

The Recommended Plan, Alternative 5R (**Figure ES-2**), consists of the following components:

- In the south and southeast (Flow-way 1): conveyance structures in the C-18 Canal, a pump station at the M-1 Canal, and earthwork to improve connectivity in the Grassy Waters Triangle.
- In the southwest and west (Flow-way 2): a 9,500 acre-foot above ground storage reservoir with pump stations and inflow and discharge canals, 4 co-located aquifer storage and recovery wells; new canals, structures, and a pump station to connect the M-O Canal to the reservoir and wetland restoration in Loxahatchee Slough.
- In the north (Flow-way 3): wetland restoration sites (Kitching Creek, Gulfstream East, Moonshine Creek, Cypress Creek, and Pal-Mar East) and a flow-through attenuation facility including a pump station.
- Recreation features: gravel parking with boat ramps and trailheads, dry vault toilets, shelters, small boardwalks and bridges, information signs, and Americans with Disabilities Act compliant fishing platforms (Recreation features are not shown in the Figure).
- Monitoring and Adaptive Management Plan: The monitoring and adaptive management plan will help ensure ecosystem restoration success is evaluated and inform adaptive management options to improve project success, if needed.

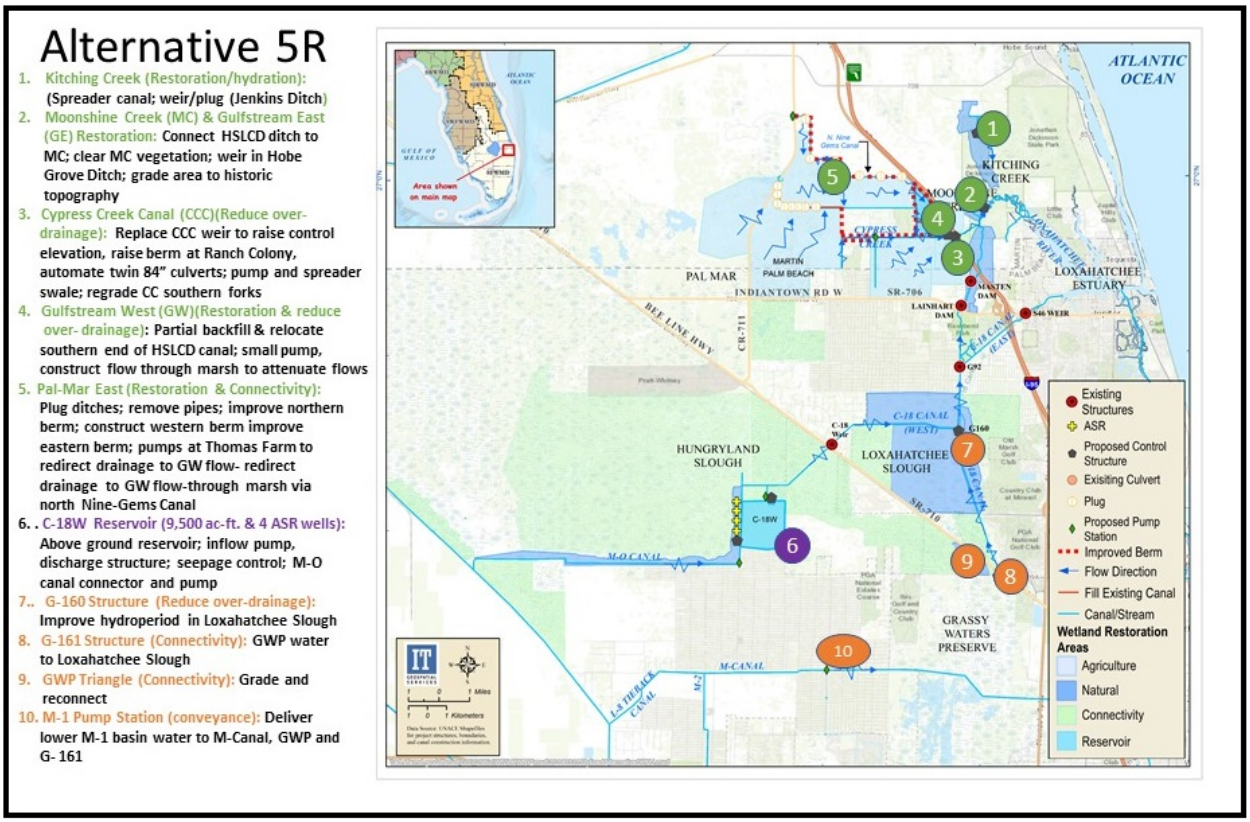

Figure ES-2. LRWRP Recommended Plan.

Benefits of the Recommended Plan

The Recommended Plan would deliver 98% of the wet season restoration flow target and 91% of the dry season restoration flow target for the Northwest Fork of the Loxahatchee River. Restoration of season flows will reverse the trend of increasing salinity levels and help conserve the remaining riverine cypress habitat designated as the first National Wild and Scenic River in Florida. Restored flows will also promote recovery of important freshwater vegetation (tapegrass, *Vallisneria americana*) and estuarine zones (oligohaline and mesohaline) that are important for federally managed fish species, protected species (Florida manatee, *Trichechus manatus latirostris*), and oysters.

The Recommended Plan improves wetland hydrology in the Pal-Mar natural area complex and restores 17,000 acres of various types of agricultural land that are part of the historical Greater Everglades. An additional 10,000 acres of natural areas are improved in the J.W. Corbett Wildlife Management Area, Loxahatchee Slough, and Kitching Creek. These habitats collectively include a unique mix of ridge and slough, mesic and wet flatwoods, wet prairie, cypress floodplain, cypress strand, dome swamps, depression marsh, mesic and hydric hammock plant communities. These restored wetland plant communities will provide foraging and nesting habitat for and contribute to the recovery of the endangered Everglade snail kite, threatened eastern indigo snake, threatened Florida manatee, and threatened wood stork. In addition, the restored wetlands will contribute to prey production and increased foraging opportunities for wide ranging wading birds. The restoration actions also improve

connectivity for over 78,000 acres of natural areas and restored wetlands that benefit many species of flora and fauna both endangered and important recreational species, such as deer and ducks. Achieving these ecosystem benefits requires that all three flow-ways be completed and work together. The flow-ways are not separable elements.

While the overall project purpose is ecosystem restoration, the wetland restoration components will provide multiple recreation and economic opportunities for the local areas in the form of hunting, fishing, boating, and other outdoor recreation. The Recommended Plan includes a boat ramp and support facilities for access to the C-18W Reservoir, a fishing platform at the restored Cypress Creek, and small bridges to improve existing hiking trails that go through areas to be restored. Based on a 2.75 percent interest rate and a 50-year period of analysis, the average annual cost of the recreation features is $209,000 and the average annual benefits are $464,000, resulting in net benefits of $255,000 and a 2.22 to 1 benefit to cost ratio.

The Recommended Plan meets the requirements of the WRDA 2000 Savings Clause by maintaining current levels of service for flood protection and causing no elimination of existing legal sources of water supply within the areas affected by the project (**Annex B**).

ENVIRONMENTAL CONSIDERATIONS

The Recommended Plan has been identified to be environmentally preferable for meeting project objectives within the study area. All practicable means to avoid or minimize adverse environmental effects have been incorporated into the Recommended Plan. An Adaptive Management and Monitoring Plan is included in the Final PIR (**Annex D**) that describes the methodology to monitor ecosystem restoration performance and provide options to improve restoration performance, if needed. The Invasive and Nuisance Species Management Plan **(Annex F)** describes actions associated with managing the spread of invasive species that would otherwise impact restoration performance. Adverse effects associated with implementing the Recommended Plan are expected to be negligible to moderate. Temporary short-term impacts to air quality, the noise environment, aesthetic resources, vegetation, and disturbances to and displacement of fish and wildlife resources to other nearby habitat are expected from operation of construction equipment through lands designated for staging, access, and construction, and from the conversion of agricultural lands in the footprint of the C-18W Reservoir.

No significant direct adverse impacts to wetlands are expected from the construction of the project; historically drained wetlands will be restored or enhanced when agricultural lands are restored to wetlands. Threatened and endangered species that USACE anticipate may be affected, either beneficially or adversely, by the project include: Audubon's crested caracara, Everglade snail kite and its critical habitat, wood stork, red-cockaded woodpecker, Florida manatee and its critical habitat, Florida bonneted bat, Florida panther, eastern indigo snake, and Okeechobee gourd. The USACE sent a Biological Assessment (**Annex A**) to the U.S. Fish and Wildlife Service to initiate consultation. The U.S. Fish and Wildlife Service provided a Biological Opinion that included minimization and conservation measures to avoid or minimize harmful effects to endangered species potentially affected by the project. Additionally, listed species managed by the National Marine Fisheries Service, including smalltooth sawfish and its critical habitat, green sea turtle, leatherback sea turtle, Kemp's Ridley sea turtle, loggerhead sea turtle, corals, and Johnson's seagrass, have been addressed as part of a previously completed CERP programmatic Biological Opinion.

The Recommended Plan has the potential to have adverse effects on undiscovered cultural resources in the project area. The specific effects cannot be assessed until the detailed design phase of the project. USACE has coordinated a Programmatic Agreement with the Florida State Historic Preservation Office (SHPO) and the Advisory Council on Historic Preservation to conduct a phased identification and evaluation of historic properties during the project's design phase. Avoidance of adverse effects to cultural resources is preferred, and therefore, the Project Team will consider ways to reduce or eliminate impacts to cultural resources. Pursuant to Section 106 of the National Historic Preservation Act (54 U.S.C. 306108) and its implementing regulations (36 CFR 800), where possible, the project design will be modified to avoid affecting significant historic properties and culturally significant sites. Where avoidance is not possible, minimization and/or mitigation measures will be considered. Future mitigation measures will be developed during the preconstruction engineering and design phase in consultation with the SHPO, tribal groups, and other interested parties as established in implementing regulations for Section 106 of the National Historic Preservation Act.

COST ESTIMATE AND IMPLEMENTATION PLAN

Table ES-2 presents the cost to implement the LRWRP. The total first cost of the LRWRP (October 2019 price level) of $740,760,000 includes construction, non-construction items, and contingency (see **Appendix B** for cost details).

Table ES-2. Cost estimates.

Items	Cost[1, 2, 3]
Construction - Ecosystem Restoration Features	$342,303,000
Construction - Recreation Features	$3,898,000
Construction Features Sub-Total	**$346,201,000**
Preconstruction Engineering and Design (PED)	**$55,755,000**
Construction Management (S&A)	**$34,956,000**
Lands and Damages	**$303,848,000**
Total First Cost	**$740,760,000**

[1] Construction costs in this table include contingencies
[2] October 2019 price level
[3] Recreation costs are not included in the ecosystem restoration cost estimates

Implementation of LRWRP by USACE and SFWMD will occur over many years. A Project Partnership Agreement (PPA) is a legally binding agreement that describes the roles and responsibilities of the USACE and SFWMD for real estate acquisition, design, construction, and operations and maintenance. The PPA will include the construction of project features that maximize benefits to the extent practicable consistent with project dependencies. Development of sequencing for LRWRP components also takes into consideration other factors that influence implementation such as land availability, funding availability, cost-share balance between the USACE and the SFWMD, and the integration of projects to be constructed by other agencies. Sequencing is shown in **Table ES-3**. Approximately 28,000 acres of land are required. Most of the required land is already in public ownership.

Table ES-3. Proposed implementation sequencing.

Project Features	Construction Sequence
Kitching Creek	1
Moonshine Creek and Gulfstream East	1
Grassy Waters Preserve Triangle	1
M-1 Canal Pump Station	1
C-18W Reservoir	1
ASR well 1	1
ASR wells 2, 3, 4	2
Gulfstream West	3
Pal-Mar East	4
Cypress Creek Canal	4
Pump and Spreader Swale at Mack Dairy Road	5
G-160 and G-161 Modifications (if needed)	6

COORDINATION WITH TRIBAL NATIONS, AGENCIES AND THE PUBLIC

The planning process for the LRWRP study involves extensive coordination with the public and federal, tribal, state, and local resource management and regulatory agencies. A Notice of Intent to prepare an Integrated PIR and EIS was released in January 2015, and a public scoping meeting was held in January 2015, in compliance with the National Environmental Policy Act (NEPA). An interagency Project Delivery Team met regularly throughout the study, providing federal, tribal, state, local agencies, and the general public opportunities to comment on planning assumptions, evaluation tools and methods, and alternative plans. The SFWMD's Governing Board met monthly throughout the study. The SFWMD Water Resources Analysis Coalition (now known as Water Resources Accountability and Collaboration Forum) also met monthly throughout the study, providing an additional forum for public participation and opportunities for information to be provided to elected and appointed officials and the public.

STAKEHOLDER FEEDBACK AND REMAINING UNCERTAINTIES

Land Acquisition

During project scoping, stakeholders expressed concerns about potential impacts of private land acquisition and encouraged the use of public lands to the extent practicable. Most lands required for the Recommended Plan are already owned by the SFWMD and other public agencies. Uncertainties surrounding land not yet acquired include willingness of landowners to sell; acquisition schedule risk to meet construction schedules; the potential for any unknown utility relocations not identified during the study; the potential presence of minerals and mineral rights on lands to be acquired; the potential for hazardous, radioactive, or toxic materials on the lands to be acquired.

Meeting Additional Regional Ecosystem Restoration Needs

The Recommended Plan provides a significant increase in water flow to the federally designated Wild and Scenic Northwest Fork of the Loxahatchee River, restores 17,000 acres of agricultural land back to wetlands and improves an additional 10,000 acres of natural areas that were part of the historical Greater Everglades system. The Recommended Plan will improve connectivity benefits over 78,000 acres of natural and restored habitat. Many agency stakeholders requested more ecosystem restoration outputs during the LRWRP study. There were requests for more water to be delivered to the Loxahatchee River

and more acres of wetland restoration. The LRWRP Recommended Plan represents the best balance of these two outputs.

Maintain Water Supply

During the LRWRP study, municipal and industrial water supply stakeholders expressed concerns about the lack of progress on CERP projects intended to increase regional water supply, and that the LRWRP must not reduce their water supply. The Recommended Plan uses water for restoration purposes that otherwise would leave the project area too fast and be sent to tide. Thorough analysis determined there would be no reduction of water supply. The CERP includes other measures that were not part of LRWRP, and LRWRP does not preclude additional water resources projects in the future that may include other measures from CERP that may provide increased municipal and industrial water supply.

Maintain Existing Level of Service for Flood Protection

Since the C&SF project and resulting urban and agricultural development adversely impacted many wetlands in the project area, the disturbed wetlands that the Recommended Plan would restore are located adjacent to developed land. Stakeholders are concerned that restoring wetlands may increase the likelihood of flooding in developed areas. Existing modeling shows no increased flooding in developed areas.

Effects of Climate Change

Although the magnitude of the effects of climate change, including rising sea levels, temperature changes, and changing rainfall patterns is uncertain, it is generally acknowledged that climate change will affect both natural system and human environmental conditions in south Florida during the next century. The Recommended Plan boosts resiliency to potential climate change effects by increasing freshwater in the Loxahatchee River and rehydrating wetlands within the watershed to buffer natural system areas against sea level rise and minor decreases in rainfall.

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Table of Contents

1 INTRODUCTION 1-1
1.1 Central and Southern Florida Project 1-1
1.2 Comprehensive Everglades Restoration Plan 1-2
1.3 Project Purpose and Need 1-3
1.4 Scope of Study 1-4
1.5 Project and Study Area 1-5
1.6 Problems and Opportunities 1-10
1.6.1 Watershed Hydrological and Ecological Problems 1-10
1.6.2 Opportunities 1-11
1.7 Objectives and Constraints 1-12
1.7.1 LRWRP Planning Objectives 1-12
1.7.2 CERP and LRWRP goals and objectives 1-13
1.7.3 LRWRP Planning Constraints 1-14
1.8 Report Authority 1-15

Tables

Table 1-1. CERP components considered in LRWRP. 1-4
Table 1-2. Description of the LRWRP natural areas. 1-5
Table 1-3. Objectives of CERP and LRWRP. 1-14

Figures

Figure 1-1. Pre-drainage versus managed Everglades system. 1-2
Figure 1-2. LRWRP location within the south Florida landscape. 1-3
Figure 1-3. Natural lands ownership in the LRWRP study area. 1-8
Figure 1-4. Detailed view of natural area boundaries near the Loxahatchee River and estuary. 1-9

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1 INTRODUCTION

The Everglades ecosystem has been altered by 120 years of highly effective efforts to drain water off the land. Direct land impacts due to development and farming have reduced the spatial extent of natural areas by almost 50% and the south Florida ecosystem has been extensively impacted as a result of water management activities intended to control flooding and provide water supply to those developed and agricultural areas. As a result, south Florida, including the remaining Everglades ecosystem, no longer exhibits the functionality, richness, and spatial extent that historically defined the pre-drainage system. The Loxahatchee River Watershed Restoration Project (LRWRP) was developed to restore function and increase spatial extent of wetlands in a portion of the south Florida ecosystem.

Section 1 contains the Purpose of and Need for Action statements of the integrated NEPA document.

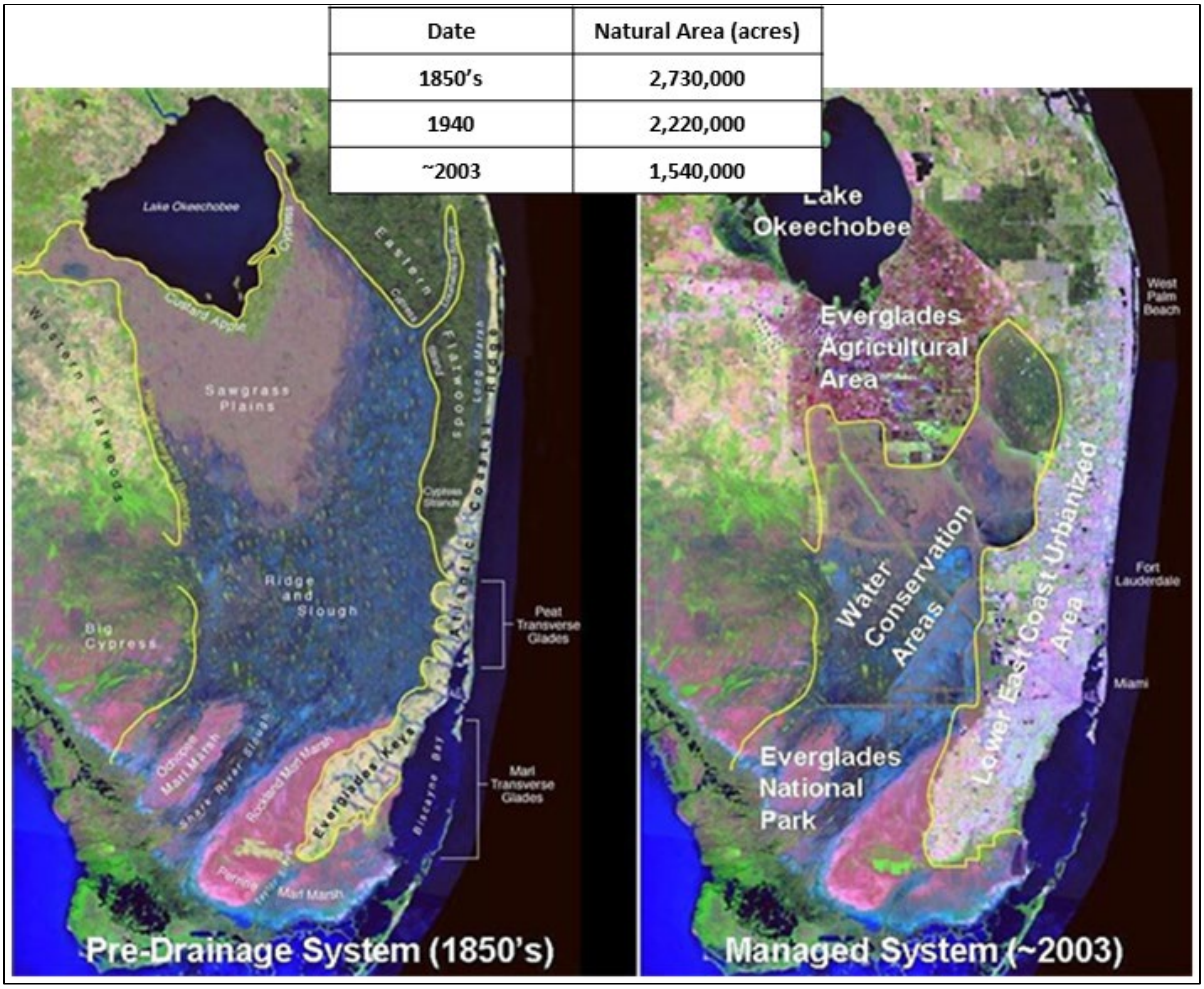
1.1 Central and Southern Florida Project

Historically, the Everglades was a shallow wetland conveying water from Lake Okeechobee to the southern coast of Florida. Although modifications to the flow of water were begun in the 1880s, most of the flow alterations were associated with the development of the Central and Southern Florida (C&SF) Flood Control Project, which was originally authorized by Congress in 1948. In the last 50 years, the construction of the C&SF Project has created many problems by supporting the conversion of nearly half of the original Everglades ecosystem to agricultural and urban uses. **Figure 1-1** shows the boundaries of the wetland in the pre-drainage system and in 2003, and acreages of the wetland system in the pre-drainage system, in 1940 before the C&SF Project, and in 2003 after substantial completion of the C&SF Project and the resulting changes in land use.

In 1947, 100 inches of rain fell on south Florida, more than tripling the region's total rainfall for 1945 and ending one of the worst droughts in Florida history. In a few weeks, the rain had drenched farmland and filled lakes and canals. Then in the space of just 25 days, two hurricanes and a tropical disturbance dumped more water on an already saturated area. When the rains finally ceased, 90 percent of southeastern Florida, from Orlando to the Florida Keys, was under water.

The disastrous flood in 1947, coupled with the experiences of the drought in 1945 and the intrusion of saltwater into the aquifer made it imperative that immediate corrective action be started. These actions were needed to prevent further loss of life and damage to property because of floods, and to conserve water for beneficial uses during periods of drought. The Corps prepared a comprehensive report in 1947. Congress authorized the Central and Southern Florida (C&SF) Project as part of the Flood Control Act of June 30, 1948, for the purposes flood control, water level control, water conservation (= agricultural and municipal water supply), prevention of salt water intrusion, and preservation of fish and wildlife. The first phase, authorized in the Flood Control Act of 1948, consisted of most of the works necessary to afford flood protection to the agricultural development south of Lake Okeechobee and to the highly developed urban area along the Lower East Coast of the State. The second phase, authorized by the Flood Control Act of September 3, 1954, consisted of all remaining works of the original 1947 comprehensive report. These works include the Water Conservation Area levees, Lower East Coast canals, Lake Okeechobee levees, Kissimmee River Channelization, and the South Dade System.

Construction of the C&SF Project began in 1950. Many of the features were constructed by the early 1980s, but additional construction has continued through 2018. Several canals and structures within and near the Loxahatchee River watershed were completed by 1958.



Date	Natural Area (acres)
1850's	2,730,000
1940	2,220,000
~2003	1,540,000

Figure 1-1. Pre-drainage versus managed Everglades system.

The C&SF Project greatly reduced flood impacts and allowed extensive development of southern Florida. However, the C&SF Project also generated several unintended consequences, including too much or too little water for the South Florida ecosystem; soil subsidence; 50 percent reduction in spatial extent of the natural system; declining estuary health; massive reductions in wading bird populations; degradation of water quality; loss of native habitat to invasive exotic vegetation; contributing conditions for listing 68 species as Federally threatened or endangered; repetitive water shortages; and salt water intrusion.

1.2 Comprehensive Everglades Restoration Plan

The Comprehensive Everglades Restoration Plan (CERP) was documented in the 1999 Central and Southern Florida (C&SF) Project Comprehensive Review Study Final Integrated Feasibility Report and Programmatic Environmental Impact Statement (U.S. Army Corps of Engineers 1999). CERP was approved by Congress as a framework for the restoration of the natural system in Section 601 of the Water Resources Development Act of 2000 (WRDA, 2000). The purpose of the CERP is to modify structural and operational components of the C&SF Project to achieve restoration of the Everglades and the South Florida ecosystem, while providing for other water-related needs such as urban and agricultural water supply and flood protection.

The CERP identified 68 different components. These components will work together to benefit the ecological structure and function of more than 2.4 million acres of the South Florida ecosystem by improving and/or restoring the proper quantity, quality, timing and distribution of water in the natural system. The CERP will also address other concerns such as urban and agricultural water supply and maintain existing levels of service for flood protection in those areas served by the project. The CERP components were originally planned for implementation over an approximate 40 year period. The CERP is designed to achieve more natural flows by re-directing current flows that are currently discharged to the Atlantic Ocean and Gulf of Mexico, to a more restored flow of water that is distributed throughout the system similar to pre-drainage conditions.

The Loxahatchee River Watershed Restoration Project (LRWRP) is part of the CERP. The first panel in **Figure 1-2** shows the location of the study area near the eastern coast of Florida in relation to the developed landscape and the boundary of the South Florida Water Management District (SFWMD, outlined in blue). The second panel shows the study area over the pre-development condition. The yellow lines show the main extent of the pre-development wetlands. The ecology of the watershed has also undergone significant changes. Over the last fifty years, many of these wetlands were drained for agricultural production and urban development. The drainage resulted in a substantial reduction in the spatial extent of wetlands in the watershed and impacted the functioning of the remaining wetlands, as many of them have lost vital hydrologic connections.

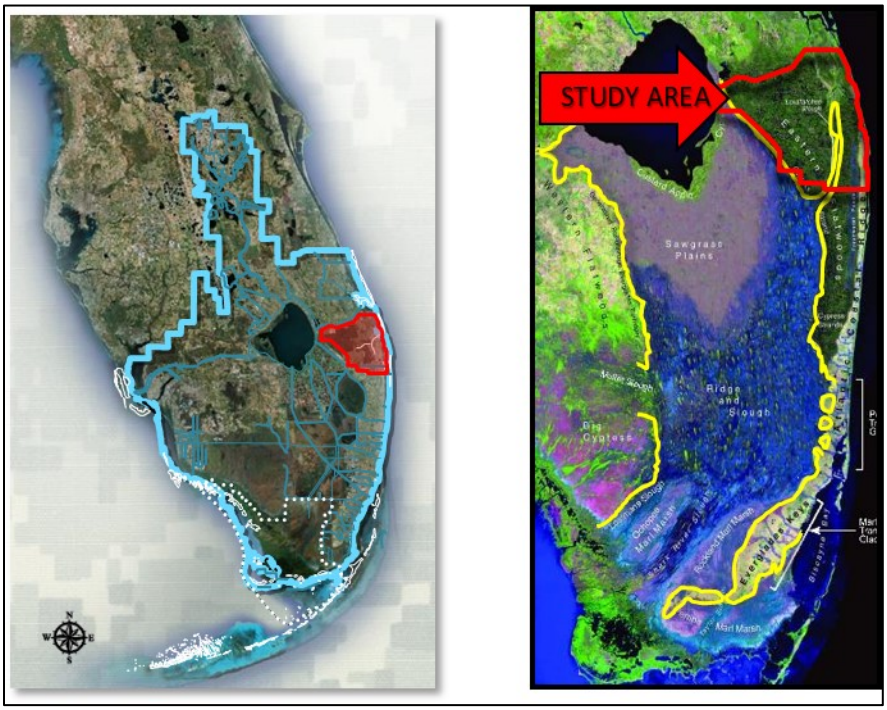


Figure 1-2. LRWRP location within the south Florida landscape.

1.3 Project Purpose and Need

As envisioned in CERP, the purpose of LRWRP is to restore and sustain the overall quantity, quality, timing, and distribution of freshwaters to the federally designated “National Wild and Scenic” Northwest Fork of

the Loxahatchee River (NWFLR) for current and future generations. This project also seeks to restore, sustain, and reconnect the area's wetlands and watersheds that form the historic headwaters for the river.

The LRWRP seeks to address these goals by developing alternatives that will capture, store, and redistribute water currently lost to tide; rehydrate headwater natural areas that have been hydrologically impacted by excessive draining and water diversions; reduce peak discharges to the project's estuarine systems to improve salinities (water quality); improve timing and distribution of water from the upstream watershed to increase the resiliency of freshwater riverine habitats to future sea-level changes; and reestablish connections among natural areas that have become spatially and/or hydrologically fragmented. If implemented, these actions will help restore more natural water deliveries, promote improved health and functionality of wetland and upland areas, and increase the quantity and quality of habitat available for native wildlife and vegetation.

1.4 Scope of Study

The scope of the LRWRP includes three components of the CERP: K, GGG, and an Other Project Element (OPE) (**Table 1-1**). Components K and GGG are presented separately in the CERP. Component K includes a 48,000 acre-foot reservoir, plus aquifer storage and recovery, pumps, and water control structures. Component GGG is the same 48,000 acre-foot above ground/in-ground reservoir described in Component K, but without the other measures. During the formulation of alternative plans, scales or sizes of these components from the Comprehensive Plan were analyzed. WRDA 2000 recognized that the CERP was conceptual in nature and that refinements would be required during further studies and implementation. Changed conditions since 1999, new scientific information, and learning from the first projects to be implemented all should influence the selection of specific measures and scales of later projects, such as LRWRP. Section 3 of this PIR contains an expanded version of **Table 1-1** and further discussion of features from CERP.

Table 1-1. CERP components considered in LRWRP.

Component from the Comprehensive Plan	What's involved	Purpose
Component K L-8 Project	• 48,000 acre-foot above ground/in ground reservoir • Aquifer Storage and Recovery (ASR) wells with combined capacity of 50 million gallons per day with pre and post water quality treatment • Series of pumps, water control structures and canal capacity improvements in the M Canal • New structure in south leg of C-18 canal • Conveyance under Bee Line HWY & Northlake Blvd	Increase water supply availability and flood protection, provide flows to enhance hydroperiods in Loxahatchee Slough, increase base flows to NWFLR, reduce high discharges to Lake Worth Lagoon (LWL)

Component from the Comprehensive Plan	What's involved	Purpose
Component GGG C-51 and Southern L-8 Reservoir	• 48,000 acre-foot above ground/in ground reservoir • Note: this is the same 48,000 acre-foot reservoir that is part of Component K	Increase water supply availability and flood protection, provide flows to enhance hydroperiods in Loxahatchee Slough, increase base flows to NWFLR, reduce high discharges to Lake Worth Lagoon (LWL)
Component OPE Pal-Mar and Corbett WMA Hydropattern Restoration	Water control structures, canal modifications and acquisition of 3,000 acres between Pal-Mar and Corbett; provide hydrologic connections between Corbett and 1) Moss 2) C-18 Canal 3) Indian Trail Improvement District (ITID) and 4) L-8 Borrow Canal	Extend the spatial extent of protected natural areas; increase connectivity of hydrology, flora, and fauna between natural areas; improve seasonal timing and distribution of water to improve hydropatterns in drained areas

1.5 Project and Study Area

The LRWRP study area is approximately 480,000 acres (750 square miles) and is located in northern Palm Beach County and southern Martin County (**Figure 1-2**). The study area is characterized as highly urbanized in the eastern portion, and transitions to extensive natural areas to the west and north (**Figure 1-3**). The study area is bounded on the north by the C-44 Canal, on the south by the C-51 Canal, on the west by the L-8 Canal and Lake Okeechobee, and on the east by the Loxahatchee River Estuary and Lake Worth Lagoon. The project area includes all of the Loxahatchee River watershed and limited portions of the St. Lucie River watershed. C&SF Project features within the study area include the L-8 Canal, the east and west legs of the C-18 Canal, and the C-51 Canal. Transportation infrastructure within the project area includes the Florida Turnpike and Interstate 95, as well as several major east/west county and state roadways (Indiantown Road [SR 706], PGA Boulevard [SR 708], Beeline Highway [SR 710], and Northlake Boulevard). This infrastructure and other development within the watershed have resulted in lowered groundwater levels and altered drainage patterns and flow regimes within the natural and less developed areas.

The LRWRP study includes eight major named natural areas under state, county, and city ownership. See **Table 1-2** for descriptions and **Figure 1-3** and **Figure 1-4** for locations. Each of these areas have experienced some level of impacts from the drainage, water supply, and flood protection afforded by C&SF Project and the agricultural and urban development that followed.

Table 1-2. Description of the LRWRP natural areas.

Natural Area	Description
Jonathan Dickinson State Park	Jonathan Dickinson State Park (JDSP) is located in the northeast section of the project area within Martin and Palm Beach Counties and is comprised of 11,471 acres. The park contains portions of several branches of the Loxahatchee River and its upstream tributaries (Northwest Fork, reaches of the North Fork, Cypress Creek, Moonshine Creek, Hobe Grove Ditch, Wilson's Creek, and Kitching Creek).

Natural Area	Description
Northwest Fork of the Loxahatchee River (NWFLR)	The NWFLR, one of Florida's two federally designated National Wild and Scenic Rivers, is a natural river channel that originates in the Loxahatchee and Hungryland Sloughs. Downstream from these sloughs, the NWFLR receives additional input from the other major tributaries of the Loxahatchee River: Cypress Creek/Ranch Colony Canal, Hobe Grove Ditch, and Kitching Creek. A cypress riverine swamp community historically dominated the floodplain of the Loxahatchee River with freshwater stream swamps and cypress communities present upstream from river mile 6.5 and dominant within the floodplain above river mile 8.0.
Loxahatchee River Estuary	The Loxahatchee River Estuary is downstream from the designated National Wild and Scenic River. Salt water from the Atlantic Ocean flows through Jupiter Inlet, merging with the freshwater that flows in from the north, northwest and southwest forks of the river, forming the estuary. This shallow embayment has an average depth of 3.5 feet, a maximum depth of 15 feet, and covers an area of approximately 380 acres.
Pal-Mar	Pal-Mar comprises more than 37,000 acres in southern Martin and northern Palm Beach counties, and forms a linkage between J.W. Corbett WMA and JDSP. Cypress Creek historically drained the Pal-Mar area. Due to the transformation of the historic creek into the Cypress Creek Canal and the diversion of water from the historic creek into the Ranch Colony Canal, flows into the creek have been greatly altered and it is no longer a receiving body of Pal-Mar surface water. Central Pal Mar includes a canal/ditch system that has caused some impacts to hydrology. Western Pal-Mar is primarily a natural area and occurs as a mosaic of wetland/upland communities including depression marsh, wet prairie, strand and dome swamps, pine flatwoods and sloughs. Northern and eastern Pal-Mar have been converted to agricultural usage and have undergone significant hydrological changes. At the southern end of Pal-Mar, the 6,600 acre Pine Glades Natural Area feeds Pal-Mar through culverts under Indiantown Road.
J.W. Corbett Wildlife Management Area (WMA)	J.W. Corbett WMA encompasses approximately 62,000 acres and is located in the northwest section of the project area. It contains extensive hydric/mesic flatwoods, depression marshes, wet prairies, strand and dome swamps and hydric/mesic hammocks. An intact Everglades sawgrass marsh ecosystem occurs along the southern boundary of J.W. Corbett WMA, and is considered a remnant portion of the Greater Everglades ecosystem. Hungryland Slough Natural Area maintained by Palm Beach County connects J.W. Corbett WMA to the western portion of Loxahatchee Slough.
Loxahatchee Slough	Loxahatchee Slough was historically one of the most prominent flow ways in the study area and contained a large portion of the historic headwaters of the Northwest and Southwest Forks of the Loxahatchee River. The 13,000 acre site is the single most ecologically-diverse tract of protected land in Palm Beach County, including nine distinct community types. The slough used to extend all the way to what is now Loxahatchee National Wildlife Refuge, but has been cut off by the levees that surround the Refuge and by the C-51 and C-18 Canals. These features have altered historic drainage patterns in this area and have allowed for extensive invasions by melaleuca shrubs and small trees that have required extensive eradication efforts by Palm Beach County to reduce the infestations.
Grassy Waters Preserve	The southern half of the historical Loxahatchee Slough has been impounded to form the Grassy Waters Preserve (GWP). The GWP is a managed wetland ecosystem, approximately 12,800 acres (20 square miles), which is owned and operated by the City of West Palm Beach. GWP serves as a surface water catchment, groundwater recharge and storage system for public water supply. GWP is also known as the West Palm Beach Water Catchment Area. The City's management of the GWP as an element of the water supply system has protected and sustained most of this system in a high quality wetland condition. The wetlands within this catchment area include wet prairies (sawgrass and spikerush), sloughs and cypress and other tree islands configured in a remarkably natural mosaic.

Natural Area	Description
Dupuis Wildlife and Environmental Area (WEA)	The Dupuis WEA includes 21,875 acres located in the westernmost section of the study area, between J. W. Corbett WMA and Lake Okeechobee. Once part of the Everglades ecosystem, the hydrology of the area was altered through drainage. In addition, habitats have been altered by former agricultural operations in the area. Habitats on the property include ponds, wet prairies, cypress domes, pine flatwoods, and remnant Everglades marsh.

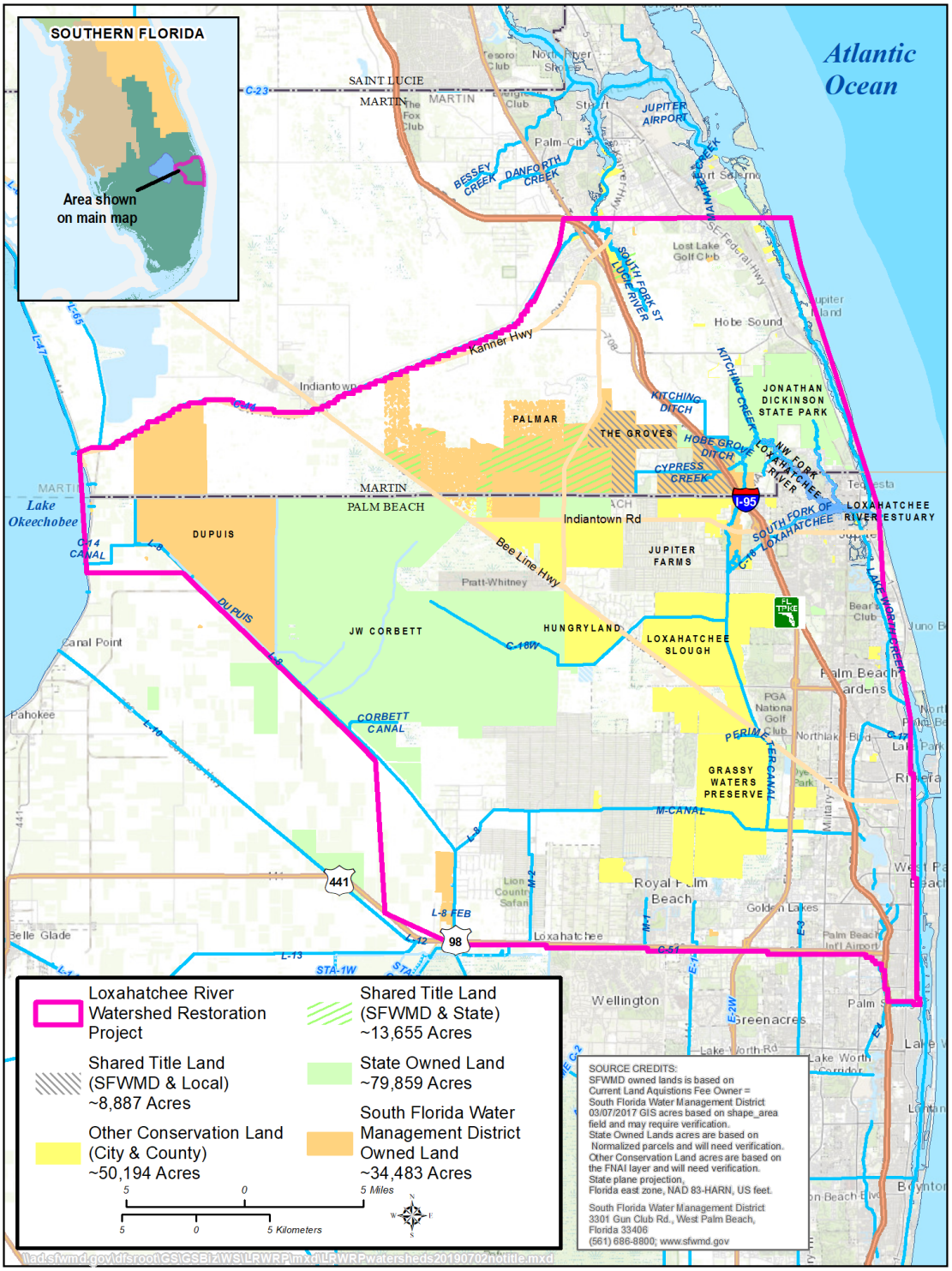


Figure 1-3. Natural lands ownership in the LRWRP study area.

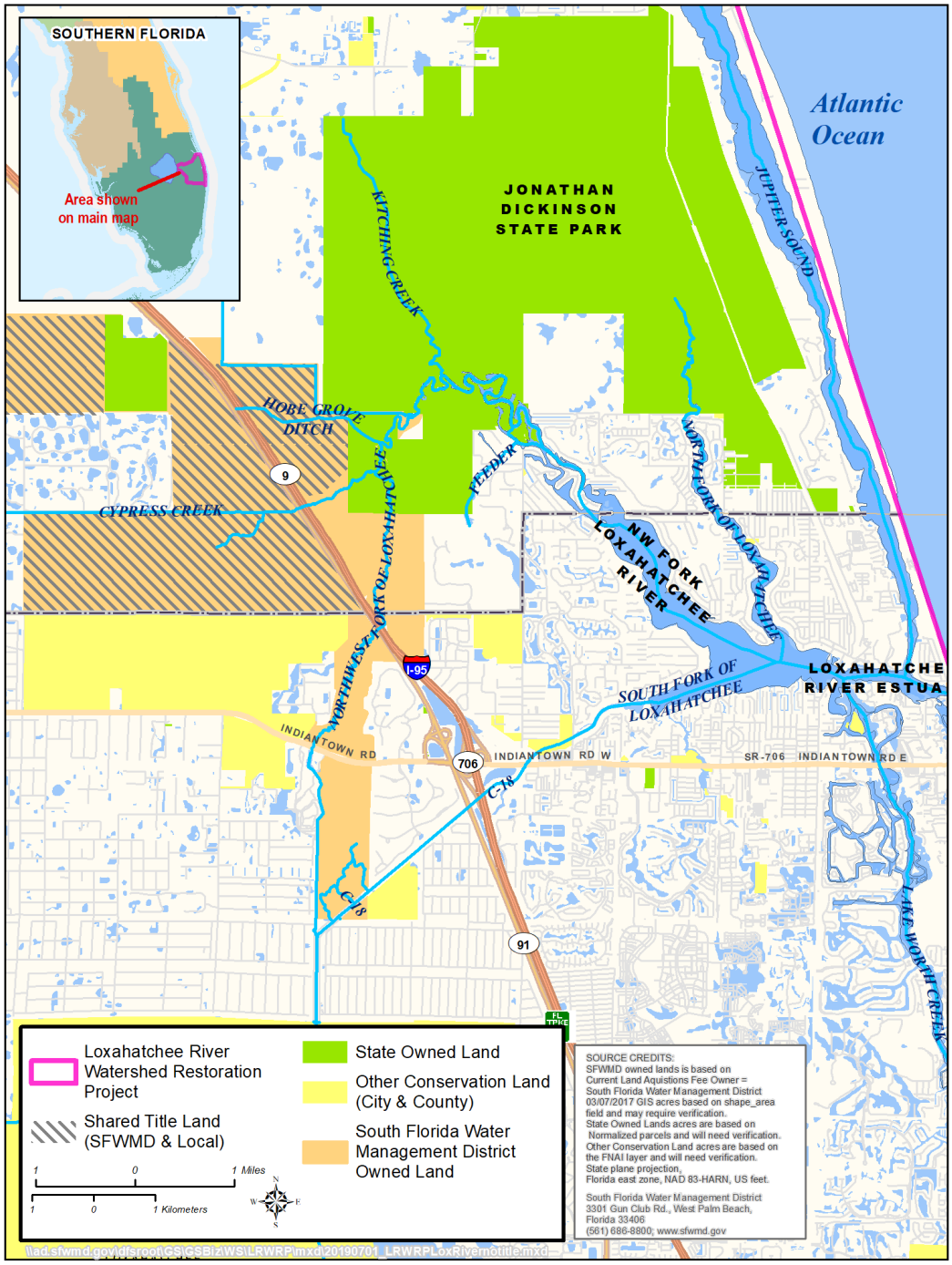


Figure 1-4. Detailed view of natural area boundaries near the Loxahatchee River and estuary.

1.6 Problems and Opportunities

Van Arman et al. (2005) developed a conceptual ecological model for the Loxahatchee watershed that characterized the wetland, riverine, and estuarine components pre-development and how they have been affected by hydrologic alterations, urban and agricultural development, and water management infrastructure and operations. C&SF Project features C-18 Canal, C-18W Canal, and S-46 contributed to the problems. The following information documents the project related problems known to exist currently, many of which are expected to worsen in the future if no action is taken.

1.6.1 Watershed Hydrological and Ecological Problems

These ecological problems exist within the Loxahatchee River watershed:

1. Altered timing and distribution of headwater base flows to the Northwest Fork of the Loxahatchee River
2. Increased salinity effects on formerly freshwater reaches of the Loxahatchee River
3. Loss of freshwater cypress floodplain adjacent to Loxahatchee River
4. Increased wet season flows to Southwest Fork and Loxahatchee Estuary
5. Degraded natural area structure and function from altered hydrology
6. Conversion of natural areas to agricultural, residential and industrial uses
7. Loss of connectivity and barriers to flow between natural areas, river, and estuary
8. Reduced native floral and faunal populations and diversity
9. Degraded water quality in natural areas

<u>Problems 1, 2, 3 and 4: Flow to Loxahatchee River, Floodplain, and Estuary</u>

The hydrologic conditions in the tributary basins to the Loxahatchee River and estuary have been altered by the construction of canals, channelization of natural waterways, drainage and/or impoundment of wetlands, and increased groundwater withdrawals. The construction in 1957-1958 of the C&SF Project features C-18 Canal and the S-46 Discharge Structure for flood control purposes diverted freshwater that flowed naturally to the Northwest Fork towards the Southwest Fork. This resulted in the over drainage of headwaters from the NWFLR and increased discharges, often excessively, directly into the Loxahatchee estuary. The channelization of flows in the Cypress Creek basin has over-drained area wetlands and results in large erosive stormwater discharges in Cypress Creek.

These alterations have adversely affected both the Loxahatchee River and estuary and produced insufficient freshwater base flows to the river and estuary during the dry season. Insufficient base flows to the NWFLR have resulted in higher salinity levels. Cypress and other freshwater vegetation intolerant of elevated saline conditions have been replaced by mangroves and other estuarine plant communities. Sea-level rise will continue to convert freshwater habitat to estuarine habitat without restoration of dry season base flows to the river.

The lack of storage in the tributary basins results in periods of excessive freshwater inflow to the Loxahatchee estuary in the wet season, impacting seagrasses, shellfish populations, and other fish and invertebrate communities residing in the estuary. Large pulses of freshwater followed by periods of

insufficient freshwater inflow result in an unnatural salinity oscillation, further degrading ecological communities requiring stable salinity regimes.

Problems 5, 6, 7 and 8: Degraded freshwater wetland structure and function and conversion to other land uses

The construction of canals, channelization of natural waterways, and barriers to flow produced hydrologic changes that have degraded wetland structure and function. Habitat fragmentation is only expected to worsen in the future with increased development pressure. Some canals reduced the ability of wetlands to store water. The lack of storage in the tributary basins results in periods of excessive and insufficient freshwater inflow to the Loxahatchee River and estuary.

Shortened hydroperiods in the Loxahatchee Slough and Cypress Creek/Pal-Mar/Groves basin wetlands reduced foraging and nesting habitat for the federally endangered Everglade snail kite, wood storks, wading birds, and other wetland dependent species.

The historic connection between GWP and the downstream remnants of the Loxahatchee Slough and River have been impacted by existing roadways and channelization. This limits the amount of freshwater that can be sent downstream to the Loxahatchee River. Reduced freshwater flows contribute to salinity imbalances in the River and reduce the potential extent of additional viable wildlife habitat in Loxahatchee Slough.

Problem 9: Degraded water quality in Grassy Waters Preserve (GWP)

GWP consists of a 19 square mile wetland water catchment area that is the predominant remnant headwaters of the Loxahatchee Slough and “Wild and Scenic” Loxahatchee River. The wetlands within this catchment area include wet prairies (sawgrass and spike rush), sloughs, and cypress and other tree islands configured in a natural mosaic. While there are areas of degradation in GWP, it provides foraging and nesting habitat for snail kites, wood storks, roseate spoonbills, and multiple other wildlife species. When necessary, the City of West Palm Beach supplements their water supply with water from Lake Okeechobee. Lake Okeechobee water is high in nutrient concentrations and as a result of routing this water through the M-Canal, the fringes of GWP have experienced vegetative changes consistent with the effects of degraded water quality. These alterations to wetland vegetation have potentially affected suitable breeding habitat for both native and introduced exotic apple snails, the preferred prey of snail kites.

1.6.2 Opportunities

There are opportunities to include recreation-related features to increase recreational access and use of the natural lands in the project area. Tourism is a “critical industry”, as identified by the Governor’s Commission for a Sustainable South Florida Initial Report (1995). A healthy ecosystem and its attendant tourism are the mainstays of the regional economy, as reflected by the relative domination of economic activity there in the services, retail trade, and fisheries industries. Many Floridians also visit natural areas regularly to enjoy a variety of outdoor activities, primarily hunting, fishing, kayaking, and hiking. All recreational features would be compatible with ecological restoration.

The C&SF project is a multi-purpose project that includes providing water supply to meet municipal, industrial, and agricultural uses. Drainage, water supply, and flood protection afforded by the C&SF Project have provided for the growth of south Florida's population. In south Florida’s Lower East Coast

(LEC), groundwater from the surficial aquifer system is the predominant source of water for municipal and industrial uses.

Opportunities may occur to improve water supply and flood risk management. Improvements to water supply and level of service for flood risk management may occur as a result of ecosystem restoration planning and will be captured as ancillary benefits. Opportunities exist to capture excess water to reduce water supply restrictions in the Northern Palm Beach County Service Area. The Ranch Colony and the Links developments located in southern Martin County, and the Indian Trail Improvement District in the L-8 Basin experience flooding during heavy rainfall events. Opportunity exists to reduce frequency of flooding events by keeping more water in the natural areas for restoration purposes.

1.7 Objectives and Constraints

This subsection discusses the project's objectives and constraints.

1.7.1 LRWRP Planning Objectives

The planning objectives are based on the project area problems and opportunities described in this chapter and informed by the description of existing and predicted future conditions in Chapter 2. The measurement methods listed below are extensively described in Appendix G: Environmental Benefits Model.

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.

This objective addresses problems 1, 2, and 3 related to disrupted timing, distribution, and quantity of flows to the Loxahatchee River and adjacent floodplain that has allowed salinity intrusion and degradation of the last remaining riverine cypress floodplain in Southeast Florida. This objective is measured by the ability to meet flow, floodplain inundation, and salinity envelope targets in the NWFLR as stated in the state restoration plan (SFWMD 2006).

2. Restore oysters, seagrass and other estuarine communities in the Loxahatchee River Estuary.

This objective addresses problems 2 and 4 by reducing the frequency of high wet season flows to the estuary. In addition, the oyster, seagrass, and estuarine communities will be preserved from the future effects of sea-level rise, and enhanced by promoting expansion into more historic locations of estuarine habitat zonation. Estuary salinity benefits will be measured based on the relationship of flows to the NWFLR and corresponding salinity zonation downstream for each important habitat zone.

3. Increase natural area extent of wetlands.

This objective addresses problems 5 and 6 by reversing the trend of wetland conversion to agriculture and urban uses and improving hydrology to restore structure and function of wetlands in the watershed. This objective is measured by calculating additional acres of natural areas added that achieve restored hydrologic regimes of the primary wetland habitats that were once found on the agricultural lands.

4. Restore connections between J. W. Corbett WMA, Pal-Mar/Cypress Creek basin, Loxahatchee Slough, Grassy Waters Preserve and Loxahatchee River to improve hydrology, sheetflow, hydroperiods, natural storage, and vegetation communities.

This objective addresses problem 7 by reconnecting natural areas to achieve improved wetland function that benefits fish and wildlife, hydrologic connection of flow to the Loxahatchee River, and incidental water quality improvements. This objective is measured by the increase in connectivity between natural areas compared to the total maximum score achievable. The project will rely on information from previous studies, site visits, and areal mapping to find opportunities to reconnect historic wetlands and natural areas.

5. Restore native plant and animal species abundance and diversity in Loxahatchee River watershed natural areas, river, and estuary.

This objective addresses problems 5 and 8 by restoring hydrology to improve wetland structure and function, so that native plant and animal species populations and diversity will improve. Improvements to Loxahatchee River Watershed natural area hydrology regimes are measured by the estimated achievement of appropriate depth and duration of stage targets. Desired targets are based on prior project plan formulation literature data and model output for predevelopment conditions or existing conditions in un-impacted areas for each major wetland plant community. In addition to habitat units, best professional judgment based on literature review and model output will be used based on the restored area's likelihood of improving fish and wildlife species life history characteristics.

During the NEPA Scoping process, agencies and stakeholders expressed a desire for this project to address water supply as an objective. Ecosystem restoration is the primary goal of the study, and formulation will address ecosystem restoration objectives. The LRWRP did not expand its scope to formulate for a water supply objective. However, because the Savings Clause requires that water supply not be adversely impacted, the effects of alternatives on water supply will be evaluated. Positive effects to water supply will be identified as ancillary benefits.

Water quality is recognized as a problem in Grassy Waters Preserve and for certain areas of the Loxahatchee River Estuary. USACE water quality policy for CERP dated November 30, 2007 from the Assistant Secretary of the Army indicates that it is against Federal policy to recommend for implementation projects or features that would result in treating or otherwise abating pollution problems caused by other parties where they have a legal responsibility for remediation. Following CERP Guidance Memorandum 23 on water quality consideration during planning and in project implementation reports (PIRs), water quality is primarily treated as a constraint in formulation.

1.7.2 CERP and LRWRP goals and objectives

Section 601(h) of WRDA 2000 states "[t]he overarching objective of the Plan is the restoration, preservation, and protection of the South Florida Ecosystem while providing for other water-related needs of the region, including water supply and flood protection". LRWRP has one or more ecological objectives that correspond to each of the CERP ecological objectives (**Table 1-3**).

Table 1-3. Objectives of CERP and LRWRP.

CERP Objective	LRWRP Objective
Increase the total spatial extent of natural areas.	Objective 3: Increase natural area extent of wetlands.
Improve habitat and functional quality.	Objective 1: Restore wet and dry season flows of water to the National Wild and Scenic NWFLR and the river floodplain. Objective 2: Restore oysters, seagrass and other estuarine communities in the Loxahatchee River Estuary. Objective 4: Restore connections between J. W. 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.
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.
Increase availability of fresh water (agricultural/municipal & industrial).	No corresponding objective. Potential incidental benefit to increase availability of water supply.
Reduce flood damages (agricultural/urban).	No corresponding objective. Potential incidental benefit.
Provide recreational and navigation opportunities.	No corresponding objective, but project will provide recreational opportunities consistent with ecosystem restoration.
Protect cultural and archeological resources and values.	No corresponding objective, but project will protect cultural and archeological resources and values.

1.7.3 LRWRP Planning Constraints

Three project constraints are recognized:

1. Do not reduce the existing levels of service for flood protection by Plan implementation (Savings Clause, Section 601 (h)(5)(B) of WRDA 2000).
2. Do not eliminate or transfer existing sources of water by Plan implementation until replacement sources of water of comparable quantity and quality are made available (Savings Clause, Section 601 (h)(5)(A) of WRDA 2000).
3. Meet applicable water quality standards. CERP Guidance Memorandum 23 and Corps guidance ER 1110-2-8154 will be followed to ensure the Recommended Plan will not: cause or contribute to violations of water quality standards; increase pollutant load to water for which a total maximum daily load (TMDL) has been established unless appropriately mitigated (offset by equivalent load reduction); or, degrade water quality in Outstanding Florida Waters, unless otherwise authorized by rule or statue. Further discussion on water quality is contained throughout the document with respect to existing and future without project conditions, plan formulation, evaluation of water quality effects of alternatives, and required water quality monitoring associated with specific features.

1.8 Report Authority

The WRDA of 2000 approved the CERP as a framework for modifications to the C&SF Project in Section 601(b)(1)(A). The LRWRP PIR will be submitted to Congress in compliance with Section 601(d) of WRDA 2000, titled “Authorization of Future Projects.”

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Table of Contents

2 EXISTING AND FUTURE WITHOUT PROJECT CONDITIONS 2-1
2.1 "With" and "Without" Comparisons 2-1
2.2 Planning Horizon 2-1
2.3 Existing Ecological Description/Setting 2-2
2.4 Comparison of Existing and Future Without Project Conditions 2-7
2.5 Structural and Operational Assumptions for Future Without Project Conditions ... 2-18
2.5.1 Structures G-160 and G-161 in the C-18 Canal 2-18
2.5.2 Additional Structures 2-18
2.5.3 Other CERP Projects 2-19
2.6 Related Restoration Projects by Non-federal Agencies 2-20
2.7 Related Studies 2-20
2.7.1 L-8 Basin General Reevaluation Report (GRR) (2001) 2-21
2.7.2 Cypress Creek/Pal-Mar and the Groves Basin Study (2002) 2-21
2.7.3 Northern Palm Beach County Comprehensive Water Management Plan (2002) 2-21
2.7.4 The Loxahatchee River Watershed Action Plan (2002) 2-21
2.7.5 Loxahatchee River Minimum Flows and Minimum Water Levels (MFLs) (2002) 2-22
2.7.6 Restoration Plan for the Northwest Fork of the Loxahatchee River (2006) 2-22
2.7.7 CERP Project - North Palm Beach County Part 1 Plan Formulation 2-22
2.7.8 Restoration Strategies 2-23
2.8 Native Americans 2-23

Tables

Table 2-1. Existing Conditions and Future Without Project Conditions. 2-8

Figures

Figure 2-1. LRWRP planning horizon 2-2
Figure 2-2. Natural lands ownership in the LRWRP study area. 2-4
Figure 2-3. LRWRP sub-watersheds and structures 2-5
Figure 2-4. Detailed view of sub-watersheds near the Loxahatchee River and estuary. 2-6
Figure 2-5. Authorized ecosystem restoration projects in southern Florida 2-20

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2 EXISTING AND FUTURE WITHOUT PROJECT CONDITIONS

This section provides a description of existing and future without (FWO) project conditions within the study area and a definition of the FWO project condition and how and why it is developed. This section also contains an overview of the "Affected Environment" of the integrated NEPA document. More detailed information on the Affected Environment can be found in Appendix C.1.

2.1 "With" and "Without" Comparisons

The U.S. Water Resources Council's *Principles and Guidelines* provide the instructions and rules for federal water resources planning. One *Principles and Guidelines* requirement is to evaluate the effects of alternative plans based on a comparison of the most likely future conditions with and without those plans in place. In order to make this type of comparison, descriptions (often called forecasts) must be developed for two different future conditions: the FWO project condition and the future with project condition. Note that the project referred to in this context is any one of the alternative plans that have been considered in the study. The FWO project condition describes what is assumed to be in place if none of the study's alternative plans are implemented. The FWO project condition is the same as the alternative of "no action" that is required to be considered by the federal regulations implementing the National Environmental Policy Act (NEPA) of 1969. The future with project condition describes what is expected to occur as a result of implementing each alternative plan that is being considered in the study. The differences between the future without project condition and the future with project condition are the effects of the project.

2.2 Planning Horizon

The planning horizon encompasses the planning study period, construction period, economic analysis period, and the effective life of the project. The time frame used when forecasting future with and without project conditions while considering impacts of alternative plans is called the period of economic analysis. It may also be referred to as simply the period of analysis. It is the period of time over which scientists think extending the analysis of the plan impacts is important. This time period is frequently confused with the planning horizon, which is a longer and more encompassing concept. **Figure 2-1** shows that the period of analysis is part of the planning horizon.

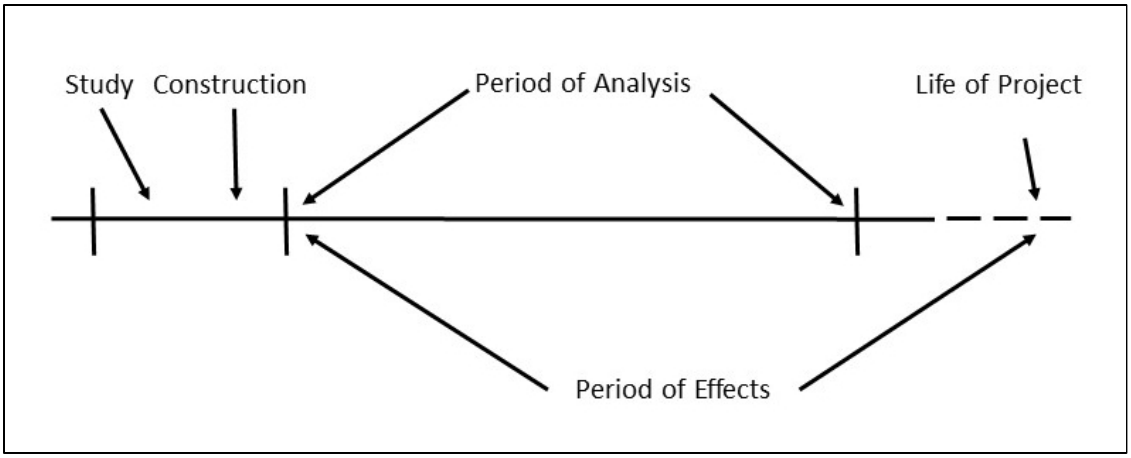

Figure 2-1. LRWRP planning horizon.

The period of analysis for water resources projects usually falls between 50 and 100 years. Even if project structures last more than 100 years, there is too much inherent uncertainty to reliably forecast conditions and impacts beyond 100 years. The start of the period of analysis (base year) for the LRWRP is 2025. By incorporating a 50-year period of analysis to reflect beneficial and adverse effects of the project through time, the period of analysis for LRWRP ends in the year 2075. Accounting for the beneficial and adverse effects of LRWRP through time is largely based on hydrologic modeling and performance measure evaluation.

2.3 Existing Ecological Description/Setting

Existing and FWO project conditions within the study area are summarized in the following descriptions. Existing and FWO project conditions are further documented in **Appendix C.1**.

The Northwest Fork of the Loxahatchee River (NWFLR) is one of Florida's two federally designated National Wild and Scenic Rivers and supports one of the last vestiges of native cypress floodplain swamp in southeast Florida. The river originates in both the Loxahatchee and the Hungryland Sloughs, located south of and west of the NWFLR (**Figure 2-2**). The Central and Southern Florida (C&SF) Project cut off this connection and had unintended consequences of altering hydrology of the Loxahatchee Slough and River (McVoy et al. 2011). Downstream from Loxahatchee and Hungryland Sloughs, the Northwest Fork receives additional input from the other major tributaries of the Loxahatchee River: Cypress Creek/Cypress Creek Canal, Hobe Grove Ditch, and Kitching Creek.

There are 8 major sub-watersheds within the Loxahatchee River watershed area (see **Figure 2-3**):

- The Kitching Creek Basin is in the northeastern portion of the watershed, draining into the NWFLR. The southern portion of the 18 square miles of this basin contribute runoff from natural lands, such as Jonathan Dickinson State Park (JDSP).

- The Grove Basin consists of 17 square miles of predominately agricultural land that discharges into the NWFLR either via Cypress Creek or via Hobe Grove Ditch.

- The Pal-Mar Basin is a 43 square mile basin draining mostly wetlands in the western portions of the watershed. It includes the sparse residential communities of Ranch Colony, the Links, and Old Trail, and is one of the major tributaries to the NWFLR.

- The Jupiter Farms Basin is over 15 square mile area with the majority of the land area comprising the South Indian River Water Control District (SIRWCD). This area is a rural, residential community with a managed lengthy canal system that is controlled by gravity control structures. Some canals discharge directly to the NWFLR while others discharge to the NWFLR via SIRWCD's Canal 14.

- The Historic Cypress Creek Basin is a more than 6 square mile area that includes the Wild and Scenic River reach of the Loxahatchee River.

- The Loxahatchee Estuary is a 2 square mile area of highly developed urban land use. This basin accepts runoff from the three forks (NW, SW and North) of the Loxahatchee River.

- The C-18/Corbett Basin encompasses approximately 103 square miles in northern Palm Beach County. This basin includes a portion of the J.W. Corbett Wildlife Management Area (WMA), the Hungryland Slough Natural Area, the Loxahatchee Slough, and miscellaneous agricultural and residential communities. This basin's main drainage facility includes the two forks of the C-18 (C&SF) Canal. Water surface elevations within this canal system are controlled by three structures; C-18 weir at the west, G-92 culvert that diverts water to the SIRWCD's C-14 Canal, which conveys water to the NWFLR, and S-46 spillway that discharges to tide via the SW Fork.

- The L-8 Basin encompasses approximately 157 square miles in northwestern Palm Beach and southwestern Martin Counties. It includes a portion of J.W. Corbett WMA, Dupuis Wildlife and Environmental Area, Indian Trail Improvement District (ITID), and agricultural and residential lands. The L-8 Canal is connected to the City of West Palm Beach's M-Canal via the L-8 Tieback Canal and the Control 2 Pump Station. The south end of the L-8 Canal terminates at its intersection with the C-51 Canal.

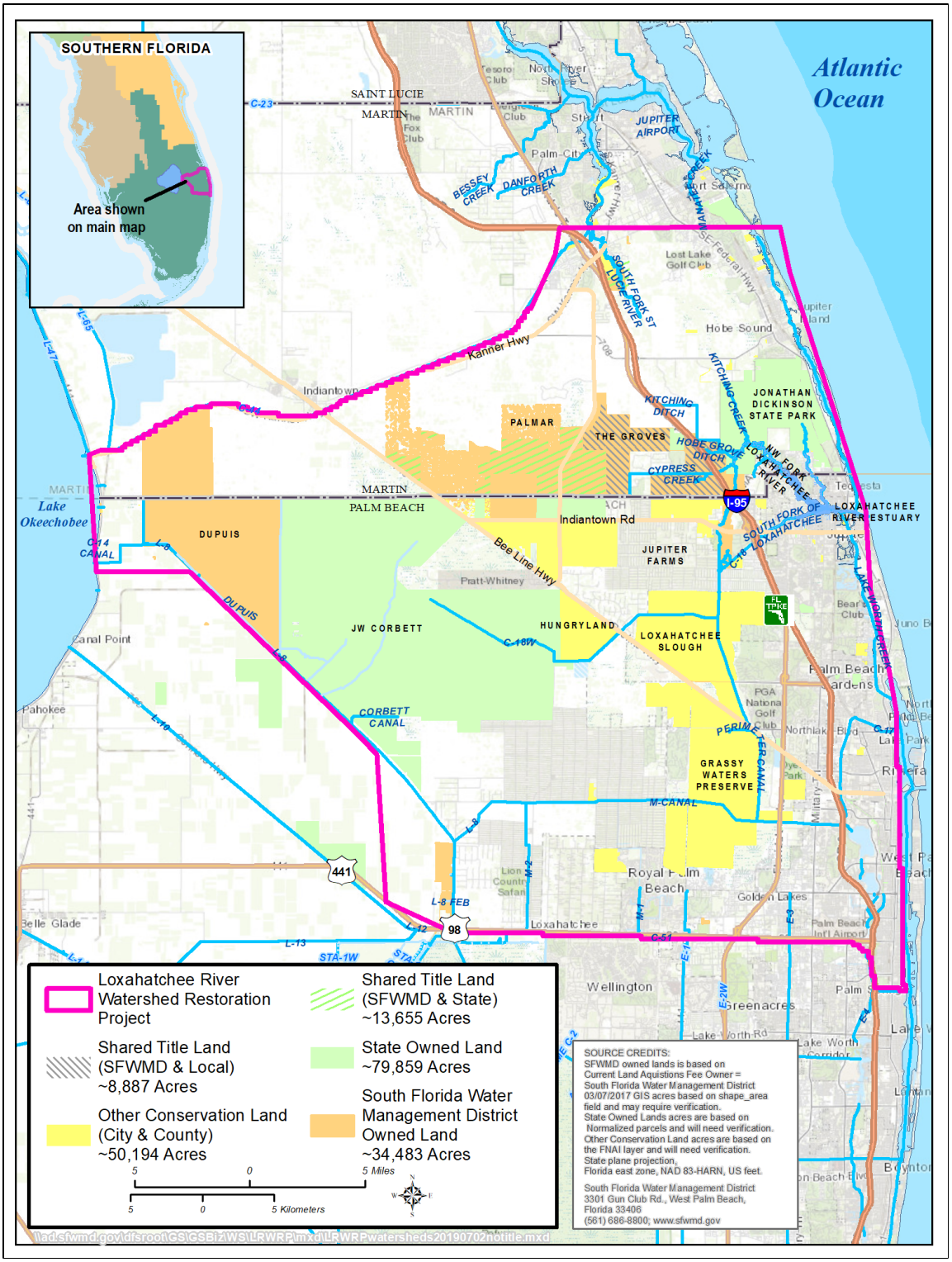

Figure 2-2. Natural lands ownership in the LRWRP study area.

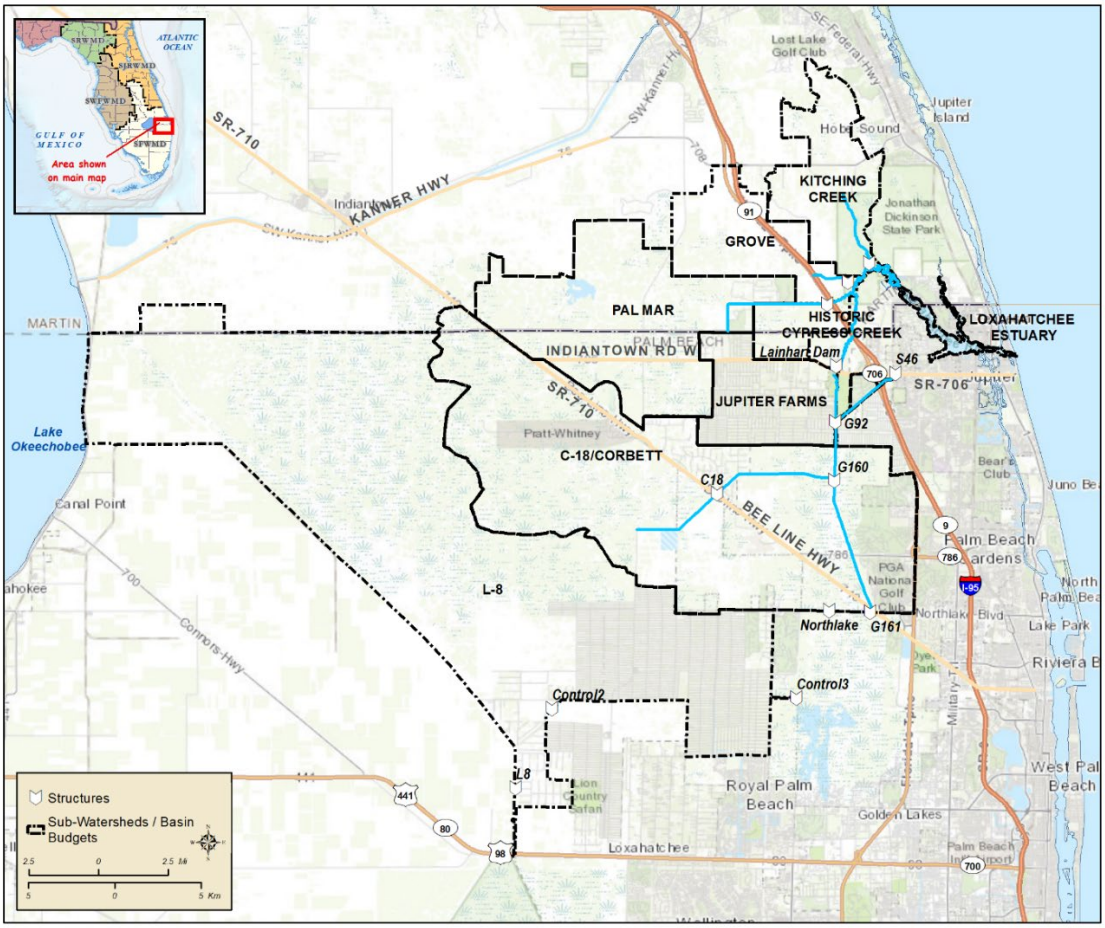

Figure 2-3. LRWRP sub-watersheds and structures.

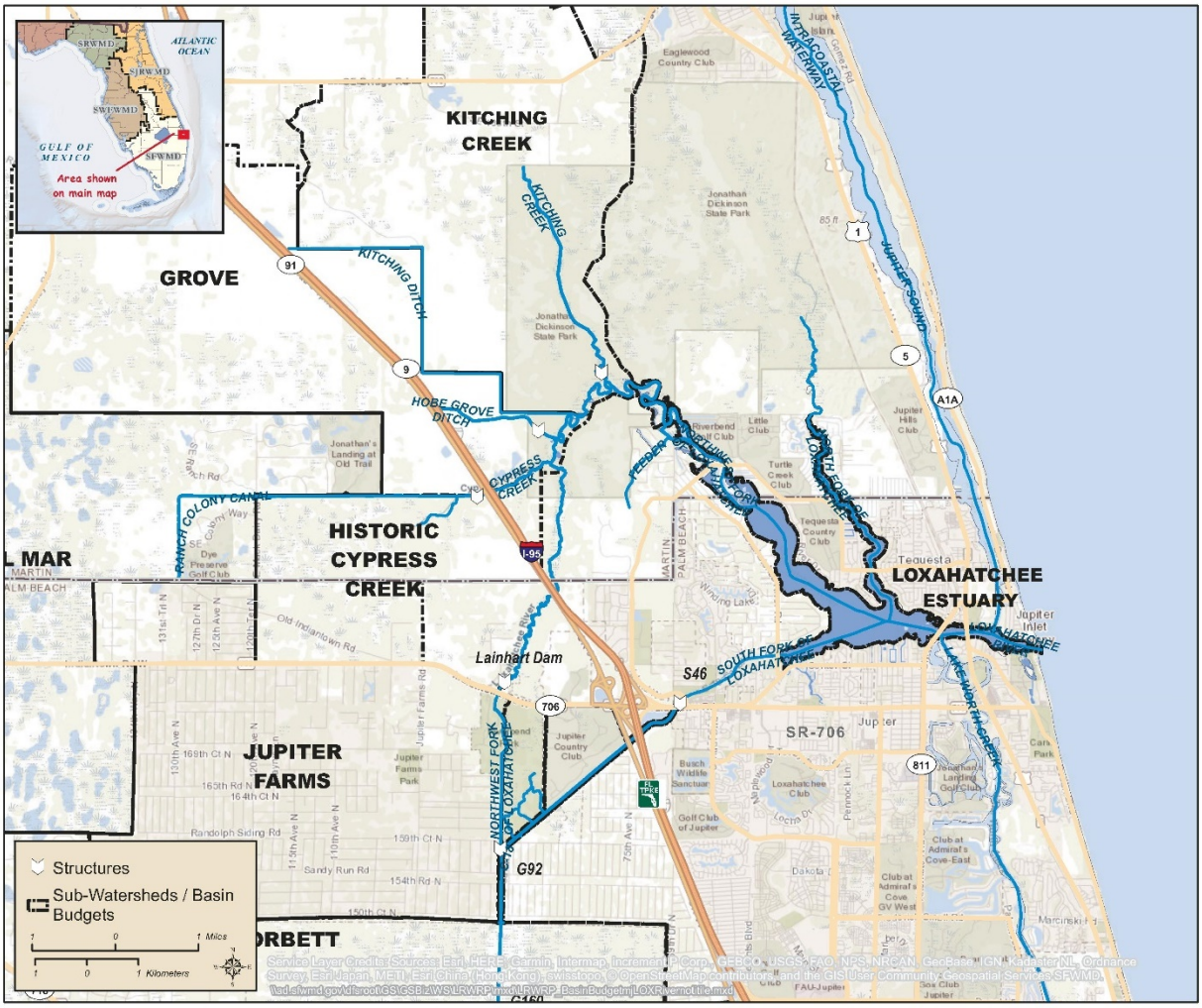

Figure 2-4. Detailed view of sub-watersheds near the Loxahatchee River and estuary.

Most of the surface water runoff from the Loxahatchee Watershed historically drained through Hungryland and Loxahatchee Sloughs to the Northwest Fork where tidal interaction was limited. Flood control improvements that were implemented with the construction of the C&SF project canals and levees altered hydroperiods and water depths within the study area, and resulted in reduced flows to the Northwest Fork by diverting freshwater that historically flowed naturally to the Northwest Fork to the Southwest Fork and to tide. The altered drainage patterns and lowered groundwater levels due to canals, roads, and levees in many upper watershed natural areas further limited dry season flows. The permanent opening and stabilization of the Jupiter Inlet further compounded problems resulting from diminished flows by allowing more saltwater movement up the estuary. Significant reduction of the groundwater levels and lack of surface water storage in the tributary basins results in uncontrolled excess wet season flows, and limited availability of surface and ground water in the dry season.

These hydrologic alterations have substantially altered the species composition and structure of the native plant communities, reduced the abundance and diversity of animals, and facilitated the spread of

non-native vegetation. The various drainage and flood control features dissected the landscape into a mosaic of variously-sized habitat patches. The canals adjacent to the project area generally create barriers to wildlife movement, interfering with or preventing life functions of many native wildlife species. The channelization of flows in the parts of the Pal-Mar and Groves basins over-drains area wetlands and results in large erosive stormwater discharges in Cypress Creek. Ditching has increased drainage and reduced connectivity of natural upstream wetlands, altering hydroperiods and degrading their structural integrity and function. The large pulses of freshwater followed by periods of insufficient freshwater inflow into the Loxahatchee River estuary result in an unnatural salinity oscillation, further degrading ecological communities requiring stable salinity regimes. Insufficient base flows to the NWFLR have resulted in extensive changes to the riparian river vegetation. Collectively, the hydrologic changes have promoted the upstream movement of saltwater. As a result, cypress and other freshwater vegetation intolerant of elevated salinity conditions have been replaced by mangroves and other estuarine plant communities. If freshwater dry season flows are not increased to improve riverine system resilience, the salinity cline will continue to extend farther up river than under historical conditions, thereby converting more freshwater habitat to estuarine habitat. These effects are likely to be exacerbated by potential sea level rise (SLR) effects.

Wetland habitats, including wet flatwoods, hydric hammocks, and several different types of freshwater marshes and swamps, are vital components of the project area and dominate much of the western landscape. Wetland habitats are the most impacted areas within the project boundary both in acreage and numbers. A wetland assessment study conducted within the Pal-Mar/Cypress Creek and the Groves basins reported a substantial net loss in total wetland acreage ranging from 25% to 90% within the selected project study areas, based on photo-interpretation of 1940 and 2000 aerial photographs (C&N Environmental Consultants 2002). Key project wetland areas include Loxahatchee Slough, Pal-Mar, Cypress Creek, J.W. Corbett WMA, Jonathan Dickinson State Park, GWP, Dupuis Reserve, Hungryland Wildlife and Environmental Area and the Loxahatchee River floodplain.

Although the general extent of the natural areas within the project area is not expected to change significantly during the planning period, overall negative ecological trends in the remaining portions of the Loxahatchee River watershed are expected to continue into the future, with additional loss of resources through landscape alterations and degradation of habitat. Though some development may encroach, and some wetland impacts may occur, mitigation requirements should lead to replacement of lost wetland areas. Although land use projections indicate no net loss, impacts to surface and groundwater hydrology and the effects of the existing infrastructure and future water management practices will continue to cause drying out of the natural system.

