ANNEX D
ADAPTIVE MANAGEMENT AND MONITORING PLANS (AMMP) FOR THE LAKE OKEECHOBEE STORAGE RESERVOIR PROJECT

Adaptive Management and Ecological Monitoring Plans

Water Quality Monitoring Plan

Hydrometeorological Monitoring Plan

Table of Contents

List of Tables

List of Figures

D MONITORING PLANS

This annex contains the following monitoring plans:

1. Adaptive Management and Ecological Monitoring Plans
2. Water Quality Monitoring Plan
3. Hydrometeorological Monitoring Plan

Part 1: Adaptive Management and Ecological Monitoring Plans

D.1 Introduction to the LOCAR Adaptive Management and Ecological Monitoring Plans

The primary objective of the Lake Okeechobee Storage Reservoir Section 203 Study (LOCAR, Project, or Section 203 Study) Adaptive Management and Ecological Monitoring Plans (AMMP) is to identify the monitoring necessary to inform the decision-makers, LOCAR partner agencies, and the public on achieving restoration success, as well as address uncertainties related to Project performance that can be addressed with efficiently structured approaches. The AMMP follows the Comprehensive Everglades Restoration Plan (CERP) Guidance Memorandum 56 on the Integration of Adaptive Management into Program and Project Management. The monitoring plans specify what monitoring is necessary to measure and detect: benefits of capturing, storing, and redistributing water entering the northern Lake Okeechobee to improve lake stage levels for both environmental restoration and water supply purposes, and also improving flows to the Caloosahatchee and St. Lucie Estuaries (collectively, the "Northern Estuaries"). LOCAR's planning process and Recommended Plan selection were based on extensive existing scientific knowledge of Lake Okeechobee, the Lake Okeechobee Watershed, and the Northern Estuaries; understanding of the problems and opportunities; and the evaluation of alternatives and estimation of the potential Project restoration performance. While the Section 203 Study is based on a wealth of knowledge, the Adaptive Management (AM) plan is provided to help address uncertainty that exists, as in every natural resource management and restoration effort. While the ecological monitoring plan focuses on assessing LOCAR s meeting Project objectives (per Water Resources Development Act [WRDA] 2016 guidance), AM monitoring focuses on addressing Project uncertainties (per U.S. Army Corps of Engineers [Corps] Implementation Guidance on Section 1161 of 2016 WRDA; Corps 2017) that may be more specific in their location and/or scale than the overall Project objectives. Because most attributes in the ecological monitoring help address Project uncertainties as well as assess meeting project objectives, the ecological monitoring plan is contained within **Part 1** of **Annex D**. The AM monitoring focuses on addressing Project uncertainties that might not be conducted per the ecological monitoring plan. These plans will monitor ecosystem responses to changes in lake stage and flows into the estuaries that are expected through improvements with implementation of LOCAR. Monitoring described in the AM plan addresses specific AM uncertainties to determine the need for project adjustments that would improve ecosystem restoration performance. The ecological monitoring plan also contains the monitoring and associated costs required under the U.S. Fish and Wildlife Service's Final Biological Opinion (BO) for LOCAR, which was provided November 30, 2023. The BO and associated monitoring information for LOCAR is found in **Annex A**, *Fish and Wildlife Coordination Act and Endangered Species Act Compliance*, in the Final Environmental Impact Statement (EIS). Cost estimates for monitoring associated with the BO, including a Project-wide contingency cost, will be included in **Section 6** of the Feasibility Study.

The AMMP will be closely coordinated with the CERP Restoration Coordination and Verification (RECOVER) Monitoring and Assessment Plan (MAP) activities to ensure that measures and targets selected by the Project team are consistent with systemwide measures and leverage existing monitoring to avoid duplication of efforts. Furthermore, the monitoring plans will ensure temporal and spatial coverage of parameters that are appropriate to detect changes at the Project level. The monitoring plans will fill gaps in the MAP monitoring parameters to address LOCAR-specific needs by adding additional Project-level parameters not included in the MAP. Thus, the LOCAR monitoring plans will cover the LOCAR regions within Lake Okeechobee and the Northern Estuaries with greater spatial and temporal resolution to detect ecological changes resulting from Project-level implementation to evaluate Project success.

D.1.1 Structure of the LOCAR Adaptive Management Plan

The LOCAR AM plan is organized by Project objective. For each LOCAR Project objective, monitoring parameters have been identified to measure progress toward success of meeting the objective. Uncertainties for each objective were identified through a robust process described below in **Subsection D.3**. The AM plan provides a screened and prioritized summary of specific uncertainties that can be addressed with efficiently structured approaches. The AM plan describes the approaches (called "strategies") and suggests management options to adjust Project implementation for future consideration if needed. The AM plan is a culmination of input from well-developed Corps planning procedures, extensive scientific and local knowledge developed over decades of experience, and input from the LOCAR Project Team during preconstruction engineering and design (PED). **Table D-1** summarizes the (1) AM uncertainties, (2) monitoring attributes, (3) monitoring methodology and frequency, (4) monitoring cost estimates, (5) LOCAR monitoring locations, (6) current MAP monitoring component, (7) current monitoring by other agencies/universities, and (8) performance measures and ecological indicators. The main goal of the AM and ecological monitoring plans is to detect the expected improvements from LOCAR features and operations as well as to specify strategies, timing, and appropriate monitoring to address the LOCAR uncertainties.

D.1.2 LOCAR Adaptive Management Plan Background

LOCAR's planning and Recommended Plan selection were based on fulfilling CERP's Component A objectives, previous studies, as well as scientific knowledge of the Everglades ecosystem, Lake Okeechobee, and associated estuaries (Davis and Ogden 1994; Corps and SFWMD 1999; DOD 2003; RECOVER 2004; Ogden 2005; RECOVER 2009; McVoy et al. 2011; RECOVER 2011a and USACE and CERP guidance).

The U.S. Congress understood CERP uncertainties and required CERP to include AM for individual projects (WRDA 2000). The 2003 Programmatic Regulations outlined an AM program that would provide the tools needed to gather new information from the RECOVER MAP (RECOVER 2009) and incorporate new information (including project-level monitoring outputs), so that CERP could be adjusted to ensure restoration success.

The National Research Council's Committee on the Independent Scientific Review of Everglades Restoration Progress (CISRERP) endorsed the CERP AM program (NRC 2007) and concluded "…uncertainties remain about the degree to which a resilient, self-sustaining ecosystem can be restored under the dramatically changed environment of South Florida…" (NRC 2008). The CISRERP noted AM is essential for "…designing management strategies for dealing with complex ecosystem projects for which probable ecosystem responses are poorly known and hence, difficult to predict…" (NRC 2007). The CISRERP further reinforced its view regarding the inclusion of AM in CERP project planning and implementation by stating "…Given the enormous scope and complexity of the restoration effort, the success of the CERP depends on strategic, high-quality, responsive, and sustained science and an effective adaptive management framework…" (NRC 2010).

Table D-1. LOCAR AM Strategies: Template and Definitions.

LOCAR AM Uncertainty and ID#. *The uncertainty is a question faced during planning or implementation regarding the best restoration actions to achieve desired goals and objectives within constraints, which cannot be fully answered with available data or modeling. Uncertainties were screened and prioritized to determine which to include in the AM Plan.*

LOCAR Objective or Constraint: *Uncertainties needed to be related to LOCAR objectives or constraints, among other criteria, to be included in the AM Plan. This rule helped to focus the scope of the AM Plan.*
Region(s). *Area of LOCAR footprint to which the uncertainty and strategy pertain.*
Associated LOCAR features: *Structures or measures to which the uncertainty and strategy pertain.*
Driver or uncertainty type: *Unlike most AM Plans, not all LOCAR AM uncertainties and strategies are ecological. Types such as Engineering and Operations are identified.*

What is expected to be learned by addressing this uncertainty, that is, how will LOCAR benefit from addressing this uncertainty? *Why the uncertainty needs to be addressed in LOCAR.*

Expectations or hypotheses to be tested to address the uncertainty, and attribute(s) that will be measured to test each. *A scientific approach begins with a well-informed, pointed, detailed statement that will be tested. For the purposes of LOCAR's AM Plan, the statement can be referred to as an "expectation" or "hypothesis." Approaching uncertainties scientifically is efficient because it is targeted; a properly identified hypothesis statement is the most important step to lead to effective, efficient methodology to address an uncertainty. It leads to proper identification of what to measure, how, how often, how to analyze, etc.*

More Information on attributes to be measured:

- **What is expected to be learned by measuring this attribute, that is., how will LOCAR benefit from knowledge gained about this attribute?**
- **What is the timeframe in which changes to this attribute are expected to be measurable?**
- **Is this attribute complemented by other monitoring programs within and/or outside of LOCAR? If so, provide reference to other monitoring. Note the monitoring paid for by others in the LOCAR AM budget spreadsheet.**
- **When during LOCAR's lifecycle should this monitoring begin and end?**

Methodology for testing each expectation or hypothesis (including frequency of monitoring) and for reporting: *More information on what to measure, how, how often, how to analyze, and when and how to report results. PLEASE NOTE: The LOCAR AM Plan varies in the level of methodology detail provided; in several cases, the details will be formed during LOCAR's detailed design phase. In ALL cases, methodology will be reviewed, updated, and adjusted if needed by agency subject experts, before initiation, to best meet the intent of the AM Plan.*

Thresholds that may trigger need for adaptive management action. *Thresholds are a point, range, or limit that signifies when restoration performance is veering away from expectations and is trending toward an unintended outcome. Triggers/thresholds should be described per attribute to be monitored because each should result in an outcome that informs management decisions.*

Management options that may be chosen based on test results. *Management Options are provided in case a performance trigger or threshold is crossed, which would indicate that LOCAR performance needs to be adjusted. The Management Options are suggested paths forward and adjustments that can be made to keep LOCAR progressing toward objectives and within constraints. The Management Options are summarized in 11x17 pull-out tables after each region's strategies.*

AM–adaptive management; LOCAR–Lake Okeechobee Storage Reservoir Section 203 Study

Per the 2003 Programmatic Regulations, CERP produced guidance for project teams to develop AM plans and integrate AM activities into all phases of a project lifecycle including planning, design, construction, and operations (Corps and SFWMD 2011; RECOVER 2011b). These are appropriate to CERP's large scale and complexity, individual projects, new non-CERP water infrastructure projects, and the shifting nature of its ecosystems. The detailed guidance's intent is to improve restoration performance and reduce costs by increasing certainty throughout project implementation. The CERP guidance is consistent with the Everglades AM WRDA 2000 authorization and follows the more general 2009 AM guidance from Corps Headquarters on implementing Section 2039 of WRDA 2007.

Uncertainty exists in every natural resource management and restoration effort because many ecosystem processes are not linear. The processes work synergistically, and will unfold in a future climate that is likely to be different than the one used when formulating the Recommended Plan. The LOCAR AM plan will address key uncertainties identified during planning related to achieving restoration success and adjust the Recommended Plan to improve performance if necessary.

D.1.2.1 Definitions

Definitions that will help the reader understand the LOCAR AM Plan include the terms below. The concepts and definitions are described in more detail in CERP Guidance Memorandum (CGM) 56 (2010) and in the CERP Adaptive Management Integration Guide (RECOVER 2011b).

- **Adaptive Management** – A scientific process for continually improving management policies and practices by learning from their outcomes. AM links science to decision-making to improve restoration performance, efficiency, and probability of success. In the context of Lake Okeechobee Watershed and estuary restoration, AM is a structured approach to address uncertainties by implementing one project component or criteria for best project designs and operation to achieve restoration goals and objectives by linking science to decision-making and adjusting implementation to improve the probability of restoration success.
- **Uncertainty** – Risk identified during planning or implementation regarding the best actions to achieve desired goals and objectives within constraints, which cannot be fully answered with available data or modeling.
- **Management Options** – Potential structural, non-structural, and/or operational actions to be undertaken to improve restoration performance. AM plans contain potential management action "options" to improve performance in meeting project/program goals and objectives.
- **Strategies** – A plan to address uncertainties identified in the AM plan. CERP AM strategies fit into the following approaches:
    - ***Active Adaptive Management*** – Multiple pilot projects or design tests are implemented to determine the most efficient and effective way to achieve desired goals and objectives. Each design or operational action is monitored and assessed, and results inform implementation of a project component's or operations' best design. Pilot projects or design tests are usually conducted during implementation of the project component that they inform.
    - ***Passive Adaptive Management*** – A project component or operational criteria is implemented to test its ability to achieve desired goals and objectives. Results are monitored, assessed, and communicated to the appropriate participating agencies to determine how best to adjust

project component designs, operations, and/or LOCAR contingency options, or inform future CERP projects.

D.1.2.2 Conceptual Ecological Models

Conceptual Ecological Models (CEM) guided the LOCAR ecosystem restoration project planning. CEMs provide a link between early planning (e.g., an effective statement of problem, need, opportunity, and constraint) and later evaluation and implementation (Corps, EAB 2006). Conceptual ecological models are key components of the AM Program described in the Programmatic Regulations for CERP.

The total south Florida ecosystem encompasses natural areas that were once interconnected and embedded within the vast Everglades basin that originally extended from the Atlantic Ocean to the Gulf of Mexico and from the Upper Kissimmee Basin headwaters to Florida Bay and Biscayne Bay, including the Caloosahatchee, St. Lucie, and Indian River Lagoon estuaries.

Defining characteristics of the ecosystem have been altered by three external drivers that create stressors on the system: water management; land-use management and development; and climate change and sea level rise. Restoration of this system will be successful when defining characteristics of the pre-altered system are recovered.

D.1.2.2.1 Lake Okeechobee CEM

The Lake Okeechobee CEM (Havens and Gawlik 2005) was used to develop the Lake Okeechobee uncertainties and AM strategies described in this AM plan. The main stressors on Lake Okeechobee are (1) large inputs of nutrients from agricultural and other anthropogenic land uses in the watershed; (2) unnatural variation in water levels due to channelization of inflows and dike containment; and (3) rapid colonization of non-native plants. Ecological effects are complicated due to three distinct in-lake zones with different water chemistry, physical properties, and biota. The central pelagic zone has turbid, nutrient-rich water and phytoplankton dominance. The shallow southern, western, northwestern, and northern nearshore zones have submerged plant or phytoplankton dominance (at low versus high water levels, respectively). The western and northwestern littoral zones is dominated by emergent wetland plants.

Changes in water levels influence nutrient flow between zones, creating a synergistic effect between stressors. Under high water conditions, there is considerable advective transport of nutrients from the pelagic zone into the nearshore and littoral zones. Under low water conditions, the littoral zone is cut off hydrologically and becomes a rainfall-driven, oligotrophic wetland. Low water also facilitates drying and wildfires in the littoral zone, which in turn influences expansion of non-native plants and recovery of native plants from buried seed banks. These factors influence fish, wading birds, and other animals depending on littoral and nearshore plant communities for nesting and foraging habitat (Havens and Gawlik 2005).

D.1.2.2.2 Caloosahatchee Estuary CEM

The Caloosahatchee Estuary CEM (Barnes 2005) was used to inform the uncertainties and develop the AM strategies for the Caloosahatchee River and Estuary. In the Caloosahatchee system, physical alterations and changes in estuarine salinity, flows, and nutrient inputs can affect estuarine fishes, dolphins, manatees, and benthic communities, including bivalves and submerged aquatic vegetation (SAV). These estuarine attributes can be used as indicators of restoration success (Barnes 2005).

