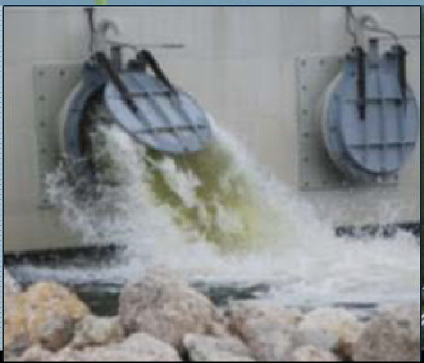
Program-Level Adaptive Management Plan

COMPREHENSIVE EVERGLADES RESTORATION PLAN



Restoring America's Everglades

CERP PROGRAM-LEVEL ADAPTIVE MANAGEMENT PLAN

Version 1.0

REstoration COordination and VERification

September 8, 2015

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Tables

Figures

ACRONYMS AND ABBREVIATIONS

A

AM Adaptive Management
AMIG Adaptive Management Integration Guide
ASR Aquifer Storage and Recovery

B

BMP Best Management Practices

C

C&SF Central and Southern Florida Project
CERP Comprehensive Everglades Restoration Plan
CGM CERP Guidance Memorandum
CEM Conceptual Ecological Model
CFR Code of Federal Regulations
CISRERP Committee on the Independent Scientific Review of Everglades Restoration Progress

D

DCT Design Coordination Team
DOD Department of Defense
DOA Department of Army
DPM DECOMP Physical Model

E

EC Engineering Circular

F

FACA Federal Advisory Committee Act
FEB Flow Equalization Basin

G

GE Greater Everglades

I

IDS Integrated Delivery Schedule
IDM Information Data Management
ICU Initial CERP Update
IRL Indian River Lagoon

L

LO Lake Okeechobee
LOWP Lake Okeechobee Watershed Project
LORS Lake Okeechobee Regulation Schedule

M

MAP Monitoring and Assessment Plan
MFL Minimum Flows and Levels

N

NE Northern Estuaries
NRC National Research Council
NSM Natural Systems Model
NSRSM Natural Systems Regional Simulation Model

P

PDT Project Delivery Team
PIR Project Implementation Report
PM Performance Measure
PSU Practical Salinity Units

Q

QET Quarterly Executive Team
QAT Quarterly Agency Team
QAOT Quality Assurance Oversight Team
QASR Quality Assurance Systems Requirements

R

RECOVER REstoration COordination and VERification
R-EMAP Regional Environmental Monitoring and Assessment Program

S

SCS Southern Coastal Systems
SFERTK South Florida Ecosystem Restoration Task Force
SFWMD South Florida Water Management District
SKG Scientific Knowledge Gained
SOM System Operating Manual
SSR System Status Report
STA Stormwater Treatment Area

T

TMDL Total Maximum Daily Load
TN Total Nitrogen
TP Total Phosphorus
TS Taylor Slough

U

USACE U.S. Army Corps of Engineers
USDOI U.S. Department of Interior

W

WCA Water Conservation Area
WRAC Water Resources Advisory Committee
WRDA Water Resources Development Act

V

VEC Valued Ecosystem Component

Y

YB Yellow Book - Comprehensive Everglades Restoration Plan

1 OVERVIEW AND SUMMARY

The purpose of the Comprehensive Everglades Restoration Plan (CERP) Programmatic Adaptive Management (AM) Plan is to describe: 1) the scientific framework and processes upon which Everglades restoration is being undertaken; 2) how new knowledge is being integrated into decision making; and 3) how and when adjustments to Plan implementation can be made. This CERP Programmatic AM Plan describes existing components of the AM program and addresses some of those components that have not yet been fully developed (see Table **1-1**, **Figure 1-1**). Components of the CERP AM Program, such as the Monitoring and Assessment Plan (MAP) (RECOVER 2009), were initiated early in CERP implementation to provide information to address key system-wide uncertainties about the ecosystem and establish reference conditions. Guidance documents, such as the CERP AM Integration Guide (AMIG or Guide), were developed relatively recently, and project-level AM plans were developed for several CERP projects. This document, however, represents the first attempt at capturing the programmatic uncertainties facing multiple CERP projects and the strategies to address them in one document. The AM Plan is a product of the interagency Restoration Coordination and Verification (RECOVER) Adaptive Management Team and provided by the RECOVER Leadership Group to the CERP Design Coordination Team (DCT) for approval. The CERP Programmatic AM Plan is intended for use by CERP staff involved with implementation of the AM program, CERP decision makers and managers, implementing agencies and agency partners and non-governmental stakeholders to document how RECOVER science activities are addressing key uncertainties linked to current and future management decisions. This document is a living document to be updated based on new information from completed adaptive management strategies, changes in project schedules, changes in CERP performance expectations, and other relevant information to achieving CERP restoration goals and objectives.

Using the nine AM activities described in the CERP AMIG (RECOVER, 2011), the CERP Programmatic AM Plan links information from these components of the AM program and describes how they bring new knowledge to CERP decision makers. **Table 1-1** and **Figure 1-2** depict the nine CERP AM activities and the corresponding foundation documents that describe the component, as well as the AM products emerging from implementation of each activity, and the responsible CERP parties. Activities in **bold** indicate components of the AM Plan that have not yet been fully developed, but will be in the future as CERP progresses. Activities with a * indicate components that were developed as part of this plan. The key gaps in the CERP AM Program that this document fills are:

1) identifying and prioritizing programmatic uncertainties,
2) proposing strategies to address programmatic uncertainties, and
3) identifying management options matrices that link monitoring observed ecological response(s) to restoration projects in order to improve restoration performance.

Table 1-1. COMPONENTS OF THE ADAPTIVE MANAGEMENT PROGRAM

AM Activity	**Documents and Efforts**	**Responsible Party**[1]
Activity 1: Stakeholder Engagement and Interagency Collaboration	USACE Planning Manual; USACE Planning Guidance Notebook; CGM 011.02; AMIG; CGM 056.00	PDTs; RECOVER; DCT; QAT; QET; WRAC; South Florida Ecosystem Restoration Task Force, Working Group and Science Coordination Group
Activity 2: Establish/Refine Goals and Objectives	CERP Plan or "Yellow Book"; 2003 CERP Vision Statement	CERP Implementing Agencies
	2010 Shared Definition of Everglades Restoration	RECOVER; CERP Implementing Agencies
Activity 3: Identify and Prioritize Uncertainties	"Yellow Book"	CERP Implementing Agencies
	MAP; **List of Programmatic Uncertainties***	RECOVER
Activity 4: Apply Conceptual Ecological Models and Develop Hypotheses and Performance Measures	Conceptual Ecological Models (CEMs); Hypothesis Clusters; RECOVER-Project Performance Measures; Predictive Tools	RECOVER
	Interim Goals/Interim Targets	USACE; USDOI; State of Florida; RECOVER
Activity 5: Alternative Development and Implementation	"Yellow Book"; Project Implementation Reports; Integrated Delivery Schedule (IDS); **System Operating Manual (SOM)**	CERP Implementing Agencies
	Programmatic AM Plan including AM Strategies and Management Options Matrices*	RECOVER
Activity 6: Monitoring	MAP; Project-level; Non-CERP	RECOVER
	Data management	IDM: QAOT

Activity 7: Assessment	System Status Report (SSR); Scientific Knowledge Gained (SKG) document; Peer Review Reports	RECOVER
Activity 8: Feedback to Decision Making	AMIG	RECOVER
	Assessment and Options Reports	DCT; QET; QAT
Activity 9: Adjustment	**SOM; Comprehensive Plan Modification Report;** IDS	CERP Implementing Agencies; DCT; QET; QAT

Section 1 of this document provides the foundations of CERP Program-Level Adaptive Management. Section 2 covers adaptive management definitions, principles, and guidance. Finally, section 3 describes the components that were developed as part of this plan, including programmatic uncertainties, AM strategies to address them, and management options matrices that outline potential future management actions to improve restoration performance if outcomes are not as expected based on observed ecological response(s).Appendix A of this document describes the components that have already been developed for CERP at the program-level along with their foundation documents and responsible parties.

[1] Responsible Party Acronyms: PDT – Project Delivery Team, REstoration COordination and VERification (RECOVER), DCT - Design Coordination Team, QAT - Quarterly Agency Team, QET - Quarterly Executive Team, WRAC - Water Resources Advisory Committee, IDM – Information Data Management, QAOT – Quality Assurance Oversight Team; CERP Implementing Agencies – USACE and SFWMD.

Figure 1-1 DIAGRAM OF CERP ADAPTIVE MANAGEMENT PROGRAM COMPONENTS

Legend: Green = RECOVER product or responsibility; Blue = Programmatic (encompassing projects and RECOVER) product or responsibility. All components shown as circles are either existing or in development.

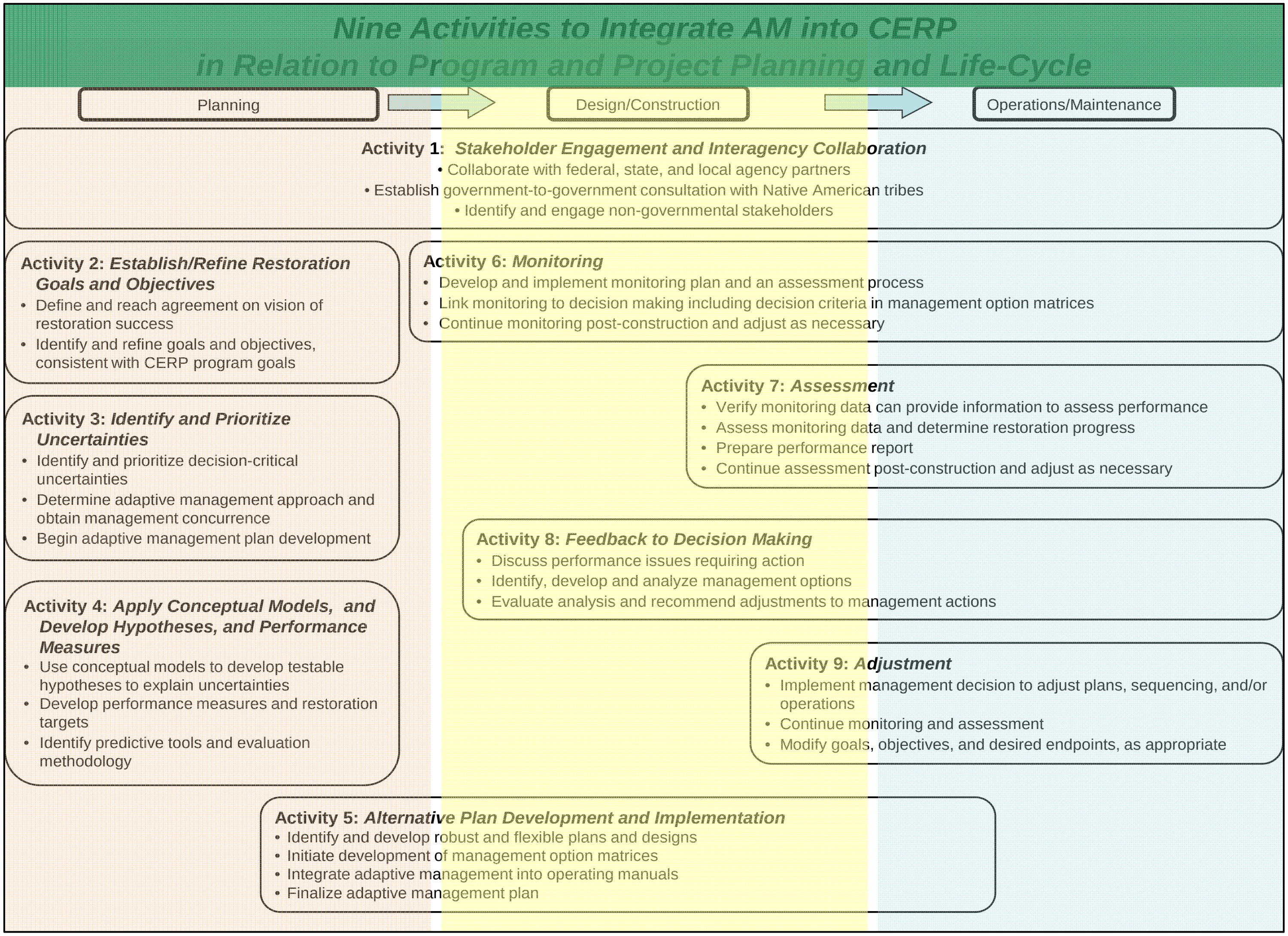

Figure 1-2 NINE ACTIVITIES TO INTEGRATE AM INTO CERP IN RELATION TO PROGRAM AND PROJECT PLANNING AND LIFE-CYCLE

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2 INTRODUCTION

2.1 Adaptive Management Requirements

In 2000, the U.S. Congress approved the Comprehensive Everglades Restoration Plan (CERP) under that year's Water Resources Development Act (WRDA). CERP provides a framework and guide to restore, protect, and preserve the water resources of Central and Southern Florida. The overarching goal of CERP is to improve freshwater flows for Everglades restoration while enhancing water supply and maintaining existing levels of flood risk reduction (USACE and SFWMD, 1999). Accomplishing this goal is a large and complex undertaking, thus CERP contains 68 project components and associated operational regimes that are designed to capture, store, and redistribute fresh water currently lost to tide. The Central and Southern Florida Project Comprehensive Review Study (Restudy) recognized that there are uncertainties regarding Everglades restoration, and that adaptive management is needed to address these questions and to improve CERP implementation over time.

With CERP's approval, the U.S. Congress requested adaptive management (AM) principles during Everglades restoration by stating "that the agencies responsible for project implementation…will seek continuous improvement of the Plan based upon new information, improved modeling, new technology, and changed circumstances" (U.S. Senate, 2000). Congress directed the U.S. Secretary of the Army to develop Programmatic Regulations for CERP to ensure that the Plan's goals and purposes are achieved. Per 33 Code of Federal Regulations 385.31, the Programmatic Regulations direct the U.S. Army Corps of Engineers (USACE) and the South Florida Water Management District (SFWMD or District) (known as CERP implementing agencies) to develop an AM program that included monitoring and assessment of ecosystem restoration performance, periodic updates to CERP, and continuous planning improvements (DOD, 2003).

Subsequent USACE guidance describes the requirements for AM plans for ecosystem restoration projects. Engineering Circular (EC) 1105-2-210 recommends an AM plan for complex projects that have high levels of risk and uncertainty to allow for contingencies to address problems during or after project construction (para. 21 of USACE, 1995). EC 1105-2-409 repeats this concept by stating "If the need for a specified adjustment is anticipated due to high uncertainty in achieving the desired outputs/results, the nature and cost of such actions should be explicitly described in the specifically authorized project's decision document. The adaptive management plan may be shown as a contingency item" (USACE, 2005). Finally, implementation guidance for Section 2039 of WRDA 2007, issued in 2009, provides the most recent guidance on adaptive management, stating "an adaptive management plan will be developed for all ecosystem restoration projects ... appropriately scoped to the scale of the project" (para. (3)(d) of USACE, 2009).

In 2008 the U.S. Department of the Interior (USDOI) issued an Adaptive Management Implementation Policy that encourages the use of adaptive management as a tool in managing lands and resources and defines the responsibilities of USDOI offices and groups in its implementation (USDOI, 2008). Subsequently, in 2009 the *Adaptive Management: The U.S. Department of the Interior Technical Guide* was published to aid managers and practitioners in determining when and how to apply adaptive management (Williams et al., 2009). The CERP Adaptive Management Integration Guide (AMIG) described below was largely based on the USDOI Technical Guide and its nine steps (**Figure 1-2**) for applying AM, as well as the USACE Six Step Planning Process and Project Life-Cycle (Yoe and Orth, 1996).