2.4 Comparison of Existing and Future Without Project Conditions

Table 2-1 provides a comparison of existing and FWO project conditions. The table also includes references to sections within **Appendix C.1** that provide further details.

Table 2-1. Existing Conditions and Future Without Project Conditions.

Conditions	Existing Conditions	Future Without Project Conditions
Climate (including Sea Level Rise) (Appendix C.1 Section C.1.2)	The climate of the project areas is considered subtropical, with distinct wet and dry seasons, high rates of evapotranspiration (ET) and floods, droughts, and hurricanes. Almost two-thirds of annual rainfall is received during the wet season (May through October). Tropical storms and hurricanes provide major contributions to wet season rainfall with a high level of inter-annual variability and a low level of predictability. The balance of rainfall occurs during the dry season months (November through April). Average annual rainfall over the modeling period of record (POR) within northern Palm Beach and southern Martin counties is 62.6 inches, with variability from 45.7 to 89.9 inches (LECSR POR). Reference ET data from 2006 to 2014 was derived from North American Land Data Assimilations Systems (NLDAS) data, which provided complete spatial coverage of reference ET amounts using a predetermined grid resolution (2 km by 2 km; Brown 2013). ET returns an average of approximately 59 inches of water per year to the atmosphere (Giddings and Obeysekera 2018)	Climate change is expected to alter rainfall and ET patterns over the next 100 years. Sea levels relative to the Loxahatchee River and Estuary could rise 0.4 to 2.4 ft. over the next 50 years depending on the SLR scenario. The future conditions could ultimately effect the salinity levels within the river and estuary. Some examples of sea level change impacts in the future would be continued saltwater intrusion, reduced freshwater supply, retreating shoreline, and habitat transition. Flood damage reduction may also decline as a result of SLR. Most coastal flood control structures are gravity driven. Discharge capability of these structures may be reduced. The regional hydrologic models used to simulate with- and without project conditions require climatic and tidal data as boundary conditions. The model tidal boundary used in the regional hydrologic model was developed using historic tidal data from two primary (Naples and Virginia Key) and five secondary National Oceanic and Atmospheric Administration stations (Flamingo, Everglades, Palm Beach, Delray Beach, and Hollywood Beach). Simulation model tidal boundary conditions that reflect future sea level change were not available for the range of potential SLR expected. FWO sea level change scenarios are further described in **Section 6** and **Appendix H** as part of the assessment of the impacts of sea level change on project benefits (per USACE guidance ER 1100-2-8162 and ECB 2018-14). .
Geology (Appendix C.1 Section C.1.4)	Surface and shallow subsurface geology consists of undifferentiated, and mostly unconsolidated marine silicate and carbonate sands, silts, and limestone of Quaternary age, overlain by Holocene freshwater wetland soils. Thickness of Quaternary marine deposits is to approximately 100 ft to 150 ft below land surface (BLS) in Martin and Palm Beach Counties. There are no	The shallow subsurface geology is unlikely to change if this project is not implemented because most properties proposed for ecosystem restoration activities are under state or local ownership. It is likely that limerock mining operations will continue and even expand in western Palm Beach County outside of the project area with or without project implementation.

Conditions	Existing Conditions	Future Without Project Conditions
	active mining operations in the project area, although there are significant limerock mining operations on private lands to the west and south of the project area. Mining generally proceeds to depths of 40 to 60 ft BLS depending on rock quality. There are several deep borings constructed for Floridan Aquifer characterization showing deep subsurface geology of Eocene and Oligocene limestones to depths of 2,000 ft. There are a few historical exploratory boreholes completed for oil exploration extending to depths of 12,000 ft BLS in the project area.	
Soils (Appendix C.1 Section C.1.5)	Natural Resource Conservation Service (NRCS) soils data were used to identify the hydric soil types present within the project area. The NRCS has classified hydric soil groups based on their drainage characteristics. Soil groups A (drained sand and gravel with low runoff potential), B (moderately coarse soils with moderate infiltration rates), C (finer soils with low infiltration rates), and D (chiefly clay soils with high runoff potential) are all present within the project area. The hydrologic conditions in the project area have been altered by the construction of canals, channelization of natural waterways, drainage and/or impoundment of wetlands, and increased groundwater withdrawals. For geotechnical purposes, surface soils consist of poorly graded sands (SP) and sands with silt (SP-SM) in upland and over-drained areas. The areal extent of wetland peats represents less than 1 percent of the project area.	Hydric soil types in areas not affected by restoration activities would not be expected to change classification group. Hydric soil types that receive less water than under present conditions may convert to drier classification groups. Conversely, hydric soil types that receive more water than under present conditions may develop reduced infiltration rates and increased runoff potential characteristic of wetter classification groups. Based on current land use indicators, the landscape of south Florida would be developed consistent with County Growth Management Plans. While the majority of development is expected to occur on previously farmed lands, some wetland soils located in the area could be altered as a result of potential development. Wetland soils would be drained and/or displaced with fill materials to support the urban development. Existing C&SF drainage structures will continue to maintain reduced hydroperiod in many locations, continuing peat soil loss by oxidation and lightning-induced fires.
Vegetation (Appendix C.1 Section C.1.7)	The freshwater portion of the river supports beds of tapegrass (a freshwater submerged aquatic plant) and riverine cypress swamp. The estuarine portion of the river supports seagrasses, oysters and mangroves. Several types of freshwater wetlands are present in the project area, including wet flatwoods, hydric hammocks,	Possible future development, changes in availability and distribution of freshwater, and continued reduced flows to the Loxahatchee River could exacerbate and increase the rate of incursion of estuarine species into the freshwater floodplain

Conditions	Existing Conditions	Future Without Project Conditions
	depression marshes, wet prairies, floodplains, dome and strand swamps.	swamp, as well as cause changes in the existing wetland communities.
Invasive and Nuisance Species (Appendix C.1 Section C.1.23)	Florida Exotic Pest Plant Council (FLEPPC 2017) lists indicate 110 species of non-native plants have been documented to occur within the project area; 59 are FLEPPC Category I, 39 are FLEPPC Category II, and 22 are considered noxious weeds; 65 non-native animal species have been documented to occur within the project area.	It is expected that most of the invasive non-native plants and animals would continue to occur in the project area on private lands because the species are widespread in south Florida and propagules and organisms are transported readily throughout the region. Anthropogenic effects would continue to negatively impact the project area. New invasions and the expansion of invasive plant and animal species currently present would continue in the future without project scenario in those lands that are not managed actively. Native nuisance species such as cattails, Brazilian pepper, and downy rose myrtle would persist and could expand in the project area.
Threatened and Endangered Species (Appendix C.1 Section C.1.8)	The variety of natural habitats in the project area support eight threatened and endangered species for which analysis was requested by the USFWS: four birds (Everglade snail kite, wood stork, northern crested caracara, red-cockaded woodpecker), one reptile (eastern indigo snake), three mammals (Florida manatee, Florida bonneted bat, Florida panther), and one plant (Okeechobee gourd). Designated critical habitat for the Everglade snail kite and West Indian manatee did not occur within the project area. Many state listed species also occur throughout the project study area.	Existing federal laws [e.g., the Endangered Species Act, Marine Mammal Protection Act, the Migratory Bird Treaty Act, and Fish and Wildlife Coordination Act], federal regulations, and Executive Orders, along with similar state regulations, should be sufficient to preserve the continued existence of most endangered plant and animal species in the proposed project area. Given the projected decline of the system, there would likely be adverse effects (population declines, changes in distribution) to many threatened and endangered species that live within the project area; however, some of these effects would be partially mitigated potentially by development and implementation of species recovery plans and other public and private efforts.
Fish and Wildlife Resources (including state listed species)	Diverse fish and wildlife species occur throughout the project area including freshwater and saltwater species of aquatic macroinvertebrates, fish (both typical prey species and predatory fish), amphibians and reptiles, birds, with an emphasis on the	Existing C&SF, county, and municipal canals and drainage structures would continue to drain and de-hydrate the landscape. Disruption of the pre-development hydrology caused decreases in the ecological integrity of aquatic vegetation communities, and

Conditions	Existing Conditions	Future Without Project Conditions
(Appendix C.1 Sections C.1.10 and C.1.11)	iconic colonial wading birds characteristic of south Florida, and mammals.	disruption of aquatic productivity and function; these changes would likely persist or worsen. These changes have caused repercussions throughout the food web, including effects on wading birds, raptors, larger predatory fishes, reptiles, and mammals. These detrimental effects are likely to continue.
Essential Fish Habitat (Appendix C.1 Section C.1.9)	Constrained seasonal flows result in reduced habitat availability and undesirable water chemistry in the freshwater and estuarine zones of the river. Essential Fish Habitat for fish and invertebrates occurs in the estuary and river. Corals and live bottom habitat are likely not affected in the 20 meter and 30 meter offshore reefs. The absence of freshwater flows and/or the release of high level freshwater discharges into estuarine systems and coastal areas currently cause unfavorable conditions.	The Magnuson-Stevens Fishery Conservation and Management Act provides a mechanism to manage existing fisheries. The FWO project conditions would not improve the inflow of freshwater to the Loxahatchee estuary and Jupiter Inlet. Absence of seasonal freshwater flows will continue to result in reduced habitat availability and undesirable water chemistry in the freshwater and estuarine zones of the river.
Hydrology (Appendix C.1 Section C.1.12)	For this project, the area was refined to address specific questions with existing and proposed features in northern Palm Beach and southern Martin counties. The eastern boundary coincides with the Atlantic Ocean and follows the brackish Intracoastal Waterway (ICW), which serves as a stable physical boundary. The St. Lucie (C-44) Canal from the St. Lucie Estuary west to Lake Okeechobee is the northern boundary. The southern model boundary is the physical boundary of the L-10, L-12, and C-51 canals in central Palm Beach County. The Existing Condition Baseline (ECB) includes most features currently operating, with some exceptions. Features simulated in the ECB include the recent modifications to the G-92 structure, the North Lake Boulevard weir, wetland improvement areas constructed by Palm Beach County, regional system deliveries to the City of West Palm Beach, the east Corbett weir, and the existing canal operations for the SFWMD canals, local water control districts (298 Districts), and local developments. The main change from existing conditions not presently observed is the public water supply utility demand, which is based on SFWMD-permitted allocation, not on recently observed use. The	The FWO condition includes all ECB assumptions, except the L-8 Flow Equalization Basin (FEB) is assumed to be operational and receiving water from beyond the L-8 Basin. In addition, the FWO includes the recent proposal for the Avenir property, which creates two wetland areas in the northern portion of the property and an urban development in the southern section of the property. Additionally, reduced surface water flow volumes, and flashy storm flows to the Loxahatchee Slough and River would continue or increase as development occurs on former agricultural lands in the project area. Depressional wetlands and wetlands would continue to be over-drained, and would be characterized by upland plant communities and invasive species.

Conditions	Existing Conditions	Future Without Project Conditions
	Loxahatchee River Slough is bisected by the C-18 Canal resulting in diminished natural surface water flows. In addition, drainage and water control structures (ditching, canals, berms, weirs) have resulted in over-drained lands to in the northwest and western portions of the project area and reduced natural flow volume and durations through Cypress Creek and the Loxahatchee Slough. Over-drained areas show reduced hydroperiod durations, loss of hydric soils, and subsequent occupation by upland plant communities (e.g. slash pine) and invasive plant species (Old World climbing fern and Melaleuca).	
Water Quality (Appendix C.1 Section C.1.13)	Aquatic habitats within the LRWRP project area are very diverse and water quality conditions associated with those water bodies are correspondingly highly variable. Freshwater surface water systems within the project area include extensive wetland systems and both natural and man-made lakes. In addition to the relatively natural aquatic habitats, there are also extensive man-made canal networks and, while these are considered freshwater surface waters, their physical and chemical characteristics often differ markedly from natural systems. Variability in water quality within the Loxahatchee River watershed mirrors the diversity of land use. Within basins predominated by undeveloped lands that remain relatively pristine the water quality is characterized by low nutrient levels, variable but often elevated dissolved oxygen levels reflective of high biological productivity, and low concentrations of pollutants typically associated with land development (metals, petroleum hydrocarbons, other organics). Phosphorus and nitrogen compounds are of concern to the ecosystems of the Loxahatchee River Watershed, including the Loxahatchee River and Slough, Grassy Waters Preserve (GWP), and the Loxahatchee Estuary, as they have the ability to negatively affect the flora and fauna of aquatic ecosystems. There are several water bodies within the project boundary that have been identified to be	Implementation of water quality total maximum daily loads (TMDLs) and any future associated basin management action plans (BMAPs) within the study area should result in improved water quality conditions. TMDLs and BMAPs have been developed for Lake Okeechobee. Reasonable Assurance Plans are in the planning stage for other Loxahatchee river watershed area basins. Reasonable Assurance Plans are an alternative to Total Maximum Daily Load and Basin Management Action Plan development. Reasonable Assurance Plans are related to assessment category 4b for waters that are not placed on the 303(d) list as described in the state of Florida's Impaired Waters Rule in section 62-303.600, F.A.C. Reasonable Assurance Plans (4b) provide an implementation schedule and resource commitments that there are, or will be, pollutant loading reductions that will result in the waterbody achieving water quality targets to attain and maintain the designated use. Effects on water quality from agricultural activities should be reduced as land use near urban areas converts to residential and commercial development. Water quality in urban areas should improve somewhat as stormwater controls are implemented in areas that undergo redevelopment. The Loxahatchee River District has implemented efforts to move residential areas from septic

Conditions	Existing Conditions	Future Without Project Conditions
	impaired and for which a Total Maximum Daily Load (TMDL) planning effort is underway. Additional discussion of TMDLs and water quality is included in Appendix C.1.	systems to sewer wastewater treatment plant systems, which should reduce additional nutrient inputs to the river.
Air Quality (Appendix C.1 Section C.1.14)	Existing air quality in the affected environment is good to moderate. Martin and Palm Beach Counties continue to be classified by the United States Environmental Protection Agency (USEPA) as attainment/maintenance areas for the pollutant ozone (Southeast Florida Intrastate AQCR (established 12/11/70, 42 CFR 481.49).	It is anticipated that increased population and economic expansion in southeast Florida will result in an increase in ozone and other air quality pollutants. It is possible that counties, specifically Martin and Palm Beach, may be classified as air quality non-attainment zones if the population increases and economic expansion continues at the present day rates and air quality standards become more stringent in the future.
Hazardous, Toxic and Radioactive Waste (HTRW) (Appendix C.1 Section C.1.15)	Some lands potentially used for this project have a past or present agricultural land use. Activities conducted over the past 100 years are likely to have resulted in the presence of some HTRW materials on some of this land. State and Federal databases include information on the known HTRW contamination sites. Phase I and II environmental site assessments will be used to identify unknown HTRW sites as well as test cultivated areas for the presence of residual agricultural chemicals.	In the absence of the project, potential project lands would likely continue to be farmed. This would likely result in continued minor HTRW contamination associated with storing and applying agricultural chemicals as well as petroleum products. Cultivated soils would continue to have agricultural chemicals applied which may accumulate in the soils depending upon the properties of chemicals. Should a subsequent landowner opt to change the land use to something other than agriculture, they would have to meet all applicable Federal and State regulatory levels for that land use, which may require remediation of residual agricultural chemicals.
Noise (Appendix C.1 Section C.1.16)	Natural areas are generally characterized by natural noise sources, except where human activities produce noises from sources such as recreational vehicles (air boats, ATVs, swamp buggies, and motor boats, trucks, and cars). Existing sources of noise outside of the rural communities are sources such as vehicular traffic, agricultural vehicles, etc. The Pratt-Whitney jet engine test facility lies west of Hwy 711, between Pal-Mar and Corbett WMA. Within urban areas, existing sources of noise include transportation arteries, construction and land development, and operations at commercial and industrial facilities.	Sources of noise associated with surrounding land use are expected to be similar to those described in existing conditions. Noise impacts will change in areas where land use is projected to change from agriculture to more intensive uses such as residential/commercial. Within rural municipalities and urban areas, sound levels would be expected to be of greater intensity, frequency, and duration as areas are further developed from agricultural to residential/commercial due to increased noise from traffic, construction associated with development, and increased operations at commercial and industrial facilities.

Conditions	Existing Conditions	Future Without Project Conditions
Aesthetics (Appendix C.1 Section C.1.17)	Natural areas within south Florida are comprised of a variety of wetlands, marshes, wet prairies, pine flatwoods, and swamps. The land is very flat, with slight topographic rises on some levees and along ditch banks. Much of the visible topographic features are a result of human development, such as canals and levees. Pleasant perspectives of natural areas and the Loxahatchee River corridor are visible from distances near these features.	Urbanization is expected to occur in some areas in the future, resulting in some potential loss of opportunity to view aesthetically pleasing undeveloped agricultural and natural areas. Additional development would increase light pollution and minimize the ability to view dark-sky astronomical features.
Land Use (including wetlands and agriculture) (Appendix C.1 Section C.1.18)	The existing use of land within the study area varies widely and is generally agriculture and natural areas for conservation in the west, transitioning to suburban and high-density multi-family and industrial urban uses in the east. Wetlands: Seven major wetland types are found in the project area: freshwater depression marsh, dome swamp, floodplain swamp, strand swamp, hydric hammock, wet prairie, and hydric flatwoods. Agriculture: Agricultural production is an important sector of the state's economy. Despite continued urban expansion, agriculture throughout south Florida remains a valuable industry and employer. Agricultural products in the LRWRP study area includes sugarcane, citrus, peppers and similar vegetables.	Urban or commercial development may occur within major urban service areas located within the project area. Agriculture is expected to remain a dominant industry, although some presently agricultural areas may transition to urban or other development, Additional developments are being considered in the Avenir development (former Vavrus property) and on the property where the Shallow L-8 impoundment was proposed. These proposals would result in converting some acreage from agriculture to urban/suburban use. Some areas may be maintained undeveloped or modified by restoration efforts not conducted by USACE. Wetlands: Wetland areas may remain unchanged, or may show changes in vegetative patterns due to modified hydrologic conditions, or may be altered due to land use changes. Agriculture: Agriculture is considered fully developed in most areas of south Florida, where permitted acres and cropping practices are not projected to change significantly. Sugarcane, other field crops, sod, and greenhouse/nursery are expected to increase slightly over the planning horizon, while citrus will likely decline due to citrus greening disease and other pests.
Socioeconomics (including	Population: Based on 2010 Census count of total population as reported by the United States Census Bureau and 2017 population	Population: The LRWRP study area is situated in Palm Beach County and Martin County, the populations of which are

Conditions	Existing Conditions	Future Without Project Conditions
populations, municipal and industrial (M&I water supply/demand, flood control, and recreation) (Appendix C.1 Sections C.1.19, C.1.20, and C.1.25)	estimates by the University of Florida's Bureau of Economic and Business Research (BEBR 2017), the populations of Martin and Palm Beach counties increased by 4.6% and 7.1%, respectively, from 2010 through 2017. Florida's overall growth rate was estimated at 8.9% over this same period. Economic Activities: The industries that employ the greatest percentage of residents in both Martin and Palm Beach Counties are (1) educational services and health care; (2) the professional, scientific, management, and administrative service industries, and (3) retail trade in Palm Beach County and recreation/entertainment (including accommodation and food services) industries in Martin County, based on U.S. Census Bureau's 2012-2016 American Community Survey (ACS). Municipal and Industrial (M&I) Water Supply/Demand: Well fields in the surficial aquifer are the primary source of municipal water supplies, which meet domestic and some industrial demands. Industrial demands, including manufacturing, food processing, and power plant processes primarily use groundwater, while mining operations generally use surface water. The South Florida Water Management District (SFWMD) adopted a restricted allocation area rule for the Loxahatchee River watershed water bodies in 2007 that, in general, limits consumptive use withdrawals from the water bodies to the maximum used between 2001 and 2006. The actual public water supply withdrawals from the surficial aquifer in 2014 were 78 million gallons per day (MGD) from utilities within the project area. Flood Control: Areas may become flooded during heavy rainfall events due to antecedent conditions that cause saturation and high runoff from developed areas.	projected to increase by 28% and 21%, respectively, between 2017 and 2045 based on estimates by the University of Florida BEBR. These projected increases in population are slightly lower than that of 34% for the state of Florida overall. Economic Activities: Employment estimates released by the Florida Department of Economic Opportunity (FDEO) show that the industries projected to gain the most new jobs in Palm Beach County over the period from 2017 to 2025 are (1) Ambulatory Health Care Services; (2) Professional, Scientific, and Technical Services; and (3) Food Services and Drinking Places. Projections through 2027 by the Florida Office of Economic and Demographic Research also show annual growth in the number of tourists visiting the state. M&I Water Supply/Demand: In the Lower East Coast (LEC) planning area, groundwater from the surficial aquifer system is the predominant source of water for M&I uses. The restricted allocation area rule for the Loxahatchee River Watershed remains in effect. As a result, M&I users' reliance on water from alternative sources such as the Floridan aquifer, reuse, and other sources will grow significantly. Use of these alternative sources to meet a portion (10-15%) of future demands will continue in the future. Future public water supply demand from the surficial aquifer is estimated to increase from 738 MGD to 947 MGD within the project area. This estimate is based on a 25% population increase between 2016 and 2040. Public water supply demand from the Floridan Aquifer System is estimated to increase from 52.56 MGD to 104.41 MGD between 2016 and 2040. Like public water supplies, industrial demands are turning to alternative sources of water than the surficial aquifer system. Industrial demands are predicted to grow at the same rate as population.

Conditions	Existing Conditions	Future Without Project Conditions
	Recreation: Many opportunities exist to expand recreational activities because there are extensive acreages of natural lands, preserves and parks within the LRWRP area. These activities include, but are not limited to, hunting, camping, bicycling, hiking, horseback riding, canoeing, boating, swimming, and freshwater and saltwater fishing. There are also passive recreational activities available such as bird watching, nature photography, and nature appreciation.	Flood Control: Flood damage reduction needs have increased since the original C&SF Project was constructed and will likely continue to increase in the future. As agricultural and urban development continues, the volume, duration, and frequency of floodwaters may increase, and the actual level of flood damage reduction may decline in some areas. Flood damage reduction may also decline as a result of sea level change. Most coastal flood control structures are gravity driven. Discharge capability of these structures may be reduced. Recreation: Natural areas support a significant amount of outdoor recreation in the LRWRP, however, continued deterioration of these areas due to water management practices and continued development of urban infrastructure could reduce the quality of the recreational experience. All areas throughout south Florida are expected to have significant increases in demands for selected recreation activities with a commensurate need to increase development of the region's recreational resources and facilities. Many of the expenditures that support recreation come from tourists. It is important to recognize that participation in specific types of recreational activities is often linked to demographic factors such as age and income. Participation in activities requiring vigorous exercise is considerably higher for young people than for senior citizens, as there is growing awareness of the importance of maintaining physical fitness; as a result, an aging population is increasing their participation. There will be a continued need to consider and increase supply for activities such as hunting, camping, bicycling, hiking, horseback riding, canoeing, boating, scuba and snorkeling, and freshwater and saltwater fishing. In addition to the physical benefits an increased supply in active recreation provides, passive recreation such as bird

Conditions	Existing Conditions	Future Without Project Conditions
		watching, nature photography, and nature appreciation have been shown to benefit overall mental health and longevity.
Cultural Resources (includes Culturally Significant and Historic Properties) (Appendix C.1 Section C.1.22)	Many cultural resources are present throughout Palm Beach and Martin Counties. The Florida Master Site File (FMSF) data from the Florida Division of Historical Resources lists 38 National Register of Historic Places (NRHP) listed, 114 archaeological sites, 18 historical resources groups, 7 cemeteries, 13 bridges, and 6,751 standing structures, within the LRWRP study area. Most of the 38 NRHP listed sites are found in the central to western side of the project area, many of which are prehistoric campsites and middens. There are multiple sites concentrated on the west side of the Loxahatchee River and along Loxahatchee Slough. There is a potential that significant unrecorded archaeological sites are located within each of the proposed alternatives.	Future economic growth within the study area may lead to population increase and development of agricultural lands. Future development and expansion of infrastructure has the potential to adversely impact cultural resources during construction of roads, sewer systems and other facilities.

2.5 Structural and Operational Assumptions for Future Without Project Conditions

2.5.1 Structures G-160 and G-161 in the C-18 Canal

For LRWRP planning and analysis, this study assumes that structures G-160 and G-161 (**Figure 2-3**) are not part of the FWO condition even though they were constructed in the mid-2000s. The structures are evaluated as measures or features that may be included in project alternative plans. This decision was first made in the 2005 Feasibility Scoping Meeting Guidance Memorandum for the North Palm Beach County Part 1 study (predecessor study to LRWRP). The decision was confirmed for the LRWRP study in 2017.

It is important to note that the Comprehensive Everglades Restoration Plan (CERP) included the Loxahatchee Slough structure (G-160) and the Northlake Boulevard structure (G-161) components for the purpose of providing flows and enhancing hydroperiods in the Loxahatchee Slough, and to increase base flows to the NWFLR.

The SFWMD recognized that G-160 and G-161 water control structures were necessary to provide connectivity between the river and its historic headwaters and essential to deliver necessary dry season restorative flows to the NWFLR. In parallel with the earlier CERP study for North Palm Beach County Part 1 (NPBC-Part 1), the SFWMD moved ahead with the design and construction of G-160 and G-161. G-160 was constructed in 2004 and G-161 was constructed in 2007. These structures provide early and necessary benefits to the Loxahatchee Slough and the Loxahatchee River, while allowing delivery of additional water from and maintaining a more rainfall driven hydroperiod within the Grassy Waters Preserve (GWP).

During the LRWRP study, the Jacksonville District and SFWMD evaluated alternatives that include G-160 and G-161 and alternatives without the structures. Alternatives with the measures included both the cost of the structures and the ecosystem benefits they provide. The USACE and SFWMD will follow the requirements of Section 6004 of WRDA 2007 to execute a pre-partnership credit agreement (PPCA). A PPCA is one of the steps required in order to preserve potential credit to the non-federal sponsor for the costs of early construction. A PPCA was not prepared prior to construction because the construction occurred before enactment of WRDA 2007.

2.5.2 Additional Structures

Palm Beach Aggregates is currently excavating limestone from the C-51 Phase II rock mine. This mine is located south of the L-8 Canal, and immediately north and west of the existing C-51 Reservoir Phase I and L-8 Flow Equalization Basin. Mining is expected to continue. In the FWO condition, the facility is assumed to be a water-filled lake with a security fence. It would cover approximately 1,600 acres and be approximately 20 feet deep. This excavated mine is considered for potential use as an in-ground reservoir by the LRWRP study. Additional embankments, pump stations, and channels would allow storage as large as 44,000 acre-feet.

The proposed Avenir residential and commercial development is assumed to be complete in the FWO condition. Avenir has received most required permits and authorizations for construction. Avenir would be located between Northlake Boulevard, the North County Airport, the C-18W Canal, and the Mecca Farm property. The southern portion of the property will be developed. The northern portion will be conservation, restoration, or mitigation land. Agricultural drainage ditches in the northern area will be plugged and the area will have rain-driven hydrology with little additional surface water input from other

locations. There will be an access road from the southern developed portion northward to the Beeline Highway. There will be a canal or similar feature for release of flood water from the southern developed area northward toward the C-18W canal.

Martin County is repairing and improving a berm along the eastern edge of the Culpepper property in Pal-Mar. The work is assumed complete in the FWO condition. The complete berm will allow LRWRP to restore hydrology in Culpepper and help keep the water in Culpepper rather than lose the restoration water to the drainage canals of the residential areas immediately east of Culpepper.

2.5.3 Other CERP Projects

LRWRP assumes all CERP projects already authorized by Congress will be constructed and are part of the FWO condition. Authorized CERP projects are Indian River Lagoon-South, Picayune Strand Restoration Project, Caloosahatchee River (C-43) West Basin Storage Reservoir Project, Site 1 Impoundment Project, Broward County Water Preserve Areas Project, Biscayne Bay Coastal Wetlands Project, C-111 Spreader Canal Western Project, Melaleuca Eradication, Central Everglades Planning Project, and Central Everglades Planning Project Everglades Agricultural Area Reservoir. **Figure 2-5** shows the locations of pre-CERP ecosystem restoration projects and the authorized CERP projects except for one. Melaleuca Eradication is not shown because the project is a building for rearing biological control agents rather than a project that modifies hydrology. Some CERP projects, such as Central Everglades (USACE 2014), extensively interact with adjacent projects and achievement of project benefits depends on the completion and operation of the earlier projects. The LRWRP is almost entirely separate from the areas restored by these other, authorized projects and does not rely on their completion. The Loxahatchee watershed flows generally eastward to Jupiter Inlet and the Atlantic Ocean, and waters from the authorized restoration projects do not flow into the Loxahatchee watershed.

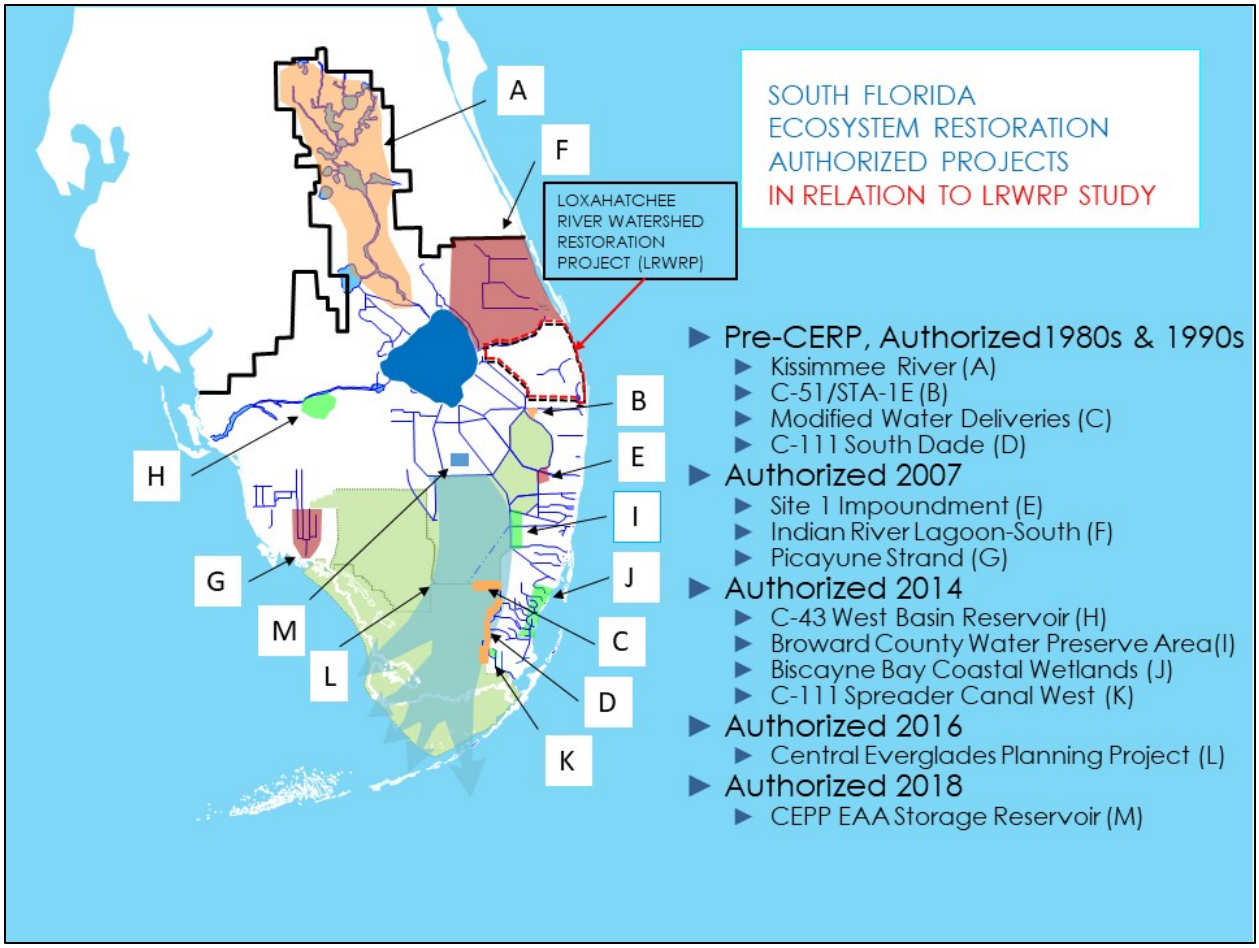

Figure 2-5. Authorized ecosystem restoration projects in southern Florida.

2.6 Related Restoration Projects by Non-federal Agencies

The following additional non-CERP projects have either been completed or are currently underway in an effort to improve environmental conditions in the project area:

- Palm Beach County: Cypress Creek Restoration, Hungryland Slough, Loxahatchee Slough Restoration, Pine Glades, Riverbend Park Hydrologic Restoration;
- Town of Jupiter: Jones Creek Restoration;
- Martin County: Culpepper Ranch, Cypress Creek Natural Area, Cypress Creek Weir.

Additional information on these projects can be found in the Loxahatchee River Preservation Initiative website (Loxahatchee River Preservation Initiative 2014).

2.7 Related Studies

A number of studies help describe existing conditions in parts of the study area.

2.7.1 L-8 Basin General Reevaluation Report (GRR) (2001)

The purpose of the L-8 GRR was to develop a regional plan for addressing the water resource problems within the L-8 Basin, as well as outside the basin (USACE 2001). The GRR was intended to cover the L-8 Basin and surrounding areas which are affected flows through the basin including the Loxahatchee Slough, the Lake Worth Lagoon, Lake Okeechobee, the City of West Palm Beach WCA (GWP), Water Conservation Area-1, STA 1 East and C-51. It was the intent of the GRR to select a plan that would have operational capability and flexibility to aid in the restoration of the J.W. Corbett WMA, Dupuis Reserve and Loxahatchee Slough, to reduce impacts to Lake Worth Lagoon, and to improve flood protection to the L-8 Basin. During the course of the L-8 GRR it became apparent that many of these same project purposes were being evaluated as part of the Restudy, and that the most efficient and effective way to address the water management issues of this area would be to develop solutions through the CERP process. This report provides information to support formulation of problems, opportunities, and management measures to address LRWRP objectives.

2.7.2 Cypress Creek/Pal-Mar and the Groves Basin Study (2002)

The SFWMD, Martin County, Palm Beach County, the Florida Fish and Wildlife Conservation Commission and the Florida Department of Environmental Protection (FDEP), teamed up to initiate this water resource study on the Cypress Creek/Pal-Mar and the Groves basins; two of the seven sub-basins in the Loxahatchee River watershed. These two basins occupy approximately 63 square miles (40,500 acres) in Martin and Palm Beach Counties and provide a significant source of surface water to the NWFLR. The majority of runoff from this basin is through overland flow from west to east and then transitions into the Ranch Colony Canal and Cypress Creek. The eastern portion of the basin has been significantly altered to accommodate agricultural and residential land uses. The primary objective of the study was to develop a set of models representing the hydrologic and hydraulic processes in these basins and to assess historic hydroperiods in the Cypress Creek/Pal-Mar and Groves Basins, flooding and scouring in the canals, the long-term basin-scale water budget and the water quality in the project area. Elements of these models are available for use in the LRWRP formulation of benefits and evaluation of constraints.

2.7.3 Northern Palm Beach County Comprehensive Water Management Plan (2002)

During the seven-year period from 1994-2001, the SFWMD and the City of West Palm Beach led a cooperative effort to develop the Northern Palm Beach County Comprehensive Water Management Plan (SFWMD 2002a). The general goals of this effort were to provide adequate present and future water supplies, protect water quality, provide flood protection for urban and agricultural lands, and protect and enhance important environmental resources. Specific measures that were developed to achieve these goals included: the impoundment of surface water in the C-51 and L-8 Basins, the linkage of storage areas through existing canal systems and newly constructed pumps and water control structures, the reconnection of historical flows north into the C-18 Basin and the Loxahatchee Slough, and augmentation of base flows to the NWFLR. This report provides the background for LRWRP plan formulation for watershed benefits and to evaluate water supply and flood damage reduction risk constraints.

2.7.4 The Loxahatchee River Watershed Action Plan (2002)

This action plan published by FDEP outlines a comprehensive assessment of the current condition and needs of the seven major sub-basins of the watershed, which are JDSP/Kitching Creek, Coastal, Estuary, C 18 Canal/J.W. Corbett WMA, Cypress Creek/Pal-Mar, Groves, and Wild and Scenic/Jupiter Farms. The Plan included over 60 proposed environmental projects in areas of educational activities, land management

activities, and "turn-dirt" improvement projects. This report provides further information on Loxahatchee River Watershed problems and opportunities, as well as management measures to consider in LRWRP plan formulation.

2.7.5 Loxahatchee River Minimum Flows and Minimum Water Levels (MFLs) (2002)

Florida law requires the Water Management Districts to develop a priority list and schedule for the establishment of MFLs for surface waters and aquifers within their jurisdiction (Section 373.0421 Florida Statutes). This list identified the need to develop a MFL for the Loxahatchee River, which was completed in the SFWMD's report, "Technical Documentation to Support Development of Minimum Flows and Levels for the Northwest Fork of the Loxahatchee River" (SFWMD 2002b). The MFL criteria developed for the NWFLR were to protect the remaining floodplain swamp community and downstream estuarine resources against significant harm. This document provided information to support project performance measure documentation in combination with any modifications needed to consider sea level change effects on sustaining the NWFLR.

2.7.6 Restoration Plan for the Northwest Fork of the Loxahatchee River (2006)

In partnership with the FDEP, Florida Park Service District 5 office (FPS-District 5), and the Loxahatchee River Environmental Control District (LRD), the SFWMD developed a Restoration Plan for the NWFLR (SFWMD 2006). After an analysis of historic and current flora and fauna communities, the Northwest Fork ecosystem was partitioned into five valued ecosystem components (VEC) including cypress swamp and hydric hammock in the freshwater riverine floodplain, cypress swamp in the tidal floodplain, fish larvae in the oligohaline zone, oysters in the mesohaline zone, and seagrasses in the polyhaline zone downstream. Performance measures for each VEC were developed to relate flow and stage in the floodplain and salinity in the river to the ecological health of the VECs and were used to evaluate the relative biological effects of each restoration flow alternative. It is important to note that one of the goals of these evaluations was to not only restore the river's health, but to ensure in the process that the downstream estuarine communities would not be harmed by increases in freshwater flows. Based on the application of hydrologic and salinity models, a preferred restoration flow was identified. This information was used to support performance measure documentation and benefits methodology for the NWFLR.

Since 2006, monitoring efforts recommended by the 2006 Restoration Plan have been conducted that culminated in an Addendum to the Restoration Plan (SFWMD 2012). The 2012 Addendum is a compilation of new knowledge gained during the five years subsequent to the release of the 2006 Restoration Plan and focuses on analysis of factors identified in that plan as needing more attention. The new research and monitoring results were organized into six major categories: (1) salinity and stage, (2) floodplain vegetation, (3) floodplain fish and wildlife, (4) estuarine flora and fauna, (5) water quality, and (6) restoration progress. In addition, this addendum evaluates the 2006 flow scenario in light of the results of these monitoring efforts. As part of the restoration plan update, the initial modeling that established restoration flow targets for the Northwest Fork was re-examined using new flow, salinity, and biological data and found to be valid. These flow targets are being used for this LRWRP Project.

2.7.7 CERP Project - North Palm Beach County Part 1 Plan Formulation

Between 2003 and 2010, the SFWMD and the USACE collaborated on the plan formulation for the North Palm Beach County Part 1 Project, a CERP project that included six of eight components of the Restudy that were located in northern Palm Beach and southern Martin counties. The Project Delivery Team (PDT) developed and analyzed a final array of seven alternatives resulting in the identification of a Tentatively

Selected Plan (TSP). That plan included a primary storage component of 45,000 acre foot (the L-8 Reservoir) and a collection of management measures that relied on a flow-way based delivery concept to provide restoration flows to the Loxahatchee River and its tributaries, as well as to provide for hydrologic restoration and connectively within the greater Loxahatchee River Watershed. Because the primary storage component included in the TSP was under consideration to be used as a flow equalization basin for addressing water quality concerns in the Everglades Protection Area, the team was asked to delay further analysis. Much of the work that was completed to develop the TSP was updated and used to refine alternatives for this renewed study.

2.7.8 Restoration Strategies

In 2012, to address water quality concerns associated with existing flows to the Everglades Protection Area, SFWMD, FDEP and the United States Environmental Protection Agency (USEPA) established a Water Quality Based Effluent Limit (WQBEL) for Total Phosphorus (TP) in discharges from Everglades STAs to assure that such discharges do not cause or contribute to exceedances of the State of Florida's numeric TP criterion in the EPA. Additionally, a suite of projects that work in conjunction with the Everglades STAs to meet the WQBEL were identified. These projects consist primarily of Flow Equalization Basins (FEB), STA expansions and associated infrastructure and conveyance improvements. Design and construction of many of the projects is currently ongoing and the entire suite of projects is scheduled to be completed by 2025. The L-8 Reservoir/FEB, located just north of STA-1E and STA-1W in the Restoration Strategies Eastern Flow Path, will provide approximately 45,000 acre feet of storage. The primary purpose of the L-8 Reservoir/FEB is to attenuate peak stormwater flows, temporarily store stormwater runoff and improve inflow delivery rates to STA-1E and STA-1W, thereby providing enhanced operation and phosphorus treatment performance to assist in achieving state water quality standards in the EPA. The L-8 Reservoir/FEB may also be used to assist in maintaining minimum water levels and reducing the frequency of dryout conditions within STA-1E and STA-1W, thus improving treatment performance of these STAs.

2.8 Native Americans

There are two federally recognized tribes within Florida: the Miccosukee Tribe of Indians of Florida and the Seminole Tribe of Florida. Both tribes share a long history of inhabiting the project area and maintain continued traditional and cultural practices in the region. These tribes regard the indigenous population of Florida as their ancestors. Readers should note that neither tribe has landholdings within the project area. Both tribes migrated into the region from Georgia and Alabama during the 18th and 19th centuries - fleeing the U.S. Army and evading the forced relocation policies of the Indian Removal Act (1830). Many of these groups moved into the swamp areas of southern Florida inhabiting the Everglades and remote areas of the region. The advent of the Civil War led to the abandonment of these removal efforts and the various Native American groups were largely left undisturbed. In 1928, the Tamiami Trail opened the Everglades to tourism and allowed access for Native American groups to share in the larger southern Florida economy.

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

Today the Miccosukee Tribe of Indians of Florida generally occupy reservations within two counties of southern Florida. The population primarily resides within the Tamiami Trail Reservation located 40 miles west of Miami, occupying a land area of 712.64 acres. The Miccosukee also maintain a perpetual lease within Water Conservation Area 3A on lands administered by the SFWMD. The tribe uses this lease to maintain their uniquely-adapted Everglades traditional and cultural lifeways including subsistence agriculture, medicinal practices, ceremonial activities, hunting, and fishing. Alligator Alley Reservation is the Miccosukee Tribe's largest reservation consisting of 74,812.37 acres, on the north and south sides of State Highway 84. Approximately 50,000 acres of this land is set aside for wetlands conservation, and the remaining is planned for development. Two additional smaller reservations are known as the Krome Avenue Reservations, located at the intersection of Krome Avenue and Tamiami Trail. These smaller reservations administer the Miccosukee Indian Resort and Gaming operations and the Miccosukee Tobacco Shop. The Miccosukee do not have landholdings in the project area.

The Seminole Tribal members reside on several reservations and properties, with the largest being those of Big Cypress, Hollywood, and Brighton Reservations. Hollywood is the headquarters location for the Seminole Tribe of Florida and the smaller reservations are Tampa, Fort Pierce, and Immokalee. As with the Miccosukee Indians of Florida, the Seminole Tribe of Florida practice traditional cultural activities uniquely adapted to the Everglades, including hunting, fishing, agriculture, medicinal, and ceremonial activities. They also engage in modern entrepreneurship through various enterprises including cattle ranching, gaming, and businesses centering on tourism. The culture and traditional practices of both tribes are closely aligned to the Everglades in such a way that careful consideration of effects is warranted. The Seminole do not have landholdings in the project area.

Table of Contents

3 PLAN FORMULATION 3-1
3.1 Plan Formulation Concepts 3-1
3.2 CERP Components 3-2
3.3 Management Measures 3-5
3.3.1 Identify Management Measures 3-5
3.3.2 Management Measure Screening 3-6
3.3.3 Components 3-7
3.4 Options – Combinations of Components Within Flow-ways 3-9
3.4.1 Identify Options 3-9
3.4.2 Screen Options 3-11
3.4.3 Summary of Screening Decisions of Options 3-14
3.5 Initial Alternatives 3-15
3.5.1 Developing Initial Alternatives from Options 3-15
3.5.2 Alternative 10 is the CERP Alternative 3-16
3.6 Screening Initial Alternatives 3-18
3.7 Alternatives Carried Forward 3-20

Tables

Table 3-1. CERP components considered in the LRWRP study. 3-3
Table 3-2. LRWRP components. 3-8
Table 3-3. Options for Flow-way 1. 3-9
Table 3-4. Options for Flow-way 2. 3-10
Table 3-5. Options for Flow-way 3. 3-11
Table 3-6. Screening scores for options in each flow-way. 3-13
Table 3-7. Options contained within each initial alternative plan. 3-16
Table 3-8. Comparison of CERP components and LRWRP Alt 10. 3-17
Table 3-9. Results of scoring of initial LRWRP alternatives. 3-19
Table 3-10. Major features of the alternatives. 3-23

Figures

Figure 3-1. Overview of plan formulation steps. 3-2
Figure 3-2. General location of flow-ways. 3-7
Figure 3-3. Locations of major features and expected restored wetlands for Alternatives 2 & 5. .. 3-24
Figure 3-4. Locations of major features and expected restored wetlands for Alternatives 10 & 13.3-25

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3 PLAN FORMULATION

The Loxahatchee River Watershed Restoration Project (LRWRP) plan formulation is based on the problems and objectives described in Section 1 and the existing and future without project conditions described in Section 2. This section summarizes a series of steps performed by the PDT that moves the team from a condition with broad, non-specific ideas to achieve the LRWRP restoration objectives to a small number of specific action alternatives. This section describes qualitative and semi-quantitative analyses that reduce the uncertainty and narrow the choices to the ones most likely to produce the ecosystem restoration benefits. Section 3 concludes with a small set of focused alternatives that are carried forward into Section 4, which summarizes results of a detailed modeling analysis on these few alternatives and concludes with the identification of the Recommended Plan. In addition, Section 3 also contains the Alternatives Description that is part of the NEPA EIS.

3.1 Plan Formulation Concepts

Plan formulation, the development of measures, grouping the measures, and assembly of full alternatives for LRWRP considered these concepts:

- Policy. U.S. Army Corps of Engineers (USACE) recently issued several refinements to long-standing policy and procedures on formulating plans for water resources projects (U.S. Army Corps of Engineers 2014, 2018). There is renewed emphasis to rely on existing information early in studies, to complete critical analyses and data collection at the correct time, and to defer other actions to later if not needed for the immediate decisions. These and other actions help study teams complete studies more efficiently and more quickly than was possible in the past.
- Comprehensive Everglades Restoration Plan (CERP). The LRWRP is part of the CERP. CERP was approved by Congress in Section 601(b)(1)(A) of the Water Resources Development Act of 2000 (WRDA 2000) as a framework for the restoration of the natural system. This framework includes 68 components for implementation. LRWRP measures and alternative plans should be consistent with this framework and the CERP components proposed for this part of the Everglades system. LRWRP plan formulation considers the alternative plan described in the CERP and how LRWRP would work with other CERP projects that are already authorized by Congress.
- Development. The Central and Southern Florida (C&SF) Project helped support urbanization and population growth in the project area and throughout south Florida. The LRWRP focuses first on restoration of undeveloped lands that were impacted by nearby development, then considers restoration of former agricultural lands that were once wetlands. LRWRP avoids urban and suburban development.
- Savings. The CERP Savings Clause Section 601(h)(5) of WRDA 2000 require that each project comply with requirements to not reduce levels of service for flood protection and not eliminate or transfer an existing legal source of water until a new replacement source is available. The C&SF Project is a multi-purpose project for flood protection, water supply, prevention of salt water intrusion, environment and other purposes. Many existing C&SF features perform multiple purposes. CERP regulations require that each study confirm that implementation of a CERP project would not remove the existing societal benefits produced by the C&SF project.
- Science. CERP studies rely on best available science. An interagency group of scientists developed a science-based plan for restoration of the Loxahatchee River. This plan described valued

ecosystem components and developed flow targets that would establish conditions to restore these valued components. The PDT relied on the best science in this restoration plan to establish the LRWRP flow targets.

- Uncertainty. There are multiple types of risk and uncertainty during a planning study. The PDT recognized uncertainty associated with using existing information during the screening decisions, so used a coarse (1 to 4) scale to estimate performance rather than a fine-grained scale that would suggest greater precision. In addition, screening decisions relied on engineering judgment together with the coarse quantitative scores. Uncertainties are reduced during the course of the study as additional information is gathered and selected analyses are completed.
- Changes. While proposing measures and alternatives, and during screening, the PDT considered the ability of the measures and alternatives to adjust to changing conditions or to perform effectively in spite of changing conditions. Later, once the Recommended Plan was identified, the PDT included an adaptive management plan that includes optional changes to implement into the project if the ecosystem does not respond as expected or the alternative does not do what it was designed to do.

The PDT embraced these concepts while completing a series of steps of building and screening decisions to narrow down to a few reasonable alternatives from which to identify the Recommended Plan. **Figure 3-1** displays an overview of the steps. The rest of Section 3 expands on each of these steps.

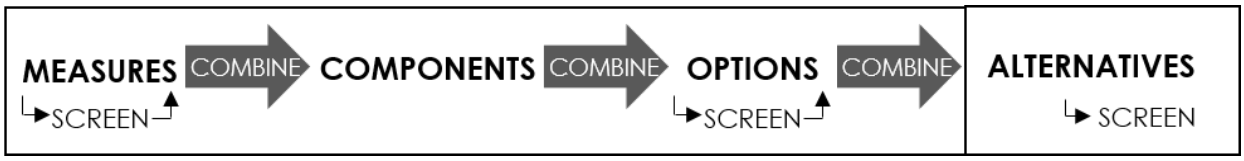


Figure 3-1. Overview of plan formulation steps.

3.2 CERP Components

CERP contains 68 components proposed for locations distributed across south Florida. Since this LRWRP study is part of CERP, initial plan formulation began with an analysis of the proposed CERP components from the Comprehensive Plan (U.S. Army Corps of Engineers 1999) that address the Loxahatchee River Watershed and the objectives of LRWRP. The three components are presented in **Table 3-1**. Component K includes a 48,000 acre-foot reservoir, plus aquifer storage and recovery, pumps, and water control structures. Component GGG is the same 48,000 acre-foot above ground/in-ground reservoir described in Component K, but without the other measures. The third component is an Other Project Element (OPE) called Pal-Mar and J.W. Corbett WMA Hydropattern Restoration. This component, like most OPEs in the CERP Recommended Plan, was conceptually described in the Comprehensive Plan report.

Table 3-1. CERP components considered in the LRWRP study.

Component from the Comprehensive Plan	Design and Details	Purposes
Component: K, L-8 Project **Main Report Section**: 9.1.8.2 Water Preserve Areas / L-8 Basin **Appendix A4:** Component K6, L-8 Project	**Design**: (1) 48,000 acre-foot storage: above ground/in ground reservoir, with pumps; embankment with slurry wall; 1,500 cfs inflow pump at reservoir; 1,500 cfs emergency outflow; 300/400 cfs pumped outflow at reservoir; 1,000 cfs back pump in C-51 Canal near S-155A; (2) Aquifer Storage and Recovery (ASR) for 50 million gallons per day with pre and post water quality treatment. ASRs located along the City of West Palm Beach Lake Mangonia (water supply lake); (3) M Canal Improvements: increase pump capacity to 300 cfs in L-8 Tieback Canal, water control structures (300 cfs Upper M-1 Basin Pump, 200 cfs Lower M-1 Basin pump), and canal capacity improvements; (4) New structure in south leg of C-18 canal just south of the west leg; (5) 50 cfs pump for water supply deliveries to utilities; (6) Recharge canal for coastal wellfields; (7) Culverts under Bee Line Highway for deliveries to Loxahatchee Slough; (8) Stormwater treatment areas, TBD. **Assume**: Indian Trail Improvement District will adopt an operation plan which prioritizes discharges first to M-Canal/Grassy Waters Preserve (GWP) and second to C-51 Canal. **Operation**: Capture excess L-8, C-51, and C-17 basin water in the reservoir. Release from reservoir to L-8 Tieback Canal and M-Canal to GWP; From GWP, deliver water either to water supply facilities to meet urban water supply demands or pass through flow to enhance hydroperiods in Loxahatchee Slough and increase base flows to the Northwest Fork of the Loxahatchee River.	**Purposes**: Reduce **number and magnitude** of discharge events to Lake Worth Lagoon (LWL) that exceed desired average flow rate of 500 cfs; Reduce average **annual volume discharged to tide** in the C-51 Canal) by redirecting storm water runoff into storage for subsequent **water supply** (route through GWP to Lake Worth Drainage District) and **environmental** (route through GWP to Loxahatchee Slough and River); Provide **increased drainage** [reduce flood risk] to the C-51 Basin and southern L-8 Basin by lowering average stages in the C-51 Canal. Increase **water supply** availability; Provide flows to enhance **hydroperiods** in Loxahatchee Slough; Increase **base flows** to Northwest Fork of the Loxahatchee River;
Component: GGG, C-51 and Southern L-8 Reservoir **Main Report Section:** 9.1.8.2 Water Preserve Areas / L-8 Basin	**Design**: (1) 48,000 acre-foot storage: above ground/in ground reservoir, with pumps; embankment with slurry wall; 1,500 cfs inflow pump at reservoir; 1,500 cfs emergency outflow; 300/400 cfs pumped outflow at reservoir; 1,000 cfs back pump in C-51 Canal near S-155A; (2) Assume 1,800 acre reservoir with 1,200 usable acres with the water level fluctuating from 10 feet above grade to 30 feet below grade. The final size, depth and configuration will be determined through more detailed planning and design.	Reduce **number of events** when discharges to Lake Worth Lagoon (LWL) exceed desired average flow rate of 500 cfs; Reduce **magnitude of events** exceeding desired flow rate of 500 cfs; Reduce **average annual volume discharged to tide** (over S-155 structure in the C-51 Canal) by detaining storm water runoff for

Appendix A4: Component: GGG6, C-51 and Southern L-8 Reservoir	**Operation**: Fill the reservoir with excess water from southern L-8 basin (L-8 Canal) and the C-51 Basin (C-51 Canal), when excess water flows over the S-155 structure. Releases through L-8 Tieback Canal, M-Canal, to GWP; then either to water supply facilities or to Loxahatchee River for environmental benefits. **Note**: This 48,000 acre-feet reservoir in Component GGG is the same 48,000 acre-feet reservoir that is part of Component K.	subsequent **environmental** (route through GWP and Loxahatchee Slough and River) and **water supply** (route to GWP and Lake Worth Drainage District); Provide **increased drainage** to the C-51 Basin and southern L-8 Basin by lowering average stages in the C-51 Canal. Increase water supply availability and flood protection. Provide flows to enhance hydroperiods in Loxahatchee Slough. Increase base flows to Northwest Fork of the Loxahatchee River.
Component: Other Project Element, Pal-Mar and J.W. Corbett WMA Hydropattern Restoration. **Main Report Section**: 9.1.8.1, Pal-Mar and J.W. Corbett WMA Hydropattern Restoration. **Appendix A6:** Pal-Mar and Corbett Hydropattern Restoration.	**Design**: not specified. **Operation**: not specified. **General text**: Water control structures, canal modifications and acquisition of 3,000 acres between Pal-Mar and Corbett. Provide hydrologic connections between Corbett and 1) Moss Property, 2) C-18 Canal, 3) Indian Trail Improvement District, and 4) L-8 Borrow Canal. Hydrologic connections and acquisition of this remaining privately owned parcel of land would form an unbroken 126,000-acre greenbelt extending from the Dupuis Reserve near Lake Okeechobee across the Corbett WMA, and connecting with Jonathan Dickinson State Park.	**Purposes**: Extend the **spatial extent** of protected natural areas; Increase **connectivity** of hydrology, flora, and fauna between natural areas; Improve seasonal timing and distribution of water to improve **hydropatterns** in drained areas.

Almost all of the measures from the L-8 Project (K), the C-51 and Southern L-8 Reservoir (GGG), and Pal-Mar Corbett Hydropattern Restoration (OPE) were included in the management measures considered during plan formulation. The 48,000 acre-foot above ground/in ground reservoir described in CERP (#1 of Component K and #1 of Component GGG in **Table 3-1**) cannot be implemented exactly as it was described in 1999. This reservoir has been repurposed as a flow equalization basin for Stormwater Treatment Areas (STAs) 1E and 1W as part of the State of Florida's Restoration Strategies to achieve water quality standards. It is not available for LRWRP. LRWRP considers a similar reservoir proposed for a nearby location. USACE policy guidance does not support formulation for single purpose water supply measures (#2, #5, and #6).

3.3 Management Measures

Management measures are the smallest building blocks of alternative plans. Management measures can be features that are constructed or removed. They can also be operational changes. Management measures are developed to address project objectives and to avoid project constraints.

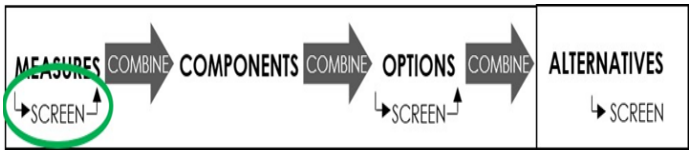
3.3.1 Identify Management Measures

The first step to develop alternative plans is to identify management measures (**Figure 3-1)**. The PDT assembled a list of 98 management measures for LRWRP from multiple sources. The first source of measures came from the CERP report (U.S. Army Corps of Engineers 1999) and the largest set of management measures came from the North Palm Beach County – Phase 1 study effort. Additional management measures came from agency PDT members and the public. At the broadest level, the management measures provide storage, reduce drainage, or improve connectivity/reduce barriers. The measures can be further grouped in the following descriptive categories:

1. Storage features - shallow, intermediate and deep water reservoirs, and aquifer storage and recovery for capturing, holding and delivering both normal and peak flows and releasing water when water is required.
2. Control structures – structures to help control water to desirable elevations while still allowing for flow, e.g. weirs, gates at culverts.
3. Backfill or plugging of canals – internal drainage and routing features in the system would be plugged, partially or completely backfilled to improve surface water distribution and eliminate drainage.
4. Seepage barriers – to reduce seepage from restored wetlands into nearby private lands or to reduce seepage from natural areas into canals.
5. Spreader canal – shallow canals or swales to distribute and improve water delivery.
6. Pump stations - new pump stations to distribute and improve water delivery.
7. Conveyance canals – canals to move water into and out of surface water features.
8. Bridges and culverts – new structures to be used to allow water flows through existing barriers in the systems.
9. Removal of levees and berms – levees or berms would be degraded or removed to allow water to sheetflow freely.
10. Operational changes or other non-structural structural solutions – adjustments to operational criteria to improve timing and distribution of flow.
11. Vegetation management measures – Measures to control invasive/exotic species, promote restoration of native species, and/or improved habitat structure and function (e.g., vegetation removal, treatment, fire, plantings). Measures will also be considered to support estuarine habitat structure, such as, oyster restoration (e.g., substrate, oyster spat, and cultch) and/or submerged aquatic vegetation plantings.
12. Adaptation planning measures - Salinity barriers such as Obermeyer weirs or oyster bars to limit salinity intrusion from increased sea levels.

Most of the 98 management measures are distinct features or actions. Only a few of them are different sizes or different locations of a particular feature. The full list of management measures is available in Appendix E - Plan Formulation, **Table E-1**.

3.3.2 Management Measure Screening



The second step to develop alternative plans is to screen some of the management measures from further consideration. PDT members applied prior experience and professional judgment to assign each management measure a yes or no for each of the following criteria.

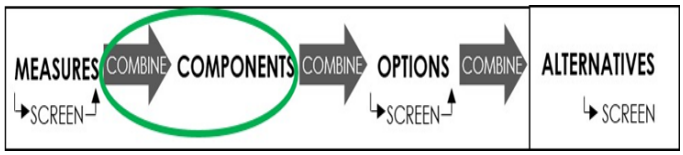
1. Contribute to at least one of the five project objectives
2. Avoids violation of the three project constraints
3. Acceptability to stakeholders and sponsor
4. No significant adverse environmental impacts
5. Not cost prohibitive

A management measure had to meet at least one of the five project objectives and not violate any of the project constraints for the measure to be retained. A management measure also had to meet three additional criteria: be acceptable, not create significant adverse environmental effects, and not be cost prohibitive.

Twelve of the 98 measures were assigned “no” for one or more of the criteria, and were eliminated from further analysis. One measure was initially screened but the decision was reversed and the measure was retained. Seventy-four measures were retained for further analysis and potential inclusion in project alternatives. The remaining 11 measures had too much uncertainty to make a clear decision to retain or eliminate. These 11 measures were tentatively kept until additional information was developed. Results of screening decisions for each of the 98 management measures are shown in Appendix E - Plan Formulation, **Table E-1**.

Sea level rise (SLR) was considered while screening the measures, but it was not an explicit screening criterion for the measures. Relative sea level is rising in south Florida, but the future rate is uncertain. Most of the management measures would be located well inland and at elevations higher than the 2.4 feet sea level rise predicted by the USACE high rate curve in 50 years and the 6.5 feet in 100 years (see **Appendix H** for details of sea level rise calculations). SLR was not expected to affect these management measures. Although SLR was not an explicit screening criterion, it is anticipated that increasing the base flow to the Loxahatchee Estuary would limit saltwater intrusion, thereby potentially reducing the effect of sea level rise. Therefore, the alternative in which the wet and dry season daily flow target is met, in terms of percent of days, would likely perform the best against SLR.

3.3.3 Components



The third step to develop alternative plans is to combine individual management measures into components. Components are sets of management measures that are defined by dependency or adjacency. A measure is dependent when it requires other measure(s) to be implemented in order for it to work. The measures of a component are usually located near each other. Generally, the measures of a component are implemented together or not implemented at all. When identifying components, the PDT also identified and removed measures that were redundant.

Flow-ways (FW) are locations in the study area based on existing natural areas, topography, and associated canals, and are generally separated from each other by developed lands. Each flow-way represents a pathway for water to flow from the watershed to the Loxahatchee River. See **Figure 3-2** for the general locations of the three flow-ways. The PDT produced 22 components, 8 in FW1, 7 in FW2, and 7 in FW3. **Table 3-2** lists the names of the components by flow-way.

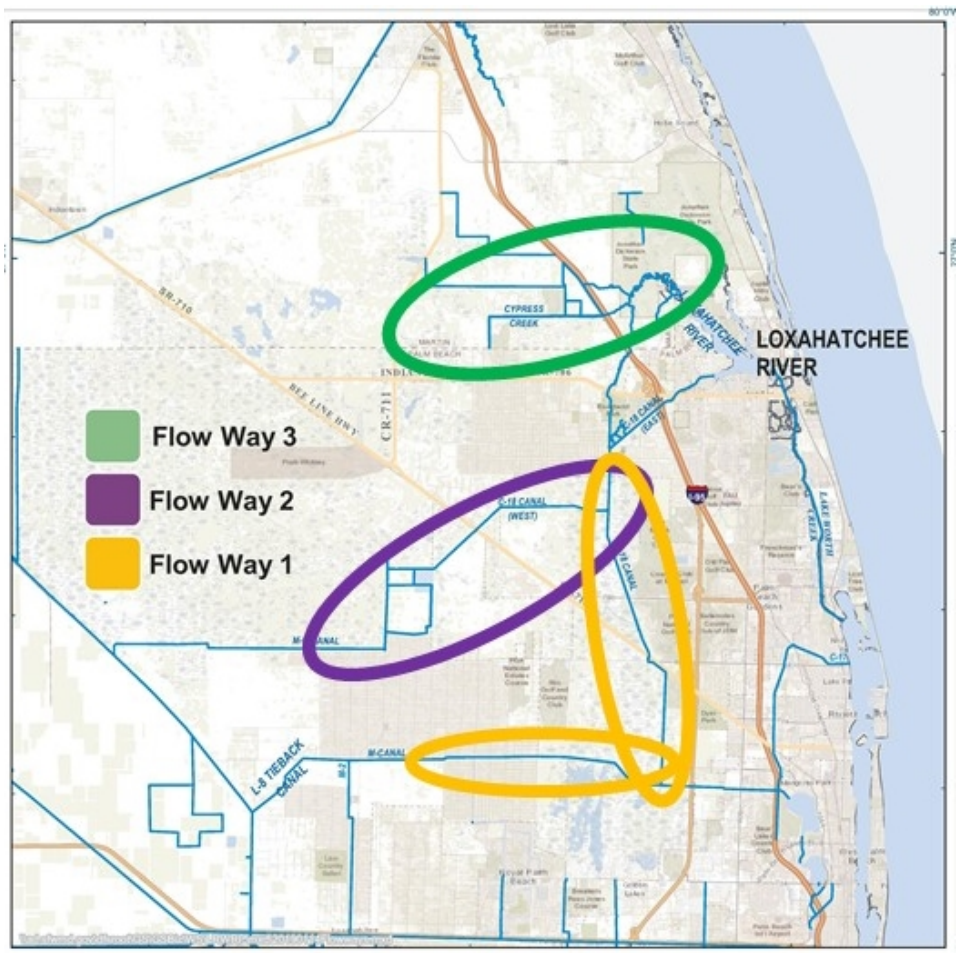


Figure 3-2. General location of flow-ways.

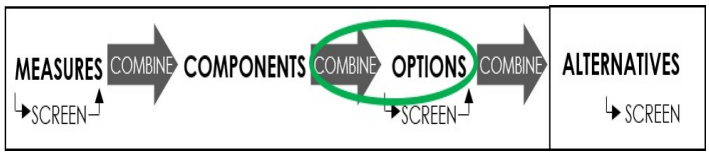
Table 3-2. LRWRP components.

Flow-way	Component Name	Description and Purpose
1	G-160	Structure in canal, to restore hydroperiod in Loxahatchee Slough
1	G-161	Release Grassy Waters Preserve (GWP) water to Loxahatchee Slough
1	GWP triangle	Remove topographic barriers (berms) to improve connectivity
1	ITID water to M Canal to GWP	Pump station within ITID to send ITID Lower M-1 Basin water from M-1 Canal to M Canal, then east to GWP and north to C-18 Canal and Loxahatchee Slough
1	M Canal improvements	Conveyance, WQ feature
1	Shallow storage, L-8 Basin	Location, size TBD; include pump, channels
1	Deep storage, L-8 Basin	C-51 Reservoir, volume TBD, include pump, channels…
1	Moss Restoration	Large restoration, connect J.W. Corbett WMA, reroute ITID discharges, flow-way, connect to L-8 Canal (or without ITID discharges)
2	C-18W Reservoir	Above ground reservoir (several volumes), inflow pump, discharge structure, seepage control, located on the Mecca Farm property near the C-18W Canal
2	ASR at C-18 W storage	Several numbers of wells, supplement volume of the reservoir
2	Relocate C-18 weir	Relocate from east side to west side of Beeline Highway, w/ or w/o back-pump
2	Connect M-O Canal to the Mecca Farm property or the C-18W Reservoir	A canal, uses pump
2	Natural storage on the Mecca Farm property	Restore natural topography, culverts under Beeline, bridge for Beeline, backfill interior canals in J.W. Corbett WMA, pump to protect Caloosa development
2	Luckey Tract seepage barrier	To keep Luckey Tract water on-site, rather than seep south into the C-18W Canal
2	Structure in C-18W Canal	Near confluence of C-18 Canal, to increase stage in C-18W Canal and improve conditions in Luckey Tract and Loxahatchee Slough
3	Kitching Creek Hydration	Spreader Canal at Jenkins Ditch at Johnathan Dickinson State Park (JDSP) northern boundary; weir or plug on Jenkins Ditch near connection with Kitching Creek
3	Moonshine Creek & Gulfstream East	Connect Hobe St. Lucie Conservancy District (HSLCD) ditch to Moonshine Cr; clear vegetation in Moonshine Creek; fill Gulfstream ditch and re-grade to historic topography
3	Cypress Creek Canal	Replace Cypress Creek Canal weir; raise northern berm at Ranch Colony
3	Restore Gulfstream West as a Flow through Marsh	Partial backfill & relocate southern end of HSLCD canal, small pump, flow through marsh, discharge structure
3	Restore Nine Gems (part of Pal-Mar East)	Plug N-S ditches; remove pipes; improve northern berm; construct western berm
3	Culpepper (part of Pal-Mar East) and edge of Pal-Mar	Automate existing twin 84 inch culverts; improve eastern berm; backfill northern canal; pumps at Thomas Farm to redirect drainage to north side of Nine Gems
3	Cypress Creek Natural Area and Shiloh	Pump & spreader swale at Mack Dairy Road; restore channel & marsh in south prong Cypress Creek within Shiloh; reconnect central prong Cypress Creek to Cypress Creek Canal

3.4 Options – Combinations of Components Within Flow-ways

The 22 components were combined into larger groups called "options". Options are the next larger building block toward complete alternative plans for ecosystem restoration. Section **3.4.1** describes how the options were assembled from smaller components, and Section **3.4.2** describes how the number of options was reduced to the ones that would be combined to produce complete alternative plans.

3.4.1 Identify Options



The fourth step to develop alternative plans is to combine components into options. The strategy for assembling options included an initial focus on the largest problems or opportunities in a flow-way. After that, additional components were added so that the entire option would continue to work as effectively as possible to achieve the study objectives. The focus items for assembling options and tables displaying the components within each option are presented below for each flow-way.

In Flow-way 1, the first focus was on conveying water already in the watershed and rehydrating wetlands drained by the C-18 Canal. The second focus was storing water from sources that currently send water away from the Loxahatchee River watershed, then delivering the water toward the river. **Table 3-3** displays a "y" highlighted green for each component included in each Flow-way 1 option and an "n" when the component is not part of the Flow-way 1 option. Flow-way 1 options are labeled 1-A through 1-G. The structures G-160 and G-161 are part of early construction and are kept together during formulation. Options 1-A through 1-D incorporate all combinations of Components G-160/161, ITID water and M Canal Improvements. M Canal Improvements could be implemented without new storage features (1-C), but deep storage in L-8 Basin was assumed to require M Canal Improvements (1-G), so deep storage without M Canal Improvements was not included. Shallow storage in L-8 Basin would not require the added conveyance of M Canal Improvements.

Table 3-3. Options for Flow-way 1.

Component	Description/purpose/estimated benefit	No Action	1-A	1-B	1-Bi	1-C	1-D	1-E	1-F	1-G
G-160	Restore hydroperiod in Loxahatchee Slough	n	y	y	y	y	y	y	y	y
G-161	GWP water to Loxahatchee Slough	n	y	y	y	y	y	y	y	y
GWP triangle	Improve connectivity	n	n	y	y	y	y	y	y	y
ITID water to GWP to Loxahatchee Slough	Pump, IDIT M-1 Canal to M Canal, to GWP	n	n	n	y	n	y	n	n	n
M Canal improvements	Conveyance, WQ feature	n	n	n	n	y	y	n	n	y
Deep storage, L-8 Basin	C-51 Reservoir, volume TBD, include pump, channels…	n	n	n	n	n	n	n	n	y
Shallow storage, L-8 Basin	Location, size TBD; include pump, channels	n	n	n	n	n	n	n	y	n

Component	Description/purpose/estimated benefit	No Action	1-A	1-B	1-Bi	1-C	1-D	1-E	1-F	1-G
Moss Restoration	Connect to J.W. Corbett WMA, reroute ITID discharges, flow-way, connect to L-8 Canal	n	n	n	n	n	n	y	n	n

In Flow-way 2, the first focus was on storing water from sources that currently send water away from the watershed, then deliver the water to the Loxahatchee River. The second focus was on restoring wetlands within the flow-way. **Table 3-4** displays a "y" highlighted green for each component included in each Flow-way 2 option and an "n" when the component is not part of the Flow-way 2 option. Flow-way 2 options are labeled 2-A through 2-H. An Option with all Components is not feasible. First, we cannot implement a reservoir (C-18W) and a natural flow-way on the same location. Second, including both the Luckey Tract seepage barrier and the structure in the C-18W Canal is not reasonable because both would serve the same purpose to keep water from flowing from Luckey to the canal. One of the two would be sufficient.

Table 3-4. Options for Flow-way 2.

Component	Description/purpose/estimated benefit	No Action	2-A	2-B	2-C	2-D	2-E	2-F	2-G	2-H
C-18 W Reservoir	Above ground reservoir, inflow pump, discharge structure, seepage ctrl	n	y	y	y	y	y	y	y	n
ASR at C-18 W storage	Several numbers of wells, supplement volume of the reservoir	n	n	y	n	n	y	y	y	n
Relocate C-18 weir	To west side of Beeline Hwy, w/o backpump	n	n	n	y	n	y	n	y	n
Connect M-O Canal to Mecca property or C-18 W Reservoir	By canal, uses pump	n	n	n	n	y	n	y	y	y
Structure in C-18W Canal	Near confluence of C-18 Canal, to increase stage in canal and improve Luckey Tract and Loxahatchee Slough	n	n	n	n	n	n	n	y	n
Natural storage on Mecca property	Restore natural topography, culverts under Beeline Hwy, bridge for Beeline Hwy, backfill interior canals in J.W. Corbett WMA, pump to protect Caloosa and Wind-in-the-Pines developments	n	n	n	n	n	n	n	n	y
Luckey Tract seepage barrier	To keep Luckey water from seeping to C18W	n	n	n	n	n	n	n	n	y

In Flow-way 3, the overall approach was to reduce rapid drainage and retain water on the landscape longer, to restore wetlands and improve base flow to the Loxahatchee River. The first focus was on reducing the rapid runoff through the three modified historic creeks. The second focus was further elimination of drainage features in the landscape gradually farther from the creeks. **Table 3-5** displays a "y" highlighted green for each component included in each Flow-way 3 option and an "n" when the

component is not part of the Flow-way 3 option. Flow-way 3 options are labeled 3-A through 3-F. In summary, the PDT developed 22 options: 8 for FW 1, 8 for FW 2, and 6 for FW 3.

Table 3-5. Options for Flow-way 3.

Component	Description/purpose/estimated benefit	No Action	3-A	3-B	3-C	3-D	3-E	3-F
Kitching Creek Hydration	Spreader canal at Jenkins Ditch at JDSP northern boundary; weir or plug on Jenkins Ditch near connection with Kitching Creek	n	y	y	y	y	y	y
Moonshine Creek & Gulfstream East	connect HSLCD ditch to Moonshine Creek; clear veg in Moonshine Creek; fill Gulfstream ditch and re-grade to historic topography	n	y	y	y	y	y	y
Cypress Creek Canal	replace Cypress Creek Canal weir; raise northern berm at Ranch Colony	n	n	y	y	y	y	y
Restore Gulfstream West as a Flow through Marsh	partial backfill & relocate southern end of HSLCD Canal, small pump, flow through marsh, discharge structure	n	n	n	y	y	y	y
Restore Nine Gems (part of Pal-Mar East)	plug N-S ditches; remove pipes; improve northern berm; construct western berm	n	n	n	n	y	y	y
Restore Culpepper (part of Pal-Mar East, and edge of Pal-Mar)	Automate existing twin 84 inch culverts, improve eastern berm; backfill northern canal; pumps at Thomas Farm; redirect drainage to north side of Nine Gems	n	n	n	n	n	y	y
Cypress Creek Natural Area and Shiloh	pump & spreader; restore channel & marsh in south prong Cypress Creek in Shiloh; reconnect central prong Cypress Creek to Cypress Creek Canal	n	n	n	n	n	n	y

3.4.2 Screen Options

The fifth step to develop alternative plans is to screen options. The options per flow-way underwent screening within flow-ways using the eight criteria listed below. Each option was assigned a score of 1 (worse) to 4 (better) for each criterion. Screening scores were developed during a series of meetings by an interagency team with representatives from USACE, SFWMD, U.S. Fish and Wildlife Service, Florida Department of Environmental Protection, Florida Department of Agriculture and Consumer Services, Loxahatchee River District, Jonathan Dickinson State Park, Martin County, Palm Beach County, City of West Palm Beach, and Indian Trail Improvement District. These representatives have extensive experience in the study area and brought biological, hydrology and water management, and engineering experience to the team.

1. **Volume and Timing to Lainhart Dam** (FW1 & FW2 only) (interpret prior modeling)
2. **Timing of Discharge to Northwest Fork** (FW3 only) (professional judgment)

3. **Natural Storage/Wetland Restored Area** (GIS of hydric soils)
4. **Connectivity** (the removal of barriers to flow and migration) (ecological criteria)
5. **Flexibility** (the speed, ease, efficiency of moving water to adjust to short-term, real-time changing conditions) (professional judgment)
6. **Robustness** (to function effectively in the face of longer-term, uncertain future events, such as climate change [inland hydrology or sea level]) (professional judgment)
7. **Compatibility** (with future restoration increments) (professional judgment)
8. **Nearness to NW Fork** (wetland restoration closer to the Northwest Fork will provide more benefits to the river than restoration farther away.) (GIS)

Table 3-6 shows the screening scores for each option. The scores for all the options were summed. Quantitative planning level cost estimates were not available at the time of the screening. Individual screening decisions are discussed in the text that follows the table.

Table 3-6. Screening scores for options in each flow-way.

Option Description	Option Code	Flow vol-ume to Lainhart Dam	Timing of Discharges to NW Fork	Natural Area Storage	Con-nectiv-ity	Level 1 Sub-total	Flexibility (Adapta-bility)	Robustness (Adaptabil-ity)	Compatibility w/ Future Projects (Adaptability)	Nearness to NW Fork	Level 2 Subtotal	Total Levels 1 + 2
Future Without Project	1-FWO	1	not scored	1	0	2.0	1	1	1	1	4.0	6.0
G-160, G-161	1-A	1.5	not scored	4	1	6.5	2	1	3	4	10.0	16.5
G-160, G-161 plus GWP triangle	1-B	2	not scored	4	1	7.0	2	1	3	4	10.0	17.0
1-B +ITID water to M Canal to GWP	1-Bi	2	not scored	4	1	7.0	3	1	3	3	10.0	17.0
1-B+ M Canal improvements	1-C	2.5	not scored	4	1	7.5	3	1	3	3.5	10.5	18.0
1-Bi + M Canal improvements	1-D	3	not scored	4	1	8.0	3	1	3	3	10.0	18.0
1-A + Moss	1-E	2	not scored	4	2	8.0	2	1	3	2.5	8.5	16.5
1-B + shallow storage L8 basin	1-F	4	not scored	4	2	10.0	4	2	4	2.5	12.5	22.5
1-B + C51 Res phase 2	1-G	4	not scored	4	2	10.0	4	2	4	2.5	12.5	22.5
Future Without Project	2-FWO	1	not scored	1	0	2.0	1	not scored	1	1	3.0	5.0
C-18W reservoir (7,200 or 9,500 AF)	2-A	2	not scored	1	1	4.0	2	not scored	3	2	7.0	11.0
2-A + ASR	2-B	3	not scored	1	1	5.0	3	not scored	2	2	7.0	12.0
2-A + relocate C-18w weir	2-C	2	not scored	1	1	4.0	3	not scored	3	2.5	8.5	12.5
2-A + connect M-O to Mecca	2-D	3	not scored	1	1	5.0	3	not scored	3	1.5	7.5	12.5
2-B + relocate C-18W weir	2-E	3	not scored	1	1	5.0	4	not scored	2	2.5	8.5	13.5
2-B + Connect M-O to Mecca	2-F	4	not scored	1	1	6.0	4	not scored	2	2	8.0	14.0
2-B + relocate weir + connect M-O	2-G	4	not scored	1	1	6.0	4	not scored	2	2	8.0	14.0
natural storage PBC	2-H	3	not scored	4	4	11.0	1	not scored	4	4	9.0	20.0
Future Without Project	3-FWO	not scored	1	1	0	2.0	1	1	1	1	4.0	6.0
Kitching + Moonshine/Gulf E	3-A	not scored	2	1	1	4.0	2	1	3	3.5	9.5	13.5
3-A + Cypress Cr Canal	3-B	not scored	2	1	2	5.0	3	2	4	4	13.0	18.0
3-B + Gulfstream W (relocate dog-leg)	3-C	not scored	2.5	2	3	7.5	3	2.5	4	3.5	13.0	20.5
3-C + Nine Gems	3-D	not scored	3	3	3	9.0	3	3	4	3.5	13.5	22.5
3-D + Culpepper (reroute Thomas drainage)	3-E	not scored	4	4	3	11.0	4	4	4	3	15.0	26.0
3-E + Cypress Cr Nat Area, Shiloh	3-F	not scored	4	4	3	11.0	4	4	4	3	15.0	26.0

3.4.3 Summary of Screening Decisions of Options

Using information developed at the time of screening, some of the measures were considered unlikely to be effective or efficient. Options with these measures were screened out. The best scoring option for each flow-way was retained. In general, when scores were tied, the options with more measures (and expected higher costs) were screened from further evaluation.