D.1.2.3 St. Lucie Estuary and Indian River Lagoon CEM

The St. Lucie Estuary and Indian River Lagoon CEM (Sime 2005) informed uncertainties and AM strategies. External drivers resulting in St. Lucie Estuary and Indian River Lagoon ecological stressors include agriculture; urban land use; development and ensuing construction; and water management in the estuary's and lagoon's local watersheds and Lake Okeechobee's larger drainage basin. Sea level rise is also a factor affecting these system's ecology. These drivers result in major stressors including Lake Okeechobee high-volume freshwater flows, basin flood flows, and basin water withdrawals. These alter freshwater flow volume and timing, which in turn alter estuary salinity and increase turbidity and color.

The key ecological attributes affected by these stressors include SAV, oyster communities, estuarine fish communities, sport and commercial fisheries, estuarine benthic communities, shoreline habitat, and nearshore reefs. The critical linkages between stressors and attributes described in the CEM were informed estuary uncertainties in LOCAR and the AM strategies in this AM plan (Sime 2005).

D.1.2.4 AM Implementation

AM activities will be implemented during upcoming phases of LOCAR and the AM plan will be updated accordingly. AM options proposed in this plan may be refined as more data becomes available, key questions are answered, and new monitoring requirements are identified by monitoring programs and restoration projects. Funding for items described in this AM is not guaranteed and will be reconsidered as LOCAR is closer to implementation. Monitoring and AM decisions will be made commensurate with available funding at that time.

D.1.2.5 AM Summary

There is extensive knowledge about Lake Okeechobee, but uncertainties that need to be addressed were evident during project planning. The AM plan provides a mechanism to systematically address uncertainties during LOCAR's implementation, confirm project performance is on the right trajectory, detect needed adjustments as soon as possible, and provide sound data to inform operations and implement decisions. The monitoring plans detect performance gaps and the AM plan describes options for adjusting the LOCAR, if needed, to remain on track with performance expectations, as well as suggesting future CERP options to meet overall CERP restoration goals.

D.1.3 How the LOCAR Adaptive Management and Monitoring Plan Was Developed: Identification, Screening, and Prioritization of LOCAR Uncertainties

The LOCAR AM plan development consisted of the following activities, consistent with the Corps planning guidance and CERP AM guidance:

- LOCAR Project Team and stakeholder involvement;
- Identification and prioritization of key LOCAR AM uncertainties, also referred to simply as "uncertainties" throughout this AM Plan (**Subsection D.1.4**) related to achieving the LOCAR goals and objectives and avoiding constraints (**Section 1** of the Section 203 Study);
- Development of AM strategies to address the uncertainties during LOCAR design, construction, and operations that consider existing regional conceptual ecological models, hypotheses, performance measures, and monitoring (**Subsection D.1.4**);

- Identification of monitoring thresholds and/or triggers and associated management options to adjust, if necessary, based on feedback from assessments (**Subsection D.1.4**); and
- Development of an AM implementation process to carryout AM activities during design, construction, operations related to baseline and post-Project construction monitoring, tests, analyses, and the process for communicating scientific findings to decision-makers, restoration partners, and the public (**Subsection D.1.4**).

A list of uncertainties was screened using the following criteria:

1. **Must be directly related to LOCAR goals, objectives, or "constraints."** The constraints included, but were not limited to, the legal/Corps definition of constraints.
2. **Must be at Project-scale**. Although LOCAR is large, it is not a systemwide scale. Systemwide uncertainties were routed to appropriate groups.
3. **Must have AM options** (i.e., ability to be addressed during implementation, improved by adjusting LOCAR). In some cases, additional ability to address the uncertainty with a future increment of restoration was noted as a "future opportunity," but this feature was not sufficient to pass this LOCAR AM criterion.
4. **Must be an uncertainty**. It should not include items that are already known. For example, the question should not ask "What are the effects of reduced freshwater flows on oysters in the St. Lucie Estuary?" which is known. Instead ask, "Will LOCARS's improvements to salinity regimes be sufficient for recruitment of new oyster populations or will supplemental habitat enhancement be required?".
5. **Must have measurable attribute(s).** The uncertainty needs at least one attribute that is measurable that will provide information to resolve the uncertainty (i.e., the attribute must be a trait able to change in the timeframe of the AM plan, and one that is distinct from the "background noise" of natural variability). Long-term changes need a faster responding surrogate-measure for the AM plan.

After a list of screened uncertainties was identified, the following criteria were used to prioritize them:

Risk: What is the risk (i.e., high, medium, low) of not meeting LOCAR restoration goals if this uncertainty is not addressed?

- Low risk means that even if the uncertainty is not addressed, it does not pose much risk to achieving LOCAR goals and objectives.
- Medium risk means that if the uncertainty is not addressed it may or may not affect achievement of a goal/objective.
- High risk means that without addressing this uncertainty, there is a high risk to not achieving LOCAR goals and objectives.

Knowledge: What is the level (i.e., high, medium, low) of understanding of this uncertainty (i.e., how much is known about this uncertainty)?

- Low understanding means little is known about the question/issue or how to address it.
- Medium understanding means some information is known in some geographical areas, but not all.

- High understanding means much is known about addressing this question in multiple geographical areas.

Relevance to Adaptive Management for LOCAR: What is the level of confidence (i.e., high, medium, low) that anything could be done to address the uncertainty? The team's preliminary identification of management options helped to determine this.

- Low confidence means that even if this uncertainty is addressed, LOCAR or operations will not be able to be modified given the results of LOCAR implementation.
- Medium confidence means if this question is addressed, a connection to future CERP project implementation is established/documented, but future adjustments to LOCAR may or may not be limited, especially if indicator response is longer than 10 years and is more relevant to RECOVER systemwide monitoring.
- High confidence means if this question is addressed, LOCAR design, implementation, and/or operations can be modified to improve restoration results.

The identification, screening, and prioritization process resulted in a final prioritized list of uncertainties. This list was used to develop strategies, management options, and costs to develop the AM Plan.

The AMMP provides a screened and prioritized summary of specific uncertainties that can be addressed with efficiently structured strategies. The AMMP describes strategies and suggests management options for future consideration if needed.

Per CERP's AM guidance, the management options included in this AM Plan can be described as the following:

1. Informing LOCAR Implementation—Results of monitoring a Project component may inform design, construction, and/or operation of subsequent Project components;
2. Informing Project Operations—Results inform Project operations and/or system operating manuals; and
3. LOCAR AM Contingency Options—Monitoring results may suggest a need to implement additional restoration actions, called "management options," pending all required and applicable coordination, policies, and permitting.

The strategies and management options comprise the bulk of this AM plan. Adaptive management activities will be implemented during the coming phases of LOCAR, and the AM plan will be updated accordingly. At such time, more baseline data and lessons learned will be available from other monitoring programs and restoration projects. Given the new knowledge and answers to key questions, the AM strategies and options proposed in this AMMP may need refinement. Therefore, items included in this plan are not guaranteed to be funded as-is but will be considered again when LOCAR is closer to being implemented and as appropriate, and funding decisions will be made commensurate with available funding at that time.

It should be noted that cost estimates in this plan were provided using the best available information at the time of writing. Costs for recommended AM and monitoring may be different during implementation. Therefore, several detailed estimates provided in this AM and monitoring plan may be lower than the amounts shown in the cost summary tables that include the contingency (**Table 6-9** in **Section 6**, and **Table D-7**). The contingency percentage was based on a Project-wide analysis and therefore it should not be

assumed that the additional contingency amounts shown in the summary cost tables will be available specifically to fund monitoring.

D.1.4 LOCAR Adaptive Management Uncertainties, Strategies, and Management Options

LOCAR uncertainties in this section consist of prioritized needs and opportunities to learn in order to make scientifically sound recommendations to refine LOCAR design, construction, and operations. The strategies and management options provided to address each uncertainty are intended to guide LOCAR performance in the face of inevitable uncertainties with existing knowledge and knowledge that gained through monitoring and assessment. The strategies are focused on LOCAR to maximize return on investment for resources invested in the AM activities. As with the other monitoring plans in **Annex D**, the monitoring proposed in the AM strategies was guided in part by two objectives: to be complete from a LOCAR perspective by providing the monitoring required to address LOCAR-specific uncertainties; and to integrate with other Lake Okeechobee Watershed and estuary monitoring to take advantage of existing monitoring efforts, knowledge, and information, and thereby leverage dollars committed and spent elsewhere to avoid redundancies and ensure cost-effectiveness. Where possible, the LOCAR AM strategies rely on existing monitoring resources such as physical instrumentation, stations, locations, servicing, and analysis efforts funded by RECOVER, CERP sponsors, and partner agencies. Therefore, the monitoring requirements described here are limited to the additional, marginal increase in monitoring resources and analysis efforts needed to address LOCAR-specific AM questions. This point is discussed in the LOCAR Adaptive Management Implementation section of this plan, and **Table D-5** is provided to show leveraged monitoring. In addition, it should be noted that the timing of the strategies is staggered throughout the design and implementation of LOCAR. Please see **Section 1.6** (Implementation of LOCAR Adaptive Management) and the associated figures and tables for more detail on the estimated start and stop times for each AM strategy.

The uncertainties, their identification numbers (ID#), and the LOCAR objectives and/or constraints are listed in the subsections to follow for reference. The Project objectives and constraints are described in detail in LOCAR Section 203 Study **Section 1** (Introduction). A list of uncertainties that were screened out is provided in the final section of this AM plan (**Table D-9**) to show the array of ideas that were considered and brief notes from the screening process. As the LOCAR Project team learns from LOCAR implementation, the list of LOCAR AM uncertainties will be updated to identify which have been addressed and where the risks to achieving LOCAR restoration success have been reduced. During implementation, additional AM and monitoring may be required based on findings and new science available at that time.

The remainder of this section of the AMMP provides strategies for addressing the following screened uncertainties:

Note: The uncertainty identification (ID) numbers below refer to the ID numbers assigned to each uncertainty during AM screening, and therefore may not appear sequential because those that did not pass screening are no longer included. The ID numbers were maintained for organizational purposes; future refinements of the LOCAR AM Plan may include re-numbering of the uncertainties.

D.1.4.1 Lake Okeechobee

- Will ecological indicators respond to lake changes as expected? (ID#25; LOCAR Objective 1)

- Will fish and wildlife communities' benefit from the Project's effect on lake stages or will additional habitat management be needed? (ID#26; LOCAR Objective 1)
- How will new hydrologic regimes affect the occurrence of invasive (native and/or non-native) or undesirable vegetation species in Lake Okeechobee? (ID#17; LOCAR Objective 1)

D.1.4.2 Estuaries

- When flows from Lake Okeechobee are reduced and salinity regimes for SAV are improved, what changes to SAV extent and species composition/diversity will occur in the estuaries? (ID#12; LOCAR Objective 2)
- When flows from Lake Okeechobee are altered, and salinity regimes for oysters are improved, what changes to oyster abundance, density, extent, and recruitment will occur in the estuaries? (ID#16; LOCAR Objective 2)

AM strategies are provided in this section to describe and address each LOCAR AM uncertainty and inform LOCAR implementation based on the body of existing scientific knowledge of Lake Okeechobee Watershed restoration. This section comprises the bulk of the LOCAR Adaptive Management Plan. It provides one-to-two-page strategy descriptions for each uncertainty (sometimes combined, where appropriate) and summary tables of suggested management actions to improve restoration performance, as illustrated in **Table D-1.**

The strategy write-ups include detailed descriptions:

- Information on drivers of the uncertainty, restoration targets, and LOCAR targets for particular attributes of the ecosystem associated with the uncertainty (such as a key species or ecological features);
- Information on how these attributes will be monitored to track progress toward the targets;
- The timeframe in which changes in these attributes will be measurable; and
- Identification of a trigger or threshold that would give early warning that LOCAR performance is veering away from restoration expectations.

The "timeframe in which changes will be measurable" does not imply that changes will be complete in that timeframe; rather, it provides an estimate of time needed to begin to be able to distinguish LOCAR effects. For practicality, the LOCAR AM Plan screening criteria included the need to have attributes measurable within the time of the AM Plan, which in some cases necessitated a 'proxy' attribute to be measured that would represent expected changes on a longer time scale. In addition, the triggers and thresholds were identified with the best available information, but the AM team recognizes that they should be updated to keep current with best available science.

Following the strategies, tables of suggested management options called Management Option Matrices (MOM) are provided. These provide suggestions of paths forward and adjustments that can be made in order to keep LOCAR progressing toward the targets, based on specific decision criteria, (e.g., a trigger or threshold is crossed reflecting unintended effects related to a constraint or is not crossed reflecting lack of progress towards restoration goals and objectives).

The purpose of the two formats is to provide: 1) background and detail of each strategy in the one-to-two-page write-ups, and 2) a table reference summary and crosswalk that relates monitoring to specific decision criteria and potential actions for multiple strategies in a specific area. The detailed write-up descriptions are referred to as the "strategies" and the summary tables are referred to as MOMs (**Table D-1**). The strategies and MOMs provide synopses of the best available information, which in some cases is sparse and will need to be developed further as LOCAR moves toward implementation and the AM plan is updated based on new information gained about the best Project design and operations to achieve restoration goals.

AM activities will be implemented during the coming phases of LOCAR, and the Adaptive Management Plan will be updated accordingly. At such time, more baseline data and lessons learned will be available from other monitoring programs and restoration projects. Given new knowledge and answers to key questions, the AM options proposed in this plan may need refinement. Therefore, items included in this plan are not guaranteed to be funded as-is but will be considered again when LOCAR is closer to being implemented and as appropriate, and funding decisions will be made commensurate with available funding at that time.

The LOCAR AM uncertainties and the strategies to address them are provided in the format shown in **Table D-1**. The uncertainties and strategies are presented by Project objective, and each objective set is followed by an 11 by 17-inch pull-out table of suggested management options that can support LOCAR and potentially CERP refinement (MOMs). The MOM shown in **Table D-2** and throughout the AM plan help link monitoring identified in specific AM strategies to decision criteria and suggested management options to consider for adjusting LOCAR if monitoring reveals performance issues related to LOCAR operations. The timeframe to detect changes does not imply that changes will be complete in that timeframe; rather, it provides an estimate of time needed to begin to be able to distinguish effects of LOCAR. These timeframes are indications of response speeds, not limits on how long the monitoring will be conducted.

Table D-2. Lake Stage Management Option Matrix.

Uncertainty Tracking ID#	Timeframe to Detect Change of Attributes*	Attribute or Indicator	Proposed Property to be Measured and Frequency	Decision Criteria: Trigger(s) for Management Action	Management Action Options Suggestions
#25 Will ecological indicators (EI) respond to lake stage changes as expected? **#17** How will new hydrologic regimes affect the occurrence of invasive (native and/or non-native) or undesirable vegetation species in Lake Okeechobee?	1 year	EI: *Chara*, vascular SAV, and cyanobacteria. EAV species groups in littoral zone.	Abundances of EI, as well as acreage of total SAV in nearshore and 9 EAV species in the littoral zone. Annual monitoring of *Chara*, vascular SAV, nearshore SAV, phytoplankton, and littoral EAV.	SAV coverage of less than 35,000 acres and/or fewer than half of select littoral zone species coverage values are met. Species include bulrush, sawgrass, beakrush/spikerush, cattail, willow, floating leaf, torpedo grass, other invasive (native and/or non-native) or undesirable species, and woody vegetation.	Adjust water level operations in Lake Okeechobee as appropriate for the ecological indicators included but not limited to recessions, low water, reduced highs, etc. Additional habitat management operations, e.g., invasive (native and non-native) or undesirable vegetation removal, prescribed burning, plantings, etc. Implement additional fish monitoring or analyses.