2.2 CERP Governance and Funding for Adaptive Management

CERP is a 50/50 partnership between the USACE and SFWMD, the implementing agencies, that is being implemented in coordination with other federal, state, and local partner agencies and two Native American Tribes. REstoration COordination and VERification (RECOVER) is an interagency scientific oversight team that is responsible for system-wide evaluation, monitoring and assessment, and coordination of the CERP AM program. RECOVER is the primary scientific coordinating body that reports the science used to inform management decisions. The USACE and SFWMD managers will consider AM-related issues brought forward by RECOVER or PDTs and make decisions to implement CERP project-level and programmatic AM efforts. USACE and SFWMD will coordinate with other federal, state, and local partner agencies, as well as Tribes to address any issues or concerns associated with adaptive management activities. Throughout CERP planning and implementation there are also opportunities for public and/or non-governmental stakeholder input, as described in Section 2.1 (e.g., comment periods at PDT meetings, public workshops, public reviews, and South Florida Ecosystem Restoration Task Force and SFWMD Water Resource Advisory Committee [WRAC] meetings). Appendix D of the CERP AM Integration Guide (AMIG) further outlines the roles and responsibilities of CERP teams and decision makers, and describes the overall CERP decision-making process, through which AM is implemented (RECOVER, 2010a).

Funding for adaptive management activities is primarily integrated into individual project implementation reports (PIRs) at the project-level and into CERP planning and design costs at the program-level. Individual project adaptive management plans may include contingency options and their associated costs that are linked to monitoring and decision criteria that provide information about the need to implement the contingency options. These funds are captured as part of project construction costs (06 Feature Code) that are held as contingency (USACE, 2009a). At the program-level, changes to existing projects that are captured by project AM plans would need to be budgeted using the USACE two-year budget cycle after the need has been determined and the specific change has been concurred upon by USACE, the State of Florida, and USDOI. Changes outside of Congressionally-authorized and approved projects will need to be incorporated into existing draft or new PIRs to seek authorization and approval (DOD, 2003). Changes to operations within existing approved operations plans are implemented upon review and concurrence by USACE and SFWMD water managers and funded by operations and maintenance funds. Changes requiring new operations plans, such as project operating manuals or updates to the System Operating Manual (SOM) described in the CERP programmatic regulations (33 CFR

385.28 Operating Manuals and Adaptive Management section 385.31), would be funded using CERP design funds. Program-level monitoring and assessment is covered under the Adaptive Assessment and Monitoring funds allocated annually.

2.3 CERP Adaptive Management Program

2.3.1 Definition and Principles

In general, adaptive management is a formal process for continually improving management policies and practices by learning from their outcomes (Taylor et al., 1997). In the context of Everglades restoration, CERP adaptive management is a structured management approach for addressing uncertainties by testing hypotheses, linking science to decision making, and adjusting implementation, as necessary, to improve the probability of restoration success.

Principles of CERP AM:

- Promote stakeholder engagement, interagency collaboration, and conflict resolution.
- Employ a formal, science-based management approach using new information to address scientific/technical uncertainties affecting restoration goals and objectives.
- Incorporate flexibility and robustness into all project phases – planning, design, construction, and operations – to address uncertainties affecting goals and objectives.
- Iteratively incorporate scientific information into the decision-making process to allow for changes as implementation proceeds.
- Seek to use the most cost-effective approach to maximize ecosystem restoration.

The CERP AM Program is designed to address uncertainties related to the ecosystem to be restored, restoration design or associated restoration endpoints, which have the potential to impact the ability to achieve desired goals and objectives that includes achieving expected CERP performance, interim goals and interim targets (see AMIG for more information). Those uncertainties are categorized as either scientific/technical (related to achieving ecological goals and objectives) or policy/management (related to political or funding constraints, or competing objectives or values), and differing strategies are required to address each (see Section 2.3).

2.3.2 Guidance

In 2006, the CERP AM Strategy was developed to provide a high-level framework for the application of adaptive management to Everglades restoration (RECOVER, 2006a). In 2010, the CERP AMIG was finalized and describes, in more detail, how to apply adaptive management to the CERP program and its constituent projects through the use of nine AM activities that are performed during the life-cycle of CERP implementation (RECOVER, 2010a). As noted above, these activities are based on the nine steps described in the USDOI Technical Guide, but they have been modified to be specific to CERP as each application of AM is unique.

2.4 Types of Adaptive Management for CERP Implementation

As described more fully in the CERP AMIG, there are generally two types of AM approaches used in implementing restoration programs: active and passive. Passive AM reduces uncertainty by using a single design or operational plan (the Recommended Plan) to test hypotheses regarding the hydrological or ecological responses to planned management actions (Gregory et al., 2006). The passive AM approach is more frequently used by CERP, and thus is an important element of this plan. With this passive approach, hypotheses regarding key restoration benefits for specific CERP projects will be identified early and will be addressed through post-construction monitoring, assessment, and feedback to decision making.

In other cases, more active measures may be appropriate to address key uncertainties limiting CERP implementation. Active AM reduces these uncertainties by using multiple designs or operational criteria, such as field tests, to test competing hypotheses about hydrological or ecological responses to proposed management actions (Gregory et al., 2006). Perhaps the best example of an active AM application for CERP is the Water Conservation Area 3 Decompartmentalization and Sheetflow Enhancement (Decomp) Physical Model, designed to test alternative measures to reestablish ridge and slough topography and enhance localized sheetflow. Additional information on the pros and cons of passive and active adaptive management approaches can be found in Section 2 of the CERP AMIG and Gregory et al., 2006.

3 CERP PROGRAMMATIC AM COMPONENTS IN PROGRAM-LEVEL ADAPTIVE MANAGEMENT PLAN

This section describes the AM components that are being developed for the first time as part of this CERP Programmatic AM Plan. As stated in the overview, there are three primary components that have been missing from the CERP AM program that are being developed as part of this plan:

1) the identification and prioritization of programmatic uncertainties and the identification of existing AM strategies to address them,
2) the development of AM strategies to address prioritized the uncertainties, and
3) the development of management options matrices related to the programmatic uncertainties and strategies.

This section describes the purpose of each of these components and the approach that was used to develop them. The actual components themselves are organized by RECOVER regions – 1) Total System, 2) Lake Okeechobee, 3) Northern Estuaries, 4) Greater Everglades, and 5) Southern Coastal Systems.

3.1 Identification and Prioritization of Uncertainties and Existing AM Strategies (Activity 3)

3.1.1 Purpose

As mentioned in Section 2, this programmatic AM plan represents the first documentation of a comprehensive list and ranking of programmatic uncertainties. The purpose of developing this list was to capture, in one location, the primary scientific/technical and policy/management uncertainties affecting the achievement of CERP goals and objectives, and prioritize which are most important to address, in a transparent way. In addition, this effort identified existing strategies in place to address these uncertainties (e.g., performance measure and model development, refined monitoring design), as well as any gaps that need to be filled (see Section 3.2).

3.1.2 Approach

The initial list of uncertainties was gathered from existing sources such as the 2004 and 2009 MAP documents, various project-related planning studies, the 2009 System Status Report and the "Yellow Book". The uncertainties were organized by the following geographic categories: Total System, Lake Okeechobee, Northern Estuaries, Greater Everglades, and Southern Coastal Systems. In addition to the uncertainty itself, the following corresponding information was included:

1) relevance (e.g., related to restoration targets, ecosystem processes, water supply/flood control, short/long-term trade-offs, design of restoration projects, etc.),

2) linkage to CERP projects, including which phase(s) it affects (i.e., planning, design, monitoring, operations, and/or scheduling),
3) category of uncertainty (i.e., ecological, engineering and/or policy), and
4) existing and/or potential strategies to address it.

The initial list was reviewed by the RECOVER Regional Coordinators (RCs) (regional uncertainties lists) and RECOVER Executive Committee (REC) to ensure all relevant uncertainties were included, revise the wording as appropriate, add or remove uncertainties and fill in the corresponding information to the extent possible. The CERP AM Team then developed a set of criteria for prioritizing the uncertainties based on those that were used as part of the same process for the Water Conservation Area (WCA) 3A Decompartmentalization and Sheetflow Enhancement (Decomp) project AM plan. The criteria were:

- **1a. Knowledge:** What is the level of understanding (high, medium, low) of this uncertainty (i.e., how much is known about this uncertainty)?
- **1b. Relevance (Actionable):** What is the level of confidence (high, medium, low) that addressing this uncertainty will resolve/improve design of CERP projects or enable a more ecologically effective approach to operations of the regional system?
- **1c. Risk:** What is the risk (high, medium, low) of not meeting CERP restoration goals if this uncertainty is not addressed?

Using the criteria, the RECOVER RCs and REC, with input from regional team members, ranked the uncertainties within each of their regions in 2012 using the look-up **Table 3-1**. Priority 1 and 2 CERP programmatic uncertainties are listed in **Table 3-2**.

Table 3-1 - Look-up Table for Uncertainty Prioritization

Risk	Knowledge	Relevance	Tier
High	Low	High	High
Med	Low	High	High
High	Low	Med	High
High	Med	High	High
High	Med	Med	Med
Med	Med	High	Med
High	High	High	Med
High	High	Med	Med
Med	High	High	Med
Med	Med	Med	Med
Med	Low	Med	Med
Low	Med	Low	Low
Med	Med	Low	Low
Low	Med	Med	Low
Med	High	Med	Low
Med	High	Low	Low
Low	High	Med	Low
Low	High	Low	Low

Table 3-2 - Priority 1 CERP Programmatic Uncertainties.

Priority 1 CERP Programmatic Uncertainties		
Topic	ID	Uncertainty Description
Storage	LO-4	Will enough storage be constructed to enable increased ability to regulate Lake Okeechobee (LO) stages to reduce extreme high and low periods?
Storage	NE-2	Will storage projects (e.g., Aquifer Storage and Recovery) provide enough capability to protect estuarine resources in both dry and wet seasons?
Oysters	NE-5	What is the effect on recruitment patterns due to water quality (nutrients and suspended solids), given adequate numbers of spawning oysters?
Processes	GE-1	What is role of flow velocities and flow volumes in maintaining ridge-and-slough patterns? Sediment mobilization vs. Distal feedback mechanisms.
Design	GE-6	What areas can be restored quickly (decadal) vs. slowly (century-millenia)? Can ridge and slough patterns be reestablished simply by restoring hydrology?
Water Quality	GE-7	How should restoration projects be designed to implement restoration features and operations that deliver increments of clean water to priority restoration areas?
Design	GE-12	Is complete backfilling of canals and removal of levees and ecological and hydrologic necessity for restoration?
Targets	SCS-3	What are volumes and patterns of flow required to restore submerged aquatic vegetation, oysters, and fish communities in coastal Everglades?
Climate Change	SCS-5 and 6	To what degree will sea level rise affect restoration efforts? How will Sea-Level Rise affect coastal soils? What spatially sustainable areas should restoration activities focus, how are priorities determined?
Targets	TS-1	What are the hydrological needs of the total Everglades (natural) and Human (Urban and Agricultural) systems? How much of this need is provided by CERP and how much more storage is needed?
Climate Change	TS-2	What hydrological/ ecological/human changes may be driven by uncertain future demands from agriculture and urban, as well as effects of climate change (changes in regional water balance) and sea level rise (causing elevated water tables)?
Climate Change	TS-3	How will climate change affect the regional water balance? How will the hydrologic assumptions used for CERP projects be affected?
Balance Goals	TS - 4	If the lake stage in Lake Okeechobee is achieved for LO indicators, will the rest of CERP NE projects be able to address NE and its effects on downstream water bodies.
Priority 2 Programmatic Uncertainties		

Topic	ID	Uncertainty Description
Water Quality	LO-1C	How will biotic components in the lake respond if water quality goals are not met for various scenarios of years (10, 20, 30)?
Hydrology	LO-3	How will Lake Okeechobee stage levels be affected by currently planned CERP and Non-CERP projects that adjust the timing and/or quantity of water flowing into or out of Lake Okeechobee?
Estuarine	NE-3	Will currently planned CERP and non-CERP projects provide a enough flexibility in design or enough storage to provide flows necessary to maintain favorable salinity regimes to support NE flora and fauna?
Estuarine	NE-4	Can a salinity range be established that encompasses sustainability for multiple valued ecosystem components, even if the range is not optimal for all?
Estuarine	NE-6	What is the significance of preaation pressure on juvenile oysters within restored salilnity regimes in the estuaries?
Estuarine	NE-7	If salinity and sediment conditions are known, can the health of the benthic infaunal community be predicted and assessed?
Estuarine	NE-8	What is the long-term effectiveness of CERP infrastructure projects under anticipated sea-level rise?
Estuarine	NE-9	Once flows and salinity regimes are restored, what additional measure (e.g., hard substrate) are necessary to reestablish oysters?
Estuarine	NE-11	What areas of the estuaries potentially provide sustainable conditions for submerged aquatic vegetation and what additional measure sare require to achieve restoration once flows have been restored?
Fauna	GE-2	What are the restoration targets (interim/full) for wading bird populations?
Fauna	GE-3	What are the targets for fish and crayfish densities that can sustain multiple wadin bird species during the nesting season?
Endangered Species	GE-4	How will multiple endangered species respond to restoration efforts over time, and how can adverse effects be avoide, minimized, or counteracted?
Endangered Species	GE-5	Are their potentially conflicting habitat requirements for multiple species and what is to be restored? How should this be addressed?
Landscape	GE-10	How do flow depth, velocities, durations, species, and nutrients interact in landsapce pattern generation/maintenance?
Invasives	GE-11	How do exotic species affect restoration success and how restoration efforts are planned and implemented?
Fauna	GE-13	Are upward trends in alligator densities and body condition expected as a result of CERP-related projects?
Hydrology	SCS-4	How can we reasonably and accurately quantify the volume of water required for restoration of Biscayne Bay (BB), Florida Bay (FB) and the Southwest Coast acknowledging real-world constraints?
Invasives	SCS-10	What is the effect of exotics on the Southern Coastal Systems? How will the spread and costs associated with the control, and success of the control of exotics impact restoration?
Endangered Species	SCS-11	How will threatened and endangered species issues vs. hydrologic reatoration requirements be resolved within the confines of existing Federal laws?

Water Quality	SCS-12	What controls the input and methylation rates that affect accumulation rates of methylmercury by coastal fauna?
Fauna	SCS-13	What are the conditions on the coast that promote the return of the coastal rookeries?
Land Use	SCS-14	How will further development on the coast and water supply demands affect salinity and restoration efforts?

The RECOVER Executive Committee reviewed the rankings, which were then coordinated with the DCT to obtain management feedback as early as possible consistent with guidance in the CERP AMIG. The CERP program-level AM plan was put on hold to support development of the Central Everglades Planning Project (CEPP) AM plan and development of the 2014 SSR. The RECOVER Regional Coordinators and Executive Committee reviewed and updated the uncertainties in 2014 based on knowledge gained from the CEPP AM plan and 2014 SSR. A RECOVER-wide review of the uncertainties and their rankings was conducted and the list was finalized. The final list will be presented to the DCT as well as the DOI's Working Group and Science Coordination Group.