Seven options were screened from further evaluation: 1-C, 1-D, and 1-E; 2-C, 2-E, and 2-G; and 3-A. These are highlighted red in **Table 3-6.** Seven options were carried forward to become the building blocks of LRWRP alternatives: 1-B, 1-F, and 1-G; 2-B and 2-H; 3-B and 3-E. These are highlighted green in **Table 3-6.** Specific decisions for each flow-way are discussed below.

3.4.3.1 Screening Decisions for Flow-way 1

M Canal improvements were expected to be very expensive (limited access, potential contaminants, real estate, roads and bridges). Options with this measure (1-C, 1-D) were not retained.

ITID water pumped from the M-1 Canal to the M Canal would be a new source of water for restoration and would cost less than M Canal improvements. Since the entry point to the M Canal would be downstream of most anticipated canal improvements, the canal improvements are expected to provide only small benefits that are not expected to be worth the cost. An ITID pump station to the M Canal is preferred over M Canal improvements. However, the team that assigned scores was unable to give different scores for Option 1-B (without the pump to the M Canal) and Option 1-Bi (with the pump to the M Canal). There was not enough information at that time to assign different scores. **Option 1-B** was retained rather than Option 1-Bi.

Options 1-F and 1-G contain different large storage measures. Each measure has the potential to store and later deliver a large volume of water. Multiple local government representatives expressed support for the C-51W Reservoir of Option 1-G. Both **Option 1-F** and **Option 1-G** were retained.

3.4.3.2 Screening Decisions for Flow-way 2

Relocating and raising the C-18W Weir was not expected to provide substantial flow volume benefits from the C-18W Reservoir. Options 2-C, 2-E, and 2-G with this measure were not retained.

Site constraints prohibit a large number of ASR wells at C-18W Reservoir.

The PDT retained C-18W Reservoir plus ASR wells (**Option 2-B**) and retained natural storage on the Mecca site (same location as C-18W Reservoir) (**Option 2-H**). Connecting the M-O Canal to the Mecca site (part of Option 2-F) showed promise for retaining, but it was not chosen at this time.

(NOTE: sensitivity runs during modeling showed that bringing ITID water through the M-O Canal and the M-O Connector to the C-18W Reservoir/Mecca site provided substantial benefits, and this connector canal was added to all of the final alternatives).

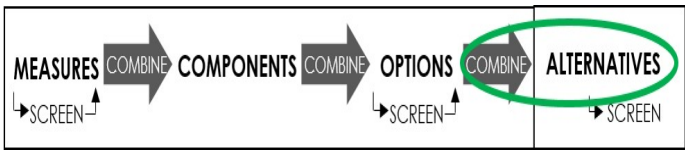
3.4.3.3 Screening Decisions for Flow-way 3

The FW3 options were expected to change the timing of water discharges to the NWFLR, but were not expected to change volume of water, so volume was not scored.

Although quantitative cost estimates were not yet available, the PDT expected a substantial cost increase from Option 3-B to Options 3-C, 3-D, 3-E, 3-F. The PDT selected **3-B**. Option 3B includes measures to stop the overdrainage by and the pulse discharges from the Cypress Creek Canal. The PDT predicted increasing scores for 3C to 3E and expected continuously increasing costs. Option 3-E and 3-F received the same score even though cost would increase. Thus **Option 3-E** was carried forward.

(NOTE: During the modeling phase, after developing alternatives, the PDT added the Shiloh and Mack Dairy Road pump and spreader swale measures from Option 3F to Alternative 13, which originally included Option 3E. This allowed the PDT to use modeling to identify whether Option 3-E or 3-F would be cost effective.)

3.5 Initial Alternatives



The sixth step to develop alternative plans is to combine options into complete alternatives. Prior studies and recent modeling demonstrated that contributions from all three flow-ways are needed for the project to approach restoration flows to the NWFLR.

3.5.1 Developing Initial Alternatives from Options

Alternatives were assembled by first starting with the options that were retained after screening, then combining one option from each flow-way. The following bullet entries describe how the options were combined and **Table 3-7** shows the options that comprise each alternative.

- Option 1-F plus all four possible combinations of the Options 2-B or 2-H with 3-B or 3-E produced Alts 1, 2, 3, and 4.
- Option 1-B plus four possible combinations of the options from Flow-way 2 and Flow-way 3 produced Alts 5, 6, 7, and 8b. In order to evaluate larger storage volumes, Alt 5 was then adjusted to change the C-18W Reservoir volume from 7,200 ac-ft to 9,500 ac-ft, to change the number of ASR wells from 2 to 4, and to replace Option 3-B with Option 3-E. Alt 5 is the only alternative that contains the 9,500 ac-ft reservoir.
- Option 1-G, which includes the in-ground C-51 Phase 2 Reservoir, is the starting point for Alts 9, 10, 11, and 12. Alts 9 and 10 also include the C-18W Reservoir (from Option 2-B), and either Option 3-B or 3-E. Alts 9 and 10 were proposed by a group of local government representatives.
- Alts 11 and 12 also include the L-8 Basin Shallow Reservoir (from Option 3-F). Alt 11 then adds the C-18W Reservoir (from Option 2-B). Alt 12 then adds the natural storage (from Option 2-H).
- Three more alternatives were modified to allow investigation of specific questions. Alt 13 is a modified version of Alt 4 that includes ASR wells adjacent to the L-8 Basin Shallow Storage (of Option 1-F). There was concern that the L-8 might not have sufficient capacity to deliver water

late into the dry season. Alt 14 is a modification of Alt 2 that does not include G-160 and G-161 in Flow-way 1. Alt 15 is a modification of Alt 5 that does not include G-160 and G-161 in Flow-way 1. Comparison of Alts 14 and 15 with Alts 2 and 5 allow evaluation of contributions of G-160 and G-161.

Table 3-7. Options contained within each initial alternative plan.

Alternative	Option 1-B: G-160, G-161, GWP Triangle, M-1 Pump Station	Option 1-F: G-160, G-161, GWP Triangle, Shallow L-8 Reservoir	Option 1-G: G-160, G-161, GWP Triangle, C-51 Reservoir	Option 2-B: C-18W Reservoir (7,200 AF) & ASR	Option 2-H: Natural Storage	Option 3-B: Kitching, Moonshine, Gulfstream East, Cypress Creek Canal	Option 3-E: Kitching, Moonshine, Gulfstream East, Cypress Creek Canal, Gulfstream West, Pal-Mar E
1	n	y	n	n	y	y	n
2	n	y	n	y	n	n	y
3	n	y	n	y	n	y	n
4	n	y	n	n	y	n	y
5	y	n	n	y, 9,500 AF & 4 ASR	n	n	y
6	y	n	n	y	n	n	y
7	y	n	n	n	y	y	n
8b	y	n	n	n	y	n	y
9, Local Gov Option	n	n	y	y, w/o ASR	n	n	y
10, Local Gov Option	n	n	y	y, w/o ASR	n	y	n
11	n	n	Y, + L-8 Shallow	y	n	n	y
12	n	n	Y, + L-8 Shallow	n	y	y	n
13, Alt 4 plus ASR	n	Y, + ASR	n	n	y	n	y
14, Alt 2 w/o G-160, G-161	n	y, w/o G-160 G-161	n	y	n	n	y
15, Alt 5 w/o G-160, G-161	y, w/o G-160 G-161	n	n	y	n	n	y

3.5.2 Alternative 10 is the CERP Alternative

The CERP Programmatic Regulations (33 CFR 385.26) require that the alternative from the Comprehensive Plan be analyzed in each Project Implementation Report (PIR). As described earlier, some of the management measures described in CERP cannot be implemented as exactly as they were described. One of the fifteen LRWRP alternatives, Alternative 10, includes the measures and purposes of the CERP Component K, Component GGG, and the Pal-Mar OPE that were not initially screened and could possibly

be implemented. The measures and purposes of the three CERP components and LRWRP Alternative 10 are compared in **Table 3-8** and in the following text.

Table 3-8. Comparison of CERP components and LRWRP Alt 10.

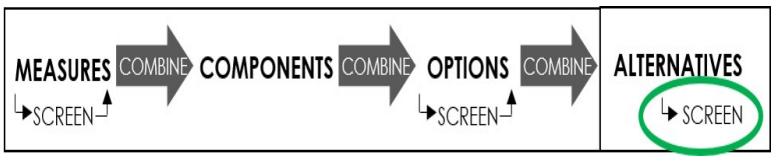
CERP Component and Measures	Purposes	LRWRP Measures
K and GGG: 48,000 ac-ft	Store to reduce loss of water and deliver for other uses	44,000 ac-ft
K and GGG: collect water from L-8 basin and C-51 basin	Sources of water for the storage measures	Collect water from L-8 basin
K and GGG: send water to L-8 Tieback, M Canal, GWP, culverts at Beeline, C-18 Canal, structure in C-18W canal	Deliver stored to existing storage at GWP	Send water to L-8 Tieback, M Canal, GWP, culverts at Beeline, C-18 Canal, structure in C-18W canal
K: culverts under Beeline at C-18 Canal, structure in C-18W canal	Release water from GWP for ecosystem restoration in Loxahatchee Slough & NWFLR	Culverts under Beeline at C-18 Canal, structure in C-18W canal
K: 50 mgd of ASRs at Lake Mangonia, 50 cfs pump and canal for wellfield recharge	Use water from GWP for urban water supply	(no corresponding measure, single purpose water supply measures not policy compliant)
OPE: water control structures, canal modifications specific measures were not specifically itemized in CERP	Hydrologic connections among J.W. Corbett WMA, Pal-Mar, C-18 Canal for ecosystem restoration	Modify structures in Culpepper, Cypress Creek Canal, Gulfstream West and East, storage near C-18W Canal

Alternative 10 includes a 44,000 acre-foot in-ground/above-ground reservoir with associated pump stations, seepage management, overflow, and conveyance canals. This reservoir would replace the 48,000 acre-foot reservoir described in CERP in 1999. The reservoir proposed in 1999 has been repurposed as a flow equalization basin for STAs 1E and 1W as part of the State of Florida's Restoration Strategies to achieve water quality standards and is no longer available for use in CERP.

Alternative 10 would receive and store water from the L-8 Basin/L-8 Canal. It would release water to the L-8 Tieback Canal, M Canal, and GWP, then to Loxahatchee Slough and the NWFLR. At this stage of the study, increasing the conveyance capacity of the M Canal does not appear to be necessary. Alternative 10 contains a structure in the C-18 Canal south leg near the C-18W Canal and structures for conveyance between GWP and Loxahatchee Slough. USACE policy and guidance does not support formulation for single purpose water supply measures (ASRs for 50 million gallons per day, a 50 cfs pump station for water supply deliveries to utilities, and a recharge canal for coastal well fields). Alternative 10 would not receive water from the C-51 Canal.

The Comprehensive Plan does not describe measures for the Pal-Mar OPE. Alternative 10 includes measures to achieve the purposes of the OPE. Alternative 10 connects Pal-Mar, J.W. Corbett WMA, ITID, C-18 Canal, and the L-8 Canal. Alternative 10 includes a reservoir at the western end of the C-18W Canal, and canals and weirs to connect the reservoir with eastern J.W. Corbett WMA and ITID. The L-8 Canal is connected to the rest of the system via the GWP as described above for Component K. Alternative 10 also modifies canals and constructs water control structures for hydropattern restoration in the northeastern portion of the project area.

3.6 Screening Initial Alternatives



The seventh step is to screen some of the initial alternatives to identify the alternatives with the greatest likelihood of becoming the Recommended Plan. The PDT assigned quartile scores for each of the fifteen alternatives using seven of the criteria used for screening options in Section **3.4.2**. The scores for all fifteen alternatives are shown in the following table (**Table 3-8**). Level 1 criteria are directly linked to the planning objectives. Level 2 criteria address additional beneficial characteristics of alternatives. Quantitative cost estimates were not available at the time of screening, so cost effectiveness analysis could not be performed at that time.

After reviewing the results, the PDT screened out six alternatives (1, 3, 6, 7, 14 and 15) because of low scores for the planning objectives criteria (Level 1 subtotal). These alternatives are below the double line and highlighted with red in **Table 3-8**. The remaining nine alternatives (2, 4, 5, 8b, 9, 10, 11, 12, 13) were given additional consideration. The five alternatives with the highest Level 1 scores were initially retained for analysis. The Level 1 scores for the next four alternatives were 13.0, only 0.5 less than the top five alternatives. This might not be a significant difference, so the PDT then considered whether these next four, slightly lower scoring alternatives that were not initially screened might have advantages such that they should be retained rather than one or more of the alternatives with slightly higher scores. Four pairs of similar alternatives were compared.

Table 3-9. Results of scoring of initial LRWRP alternatives.

Altern -ative	Flow volume to Lainhart Dam (Level 1)	Timing of Dis-charges to NW Fork (Level 1)	Natural Area Storage (Level 1)	Connect ivity (Level 1)	Flexibilit y (Adapta bility) (Level 2)	Adaptabil ity Robust (Adaptabi lity) (Level 2)	Nearness to Northwes t Fork (Level 2)	Level 1 Sub-total	Level 2 Sub-total	Total
12	4	3.5	4	4	3	3.5	2	15.5	8.5	24
11	4	4	3	4	4	4	2	15	10	25
9	4	3.5	3	4	4	3	3	14.5	10	24.5
5	4	2.5	3	4	2	2.5	3	13.5	7.5	21
13 (4)	3	2.5	4	4	1	1.5	3	13.5	5.5	19
10	4	3	3	3	4	3	3	13	10	23
2	3	3	3	4	3	2	3	13	8	21
8b	2.5	2.5	4	4	3	1.5	3	13	7.5	20.5
4	2.5	2.5	4	4	1	1.5	3	13	5.5	18.5
6	2	2.5	3	4	2	1.5	3	11.5	6.5	18
1	2.5	2	4	3	1	1.5	3	11.5	5.5	17
7	1.5	1.5	4	3	1	1	3	10	5	15
3	3	2.5	2	2	3	2	3	9.5	8	17.5
15 (5)	3.5	2.5	1	2	1.5	2.5	2	9	6	15
14 (2)	2.5	3	1	2	2.5	2	3	8.5	7.5	16
FWO	1	1	1	1	1	1	1	4	3	7

Alternatives 9 and 10 are similar. The middle scoring Alternative 10 has fewer measures in FW3 than Alternative 9, and is closest of all the alternatives to the Restudy Alternative. Additionally, retaining Alternative 10 allows the PDT to evaluate if the additional benefits to restoring a larger part of Pal-Mar merits the additional cost. For both of these reasons, the PDT switched out Alternative 9 and will carry forward Alternative 10.

Alternatives 11 and 2 are similar. The middle scoring Alternative 2 contains two storage reservoirs that the PDT believed will sufficiently meet the demands of the Loxahatchee River. The 3rd reservoir (C-51 Storage) of Alternative 11 produced a higher score during initial screening, but three reservoirs are not expected to be required. The PDT switched out Alternative 11 for Alternative 2.

Alternatives 13 and 4 are similar. Both alternatives attempt to restore large disturbed wetlands along the C-18W Canal and both have a small storage reservoir near the L-8 Canal. However, only the higher scoring Alternative 13 has a second storage measure, ASR wells, adjacent to this reservoir. The PDT decided that the small reservoir by itself might not be able to deliver enough water to restore the wetlands and meet flow targets for the Loxahatchee River, and the greater likelihood of additional ecosystem benefits from the ASR wells would be worth the small increase of cost. The higher scoring Alternative 13 was retained.

Alternatives 12 and 8b are similar. Both alternatives attempt to restore large disturbed wetlands along the C-18W Canal. Alternative 12 contains two storage reservoirs near the L-8 Canal. The PDT decided that

Alternative 8b, which does not have any additional storage upstream of the disturbed wetlands, would not be able to deliver enough water to restore the wetlands and meet flow targets for the Loxahatchee River. Similar to the conclusion supporting Alternative 13 (prior paragraph), the PDT decided that the second storage reservoir that is in Alternative 12 would be needed. Subsequent analysis will show whether the benefits are worth the increased cost. The higher scoring Alternative 12 was retained.

The five alternatives remaining after this screening, 2, 5, 10, 12, and 13, were presented at the Alternatives Milestone Meeting on April 25, 2016. The Vertical Team directed the PDT to continue to refine and evaluate the alternatives, then complete the evaluation and comparison of these plans to identify the Recommended Plan. During refinement of these alternatives, prior to H&H modeling, the PDT screened Alternative 12 from further analysis. The risks posed by constructability concerns, operational complexity and uncertainty, the likelihood of adverse impacts, and high construction and OMRR&R costs all supported the decision to screen Alternative 12.

3.7 Alternatives Carried Forward

The results of the first rounds of screening analyses yielded four alternatives, 2, 5, 10, and 13, that were carried forward for further analysis. These four alternatives are briefly described in the following paragraphs and outlined in **Table 3-9**, **Figure 3-3**, and **Figure 3-4**. The screening described in **Section 3.6** is sufficient to remove the clearly low performing alternatives from further consideration, but was not sufficient to distinguish among similarly performing alternatives to pick a Recommended Plan. To reduce the risk and uncertainties with the performance and effects of these alternatives, the PDT developed additional details for each alternative, then analyzed each alternative's performance using a hydrology and hydraulics model. The results of the analysis and comparison are described in Section 4.

Alternative 2 is distinguished by two storage reservoirs, one with associated ASR wells, and other measures, to capture water that would be lost to tide, and then release it at the appropriate time to improve deliveries to the NWFLR. The majority of increased water volume would pass through Flow-way 2.

- **Flow-way 1**: add structure that connects GWP to the C-18 Canal to increase delivery from the south into Loxahatchee Slough, and a second structure in the C-18 Canal to restore Loxahatchee Slough by reducing the rapid drainage of wetlands in the slough, all while not flooding adjacent residential areas.
- **Flow-way 2**: capture water from the L-8 Canal, ITID, and J.W. Corbett WMA that otherwise would be delivered to the C-51 Canal and to tide, and redirect the water northward to the NWFLR to achieve restoration flow targets and benefit the Loxahatchee river, estuary, and floodplain. The L-8 Shallow Storage Reservoir, C-18W Storage Reservoir and two ASR wells would store some of this water to be released to establish a more natural seasonal timing of delivery to the river.
- **Flow-way 3**: plug, backfill, or add water control structures in canals and ditches in the northern part of the project area (Kitching Creek, Moonshine Creek, Gulfstream East, Pal-Mar East (Nine Gems), Culpepper) to reduce overdrainage and restore water levels in these disturbed wetlands, and restore base flow to the NWFLR. Re-grade some areas to wetland elevations. A flow-through wetland on Gulfstream West would capture pulsed discharges of water from northern agricultural areas and retain the water for on-site benefits and for improved timing of release to the River. Pumps and berm improvements would ensure that nearby residential and agricultural areas would not be adversely impacted by the changed hydrology of the restored wetlands.

Alternative 5 is distinguished by one storage reservoir with associated ASR wells, and other measures, to capture water that would be lost to tide, then release it at the appropriate time to improve deliveries to the NWFLR. The majority of increased water volume would pass through Flow-way 2.

- **Flow-way 1**: add structure that connects GWP to the C-18 Canal to increase delivery from the south into Loxahatchee Slough, and a second structure in the C-18 Canal to restore Loxahatchee Slough by reducing the rapid drainage of wetlands in the slough, all while not flooding adjacent residential areas.
- **Flow-way 2**: capture water from ITID and J.W. Corbett WMA that otherwise would be delivered to the C-51 Canal and to tide, and redirect the water northward to the NWFLR to achieve restoration flow targets. The C-18W Storage Reservoir and four ASR wells would store some of this water to be released to establish a more natural seasonal timing of delivery to the river and benefit the Loxahatchee river, estuary, and floodplain.
- **Flow-way 3**: plug, backfill, or add water control structures in canals and ditches in the northern part of the project area (Kitching Creek, Moonshine Creek, Gulfstream East, Pal-Mar East (Nine Gems), Culpepper) to reduce overdrainage and restore water levels in these disturbed wetlands, and restore base flow to the NWFLR. Re-grade some areas to wetland elevations. A flow-through wetland on Gulfstream West would capture pulsed discharges of water from northern agricultural areas and retain the water for on-site benefits and for improved timing of release to the River. Pumps and berm improvements would ensure that nearby residential and agricultural areas would not be adversely impacted by the changed hydrology of the restored wetlands.

While Alt 2 and Alt 5 share many of the same features, there are a few key differences between these two alternatives. Alt 2 includes the L-8 Shallow Reservoir and collects water from the L-8 Canal, while Alt 5 does neither. The C-18W Reservoir in Alt 2 is smaller than the C-18W Reservoir in Alt 5. Alt 2 has only two ASR wells while Alt 5 has four ASR wells. Alt 5 includes a small pump station at the M-1 Canal near the M Canal to deliver water from ITID, while Alt 2 does not.

Alternative 10 is distinguished by a large in-ground storage reservoir and other measures that are used collectively to capture water that would be lost to tide, then release it at the appropriate time to improve deliveries to the NWFLR. The majority of increased water volume would pass through Flow-way 1.

- **Flow-way 1**: Constructing the C-51 Phase 2 Reservoir, a large in-ground reservoir that would store water from the L-8 Canal. Water would be released from the reservoir back into the L-8 Canal, then to the M Canal and a proposed pipeline that would bypass GWP and release water into the C-18 Canal and then to the NWFLR. To minimize water quality concerns with using large volumes of L-8 Canal water, a structure on the L-8 Canal near Lake Okeechobee would be closed. Since Lake Okeechobee water passing through this structure is a backup water supply for the City of West Palm Beach, some of the storage in the C-51 Reservoir would be dedicated to replace the backup water supply.

  Flow-way 1 also includes an additional structure that connects GWP to the C-18 Canal to increase delivery from the south into Loxahatchee Slough, and a second structure in the C-18 Canal to restore Loxahatchee Slough by reducing the rapid drainage of wetlands in the slough, all while not flooding adjacent residential areas.

- **Flow-way 2**: capture water from ITID and J.W. Corbett WMA that otherwise would be delivered to the C-51 Canal and to tide, and redirect the water northward to the NWFLR to achieve restoration flow targets. The C-18W Storage Reservoir would store some of this water for release into the dry season and establish a more natural seasonal timing of delivery to the river and benefit the Loxahatchee river, estuary, and floodplain.
- **Flow-way 3**: plug, backfill, or add water control structures in canals and ditches in the northern part of the project area (Kitching Creek, Moonshine Creek, and Gulfstream East) to reduce overdrainage and restore water levels in these disturbed wetlands, and restore base flow to the NWFLR. The extent of canal and ditch modifications would be much smaller than the modifications proposed in Alts 2, 5, and 13. Re-grade some areas to wetland elevations. Berm improvements would ensure that nearby residential and agricultural areas would not be adversely impacted by the changed hydrology of the restored wetlands.

Alternative 13 is distinguished by incorporating the natural storage function of wetlands, with other measures, to capture water that would be lost to tide, then release it at the appropriate time to improve deliveries to the NWFLR. The majority of increased water volume would pass through Flow-way 2.

- **Flow-way 1**: adding a structure that connects GWP to the C-18 Canal to increase delivery from the south into Loxahatchee Slough, and a second structure in the C-18 Canal to restore Loxahatchee Slough by reducing the rapid drainage of wetlands in the slough, all while not flooding adjacent residential areas.
- **Flow-way 2**: capture water from the L-8 Canal, ITID, and J.W. Corbett WMA that otherwise would be delivered to the C-51 Canal and to tide, and redirect the water northward to achieve wetland restoration in the watershed and restoration of flow targets for the NWFLR and benefit the Loxahatchee river, estuary, and floodplain. The L-8 Shallow Storage Reservoir with four ASR wells would store water for delivery into the dry season. Water would be conveyed to the C-18W site, would be restored to wetlands, and to additional disturbed wetlands to the east. These wetlands would function as natural storage, holding water deeper in the wet season and gradually releasing water toward the C-18W Canal and Loxahatchee Slough into the dry season.
- **Flow-way 3**: plug, backfill, or add water control structures in canals and ditches in the northern part of the project area (Kitching Creek, Moonshine Creek, Gulfstream East, Pal-Mar East (Nine Gems), Culpepper) to reduce overdrainage and restore water levels in these disturbed wetlands, and restore base flow to the NWFLR. Re-grade some areas to wetland elevations. A flow-through wetland on Gulfstream West would capture pulsed discharges of water from northern agricultural areas and retain the water for on-site benefits and for improved timing of release to the River. A pump station and spreader swale would move water from the Cypress Creek Canal into adjacent wetlands. Pumps and berm improvements would ensure that nearby residential and agricultural areas would not be adversely impacted by the changed hydrology of the restored wetlands.

Table 3-10. Major features of the alternatives.

Flow-way	Project Feature	Feature Type	Alt 2	Alt 5	Alt 10	Alt 13
1	G-160	Conveyance	Yes	Yes	Yes	Yes
1	G-161	Conveyance	Yes	Yes	Yes	Yes
1	GWP Triangle	Conveyance/Storage	Yes	Yes	Yes	Yes
1	M-1 Lower Pump Station	Pump Station	no	Yes	no	no
1	C-51 Phase II Reservoir	Storage	no	no	44k ac-ft	no
1	Pump Station & Pipeline at GWP	Conveyance	no	no	Yes	no
2	C-18W Reservoir	Storage	7.2k ac-ft	9.5k ac-ft	7.2k ac-ft	no
2	Aquifer Storage & Recovery	Storage	2 wells	4 wells	no	4 wells
2	M-O Canal Connector	Conveyance/Pump	Yes	Yes	Yes	Yes
2	C-18W Canal Weir Modification	Conveyance	no	no	no	Yes
2	L-8 Shallow Storage	Storage	4.3k ac-ft	no	no	6.5k ac-ft
2	C-18W Natural Storage	Storage	no	no	no	Yes
3	Pal-Mar East	Conveyance/Storage	Yes	Yes	no	Yes
3	Thomas Pepper Farm	Conveyance	Yes	Yes	no	Yes
3	Gulfstream West	Conveyance/Storage	Yes	Yes	no	Yes
3	Ranch Colony Canal	Conveyance/Storage	Yes	Yes	Yes	Yes
3	Gulfstream East and Moonshine	Conveyance/Storage	Yes	Yes	Yes	Yes
3	Kitching Creek	Conveyance/Storage	Yes	Yes	Yes	Yes
3	Mack Dairy Road Pump & Spreader Swale	Conveyance	no	no	no	Yes

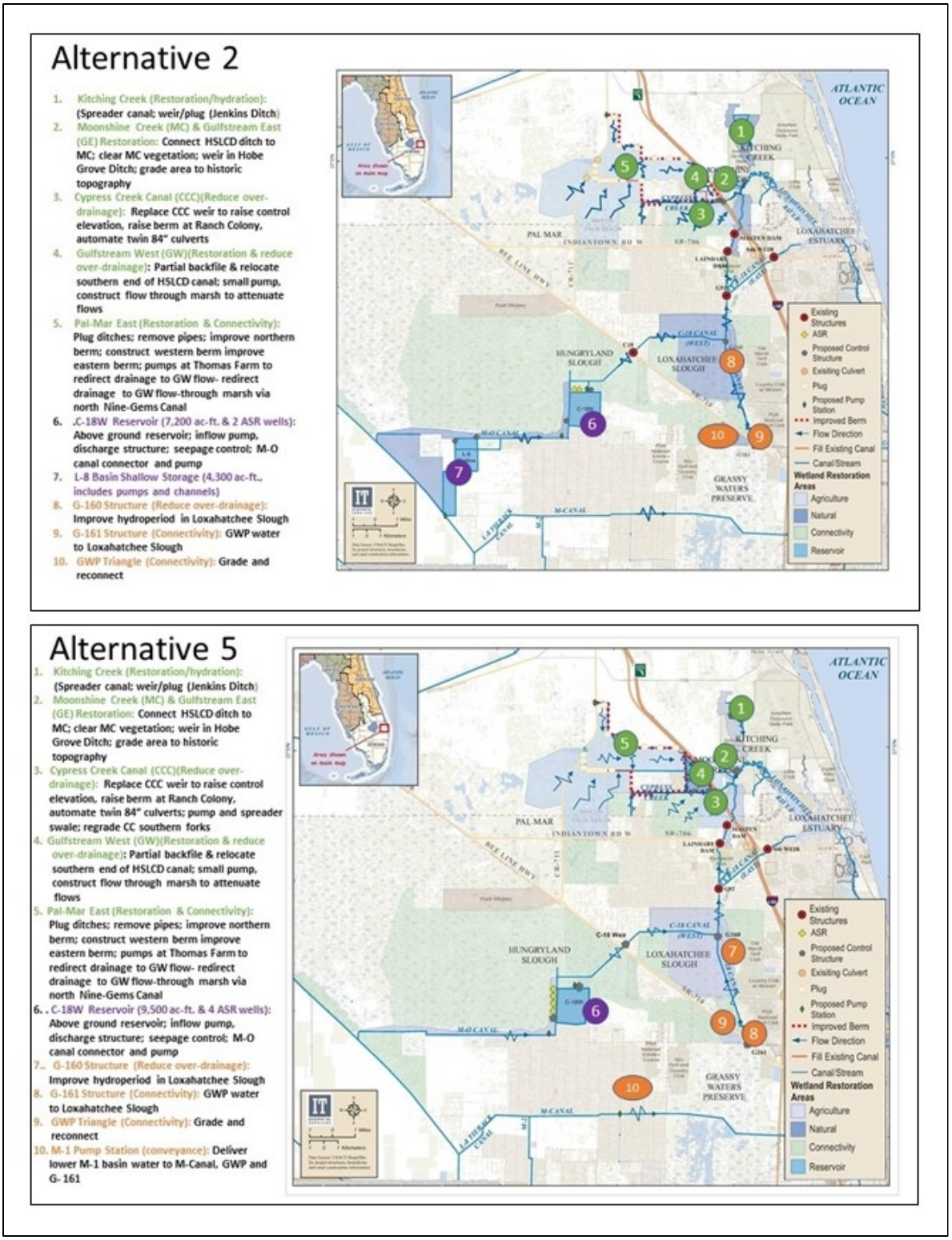


Figure 3-3. Locations of major features and expected restored wetlands for Alternatives 2 & 5.

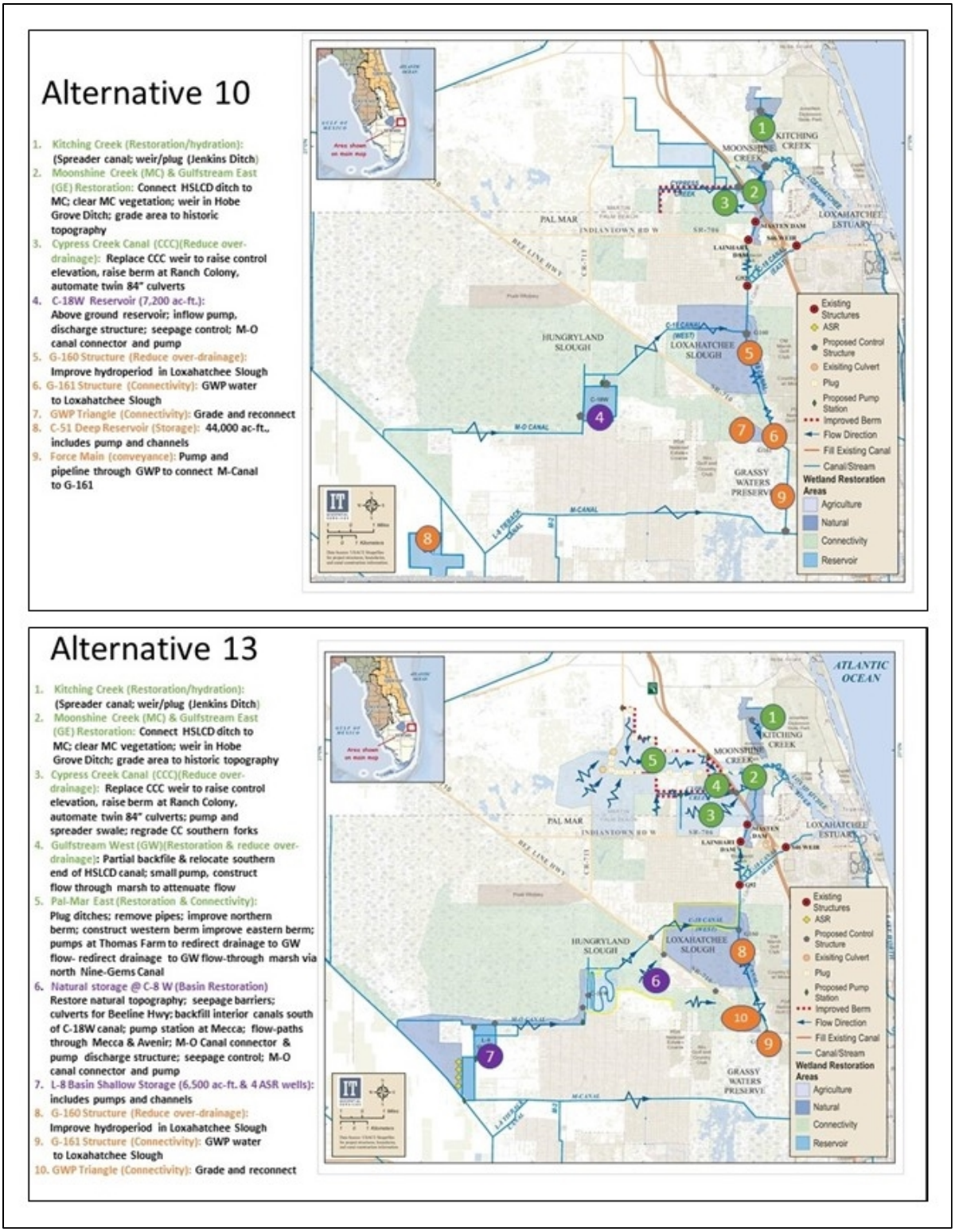


Figure 3-4. Locations of major features and expected restored wetlands for Alternatives 10 & 13.

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TABLE OF CONTENTS

4 PLAN EVALUATION 4-1
4.1 Effectiveness 4-1
4.2 Efficiency Analysis: Environmental Benefits and Costs of Alternative Plans 4-4
4.2.1 Costs of Final Array of Alternative Plans 4-5
4.2.2 Average Annual Costs 4-6
4.2.3 Ecological Benefits Evaluation 4-7
4.2.4 Cost Effectiveness and Incremental Cost Analysis 4-13
4.2.5 Efficiency Conclusion 4-18
4.3 Completeness 4-18
4.4 Acceptability 4-19
4.5 Summary of Principles and Guidelines Evaluation Criteria 4-20
4.6 Revised Alternatives and the Recommended Plan 4-20
4.6.1 Costs and Benefits of the Revised Alternatives 4-21
4.6.2 CE/ICA for River, Estuary, and Floodplain Benefits 4-21
4.6.3 CE/ICA for Watershed Benefits 4-22
4.6.4 Discussion of Revised Alternatives 4-23
4.6.5 Sea Level Rise Considerations for Alt 5R 4-24
4.6.6 The Recommended Plan is Alt 5R 4-25
4.7 RECOVER System-wide Evaluation 4-25
4.8 RECOVER Consistency 4-27

Tables

Table 4-1. Effectiveness for Objective 1, flows to the river. 4-2
Table 4-2. Effectiveness for Objective 2, estuarine communities. 4-2
Table 4-3. Effectiveness for Objective 3, area of wetlands. 4-3
Table 4-4. Effectiveness for Objective 4, connectivity. 4-4
Table 4-5. Effectiveness for Objective 5, plant and animal abundance and diversity. 4-4
Table 4-6. Estimated Preconstruction Engineering and Design (PED) and construction durations assumed for CE/ICA (in months). 4-6
Table 4-7. Planning level costs and average annual costs of alternative plans. 4-7
Table 4-8. Performance measures used to quantify plan benefits. 4-8
Table 4-9. Total habitat units for each alternative condition. 4-9
Table 4-10. Percentage of river and estuary benefits achieved over time. 4-10
Table 4-11. Percentage of floodplain benefits achieved over time. 4-10
Table 4-12. Percentage of watershed wetlands benefits achieved over time. 4-10

Table 4-13. Average annual habitat units and average annual benefits. 4-13
Table 4-14. Cost effectiveness of alternative plans - river, estuary, floodplain benefits. 4-14
Table 4-15. Incremental cost analysis - river, estuary, floodplain benefits. 4-15
Table 4-16. Cost-effectiveness of alternative plans - watershed benefits. 4-16
Table 4-17. Incremental cost analysis watershed benefits. 4-17
Table 4-18. Cost-effectiveness of alternative plans - combined benefits. 4-17
Table 4-19. Incremental cost analysis - combined benefits. 4-18
Table 4-20. Summary of principles and guidelines evaluation criteria..... 4-20
Table 4-21. Cost-effectiveness analysis - river, estuary, and floodplain benefits of revised alternatives. 4-22
Table 4-22. Cost effectiveness analysis - watershed benefits of revised alternatives. 4-23
Table 4-23. Average area (acres) in the Loxahatchee River with salinity less than 2 psu. 4-24

Figures

Figure 4-1. Annual river, estuary, floodplain HUs over time. 4-11
Figure 4-2. Annual watershed HUs over time..... 4-12
Figure 4-3. Average annual cost and average annual river, estuary, floodplain benefits. 4-14
Figure 4-4. Incremental cost and output of best buy plans for river, estuary, floodplain benefits. 4-15
Figure 4-5. Average annual cost and average annual watershed benefits..... 4-16
Figure 4-6. The LRWRP Recommended Plan, Alternative 5R. 4-25

4 PLAN EVALUATION

Upon identification of the final array of alternatives, each alternative was modeled, then evaluated for its effects on the environment. See Section 5 for details of ecological and social benefits. The alternatives were compared using the USACE's "Principles and Guidelines" criteria (completeness, acceptability, efficiency, and effectiveness), which are:

- Effectiveness: Extent to which an alternative plan alleviates the specified problems and achieves the specified opportunities (evaluated in **Subsection 4.1**)
- Efficiency: Extent to which identified plans maximize environmental benefits compared to costs (evaluated in **Subsection 4.2**)
- Acceptability: Workability and viability of the alternative plan with respect to acceptance by state and local entities and the public and compatibility with existing laws, regulations, and public policies (evaluated in **Subsection 4.3**)
- Completeness: Extent to which a given alternative plan provides and accounts for all necessary investments or other actions to ensure the realization of the planned effects (evaluated in **Subsection 4.4**)

Project benefits were quantified using project specific performance measures, planning level costs were calculated for each alternative plan, and an analysis was conducted using Cost Effectiveness and Incremental Cost Analysis (CE/ICA) to identify alternatives that maximize environmental benefits compared to costs. The evaluation and comparison resulted in the identification of the National Ecosystem Restoration (NER) plan and the Recommended Plan. All steps were performed under the assumption that all other CERP projects authorized by Congress are in place and that LRWRP would be the next added CERP increment.

4.1 Effectiveness

An effective alternative alleviates the specified problems and achieves the specified opportunities for the LRWRP. Because LRWRP problems and opportunities drove the development of planning objectives (see Section 1 of the report), effectiveness was evaluated by how well the alternatives would achieve the planning objectives. **Table 4-1**, **Table 4-2**, **Table 4-3**, **Table 4-4**, and **Table 4-5** present how each alternative would perform with respect to each objective. Additional details on hydrologic performance can be found in Appendix A. Additional details on ecological performance can be found in **Section 5**, **Appendix C.2.1**, and **Appendix G**.

Table 4-1. Effectiveness for Objective 1, flows to the river.

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.				
Low flows to the Northwest Fork of the Loxahatchee River (NWFLR) and its floodplain have contributed to the loss of the rare riverine cypress forest and its transition to communities of salt tolerant vegetation such as mangroves. The 2006 Loxahatchee River Restoration Plan developed flow targets at Lainhart Dam for the wet and dry seasons. The wet season target is daily flow greater than 110 cfs for greater than 120 days. The dry season target is 100% of time with 30-day rolling average greater than 69 cfs. An exceedance of minimum flows and levels (MFL) occurs when flow is less than 35 cfs for more than 20 consecutive days. For wet and dry seasons, this table shows the percent of the days per season, averaged across years, which meet the target for that season. All four alternatives achieve flow targets for the wet season. All four alternatives make improvements (see below) over the FWO for the dry season restoration target. Alt 13 performs substantially poorer than the other alternatives in the dry season. Alt 13 is the only alternative that still shows exceedances of minimum flows and levels for the 41-year period of analysis. Alt 10 performs the best for the dry season.				
(Wet and Dry Season Flow at Lainhart Dam, 0-100% scale, target is 100%) *(number of Minimum Flow and Level exceedances, target is 0)*				
Future Without (FWO) Project Condition	**Alt 2 (Two reservoirs)**	**Alt 5 (One reservoir)**	**Alt 10 (In-ground reservoir)**	**Alt 13 (Natural storage)**
Wet Season (78%)	98%	98%	100%	98%
Dry Season (65%)	87%	91%	95%	80%
MFL exceedances (17)	0	0	0	12

Table 4-2. Effectiveness for Objective 2, estuarine communities.

Objective 2: *Restore* oysters, seagrass, and other *estuarine communities* in the Loxahatchee River Estuary.
Long-term restoration of ecological communities in the Loxahatchee River Estuary is inferred from dry season flows at Lainhart Dam and the corresponding salinity restoration targets described in the 2006 Loxahatchee River Restoration Plan. The goal is to increase base flow to limit saltwater intrusion in the tidal floodplain while maintaining the appropriate environmental conditions in the riverine floodplain for aquatic dependent species, communities and wildlife. Base flows should be high enough to provide groundwater movement from the river channel to the surrounding floodplain soils and should be high enough to support fish passage during lower flow conditions. High flows during the wet season particularly in the months of August–November are critical for maintaining the hydroperiod of the floodplain cypress swamp and many other native flora dependent on seasonal high water levels in the riverine floodplain. Salinity target zones representing various portions of the river and estuary have been developed as part of the Restoration Plan for the Northwest Fork of the Loxahatchee River (SFWMD 2006). These “salinity envelopes” are used as surrogates for key Valued Ecosystem Components (VECs) (USEPA 1987). Besides the freshwater floodplain VEC, the river and estuary have been divided into four major salinity zones: #1 Freshwater: salinity = 0 practical salinity units (psu), #2 Oligohaline: 2 to 8 psu, #3 Mesohaline: 10 to 20 psu, and #4 Polyhaline: 20+ psu. Tidal floodplain, Vallisneria americana, fish larvae and juveniles, oysters, and seagrass, respectively, were targeted as ecological indicators in these zones. A salinity model was used to estimate changes in salinity. The sensitivity of the tool and how salinity performance was scored was limited, as well as baseline salinities for the tidal river which appear to meet targets. The results indicate slight improvements in the Vallisneria, Oligohaline, and Mesohaline zones for all alternatives with the most improvement from Alt 10 and least improvement from Alt 13. The polyhaline zone remains unchanged except for a slight decrease in performance from Alts 5 and 10. The biggest lift is

Objective 2: *Restore* oysters, seagrass, and other *estuarine communities* in the Loxahatchee River Estuary.					
with the mesohaline zone. These results are consistent with the dry and wet season flows from Lainhart Dam, which are more sensitive to estimating restoration performance downstream in the tidal river and estuarine zones.					
(Performance measure for estuarine communities, 0-1.00 scale, target is 1.00)					
Salinity Zone	**FWO**	**Alt 2 (Two reservoirs)**	**Alt 5 (One reservoir)**	**Alt 10 (In-ground reservoir)**	**Alt 13 (Natural storage)**
Tidal River (0-2 psu)	1.0	1.0	1.0	1.0	1.0
Vallisneria- (0-5 psu)	0.78	0.80	0.80	0.81	0.79
Oligohaline – Fish larvae (2-8 psu)	0.21	0.23	0.23	0.24	0.23
Mesohaline – Oysters (10-20 psu)	0.39	0.45	0.45	0.46	0.43
Polyhaline - Seagrass (>20 psu)	0.92	0.92	0.91	0.91	0.92

Table 4-3. Effectiveness for Objective 3, area of wetlands.

Objective 3: *Increase natural area extent of wetlands.*					
Over-drainage and conversion to urban and agricultural uses reduced the extent of wetlands in the project area. LRWRP alternatives use various measure to restore wetlands in the watershed. The restored wetlands provide improved habitat for natural communities, and fish and wildlife species. Restored wetlands provide on-site benefits, connectivity with other natural areas, and improved timing of water deliveries to the Loxahatchee River. All alternatives restore wetlands in the watershed. Alt 13 restores the greatest number of acres because it would restore wetlands on the C-18W site and western Loxahatchee Slough that are not attempted to be restored by the other alternatives. Alt 10 restores the fewest number of acres because it has fewer measures in Flow-way 3 than the other alternatives. Alts 2 and 5 restore approximately the same number of acres of wetlands.					
(Number of acres restored, more is better).					
Habitat Restored	**FWO**	**Alt 2 (Two reservoirs)**	**Alt 5 (One reservoir)**	**Alt 10 (In-ground reservoir)**	**Alt 13 (Natural storage)**
Restored agricultural areas (formerly functioning wetlands)	0	13,356	16,292	2,009	17,673
Restored natural areas (existing but impacted wetlands),	0	12,352	9,546	7,904	13,803
Total,	0	25,708	25,838	9,913	31,476

Table 4-4. Effectiveness for Objective 4, connectivity.

Objective 4: *Restore connections* between Corbett Wildlife Management Area, Pal-Mar/Cypress Creek basin, Loxahatchee Slough, Grassy Waters Preserve and Loxahatchee River to improve hydrology, sheetflow, hydroperiods, natural storage, and vegetation communities.				
Reconnecting natural areas provides opportunities for flora and fauna to move between areas and for water to reach the Loxahatchee River. Connectivity performance is estimated using scores for four criteria: hydrologic connectivity, greenway and overland connections, water quality incidental improvements, and foraging, breeding, and nesting conditions for endangered and/or rare species. Each criterion was estimated using GIS and best professional judgment. All four alternatives improve connectivity. Alt 13 has more connections via C-18 west natural storage through Avenir to Loxahatchee at two locations, which contributes to its highest score. Alt 10 restores the lowest connectivity. Alts 2 and 5 restore the same amount of connectivity.				
(Quality of connection, range 0 to 1.00, higher is better).				
Future Without (FWO) Project Condition	**Alt 2 (Two reservoirs)**	**Alt 5 (One reservoir)**	**Alt 10 (In-ground reservoir)**	**Alt 13 (Natural storage)**
0	0.67	0.67	0.46	0.83

Table 4-5. Effectiveness for Objective 5, plant and animal abundance and diversity.

Objective 5: *Restore native plant and animal species abundance and diversity* in Loxahatchee River watershed natural areas, river, and estuary.				
Objective 5 is estimated based on restoration of habitat for these species. Habitat restoration for fish and wildlife is quantified using a combination of the average wetland hydrology scores and connectivity scores (shown in objective 4) for each alternative. Wetland hydrology will be restored by project alternatives and improve wetland structure and function. Connectivity allows for more access and/or availability of habitat for fish and wildlife life history characteristics (feeding, breeding, nursery, and growth to maturity). All alternatives performed better than the FWO. Alt 13 would produce the greatest restoration of plant and animal species abundance and diversity. Alt 10 would provide the least. Alts 2 and 5 would provide the same restoration, intermediate between Alts 13 and 10. The relationships among the alternatives for restoration of fish and wildlife (objective 5) is parallel to the patterns predicted for wetland acres restored (objective 3) and for connectivity (objective 4).				
(Index score for native plant and animal abundance and diversity, range 0 to 1.00, higher is better).				
Future Without (FWO) Project Condition	**Alt 2 (Two reservoirs)**	**Alt 5 (One reservoir)**	**Alt 10 (In-ground reservoir)**	**Alt 13 (Natural storage)**
0.32	0.48	0.48	0.39	0.53

4.2 Efficiency Analysis: Environmental Benefits and Costs of Alternative Plans

The LRWRP recommended plan is justified by the environmental benefits derived by the South Florida ecosystem; however, a comparison of the benefits and costs of alternative plans is also conducted to ensure that a selected alternative is efficiently producing the environmental benefits. The measurement of efficiency is the extent to which an alternative plan is the most cost-effective means of alleviating the specified problems and realizing the specified opportunities, consistent with protecting the nation's environment. CE/ICA is used to help identify the plans that reasonably maximize ecosystem restoration.

As the name suggests, the CE/ICA has two distinct steps. The first step, cost effectiveness (CE) analysis, identifies which alternative plans are cost effective. A cost effective plan has the following characteristics:

1. The same level of output could not be produced by another plan at less cost;
2. A larger level of output could not be produced by another plan at the same cost; and
3. A larger level of output could not be produced by another plan at less cost.

The second step is the incremental cost analysis (ICA). Cost effective plans are compared by examining the additional (incremental) costs for the additional (incremental) amounts of output produced by successively larger cost effective plans. The plans with the lowest incremental costs per unit of output for successively larger levels of output are called best buy plans. The results of these calculations and comparisons of costs and outputs between alternative plans provide a basis for addressing the decision question "Is it worth it?" (i.e., are the additional outputs worth the costs incurred to achieve them)?

The CE/ICA analysis follows guidance from the U.S. Army Corps of Engineers (USACE), Engineering Regulation (ER) 1105-2-100, Appendix E, para. E-36. Costs are based initially on a planning level estimate and benefits are based on the habitat unit (HU) evaluation. As per this guidance, CE/ICA analysis compares the alternative plans' average annual costs against the appropriate average annual HU estimates. This ensures an "apples to apples" comparison. The average annual benefits (lift) are calculated as the difference between with-plan and without-plan conditions over the 50-year period of analysis (through year 2075).

4.2.1 Costs of Final Array of Alternative Plans

Costs of a plan represent the value of goods and services required to implement and operate/maintain the plan. The cost estimate for the alternatives includes construction; lands, easements, right-of-ways, relocation (LERR); preconstruction engineering and design (PED); construction management; and operation, maintenance, repair, replacement, and rehabilitation (OMRR&R). For comparison of alternatives in this report and analysis, costs are expressed in October 2018 price levels.

The costs generated by this tool are planning level costs, not absolute costs. These costs should only be used to compare the costs of alternatives relative to one another and are not to be used as the detailed costs for construction. These costs were developed using historical costs from USACE and SFWMD constructed projects, and recent cost estimates developed for similar features in other projects.

A preliminary analysis of the real estate requirements of the final array was completed. Each parcel required for construction or restoration activities was identified, characterized, and a value estimate was calculated. The real estate was valued in fee, however, lesser estates and interests in land could be considered as more information becomes available.

The costs of adaptive management and monitoring are not included in the cost estimates used to evaluate and compare alternative plans. Adaptive management and monitoring costs are assumed to be similar for all of the alternative plans because the same environmental resources would be monitored under each plan, and similar management options would be included if the alternatives did not perform as well as expected. The adaptive management and monitoring plan and cost estimate for the project was developed after the recommended plan was selected.

4.2.2 Average Annual Costs

The timing of a plan's costs is important. Construction and other initial implementation costs cannot simply be added to periodically recurring costs for project operation, maintenance and monitoring if meaningful and direct comparisons of the costs of the different alternatives are to be made. A common practice of equating sums of money across time with their equivalent at an earlier point in time is the process known as discounting. Through this mathematical process, which involves the use of an interest rate (or discount rate) officially prescribed by federal policy for use in water resource planning analysis (set at 2.75% at the time of the evaluation), the cost time streams for the alternative plans were mathematically translated into an equivalent time basis value.

There is some uncertainty as to how any of the alternatives would be implemented. It is recognized that any of the plans would likely be implemented over a considerable length of time. Because a precise construction schedule was not developed for each alternative plan included in the CE/ICA, the assumptions listed below were used to derive the construction duration estimates and used in the calculation of annualized costs and habitat units. The duration estimates are displayed in **Table 4-6**.

1. An annual budgetary limit of $40,000,000 total available for project implementation is assumed based on the SFWMD's and SAJ's experience with previous ecosystem restoration projects in south Florida.
2. Costs of real estate already acquired by the NFS were not considered as part of the $40 million per year budgetary limit, although these costs were included in the total project cost and Interest During Construction (IDC) calculations discussed below.
3. Construction costs are assumed to incur on an equal monthly basis during the implementation of the alternative plans.

Table 4-6. Estimated Preconstruction Engineering and Design (PED) and construction durations assumed for CE/ICA (in months).

Alternative	Alt 2	Alt 5	Alt 10	Alt 13
PED Duration (months)	24	24	24	24
Construction Duration (months)*	118	94	153	81

*Construction durations are rounded to the closest full month.

ER 1105-2-100 requires that IDC be computed, which represents the opportunity cost of capital incurred during the construction period. IDC was computed for PED costs and construction costs from the middle of the month in which the expenditures were incurred until the first of the month following the estimated construction completion date, and also assume the constrained timelines in **Table 4-6**. IDC was computed for the total real estate cost starting three months prior to construction commencing, as this is typically the time when real estate associated with a project is certified.

The total first cost is the sum of construction, real estate, PED, and construction management. The total project investment is the first cost plus IDC. **Table 4-7** summarizes the first cost, total investment cost and average annual costs of each alternative plan. The least costly plan in average annual terms is Alt 5, followed closely by Alt 13. The average annual costs for Alt 2 and Alt 10 are significantly higher than the other two alternative plans.

Table 4-7. Planning level costs and average annual costs of alternative plans.

Cost Component*	Alt 2*	Alt 5*	Alt 10*	Alt 13*
Construction	$320,011,000	$287,125,000	$448,847,000	$191,479,000
Lands	$170,389,000	$115,084,000	$98,246,000	$230,255,000
Preconstruction, Engineering, & Design	$13,903,000	$12,485,000	$18,961,000	$8,938,000
Construction Management	$14,700,000	$13,201,000	$20,048,000	$9,451,000
Total First Cost	**$519,004,000**	**$427,895,000**	**$586,102,000**	**$440,123,000**
Interest During Construction: Construction	$53,715,000	$37,619,000	$99,732,000	$21,598,000
Interest During Construction: Lands	$53,637,000	$28,167,000	$41,472,000	$47,986,000
Total Interest During Construction	**$107,352,000**	**$65,786,000**	**$141,204,000**	**$69,585,000**
Total Project Investment	**$626,355,000**	**$493,681,000**	**$727,306,000**	**$509,708,000**
Avg. Annual Cost: Total First Cost & Total IDC	$23,201,000	$18,286,000	$26,940,000	$18,880,000
Avg. Annual Cost: OMRR&R	$4,269,000	$3,745,000	$2,185,000	$4,128,000
Average Annual Cost	**$27,470,000**	**$22,031,000**	**$29,125,000**	**$23,008,000**

*October 2018 price levels. Costs do not include costs of recreation features.

*Annual costs are based on a 50-year period of analysis and 2.75%.

*Costs are planning level costs and may not coincide exactly with the detailed costs of the recommended plan presented in other sections of the report.

* Planning level costs include 32-45% contingency due to the limited design of alternatives.

* Any discrepancies in the sum of costs are due to rounding.

4.2.3 Ecological Benefits Evaluation

The Project Delivery Team (PDT) devised a project specific tool, referred to as a planning model, to evaluate HUs for alternatives within the LRWRP project area. The primary areas evaluated included the Loxahatchee Estuary, the NWFLR, and the wetlands within the Loxahatchee River watershed. The LRWRP planning model is a Microsoft Excel spreadsheet that uses project performance measures to derive a HU score that represents the ecological performance achieved by each alternative. This planning model was approved for use by the USACE Ecosystem Restoration Planning Center of Expertise on August 26, 2016. The complete description of the model, equations and calculations, and further information pertaining to the alternative evaluation is described in Appendix G. The HU score produced by the planning model represents an “end point” of total performance of each alternative. The HUs for the alternatives represent conditions once the ecological systems have had time to respond fully to the hydrological changes produced by the alternatives.

These model-predicted “end point” HUs must undergo several modifying steps before fair comparisons of alternatives can be done. These steps are listed below and expanded upon in the next four subsections:

1. Begin with the unadjusted HUs.
2. Adjust for rate of response. Some communities respond more quickly than others (e.g. grasses respond faster than trees).
3. Adjust for start time. Higher cost alternatives take longer to build than lower cost alternatives, thus take longer to begin producing ecological benefits.
4. Calculate average annual HUs. The benefit of an alternative equals average annual HUs with the alternative minus average annual HUs without an alternative (FWO)

4.2.3.1 Total Unadjusted Habitat Units

Conceptual ecological models (CEMs), as used in the Everglades restoration program, are non-quantitative planning tools that identify the major anthropogenic drivers and stressors on natural systems, the ecological effects of these stressors, and the best biological attributes or indicators of these ecological responses (Ogden et al. 2005). These CEMs have been peer reviewed and provide the framework for the planning and assessment of the CERP. The LRWRP planning model was used to aggregate the results of project performance measures. Each of the performance measures for the LRWRP planning effort was derived from those approved for use in LRWRP by Restoration, Coordination and Verification (RECOVER). Three performance measures were identified (**Table 4-8**).

Each performance measure has a predictive metric and targets based on hydrologic requirements necessary to meet empirical or theoretical ecological thresholds. Detailed estimates of hydrology across the 41-year period of record (January 1965 – December 2005) generated by the Lower East Coast Subregional Model – North Palm version (LECSR-NP) hydrologic model were used to calculate performance measure scores.

Table 4-8. Performance measures used to quantify plan benefits.

Region	Performance Measure (PM)	Description
Salinity and Flow (Loxahatchee River floodplain and Loxahatchee Estuary)	Salinity and Flow Performance Measure 1 PM 1.1 Wet Season Flow Targets PM 1.2 Dry Season Flow Targets	Measure of the frequency of flows correlated to downstream estuarine salinities favorable to freshwater, estuarine and marine fish; shellfish; oysters and Submerged Aquatic Vegetation (SAV). Measure of temporal-seasonal agreement between predicted salinity regimes in and pre-drainage salinity targets.
Watershed (lands in the watershed)	Watershed Hydrology, Performance Measure 4 PM 4.1 Hydroperiod	Measure of hydrologic conditions favorable for nine wetland plant community types.
Watershed (lands in the watershed)	Connectivity, Performance Measure 9 PM 9.1 Hydrologic PM 9.2 Greenway PM 9.3 Water Quality PM 9.4 Fish and Wildlife (Endangered and/or Rare Species)	Measure of connectivity based on hydrologic connections of wetlands, occurring within proposed greenbelts, providing more natural overland flow for nutrient filtration, and supporting fish and wildlife function connectivity between restored habitats.

Performance measure scores are displayed as a function of restoration potential or achievement of the target with the minimum value of zero representing a fully degraded ecosystem and a maximum value of 100 representing the restoration target. Habitat suitability indices in performance measure 4 (watershed hydrology) and 1 (river flows and estuarine performance) were developed based on 8 major plant communities in the watershed and 6 major habitat zones in the river and estuary. In the watershed, the area associated with indicator regions that identify the dominate habitats used for the hydrologic target and index is multiplied by the index number to identify HUs. Performance measure 9 (connectivity) is also associated with the watershed HU calculation, but is indexed based on qualitative analysis of four criteria and multiplied by the whole watershed acreage. For the watershed score, watershed hydrology (PM 4) accounts for 90% of the HU score and connectivity (PM 9) accounts for 10%. For the river score, river flows were compared to restoration flow targets, indexed 0-1 and multiplied by habitat zone acreage to produce HUs. The river/estuary and floodplain zones do not overlap, so the river-related HUs for each zone can be added to produce the total HUs for each alternative. The planning model used to identify HUs is explained in detail in **Appendix G**.

HU results for the existing conditions baseline (ECB), the FWO project condition, and the alternatives are displayed in **Table 4-9**.

Table 4-9. Total habitat units for each alternative condition.

Benefit Region	ECB	FWO	Alt 2	Alt 5	Alt 10	Alt 13
River and Estuary	1,029	1,029	1,377	1,441	1,504	1,266
Floodplain	314	314	420	440	459	386
Watershed (Wetlands and Connectivity)	25,711	25,407	37,747	37,516	30,892	41,300

Section 1 of the PIR describes how the C&SF project has already degraded the wetland hydrology and wetland conditions from pre-drainage times to today. Hydrology is not anticipated to further degrade much in the future without the project. Since the ecosystem benefits model uses hydrology as an indicator of wetland status and since the hydrology is not expected to continue to change, **Table 4-9** shows that the benefit model predicts the ECB and FWO conditions will be essentially the same and that there will be minimal further degradation of habitat. Section 1 also notes that the intent of LRWRP is to wetland restoration benefits by restoring regional hydrology toward pre-drainage conditions rather than achieve wetland benefits by preventing further degradation of hydrologic conditions. If an alternative was able to completely restore historic wetland hydrology and wetland conditions, it would produce 78,339 habitat units.

The habitat units in **Table 4-9** represent the model-predicted conditions for the FWO and alternatives once the ecological systems have fully responded to the hydrological changes produced by the alternatives. These “end point” HUs must be adjusted before they are compared to each other. The adjustments are for the rate of response of the ecosystem to the hydrologic changes and the differing lengths of time when construction is complete and ecosystem changes start to occur. After these adjustments are incorporated, average annual HUs can be calculated.

4.2.3.2 Adjust for Rate of Response

The first adjustment to “end point” HUs is for the rate of response of the ecosystem to the hydrologic changes. Natural ecosystems are complex, dynamic systems and the exact functional form of the

relationship among variables is rarely if ever known. South Florida ecosystems have been subject to extensive research and monitoring, and credible estimates of response times can be predicted based on how key ecosystem components have responded to varying hydrologic conditions. The rate at which LRWRP benefits accrue over various time intervals, depending on the region, was estimated using these inferences. Linear interpolation was used as a simple method for inferring the rate at which benefits would accrue between those time intervals for each of the three regions of the project area for both the FWO and future with project conditions.

Loxahatchee River and Estuary: An ecological response time for the Loxahatchee River Estuary was estimated based on the expected response time of oysters and SAV to improved salinities. The ecological response time was estimated to be approximately 6 years until full impact would be realized. See **Table 4-10**.

Table 4-10. Percentage of river and estuary benefits achieved over time.

0-2 years	2-5 years	5-20 years	20-50 years	50-100 years
20%	75%	100%	100%	100%

Loxahatchee River Floodplain: An ecological response time for floodplain of the NWFLR was estimated based on the ability of LRWRP to improve conditions riverine cypress forests to recruit and grow to maturity, but also understory shrub and other smaller vegetation area types. The ecological response time for the river floodplain was estimated to be approximately 75-100 years until full impact would be realized, with a large percentage of benefits accruing earlier once the desirable hydrological conditions have been restored. See **Table 4-11**. Floodplain restoration could be accelerated with cypress tree plantings. However, this timeline is conservative and assumes natural recruitment.

Table 4-11. Percentage of floodplain benefits achieved over time.

0-2 years	2-5 years	5-10 years	10-30 years	30-50 years	50-75 years	75-100 years
0%	30%	50%	60%	75%	80%	100%

Loxahatchee Watershed: The ecological response time for the Loxahatchee River watershed was estimated based on the ability of LRWRP to improve conditions for aquatic and herbaceous, shrubby, and forested vegetation communities; periphyton; piscivorous fish; and aquatic prey organisms in the diverse headwaters watershed consisting of mesic and wet flatwoods, mesic and hydric hammocks, wet prairies, depression and slough marsh, and floodplain, strand, and dome swamps. The expected ecological response time is estimated to be 75-100 years until full impact would be realized with a large percentage of benefits accruing earlier once the desirable hydrological conditions have been restored. See **Table 4-12**.

Table 4-12. Percentage of watershed wetlands benefits achieved over time.

0-2 years	2-5 years	5-10 years	10-30 years	30-50 years	50-75 years	75-100 years
50%	60%	70%	75%	80%	95%	100%

4.2.3.3 Adjust for differing start times

The second adjustment to "end point" HUs is for the differing lengths of time when construction is complete and ecosystem changes start to occur. The alternative plan with the shortest estimated duration to complete construction will start accruing benefits prior to all other plans. Thus the start of the 50-year period of benefit accrual considered in this analysis is set by Alt 13. Alt 5 will begin accruing benefits approximately one year after Alt 13, Alt 2 approximately three years after Alt 13, and Alt 10 approximately six years after Alt 13. The progression of ecosystem responses (habitat units) coming online and then subsequently accruing over the 50-year analysis period is included in **Figure 4-1** for the river and estuary (consists of riverine floodplain and estuary) and **Figure 4-2** for the watershed (consisting of wetlands and connectivity). These figures incorporate the differences in rate of response as well as start times.

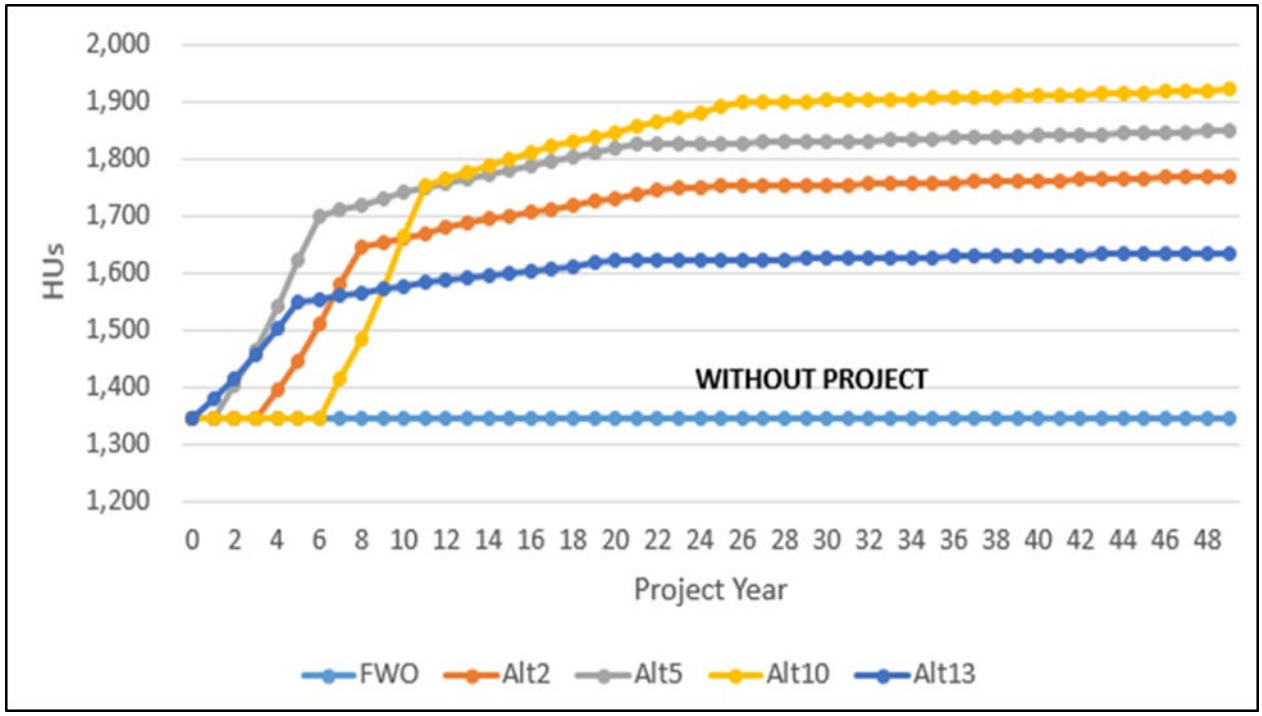

Figure 4-1. Annual river, estuary, floodplain HUs over time.

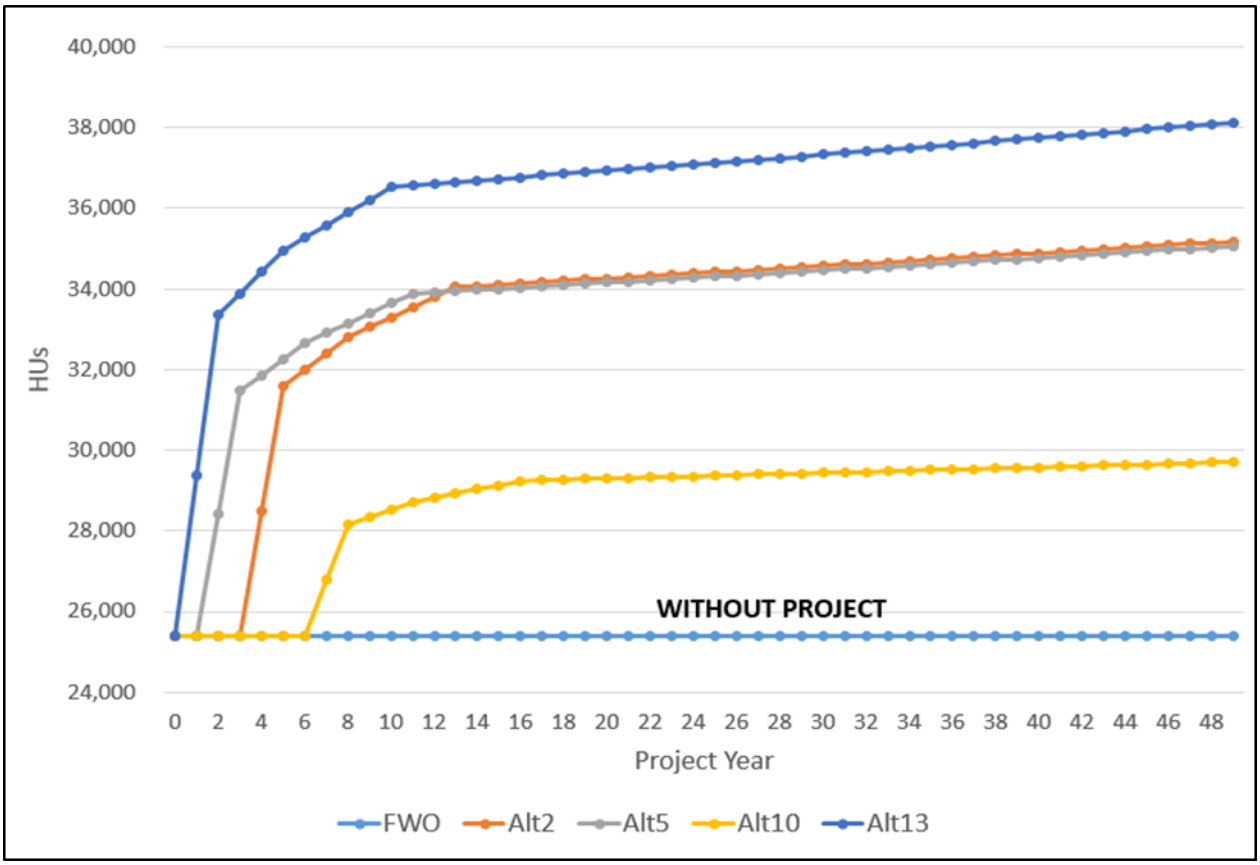

Figure 4-2. Annual watershed HUs over time.

4.2.3.4 Average Annual Habitat Units and Average Annual Benefits

Table 4-13 presents the average annual habitat units for the future without project condition and for each alternative for the 50-year period of analysis. In calculating lift in HUs for each alternative, the FWO number of habitat units is assumed to stay constant throughout the period of analysis.

The table also displays the average annual benefits, or lift, for each alternative. Benefits are the difference between the average annual habitat units with the alternative plan and the average annual habitat units in the FWO. Alt 13 yields the greatest average annual lift in wetland/connectivity HUs, while producing in the least HU lift of the four alternative plans for river and estuary HUs. Similarly, Alt 10 performs the best for one HU type (river and estuary) but the worst for the other (wetland/connectivity). Alt 5 ranks second in lift for both habitat types and Alt 2 is third for both habitat types.

Table 4-13. Average annual habitat units and average annual benefits.

Habitat	Future Without Project	Alt 2	Alt 5	Alt 10	Alt 13
River / Estuary and Floodplain Average Annual Habitat Units	1,343	1,684	1,767	1,744	1,593
River / Estuary and Floodplain Average Annual Habitat Unit Benefit	0	341	424	431	250
Watershed (wetlands & connectivity) Average Annual Habitat Units	25,407	33,461	33,696	28,727	36,540
Watershed (wetlands & connectivity) Average Annual Habitat Unit Benefit	0	8,054	8,289	3,320	11,133

4.2.4 Cost Effectiveness and Incremental Cost Analysis

Sometimes it is difficult to summarize the results of CE/ICA when the analyses are performed separately on HUs for distinct species, communities, or geographic areas. This phenomenon often occurs simply because different management measures or alternative plans have different functions, provide different types of output, and provide benefits to different biological communities. This is the case for the LRWRP, in which certain features or alternatives provide greater benefits to the NWFLR, the river floodplain, and the Loxahatchee Estuary, while other alternatives provide greater benefits for the wetlands within the Loxahatchee River watershed.

CE/ICA was performed for each type of habitat benefit separately as well as combined. A combined HU score summing all areas of the study area does not appropriately represent the geographically small but highly significant NWFLR. The Loxahatchee watershed contains more than 20 times as many acres as the river, floodplain, and estuary, and the combined HU score for all areas is dominated by the watershed HUs and masks benefits to the river.

4.2.4.1 River, Estuary, Floodplain

The first step of the CE/ICA determined which plans were cost effective for providing river and estuary benefits. **Table 4-14** outlines the four alternative plans in the final array, the average annual HU lift for the river and estuary for each alternative plan, average annual cost per unit output for each alternative plan, and whether each alternative is cost effective. Alt 5 and Alt 10 are both cost effective action alternatives for producing a lift in river and estuary HUs and are carried forward to the ICA. Alt 13 and Alt 2 produce fewer HUs than Alt 5 for a greater cost, making those plans non-cost effective. This is shown graphically in **Figure 4-3**.

Table 4-14. Cost effectiveness of alternative plans - river, estuary, floodplain benefits.

Alternative*	Average Annual Cost CRF (i=2.75%, n=50)	Average Annual NER Benefits (HU Lift)	Average Annual Cost per Unit Output	Cost Effective?	Best Buy?
No Action	$ 0	0	N/A	Yes	Yes
Alt 13	$23,008,000	250	$92,000	No	No
Alt 2	$27,470,000	341	$80,000	No	No
Alt 5	$ 22,031,000	424	$ 52,000	Yes	Yes
Alt 10	$ 29,125,000	431	$ 68,000	Yes	Yes

* Alternatives are displayed in order of increasing average annual benefits.
All $ values rounded to the $1,000's.
Any discrepancies in costs are due to rounding.
Average annual costs include construction; PED; construction management; IDC; and O&M.

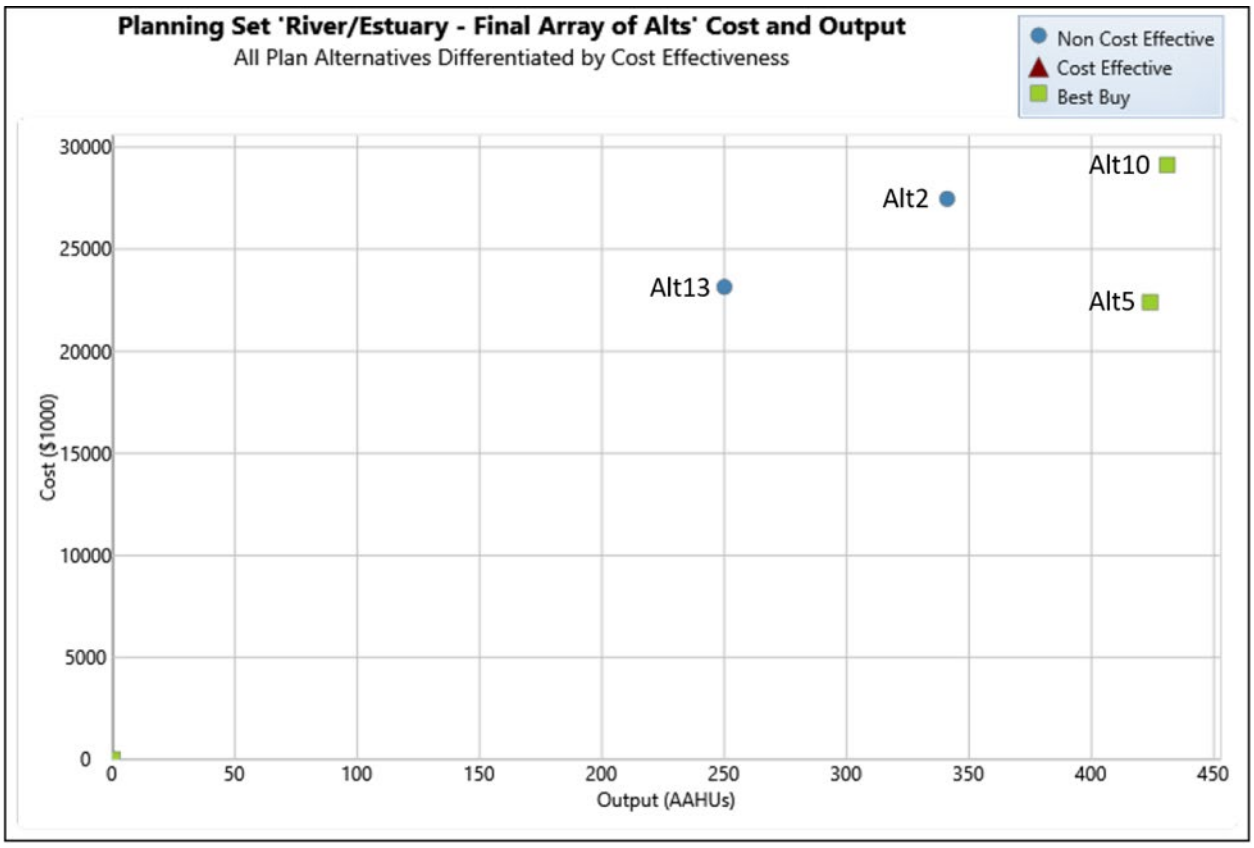

Figure 4-3. Average annual cost and average annual river, estuary, floodplain benefits.

Table 4-15 shows the incremental cost analysis for the best buy plans for benefit to the river/estuary. The 424 HU lift gained by going from No Action to Alt 5 is substantial and at a reasonable $52,000 cost per HU. It is worth it to choose Alt 5 rather than No Action. The HU lift gained by going from Alt 5 to Alt 10 is approximately seven units (7.17 HUs), each of which has an incremental cost of approximately $989,000. The additional HUs from Alt 10 are 19 times as expensive per HU than the approximately $52,000 per unit for the first 424 units of lift provided by Alt 5. If the recommendation among

alternatives was based only on river/estuary benefits, it would not be worth it to recommend Alt 10 rather than Alt 5. These increments are shown in **Figure 4-4**.

Table 4-15. Incremental cost analysis - river, estuary, floodplain benefits.