Uncertainty Tracking ID#	Timeframe to Detect Change of Attributes*	Attribute or Indicator	Proposed Property to be Measured and Frequency	Decision Criteria: Trigger(s) for Management Action	Management Action Options Suggestions
#26 Will fish and wildlife communities' benefit from the project's effect on lake stages, or will additional habitat management be needed?	1 year	Current annually monitored species: wading birds, snail kites, fish.	Annual wading-bird abundance and nesting effort/success; snail kite nesting effort/success; fish composition/catch rate/age distribution.	Substantial reductions in abundance/composition/catch rates/age distributions of listed attributes. Annual wading bird abundance reduced by 50 percent and reduction in nesting effort/ success of 50 percent. Annual snail kite reduction to below the 3-year moving average in nesting effort/success. Annual fish composition/catch rate/age distribution reduced by 50 percent.	Adjust water level operations as appropriate for the listed attributes included but not limited to recessions, low water, or reduced highs. Additional habitat and/or species management operations, e.g., invasive (native and/or non-native) or undesirable species removal, prescribed burning, plantings, and harvest regulations. Implement additional faunal monitoring or analyses. Implement additional fish monitoring or analyses.

*Timeframe could be shorter or longer, depending upon prevailing weather patterns.
EAV–emergent aquatic vegetation; EI–ecological indicator; SAV–submerged aquatic vegetation.

D.1.5 LOCAR Objective 1—Lake Okeechobee Strategies and Management Options

Objective 1 of LOCAR is to improve quantity, timing, and distribution of flows into Lake Okeechobee to maintain ecologically desired lake stage ranges more often. The following AM strategies were developed to address the uncertainties about maintaining the ecologically desired lake stage ranges. From the AM uncertainties, a monitoring plan is presented in **Subsection D.1.8** that documents the ecological monitoring and AM monitoring required to measure success of the Project in reaching the goals of Objective 1.

D.1.5.1 Lake Okeechobee Ecological Indicators: Fish and Wildlife Communities

LOCAR is expected to benefit floral and faunal communities of Lake Okeechobee by improving the quantity, timing, and distribution of flows into the lake, resulting in more ecologically desired lake stages. These expectations are based on known or assumed relationships of certain indicators and species to lake stage, based on varying periods of record. For many of the datasets, the period of record is marked by extreme weather events including multiple hurricanes and record low lake levels, some of which occurred within 1 to 2 years of each other. While there is ample evidence regarding the effects of extreme lake stages, there is more uncertainty regarding the effects of stabilized water levels as predicted to occur with LOCAR. How the indicators and faunal communities respond will depend on the extent to which the frequency and duration of high lake stages are reduced because of additional water storage constructed in the Lake Okeechobee Watershed.

The LOCAR AM strategy described here focuses on continuing long-term monitoring programs and updating analyses to improve LOCAR's ability to achieve benefits in the lake ecosystem, concurrent with Project objectives. This topic is included in the AM Plan because of its level of uncertainty and risk to LOCAR outcomes, its ability to be addressed through management options, and to ensure that it remains part of LOCAR discussions as lessons are learned throughout the implementation of the Project.

LOCAR AM Uncertainty #25, #26 –Will ecological indicators respond to lake changes as expected? Will fish and wildlife communities' benefit from the Project's effect on lake stages or will additional habitat management be needed?

Objective or Constraint: These uncertainties are related to the objective of improving the quantity, timing, and distribution of flows into Lake Okeechobee to maintain ecologically desired lake stage ranges (Objective 1).

Region(s): Lake Okeechobee

Associated Project Features: Deep Reservoir

Driver or Uncertainty Type: Ecological

What is expected to be learned by addressing this uncertainty (i.e., how will LOCAR benefit from addressing this uncertainty)? Little new monitoring is proposed in this AM strategy other than annual aerial/satellite imagery collection and classification for the littoral marsh. However, continuation of many ongoing monitoring efforts conducted by various entities and updating analyses will be key to addressing these uncertainties. Most of the specified ecological indicators are monitored by South Florida Water Management District (SFWMD) including classifying littoral vegetation, when available, while various

faunal groups are monitored by the Corps and Florida Fish and Wildlife Conservation Commission (FWC). Thus far, these projects have provided fairly strong evidence for lake stage targets but need to be collected across a wider variety of climate conditions to verify assumptions and refine predicted relationships. Specifically, the monitoring of the indicators and fauna need to assess how stabilization of water levels overall, with consistent reductions in high lake stages, will have on Lake Okeechobee's resources, especially in regard to community resilience, for example. Increasing the frequency and reliability of imagery collection and classification will improve the ability to detect change on a lake-wide scale and be critical to discerning Project-related effects from climate or other variability.

Expectations and hypotheses to be tested to address uncertainty, and attribute(s) that will be measured to test each. The expectation to be tested is that maintaining lake stages within ecologically desired ranges more frequently will offset impacts from very minor increases in the frequency of extreme low lake stages. Additionally, the expectation that reducing the frequency of moderate high stages (e.g., over 16 feet [ft] National Geodetic Vertica Datum of 1929 [NGVD29]) will be enough to restore submerged aquatic vegetation habitats at lower elevations after extirpation from storm events. Reference the 2020 RECOVER performance measure for Lake Okeechobee for a definition of the most recent information with respect to ecologically desirable ranges (RECOVER 2020).

The attributes to be measured are representative of ecological conditions on the lake, and how they respond will be a direct measurement of LOCAR's impact to the system. Many of them will be monitored in the nearshore region, which is the area where changes in lake stages have the most immediate impact. These include submerged and emergent aquatic vegetation (SAV and EAV), cyanobacteria, phytoplankton, and sportfish (e.g., largemouth bass [*Micropterus salmoides*]) data. Wading birds, snail kites, and vegetation composition/distribution will be monitored throughout the marsh while fish communities will be assessed in the nearshore and pelagic zones.

Most of the attributes respond relatively quickly to hydrological changes or the indirect effects of stage variations on water quality parameters. While initial responses may be detected within a year in some cases, correlating those responses to Project implementation would likely take several years and cover a variety of climate conditions. Monitoring should be implemented concurrent with Project implementation and continue through extreme dry and wet conditions (5 to 10 years) to fully evaluate responses.

Methodology for testing each expectation or hypothesis. Little new monitoring is proposed to address these uncertainties other than classifying annual imagery (aerial or satellite) for the littoral marsh. All the monitoring proposed relies on existing long-term datasets and on maintaining or expanding monitoring programs that are currently running. LOCAR-specific analyses would be needed to determine how Project operations affect various ecological indicators; these are currently being supported by various groups, but if that monitoring is discontinued, LOCAR would need to fill the gaps.

For SAV and EAV mapping procedures, wading-bird foraging surveys, and fish monitoring see the Lake Okeechobee chapter of many South Florida Ecosystem Reports (SFER) (e.g., Zhang and Welch 2018). For information on wading-bird nesting colonies see the annual South Florida Wading Bird Report (SFWBR) (e.g., Cook and Baranski 2018), and for snail kites, see annual demographic reports from University of Florida's snail kite monitoring program (e.g., Fletcher et al. 2015).

How results will be reported and the triggers/thresholds that indicate good CERP performance or need for AM action:

The results for many of the monitoring activities, regardless of whether there was a significant relationship with LOCAR operations, are reported on annually in the SFER and once every 5 years in the RECOVER System Status Report (SSR). Wading bird nesting is reported in the annual South Florida Wading Bird Report (SFWBR) and snail kite nesting in the annual demographic reports from the University of Florida (e.g., Fletcher et al. 2015).

For Uncertainty #25, related to ecological indicators, those will be evaluated separately on an annual basis in the SFER.

For individual triggers/thresholds that would indicate a need for action, see **Table D-2**.

Habitat Management Options

For habitat management, one AM option would be to manipulate operations to affect lake stages so that they better align with needs of specific flora or fauna. For example, if operations appear to be having detrimental impacts to a particular group due to high recession rates or high lake stages, reducing those stressors through operations might be feasible.

There are also various habitat management actions that could be implemented to reach target vegetation compositions or to improve habitat for specific wildlife like fish, wading birds, and snail kites. Further, for harvested species like sportfish, regulations on the fishery could be revisited as well. Other options are provided in **Table D-2**.

D.1.5.2 Lake Okeechobee: Invasive or Nuisance Vegetation

LOCAR Uncertainty #17 –How will new hydrologic regimes affect the occurrence of invasive species in Lake Okeechobee?

Objective or Constraint: LOCAR Objectives #1 and #3

Region(s): Lake Okeechobee

Associated Project Feature: Deep Reservoir

Driver or Uncertainty Type: Ecological and Operational

What is expected to be learned by addressing this uncertainty (i.e., how will LOCAR benefit from addressing this uncertainty)? This will improve the understanding and control of invasive species dynamics within the lake and the efficacy of implementing these types of sites elsewhere in the region to achieve habitat restoration.

Expectations or hypotheses to be tested to address uncertainty, and attribute(s) that will be measured to test each. The expectation is that the effect of reduced frequency and duration of high lake stages may have differential effects on invasive plants in the lake. During high lake stages, nuisance species like cattail (*Typha* spp.) can expand into higher elevations and displace desirable native communities. This issue is likely to be mitigated by reduction of high stage durations through creation of watershed storage associated with this Project. However, slight increases in low stage durations may occur with the Project

relative to FWO, which may cause expansions of other exotic species like torpedograss (*Panicum repens*), which tends to expand downslope during low stages and is subsequently difficult to eradicate. The proposed vegetation mapping will detect this and identify areas for control or management. It is expected that this type of work will be more intensive if there are dry periods in the early phases of the Project but should reduce in scale with regular maintenance activities. The attributes to be monitored are the location, percentage, and types of invasive species in the lake. Monitoring for invasive species will be covered in the Invasive and Nuisance Species Management Plan for LOCAR (**Annex G**).

What is the time frame in which changes to this attribute are expected to be measurable? Although changes could occur any time, we expect the greatest change and potential need for action to occur within 5 years of Project operation, particularly if dry climatic conditions persist.

When during LOCAR's life cycle should this monitoring begin? Within 12 months of beginning operations.

Methodology for testing each expectation or hypothesis. Assessment of sites via aerial or photographic interpretation in conjunction with ground surveys. Invasive vegetative communities may be mapped to show location and species composition. Post-treatment surveys may report the percentage of invasive species controlled or eliminated.

Triggers/thresholds that indicate good Project performance or need for AM action: Minimal unwanted invasive species. Species targets are identified in the EAV RECOVER PM and could be used as thresholds for invasive and exotic species as well.

Management options that may be chosen to reduce the impacts of invasive species. Please refer to **Annex G**, the LOCAR INSMP and **Table D-4** Invasive Species Management Option Matrix. The efforts of the INSMP and the AM strategy will be coordinated to minimize redundancy. Remediation techniques (flooding, burning, or herbicide) may be appropriate for cost and efficacy.

D.1.6 LOCAR Objective 2—Estuaries Strategies and Management Options

Objective 2 of LOCAR is to improve estuary flows from Lake Okeechobee to improve the salinity regime and the quality of oyster, SAV, and other estuarine community habitats in the Northern Estuaries. The following AM strategies were developed to address the uncertainties about improving estuary flows from Lake Okeechobee. From the AM uncertainties, a monitoring plan is presented in **Subsection D.1.9.2** that documents the ecological monitoring and AM monitoring required to measure success of the Project in reaching the goals of Objective 2.

D.1.6.1 Estuaries—Submerged Aquatic Vegetation Strategy

Within and between years, there will be seasonal and inter-annual conditions which may, in the short term, dampen the ability to detect changes to SAV between these short-term environmental conditions and restoration. Inherent uncertainties for SAV include species-specific responses to the Project-related salinity regimes.

LOCAR AM Uncertainty #12: Submerged Aquatic Vegetation—When flows from Lake Okeechobee are altered, are the appropriate salinity regimes for SAV established with the estuaries, and is this evident by changes in SAV abundance, extent, and species composition/diversity?

LOCAR Objective or Constraint: Objective 2—Restore and/or maintain estuarine communities (oysters, fish, seagrass).

Region(s): St. Lucie Estuary (SLE) & Caloosahatchee River and Estuary (CRE)

Associated LOCAR Features: Deep reservoirs

What is expected to be learned by addressing this uncertainty, i.e., how will LOCAR benefit from addressing this uncertainty?

SAV plays a critical role in influencing the population, community, and ecosystem dynamics of estuarine environments. Altered hydrologic activity (e.g., restorative freshwater flows) may influence the abundance and distribution of SAV including estuarine seagrasses and have marked positive effects on SAV with a lower salinity tolerance. However, if target freshwater flows are not achieved, there may be neutral or deleterious effects to SAV distribution, abundance, and productivity. Elucidating how restoration performance may influence SAV in the Northern Estuaries is imperative so that AM actions can be undertaken, ensuring restoration success.

Schedule and methodology for monitoring SAV:

RECOVER SAV MAP monitoring for the Northern Estuaries was updated in Spring 2018. The new protocol, the Northern Everglades Northern Estuaries SAV Ecosystem Assessment (NESEA), applies a nested, three-tiered hierarchical approach to address multiple scales of SAV monitoring in the Northern Estuaries region, namely: 1) landscape, 2) patch, and 3) shoot-level scales. The tiers are summarized as:

- **Tier 1—**Landscape-scale from which information on systemwide, long-term trends is attained. Currently, SFWMD has historical and current aerial mapping data for the east coast. Aerial mapping has previously occurred every 2 years, most recently in spring 2017 through a current collaboration with St. John's River Water Management District (SJRWMD) and Florida Department of Environmental Protection (FDEP). Flights and photographs for the next set of maps will be completed in May of 2023 and final maps completed in May 2024. This mapping has been ongoing since the late 1980s and is expected to continue. On the CRE, mapping is being performed approximately once every 5 years by the RECOVER program.
- **Tier 2—**Patch-scale measures which examine segments (or basins) of the system to determine segment-specific trends in ecological conditions at the species-specific level. This sampling may take place at the end of the dry and wet seasons.
- **Tier 3—**Fixed-point sampling by which statistically significant differences in specific plant responses to environmental stressors at a shoot-scale range are measured. Metrics such as biomass and shoot density are attained at this level. This sampling may occur every other month from April through November.

Triggers/thresholds that indicate good LOCAR performance or need for AM action, and subsequent management options:

To assess the LOCAR performance or whether there is a need for AM action as it pertains to SAV, decision criteria to trigger management action needs to be developed for each of the estuaries based on the best available science and known seagrass ecology and population dynamics. For all of the monitored groups,

one AM option would be to optimize flows to get the correct salinity in the correct locations so that salinity regimes better align with needs of the SAV species distribution.