Further on in this section, CERP programmatic uncertainty tables describe the uncertainties prioritized in each region. The tables include the following headers:

1. *Unique ID* – Region abbreviation and order of uncertainty when initially proposed.
2. *Uncertainties* – CERP uncertainty related to achieving CERP goals and objectives or remaining within constraints. Majority were identified from previous CERP documents: Yellow Book, Project Implementation Reports, Monitoring and Assessment Plan, System Status Report, and other South Florida Synthesis reports.
3. *Uncertainty Details* – Specific details for each uncertainty to help further describe the significance of the question.
4. *Relevance* – How does this relate to yellow book performance measures, other uncertainties, interim goals, specific monitoring, projects, and other relevant information.
5. *Knowledge-Level of Understanding* – what is the level of understanding (high, medium, low) of this uncertainty (i.e., how much is known about this uncertainty)?
   a. Low understanding means little is known about the question/issue or how to address it;
   b. Med understanding means some information is known in some geographical areas, but not all; or
   c. High understanding means a lot is known about addressing this question in multiple geographical areas.
6. *Relevance (Actionable)* – Level of Confidence that actions can be taken: Relevance (Actionable): What is the level of confidence (high, medium, low) that addressing this uncertainty will resolve/improve design of CERP projects or enable a more ecologically effective approach to operations of the regional system?
   a. Low confidence means that even if we address this uncertainty, CERP projects or operations will not be able to be modified given the results of CERP implementation;

   b. Medium confidence means if we address this question, a connection to restoration project implementation is established/documented but future adjustments may or may not be limited; or
   c. High confidence means if we address this question, we could modify CERP project and operations to improve restoration results.
7. *Risk – Level of risk to meeting goals* - Risk: What is the risk (high, medium, low) of not meeting CERP restoration goals if this uncertainty is not addressed?
   a. Low risk means that even if the uncertainty isn't addressed, we don't believe it poses much risk to achieving CERP goals and objectives;
   b. Medium risk means that if the uncertainty isn't addressed it may or may not affect achievement of a goal/objective; and
   c. High risk means that without answering this uncertainty, there is a high risk we will not achieve CERP goals and objectives.
8. *Strategy Characterization* (Tier 1, 2, or 3) - Uncertainties are characterized based on a look-up table for the three criteria used in order to prioritize strategies to address them.
   a. Tier 1: Decision-Critical (Showstopper) – The restoration project/component will be paralyzed if this uncertainty isn't addressed. In other words, failure to address this uncertainty could "stop" progress towards meeting CERP restoration goals. These uncertainties have low knowledge, high relevance and high risk;
   b. Tier 2: High Priority (Advances AM) – These uncertainties have medium knowledge, medium relevance, and medium/high risk; or
   c. Tier 3: Important (Useful but low relevance) – These uncertainties have low to high knowledge, but more importantly they have low relevance and low/medium risk.
9. *Category of Uncertainty* - Uncertainties are typically related to CERP hydrological and/or ecological goals, some are specific to engineering technologies, others are related to chemical (water quality) goals, and other uncertainties are policy questions that can be informed by RECOVER science but require a policy/management solution to address.
10. *Existing and Potential Recommended Strategies* - Brief description of how the uncertainty might be addressed: 1. Model and performance measure development; 2. Monitoring of restoration project response; or 3. Field test of operations, design, physical model, or mesocosm.

3.2 Development of New AM Strategies to Address Uncertainties

Adaptive management strategies were developed by RECOVER Regional Coordinators to address programmatic uncertainties that were determined to be priority 1 and 2. First, existing strategies were identified that involved MAP monitoring of restoration status and response, adaptive management physical models and/or field tests, and/or specific research and data syntheses that were currently underway. Then, new AM strategies were developed for uncertainties that did not have existing strategies to address them. The new strategies were brought forward to the CERP Implementing Agencies and RECOVER Leadership Group for consideration and approval as part of future fiscal year workplans.

RECOVER Regional Coordinators used the CERP Program-Level Adaptive Management Strategy Template to document the type of strategy being proposed (such as sensitivity analyses, modeling tests, system-wide planning and evaluation, data mining, monitoring pre/post-restoration responses, physical models/field tests or policy/management decisions). The strategies also linked existing MAP hypotheses, modeling, performance measures, specific tests or other scientific efforts that provided background and documentation on the science supporting the strategy. The CERP Program-Level AM Strategies can be located in Appendix 2.

<u>Example template:</u>

1. **CERP AM Uncertainty and ID#.** *Use language from Programmatic Uncertainties Table. The uncertainty is a question faced during planning or implementation regarding the best restoration projects/actions to achieve desired goals and objectives within constraints, which cannot be fully answered with available data or modeling.*

2. **CERP Objective or Constraint:** *Use Master Yellow Book objectives spreadsheet. Uncertainties need to be related to CERP objectives (see appendix A) or constraints, among other criteria, to be included in the AM Plan. This rule helped to focus the scope of the AM Plan.*

3. **Location of Uncertainty and Ecosystem Indicator (Include Map):**
   a. **Region(s).** *Region and Sub-Area of CERP footprint to which the uncertainty and strategy pertain.*
   b. **Associated CERP Projects, Structures, and Operations:** *Use South Florida Projects Schedule and Yellow Book. Refer to CERP Structures or measures to which the uncertainty and strategy pertain.*

4. **What is expected to be learned by addressing this uncertainty, i.e., how will CERP benefit from addressing this uncertainty?** *This is a short summary of why addressing this key uncertainty is important to be addressed specifically related to achieving CERP restoration success. It can include information from the uncertainty details column in the programmatic uncertainties spreadsheet.*

5. **Expectations or hypotheses to be tested to address the uncertainty, and attribute(s) that will be measured to test each.** *State succinctly what is proposed to address the uncertainty and reference supporting documents if existing strategy (2-3 lines). RECOVER and RECOVER agencies have produced many scientific documents (science plans, performance measure documentation sheets, MAP, monitoring/modeling scopes of work) that outline the scientific approach to addressing many of these questions. This section references each of those documents that helps address the uncertainty and includes the following: a. Identify Science Plan, performance measure/MAP hypothesis, and/or MAP/modeling scope of work name and current weblink; b. List specific stressor, effect, or attribute (restoration indicator) being measured; c. (new) Time frame to begin to be able to measure change; and d. (new) when during CERP's life Cycle should AM strategy (modeling, monitoring, analysis, or test) begin and end.*

6. **Thresholds that indicate good CERP performance or need for adaptive management action.** *Thresholds are a point, range, or limit that signifies when restoration performance is on track for a particular set of projects or veering away from expectations and is trending toward an unintended outcome. Thresholds should be described per stressor/attribute (restoration indicator) to be monitored because each should result in an outcome that informs management decisions. If this is an information gap, please note how it could be filled.*

The following CERP Programmatic AM Strategies were developed to address priority 1 programmatic uncertainties:

- LO-4/NE-2 – *Evaluation and System-wide Planning* - Refinement of performance measures and application to regional project planning to support achievement of multiple CERP goals.
- NE-5 – *Evaluation* – Development of Particle Transport Model to separate potential effects of water quality from estuarine flushing and inform oyster cultch placement and seasonal operations on Caloosahatchee followed by St. Lucie.
- SCS-3 – *System-wide Planning and Assessment*– Evaluation of restoration increments of water (pre-CERP, current, CEPP, CERP) using salinity and ecological models. Monitoring of C-111 SC and Biscayne Bay and responses to operational tests.
- SCS-5/6 – *System-wide Planning and Assessment* – Conduct risk and vulnerability assessment of climate effects on restoration benefits and how restoration can mitigate effects in GE/SCS. Implement monitoring proposed by CEPP to assess actual sea-level rise influence.
- GE-1 – *Evaluation and Field Tests* – Develop performance measures to evaluate effects on tree islands and ridge and slough in different parts of the system. Conduct field tests of flow (Decomp Physical Model), tree islands and ridge and slough mescosms (LILA), and flow/active marsh improvement/operations tests in key areas.
- GE-6 – *System-wide Planning and Evaluation* – Synthesize, develop, and apply performance measures to identify ridge and slough landscape restoration and degradation trajectories.
- GE-7 – *Assessment* – Synthesis of landscape monitoring, REMAP, DECOMP Physical Model, LILA, and Operations tests to inform future planning, design, and implementation of new increments of clean water moving into the Everglades landscape to maximize restoration results.
- GE-12 – *Physical Model Test* – Extend Decomp Physical Model operations and monitoring to build statistical strength of data to determine backfill treatment benefits and address additional landscape uncertainties (nutrients, flow velocity, active restoration actions).

3.3 Development of Management Options Matrices

A management options matrix (MOM) is an organized table of summarized suggestions of how to make restoration improvements if performance is not reaching expected outcomes. A MOM includes: 1) the target areas of interest, i.e., usually the location or topic of a specific uncertainty or group of uncertainties; 2) restoration indicators (stressors/attributes) that are monitored that to assess actual performance in each area; 3) decision criteria triggers that indicate when new action is needed, i.e., the thresholds or targets and associated timing that indicate when performance is acceptable/not acceptable; and 4) suggested management options that could improve the performance. For the CERP Program-Level AM Plan, suggested management options usually relate to period 1, 2, or 3 CERP and non-CERP restoration projects and/or operations of those projects. Period 1 is defined as projects that are currently under construction or are operational between the years 2014-2018. Period 2 is defined as projects with chief reports, Congressional authorizations, or scheduled for completion during the years 2019 to 2028. Period 3 includes projects originally identified in the 2000 authorized CERP Plan, but don't have any plans approved by SFWMD and USACE, nor Congressional authorization.

The MOMs are complimented by more thorough descriptions of the uncertainties, monitoring, and suggested actions, as described in Sections 3.3 – 3.9 of this Program-Level Adaptive Management Plan, so that the MOMs can remain brief tables while the more detailed information can be accessed as needed. The MOMs are intended for use as quick-reference tables by program managers (e.g., RECOVER, DCT, QET and QAT), system operators, scientists, and other participants in adaptive management discussions. Please note that the MOM conceptual options would need to be integrated and implemented with the programs, operational rules, regulations, and constraints in place at the time they are being considered in the future. Those details are not included in each MOM. The Program-Level AM Plan's matrix will be used for implementation of CERP projects affecting the Lake Okeechobee region, Caloosahatchee River Estuary, St. Lucie estuary, Greater Everglades regions, and Florida Bay and Biscayne Bay areas. A Diagram presenting each element of a MOM is provided below (**Figure 3**).

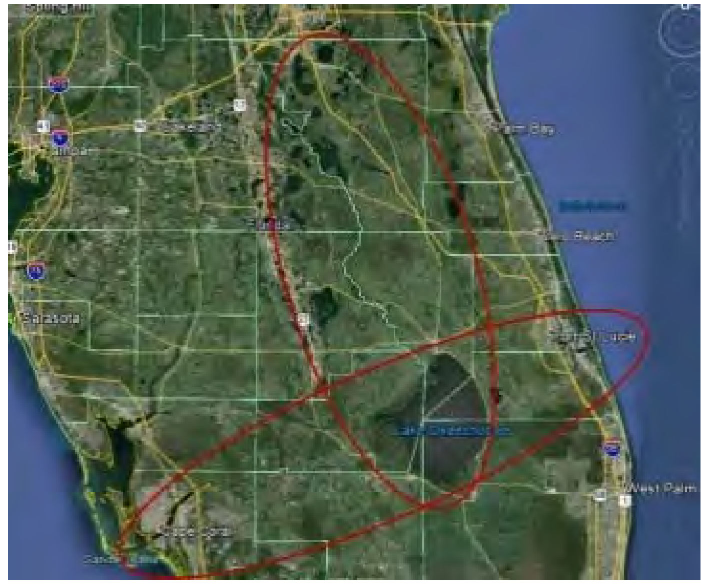
The Program-Level AM Plan's matrix links the RECOVER MAP restoration indicators (i.e., physical and biological attributes indicating progress towards restoration) to the following:

1. Uncertainty ID – Reference number and region to programmatic uncertainty list and AM strategy write-up;
2. Indicator – Restoration indicator (stressor/attribute) and specific parameters being monitored;
3. Thresholds – Incremental performance expected to be achieved by initial projects in time period 1 or as stated in interim goals, ordered based on expected time frame for a response;
4. Full Restoration Target – Full CERP restoration performance described in RECOVER performance measure documentation sheets, relevant scientific and agency publications, by RECOVER approved model runs and modeling evaluations from large scale CERP restoration planning efforts, and potentially also informed by Natural Systems Regional Simulation Model output;
5. Triggers for Management Action – Combination of threshold range/value and expected timeframe after project is implemented to achieve actual threshold if describing restoration goal, or range/value to avoid if describing a constraint. This information will help ensure future assessments are clear when there are performance issues that require management

decisions to address. Triggers are not self executing and require analysis of issues and options in appropriate decision documents before any actions is taken;

6. Management Action Options – Management action options identified to help improve performance, if known at this point in time. Options for the CERP programmatic AM Plan are usually CERP restoration projects and operations suggestions in order of progression consistent with current project schedules (e.g., period 1 [2014-2018], period 2 [2019-2028], and period 3 [2029-2050]). The matrix includes options for AM adjustments if the threshold is reached. The options are presented in the order in which they should be considered based on factors such as anticipated effectiveness, ease of implementation, cost, etc.

3.4 Lake Okeechobee



Lake Okeechobee is a large, shallow, eutrophic lake located in central south Florida greatly influenced by upstream watershed flow in the Kissimme Valley, as well as water management connections to the Northern Estuaries and Greater Everglades areas. Historical and background information, including its importance to the south Florida ecosystem and the impacts development has had on the lake can be found in Aumen (1995), Steinman et al. (2002), Havens and Gawlik (2005), Engstrom et al. (2006) and the 2007 and 2009 Lake Okeechobee System Status Report chapters (RECOVER 2007, 2011). Lake Okeechobee has three subregions: a littoral marsh, open water (pelagic) region and transitional nearshore region. These subregions can function in ecologically dissimilar ways and respond to changes in water levels and water quality in distinct and often different ways. Ecological assessments for Lake Okeechobee suggest that relationships exist between water levels, nutrient concentrations and flora and fauna communities, such as submerged aquatic vegetation and fish. - See more at: http://www.evergladesplan.org/pm/ssr_2014/mod_lo_2014.aspx#sthash.3NsPtIXa.dpuf

Table 3-3 - CERP and Non-CERP Projects Affecting Lake Okeechobee Restoration Indicators.