Alternative*	Average Annual Plan Cost	Average Annual Plan Outputs (Habitat Units)	Incremental Average Annual Cost Increase	Incremental Average Annual Habitat Unit Increase	Incremental Average Annual Cost/Average Annual Habitat Unit
No Action Plan	$0	0	N/A	N/A	N/A
Alt 5	$22,031,000	424	$22,031,000	424	$52,000
Alt 10	$29,125,000	431	$7,094,000	7.17	$989,000

*Alternatives are displayed in order of increasing average annual benefits.
Alt 5 is compared to No Action Plan and Alt10 is compared to Alt5.
All costs rounded to the $1,000's.

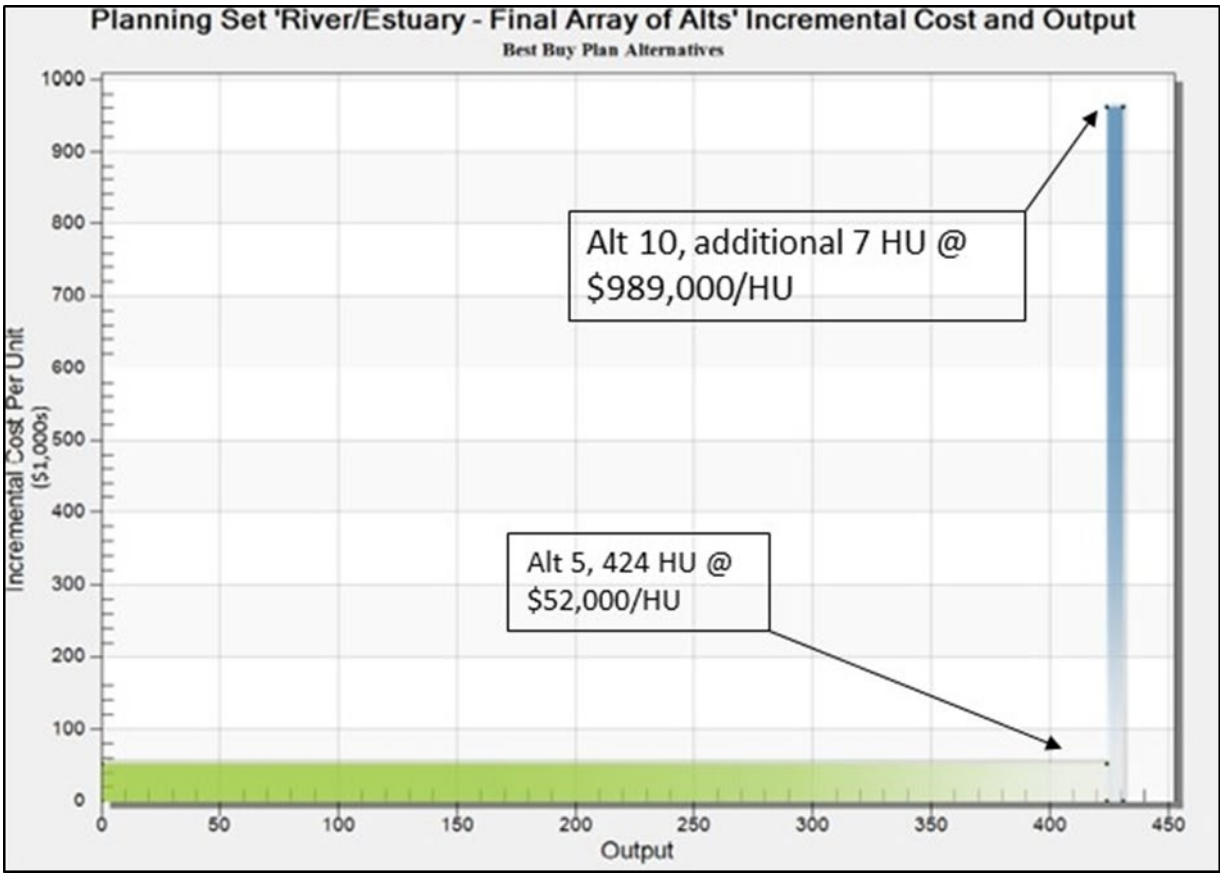

Figure 4-4. Incremental cost and output of best buy plans for river, estuary, floodplain benefits.

4.2.4.2 Watershed

The first step of the CE/ICA determined which plans were cost effective for providing watershed benefits. **Table 4-16** outlines the four alternative plans in the final array, the average annual HU lift for the

wetland/connectivity for each alternative plan, average annual cost per unit output for each alternative plan, and whether each alternative is cost effective and a best buy. Alt 5 and Alt 13 are both cost effective action plans. Alt 13 is the best buy action plan and is carried forward to the ICA. Alt 2 and Alt 10 are not cost effective because they cost more than both Alt 5 and Alt 13 and produce a smaller lift in watershed HUs than those alternatives. This is shown graphically in **Figure 4-5**.

Table 4-16. Cost-effectiveness of alternative plans - watershed benefits.

Alternative*	Average Annual Cost CRF (i=2.75%, n=50)	Average Annual NER Benefits (HU Lift)	Average Annual Cost per Unit Output	Cost Effective?	Best Buy?
No Action Plan	$0	0	N/A	Yes	Yes
Alt 10	$29,125,000	3,320	$8,800	No	No
Alt 2	$27,470,000	8,054	$3,400	No	No
Alt 5	$22,031,000	8,289	$2,700	Yes	No
Alt 13	$23,008,000	11,133	$2,100	Yes	Yes

* Alternatives are displayed in order of increasing average annual benefits.
Average annual cost rounded to the $1,000's; average annual cost per unit output rounded to the $100's.
Any discrepancies in costs are due to rounding.
Average annual costs include construction; PED; construction management; IDC; and OMRR&R.

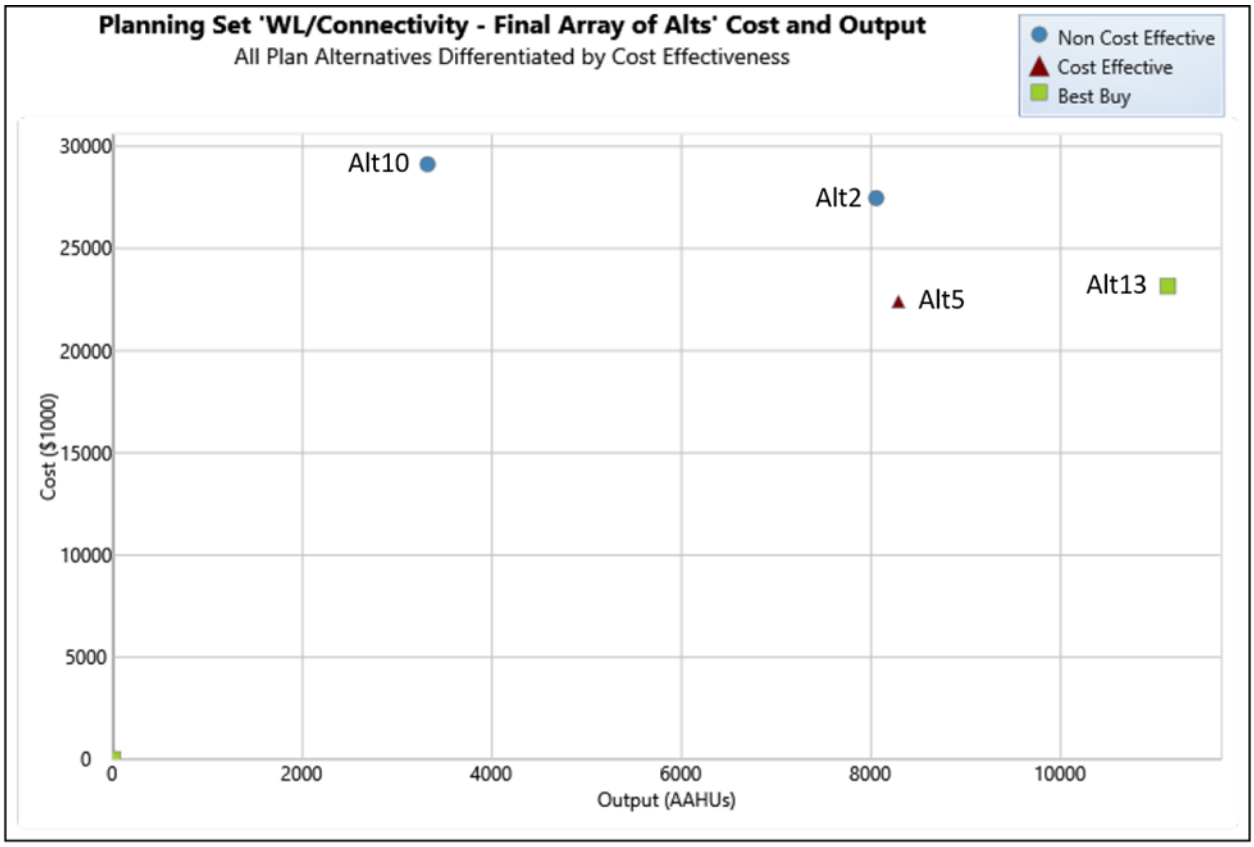

Figure 4-5. Average annual cost and average annual watershed benefits.

The incremental Cost analysis on the cost effective plans (**Table 4-17**) identified No Action and Alt 13 as Best Buy plans. This plan has the lowest average annual incremental cost per HU of the two cost effective plans and also produces the greatest HU output of the two cost-effective plans. If the recommendation among alternatives was based solely on watershed benefits, Alt 13 would be worth the investment and recommended over the cost effective but not best buy Alt 5.

Table 4-17. Incremental cost analysis watershed benefits.

Alternative*	Average Annual Plan Cost	Average Annual Plan Outputs (Habitat Units)	Incremental Average Annual Cost Increase	Incremental Average Annual Habitat Unit Increase	Incremental Average Annual Cost/ Average Annual Habitat Unit
No Action Plan	$0	0	N/A	N/A	N/A
Alt 13	$23,008,000	11,133	$23,008,000	11,133	$2,100

* Alternatives are displayed in order of increasing average annual benefits.
Average annual plan cost and incremental cost rounded to the $1,000's.
Average annual cost incremental cost per HU rounded to the $100's.

4.2.4.3 Combined Benefits

CE/ICA was also performed after combining the habitat units in the river, estuary, and floodplain with the habitat units in the watershed. **Table 4-18** shows the results of the cost effectiveness analysis and **Table 4-19** shows the results of incremental cost analysis on the best buy plans from the cost effectiveness analysis. The results of the CE/ICA on the combined habitat units are identical to the results for the watershed habitat units presented in **Section 4.2.4.2**. No Action, Alt 5, and Alt 13 are cost effective. No Action and Alt 13 are best buys.

Table 4-18. Cost-effectiveness of alternative plans - combined benefits.

Alternative*	Average Annual Cost CRF (i=2.75%, n=50)	Average Annual NER Benefits (Summed) (HU Lift)	Average Annual Cost per Unit Output	Cost Effective?	Best Buy?
No Action	$0	0	N/A	Yes	Yes
Alt 10	$29,125,000	3,751	$7,800	No	No
Alt 2	$27,470,000	8,395	$3,300	No	No
Alt 5	$22,031,000	8,712	$2,500	Yes	No
Alt 13	$23,008,000	11,383	$2,000	Yes	Yes

* Alternatives are displayed in order of increasing average annual benefits.
Average annual cost rounded to the $1,000's; average annual cost per unit output rounded to the $100's.
Any discrepancies in costs are due to rounding.
Average annual costs include construction; PED; construction management; IDC; and OMRR&R.

Table 4-19. Incremental cost analysis - combined benefits.

Alternative	Average Annual Cost	Average Annual Benefits (Summed) (Habitat Units)	Incremental Average Annual Cost Increase	Incremental Average Annual Habitat Unit Increase	Incremental Average Annual Cost/ Average Annual Habitat Unit
No Action	$0	0	N/A	N/A	N/A
Alt 13	$23,008,000	11,383	$23,008,000	11,383	$2,000

Sections 4.2.4.1 and 4.2.4.2 above contain results of combining similar habitat units across multiple geographic areas. Further combining different types of habitat units across geographic locations creates challenges for interpretation.

Ecological benefits in the river, estuary, and floodplain are of different kind and higher significance than the ecological benefits in the wetlands of the contributing watershed. The river, floodplain, and estuary is designated part of the National Wild and Scenic River system, Outstanding Florida Waters, and includes regionally rare riverine cypress forest. The NWFLR is the only place in south Florida where riverine cypress forest benefits can be produced. Even though the wetlands in the watershed do not have these official designations and are not as unique as riverine cypress forest, the watershed contains valuable and regionally significant habitat types including forested, depressional, and strand wetlands, and mesic and hydric pine flatwoods.

Even though they are highly significant resources, the river, estuary, and floodplain represent a small proportion of the entire project area and habitat units relative to the wetlands in the watershed. River, estuary, and floodplain habitat units are only 2% of the combined habitat units for Alt 13 and 11% of the combined habitat units for Alt 10. The results for other alternatives fall between these percentages. With river, floodplain, and estuary habitat such small percentages of the combined habitat units, the watershed benefits dominate the analysis. The results for the combined habitat mirror the results when watershed benefits were analyzed separately, and mask the differing performance of the alternatives for river, floodplain, and estuary benefits.

4.2.5 Efficiency Conclusion

Efficiency is evaluated using cost effectiveness and incremental cost analysis. The only cost effective plan for both habitat types is Alt 5. Alt 5 is also a Best Buy plan for river, estuary, and floodplain benefits. Alt 2 is cost effective for neither habitat type. Alt 10 is cost effective for the river, estuary, and floodplain only, and Alt 13 is cost effective for the watershed only. Based on the cost effectiveness and incremental cost analysis for both habitats, Alt 5 is the most efficient plan. This is the same conclusion reached for the effectiveness criterion in **Subsection 4.1**.

4.3 Completeness

A complete alternative plan provides and accounts for all necessary investments or other actions to ensure the realization of the plan's effects.

All four alternatives rely on additional water from a local drainage district, Indian Trail Improvement District (ITID). The assumption that ITID water will be available is only a low risk to implementation of the LRWRP alternatives. ITID currently releases water at its northern boundary and to the south under certain conditions, and these releases are likely to continue in the future. A change in operation of ITID flood control infrastructure is assumed but is not a formal management measure in the alternatives. ITID has expressed that it would discharge more water than is currently allowed by its permits, if its permits were modified, in order to better reduce flooding in its service area. Implementation of any of the four alternatives would include infrastructure that would accept the additional water discharged by ITID at its northern boundary.

Alt 13 does not yet have an administrative method to allow the LRWRP to flow water across the proposed Avenir wetland mitigation site, or a replacement mitigation site (if necessary). The PDT did not work to resolve this situation since the effectiveness and efficiency criteria pointed the team toward Alt 5 rather than Alt 13.

Alt 10 relies on an independent third party (rock mining company) to excavate the hole that would become the in-ground reservoir. While the rock mining company has expressed interest in having the LRWRP use the rock mine after rock removal is complete, USACE does not have a contract agreement or other authority to ensure that the completed rock mine is the size required for the LRWRP. If mining stops and the rock mine is too small for the LRWRP, further excavation of the in-ground reservoir by USACE is not planned. Excavation of this volume of material would be very costly, and USACE would not be able to recover the cost by selling the rock, as is done by private rock mining companies. Stockpiling and managing up to 40,000 acre-feet (~64 million cubic yards) would be cost prohibitive.

Since effectiveness (**Subsection 4.1**) and efficiency (**Subsection 4.2**) criteria pointed the team toward Alt 5, and completeness and acceptability support Alt 5, the team chose not to work through and to attempt to fully resolve the completeness concerns with Alt 13 and Alt 10.

4.4 Acceptability

An acceptable alternative plan is workable and viable with respect to acceptance by state and local entities and the public and compatible with existing laws, regulations, and public policies.

Alts 2 and 5 have no acceptability concerns. Alts 10 and 13 have acceptability concerns that represent risks that these alternative might not be implementable.

Alt 13 has acceptability risks such that the alternative might not be implementable. Alt 13 would use the C-18W site as a restored wetland with natural storage of water. Water from the C-18W site would be moved eastward across the adjacent, privately owned disturbed wetland to a third disturbed wetland farther east that would be restored by Alt 13. The owner of the privately owned land adjacent to the C-18W site received permits in 2018 to be used as a compensatory wetland mitigation site for the proposed Avenir mixed-use development. Alt 13 does not have an administrative method or proposed path to an agreement that would allow LRWRP to flow water across this wetland mitigation site. There is a risk that an acceptable agreement might not be achievable. Avenir might not have an alternate site for wetland mitigation. USACE might be unwilling to take-on the mitigation obligations of the private developer.

Alt 10 also has acceptability risks that the alternative might not be implementable. As part of the water quality compliance approach for Alt 10, structure S-76 near Lake Okeechobee would be closed to prevent

Lake Okeechobee's high nutrient water from entering the L-8 Canal and being transported to the in-ground reservoir. Even incrementally reducing the get-away capacity of Lake Okeechobee may be unacceptable. The in-ground reservoir would be a replacement water supply source for the City of West Palm Beach, in accordance with the Savings Clause. Only a portion of the storage capacity of the reservoir would be used for restoration of the Loxahatchee River. None of the other three alternatives create this new potential direct conflict for limited water during dry conditions – a conflict that must be managed by future project operators.

Since effectiveness (**Subsection 4.1**) and efficiency (**Subsection 4.2**) criteria pointed the team toward Alt 5, and completeness and acceptability support Alt 5, the team chose not to work through and to attempt to fully resolve the acceptability issues with Alt 13 and Alt 10.

4.5 Summary of Principles and Guidelines Evaluation Criteria

Table 4-20 summarizes the effectiveness, efficiency, completeness, and acceptability analyses described in **Subsections 4.1** through **4.4**. The "plus" (+) symbols in table represent the relative effectiveness in meeting each planning objective – more (+) is better. Based on all four criteria, Alt 5 would be the NER Plan and the Recommended Plan.

Table 4-20. Summary of principles and guidelines evaluation criteria.

Criteria	Alt 2	Alt 5	Alt 10	Alt 13
Effectiveness in Meeting Objective 1: Flow at Lainhart Dam	++	++	+++	+
Effectiveness in Meeting Objective 2: River/Estuary	++	++	++	+
Effectiveness in Meeting Objective 3: Acres restored	++	++	+	+++
Effectiveness in Meeting Objective 4: Connectivity	++	++	+	+++
Effectiveness in Meeting Objective 5: Plant & Animal Abundance & Diversity	++	++	+	+++
Efficiency for River/Estuary Habitat Units	No	Cost Effective Best Buy	Cost Effective Best Buy	No
Efficiency for Wetland Habitat Units	No	Cost Effective	No	Cost Effective Best Buy
Completeness	Yes	Yes	Yes	No
Acceptability	Yes	Yes	No	No

4.6 Revised Alternatives and the Recommended Plan

Based on the four Principles and Guidelines criteria, Alt 5 would be recommended over Alts 2, 10, and 13. After reviewing the results, PDT agencies requested additional analysis of modified alternatives. Different agency stakeholders continued to express strong support for Alts 5, 10 or 13.

PDT agencies and stakeholders reformulated Alts 10 and 13 to focus on strengthening the performance where those alternatives were weakest in comparison to the other alternatives. Additionally,

stakeholders requested the team formulate revisions to Alt 5 to improve its performance. The new alternatives are labeled 10R, 13R, and 5R.

PDT agencies and stakeholders requested that Alt 10 be revised to improve its performance for the watershed wetlands and that Alt 13 be revised to improve its performance for the river, estuary, and floodplain. Alt 10 had fewer wetland restoration measure in Flow-way 3 than Alts 2, 5, and 13. In Alt 10R, the Flow-way 3 restoration measures of Alt 10 were replaced with the Flow-way 3 wetland restoration measures from Alt 13. Alt 13R is Alt 13 revised to improve its river, estuary, and floodplain performance. Alt 13 had lower performance for river, estuary, and floodplain benefits than Alts 2, 5, and 10. Alt 13R includes the measures of Alt 13 plus the deep in-ground reservoir and associated features from Alt 10 that greatly contributed to river, estuary and floodplain benefits. Alt 5R is Alt 5 modified to improve watershed performance by adding the Mack Dairy Road pump station and spreader swale Flow-way 3 wetland measure from Alt 13.

4.6.1 Costs and Benefits of the Revised Alternatives

New cost estimates for the revised alternatives were prepared using portions of the costs of the initial four alternatives. Ecosystem benefits of the revised alternatives was inferred from the known performance of the original, modeled alternatives, in locations affected by the revised features. The three revised alternatives contained additional selected measures from the alternatives that had already undergone H&H modeling and detailed analysis. The revised alternatives were not re-modeled. Average annual costs and average annual benefits for the revised Alts 10R, 13R and 5R were calculated using the same methods described in Sections 4.2.2 and 4.2.3 for Alts 2, 5, 10, and 13.

Since **Subsections 4.1** through **4.5** showed Alt 5 is preferred over Alts 2, 10, and 13, only Alt 5 was carried forward to the analysis of revised alternatives. The other three original alternatives were not carried into the analysis of revised alternatives. Whether a revised alternative performs better or worse than its unrevised version does not matter to the decision on a Recommended Plan. In order to become the Recommended Plan, a revised alternative will have to be “better” than Alt 5.

4.6.2 CE/ICA for River, Estuary, and Floodplain Benefits

Table 4-21 presents the average annual costs and benefits, and a cost effectiveness analysis for river, estuary and floodplain benefits of Alt 5 and the revised alternatives. For river, estuary, and floodplain benefits, No Action and Alt 5 were the only cost effective plans and the only best buy plans. Alt 5R has the same river benefits as Alt 5, but because of the small additional cost for Alt 5R to achieve more wetland benefits, Alt 5R is not cost effective for river benefits. If river, estuary, and floodplain benefits were the only selection criterion, Alt 5 would be recommended over Alt 5R. If only the revised alternatives were considered, Alt 5R would be cost effective and a best buy, and would be recommended over the other revised alternatives.

Table 4-21. Cost-effectiveness analysis - river, estuary, and floodplain benefits of revised alternatives.

Alternative*	Average Annual Cost CRF (i=2.75%, n=50)	Average Annual River Estuary Floodplain Benefits	Average Annual Cost per Average Annual Benefit	Cost Effective?	Best Buy?
No Action	$0	0	N/A	Yes	Yes
Alt 13R	$41,387,000	408	$101,000	No	No
Alt 10R	$37,379,000	419	$89,000	No	No
Alt 5	$22,031,000	424	$52,000	Yes	Yes
Alt 5R	$23,316,000	424	$55,000	No	No

* Alternatives are displayed in order of increasing average annual benefits.
Average annual cost rounded to the $1,000's; average annual cost per unit output rounded to the $100's.
Any discrepancies in costs are due to rounding.
Average annual costs include construction; PED; construction management; IDC; and OMRR&R.

While Alt 10R and Alt 10 have the same measures for river performance, the average annual river, estuary, and floodplain benefits of Alt 10R (419) were slightly reduced from 431 for Alt 10 (431) (**Table 4-14**). This is because the substantial additional cost and longer duration of construction for Alt 10R to achieve additional wetland benefits would delay the time when river and wetland ecosystem benefits would begin. This shorter duration of river benefits reduced the average annual river benefit across the 50-year analysis period.

The in-ground reservoir was included in Alt 13R to improve river benefits over Alt 13, and it did improve river benefits from 250 average annual habitat units (see **Table 4-14**) to 408 (**Table 4-21**). However, the additional reservoir was also very expensive. Similar to the comparison of Alt 10R and Alt 10, the substantial additional cost and longer duration of construction for Alt 13R to achieve additional river benefits would delay the time when river benefits would begin. This shorter duration of river benefits reduced the average annual river benefit across the 50-year analysis period and prevented Alt 13R from fully achieving the 431 average annual habitat units of Alt 10.

4.6.3 CE/ICA for Watershed Benefits

Table 4-22 presents average annual costs and benefits, and a cost effectiveness analysis for watershed wetlands benefits of Alt 5 and the revised alternatives. No Action, Alt 5, and Alt 13R are cost effective plans. No Action and Alt 5R are best buy plans. If watershed benefits were the only selection criterion, Alt 5R would be recommended over Alt 5.

Table 4-22. Cost effectiveness analysis - watershed benefits of revised alternatives.

Alternative*	Average Annual Cost CRF (i=2.75%, n=50)	Average Annual Watershed Benefits	Average Annual Cost per Average Annual Benefit	Cost Effective?	Best Buy?
No Action	$0	0	N/A	Yes	Yes
Alt 10R	$37,379,000	7,820	$4,800	No	No
Alt 5	$22,031,000	8,289	$2,700	Yes	No
Alt 13R	$41,387,000	9,131	$4,500	No	No
Alt 5R	$23,316,000	9,138	$2,600	Yes	Yes

* Alternatives are displayed in order of increasing average annual benefits.
Average annual cost rounded to the $1,000's; average annual cost per unit output rounded to the $100's.
Any discrepancies in costs are due to rounding.
Average annual costs include construction; PED; construction management; IDC; and OMRR&R.

Alt 10R was formulated to increase wetland benefits, and Alt 10R has more than double the watershed average annual habitat units of Alt 10. However Alt 10R, much like Alt 10, is very costly and is not cost effective for watershed benefits when compared to Alt 5 or Alt 5R.

Alt 13R revised Alt 13 to improve its river, estuary, and floodplain performance and retains the same measures from Alt 13 that contribute greatly to watershed benefits. Alt 13R had lower watershed average annual habitat units than Alt 13. This is because Alt 13R had higher costs than Alt 13 and also took longer to build and start producing watershed benefits. These both reduce the calculated watershed average annual habitat units.

Alt 5R is Alt 5 modified to improve watershed performance by including two wetland measures from Alt 13. Alt 5R is cost effective and a best buy for watershed benefits. Alt 5 is cost effective but not a best buy. Alt 5R has the lowest cost per habitat unit of the array of revised alternatives and Alt 5. Compared to Alt 5, Alt 5R has a 10.2% increase of average annual watershed wetland benefits for only a 5.5% increase of average annual cost (**Table 4-22**).

4.6.4 Discussion of Revised Alternatives

Alts 10R and 13R were developed to provide better performance than Alts 10 and 13. Analysis determined that they did provide better ecological performance. However, for river, estuary, and floodplain benefits, neither Alt 10R nor Alt 13R are cost effective. Alt 5 is cost effective and a best buy, just as it was when compared to the original Alts 2, 10, and 13 (**Table 4-14** and **Table 4-15**). Alt 5R has the same river benefits as Alt 5. For watershed benefits, neither Alt 10R nor Alt 13R are cost effective. Alt 5 and Alt 5R are cost effective, and Alt 5R is a best buy.

One of the reasons that Alts 10R and 13R not cost effective for river or watershed benefits is that they are much more costly than Alts 10 and 13, and more costly than Alts 5 and 5R. Even if Alts 10R and 13R were cost effective for benefits, their high costs might not be supported. Additionally, Alt 10R carries the same concerns as Alt 10 regarding completeness (Section **4.3**) and acceptability (Section **4.4**). Alt 13R has the same concerns as Alt 13 regarding completeness and acceptability, plus the same concerns associated with the in-ground reservoir of Alt 10.

For all of these reasons, Alts 10R and 13R are no longer considered over Alts 10 and 13.

Subsections 4.1 through 4.5 showed Alt 5 is recommended over Alts 2, 10, and 13. Subsection 4.6 showed that Alts 10R and 13R are not worth it verses Alts 5 and 5R and not worth it versus Alts 10 and 13.

The remaining decision is between Alt 5 and Alt 5R. Alt 5R was cost effective and a best buy for watershed average annual benefits while Alt 5 was cost effective but not a best buy. For a small increase of cost, Alt 5R provides more watershed benefits than Alt 5, and a lower average cost per watershed habitat unit than Alt 5. All this comes with no loss of river benefits. Alt 5R is worth the additional cost over Alt 5 and it replaces Alt 5 in the analysis. Alternative 5R is the Recommended Plan.

4.6.5 Sea Level Rise Considerations for Alt 5R

In order to evaluate the sea level rise impact on Alt 5R for the 50-year planning horizon, a curvilinear three-dimensional hydrodynamic model CH3D was applied to the Northwest Fork of the Loxahatchee River and the Loxahatchee River Estuary. **Appendix H** contains expanded results. Alt 5R and the FWO condition were run with 3 projected sea level rise conditions. All of the river, estuary, and floodplain valued ecosystem components (**Table 4-1** and **Table 4-2**) were assessed. The salinity output results for the freshwater tidal zones (0-2 psu) (**Table 4-23)** are presented because this lowest salinity habitat zone is more sensitive to salinity and sea-level change than the other river and estuarine zones.

The freshwater tidal zones performance of Alt 5R differs very little among the three sea level rise scenarios. For acreage of freshwater tidal zones, Alt 5R would have 97 acres with no sea level change and 93.1 acres with high sea level change in the dry season, a 3.9 acre (4%) decrease. In the wet season, acreage would change from 148 to 129.8, an 18.2 acre (14%) decrease. For the difference between Alt 5R and FWO (benefit), in the dry season, the difference is 12 acres (96-84) under the low sea level change scenario and 11.5 acres (93.1-81.6) in the high sea level rise scenario. In the wet season, the difference is 3 acres (133-130) in the low level change scenario and 1.8 (129.8-128) acres in the high sea level rise scenario.

Table 4-23. Average area (acres) in the Loxahatchee River with salinity less than 2 psu.

SLR Scenario*	Flow	Dry season	Wet season
SLR0	FWO	Data not available	Data not available
SLR0	Alt 5R	97	148
SLR1	FWO	84	130
SLR1	Alt 5R	96	133
SLR2	FWO	83	128
SLR2	Alt 5R	93.8	130.2
SLR3	FWO	81.6	128
SLR3	Alt 5R	93.1	129.8

* SLR0 = no sea level rise. SLR1= low sea level rise. SLR2 = intermediate sea level rise. SLR3 = high sea level rise.

The hydrodynamic salinity model was applied only to Alt 5R. However, similar results would be expected for Alternatives 2, 10, and 13. All of the final alternatives also increase water delivery to the NWFLR to produce benefits in the river, estuary, and floodplain using storage, conveyance, and restoration measures upstream in the watershed.

4.6.6 The Recommended Plan is Alt 5R

Alternative 5R is the Recommended Plan (**Figure 4-6**). Evaluations using the four "Principles and Guidelines" criteria (effectiveness, efficiency, completeness, and acceptability) support Alternative 5 over Alternatives 2, 10, and 13. Additional analysis of Alternative 5 with revised alternatives 5R, 10R, and 13R concluded with a recommendation of Alternative 5R. The RECOVER system-wide evaluation of Alternatives 2, 5R, 10, and 13 identified the same patterns of performance of the alternatives that the PDT identified – Alternative 10 performing best for the river but worst for the watershed wetlands, Alternative 13 performing best for the watershed wetlands but worst for the river, and Alternative 5R performing second best for both river and watershed.

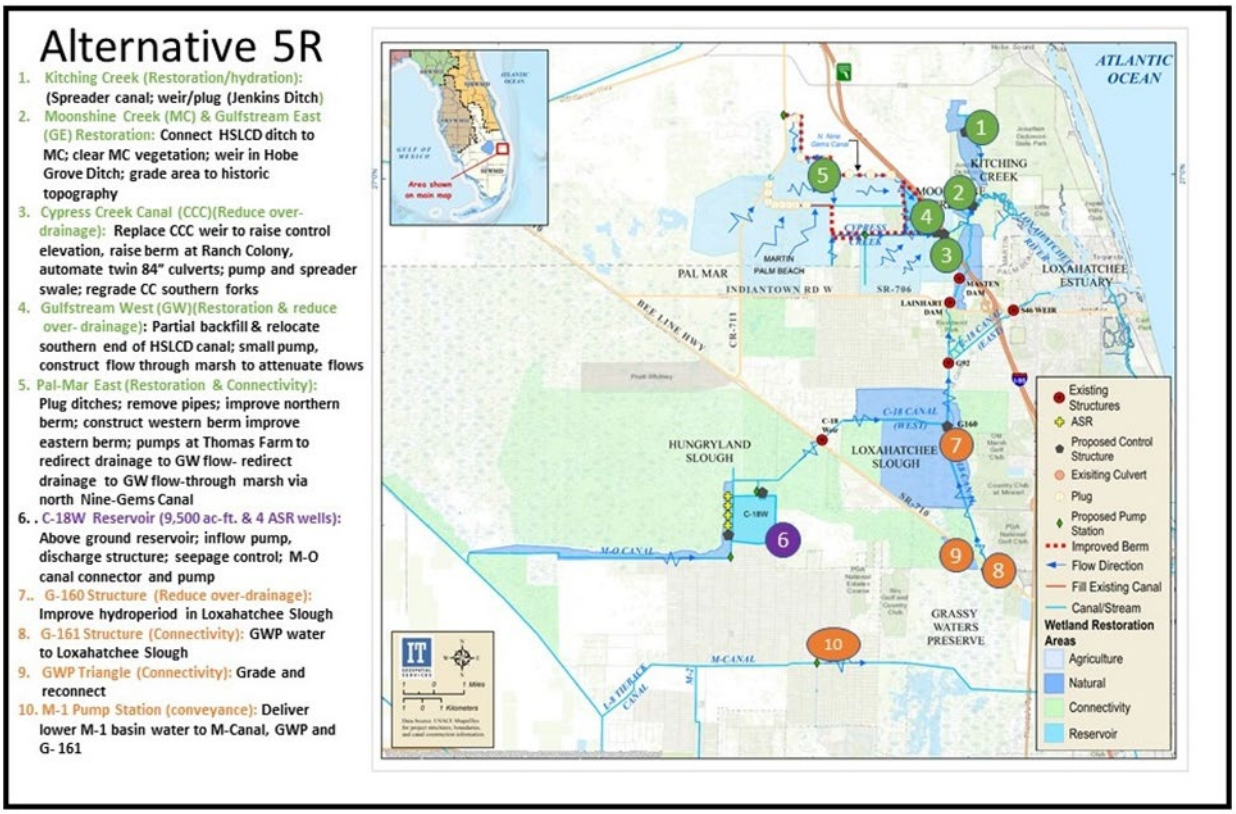

Figure 4-6. The LRWRP Recommended Plan, Alternative 5R.

4.7 RECOVER System-wide Evaluation

As required in the CERP Programmatic Regulations, the RECOVER team, CERP's interagency science group, evaluated ecological effects of the final array of alternatives (Alt 2, Alt 5R, Alt 10 and Alt 13) for the LRWRP. The scope of the review covered all areas expected to be improved by CERP, beyond the boundaries of the LRWRP footprint, and includes performance measures (PMs), evaluation tools, and best professional judgment that reach beyond the tools and expertise of the traditional USACE planning

process. The tools and professional backgrounds of the reviewers represented decades of experience studying and modeling the ecology of south Florida. The purpose of the review was three-fold: to provide insight into whether some alternatives performed better ecologically than others, to indicate whether alternatives may lead to unintended ecological conditions, and to investigate unintended effects beyond LRWRP's boundaries that could potentially contradict CERP on a regional scale.

Key Findings:

- All areas that LRWRP intends to improve can be improved by the proposed alternatives included in the final array. These areas include the NWFLR and Estuary in the Northern Estuaries RECOVER Module (NE), the Loxahatchee Watershed between the Northern Estuaries, Greater Everglades RECOVER Module (GE), and the Lake Okeechobee RECOVER Module (LO). LRWRP will not have an impact to the lake stage within the LO. LRWRP will not affect the Southern Coastal Systems RECOVER Module (SCS). In terms of overall ecological and hydrological restoration, Alt 5R outperforms all other alternatives in the final array.
- Modeling of the hydrology, salinity, and associated ecology of the NWFLR and associated Loxahatchee Estuary, showed an increase in freshwater flow throughout the NWFLR 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 NWFLR and Estuary had a notable positive influence in the "Floodplain Swamp and Hydric Hammock in the Freshwater Riverine Floodplain" 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 "Floodplain Swamp in the Tidal Floodplain" VEC and "Seagrasses in the Polyhaline Zone" VEC (7 acre difference between FWO [727 acres] and worst performing alternative [Alt 10 = 720 acres) for the Polyhaline Zone. Overall, Alt 10 provides the most improvement in freshwater flow and the most enhancement of salinity conditions throughout the VECs, as a whole, within the NWFLR and Estuary.
- In the Loxahatchee Watershed, general improvement in watershed hydrology (Performance Measure 4 scores, in %) 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 NWFLR and Estuary. Alt 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 Alt 10 performed best in the NWFLR, it performed the worst of all alternatives with regard 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 (Alt 10) to 0.83 (Alt 13) compared to 0 for the FWO scenario.
- Regarding Lake Okeechobee lake stage, Alt 10 includes construction of a deep reservoir associated with C-51. This feature would reduce water deliveries, via the L-8 Canal, from Lake Okeechobee to the LRWRP area. 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 ac-ft per day (24,254 ac-ft per month). None of the other LRWRP alternatives in the final array contain features that would impact Lake Okeechobee lake stage.

- The use of a small number of Aquifer Storage and Recovery Wells (ASRs) 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.
- LRWRP is consistent with the ecological restoration targets established throughout the NE PMs. 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 (Alt 2), 140 ac-ft (Alt 10), and 350 ac-ft (Alt 13) compared to the FWO. However, Alt 5R increases average wet season flow by 700 ac-ft compared to the FWO. The magnitude of these changes in flow, increasing or decreasing, are considered small.
- There was consensus that proceeding with an adaptive management approach can further increase the benefits of LRWRP and positively influence the implementation of LRWRP in ecologically sensitive areas. Adaptive management provides a means to learn during implementation and operations, improves delivery of benefits, and can minimize impacts. Therefore, adaptive management is a significant source of ecological risk buy-down for LRWRP.

4.8 RECOVER Consistency

The LRWRP PDT considered RECOVER's evaluation and found it consistent with the selection of Alt 5R as the best alternative to meet the project objectives in the most effective, efficient, complete and acceptable project alternative.

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Table of Contents

5 EFFECTS OF THE FINAL ARRAY OF ALTERNATIVES AND THE RECOMMENDED PLAN..... 1
5.1 Climate..... 2
5.2 Physical Landscape..... 3
5.3 Vegetative Communities..... 3
5.3.1 Northwest Fork Loxahatchee River..... 3
5.3.2 Loxahatchee River Estuary..... 5
5.3.3 Loxahatchee River Watershed..... 5
5.4 Threatened and Endangered Species..... 11
5.5 State Listed Species..... 13
5.6 Wildlife..... 13
5.6.1 Invertebrates..... 14
5.6.2 Fish..... 14
5.6.3 Amphibians and Reptiles..... 14
5.6.4 Birds..... 15
5.6.5 Mammals..... 15
5.7 Essential Fish Habitat..... 15
5.8 Hydrology..... 16
5.9 Water Quality..... 17
5.10 Air Quality..... 19
5.11 Hazardous, Toxic and Radioactive Waste..... 19
5.12 Noise..... 19
5.13 Aesthetics..... 19
5.14 Land Use..... 20
5.14.1 Wetlands..... 20
5.14.2 Agriculture..... 22
5.15 Socioeconomics..... 22
5.15.1 Population..... 22
5.15.2 Economic Activities..... 22
5.15.3 Socioeconomics: Water Supply and Flood Control..... 23
5.15.4 Recreation..... 24
5.16 Environmental Justice..... 25
5.17 Cultural Resources..... 25
5.18 Effects on Native Americans..... 27

5.19 Invasive Species 28

Tables

Table 5-1. Summary of hydrologic conditions and dominant riverine and upper tidal canopy species (Sources: Restoration Plan for the NW Fork of the Loxahatchee River [SFWMD 2006] and USGS [2002]). 4
Table 5-2. Loxahatchee River watershed wetland types and expected inundation periods. 6
Table 5-3. Summary of alternative plan hydrologic improvements in inundation duration days over the period of record by indicator region. 8
Table 5-4. Effects of alternatives on Federal threatened and endangered species. 12
Table 5-5. Effects of FWO and alternatives on hydrology. 16
Table 5-6. Summary of effects of alternatives on water quality - total phosphorus concentrations and loads from LECSR-NP modeling. 18
Table 5-7. Summary of effects of alternatives on water quality - total nitrogen concentrations and loads. 18
Table 5-8. Acres of restored wetlands by alternative. 21
Table 5-9. Effects of alternatives on water supply and flood control. 24
Table 5-10. Effects of alternatives on recreation. 24
Table 5-11. Effects of the final array of alternative on cultural resources. 26
Table 5-12. Response of invasive species by alternative. 28

List of Figures

Figure 5-1. Map of indicator regions used to evaluate project effects on dominant wetland community types. 7

5 EFFECTS OF THE FINAL ARRAY OF ALTERNATIVES AND THE RECOMMENDED PLAN

This section evaluates the anticipated environmental effects of the alternative actions described in **Section 3.0** and **Section 4.0**. Since the final array of alternatives contained a no action alternative (referred to throughout the report as the Future Without [FWO]), the other four action alternatives were evaluated against the FWO to describe changes to existing conditions with implementation of each action alternative. These potential effects are summarized within this section and the analysis represents the "Environmental Consequences" analysis of the integrated NEPA EIS document.

The significance of project effects is determined through an evaluation of context, intensity, duration, and cumulative nature. A summary of significant or non-significant effects is provided in this section and full details are discussed in **Appendix C.2.1**. The following definitions were used to evaluate the context, intensity, duration, and cumulative nature of impacts associated with project alternatives.

Under the National Environmental Policy Act (NEPA), one purpose is to identify at an early stage the significant environmental issues deserving of study and deemphasize insignificant issues, narrowing the scope of the environmental impact statement accordingly (40 CFR Sec 1501.1). In accordance with the Council on Environmental Quality's (CEQs) regulations [43 FR 56003, Nov. 29, 1978; 44 FR 874, Jan. 3, 1979], 40 CFR Sec 1508.27 states that "significantly" as used in NEPA requires considerations of both context and intensity:

(a) Context. This means that the significance of an action must be analyzed in several contexts such as society as a whole (human, national), the affected region, the affected interests, and the locality. Significance varies with the setting of the proposed action. Both short and long-term effects are relevant.

(b) Intensity. This refers to the severity of impact. The following factors should be considered in evaluating intensity:

(1) Impacts that may be both beneficial and adverse. A significant effect may exist even if the federal agency believes that on balance the effect will be beneficial.

(2) The degree to which the proposed action affects public health or safety.

(3) Unique characteristics of the geographic area such as proximity to historic or cultural resources, parklands, prime farmlands, wetlands, wild and scenic rivers, or ecologically critical areas.

(4) The degree to which the effects on the quality of the human environment are likely to be highly controversial.

(5) The degree to which the possible effects on the human environment are highly uncertain or involve unique or unknown risks.

(6) The degree to which the action may establish a precedent for future actions with significant effects or represents a decision in principle about a future consideration.

(7) Whether the action is related to other actions with individually insignificant but cumulatively significant impacts. Significance exists if it is reasonable to anticipate a cumulatively significant impact on the environment. Significance cannot be avoided by terming an action temporary or by breaking it down into small component parts.

(8) The degree to which the action may adversely affect districts, sites, highways, structures, or objects listed in or eligible for listing in the National Register of Historic Places or may cause loss or destruction of significant scientific, cultural, or historical resources.

(9) The degree to which the action may adversely affect an endangered or threatened species or its habitat that has been determined to be critical under the Endangered Species Act of 1973.

(10) Whether the action threatens a violation of Federal, State, or local law or requirements imposed for the protection of the environment.

For this analysis, the level of intensity is defined as follows:

- Negligible - effect to the resource or discipline is barely perceptible, not measurable and/or is confined to a small area
- Minor - effect to the resource or discipline is perceptible, measurable and is localized to a portion of the project area
- Moderate - effect is clearly detectable and could have an appreciable effect on the resource or discipline; or the effect is perceptible and measurable throughout the project area
- Major - effect would have a substantial, highly noticeable influence on the resource or discipline on a regional scale

Duration: For this analysis, the duration of the effects is defined as follows:

- No duration: no effect
- Short term: effects that last less than one year
- Long term: effects that last longer than one year

5.1 Climate

Under the FWO conditions, the regional climate would be unaffected by the implementation of any project alternatives. Implementation of any of the LRWRP alternatives would have a negligible, regional, long-term effect on climate within the action area. Negligible, localized effects to microclimate may occur under all LRWRP action alternatives as a result of redistribution of surface water and groundwater and resultant shifts in vegetation community composition and distribution.

5.2 Physical Landscape

Under the FWO conditions, without actions that change hydrology or connect disjunct land parcels, lands within the project area will remain over-drained and marginally connected. The existing wetlands within the project area would continue to be drained by adjacent ditches and canal systems, and the continued drawdown of the groundwater in close proximity to the Northwest Fork of the Loxahatchee River (NWFLR) would continue to have an impact on the base flows to the river.

- Geology: Geologic conditions would be unchanged as a result of implementation of Alts 2, 5R, and 13 of the LRWRP alternatives. There are active mining sites located in the project planning area, south and west of the L-8 canal. Mining impacts specific to geology can include erosion, changes in seepage volume, and contamination of soil, groundwater, and surface water by chemicals used in the mining process. In Alt 10, a portion of this mining site is proposed to be repurposed as a water storage facility, resulting in a minor long-term effect. Although the rock formation in the area is relatively tight, there is potential interaction with groundwater, and a likelihood for chloride levels to be higher than background levels.
- Soils: All of the alternatives result in major long-term improvement to wetland hydroperiods: affected acres in each alternative are, respectively, 26,105 (Alt 2), 26,235 (Alt 5R), 10,000 (Alt 10), and 31,873 (Alt 13). Many areas of hydric soils would revert to a less drained condition.
- Aquifers: Groundwater levels in the unconfined surficial aquifer system (SAS) would rise in those areas where wetland rehydration is proposed. Additionally, ASR is contemplated to augment above-ground storage in Alts 2, 5R, and 13. Increased storage volume in the subsurface will ensure water availability for the Loxahatchee River, particularly in the dry season. In areas where the Upper Floridan Aquifer (UFA) and Avon Park Permeable Zone (APPZ) are more saline, ASR will freshen the aquifer. Recharged surface water will displace native groundwater in both aquifers of the Floridan Aquifer System (FAS). These effects are expected to be moderate and persist over the long term.

5.3 Vegetative Communities

The effects of the final array of alternatives on the vegetative communities are documented below and compared to the FWO. Refer to **Appendix C, subsection C.2.1.3**, which contains more detailed information.

5.3.1 Northwest Fork Loxahatchee River

Two control structures, known colloquially as the Lainhart and Masten Dams, are located on the federally designated "Wild and Scenic" NWFLR. These two structures are technically weirs that were initially installed by adjacent landowners in the 1930s. The original structures were replaced in the mid-1980s and were reconstructed in 2017 to offset seepage issues. The Lainhart and Masten Dams control and regulate upstream water levels to maintain the hydrology of the river ecosystem and, therefore, serve a crucial role in protecting the cypress swamp floodplain. Modeling has shown that without the two dams in place, water levels within the river would be nearly 1.5 feet lower, draining the freshwater swamp and encouraging continued saltwater intrusion, further exacerbating an already low flow condition. The ecological integrity of the riverine floodplain is largely determined by regional hydrologic conditions and by how much flow is delivered to the river over Lainhart Dam, which in turn impacts the hydrologic factors that

influence the integrity of the vegetative community types that exist in the riverine floodplain. These factors are the maximum dry season water elevations within the river channel, the minimum wet season water elevations in the floodplain, the durations of each and the water stages over the floodplain during transitions period. The restoration flow target is a variable dry season flow between 50 and 110 cfs, with a mean monthly flow of 69 cfs over Lainhart Dam. To simplify the analysis, the PDT used a rolling 30-day average of >68 cfs to determine how well the dry season target was met. Additionally, to maintain the appropriate wet season water elevations in the floodplain, the wet season target was a minimum of 110 cfs for 120 or more days in the wet season. Wet season analysis was pass/fail (that is, if there was a flow of greater than 110 cfs for 120 days or more in a given year, the target was met, otherwise it was not).

Three distinct reaches (riverine, lower tidal, and upper tidal) and four major forest community types (swamp, bottomland hardwood, hydric hammock, and upland) are identified on the floodplain of the NWFLR. **Table 5-1** summarizes hydrologic conditions and dominant canopy species of the floodplain forest and upper tidal communities.

Table 5-1. Summary of hydrologic conditions and dominant riverine and upper tidal canopy species (Sources: Restoration Plan for the NW Fork of the Loxahatchee River [SFWMD 2006] and USGS [2002]).

Forest Type	Typical Hydrologic Condition	Dominant Canopy species
Mesic Hammock	Rarely inundated, sandy soils elevated and dry quickly after flood waters recede	Live oak
Hydric Hammock	Flooded average of 2 months annually	Sabal palm
Riverine 1	Flooded average of once every 3 years, sometimes for durations of 1-2 months or more, sandy soils dry quickly	laurel oak, cocoplum, dahoon holly, water hickory, red bay
Riverine 2	Flooded average of 1 month every year, loamy, clay soils remain saturated for a month or more following	red maple, button bush, swamp bay, coastal plain willow
Riverine 3	Flooded average of 4-7 months each year, mucky, clay soils remain saturated another 5 months	bald cypress, water ash
Riverine 4	Flooded 2- 3 months every year, generally sandy soils	bald cypress, sabal palm
Upper Tidal 1	Flooded 2-3 months every year, loamy muck and sandy soils dry quickly in some areas and remain saturated in others	white mangrove, pond apple, red maple, coastal plain willow, button bush, bald cypress
Upper Tidal 2	Flooded monthly by high tides or high river flows, or flooded daily by high tides from 9-11 months of the year with soils continuously saturated	water ash, red mangrove, white mangrove, pond apple

All alternatives were conceptualized to deliver restoration flows that best balance these hydrologic factors, measured as flow over Lainhart Dam, by capturing and attenuating discharges that would otherwise be sent to tide, and then using that water to deliver flows as determined by the restoration schedule to the river. For all alternatives, above ground (or in the case of Alt 10, below ground) storage features of

variable size were considered. Three of the alternatives (2, 5R, and 13) also augmented this above-ground storage with ASR wells. All of the impoundments/reservoirs are situated on land that was formerly cultivated for agriculture (citrus groves or, in the case of the C-51 Phase II site in Alt 10, sugar cane). For Alts 2, 5R and 10, an above ground reservoir of variable depth would be constructed in the western C-18 Basin, adjacent to the J.W. Corbett Wildlife Management Area (WMA). In Alt 10, an additional below ground storage facility is proposed south of the L-8 Canal. The ability of each alternative to deliver flows to meet the restoration flow targets was assessed. All alternatives performed well and met the wet season target 98% of the time or better. River performance was maximized by Alt 10, which met the dry season target 95% of the time, while Alts 2, 5R, and 13 met the dry season targets 87%, 91%, and 80% of the time, respectively.

5.3.2 Loxahatchee River Estuary

In addition to the riverine and tidal zones outlined above, several estuarine valued ecosystem component zones are present for the Loxahatchee River. These zones include freshwater (characterized by tapegrass, a freshwater submerged aquatic vegetation (SAV), oligohaline (low salinity, larval and juvenile fish), mesohaline (oysters) and polyhaline (seagrass). The Loxahatchee River estuary is a species rich system that is influenced by its proximity to the western edge of the Florida current and adjacent tropical marine ecosystems. Dissolved nutrients and detritus, along with optimal temperature and salinity within the oligohaline zone provide the appropriate conditions for larval invertebrate and juvenile fish development. Low salinity and detritus associated with freshwater inputs contribute to productivity in this zone. The mesohaline zone is transitional between freshwater and seawater with a salinity averaging between 10 and 20 psu and is especially conducive to oyster production (Woodward-Clyde 1998). Changes in freshwater runoff in the Loxahatchee can alter the salinity gradient and affect the location of oysters within the estuary. The polyhaline zone supports seagrass communities, which in turn support diversity and biological productivity in the estuary. Most commercial and recreational fish spend at least some time of their life history in seagrass beds. Seagrass species include shoal grass, manatee grass, turtle grass, and Johnson's seagrass.

Flows over Lainhart Dam were used as an indicator of each habitat zone downstream based on the dry season performance measure criteria of mean monthly flow of 69 cfs or greater in the Restoration Plan (SFWMD 2006). Alt 10 provides the most storage overall and scored 95%, followed by Alt 5R scoring a 91% and, thus, have the largest amount of storage closest to the river. Alt 2 followed right behind with a score of 87%, where the additional shallow L-8 storage and smaller C-18 west storage did not perform as well in meeting river targets. Alt 13 performed the worst in meeting river targets with an 80% score, likely due to the relative inefficiency of the L-8 Shallow Impoundment feature.

5.3.3 Loxahatchee River Watershed

Due to changes in the quantity, quality, distribution, and timing of water in the Loxahatchee watershed, moderate and significant improvements to the wetland hydrology and vegetation would occur to various degrees under each alternative. The primary factors influencing the distribution of dominant freshwater wetland plant species in the watershed are soil type, soil depth, and hydrological regime (FWS 1999). Major wetland types and their appropriate inundation periods are shown in **Table 5-2**.

Table 5-2. Loxahatchee River watershed wetland types and expected inundation periods.

Plant Community	Desired Inundation (days)	Primary Plant Species
Mesic Flatwoods (MF)	≤ 30	S. Florida slash pine, fetterbush, stagger bush, saw palmetto, gallberry, wiregrass, shiny blueberry
Mesic (Oak) Hammock (MH)	0-60	Live oak and associated hardwoods
Hydric Flatwoods (HF)	30-60	S. Florida slash pine, mid-story vegetation is relatively absent but may include red or loblolly bay, dahoon holly and pond cypress, gallberry, sweet pepper bush, blue maidencane, toothache grass redroot
Hydric Hammock (HH)	30-60	Evergreen hardwood and/or palm forest with an understory of palms and ferns
Depression Marsh (DM)	180-300	Edges are yellow eyed grass, beaksedges, St. John's wort, blue maidencane, with deep zones including duckweed, spikerush, pickerelweed, water lilies, occasionally sawgrass and coastal plain willow
Wet Prairie (WP)	60-180	Meadow beauty, nutrush, beak sedges, yellow eyed grass, corkwood, sundews
Strand Swamp (SS)	210-300	Bald cypress, coastal plain willow, pond apple, red maple
Dome Swamp (DS)	210-300	Pond cypress, sweet bay, swamp bay, fetter bush, Virginia willow, buttonbush, royal and cinnamon fern, redroot, lizard's tail

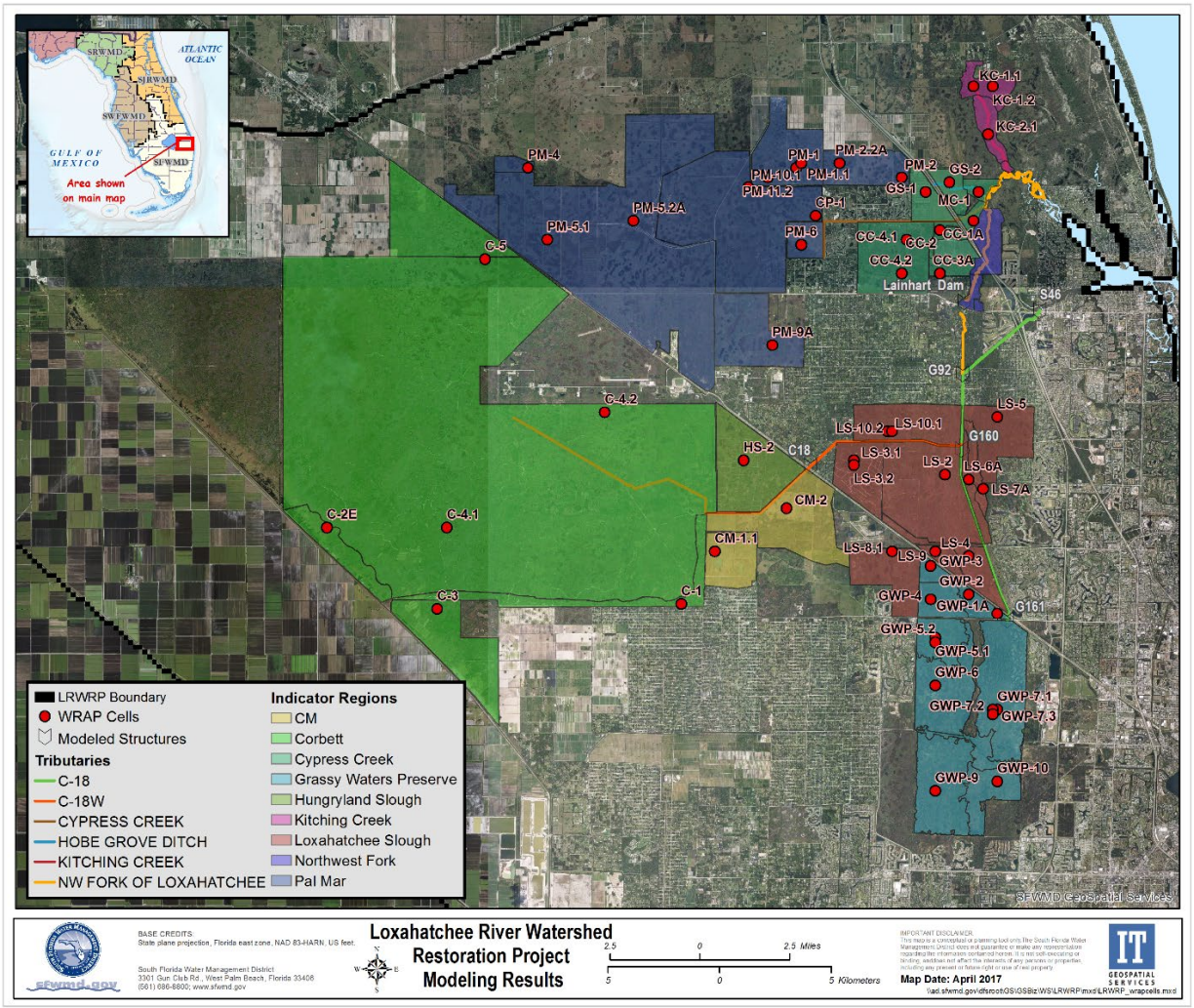

Figure 5-1. Map of indicator regions used to evaluate project effects on dominant wetland community types.

For the analysis, areas within the watershed were parsed into indicator regions for which specific wetland types were most prevalent. These indicator regions are associated with the flow-way concept and were used to help determine project benefits (**Figure 5-1**). The red dots reflects areas assessed in the field using the Wetland Rapid Assessment Procedure (WRAP) and indicate the sites of model cells that were used for evaluation. **Table 5-3** provides a summary of expected hydrologic improvement in inundation duration relative to the hydrology targets compared to the FWO alternative for the period of record for the dominant vegetation type in each indicator region.

Table 5-3. Summary of alternative plan hydrologic improvements in inundation duration days over the period of record by indicator region.

Indicator Region	Key Natural Area	Site	Acres	Dominant Community Types*	Flow-way (FW) Designation	Alt 2	Alt 5R	Alt 10	Alt 13
C-1	J.W. Corbett WMA	Edge effect along the M-0 Canal	1,642	DM; WP	FW2	92	97	31	55
C-2	J.W. Corbett WMA	Edge effect along the L-8 Canal	1,226	DM; DS; WP; HF/MF; HH	FW2	0	0	0	0
C-3	J.W. Corbett WMA	Moss Property	2,806	DS; FM; WP; HF	FW2	293	0	0	256
C-4	J.W. Corbett WMA	Unimpacted areas	25,500	DM; WP; DS; SS	FW2	-1	-1	-1	-1
C-5	J.W. Corbett WMA	3000-acre triangle	3,170	DM; WP; DS; SS; HF	FW2	0	0	0	0
CC-1	Cypress Creek	Transect 5	202	FS	FW3	1	1	0	1
CC-2	Cypress Creek	West of Gulfstream Citrus	207	FS	FW3	556	556	158	556
CC-3	Cypress Creek	Lox River Natural Area/Gauge 2	394	WP; DS	FW3	3	107	2	107
CC-4	Cypress Creek	Renaissance Village Wetland	2,542	DM; WP; SS; HF	FW3	86	1365	64	1365
CM-1	J.W. Corbett WMA	C-18 West Reservoir	1,381	n/a	FW2	0	0	0	1229
Cm-2	J.W. Corbett WMA	Avenir	3,191	n/a	FW2	-127	-104	-121	-410
GS-1	Gulf Stream east	Gulfstream Citrus	543	n/a	FW3	6	6	0	6
GS-2	Gulf Stream west	Gulfstream Citrus	737	n/a	FW3	543	543	0	543
GWP-10	Grassy Waters Preserve	Southeast corner	1,107	DS; DM; WP;SS; DS	FW1	248	248	0	248
GWP-1	Grassy Waters Preserve	G-161 triangle	42	DS; DM; WP;SS; DS	FW1	0	-54	44	0
GWP-2	Grassy Waters Preserve	West of G-161 triangle including Hog Island	397	DS; DM; WP;SS; DS; HF	FW1	-2	-2	-1	-2
GWP-3	Grassy Waters Preserve	Upper triangle-south of Beeline and north of berm	308	DS; DM; WP;SS; DS; HF	FW1	123	123	122	116

Indicator Region	Key Natural Area	Site	Acres	Dominant Community Types*	Flow-way (FW) Designation	Alt 2	Alt 5R	Alt 10	Alt 13
GWP-4	Grassy Waters Preserve	South of the berm and west of Hog Island	755	DS; DM; WP;SS; DS; HF; MF	FW1	-4	-4	-3	-6
GWP-5	Grassy Waters Preserve	Northwest corner (willow area; ~1500 acres)	977	DS; DM; WP;SS; DS; HF	FW1	-19	-19	-13	-50
GWP-6	Grassy Waters Preserve	South of willow area & north of M Canal	2,134	DS; DM; WP;SS; DS; HF	FW1	-10	0	-344	-4
GWP-7	Grassy Waters Preserve	North of M Canal east of Hog Island	2,992	DS; DM; WP;SS; DS; HF	FW1	0	-13	143	0
GWP-8	Grassy Waters Preserve	M Canal edge effects	594	DM; SS	FW1	-2	-61	311	-3
GWP-9	Grassy Waters Preserve	South of M Canal and west of Hog Island	2,518	DS; DM; WP;SS; DS; HF	FW1	0	-80	215	-1
HS-2	Hungryland Slough	Palm Beach County Natural Area	2,867	–	FW2	0	0	0	0
KC-1	Kitching Creek	Headwaters	656	FS; HH	FW3	124	124	124	124
KC-1.1	Kitching Creek		658	FS; HH	FW3	433	433	433	433
KC-2	Kitching Creek	Mid-portion	584	FS; HH	FW3	5	5	3	5
LS-10	Loxahatchee Slough	Site 7	1,891	DM; WP; SS	FW1	380	385	381	376
LS-2	Loxahatchee Slough	West of C-18 Canal	3,849	DM; WP; SS	FW1	199	199	199	199
LS-3	Loxahatchee Slough	Sandhill Crane	1,451	WP; DM	FW2	2	3	3	383
LS-4	Loxahatchee Slough	Roma Parcel	772	WP	FW1	50	46	18	33
LS-5	Loxahatchee Slough	East of C-18	1,782	DM; WP; SS	FW1	13	15	16	14
LS-6	Loxahatchee Slough	Melaleuca site south	405	DM; WP; SS	FW1	394	394	383	394
LS-7	Loxahatchee Slough	Site adjacent to melaleuca (SE)	426	SS	FW1	364	371	394	363
LS-8	Loxahatchee Slough	Southwest slough	1,666	–	FW2	-10	-10	-8	-51

Indicator Region	Key Natural Area	Site	Acres	Dominant Community Types*	Flow-way (FW) Designation	Alt 2	Alt 5R	Alt 10	Alt 13
LS-9	Loxahatchee Slough	–	576	–	FW2	-13	-14	-16	-43
MC-1	Moonshine Creek	Moonshine Creek/Hobe Grove Ditch	266	FS	FW3	0	0	0	0
PM-1	Pal-Mar (Martin Co.)	Unimproved Nine Gems Parcel	2,177	DM; WP	FW3	608	608	0	603
PM-10	Pal-Mar (Martin Co.)	Part of Pal-Mar 5	7,181	DM; WP	FW3	3143	3143	-1	3143
PM-2	Pal-Mar (Martin Co.)	Improved Nine Gems Parcel	1,452	DM; WP	FW3	456	456	372	456
PM-3	Pal-Mar (Martin Co.)	Area 3	709	DM; WP	FW3	390	390	0	390
PM-4	Pal-Mar (Martin Co.)	Area 2	284	DM; WP	FW3	0	0	0	0
PM-5	Pal-Mar (Martin Co.)	Unimpacted Pal-Mar	19,672	DM; WP	FW3	0	0	0	0
PM-6	Pal-Mar (Martin Co.)	Culpepper Ranch	636	DM; WP	FW3	2	2	0	2
PM-9	Pal-Mar (PBC)	Impacted site	2577	DM; WP	FW3	0	0	0	0

For all alternatives, above ground storage features with associated seepage canals and embankments would be constructed to deliver restoration flows to the NWFLR. Existing drainage features (ditches and water control structures) would be modified or constructed to restore wetland communities and restore base flows to the tributaries of the NWFLR. Ground water and surface water levels have been more significantly depressed in Flow-way 3, where there are deep canals (which are relatively large drainage features) that have limited or no control structures, than in Flow-ways 1 and 2. Alts 2, 5R, and 13, but not Alt 10, include the construction of a flow through marsh in Flow-way 3, and the full removal of berms and ditches between Pal-Mar West and Pal-Mar East. The marsh will attenuate flows from an adjacent agricultural area and, combined with a proposed control structure in the Cypress Creek Canal, will improve overall groundwater levels on more than 12,000 acres. Increasing groundwater levels in near proximity to the Cypress and Moonshine Creek tributaries and the NWFLR will also improve baseflow conditions throughout the area, and reduce flashy discharges to the tributaries. All four alternatives improved hydroperiods and sheet flow in the Flow-way 3 area (Pal-Mar East, Cypress Creek, Kitching Creek and Moonshine Creek) as compared with the FWO, however, the scope of changes proposed in this area are less comprehensive for Alt 10, resulting in less wetland vegetation improvement in Flow-way 3. The Mack Dairy Spreader Canal in Alts 5R and 13 provides more lift to Cypress Creek Natural Area compared to Alts 2 and 10.

Alt 13 performed the best for wetland improvement overall due to the extensive natural storage area proposed in Flow-way 2, which extended into the western portion of the Loxahatchee Slough and Northern GWP. The primary purpose of the impoundments as defined above is storage to augment flow to the river to meet restoration targets; however, some marginal habitat quality may be realized with the impoundments. Groundwater improvements that provide hydroperiod improvement to adjacent areas such as the Moss property in J.W. Corbett WMA, located adjacent to the L-8 Canal, are realized in Alts 2 and 13 as a benefit associated with the L-8 Shallow Impoundment included in those alternatives.

All four action alternatives provide improvements in hydroperiods in Flow-way 1 due to the G-160 and G-161 structures improving hydroperiods for dominant vegetation communities particularly in the eastern portions of the Loxahatchee Slough adjacent to the C-18 Canal. The modeling shows moderate improvements and does not reflect the total improvement from these structures that were already constructed as part of the SFWMD Acceler8 program to get early restoration benefits due to operational changes in the FWO. Alt 10 appears to improve hydrology in GWP by reducing over-inundation based on dominant plant community targets from the higher regulation schedule implemented in the existing conditions. However, a site visit conducted to assess effects on wetland plant communities from the higher schedule determined that vegetation did not show signs of stress.

These vegetation effects from alternative plans are further detailed in **Appendix C.2** for all flow-ways and indicator regions.

5.4 Threatened and Endangered Species

The natural mosaic of uplands and wetlands also provides habitat for a number of listed animal species including wetland dependent species such as the wood stork, Audubon's crested caracara, and the Everglade snail kite.

Red-cockaded woodpeckers often nest in wet pine flatwoods and formerly occurred in JDSP and other locations within the project area. In 1999, only about 25 clans composed of two to eight individuals were known to occur within J.W. Corbett WMA. Since 2006, 92 of these birds have been relocated from public land in Florida and Georgia to the Dupuis WMA in the western watershed. An average of 45% of these woodpeckers have stayed in the area for a least one year. Additionally, the number of breeding pairs and young produced has increased and, in 2015, 12 breeding pairs produced 17 fledglings (http://www.ces.fau.edu/dupuis/wildlife-studies.php). Pal-Mar provides a corridor for red-cockaded woodpecker from J.W. Corbett WMA to JDSP, although portions are privately owned and are not in conservation lands (TCRPC 1999). No adverse effects to red-cockaded woodpeckers are anticipated due to their occurrence on already-protected conservation lands.

A threatened species, the West Indian manatee, is an important marine mammal that lives within the estuarine and marine waters of the project area. The Loxahatchee River, along with several other locations such as Jupiter Sound and the North Palm Beach Waterway (NPBW), supports a 'relatively moderate' abundance of manatees in comparison to other areas of the county (Florida Atlantic University CUES 2007). Species under NMFS's purview occur in the estuary, including Johnson's seagrass and, further offshore, the possible occurrence of ESA-listed corals in the Florida Reef Tract (FRT).

The USACE initiated consultation with the USFWS on potential effects of nine species, pursuant to the USFWS letter providing a list of potentially affected species received April 20, 2017 and the Fish and

Wildlife Coordination Act Report received January 24, 2020 (**Table 5-4**). Details of the life history of each species and the Corps' effects determinations are found in the Biological Assessment in **Annex A**. **Appendix C.2.1** contains a comparison of the FWO and alternatives.

Table 5-4. Effects of alternatives on Federal threatened and endangered species.

Species	FWO	Alternatives 2, 5R, 10, 13
Everglade snail kite	Hydroperiods would be unchanged; habitat availability would be unchanged. Everglade snail kite presence would remain primarily in GWP, also in Pal-Mar, and potentially Loxahatchee Slough.	Rehydration and vegetation shifts within wetlands would increase suitable habitat for apple snails, thereby increasing spatial extent of suitable foraging opportunities for snail kites providing a moderate beneficial effect in Pal-Mar and Cypress Creek. Alternatives would provide a significant beneficial effect to species foraging habitat in Loxahatchee Slough, which is adjacent to known habitat in GWP. Based on performance measure 4, Alt 13 would have the most potential benefit, followed by Alts 5R and 2, and Alt 10 the least overall improvement to potential Everglade snail kite habitat. Additional water from G-161 from GWP to the river is not expected to alter hydroperiods.
Wood stork	Nesting colonies occur at the Palm Beach County Solid Waste Authority pond and the BallenIsles Golf Course stormwater detention pond; project features are within core foraging areas; foraging opportunities would be generally unchanged.	Restoration of wetlands from former agricultural sites and improvement of natural area hydrology will provide increased foraging opportunities for the wood stork. Restoration actions are likely to improve the timing of wetland hydroperiods and recession rates in Pal-Mar, Cypress Creek Natural Area, JDSP, and Loxahatchee Slough. Impoundments will maintain a minimum water depth of 6 inches and soil inversion of any contaminated soils to avoid any risk of bioaccumulation of contaminants from former agricultural sites. Foraging habitat benefits are highest with Alt 13 (C-18 natural flow-way), followed by Alts 5R and 2, and Alt 10 providing the least overall improvement to wood stork foraging habitat.
Audubon's crested caracara	Widespread foraging and possible unknown nesting; foraging opportunities could decrease with future land development.	Foraging opportunities would be preserved in natural areas; hydrologic restoration to former citrus groves and other parcels could make them less attractive for foraging to caracara.
Red-cockaded woodpecker	No adverse effects to red-cockaded woodpeckers are anticipated due to their occurrence on already-protected conservation lands.	Red-cockaded woodpeckers often nest in wet pine flatwoods; rehydrated wetlands would potentially support increased acreage of nesting habitat.
Eastern indigo snake	Maintenance of current water levels would not affect upland habitat.	Potential loss of habitat as former citrus is converted to a flow through marsh and the habitat loss in the footprint of the C-18W Reservoir.
West Indian manatee	Lack of dry season and wet season flows to the NWFLR (Lainhart Dam and tributaries) will continue to negatively affect tapegrass and other	All alternatives improve wet season flows from 78% to 98% or 100% for Alt 10. Dry season flows are improved from between 57% and 65% to 95% by Alt 10 with the larger storage feature, followed by Alt 5R to 91%, Alt 2

Species	FWO	Alternatives 2, 5R, 10, 13
	freshwater submerged aquatic vegetation. Salinity fluctuations in Florida Bay and southern estuaries would continue, potentially reducing seagrass distribution or density, thus reducing foraging opportunities. Freshwater high volume flows into the South Fork and Middle Estuary of Loxahatchee River from S-46 would continue to degrade seagrasses.	to 87%, and Alt 13 to 80%. Flow improvements are likely to improve low salinities (less than 5 psu) in the area of the river where tapegrass is expected to improve (River Mile 10.5 to 6.5), thereby increasing foraging potential for manatee within this region and provide minor beneficial effects. There is a minimal reduction in high volume discharge events or seasonal low volumes from S-46 and a slight change in lower salinity conditions near River mile 4.0. This results in little to no improvements of low salinity stress on seagrass beds, and minimal increase in stress from Northwest Fork flows.
Florida panther	Maintenance of current water levels would not affect upland habitat.	Panther are rare in the project area; hydrologically restored areas could be less attractive habitats.
Florida bonneted bat	The project area is not within the current consultation area for bats.	The project area is not within the current consultation area for bats.
Okeechobee gourd	Maintenance of current water levels would not affect water levels in Lake Okeechobee.	The project would not affect water levels in Lake Okeechobee, therefore, it would not affect gourd habitat.

5.5 State Listed Species

The CERP project area contains habitat suitable for the presence, nesting, and/or foraging of 12 state-listed threatened species, including the American oystercatcher, black skimmer, least tern, little blue heron, roseate spoonbill, tricolored heron, reddish egret, Florida burrowing owl, Florida sandhill crane, southeastern American kestrel, gopher tortoise, and Florida pine snake.

While small areas of habitat used by many of these animal species may be affected by this project, Alts 2, 5R, 10, or 13 are not likely to adversely affect and would have a negligible to beneficial effect on protected state species. There may be some modification or loss of upland habitat for terrestrial species such as Florida pine snakes. Impacts to wading bird species would vary depending on leg length – wading birds are grouped into short-legged and long-legged waders, and forage availability varies relative to leg length and accessibility. Long-legged waders can access deeper water bodies to forage, while short-legged waders require greater draw-down before the same water bodies are accessible to them for foraging. Subtle changes in water quality can also affect the prey base so that net effects on forage availability can be variable. Overall, negligible to beneficial long term impacts are anticipated to state listed species as a result of this project. For a more detailed analysis, please refer to **Appendix C.2.1**.

5.6 Wildlife

A comparison of FWO and LRWRP alternatives and their potential effects on wildlife within the LRWRP action area are summarized in the following sections. For a more detailed analysis, please refer to **Appendix C.2.1.4**. Further details on the effects of the alternatives can be found in the Fish and Wildlife Coordination Act Report in **Annex A**.

5.6.1 Invertebrates

Negligible and less than significant effects to the invertebrate community within the watershed are anticipated under the FWO scenario and any LRWRP action alternative. Aquatic invertebrates would rapidly colonize newly re-hydrated areas with implementation of any alternative providing a moderate and significant beneficial effect, directly benefiting aquatic invertebrates within the action area. Increase in stages and hydroperiods within parcels would promote wetland vegetation transition, increasing periphyton, which is a primary component of invertebrate diets, including apple snails.

Aquatic macroinvertebrates such as crayfish, riverine grass shrimp, amphipods, Florida apple snail, Seminole ramshorn, Atlantic rangia, and numerous species of aquatic insects, form a vital link between the algal and detrital food web base of freshwater wetlands and the fishes, amphibians, reptiles, and wading birds that feed upon them (USACE 1999). Crayfish are important components within the Everglades food web, serving as primary dietary components of higher trophic level species including fish, amphibians, alligators, wading birds, and mammals such as raccoons and river otters (Kushlan and Kushlan 1979). Increases in hydroperiod associated with implementation of any alternative would likely increase crayfish density resulting in increased native crayfish productivity having a moderate beneficial effect. Alternative 13 will improve the greatest amount of invertebrate wetland habitat for aquatic invertebrates: 31,476 acres in J.W. Corbett WMA, Cypress Creek Natural Area, Kitching Creek, Gulfstream, Pal-Mar, Loxahatchee Slough, and C-18 West. Alts 5R and 2 will provide 26,235 acres and 26,105 acres, respectively, in J.W. Corbett WMA, Cypress Creek Natural Area, Kitching Creek, Gulfstream, Pal-Mar, and Loxahatchee Slough. Alt 10 will provide 17,954 acres in Cypress Creek, Kitching Creek, Pal-Mar, and Loxahatchee Slough.

5.6.2 Fish

Implementation of any alternative is expected to significantly improve conditions for fish species throughout the LRWRP watershed and have a moderate beneficial effect. Improvements to fish communities would mirror that of invertebrate communities. Additional analysis of invasive and exotic fish can be found in **Section 5.19**. Alternatives that improve dry season flows the most (Alts 10 and 5R) would provide the most benefits to juvenile fish communities in the oligohaline portion of the river. Alt 2 and, to a lesser extent, Alt 13, provide some improvements to juvenile fish habitat from more modest increments of restoration flows.

5.6.3 Amphibians and Reptiles

Minor beneficial effects to the amphibian and reptile communities are anticipated under each alternative. Rehydration within previously dry areas would increase spatial extent of suitable habitat for aquatic amphibian species in this area. Similarly, increased hydroperiods would also benefit aquatic amphibian species. As hydrology improves within parcels, it is expected that amphibian species richness will also change, and likely declines in some amphibian species will be offset by favorable habitat conditions for other species. Increase in forage prey availability (i.e., crayfish and other invertebrates, fish) in areas rehydrated by LRWRP implementation will also directly benefit amphibian and reptile species. Restoration of agricultural area historic hydrologic patterns to freshwater wetlands (primarily seasonal depression marsh) may diminish available habitat for the gopher tortoise. Each work area will be re-surveyed before construction begins and standard protection and conservation measures will be implemented during construction to reduce impacts to gopher tortoises and other affected species.

5.6.4 Birds

Colonial wading birds forage opportunistically and are anticipated to show a moderate and significant beneficial effect with implementation of any LRWRP alternative. Impacts to the snail kite, wood stork, and red-cockaded woodpecker are discussed further in **Appendix C.2.1**, **Section C.2.1.5**, and **Annex A**.

As predicted by the Trophic Hypothesis (RECOVER 2004), an increase in density of small fishes will directly benefit higher trophic level predators such as wading birds. Therefore, it is predicted that the alternatives that provide the greatest benefit to small fishes as described in **Section C.1.11** will also perform best overall for wading birds. Crayfish are a particularly important forage resource for nesting white ibis. Appropriate foraging conditions and crayfish densities within core foraging areas of nesting wading bird colonies can reduce foraging flight distance, thereby enhancing overall body condition. As indicated in **Section C.1.11**, increases in hydroperiod associated with implementation of any LRWRP action alternative would likely increase small fish and crayfish density within depression marsh, cypress dome, and wet prairie habitats of Pal-Mar, J.W. Corbett WMA, Cypress Creek Natural Area, Loxahatchee Slough, Kitching Creek, and Gulfstream. The SWA and BallenIsles wood stork colonies are located on the eastern edge of the project area and would benefit from increased foraging in shorter hydroperiod marshes during the pre-breeding season and then shifting to longer hydroperiod wetlands as the dry season progresses. Hydrological patterns that produce a maximum number of patches with high prey availability (i.e., high water levels at the end of the wet season and low water levels at the end of the dry season) are necessary for high reproductive outputs (Gawlik 2002, Gawlik et al. 2004). Depending upon the elevation and microtopography, implementation of any of the LRWRP action alternatives would produce a variety of wetland habitats that would support prey densities conducive to successful wading bird foraging.