D.1.6.2 Estuaries–Oyster Strategy

Within and between years there will be seasonal and inter-annual conditions which may, in the short term, dampen the ability to detect changes to oysters between these short-term environmental conditions and restoration. Besides adult oysters needing the correct salinity ranges, larvae and spat production, and recruitment success also depend upon specific salinity ranges. The decision criteria and management action options consider whether the intended changes in salinity timing are met.

LOCAR AM Uncertainty #16: Oysters—When flows from Lake Okeechobee are altered, are the appropriate salinity regimes for oysters established with the estuaries, and is this evident by changes in oyster abundance, density, extent, and recruitment?

Driver or uncertainty type: Ecological

LOCAR Objective or Constraint: Objective 2—Restore and/or maintain estuarine communities (oysters, fish, and seagrass).

Region(s): St. Lucie Estuary (SLE) & Caloosahatchee River and Estuary (CRE)

Associated LOCAR Features: Deep reservoir

What is expected to be learned by addressing this uncertainty, that is, how will LOCAR benefit from addressing this uncertainty?

Oyster communities in coastal estuaries have respective salinity envelope requirements to persist within a system. The timing and duration of altered freshwater flows due to restoration activities will affect the desired areal extent and abundance of oysters.

Schedule and methodology for monitoring oysters:

- Growth – measured monthly.
- Disease prevalence – measured monthly.
- Predation – measured monthly.
- Recruitment – measured monthly.
- Reproductive Development – measured monthly.
- Density and live/dead counts – measured 2 times per year.

Within and between years there will be seasonal and inter-annual conditions which may, in the short term, dampen the ability to detect changes to oysters between short-term environmental conditions post-restoration; therefore, mapping should occur pre-restoration, and then again 5 years after restoration implementation, and once every 5 years after to track long-term change and inform AM.

Triggers/thresholds that indicate good LOCAR performance or need for AM action and subsequent management options:

For all the monitored groups, one AM option would be to change operations to increase or decrease flows if the salinity envelope is not correct so that they better align with needs of the oysters. To assess LOCAR performance or whether there is a need for AM action as it pertains to oysters, decision criteria to trigger management action need to be developed for each of the estuaries based on the best available science and known oyster ecology and population dynamics (**Table D-3**).

- Identifying triggers for AM in the Northern Estuaries, especially the SLE and CRE, is complicated by occasional (or seasonal), extended periods of freshwater inputs following high rainfall or tropical storm events. For example, since 2005, five major, estuary-wide die-offs in the SLE have been observed including in late 2017 after Hurricane Irma. This die-off followed approximately 45 to 60 days of flows resulting in salinities under 5, often paired with temperatures above 25°C (M. Parker, pers. comm.). Generally, oysters return within 4 to 8 months, which is attributed to persistent seed sources in the southern Indian River Lagoon (IRL; outside of the SLE proper). These larval oysters are transported through tidal forces from the mouth of the estuary/IRL and repopulate dead shell material (M. Parker, pers. comm.). AM management triggers may be developed for the estuaries following this dynamic, whereby a given amount of time for oyster recruitment is used as a threshold. This will vary by estuary and by location in the estuary. This also emphasizes the importance of remnant oysters in these highly urbanized systems.

Table D-3. Estuaries oyster and submerged aquatic vegetation (SAV) Management Option Matrix.

Uncertainty Tracking ID#	Timeframe to Detect Change of Attributes	Attribute or Indicator	Proposed Property to be Measured and Frequency	Decision Criteria: Trigger(s) for Management Action	Management Action Options Suggestions
#12 and #16	Oysters: 5 years (acres of live oysters) SAV: 5 years	Oysters SAV	Oyster Monitoring: Monthly at 18 existing sites for: growth, disease, predation, reproductive development; recruitment; density, and live and dead counts (twice per year–spring and fall). Every 3-5 years, conduct estuary-wide substrate mapping for spatial extent and distribution of oyster and oyster shell. SAV Monitoring: **Tier 1** - Landscape scale – aerial mapping every 2 years. **Tier 2** - Patch-scale – species-specific cover and abundance at the end of the dry and wet seasons. **Tier 3** - Fixed-point sampling – cover, abundance, shoot-density, canopy height, and above-ground and below-ground biomass sampling occurs every other month from April through November.	Oysters: TBD SAV: TBD	Oysters: Change operations to increase or decrease flows if salinity envelope is not correct. SAV: Optimize flows to attain optimum salinity along estuarine gradient.

SAV–submerged aquatic vegetation

Table D-4. Invasive Species Management Option Matrix.

Uncertainty Tracking ID#	Timeframe to Detect Change of Attributes	Attribute or Indicator	Proposed Property to be Measured and Frequency	Decision Criteria: Trigger(s) for Management Action	Management Action Options Suggestions
#17 How will new hydrologic regimes affect the occurrence of invasive species in Lake Okeechobee?	Seasonally to years	Percent of invasive plant coverage, or appearance of new invasive species, or changes in density of existing invasive species.	Percent of invasives and species composition; measured annually or biannually during vegetation mapping of the littoral zone.	Infestations above targets described in EAV PM	Use standard practices (burning, flooding, and herbicides) or novel techniques to control or eradicate invasive plants; also refer to Invasive and Nuisance Species Management Plan. This MOM will be coordinated as much as possible with the Invasive and Nuisance Species Management Plan to minimize redundancy.

EAV–emergent aquatic vegetation; MOM–management option matrix; PM–performance measure

D.1.7 LOCAR Adaptive Management Monitoring Plan

Table D-5 summarizes the AM monitoring and includes (1) uncertainty, (2) monitoring attributes, (3) RECOVER costs, (4) other agency costs, (5) LOCAR costs, and (6) sampling frequency that summarizes the monitoring required to address the uncertainties described in **Subsection D.1.4**. In **Table D-5**, LOCAR monitoring costs are shown as if all monitoring will take place in one 10-year window. Therefore, LOCAR costs here are a 'worst case,' whereas the actual monitoring schedule is expected to be staggered over the LOCAR implementation schedule as shown in **Figure D-1** and would therefore cost the Project less per year.

D.1.8 Adaptive Management Monitoring

Table D-5 summarizes the AM monitoring to address the prioritized uncertainties. The AM monitoring also covers some of the Project-level monitoring described in **Table D-6** and is noted in where AM monitoring will also be used as Project-level monitoring.

Table D-5. LOCAR AM Monitoring Cross-walked with Other Monitoring Programs.

LOCAR Objective	Category or Specific LOCAR Area	Uncertainty	AM ID# or PM	Proposed Attributes to be Monitored	Ongoing RECOVER 1-yr Cost	Ongoing Other Agency 1-yr Cost	LOCAR 1-yr Cost*	Proposed Sampling Frequency	Notes
1	Lake Okeechobee	Will ecological indicators respond to lake stage changes as expected?	25	Abundances of ecological Indicators: *Chara* – nearshore 1 km grid cell centers Cyanobacteria – three pelagic and one nearshore site SAV – nearshore 1 km grid cell centers and 20 nearshore transects across 4 sites	$0	All but EAV: $201,610 (SFWMD)	Littoral EAV: $25,000 (per year)	Annual summer: *Chara*, vascular SAV, nearshore SAV, cyanobacteria, littoral EAV	
1	Lake Okeechobee	Will fish and wildlife communities' benefit from the Project's effect on lake stages or will additional habitat management be needed?	26	Wading birds, snail kites, fish	Wading bird nesting: $100,000	Snail Kites: $150,000 (Corps regulatory) Wading Bird Foraging: $25,000 (SFWMD) Fish: $25,500 (FWC electrofishing)	$0	Annual: wading bird and snail kite abundance and nesting effort/success, fish composition/catch rate/age distribution	
2	Estuaries	Submerged Aquatic Vegetation When flows from Lake Okeechobee are altered, and salinity regimes for SAV are improved, what changes to SAV abundance, extent, and species composition/diversity will occur in the estuaries?	16	Tier 1 - Landscape scale – aerial mapping every 2 years on the east coast, every 5 years on the west coast. Tier 2 – Patch-scale – species specific cover and abundance at the end of the dry and end of the wet season. Tier 3 – Fixed-point sampling – cover, abundance, shoot density, canopy height, above and below ground biomass – sampling occurs every other month from April through November.	$200,000 every 2 or 5 years for Tier 1 mapping $105,000 for Tiers 2 and 3	NA	$0	Tier 1 –aerial mapping every 2 or 5 years Tier 2 –at the end of the dry and end of the wet season. Tier 3 –every other month from April through November	RECOVER maps SAV approximately once every 5 years (CRE), and S-IRL through a partnership with SJRWMD mapped approximately every 2 years.
2	Estuaries	Oysters When flows from Lake Okeechobee are altered and salinity regimes for oysters are improved, what changes to oyster abundance, extent, density, and recruitment will occur in the estuaries?	12	Monthly at 18 existing sites for: growth, disease, predation, reproductive development; recruitment, density, and live and dead counts (twice per year– spring and fall). Every 3-5 years, conduct estuary-wide substrate mapping for spatial extent and distribution of oyster and oyster shell.	Annually: $155,000 Mapping every 3-5 years: $300,000	NA	$0	Monthly at existing RECOVER sites	RECOVER oyster mapping was completed in 2019 and will be repeated approximately every five years.

AM–adaptive management; Corps–U.S. Army Corps of Engineers; CRE–Caloosahatchee River and Estuary; EAV–emergent aquatic vegetation; LOCAR–Lake Okeechobee Storage Reservoir Section 203 Study; PM–performance measure; RECOVER–Restoration Coordination and Verification; SAV–submerged aquatic vegetation; SJRWMD–St John's River Water Management District; yr.–year.

Table D-6. LOCAR Project-specific Monitoring Cross-walked with Other Monitoring Programs.

Objective	Proposed Monitoring Attributes	Proposed Monitoring Methodology	Proposed Number of Transects / Sampling Points	Proposed Monitoring Frequency	Proposed Monitoring Locations	Estimated Annual Cost	Current Monitoring (Other)	Current Monitoring (RECOVER)	Performance Measures/Ecological Indicators	Monitoring Targets
1 - Improve quantity, timing, and distribution of flows into Lake Okeechobee to maintain ecologically desired lake stage ranges more often.	Abundance of ecological Indicators (*Chara*, cyanobacteria, panfish [bluegills and redear sunfish] and vascular SAV), as well as acreage of total SAV in nearshore and coverage of 9 EAV species groups in the littoral zone.	See Table D-11	See Table D-11	See Table D-11	See Table D-11	$0	See Table D-11	NA	RECOVER Lake Okeechobee Ecological Indicator PMs Lake Stage Envelope PM Extreme High and Extreme Low Lake Stage PMs.	The Ecological Indicator PMs target is a cumulative point score of 427 points over the 41 period of record (POR) lake stages. The annual summer nearshore SAV target is 50,000 acres. The littoral EAV cumulative target is 28,825 hectares with four of the individual targets including a range that could be smaller and three including a range that could be larger. The annual sentinel sites cumulative target is 850 hectares with the same indicators having either smaller or larger ranges.
2 - Improve estuary flows from Lake Okeechobee to improve the salinity regime and the quality of oyster, SAV, and other estuarine community habitats in the Northern Estuaries.	Monthly at 18 existing sites for: growth, disease, predation, reproductive development; recruitment; density, and live and dead counts (twice per year–spring and fall) Every 3-5 years, conduct estuary-wide substrate mapping for spatial extent and distribution of oyster and oyster shell.	See Table D-11	See Table D-11	See Table D-11	See Table D-11	$0	See Table D-11	Monthly at 18 existing sites for: growth, disease, predation, reproductive development; recruitment; density, and live and dead counts (twice per year–spring and fall). Every 3-5 years, conduct estuary-wide substrate mapping for spatial extent and distribution of oyster and oyster shell.	RECOVER Northern Estuaries Salinity Envelope PM RECOVER Oyster PM.	Maintain a salinity range favorable to fish and oysters.
2 -Improve estuary flows from Lake Okeechobee to improve the salinity regime and the quality of oyster, SAV, and other estuarine community habitats in the Northern Estuaries.	Submerged Aquatic Vegetation Tier 1 - Landscape scale – aerial mapping every 2 years Tier 2 - Patch-scale – species specific cover and abundance at the end of the dry and wet seasons. Tier 3 - Fixed-point sampling – cover, abundance, shoot density, canopy height, above and below ground biomass-sampling occurs every other month from April through November	See Table D-11	See Table D-11	See Table D-11	See Table D-11	$0	See Table D-11	Fixed transects 3x/year during growing season for monitoring. Mapping 1x/3-5 years.	RECOVER Northern Estuaries Salinity Envelope PM RECOVER SAV PM.	Maintain a salinity range favorable to SAV coverage.

EAV–emergent aquatic vegetation; LOCAR–Lake Okeechobee Storage Reservoir Section 2023 Study; Northern Estuaries–Caloosahatchee and St. Lucie Estuaries; PM–performance measure; RECOVER–Restoration Coordination and Verification; SAV–submerged aquatic vegetation.

D.1.9 LOCAR Ecological Project-level Monitoring Plan

The ecological monitoring focuses on LOCAR's success at meeting Project objectives (per WRDA 2016 guidance), while the AM monitoring focuses on addressing Project uncertainties (per Corps Implementation Guidance on Section 1161 of 2016 WRDA; Corps 2017) that may be more specific in their location and/or scale than the overall Project objectives. The ecological monitoring plan specifies what monitoring is necessary to measure and detect the benefits of capturing, storing, and redistributing water entering the north part of Lake Okeechobee to improve lake stage levels for both environmental restoration and water supply purposes and improving flows to the Northern Estuaries.

The Lake Okeechobee Watershed Restoration Project (LOWRP) ecological monitoring plan also contains the monitoring and associated costs required under the U.S. Fish and Wildlife Service (USFWS) BO and other agency permits that are needed to protect and conserve natural resources. The 2023 Final BO for the LOCAR Recommended Plan and associated monitoring information for LOCAR can be found in **Annex A**. Cost estimates for monitoring associated with the 2023 Final BO, including a Project-wide contingency cost, are in **Subsection D.1.7**.

The LOCAR ecological monitoring plan will be closely coordinated with the CERP RECOVER MAP to ensure that measures and targets selected by the Project teams are consistent with systemwide measures and to avoid duplication of efforts. Furthermore, the LOCAR ecological monitoring plan will ensure temporal and spatial coverage of monitoring parameters that are appropriate to detect changes at the Project level. The ecological monitoring plan will add additional Project-level parameters not included in the MAP to address LOCAR-specific needs to evaluate Project success.

For each LOCAR objective, ecological monitoring has been identified to measure progress toward success of meeting the objective.

D.1.9.1 Objective 1

Improve quantity, timing, and distribution of flows into Lake Okeechobee to maintain ecologically desired lake stage ranges more often.