Time Period (Relative)	CERP and Non-CERP Project/Components Affecting Lake Okeechobee	Current Schedule Timeframe (April 2014 and updated where possible)
Period 1 – 2014-2018	Lake Okeechobee Regulation Schedule (LORS)	In effect
	Kissimmee River Restoration	Estimate complete by 2017
	Taylor Creek/Nubbin Slough Storage and Treatment area (STA)	2010-2015
	Lakeside Ranch STA phase 1	2012
	Dispersed Water Storage	Started in 2012, ongoing
Period 2 – 2019-2028	Central Everglades Planning Project	Beyond 2014
	C-43 West Basin Storage Reservoir	Beyond 2014
	Kissimmee chain of Lakes (Headwaters Revitalization Schedule)	2019-2022
	Everglades Headwaters National Wildlife Refuge	2013-2028
	Lakeside Ranch STA phase 2	Beyond 2014
	Northern Everglades Projects	Beyond 2014
	Herbert Hoover Dike Rehabilitation	Completion estimated by 2025
Period 3 – 2029-2050	Lake Okeechobee Aquifer Storage and Recovery (ASR)	Beyond 2014
	Lake Okeechobee Watershed	2019-2023

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3.4.1 Lake Okeechobee Uncertainties Table

ID	Uncertainties (Source)	Uncertainty Details	Relevance	Knowledge - Level of understanding	Relevance (Actionable) - Level of confidence that actions can be taken	Risk - Level of risk to meeting goals	Strategy Priority Tiering	Category of Uncertainty (Primary/ Secondary)	Existing and Potential Recommended Strategies
LO-1	**LO-1A.** Once all of the State's currently envisioned watershed BMP's are in place (anticipated by 2020 in TMDL documentation), what additional watershed projects will be necessary, if any, to meet the 105 metric tons/yr phosphorus TMDL for the lake?	This uncertainty involves the timing and intensity of BMP implementation required for a sufficient reduction in watershed phosphorus and for the watershed to revert to a phosphorus sink (to achieve the TMDL). It also includes concomitant reductions of other non-point source pollutants (e.g., turbidity, nitrogen) that are currently of lesser importance than phosphorus. The phosphorus TMDL is a phased approach with 2020 representing a decision point (start of Phase 3) for the State's continued implementation of the non-point source phosphorus reduction programs. This uncertainty also highlights the need for a comprehensive watershed phosphorus model to track progress of individual projects. Although this is primarily a State initiative (DEP, SFWMD, FDACS), the CERP Lake Okeechobee Watershed Project and Aquifer Storage and Recovery Project are linked because they would perform some nutrient reduction as currently envisioned.	There is an order to these uncertainties in that LO-1 needs to be addressed prior to LO-2, then LO-3. These uncertainties affect the watershed nutrient input, ecological state of the lake from primary producers to upper-level consumers; affects amount of treatment needed for downstream Greater Everglades system. This question also relates to Northern Estuary water quality.	Medium	Medium	Low	3	Chemical/ Ecological	FDEP TMDL document at: http://www.dep.state.fl.us/water/tmdl/final_tmdl.htm FDEP non-point source programs are at: http://www.dep.state.fl.us/water/nonpoint/ SFWMD Works of the District info is at: http://www.sfwmd.gov/portal/page/portal/xweb%20-%20release%202/lake%20okeechobee%20wod%20permits FDACS BMP info is at: http://www.freshfromflorida.com/Divisions-Offices/Agricultural-Water-Policy . Additional ecological monitoring and research to determine the response attributes and temporal variability associated with biotic components (birds, fish, herpetofauna, macroinvertebrates, macrophytes, plankton, periphyton) of environmental restoration projects, as well as information on sediment water interactions. Existing related monitoring includes that done as part of LO Water Quality and Phytoplankton Hypothesis Cluster (see MAP);LO Native Fish Hypothesis Cluster (see MAP); LO Macroinvertebrate Community (see MAP); LO Emergent-Submerged Vegetation Mosaic (see MAP) and lake stage monitoring (see MAP).
	LO-1B. Once the TMDL is being consistently met, how long will it take for the pelagic and nearshore zone water quality phosphorus goals to be reached?	This considers the time needed for existing in-lake phosphorus-rich muck/sediment to either be overlain by cleaner lake sediments and thereby greatly reducing bioavailability, or exported from the lake.							
	LO-1C. The TMDL does not have a required deadline for complete implementation, so how will biotic components in the lake respond if water quality goals are not met for 10, 20, 30, etc years?	How will SAV, fish, and macroinvertebrates in the Lake respond if: (1) the existing poor WQ conditions persist for many years, if pelagic sediment P loading is not addressed, or (2) water quality improves but only moderately in the same time frame? Are their new or improved performance measures for species/guilds other than SAV or algae that can be developed to reflect WQ changes?				Medium	2		
LO-3	How will lake stage levels be affected by <u>currently planned</u> CERP and Non-CERP projects that adjust the timing or quantity of water that flows into, or from, Lake Okeechobee?	There are many planned or implemented CERP and Non-CERP initiatives in the watershed that may alter the amount or timing of flows, but there's a lack of a comprehensive model to track or predict project results. Additionally there is uncertainty regarding water supply and population growth north of the Lake.	Links to TS-1, relates to water supply, storage and to a lesser degree, nutrient reduction.	Medium	Medium	Medium	2	Socio-Economic/ Policy	Continued review of CERP-related water storage projects and strategies and evaluation of the feasibility of these projects; update Florida 2060 population and water usage growth projections. Relates to Water Supply for LO Service Area PM, which may be reviewed as part of new WS/FC RECOVER team.

ID	Uncertainties (Source)	Uncertainty Details	Relevance	Knowledge - Level of understanding	Relevance (Actionable) - Level of confidence that actions can be taken	Risk - Level of risk to meeting goals	Strategy Priority Tiering	Category of Uncertainty (Primary/ Secondary)	Existing and Potential Recommended Strategies
LO-4	How much additional water storage will need to be constructed in the watershed to enable water managers to regulate LO stages, so as to substantially reduce extreme high and low Lake stage periods and provide additional benefits to LO ecology?	There is uncertainty about the ability to maintain the lake in the ecologically beneficial stage envelope over the long term, and the response of biota that depend on lake stage fluctuations, such as wading birds, fish, macroinvertebrates, plankton, emergent and submerged plant communities. Also how will modifications to the lake regulation schedule post-HHD completion alter stage envelope performance (will we see higher lake stages outside of the envelope?) Will enough water storage be constructed in the watershed to ensure that consistent, annual seasonal stage fluctuations (that mimic the pre-Herbert Hoover Dike era fluctuations [ca. approximately two feet]) will occur? Will this storage also enable water to be moved in and out of the lake to avoid extreme lake stage impacts like rapid increases from the passage of tropical systems and substantial decrease from prolonged droughts (i.e., minimize the occurrence of those extreme stages outside the envelope)? Can the dynamic nature of the ecological conditions in Lake Okeechobee be reduced to a more predictable, slower changing environment by significantly reducing the frequency of severe changes in lake stage and related disturbance events?	This uncertainty is related to LO-3 but is about future water storage that is unplanned. It affects lake ecology, from primary producers to upper-level consumers and to what degree increased ecological benefits may occur. The downstream estuaries also are affected. Resulted from new storage alternatives modeled in the 2014 SSR.	High	High	High	1	Hydrological / Ecological	Continued monitoring of ecological components whose health is reflected by lake stage status, such as birds, fish, herptofauna, macrophytes, macroinvertebrates, plankton and periphyton. Related existing monitoring includes that done as part of LO Native Fish Hypothesis Cluster (see MAP); Macroinvertebrate Community (see MAP); Emergent-Submerged Vegetation Mosaic (see MAP); Wading Bird Nesting (see 2009 SSR) and lake stage monitoring (see MAP). Additional modeling to quantify/ evaluate the significance and importance of water storage per project. Related modeling conducted for LOW Construction Project Phase II Technical Plan thus far includes STCALC and RESOPT (see AFB documentation for LOW). Other related projects include FRESP (see Section 3.2.2 BMPs of SKG document) and RWCAs (see Section 1.7.4 of SKG document).
Uncertainties considered but screened out									
LO-5	If state and local-level efforts to reduce watershed nutrient loading and in-lake nutrient levels are scaled-back or eliminated due to budgetary constraints or other reasons, how will the larger concerns about northern watershed additional water storage, if water quality is a hard constraint?	Links to TS-1 and LO-4, LO-6. Affects water storage, lake stage operations and lake ecology. While a plan has been formulated, there is uncertainty as to the ability of water storage elements to be constructed, due to budgetary constraints at the federal, state and local levels. The inability to construct adequate water storage in the watershed will result in uncertainties regarding long-term environmental restoration of the lake and the timeline wherein restoration can be expected to occur. Will efforts to control water quality be picked up at the federal level? Will nutrient abatement efforts be placed on hold due to litigation by agencies at all governmental levels, thus delaying restoration activities and achievement of nutrient criteria goals? Related modeling conducted for LOW project thus far includes STCALC and RESOPT (see AFB documentation for LOW). Other related projects include FRESP (see Section 3.2.2 BMPs of SKG document) and RWCAs (see Section 1.7.4 of SKG document).	Affects lake ecology, drinking water suitability and the ability and timeframe needed for restoration of the lake to prescribed environmental goals and numeric criteria. Also affects downstream estuary water quality and ecology.	High	Medium	High	1	Chemical/ Policy	Additional modeling to quantify evaluate the significance and importance of this watershed storage relative to that provided by other project elements (e.g. ASR wells) and potential nutrient sink/export contributions these reservoirs may provide. Additional modeling and research is recommended to determine optimum BMP nutrient removal/reduction projects; quantity, size and nutrient removal efficiencies needed to provide sufficient nutrient removal to meet or exceed the future TMDL. Related existing modeling includes the Watershed Assessment Model (WAM) simulations and existing monitoring includes BMP monitoring conducted by the SFWMD (see Section 3.2.2 BMPs of SKG document for more details).

ID	Uncertainties (Source)	Uncertainty Details	Relevance	Knowledge - Level of understanding	Relevance (Actionable) - Level of confidence that actions can be taken	Risk - Level of risk to meeting goals	Strategy Priority Tiering	Category of Uncertainty (Primary/ Secondary)	Existing and Potential Recommended Strategies
Uncertainties considered but screened out									
LO-7	Will CEPP water deliveries south adversely or positively affect LO littoral zone ecology. (Uncertainty #3 from CEPP AM Plan)	If CEPP projects are constructed and up to 250k ac ft of water is sent south from the lake on an annual basis, will the biota in the littoral zone be adversely affected when lake water levels are extremely low and positively affected when lake water levels are extremely high.	Links to TS-1 and LO-4. Affects water storage, lake stage operations and lake ecology.	High	Medium	High	1	Policy/ hydrological	Additional modeling to quantify/ evaluate the significance and importance of this water storage relative to that provided by other project elements (e.g. ASR wells). Related modeling conducted for LOW Construction Project Phase II Technical Plan thus far includes STCALC and RESOPT (see AFB documentation for LOW). Other related projects include FRESP (see Section 3.2.2 BMPs of SKG document) and RWCAs (see Section 1.7.4 of SKG document).
LO-8	Are there uncertainties about biotic responses to lake stage fluctuations?	There is uncertainty about the viability and timeline for the federally proposed water storage projects in the northern portion of the watershed. While a plan has been formulated, there is uncertainty as to the ability of water storage elements to be constructed, due to budgetary constraints at the federal level. If these budgetary constraints are long-term, there is uncertainty whether implementation of these watershed storage projects will occur and how they will be prioritized and funded. The inability to construct adequate water storage in the watershed will result in uncertainties regarding long-term environmental restoration of the lake and the timeline wherein restoration can be expected to occur.	Links to TS-1 and LO-4. Affects water storage, lake stage operations and lake ecology.	High	Medium	High	1	Policy/hydrological	Additional modeling to quantify/ evaluate the significance and importance of this watershed storage relative to that provided by other project elements (e.g. ASR wells) and potential nutrient sink/export contributions these reservoirs may provide. Related modeling conducted for LOW Construction Project Phase II Technical Plan thus far includes STCALC and RESOPT (see AFB documentation for LOW). Other related projects include FRESP (see Section 3.2.2 BMPs of SKG document) and RWCAs (see Section 1.7.4 of SKG document).
LO-6	Will necessary Northern watershed water storage/reservoir be constructed?	There is uncertainty about the viability and timeline for the federally proposed water storage projects in the northern portion of the watershed. While a plan has been formulated, there is uncertainty as to the ability of water storage elements to be constructed, due to budgetary constraints at the federal level. If these budgetary constraints are long-term, there is uncertainty whether implementation of these watershed storage projects will occur and how they will be prioritized and funded. The inability to construct adequate water storage in the watershed will result in uncertainties regarding long-term environmental restoration of the lake and the timeline wherein restoration can be expected to occur.	Links to TS-1 and LO-4. Affects water storage, lake stage operations and lake ecology.	High	Medium	High	1	Policy/hydrological	Additional modeling to quantify/ evaluate the significance and importance of this watershed storage relative to that provided by other project elements (e.g. ASR wells) and potential nutrient sink/export contributions these reservoirs may provide. Related modeling conducted for LOW Construction Project Phase II Technical Plan thus far includes STCALC and RESOPT (see AFB documentation for LOW). Other related projects include FRESP (see Section 3.2.2 BMPs of SKG document) and RWCAs (see Section 1.7.4 of SKG document).

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3.4.2 Lake Okeechobee AM Strategies

3.4.2.1 LO-1 - Timing of Restoration Performance

1. **CERP AM Uncertainty:** Once all of the State's currently envisioned watershed Best Management Practices (BMP)'s are in place (anticipated by 2020 in Total Maximum Daily Loads [TMDL] documentation), what additional watershed projects will be necessary, if any, to meet the 105 metric tons/yr phosphorus TMDL for the Lake? LO-1A. Once the TMDL is being consistently met, how long will it take for the pelagic and nearshore zone water quality phosphorus goals to be reached? LO-1B. The TMDL does not have a required deadline for complete implementation, so how will biotic components in the lake respond if water quality goals are not met for 10, 20, 30, etc years? LO-1C.
2. **CERP Objective or Constraint:** CERP Planning Goals: 1 and 2. Public Objectives: 2 and 3. Public Constraints: 1, 2, 7 and 8.
3. **MAP that Includes:**
   - **a. Region(s).** Lake Okeechobee and watershed, Caloosahatchee and St. Lucie Rivers and associated estuaries
   - **b. Associated CERP Projects, Structures, and Operations:** Lake Okeechobee Watershed Project, BMP Implementation, Kissimmee River Restoration Project, Aquifer Storage and Recovery (ASR) wells around the lake, Northern Everglades and Estuaries Protection Programs, in-lake chemical treatment and sediment removal.
4. **What is expected to be learned by addressing this uncertainty; how will CERP benefit from addressing this uncertainty?** "Improved estimates of when LO ecological restoration can be expected and information to support decisions on how much additional lake inflow nutrient reduction water treatment is needed beyond what is already planned. A larger database containing information on nutrient movement within and out of the watershed, which will improve the ability to model and forecast how long it will take the watershed to become a nutrient (phosphorus) sink rather than nutrient exporter, how long it will take water quality goals to be achieved in the Lake and how the nearshore and pelagic biotic components (e.g., fish, wading birds, aquatic plants, macroinvertebrates, plankton, periphyton) will positively respond by increased abundances or areal coverage, to the improved water quality conditions. Also, an increased ability to model and forecast how the biotic components in the Lake may be negatively impacted by reductions or greater variability in abundances or areal coverage, if the TMDL is not consistently met or if water quality goals in the watershed and the Lake are not met for several decades. Also, the ability to estimate how much additional water treatment beyond that provided by vegetation in the stormwater treatment areas (STA's) south of the Lake, if any, will be needed for water being sent south to the Everglades or to the coastal estuaries once water quality goals in the Lake are consistently met. **Expectations or hypotheses to be tested to address the uncertainty, and attribute(s) that will be measured to test each.**
   - i. **Reference Existing Scientific Documents that Outline Approach to Address Uncertainty: LO watershed and in-lake water** *q*uality mosaics, LO Water Quality and phytoplankton hypothesis cluster (3.1.6), Lake water phosphorus relationship to submerged plant biomass and cover, Submerged plant/periphyton interrelationships with light, nutrients, and water depth, LO diatom:cyanobacteria ratio, LO vegetation

mosaic, LO fish condition and population structure (3.4.3.6), LO macroinvertebrate community hypothesis cluster (3.1.4).

ii. **MAP hypotheses name and number –** Lake Okeechobee Conceptual Ecological Model MAP 2004 Section 3.4.2.2, Ecological Communities and Effects of Water Stages, MAP 2009, Section 3.1.

iii. **Ecological Component Models –** Lake Okeechobee environmental model (LOEM) which projects SAV, periphyton and phytoplankton responses to in-lake nutrient and suspended solids concentrations. A water quality model which estimates the lake water quality recovery period after the TMDL is consistently achieved along with either in-lake chemical treatment, sediment removal or no further restoration efforts beyond achieving the TMDL may be able to be used in conjunction with the LOEM to predict long-term changes in SAV, periphyton and phytoplankton abundances after water quality goals have been attained.

b. **Specific ecosystem stressor (s), effect(s), or attribute(s) being measured:** 1. Phosphorus concentrations, 2. Suspended solids concentrations, 3. In-Lake muck resuspension events, 4. Phytoplankton and cyanobacteria abundance and distribution, 5. Fish abundance and distribution, 6. SAV abundance and distribution.

c. **Time frame to begin to be able to measure change after a restoration action is taken:** Ranges from 30 days (Cyanobacteria), to 1 year (Phosphorus, SAV), to multiple years (fisheries).

d. **When during CERP's life cycle should the AM strategy (modeling, monitoring, analysis, or testing) begin?** Now to support the implementation of additional watershed BMP's and projects with the goal of attaining the phosphorus TMDL as soon as possible.