5.6.5 Mammals

As compared with FWO, potential minor beneficial effects to mammals within the LRWRP action area are anticipated with implementation of any alternative. Small mammals including raccoons and river otters would benefit from increased crayfish and small prey fish biomass in the watershed and river floodplain. The increase in water availability and rehydration within the tributaries (Moonshine, Cypress, and Kitching Creeks) and Loxahatchee River under all action alternatives will likely benefit river otter as a result of increased foraging opportunities in floodplain swamps.

5.7 Essential Fish Habitat

The on-shore project area is within the jurisdiction of the South Atlantic Fishery Management Council (SAFMC). The state of Florida recognized the important habitats in the area by designating the Loxahatchee River Lake Worth Creek Aquatic Preserve, which encompasses all forks of the river. EFH is mapped within the Loxahatchee River, Jupiter Inlet, Indian River Lagoon, and waters immediately offshore for five management groups (NMFS 2001): snapper-grouper complex (gray snapper, white grunt, red porgy), spiny lobster, coral, coral reefs, and live/hard bottom habitats of the South Atlantic Region (Ahermatypic stony corals, black corals, Hermatypic stony corals, Octocorals, Pennatulacea), coastal migratory pelagics of the gulf of Mexico and South Atlantic (cobia, king mackerel, Spanish mackerel) and several highly migratory species. The golden crab fishery of the South Atlantic region occurs offshore and a figure depicting its range is not provided in this discussion. The FWO scenario would likely facilitate continued decline in estuarine integrity. Alternative 10 provides slightly better performance than Alts 2

or 5R for riverine targets. Alt 13 provided the least improvement in seasonal freshwater flows to the river and estuary. A detailed analysis of EFH can be found in **Appendix C.1.9** and **C.2.9.**

5.8 Hydrology

All alternatives variously improve wet season and dry season flows to the NWFLR and the Loxahatchee River estuary by capturing excess freshwater lost to tide and sending flows to meet dry season flow targets. The timing of tributary creek flow and ground water is improved variously by the alternatives. This results in improvements to downstream freshwater river and estuarine salinity conditions important to various habitat zones and flora/fauna species. The alternatives variously improve watershed hydrology by decreasing ponding and drainage through removal of berms, filling of ditches, connecting surface water and ground water flows between natural areas where they were cut off, moving water as sheetflow via spreader canals and natural flow-ways across parcels. A summary of the anticipated hydrologic effects of the alternative actions, which were described in **Section 3**, is presented in **Table 5-5**. A detailed discussion of the anticipated hydrologic effects of the alternatives is provided in **Appendix C.2**.9.

Table 5-5. Effects of FWO and alternatives on hydrology.

Geographic Region and Alt	Hydrologic Effects
NWFLR, FWO	As measured at Lainhart Dam, for the period of record, the target wet season flows are met 78% of the time, and the target dry season flows are met between 57% and 65% of the time. Tributary creeks will continue to be drained with limited groundwater contribution during the dry season and flashy flows would continue to occur during the wet season. Downstream salinities will continue to be higher than desirable and, with gradual sea-level rise, salinities will continue to increase up the NWFLR, impacting tapegrass, oligohaline, and tidal/freshwater riverine cypress forest zones.
NWFLR, All Alts	All alternatives increased wet season flows up to 98% of target. Alt 2, Alt 5R, Alt 10, and Alt 13 increase dry season Lainhart Dam flows to 87%, 91%, 95%, and 80%, respectively. All alternatives improve timing of Kitching Creek flows. Alts 2, 5R, and 13, and to a lesser degree Alt 10, improve timing and distribution of flows to Moonshine and Cypress Creek.
FW1, FWO	Hydrology south of Northlake Boulevard within GWP remains in good condition. Although the project assumes that G-160 and G-161 are project features, the modeling shows hydrologic improvement that has occurred with the implementation of the operation of these structures. Therefore, the modeling does not reflect the condition that Loxahatchee Slough would remain drained as it would without the structures.
FW1, All Alts	G-160 and G-161 improve Loxahatchee Slough hydroperiods in all alternatives. Minor changes to the hydrology occur in GWP south of Northlake Boulevard for Alts 2, 5R, and 13, and more moderate decreased stages occur in Alt 10. All alternatives improve stages and hydroperiods In the GWP triangle, north of Northlake Boulevard.
FW2, FWO	Hydrology would be restored in the C-18 West Reservoir area as a result of a proposed mitigation project on the Avenir property. J. W. Corbett WMA and Hungryland Slough will remain slightly drained.
FW2, All Alts	Alts 2 and 13 show the largest improvements to J.W. Corbett WMA hydrology as a result of seepage from the L-8 Shallow Impoundment. Alts 5R and 10 show modest improvements to J.W. Corbett WMA hydrology on the southern and eastern areas adjacent to the C-18 West Reservoir and M-O Connector Canal.

Geographic Region and Alt	Hydrologic Effects
FW3, FWO	Large acreages of agricultural lands in Pal-Mar, Cypress Creek, Moonshine Creek and Kitching Creek will continue to be drained.
FW3, All Alts	Alts 2, 5R, and 13 improve the hydrology within the Cypress Creek natural area by 550 days over the period of record on approximately 3,500 acres, while Alt 10 improves the hydrology by 160 days over the period of record on approximately 557 acres. All alternatives improve the hydrology by 240 days over the period of record on approximately 740 acres in Moonshine Creek and Gulfstream East. Gulfstream West flow-through marsh attenuates flows from adjacent areas, consequently, its hydroperiod will be longer and the water depth will be deeper than if it were in its natural condition. The stage change affects approximately 550 acres, and this area will be slightly over-inundated for a period of 2,448 days from historic targets, but is key to providing flow from Pal-Mar to Cypress Creek. In all alts, there are two indicator regions of floodplain swamp in Kitching Creek; with improvements ranging from 124 days to 423 days over the period of record. Hydroperiods improve with the spreader canal and plugging of Jenkins Ditch. Pal-Mar hydrology is greatly improved in Alts 2, 5R, and 13.

5.9 Water Quality

The assessment of project impacts to water quality is summarized in **Table 5-6** below. The detailed analyses are found in **Appendix C.1.13** and **Appendix C.2.13**. The effects of the alternatives were evaluated in comparison to both existing conditions as well as FWO. The evaluation was performed using LECSR-NP modeling and based on current conditions. The assumptions made in the model are detailed in Appendix C.

The water quality evaluation focuses on the three geographic flow-ways and the Loxahatchee River as well as specific locations within the basin. The primary focus of the water quality alternative evaluation was the impact of the changed flow on the concentration and total daily loads of phosphorus and nitrogen at various points. **Table 5-6** summarizes total phosphorus (TP) concentrations and loads and **Table 5-7** summarizes total nitrogen (TN) concentrations and loads from spreadsheet analysis of LECSR-NP modeling of flows and existing conditions baseline assumptions for starting TP and TN concentrations.

Alternatives 2, 5R, 10, and 13 were evaluated as part of this review. All alternatives showed a net decrease in system wide (all Loxahatchee River Watershed structure flows) phosphorus both in concentration and load. In relation to FWO, Alt 2 has the lowest system reduction, whereas, Alt 10 showed the greatest reduction of nutrients to M-canal and Grassy Waters Preserve. However, Alt 10 would have more TP loading to the Loxahatchee River due to the force-main delivery of nutrients directly from the M-canal to the C-18 canal. None of the alternatives showed a detrimental net increase to the amount of phosphorus in the system. Nutrient retention (TN) assumptions for wetland restoration were updated from the Draft PIR/EIS from 5 to 10 percent based on coordination with the state of Florida's reasonable assurance plan process. Total nitrogen to the Loxahatchee River Northwest Fork in total daily loads would remain unchanged and/or be even lower for all alternatives except Alt 10. TN loads would decrease at the S-46 inflow to Loxahatchee River Southwest Fork for all alternatives. TN concentration to the river would be lower for all alternatives.

The project is not expected to degrade water quality but will instead result in water quality improvements as part of the work accomplished.

Table 5-6. Summary of effects of alternatives on water quality - total phosphorus concentrations and loads from LECSR-NP modeling.

Site	ECB TP (ppb)	ECB Load (kg)	FWO TP (ppb)	FWO Loads (kg)	Alt 2 TP (ppb)	Alt 2 Load (kg)	Alt 5R TP (ppb)	Alt 5R Loads (kg)	Alt 10 Loads (ppb)	Alt 10 loads (kg)	Alt 13 TP (ppb)	Alt 13 Load (kg)
CS3	92	6,428	92	6,430	92	6,494	76	6,415	35	1,764	92	6,502
C-18W	41	2,226	41	2,294	34	2,276	28	2,279	31	2,621	25	1,742
G-161	10	0	10	0	10	12	10	34	35	463	10	13
G-92	41	3,502	41	3,517	24	2,636	21	2,265	22	2,521	19	1,885
Lainhart Dam	43	5,674	43	5,688	31	4,805	28	4,432	28	4,676	27	4,075
S-46	41	2,326	41	2,326	24	1,093	21	1,006	22	1,017	19	858
LR_NWF	50*	12,695	50*	12,709	41*	10,980	39*	10,607	39*	11,080	39*	10,142

Note: * = Target is 54 ppb.

Table 5-7. Summary of effects of alternatives on water quality - total nitrogen concentrations and loads.

Site	ECB TN (mg/L)	ECB Loads (tons)	FWO TN (mg/L)	FWO Loads (tons)	Alt 2 TN (mg/L)	Alt 2 Load (tons)	Alt 5R TN (mg/L)	Alt 5R Loads (tons)	Alt 10 TN (mg/L)	Alt 10 Loads (tons)	Alt 13 TN (mg/L)	Alt 13 Loads (tons)
G-92	0.92	78	0.92	78	0.87	94	0.87	96	0.87	102	0.87	88
S-46	0.95	53	0.95	53	0.9	40	0.9	44	0.9	42	0.9	41
LR_NWF	1.17*	297	1.17*	297	1.11*	297	1.10*	297	1.12*	314	1.12*	289

Note: * = Target is 1.20 mg/L.

5.10 Air Quality

The project location is currently in an attainment area and the work being performed will not cause the project to become a non-attainment area. Comparison of the FWO and alternatives is summarized in **Appendix C.1.14**. The project will have limited effect on air quality. The negligible, temporary air quality effects will be a result of emissions from construction equipment and possible dust. These effects will be limited by ensuring BMPs are used to limit air quality effects. Long-term effects are not expected as ASR pumps and pump stations will be powered using electric motors. Project pump stations are not for flood control, so electric power for operations is appropriate.

A detailed analysis of project impacts on air quality compliance and to emissions of CO_2 is provided in **Appendix C.2.1**.

5.11 Hazardous, Toxic and Radioactive Waste

Phase 1 and Phase 2 environmental site assessments were conducted on lands that the SFWMD acquired for this project. These assessments identified the extent and type of contaminants of concern and those contaminants will be remediated prior to execution of the project and before the lands are certified for use. FDEP is the responsible authority, delegated by EPA, for human health issues related to soil and water contamination. The SFWMD will obtain concurrence from the FDEP waste cleanup group that any remediation activity has been satisfactorily completed. USFWS is the authority with regards to ecological risk with regards to soil and water conditions. The SFWMD will also obtain concurrence from the USFWS that the project lands are suitable for their intended use. The concurrence from these two agencies will constitute documentation that the project lands are suitable for intended use per the Resource Conservation and Recovery Act, as amended by the Hazardous and Soils Waste Amendments of 1984; Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) as amended by the 5.26.21 Superfund Amendments and Reauthorization Act of 1996; and the Toxic Substances Control Act of 1976. The expanded Hazardous, Toxic and Radioactive Waste (HTRW) assessment is found in **Appendix C.2.15**. HTRW reports and correspondence are available at no charge upon request. The residual agricultural chemical policy is found in **Appendix C.4.42**.

5.12 Noise

All action alternatives would result in minor and short-term increases in noise during construction as compared with the FWO. All alternatives include pump stations which will result in minor, localized, long term increases in noise. Pump stations will use hospital grade silencers or mufflers to reasonably reduce any noise impact.

5.13 Aesthetics

Better modulated flows to NWFLR would improve the aesthetic appeal of the river, improve water clarity, and shorten the extent of the salinity wedge pushing upstream, benefiting the tapegrass beds. Improved aesthetics could also lead to an increase in wildlife viewing opportunities. Aesthetic appearance would be unchanged or decline under the FWO scenario, while the action alternatives would result in temporary, short-term, minor effects to aesthetics during construction of all features. The action alternatives show a major beneficial long term effect in increased aesthetic value over the FWO due to restoration of hy-

dropatterns and sheetflow throughout the project area. Restored strands, marshes, wet prairie, and forests provides additional habitat for native plants and animals and increased opportunities for wildlife viewing.

The proposed C-18W Reservoir embankment conceptual design includes a 20-ft high crest. A vegetated area is proposed to serve as a visual buffer between the southern limit of SFWMD-owned lands at this site and adjacent developed areas.

5.14 Land Use

Most of the land in consideration for the LRWRP is in public ownership, having been acquired early in the CERP in anticipation of this project. In the FWO condition, these lands may be at risk to be listed as surplus property, and as such could be at risk to development. In the LRWRP alternatives, physical storage features (reservoirs, impoundments, flow-through marsh) have been conceptualized on lands that were formerly in agricultural production (fallow citrus, row crops). Wetland restoration and connectivity features are located primarily on unimproved or improved pasture lands, or on existing forested or non-forested wetlands that have been over-drained by water management practices. Alternative 13 would provide the most change (17,673 acres) from former agricultural lands to wetlands in Flow-way 3 and Flow-way 2, followed by Alts 5R (16,292 acres) and 2 (13,356 acres), and Alt 10 (2,009 acres) providing the least change of agricultural lands to restored wetlands (**Table 5-8**).

All of the alternatives will result in improvements of the hydrologic regime (% relative to wet season and dry season target flows) in the historic NWFLR riverine floodplain compared to the FWO, with all alternatives improving wet season flows 98% as compared to 78% in the FWO base condition; and Alts 2, 5R, 10, and 13 improving dry season flows, respectively, 95%, 91%, 87%, and 80% as compared to the FWO base condition (ranging 58%-60%).

Real estate and associated ownership estates are discussed in detail in **Appendix D – Real Estate**.

5.14.1 Wetlands

Effects on wetlands and uplands are summarized for the final array of alternatives in Appendix G and see information in **Table 5-8**. The action alternatives show a major beneficial effect with an increase in wetland/upland habitat and wetland function over the FWO with some differences between alternatives. The differences stem from different project features (location and degree of backfilling; whether or not spreader swales are proposed, and hydrological changes proposed). For example, Alt 10 does not include ditch filling and berms on the Pal-Mar East properties, while the other alternatives do include these activities. Although impacts to wetlands are expected in the FWO condition as a result of increased development pressure, these losses would, for the most part, be offset by project specific mitigation requirements and thus there would be minimal loss of wetlands. For the alternatives, there are expected to be improvement to wetland hydroperiods as a result of improving hydrology. This is especially true in the Flow-way 3 area, where substantial improvement in wetland hydroperiods are expected. Also in Flow-way 3, there are several areas that will be graded to more natural topography (Shiloh, Gulfstream East) that can be considered as gains in wetland acreage. The sum of improvements to wetland hydrology on the natural areas combined with the enhancements of wetland hydrology on agricultural lands results in the total expected acreage of hydrologic improvement.

Table 5-8. Acres of restored wetlands by alternative.

Project Area	FW	FWO AGR	FWO NAT	Alt 2 AGR	Alt 2 NAT	Alt 5R AGR	Alt 5R NAT	Alt 10 AGR	Alt 10 NAT	Alt 13 AGR	Alt 13 NAT
Cypress Creek	FW 3	-	-	557	0	3,493	0	557	0	3,493	0
Kitching Creek	FW 3	-	-	0	1,243	0	1,243	0	1,243	0	1,243
Gulfstream	FW 3	-	-	1,280	0	1,280	0	0	0	1,280	0
Pal Mar	FW 3	-	-	11,519	0	11,519	0	1,452	0	11,519	0
J.W. Corbett WMA	FW 2	-	-	0	4,448	0	1,642	0	0	0	4,448
Hungryland	FW 2	-	-	0	0	0	0	0	0	0	0
C-18 West	FW 2	Slight decrease from over inundation	-	0	0	0	0	0	0	1,381	0
Loxahatchee Slough	FW 1	-	Modeled improved hydrology from operations	0	6,661	0	6,661	0	6,661	0	8,112
Grassy Waters Preserve	FW 1	-	-	0	397	0	397	0	8,041	0	397
Subtotal	-	-	-	13,356	12,749	16,292	9,943	2,009	15,945	17,673	14,200
Grand Total per Alt	-	-	-	26,105	n/a	26,235	n/a	17,954	n/a	31,873	n/a

Notes: FWO – Future without project; AGR – agricultural; NAT – natural area.

5.14.2 Agriculture

Modest reduction in overall agricultural acreage is expected in the study area within FWO as compared to the existing condition. Agricultural acreage is expected to decline slightly in both Martin and Palm Beach counties, primarily due to urbanization. The number of acres cultivated in any given year is driven by market forces and cultivation practices such as rotating crops (SFWMD Draft LEC Water Supply Plan, 2013). For the LRWRP, the properties proposed for reservoir or wetland features are fallow citrus or pasture lands that have already been acquired. The exception is the proposed shallow impoundment in Alt 2 and Alt 13, which is located on active row crop agricultural land. The overall impact to agriculture is minor.

5.15 Socioeconomics

The socioeconomic factors of population and economic activities were compared for FWO and alternatives. The results of this comparison are presented in the following subsections 5.15.1 and 5.15.2.

5.15.1 Population

The LRWRP study area is situated in Palm Beach County and Martin County, the populations of which are projected to increase by 28% and 21%, respectively, between 2017 and 2045 based on estimates by the Bureau of Economic and Business Research (BEBR) at University of Florida.[1] These projected increases in population are slightly lower than that of 34% for the state of Florida overall during the same period. Population projections are not anticipated to differ between the FWO and alternative conditions.

5.15.2 Economic Activities

Overall economic activities of the study area are not expected to differ between the FWO and alternative conditions. However, there are a few relatively small impacts of the different alternatives on isolated economic activities, mainly tied to changes in land use, which are outlined below:

State-owned land in the Shiloh Farms area is currently leased for use in agriculture as well as cattle leases in Gulfstream West. In Alt 5, Alt 5R, and Alt 13, this land would be used as part of the project and, thus, would no longer be used for agricultural purposes.

Avenir, a mixed-use development including commercial and residential structures, is currently planned in Palm Beach Gardens. The location of this future development is on lands that are included in Alt 13. Thus, the development and associated economic activities could not go forward in this location with the implementation of Alt 13.

The proposed site of the shallow storage in L-8 Basin (south of the M-O Canal) in Alt 2 and Alt 13 is currently farmland. Building a reservoir there would preclude agriculture on this land in the future.

[1] BEBR releases low, medium, and high population projections. The numbers shown here are based on the medium projections.

The restoration of the area under the proposed alternative is anticipated to improve the recreation experience for all visitors interested in ecotourism. This improvement in the recreation experience will likely have positive impacts on the regional economy. Appendix F of this report more fully details current recreation potential as well as the increase expected upon completion of the proposed alternative.

There are no known adverse impacts to property values in adjacent residential communities. The nearest residential community is located to the south of the C-18W reservoir. However, road access for construction will not go through that community and access will be from the northeast of the site, which is primarily rural and natural undeveloped areas. If there were any adverse impacts from construction disturbance, they would not be compensable under Florida law. Measures are included to reduce both visual and noise disturbances from operating the C-18W reservoir. Real estate experts in the USACE have indicated that real estate values increase around reservoirs due to recreational benefits. The community directly south of the reservoir will be able to access the reservoir from a road to the west for hiking, biking and fishing activities. There is a potential for real estate values to increase due to access to new recreational opportunities.

5.15.3 Socioeconomics: Water Supply and Flood Control

A summary of the anticipated effects on water supply and flood control of the alternative actions is presented in Table 5-9. Alternatives are compared to the FWO; similarly, the water supply and flood control effects of the FWO are described based on comparison to the ECB. The summary of regional performance differences (**Table 5-9**) includes quantitative comparisons between the ECB and FWO and between the FWO and alternatives based on LECSR-NP modeling representations of these baselines and alternatives. The period of simulation (1965-2005) used for the LRWRP hydrologic modeling encompasses a wide range of historical climatologic and meteorologic conditions that are representative of south Florida hydrology. This analysis period includes several moderate wet and moderate dry periods, as well as less frequent and potentially more impactful periods of both extreme high rainfall and extreme drought conditions.

The total water and the water made available for the natural system and other-water-related needs are quantified when all project features are constructed, and the project is expected to be operational as identified in the with-project condition, the Recommended Plan. The pre-project water expected to be available when the project is operational is represented by FWO. The difference between these two conditions, which is computed for each water year within the period of simulation, represents the water made available by the project (Recommended Plan minus FWO).

Each alternative was assessed as to the percent of demands not met, and frequency of water restrictions for Water Restriction Area (WRA) 1 and WRA 2 as compared to the FWO. The alternatives did not change water restriction frequency, and percent demands not met were either very slightly improved or not changed. Therefore, no water was quantified for other water-related needs in the LOSA. However, by virtue of additional water being stored in the C-18 Reservoir and improved hydroperiods within the Project Study Area, additional water may reach water users located in LOSA. Conclusions: Implementation of the Recommended Plan will not cause existing legal water sources to be eliminated or transferred; the LECSR model results indicate that implementation of the Recommended Plan will not reduce the levels of service for flood protection within the areas affected by the project.

The identification of water for the natural system captures the quantity, timing, and distribution of water. Hydrologic model data extracted from the LECSR-NP simulations were used to develop the volume probability curves at five locations in the regional system: C-18W Reservoir outflows to C-18W Canal, inflows to Loxahatchee Slough over G-161, flows over Lainhart Dam, flows from ITID to the C-18W Reservoir and M-1 Pump Station flows to the M-Canal. These locations represent the additional inflows where ecosystem benefits (habitat units) are expected as a result of implementation of the Recommended Plan. The difference between FWO and Recommended Plan average annual volumes delivered from each of these sources was calculated, then sorted (high to low) to generate the probabilities at the 10th, 50th, and 90th percentiles as well as exceedance curves which may result from a variety of meteorological conditions. Note that except for Lainhart Dam, the other four of five flows are not in the FWO scenario. Therefore, the FWO 10%, 50%, and 90% exceedance flows are zero.

Table 5-9. Effects of alternatives on water supply and flood control.

Flow-way	FWO	Alts 2, 5, 10, 13
Flow-way 1	No effect	Alt 10 - majority of increased water volume would pass through Flow-way 1.
Flow-way 2	No effect	Alt 2 - majority of increased water volume would pass through Flow-way 2. Alt 5 - majority of increased water volume would pass through Flow-way 2. Alt 13 - majority of increased water volume would pass through Flow-way 2.
Flow-way 3	No effect	Alts 2, 5, 10, 13 – pumps and berm improvements would ensure no adverse effects to adjacent properties.

5.15.4 Recreation

Alternative effects on recreation are presented in **Table 5-10** with additional details provided in **Appendix C.2.1.20**. All of the alternatives project additional water to the NWFLR, meeting 98% of the flow targets in the wet season, and variably meeting flow targets in the dry season and provide for connecting natural areas within the watershed to varying degrees. With additional recreational features such as pedestrian bridges, improved trails, or launching/portage facilities, all alternatives could have a moderate improvement on recreational experiences

Table 5-10. Effects of alternatives on recreation

Geographic Region	FWO	With Project Conditions
Flow-way 1	No effect	Flow-way 1 includes the C-51 Phase II reservoir in Alt 10 and this deep storage reservoir could provide opportunities for boating or other water-based activities. Flow-way 1 also includes GWP and the eastern Loxahatchee Slough. Improvements to hydrology in all alternatives could improve the passive recreation such as hiking, biking and birdwatching experience.
Flow-way 2	No effect	Alt 13 would result in significant improvements to the western watershed and provide connectivity between J.W. Corbett WMA and Loxahatchee Slough and River, enhancing hiking and other opportunities in the C-18 W impoundment in Alt 2,5R and 10.
Flow-way 3	No effect	Flow-through marsh in Alt 2, Alt 5R and Alt 13 could provide passive recreational activities such as birdwatching, hiking or bicycling.

Geographic Region	FWO	With Project Conditions
Loxahatchee River and Estuary	No effect	Improvement in dry season flow to the NWFLR could improve dry season kayak and canoe experiences for all alternatives except Alt 13. Flow-way 3 offers opportunities for additional kayak or canoe access to the River.

5.16 Environmental Justice

The LRWRP alternatives (Alt 2, Alt 5R, Alt 10, and Alt 13) do not present impacts that are high, adverse and disproportionate to low income or minority populations. The alternatives do not (a) exclude persons from participation in, (b) deny persons the benefits of, or (c) subject persons to discrimination because of their race, color, or national origin. Public scoping efforts did not identify environmental justice concerns attributable to the proposed project alternatives.

As outlined in **Appendix C, Part 2**, only one potential environmental justice population was identified within a 2-mile buffer of the Recommended Plan project features just east of GWP. This minority and low-income population would not be adversely affected by the project because the project overall does not result in increased risk of flooding or water supply associated with features affecting GWP.

5.17 Cultural Resources

The Florida Master Site File (FMSF) data from the Florida Division of Historical Resources lists 38 nationally registered sites, 114 archaeological sites, 18 historical resources groups, 7 cemeteries, 13 bridges, and 6,751 standing structures, within the LRWRP study area. Most of the 38 NRHP listed sites are found in the central to western side of the project area, many of which are prehistoric campsites and middens. There are multiple sites concentrated on the west side of the Loxahatchee River and along Loxahatchee Slough. The resources utilized to make preliminary determinations of effects on cultural resources for this feasibility study included previous cultural resources survey reports, FMSF data, and ongoing and continuing consultation with the federally-recognized Miccosukee Tribe of Indians of Florida and the Seminole Tribe of Florida. In addition, a cultural resources survey conducted for the LRWRP feasibility study that included three areas in the Pal-Mar East region subject to Phase 1 intensive-level cultural resources investigations (**Appendix C-2**), and six areas (J.W. Corbett WMA, Loxahatchee Slough, Kitching Creek, Mecca, Grassy Waters Triangle and linear feature) subject to reconnaissance-level investigations (**Appendix C-2)** following the *Florida Division of Historical Resources Module Three Guidelines for use by Historic Preservation Professionals.* This survey of 5,043 acres was conducted for USACE, Jacksonville District, under Contract No. W91278-15-0046, Task Order #CS1. The survey identified no cultural resources eligible for inclusion in the NRHP.

Table 5-11 presents FWO and effect of Alts 2, 5R, 10, and 13 on cultural resources. See **Section 4** for criteria used to evaluate the alternatives. **Appendix C.2.22** contains a description of the full preliminary analysis, background information, and description of terms.

Table 5-11. Effects of the final array of alternative on cultural resources.

Geographic Region/Feature	Alternatives	Cultural resources (Please refer to Cultural Resources in Appendix C.2.22 for further details)
Kitching Creek	2, 5R, 10, and 13	No effect on cultural resources
Moonshine Creek and Gulfstream East	2, 5R, 10, and 13	Potential adverse effects to 8MT1045 and 8MNT1344. There is a potential to adversely affect unidentified historic properties.
Cypress Creek Canal	2, 5R, 10, and 13	There is a potential to adversely affect unidentified historic properties.
Gulfstream West	2, 5R, and 13	There is a potential to adversely affect unidentified historic properties.
Pal-Mar East	2, 5R, 10, and 13	Potential adverse effects to 8MT01453 (Jupiter Road)
Natural Storage C-18W	2, 5R, 10, and 13	Potential adverse effects on 8PB06294, 8PB13929, and 8PB11489
L-8 Shallow Storage	2 and 13	No effect on cultural resources
C-51 Deep Storage	10	No effect on cultural resources
G-160 and G-161	2, 5R, 10, and 13	Potential adverse impacts to 8PB14419
Grassy Waters Preserve Triangle	2, 5R, 10, and 13	No effect on cultural resources
M-1 Pump Station	5R	There is a potential to adversely affect unidentified historic properties
FWO (all geographic regions and features)	FWO	Future development and construction related to population growth has the potential to effect cultural resources; however, state and federal regulations would apply as appropriate

Prehistoric archeological sites 8PB6294, 8PB13939, 8PB11489 and 8PB14419 are potentially adversely impacted from LRWRP construction activities. Prior to designing and implementing cultural resources field investigations for the LRWRP feasibility study, consultation with the Miccosukee Tribe of Indians of Florida and the Seminole Tribe of Florida Tribal Historic Preservation Office (THPO) was coordinated and each of the alternatives were evaluated for their potential to effect existing cultural resources by areas of potential impact including construction, impoundment, and restoration (**Appendix C.2, Table 5.2**).

In summary, there remains a moderate to high probability that additional prehistoric resources will be encountered within the Loxahatchee River watershed. These resources include prehistoric campsites, shell middens, and burial mounds. Consultation with the appropriate federally-recognized tribes is ongoing and will be completed prior to project implementation. In accordance with the National Historic Preservation Act (NHPA), consultation was initiated with the Seminole Tribe of Florida's THPO; the Miccosukee Tribe of Indians of Florida Native American Graves Protection and Repatriation Act (NAGPRA) Representative; the State Historic Preservation Office (SHPO); and the Palm Beach County Archaeologist. During formal consultations, several survey areas were evaluated in regard to the LRWRP's potential effects on cultural resources. These areas are identified as GWP, Loxahatchee Slough, Kitching Creek, J.W. Corbett WMA, Mecca, and Pal-Mar. Eighteen cultural resources surveys were previously conducted within a half-mile buffer zone of these areas. Based on analyses of these surveys, it was determined that additional cultural resources surveys were needed to identify the types and nature of sites within these

specific areas of potential effect for the feasibility study. It was also decided that additional surveys may be needed during the Pre-construction, Engineering, and Design (PED) phase.

In conjunction with the NHPA, formal consultation was initiated with the Seminole Tribe of Florida's THPO; the Miccosukee Tribe of Indians of Florida's NAGPRA representative; and the Florida SHPO (Appendix C). Three conclusions were drawn:

1. Additional surveys are needed to identify cultural resources within the specific area of potential effect.

2. As the LRWRP project progresses, additional surveys will be necessary during the PED phase, when feature designs are finalized and construction staging areas are determined.

3. Compliance with Section 106 of the NHPA will be conducted in a phased process and will not be completed during the current feasibility phase of the project. Each suite of features will be subject to separate consultation and consideration of effects during PED as the Area of Potential Effect (APE) may be subject to change based on final designs or modifications of project features. This approach has been coordinated with the consulting parties referenced above and is documented in the Record of Decision (ROD) in accordance with Section 106 of the NHPA (36 CFR § 800.4[b][2]). Compliance with Section 106 of the NHPA will be complete prior to construction of each feature.

Under the NEPA process (Section 40 CFR 1501.2(d) (2)), formal consultation for the LRWRP feasibility is ongoing. For consideration under NHPA, determinations of potential effects and mitigation of those effects on cultural resources listed in **Table 5-11** are preliminary and should not be considered final. As required under the NHPA, further Section 106 consultation is required and will be completed during the PED phase, once a refined APE has been developed. USACE has coordinated a Programmatic Agreement with Florida SHPO and the Advisory Council on Historic Preservation (ACHP) to conduct a phased identification and evaluation of historic properties during the project's design phase. Dependent on further consultation with the Florida SHPO and the results of Phase I cultural resources investigations, project design modification may be necessary to avoid or minimize impact to historic properties. Phase II NRHP eligibility testing or mitigation may be required if impacts cannot be avoided.

USACE prefers to avoid adverse effects to cultural resources; therefore, throughout the planning process for LRWRP, the project archeologist, engineers, and plan formulators have worked closely together to determine alternatives and features of alternatives that reduce or eliminate such impacts. Pursuant to 36 CFR 800.1, where possible, the project design will be modified to avoid impacting significant historic properties and culturally significant sites. Where avoidance is not possible, minimization and/or mitigation measures will be considered, which could include, but are not limited to, data recovery excavations. The mitigation measures will be developed in consultation with SHPO, federally recognized tribes, and other interested parties as established in implementing regulations for Section 106 of the NHPA.

5.18 Effects on Native Americans

No portion of the proposed LRWRP exists within or adjacent to known Native American-owned lands, reservation lands or Traditional Cultural Properties. However, Native American groups have lived throughout this region in the past, and their descendants continue to live within the State of Florida and

throughout the United States. Pursuant to Section 106 of the NHPA (16 USC 470), obligation regarding USACE Trust Responsibilities to federally-recognized Native American Tribes, and in consideration of the Burial Resources agreement between USACE and the Seminole Tribe of Florida, consultation on the project will continue to be coordinated. Moreover, consultation with the appropriate federally-recognized tribes is ongoing and will be completed prior to project implementation.

5.19 Invasive Species

All action alternatives have the potential and likelihood for introducing and spreading non-native invasive and native nuisance plant and animal species. A detailed description of the effects of each feature is provided in **Appendix C.2.1.18**. Proposed restoration activities may have a minor to major effect on the ecosystem drivers that directly or indirectly influence the spread 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). Disturbed areas resulting from construction are likely to become established with non-native invasive and native nuisance species. New flows created by operations of the proposed features may serve as vectors to spread invasive and native nuisance species into new areas. The large number of existing and potential invasive plant and animal species and the often incomplete knowledge of invasive mechanisms for each species create moderate to high uncertainty in this evaluation. Long-term monitoring in an adaptive management framework is critical to ensure efficient management of the most threatening non-native invasive species in the restoration footprint. Effects of alternatives are summarized in **Table 5-12**. Proposed management activities to address invasive species are provided in **Annex F**.

Table 5-12. Response of invasive species by alternative.

Flow-way	FWO	Alt 2	Alt 5R	Alt 10	Alt 13
Flow-way 1	Negligible effect on actively managed invasive species. Minor to moderate expansion of invasive species in areas not managed.	Recruitment of terrestrial invasive species potentially reduced, effects minor to moderate. Invasive aquatic plant species will expand effects minor to moderate. Potential to introduce new invasive aquatic plants and fish species due to connection. Effects considered to be long term.	Recruitment of terrestrial invasive species potentially reduced, effects minor to moderate. Invasive aquatic plant species will expand effects minor to moderate. Potential to introduce new invasive aquatic plants and fish species due to connection. Effects considered to be long term.	Same as Alt 2 & Alt 5R. In addition, moderate effects reducing terrestrial invasive species & increasing emergent aquatic vegetation (EAV), submerged aquatic vegetation (SAV) & floating aquatic vegetation (FAV).	Same as Alt 2 & Alt 5R.

Flow-way	FWO	Alt 2	Alt 5R	Alt 10	Alt 13
Flow-way 2	Negligible effect on actively managed invasive species. Minor to moderate expansion of invasive species in areas not managed.	Moderate effects with removal of terrestrial invasive species. Establishment of invasive EAV, SAV and FAV will occur with potential for minor to moderate effects. Invasive fish and snail species will invade and persist. Effects considered to be long term.	Moderate effects with removal of terrestrial invasive species. Establishment of invasive EAV, SAV and FAV will occur with potential for minor to moderate effects. Invasive fish and snail species will invade and persist. Effects considered to be long term.	Moderate effects with removal of terrestrial invasive species. Establishment of invasive EAV, SAV and FAV will occur with potential for minor to moderate effects. Invasive fish and snail species will invade and persist. Effects considered to be long term.	Same as Alt 2 & Alt 5R. In addition, recruitment of terrestrial invasive species potentially reduced with additional water flow.
Flow-way 3	Negligible effect on actively managed invasive species. Minor to moderate expansion of invasive species in areas not managed.	Effects to invasive species would be similar for all alternatives. Recruitment of terrestrial invasive species potentially reduced, effects minor to moderate. Minor reduction of existing terrestrial species. Moderate to major effects due to expansion of invasive EAV, FAV and SAV species. Introductions of new invasive species to the area are likely to occur. Effects considered to be long term.	Effects to invasive species would be similar for all alternatives. Recruitment of terrestrial invasive species potentially reduced, effects minor to moderate. Minor reduction of existing terrestrial species. Moderate to major effects due to expansion of invasive EAV, FAV and SAV species. Introductions of new invasive species to the area are likely to occur. Effects considered to be long term.	Effects to invasive species would be similar for all alternatives. Recruitment of terrestrial invasive species potentially reduced, effects minor to moderate. Minor reduction of existing terrestrial species. Moderate to major effects due to expansion of invasive EAV, FAV and SAV species. Introductions of new invasive species to the area are likely to occur. Effects considered to be long term.	Effects to invasive species would be similar for all alternatives. Recruitment of terrestrial invasive species potentially reduced, effects minor to moderate. Minor reduction of existing terrestrial species. Moderate to major effects due to expansion of invasive EAV, FAV and SAV species. Introductions of new invasive species to the area are likely to occur. Effects considered to be long term.

Flow-way	FWO	Alt 2	Alt 5R	Alt 10	Alt 13
Loxahatchee River and Estuaries	Negligible effect on actively managed invasive species. Minor to moderate expansion of invasive species in areas not managed.	Minor to moderate effects due to reconnection and the potential to spread and/or introduce new invasive species into the river and estuaries. Effects considered to be long term.	Minor to moderate effects due to reconnection and the potential to spread and/or introduce new invasive species into the river and estuaries. Effects considered to be long term.	Minor to moderate effects due to reconnection and the potential to spread and/or introduce new invasive species into the river and estuaries. Effects considered to be long term.	Minor to moderate effects due to reconnection and the potential to spread and/or introduce new invasive species into the river and estuaries. Effects considered to be long term.

Table of Contents

6 RECOMMENDED PLAN 1
6.1 Plan Components 1
6.1.1 Features 1
6.1.2 Lands and Interests in Lands 10
6.1.3 Project Operations Manual 14
6.1.4 Adaptive Management and Monitoring Plan 15
6.1.5 Invasive and Nuisance Species Management Plan 17
6.1.6 Recreation Plan Features 17
6.2 Plan Accomplishments 18
6.2.1 Ecological Benefits 18
6.2.2 Significance of Ecosystem Benefits 18
6.2.3 Progress toward Interim Goals and Interim Targets 21
6.2.4 Ecosystem Services 23
6.3 Environmental Considerations 24
6.3.1 Cumulative Impacts 24
6.3.2 Incomplete or Unavailable Information 27
6.3.3 Unavoidable Adverse Environmental Effects 28
6.3.4 Irreversible and Irretrievable Commitment of Resources 30
6.3.5 Environmental Operating Principles 31
6.4 Cost Estimates 31
6.4.1 Construction 32
6.4.2 Real Estate 33
6.4.3 Operations, Maintenance, Repair, Replacement, and Rehabilitation 36
6.4.4 Monitoring and Adaptive Management 36
6.4.5 Invasive Species Management 38
6.4.6 Cultural Resources Preservation Costs 38
6.5 Cost Estimate for Recreation Elements 39
6.6 Cost Sharing 40
6.6.1 Cost Sharing of Construction and Real Estate 41
6.6.2 Cost Sharing of OMRR&R 41
6.6.3 Cost Sharing of Monitoring 41
6.6.4 Cost Sharing of Cultural Resources Preservation 42
6.6.5 Non-Federal Sponsor Work-in-Kind for Construction 42

6.7 Plan Implementation 42
6.7.1 Implementation and Construction Sequencing 42
6.7.2 Pre-construction Engineering and Design 47
6.7.3 Construction 47
6.7.4 Operational Testing and Monitoring Period 48
6.7.5 Floodplain Management and Flood Insurance Programs Compliance 48
6.7.6 Environmental Commitments 49
6.8 Project Assurances and Savings Clause Summary 50
6.8.1 Level of Service for Flood Protection 50
6.8.2 Effects on Water Supply for Existing Legal Sources 52
6.8.3 Water Restriction Area 1 (WRA 1) (Southern Martin County) 52
6.8.4 Water Restriction Area 2 (WRA 2) (North Palm Beach County) 55
6.8.5 Effects on Tribal Compact 57
6.8.6 Identification of Water Made Available for the Natural System and Other Water Related Needs 58
6.9 Project Concerns 59
6.10 Risk and Uncertainty 60
6.10.1 Planning 60
6.10.2 Design and Construction 61

Tables

Table 6-1. LRWRP progress towards meeting interim goals. 22
Table 6-2. LRWRP progress towards meeting interim targets. 23
Table 6-3. Summary of Cumulative Effects 24
Table 6-4. Total First Cost. 31
Table 6-5. Investment Costs and Average Annual Costs 32
Table 6-6. Real Estate Requirements for Project Features. 33
Table 6-7. Summary of Baseline Cost Estimates for Real Estate. 36
Table 6-8. Summary of Cost Estimates for Construction Phase Monitoring and Adaptive Management. 37
Table 6-9. Summary of Cost Estimates for Post-Construction Monitoring and Adaptive Management. 37
Table 6-10. Summary of Cost Estimates for Invasive Species Management. 38
Table 6-11. Summary of Cost Estimates for Cultural Resources Preservation. 39
Table 6-12. Summary of Recreation Costs and Benefits. 40
Table 6-13. Cost Share for the LRWRP Recommended Plan. 40

Table 6-14. The frequency, duration and severity of water shortages in the pre-project and post-project simulations for WRA 1. 53
Table 6-15. Million gallons of demand not met due to water restrictions for all use categories in WRA 1 for the ECB, FWO and Recommended Plan simulations for the period of record 1965-2005. 55
Table 6-16. Frequency, duration and severity of locally triggered water use cutbacks in WRA 2. 55
Table 6-17. Million gallons of demand not met due to water restrictions for all use categories in WRA 2 for the ECB, FWO and Recommended Plan for the period of record 1965-2005. 57
Table 6-18. Average annual water (1,000 ac-ft) made available by the project for the natural system....59

Figures

Figure 6-1. The Recommended Plan. 2
Figure 6-2. Flow-way 1 structures and flows. 3
Figure 6-3. Flow-way 2 structures and flows. 5
Figure 6-4. Flow-way 3, western, structures and flows. 7
Figure 6-5. Flow-way 3, eastern, structures. 8
Figure 6-6. Evolution of the Project Operating Manual. 15
Figure 6-7. LRWRP Recommended Plan Recreation Features. 17
Figure 6-8. Unconstrained LRWRP PED, construction, and OTMP sequencing. Values are in millions of dollars. 45
Figure 6-9. Constrained LRWRP PED, construction, and OTMP sequencing. Values are in millions of dollars. 46
Figure 6-10. Stage duration curve for the ECB, FWO and Recommended Plan for the Mecca Southern Point. 51
Figure 6-11. Locally triggered water restrictions in WRA 1 during the ECB simulation. 53
Figure 6-12. Locally triggered water restrictions in WRA 1 during the FWO simulation. 54
Figure 6-13. Locally triggered water restrictions in WRA 1 during the Recommended Plan simulation. 54
Figure 6-14. Locally triggered water restrictions in WRA 2 during the ECB simulation. 56
Figure 6-15. Locally triggered water restrictions in WRA 2 during the FWO simulation. 56
Figure 6-16. Locally triggered water restrictions in WRA 2 during the Recommended Plan simulation. 57
Figure 6-17. Exceedance Curve of average annual water (1,000 ac-ft) made available by the project for the natural system. 59

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6 RECOMMENDED PLAN

The purposes of LRWRP are to restore and sustain the flow of freshwater to the federally designated "National Wild and Scenic" Northwest Fork of the Loxahatchee River (NWFLR), and to provide flows to enhance hydroperiods in the Loxahatchee Slough; increase connectivity of hydrology, flora, and fauna between natural areas; and improve seasonal timing and distribution of water to improve hydropatterns in over-drained wetland areas throughout the historic headwaters of the river.

The LRWRP Recommended Plan includes a surface storage reservoir, aquifer storage and recovery (ASR) wells, and other structures to capture and store water that is currently lost to tide, and redistributes it to increase volume and improve timing of water deliveries to the NWFLR. Preliminary modeling based benefits on the assumption of that 70% of the water volume stored in the aquifer via the ASR wells, can be recovered into the reservoir. The Recommended Plan will achieve 91% of the dry season restoration target flows and 98% of the wet season restoration target flows to the NWFLR measured at Lainhart Dam.

The Recommended Plan also includes new pump stations and canals, ditch plugs, new and modified culverts and weirs, and other management measures to rehydrate over-drained wetlands in the watershed. These measures will restore more natural water deliveries to the Loxahatchee River, promote improved health and functionality of wetland and upland areas, restore hydrologic and ecological connectivity among natural areas, and provide increased quantity and quality of habitat available for wildlife and native vegetation. The Recommended Plan will restore wetland hydrology to 17,000 acres of former wetlands that had been converted to agriculture and an additional 10,000 acres of existing disturbed wetlands in the J.W. Corbett Wildlife Management Area (WMA), Loxahatchee Slough, Culpepper Ranch (part of Pal-Mar), Pal-Mar East (Nine Gems), Cypress Creek Natural Area, and Kitching Creek. These restored wetlands will connect with 51,000 acres of other wetland communities in the area, resulting in 78,000 acres of connected habitat.

6.1 Plan Components

This section describes components of the Recommended Plan. It first describes features, and then describes real estate requirements, project operations, adaptive management and monitoring, invasive species management, and recreation features.

6.1.1 Features

The features of the Recommended Plan (**Figure 6-1**) are organized into three geographic areas, or flow-ways. All features described below are based on modeling and engineering analysis of the Recommended Plan.

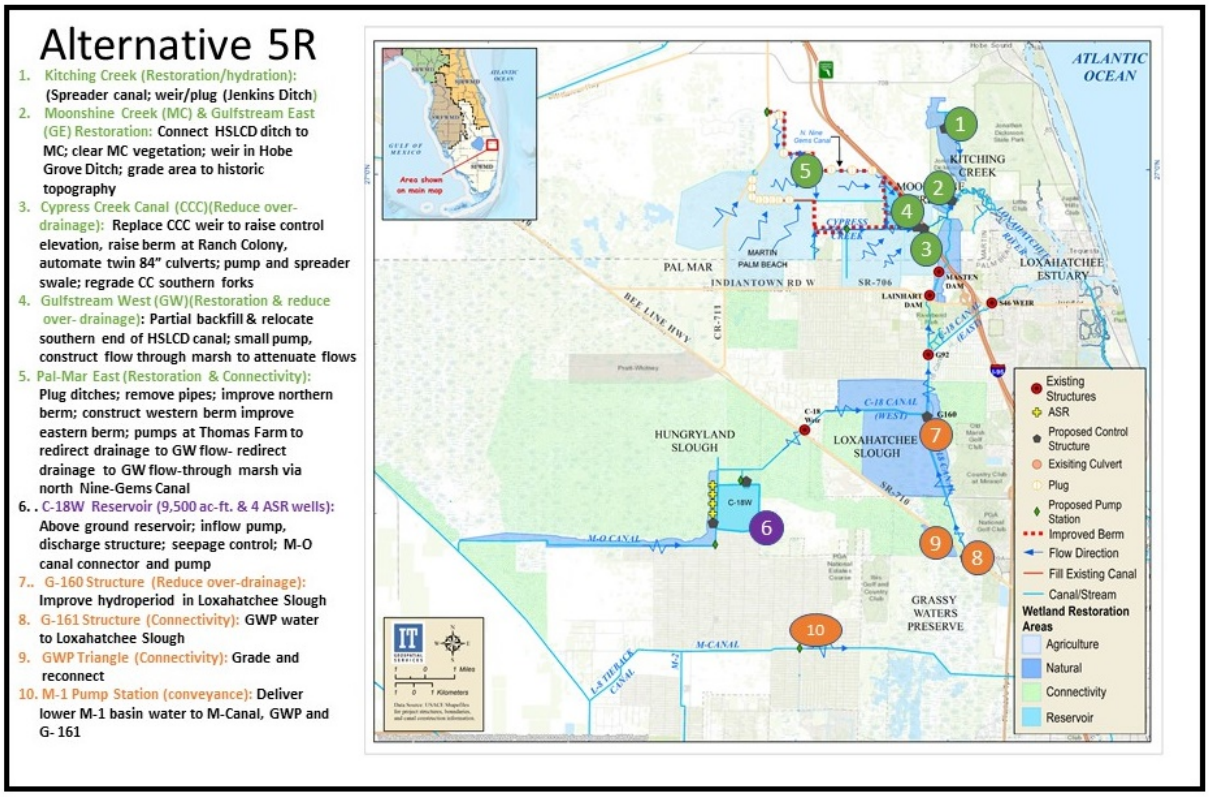


Figure 6-1. The Recommended Plan.

6.1.1.1 Flow-way 1

Flow-way 1 is located in the southeast and southernmost portion of the project area (**Figure 6-1** and **Figure 6-2**). This flow-way uses M-1 Basin canals, the M-Canal, and the C-18 Canal to route water from upstream project area basins to the Loxahatchee River.

A pump station (S-100) will deliver up to 75 cfs to the M-Canal from Indian Trail Improvement District (ITID) Lower M-1 Basin when M-1 Basin canal stage conditions allow. Operations of the M-1 Basin allow for water to be pumped to the M Canal when stages in the M-1 Canal are above 17.0 ft NGVD29 (15.5 NAVD88) in the dry season and 15.0 ft NGVD29 (13.5 NAVD88) in the wet season.

The G-161 structure will act as the gateway through which water will be transported from Grassy Waters Preserve (GWP) through the system to the NWFLR. The structure will be just west of the intersection of the Beeline Highway and Northlake Boulevard. Water will flow from GWP into the northern GWP triangle area, north of Northlake Boulevard. The operable structure will pass up to 150 cfs through two 60-inch diameter culvert barrels with a total length of 240 ft.

The GWP Triangle is located northwest of the intersection of Beeline Highway (SR-710) and Northlake Boulevard. Hydrologic restoration of this area will be accomplished through earth work and strategic construction of a natural conveyance feature, a shallow swale with gentle slopes, running in a west to east direction, which will allow water discharged from G-161 to be spread westward to help improve the

hydroperiod in the area. The shallow swale will allow for a hydrologic connection between the western and eastern portions of the triangle. When water levels are high in the western triangle (or vice versa), this shallow swale will facilitate connectivity and equalization of the triangle hydrology, enabling storage and hydroperiod improvement. This provides flexibility to the system and improves the wetland storage capability. Water will move from the GWP Triangle to the C-18 Canal under a railroad bridge and through an existing culvert beneath the Beeline Highway.

Figure 6-2. Flow-way 1 structures and flows.

The G-160 structure will be a reinforced concrete spillway designed to enhance delivery of the restoration flows to the NWFLR while maintaining water elevations within the Loxahatchee Slough. Discharges from

G-160 will be controlled by two stem-operated vertical lift gates. The design discharge rate, to maintain flood control capability, will be approximately 2,000 cfs via two spillway bays, each 25 ft in length. The structure will be operable to allow for the dual purposes of flood risk management and environmental restoration. The operable gates allow for management of upstream stages to mimic natural slough recession and ascension in water depth between the wet and dry seasons.

6.1.1.2 Flow-way 2

Flow-way 2 is located in the west central portion of the project area (**Figure 6-1** and **Figure 6-3**). Its primary canal conveyances are the M-O and C-18W Canals. Features in Flow-way 2 capture water from ITID and the J.W. Corbett WMA that otherwise would be delivered outside the Loxahatchee River Watershed, and redirect this water northward to the NWFLR to achieve restoration flow targets. The C-18W Reservoir and four co-located ASR wells will store some of this water to be released during the dry season and establish a more natural seasonal timing of delivery to the river.

A new M-O Connector Canal (C-101W) will link the eastern terminus of the M-O Canal, along the eastern border of the J.W. Corbett WMA, to the planned Seminole-Pratt Whitney Road culverts. The 3,500 feet long canal will bring excess water from the ITID upper basin to the culverts. Due to the topography of the area, a 175 cfs pump station (S-109) will pump from the M-O Canal to this connector canal.

Three 72-in gated culvert structures (S-107) will replace an existing sheet pile weir at the eastern edge of the J.W. Corbett WMA. The operable structure will help control discharges towards the reservoir while simultaneously providing improved ecological conditions within the J.W. Corbett WMA due to the operational flexibility during the wet and dry seasons and minimizing the likelihood that existing nearby berms would need to be modified.

A multi-barrel culvert, containing three 78-in barrels, will cross under Seminole-Pratt Whitney Road and be sized to carry the M-O connector flow to the new seepage canal for the C-18W Reservoir. The water will be pumped from the seepage canal into the reservoir at a rate of up to 175 cfs and will be located along the western perimeter of the C-18W Reservoir. This pump station is sized to pump inflow from J.W. Corbett WMA and M-O Canal Connector into the reservoir. The pump station will also contain a 30 cfs pump for the purpose of controlling seepage from the reservoir.

The C-18W Reservoir is a 9,500 ac-ft aboveground reservoir on approximately 1,600 acres of a 1,920 acre former citrus grove. The reservoir will provide pumped diversion and storage of excess flows from the adjacent C-18W Canal, J.W. Corbett WMA, and from ITID upper basin via the M-O Canal. The reservoir will release water back to the C-18W Canal for delivery to Lainhart Dam and the Loxahatchee River downstream. The embankment height will be approximately 20 ft above natural ground elevation with a normal design pool depth of approximately 7.5 ft and a normal pool elevation of 27.5 ft NAVD88.

Figure 6-3. Flow-way 2 structures and flows.

The main inflow/discharge canal (C-101N) for the C-18W Reservoir is located between the C-18W Canal and the northern embankment of the reservoir. A 150 cfs inflow pump station (S-101A) will bring available water into the reservoir from the C-18W Canal. The reservoir will have two main outflow structures 1) a gated culvert discharge structure (S102) for normal operations; and 2) an emergency overflow spillway (S-101B). Both will be along the northern side of the reservoir. The normal discharge structure will include two 4 ft by 6 ft box culverts that discharge 300+ cfs, depending on the stages within the reservoir. The proposed overflow spillway design is an 80 ft wide concrete spillway crest at an elevation of 29.3 ft

NAVD88.The reservoir is surrounded by a seepage collection canal, C-101E and C-101W, which can discharge into the C-101N through two culverts, S-103W and S-103E.

The seepage management system proposed for the C-18W Reservoir consists of three components: internal drainage features within the embankment such as chimney and blanket drains to control water flow; 2) an appropriately sized perimeter canal that surrounds the embankment to control seepage; and 3) small pump stations to convey canal water either back into the reservoir or into the C-18W Canal.

A four-well ASR system will be co-located with the C-18W Reservoir to augment surface storage capacity and provide greater flexibility in reservoir operations. The source of surface water for aquifer recharge will be directly from the C-18W Reservoir. Each well will pump surface water into the Floridan Aquifer System at 5 million gallons per day (MGD). Water will be recovered at a rate of 5 MGD and discharged into the C-18 Reservoir, for subsequent distribution into the C-18W Canal. Benefits calculations are based on the assumption that only 70% of the stored water volume can be recovered.

6.1.1.3 Flow-way 3

Flow-way 3 is located in the northern portion of the project area, within southern Martin County, and consists of the watersheds within the northern portion of the project study area (**Figure 6-1**, **Figure 6-4**, and **Figure 6-5**). Flow-way 3 actions include installing plugs, backfill, and adding water control structures in canals and ditches to reduce overdrainage, restore water levels in semi-drained wetlands, and restore base flow to the NWFLR. A flow-through wetland will capture pulsed discharges of water from northern and western agricultural areas and retain the water for on-site benefits and for improved timing of release to the river. Pumps and berm improvements will ensure that nearby residential and agricultural areas will not be adversely impacted by the changed hydrology of the restored wetlands.

Pal-Mar East (Nine Gems): On the Pal-Mar East property, internal drainage canals will be filled and small drainage pipes and culverts will be removed to reduce drainage and improve hydroperiods and ecology within the area. Minor improvements to existing berms will be necessary at irregular intervals along the Pal-Mar East northern and eastern border to ensure water is held on site during larger storm events. This berm improvement will become L-111.

The existing canal along south and west sides of Pal-Mar East will be partially plugged or backfilled. This will improve connectivity of Culpepper with Nine Gems and allow water to flow from Culpepper to Nine Gems rather than being captured in the existing canal. This canal provides drainage for Thomas Pepper Farm, so alternative drainage for the farm will be required. Additional discharge capability from the Nine Gems area will be accomplished through the S-114A, -B, and -C structures, which ultimately discharge out S-114D to the Cypress Creek Canal.

Thomas Pepper Farm: The Thomas Pepper farm is located to the west of Pal-Mar East Property and Pratt Whitney Road (SR-711). Because the canal and ditch removals for restoration of Pal-Mar East will disrupt the existing drainage for the farm, an existing drainage ditch that runs along the northern boundary of Pal-Mar will be deepened and/or widened to handle additional flow from the pepper farm. A new culvert and pump will be required to re-route the farm's drainage under Pratt-Whitney Road and into the newly expanded drainage canal. The pump location will likely be required to be on the site of the pepper farm.

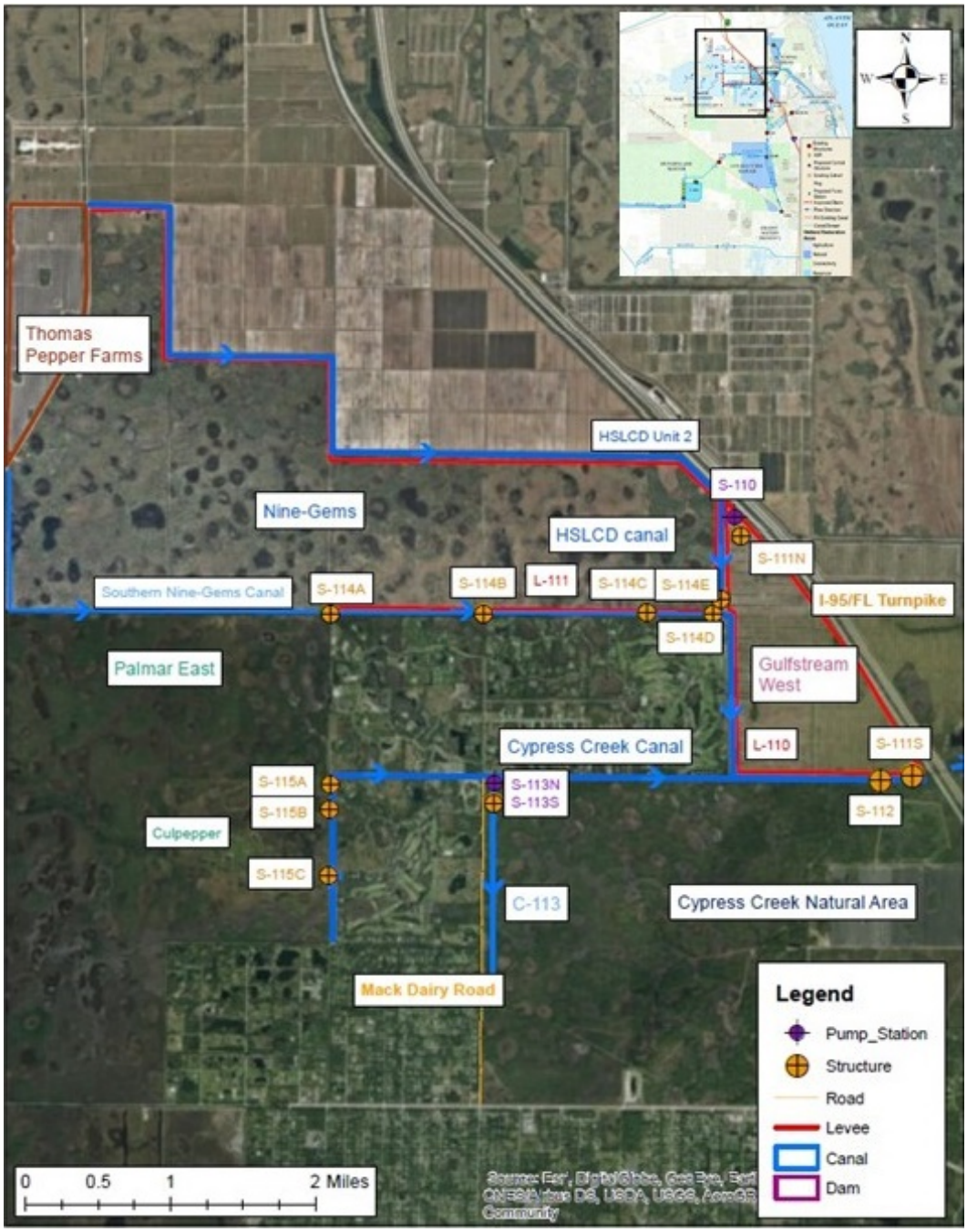


Figure 6-4. Flow-way 3, western, structures and flows.

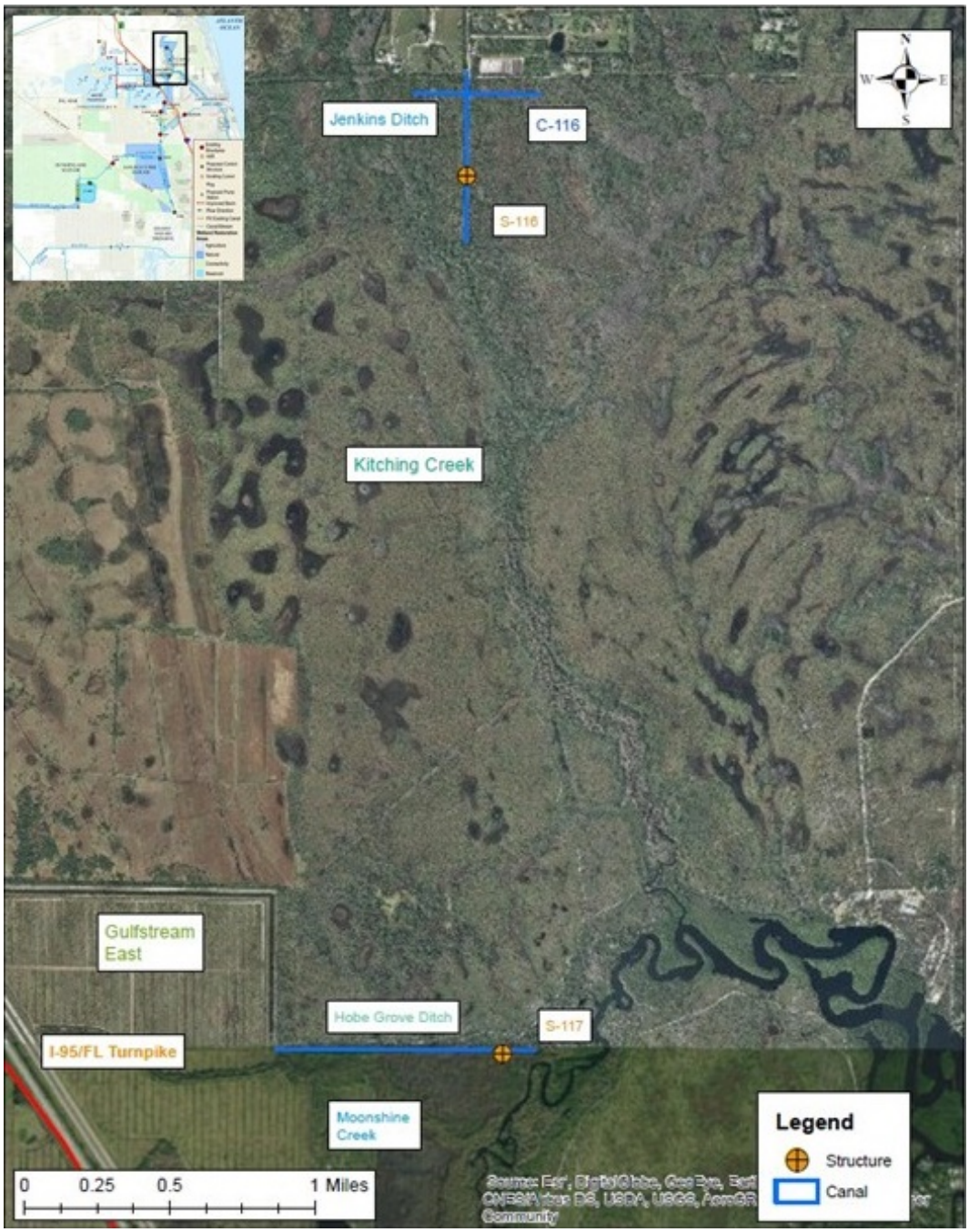


Figure 6-5. Flow-way 3, eastern, structures.

Cypress Creek Canal (also known as Ranch Colony Canal): Modifications to three Culpepper control structures (S-115A, S-115B and S-115C) include adding telemetry operated gates to allow the structures to achieve a more desirable hydroperiod within the Culpepper property of Pal-Mar East, while simultaneously reducing discharges into the Cypress Creek Canal.

Berm improvements along the Cypress Creek Canal and minor modifications (widening and deepening) along the eastern border of Pal-Mar East (western border of a developed area) will improve conveyance capacity to meet the design storm requirements.

A new control structure (S-112) near the eastern end of the Cypress Creek Canal will improve management of water elevations within the canal during the wet and dry season. The structure will be a two-bay concrete ogee spillway with telemetry operated vertical lift gates. Each bay will be 16 ft wide with a crest elevation at approximately 6.5 ft NAVD88. During the dry season, the gates will hold additional water in the canal, assisting in the improvement of groundwater levels by reducing groundwater draw down in Pal-Mar East and the Cypress Creek Natural Area. During the wet season, the gates will help maintain restoration target states in Pal-Mar East and the Cypress Creek Natural Area. The gates will open to allow high volume flows to pass without causing adverse flooding to nearby developed areas. The design will maintain or slightly improve the current flood protection for the surrounding developments and reduce flashy discharges into the natural portion of Cypress Creek to the east.

Mack Dairy Spreader Swale: The Mack Dairy Spreader Swale will extend approximately 4,900 feet south from the Cypress Creek Canal, parallel to Mack Dairy Road. It will have an average depth of 2 feet, bottom width of 5 feet, 4H:1V side slopes, and the western edge of the spreader will be higher elevation than the eastern edge. A 20 cfs pump station (S-113N) will send water from the Cypress Creek Canal into the spreader swale. The discharge bay of the pump station will contain a concrete weir (S-113S) which will assist in distributing water in a southerly direction, then allowing the natural topography to cause the water to flow east across the Cypress Creek Natural Area toward the Loxahatchee River, restoring historical flow patterns. The easterly forks of Cypress Creek will be re-graded to maintain low flow velocities and promote native vegetation.

Gulfstream West: The Gulfstream West flow-through marsh feature will pump water from the existing Hobe St. Lucie Conservancy District (HSLCD) drainage canal into a series of collection ditches and spreader berms that will promote sheetflow and re-hydration of the site. The site will be graded and existing drainage ditches will be removed to provide a more uniform topography and slight gradient to promote flow in a southerly direction. A perimeter levee (L-111) will ensure water is held on-site. A 150 cfs pump (S-110) will discharge runoff from Thomas Pepper Farm, HSLCD and Pal-Mar East into the flow through marsh. The existing HSLCD discharge canal will be straightened and used as a bypass canal if runoff exceed 150 cfs or when water elevations within the flow-through marsh exceed an average depth of 3 feet. The outflow structure (S-111S) will be a notched weir and is designed to discharge a variable rate depending on the marsh depth, with discharges over 250 cfs when water depth within the marsh exceeds 4 feet. At 2.75 feet of depth the discharge will be approximately 30 cfs as baseflow to the Loxahatchee River. All discharge from the flow-through marsh is downstream of the new Cypress Creek Canal structure.

Gulfstream East and Moonshine Creek: The existing drainage ditches in Gulfstream East will be filled and the site will be re-graded to the historical topography. The Hobe Grove Ditch and Moonshine Creek are partially separated due to heavy vegetation and sediment. The proposed feature will connect the Hobe Grove Ditch and Moonshine Creek. Additionally, a new weir (S-117) will be installed at the eastern extent of the Hobe Grove Ditch to help hold additional water within the ditch, improving the groundwater levels while helping to promote additional flow down the historic Moonshine Creek. The proposed weir elevation is 7.5 ft NGVD29 (6 ft NAVD88).

Kitching Creek: A spreader swale (C-116) will be constructed to the east and west from Jenkins Ditch at the north end of the Jonathan Dickinson State Park (JDSP). This swale will help distribute flows to historic

Kitching Creek channels instead of directly down the ditch. A gated culvert (S-116) will be constructed in the ditch upstream of the main Kitching Creek channel at elevation 11.0 ft NGVD to aid in the dispersion of water into the spreader system.

6.1.2 Lands and Interests in Lands

The following real estate interests and lands identified below are required for the construction and operations, maintenance, repair, replacement, and rehabilitation (OMRR&R) of LRWRP. Approximately 81 parcels of land will be impacted by the project. The following real estate interests identified below for each project feature are required for the construction and OMRR&R of LRWRP.

The Comprehensive Everglades Restoration Plan as approved by Congress in WRDA 2000, consists of 68 components with the South Florida Water Management District (SFWMD) as the non-federal Sponsor of a vast majority of the proposed components. The SFWMD in 2007 requested one master document that would address most if not all of the terms and conditions that were in standard Project Partnership Agreements at the time. The Department of the Army and the South Florida Water Management District negotiated a Master Agreement for the cooperation in constructing and operating, maintaining, repairing, replacing, and rehabilitating Projects Authorized to be undertaken pursuant to the Comprehensive Everglades Restoration Plan. The Master Agreement was executed on August 13, 2009 by and between the Department of the Army represented by the Deputy Assistant Secretary of the Army (Civil Works) and the South Florida Water Management District represented by the Chair of its Governing Board. As part of the Master Agreement, the parties recognized that some of the proposed projects would potentially be located on lands owned by other governmental entities (the State of Florida, local counties, local Cities, or other governmental entities). It was also recognized by the parties that the lands owned by these governmental entities were acquired using funds that prohibited the conveyance of the lands or interest in lands. The other governmental entities supported the CERP and desired that their lands be included in proposed projects. As part of the Master Agreement, the parties included Article III, subparagraph E.

In accordance with the terms of ARTICLE III - LANDS, EASEMENTS, RIGHTS-OF-WAY, RELOCATIONS AND COMPLIANCE WITH PUBLIC LAW 91-646, AS AMENDED of the Master Agreement subparagraph E provides: “The Government recognizes that the Non-Federal Sponsor in limited circumstances will be entering into supplemental agreements with the State of Florida or another Florida governmental entity whereby (1) the State of Florida or another Florida governmental entity, rather than the Non-Federal Sponsor, has acquired or will acquire required lands, easements, and rights-of-way, and (2) the State of Florida or another Florida governmental entity will dedicate the land interests it owns to the authorized CERP Project and ensure that such lands, easements, and rights-of-way are retained in public ownership for uses compatible with the purposes of the authorized CERP Project and shall not be conveyed, transferred, altered, or otherwise encumbered without the advance written consent of the Non-Federal Sponsor and the Government. These supplemental agreements shall be limited in effect to the signatory parties and shall not reduce or alter in any way the requirements of this Master Agreement and any PPA that makes the Non-Federal Sponsor solely responsible for providing lands, easements, and rights-of-way that are required for the construction, operation, maintenance, repair, replacement, and rehabilitation of the authorized CERP Project.”

Use of Supplemental Agreements between the SFWMD as non-Federal Sponsor and the State of Florida or another Florida governmental entity whereby the State of Florida or another Florida governmental

entity, rather than the Non-Federal Sponsor have been approved in the following CERP Projects: Biscayne Bay Coastal Wetland, C-111 West Spreader Canal, and Broward County Water Preserve Areas.

6.1.2.1 Flow-way 1

M-1 Lower Pump Station

Fee is required for this feature; construction of this feature is within the M-Canal. The M Canal is owned in fee by the Indian Trail Improvement District and the City of West Palm Beach. SFWMD will be required to provide fee either through acquisition from Indian Trail Improvement District and the City of West Palm Beach or by Supplemental Agreement between the SFWMD and Indian Trail Improvement District and the City of West Palm Beach. The parties can execute a Supplemental Agreement to provide the required lands pursuant to the terms and conditions of the CERP Master Agreement ARTICLE III as set forth in Section 6.1.2 above.

M Canal

A perpetual channel easement is required for this existing canal. The M Canal is owned in fee by the Indian Trail Improvement District and the City of West Palm Beach. In the event that neither can convey fee title to the SFWMD, then they can execute a Supplemental Agreement to provide the required lands pursuant to the terms and conditions of the CERP Master Agreement ARTICLE III as set forth in Section 6. 1.2 above.

Grassy Waters Preserve Triangle

Fee is required for earthwork and strategic construction of a swale. The Grassy Waters Preserve Area is owned in fee by the City of West Palm Beach. In the event that the City of West Palm Beach cannot convey fee title to the SFWMD, then they can execute a Supplemental Agreement to provide the required lands pursuant to the terms and conditions of the CERP Master Agreement ARTICLE III as set forth in Section 6.1.2 above.

G-161

Fee is required for the G-161 feature. Any potential work required to allow for proper flow through the conveyance channel to include flows under both the Beeline Highway and Northlake Boulevard that connect the GWP to the C-18 Canal and under an existing railroad bridge, temporary construction easements and perpetual channel easements are required. The SFWMD owns fee to this area.

G-160

Fee is required for the G-160 feature. Construction of this feature will be within the C-18 Canal. C-18 Canal is a Central and Southern Florida Flood Control Project feature, and SFWMD holds a permanent easement for canal operations. Underlying fee ownership is public, owned by Palm Beach County. Palm Beach County owns fee title to this area and the SFWMD owns a Conservation Easement. The Conservation Easement does not give the SFWMD the right to flow water across the property nor the right to retain water on the properties. In the event that the Palm Beach County cannot convey fee title to the SFWMD, then they can execute a Supplemental Agreement to provide the required lands pursuant to the terms and conditions of the CERP Master Agreement ARTICLE III as set forth in Section 6.1.2 above.

Loxahatchee Slough

Palm Beach County owns fee title to this area and the SFWMD owns a Conservation Easement. The Conservation Easement does not give the SFWMD the right to flow water across the property nor the right to retain water on the properties. In the event that the Palm Beach County cannot convey fee title to the SFWMD, then they can execute a Supplemental Agreement to provide the required lands pursuant to the terms and conditions of the CERP Master Agreement ARTICLE III as set forth in Section 6.1.2 above.

6.1.2.2 Flow-way 2

C-18W Reservoir

C-18W Reservoir: above ground reservoir, Estate Required Fee, 1 Parcel. SFWMD owns fee to the approximately 1,650 acres needed for the reservoir.

Four Well Aquifer Storage and Recovery System

The real estate requirement for this feature is within the lands required for the C-18W Reservoir; Fee is required. SFWMD owns fee to these lands.

M-O Connector Canal

A perpetual channel easement is required for the M-O Connector canal. SFWMD has acquired easements along the north side of the M-O Canal, as well as along the west side of the proposed C-18W Reservoir. During Preconstruction, Engineering, and Design (PED), the project will determine if these easements are adequate for the project or if additional area is required. If the easements owned by SFWMD are not adequate, SFWMD will be required to acquire the necessary perpetual channel easements.

M-O Canal Connector Pump Station

Fee title is required for this feature. This land is owned in fee by the Florida Fish and Wildlife Commission. In the event that the Florida Fish and Wildlife Commission cannot convey the fee title to the SFWMD, then they can execute a Supplemental Agreement to provide the required lands pursuant to the terms and conditions of the CERP Master Agreement ARTICLE III as set forth in Section 6.1.2 above.

M-O Canal: existing feature already constructed, though some improvement may be necessary to ensure appropriate conveyance capacity. The underlying fee ownership is by private individual owners, subject to an Easement to the Indian Trail Improvement District (ITID) for road and drainage purposes. Perpetual Channel Easement for Public Right-of-way is required. During PED, the project will determine if these easements are adequate for the project or if additional area is required. In the event that the ITID cannot convey the existing easements to the SFWMD, than they can execute a Supplemental Agreement to provide the required lands pursuant to the terms and conditions of the CERP Master Agreement ARTICLE III as set forth in Section 6.1.2 above.

6.1.2.3 Flow-way 3

Pal-Mar East (Nine Gems)

Pal-Mar East (Nine Gems): filling or plugging of existing north to south drainage canals, internal grading, small drainage pipes and culverts will be removed and backfilled, minor berm improvements. The SFWMD has acquired the Pal-Mar East properties, except for four (4) drainage ditches under easement by the Hobe St. Lucie Conservancy District (HSLCD), approximately 235 acres on the western boundary between the property and Pratt Whitney Road (SR 711), and 60 acres on the north east corner of the property. The four drainage easements owned by HSLDC will be treated as a facility/utility relocation and the appropriate real estate interests will be acquired via the relocation agreement. The relocation agreement will be done in accordance with the required Attorney's Opinion of Compensability. The planning models showed the 235 acre and 60 acre components to be unimpacted by the restoration, however, this will need to be confirmed with the detailed, event-based modeling during PED. If the properties are affected they will either need to be acquired in Fee, or protected with a seepage barrier or other physical structure. A temporary easement will be required to complete the minor berm work and removal of small drainage pipe along the northern boundary of the property.

Thomas Pepper Farm

The project feature is the backfill of the existing Thomas Pepper farms drainage canal, rehabilitate the existing berms, construction of a new culvert and pump. The existing drainage on the farm will be rerouted and connected to the Hobe St. Lucie Conservancy District (HSLCD) canal on the north side of the Pal-Mar East (Nine-Gems) property. The estate required for the Thomas Pepper Farm is fee. An agreement will be coordinated with HSLDC to allow for permanent drainage into the existing HSLDC canal, estate to be determined in conjunction with the agreement.

Cypress Creek Canal:

Temporary easements are required for the construction of the two-bay concrete ogee spillway, and berm improvements. The portion of the canal where the structure will be constructed is owned by the SFWMD, shared title with Martin County. The portion of the canal adjacent to the residential communities is privately owned. During PED, it will be determined if Temporary Easements are required from the private landowners. Martin County has an easement to operate and maintain the canal, so the SFWMD will be required to obtain Temporary rights from Martin County as deemed necessary during PED.

Gulfstream West

Fee is required for the flow-through marsh, extensive earthwork, the levee and the collection ditches with spreader berms. The SFWMD has acquired the property necessary to complete the construction of the flow through marsh, with the exception of the canal that transects the property. SFWMD will be required to acquire fee to the canal.

Gulfstream East and Moonshine Creek

Fee is required for the weir and for the restoration work that may affect the Hobe Grove drainage ditch, which are owned by HSLCD. The SFWMD has acquired the parcels necessary to complete the hydroperiod restoration work.

Kitching Creek

Fee is required for the proposed project features of a spreader swale and sheet pile weir. The proposed improvements are within JDSP. The State of Florida, Trustees of the Internal Improvement Trust Fund

owns fee title to these lands and cannot convey fee title. SFWMD can execute a Supplemental Agreement to provide the required lands pursuant to the terms and conditions of the CERP Master Agreement ARTICLE III as set forth in Section 6.1.2 above.

Mack Dairy Spreader Swale

Fee is required to construct the swale on the southern portion of the area, these properties are owned in fee by Palm Beach County and Martin County. The SFWMD has a conservation easement over most of the property needed to increase water levels and complete the hydroperiod restoration. The Conservation Easement does not give the SFWMD the right to flow water across the property nor the right to retain water on the properties. In the event that the Palm Beach County cannot convey fee title to the SFWMD, then they can execute a Supplemental Agreement to provide the required lands pursuant to the terms and conditions of the CERP Master Agreement ARTICLE III as set forth in Section 6.1.2 above. For the portion of the lands in Martin County, these properties are owned in fee by Martin County. The SFWMD has a conservation easement over most of the property needed to increase water levels and complete the hydroperiod restoration. The Conservation Easement does not give the SFWMD the right to flow water across the property nor the right to retain water on the properties. In the event that the Palm Beach County cannot convey fee title to the SFWMD, then they can execute a Supplemental Agreement to provide the required lands pursuant to the terms and conditions of the CERP Master Agreement ARTICLE III as set forth in Section 6.1.2 above.