This objective has three main components: one is the amount of time Lake Okeechobee remains in the ecologically preferred envelope; another is the amount of time the lake is above the extreme high lake stage and the amount of time the lake is below the extreme low lake stage, and the third is the ecological response to lake hydrology. The nearshore and pelagic regions of Lake Okeechobee are occupied by a number of key ecological communities, which can be used to evaluate the environmental health of the lake as a function of their responses to changing hydrologic conditions. For this objective, two attributes will be monitored: 1) lake stage, and 2) ecological indicators (vascular SAV, *Chara*, panfish, and cyanobacteria). Lake stage data will be leveraged from existing monitoring networks and the LOCAR Hydrometeorological Monitoring Plan (**Annex D, Part 3**). Ecological indicator data will be leveraged from existing monitoring done by the SFWMD, but additional monitoring of panfish will be required for this Project. The detailed field methodology to accomplish this objective will be described in more detail once LOCAR is authorized. Additional AM monitoring may be required and is discussed in **Subsection D.1.12** and **Table D-5**.

D.1.9.2 Objective 2

Improve estuary flows from Lake Okeechobee to improve the salinity regime and the quality of oyster, SAV, and other estuarine community habitats in the Northern Estuaries.

Using LOCAR planning model output, areas have been identified within the Northern Estuaries where the most change is expected due to LOCAR. In these areas, salinity conditions will improve the habitat for oysters and SAV, which will be the attributes to measure for Project success in meeting Objective 2. For this objective, three attributes will be monitored: 1) Lake Okeechobee flows to the Northern Estuaries, 2) oyster abundance, health, and distribution; and 3) SAV shoot count, density, and canopy cover. Lake flow data will be leveraged from existing monitoring networks and the LOCAR Hydrometeorological Monitoring Plan (**Annex D, Part 3**). The monitoring methodology includes gage data at Structure 79 (S-79) and Structure 80 (S-80). Oyster and SAV data will be leveraged from the RECOVER MAP. Oyster data will include density, live and dead counts, growth, disease, predation, reproductive development, and recruitment. SAV data will include a nested, multi-tiered monitoring approach that looks at regional, patch, and shoot-level responses to environmental change, and may include aerial mapping, haphazard sampling within tessellated hexagons, and Braun-Blanquet densities, shoot counts, and biomass metrics to better understand within-bed productivity, respectively. The detailed field methodology to accomplish this objective is described in the RECOVER MAP and will be described in more detail once LOCAR is authorized and the SAV protocol is approved by the RECOVER Executive Committee. Additional AM monitoring may be required and is discussed in **Subsection D.1.6**

D.1.10 Biological Opinion Monitoring and Regulatory Monitoring

The LOCAR AMMP is to contain the monitoring and associated costs required under the BO and other agency permits that are needed to protect and conserve natural resources.AM provides an interdisciplinary, integrated, structured process for lowering risk, increasing certainty, and informing decisions. For AM to be successful in ensuring the delivery of intended benefits and avoiding unintended negative impacts of LOCAR, AM activities should continue beyond project Planning for the entire Project lifecycle from completion of the Section 203 Study through all aspects of monitoring, engineering, design, construction, operations, and maintenance components. In addition, mechanisms must be in place to collect, manage, analyze, synthesize, coordinate, and integrate new information into management decisions. AM implementation can only succeed when decision makers have sufficient funding and staffing resources to implement the AM and monitoring plans. In addition, success requires political and stakeholder support to implement the AM decision methodology and adjust management decisions based on what is learned.

Per the Programmatic Regulations for CERP (2003), an AM process has been developed for CERP that guides systemwide CERP AM and Project-level AM (CGM 56 2010; RECOVER 2011b). This detailed CERP guidance adheres to WRDA 2007 and the WRDA 2007 implementation guidance provided by the Corps in 2009 in that it focuses on using monitoring information to inform projects and project components by resolving uncertainties and providing mechanisms to efficiently incorporate new knowledge in project planning, design, and implementation. LOCAR has and will use this framework to implement AM. Doing so will allow LOCAR to both take advantage of and contribute to work being done systemwide and by other projects. Because new information is continually becoming available, the LOCAR AMMP must be recognized as a living document that is improved upon through incorporation of new information. In

particular, as each Project component is designed and implemented, specific AM strategies and monitoring should be reviewed and adjusted as necessary. Throughout the implementation of the LOCAR AM plan, the LOCAR AM team will coordinate the AM monitoring, analysis, and reporting throughout the life of the Project. RECOVER will serve as an advisory group to implementation of the LOCAR AM plan because RECOVER has expertise from multiple agencies and disciplines, such as hydrologists, engineers, and water managers. The LOCAR AM team will be the central organizing entity of the AM monitoring, analysis, reporting, and elevating of options to adjust LOCAR, and the LOCAR AM team will continually coordinate with others to ensure that a full suite of experts is included. The LOCAR AM team will coordinate with project managers to inform possible AM actions as outlined in subsequent sections. LOCAR Project funds during PED, construction, and operations and maintenance (O&M) will support coordination efforts conducted by the LOCAR AM team and the AM strategies described in this LOCAR AM plan. LOCAR funds will be used to fund monitoring directly related to LOCAR AM monitoring needs; the funds are not designed to replace RECOVER's systemwide monitoring and science efforts. However, the RECOVER systemwide monitoring information will be used in combination with LOCAR's monitoring data to best address key questions about achieving restoration success. The intent is to have complementary efforts that maximize efficiency of monitoring. The LOCAR AM team will be responsible for ensuring that the AM Plan is implemented, and that the information is appropriately managed and integrated into the CERP decision process as outlined in the Adaptive Management Integration Guide (RECOVER 2011b). This section identifies which AM activities will occur during the phases of LOCAR Project implementation and how they relate back to the Project's AM plan. Unless otherwise noted, RECOVER will be engaged in all activities. AM will be reiterated in the coming phases of LOCAR, and the AM Plan will be reviewed and updated. At such time, more baseline data and lessons learned will be available from other monitoring programs and restoration projects. Given the new knowledge, key questions, monitoring thresholds/triggers, and AM options proposed in this plan may need refinement. Therefore, items included in this plan are not guaranteed to be included or funded as-is but will be refined and considered again prior to LOCAR implementation.

AM was incorporated during LOCAR's planning with AM experts integrally involved throughout the planning process. All of the items in the CERP "Project Level Adaptive Management Checklist" were considered and/or incorporated during the planning of LOCAR. CEMs were used for the other Project areas, including Lake Okeechobee, Northern Estuaries, and the total system. A cost effectiveness/incremental cost analysis of the future AM options was not conducted due to time constraints during planning. AM activities on the checklist that will take place during and after the Project's implementation are described in the AM Plan (RECOVER 2015). The following subsections identify how AM has been and will be incorporated into each LOCAR Project phase, including planning, design, construction, and O&M.

D.1.11 How Adaptive Management Activities Were Applied during LOCAR Planning

Concerns and uncertainties were identified in an initial step for LOCAR, discussed throughout the Corps "In Progress Review" meetings, and discussed throughout the interagency and public participation process. During screening of management measures to develop alternative plans, screening criteria included flexibility (i.e., the speed, ease, efficiency that a management measure could move water to adjust to changing real-time conditions, such as storms or extreme events), robustness (i.e., the ability to function effectively in the face of broad-scale, uncertain future conditions, such as climate change [NRC

2007]), and future compatibility (i.e., the efficiency with which this management measure or configuration would complement future restoration work). Finally, a broadly invited interagency team developed the AM plan to prioritize the remaining uncertainties and describe in the plan how they may be addressed through the life of LOCAR and inform CERP implementation.

Overall, the inclusion of AM principles during this study provided several avenues to address and reduce risks and uncertainties and, during its continued implementation in the following phases of LOCAR, will provide a mechanism to continue LOCAR's achievement of its vision, goals, and objectives and effectively remain within its constraints.

D.1.12 How Adaptive Management Activities Will be Applied during LOCAR Implementation

The LOCAR AM team, which includes a member of RECOVER in an advisory role, will work with the LOCAR project managers to develop workplans and monitoring scopes of work in coordination with other technical resource providers as needed to provide the budget, schedule, and details to execute the AM strategies identified in the AM plan. Additional technical expertise should be engaged as needed. AM activities will be implemented in sequence with the Project components being implemented (see **Figure D-1**). Workplans will include all necessary activities, resources needed, and schedule for completion so that they can be resourced appropriately and tracked by the project manager for progress and execution as part of the Project schedule and implementation plan during design, construction, and operations.

Project components will be implemented in a staggered fashion due to budget (i.e., amount of funds available each year), regulatory requirements (i.e., permits and compliance monitoring feedback), and LOCAR dependency constraints (i.e., state and federal projects required prior to implementation of a specific LOCAR Project component). Time needed to conduct certain AM activities and tasks to inform subsequent Project components is incorporated in the LOCAR implementation schedule and the strategies section of the LOCAR AM Plan. Each AM strategy workplan will explain the timing needed to observe, understand, and report restoration performance results from any design tests, pilot projects, and/or response to phases of Project components or full Project components being implemented to inform LOCAR implementation. **Figure D-1** shows that AM can proceed associated with a Project component, phase, full Project component, or test, with associated monitoring, to inform subsequent restoration actions. Monitoring should be implemented before and after Project implementation and operation for regulatory compliance, restoration response, and AM purposes, as described in the AMMP. The monitoring data assessed after construction, and any other current information, can then be coordinated with appropriate CERP agencies to determine progress or the need for adjustments. Adjustments are implemented as part of the AM strategies or made to the next set of LOCAR Project components. The information can also be used to inform future CERP projects.

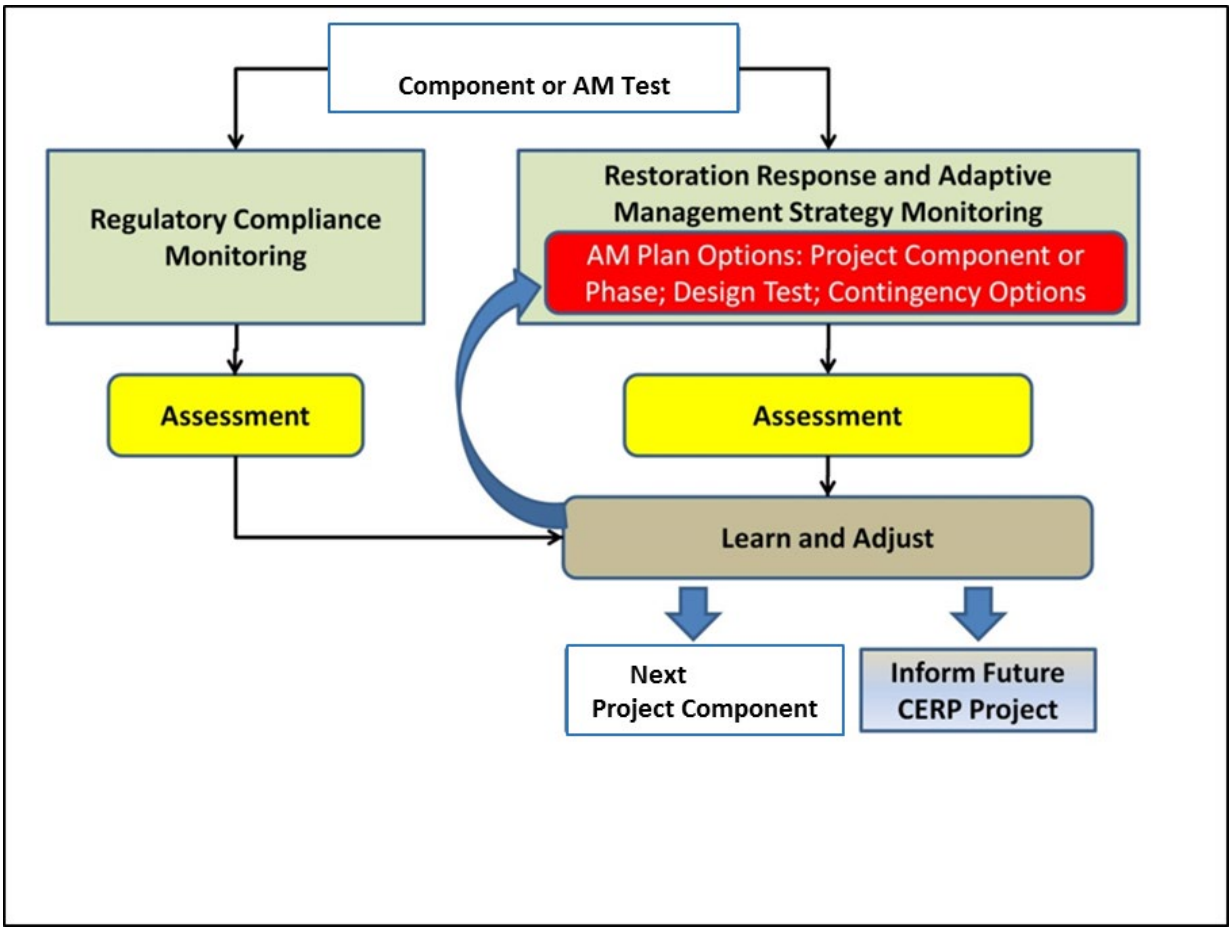

Figure D-1. Adaptive management strategies and Project implementation diagram.

AM during LOCAR's implementation will incorporate learning to reduce uncertainties and associated risk with some of the components, with the intent of achieving cost savings and providing the ability for certain Project components to be implemented more efficiently. For this learning to occur, AM strategies will need to be implemented in sequence with the Project schedule.

D.1.13 Design

AM activities will also be executed during the PED phase of the Project. AM strategies may involve operational tests and phased implementation and will be discussed during value engineering and detailed design to determine the full scope of each test, Project construction phase, and implementation. Members of the LOCAR AM team tasked with overseeing LOCAR AM will coordinate with the engineers and water managers to ensure that Project designs, tests, and project operations manual allow flexibility for AM implementation, as well as ensure monitoring plan designs, thresholds-triggers, and reporting are consistent with engineering design and water management needs. AM strategies will also involve updates to monitoring and assessment plans to better develop experimental designs, monitoring locations, and analysis methods, as well as initiate baseline monitoring data. Some AM activities will need to begin early enough to allow development of the monitoring plan design and to implement monitoring contracts to support establishment of a minimal baseline before construction of LOCAR Project components is completed.

D.1.14 Monitoring and Experimental Design

Other agency monitoring, and other contracts (e.g., RECOVER MAP) that are being relied upon to inform the LOCAR implementation as identified in the AMMP (**Table D-6**) will be reviewed to determine if changes in scope and frequency are needed to better capture LOCAR effects. The activities described here fall within the approved LOCAR AM budget. LOCAR-specific monitoring identified in the monitoring and AM plan will require scopes of work, schedules, and assessment protocols to be developed and coordinated by the LOCAR AM team to determine monitoring location and potential experimental design details to update the monitoring plan. Data analysis and modeling may be needed to inform the statistical sampling design needed for monitoring to be able to test LOCAR Project hypotheses. Before and after, control designs will be specified in the monitoring plan update, consistent with the parameters identified in each strategy and within the constraints specified by regulatory permits. LOCAR monitoring plan design will use existing data where possible, for example, RECOVER and other agency monitoring efforts. AM strategies maybe updated with more detailed decision trees to outline the decision-points associated with triggers/thresholds identified in each strategy. Decision trees will describe who receives reports, who provides guidance on decisions associated with the results, and what potential adjustments might occur. Updated monitoring plans will be coordinated for approval by implementing agencies and concurrence by participating agencies and Tribes.