5. **Triggers/thresholds that indicate good CERP performance or need for adaptive management action.** Phosphorus TMDL; others *TBD, based on water quality monitoring in the watershed and lake and updated/new biotic component performance measure documentation sheets.*

3.4.2.2 LO-3 – Lake Stage Performance Related to Current Projects

1. **CERP AM Uncertainty and ID** How will lake stage levels be affected by currently planned CERP and Non-CERP projects that adjust the timing or quantity of water that flows into, or from, Lake Okeechobee?
2. **CERP Objective or Constraint:** Planning Goals 1, 2; Public Objectives: 1, 2, 3, 4, 5, 6; Public Constraints: 1, 4, 6, 7, 8.
3. **Location of Uncertainty and Ecosystem Indicator (Include Map):**
   a. **Habitat(s) and Region(s).** Lake Okeechobee, Kissimmee Chain of Lakes (KCOL), Kissimmee River, secondarily, the Caloosahatchee and St. Lucie Estuaries
   b. **Associated CERP Projects, Structures, and Operations:** Kissimmee River Restoration Project (KRRP), Lake O Watershed Project, Lake O Regulation Schedule; Herbert Hoover Dike Rehab, Lake O Temporary Forward Pumps, C-44 Reservoir, C-43 Reservoir, Central Everglades Planning Project (CEPP), storage of additional water north of Lake O, Indian River Lagoon-South Project, and operations of Lake Okeechobee, KCOL, and KRRP. Central Florida Watershed Initiative (CFWI) is not a CERP project, rather water supply.
4. **What is expected to be learned by addressing this uncertainty and how will CERP benefit from addressing this uncertainty?** There is a trend of increasing anthropogenic water usage (ground water and surface water) over the last 50 years. Also, because of

development, the timing of water flows into Lake O has become more "flashy." Addressing this uncertainty will allow us to predict if the current (or future) amount of water use is negatively affecting the ability of stages in Lake O to fluctuate in a way that supports its ecology. It also links the future operations of the KCOL (Headwaters Revitalization, KBMOS) and KRRP (autumn flow pulse) on Lake O stages and potentially estuary discharges. Addressing this uncertainty would also allow for an analysis of future system-wide water budget scenarios and trade-offs of achieving multiple objectives related to Lake O stages and flows.

5. **Specific expectations and hypotheses to be tested to address each uncertainty, including the attribute(s).** Monitoring of basin-wide rainfall, surface flows, and water usage will allow managers to detect or predict the magnitude of effects of altered (from existing baseline) hydrology on Lake O stages.
   a) **Reference Existing Scientific Document that outlines Approach to address uncertainty:**
      i. **RECOVER Performance Measures –** LO lake stage, LO vegetation mosaic, LO fish population density, age, structure and condition, LO macroinvertebrates.
      ii. **MAP Hypothesis Name and Number:** From MAP 2009: Emergent-Submerged Vegetation Mosaic Hypothesis Cluster (Section 3.1.3); Macroinvertebrate Community Hypothesis Cluster (3.1.4); Native Fish Hypothesis Cluster (Section 3.1.5).
      iii. **Models:** South Florida Water Depth Assessment Tool (for KRRP water depths) and Spreadsheet models (used by the SFWMD to determine flows from Lake Kissimmee to the River). In Lake O, there are several biotic components and their responses to storage scenario models are under evaluation by SFWMD (See LO-4).
   b) **Specific stressor, effect, or attribute being measured:** quantify the reduction in water or the change in timing of flows into Lake O and associated changes in lake stages and biotic response (in conjunction with LO-4).
   c) **Time frame to begin to be able to measure change:** Within 1 year of changing water deliveries to Lake O. KRRP completed as early as 2017 (Headwaters Revitalization regulation schedules go into effect; Lake Kissimmee to River October pulses have already occurred, but may become more frequent after 2017). CFWI is likely still a few years out.
   d) **When during CERP's life Cycle should AM strategy (modeling, monitoring, analysis, or test) begin and end:** Because monitoring programs currently exist, they should be continued.
6. **Triggers/thresholds that indicate good CERP performance or need for adaptive management action.** TBD (for non-SAV, emergent plant components). For SAV and emergent plants: A significant decrease in littoral or near shore vegetation coverage, *i.e.*, a reduction in vegetation coverage of >20% which persists for one growing season (Spring to Fall) that is causally linked to lake stage. A more refined threshold that identifies optimal species distribution and composition may be developed.
7. **References**

U.S. Army Corps of Engineers. 2013. Adaptive Management Plan for the Central Everglades Planning Project (CEPP). CEPP Draft PIR and EIS, October 2013, Annex D.

3.4.2.3 LO-4 - Additional Storage Needed to Meet LO Ecological Goals

1. **CERP AM Uncertainty and ID** How much additional water storage will need to be constructed in the watershed to enable water managers to regulate LO stages, so as to substantially reduce extreme high and low Lake stage periods and provide additional benefits to LO ecology?
2. **CERP Objective or Constraint:** CERP Planning Goal: 1 and 2. Public Objectives: 2, 3 and 4.
3. **MAP that Includes:**
   a. **Region(s).** Lake Okeechobee and watershed, Caloosahatchee and St. Lucie Rivers and associated estuaries
   b. **Associated CERP Projects, Structures, and Operations:** North of Lake Okeechobee Storage Reservoir, Kissimmee River Restoration Project, Lake Okeechobee Watershed Project, ASR wells around the lake, Central Everglades Planning Project, C43 Reservoir and STA, C44 Reservoir and STA.
4. **What is expected to be learned by addressing this uncertainty, i.e., how will CERP benefit from addressing this uncertainty?** Reduced uncertainty of how littoral marsh and nearshore food webs and biotic components (e.g. fish, wading birds, aquatic plants, macroinvertebrates, phytoplankton, periphyton) benefit from lake stages being more consistently in the ecologically beneficial stage envelope and seasonally being more often in the preferred portion of the fluctuating ecologically beneficial stage envelope. Additionally, reduced uncertainty as to the approximate amount of accrued additional ecological benefits based on the ability to store more water in the watershed and better manage lake stages, reducing extreme high and low lake stage events. Reduced uncertainties also will be realized in terms of water supply benefits to the northern estuaries in terms of reduced high pulse releases and increased low pulse releases to better maintain salinity levels.
5. **Expectations or hypotheses to be tested to address the uncertainty, and attribute(s) that will be measured to test each.** Additional model refinement of ecological benefits anticipated from additional watershed storage and operational adjustments to maximize ecological benefits will help reduce additional watershed storage benefit uncertainties. Refinement of some of the existing performance measures and adding new ecological performance measures also will help reduce additional watershed reservoir/water storage uncertainties with regards to benefits for the nearshore and littoral marsh regions o the lake.
   a. **Reference Existing Scientific Documents that Outline Approach to Address Uncertainty:**
      i. **RECOVER Performance Measures –** LO lake stage, water quality mosaic diatom:cyanobacteria ratio, vegetation mosaic, fish population density, age, structure and condition, and macroinvertebrates.
      ii. **MAP hypotheses name and number –** Lake Okeechobee Conceptual Ecological Model MAP 2004 Section 3.4.2.2, Ecological Communities and Effects of Water Stages.
      iii. **Ecological Component Models –** Several biotic components (Cyanobacteria, Fish, Periphyton, SAV, Wading Birds) and their responses to reservoir storage scenario models are being evaluated by SFWMD staff to identify how much watershed storage will provide the most potential additional ecological benefits to each biotic component. The results of this analysis may result in both updated and new Lake

Okeechobee ecological performance measures to be used in modeling/evaluation and monitoring/assessment of lake stages and biotic component responses.

b. **Specific ecosystem stressor (s), effect(s), or attribute(s) being measured:** 1. Cyanobacteria abundance and distribution, 2. Fish abundance and distribution, 3. SAV abundance and distribution, 4. Wading Bird Foraging Distribution and Abundance, 5. Wading Bird Nesting Colony Location, Size, and Timing, 6. Wading Bird Nesting Success.

c. **Time frame to begin to be able to measure change after a restoration action is taken:** 30 days (Cyanobacteria), (Fish), 365 days (Fish, SAV, Wading Birds).

d. **When during CERP's life cycle should the AM strategy (modeling, monitoring, analysis, or test begin)?** Now to support lake regulation schedule operations and provide estimates for which watershed reservoir/additional storage volume is anticipated to provide the maximum amount of ecological, water supply and flood control benefits.

6. **Triggers/thresholds that indicate good CEPP performance or need for adaptive management action.**

TBD based on Reservoir Scenario modeling and updated/new biotic component performance measure documentation sheets.

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3.4.3 Lake Okeechobee Management Options Matrix

Uncertainty ID	Indicator	Threshold (Interim/Project Restoration Goal)	Full Restoration Target	Trigger(s) for Management Action	Management Action Option 1	Management Action Option 2	Management Action Option 3
LO-4, LO-3	**Stage** USACE: stage monitoring (daily)	LORS: Number of days over 41-year POR: < 12.56 ft. = 5128; > 17.25 ft = 2; Minimum simulated = 8.0 ft PM scores: Extreme low/high = 84/99; Stage envelope (above/below) = 81/26 MFL violations (<11 ft for >80 days) over POR = 6; Source: USACE 2007: App. E Band 1 (2015 – LOWP): PM scores: Stage envelope (above/below) = 51.38/64.58; Extreme lake stage (high/low) = 80.56/96.30; MFL violations over POR = 6; Source: RECOVER 2010 Interim Goals: Number of events >17 ft annually: 2010: 3; 2015: 2 Number of events >15 ft annually: 2010: 2; 2015: 2 Number of events <12 ft annually: 2010: 3; 2015: 2; Source: RECOVER 2005a	Maintain lake stage within desired envelope of 12.5 and 15.5 ft. Zero weeks of extreme low (below 10 ft) or high (above 17 ft) levels. Source: RECOVER 2007a.	Precipitation and inflow amounts and to a lesser extent, salinity in SLE and Caloosahatchee estuaries. Excessive high lake stages and releases of excessive water to the coastal estuaries on a frequent basis. The Lake Okeechobee Minimum Flow and Level is the low lake stage trigger.	Open/keep closed outflow structures as needed. Adjust LORS operation protocols as needed and determine the necessary amount of additional water storage needed in the watershed to help meet the restoration target.	Build more water storage in the watershed	Not established
LO-4, LO-7	Biological Indicators (Apple Snail Density, Benthic Macroinvertebrates, Emergent Aquatic vegetation, Fish, Herpetofauna***, Periphyton***, Plankton, SAV, Snail Kites, Wading Birds).	Not established	Varies by indicator Source: RECOVER 2005d, 2007c,d,e,f	Significant reduction in relative abundances of any biological indicator	Adjust LORS operation protocols to maintain the lake in the ecologically beneficial (12.5 ft – 15.5 ft) stage envelope as often as possible and determine the necessary amount of additional water storage needed in the watershed.	Build more water storage in the watershed	Not established
LO-1, LO-5	Water quality – Inflow (**Nutrients**, DO, Chl-a, etc.) SFWMD: Inflow WQ monitoring (Bi-weekly to monthly) 50 years for restoration response. SFWMD: River channel DO concentration measurements (daily)	KRRP: 22% P load reduction (being modified) Mean, daytime DO concentrations of • 2-4 mg/l to 5–7 mg/L (near surface; dry season) • <2 mg/l to 3-6 mg/l (near surface; wet season) • > 1 mg/L for 50 % of the time (within 1 m of channel bottom) • > 2 mg/L more than 90% of the time (annually) (in river channel) Mean turbidity in the restored river channel will not differ significantly from mean turbidity in similar South Florida streams (3.9 NTU), and the median total suspended solids concentration will not exceed 3 mg/L. Source: USACE 1991 Lake O watershed Goal: 40% overall reduction in total Phosphorus Load to Lake Okeechobee Source: FDEP 2001 BMPs: P reduction of 86.6 mt/yr FRESP and other dispersed water projects: P reduction of 36.2 mt/yr	105 metric tons/year from surface inflows, with continued monitoring of inflows and rainfall. Source: RECOVER 2007b	Continued elevated nutrient and Chl-a concentrations in the lake inflow water.	Increase best management practice (BMP) implementation in the watershed.	Implement water storage projects (e.g. storage reservoirs, ASR wells) in the watershed.	Increase size and scope of watershed runoff chemical treatment (e.g. with Alum) to reduce lake inflow nutrient concentrations.

Uncertainty ID	Indicator	Threshold (Interim/Project Restoration Goal)	Full Restoration Target	Trigger(s) for Management Action	Management Action Option 1	Management Action Option 2	Management Action Option 3
		Hybrid Wetland Treatment Technology: P reduction of 4 mt/yr LO ASR (Kissimmee Pilot): P reduction of 1.3 mt/year STA in Taylor Creek/Nubbin Slough: 15.8 mt/yr Lakeside Ranch STA (Phases I and II): P reduction of 19 mt/yr Other projects: P reduction of 153.5 mt/yr LOWP: P reduction of 74.28 mt/yr Source: LOWP DRAFT PIR					
LO-1, LO-5	Water quality – Lake (**Nutrients**, DO, Chl-a, etc.) SFWMD: Pelagic WQ monitoring (monthly)	Interim Goals: • 2010: ~80 ppb TP • 2015: ~75 ppb TP Source: RECOVER 2005b Frequency of algae blooms (≥40 ppb Chl-a): • 2010: ~0.8% • 2015: ~0.2% Source: RECOVER 2005c	In-lake arithmetic average values at or below 40 ppb TP. Pelagic TN:TP long-term average mass ratio: > 22:1. Source: RECOVER 2007b Chl-a: < 5% of water samples collected with bloom concentration > 40 ppb. <50% cyanobacteria composition and a >1.5:1 diatom:cyanobacteria biovolume ratio Turbidity: Secchi disk visible on lake bottom in shoreline region from May to Sept. Source: RECOVER 2007c, RECOVER 2005c	Continued elevated nutrient and Chl-a concentrations in the nearshore and pelagic zones.	Implement water storage projects (e.g. storage reservoirs, ASR wells) in the watershed.	Chemical treatment (e.g. with Alum) of the pelagic zone sediments or removal of pelagic mud sediments when possible, to reduce lake nutrient concentrations	Not established
LO-4, LO-7	Invasive/exotic species SFWMD/USACE: Surveys of areal coverage in nearshore and littoral marsh (approx. quarterly) 50 years for restoration response.	Not established	Torpedograss/cattail: Large reductions in distributions Source: RECOVER 2007d	Large increases in invasive/exotic species coverage	Aerial or ground chemical treatment of large continuous areas	Aerial treatment with fire induction materials	Not established

3.5 Northern Estuaries

The Northern Estuaries include the following estuaries: Caloosahatchee River Estuary, St. Lucie Estuary and Southern Indian River Lagoon, Loxahatchee River Estuary, and Lake Worth Lagoon Historically, natural freshwater discharges into these water bodies sustained an appropriate range of salinity conditions, which supported healthy plant and animal communities. However, freshwater inflows to all the Northern Estuaries have been altered from the pre-development state. The particular details of landscape changes in the contributing watersheds may be different, but the major results have been fairly consistent: in general, flows are more variable and extreme, with higher high flows and lower low flows. In estuarine receiving waters, this higher variability in freshwater inflow results in a concomitant increase in salinity variability and extremes that degrade and damage existing plant and animal communities. Because the general effect of altered freshwater inflows on salinity in estuarine receiving waters is similar among the Northern Estuaries, so is the major hypothesized outcome of Comprehensive Everglades Restoration Plan (CERP) implementation. The construction and operation of CERP projects will help regulate freshwater inflows, which will in-turn provide salinity envelopes that avoid damaging high and low salinity extremes (RECOVER 2007) (See list of projects affecting the Caloosahatchee in **Table 3-4**and affecting the St. Lucie Estuary in **Table 3-5)**. The Loxahatchee River Watershed Restoration Project adaptive management plan will cover the Loxahatchee River Estuary - See more at: http://www.evergladesplan.org/pm/ssr_2014/mod_ne_2014.aspx#sthash.b3eROZSC.dpuf

Table 3-4– CERP and Non-CERP Projects Affecting the St. Lucie Estuary

Time Period	CERP/non-CERP Project/Component affecting St. Lucie/IRL	Current Schedule Timeframe (April 2014 and updated where possible)
Period 1 - 2012-2018	Lake Okeechobee Regulation Schedule (LORS)	In effect
	State of Florida Northern Everglades projects[2]	2011 – beyond 2014
Period 2 - 2019-2028	Indian River Lagoon – South (IRL-S) –C-44 Reservoir and STA	2019
	Central Everglades Planning Project	?
Period 3 - 2029-2050	Aquifer Storage and Recovery	?
	Lake Okeechobee Watershed	?
	IRL-S: C-23, C-24, C-25; Muck Removal; and Addition of Artificial Substrate	?