6.1.2.4 Staging and Access

Staging areas will be within the project footprint and identified during PED of this project. Access areas will be by public roads and non-federal sponsor owned lands situated within the project area; other access areas will be identified during PED for this project. A temporary work area easement will be required for areas identified for access outside the project area.

6.1.3 Project Operations Manual

The Draft Project Operating Manual (POM) includes operating criteria based on the Recommended Plan hydrologic modeling assumptions and generally discusses the transitions to operations during the construction phase, the Operational Testing and Monitoring Period (OTMP), and the long-term Operations and Maintenance (O&M) phase (**Annex C**). The POM assumes completion of all LRWRP components. Development of the POM is an iterative process that will continue throughout the life of the project (**Figure 6-6**). The POM will be updated at periodic intervals during the detailed design, construction and operational testing and monitoring period of the project. Refinements to the operating criteria in the POM will be made as more project design details, data, operational experience, and general information are gained during these project phases. It is also anticipated that once the POM is completed and the long-term operations and maintenance phase is underway, it may be necessary to revise the POM from time to time based on additional scientific information and implementation of CERP or non CERP activities.

It is important to understand that the POM will develop over time as the details of the design of LRWRP components are developed. The first draft is presented in this document with the recognition that multiple revisions and operational fine-tuning would occur over the life of the project. The operations discussed herein represent the start-up operational strategy. The draft POM is presented with the recognition that multiple revisions and operational refinements will occur over the life of the project, as described in **Figure 6-6**. The USACE and SFWMD will share in the responsibilities for conducting water management operations during the OTMP.

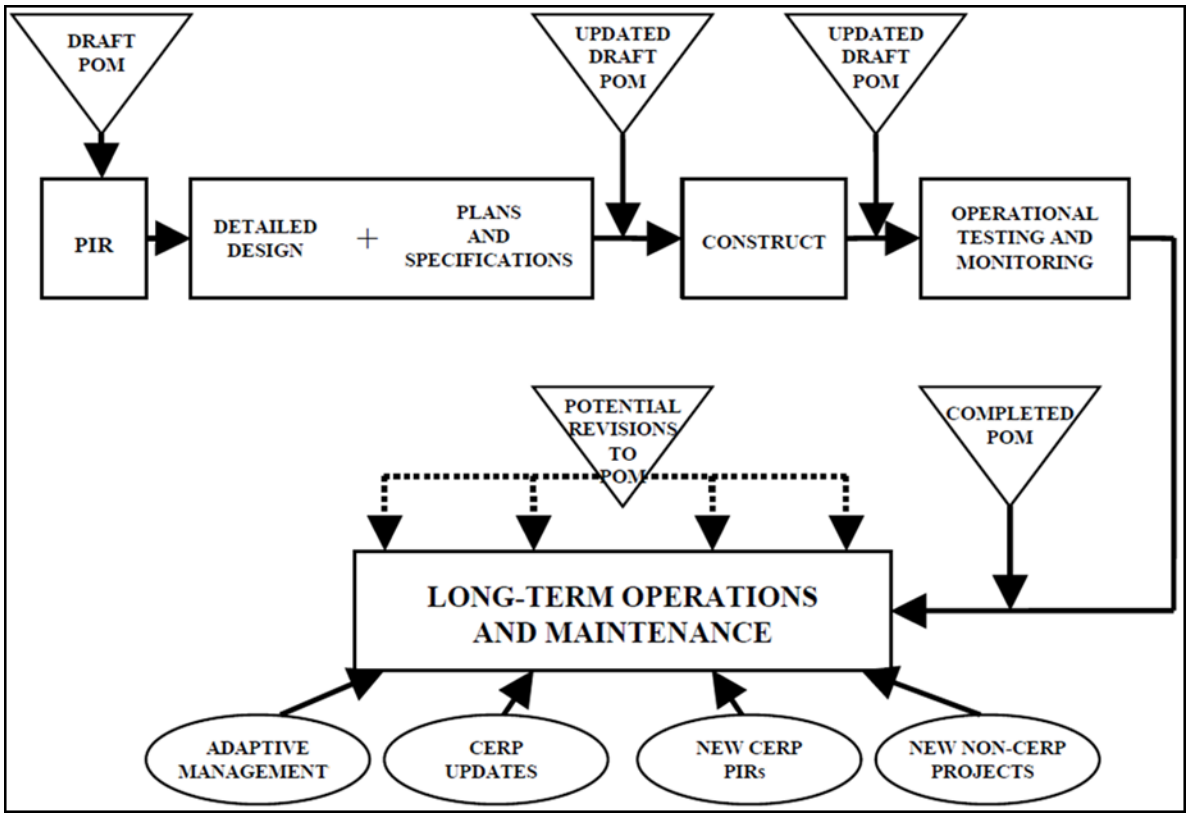


Figure 6-6. Evolution of the Project Operating Manual.

6.1.4 Adaptive Management and Monitoring Plan

The LRWRP Adaptive Management (AM) and Monitoring Plans (**Annex D**) identifies the monitoring information needed to inform LRWRP implementation and to document restoration progress to agencies, the public, and Congress. The overall objective of the AM and Monitoring Plan is to focus resources on refinement of LRWRP to fine-tune performance due to inevitable uncertainties, based on existing knowledge and knowledge that will be gained through monitoring and assessment. These uncertainties may be specific to operating structures (hydrometeorologic monitoring), water quality constraints (anticipated water quality permit monitoring), or achieving ecosystem restoration success.

CERP's interagency science group, the Restoration Coordination and Verification group (RECOVER) provided significant support in the development of the AM and Monitoring Plan, as did Project Delivery Team (PDT) scientists, engineers, and water operators. Expertise included input from more than 11 agencies, consisting collectively of decades of scientific and operational knowledge of the Everglades, the Loxahatchee River and Watershed, and the Loxahatchee River estuary. Using this knowledge, key questions were identified for analysis to inform LRWRP design, implementation, and potential adjustments for optimizing project performance.

The LRWRP AM and Monitoring Plans contain descriptions of monitoring that should address specific uncertainties identified during project planning, required parameters such as water quality and water levels, and ecological features that track the project's progress toward success. The monitoring data will indicate progress toward the project objectives, and LRWRP's conformance to applicable legal requirements. The monitoring descriptions are found in detail in **Annex D Part 1 Sections D.1.3 – D.1.4 to**

D.1.9 and in **Annex D Parts 2, 3**. The monitoring parameters, their value to LRWRP, timeframe needed to see changes, measurement frequencies, decision criteria for triggering adaptive management options, and suggested adaptive management options are provided in the AM Plan text. Monitoring durations, which are specified in Annex D, are dependent on the intended use of the monitoring: regulatory monitoring will be continued as long as required by applicable regulations and the adaptive management and ecological success monitoring will continue up to 10 years, per WRDA 2007 Section 2039, in coordination with the phases of LRWRP construction. See **Annex D Part 1 Section 1.10**, "How Adaptive Management Activities Will be Applied During LRWRP Implementation" for a description of the rolling implementation of the monitoring and the feedback that the data will provide to inform management decisions.

Part 1 of the AM and Monitoring Plans (Annex D) is the LRWRP AM Plan. A fundamental principle of AM is that a project can be adjusted to achieve higher performance toward the project's goals and objectives and to remain within its constraints. In AM the adjustments are based on a scientifically efficient and sound process of learning from data. These adjustments should be viewed as intelligently fine-tuning the project, the need for which is almost inevitable in large-scale, long-term restoration projects like CERP and LRWRP. Given this fundamental principle of AM, the LRWRP AM Plan provides suggestions for potential improvements and refinements of aspects of LRWRP if necessary, called Adaptive Management Options (AM Options). The suggestions are based on current experience and knowledge and are not required actions, nor are they meant to limit agencies from considering other options. All of the AM Options are considered part of the recommended plan for authorization, although some would require more information about project footprint and performance in order to perform a full National Environmental Policy Act (NEPA) analysis, permitting, and agency coordination before they could be initiated. The AM Options are included in the LRWRP cost estimates and described here per WRDA 2007 USACE implementation guidance (August 2009). The AM Options are not automatic; they are informed suggestions provided as part of the recommended plan that capture current knowledge of what may be needed in the future to adjust and maximize performance as LRWRP progresses. Additional options that are also considered part of the recommended plan but would not require as extensive additional analysis are listed in the LRWRP AM Plan where they are summarized per LRWRP region (**Annex D Part 1**).

Flows on average are expected to increase for the dry season to improve salinity conditions in the Loxahatchee River and Estuary but are not expected to increase to a point where additional sediment would impact benthic invertebrates, oysters, and/or seagrass estuarine health. There are existing fine sediments and muck that might prohibit maximum performance for juvenile fish, benthic habitat, and oysters achieved through hydrologic restoration. Sediment management could be an important driver of restoration success and several actions could be considered in the future for maximum restoration performance, if determined to be needed. These actions include: 1) installing a sediment trap to reduce sediment runoff into the system; 2) removing or capping fine sediments will aid seagrass and benthic communities by reducing the burying of hard bottom substrate and increasing light availability; and 3) installing breakwaters could assist in protecting areas from shear stress and/or promote sediment accumulation.

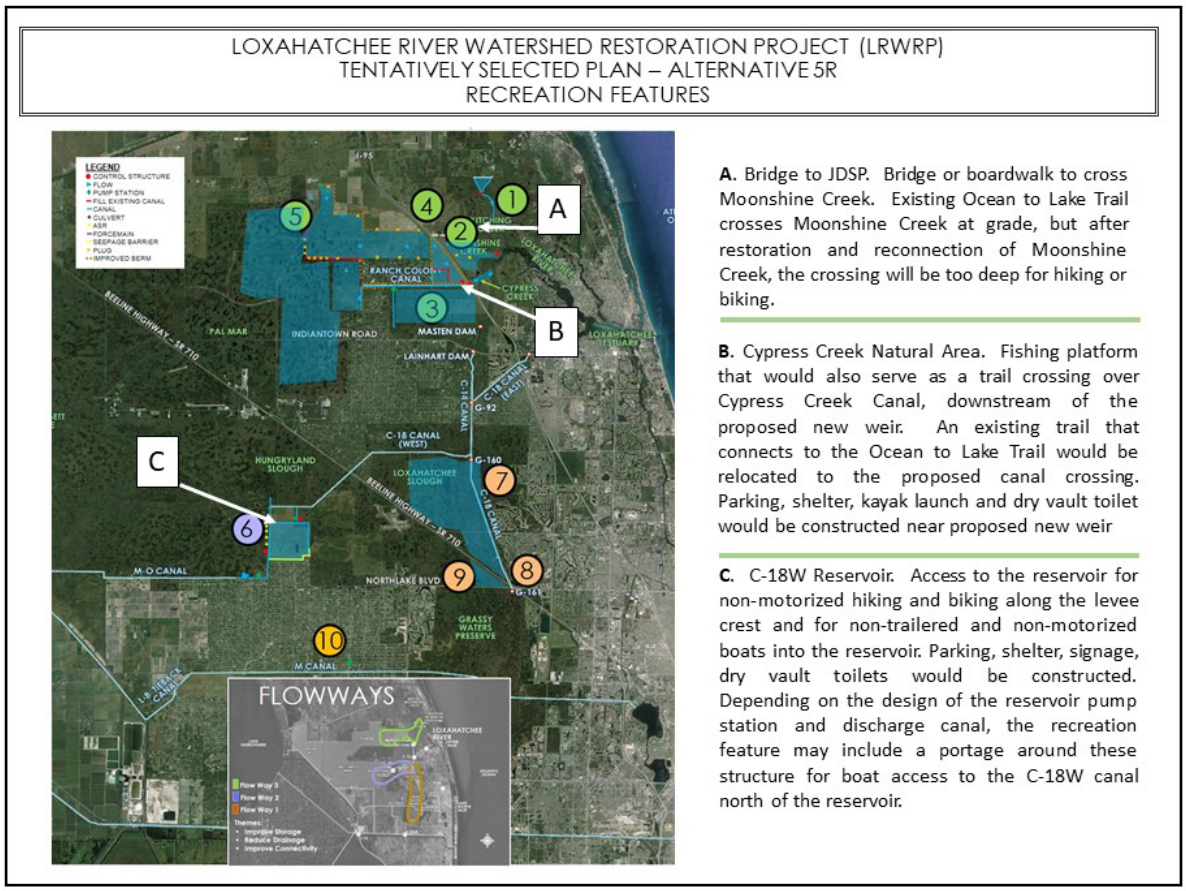
In addition to the AM Plan, Annex D contains the Hydrometeorological Monitoring Plan (Part 2) and Water Quality Monitoring Plan (Part 3). These plans address regulatory monitoring associated with water quality and operating the LRWRP project features. Ecological monitoring for restoration success has been integrated into the adaptive management plan. An ecological monitoring plan may be required once endangered species act consultation is completed with U.S. Fish and Wildlife Service (FWS), which may or may not result in additional requirements under a Biological Opinion (BO).

6.1.5 Invasive and Nuisance Species Management Plan

The Invasive and Nuisance Species Management Plan (INSMP) was developed in accordance with Executive Order (EO) 13112, entitled Invasive Species, signed February 3, 1999, the USACE Invasive Species Policy and CERP Guidance Memorandum 062.00, Invasive Species. The purpose of the INSMP is to outline measures for preventing, controlling, reducing and monitoring invasive species within the LRWRP footprint in order to achieve restoration benefits. To achieve these goals, the plan proposes to complete both initial and long-term invasive species management. The INSMP is a living document and will be updated throughout design, construction and OMRR&R. The INSMP is located in **Annex F**.

6.1.6 Recreation Plan Features

The proposed recreation features will increase access to project lands and provide connections between existing multipurpose recreational trails. Two sites are recreation features that focus on the opportunities created by project features and are located adjacent to restoration features. Facilities include sufficient gravel parking with boat ramps and trailheads, dry vault toilets, shelters, and Americans with Disabilities Act compliant fishing platforms. The proposed bridge site was selected after evaluating multiple sites. These other sites were eliminated due to lack of land ownership rights or because wider canals would require a greater span along the route. All three recreation features are briefly described in **Figure 6-7** below. The Recreation appendix, **Appendix F**, has additional details.



A. Bridge to JDSP. Bridge or boardwalk to cross Moonshine Creek. Existing Ocean to Lake Trail crosses Moonshine Creek at grade, but after restoration and reconnection of Moonshine Creek, the crossing will be too deep for hiking or biking.

B. Cypress Creek Natural Area. Fishing platform that would also serve as a trail crossing over Cypress Creek Canal, downstream of the proposed new weir. An existing trail that connects to the Ocean to Lake Trail would be relocated to the proposed canal crossing. Parking, shelter, kayak launch and dry vault toilet would be constructed near proposed new weir

C. C-18W Reservoir. Access to the reservoir for non-motorized hiking and biking along the levee crest and for non-trailered and non-motorized boats into the reservoir. Parking, shelter, signage, dry vault toilets would be constructed. Depending on the design of the reservoir pump station and discharge canal, the recreation feature may include a portage around these structure for boat access to the C-18W canal north of the reservoir.

Figure 6-7. LRWRP Recommended Plan Recreation Features.

6.2 Plan Accomplishments

This section briefly describes the many ecological benefits of the Recommended Plan.

6.2.1 Ecological Benefits

The Recommended Plan reduces the amount of water rapidly discharged to tide through the Central and Southern Florida (C&SF) system by capturing and storing water in the C-18W Reservoir and ASR wells, and through restoring or improving existing wetland hydrology. The Pal-Mar natural area complex will restore hydrologic patterns on 17,000 acres of various types of agricultural land, including fallow citrus orchard, ranch, and pasture, that are part of the historical Greater Everglades. An additional 10,000 acres of natural areas will be improved hydrologically in the J.W. Corbett WMA, Loxahatchee Slough, and Kitching Creek. These habitats collectively include a unique mix of ridge and slough, mesic and wet flatwoods, wet prairie, cypress floodplain, cypress strand, dome swamps, depression marsh, mesic and hydric hammock plant communities. These restored wetland plant communities will provide foraging and nesting habitat for and contribute to the recovery of the endangered Everglade snail kite, threatened wood stork, threatened eastern indigo snake, and several state-listed threatened wading birds. In addition, the restored wetlands will contribute to prey production and increased foraging opportunities for the CERP system-wide wading bird performance measure. The restoration actions also improve connectivity for over 78,000 acres of natural areas and restored wetlands that benefit many species of flora and fauna both endangered and important recreational species, such as white-tailed deer and ducks. Ultimately, capturing flows and releasing them at the right time and location helps achieve 91% of dry season flow targets to the designated national wild and scenic NWFLR. Restored flows will benefit restoration and maintenance of the last riverine cypress habitat in southeast Florida, riverine tapegrass habitat, improved oligohaline salinity zones that support juvenile sportfish species, and improved mesohaline salinity zones that support oyster habitats used by many federally-managed fishery species, and improved riverine and estuarine conditions for the threatened Florida manatee. Achieving the ecosystem benefits of the project requires completion of all three flow-ways and that they work together. The flow-ways are not separable elements. These restored habitats in the river and watershed will enhance recreation and tourism benefits because they are readily accessible, given their proximity to 1.3 million people of Martin and Palm Beach counties.

6.2.2 Significance of Ecosystem Benefits

The CERP consists of 68 integrated components that collectively address aquatic ecosystem problems associated with the implementation of the federal Central and Southern Florida Project (C&SF project). The C&SF project was originally intended to drain the Everglades and provide flood protection and water supply in south Florida via a massive system of canals and levees. In so doing, the project caused major disruptions throughout the 18,000 square mile Everglades and associated estuaries due to the induced hydrologic changes, including impacts to two Native American Tribal Reservations, large scale habitat degradation, unnatural catastrophic fires that eliminate all plants and soil, leaving only bedrock, and the loss of the structure and functioning of nationally and internationally recognized ecosystems. CERP's goals include restoring the quantity, quality, timing, and distribution of fresh water throughout the Everglades to restore the structure, function, and dynamic processes of its ecosystems. With the passage of WRDA 2000, the CERP was approved as a national priority and a "framework for modifications and operational changes to the C&SF Project that are needed to restore, preserve, and protect the South Florida ecosystem while providing for other water-related needs of the region, including water supply and flood protection."

The LRWRP, as part of the CERP, will provide substantial environmental restoration in the Loxahatchee River watershed, the Northwest Fork of the Loxahatchee River and the river's associated estuary. The C&SF Project disrupted the flow of freshwater through the watershed to the river, resulting in a lack of freshwater delivery to the Northwest Fork of the Loxahatchee River and associated degradation of the associated riverine and estuarine ecosystems. The institutional, technical and public importance of this restoration project is demonstrated by the following discussion:

6.2.2.1 Institutional Significance

The Everglades system is the heart of south Florida, and sustains the economic and cultural growth of the region. The Loxahatchee Slough contains the same unique ridge and slough landscape, tree islands, and unique mix of species that supported designating the Everglades as a World Heritage Site.

10.3 miles of the Northwest Fork of the Loxahatchee River (NWFLR) are designated as the first National Wild and Scenic River in Florida. Portions of the river and estuary are also designated as Outstanding Florida Waters and as an Aquatic Preserve, and are located within Jonathan Dickinson State Park, which contains outstanding examples of unique ecosystems and cultural and archeological treasures. The Loxahatchee River contains the last remaining riverine cypress stands in Southeast Florida.

Restoration of the Loxahatchee River watershed will contribute to achieving CERP goals and objectives. Restoration of the natural flows to the Loxahatchee River will improve fish nursery habitat for a number of federally important recreational and commercial fish species, as well as support improvements to critical habitat for the threatened Florida manatee.

The LRWRP is consistent with the aquatic ecosystem restoration mission of USACE to pursue ecosystem restoration (national ecosystem benefits) and is integral to the continued operation and function of the C&SF Project to meet multiple objectives. The LRWRP would support the USACE Campaign Plan by delivering reliable, resilient, and sustainable water resource solutions through collaboration with partners and strategic engagement and communication with stakeholders. Additionally, the LRWRP is a primary example of watershed integration, addressing the needs of the South Florida ecosystem while balancing the needs of the overall human environment. As such, the LRWRP is in both the federal and USACE interest.

Seminole Tribe of Florida and Miccosukee Tribe of Indians of Florida historically used lands related to their unique cultural histories are within the study area

Multiple state and locally-owned natural areas including Jonathan Dickinson State Park, J. W. Corbett Wildlife Management Area, Loxahatchee Slough Natural Area, Hungryland Slough, Grassy Waters Preserve, Pine Glades Natural Area, etc. were established to protect their recognized unique habitats and species from imminent urban development

Multiple federally listed species occur within the study area, including nine species for which the USACE is consulting with the U. S. Fish and Wildlife Service pursuant to the Endangered Species Act, including wood stork, Everglade snail kite, northern crested caracara, red-cockaded woodpecker, Florida manatee, Florida bonneted bat, Florida panther, eastern indigo snake, and Okeechobee gourd.

The significance of Everglades restoration to multiple agencies and the two tribes is exemplified by the interagency participation and commitment to the South Florida Restoration Task Force, established by

section 528(f) of WRDA 1996. The Task Force consists of seven federal, two tribal, and five state and local government representatives.

6.2.2.2 Public Significance

Martin County and Palm Beach County, the two counties within which the project area is located, have participated continuously in the project planning and as participants on the Project Delivery Team. Similarly, the local cities have participated.

The LRWRP PDT includes representatives from federal, state, local, NGO, and the public, who have engaged in sub-discipline team meetings in addition to PDT meetings.

The LRWRP NEPA scoping mailing went to several hundred addressees (both individuals and organizations) and voluminous comments were received; the draft PIR/EIS was released for public comment in spring 2019 and numerous agency and public comments were received; the USACE held two local public meetings at which around 200 members of the public and organizational representatives commented on the draft PIR/EIS.

Representatives of federal, state, and local governmental agencies, elected officials at all governmental tiers, regional scientists, conservationists, agriculturists, recreationalists, and numerous journalists attended the LRWRP draft PIR/EIS public meetings.

6.2.2.3 Technical Significance

The LRWRP project area includes the NWFLR, one of two federally designated “Wild and Scenic Rivers” in Florida.

The NWFLR supports unique ecosystems and habitats, including the unique undisturbed riverine cypress swamp bordering the upper reaches of the NWFLR. Other regionally significant habitat types are present including forested, depressional, and strand wetlands, and mesic and hydric pine flatwoods.

Several organizations are working together to conserve ecological corridors throughout Florida, which include lands in the LRWRP study area. This point could fit under either the Institutional and/or Public Significance justifications because the work involves agencies and the public and several land management plans. However it is listed here because of the technical purpose of the corridor plans: they benefit far-ranging species such as Florida black bears and federally endangered Florida panthers by providing them greater ranges, thereby reducing habitat fragmentation, diminishing intra-specific territorial competition, and providing spatial flexibility for species to adjust to climate change and sea level rise. Examples:

> The Florida Wildlife Corridor - http://floridawildlifecorridor.org/maps/
>
> Florida Greenways and Trails System Plan (FGTS Plan) - https://www.dep.state.fl.us/gwt/FGTS_Plan/2016,7_FGTS_UPDATE.htm

Three major ecological drivers in the study area are the hydrologic regime (sheetflow, flow paths, and hydroperiods), maintaining low-nutrient conditions (referred to as oligotrophic conditions) of water

entering the NWFLR, and delivering seasonally appropriate discharge volume to the NWRLR. These are impacted by the C&SF system, roads, and other canals/levees. These ecological drivers are recognized in the problem and objectives statements for LRWRP.

6.2.3 Progress toward Interim Goals and Interim Targets

Section 601(h)(3)(C)(III) of WRDA 2000 (P.L. 106-541) requires that CERP promulgate Programmatic Regulations which would include the "establishment of interim goals to provide a means by which the restoration success of the Plan may be evaluated throughout the implementation process." Section 385.38 of the Programmatic Regulations (33 CFR Part 385) describes the intent and the underlying principles for establishing interim goals and a process for their development. Recommendations for interim goals and interim targets were developed by RECOVER in 2005. An intergovernmental agreement signed in 2007 among the USACE, DOI and SFWMD established interim goals for CERP. Section 385.39 also established the requirement to develop interim targets to measure progress toward meeting other water-related needs of the south Florida region, and described the intent, underlying principles, and the process for establishing interim targets. An agreement signed in 2007 between the USACE and SFWMD established interim targets.

The Programmatic Regulations also required that each PIR describe how the project contributes to the achievement of interim goals and interim targets (s. 385.26(a)(3)(xv)). Quantitative and qualitative predictions based on results from the RECOVER approved performance measures, information gained from additional ecological planning tools and best professional judgment was used to evaluate the progress towards the interim goals.

6.2.3.1 Progress toward Interim Goals

Each of the performance measures for the LRWRP planning effort were developed specifically for analysis of the LRWRP and reviewed by RECOVER. Detailed information about the performance measures and the methodology that was used to quantify ecosystem benefits and support plan evaluation and selection of the Recommended Plan can be found in **Appendix G**. The LRWRP Planning Model underwent peer review per Engineering Circular (EC) 1105-2-412, 31 May 2011 (Assuring Quality of Planning Models) and was recommended for single-use by the National Ecosystem Restoration Planning Center of Expertise (ECO-PCX) on July 27, 2016. The USACE HQ Model Certification Panel approved the LRWRP Planning Model on August 16, 2016. Outputs from the regional hydrologic model used in plan formulation, the Lower East Coast Sub-Regional – North Palm (LECSR-NP) were also used to evaluate and help quantify LRWRP's progress towards meeting interim goals relevant to LRWRP objectives. The LECSR-NP was approved for use through the current USACE Engineering software validation process.

Table 6-1 is a summary is a summary of the LRWRP's effects on the interim goal indicators. Most analyses compare the Recommended Plan to the Future Without Project condition (FWO). When ac-ft are cited, this refers to an analysis of an average annual water budget over the 41-year period of hydrologic model simulation (1965-2005).

Table 6-1. LRWRP progress towards meeting interim goals.

Northern Estuaries Indicators
1.1 Eastern (American) Oysters: Increase areal coverage of American oysters in the Caloosahatchee, St. Lucie and Loxahatchee Estuaries, and the Lake Worth Lagoon. In the NWFLR, more acres suitable to the salinity range of oysters (mesohaline conditions with 10 to 20 psu) were estimated under LRWRP Recommended Plan relative to the FWO and Existing Conditions Baseline (ECB) regardless of season (wet and dry). Increased flow and availability of freshwater improves conditions for oysters in the dry season. On average, taking into account both wet and dry seasons, the Recommended Plan provides an additional 10 acres of suitable saline habitat compared to the ECB and an additional 12 acres compared to the FWO. LRWRP increases the amount of acres within mesohaline conditions suitable for oyster survival and recruitment relative to both the ECB and FWO.
1.2 Submerged Aquatic Vegetation (SAV): Increase the areal coverage and improve the functionality of submerged aquatic vegetation in the northern estuaries. In the NWFLR, two valued ecosystem components (VECs) focus on the restoration of salinity conditions related to SAV, tapegrass in the oligohaline zone and seagrasses in the polyhaline zone. The Recommended Plan slightly increases the amount of acres suitable (salinity less than 5 psu) for tapegrass compared to the ECB and FWO (73 acres versus 72 acres). The Recommended Plan slightly decreases the acreage suitable for seagrasses within the polyhaline zone (salinity greater than 20 psu) compared to the ECB and FWO (672 acres [Recommended Plan] versus 675 acres [ECB] and 673 acres [FWO]). The reduction in acres suitable for seagrasses is expected given the increase of freshwater flow to the NWFLR. The slight decrease in suitable saline acreage for seagrasses is not significant. Overall, the acreage within ideal salinity conditions for SAV is equal (+1 for *Vallisneria* and -1 for seagrasses) resulting in no net loss of SAV within the Loxahatchee River and Estuary.
Greater Everglades Indicators
3.4 System-Wide Spatial Extent of Natural Habitat: Increase spatial extent of natural habitat. 17,000-acre increase in Corbett – Pal-Mar indicator region. Areas are restored from agricultural land use to natural wetland extent with restored hydrologic function.
3.11 System-Wide Wading Bird Nesting Pattern: Increase the total number of nesting pairs in the Everglades; increase the percentage of wading birds nesting in estuarine locations; increase the frequency of super colony events; establish conditions that encourage wood stork nest initiation earlier in the winter. Despite the inability to fully restore the historical hydrological connection between the Loxahatchee Watershed Everglades, LRWRP can still improve connectivity to the Everglades by increasing the extent and quality of wetlands within the Loxahatchee Watershed. Improved hydrological conditions and quality of foraging area within the LRWRP footprint can provide nearby wading birds, including wood storks, with additional and/or more productive food resources needed to initiate and sustain reproduction. Wood storks will forage up to 50 km, while small herons forage up to 30 km, making much of the LRWRP project area available for foraging. The diversity of habitats and prey expected from the implementation of LRWRP may provide foraging habitats in addition to the Water Conservation Areas (WCAs) within the Greater Everglades Region.
3.12 Snail Kite: Increase the areal extent of suitable foraging habitat for snail kites. The Everglade snail kite has, historically, nested and foraged within the LRWRP footprint. The snail kite is a specialist in that they essentially forage exclusively on apple snails. LRWRP will increase suitable habitat for apple snails providing higher sustainability of apple snail populations. In turn, healthier apple snail populations will provide necessary resources to maintain, and potentially, increase snail kite populations and reproduction.
System-wide Water Volume
5.1 Quantity of Freshwater Lost to Tide: Reduce the quantity of freshwater lost to tide. Goals for LRWRP involve the restoration of flows to the NWFLR and Loxahatchee River Estuary by improving connectivity and distribution of water throughout the Loxahatchee Watershed[1]. Thus, the majority of freshwater making it to tide is not only beneficial, but necessary to the restoration of salinity regimes within the river and estuary to support the restoration of ecologically important floral and faunal species. The average annual water budget for Recommended Plan shows a deficit of 440 ac-ft throughout the watershed which is considerably small and is effectively the same as the FWO. More importantly, during the dry season, when water is more infrequent, Recommended Plan stores and retains an average of 6,950 ac-ft of additional water within the watershed compared to the FWO.

Note: [1]Water is re-distributed from the Southwest Fork via S-46 to the Northwest Fork via G-92 and Lainhart Dam.

6.2.3.2 Progress towards Interim Targets

Each of the performance measures for the LRWRP planning effort was developed specifically for analysis of the LRWRP, reviewed by RECOVER, and applied for interim targets. Output from the regional hydrologic model used in plan formulation (LECSR-NP) was also used to evaluate and help quantify LRWRP's progress towards meeting interim targets. **Table 6-2** is a summary of the LRWRP's effects on interim target indicators. Most analyses compare Recommended Plan to the FWO. The interim targets analyzed in this section are based upon the objectives of LRWRP

Table 6-2. LRWRP progress towards meeting interim targets.

Indicators	Interim Target	Summary of Project Effects
1. Water Volume	Distribute water across the ecosystem in a manner that reflects natural conditions while providing for other water-related needs of the region.	In general, increased water supplies, increased watershed connectivity, and improved spatial distribution to the natural systems enables increased water for other water related needs within and adjacent to the LRWRP project footprint.
2. Water Supply to the Lower East Coast Service Area (LECSA)	Increase water supplies available for meeting existing and future water supply needs including the water supply rights of the Seminole Tribe of Florida, State of Florida, and the SFWMD.	Increased storage within the LRWRP footprint during the dry season does not reduce existing level of service for water supply.

6.2.4 Ecosystem Services

Ecosystem services can be defined as the benefits human beings receive from resources and processes supplied by ecosystems (Murray et al. 2013). Some ecosystem services are material resources that can be used by people, such as food, timber, water, and medicine. Other ecosystem services come from ecological processes, such as carbon sequestration that results from the formation of peat soils. Describing ecosystem services helps capture a fundamental value of ecosystems: that they support human life on earth.

LRWRP will improve the ecological condition of multiple natural areas in the Loxahatchee River watershed and downstream Loxahatchee River and estuary, boosting numerous ecosystem services. The services expected to improve include aesthetics and wildlife-associated activities such as educational opportunities; wildlife photography, tours, viewing, and nature appreciation, which can facilitate mental well-being; ecological connectivity of landscapes; biodiversity and species composition; commercial and recreational fishing; some kinds of hunting and frogging; recreation in the forms of biking, hiking, and non-motorized boating; water quality nutrient and sediment assimilation; atmospheric carbon sequestration; and water supply to existing legal uses in LECSA.

6.3 Environmental Considerations

This section provides a discussion of the NEPA analysis of cumulative impacts, incomplete or unavailable information, unavoidable adverse environmental effects, and irreversible and irretrievable commitments resulting from the proposed project.

6.3.1 Cumulative Impacts

Cumulative environmental effects for the proposed action were assessed in accordance with guidance provided by the President's Council on Environmental Quality (CEQ). The primary goal of cumulative effects analysis is to determine the magnitude and significance of the environmental consequences of the proposed action in the context of the cumulative effects of other past, present, and future actions. **Table 6-3** shows the net cumulative effects of the various resources which are directly or indirectly impacted. LRWRP is expected to contribute to a net beneficial cumulative impact on the regional ecosystem. Further information on cumulative effects can be found in **Appendix C.2.2.2.**

Table 6-3. Summary of Cumulative Effects

Hydrology	
Past Actions	Flood and water control projects have greatly altered the natural hydrology and increased salinities in the Loxahatchee River.
Present Actions	Federal and State agencies are coordinating on and implementing projects to improve hydrology.
Proposed Action	Reductions in high discharge events from NWFLR and number of low flow days will improve salinity. Significant beneficial hydrologic effects are anticipated within the Loxahatchee River watershed through restoration of sheetflow and rehydration of previously drained areas. Improved hydrologic conditions will result from increasing depths and extending hydroperiods in Pal-Mar, J. W. Corbett WMA, Cypress Creek Natural Area, and Loxahatchee Slough.
Future Actions	Other restoration projects are proposed in the watershed by other entities to restore hydrology to more natural conditions.
Cumulative Effect	Hydrology to selected parcels and NWFLR would be improved, historic hydrologic conditions would not be fully restored to pre-drainage conditions. LRWRP is expected to improve the quantity, quality, timing and distribution of NWFLR freshwater flow.
Threatened and Endangered Species	
Past Actions	Water management practices and urbanization have resulted in the degradation of existing habitat function and direct habitat loss leading to negative population trends of threatened and endangered species.
Present Actions	Ongoing efforts have been made by federal and state agencies to implement projects to improve hydrology within the project area. Ongoing projects in the western watershed have been implemented to manage red-cockaded woodpecker populations. The USFWS Multi-species Recovery Plan is used as a management tool.
Proposed Action	The proposed project would not affect Everglade snail kite critical habitat, Florida manatee critical habitat, or the Okeechobee gourd. USACE determined that the project may affect but is not likely to adversely affect Everglade snail kite, wood stork, Audubon's crested caracara, eastern indigo snake, Florida panther, West Indian manatee, or Florida bonneted bat (See **Annex A**). The project would have no effect

	on National Marine Fisheries Service regulated species including green sea turtle, leatherback sea turtle, Hawksbill sea turtle, loggerhead sea turtle, Kemp's ridley sea turtle, smalltooth sawfish, and small tooth sawfish critical habitat, or Endangered Species Act (ESA)-listed corals.
Future Actions	Ongoing projects would be implemented to maintain threatened and endangered species within the project area. Everglades Restoration Transition Plan (ERTP) implementation represents a paradigm shift from single species to multi-species management. ERTP includes performance measures specifically directed at managing water levels and releases for the protection of multiple species and their habitats within the project area.
Cumulative Effect	Habitat improvement, monitoring and management of threatened and endangered species are anticipated to allow populations to be maintained. Improvement of degraded populations is expected to be facilitated by the restoration and enhancement of suitable habitat through efforts to restore more natural hydrologic conditions within the project area.
Fish and Wildlife Resources	
Past Actions	Water management practices have resulted in aquatic vegetation community changes and a resultant disruption of aquatic productivity and function that has had repercussions through the food web, including effects on wading birds, large predatory fishes, reptiles and mammals.
Present Actions	Ongoing efforts have been made by federal and state agencies to implement projects to improve hydrology within the project area to restore habitat conditions for fish and wildlife resources.
Proposed Action	Reductions in the number of high discharge events to the Loxahatchee River estuary are anticipated to improve suitable habitat for key indicator species such as oysters. Significant beneficial effects are anticipated within the Loxahatchee watershed. Improved hydrology within previously drained areas of the watershed would increase the spatial extent of suitable habitat for many fish and wildlife resources. Increases in forage prey availability (crayfish, other invertebrates, and fish) would directly benefit amphibian, reptile, small mammal, and wading bird species. Nesting and foraging activities of resident bird species are anticipated to be significantly improved. Increased freshwater flows to Loxahatchee estuary would aid in improving suitable habitat for manatees, shellfish and crustaceans, fish, and sea turtles, among other species.
Future Actions	Some level of improvement to fish and wildlife resources is expected to occur as a result of implementation of projects with the capability of improving the timing, quantity, quality and distribution of freshwater flow to the study area.
Cumulative Effect	Habitat improvement efforts are anticipated to benefit fish and wildlife resources.
Vegetation and Wetlands	
Past Actions	Drainage of Florida's interior wetlands, conversion of wetlands to agriculture, and urban development has reduced the spatial extent and quality of wetland resources.
Present Actions	Federal, state, and local regulatory agencies are undertaking programs to reduce wetland losses.
Proposed Action	Reductions in the number of high discharge events and increased dry season flows to the Loxahatchee estuary are anticipated to improve conditions for aquatic vegetation and seagrass communities. Significant beneficial effects are anticipated

	within the Loxahatchee River watershed via improved hydroperiods and sheetflow that would result in reducing soil oxidation.
Future Actions	Some level of improvement to vegetative communities is expected to occur as a result of implementation of projects with the capability of improving the timing, quantity, quality and distribution of freshwater flow to the study area. More natural hydrology as part of the CERP would assist in restoring natural plant communities.
Cumulative Effect	While the spatial extent of natural plant communities would not be restored to historic extent and proportions, the quality and quantity of vegetative communities would be improved.
Cultural Resources	
Past Actions	Environmental restoration projects, flood and water control projects, agriculture, and urban sprawl have had adverse unmitigated effects to cultural resources, either directly or indirectly.
Present Actions	Ongoing efforts have been made by federal and state agencies to improve hydrology and connectivity in the Martin and Palm Beach Counties, and continue to have potential adverse effects to cultural resources.
Proposed Action	While effects of the proposed action have been evaluated, a final determination of effects on cultural resources is not complete. Each suite of features will be subject to separate consultation and consideration of effects during PED as the Area of Potential Effect (APE) may be subject to change based on final designs or modifications of project features. Consultation with stakeholders, including the Florida State Historic Preservation Office (SHPO), Advisor Council on Historic Preservation (ACHP), Seminole Tribe of Florida and Miccosukee Tribe of Indians of Florida is currently ongoing. USACE has coordinated a Programmatic Agreement with Florida SHPO and the ACHP to conduct a phased identification and evaluation of historic properties during the project's design phase. Dependent on further consultation with the Florida SHPO and the results of Phase I cultural resources investigation, project design modification may be necessary to avoid or minimize impact to historic properties. Phase II National Register of Historic Places (NRHP) eligibility testing or mitigation may be required if impacts cannot be avoided.
Future Actions	Continued improvements and management of hydroperiods for restoration projects could stabilize the environment and prevent impacts to cultural resources. Transferring significant cultural sites within the project area from private ownership into public ownership may assist in protecting sites from impacts from agriculture and looting and other anthropogenic activities.
Cumulative Effect	Cumulative effects to historic properties and culturally significant sites will potentially have long-term adverse effects if not avoided. Mitigation measures for effects to historic properties could potentially reduce the cumulative effect to minor long-term adverse effects. Mitigation measures for culturally significant sites are unknown.
Water Quality	
Past Actions	Water quality has been degraded from urban, suburban, commercial, industrial, recreational and agricultural development.
Present Actions	Federal and state projects would temporarily elevate localized levels of suspended solids and turbidity.

Proposed Action	Implementation of the project is not expected to significantly affect the water quality of the Loxahatchee River watershed. Total Nitrogen (TN) and Total Phosphorus (TP) concentration, and TP load are lowered to the river. TN load is likely to remain unchanged even with greater volumes of water.
Future Actions	Future state and local projects to manage Total Maximum Daily Load (TMDL) and Reasonable Assurance Plan projects would decrease nutrient concentration and loadings to the project area.
Cumulative Effect	Water quality is expected to slowly improve over existing and recent past conditions due to future state and local water quality management programs. The USACE and SFWMD are committed to ensuring that project feature implementation will comply with water quality standards.
Water Supply/Flood Control	
Past Actions	Water supply and flood control for agricultural and urban users has benefited from construction and operation of the C&SF Project.
Present Actions	The SFWMD has implemented Restricted Allocation Area Rules to cap users dependent on water supplies from Lake Okeechobee and the North Palm Beach County/Loxahatchee River watershed water bodies. The C&SF Project is operated together with local drainage districts to provide local flood control.
Proposed Action	Implementation of the project would likely have no effect on water supplies to agricultural and municipal users dependent on Lake Okeechobee. Agricultural, municipal, and industrial water supply in the Northern Palm Beach County service area and LECSA 1 and Martin County will not be affected by project implementation in the future. The proposed action will not reduce local flood control.
Future Actions	Future water supply would not change in the future unless additional CERP storage or hydrologic improvements are implemented to increase water availability. The proposed action will not affect future local flood control.
Cumulative Effect	Water supply available for agricultural and urban users is expected to remain stable unless additional storage mechanisms are implemented. Local flood control is not expected to be affected.

6.3.2 Incomplete or Unavailable Information

The analyses provided in this document are based upon current knowledge of the physical and biological conditions in the action area and on projections of the most probable future conditions, as indicated by hydrologic models. The PDT recognizes that there is uncertainty in the predictions derived from these models that stems from input variability and measurement errors, parameter uncertainty, model structure uncertainty and algorithmic (numerical) uncertainty as outlined in the CERP Model Uncertainty Workshop Report (RECOVER 2002). These uncertainties are also translated into uncertainty as to whether the specific performance indicators and measures used to characterize the overall system performance actually capture that overall performance. The likelihood of capturing all the processes occurring in a system as complex as the Everglades within simulation models is low. Even with a comprehensive model uncertainty analysis for LRWRP, there will always be some uncertainty present in predicting environmental benefits associated with any CERP project because of the size and complexity of the Everglades ecosystem as well as the difficulty in fully understanding its physical and biological processes. However, the outputs of the sub-regional hydrologic models used to assess projected hydrologic changes and to quantify ecosystem benefits for CERP were the best data available to predict the most likely

hydrologic changes as a result of the project. Even though uncertainty is recognized, ecological benefits derived from performance measure metrics are useful in making planning level decisions. These values provide a quantitative means for comparing alternatives to identify the best performing alternative.

It is recognized that new technical information or models may be developed as the selected plan is implemented and that the observed results may differ from predicted results. Considering this, it may be necessary to adjust operations to address the new information or observed results to achieve better performance for environmental restoration and protection to ensure the health, safety, and well-being of the general public and affected individuals. Using an AM approach during implementation of CERP, as documented in **Annex D**, would provide new information to address uncertainties and risks over time, decrease the potential for costly mistakes, and ultimately support fulfillment of the CERP restoration goals and objectives.

6.3.3 Unavoidable Adverse Environmental Effects

As discussed under each resource in **Section 5.2**, adverse effects associated with implementing the Recommended Plan is expected to be negligible to moderate. Unavoidable potentially adverse impacts that would result from implementation of the Recommended Plan include effects to the loss of arable agricultural acreage due to the construction of the C-18W reservoir, and temporary, short term impacts to air quality, the noise environment, and aesthetic resources from operation of construction equipment through lands designated for staging, access and construction. Temporary disturbances to and displacement of fish and wildlife resources to other nearby habitats would occur during construction. Alligators that use various canals proposed for backfilling could be temporarily affected until they are able to move into other areas of suitable habitat created as a result of LRWRP implementation. Native vegetation that currently exists on canal banks and spoil mounds would be removed during construction where these features would be degraded and/or in areas where new project features would be constructed. The reader is referred to section 6.7.6 for commitments being made to avoid/minimize impacts.

Many non-native invasive plant and animal species are flourishing in a variety of habitats and are negatively affecting the ecology throughout the Loxahatchee River watershed and estuary. Non-native invasive plant infestations in the project area may be exacerbated by soil disturbance during construction and hydrological modification and may require management. Various reptile and non-native fish species occur in the area and their distributions or populations could change in response to habitat changes or changes in connectivity within the project area, however, the extent of the impact is uncertain and unpredictable.

Publicly-owned lands are being used for the Recommended Plan. Portions of the project footprint are currently leased for purposes of agricultural production, including grazing and row crops. The Corps requested a determination from the Natural Resources Conservation Service (NRCS) regarding potential adverse impacts on prime and unique farmland, and obtained a determination from NRCS that the C-18W Reservoir would be the only project feature that would decrease acreage of prime and unique farmland. Loss of low functioning wetland acreage would occur with implementation of the Recommended Plan as a result of the construction of the C-18W Reservoir and canal backfilling. The loss of approximately 155 acres (91.5 acres in one above-ground impoundment, 13.5 acres of drainage ditches, and 50 acres of borrow pits) would occur within the highly impacted former agricultural Mecca site and is considered a net loss of 0 habitat units using the Wetland Rapid Assessment Procedure (WRAP). Ultimately, this minor loss would be greatly offset by improved conditions to wetland acreage within other project areas. **Section**

5.14.1 evaluates increases in wetland acreage directly associated with implementation of the Recommended Plan. The Recommended Plan provides a net gain of wetland acreage of over 16,000 acres.

The Recommended Plan will potentially have adverse effects to cultural resources, some of which are unavoidable and long term, and/or cannot be assessed until the detailed design phase of the project. Avoidance of adverse effects to cultural resources is the Corps' preference, therefore, throughout the planning process for LRWRP, the project archaeologist, engineers, and plan formulators have worked closely to determine alternatives and features of alternatives that reduce or eliminate impacts to cultural resources. Pursuant to 36 CFR 800.1, where possible, the project design will be modified to avoid impacting significant historic properties and culturally significant sites. Where avoidance is not possible, other mitigation measures will be considered. As consulted on throughout LRWRP, mitigation measures will be developed during the PED phase in consultation with the SHPO, tribal groups and other interested parties as established in implementing regulations for Section 106 of the National Historic Preservation Act (NHPA) (see **Appendix C.5**).

The LRWRP study area encompasses approximately 480,000 acres (750 square miles) and includes all of the Loxahatchee River watershed and limited portions of the St. Lucie River watershed within Martin and Palm Beach Counties. The Florida Master Site File (FMSF) data from the Florida Division of Historical Resources lists 38 nationally registered sites, 114 archaeological sites, 18 historical resources groups, 7 cemeteries, 13 bridges, and 6,751 standing structures, within the LRWRP study area. Most of the 38 NRHP listed sites are found in the central to western side of the project area, many of which are prehistoric campsites and middens. There are multiple sites concentrated on the west side of the Loxahatchee River and along Loxahatchee Slough.

Prior to designing and implementing cultural resources field investigations for the LRWRP study, consultation with the Miccosukee Tribe of Indians of Florida and the Seminole Tribe of Florida Tribal Historic Preservation Office (STOF-THPO) was coordinated and each of the alternatives were evaluated for their potential to effect existing cultural resources by areas of potential impact including construction, impoundment, and restoration (Appendix C.2, Table C.2-36). Additionally, gaps in the information currently available for evaluating impacts to cultural resources (related to either survey age, limited scope and geographic coverage, or the absence of cultural resources surveys), is also discussed in detail in the discussion of components either shared or particular to each of the alternatives (2, 5R, 10, and 13) in Appendix C.2, sections C.2.22.5 – C.2.22.15).

Briefly summarized, eleven components were evaluated regarding their effect on cultural resources, or whether or not additional cultural resources surveys would be required during PED to make such determination. These project components include: Kitching Creek in JDSP; Moonshine Creek (MC) and Gulfstream East (GE); Cypress Creek Canal; Gulfstream West; Palmar East; Natural Storage C-18W Basin; L-8 Basin Shallow Storage; C-51 Deep Reservoir Storage; G-160 and 161 Structures; GWP Triangle; and M-1 Pump Station. All of these components were assessed to not be adversely effected by inundation because any hydration associated with these components will not exceed historic pre-drainage patterns or velocities.

For the current study, no cultural resources investigations were conducted in the MC and GE restoration area, the Cypress Creek Canal, Gulfstream West, C-51 Deep Reservoir Storage, and the M-1 Pump Station. During consultation and discussions of survey methodologies and approaches, the STOF-THPO, Miccosukee tribal representative, and USACE acknowledged that further investigations of these areas

would be required during PED because of the age, limited nature, and geographic coverage of previous cultural resources reconnaissance investigations.

In support of the present study, cultural resources surveys were conducted for Kitching Creek, Cypress Creek Canal, Palmar East, Natural Storage C-18W Basin, L-8 Basin Shallow Storage, and GWP. These included reconnaissance-level cultural resources assessment surveys and intensive-level investigations. Aside from archaeological monitoring requirements and/or avoidance measures at 8MT1284 in Kitching Creek and 8MT01453 in Palmar East, the Corps determined that ground-disturbing activities or inundation occurring within these surveyed parcels will pose no effect on cultural resources eligible for inclusion in the NRHP.

During this study, 5,042.62 acres of the Recommended Plan were surveyed for cultural resources. Based on final designs or modifications of the project features, additional work may be required for compliance with the NHPA. While the USACE is currently in compliance with the procedural requirements of the NHPA, the USACE recognizes that additional cultural resource surveys, NRHP evaluations, and determination of effects made in consultation with the SHPO, appropriate federally-recognized tribes, and other interested parties will be required in PED. Consultation is currently ongoing with regards to the determination of effects and potential mitigation of effects, and therefore should be considered preliminary. The effects associated with each Alternative have been preliminarily considered for this study. A final identification, evaluation of historic properties, and determination of effects, as required under Section 106 of the NHPA, will not be made until the project is authorized and project features are sited during the subsequent PED phase.

In summary, USACE is has coordinated a Programmatic Agreement with the Florida State Historic Preservation Office (SHPO) and the Advisory Council on Historic Preservation to conduct a phased identification and evaluation of historic properties during the project's design phase. Avoidance of adverse effects to cultural resources is preferred, and therefore, the Project Team will consider ways to reduce or eliminate impacts to cultural resources. Pursuant to Section 106 of the National Historic Preservation Act (54 U.S.C. 306108) and its implementing regulations (36 CFR 800), where possible, the project design will be modified to avoid affecting significant historic properties and culturally significant sites. Where avoidance is not possible, minimization and/or mitigation measures will be considered. Future mitigation measures will be developed during the preconstruction engineering and design phase in consultation with the SHPO, tribal groups, and other interested parties as established in implementing regulations for Section 106 of the National Historic Preservation Act.

With regards to sites containing human remains, the Corps is currently in consultation with the Seminole Tribe of Florida and the Miccosukee Tribe of Indians of Florida to draft a new policy guidance memorandum to update and expand the 2008 CERP Policy on Human Remains that currently applies to the LRWRP study area, to apply to all Civil Works and Regulatory actions within the respective jurisdiction of these Jacksonville District programs in the State of Florida. This document is an internal guidance memorandum designed to consolidate and clarify existing Corps documents regarding the treatment of human remains pursuant to Section 106 of the NHPA and the Jacksonville District's Federal Trust Responsibilities for the State of Florida (see **Appendix C.5** (2008 CERP Policy)).

6.3.4 Irreversible and Irretrievable Commitment of Resources

An irreversible commitment of resources is one in which the ability to use and/or enjoy the resource is lost forever. An irretrievable commitment of resources is one in which, due to decisions to manage the

resource for another purpose, opportunities to use or enjoy the resource as they presently exist are lost for a period of time. Construction of the proposed project will include many features considered permanent, as well as modifications to existing C&SF Project features, which may be deemed irreversible. This would include project features in the watershed that would change the distribution and conveyance (location, direction, depth, volume, and/or timing) of the available water. The proposed project would also include features necessary to control increased seepage along the boundary of the C-18W Reservoir. Such construction and structural modifications are proposed on such a large scale that these features represent an irreversible and irretrievable commitment of resources. Resources to be committed if the project is approved include expenditures of state and federal funding, labor, energy and project materials to build, operate and maintain the proposed project.

6.3.5 Environmental Operating Principles

The proposed project is consistent with the USACE Environmental Operating Principles (EOP), particularly with respect to the south Florida ecosystem-wide approach for plan formulation, evaluation, and selection, and a holistic consideration of water resources needs and solutions to water resources problems in the study area. The re-energized USACE 2012 Environmental Operating Principles (EOPs) are addressed for this project as follows:

1. Each element of human health, welfare, and viability of natural systems was thoroughly assessed throughout this report using established plan formulation processes and best professional judgment;
2. Impacts to the environment were thoroughly assessed in this report and any impacts have been thoroughly evaluated and minimized to the extent practicable;
3. The USACE developed an Adaptive Management (AM) and Monitoring Plan for LRWRP to identify the monitoring information needed to inform implementation and to ensure the proposed project is achieving the intended purposes within its constraints;
4. The USACE collected a great deal of information throughout the preparation of this study which has been thoughtfully prepared and organized in a manner so as to facilitate a greater knowledge base about the area, its challenges, and the opportunities that can be achieved;
5. The USACE worked with many agencies, individuals, and groups throughout this study, sharing scientific information and exchanging ideas for the betterment of a design that will find solutions to the problem while maintaining the level of quality within the surrounding environment.

6.4 Cost Estimates

Table 6-4 shows the estimated first costs and **Table 6-5** shows the total investment costs and average annual cost estimates for the Recommended Plan. The rest of this section provides additional detail for the values in these two cost summary tables.

Table 6-4. Total First Cost.

Cost Phase Elements	Cost Estimate
02 Relocations	$2,021,000
03 Reservoirs	$70,187,000
08 Roads, Railroads & Bridges	$8,444,000
09 Channels & Canals	$57,158,000
11 Levees & Floodwalls	$29,277,000

13 Pumping Plant	$80,438,000
14 Recreation Facilities	$3,898,000
15 Floodway Control & Diversion Structures	$82,888,000
19 Buildings, Grounds & Utilities	$11,890,000
Sub-Total for Construction Phase Elements	**$346,201,000**
Lands and Damages	$303,848,000
Preconstruction, Engineering, & Design	$55,755,000
Construction Management	$34,956,000
Total First Cost Estimate	**$740,760,000**

*October 2019 price levels.
*Feasibility level costs include 33% contingency based on a formal cost and schedule risk analysis.
*First cost is higher than the estimate in Section 4 because this estimate includes additional engineering design, additional real estate, and adaptive management options.

Table 6-5. Investment Costs and Average Annual Costs.

Total Cost Estimates	Cost Estimate
Total First Cost	**$740,760,000**
Interest During Construction – Construction	$101,035,000
Interest During Construction – Lands	$130,179,000
Total Interest During Construction	**$231,214,000**
Total Investment Cost	**$971,974,000**
Annualized Total Project Investment	**$36,003,000**
OMRR&R of New Project Features	$3,863,000
OMRR&R Invasive Species	$536,000
OMRR&R Management Sub-Total (Cost Estimate per Year)	**$4,399,000**
Water Quality Monitoring	$400,000
Hydro-meteorological Monitoring	$200,000
Ecological – Biological Opinion Monitoring	$0
Ecological –Ecological Success Monitoring (up to 10 years, average annual)	$240,000
Adaptive Management Monitoring (up to 10 years, included with Ecological Success)	$0
Invasive Species Monitoring	$49,000
OMRR&R Monitoring Sub-Total (Cost Estimate per Year)	**$889,000**
Total Average Annual Cost	**$41,292,000**

*October 2019 price levels.
*Annual costs are based on a 50-year period of analysis and 2.75%. Costs include 33% contingency.
* Endangered Species Act coordination is based on Final Biological Opinion.

6.4.1 Construction

The cost estimates in **Table 6-4** for features to be constructed are based on the same information used to develop the construction cost estimates for Alts 2, 5, 10, and 13, for comparison of alternatives in Section

4 of this PIR. The cost estimates for cultural resources preservation and adaptive management options are new estimates that were not available during the comparison of alternatives.

Cultural resources preservation actions and cost estimates are expanded in **Section 6.4.5** below. Adaptive management options are the modifications to the project that might be implemented if monitoring of ecosystem restoration benefits indicates that the project is not performing as well as expected. Details of the adaptive management options are briefly discussed in **Section 6.1.4** and thoroughly described in Annex D.

6.4.2 Real Estate

6.4.2.1 Non-Federally Owned Lands

The SFWMD owns much of the lands required for the project in fee. Property was acquired using either SFWMD or State of Florida funds, no federal funds. The total real estate required for the project includes 27,999 acres for hydroperiod improvement and approximately 1,650 acres for construction of a reservoir (C-18W Reservoir), associated infrastructure, and other miscellaneous pump stations and structures. The non-federal sponsor has acquired the majority of the lands required for the project, either in fee, or with conservation easements as shown in **Table 6-6**.

Table 6-6. Real Estate Requirements for Project Features.

Flow-way	Feature	Feature Type	Required Estate	Estimated Acreage	Current Sponsor Estate
1	G-160	Structure	Fee	2.5	Canal Easement
1	G-161	Structure	Fee	3.0	Fee
1	Grassy Waters Preserve Triangle	Earthwork	Fee	397	Unacquired
1	M-1 Lower Pump Station	Pump Station	Fee	2.0	Unacquired
1	Loxahatchee Slough	Operational changes, hydroperiod improvement	Fee or Conservation Easement	7,245	Acquired Palm Beach County, Fee, SFWMD Conservation Easement on ~ 12,000 acres which provides a buffer of ~ 2,500 yards east and west of the central restoration area
2	C-18W Reservoir	Impoundment	Fee	~1,850	Fee
2	Aquifer Storage & Recovery (ASR)	Wells	Fee	Within C-18W footprint	Fee
2	M-O Canal Connector	Pump, Canal	Fee	~100	Perpetual Easements
2	J. W. Corbett WMA	Operational modification	Fee	1,642	Unacquired

Flow-way	Feature	Feature Type	Required Estate	Estimated Acreage	Current Sponsor Estate
3	Palmar East	Earthwork, wetland restoration	Fee	12,119	Various, mostly acquired, some existing easements to be acquired, some private parcels to be determined during PED
3	Thomas Pepper Farm	Drainage modifications	Fee	TBD	Unacquired
3	Pal-Mar East (Nine Gems) northern canal	Drainage modifications, berm improvements	Fee	~60	Unacquired
3	Cypress Creek Canal	Structure, canal improvements	Fee for structure, Temporary easement for canal improvements	TBD	Fee acquired
3	Cypress Creek Restoration	Mack Dairy Spreader, hydroperiod improvement	Fee, Perpetual Conservation Easement	3,693	Fee and conservation easement acquired
3	Gulfstream West Flow through Marsh	Impoundment	Fee	750	Fee acquired, existing easement encumbrance to transfer
3	Gulfstream East, Moonshine Creek	Earthwork, weir	Fee, easement for weir	650	Fee Acquired, easement needed
3	Kitching Creek	Earthwork, weir	Fee	1243	TIITF (JDSP)
3	River Floodplain	Increased flows to provide floodplain hydration and increase riverine connectivity	Perpetual Easement	~460	Fee

6.4.2.2 Relocations, Alterations, Vacations, and Abandonments

Only two relocations are expected for this project.

The Thomas Pepper farm is located to the west of the Pal-Mar East Property and Pratt Whitney Road (SR-711). Currently, the farm drains to the south through a culvert under the road, and then through a canal that bisects the Pal-Mar East property. This canal is owned and operated by the Hobe St. Lucie Conservancy District (HSLCD). It continues east and south to eventually discharge into the Cypress Creek Canal and ultimately to the NWFLR via Cypress Creek. The canal through which the Thomas Pepper farms currently drains causes a disruption in sheet flow from the southern portion of Pal-Mar East flowing in a northerly direction. Due to the topography, the northwest corner of southern portion of Pal-Mar East (south of this canal and to the east of Pratt Whitney Road (SR 711) may have periods of over-inundation due to the small berm that separates the natural area of Pal-Mar East from the Thomas Pepper drainage canal. The proposed design is to backfill that portion of the existing HSLCD canal that provides drainage

to Thomas Pepper farms and then smooth the existing berms to promote sheet flow from southern Pal-Mar East to the north/eastern portions of the property. The new drainage pattern would divert water from the Thomas Pepper Farm to another existing HSLCD canal located along the northern border of Pal-Mar East, between Pal-Mar East and the HSLCD agricultural land. This will require modification of a drainage ditch that currently exists along the northern boundary of Pal-Mar. The existing ditch shall be widened and deepened to handle the additional outflow from Thomas Pepper Farms. Additionally, a new culvert and pump will be required to re-route the Farm's drainage under Pratt Whitney road and into the newly constructed drainage canal. Because the HSLCD is a water control district codified by House Bill No. 1433 of Ch. 2005-339, in accordance with section 298.001, Florida Statutes, acquisition of the drainage ditches owned by the HSLCD and improvement of the other drainage ditches owned by the HSLCD will be a utility/facility relocation. A Preliminary Attorney's Opinion of Compensability is not required under Chapter 12 of ER 404-1-12 or Real Estate Policy Letter 31, dated January 11, 2019.

Palm Beach County Pump Station Replacement-There is an existing pump station owned by Palm Beach County, which serves the Palm Beach County Water Treatment Plant located adjacent to the southeastern corner of what will be the C-18W reservoir. The pump station conveys flows from the water treatment plant via a County owned ditch into an existing wetland which will be within the C-18W reservoir. This pump station will be demolished and replaced. The new pump station will be located outside the northeastern corner of the C-18W reservoir, and will discharge via the existing County owned ditch into an existing wetland to the northeast of the C-18W Reservoir on lands owned in fee by SFWMD. This pump station will be relocated as a replacement and need not conform to USACE design standards. The location of the C-18W reservoir embankment will not impact the Palm Beach County utility corridor or the existing County owned ditch.

Further assessments will be conducted during PED phase of the project to determine if any of the other utilities listed in Section D.19 of the Real Estate Appendix will have to be relocated.

Preliminary Attorney's Opinions of Compensability were not prepared. A Preliminary Attorney's Opinion of Compensability is not required under Chapter 12 of ER 404-1-12 or Real Estate Policy Letter 31, dated January 11, 2019. The Government will make a final determination if surveys during PED identify relocations, alterations, vacations, and/or abandonments are required. A Final Attorney's Opinion of Compensability will be prepared in writing for each proposed relocation, alteration, vacation, and/or abandonment.

"ANY CONCLUSION OR CATEGORIZATION CONTAINED IN THIS REPORT THAT AN ITEM IS A UTILITY OR FACILITY RELOCATION TO BE PERFORMED BY THE NON-FEDERAL SPONSOR AS PART OF ITS LERRD RESPONSIBILITIES IS PRELIMINARY ONLY. THE GOVERNMENT WILL MAKE A FINAL DETERMINATION OF THE RELOCATIONS NECESSARY FOR THE CONSTRUCTION, OPERATION, OR MAINTENANCE OF THE PROJECT AFTER FURTHER ANALYSIS AND COMPLETION AND APPROVAL OF FINAL ATTORNEY'S OPINIONS OF COMPENSABILITY FOR EACH OF THE IMPACTED UTILITIES AND FACILITIES." (ER 405-1-12, paragraph 12-17.c.(6))

6.4.2.3 Real Estate Cost Estimate

The real estate cost estimate for lands and damages the Recommended Plan is approximately $241,053,000 (rounded) (**Table 6-7**). A 25% contingency is added in the amount of $60,263,000 to the overall real estate estimate for the project. The real estate cost estimate of lands required for the construction, operation, and maintenance to include the contingency is approximately $301,316,000.

The estimate of the federal real estate incidental acquisition cost including a contingency is $1,013,000. This cost includes project real estate planning, mapping, review, oversight, monitoring, administrative and legal costs, crediting review costs, certification of lands required for project purposes, real estate analysis or other requirements that may be necessary during PED. The estimate of the non-federal sponsor incidental costs associated with the acquisition including a contingency is $1,519,000.

The total real estate cost estimate including contingencies to implement this project is approximately $343,848,000. The non-federal sponsor will receive credit towards its share of real estate project costs incurred for certification of lands to include incidental costs, see **Table 6-7**.

Table 6-7. Summary of Baseline Cost Estimates for Real Estate.

Category	Cost
Lands & Damages	$241,053,000
Lands & Damages Contingency (25%)	$60,263,000
Subtotal Lands & Damages	**$301,316,000**
Federal Review of Non-Federal Sponsor	$810,000
Federal Review of Non-Federal Sponsor - Contingency (25%)	$203,000
Subtotal Federal Review Costs	**$1,013,000**
Non-Federal Sponsor Administrative Costs	$1,215,000
Non-Federal Sponsor Administrative Cost - Contingency (25%)	$304,000
Subtotal Non-Federal Administrative Costs	**$1,519,000**
TOTAL RE COST ESTIMATE	**$303,848,000**

Note: Land & Administrative costs are shown in current dollar estimates

6.4.3 Operations, Maintenance, Repair, Replacement, and Rehabilitation

OMRR&R begins after physical project construction and Operational Testing and Monitoring is complete, and generally includes all operation activities and maintenance needed to keep the project features functioning as intended. **Table 6-5** displays the average annual cost for OMRR&R of the project features.

6.4.4 Monitoring and Adaptive Management

The methods, locations, timing, and funding requirements for conducting adaptive management and monitoring are included in Annex D. The LRWRP monitoring plan was designed to provide the monitoring required addressing LRWRP specific needs while being integrated with other Everglades monitoring to take advantage of existing monitoring efforts, knowledge, and information. The LRWRP AM and Monitoring Plan leverages several existing programs to avoid redundancies and insure cost-effectiveness. The monitoring requirements described in the LRWRP plan are limited to the additional increase in monitoring resources and analysis efforts needed to address LRWRP-specific questions. The LRWRP monitoring plan assumes these other monitoring efforts will continue into the future at least for the period required by LRWRP.

Adaptive management and monitoring costs accrue during different phases of the project, as shown in **Table 6-8** and **Table 6-9**. Construction for adaptive management options, pre-construction data

investigation, construction phase monitoring, and OTMP are all construction based activities and are included in the construction phase costs in **Table 6-4**. Post construction monitoring will occur during either 10-year cycles or for the life of the project, including the period of analysis, and are part of OMRR&R costs. Endangered species Act coordination is ongoing. A draft BO was issued in July 2019, and a final BO will be issued in November 2019. Endangered species monitoring costs including contingencies, required to meet the terms and conditions contained in the BO, will be included in the Final PIR/EIS.

Table 6-8. Summary of Cost Estimates for Construction Phase Monitoring and Adaptive Management.

Actions Funded with Construction Funds	Cost (Oct 2019 price level)
Pre-construction Data Investigation for Adaptive Management	$50,000
Pre-construction USFWS BO Ecological Monitoring	$350,000
Subtotal for Monitoring during Pre-Construction	**$400,000**
Adaptive Management Monitoring during Construction	$0
Water Quality Monitoring during Construction	$20,000
Ecological Monitoring during Construction	$0
USFWS BO Ecological Monitoring during Construction	$550,000
Subtotal for Construction Phase	**$570,000**
Water Quality Monitoring during OTMP	$620,000
Hydro-meteorological Monitoring during OTMP	$200,000
USFWS BO Ecological Monitoring during OTMP	$0
Subtotal for OTMP	**$820,000**
Adaptive Management Options	**$3,831,000**
Total for Pre-Construction, Construction, and OTMP	**$5,621,000**

Table 6-9. Summary of Cost Estimates for Post-Construction Monitoring and Adaptive Management.

Actions Funded with Operations and Maintenance Funds	Average Annual Cost
Ecosystem Success Monitoring, up to 10 years (Average annual cost, 50 yrs., 2.75%, based on $731,000 per year for a 10-year cycle)	$245,000
Adaptive Management Monitoring, up to 10 years (included with Ecosystem Success Monitoring)	included
Subtotal Post Construction Monitoring	**$245,000**
Hydro-Meteorological Monitoring, life of project	$200,000
Water Quality Monitoring, life of project	$400,000
USFWS BO Ecological Monitoring, life of project	$0
Subtotal Post-Construction OMRR&R	**$600,000**

6.4.5 Invasive Species Management

Invasive species management costs accrue during all phases of the project, as shown in **Table 6-10** below. Pre-construction management activities, construction phase activities, and Operational Testing and Monitoring Period (OTMP) activities are all construction-based activities and are included in the construction costs of **Table 6-4**. Some post-construction monitoring and management will occur during 10-year cycles and other monitoring and management will occur for the life of the project, including the period of analysis, and are part of OMRR&R costs. Management of invasive species including surveillance, control, etc. will occur throughout the OMRR&R phase. **Table 6-5** also contains the average annual cost for invasive species management actions.

Table 6-10. Summary of Cost Estimates for Invasive Species Management.

Activity and Phase	Costs
Pre-Construction Management and Monitoring	$3,982,000
Construction Phase Management	$893,000
Operational Testing and Monitoring Period (OTMP)	$509,000
Total Invasive Species Management During Construction	**$5,384,000**
Post Construction Monitoring Costs – average annual cost (50 yrs., 2.75%, based on $148,000 per year for a 10-year cycle)	$49,000
Post Construction Management Costs – average annual cost (occurs for life of project, including the period of economic analysis)	$536,000
Total Invasive Species Management Post-Construction (average annual)	**$585,000**

6.4.6 Cultural Resources Preservation Costs

The identification, evaluation and mitigation of cultural resources for the life of the project are included in **Table 6-11**. Pursuant to ER 1105-2-100, Appendix C-4.d(6)(c), and the Archaeological and Historic Preservation Act, Section 7, data recovery costs are capped at 1% of the total estimated amount authorized for appropriation. Data Recovery is 100% federal responsibility until the cost of Data Recovery reaches 1% of the total project cost. Afterwards, anything above the 1% cap will be cost shared between the Government and the non-federal sponsor as identified in ER 1105-2-100, Appendix C-4.h(3).

Costs in **Table 6-11** account for preliminary Phase I cultural resources surveys wherein the goal of the survey is to locate, identify, and evaluate cultural resources within the area of potential effects; Phase II evaluation studies wherein archaeological test excavation are undertaken to determine site integrity and NRHP eligibility; and Phase III data recoveries wherein an archaeological site is scientifically excavated as a mitigation of an adverse effect. The $4.2 million estimate for data recovery is more than 1% of the federal share (50%) of total project cost estimate of $738 million in **Table 6-4**. The data recovery costs up to 1% of the federal share of the total project cost is entirely a federal cost. The cost of data recovery above 1% of the federal share of the total project cost is cost shared. The cost sharing table in Section **6.6** will incorporate this unequal sharing of cultural resources costs.

Table 6-11. Summary of Cost Estimates for Cultural Resources Preservation.

Recommended Plan Feature	Cost of Phase I	Cost of Phase II	Cost of Phase III (Data Recovery)[1]	Total
Kitching Creek (Hydration): Spreader canal; weir/plug (Jenkins Creek)	No Costs – No Effect	No Costs – No Effect	No Costs – No Effect	No Costs
Moonshine Creek and Gulfstream East (including weir at Hobe Grove Ditch)	$235,000	$400,000	$750,000	$1,385,000
Cypress Creek Canal (includes berm at creek & spreader swale at Mack Dairy Road	$235,000	$400,000	$750,000	$1,385,000
Gulfstream West	$240,000	$400.000	$750,000	$1,390,000
Pal-Mar East	No Costs – No Effect	No Costs – No Effect	No Costs – No Effect	No Costs
Natural Storage near C-18W Canal	No Costs – No Effect	No Costs – No Effect	No Costs – No Effect	No Costs
G-160 and G-161	$200,000	$300,000	$750,000	$1,250,000
Grassy Waters Preserve Triangle	No Costs – No Effect	No Costs – No Effect	No Costs – No Effect	No Costs
M-1 Pump Station	$100,000	$300,000	$750,000	$1,150,000
Corps PED Management	$125,000	$215,000	$450,000	$790,000
Total [2]	**$1,135,000**	**$2,015,000**	**$4,200,000**	**$7,350,000**

[1] *Federal share of Data Recovery is 100% up to 1% of the federal share of the total project cost ER 1105-2-100, App. C, para. C-4.d.(5)(f). In the event that data recovery costs exceed 1% level, those costs exceeding 1% the remainder of the cost will be shared 50/50 with the non-federal sponsor ER 1105-2-100, App. C, para. C-4.h.(3)*.

[2] *Cultural resources costs include PED Management costs and the total is rounded*.

6.5 Cost Estimate for Recreation Elements

The expenditures attributed to recreation features are justified using a benefit to cost ratio. The tangible economic justification of the proposed project can be determined by comparing the equivalent average annual costs with the estimate of the equivalent average annual benefits realized over the period of analysis. The average annual recreation benefits and costs are summarized in **Table 6-12**. The federally mandated project evaluation interest rate of 2.750%, an economic period of analysis of 50 years and October 2019 price levels were used to evaluate economic feasibility. The benefit to cost ratio for the recreation features is 2.22 to 1, with net annual benefits of $255,000. For a more detailed review of the recreation analysis, including an explanation of how the unit day value was derived and how daily use was calculated, please refer to **Appendix F** of this report.

Table 6-12. Summary of Recreation Costs and Benefits.

Item	Value
Recreation Elements (include 33% contingency)	$3,898,000
PED and Construction Management	$1,022,000
Total Recreation Costs	$4,920,000
Interest During Construction	$60,000
Total Investment	$4,980,000
Amortized Total Investment	**$184,000**
Annual OMRR&R	**$25,000**
Average Annual Cost	**$209,000**
Unit Day Value	$10.09
Daily Use	127
Annual Use (users x 365 days)	46,000
Average Annual Benefit	**$464,000**
Benefit to Cost Ratio	2.22 to 1
Net Annual Benefits	$255,000

6.6 Cost Sharing

The total first cost of the restoration features of LRWRP (**Table 6-13**), including the value of LERR and PED costs, will be shared between the Federal Government and the non-federal sponsor under the CERP program as a whole. The non-federal sponsor will provide cash, perform work-in-kind during planning, engineering and design or manage a portion of construction as necessary to meet its 50% share of the total first cost of the project to be balanced according to Section 601(e) of WRDA 2000. Operating costs are also shared 50% (Section 601(e)(4) of WRDA 2000).

Table 6-13. Cost Share for the LRWRP Recommended Plan.

Item	Federal Cost	Non-Federal Cost	Total[1]
Ecosystem Restoration Construction[2]	$322,062,500	$20,240,500	$342,303,000
PED	$27,877,500	$27,877,500	$55,755,000
Construction Management	$17,478,000	$17,478,000	$34,956,000
LERR	$1,013,000	$302,835,000	$303,848,000
Adjustment for CR data recovery of $3,704,000 that is 100% federal cost[2]	$1,852,000	($1,852,000)	$0
ER Subtotal[2]	**$370,283,000**	**$366,579,000**	**$736,862,000**
Recreation (NED) Subtotal	**$1,949,000**	**$1,949,000**	**$3,898,000**
Total Project First Cost[2]	**$372,232,000**	**$368,528,000**	**$740,760,000**
Average Annual Costs			
OMRR&R - LRWRP Features	**$1,931,500**	**$1,931,500**	**$3,863,000**
OMRR&R - Invasive Species Monitoring and Management (average annual)	**$292,000**	**$292,000**	**$584,000**

OMRR&R - Monitoring (Ecosystem Restoration Success and Adaptive Management, Average Annual [10- year cycle, $731,000/year, 2.75%])3	**$122,500**	**$122,500**	**$245,000**
OMRR&R - Monitoring (hydro-meteorological, water quality, biological opinion) (annual cost, life of project)	**$300,000**	**$300,000**	**$600,000**
OMRR&R - Recreation	**$0**	**$25,000**	**$25,000**

[1]Construction costs totals are Oct 2019 First Costs rounded to the nearest $1,000 and include a 33% contingency.
[2]Federal costs include cultural resources data recovery up to 1% of the federal share of the project.
[3]10-year monitoring costs, total and average annual, are in Table 6-9.

6.6.1 Cost Sharing of Construction and Real Estate

The costs for construction and LERR are part of the first cost of the project, and all first costs are shared at the CERP program level. The non-federal sponsor is responsible for acquisition of LERR so the costs are shown in the non-federal column of **Table 6-13**. Construction costs are adjusted in the table to balance the LERR costs and retain the overall cost sharing.

6.6.2 Cost Sharing of OMRR&R

Section 601(e)(4) of the WRDA 2000 specifies that the OMRR&R of authorized projects of the CERP would be cost shared equally by the Federal Government and the non-federal sponsor. Consistent with the provisions of Section 601(e)(4) of the WRDA of 2000 and given the multi-objective nature of the features in this plan, it is appropriate for the OMRR&R associated with the features of this plan to be shared equally between the Federal Government and the non-federal sponsor. The Federal and non-federal sponsor's obligations to provide OMRR&R will continue indefinitely unless the project is de-authorized by Congress. OMRR&R costs associated with recreation features of the plan will be funded 100% by the non-federal sponsor.

6.6.3 Cost Sharing of Monitoring

CERP post construction project monitoring is cost-shared with the non-federal sponsor for a maximum period of 10-years for performance based ecological monitoring, and in perpetuity for hydrometeorologic and statutorily required monitoring. Given that the construction of all project features may require more than 10-years, the duration of cost-shared performance based ecological monitoring will extend past 10 years for the entire project; however, each monitoring activity associated with individual project features will not be cost-shared for more than 10-years post transfer of project component to local sponsor. Annex D Part 1, AM Plan provides the explanation of rolling implementation of 10-year monitoring windows. These efforts will be cost shared during the construction phase of the project in accordance with Section 601(b)(2) of WRDA 2000. After construction the costs will become part of the project's OMRR&R plan and cost-shared as described in the recommendations section of this report.

System-wide monitoring will be performed as part of the CERP Monitoring Assessment Plan implemented by RECOVER. Data collected as part of this monitoring program is critical to the overall success of CERP Projects. Funding for system-wide monitoring is provided by and for RECOVER, and is independent from project-level funding. A draft Project Operating Manual (Annex C) has been developed for use in water

management. Operational monitoring will be cost shared during the operation and maintenance phase of the Project.

6.6.4 Cost Sharing of Cultural Resources Preservation

Data recovery is 100% federal responsibility until the cost of data recovery reaches 1% of the total project cost. Data recovery caps are identified in ER 1105-2-100, Appendix C-4.d(6)(d), and the Archaeological and Historic Preservation Act, Section 7.

6.6.5 Non-Federal Sponsor Work-in-Kind for Construction

Should the non-federal sponsor construct portions of the LRWRP prior to execution of a PPA, then this work must be covered by a Pre-Partnership Credit Agreement (PPCA). Crediting would be afforded under the PPA when executed. Such credit would be applied toward the non-federal sponsor's share of the costs associated with the implementation of the CERP as authorized by Section 601(e)(5)(C) of WRDA 2000, shall not include cash reimbursements, and shall be subject to: a) the authorization of the LRWRP project by law; b) a determination by the Secretary of the Army that the construction work completed under the PPCA is integral to the authorized CERP restoration project; c) a certification by the District Engineer that the costs are reasonable, allowable, necessary, auditable, and allocable; and d) a certification by the District Engineer that the activities have been implemented in accordance with USACE design and construction standards and applicable Federal and State laws. Also, per Section 601(e)(5)(E) of the Water Resources Development Act of 2000, in-kind credit is subject to audit by the Secretary.

For construction conducted prior to WRRDA 2014, USACE guidance is to begin PPCA as soon as possible after identifying the Recommended Plan. The PDT will soon start a PPCA for G-160 and G-161. USACE and the SFWMD will likely execute a PPCA prior to receipt of federal appropriations in order to refine the design and initiate construction of the C-18W Reservoir.

6.7 Plan Implementation

Implementation of LRWRP will occur over many years and include many actions by USACE and SFWMD. This subsection discusses the major implementation phases that are expected to occur after Congressional authorization and appropriation of funding for project construction. The remaining features will be designed under the PPA will cover phased construction of the feature groups to achieve the inter-related project hydrologic and ecological benefits. The PPA will include the construction of logical groupings of plan elements, agreed upon by the USACE and SFWMD, that maximize benefits to the extent practicable consistent with project dependencies and the LRWRP AM and Monitoring Plans (see Annex D).