D.1.14.1 Baseline Monitoring

In cases where there is not sufficient pre-Project data monitoring, contracts will need to be initiated prior to construction of specific LOCAR components. Final assignment of agency monitoring responsibilities will be made after state and federal regulatory permits are issued for a component. The LOCAR AM team will coordinate and implement monitoring with in-house agency resources or via contracts with CERP partner agencies and/or contracted universities or consultants to most efficiently and effectively execute the monitoring plan designs. Designated contacts will ensure that results are shared with the partnering agencies and non-governmental stakeholders for the duration of the monitoring plan. In addition, prior to construction of any component and/or test, a baseline monitoring report will be developed by the AM team as stated in the monitoring and AM plans.

D.1.14.2 Pre-construction Engineering and Design

Project component designs will be reviewed to ensure Project component designs are consistent with the testing objectives identified in the AM Plan uncertainties. Further data analysis or review of other Project design and monitoring information may be required to inform the design of LOCAR Project. In addition, monitoring locations that need to be installed prior to construction for baseline monitoring will be coordinated with the PED team to ensure they are aligned properly. The PED team will share Project component plans and specifications with the LOCAR AM team. Monitoring contract schedules will be aligned with Project construction schedules and operating protocol as defined in the Project component's operational strategy and consistent with the experimental design outlined in the AM Plan. Members of the LOCAR AM Team will also be responsible for conveying results from annual monitoring reports to the PED team to help determine options for improving Project designs.

D.1.14.3 Project Operating Manuals

Project operating manuals are developed during design by water managers in coordination with engineers and hydrologists to specify the operating criteria for each structure. Water managers and engineers will

coordinate with the LOCAR AM team to understand what hydrologic analysis is needed to inform operational criteria to be used as part of AM tests. In addition, the LOCAR AM team will work with water managers, planners, and hydrologists to ensure that flexibility is incorporated into the Project operational plan to allow for potential adjustments in the future consistent with regulatory constraints and National Environmental Policy Act (NEPA) analysis. The LOCAR AM team will work with water managers to identify the monitoring information, triggers, and process to be included in the Project operating manual that will inform operational adjustments. Project operating manuals should also include the process by which operational changes will be assessed throughout the year to integrate with assessments of monitoring data and report the effects of operational decisions, as applicable at pertinent Project meetings. Draft Project operating manuals will be reviewed by the LOCAR AM team and regulatory agencies to coordinate with the AM strategies outlined in the monitoring and AM Plan and with regulatory permit requirements.

D.1.15 Construction

Construction schedules, construction contract language, and implementation progress will be coordinated with the LOCAR AM team to ensure that appropriate flexibility is included as needed to be effective in fulfilling the intent of the AM Plan. Schedules and implementation should include monitoring and operational tests consistent with the AM strategies described in the AM Plan to learn from Project component implementation. In some cases, when agreed to by the implementing agencies, AM strategies may require adjustment to construction schedules to learn from implementation of one phase to inform additional phases. This logic will reduce uncertainty and risk, could reduce cost, and will need to be incorporated into the construction schedule and contracting approaches to ensure this flexibility.

D.1.16 Post-construction Monitoring and Operations, Maintenance, Repair, Replacement, and Rehabilitation

This subsection discusses how AM will handle post-construction monitoring and operations, maintenance, repair, replacement, and rehabilitation (OMRR&R).

D.1.16.1 Post-construction Monitoring

The LOCAR-specific Project monitoring, RECOVER systemwide monitoring, and other agency monitoring will be assessed by the LOCAR AM team to determine the restoration performance related to key Project components or groups of components. The timing outlined in each strategy will determine when data analysis and reporting should occur based on the temporal and spatial scale of the parameters being assessed. The triggers and thresholds outlined in the MOMs and AM strategies will guide the frequency of reporting and whom the reports are intended to inform. For example, strategies developed to address higher risk uncertainties may require more frequent reporting to LOCAR implementing agencies and associated regulatory agencies to ensure constraints are addressed. Other strategies will have monitoring implemented after a particular Project component is constructed for a specific timeline to report results to inform LOCAR operations or construction of subsequent Project components.

D.1.16.2 Post-construction Assessment, Reporting, and Linking to Decision-making

The LOCAR assessment results will be reported to the implementing agencies and LOCAR partner agencies as part of the RECOVER system-status report, South Florida Environmental report, as applicable reporting, independent of these forums may also be pursued by the LOCAR AM team. The process for reporting results to decision-makers is provided in the CERP science feedback to decision-making diagram in the

CERP Adaptive Management Integration Guide (Figure 3-9 of RECOVER 2011b). The process has changed slightly since publication: 1) Senior-level decision-making/coordination bodies have been renamed from the "Joint Project Review Board" to the "Quarterly Executive Team", and the "Quality Review Board" to the "Quarterly Agency Team".

Monitoring results will be reported in the context of the triggers/thresholds identified in the AM strategies (e.g., if performance remains within the triggers/thresholds that are provided to indicate need for adjustments, then the operations may continue, or the next Project component may be constructed based on the demonstrated results). Constraint triggers/thresholds that are "triggered" will be reported to LOCAR implementing agencies and associated regulatory agencies with suggestions of management options to implement, as stated in the AM Plan MOMs, to be evaluated by the agencies to decide what action is needed. Results of multiple monitoring trends will be integrated as part of a multiple lines of evidence analysis (Burton et al. 2002; RECOVER 2006) to inform the potential need for adjusting LOCAR implementation or documenting success.

Suggested options to adjust CERP implementation fall into several categories, listed here by level of effort required to implement:

1. Operational Decisions: Operations decisions are weekly/monthly but get reported and summarized annually.
2. NEPA Covered Options, No Modeling Needed: LOCAR AM plan options that are covered by NEPA and do not require additional modeling or analysis beyond what has been discussed by scientists and managers.
3. NEPA-covered Options, Requires Modeling: LOCAR AM plan options that are covered by NEPA, but may require model runs to determine best option.
4. Not NEPA Covered: LOCAR AM options that have not yet undergone sufficient NEPA analysis and therefore require additional environmental review and public comment, and potentially additional modeling.
5. Not Included in LOCAR AM Plan: In some cases, the monitoring results may indicate the need for an option not identified in the AM plan or Section 203 Study. This may result in agency-approved temporary adjustment to LOCAR implementation and operations to avoid the constraint while potential Project adjustments are further scoped, analyzed, approved, and budgeted for implementation.

The Corps Jacksonville District, in consultation with federal and state resource agencies, the Corps South Atlantic Division, and SFWMD, will guide decisions on determining whether restoration success has been achieved or additional operational, structural, or other contingency options identified in the AM Plan MOMs need to be implemented.

D.1.17 LOCAR Adaptive Management Plan Cost Estimate

Identification of the LOCAR monitoring contained in **Annex D** was guided partly by two objectives. First, it must be complete from a LOCAR perspective in that it must provide the monitoring required to address LOCAR-specific needs. Second, it must be integrated with other Everglades monitoring to take advantage of existing monitoring efforts, knowledge, and information and thereby leverage dollars committed and spent elsewhere to avoid redundancies and ensure cost effectiveness. These two objectives guided

development of the AMMP, hydrometeorological monitoring plan, and the water quality monitoring plan. Where possible, LOCAR will rely on existing monitoring resources, such as physical instrumentation, stations, locations, servicing, and analysis efforts, funded by RECOVER, CERP sponsors, and partner agencies. Therefore, the monitoring described in the LOCAR AMMP is limited to the additional, marginal increase in monitoring resources and analysis efforts needed to address LOCAR-specific questions. It is assumed that the monitoring programs will continue for at least the time needed by LOCAR. The cost estimate for the AM monitoring and Project-specific monitoring can be found in **Table D-7**. **Table D-8** presents the cost estimate for all parts of the LOCAR AMMP, including AM monitoring, Project-level monitoring, water quality monitoring, hydrometeorological monitoring, required USFWS BO monitoring, and other required regulatory monitoring.

Table D-7. Adaptive Management and Monitoring Cost Estimate.

LOCAR Objective	Category or Specific LOCAR Area	Uncertainty or Project PM	AM ID# or PM	Proposed Attributes to be Monitored	Ongoing RECOVER 1-yr Cost	Ongoing Other Agency 1-yr Cost	LOCAR 1-yr Cost
1	Lake Okeechobee	Will ecological indicators respond to lake stage changes as expected?	AM 25	Abundances of ecological Indicators (*Chara*, cyanobacteria, panfish (bluegills and redear sunfish) and vascular SAV), as well as acreage of total SAV in nearshore and coverage of 9 EAV spp. groups in littoral zone	$0	$206,890	$0
1	Lake Okeechobee	Will fish and wildlife communities' benefit from the Project's effect on lake stages or will additional habitat management be needed?	AM 26	Wading birds, snail kites, fish	$100,000	$200,000	$0
2	Estuaries	Oysters - When flows from Lake Okeechobee are altered, and salinity regimes for oysters are improved, what changes to oyster abundance, density, extent, and recruitment will occur in the estuaries?	AM 12	Monthly at 18 existing sites for: growth, disease, predation, reproductive development; recruitment; density, and live and dead counts (twice per year–spring and fall). Every 3-5 years, conduct estuary-wide substrate mapping for spatial extent and distribution of oyster and oyster shell.	$155,000 (for monthly, & biannual) $300,000 for mapping every 3-5 years	$0	$0
2	Estuaries	Submerged Aquatic Vegetation - When flows from Lake Okeechobee are altered, and salinity regimes for SAV are improved, what changes to SAV	AM 16	Tier 1 - Landscape scale – aerial mapping every 2 years Tier 2 - Patch-scale - species-specific cover and abundance at the end of the dry and end of the wet season. Tier 3 – Fixed-point sampling – cover, abundance, shoot density,	$102,000	$0	$0

LOCAR Objective	Category or Specific LOCAR Area	Uncertainty or Project PM	AM ID# or PM	Proposed Attributes to be Monitored	Ongoing RECOVER 1-yr Cost	Ongoing Other Agency 1-yr Cost	LOCAR 1-yr Cost
		abundance, extent, and species composition and diversity will occur in the estuaries?		canopy height, above and below ground biomass - sampling occurs every other month from April through November.			
3	Invasive Species	How will new hydrologic regimes affect the occurrence of invasive (native and non-native) or undesirable species in the lake?	AM 17	% invasives, species composition	$0	$0	$60,000
				Total Annual Adaptive Management and Ecological Monitoring Costs	$457,000	$406,890	$60,000

AM–adaptive management; EAV–emergent aquatic vegetation; LOCAR–Lake Okeechobee Storage Reservoir Section 203 Study; PM–performance measure; Project–Lake Okeechobee Storage Reservoir Section 203 Study; RECOVER–Restoration Coordination and Verification; SAV–submerged aquatic vegetation; yr.–year

Table D-8. Total Cost Estimate for AM, Project-level, Water Quality, Hydrometeorological, and Biological Opinion.

Part	Annual (1-year)	2 to 5-year	10-year	6 to 50-year
Adaptive Management and Monitoring Plan	$853,000	$4,265,000	$8,530,000	N/A
Water Quality	$492,978	$1,204,988		$12,474,296
Hydrometeorological	$ 1,323,900	$6,619,500		$66,195,000
Biological Opinion	$250,000	$1,250,000		N/A
Total	**$2,919,878**	**$13,339,488**	**$8,530,000**	**$76, 846,504**

AM–adaptive management; Project–Lake Okeechobee Storage Reservoir Section 203 Study

D.1.18 LOCAR Screened Uncertainties

Table D-9 lists the uncertainties screened out of the AM Plan. Reasons for screening out suggested uncertainties included lack of direct relevance to Project objective or constraint, low ratings in the screening criteria (Tier 3) described earlier in this plan, inappropriate scale for LOCAR (systemwide scale questions may be more appropriate to include in the RECOVER Systemwide AM Plan; very small-scale questions may have scored low in the screening criteria), lack of ability to improve LOCAR performance by understanding more about the uncertainty, or simply that the uncertainty was already covered by another that had been suggested (duplicates).

Table D-9. Uncertainties Screened from the AM Plan.

Uncertainty ID #	Category	Risk or Question or Uncertainty	Meeting Notes and Discussions	Rationale of Uncertainty Removal
23, 24	Lake Okeechobee	Are we meeting lake stage envelope with projected frequency?	Not screened out initially, went through the prioritization process.	Tier 3 of prioritization, so not carried forward.
16	Fauna	Will displacement of upland species (T&E and others) from reservoir footprint result in impacts to adjacent landowners?	Not screened out initially, went through the prioritization process.	Tier 3 of prioritization, so not carried forward.
30	Reservoirs	If ideal design is implemented and negative impacts to fish/other spp. occur, are there other options that could be implemented to offset those negative effects?	Not screened out initially, went through the prioritization process.	Tier 3 of prioritization, so not carried forward.
35	Water Quality	Will the Project result in mobilization of pollutants (i.e., nitrogen and phosphorus) from the reservoir?	Not screened out initially, went through the prioritization process.	Tier 3 of prioritization, so not carried forward.
42	Water Supply	Will there be unanticipated changes in water levels that impact existing level of service to nearby residential areas?	Not screened out initially, went through the prioritization process.	Tier 3 of prioritization, so not carried forward.
6	Climate Change	Will a major storm event overwhelm the flows to reservoirs and flows to estuaries?	If a severe weather event overwhelms reservoirs, AM strategies may not be feasible/effective, and may be secondary to health and safety concerns.	AM not feasible.
7	Climate Change	Will climate change have effects on water supply and reservoir operations?	Depending on context this may be a program- or system-scale uncertainty; what AM strategies could be implemented to offset climate change at a Project level?	Systemwide, not Project-level AM.
8	Climate Change	Will Project changes offset SLR effects? How will it affect what we are trying to do?	Depending on context this may be a program- or system-scale uncertainty; what AM strategies could be	Systemwide, not Project-level AM.

Uncertainty ID #	Category	Risk or Question or Uncertainty	Meeting Notes and Discussions	Rationale of Uncertainty Removal
			implemented to offset climate change at a Project level?	
9	Engineering	How will the southern reservoir affect this Project?	Effects from outside projects would be addressed under their respective scopes.	Not Project-level.
10	Engineering	Reservoir - will there be seepage through the berm of the reservoir?	Strategies to address seepage may not fall under AM Plan; concern to be reported to Engineering team.	Engineering design concern - covered in PED, not AM.
11	Engineering	Reservoir - will there be seepage into the groundwater table?	Strategies to address seepage may not fall under AM Plan; concern to be reported to Engineering team.	Engineering design concern - covered in PED, not AM.
15	Estuaries	How will Lake Okeechobee water quality affect our ability to restore the estuaries?	Water quality is not an objective of the Project.	Not Project-level.
27	Land Use	How will land use in the watershed outside of the Project feature?	This may exceed Project scale and would be addressed under NEPA.	Not Project-level and Project-level uncertainties covered in the EIS under NEPA.
28	Operations	How will a change in lake regulation schedule affect this Project?	This would be addressed during Plan Formulation.	Addressed during plan formulation.
29	Reservoirs	Maintain reservoir levels - drought, dry season, wet season.	Need additional information/specific question; none proposed by team in subsequent discussions.	No specific uncertainty identified.
24	Lake Okeechobee	Extreme high and low - duration and frequency.	Discussed during teleconferences; concept merged with Uncertainties 23 and 25.	Merged with Uncertainties 23 and 25.
31	Reservoirs	Will there be recreational access to the reservoirs?	This would be addressed under NEPA.	Not an AM uncertainty - addressed in the EIS.
32	Reservoirs	Buffer lands around the reservoirs to protect uplands in the area.	This would be addressed during Project design.	Not an AM uncertainty - addressed during PED.
33	Reservoirs	Effect of reservoirs on groundwater levels.	There is existing knowledge/modeling for anticipated effects to groundwater levels. Also, how would this be related	Not tied directly to a Project objective or constraint.