Table 3-5– CERP and Non-CERP Project Affecting the Caloosahatchee River Estuary

Time Period (Relative)	CERP Project/Component Affecting Caloosahatchee	Integrated Delivery Schedule (IDS) Timeframe (October 2010)
Period 1 – 2014-2018	Lake Okeechobee Regulation Schedule (LORS)	In effect
Period 2 – 2019-2028	Central Everglades Planning Project	?
	C-43 West Basin Storage Reservoir	TBD
Period 3 – 2029-2050	Lake Okeechobee and C-43 Basin Aquifer Storage and Recovery (ASR)	Beyond 2014
	Caloosahatchee Back-pumping with Storm-water Treatment	?
	Lake Okeechobee Watershed	?

[2] Non-CERP projects, e.g., state funded Northern Everglades projects, will provide synergistic benefits with CERP projects in attempting to achieve restoration goals. However, this management option matrix focuses primarily on monitoring CERP project effects.

3.5.1 Northern Estuaries Programmatic Uncertainties

ID	Uncertainties (Source)	Uncertainty Details	Relevance	Knowledge - Level of understanding	Relevance (Actionable) - Level of confidence that actions can be taken	Risk - Level of risk to meeting goals	Strategy Characterization	Category of Uncertainty (Primary/ Secondary)	Existing and Potential Recommended Strategies
NE-1	How do changes in salinity affect the reproductive success and growth of juvenile fish in the estuary?	FWRI Study (2004-2007) addressed effects of freshwater inflow and other factors on the abundance and structure of fish communities in the Caloosahatchee. When compared to the Peace and Myakka Rivers, channel communities in the Caloosahatchee appeared degraded.	Links to TS-2, 6, NE-4. It is the public perception of CERP achieving restoration.	Medium	Medium/ High	Low	3	Ecological	Conduct literature review and mesocosm studies
NE-2	Will ASR provide enough storage to protect the resources in both the dry and wet seasons?		Links to TS-1 and LO-2. Relates to achieving CERP goals and objectives.	Medium	Medium/ High	High	1	Ecological/ Hydrological	ASR Regional Study will help address what amount of ASR will be realistically available to understand potential storage and benefits to NE.
NE-3	Uncertainty exists in the ability of projects to have sufficient flexibility in design, or even adequate reservoir storage, to provide appropriate flows for the estuaries to maintain favorable salinity regimes suggested by NE indicator species.	Salinity and flow regimes have been established	Relates to achieving CERP goals and objectives.	High	Medium/ High	High	2	Policy/ Hydrological	Conduct modeling that reflects actual implementation schedules and PIR reservoir sizes and operations. Continued monitoring after constructing C-43, IRL-S will help address this.
NE-4	Can a salinity range be established that encompasses sustainability for multiple VECs, although the range may not be optimal for all?	Salinity ranges have been established.	Links to TS-2, NE-4, and LO-2. Relates to achieving Interim Goals.	High	Medium/ High	High	2	Ecological/ Hydrological	Continue monitoring after construction of C-43, IRL-S will confirm efficacy of established envelopes. 2014 SSR helped address some of those questions: SAV, Oysters. Ideal envelopes help indicate that VECs responded well

ID	Uncertainties (Source)	Uncertainty Details	Relevance	Knowledge - Level of understanding	Relevance (Actionable) - Level of confidence that actions can be taken	Risk - Level of risk to meeting goals	Strategy Characterization	Category of Uncertainty (Primary/ Secondary)	Existing and Potential Recommended Strategies
NE-5	If there is an adequate number of spawning oysters, what is the effect on recruitment patterns due to water quality (nutrients and suspended solids)?	Are the larvae killed by poor water quality (nutrients and suspended solids), or are they simply flushed downstream?	Relates to achieving Interim Goals.	Medium	Medium/ High	High	1	Ecological/ Hydrological	Development of a Particle Transport Model would help us to separate potential effects of water quality from estuarine flushing and inform oyster cultch placement. Information from mesocosm (salinity tolerance) should be incorporated. Develop first in Caloosahatchee. Mesocosm study completed and addressed questions about oyster larvae recruitment, salinity, and temperature effects.
NE-6	What is the significance of predation pressure on juvenile oysters within restored salinity regimes in the estuaries?	A method for quantifying predation needs to be developed before its significance can be determined.	Links to NE-4. Relates to development of an assessment tool (habitat suitability index) that will help to detect change and optimize prediction/assessment.	Medium	High	Medium	2	Ecological	Need to develop a good method for monitoring (quantifying) predation rates as a function of salinity and location in the estuary.
NE-7	If salinity and sediment conditions are known, can the health of the benthic infaunal community be predicted and assessed?	Need to establish whether the MAMBI index is appropriate for this application.	Relates to development of predictive and assessment tools that will help to detect change and optimize prediction/ assessment.	Medium	High	Medium	2	Ecological	Develop a macrobenthic modeling tool based on literature and existing MAP (i.e., NE Benthic Infaunal Invertebrates Hypothesis Cluster monitoring) and other monitoring data sources. Tool could help target muck removal. Highly dependent on sediment.

ID	Uncertainties (Source)	Uncertainty Details	Relevance	Knowledge - Level of understanding	Relevance (Actionable) - Level of confidence that actions can be taken	Risk - Level of risk to meeting goals	Strategy Characterization	Category of Uncertainty (Primary/ Secondary)	Existing and Potential Recommended Strategies
NE-8	What is the long-term effectiveness of CERP infrastructure projects under anticipated sea level rise?	Need to establish the effect of sea level rise on the floral and faunal communities in the Northern Estuaries.	Links to TS-6 and SCS-3. Affects the water budget, fresh groundwater supply, extents of tidal influence on floral and faunal communities in the ENP and northern estuaries.	low	Medium	medium	2	Engineering	Sea-Level Change analysis in NE estuaries.
NE-9	Once flows and salinity regimes are restored, what additional measures (e.g. hard substrate) are necessary to reestablish oysters?	Caloosahatchee lacks hard substrate in areas anticipated to be colonized. Even existing substrate is lost to sedimentation if oysters are unable to replenish substrate naturally (SLE,LWL).	Relates to achieving Interim Goals.	High	high	high	2	Ecological	Related existing monitoring includes that done as part of NE Oyster Hypothesis Cluster (see MAP and SSR). May also include further studies on sedimentation.
NE-11	What areas of the estuaries potentially provide sustainable conditions for submerged aquatic vegetation and what additional measures are required to achieve restoration once flows have been restored?	Uncertainties for freshwater species revolve around herbivory, for all SAV light availability may be an issue even under restored conditions.	Relates to achieving Interim Goals.	high	medium	high	2	Ecological	Related existing monitoring includes that done as part of NE SAV Hypothesis Cluster (see MAP and SSR).
NE-12	How effective will reservoirs and Stormwater Treatment Areas be at improving water color (i.e., reduction of dissolved organic matter) for the reestablishment of submerged aquatic vegetation beds downstream?		Relates to achieving Interim Goals.	low	low	medium	3	Ecological	Related existing monitoring includes that done as part of NE SAV Hypothesis Cluster (see MAP and SSR for all).

ID	Uncertainties (Source)	Uncertainty Details	Relevance	Knowledge - Level of understanding	Relevance (Actionable) - Level of confidence that actions can be taken	Risk - Level of risk to meeting goals	Strategy Characterization	Category of Uncertainty (Primary/ Secondary)	Existing and Potential Recommended Strategies
Uncertainties Considered but Screened Out									
NE-10	Once recommendations are made for additional measures, it is uncertain whether or not they will be implemented. For example, the addition of hard substrate in the IRL-S plan was deleted from the Chief's Report.		Can be affected by CERP management actions. Goals will not be achieved unless all management measures in the PIR are kept intact.	n/a	high	high	1	Policy	
	What is the effect of near anoxic conditions on infaunal macroinvertebrates?		Relates to sequencing of projects. For example, muck removal sequence implementation.					Ecological	
	What is the current and historical pre-canal distribution of oyster buildups in the Northern Estuaries?		Information would help set ecological attribute targets based on function (i.e. water quality improvement, reefs as habitat)					Ecological	
	What are the volumes and patterns of flow required to restore SAV, oysters, and fish communities in coastal estuaries/bays? (Notes from Southern Everglades Adaptive Management Strategy Session, 2008)		Information would help set ecological attribute targets. Also could establish targets based on function (i.e. water quality improvement, prey-base)					Ecological	

3.5.2 Northern Estuaries AM Strategies

3.5.2.1 NE-2 – ASR Meeting Storage Needs and NE-3 – Project ability to have sufficient flexibility in design, or even adequate reservoir storage, to provide appropriate flows to maintain favorable salinity regimes suggested by NE indicator species.

1. **CERP AM Uncertainty and ID#** Will ASR provide enough storage to protect the resources in both the dry and wet seasons? Uncertainty exists in the ability of projects to have sufficient flexibility in design, or even adequate reservoir storage, to provide appropriate flows for the estuaries to maintain favorable salinity regimes suggested by NE indicator species.
2. **CERP Objective or Constraint:** Reducing high volume discharges from Lake Okeechobee to the northern estuaries and supplementing dry season flows where required (e.g. Caloosahatchee).
3. **MAP that Includes:**
   a. **Region(s).** *Northern Estuaries*
   b. **Associated CERP Projects, Structures, and Operations:** *Loxahatchee River Watershed Restoration Project (LRWPR), C-43, IRL-S, ASR, all Lake Okeechobee projects, S-77, S-79, S-80 and all Lake Okeechobee operations.*
4. **What is expected to be learned by addressing this uncertainty, i.e., how will CERP benefit from addressing this uncertainty?** CERP benefits to the northern estuaries can be optimized if sufficient information is known about how much storage ASR will provide and if sufficient flexibility in design and reservoir storage is provided to maintain flows to the Northern Estuaries in order to maintain favorable salinity regimes. The salinity regimes and flow regimes have been established. The uncertainty is if the CERP projects have enough storage and design flexibility to meet those regimes. ASR and other types of storage technologies will reduce high Lake Okeechobee stages, which will reduce the frequency and intensity of high flow discharges to the estuary. In addition, ASR technology can be used to meet low flow discharge needs during the dry season and extremely dry events.
5. **Expectations or hypotheses to be tested to address the uncertainty, and attribute(s) that will be measured to test each.**
   a. **Reference Existing Scientific Documents that Outline Approach to Address Uncertainty:**
      i. **RECOVER Performance Measures –** Northern Estuaries Salinity Envelope, Northern Estuaries Oyster Habitat, Northern Estuaries Benthic Macroinvertebrates, Northern Estuaries Submerged Aquatic Vegetation, Northern Estuaries Fish Communities. Interim Goal 1.1 American Oysters in Northern Estuaries and Interim Goal 1.2 Submerged Aquatic Vegetation in Northern Estuaries.
      ii. **MAP hypotheses name and number –** Oyster Health and Abundance Hypothesis Cluster MAP 2009 Section 3.2.3.1, Submerged Aquatic Vegetation Hypothesis Cluster MAP 20009 Section 3.2.3.2, Benthic Infaunal Invertebrates Hypothesis Cluster MAP 2009 Section 3.2.3.3, Fisheries Hypothesis Cluster MAP 2009 Section 3.2.3.4.
      iii. **Models –** The ASR Regional Study has model data that can be used to understand potential storage and benefits to the Northern Estuaries. Additional modeling needs to be conducted that reflects actual implementation schedules and PIR reservoir sizes and operations

b. **Specific ecosystem stressor (s), effect(s), or attribute(s) being measured:** 1. Salinity Monitoring Network, 2. Water Quality Monitoring Network, 3. Oyster Health and Abundance Monitoring, 4. Submerged Aquatic Vegetation Monitoring, 5. Benthic Macroinvertebrate Monitoring.

c. **Time frame to begin to be able to measure change after a restoration action is taken:** This will be variable, depending on the parameter. For salinity 4 or 5 years would be necessary as this would include wet, dry and "normal" years. Given ample substrate the time frame for oysters should be similar as these populations are not limited by larval supply.

d. **When during CERP's life cycle should the AM strategy (modeling, monitoring, analysis, or test begin)?** As soon as the ASR Regional Study is complete because it will define the amount of ASR that will be realistically available to understand the potential storage capacity and the benefits to the Northern Estuaries. Scenario modeling and northern estuaries performance evaluation that reflects actual implementation schedules and PIR reservoir sizes and operations, based on current signed chief reports, Plans and Specifications, final operations plan assumptions and current schedules. Continued monitoring after constructing C-43, IRL-S will help address this.

6. **Triggers/thresholds that indicate good CERP performance or need for adaptive management action.**
TBD based on the ASR study.

3.5.2.2 NE-4 – Salinity Range to Sustain multiple Valuable Ecosystem Components

1. **CERP AM Uncertainty and ID#.** Can a salinity range be established that encompasses sustainability for multiple Valuable Ecosystem Components (VECs), although the range may not be optimal for all?
2. **CERP Objective or Constraint:** Reducing high volume discharges from Lake Okeechobee to the northern estuaries, supplementing dry season flows where required (e.g. Caloosahatchee).
3. **MAP that Includes:**
   - **a. Region(s).** *Northern Estuaries*
   - **b. Associated CERP Projects, Structures, and Operations:** LRWPR, *C-43, IRL-S, ASR, all Lake Okeechobee projects, S-77, S-79, S-80 and all Lake Okeechobee operations.*
4. **What is expected to be learned by addressing this uncertainty, i.e., how will CERP benefit from addressing this uncertainty?** CERP benefits to the northern estuaries can be optimized if a salinity range is maintained that encompasses the optimal salinity range for multiple VECs, such as oysters, SAV, benthic infauna and fish. The salinity ranges have been established. The uncertainty is if the CERP projects will be able to maintain those ranges at the correct times of year.