6.7.1 Implementation and Construction Sequencing

USACE and SFWMD developed sequencing scenarios for the Recommended Plan that consider internal and external dependencies. Development of sequencing for LRWRP features considers that a number of previously authorized large capital investment CERP projects await implementation. Several other basic principles were considered in development of an implementation plan for LRWRP features including the following:

1. Sequencing considers the earliest opportunity to realize benefits, including the features that can provide benefits that use existing state-owned lands.

2. Where possible, sequencing should include steps and timing to test concepts, as described in the LRWRP AM Plan (**Annex D**).
3. Recreation features will be constructed in conjunction with corresponding LRWRP restoration features.
4. Calendar years assume that the LRWRP will be authorized in WRDA 2020, and appropriations will be received in 2022.

Other factors may influence implementation including funding availability, maintaining cost-share balance between the federal and non-federal sponsor, as well as the integration of projects that may be constructed by other agencies. The USACE and the SFWMD undertake integration of the Recommended Plan and the other CERP projects authorized or awaiting authorization into the CERP programs' Integrated Delivery Schedule (IDS), which contains the Master Implementation Sequencing Plan (MISP), through a robust public process.

Two implementation scenarios are proposed for the LRWRP: unconstrained funding implementation, and constrained funding implementation. Unconstrained implementation proceeds with no funding or resource restrictions and follows the schedule shown in **Figure 6-8.** Constrained implementation proceeds with approximately $40,000,000 per year funding restriction, and follows the schedule shown in **Figure 6-9**.

In the unconstrained implementation scenario, design of all major project components will be initiated during Year 1, with the exception of the ASR system at the C-18W Reservoir, and Cypress Creek components including the Mack Dairy Road spreader. ASR feasibility will be investigated with the completion of an exploratory borehole at the C-18W Reservoir location during Year 1. If successful, this exploratory borehole will be completed as the first of four ASR wells. ASR system design will be initiated once the C-18W Reservoir design is completed, because the ASR surface facility will be integrated within the pump station, and ASR recharge and recovery wellhead designs are based on the reservoir embankment design. Design of the Cypress Creek components is offset pending completion of the Gulfstream West flow-through marsh feature, because water conveyed through the Gulfstream West flow-through marsh is a major flow component of Cypress Creek. Contributed flows must be evaluated first to refine the Cypress Creek weir design. Kitching Creek modifications and Moonshine Creek and Gulfstream East feature implementation is largely independent of all other project features, and so will be initiated early in the project phasing.

The pre-construction design and engineering (PED) phase duration will be two to three years for most components, and will proceed mostly concurrently using resources from both USACE and SFWMD. Construction sequencing duration ranges from 1.5 years to 4 years, depending on complexity of the construction contracting process. Operational testing and monitoring period (OTMP) duration for major water control structures, the C-18W Reservoir and the Gulfstream West flow-through marsh, will be performed to include one full wet season and one full dry season. The OTMP duration may extend to approximately 18 months depending on the season when construction is substantially complete. Total project duration is 9 years.

In the constrained implementation scenario, design of those components that yield early ecosystem restoration benefits and flood control will be initiated first. These components also are located in the eastern portions of the project area, so that increased flows can be accommodated as restoration of western components begins. The Kitching Creek, Moonshine Creek, Grassy Waters Preserve, and the M-

1 to M-Canal pump station components will be initiated first, and on a schedule that is identical to the unconstrained implementation.

Construction duration of the C-18W Reservoir differs in the unconstrained implementation scenario. The 3-year PED phase of the C-18W Reservoir will be initiated during Year 1, but the construction duration is expanded from 3 years to 7 years. Duration of ASR system construction at the C-18W Reservoir also is expanded from 2 years to 4 years.

Design and construction of components in the western portions of the project area are deferred to later in the project (Years 7 and 8) in the constrained implementation scenario. These features include Pal-Mar East, Cypress Creek improvements, the Mack Dairy Road spreader and modifications (if needed) to G-160 and G-161. PED phase durations for these features are 3 years, but construction phase durations are expanded from 2 years to 3 years. Resources are focused on PED and construction phases of the C-18W Reservoir, and those components that provide early ecosystem restoration benefits and flood control in flow-ways two and three. Total project duration is 15 years.

Total Duration (months)	Unconstrained LRWRP Design and Construction Sequencing											
	Project Feature	Priority to Start (1=earliest)	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
			2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
90	Recreation	1	0.2	0.2	0.2	1.2	1.2	1.1	0.6	0.02		
54	Kitching Creek Modifications	1	0.5	0.5	1.35	1.4	0.02					
54	Moonshine Creek and Gulfstream East, Hobe Grove	1	0.12	0.11	1	0.8	0.08					
54	Grassy Waters Preserve Triangle	1	0.4	0.45	0.35	0.35	0.02					
54	M-1 to M-Canal Pump Station (S-100)	1	0.4	0.4	3.3	1.5	0.08					
90	C-18W Reservoir incl. PB Co. PS relocation	1	10	10	10	72	75	73	1.3	1.2		
60	(4) ASR Wells/Systems	1 and 2	2	2			5.1	5.5	18	18	0.25	
90	Gulfstream West - all components	3	2	2.5	1.5	10	10	10	0.15	0.15		
90	Pal-mar East Improvements - Nine Gems, culverts	4	0.9	0.5	0.5	10	13	12	0.13			
72	Cypress Creek Canal, Spillway, Culpepper culverts	4			1.3	1.3	1.2	7	7.5	0.06	0.06	
90	Mack Dairy Rd Spreader Swale and Pepper Farm Regrade	5			0.7	0.8	1.6	1.7	2.2	0.05		
72	G-160 Rebuild or Modify	6	0.22	2	1.9	1.9	0.13					
72	G-161 Rebuild or Modify	6	0.22	1.3	1.5	1.2	0.08					
	Subtotal		$ 16.8	$ 19.8	$ 23.4	$ 101.3	$ 106.3	$ 109.2	$ 29.3	$ 19.5	$ 0.3	$ -
					PED		CONSTRUCTION			OMTP		

* G-160 AND G-161 ARE ALREADY CONSTRUCTED. IF THEY ARE LATER DETERMINED TO REQUIRE MODIFICATIONS, THIS GRAPHIC SHOWS WHEN THEY WOULD BE MODIFIED.

Figure 6-8. Unconstrained LRWRP PED, construction, and OTMP sequencing. Values are in millions of dollars.

Total Duration (months)	Constrained LRWRP Design and Construction Sequencing																
	Project Feature	Priority to Start (1=earliest)	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15
			2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036
54	Recreation	1	0.3	0.3	2.1	2.1	0.02										
54	Kitching Creek Modifications	1	0.15	0.2	1.7	1.7	0.02										
54	Moonshine Creek and Gulfstream East, Hobe Gro	1	0.13	0.1	0.9	0.9	0.075										
54	Grassy Waters Preserve Triangle	1	0.4	0.4	0.4	0.31	0.02										
90	M-1 to M-Canal Pump Station (S-100)	1	0.4	0.4	2.4	2.4	0.075										
12	C-18W Reservoir incl. PB Co. PS relocation	1	20	15	5	30	30	30	30	30	30	30	1.2	1.3			
54	(4) ASR Wells/Systems	2	2	4.9	1			3	9	9	9	9	2				
90	Gulfstream West - all components	3	1	2.1	2	5	6	5	5	5	5	0.15	0.15				
90	Pal-mar East Improvements - Nine Gems, culvert	4								0.5	0.5	0.9	10	15	10	0.13	
72	Cypress Creek Canal, Spillway, Culpepper culvert	4								1.2	1.4	1.3	4.5	5	5	0.06	0.06
90	Mack Dairy Rd Spreader Swale and Pepper Farm	5							0.3	0.4	0.4	2	2.4	1.5	0.05		
72	G-160 Rebuild or Modify	6									0.28	1.88	1.88	1.88	0.13		
72	G-161 Rebuild or Modify	6									0.22	1.8	1.2	1	0.08		
	Subtotal		$ 24.4	$ 23.4	$ 15.5	$ 42.4	$ 36.2	$ 38.0	$ 44.3	$ 46.1	$ 46.8	$ 47.0	$ 23.3	$ 25.7	$ 15.3	$ 0.2	$ 0.1

PED CONSTRUCTION OMTP

* G-160 AND G-161 ARE ALREADY CONSTRUCTED. IF THEY ARE LATER DETERMINED TO REQUIRE MODIFICATIONS, THIS GRAPHIC SHOWS WHEN THEY WOULD BE MODIFIED.

Figure 6-9. Constrained LRWRP PED, construction, and OTMP sequencing. Values are in millions of dollars.

6.7.2 Pre-construction Engineering and Design

Appendix A represents a conceptual level of design for features that comprise the Recommended Plan. Appendix A and associated Annexes include documentation of all assumptions and conceptual designs for each of the engineering disciplines. PED for recommended plan features could begin after Congressional authorization and upon SFWMD's concurrence with the implementation phases. During PED, USACE or the non-federal sponsor will prepare an Engineering Documentation Report for each major component presented in the PIR. Subsequently, production of the initial, intermediate and final plans and specifications for each major component will be completed and reviewed, in preparation for the construction contract. All work will be coordinated and reviewed between the USACE and the SFWMD, and approved by the USACE and SFWMD prior to construction, to ensure that the work meets USACE standards and regulations and incorporates SFWMD design guidance, as applicable. PED will include site-specific surveys, geotechnical investigations, and an exploratory borehole, that if successful, will be completed as the first ASR well. During the design phase, detailed analyses, subsurface and site investigations, and refined hydraulic analyses will be conducted to prepare construction documents. During PED, project assurances, Savings Clause analysis, and operating manuals will be updated consistent with the implementation phases, if necessary. After completion of 60% final plans and specifications for a given project feature, the lead construction agency (USACE or SFWMD) will prepare and submit a Comprehensive Everglades Restoration Plan Regulatory Act (CERPRA) permit application (Florida Statutes 373.1502) to the FDEP. The FDEP will review the application material to determine if reasonable assurance that the feature will be consistent with State water quality standards in compliance with rules in effect at the time of application. After completion of the 60% design of the C-18W Reservoir, a semi-quantitative risk assessment will be performed to evaluate dam safety concerns. Results and recommendations from this analysis will inform the final design of the reservoir. See Section 6.1 for a list of plan features to be constructed. See Appendix A for limited design details and conceptual design plates.

USACE continues the usage of the NGVD of 1929 (NGVD 29) system for elevation comparisons used with monitoring data, hydrologic modeling and design for Florida. This allows the continuity of years of valuable data to be transitioned during PED to the more accurate North American Vertical datum (NAVD) of 1988 (NAVD 88). This PIR continues of the usage of NGVD and NAVD where appropriate in hydrologic modeling and preliminary design of LRWRP recommended features. In PED, the NGVD 29 elevations will be converted to NAVD 88 for design analyses and completion of construction documents (plans and specifications). In some prior instances, the local sponsor has requested both vertical datums to be referenced during PED. There are appropriate conversions based on spatial relevance to maintain design intent changing from the NGVD 29 datum to the NAVD 88 datum.

6.7.3 Construction

The project will be constructed using conventional means and methods. Multiple contracts will be awarded in a sequenced and phased approach. Construction contracts for project features will not be awarded by the USACE prior to obtaining CERPRA permit authorization or other water quality certification, as applicable. The project features will be sequenced in contracts that maximize opportunities to realize benefits with water that meets state water quality standards, capitalize on use of onsite material, reduce multiple handling scenarios, and maintain flood control operations of existing features. Adaptive Management will help with future development of the implementation and sequencing.

6.7.4 Operational Testing and Monitoring Period

Prior to initiating the operational testing and monitoring period (OTMP), each major operational component will undergo a short period of testing and commissioning. This short period includes functional performance tests on all features to verify all modes of operation and to verify other relevant contract requirements. Following the testing and commissioning, operational testing and monitoring will be conducted for one full wet season (i.e. June 1 to November 30). If the OTMP begins after the start of a wet season, the OTMP should be extended as needed to encompass a full wet season. Contractor services to be provided during the OTMP will include, but will not be limited to, the following: vegetation management including control of exotics, answering questions on equipment operation; contacting the appropriate vendor/manufacture for response or site visits; arranging and officiating supplemental owner training sessions; and assisting in resolution of functionality issues. The operational testing and monitoring period activities of the construction contractor will be separate from and supplemental to the warranty requirements of the contract. The USACE and SFWMD will share in the responsibilities for conducting water management operations during OTMP.

During OTMP the federal government and the non-federal sponsor will work together closely to identify any features that are not operating as designed. Any features that are not operating as designed will be identified in writing to the District Engineer and the non-federal sponsor. At the conclusion of OTMP, the District Engineer and the non-federal sponsor will make a determination as to whether the Project is "operational" as defined in the CERP Master Agreement. Once the Project, or a functional portion of the project, is determined to be operational, the feature(s) will be transferred to SFWMD for OMRR&R.

6.7.5 Floodplain Management and Flood Insurance Programs Compliance

As LRWRP is part of the multi-purpose C&SF program, the non-federal sponsor agrees to participate in and comply with applicable federal floodplain management and flood insurance programs consistent with its statutory authority. Not less than once each year, the non-federal sponsor shall inform affected interests of the extent of protection afforded by the authorized CERP project.

The non-federal sponsor shall publicize floodplain information in the area concerned and shall provide this information to zoning and other regulatory agencies for their use in preventing unwise future development in the flood plain and in adopting such regulations as may be necessary to prevent unwise future development and to ensure compatibility with protection levels provided by the CERP Project.

The non-federal sponsor shall comply with Section 402 of WRDA 1986, as amended (33 U.S. C. 701b-12), which requires a non-federal interest to have prepared, within one year after the date of signing a PPA for the authorized CERP Project, a floodplain management plan. The plan shall be designed to reduce the impacts of future flood events in the project area, including but not limited to, addressing those measures to be undertaken by non-federal interests to preserve the level of flood protection provided by the authorized CERP Project. As required by Section 402, as amended, the non-federal interest shall implement such plan not later than one year after completion of construction of the authorized CERP project. The non-federal sponsor shall provide an information copy of the plan to the Government upon it is preparation.

The non-federal sponsor shall prescribe and enforce regulations to prevent obstruction of or encroachment on the authorized CERP project or on the lands, easements, and rights-of-way determined by the Government to be required for the construction, operation, maintenance, repair, replacement, and rehabilitation of the authorized CERP project, that could reduce the level of protection the authorized

CERP project affords, hinder operation or maintenance of the authorized CERP project, or interfere with the authorized CERP project's proper function.

6.7.6 Environmental Commitments

The USACE commits to avoid, minimize, or mitigate adverse effects during construction activities by including the following commitments in the contract specifications:

1. The contractor will be required to keep construction activities under surveillance, management, and control to avoid pollution of surface, ground waters, and wetlands. The contract specifications will require the contractor to employ best management practices (BMPs) with regard to erosion and turbidity control.
2. The contractor will be required to prevent oil, fuel, or other hazardous substances from entering the air, ground, drainage, local bodies of water, or wetlands. The contract specifications will require that the contractor adopt safe and sanitary measures for the disposal of solid wastes and will require a spill prevention plan. The contractor will also be required to transport and dispose of any construction and demolition debris in accordance with applicable requirements.
3. The contractor will be required to keep construction activities under surveillance and control to minimize damage to the environment by noise and pollution of air resources.
4. The contractor will be required to keep construction activities under surveillance, management, and control to minimize interference with, disturbance to, and damage of fish and wildlife. The contractor will be required to inform the construction team of the potential presence of threatened and endangered species in the work area, the need for construction conservation measures, and any requirements resulting from Endangered Species Act (ESA) Section 7 consultation.
5. The contractor will be required to take appropriate measures to protect historic, archeological, and cultural resources within the work area.
6. The contractor will be required to keep construction activities under surveillance, management, and control to prevent the transfer and spread of invasive species due to construction activities. The contract specifications will require the contractor to employ BMPs and measures to prevent the transfer and spread of invasive species.

In addition, as required under WRDA 2000, the CERP Programmatic Regulations, and current USACE policy, USACE has taken the following actions:

1. The PDT has identified water to be reserved or allocated for the natural system. **Annex B** addresses this requirement.
2. The Recommended Plan has been evaluated in light of its potential effects on existing legal sources of water and the level of service for flood protection. **Annex B** addresses this requirement.
3. WRDA 2000, the authorizing legislation for CERP, has now made a formal monitoring plan a requirement for all CERP restoration projects. The Recommended Plan includes adaptive management, water quality, hydrometeorologic, and ecological monitoring activities to ensure that the intended purposes of the project will be achieved through long term operations. **Annex D** addresses this requirement.

4. In addition to the project-level monitoring plan, the PDT has developed a nuisance and exotic vegetation control plan which strives to either prevent or reduce the establishment of invasive and non-native species within the project area. **Annex F** addresses this requirement.
5. USACE guidance interpreting the WRDA of 2016 (Section 1161), requires preparation of an adaptive management plan for all ecosystem restoration projects. Adaptive management is a formal process for continually improving management policies and practices by learning from their outcomes. In the context of LRWRP, the adaptive management plan provides an approach for addressing project uncertainties by testing hypotheses, linking science to decision making, and adjusting implementation of the project as necessary, to improve the probability of restoration success. **Annex D** addresses this requirement.
6. The Recommended Plan has been evaluated in light of its potential effects on fish and wildlife resources, including effects to federally listed species. Early consultation was initiated with completion of a Biological Assessment (BA) submitted to USFWS in February, 2019. The USACE commits to mitigation requirements resulting from ESA Section 7 consultation. The draft BO was provided by the USFWS in July 2019. The USACE accepted the terms and conditions, which require implementing standard construction management practices for indigo snake, wood stork, Florida bonneted bat, and Florida manatee. The Final BO provided in November by USFWS includes final mitigation requirements to conduct pre-construction northern crested caracara surveys and implement an Environmental Protection Plan during construction. **Annex A** addresses this requirement.

6.8 Project Assurances and Savings Clause Summary

A detailed description of the legal basis, background, methods, and conclusions are included in **Annex B**. As discussed in Section 4, Alternatives 2, 5, 10, and 13 were modeled with the LECSR-NP sub-regional model and Alternative 5R was not modeled. However, Alternative 5R and 5 are very similar. This section uses results from the LECSR-NP for Alternative 5 to represent Alternative 5R. The project assurances and savings clause analysis for 5R was completed using the modeling output from 5 (due to all the presence of all those features in 5R) plus an analysis of the additional components of Alternative 13 that were carried forward into the Recommended Plan, 5R.

6.8.1 Level of Service for Flood Protection

Flood protection is evaluated by a combination of best professional judgment interpreting model results and engineering analyses. Consistent with the Final Draft C&SF CERP Programmatic Regulations, Six Program-Wide Guidance Memoranda, the same models and results used for plan formation were applied for the LRWRP Savings Clause assessment. Specifically, Guidance Memorandum #3, Savings Clause requirements provides guidance in determining whether or not the selected alternative plan and its operations meet the requirements of the Savings Clause of section 601(h)(5) of WRDA 2000. This varies from typical storm event analyses by using a long period of record simulation and focusing on the wet events included within the 1965–2005 simulation period. Stage duration curves for various areas of interest were reviewed to compare Recommended Plan relative to the ECB and the FWO and ground elevations to determine if the Recommended Plan may impact flood protection.

To identify whether the project reduces the level of service of flood protection, evaluations focus on changes to water stages and their frequency at selected representative monitoring gauge locations and at specific model cell locations within select residential and agricultural areas. The LECSR-NP model has

no capability to precisely measure flood control on individual fields or during relatively short events, but the LECSR-NP can be used as a coarse-scale tool to indicate a potential change in flood risk. Like volume probability curves, stage duration curves indicate the probability (percentage of time equaled or exceeded, on the x-axis) that a certain stage (expressed in National Geodetic Vertical Datum [NGVD] on the y-axis) is achieved as a function of historical rainfall distribution. Stages are aggregated for each day in the LECSR-NP period of simulation. Once sorted, the values are ranked from highest to lowest. A more localized analysis, with higher resolution hydrologic and/or hydraulic models, will be performed if there is an indication of significant increase in flood risk from the regional analysis. The Engineering Appendix A provides more detail on the Hydrologic Engineering Center River Analysis System (HEC-RAS) modeling performed for all of Flow-way 3 and some areas of Flow-way 2. The HEC-RAS model will provide storm event analysis over a more granular model mesh than LECSR-NP, will inform design and operations of the proposed structures, and further improve confidence that the Recommended Plan will not impact flood protection.

As an example of the stage duration curves analyzed in Annex B, **Figure 6-10** below, depicts the Mecca Southern point. This point is located in the vicinity of the northen edge of Indian Trail Improvement District residences and is adjacent to the proposed C-18W reservoir. This stage duration curve shows the ECB and FWO overlap and higher groundwater stages for the Recommended Plan, but no noticable increase in surface water stages. This is an example of the graphics and assessment done for various locations in the project study area. Many more graphics can be viewed in **Annex B**.

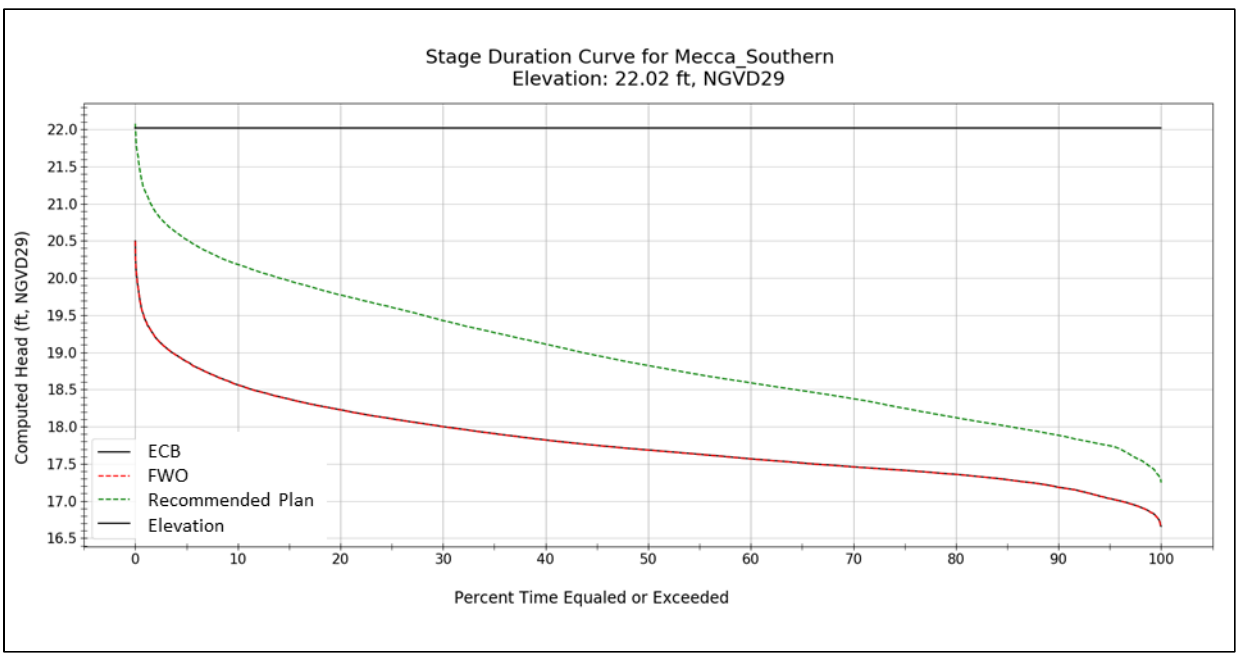


Figure 6-10. Stage duration curve for the ECB, FWO and Recommended Plan for the Mecca Southern Point.

The LECSR-NP model results show that implementation of the Recommended Plan will not reduce the levels of service for flood protection within the areas affected by the project. Additionally, storm specific HEC-RAS modeling will be performed to inform the design and operations of key Flow-way 3 project features. For example, the Cypress Creek control structure will likely be operable to provide maximum flexibility to maintain consistency with pre-project high stages.

6.8.2 Effects on Water Supply for Existing Legal Sources

Consistent with the WRDA 2000 and the Programmatic Regulations, the Savings Clause analysis removes the effects of the intervening non-CERP projects and compares the with-project condition (Recommended Plan- Alternative 5R) to the existing condition baseline (ECB) and the future without project condition (FWO).

The project area has two Water Restriction Areas (WRA). WRA 1 is the Martin County portion of the study area; WRA 2 is the Palm Beach County portion of the study area, from the Martin County line south to the C-51 Canal.

To determine if an elimination or transfer of existing legal sources of water occurred, an analysis was done using the frequency, duration and severity of water use cutbacks during the period of record. The trigger package for the LECSR-NP emulates the SFWMD water shortage policy by reducing consumptive use withdrawals when groundwater stages fall below designated levels in pre-identified trigger cells. The percentage of cutback is increased as the water levels drop further below the Phase 1 15% cutback level. There are four phases of cutbacks.

Frequency is defined as the number of years when water use cutbacks occur for three consecutive months. Duration is measured by the total number of months of cutbacks. Severity is calculated in a similar fashion as duration except months with Phase 2 or Phase 3 cutbacks count as 2 or 3, respectively.

6.8.3 Water Restriction Area 1 (WRA 1) (Southern Martin County)

Implementation of the Recommended Plan will not cause existing legal water sources to be eliminated or transferred.

Existing legal sources of water in WRA 1 include groundwater withdrawn by public utility wellfields, private wells, irrigation wells, and surface water withdrawals for landscape, recreation, and agricultural uses. Water supply demand continues to be met by locally available water sources, primarily the surficial aquifer system. When Lake Okeechobee falls into the water shortage zone and water use cutbacks are imposed, public water suppliers and others in WRA 1 are not included in the water shortage order. The area is only placed under water shortage order when local groundwater levels fall below trigger levels. This function is represented in the LECSR-NP trigger package. Although the LECSR-NP model predictions of the absolute number of water supply cutback events and the corresponding frequency of occurrence have a high degree of uncertainty, relative comparisons between the ECB, FWO and Recommended Plan provide a meaningful comparison to quantify potential effects of the project.

In WRA 1, the frequency, duration, and severity of water restrictions (water use cutbacks) triggered by dry weather including droughts are identical between the ECB, FWO and Recommended Plan (**Table 6-14**). Locally triggered events in WRA 1 are not influenced by the Recommended Plan. The same months trigger at the same level of cutback in the ECB, FWO and Recommended Plan **(Figure 6-11, Figure 6-12,** and **Figure 6-13).** As shown in **Table 6-15**, the volume of demands not met do not differ between the ECB, FWO and Recommended Plan. In part this is due to the distance between major water users and the project features.

Table 6-14. The frequency, duration and severity of water shortages in the pre-project and post-project simulations for WRA 1.

Scenario	Frequency	Duration	Severity
ECB	5	22	27
FWO	5	22	27
Recommended Plan	5	22	27

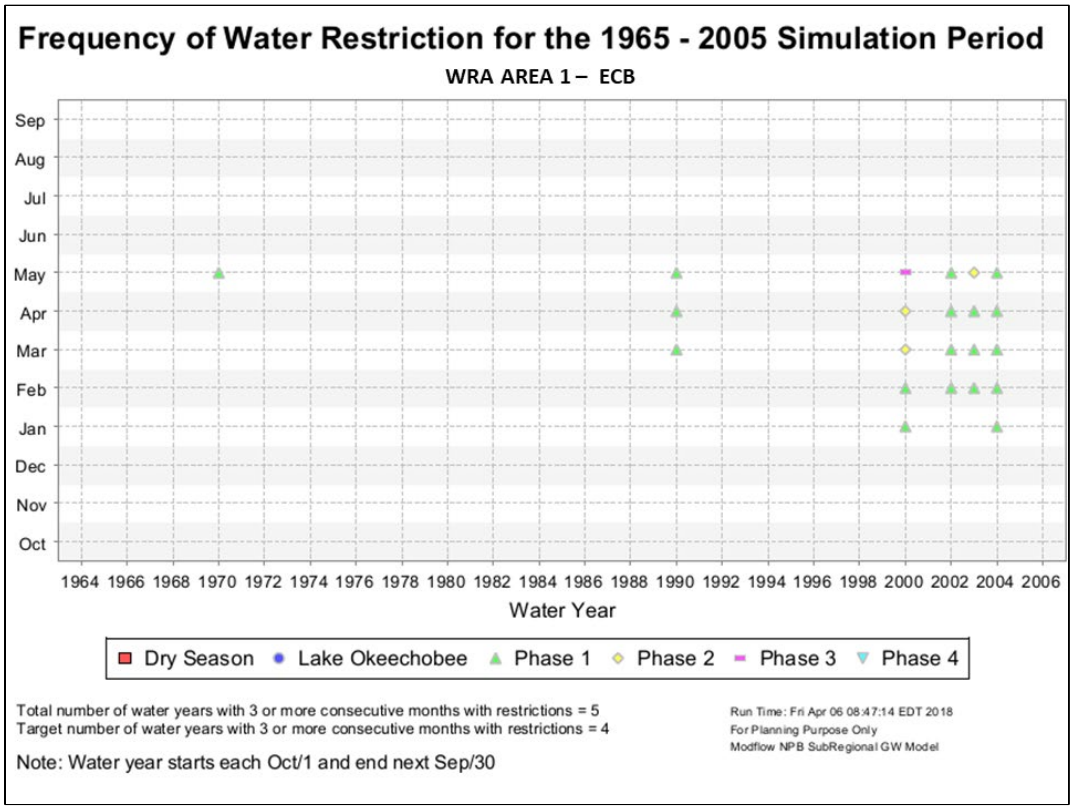


Figure 6-11. Locally triggered water restrictions in WRA 1 during the ECB simulation.

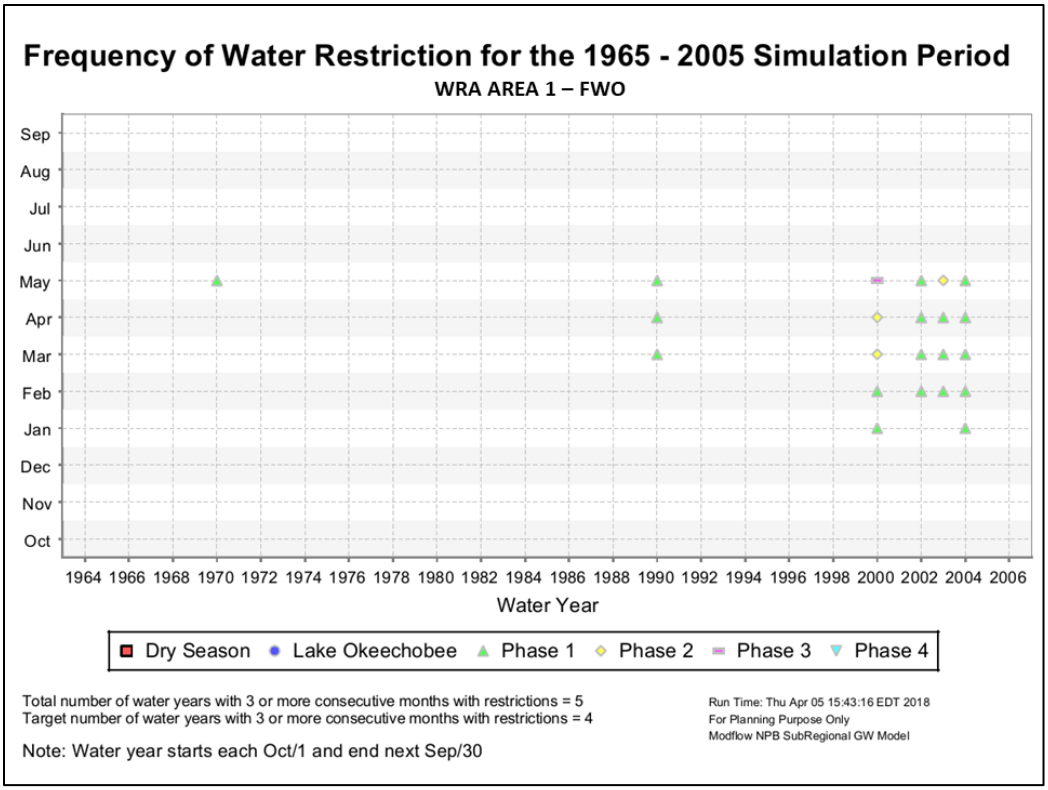


Figure 6-12. Locally triggered water restrictions in WRA 1 during the FWO simulation.

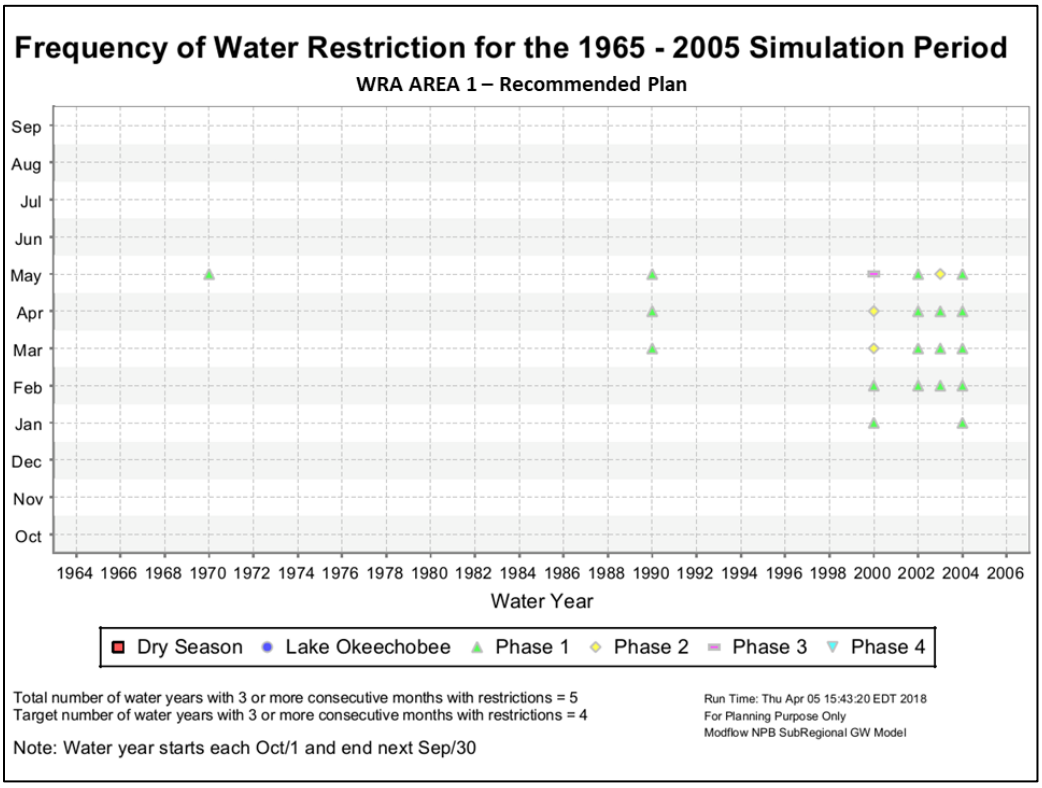


Figure 6-13. Locally triggered water restrictions in WRA 1 during the Recommended Plan simulation.

Table 6-15. Million gallons of demand not met due to water restrictions for all use categories in WRA 1 for the ECB, FWO and Recommended Plan simulations for the period of record 1965-2005.

Alt \ Type*	ASR	PWS	LAN	GOL	NUR	AG1-FL	AG1-OH	AG2-LV	IND
ECB	0	40	0	2	0	0	0	0	0
FWO	0	39	0	2	0	0	0	0	0
Recommended Plan	0	39	0	2	0	0	0	0	0

* The demands not met are categorized according to use: Aquifer Storage and Recovery (ASR), Public Water Supply (PWS), Golf Irrigation (GOL), Nursery Irrigation (NUR), Agricultural – Flood Irrigation (AG1-FL), Agricultural – Overhead Irrigation (AG1-OH), Agricultural- Low Volume Irrigation (AG2-LV) and Industrial (IND).

6.8.4 Water Restriction Area 2 (WRA 2) (North Palm Beach County)

WRA 2 does receive water supply from the regional system and water use cutbacks can be triggered by either Lake Okeechobee stages or by stages at local groundwater trigger sites in the service area. The Recommended Plan does not change either the frequency or severity of water use cutbacks relative to the ECB or FWO (**Table 6-16, Figure 6-14, Figure 6-15,** and **Figure 6-16**). The Recommended Plan results in a slight reduction in demands not met for public water supply and no change to other categories such as golf course irrigation. Over the entire 41 years of simulation, 14 years showed water use cutbacks.

In the Recommended Plan, the total demand not met for public water supply in WRA 2 in 14 years with water restrictions is 4,417 million gallons (MG) (**Table 6-17)**. The FWO had a slightly larger demand not met, 4,438 MG. Thus, the Recommended Plan showed a 21 MG improvement in demands not met. Averaged over the 14 years of cutbacks, the difference is not significant, representing an improvement of less than 1%.

Table 6-16. Frequency, duration and severity of locally triggered water use cutbacks in WRA 2.

Scenario	Frequency	Duration	Severity
ECB	2	16	16
FWO	2	16	16
Recommended Plan	2	16	16

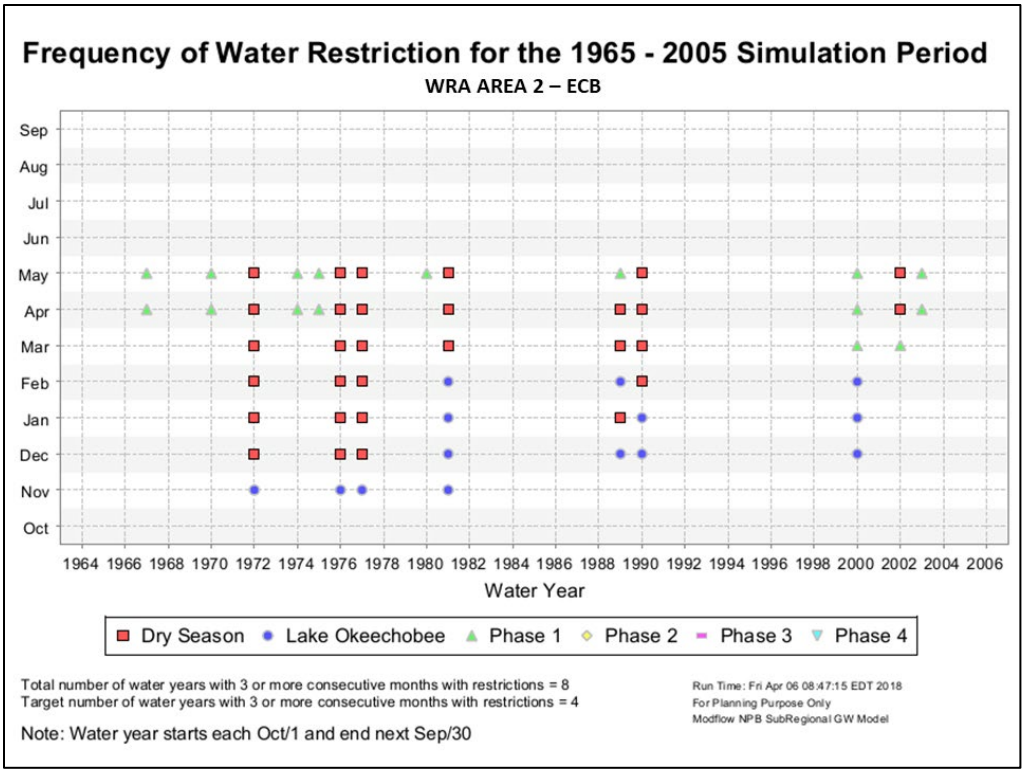


Figure 6-14. Locally triggered water restrictions in WRA 2 during the ECB simulation.

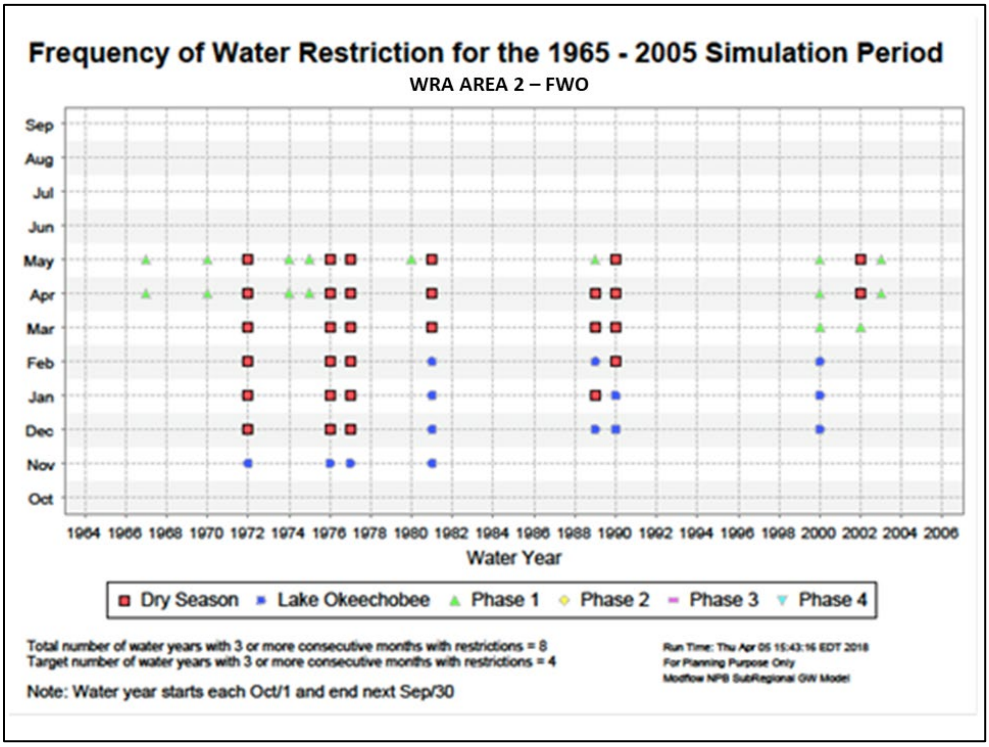


Figure 6-15. Locally triggered water restrictions in WRA 2 during the FWO simulation.

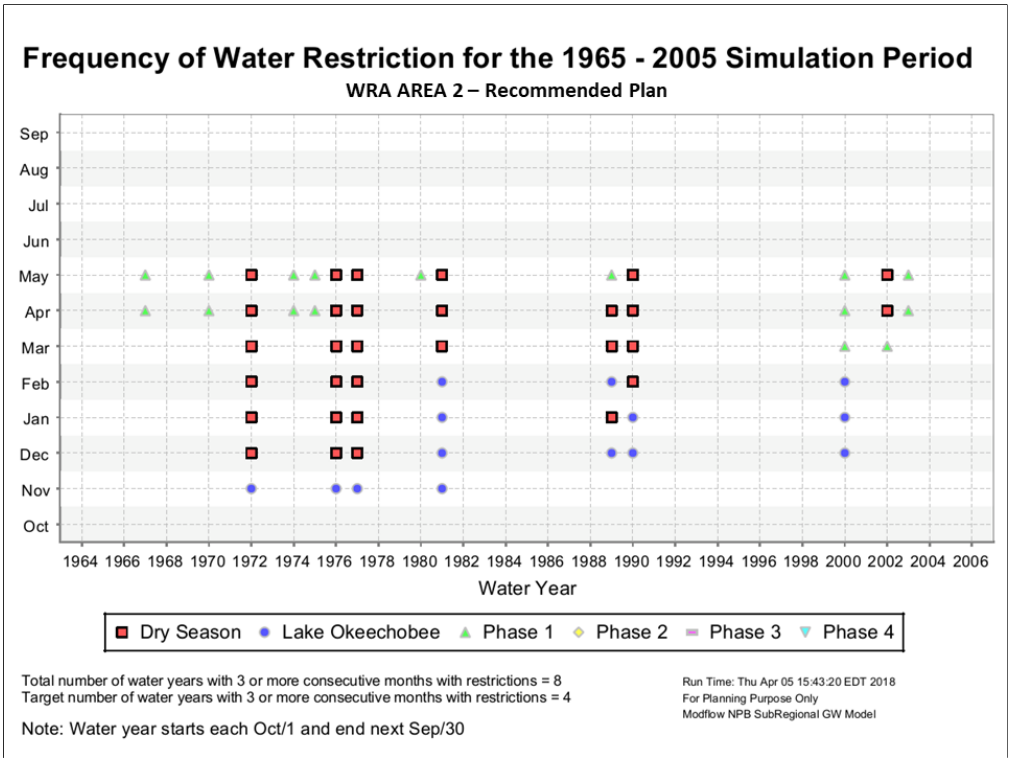


Figure 6-16. Locally triggered water restrictions in WRA 2 during the Recommended Plan simulation.

Table 6-17. Million gallons of demand not met due to water restrictions for all use categories in WRA 2 for the ECB, FWO and Recommended Plan for the period of record 1965-2005.

Alt \ Type*	ASR	PWS	LAN	GOL	NUR	AGR-FL	AGI-OH	AG2-LV	IND
ECB	0	4,438	0	51	0	0	0	0	0
FWO	0	4,419	0	51	0	0	0	0	0
Recommended Plan	0	4,417	0	51	0	0	0	0	0

* The demands not met are categorized according to use: Aquifer Storage and Recovery (ASR), Public Water Supply (PWS), Golf Irrigation (GOL), Nursery Irrigation (NUR), Agricultural – Flood Irrigation (AG1-FL), Agricultural – Overhead Irrigation (AG1-OH), Agricultural- Low Volume Irrigation (AG2-LV) and Industrial (IND).

6.8.5 Effects on Tribal Compact

There is no Tribal Compact affected by or applicable to the LRWRP project study area.

6.8.6 Identification of Water Made Available for the Natural System and Other Water Related Needs

The identification of water for the natural system captures the quantity, timing, and distribution of water. Hydrologic model data extracted from the LECSR-NP simulations were used to develop the volume probability curves at five locations in the regional system: C-18W Reservoir outflows to C-18W Canal, inflows to Loxahatchee Slough over G-161, flows over Lainhart Dam, flows from ITID to the C-18W Reservoir and M-1 Pump Station flows to the M Canal. These locations represent the additional inflows where ecosystem benefits (habitat units) are expected as a result of implementation of the Recommended Plan. The difference between FWO and Recommended Plan average annual volumes delivered from each of these sources was calculated, then sorted (high to low) to generate the probabilities at the 10th, 50th, and 90th percentiles as well as exceedance curves that represent a variety of meteorological conditions. See **Figure 6-17**.

The WRDA 2000 Project Assurance requirements are fulfilled by identifying the water for the natural system as shown in **Figure 6-17** and **Table 6-18.** The quantity, timing, and distribution of water are identified at five locations: C-18W Reservoir outflows to the C-18W Canal, inflows to Loxahatchee Slough over G-161, flows over Lainhart Dam, flows from ITID to the C-18W Reservoir and M-1 Pump Station flows to the M Canal. Additional inflows where ecosystem benefits (habitat units) are expected as a result of implementation of the Recommended Plan at these five locations. The SFWMD will protect the water made available by the LRWRP project features using its reservation or allocation authority as required by Section 373.470, Florida Statutes. Protection of water made available by LRWRP project features is required prior to the SFWMD and the Department of the Army entering into one or more project partnership agreements (PPA) to construct the LRWRP project features.

In 2007, the SFWMD protected the pre-project water for the natural system through the Restricted Allocation Area Rule (RAA) for the Everglades and North Palm Beach/Loxahatchee River Watershed water bodies. The RAA is part of the Minimum Flows and Level recovery strategy for the Northwest Fork of the Loxahatchee River. It includes surface water and groundwater from the Grassy Waters Preserve, Pal-Mar property, J.W. Corbett Wildlife Management Area, Hungryland Slough Natural Area, Loxahatchee Slough, Loxahatchee River, Riverbend Park, Dupuis Reserve, Jonathan Dickinson State Park, Kitching Creek, Moonshine Creek, Cypress Creek, Hobe Grove Ditch, and the integrated conveyance systems that are hydraulically connected to and receive water from these areas, such as the C&SF Project primary, secondary and tertiary canals.

On a monthly basis, net increases in the volume or changes in timing of direct surface water and indirect groundwater withdrawals from the RAA are prohibited over that resulting from base condition uses that were permitted as of April 1, 2006. Allocations over the base condition water use are only allowed through sources detailed in Subsection 3.2.1.E.5 of the Applicant's Handbook (SFWMD 2015), such as certified project water, implementation of offsets, alternative water supply, terminated or reduced base condition water use that existed as of April 1, 2006, or available wet season water.

The combination of protecting the pre-project existing water and the water made available by LRWRP project features is needed for LRWRP to achieve its intended benefits. **Table 6-18** below summarizes the average annual water (acre-feet) made available by the project for the natural system. The values in the table represent the difference between the Recommended Plan and the FWO.

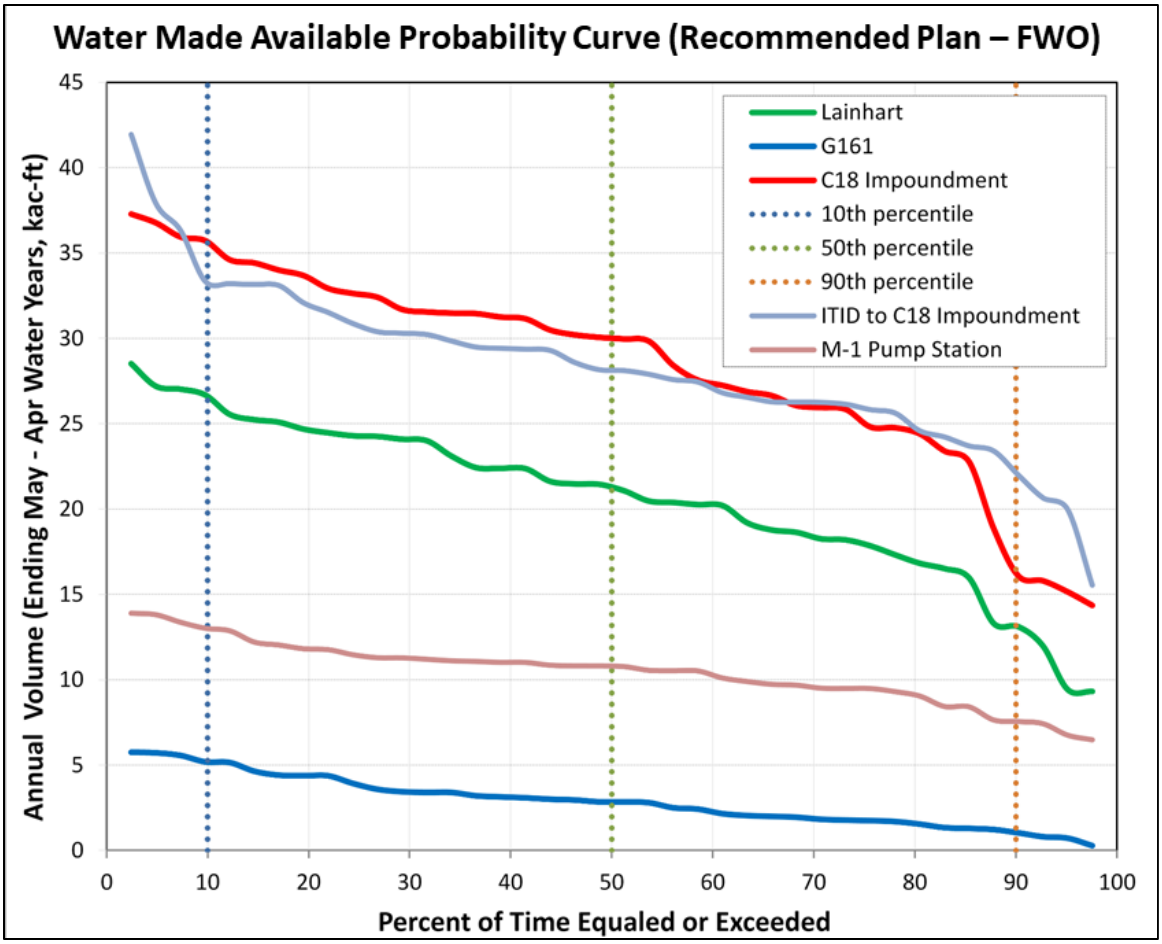


Figure 6-17. Exceedance Curve of average annual water (1,000 ac-ft) made available by the project for the natural system.

Table 6-18. Average annual water (1,000 ac-ft) made available by the project for the natural system.

Location	equaled or exceeded 10% of the time	equaled or exceeded 50% of the time	equaled or exceeded 90% of the time
Lainhart Dam	26.7	21.5	13.1
C-18W Reservoir	35.7	30.1	16.1
G-161	5.2	2.9	1.03
ITID to C-18W Reservoir	33.4	28.2	22.0
M-1 Pump Station to M Canal	13.0	10.8	7.6

6.9 Project Concerns

Many agency stakeholders requested more outputs during the LRWRP study. There were requests for more water supply, less residential flooding, more water for the Loxahatchee River, and more acres of

wetland restoration. The LRWRP Recommended Plan represents a balance of these outputs in consideration of USACE policy requirements and limitations on study schedule and study cost.

The LRWRP Recommended Plan does not preclude additional water resources projects in the future. The LRWRP Recommended Plan is part of an incremental adaptive restoration process for CERP. LRWRP incorporates portions of two of the 68 components of CERP – the L-8 Project (Component K) and the Pal-Mar and J.W. Corbett WMA Hydropattern Restoration (Other Project Element (OPE)). Implementation of LRWRP does not preclude further study and implementation of other portions of the L-8 Project or Pal-Mar Corbett OPE. Additionally, LRWRP does not preclude the other CERP components proposed for northern Palm Beach County and southern Martin County – a 48,000 ac-ft above ground/in ground reservoir (Component GGG), C-17 Backpumping and Treatment (Component X), C-51 Backpumping and Treatment (Component Y), C-51 Regional Groundwater ASR (Component LL), and Palm Beach County Agricultural Reserve Reservoir and ASR (Component VV).

6.10 Risk and Uncertainty

Issues of risk and uncertainty are inherent in the planning, design and implementation of the Recommended Plan. An overview of feasibility, forecasting, and implementation issues is presented in this section. The role of LRWRP's adaptive management strategies in addressing risk and uncertainty is discussed in the following sections and can be reviewed in more detail in the LRWRP AM Plan (Annex D). Monitoring and adaptive management strategies will continue to evaluate and address issues pertaining to construction sequencing, ecosystem connectivity, and potential for early restoration benefits. Such evaluations will continue to reduce uncertainties and increase the likelihood for overall project success.

6.10.1 Planning

Hydrologic Simulation Tools: The LECSR-NP model was approved as "Allowed for Use" only by the USACE-Jacksonville District through the current USACE Engineering software validation process. The validation reviews were conducted by qualified senior USACE engineers with support from technical experts, and USACE approval indicates that that software is technically/theoretically sound and approved for use by knowledgeable and trained staff for purposes consistent with the software's purposes and limitations. The modeling tool was used to evaluate the effects of the final array of alternatives.

Model building/generic software tools (Excel, etc.) are generally allowed for use under the validation process, but these tools are not pre-validated and additional USACE Agency Technical Review (ATR) of the inner workings of the model is required. ATR is conducted by a qualified senior team from separate USACE Districts not involved in the project.

The LRWRP modeling strategy identified these tools as the best models available for assessment of the hydrologic effects of LRWRP. Additional information on the USACE model review process and the LRWRP modeling strategy is provided in Appendix A.

Ecological Response and Project Benefits: There is no standardized methodology for predicting ecosystem benefits that result from habitat restoration projects. The LRWRP team prepared a planning model that uses peer reviewed performance measures and the LECSR-NP model to predict ecological responses in the watershed. The LRWRP planning model underwent peer review per EC 1105-2-412, March 31, 2011, "Assuring Quality of Planning Models," and was approved for single use by the USACE National Ecosystem Restoration Planning Center of Expertise on August 26, 2016.

Project Cost Estimates: The construction cost estimates in the final PIR/EIS are based on feasibility level engineering analysis and design. A sophisticated cost and schedule risk analysis was used to estimate cost contingencies. During PED and before award of construction contracts, the PDT will perform additional design and further refine the cost estimates.

Climate Change: Although the magnitude of the effects of climate change, including rising sea levels, temperature changes, and changing rainfall patterns is uncertain, it is generally acknowledged that climate change will affect both natural system and human environmental conditions in south Florida during the next century. Although the CERP was formulated in 1999 without the benefit of the current level of understanding about possible climate change effects, scientists and agency water managers agree that implementation of the plan will provide an important adaptation response for both the natural system and the human environment considering future climate change scenarios. Sea level change and stream flow trends were analyzed in Appendix H. The quantitative analysis of three USACE sea level change scenarios showed that ecosystem benefits in the river, estuary, and floodplain are not greatly reduced by higher sea level change scenarios. Most of the existing and all of the proposed structures likely would be unaffected under the high sea level change scenario for the 100 year analysis. If sea level rises faster than the USACE high rate curve or if the high rate curve is combined with extreme water events, then adverse effects to ecosystem benefits or to structure performance may occur.

6.10.2 Design and Construction

Project Schedules: Implementation of LRWRP will occur over many years and will include many actions by USACE and SFWMD. There is extensive uncertainty regarding when construction will commence and complete; they are influenced by funding, legal requirements, permitting, and authorization among other factors. USACE and SFWMD may consider entering Pre-Partnership Credit Agreements which would allow SFWMD to perform work early yet maintain the potential to receive credit for the work in a subsequent Project Partnership Agreement for construction of features.

Reservoir Design Standards: Because the C-18W Reservoir is above ground and the proposed location is directly north of a residential community, stricter and more robust design criteria are required, as outlined in the Design Criteria Memorandum 2: DCM-2 (SFWMD 2006). Therefore the highest, most current standards in design and construction are being used for the reservoir, as well as additional guidelines regarding a regular inspection program and emergency action plan that will be followed once the reservoir is constructed.

The C-18W reservoir will impound water for months at a time during each wet season, and will serve as a basin for ASR recharge and recovery water supply. The C-18W reservoir embankment is considered a dam according to criteria in USACE Engineering Regulation 1110-2-1156 based on total water volume impounded at full pool and duration of hydraulic loading. The proposed dam is considered a high-hazard facility according to ER 1110-2-1156 and Design Criteria Memorandum 1 (Hazard Potential Classification) due to the potential for life loss if the facility were to fail. A Potential Failure Mode Analysis and Qualitative Risk Assessment was completed in July 2019 for the C-18W Reservoir. The Qualitative Risk Assessment process synthesized results from the seepage analysis, dam breach analysis, foundation characteristics, wind set-up and wave run-up analyses to identify potential embankment failure modes, their locations, and the consequences of an embankment failure to adjacent communities and infrastructure.

The reservoir will be relatively shallow, with Normal Full Storage Level on the order of 7.5 feet in depth. Modeling results show that flooding from breach along the southern embankment, at Normal Full Storage

Level would be shallow, and generally less than 2 ft deep in the developed areas to the south of the reservoir site. Although residential areas and roadways could be flooded from a breach, most of the structures would not be flooded because the slightly elevated building pads keep them above the flood elevation. Modeling results show that flooding from a breach along the eastern embankment at Normal Full Storage Level would inundate only low lying depressional wetland areas adjacent to the future development. Assuming the project continues to be designed and constructed in accordance with current state of the practice for Dam Safety, this project is expected to have a low annual probability of failure and incremental risk below the societal tolerable risk threshold (as defined in ER 1110-2-1156). More details of the Potential Failure Mode Analysis and Qualitative Risk Assessment are summarized in PIR-EIS Appendix A. Engineering, Section A.2.1 Dam Safety Considerations.

Cultural Resources: Due to limited access of privately-owned lands and budget constraints during the PIR phase, cultural resources investigations have been limited to a literature search and records review for known archaeological sites and Phase I investigations on publicly owned lands. Background research and the presence of previously identified archaeological sites indicates that additional sites may be located in Moonshine Creek and Gulfstream East restoration areas, Gulfstream West, and in other construction areas not previously surveyed for cultural resources. The Recommended Plan will be subject to supplementary Phase I cultural resources surveys and each suite of features will be subject to separate consultation and consideration of effects during preconstruction engineering and design. The identification of additional and potentially significant archaeological sites may also lead to longer implementation schedules as avoidance, minimization, and/or mitigation plans are developed. USACE has coordinated a Programmatic Agreement with Florida SHPO and the Advisory Council on Historic Preservation (ACHP) to conduct a phased identification and evaluation of historic properties during the project's design phase. Pursuant to Section 106 of the National Historic Preservation Act (54 U.S.C. 306108) and its implementing regulations (36 CFR 800), where possible, the project design will be modified to avoid affecting significant historic properties and culturally significant sites. Where avoidance is not possible, minimization and/or mitigation measures will be considered. Future mitigation measures will be developed during the preconstruction engineering and design phase in consultation with the SHPO, tribal groups, and other interested parties as established in implementing regulations for Section 106 of the National Historic Preservation Act.

TABLE OF CONTENTS

7 ENVIRONMENTAL COMPLIANCE 1
7.1 Public Involvement 1
7.1.1 Scoping 1
7.1.2 Agency Coordination and Public Involvement 1
7.1.3 Draft Project Implementation Report and Environmental Impact Statement. 2
7.1.4 Comments and Responses 2
7.1.5 Statement Recipients 2
7.2 Compliance with Environmental Laws, Statutes, and Executive Orders 2
7.3 Compliance with USACE CERP Agricultural Chemical Policy 11
7.3.1 Residual Agricultural Chemicals 11
7.4 Compliance with Florida Statutes 12
7.4.1 Permits, Entitlements and Certifications 12
7.4.2 Compliance with Applicable Water Quality Standards and Permitting Requirements 13

TABLES

Table 7-1: Compliance with environmental laws, regulations, and executive orders: Recommended Plan 3
Table 7-2. Total Phosphorus Concentrations and Loads for ECB, FWO and Alternative 5R. 14
Table 7-3. Total Nitrogen Concentrations and Loads for ECB, FWO and Alternative 5R. 14

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7 ENVIRONMENTAL COMPLIANCE

The Environmental Compliance section describes how the LRWRP project is in compliance with applicable Acts, Executive Orders, and Memoranda of Agreement.

7.1 Public Involvement

7.1.1 Scoping

A National Environmental Policy Act (NEPA) scoping letter dated January 6, 2015 was used to invite comments from federal, state, and local agencies, affected Indian tribes, and other interested private organizations and individuals. Scoping comments were accepted through February 8, 2015. A Notice of Intent (NOI) to prepare an Environmental Impact Statement (EIS) for the Loxahatchee River Watershed Restoration Project (LRWRP) was published in the Federal Register (FR Volume 80, Number 5) January 8, 2015. Public scoping meetings were held January 12, 2015 in Stuart, Florida. A copy of the scoping letter, NOI, scoping letters received and a comment response matrix are located in **Appendix C.3**. Twelve Project Delivery Team (PDT) meetings that were open to the public were held from 2014 to 2018 to receive feedback on project scope, plan formulation including identification of the final array of alternatives, and input on the evaluation and selection of a tentative restoration plan.

7.1.2 Agency Coordination and Public Involvement

PDT membership consisted of those individuals designated by the U.S. Army Corps of Engineers (USACE) and the South Florida Water Management District (SFWMD), the implementing agencies, and representatives designated by other governmental agencies or tribes. Interagency participation was encouraged to take advantage of technical skills and knowledge of other agencies. Federal agency participants included the United States Environmental Protection Agency (USEPA), Unites States Fish and Wildlife Service (USFWS), United States Geological Survey (USGS), and National Park Service (NPS). Tribal participants included the Miccosukee Tribe of Indians of Florida and Seminole Tribe of Florida. State agency participants included the Florida Fish and Wildlife Conservation Commission (FWC), Florida Department of Agriculture and Consumer Services (FDACS), Florida Department of Transportation (FDOT), Florida Department of State (FDOS), and Florida Department of Environmental Protection (FDEP). Local participants included Martin and Palm Beach counties, the City of West Palm Beach, the Town of Jupiter, the Loxahatchee River District (LRD), and the Indian Trail Improvement District (ITID). Designated public comment periods provided opportunities for public participation during PDT meetings.

Public outreach efforts for LRWRP began early in the planning process. There is widespread public, political, and media interest in the restoration of the Loxahatchee River ecosystem, therefore, public participation was a critical component of the development of this Project Implementation Report (PIR). Workshops were held at key phases of the LRWRP planning process during the formulation of project objectives, management measures, and evaluation of alternatives.

Presentations were provided to SFWMD Governing Board, SFWMD Water Resources Analysis Coalition (WRAC) (formerly known as Water Resources Advisory Committee and now known as Water Resources Accountability and Collaboration Forum), Loxahatchee River Management Coordinating Council (LRMCC), and Committee on Independent Scientific Review of Everglades Restoration Progress (CISRERP).

In addition to NEPA, coordination with agencies as required by other federal laws, statues, and executive orders was conducted. At the beginning of the planning process, in September 2016, the USACE invited SFWMD, the local sponsor, FDEP, FWC, Martin County, and Palm Beach County to be cooperating agencies under NEPA for the LRWRP. The USACE sent Government-to-Government letters of invitation to be cooperating agencies under NEPA to the Seminole Tribe of Florida and the Miccosukee Tribe of Indians of Florida on October 6, 2016. The agencies provided verbal acceptance of cooperating agency status. The tribes did not accept cooperating agency status, and did not provide comments on the draft PIR/EIS. Copies of the letters requesting cooperating agency status are located in Appendix C.3, Section C.3.2.2. See **Appendix C.3** for other agency coordination with the FDEP, National Marine Fisheries Service (NMFS), State Historic Preservation Officer (SHPO), United States Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS), and USFWS. Meetings were also held individually with representatives of the Miccosukee Tribe of Indians of Florida and the Seminole Tribe of Florida, but no written comments were received (**Appendix C.5**).

7.1.3 Draft Project Implementation Report and Environmental Impact Statement

The LRWRP Draft Project Implementation Report and Environmental Impact Statement (PIR/EIS) Notice of Availability (NOA) was published in the Federal Register on March 22, 2019, and mailed to interested stakeholders to begin a 45-day review period. The Draft PIR/EIS was filed in accordance with ER-FRL-8994-7, Amended Environmental Impact Statement Filing System Guidance for Implementing 40 CFR 1506.9, and 1506.10 of the Council on Environmental Quality's Regulations Implementing the NEPA, and made available for public and agency review. Two NEPA Draft PIR/EIS public meetings were held; the first on April 18, 2019 in Jupiter, Martin County, and the second on April 19, 2019 in West Palm Beach, Palm Beach County, Florida. A copy of the NOA is located in **Appendix C.3**.

7.1.4 Comments and Responses

A comment response matrix detailing comments received during the NEPA scoping process and other public comments received during the planning process along with USACE responses are included within **Appendix C.3**; **Table C.3-1.1**.

7.1.5 Statement Recipients

Copies of the January 6, 2015 scoping letter and NOA of the Draft PIR/EIS and this document were mailed to the parties listed in **Table C.3.3-1** in **Appendix C.3**. Recipients included federal, state, and local agencies, affected Indian tribes, and other interested private organizations and individuals. A complete mailing list is available upon request. A copy of the Draft PIR/EIS and this document was posted to the USACE Jacksonville District website for Environmental Documents, under the Multiple Counties heading, at the following address:

> https://www.saj.usace.army.mil/About/Divisions-Offices/Planning/Environmental-Branch/Environmental-Documents/

7.2 Compliance with Environmental Laws, Statutes, and Executive Orders

Table 7-1 provides a summary of environmental compliance with each relevant federal act, executive order (E.O.), and other applicable environmental laws. Detailed descriptions indicating the coordination completed to date and the status of any ongoing or compliance issues are located in **Appendix C.4**.

Table 7-1: Compliance with environmental laws, regulations, and executive orders: Recommended Plan.

Law, Policies and Regulations	Status	Comments
Anadromous Fish Conservation Act	In compliance with this Act.	Proposed action would not adversely affect anadromous fish species.
Archaeological Resources Protection Act of 1979	In compliance with this Act.	Further investigations may be needed within federally-owned lands (once the project is authorized and the Preconstruction, Engineering and Design (PED) phase has started. USACE will comply with this Act.
American Indian Religious Freedom Act	In compliance with this Act.	The policy of the U.S. on and after August 11, 1978, is to protect and preserve for American Indians, Alaska Native Groups (Eskimo, Aleut), and Native Hawaiians, their inherent right of freedom to believe, express, and exercise traditional religions, including but not limited to access to sites, use and possession of sacred objects, and the freedom to worship through ceremonials and traditional rites. (Pub. L. 95–341, § 1, Aug. 11, 1978, 92 Stat. 469.)
Bald and Golden Eagle Protection Act	In compliance with this Act.	Proposed action would not adversely affect the bald eagle (the resident eagle in Florida). The project will implement the National Bald Eagle Management Guidelines (USFWS 2007) as applicable.
Clean Air Act of 1972	In compliance with this Act; required permits to be obtained.	Potential for temporary air quality impacts associated with construction emissions and dust. The proposed project is not located within a "non-attainment" area since there are none in southeast Florida. The only new potential sources of air pollution as a result of this project would be from temporary discharges from machinery during construction and construction and the operation of pump station(s). Contractors will implement BMP's to limit temporary impacts. Pursuant to sub-subparagraph 62-210.300(3)(a)(21.b., operations staff must determine if stations are exempt from air permitting or if an air general permit is required. Upon such determinations, the project will comply with this Act.
Clean Water Act of 1972	In compliance with this Act; will obtain Water Quality Certification (WQC) from the State of Florida and any required National Pollutant Discharge Elimination System (NPDES) permits.	In accordance with the Clean Water Act, a Section 404(b)(1) Evaluation has been completed and is contained within **Appendix C.4, Section C.4.32**. State of Florida Department of Environmental Protection is in support of the plan (May 1, 2019). Comprehensive Everglades Restoration Plan Regulation Act (CERPRA) permit would be sought from State of Florida for Water Quality Certification for the whole project during pre-construction design and engineering. In addition, the Corps will seek an NPDES permit if required for ASR.

Law, Policies and Regulations	Status	Comments
Coastal Barrier Resources Act of 1982 and Coastal Barrier Improvement Act of 1990	In compliance with these Acts.	The official Coastal Barrier Resources System (CBRS) maps were reviewed and the LRWRP project does not fall into any designated CBRS areas. The proposed project would not affect the nearest area "Otherwise Protected Area Jupiter Beach (CBRS Unit FL-16P)", at the mouth of the Jupiter Inlet; therefore, there are no designated coastal barrier resources in the project area that would be affected by this project.
Coastal Zone Management Act of 1972	In compliance with this Act; Consistency Determination was issued by the State of Florida.	Florida Coastal Zone Consistency Determination was prepared in accordance with the provisions of 15 CFR 930 and is located in **Appendix C.4, Section C.4.32**. The USACE has determined that the proposed action is consistent to the maximum extent practicable with the enforceable policies of Florida's approved Coastal Zone management program. Coastal Zone Management Act consistency for the Draft PIR/EIS was provided by the Florida State Clearinghouse (Florida Department of Environmental Protection, 5/17/2019): "Based on the information submitted and minimal project impacts, the state has no objections to the subject project and, therefore, it is consistent with the Florida Coastal Management Program (FCMP)." Final Coastal Zone Management Act consistency will be provided by the Florida State Clearinghouse concurrent with their review of the Final PIR/EIS (Chris Stahl, Florida State Clearinghouse Coordinator, personal communication, January 24, 2020).
Endangered Species Act of 1973	In compliance with this Act; consulting with NMFS and USFWS as appropriate.	The USACE requested concurrence from the USFWS on federally listed species and critical habitat that may be present in the project area on March 16, 2017. The USFWS provided concurrence on the species list on April 20, 2017. The USACE provided a BA to USFWS to initiate consultation for potential project effects to T&E species with the USFWS in March 2019. The USFWS provided a draft BO on July 29, 2019, and a final BO on November 12, 2019 (**Annex A – Biological Assessment, Biological Opinion**). The USFWS concurred with the Corps' determinations that the project: may affect but is unlikely to jeopardize the existence of the eastern indigo snake; may affect but is unlikely to adversely affect the threatened Audubon's crested caracara, endangered Everglade snail kite, endangered Florida bonneted bat, threatened West Indian manatee and its critical habitat, and threatened wood stork. The USACE determined that the project will have no effect on Florida panther, red-cockaded woodpecker, and Okeechobee gourd. The USFWS did not propose any conservation measures for eastern indigo snake.

Law, Policies and Regulations	Status	Comments
		A programmatic Endangered Species Act Section 7 consultation for the Comprehensive Everglades Restoration Plan (CERP) was prepared on March 15, 2013 to evaluate potential effects of CERP on listed species and designated critical habitat under the NMFS' purview. The Corps provided a Programmatic Biological Assessment for the Comprehensive Everglades Restoration Plan to NMFS on 2 July 2013. NMFS provided a Programmatic Biological Opinion for the Comprehensive Everglades Restoration Plan to the Corps on 17 December 2013.
Estuary Protection Act of 1968	In compliance with this Act.	The proposed action provides the opportunity to redirect water that is currently discharged via the SFWMD canal infrastructure to improve the quantity and seasonal timing to the NWFLR, thus reducing salinity in the river reach, increasing the distribution and quantity of tapegrass, improving floodplain hydrology, increasing the area of available manatee habitat, and expanding suitable oyster and sea grass habitat that benefit water quality and habitat functions within the Loxahatchee estuary.
Farmland Protection Policy Act of 1981	In compliance with this Act.	USACE coordinated with USDA/NRCS to meet the requirements of the Farmland Protection Act and received a determination on 11/15/2018 from NRCS indicating that restoring wetlands will not affect acreages of agricultural land, particularly grazable pasture; only the reservoir will result in farmland loss. NRCS will update their determination of acres of unique farmland that would be affected by the project when detailed design information for each plan component is available.
Federal Water Project Recreation Act/Land and Water Conservation Fund Act	In compliance with this Act.	Effects of the proposed action on outdoor recreation have been considered in **Section 5.2.15.3** and **Appendix C.2.15**. Recreational opportunities have been considered and the proposed action would not adversely affect existing recreational opportunities.
Fish and Wildlife Coordination Act of 1958, as amended	In compliance with this Act.	The USACE coordinated with USFWS throughout the project planning. USFWS participated on PDT to provide information on fish and wildlife elements on project. The USFWS provided a final Fish and Wildlife Coordination Act (FWCA) Report on January 24, 2020, included in **Annex A**. The Corps' responses to the FWCA Report recommendations are included in the Final PIR/EIS in **Annex A.3**.
Magnuson-Stevens Fishery Conservation and Management Act	In compliance with this Act.	An Essential Fish Habitat (EFH) assessment was covered by the Programmatic NMFS NEPA consultation (**Appendix C.2.7**). To document compliance, the USACE provided a letter that includes the EFH assessment to NMFS with the Notice of

Law, Policies and Regulations	Status	Comments
		Availability of the DEIS. USACE will implement relevant recommendations of the programmatic consultation.
Marine Mammal Protection Act of 1972	In compliance with this Act upon review of this PIR/EIS by USFWS.	Project construction sites would be isolated from West Indian manatees to limit access and avoid incidental take of manatees. USACE will implement standard manatee construction conditions, where necessary, to protect manatees during construction. No take of manatees is anticipated.
Marine Protection, Research and Sanctuaries Act	This Act is not applicable.	Proposed action does not consider ocean disposal of dredged material.
Migratory Bird Treaty Act of 1918	In compliance with this Act.	Consistent with the Migratory Bird Treaty Act, migratory bird surveys will be conducted prior and during construction to provide measures to avoid impacts to migratory birds nesting or foraging near project construction sites. The specifications and plans will include requirements for the Contractor to implement an Environmental Protection Plan to ensure compliance with this Act.
National Environmental Policy Act of 1969	In compliance with this Act upon public and agency review of this document, preparation of Final EIS and signing of Record of Decision.	Initial public coordination for this project began with the distribution of a scoping letter dated January 6, 2015 announcing the preparation of the Draft EIS and inviting public and agency comment (**Appendix C.3**). On January 8, 2016, a NOI to prepare an EIS was published in the Federal Register (FR Volume 80, Number 5). Public scoping meetings were held on January 12, 2015. The NOA of the LRWRP Draft PIR/EIS was published in the Federal Register on March 22, 2019, and mailed to interested stakeholders to begin the 45-day review period. Two NEPA Draft PIR/EIS public meetings were held on April 18 and 19, 2019 in Jupiter and West Palm Beach, Florida.
National Historic Preservation Act of 1966	The Corps has coordinated a Programmatic Agreement with Florida SHPO and the Advisory Council on Historic Preservation to conduct a phased identification and evaluation of historic properties during the project's design phase and prior to conclusion of NEPA. Dependent on further consultation with the Florida SHPO and the results of Phase I cultural resources investigations, project design modification may be necessary to avoid	The Corps has decided to comply with Section 106 of the NHPA through the execution and implementation of a Programmatic Agreement, as described in 36 C.F.R. § 800.14(b). Section 106 of the National Historic Preservation Act allows for a phased approach to compliance with this Act. Once the project is authorized and PED is implemented, further investigations and consultation will be conducted as necessary. Each suite of features will be consulted on as they arise to ensure that the most up to date information will be considered in the subsequent determination of effects. Consultation was initiated and is ongoing with the Florida SHPO and the appropriate federally-recognized tribes pursuant to the Act.

Law, Policies and Regulations	Status	Comments
	or minimize impact to historic properties. Phase II National Register of Historic Places eligibility testing or mitigation may be required if impacts cannot be avoided.	
Native American Graves Protection and Repatriation Act	In compliance with this Act.	This Act applies to federally owned lands, including reservation lands. Human remains and/or funerary objects were not recovered during excavations on federally owned or managed lands during the course of this feasibility study. Should inadvertent discoveries of human remains or burial resources occur during PED or construction phases of the LRWRP, guidelines pursuant to Florida Statute §872.02 and §267.031 will be followed. Ground disturbing activities will not occur on Reservation Lands. Neither human remains nor funerary objects were recovered during excavations on federally owned or managed lands during the course of this feasibility study.
Resource Conservation and Recovery Act, as Amended by the Hazardous and Soils Waste Amendments of 1984; CERCLA as Amended by the 5.26.21 Superfund Amendments and Reauthorization Act of 1996; Toxic Substances Control Act of 1976.	Phase 1 and Phase 2 environmental site assessments were conducted on lands that have been acquired for this project by the SFWMD. These assessments have identified the extent and type of contaminants of concern and those will be remediated prior to execution of the project and before the lands are certified for use.	FDEP is the responsible authority, delegated by EPA, for human health issues related to soil and water contamination. The SFWMD will obtain concurrence of the FDEP waste cleanup group that any remediation activity has been satisfactorily completed. USFWS is the authority with regards to ecological risk with regards to soil and water conditions. The SFWMD will also obtain the concurrence of the USFWS that the project lands are suitable for intended use. The concurrence from these two agencies will constitute documentation that the project lands are suitable for intended use with regards to the Resource Conservation and Recovery Act, as amended by the Hazardous and Soils Waste Amendments of 1984; CERCLA as amended by the 5.26.21 Superfund Amendments and Reauthorization Act of 1996; and the Toxic Substances Control Act of 1976.
Rivers and Harbors Act of 1899	In compliance with this Act.	Proposed action would not obstruct navigable waters of the United States.
Submerged Lands of 1953	In compliance with this Act.	The proposed project would increase freshwater flows to the Loxahatchee Estuary and provide freshwater overland flow to Loxahatchee River that will ultimately benefit the ecological habitats that occur on submerged lands of the State of Florida. The proposed project does not occur on submerged lands and no construction is expected on submerged lands.
Wild and Scenic River Act of 1968	In compliance with this Act.	The NWFLR is a designated wild and scenic river and is the beneficiary of the project.