Uncertainty ID #	Category	Risk or Question or Uncertainty	Meeting Notes and Discussions	Rationale of Uncertainty Removal
			back to at least one of the stated objectives or constraints?	
34	Reservoirs	Impacts to uplands/wetlands in reservoir footprints.	This would be addressed under NEPA.	Not an AM uncertainty - addressed in the EIS.
39	Water Quality	Nutrient inflows into Lake Okeechobee.	Need additional information/specific question; none proposed by team in subsequent discussions.	No specific uncertainty identified and not at a Project-level.
47	Lake/Estuaries	How do unrelated habitats affect restoration?	Outside Project scope.	Not in Project scope.
48	Wildlife	Will species (T&E) impact our ability to manage the features for the benefit of the Project?	This will be addressed under NEPA/ESA section 7 consultation.	Not an AM uncertainty - addressed in the EIS and under Section 7 ESA consultation.

AM–adaptive management; EIS–; Environmental Impact Statement; ESA–Endangered Species; NEPA–National Environmental Policy Act; PED–preconstruction engineering and design; Project–Lake Okeechobee Storage Reservoir Section 203 Study; SLR–sea level rise; T&E–threatened and endangered

D.1.19 References

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Part 2: Water Quality Management Plan

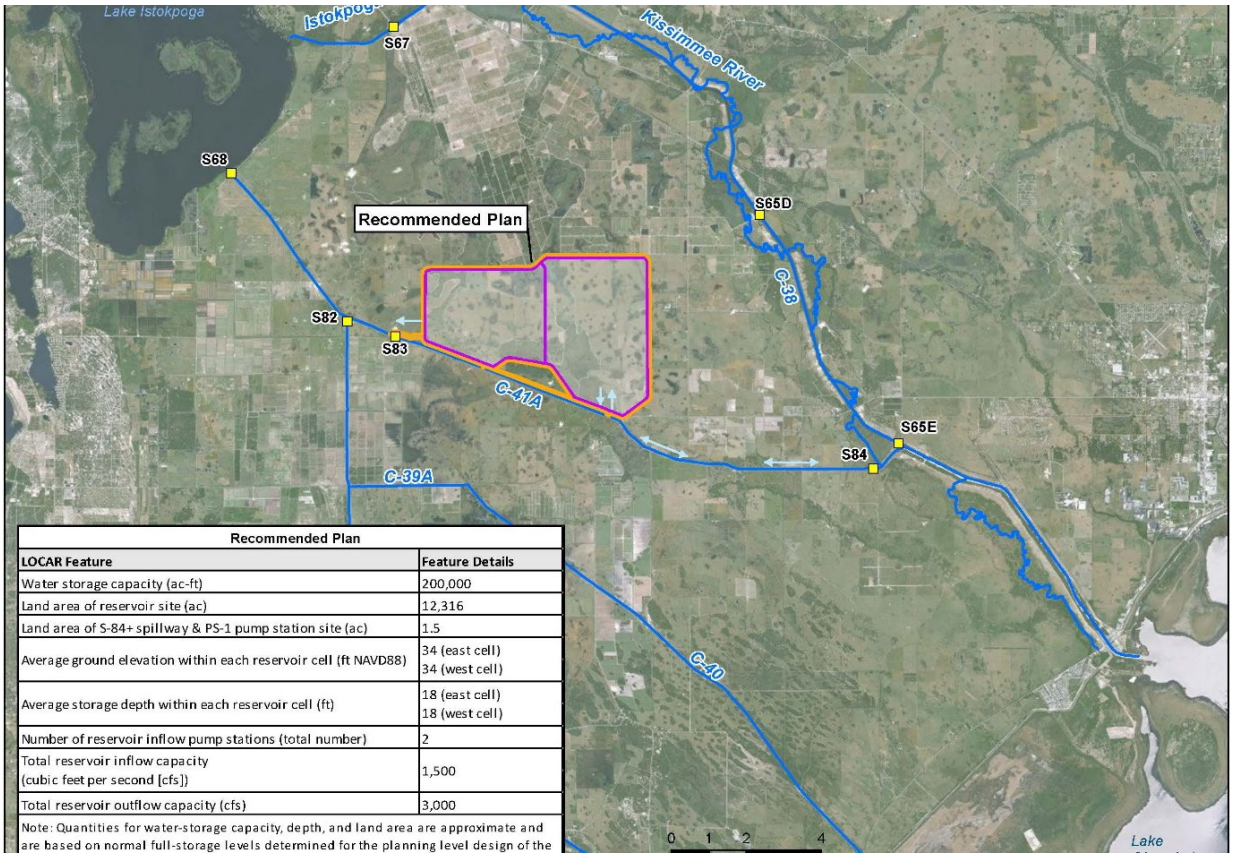
D.2 Introduction to the LOCAR Water Quality Monitoring Plan

This document serves as a preliminary reference for monitoring surface water quality for LOCAR, including features proposed in the LOCAR Recommended Plan (**Figure D-2**). Monitoring will be conducted to evaluate LOCAR's performance with regard to restoration goals and compliance with water quality standards. Specifically, the Project is intended to improve the quantity, timing, and distribution of water entering Lake Okeechobee; provide for better management of lake water levels; reduce high volume flows to the Northern Estuaries from Lake Okeechobee; improve systemwide operational flexibility; increase the spatial extent and functionality of wetland habitat; and improve water supply to existing legal water users of Lake Okeechobee. The area of the Recommended Plan extends east from Canal 40 (C-40) to the Kissimmee River. The proposed LOCAR aboveground storage feature is located northwest of the lake. The plan is organized into geographic areas: Lake Okeechobee Watershed, Lake Okeechobee, and the Northern Estuaries.

D.2.1 Project Description

The LOCAR Project features include the following elements:

1. Storage;
2. Distribution and conveyance; and
3. Seepage management.



Recommended Plan	
LOCAR Feature	**Feature Details**
Water storage capacity (ac-ft)	200,000
Land area of reservoir site (ac)	12,316
Land area of S-84+ spillway & PS-1 pump station site (ac)	1.5
Average ground elevation within each reservoir cell (ft NAVD88)	34 (east cell) 34 (west cell)
Average storage depth within each reservoir cell (ft)	18 (east cell) 18 (west cell)
Number of reservoir inflow pump stations (total number)	2
Total reservoir inflow capacity (cubic feet per second [cfs])	1,500
Total reservoir outflow capacity (cfs)	3,000
Note: Quantities for water-storage capacity, depth, and land area are approximate and are based on normal full-storage levels determined for the planning level design of the	

Figure D-2. Recommended Plan footprint map.

D.2.2 Water Quality Monitoring Objectives

The monitoring stations described in this document are referenced to satisfy requirements of LOCAR and requirements of (issued or pending) Corps 404 permits and/or State of Florida 373.1502 Comprehensive Everglades Restoration Plan Regulation Act permits for Start Up and Operational Phase Monitoring. This plan provides a preliminary outline for quantifying the quality of surface water entering and downstream of the Project Area for a period of 10 years. This plan may be updated to meet permit requirements as necessary. Surface water samples have been collected and analyzed for multiple constituents and at various frequencies within South Florida from stations adjacent to or nearby the targeted Project features. These baseline data are compiled in the SFWMD's DBHYDRO database (SFWMD 2023) and in the annual South Florida Environmental Report. The U.S. Geological Survey also collects surface water quality data in this region that may be relevant to the Project as baseline data. To access relevant data, contact the program manager at the SFWMD.

The water quality data obtained under this program will be used for these purposes:

1. Evaluate water quality status and trends;
2. Assess compliance with federal and state water quality statutes; and
3. Guide mid- and long-term resource management decisions as part of the AM Plan for the Project.

D.2.3 Surface Water Monitoring

The goal of surface water quality monitoring is to ensure that surface water quality released from the reservoir will not negatively impact the downstream area(s) and is in compliance with applicable state and federal water quality standards. The water quality monitoring plan presents a conceptual outline for surface water monitoring in relation to the operation and subsequent releases into adjacent waterways.

Surface water would be pumped from downstream of Structure 65E (S-65E) upstream of Structure 84 (S-84) into Canal 41A (C-41A). Flow out of the reservoir would be discharged upstream or downstream of S-83 via a canal and culvert into C-41A. Seepage from the reservoir would collect in the canal and be returned to the reservoir via seepage pump stations. If the seepage pump stations were not operational, the seepage collected in the canal would eventually overflow into the C-41A via overflow weir structures.

Surface water quality criteria are defined in the Florida Administrative Code, Chapter 62-302, *Surface Water Quality Criteria*. The state of Florida sets water quality criteria consistent with the Clean Water Act. The final surface water quality monitoring plan (inclusive of location of monitoring points, frequency of sampling, and required analytes) will be developed during the permitting process. **Figure D-2** illustrates surface water routing and flow directions.

D.2.4 Surface Water Quality Monitoring Cost Estimate

The following describes the minimal surface water monitoring needs for the three surface water impoundment cells, within the reservoir, included in the LOCAR Recommended Plan. **Table D-10** includes the cost of surface water monitoring. The purpose of the surface water quality monitoring is to address the expected surface water regulatory monitoring requirements and the startup monitoring required for mercury/toxicants required by CGM 42. The SFWMD is in the process of finalizing evaluation of the Project lands for hazardous, toxic, and radioactive waste and legally applied residual agricultural amendments. Some remediation may be conducted by the SFWMD (e.g., removal of aboveground fuel tanks, etc., if necessary). Pending any new information acquired from that investigation (to be completed before start of any construction activity), the surface water quality monitoring plan may have to be revisited and potentially amended. The final surface water quality monitoring plan will be developed during the permitting process.

Table D-10. Summary of Surface Water Quality Monitoring Costs.

Budget Area	Year 1	Years 2-5 Annual Cost	Years 6-50 Annual Cost
Capital (sampling platforms, equipment, vehicle cost, etc.)	$164,700	$0	$2,440
Fuel and maintenance	$12,200	$12,200	$12,200
Consumables	$0	$0	$0
Surface Water Nutrients and Ions	$793	$793	$793
Surface Water Mercury (Hg) and Toxins	$153	$0	$0
Small Fish Hg	$122	$122	$0
Small Fish Toxicants	$31	$0	$0
Large Fish Hg	$31	$31	$0
Sediment Hg and Toxins	$31	$31	$31
Annual Sums	$178,059	$13,146	$15,433
Analytical	-	-	-
Surface Water Nutrients and Ions	$199,600	$119,600	$119,600
Surface Water Hg and Toxins	$30,820	$0	$0
Small Fish Hg	$12,000	$12,000	$0
Small Fish Toxicants	$15,000	$0	$0
Large Fish Hg	$22,000	$22,000	$0
Sediment Hg and Toxins	$18,400	$0	$0
Annual Sums	$297,820	$141,600	$119,600
Staff	-	-	-
Surface Water Nutrients and Ions	$147,308	$147,308	$147,308
Surface Water Hg and Toxins	$6,412	$0	$0
Small Fish Hg	$30,217	$30,217	$0
Large Fish Hg	$14,640	$14,640	$0
Sediment Hg and Toxins	$8,433	$0	$0
Annual Sums	$207,010	$192,165	$147,308
Annual Totals	$682,889	$346,910	$282,341
Number of Years	1	4	45
Item Subtotals	$682,889	$1,387,641	$12,705,331
Grand Total			$14,775,860

D.2.5 References

SFMWD (South Florida Water Management District). 2023. DBHYDRO (Environmental Data). Available online at: https://www.sfwmd.gov/science-data/dbhydro.

Part 3: Hydrometeorological Monitoring Plan

D.3 Hydrometeorological Monitoring

This SFWMD hydrological monitoring plan follows all standard operating procedures (SOPs) for site installation, data collection, data processing, and quality assurance/quality control (QA/QC) established by Infrastructure Management Bureau's Supervisory Control and Data Acquisition Instrumentation & Telemetry Section and Hydro Data Management Section.

D.3.1 Data Quality Objectives

Developing Data Quality Objectives (DQO) is an integral and important part of a systematic planning process designed to ensure that the final results can be used for the purpose for which the data were generated. This systematic planning process for purposes of these discussions on environmental data quality is the quality system that each organization must develop, implement, and evaluate on a continuing basis.

The data will be used to measure Project performance. It will also be used to comply with monitoring requirements of an operational permit. The DQOs to be considered include accuracy, precision, sampling frequency, availability, completeness, reporting frequency, and timeliness. These are addressed in CERP's *Quality Assurance Systems Requirements*, Chapter 6, Table 6.1, dated December 7, 2010. The DQOs are further outlined in **Subsection 3.1.1** of this document.

D.3.2 Monitoring Data Elements, Indicators, and Cost Estimate

Hydrometeorological and hydraulic monitoring data will be collected, at a minimum, at each of the new structures; gate openings at gated structures; and pump stations. **Table D-11** provides a list of existing gauges at main structures within the LOCAR Project Area. Structures proposed in the Recommended Plan are subject to change during PED.

describes a preliminary list of minimal gauging needs for the reservoir. This table lists the necessary gaging parameters to be collected as part of LOCAR, which are in addition to current monitoring stations that will be leveraged for LOCAR. The headwater and tailwater stage gages located directly upstream and downstream of the structures, respectively, along with the gate openings, are used in computing flows through structures, as well as assisting in determining the operations. The 15-minute frequency is the Corps-required standard for these parameters. Breakpoint data for a pump is collected when changes to the revolutions per minute (RPM) are made, up to a frequency of 1 minute. The hydrologic and meteorological data collection equipment used for this Project would be installed either as part of the construction contract or via a separate contract with construction funding. Hydrometeorological parameters, such as surface and groundwater stages, require accurate estimates of the water elevation height compared to a known reference. All new surface water monitoring installations will be surveyed to a first order accuracy using the nearest geodetic benchmark. Reference elevations will be reported in both the North American Vertical Datum of 1988 and NGVD29. Several of the structures are located within proximity to each other and/or existing gages and, therefore, fewer new gages will be needed. See **Figure D-3** for a map of the conceptual structures proposed in the reservoir.

Table D-11. Monitoring Gauges at Existing Structures in LOCAR.

Structure	Gauge Parameter	Frequency of Reading
S-84	Headwater and tailwater stage	15-minutes
S-65E	Headwater and tailwater stage	15-minutes
S-77	Headwater and tailwater stage	15-minutes
S-78	Headwater and tailwater stage	15-minutes
S-79	Headwater and tailwater stage	15-minutes
S-308	Headwater and tailwater stage	15-minutes
S-80	Headwater and tailwater stage	15-minutes

LOCAR–Lake Okeechobee Storage Reservoir Section 203 Study

The Corps-Jacksonville District receives data from various sensors and data collection platforms to monitor surface water flows and levels. Automated timed processes provide provisional near real-time data required for water management operations. Additional data are also received through an interagency data exchange program among the SFWMD, U.S. Geological Survey, and Everglades National Park.