5. **Expectations or hypotheses to be tested to address the uncertainty, and attribute(s) that will be measured to test each.**

a. **Reference Existing Scientific Documents that Outline Approach to Address Uncertainty:**

i. **RECOVER Performance Measures –** Northern Estuaries Salinity Envelope, Northern Estuaries Oyster Habitat, Northern Estuaries Benthic Macroinvertebrates, Northern Estuaries Submerged Aquatic Vegetation, Northern Estuaries Fish Communities. Interim Goal 1.1 American Oysters in Northern Estuaries and Interim Goal 1.2 Submerged Aquatic Vegetation in Northern Estuaries.

ii. **MAP hypotheses name and number –** Oyster Health and Abundance Hypothesis Cluster MAP 2009 Section 3.2.3.1, Submerged Aquatic Vegetation Hypothesis Cluster MAP 20009 Section 3.2.3.2, Benthic Infaunal Invertebrates Hypothesis Cluster MAP 2009 Section 3.2.3.3, Fisheries Hypothesis Cluster MAP 2009 Section 3.2.3.4.

iii. **Models –** The primary VECs used as indicators of ecosystem health in the Northern estuaries are oysters and seagrass. Two approaches are being employed to determine if salinity envelopes established in these systems are protective of both VEC. The first is to analyze empirical data generated by the RECOVER MAP. The second is to use a series of linked models: 1. hydrodynamic/salinity models predict salinities in the estuaries given various combinations of CERP Projects; and 2. oyster and seagrass models that are driven by the hydrodynamic/salinity models to evaluate the potential response of the VECs..

b. **Specific ecosystem stressor (s), effect(s), or attribute(s) being measured:** 1. Salinity Monitoring Network, 2. Water Quality Monitoring Network, 3. Oyster Health and Abundance Monitoring, 4. Submerged Aquatic Vegetation Monitoring, 5. Benthic Macroinvertebrate Monitoring.

c. **Time frame to begin to be able to measure change after a restoration action is taken:** This will be variable, depending on the parameter. For salinity 4 or 5 years would be necessary as this would include wet, dry and "normal" years. Given ample substrate the time frame for oysters should be similar as these populations are not limited by larval supply.

d. **When during CERP's life cycle should the AM strategy (modeling, monitoring, analysis, or test begin)?** Now to support operations and verify initial IRL-S project implementation success. Continuation of monitoring after construction of C-43 ad IRL-S will confirm efficacy of established envelopes. Ideal envelopes help indicate that VECs responded well.

6. **Triggers/thresholds that indicate good CERP performance or need for adaptive management action.**
TBD based on the modeling.

3.5.2.3 NE-5 – Water Quality Effects on Oyster Recruitment

1. **CERP AM Uncertainty and ID#.** If there is an adequate number of adult oysters for spawning, what is the effect on recruitment patterns due to water quality?
2. **CERP Objective or Constraint:** Reducing high volume discharges from Lake Okeechobee to the northern estuaries.
3. **MAP that Includes:**
   - **a. Region(s).** *Northern Estuaries*
   - **b. Associated CERP Projects, Structures, and Operations:** LRWPR, *C-43, IRL-S, ASR, all Lake Okeechobee projects, S-77, S-79, S-80 and all Lake Okeechobee operations.*

4. **What is expected to be learned by addressing this uncertainty, i.e., how will CERP benefit from addressing this uncertainty?** Are the larvae killed by poor water quality, or are they simply flushed downstream? Mesocosm study completed and addressed questions about oyster larvae recruitment, salinity, and temperature effects. Artificial Reef installation in the St. Lucie, Loxahatchee and Caloosahatchee have demonstrated that larval supply is sufficient to support colonization.

5. **Expectations or hypotheses to be tested to address the uncertainty, and attribute(s) that will be measured to test each.** Development of a Particle Transport Model would help determine where to place oyster cultch. Information from the mesocosm (salinity tolerance) should be incorporated. Develop first in Caloosahatchee.
   a. **Reference Existing Scientific Documents that Outline Approach to Address Uncertainty:**
      i. **RECOVER Performance Measures –** Northern Estuaries Salinity Envelope, Northern Estuaries Oyster Habitat. Interim Goal 1.1 American Oysters in Northern Estuaries.
      ii. **MAP hypotheses name and number –** Oyster Health and Abundance Hypothesis Cluster MAP 2009 Section 3.2.3.1.
      iii. **Models –** Recruitment is measured on a routine monthly basis as part of the MAP. These data indicate whether larval supply is a potential problem. Artificial reefs (large and small) have been established in several systems and recruitment on to these substrates tests whether larval supply is sufficient to support colonization. The 2014 SSR helped address some of the efficacy of the salinity envelopes for oysters.
   b. **Specific ecosystem stressor (s), effect(s), or attribute(s) being measured:** 1. Salinity Monitoring Network, 2. Water Quality Monitoring Network, 3. Oyster Health and Abundance Monitoring.
   c. **Time frame to begin to be able to measure change after a restoration action is taken:** This will be variable, depending on the parameter. For salinity 4 or 5 years would be necessary as this would include wet, dry and "normal" years. Given ample substrate the time frame for oysters should be similar as these populations are not limited by larval supply.
   d. **When during CERP's life cycle should the AM strategy (modeling, monitoring, analysis, or test begin)?** Now to support operations and verify initial IRL-S project implementation success.
6. **Triggers/thresholds that indicate good CERP performance or need for adaptive management action.**
   TBD based on the modeling.

3.5.2.4 NE-6 – Predation Effects on Oyster Restoration

1. **CERP AM Uncertainty and ID#.** What is the significance of predation pressure on juvenile oysters within restored salinity regimes in the estuaries?
2. **CERP Objective or Constraint:** Reducing high volume discharges from Lake Okeechobee to the northern estuaries.
3. **MAP that Includes:**
   a. **Region(s).** *Northern Estuaries*
   b. **Associated CERP Projects, Structures, and Operations:** LRWPR (*NPBC), C-43, IRL-S, ASR, all Lake Okeechobee projects, S-77, S-79, S-80 and all Lake Okeechobee operations.*
4. **What is expected to be learned by addressing this uncertainty, i.e., how will CERP benefit from addressing this uncertainty?** Even if salinity regimes are restored, will predation pressure still be an issue and prevent the re-establishment of the oysters?
5. **Expectations or hypotheses to be tested to address the uncertainty, and attribute(s) that will be measured to test each.** A method for quantifying predation needs to be developed before its significance can be determined.

a. **Reference Existing Scientific Documents that Outline Approach to Address Uncertainty:**
   i. **RECOVER Performance Measures –** Northern Estuaries Salinity Envelope, Northern Estuaries Oyster Habitat. Interim Goal 1.1 American Oysters in Northern Estuaries.
   ii. **MAP hypotheses name and number –** Oyster Health and Abundance Hypothesis Cluster MAP 2009 Section 3.2.3.1.
   iii. **Models –** Salinity and oyster models are being evaluated to determine if they can be used to predict salinity ranges when projects are implemented. The 2014 SSR helped address some of the efficacy of the salinity envelopes for oysters.

b. **Specific ecosystem stressor (s), effect(s), or attribute(s) being measured:** 1. Salinity Monitoring Network, 2. Water Quality Monitoring Network, 3. Oyster Health and Abundance Monitoring.

c. **Time frame to begin to be able to measure change after a restoration action is taken:** Unknown, awaiting reliable measurements of predation rates.

d. **When during CERP's life cycle should the AM strategy (modeling, monitoring, analysis, or test begin)?** Now, need to develop a good method for monitoring (quantifying) predation rates as a function of salinity and location in the estuary.

6. **Triggers/thresholds that indicate good CERP performance or need for adaptive management action.**
TBD based on the monitoring predation rates.

3.5.2.5 NE-7 – Predicting Benthic Infaunal community Health

1. **CERP AM Uncertainty and ID#.** If salinity and sediment conditions are known, can the health of the benthic infaunal community be predicted and assessed?
2. **CERP Objective or Constraint:** Reducing high volume discharges from Lake Okeechobee to the northern estuaries.
3. **MAP that Includes:**
   a. Region(s). *Northern Estuaries*
   b. Associated CERP Projects, Structures, and Operations: LRWPR, *C-43, IRL-S, ASR, all Lake Okeechobee projects, S-77, S-79, S-80 and all Lake Okeechobee operations.*
4. **What is expected to be learned by addressing this uncertainty, i.e., how will CERP benefit from addressing this uncertainty?** Need to establish whether the MAMBI index is appropriate for this application. Need to develop a predictive model to assess. Tool could help target muck removal.

5. **Expectations or hypotheses to be tested to address the uncertainty, and attribute(s) that will be measured to test each.**

a. **Reference Existing Scientific Documents that Outline Approach to Address Uncertainty:**
   i. **RECOVER Performance Measures** Northern Estuaries Salinity Envelope, Northern Estuaries Benthic Macroinvertebrates.
   ii. **MAP hypotheses name and number** –Benthic Infaunal Invertebrates Hypothesis Cluster MAP 2009 Section 3.2.3.3.
   iii. **Models –** MAMBI index has been developed, but needs to be tested to see if it is appropriate to use for this purpose.

   b. **Specific ecosystem stressor (s), effect(s), or attribute(s) being measured:** 1. Salinity Monitoring Network, 2. Water Quality Monitoring Network, 3. Benthic Macroinvertebrate Monitoring.
   c. **Time frame to begin to be able to measure change after a restoration action is taken**: Requires a statistical power analysis of existing data
   d. **When during CERP's life cycle should the AM strategy (modeling, monitoring, analysis, or test begin)?** Now, Develop a macrobenthic modeling tool based on literature and existing MAP (i.e., NE Benthic Infaunal Invertebrates Hypothesis Cluster monitoring) and other monitoring data sources. Tool could help target muck removal. Highly dependent on sediment.

6. **Triggers/thresholds that indicate good CEPP performance or need for adaptive management action.**
   TBD based on the modeling results.

3.5.2.6 NE-8 – Sea-Level Rise Effects on Restoration Success

1. **CERP AM Uncertainty and ID#.** What is the long-term effectiveness of CERP infrastructure projects under anticipated sea level rise?
2. **CERP Objective or Constraint:** Reducing high volume discharges from Lake Okeechobee to the northern estuaries, supplying supplemental flow during the dry season where required.
3. **MAP that Includes:**
   a. Region(s). *Northern Estuaries*
   b. Associated CERP Projects, Structures, and Operations: LRWPR, *C-43, IRL-S, ASR, all Lake Okeechobee projects, S-77, S-79, S-80 and all Lake Okeechobee operations.*
4. **What is expected to be learned by addressing this uncertainty, i.e., how will CERP benefit from addressing this uncertainty?** Affects the water budget, fresh groundwater supply, extents of tidal influence on floral and faunal communities in the northern estuaries. Sea-level change could affect the setting of restoration targets if salinity zones/ranges shift more upstream. Sea level change analysis needs to be conducted for all the CERP projects in order to predict the effect.

5. **Expectations or hypotheses to be tested to address the uncertainty, and attribute(s) that will be measured to test each.**
   a. **Reference Existing Scientific Documents that Outline Approach to Address Uncertainty:**
      i. **RECOVER Performance Measures –** Northern Estuaries Salinity Envelope, Northern Estuaries Oyster Habitat, Northern Estuaries Benthic Macroinvertebrates, Northern Estuaries Submerged Aquatic Vegetation, Northern Estuaries Fish Communities. Interim Goal 1.1 American Oysters in Northern Estuaries and Interim Goal 1.2 Submerged Aquatic Vegetation in Northern Estuaries.
      ii. **MAP hypotheses name and number –** Oyster Health and Abundance Hypothesis Cluster MAP 2009 Section 3.2.3.1, Submerged Aquatic Vegetation Hypothesis Cluster MAP 20009 Section 3.2.3.2, Benthic Infaunal Invertebrates Hypothesis Cluster MAP 2009 Section 3.2.3.3, Fisheries Hypothesis Cluster MAP 2009 Section 3.2.3.4.
      iii. **Models –** Use a series of linked hydrodynamic/salinity models that drive ecological models of SAV and oysters to evaluate effects of CERP projects under various sea level rise scenarios. Need to incorporate the sea level rise analysis.
   b. **Specific ecosystem stressor (s), effect(s), or attribute(s) being measured:** 1. Salinity Monitoring Network, 2. Water Quality Monitoring Network, 3. Oyster Health and

Abundance Monitoring, 4. Submerged Aquatic Vegetation Monitoring, 5. Benthic Macroinvertebrate Monitoring.

c. **Time frame to begin to be able to measure change after a restoration action is taken:** Depends on realized rate of sea level rise.

d. **When during CERP's life cycle should the AM strategy (modeling, monitoring, analysis, or test begin)?** Now to include sea level rise analysis in design of the projects.

6. **Triggers/thresholds that indicate good CEPP performance or need for adaptive management action.**
TBD based on the SLR analysis.

3.5.2.7 NE-9 – Additional Restoration Measures Needed for Oyster Restoration

1. **CERP AM Uncertainty and ID#.** Once flows and salinity regimes are restored, what additional measures (e.g. hard substrate) are necessary to reestablish oysters?
2. **CERP Objective or Constraint:** Reducing high volume discharges from Lake Okeechobee to the northern estuaries.
3. **MAP that Includes:**
   - **a. Region(s).** *Northern Estuaries*
   - **b. Associated CERP Projects, Structures, and Operations: LRWPR (***NPBC), C-43, IRL-S, ASR, all Lake Okeechobee projects, S-77, S-79, S-80 and all Lake Okeechobee operations.*
4. **What is expected to be learned by addressing this uncertainty, i.e., how will CERP benefit from addressing this uncertainty?** Caloosahatchee lacks hard substrate in areas anticipated to be colonized. Even existing substrate in systems like the St. Lucie are lost to sedimentation if oysters are unable to replenish substrate naturally.

5. **Expectations or hypotheses to be tested to address the uncertainty, and attribute(s) that will be measured to test each.**

a. **Reference Existing Scientific Documents that Outline Approach to Address Uncertainty:** Charlotte Harbor NEP Oyster Restoration Plan

i. **RECOVER Performance Measures –** Northern Estuaries Salinity Envelope, Northern Estuaries Oyster Habitat. Interim Goal 1.1 American Oysters in Northern Estuaries.

ii. **MAP hypotheses name and number –** Oyster Health and Abundance Hypothesis Cluster MAP 2009 Section 3.2.3.1.

iii. **Models –** Salinity and oyster models are being evaluated to determine if they can be used to predict salinity ranges when projects are implemented. Additional modeling is needed to predict oyster establishment if muck is removed.

b. **Specific ecosystem stressor (s), effect(s), or attribute(s) being measured:** 1. Salinity Monitoring Network, 2. Water Quality Monitoring Network, 3. Oyster Health and Abundance Monitoring.

c. **Time frame to begin to be able to measure change after a restoration action is taken:** Assuming flows and salinities are favorable, artificial substrates should be colonized within months if deployed at the beginning of spawning season.

d. **When during CERP's life cycle should the AM strategy (modeling, monitoring, analysis, or test begin)?** Now to determine additional measures to include once the projects are built. Related existing monitoring includes that done as part of NE Oyster Hypothesis Cluster (see MAP and SSR).

6. **Triggers/thresholds that indicate good CEPP performance or need for adaptive management action.**
TBD based on the monitoring.

3.5.2.8 NE-11 – SAV Restoration Strategies

1. **CERP AM Uncertainty and ID#.** What areas of the estuaries potentially provide sustainable conditions for submerged aquatic vegetation and what additional measures are required to achieve restoration once flows have been restored?
2. **CERP Objective or Constraint:** Reducing high volume discharges from Lake Okeechobee to the northern estuaries, supply supplemental dry season inflows where required.
3. **MAP that Includes:**
   a. **Region(s).** *Northern Estuaries*
   b. **Associated CERP Projects, Structures, and Operations:** LRWRP, *C-43, IRL-S, ASR, all Lake Okeechobee projects, S-77, S-79, S-80 and all Lake Okeechobee operations.*
4. **What is expected to be learned by addressing this uncertainty, i.e., how will CERP benefit from addressing this uncertainty?** Uncertainties for freshwater species revolve around herbivory, for all SAV light availability may be an issue even under restored conditions.
5. **Expectations or hypotheses to be tested to address the uncertainty, and attribute(s) that will be measured to test each.**
   a. **Reference Existing Scientific Documents that Outline Approach to Address Uncertainty:**
      i. **RECOVER Performance Measures –** Northern Estuaries Salinity Envelope, Northern Estuaries Submerged Aquatic Vegetation. Interim Goal Interim Goal 1.2 Submerged Aquatic Vegetation in Northern Estuaries.
      ii. **MAP hypotheses name and number** –Submerged Aquatic Vegetation Hypothesis Cluster MAP 20009 Section 3.2.3.2.
      iii. **Models –**SAV models are being evaluated to determine what other conditions are needed for a suitable habitat. The 2014 SSR helped address some of the efficacy of the salinity envelopes for SAV. Benthic mapping was done on 2011 to map the Northern Estuaries that can be used to identify potential restoration locations.
   b. **Specific ecosystem stressor (s), effect(s), or attribute(s) being measured:** 1. Salinity Monitoring Network, 2. Water Quality Monitoring Network, 3. Submerged Aquatic Vegetation Monitoring.
   c. **Time frame to begin to be able to measure change after a restoration action is taken:** Unknown, specific restoration action needs to be determined.
   d. **When during CERP's life cycle should the AM strategy (modeling, monitoring, analysis, or test begin)?)?** Now to determine areas for potential SAV restoration. Related existing monitoring includes that done as part of NE SAV Hypothesis Cluster (see MAP and SSR). Where required, pilot field studies to determine methods for overcoming limitation of recovery by grazers.