Law, Policies and Regulations	Status	Comments
E.O. 11514, Protection of the Environment.	In compliance with this E.O.	The objectives of the proposed action are focused on environmental protection.
E.O. 11593 Protection and Enhancement of the Cultural Environment	In compliance with this E.O.	The purpose of this E.O. has been incorporated in Section 110 of the National Historic Preservation Act. Consultation is ongoing to ensure compliance for this E.O.
E.O. 11988 **Flood Plain Management**	In compliance with this E.O.	The purpose of this E.O. is to discourage federally-induced development of floodplains. Commitment of lands to restoration precludes such development.
E.O. 11990 **Protection of Wetlands**	In compliance with this E.O.	The objectives of the proposed action are focused on environmental protection and, as required by the E.O., will "minimize the destruction, loss or degradation of wetlands, and preserve and enhance the natural and beneficial values of wetlands."
E.O. 12962, Recreational Fisheries	In compliance with this E.O.	Proposed action would have a beneficial effect on recreational fisheries in Loxahatchee river and estuary.
E.O. 12898 Environmental Justice	In compliance with this E.O.	LRWRP does not present any environmental impacts that are high, adverse, and disproportionate to low income, or minority populations. Sufficient scoping and public participation ensured potential impacts were understood by the public. No comments were presented as possible environmental impacts that may be disproportionate to low income or minority populations.
E.O 13007 Indian Sacred Sites	This E.O. is not applicable.	This E.O. is directed towards executive branch agencies with statutory or administrative responsibility for the management of federal lands. The proposed action would not affect lands owned by the Department of Defense or managed by the Corps of Engineers Natural Resource Management Program.
E.O. 13045 Protection of Children	In compliance with this E.O.	Proposed action is not expected to have environmental or safety risks that may disproportionately affect children.
E.O. 13089 **Coral Reef Protection**	This E.O. is not applicable	There are no coral reefs within the project area.
E.O. 13122 **Invasive Species**	In compliance with this E.O.	A nuisance and exotic vegetation control plan has been prepared to prevent or reduce establishment of invasive and non-native species within the project area. The control plan is located in **Annex G**.
E.O. 13175 Consultation and Coordination with Indian Tribal Governments	In compliance with this E.O.	Consultations with members and representatives of the Seminole Tribe of Florida and the Miccosukee Tribe of Indians of Florida have been ongoing. See **Appendix C.3** and **Appendix C.5** for specifics. Pursuant to E.O. 13175, the Corps developed

Law, Policies and Regulations	Status	Comments
		the November 01, 2012 Tribal Policy Memorandum, which dictates federal responsibilities, including Trust Responsibilities, to federally recognized tribes.
E.O. 13186, Responsibilities of Federal Agencies to Protect Migratory Birds	In compliance with this E.O.	Proposed action would not adversely affect migratory bird species. Proposed action is expected to benefit species by improving wetland habitat and increasing the availability of foraging opportunities for many species.
Memorandum on Government to Government Regulations with Native American Tribal Governments	In compliance with this Memorandum.	The USACE has consulted with the Miccosukee Tribe of Indians of Florida and Seminole Tribe of Florida throughout the LRWRP planning process (see **Appendix C.3** and **Appendix C.5**).
FAA Memorandum of Agreement – Aircraft – Wildlife Strike Hazards	In compliance with this Memorandum.	The USACE prepared an analysis of project features relative to NPIAS airports.
Seminole Indian Claims Settlement Act of 1987	This Act is not applicable.	This Act also involves an agreement known as the Water Rights Compact, which specifically defines tribal water rights. The Seminole Tribe of Florida does not have land holdings within the project area. Therefore, this Act is not applicable in this geographic area.

7.3 Compliance with USACE CERP Agricultural Chemical Policy

The USACE HTRW policy (ER 1165-2-132) directs that construction of civil works projects in HTRW-contaminated areas should be avoided where practicable. In September 2011, the Assistant Secretary of the Army for Civil Works (ASA(CW)) provided clarification to this HTRW policy for CERP Projects (Memorandum for Deputy Commanding General for Civil and Emergency Operations, Subject: Comprehensive Everglades Restoration Plan (CERP) – Residual Agricultural Chemicals, Dated September 14, 2011). A copy of this policy is included in **Appendix C.4.42**. If specific criteria are met, this policy memorandum allows residual agrichemicals to remain on project lands and allows the USACE to integrate response actions directly (cost share) into the construction plan. However for this project, the possibility of integrating any corrective actions into the construction efforts has been eliminated and negates the application of the USACE CERP Agricultural Policy and accompanying cost share. Based on LRWRP construction requirements, the SFWMD will assume 100% of any remediation cost required for HTRW or residual agricultural chemical concerns and this remediation will not be part of the construction plan. The SFWMD will be responsible for obtaining written concurrence from the USFWS that the water impoundment areas are acceptable for intended project use with regards to ecosystem risk. The SFWMD will also be responsible for obtaining written concurrence from the Florida Department of Environmental Protection (FDEP) Waste Cleanup Group that all project lands are clear of HTRW and acceptable for intended project use. The USFWS is the final federal authority for endangered species issues/ecosystem risk. The FDEP is the EPA-delegated authority to address HTRW/human health risk. No further federal approvals are needed relative to contamination issues if the local sponsor is the action agent for any remediation activities with no federal cost share for those activities.

7.3.1 Residual Agricultural Chemicals

The LRWRP project feature requires the land conversion from agricultural production to water impoundment areas. The project sites were selected to avoid significant adverse impacts to wetland communities. The avoidance of lands containing residual agricultural chemicals is not practicable. Based upon the cumulative Phase II Environmental Assessment sampling results completed to date, as well as consideration of comparable land use for tracts that have not yet been evaluated, there is indication that limited portions of the Project footprint include soils with residual concentrations of agricultural chemicals as a result of typical application practices. Specifically, the soil sampling conducted for the project area to date has found concentrations of agricultural chemicals including copper, organochlorides, and heavy metals, consistent with legally applied pesticides found in agricultural areas used in production of citrus, vegetables, and livestock. Locations where these constituents were found include cultivated row crop areas and isolated point sources (i.e., cattle dip sites, chemical mix/storage areas, equipment staging areas, and waste disposal areas where burning occurred). Contaminant levels found during these assessments are consistent with soil concentrations found on lands with similar agricultural activities. The constituents to be evaluated as part of the Water Quality Monitoring Plan will be based upon a comprehensive evaluation of the cumulative Phase II Environmental Assessment sampling results of the subject tracts located within the Project footprint. The Water Quality Monitoring Plan (including the constituents to be evaluated) will be reviewed/approved by the USFWS and the FDEP prior to implementation. The water quality monitoring plan in **Annex D** includes a start-up operation sampling event that should be performed at the 30 or 60-day period from inundation, as well as an additional surface water sampling event that should be performed after one year of operations.

Some of LRWRP lands will remain in agricultural production for several years until the LRWRP project features are set for construction at which time the agricultural leases will be terminated. Once farming has ceased on the project lands, an Exit Assessment will be performed to determine the presence of any new potential sources of HTRW since the completion of the previous Phase II ESA, and to verify the concentration of contaminants in the cultivated areas at selected locations. The results of these audits will be provided to the FDEP and USFWS for their review, comment, and concurrence regarding the need for remedial actions if any or provide their final concurrence.

The non-federal sponsor will be 100% responsible for the cost of actions taken due to the presence of residual agricultural chemicals. Any future costs associated with the presence of residual agricultural chemicals at the federal project site will be 100% non-federal sponsor cost and responsibility. The costs for characterization of the project lands in preparation for conducting a response action for the residual agricultural chemicals and removal of soils that are hazardous waste will be included as 100% non-federal sponsor responsibility. The USACE shall not conduct actions to address residual agricultural chemicals for the SFWMD during the operation and maintenance, repair, replacement and rehabilitation (OMRR&R) phase of the project.

7.4 Compliance with Florida Statutes

The State of Florida has enacted several laws pertaining to implementation of CERP projects. These include amendments to Section 373.026 (8), Florida Statutes (F.S.), which establishes a requirement for the SFWMD to submit a report for review and approval by FDEP prior to formal submission of a request for authorization from Congress and prior to receiving an appropriation of State funds for construction and other implementation activities (except the purchase of lands from willing sellers); the enactment of Section 373.1501 F.S., which establishes the intent of the Florida Legislature with respect to CERP and the criteria for FDEP approval and the procedures to be followed by the SFWMD and FDEP for submitting and reviewing requests for approval; the enactment of Section 373.1502 F.S., which establishes permitting requirements and a process for the submittal, review, and issuance of certain regulatory permits for CERP projects; and the enactment of Section 373.470 and Section 373.472 F.S., establishing the "Save Our Everglades Trust Fund," funding and reporting requirements, and procedures for distributions from the trust fund.

The SFWMD's State Compliance Report addressing the criteria for approval listed in Section 373.1501 F.S. is included in **Annex B**. In addition to the above-described statutory requirements, other sections of Chapters 373 (Water Resources) and 403 (Environmental Control) of the F.S. include requirements that may apply to various aspects of CERP project planning and implementation. In particular, Chapter 403 F.S. and the administrative laws adopted in accordance with Chapters 373 and 403 F.S., contain the requirements for facilities that involve the discharge or potential discharge of pollutants to surface and ground waters, and the discharge of air pollutants, including facilities regulated under the Federal Clean Water and Safe Drinking Water Acts and the Federal Clean Air Act. Based on the information contained in this PIR, the recommended plan complies with the applicable provisions of the F.S. A detailed explanation of how the project complies with the applicable requirements for CERP projects contained in the F.S. is included in the final PIR/EIS in **Annex B**.

7.4.1 Permits, Entitlements and Certifications

State of Florida Department of Environmental Protection is in support of the plan (May 1, 2019).

The USACE will obtain WQC prior to advertising any construction contract as part of a Comprehensive Everglades Restoration Plan Regulation Act (CERPRA) permit. Section 402 of the NPDES permits required under the Clean Water Act may be necessary for the construction (non-point source runoff) of project features depending on means and methods of construction. This program has been delegated by the USEPA for implementation to the State of Florida (FDEP). Underground Injection Control (UIC) permits must be acquired for the construction and operational testing of the ASR well system at the C-18W Reservoir. It is likely that an NPDES permit will be required to monitor recovered water quality at the C-18W Reservoir prior to discharge into the C-18W Canal. All required permits and/or modifications to existing permits would be acquired prior to construction activities.

7.4.2 Compliance with Applicable Water Quality Standards and Permitting Requirements

The LRWRP is not expected to significantly affect Loxahatchee River compliance with applicable water quality criteria. Water quality conditions in Loxahatchee River are expected to improve as compared to the FWO project condition because in general the freshwater inflows will be greater and will be more similar to the historic hydrologic pattern before the C&SF project interrupted natural drainage to the NWFLR. Particularly in the Flow-way 3 area, more flow will be via sheet flow rather than direct canal discharges.

The water quality assessment used a spreadsheet analysis of the LECSR-NP modeling of flows, focusing on the three flow-ways and the Loxahatchee River. This tool takes existing conditions for existing sources of water and modifies volumes of water using hydrologic input from the LECSR-NP Model. The Total Phosphorus (TP) and Total Nitrogen (TN) concentrations and loads were calculated based on the estimated concentration of each water input source and adjusted based on assumptions for project features that are known to have water quality improvements (deep storage vs. shallow storage reservoirs). The assumptions made for the water quality evaluation tool are as follows:

- Reservoirs have a retention coefficient of 15% (percent phosphorus retained in reservoir) (Yong et al. 1997, Walker 1987).
- Aquifer Storage Recovery (ASR) has 40% TP removal and 10% TN removal (Vanderzalm et al. 2013).
- Runoff is based on MODFLOW Outputs.
- Shallow impoundment (less than 5’ depth) has a concentration treatment reduction of 20% for TP and 6-10% for TN (DEP 2010, Harper and Baker 2007, Yong et al. 1997, Walker 1987).
- 7% seepage loss in M-Canal reach is observed from historical data.

The primary focus was on the impact of the changed flow on the concentrations and total daily loads of phosphorus and nitrogen at various points within the basins. All alternatives showed a net decrease in phosphorus, both in concentration and load. TP and TN concentrations and loads are summarized in Tables 7-2 and 7-3 for the ECB, FWO and Alt 5R. For TP from FW1 and FW2, Alt 5R slightly improves the condition for the NWFLR, with both concentration and load decreasing. Also for FW1 and FW2, Alt 5R showed a very slight decrease in TN concentration to the NWFLR, with a concurrent slight increase in TN load (2 tons) as a result of additional flow to the NW Fork. It also showed a reduction in TN load (9 tons) to the estuary at S-46 as flows to S-46 are reduced. This is most likely the result of additional water being delivered to the river as opposed to being reflective of new nutrient input. Load reduction to the tributaries via FW3 was not specifically calculated because limited flow data was available for these basins. The expectation is that attenuation and sheet flow will reduce TP and TN flows overall by 15-20% for TP and 5% for TN, if the above assumptions are considered. Overall, the Recommended Plan will slightly improve water quality for the river and estuary.

Table 7-2. Total Phosphorus Concentrations and Loads for ECB, FWO and Alternative 5R.

Site	ECB (ppb)	ECB Load (kg)	FWO (ppb)	FWO Load (kg)	Alt 5R (ppb)	Alt 5R Load (kg)
CS3	92	6,428	92	6,430	76	6,415
C-18W	41	2,226	41	2,294	28	2,279
G-161	10	0	10	0	10	34
G-92	41	3,502	41	3,517	21	2,265
Lainhart Dam	43	5,674	43	5,688	28	4,432
S-46	41	2,326	41	2,326	21	1,006
NWFLR	50*	12,695	50*	12,709	39*	10,607

*Target 54 ppb

Table 7-3. Total Nitrogen Concentrations and Loads for ECB, FWO and Alternative 5R.

Site	ECB (mg/L)	ECB Load (tons)	FWO (mg/L)	FWO Load (tons)	Alt 5R (mg/L)	Alt 5R Load (tons)
G-92	0.92	78	0.92	78	0.87	96
S-46	0.95	53	0.95	53	0.90	44
NWFLR	1.17*	297	1.17	297	1.10	297

*Target 1.20 mg/L

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Table of Contents

8 DISTRICT ENGINEER'S RECOMMENDATIONS 1
8.1 Items of Local Cooperation 2
8.2 Recommendation for Congressional Authorization..... 7

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8 DISTRICT ENGINEER'S RECOMMENDATIONS

The LRWRP will capture, store, and redistribute water currently lost to tide; rehydrate headwater natural areas that have been over-drained; improve timing and distribution of water from the upstream watershed to the freshwater riverine habitats; and reestablish connections among natural areas that have become spatially and/or hydrologically fragmented. The Project will undo some of the unintended adverse ecological changes caused by the C&SF Project and subsequent development, and help restore more natural water deliveries, promote improved health and functionality of wetland and upland areas, and increase the quantity and quality of habitat available for native wildlife and vegetation.

LRWRP includes increments of two of the components of the Comprehensive Everglades Restoration Plan (CERP). Implementation of this Project is expected to be adaptively managed, and to be sequenced to provide increasing benefits as features are completed. This Project does not preclude future increments of CERP in this area.

The Project is integral to achieving restoration in the northeastern part of the Everglades system and contributes to system-wide ecosystem goals and objectives. The Project will restore 27,000 acres of freshwater and estuarine habitat. The restoration actions also improve connectivity over a combined 78,000 acres of natural areas. The Project will deliver 91% of the dry season restoration flows and 98% of the wet season restoration flows to the Northwest Fork of the Loxahatchee River (NWFLR), a National Wild and Scenic River.

I find the LRWRP project, located in Martin and Palm Beach counties, is an integral part of CERP. The LRWRP plan includes:

In the south and southeast (Flow-way 1): a 75 cubic feet per second (cfs) pump station to deliver water from the Indian Trail Improvement District (ITID) M-1 Basin to the M Canal, where the water would be conveyed to Grassy Waters Preserve (GWP); a gated water control structure to convey up to 150 cfs from GWP into a new conveyance swale; a reconfigured shallow swale to convey water from the GWP structure to restore adjacent wetlands and to the C-18 Canal and Loxahatchee Slough; a second water control structure farther north in the C-18 Canal to convey up to 2,000 cfs and be operated to restore Loxahatchee Slough by reducing the rapid drainage of wetlands in the slough.

In the west and southwest (Flow-way 2): a 175 cfs pump station and associated 3,500 feet long connector canal to convey excess water from the ITID upper basin and the M-O Canal toward the perimeter canal of the new storage reservoir; twin gated culverts to convey water from the eastern edge of J.W. Corbett Water Management Area (WMA) toward the perimeter canal of the new storage reservoir; operable culverts under Pratt Whitney Road; a new 9,500 acre-foot C-18W Reservoir with four ASR wells (5 million gallon per day, each) and associated distribution, inlet, and outlet structures to store water conveyed from ITID and J.W. Corbett WMA, and release the water northward into the C-18W Canal to establish a more natural seasonal timing of delivery to the Loxahatchee River.

In the north (Flow-way 3): for Pal-Mar East (Nine Gems), plug the southern perimeter canal and backfill internal drainage canals for restoration, and a new pump station and expanded northern perimeter canal to provide alternate drainage for nearby private lands; approximately 650 acre flow-through marsh, with associated perimeter berm, 150 cfs pump station, outlet structures, and realigned canals; berm improvements and operable water control structures near the western and eastern ends of Cypress Creek

Canal; 20 cfs pump station and 4,900 feet spreader swale extending south from Cypress Creek Canal; fill ditches and restore historic topography of 450 acres of Gulfstream East and Moonshine Creek; weir at eastern end of Hobe Grove Ditch; and a spreader swale and sheet pile weir in Jenkins Ditch at the headwaters of Kitching Creek.

Recreation features: gravel parking with boat ramps and trailheads, dry vault toilets, shelters, small boardwalks and bridges, information signs, and Americans with Disabilities Act compliant fishing platforms.

Monitoring and Adaptive Management Plan: Implementation of the monitoring and adaptive management plan will help ensure ecosystem restoration success is evaluated and inform adaptive management options to improve project success, if needed. Monitoring will continue until ecosystem restoration of wetlands and flows to the river are determined to be successful based on the identified criteria within the Adaptive Management and Monitoring Plan included in Annex D. Monitoring is expected to last no more than 10 years.

Therefore, I recommend that the LRWRP as described in the section of the report entitled "The Tentatively Selected Plan," with such modifications that may be deemed advisable at the discretion of the Chief of Engineers, be authorized for construction. The total estimated first cost for the LRWRP is $740,760,000 (October 2019 price level), with an estimated federal cost of $372,232,000 and an estimated non-federal cost of $368,528,000. The federal cost includes a non-shared $3,704,000 estimate for cultural resources data recovery. The project first cost includes for recreation features totaling $3,898,000, with an estimated federal cost of $1,949,000 and an estimated non-federal cost of $1,949,000. The average annual cost of the recreation features is $209,000 and the average annual benefits are $464,000, resulting in net benefits of $255,000 and a 2.22 to 1 benefit to cost ratio. The estimated total annual cost of operation, maintenance, repair, replacement, and rehabilitation (OMRR&R) is $4,447,000 with an estimated federal annual OMRR&R cost of $2,223,500 and an estimated non-federal OMRR&R cost of $2,223,500. The estimated total annual cost of monitoring, which includes both 10-year cycle costs amortized over the period of analysis and the annual cost of longer-term monitoring requirements, is $845,000, with an estimated federal cost of $422,500 and an estimated non-federal cost of $422,500. The estimated annual cost for OMRR&R of the recreation elements, a 100% non-federal sponsor responsibility, is $25,000.

8.1 Items of Local Cooperation

The above recommendations are made with the provision that the non-federal sponsor and the Secretary of the Army shall enter into a binding project partnership agreement defining the terms and conditions of cooperation for implementing the project, and that the non-federal sponsor agrees to perform the following items of local cooperation:

a. Provide 50% of total project costs consistent with the provisions of Section 601(e) of the WRDA of 2000, as amended, including authority to perform design and construction of project features consistent with federal law and regulation;
b. Provide all lands, easements, and rights-of-way, including suitable borrow and dredged or excavated material disposal areas, and perform or assure the performance of all relocations that the Federal Government and the non-federal sponsor jointly determine to be necessary for the construction, operation, maintenance, repair, replacement, and rehabilitation of the project and valuation will be in accordance with the Master Agreement;

c. Shall not use the ecosystem restoration features or lands, easements, and rights-of way required for such features as a wetlands bank or mitigation credit for any other non-CERP projects;
d. Give the Federal Government a right to enter, at reasonable times and in a reasonable manner, upon land that the non-federal sponsor owns or controls for access to the project for the purpose of inspection and, if necessary, for the purpose of constructing, completing, operating, maintaining, repairing, replacing, or rehabilitating the project;
e. Assume responsibility for OMRR&R of the project or completed functional portions of the project, including mitigation features, in a manner compatible with the project's authorized purposes and in accordance with applicable federal and state laws and specific directions prescribed in the OMRR&R manuals and any subsequent amendments thereto. Cost-sharing for OMRR&R will be in accordance with Section 601(e) of WRDA 2000, as amended. Notwithstanding Section 528(e)(3) of WRDA 1996 (110 stat. 3770), the non-federal sponsor shall be responsible for 50% of the cost of OMRR&R activities authorized under this section;
f. Operate, maintain, repair, replace, and rehabilitate the recreational features of the project; the non-federal sponsor is responsible for 100% of the cost;
g. Keep the recreation features, and access roads, parking areas, and other associated public use facilities, open and available to all on equal terms;
h. Unless otherwise provided for in the statutory authorization for this project, comply with Section 221 of the Flood Control Act of 1970 (Public Law 91-611), as amended, and Section 103 of the WRDA of 1986 (Public Law 99-662), as amended, which provides that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof until the non-federal sponsor has entered into a written agreement to furnish its required cooperation for the project or separable element;
i. Hold and save the Federal Government free from all damages arising from construction, operation, maintenance, repair, replacement, and rehabilitation of the project and any project-related betterments, except for damages due to the fault or negligence of the Federal Government or the Federal Government's contractors;
j. Keep and maintain books, records, documents, and other evidence pertaining to costs and expenses incurred pursuant to the project to the extent and in such detail as will properly reflect total project costs in accordance with the Master Agreement between the Department of the Army and the non-federal sponsor dated August 13, 2009, including Article XI Maintenance of Records and Audit;
k. Perform, or cause to be performed, any investigations for hazardous substances that are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 USC 9601-9675, that may exist in, on, or under lands, easements, or rights-of-way necessary for the construction, operation, and maintenance of the project; except that the non-federal sponsor shall not perform such investigations on lands, easements, or rights-of-way that the Federal Government determines to be subject to the navigation servitude without prior specific written direction by the Federal Government;
l. Assume complete financial responsibility for all necessary clean-up and response costs of any CERCLA-regulated materials located in, on, or under lands, easements, or rights-of-ways that the Federal Government determines necessary for construction, operation, maintenance, repair, replacement, and rehabilitation of the project;

m. As between the Federal Government and the non-federal sponsor, the non-federal sponsor shall be considered the operator of the project for purposes of CERCLA liability. To the maximum extent practicable, the non-federal sponsor shall operate, maintain, repair, replace, and rehabilitate the project in a manner that will not cause liability to arise under CERCLA;
n. Prevent obstruction of, or encroachments on, the project (including prescribing and enforcing regulations to prevent such obstructions or encroachments) such as any new developments on project lands, easements, and rights-of-way or the addition of facilities which might reduce the outputs produced by the ecosystem restoration features, hinder operation and maintenance of the project, or interfere with the project's proper function;
o. Comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (Public Law 91-646), as amended by Title IV of the Surface Transportation and Uniform Relocation Assistance Act of 1987 (Public Law 100-17), and the Uniform Regulations contained in 49 CFR part 24, in acquiring lands, easements, and rights-of-way, and performing relocations for construction, operation, and maintenance of the project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act;
p. Comply with all applicable federal and state laws and regulations, including, but not limited to, Section 601 of the Civil Rights Act of 1964 (Public Law 88-352 [42 U.S.C. 2000d]) and Department of Defense Directive 5500.11 issued pursuant thereto; Army Regulation 600-7, entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army"; and all applicable federal labor standards requirements including, but not limited to, 40 U.S.C. 3141-3148 and 40 U.S.C. 3701-3708 (revising, codifying and enacting without substantive change the provisions of the Davis-Bacon Act [formerly 40 U.S.C. 276a et seq.], the Contract Work Hours and Safety Standards Act [formerly 40 U.S.C. 327 et seq.], and the Copeland Anti-Kickback Act [formerly 40 U.S.C. 276c]);
q. Comply with Section 106 of the National Historic Preservation Act in completion of all consultation with the Florida State Historic Preservation Officer and other interested parties including federally recognized tribes and, as necessary, the Advisory Council on Historic Preservation, prior to construction as part of the preconstruction engineering and design phase of the project;
r. Provide 50% of that portion of total data recovery activities associated with historic preservation that exceed 1% of the amount authorized to be appropriated for LRWRP; data recovery costs under 1% of the authorized LRWRP cost will be funded in their entirety by the Federal Government. Any costs of data recovery that exceed 1% of the amount authorized to be appropriated for LRWRP shall not be included in project construction costs or project OMRR&R costs (as defined by the Master Agreement); therefore, credit shall not be afforded to the non-federal sponsor for costs or work-in-kind associated with data recovery activities that exceed 1% of the amount authorized to be appropriated for the LRWRP;
s. Do not use federal funds to meet the non-federal sponsor's share of total project costs unless the federal granting agency verifies in writing that the expenditure of such funds is expressly authorized and in accordance with Section 601 (e)(3) of the WRDA of 2000, as amended, and in accordance with the Master Agreement;

t. The non-federal sponsor agrees to participate in and comply with applicable federal floodplain management and flood insurance programs consistent with its statutory authority:
    1. Not less than once each year, the non-federal sponsor shall inform affected interests of the extent of protection afforded by the project;
    2. The non-federal sponsor shall publicize flood plain information in the area concerned and shall provide this information to zoning and other regulatory agencies for their use in preventing unwise future development in the flood plain, and in adopting such regulations as may be necessary to prevent unwise future development and to ensure compatibility with protection levels provided by the project;
    3. The non-federal sponsor shall comply with Section 402 of WRDA 1986, as amended (33 U.S.C. 701b-12), which requires a non-federal interest to have prepared, within one year after the date of signing a project partnership agreement for the project, a floodplain management plan. The plan shall be designed to reduce the impacts of future flood events in the project area, including but not limited to, addressing those measures to be undertaken by non-federal interests to preserve the level of flood protection provided by the project. As required by Section 402, as amended, the non-federal sponsor shall implement such plan not later than one year after completion of construction of the project. The non-federal sponsor shall provide the Federal Government an information copy of the plan upon its preparation;
    4. The non-federal sponsor shall prescribe and enforce regulations to prevent obstruction of or encroachment on the project—or on the lands, easements, and rights-of-way determined by the Federal Government to be required for the construction, operation, maintenance, repair, replacement, and rehabilitation of the project—that could reduce the level of protection the project affords, hinder operation or maintenance of the project, or interfere with the project's proper function;

u. The non-federal sponsor shall execute, or certify that Florida Department of Environmental Protection executed, under state law the reservation or allocation of water for the natural system as identified in the Project Implementation Report (PIR) for this authorized CERP project as required by Section 601(h)(4)(B)(ii) of WRDA 2000. The non-federal sponsor shall provide information to the Federal Government regarding such execution. In compliance with 33 CFR 385, the District Engineer will verify such reservation or allocation in writing. Any change to such reservation or allocation of water shall require an amendment to the project partnership agreement after the District Engineer verifies in writing, in compliance with 33 CFR 385, that the revised reservation or allocation continues to provide for an appropriate quantity, timing, and distribution of water dedicated and managed for the natural system after considering any changed circumstances or new information since completion of the PIR for the authorized CERP project;

v. Consistent with the September 14, 2011 Memorandum from the Assistant Secretary of the Army (Civil Works), the non-federal sponsor shall be 100% responsible for the cost of all actions taken due to the presence of residual agricultural chemicals, at no expense to the Federal Government. Any future costs associated with the presence of residual agricultural chemicals at the federal project site are 100% a non-federal sponsor cost and responsibility. As stated in the September 14, 2011 Memorandum, normal project engineering and construction

activities will remain part of the total project cost provided that these are the same activities required to implement the project features absent the presence of residual agricultural chemicals.

w. The determination of applicable water quality standards for the water associated with this project and any necessary treatment or remediation of this water shall be made by regulatory agencies with jurisdiction over any laws or regulations which apply to this project. Cost share for water quality treatment is as follows:
    1. If source water violates applicable surface water quality standards, the non-Federal sponsor shall be responsible for treatment costs necessary to prevent the violation of those surface water standards prior to well recharge. Additional treatment costs necessary to further reduce the concentration of pollutants in source water to meet UIC and/or applicable groundwater standards prior to well recharge shall be cost-shared as a project cost.
    2. To the extent that source water becomes contaminated by virtue of the addition of substances required for pre-injection treatment and injection, changes or interactions in the ASR well, or retrieval, all costs of treating the water to comply with applicable water quality standards shall be cost-shared as a project cost.
    3. In cases where the source water violates applicable surface water standards but there is no applicable UIC or groundwater standard for the constituent causing the violation, and there is no increase in contamination resulting from those factors identified in paragraphs (2) and (4), the non-Federal sponsor shall be responsible for treatment costs to prevent violation of applicable water quality standards prior to discharge of retrieved water back into the source water body.
    4. If the water in the affected aquifer violates applicable ground water quality standards, the non-Federal sponsor shall report this to the appropriate regulatory authorities for a determination of the party or parties responsible for causing this contamination. If the Federal project is to proceed at that site, the Non-Federal Sponsor shall certify to the Federal sponsor that any necessary measures to prevent violations of groundwater quality standards prior to surface discharge from the project at that site have been accomplished by the party or parties determined to be responsible for remediating the aquifer contamination. Costs of such measures shall not be a Federal responsibility and shall not be included in the total project costs. Where there is an increase in contamination in the groundwater resulting from those factors identified in paragraph (2) above, due to natural occurrence, or due to the subsurface interaction between stored and native aquifer water, additional treatment costs necessary to bring groundwater into compliance with applicable surface water quality standards necessary for discharge shall be cost shared as a project cost where it is determined to be economically feasible and within the scope of the original project.

8.2 Recommendation for Congressional Authorization

The recommendations contained herein reflect the information available at this time and current Departmental policies governing formulation of individual projects. They do not reflect program and budgeting priorities inherent in the formulation of a national Civil Works construction program nor the perspective of higher review levels within the Executive Branch. Consequently, the recommendations may be modified before they are transmitted to the Congress as proposals for authorization and implementation funding. However, prior to transmittal to the Congress, the sponsor, the state, interested federal agencies, and other parties will be advised of any modifications and will be afforded an opportunity to comment further.

Andrew D. Kelly, Jr.
Colonel, U.S. Army
District Commander

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Table of Contents

9 LIST OF REPORT PREPARERS 1

List of Tables

Table 9-1. Report Preparers. 1
Table 9-2. Technical and Quality Reviewers. 3

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9 LIST OF REPORT PREPARERS

This section provides a list of persons involved in the preparation of the PIR/EIS (**Table 9-1**) and technical reviewers of this document (**Table 9-2**).

Table 9-1. Report Preparers.

Name	Organization	Discipline/Expertise	Role in Document Preparation
Amanda Bredesen	USACE	Modeler	Engineering Appendix / Hydrologic Modeling Review
Andrew LoSchiavo	USACE	Biology	Ecological Benefits, water quality, adaptive management plan
Angie Huebner	USACE	Biologist	Invasive Species Management Plan
Ann Hodgson	USACE	Wildlife Biologist, Lead NEPA	Ecological effects, wildlife effects, NEPA analysis
Brad Foster	USACE	Planner	Planning Lead, Plan Formulation
Courtney Jackson	USACE	Economist	Economics, Incremental Cost Analysis
Donna Zoeller	USACE	Operations	Operations and Maintenance
Emmanuel Freeman	USACE	Real Estate	Real Estate
Erin White	USACE	Modeler	Hydrologic Modeling Review
George Ebai	USACE	Economist	Recreation
Gretchen Ehlinger	USACE	Biologist	Adaptive Management Plan
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June Mirecki	USACE	Geologist	Hydro Geotechnical Analyses/Engineering Appendix
Ken Bradshaw	USACE	Water Quality	Water Quality and HTRW Analyses/Water Quality Monitoring Plan
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Name	Organization	Discipline/Expertise	Role in Document Preparation
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Jerry Krenz	SFWMD	Planner	Recreation
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Shi Kui Xue	SFWMD	Water Quality	Water Quality Monitoring Plan
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Uditha Bandara	SFWMD	Modeling	Hydrologic Modeling Appendix

Table 9-2. Technical and Quality Reviewers.

Name	Organization	Discipline/Expertise	Role
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Chris Ralph	USACE	Civil Engineer	DQC Reviewer
David Apple	USACE	Planner	DQC Reviewer
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Gretchen Ehlinger	USACE	Biologist	DQC Reviewer
Jason Engle	USACE	Civil Engineer/H&H	DQC Reviewer
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Kevin Wittmann	USACE	Economist	DQC Reviewer
Matthew Cunningham	USACE	Civil Engineer/Cost	DQC Reviewer
Melissa Nasuti	USACE	Biologist	DQC Reviewer
Meredith Moreno	USACE	Cultural Resources	DQC Reviewer
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Jill Skaggs	SFWMD	Infrastructure	TRB Reviewer
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Name	Organization	Discipline/Expertise	Role
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Nicole Niemeyer	SFWMD	Water Quality	TRB Reviewer
Pamela Lehr	SFWMD	Water Quality	TRB Reviewer
Patricia Burke	SFWMD	Water Quality	TRB Reviewer
Patricia Gorman	SFWMD	Applied Science/Ecology	TRB Reviewer
Robert Kukleski	SFWMD	Environmental	TRB Reviewer
Sandra Smith	SFWMD	Engineer	TRB Reviewer
Steve Bousquin	SFWMD	Biologist	TRB Reviewer
Stuart VanHorn	SFWMD	Water Quality	TRB Reviewer
Yangling Zhao	SFWMD	Modeling	TRB Reviewer
Zhongwei Li	SFWMD	Operations	TRB Reviewer

Table of Contents

10 GLOSSARY OF ACRONYMS AND TERMS 1
10.1 List of Acronyms 1
10.2 Glossary of Terms 6
10.3 List of Scientific Names 18

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10 GLOSSARY OF ACRONYMS AND TERMS

10.1 List of Acronyms

A

ac	Acres
ac-ft	Acre-feet
ACHP	Advisory Council on Historic Preservation
AM	Adaptive Management
APE	Area of Potential Effect
ASR	Aquifer Storage and Recovery
APPZ	Avon Park Permeable Zone

B

BIA	Bureau of Indian Affairs
BCNP	Big Cypress National Preserve
BLS	Below Land Surface
BMP	Best Management Practice
BO	Biological Opinion

C

CE/ICA	Cost Effectiveness/ Incremental Cost Analysis
CEPP	Central Everglades Planning Project
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CERP	Comprehensive Everglades Restoration Plan
CERPRA	Comprehensive Everglades Restoration Plan Regulation Act
CEQ	Council of Environmental Quality
C&SF	Central and Southern Florida
cm/s	Centimeters Per Second
COP	Combined Operational Plan

D

DOI	Department of Interior
DPOM	Draft Project Operation Manual
DSAC	Dam Safety Action Classification

E

EAA	Everglades Agricultural Area
EAV	Emergent aquatic vegetation
ECB	Existing Conditions Baseline
EDR	Engineering Documentation Report
EFH	Essential Fish Habitat
EIS	Environmental Impact Statement
ENP	Everglades National Park
EO	Executive Order

EPA	Everglades Protection Area
ERTP	Everglades Restoration Transition Plan
ESA	Endangered Species Act
ET	Evapotranspiration
F	
FAA	Federal Aviation Administration
F.A.C.	Florida Administrative Code
FAS	Floridan Aquifer System
FAV	Floating aquatic vegetation
FDEO	Florida Department of Economic Opportunity
FDEP	Florida Department of Environmental Protection
FDOT	Florida Department of Transportation
FEB	Flow Equalization Basin
FEIS	Final Environmental Impact Statement
FIFRA	Federal Insecticide, Fungicide, Rodenticide Act
FMSF	Florida Master Site File
F.S.	Federal Statute
ft	feet
FWC	Florida Fish and Wildlife Conservation Commission
FWO	Future Without Project Condition
G	
GDM	General Design Memorandum
GRR	General Reevaluation Report
GWP	Grassy Waters Preserve
H	
HHD	Herbert Hoover Dike
HRF	Hydropattern Restoration Feature
HSLCD	Hobe St. Lucie Conservancy District
HTRW	Hazardous, Toxic and Radioactive Waste
HU	Habitat Unit
I	
IDC	Interest During Construction
IDS	Integrated Delivery Schedule
INSMP	Invasive and Nuisance Species Management Plan
IOP	Interim Operations Plan
ITID	Indian Trail Improvement District
J	

JDSP	Jonathan Dickinson State Park
K	
L	
LEC	Lower East Coast
LECSR-NP	Lower East Coast Subregional Model – North Palm version
LERRD	Lands, Easements, Rights of Way, Relocations, and Disposals
LNWR	Loxahatchee National Wildlife Refuge
LORS	Lake Okeechobee Regulation Schedule
LOSA	Lake Okeechobee Service Area
LRD	Loxahatchee River District
LRWRP	Loxahatchee River Watershed Restoration Project
LTGM	Long Term Geometric Mean
LWL	Lake Worth Lagoon
M	
M&I	Municipal and Industrial
MCDA	Multi Criteria Decision Analysis
MeHg	Methyl Mercury
MGD	Million Gallons per Day
mg/L	Milligrams Per Liter
MISP	Master Implementation Schedule Plan
MRR	Major Rehabilitation Report
MTIF	Miccosukee Tribe of Indians of Florida
MWD	Modified Water Deliveries
N	
NAGPRA	Native American Graves Protection and Repatriation Act
NEPA	National Environmental Policy Act
NER	National Ecosystem Restoration
NESRS	Northeast Shark River Slough
NHPA	National Historic Preservation Act
NMFS	National Marine Fisheries Service
NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service
NRHP	National Register of Historic Places
NRC	National Research Council
NWFLR	Northwest Fork of the Loxahatchee River

O

OMRR&R	Operations, Maintenance, Repair, Rehabilitation, and Replacement
OTMP	Operational Testing and Monitoring Period

P

PDT	Project Delivery Team
PED	Preconstruction, Engineering, and Design
PIR	Project Implementation Report
POM	Project Operating Manual
POR	Period of Record
PPA	Project Partnership Agreement
ppb	Parts Per Billion
PPCA	Pre-Partnership Credit Agreement
ppt	Parts Per Thousand
psu	Practical Salinity Units
PWS	Public Water Supply

Q

R

RAA	Restricted Allocation Area
RECOVER	Restoration Coordination and Verification
RESOPS	Reservoir Sizing Operations Screening Model
ROD	Record of Decision

S

SAFM	South Atlantic Fisheries Management Council
SAS	surficial aquifer system
SAV	Submerged Aquatic Vegetation
SDCS	South Dade Conveyance System
SFWMD	South Florida Water Management District
SHPO	State Historic Preservation Office(er)
SLR	Sea Level Rise
SRS	Shark River Slough
STA	Stormwater Treatment Area
STOF	Seminole Tribe of Florida

T

THPO	Tribal Historic Preservation Office(er)
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus

TSP	Tentatively Selected Plan

U

UFA	Upper Floridan Aquifer
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey

V

VEC	Valued Ecosystem Component

W

WQBELs	Water Quality Based Effluent Limits
WCA	Water Conservation Area
WG	Working Group
WMA	Wildlife Management Area
WPA	Water Preserve Areas
WRAP	Wetland Rapid Assessment Procedure
WRDA	Water Resources Development Act

X

Y

Z

10.2 Glossary of Terms

A

Acre — Area of land equal to 43,560 square feet. In the S.I. metric system, one acre is equal to 4,046.9 square meters or 2.471 hectares.

Acre-foot — The quantity of water required to cover 1 acre to a depth of 1 foot. Equal to 43,560 cubic feet (1,233.5 cubic meters).

Action Plan — A plan that describes what needs to be done and when it needs to be completed.

Activity — A specific project task that requires resources and time to complete.

Adaptive Management — A process for learning and incorporating new information into the planning and evaluation phases of the restoration program. This process ensures that the scientific information produced for this effort is converted into products that are continuously used in management decision-making.

Adverse Effect – In relation to historic properties, an adverse effect is found when an undertaking may alter, directly or indirectly, any of the characteristics of a historic property that qualify the property for inclusion in the NRHP in a manner that will diminish the integrity of the property's location, design, setting, materials, workmanship, feeling, or association.

Adverse Impact — The detrimental effect of an environmental change relative to desired or baseline conditions.

Affected Environment — Existing biological, physical, social, and economic conditions of an area subject to change, both directly and indirectly, as a result of a proposed human action.

Air Quality — Measure of the health-related and visual characteristics of the air, often derived from quantitative measurements of the concentrations of specific injurious or contaminating substances.

Anthropogenic — Of, relating to, or resulting from the influence of human beings on nature.

Aquatic — Consisting of, relating to or being in water; living or growing in, on or near the water; or taking place in or on the water.

Aquifer — An underground geologic formation, a bed or layer of earth, gravel or porous stone, that yields water or in which water can be stored.

Authorization — An act by the Congress of the United States, which authorizes use of public funds to carry out a prescribed action.

B

Baseline — The initial approved plan for schedule, cost or performance management, plus or minus approved changes, to which deviations will be compared as the project proceeds.

Benthic — **Bottom** of rivers, lakes, or oceans; organisms that live on the bottom of water bodies.

Best Management Practices — The best available land, industrial and waste management techniques or processes that

reduce pollutant loading from land use or industry, or which optimize water use.

Biological Opinion — Document issued under the authority of the Endangered Species Act stating the U.S. Fish and Wildlife Service and/or the National Marine Fisheries Services finding as to whether a Federal action is likely to jeopardize the continued existence of a threatened or endangered species or result in the destruction or adverse modification of critical habitat.

Borrow Canal — Canal or ditches where material excavated is used for earthen construction nearby. Also, typically denotes a canal with no conveyance or water routing purpose.

C

Canal — A human-made waterway that is used for draining or irrigating land or for navigation by boat.

Candidate Species — Plant or animal species not yet officially listed as threatened or endangered, but which is undergoing status review by the U.S. Fish and Wildlife Service or the National Marine Fisheries Service.

Central and Southern Florida Project (C&SF) — A multi-purpose project, first authorized by Congress in 1948, which provides flood control, water supply protection, water quality protection and natural resource protection.

Channel — Natural or artificial watercourse, with a definite bed and banks to confine and conduct continuously or periodically flowing water.

Coastal Ridge — Area of land bordering the coast whose topography is elevated higher than land further inland.

Comprehensive Everglades Restoration Plan (CERP) — The plan for the restoration of the greater Everglades and to meet water supply and flood protection needs in the urban and agricultural regions of south Florida.

Control Structure — A human-created structure that regulates the flow of waters or the level of waters.

Conveyance Capacity — The rate at which water can be transported by a canal, aqueduct, or ditch. In this document, conveyance capacity is generally measured in cubic feet per second (cfs).

Cost-Benefit Analysis — An analysis, often stated as a ratio, used to evaluate a proposed course of action.

Critical Habitat — A description, which may be contained in a Biological Opinion, of the specific areas with physical or biological features essential to the conservation of a listed species and which may require special management considerations or protection; these areas have been legally designated via Federal Register notices.

Cubic feet per second (cfs) — A measure of the volume rate of water movement. As a rate of stream flow, a cubic foot of water passing a reference section in 1 second of time. One cubic foot per second equals 0.0283 meter /second (7.48 gallons per minute). One cubic foot per second flowing for 24 hours produces approximately 2 acre-feet.

Culture – The National Park Service defines culture as "a system of behaviors, values, ideologies, and social arrangements. These features, in addition to tools and expressive elements such as graphic arts, help humans interpret their universe as well as deal with features of their environments, natural and social. Culture is learned, transmitted in a social context, and modifiable. Synonyms for culture include life ways, customs, traditions, social practices, and folkways. The terms folk culture and folk life might be used to describe aspects of the system that are unwritten, learned without formal instruction, and deal with expressive elements such as dance, song, music and graphic arts as well as storytelling."

Cultural Resources – Encompasses both culturally significant sites and historic properties.

Culturally Significant Site – Geographically defined areas supporting current or past human use such as a community meeting area, spiritual sites, places of worship, medicinal plant gathering areas or cemeteries and burial sites.

Culvert — A concrete, metal or plastic pipe that transports water.

D

Data – (cultural resources) Per Engineering Regulation 1105-2-100(b)(10), the DOI defines "data" as "evidence about historic and prehistoric periods, which are buried in the ground" and recovered as evidence…when construction projects pose threats that would result in their irreparable loss or destruction."

Data Recovery – (cultural resources) also known as Mitigative Excavations is a way to remedy or offset an adverse effect or a change in qualifying characteristics within an archaeological site. Through mitigative excavations, important information that makes the site eligible for NRHP listing is retrieved from the site before the site's integrity is compromised or destroyed.

Discharge — The rate of water movement as volume per unit time, usually expressed as cubic feet per second.

Dissolved Oxygen (D.O.) — The concentration of oxygen dissolved in water, sometimes expressed as percent saturation, where saturation is the maximum amount of oxygen that theoretically can be dissolved in water at a given altitude and temperature.

Dry Downs — Refers to marsh water levels going below ground in the Everglades. Dry downs occur naturally in the pre-drainage Everglades, but were not as frequent, nor as long in duration as does occur in the current system.

Dry Season — Hydrologically, for south Florida, the months associated with a lower incident of rainfall, typically November through May.

Duration — The period of time over which a task occurs, in contrast to effort, which is the amount of labor hours a task requires; duration establishes the schedule for a project, and effort establishes the labor costs.

E

Ecology — The science of the relationships between organisms and their environments, also called bionomics; or the relationship between organisms and their environment.

Ecosystem — A functional group of animal and plant species that operate in a unique setting that is mostly self-contained.

Ecotone — A transitional zone between two communities containing the characteristic species of each.

Effectiveness — A measure of the quality of attainment in meeting objectives; this is distinguished from efficiency, which is measured by the volume of output achieved for the input used.

Endangered Species — Any species or subspecies of bird, mammal, fish, amphibian, reptile, or plant which is in serious danger of becoming extinct throughout all, or a significant portion of its range. Federally endangered species are officially designated by the U.S. Fish and Wildlife Service or the National Marine Fisheries Service and published in the Federal Register.

Enhancement — Measures which develop or improve the quality or quantity of existing conditions or resources beyond a condition or level that would have occurred without an action; i.e., beyond compensation.

Environmental and Economic Equity (EEE) — A program-level activity, referred to in early phases of the program as Socioeconomic and Environmental Justice.

Environmental Consequences — The impacts to the Affected Environment that are expected from implementation of a given alternative.

Environmental Impact Statement (EIS) — An analysis required by the National Environmental Policy Act for all major Federal actions, which evaluates the environmental risks of alternative actions.

Estuary — A water passage where the tide meets a river current; an arm of the sea at the lower end of a river.

Eutrophic — Referring to a body of water which is naturally or artificially enriched in dissolved nutrients, and often shallow with a seasonal deficiency in dissolved oxygen due to high primary production.

Evaluate — To appraise or determine the value of information, options or resources being provided to a project.

Evaporation — The change of a substance from the liquid phase to the gaseous (vapor) phase.

Evapotranspiration — Evapotranspiration is part of the hydrologic cycle that is a combination of evaporation and transpiration.

Exotic species — Introduced species not native to the place where they are found.

F

Fallowed Land — Cultivated land that lies idle during a growing season.

Feasibility Study — The second phase of a project. The purpose is to describe and evaluate alternative plans and fully describe recommended project.

Federally Endangered Species — An endangered species which is officially designated by the U.S. Fish and Wildlife Service or the National Marine Fisheries Service and published in the Federal Register.

Flood Control Storage Capacity — Reservoir capacity reserved for the purpose of regulating flood inflows to reduce flood damage downstream [compare with reservoir storage capacity].

Flow — The volume of water passing a given point per unit of time.

Instream Flow Requirements — Amount of water flowing through a stream course needed to sustain instream values.

Minimum Flow — Lowest flow in a specified period of time.

Peak Flow — Maximum instantaneous flow in a specified period of time.

G

Geospatial Data — Information, which includes, but is not limited to surveys, maps, aerial photography, aerial imagery, and biological, ecological and hydrological modeling coverage's.

Goal — Something to be achieved. Goals can be established for outcomes (results) or outputs (efforts).

Groundwater — Water stored underground in pore spaces between rocks and in other alluvial materials and in fractures of hard rock occurring in the saturated zone.

Groundwater Level — Refers to the water level in a well, and is defined as a measure of the hydraulic head in the aquifer system.

Groundwater Pumping — Quantity of water extracted from groundwater storage.

Groundwater Seepage — Groundwater flow in response to a hydraulic gradient.

Groundwater Table — The upper surface of the zone of saturation, except where the surface is formed by an impermeable body.

H

Habitat — Area where a plant or animal lives.

Hammock — Localized, thick stands of trees that can grow on natural rises of only a few inches in the land.

Hectare — A unit of measure in the metric system equal to 10,000 square meters or 2.47 acres.

Historic Properties – Encompasses archaeological, traditional, and built environment resources, including but not limited to buildings, structures, objects, districts and sites over 50 years of age.

Hydraulic Gradient — Denotes slope of watercourse, above or below ground water level. Typically, defines energy loss or consumption in the conveyance process.

Hydraulic Head (Lift) — Denotes relative comparison of water stages for gravity flow. Pump stations generally provide lift or increase water level elevations.

Hydrologic Condition — The state of an area pertaining to the amount and form of water present. For example, saturated ground (water table at surface), lake stage and river flow rate.

Hydric — Characterized by, relating to, or requiring an abundance of moisture.

Hydrologic Response — An observed decrease or increase of water in a particular area.

Hydrology — The scientific study of the properties, distribution and effects of water on the earth's surface, in the soil and underlying rocks, and in the atmosphere.

Hydropattern — Refers to depth as well as hydroperiod. Hydropatterns are best understood by a graphic depiction of water level (above as well as below the ground) through annual cycles.

Hydroperiod — For non-tidal wetlands, the average annual duration of flooding is called the hydroperiod, which is based only on the presence of surface water and not its depth.

I

Impoundment — An above ground reservoir used to store water.

Independent Technical Review Team — A group autonomous of the Project Team established to conduct reviews to ensure that design products are consistent with established criteria, guidance, procedures and policies.

Indicator Species — Organism, species, or community which indicates presence of certain environmental conditions.

Invertebrate — A small animal that does not have a backbone, examples include crayfish, insects and mollusks, which can be indicators of ecosystem status.

J

K

L

Lag — The amount of time after one task is started or completed before the next task can be started or completed.

Land Classification — An economic classification of variations in land reflecting its ability to sustain long-term agricultural production.

Levee — A human-created embankment that controls or confines water.

Littoral Zone — The shore of land surrounding a water body that is characterized by periodic inundation or partial saturation by water level. Typically defined by species of vegetation found.

Local Sponsor — The South Florida Water Management District.

M

Macrophytes — Visible plants found in aquatic environments, including sawgrass, sedges and lilies.

Marl — Soils comprised of clays, carbonates, and shell remains.

Marsh — An area of low-lying wetland.

Master Program Management Plan (MPMP) — A document which describes the framework and processes to be used by the USACE and the SFWMD for managing and monitoring implementation of the Comprehensive Everglades Restoration Plan.

Mercury — Heavy metal that is toxic to most organisms when concerted into a byproduct of inorganic-organic reaction. Distributed into the environment mostly as residual particles from industrial processes.

Mitigation — To make less severe; to alleviate, diminish or lessen; one or all of the following may comprise mitigation: (1) avoiding an impact altogether by not taking a certain action or parts of an action; (2) minimizing impacts by limiting the degree or magnitude of an action and its implementation; (3) rectifying an impact by repairing, rehabilitating or restoring the affected environment; (4) reducing or eliminating an impact over time by preservation and maintenance operations during the life of an action; and (5) compensating for an impact by replacing or providing substitute resources or environments.

Model — A tool used to mathematically represent a process which could be based upon empirical or mathematical functions. Models can be computer programs, spreadsheets, or statistical analyses.

Monitoring — The capture, analysis and reporting of project performance, usually as compared to plan.

Muck — Soil type consisting of 25% to 65% plant material mixed with sand silt, and clay.

N

National Economic Development (NED) — Corps of Engineers benefit evaluation process used to justify Recreation expenditures.

No Action Alternative — The planning process by which the action agency decides to not carry forth any planned action to alter existing conditions.

O

Objective — A goal expressed in specific, directly measurable terms.

Off-peak — Less than peak design flow rate during storm runoff producing events.

Operation, Maintenance, Repair, Rehabilitation, Replacement (OMRR&R) — 100% local sponsor responsibility to OMRR&R recreation facilities and amenities.

Outreach — Proactive communication and productive involvement with the public to best meet the water resource needs of south Florida.

Oxygen Demand — The biological or chemical demand of dissolved oxygen in water. Required by biological processes for respiration.

P

Peat — Soil type consisting of 65% or more plant material with relatively little mineral matter. Everglades peat is formed mostly from partially decayed sawgrass. The upper 12 inches is a nearly black, finely fibrous peat which contains approximately 10% mineral

soil. The subsoil is brown, fibrous peat which rests on the underlying rock, sand or marl.

Performance Measure — A desired result stated in quantifiable terms to allow for an assessment of how well the desired result has been achieved.

Periphyton — The biological community of microscopic plants and animals attached to surfaces in aquatic environments, for example algae.

Phosphorus (P) — Element or nutrient required for energy production in living organisms. Distributed into the environment mostly as phosphates by agricultural runoff (fertilizer) and life cycles. Frequently the limiting factor for growth of microbes and plants in south Florida.

Programmatic Regulations — Section 601(h) of WRDA 2000 states that the overarching purpose of the Comprehensive Plan is the restoration, preservation and protection of the south Florida ecosystem while providing for the other water related needs of the region, including water supply and flood protection. The purpose of the regulations is to ensure that the goals and objectives of CERP are achieved. The regulations will contain: (1) processes for the development of Project Implementation Reports, Project Cooperation Agreements and operating manuals that ensure the goals and objectives of the plan are achieved; (2) processes that ensure new scientific, technical, or other information such as that developed through adaptive management is integrated into the implementation of the plan; and (3) processes to establish interim goals to provide a means by which the restoration success of the plan may be evaluated throughout the implementation process.

Project — A sequence of tasks with a beginning and an end that uses time and resources to produce specific results. Each project has a specific, desired outcome, a deadline or target completion date and a budget that limits the amount of resources that can be used to complete the project.

Project Partnership Agreement (PPA) — A document that describes the roles and responsibilities of the USACE and SFWMD for real estate acquisition, construction, construction management and operations and maintenance.

Project Delivery Team — An interdisciplinary group formed from the resources of the implementing agencies, which develops the products necessary to deliver the project.

Project Duration — The time it takes to complete an entire project from starting the first task to finishing the last task.

Project Implementation Report (PIR) — A decision document that will bridge the gap between the conceptual design contained in the Comprehensive Plan and the detailed design necessary to proceed to construction.

Proposed Action — Plan that a federal agency intends to implement or undertake and which is the subject of an environmental analysis. Usually, but not always, the proposed action is the agency's preferred alternative for a project. The proposed action and all reasonable alternatives are evaluated against the no action alternative.

Public Involvement — Process of obtaining citizen input into each stage of the development of planning documents. Required as a major input into any EIS.

Public Outreach — A program-level activity with the objectives of keeping the public informed of the status of the overall program and key issues associated with restoration implementation and providing effective mechanisms for public participation in the restoration plan development.

Pump Station — A human constructed structure that uses pumps to transfer water from one location to another.

Q

Quality Assurance (QA) — The process of evaluating overall project performance on a regular basis to provide confidence that the project will satisfy the relevant quality standards.

Quality Control (QC) — The process of monitoring specific project results to determine if they comply with relevant quality standards, and identifying means of eliminating causes of unsatisfactory performance.

R

Recharge — The processes of water filling the voids in an aquifer, which causes the piezometric head or water table to rise in elevation.

Record of Decision — Concise, public, legal document which identifies and publicly and officially discloses the responsible official's decision on the alternative selected for implementation. It is prepared following completion of an Environmental Impact Statement.

Regional Water Supply Plan — Detailed water supply plan developed by the District under Ch. 373.0361, F.S.

Reservoir — Artificially impounded body of water.

Reservoir Storage Capacity — Reservoir capacity normally usable for storage and regulation of reservoir inflows to meet established reservoir operating requirements.

Flood Control Storage Capacity — Reservoir capacity reserved for the purpose of regulating flood inflows to reduce flood damage downstream.

Restoration — The recovery of a natural system's vitality and biological and hydrological integrity to the extent that the health and ecological functions are self-sustaining over time.

Restoration Coordination and Verification (RECOVER) — A program-level activity whose role is to organize and apply scientific and technical information in ways that are most effective in supporting the objectives of the Comprehensive Everglades Restoration Plan.

Restudy — The Central and Southern Florida Project Comprehensive Review Study, authorized by the Water Resources Development Act of 1992, which examined the Central and Southern Project to determine the feasibility of modifying the project to restore the south Florida

ecosystem and provide for other water-related needs of the region, and which resulted in The Final Integrated Feasibility Report and Programmatic Environmental Impact Statement, which was transmitted to Congress on July 1, 1999.

Risk Analysis — An evaluation of the feasibility or probability that the outcome of a project or policy will be the desired one; usually conducted to compare alternative scenarios, action plans or policies.

S

Scoping — The process of defining the scope of a study, primarily with respect to the issues, geographic area, and alternatives to be considered. The term is typically used in association with environmental documents prepared under the National Environmental Policy Act.

Scrub — A community dominated by pinewoods with a thick understory of oaks and saw palmetto, and which occupies well-drained, nutrient-poor sandy soils.

Seepage — Water that escapes control through levees, canals or other holding or conveyance systems.

Sheet Flow — Water movement as a broad front with shallow, uniform depth.

Slough — A depression associated with swamps and marshlands as part of a bayou, inlet or backwater; contains areas of slightly deeper water and a slow current; can be thought of as the broad, shallow rivers of the Everglades.

South Florida Ecosystem — An area consisting of the lands and waters within the boundary of the South Florida Water Management District, including the Everglades, the Florida Keys and the contiguous near-shore coastal waters of south Florida.

Spatial Extent — Area that is continuous without non-integrating internal barriers or land usage.

Spillway — Overflow structure of a dam.

Spreader berm — A lateral weir used to spread water in creation of a sheetflow system over a very shallow depth.

Spreader canal — Canal used to equalize flow (to some degree) across a bank into an area with a shallow water depth. The spreader canal depth allows a water source to be delivered across the full reach enabling a deeper depth of sheetflow to occur.

Stakeholders — People or organizations having a personal or enterprise interest in the results of a project, who may or may not be involved in completing the actual work on that project.

Stormwater — Surface water resulting from rainfall that does not percolate into the ground or evaporate.

Subsidence — A local mass movement that principally involves the gradual downward settling or sinking of the earth's surface with little or no horizontal motion. It may be due to natural geologic processes or mass activity such as removal of subsurface solids, liquids, or gases, ground water extraction, and wetting of some types of moisture-deficient loose or porous deposits.

Surficial Aquifer — An aquifer that is closest to the surface and is unconfined; the water level of a surficial aquifer is typically associated with the groundwater table of an area.

Sustainability — The state of having met the needs of the present without endangering the ability of future generations to be able to meet their own needs.

Swamp — A generally wet, wooded area where standing water occurs for at least part of the year.

T

Threatened species — Legal status afforded to plant or animal species that are likely to become endangered within the foreseeable future throughout all or a significant portion of their range, as determined by the U.S. Fish and Wildlife Service or the National Marine Fisheries Service.

Tiering — Procedure which allows an agency to avoid duplication of paperwork through incorporation by reference of the general discussions and relevant specific discussions from an environmental impact statement (EIS) of broader scope into a subsequent EIS of narrower scope.

Trade-Off — Allowing one aspect of a project to change, usually for the worse, in return for another aspect of the project getting better.

Traditional Cultural Property – The NPS defines "traditional" in this context as referring "to those beliefs, customs, and practices of a living community of people that have been passed down through the generations, usually orally or through practice. The traditional cultural significance of a historic property, then, is significance derived from the role the property plays in a community's historically rooted beliefs, customs, and practices."

Tributary — A stream feeding into a larger stream, canal or waterbody.

U

V

W

Water Budget — An account of all water inflows, outflows and change in storage for a pre-specified period of time.

Water Conservation Areas (WCAs) — Marshland areas that were designed for use as storage to prevent flooding, to irrigate agriculture and recharge well fields and as input for agricultural and urban runoff; the Water Conservation Areas WCA-1, WCA-2A, WCA-2B, WCA-3A and WCA-3B comprise five surface water management basins in the Everglades; bounded by the Everglades Agricultural Area on the north and the Everglades National Park basin on the south, the WCAs are confined by levees and water control structures that regulate the inflows and outflows to each one of them.

Watershed — A region or area bounded peripherally by a water parting and draining ultimately to a particular watercourse or body of water.

Wetlands — Areas that are inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support a prevalence of vegetative or aquatic life that requires saturated or

seasonally saturated soil conditions for growth and reproduction.

Wet Season — Hydrologically, for south Florida, the months associated with a higher than average incident of rainfall, June through October.

Wildlife Corridor — A relatively wide pathway used by animals to transverse from one habitat arena to another.

Wildlife Habitat — An area that provides a water supply and vegetative habitat for wildlife.

X

Y

Z

10.3 List of Scientific Names

Common Name	Scientific Name
Air plants	*Tillandsia* spp.
Alligator flag	*Thalia geniculata*
American kestrel (southeastern sub-species)	*Falco sparverius paulus*
American oystercatcher	*Haematopus palliatus*
American watergrass	*Luziola subintegra*
American white waterlily	*Nymphaea odorata*
Amphipod	*Hyallela azteca*
Argentine black and white tegu	*Salvator merianae*
Arrowhead	*Sagittaria latifolia*
Atlantic rangia	*Rangia cuneata*
Australian pine	*Casuarina equisetifolia*
Bald cypress	*Taxodium distichum*
Black gum	*Nyssa sylvatica*
Black mangrove	*Avicennia racemosa*
Black skimmer	*Rhynchops niger*
Blue crayfish	*Procambarus allenii*
Blue maidencane	*Amphicarpum muhlenbergianum*
Bog buttons	*Lachnocaulon* spp.
Bottlebrush threeawn	*Aristida spiciformis*
Brazilian pepper	*Schinus terebinthifolius*
Broomsedge bluestem	*Andropogon virginicus*
Burmese python	*Python molurus bivittatus*
Burrowing owl	*Athene cunicularia*
Buttonbush	*Cephalanthus occidentalis*
Cabbage (sabal) palm	*Sabal palmetto*
Chapman's oak	*Quercus chapmanii*
Coastal plain willow	*Salix caroliniana*
cobia	*Rachycentron canadum*
Cocoplum	*Chrysobalanus icaco*
Cogongrass	*Imperata cylindrica*
Creeping water-primrose (primrosewillow)	*Ludwigia repens*
Cutthroatgrass	*Panicum abscissum*
Cypress	*Taxodium* spp.

Common Name	Scientific Name
Dahoon holly	*Ilex cassine*
Downy rose myrtle	*Rhodomyrtus tomentosa*
Dwarf live oak	*Quercus minima*
Everglades mink	*Mustela vison evergladensis*
Fetterbush	*Lyonia lucida*
Florida apple snail	*Pomacea paludosa*
Florida pine snake	*Pituophis melanoleucus*
Florida sandhill crane	*Grus canadensis pratensis*
Florida rosemary	*Ceratiola ericoides*
Gallberry	*Ilex glabra*
Gopher tortoise	*Gopherus polyphemus*
Gray snapper	*Lutjanus griseus*
Grouper	*Epinephelus* spp.
Gumbo limbo	*Bursera simaruba*
Johnson's seagrass	*Halophila johnsonii*
Killifish	Includes *Cyprinodon* spp. and *Fundulus* spp.
King mackerel	*Scomberomorus cavalla*
Laurel oak	*Quercus laurifolia*
Least tern	*Sternula antillarum*
Lined topminnow	*Fundulus lineolatus*
Little blue heron	*Egretta caerulea*
Live oak	*Quercus virginiana*
Longleaf pine	*Pinus palustris*
Longleaf threeawn	*Aristida palustris*
Maidencane	*Panicum hemitomon*
Manateegrass	*Syringodium filiforme*
Melaleuca	*Melaleuca quinquenervia*
Mile-a-minute	*Mikania micrantha*
Mosquitofish	*Gambusia affinis*
Mullet	*Mugil* spp.
Myrsine	*Myrsine cubana*
Nile monitor	*Varanus niloticus*
Old World climbing fern	*Lygodium microphyllum*
Oyster	*Crassostrea virginica*

Common Name	Scientific Name
Peelbark St. John's-wort	*Hypericum fasciculatum*
Pickerelweed	*Pontederia cordata*
Pigeon plum	*Coccoloba diversifolia*
Pignut hickory	*Carya glabra*
Pond apple	*Annona glabra*
Pond cypress	*Taxodium ascendens*
Pond pine	*Pinus serotina*
Pop ash	*Fraxinus caroliniana*
pupfish	*Cyprinodon* spp.
Pygmy killifish	*Leptolucania ommata*
Raccoon	*Procyon lotor*
Red bay	*Persea borbonia*
Red drum	*Sciaenops ocellatus*
Reddish egret	*Egretta rufescens*
Redface topminnow	*Fundulus rubrifrons*
Red mangrove	*Rhizophora mangle*
Red maple	*Acer rubrum*
Red porgy	*Pagrus pagrus*
Red-cockaded woodpecker	*Picoides borealis*
Riverine grass shrimp	*Palaemonetes paludosus*
River otter	*Lontra canadensis*
Roseate spoonbill	*Platalea ajaja*
Rusty lyonia	*Lyonia ferruginea*
Saltbush	*Baccharis halimifolia*
Sand cordgrass	*Spartina bakeri*
Sand pine	*Pinus clausa*
Saw palmetto	*Serenoa repens*
Sawgrass	*Cladium jamaicense*
Sherman's fox squirrel	*Sciurus niger shermani*
Swamp bay	*Persea palustris*
Swamp sawgrass	*Cladium mariscoides*
Seminole rams-horn	*Planorbella duryi*
Shoalgrass	*Halodule wrightii*
Shoebutton ardisia (scratchthroat)	*Ardisia crenata*

Common Name	Scientific Name
Silversides	*Atherinidae*
Slash pine	*Pinus elliottii*
Snook	*Centropomus* spp.
Southern magnolia	*Magnolia grandiflora*
Spanish mackerel	*Scomberomorus maculatus*
Spiny lobster	*Panulirus argus*
Spotted seatrout	*Cynoscion nebulosus*
Strangler fig	*Ficus aurea*
Swamp tupelo	*Nyssa biflora*
Sweetbay	*Magnolia virginiana*
Tapegrass	*Vallisneria americana*
Tarpon	*Megalops atlantica*
Toothachegrass	*Ctenium aromaticum*
Torpedograss	*Panicum repens*
Tri-colored heron	*Egretta tricolor*
Turkey oak	*Quercus laevis*
Turtle grass	*Thalassia testudinum*
Virginia chain fern	*Woodwardia virginica*
Water ash	*Fraxinus caroliniana*
Water hickory	*Carya aquatica*
Water hyacinth	*Eichhornia crassipes*
Water-lettuce	*Pistia stratiotes*
Wax myrtle	*Myrica cerifera*
White grunt	*Haemulon plumierii*
White ibis	*Eudocimus albus*
White mangrove	*Languncularia racemose*
Wigeongrass	*Ruppia maritima*
Wiregrass	*Aristida stricta*
Wright's nutrush	*Scleria lacustris*
Yelloweyed grass	*Xyris* spp.

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Table of Contents

11 REFERENCES 1

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11 REFERENCES

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Table of Contents

12 INDEX 2

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1 INDEX

Adaptive Management Plan, 3-2, 6-15, 6-31, 6-36, 6-47, 6-49, 6-50

Aesthetics, 2-14, 5-20

Agricultural areas, 2-15

Air quality, 2-13, 5-20, 7-3, 10-5

Alternatives, v, 1-4, 2-18, 2-22, 3-1, 3-2, 3-14, 3-15, 3-16, 3-17, 3-18, 3-19, 3-20, 3-23, 3-24, 3-25, 4-1, 4-2, 4-3, 4-4, 4-5, 4-6, 4-7, 4-9, 4-12, 4-15, 4-17, 4-18, 4-19, 4-20, 4-21, 4-22, 4-23, 4-25, 4-26, 4-27, 5-1, 5-2, 5-3, 5-4, 5-10, 5-11, 5-12, 5-13, 5-14, 5-15, 5-16, 5-17, 5-18, 5-19, 5-20, 5-21, 5-22, 5-23, 5-24, 5-25, 5-26, 5-27, 5-28, 5-29, 5-30, 6-29, 6-51, 7-1, 7-13, 10-13, 10-15, 11-9

Annual costs, 4-5, 4-6, 4-13, 4-16, 6-32, 6-39, 8-2

Best management practices, 5-21, 10-6

Biological Assessment, 6-50, 7-4

Canal, ii, 1-1, 1-4, 1-5, 1-6, 1-9, 1-10, 1-11, 2-2, 2-3, 2-6, 2-11, 2-18, 3-3, 3-4, 3-5, 3-8, 3-9, 3-10, 3-11, 3-14, 3-15, 3-16, 3-17, 3-19, 3-20, 3-21, 3-22, 4-20, 4-26, 5-3, 5-5, 5-7, 5-8, 5-9, 5-10, 5-11, 5-16, 5-24, 5-25, 6-2, 6-3, 6-4, 6-5, 6-6, 6-7, 6-8, 6-9, 6-10, 6-11, 6-12, 6-13, 6-28, 6-29, 6-34, 7-13, 8-1, 8-2, 10-6, 10-7, 10-15

Clean Air Act of 1972, 7-3

Clean Water Act of 1972, 7-3

Climate change, 6-52, 11-16

Comprehensive Everglades Restoration Plan, 6-10

Construction, 2-6

Critical habitat, 2-10, 6-19, 6-24, 6-25 7-4, 10-7

Cultural resources, 6-19, 6-26, 6-28, 6-29, 6-30

Cumulative effects, 6-24

Eastern indigo snake, 2-10, 6-18, 6-24, 7-4

Ecology, 1-3, 4-26, 6-6, 6-28

Economy, 1-11, 2-15

Ecosystem

- **Habitat**, 10-10
- **Wetlands**, 6-18

Employment, 2-15

Endangered, v, vi, 2-1, 4-4, 4-8, 5-2, 5-4, 5-11, 6-24, 6-24, 6,37, 6-49, 7-5, 10-7, 10-9, 10-10

Endangered Species Act of 1973, 5-2, 7-4

Environmental justice, v, vi, 5-26, 7-8, 10-9

Environmental Protection Agency, 2-13, 2-23, 7-1, 10-4, 11-3

Essential fish habitat, v, vi, 2-13, 5-15, 7-5

Everglade snail kite, 2-10, 5-11, 5-12, 5-30, 6-18, 6-22, 6-24, 7-4

Exotics, 6-48

Farmland Protection Policy Act of 1981, 7-5

Final array, iv, 4-5

Fish, v, vi, 2-10, 2-11, 2-22, 4-2, 4-3, 4-4, 4-8, 5-5, 5-14, 5-15, 6-12, 6-19, 6-25, 7-5, 7-8, 10-6

Flood protection, vii, ix, 1.3, 5-33, 6-41

Florida manatee (West Indian manatee), 2-10, 5-11, 5-12, 6-18, 6-19, 6-24, 7-4

Florida panther, 2-10, 5-13, 6-18, 7-4

FWO, 2-1, 2-2, 2-8, 2-18, 3-13, 3-19, 4-2, 4-3, 4-4, 4-7, 4-9, 4-12, 4-22, 4-23, 4-2, 5-1, 5-2, 5-3, 5-7, 5-10, 5-11, 5-12, 5-13, 5-14, 5-15, 5-16, 5-17, 5-18, 5-19, 5-20, 5-21, 5-22, 5-23, 5-24, 5-25, 5-26, 5-28, 5-29, 6-21, 6-22, 6-23, 6-50, 6-51, 6-52, 6-55, 6-58, 7-12, 7-13

Geology, 11-12

Habitat, 1-2, 1-4, 1-10, 1-11, 1-12, 1-13, 1-14, 2-7, 2-10, 3-5, 4-3, 4-4, 4-8, 4-9, 4-11, 4-12, 4-18, 4-22, 4-23, 5-2, 5-5, 5-11, 5-12, 5-13, 5-14, 5-15, 5-16, 5-21, 6-1, 6-16, 6-18, 6-18, 6-20, 6-22, 6-24, 6-25, 6-28, 7-4, 7-5, 8-1, 10-10, 10-18

Hazardous, Toxic and Radioactive Waste, 7-7, 7-12

Income, 2-16, 5-26, 7-8

Land use, 2-7, 2-14, 5-21, 5-23, 6-22, 7-11

Levee, 1-1, 10-11

Magnuson-Stevens Fishery Conservation and Management Act, 2-11, 7-5

Marine Mammal Protection Act of 1972, 7-6

Marine Protection, Research and Sanctuaries Act, 7-6

Mitigation, 2-7, 2-18, 4-19, 5-16, 5-21, 5-28, 6-19, 6-26, 6-29, 6-30, 6-50, 7-7, 8-3, 10-12

Modeling, 2-2, 2-22, 3-1, 3-11, 3-14, 3-15, 3-20, 4-21, 4-26, 5-11, 5-16, 5-17, 5-18, 5-24, 6-1, 6-13, 6-14, 6-47, 6-50, 6-60, 7-12, 10-12, 11-7

Monitoring plan, vi, viii, 5-32, 6-15, 6-16, 6-36, 6-49, 7-13, 9-1, 9-2

National Environmental Policy Act, 2-1, 5-1, 7-1, 7-6, 10-3, 10-9, 10-15

National Historic Preservation Act of 1966, 7-6

Natural system, 1-2, 1-3, 2-7, 3-1, 5-24, 5-25, 6-23, 6-49, 6-58, 6-61, 8-5, 10-14

No Action, 3-9, 3-10, 3-11, 4-13, 4-14, 4-15, 4-16, 4-17, 4-21, 4-22, 10-12

Noise, v, vi, 2-13, 4-1, 5-20

Okeechobee gourd, xiv, 2-10, 5-13, 6-24, 7-4

OMRR&R, vii, ix, 3-20, 4-5, 4-7, 6-10, 6-17, 6-32, 6-36, 6-38, 6-40, 7-12, 8-2, 8-3, 10-4, 10-12

Outreach, 7-1

Performance measure, 4-1, 4-8, 4-9, 4-25, 10-13

Plan formulation, ii, iii, 1-13, 2-21, 2-22, 3-1, 3-6, 9-1

Plan implementation, vii, ix, 6-42

Problems and opportunities, i, 1-11, 1-14

Project Implementation Report, ix, x, 7-2, 10-13, 11-9

Project Partnership Agreement, 6-61, 8-2, 8-5

Pump station, 3-5, 3-14, 3-17, 3-21, 6-2, 6-4, 6-5, 6-6, 8-1

Real estate, vii, viii, 5-21, 5-32, 5-33, 6-10, 6-33, 6-35, 6-41, 9-1

Recommendations, 8-1, 8-7, 11-13, 11-14

RECOVER, iv, 3-25, 4-25, 4-26, 4-27, 6-15, 6-21, 6-23, 10-14, 11-3, 11-5, 11-8

Recreation, 1-11, 2-15, 2-16, 5-5, 5-24, 5-25, 6-1, 6-17, 6-18, 6-19, 6-23, 6-39, 6-43, 7-5, 8-2, 8-3, 10-12

Red-cockaded woodpecker, xiv, 2-10, 5-11, 5-12, 7-4, 10-20, 11-7

Reservoir, 1-4, 1-5, 2-18, 2-19, 3-2, 3-3, 3-4, 3-8, 3-10, 3-14, 3-15, 3-17, 3-19, 3-20, 3-21, 4-2,

4-3, 4-4, 4-19, 4-20, 4-21, 4-22, 5-5, 5-21, 5-23, 5-24, 5-25, 6-4, 6-5, 6-6, 6-12, 6-18, 6-28, 6-35, 6-43, 6-43, 6-44, 6-61, 6-62, 7-5, 7-13, 8-1, 10-10, 10-11, 10-14

Ridge and slough, 6-18

Risk and uncertainty, viii, ix, 6-60

Rivers and Harbors Act of 1899, 7-7

Salinity, 3-5, 4-2, 4-3, 4-8, 4-24, 4-25, 5-5, 5-12, 5-16, 9-2

Scoping, ix, x, 1-13, 2-18, 6-20, 7-1, 10-15

Sea level change, 2-8, 2-16, 2-22, 4-24, 6-61

Soils, 2-9, 5-3, 5-20, 7-7, 10-12, 11-13

South Florida, 1-1, 1-2, 1-3, 1-11, 1-13, 2-14, 2-15, 2-20, 4-9, 7-1, 10-3, 10-12, 10-16

South Florida Water Management District (SFWMD), 1-3, 2-15, 2-18, 6-10, 7-1, 10-15

Stormwater Treatment Area, 10-4

Study area, i, 1-3, 1-5, 5-23

System, iv, viii, ix, 4-21, 5-3, 5-25, 6-2, 6-4, 6-8, 6-15, 7-4

Threatened and endangered, 2-10, 6-24

Tree islands, 1-6, 1-11

U.S. Army Corps of Engineers, 3-1, 4-5, 7-1,

Unavoidable Adverse Environmental Effects, vii, viii, 6-28

Vegetation, 1-3, 1-10, 1-11, 1-12, 1-13, 2-7, 2-9, 2-22, 3-5, 3-8, 4-4, 4-4, 4-8, 4-10, 5-2, 5-5, 5-6, 5-7, 5-11, 5-12, 5-13, 5-29, 6-1, 6-9, 6-22, 6-25, 6-28, 6-48, 6-50, 7-8, 8-1, 10-12

Vegetative communities, v, vi, 5-3

Water

Quality, v, vi, ix, x, 1-4, 1-11, 2-12, 2-21, 2-24, 4-4, 4-8, 4-19, 5-17, 6-15, 6-16, 6-26, 6-47, 6-48, 7-3, 7-5, 7-11, 7-13, 8-6, 9-1, 9-2, 9-3, 9-4, 11-7

Supply, v, vi, vii, ix, 1-4, 1-11, 2-11, 2-15, 4-20, 5-23, 5-24, 5-26, 6-18, 6-23, 6-27, 6-52, 9-3, 10-14, 11-2

West Indian manatee (Florida manatee), 2-10, 5-11, 5-12, 6-13, 6-19, 6-24, 7-4

Wetland, 1-1, 1-3, 1-6, 1-9, 1-10, 1-11, 1-12, 2-5, 2-7, 2-9, 2-11, 2-14, 3-19, 3-20, 3-21, 3-22, 4-3, 4-4, 4-8, 4-9, 4-10, 4-12, 4-19, 4-21, 4-22, 5-3, 5-5, 5-6, 5-7, 5-10, 5-11, 5-12, 5-14, 5-15, 5-21, 5-23, 6-1, 6-6, 6-18, 6-22, 6-25, 7-8, 7-10, 8-1, 10-16, 11-3

Wood stork, 1-11, 2-10, 5-11, 5-12, 5-15, 6-18, 6-22, 6-24, 7-4

WRDA 2000, 1-2, 1-4, 1-13, 1-14, 6-21, 6-49, 6-50, 6-52, 6-58, 8-2, 8-3, 8-4, 8-5, 10-13

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