As the Recommended Plan is optimized and further developed during PED, estimates and contingencies for hydrometeorological monitoring during Operational Testing and Monitoring Period and OMRR&R are expected to change. For the purpose of this planning phase, the cost to monitor minimal gauging needs for the reservoir is $210,000 per year. The total cost of the hydrometeorological monitoring plan is summarized in **Section 6**. This cost is also captured in **Section 6**.

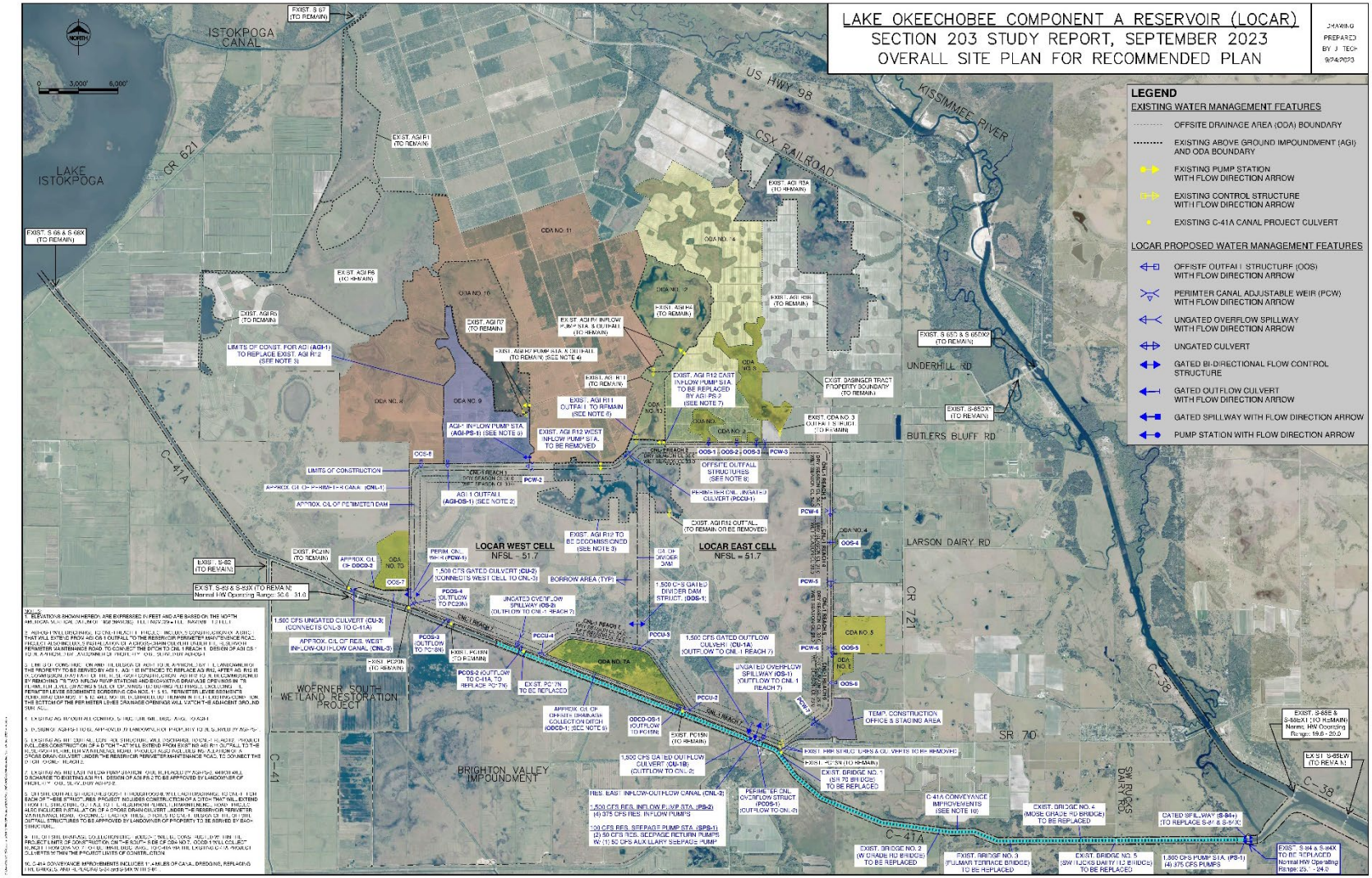


Figure D-3. Overall Site Plan with structures.

D.3.3 Procedures and Methods

Measurements will be recorded in the manner outlined in CERP's *Quality Assurance Systems Requirements*, Chapter 6, Table 6.1, dated December 7, 2010.

To summarize, surface water stages will be measured using a Serial Digital Interface (SDI) encoder at each monitoring location. The accuracy required is ±0.02 ft for critical sites and ±0.03 ft for noncritical sites. The reported resolution will be 0.01 ft and the instrument range will be 0 to 20 ft. The precision will be ±0.01 ft. The sampling frequency likely will be in 15 minute-increments (at a minimum), at zero, 15, 30, and 45 minutes past each hour (e.g., at 1,500 hours, 1,515 hours, 1,530 hours, and 1,545 hours), though breakpoint sampling may be done.

Groundwater stages will be measured using an SDI encoder at each monitoring location. The accuracy required is ±0.03 ft. The reported resolution will be 0.01 ft and the instrument range will be zero to 30 ft. The precision will be ±0.01 ft. The sampling frequency likely will be in 15-minute increments (at a minimum).

Rainfall will be measured with an accuracy of ±0.01 inches. The reported resolution will be 0.01 inches and the precision will be ±0.01 inches. The sampling frequency likely will be in 15 minute-increments (at a minimum). At this time, the location of rainfall gauges has not yet been determined.

Gate positions will be measured using gate position indicators with an accuracy of ±0.05 ft, a reported resolution of 0.01 ft, and a gate position range of either zero to 75 inches or zero to 550 inches. The precision required is ±0.02 percent full stroke. The reporting frequency will be at least and likely 15 minutes.

Pump RPMs will be measured with an accuracy of ±25 RPM and a reported resolution of 1 RPM. The pump RPM range will be zero to 3,000 RPMs. The reporting frequency will be 1 to 360 samples per hour.

Computed flows will have an accuracy uncertainty limit of 95 percent confidence interval. The accuracy will be ±10 percent for inland spillways, ±15 percent for culverts, and ±15 percent for pumps. The velocity instrumentation will have a precision of ±0.01 ft/second. The reporting frequency likely will be in 15-minute increments (at a minimum).

The hydrologic and meteorological data collection instruments utilized for this Project will be installed as part of the construction contract or under separate contract. Water stage measuring devices will be affixed to a platform in a manner to discourage vandalism using hardened cases and natural or unnatural intrusions (e.g., inclement weather and animals). Water-surface-elevation measuring devices will use SDI encoders for measuring values. Gate positions will be measured using gate-position indicators. Flow calculation equations that are used to compute flow on-site with certain instrument types, such as a programmable data logger, will be developed under the supervision of the sponsoring agencies' hydrology and hydraulics monitoring units during the execution of this monitoring plan.

D.3.4 Rationale for Indicator Selection

The indicators selected for inclusion are required under CERP's *Quality Assurance Systems Requirements*, Chapter 6, Table 6.1, dated December 7, 2010. The headwater and tailwater values are used, along with gate openings or pump RPMs, to determine the flow of water through the structure.

D.3.5 Sampling Frequency and Duration

The sampling frequency and duration is governed by CERP's *Quality Assurance Systems Requirements*, Chapter 6, Table 6.1, dated December 7, 2010.

The recording frequency for the surface water stages likely will be conducted in 15 minute-increments (at a minimum), at zero, 15, 30, and 45 minutes past each hour (e.g., at 1,500 hours, 1,515 hours, 1,530 hours, and 1,545 hours). The recording frequency for the groundwater stages likely will be conducted in 15 minute-increments (at a minimum). Rainfall recording frequency presumably will be 15 minutes. Gate positions recording frequency likely will be in 15-minute increments (at a minimum). Pump RPMs recording frequency will be by break point, with a minimum of 1 recording per hour, up to 360 recordings per hour. Computed flows computing frequency will be 15 minutes.

D.3.6 Assessment Process and Decision Criteria (Triggers and Thresholds)

Trigger elevations for surface water will take into consideration the design headwater and tailwater at the gauges' respective structures to ensure that design limits are not reached. In addition, the decision criteria will be further refined as the operations of LOCAR are developed.

D.3.7 Data Collection

This section outlines the data collected.

D.3.7.1 Sample and Data Collection Standards and Ethics

No physical samples will be collected for hydrometeorological monitoring. Data will be collected following the required standards as described in this document.

D.3.7.2 Sample Submission

No samples will be collected for hydrometeorological monitoring.

D.3.7.3 Chain of Custody

No samples will be collected for hydrometeorological monitoring.

D.3.7.4 Quality Control Samples

No samples will be collected for hydrometeorological monitoring.

D.3.7.5 Data Validation

Data validation processes will follow the current SOPs at the time of data collection. The current Corps data validation process is subject to Engineering Regulation (ER) 1110-2-8155, *Hydrometeorological Data Management and Archiving*, dated July 31, 1996, and ER 1110-2-249, *Management of Water Control Data Systems*, dated August 31, 1994. The Corps data validation may be accomplished by automated or manual means. This process may include estimating values for missing or erroneous data.

Data collected by the SFWMD will be kept as raw archive files. The adjusted (i.e., QA/QC-ed) data will be stored as processed archive files. Data collected by the Corps is maintained in databases and further computations are applied to generate addition databases of computed data.

D.3.7.6 Data Validation Processing

Data validation processing will follow the current SOPs at the time of data collection. The current Corps data validation process is subject to ER 111028155, *Hydrometeorological Data Management and Archiving*, dated July 31, 1996, and ER 11102249, *Management of Water Control Data Systems*, dated August 31, 1994.

Data processing shall be approached with the same high accuracy standards for all sites/stations regardless of mandate or permit conditions. Flow and meteorological data must be summarized or derived through review, analysis, and interpretation before they can be placed in any meaningful context, then published. Data processing involves multiple steps: 1) data retrieval, 2) data review, 3) data verification and validation, 4) data analysis of raw time-series data to ensure data quality in support of environmental monitoring and assessment activities, 5) interpretation of analysis, and 6) knowledge management.

D.3.7.7 Data Storage and Archiving

Data collected will be stored and archived in accordance with ER 1110-2-8155, *Hydrometeorological Data Management and Archiving*, dated July 31, 1996. The Corps maintains databases where all collected and computed water management data is stored and archived.

For the SFWMD, after the data validation process (generally with 1 week), all data are archived in a SFWMD database (DBHYDRO) and maintained so that end users can retrieve and review all information relative to a sampling event. If data are not suitable for DBHYDRO, they will be entered into DataOne. Field notes are maintained on an internal server either by scanning actual field note pages as Portable Document Formats or by uploading narratives from field computers as comma-separated values. All analytical data and field conditions are sent to a database designated by the sponsors for long-term storage and retrieval. The sampling agency or contractor maintains records of field notes and copies of all records relative to the chain of custody and analytical data. It is the responsibility of each agency or contractor to maintain both current and historical method and operating procedures so that at any given time the conditions that were applied to a sampling event can be evaluated. For any contracted work, original documents are to be provided to the SFWMD by the Project completion date.

D.3.8 Documentation

For all documents, the following standards should apply:

- Print text, do not use cursive handwriting.
- Dates should be recorded as “MM/DD/YYYY.”
- Time should be recorded in 24-hour format using local time.
- Logs and notes should be recorded on-site and at the time of collection.
- Entries are to be made in waterproof ink.
- Training logs must be provided and samplers should be properly trained.

D.3.9 Field Notes

Relevant field observations will be noted in a bound waterproof notebook that is Project specific. The following information will be entered into the field notes: Project name, frequency, trip type, date,

collectors, responsibilities, weather, preservation/acids, labs submitted to, sample ID, site ID, time collected, and sample type. Additional comments on observations, equipment cleaning, maintenance, and calibration will also be recorded.

D.3.10 Field Instrument Calibration Documentation

Records of field instrument calibration will be kept and SFWMD's or Corps' SOPs for calibration will be followed.

D.3.11 Corrections

Corrections to header sheets, field notes, or calibration sheets will only be made by staff who participated in the production of the document. Changes will be made by striking through the error, writing the correction, and initialing and dating the change. On occasion, a detailed explanation of the error may be required.

D.3.12 Quality Assurance and Quality Control

The following sections are referenced within the QA/QC procedures.

D.3.13 System for Assessing Data Quality Attributes

The standards as set forth under the Corps' and the SFWMD's respective requirements will be adhered to and followed in compliance with FDEP's Comprehensive Quality Assurance Plan Rule, 62-160 Florida Administrative Code and associated SOPs.

D.3.14 Data Quality Qualifiers

The data quality standards for hydrometeorological data are determined by the Corps' and SFWMD's respective guidance and will be followed in compliance with FDEP's Comprehensive Quality Assurance Plan Rule, 62-160 Florida Administrative Code and associated SOPs.

D.3.15 Field Audits

The data quality standards for hydrometeorological data are determined by the Corps' and SFWMD's respective guidance and will be followed in compliance with FDEP's Comprehensive Quality Assurance Plan Rule, 62-160 Florida Administrative Code and associated SOPs.

D.3.16 Data Analyses and Records Management

The Corps process is subject to ER 1110 2 8155, *Hydrometeorological Data Management and Archiving*, dated July 31, 1996, and ER 1110 2 249, *Management of Water Control Data Systems*, dated August 31, 1994.

The SFWMD procedures are described in its *2008 South Florida Environmental Report*, Appendix 2 1: Hydrological Monitoring Network of the South Florida Water Management District.

D.3.17 Data Quality Evaluation and Assessment

The data quality standards for hydrometeorological data are determined under the Corps' and SFWMD's respective guidance and will be followed in accordance with FDEP SOPs.

D.3.18 Adaptive Management Considerations

D.3.18.1.1 Total Adaptive Management and Monitoring Costs

Table D-12 below shows the total cost estimate for AM monitoring, ecological monitoring, water quality monitoring and hydrometeorological monitoring over the lifecycle of the Project.

Table D-12. LOCAR Total Cost Estimate for AM, Project-level, Water Quality, Hydrometeorological, and Biological Opinion.

Part	Annual (1-year)	2 to 5-year	10-year[1]	6 to 50-year
Adaptive Management and Monitoring Plan	$1,040,660.00	$5,203,300.00	$10,406,600.00	
Water Quality	$753,720.88	$1,470,085.36	$0.00	$13,147,122.60
Hydrometeorological	$1,615,158.00	$8,075,790.00	$0.00	$80,757,900.00
Biological Opinion				
Total	$3,714,539	$16,274,175	$10,406,600	$93,905,023

[1/] Adaptive Management and Monitoring (Ecosystem Restoration Success) plan costs are construction funded up to 10 years post construction, per U.S. Army Corps of Engineers Headquarters implementation guidance on Section 1161 of 2016 Water Resources Development Act.

[*Preparer's Note: Costs for monitoring defined in the Biological Opinion will be included in the Final Report*.]