6. **Triggers/thresholds that indicate good CEPP performance or need for adaptive management action.**
TBD based on the monitoring.

3.5.3 Northern Estuaries Management Options Matrices

3.5.3.1 St. Lucie River Estuary Management Option Matrix [3]

Uncertainty ID	Indicator	Threshold (Interim/Project Restoration Goal)	Full Restoration Target	Trigger(s) for Management Action	Management Action Option 1	Management Action Option 2	Management Action Option 3
NE-4 – Salinity and Vulnerable Ecosystem Components.	S-80 structure flows (LO discharge) and local basin flows Non-MAP: Automatic sampling at 5 inflow structures in SLE (continuous) IRL-S Project: Automatic sampling at 3 additional structures in SLE (continuous)	Maintain flows between 350 and 2000 cfs and reduce number of exceedence months: 2000 to 3000 cfs = 18; >3000 cfs = 5 in 31 years; < 350 cfs = 178[4] LORS: Projected number of exceedences of mean monthly flow over 36-year POR: 2000 to 3000 cfs = 42 ; >3000 cfs = 31; < 350 cfs = 103[5]	RECOVER Salinity PM: 31 months where mean flow is less than 350 cubic feet per second (cfs). 0 Lake Okeechobee regulatory discharge events (14 day moving averages > 2000 cfs) 28 Local basin flow > 2000 cfs (based upon 14 day moving averages > 2000 cfs) No more than 12 months of mean monthly flows greater than 2000 CFS, (based upon the assumption that flows in excess of 2000 cfs produce salinities below 3 ppt at Roosevelt Bridge.)	High flows and low flows are compared to rainfall, and expected to show changes compare to baseline in a minimum of 2 years, as well as comparable water years in the modeling period of record. If no changes are observed, then operational adjustments would be the next action. Rainfall will be measured from National Weather Service data in the basin. Existing monitoring of flow and salinity will be used with the exception of adding a salinity recorder at the Palm City Bridge. Flows are measured water control structures in the SLE (S-80, S-49, S-48, and Gordy Road). Salinity can be measured at Roosevelt (US1) Bridge (existing monitoring by SFWMD) and Palm City Bridge (needs to be added).	Verify validity of VEC salinity ranges: If correct, verify flow salinity relationships and predictions. If relationships are correct: Operations of the LO and the CEPP FEB will be optimized to meet the average volume delivery goal and where possible to get additional reduction of high-flow discharge events beyond what was estimated in the modeling, as well as minimize low flow exceedence events.	Optimize flows between IRL-South, Lake Okeechobee, and CEPP; consider increasing water storage capabilities in the next increment of CERP (see CEPP PIR section, "Future Opportunities").	
NE11: Areas of SAV Sustainability; NE12: Storage/ STAs and water color; NE-2: ASR storage and flow/ ecological benefits; NE-3: Storage needs for restoration	Estuarine water quality (physical parameters – Salinity and Turbidity primary, but also DO, conductivity, pH, temperature, TSS, color)	IRL-S Project: Salinity: See flow targets above. Roosevelt Bridge: 8-25 psu Source: SFWMD 2011 Turbidity: Long-term median of 2NTU Source: USACE and SFWMD 2004: App. A, p. A-70[6]	Salinity range - Roosevelt Bridge: 8-25 psu Source SFWMD 2015	Short-term (real time): (a) impending violation of MFL rule and salinity criteria, (b) adverse immediate impacts to biota Long-term: no significant decrease in salinity variability, (b) stabilization in desirable ranges along downstream gradient	If in water shortage management band, proceed with LORS 2008. If in normal ranges, regulate flow through S-80 to meet flow requirements to achieve salinity range and zones. Provide the results as feedback to the implementing agencies to further optimize water quality using IRL-South Stormwater Treatment Areas, water quality features and State water quality projects/BMPs	Complete construction of C-44 Basin Storage Reservoir (50,280 ace-ft of storage). Once online adjust operations per ecological protocols in Water Control Plan (this may or may not be written specifically for the needs of the SLE) once construction is complete.	NE-PES DWM solicitation program along with implementation of the Water Faming Program for additional storage at sites on cattle ranches and fallow citrus land
NE-2: Will ASR Storage and flow/ecological benefits NE-3: How much storage needed for restoration goals	Estuarine water quality (nutrient concentrations) Non-MAP: Grab samples at SFWMD fixed stations – 13 in SLE and 21 in IRL (monthly or quarterly)	IRL-S Project: SLE: 81 ppb TP; 0.72 mg/l TN Watershed outflow: 40 ppb TP Load to IRL: 90 ppb TP IRL: 53 ppb TP, 0.67 mg/l TN Do not exceed 15 µg/L chl-a in SLE Source: USACE and SFWMD 2004: App. A. p. A-29, A-70; FDEP 2008	110 metric tons/year of P 816 metric tons/year of N Median TP of 0.081 mg/l (TMDL) Median TN of 0.72 mg/l (TMDL) Secchi >0.9 PAR >-1.6 Source: RECOVER 2007b	Short-term (real time): Expected water quality improvement associated with completion of IRL South components should be predictable from existing models. Failure to detect predicted improvement after should trigger management action.	Provide the results as feedback to the implementing agencies to further optimize water quality using IRL-South Stormwater Treatment Areas, water quality features and State water quality projects/BMPs.	NE-PES DWM solicitation program along with implementation of the Water Faming Program for additional storage at sites on cattle ranches and fallow citrus land.	

[3] * and gray shading indicated monitoring is not funded by the MAP or is part of a CERP project monitoring plan
[4] Source: USACE and SFWMD 2004: App A, p. A-310, A-361
[5] Source: USACE 2007: App. E, p. E-34
[6] LORS: Projected number of months SLE Salinity criteria not met over 36-yr POR: <350 cfs = 103 14-d moving avg; >2000 cfs from local basins = 79;14-d moving avg. >2000 cfs from LOK reg. releases = 49 Source: USACE 2007: App. E p. E-98

Uncertainty ID	Indicator	Threshold (Interim/Project Restoration Goal)	Full Restoration Target	Trigger(s) for Management Action	Management Action Option 1	Management Action Option 2	Management Action Option 3
NE-2, 3 * (IRL-S Project Monitoring)	Mercury concentration in fish tissue IRL-S (Project): 20 crevalle jack and 20 gray snapper from SLE and IRL (annually)	Monitor as required by FDEP permit	No statistically significant (90-percent confidence level) increase in mercury bioaccumulation in fish tissue Source: RECOVER 2004	permit requirements for mercury not met	Provide the results as feedback to the implementing agencies to further optimize water quality using IRL-S STA, water quality features and State water quality projects/BMPs.	NE-PES DWM solicitation program along with implementation of the Water Faming Program for additional storage at sites on cattle ranches and fallow citrus land.	
NE-1, 2, 4 * (IRL-S Project monitoring)	Juvenile fish FISH HABITAT IRL-S (Project):Seine sampling at MAP SAV transects in SLE (monthly)		Maintain or enhance suitable habitat for juvenile fish (e.g. oyster bars, SAV beds, flood plain, oxbows), Source: RECOVER 2007e				
NE-7 Predicting health of benthic infaunal community. (IRL-S Project monitoring)	Sediment /Muck Removal/Remediation) Monitor TSS at structures	IRL-S Project: Decrease estuary sedimentation rates Source: USACE and SFWMD 2004: App K, p. K-56		After 5 years of monitoring TSS load does not decrease	Reevaluate Sedimentation Rate and sources of Sedimentation to determine additional options.	Institute management actions to control additional sources (BMPs, stormwater retrofits etc)	
NE-7 Predicting health of benthic infaunal community.	Benthic macroinvertebrates MAMBI Index MAP: SLE and IRL sites sampled for species richness, abundance and diversity (quarterly)		Benthic community parameters (species abundance, species richness and species diversity) AZTI's Marine Biotic Index (M-AMBI) A return to a healthy, well-balanced, and appropriately stable estuarine benthic community is targeted. Source: RECOVER 2007c	A minimum of 2 years after project completion is needed to detect progress in the MAMBI benthic community index score, after achieving the right flows and salinity. The RECOVER monitoring should be used to inform restoration progress. Incremental improvement expected as component reservoirs and STAs become operational	Evaluate benthic monitoring results as first indicator of issues with sediment. If salinity improves, but ecological restoration is hindered by undesired sediment (e.g., high organic, anoxic, high sulfide muck), then muck removal may be needed. Also evaluate sediments for potential toxicity, identify toxic agents.		
NE-11: Areas of SAV Sustainability	Aerial SAV mapping and in-water monitoring will be used to assess progress towards goals.	IRL-S (Project): 79 acres of shoal grass, 839 acres of widgeon grass, 4 acres of wild celery (within area of SLE described in PIR) Source: USACE and SFWMD 2004: App. A p. A-306	922 acres in SLE (see left for breakdown) Source: USACE and SFWMD 2004; Table 6-8, p. 6-72; RECOVER 2007d 19,799 acres in IRL-S Source:RECOVER 2007d	How do we know we are making progress, and after what set of projects would we actually expect it (LORSS, C-44, or CEPP, or others?) Mapping of SAV in St. Lucie every 2-3 years is needed to detect additional areas that may have improved seagrass coverage (*Halophila* and *Halodule* seagrass species). The quadzilla mapping technique or cheaper option should be used to quantify change in SAV acreage in areas where salinity is expected to have improved resulting in increased chance of SAV expansion.	If there is an issue with water quality: provide the results as feedback to the implementing agencies to further optimize water quality using IRL-South Stormwater Treatment Areas, water quality features and State water quality projects/BMPs.	If there is an issue with lack of seed source: Implement seagrass plantings, which may be a non-implementing agency restoration effort.	
NE-9: Once flows and salinity regimes are restored, what additional measures (e.g. hard substrate) are necessary to reestablish oysters	**Oyster habitat** MAP: Benthic mapping and substrate characterization (every 5 years) In-water monitoring used to measure progress towards goals for health (disease), density, acreage, recruitment.	Increase by 50 acres every 5 years Source: RECOVER 2005	922 acres of suitable oyster habitat Source: USACE and SFWMD 2004; Table 6-8, p. 6-72	A minimum 4 year period to compare to baseline and look for incremental progress towards CEPP performance expectation for oyster density and oyster health. RECOVER monitoring that measures recruitment, growth, predation, disease in existing locations can be used to understand how flow performance measure violations may be impacting salinity issues that affect these oyster parameters	922 acres of potential oyster substrate is found in SLE. Determine if salinity flow regime is being observed. Determine if substrate is a limitation.	Dredge muck of other areas noted on benthic map.	Add oyster cultch as appropriate to expand acreage (not included in the PIR)

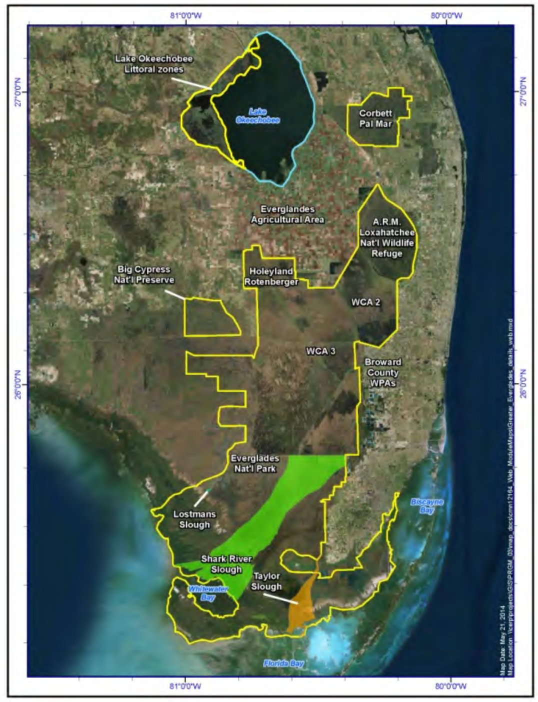
3.5.3.2 Caloosahatchee River Estuary Management Option Matrix

Uncertainty ID	Indicator	Threshold (Interim/Project Restoration Goal)	Full Restoration Target (estimated time frame)	Trigger(s) for Management Action	Management Action Option 1	Management Action Option 2	Management Action Option 3	Management Action Option 4
Immediately NE-3: How much storage needed for restoration goals NE-4: Salinity and Vulnerable Ecosystem Components.	Lake Okeechobee water releases through S-79 USACE monitoring (daily)	<u>S-79:</u> Mean monthly flow of 450 – 2800 cfs at varying percentages (74.5% of flows should be between 450 – 800 cfs)	<u>S-79:</u> Mean monthly flow of 450 – 2800 cfs at varying percentages (74.5% of flows should be between 450 – 800 cfs, 0.7 % above 2800) (Source: Appendix C, Final C-43 West Basin Storage Reservoir Project PIR (2010) West Basin Storage Reservoir should reduce flows below 450 cfs. CEPP should reduce flows above 2800 CFS at S-79	*<u>Short-term (real time - annually):</u> Not meeting mean monthly flow of 450 – 2800 OR not 74.5% of flows are between 450 – 800)* *<u>Long-term:</u> No significant increase toward achieving flow targets* *(Source: USACE and SFWMD 2010)* Particularly after CEPP and/or Reservoir become operational.	Adjust Lake Okeechobee operations according to LORS 2008 per Adaptive Protocols (2010-see Figure 6)	Adjust C-43 West Basin Storage Reservoir operations per ecological protocols in Water Control Plan (this may or may not be written specifically for the needs of the CRE) (i.e ,begin operations of C43S-9 structure for deliveries to C-43)	Optimize flows between C-43, Lake Okeechobee, the FEB complex, other projects as appropriate, and CEPP.	Implement second phase of C-43 West Basin Storage Reservoir project or ASR bands Increase water storage capability to continue to restore lower volumes of fresh water discharges to the estuaries;
Near term (2012?) NE-3 NE-4	**Salinity** <u>Non-MAP:</u> SFWMD water quality monitoring sensors (continuous) <u>MAP:</u> SAV at 4 stations* - patch-scale water quality parameters (bimonthly)	<u>Ft. Myers/Beautiful Island:</u> ≤10 ppt <u>Cape Coral Bridge:</u> <15 ppt Downstream of <u>Peppertree Pt:</u> ≥20 ppt <u>Sanibel Causeway:</u> ≥30 ppt (Source: USACE and SFWMD 2010)	<u>Ft. Myers (Yacht Basin):</u> ≤10 ppt <u>Shell Pt./San Carlos Bay:</u> 14-28 ppt (Source: Volety et al. 2009 West Basin Storage Reservoir should reduce exceedances at Ft. Myers. CEPP should reduce exceedances at Cape Coral, and Sanibel.	<u>Short-term (real time - annually):</u> Interim or or full restoration targets not met. <u>Long-term:</u> (a) no significant decrease in salinity variability, (b) stabilization in desirable ranges along downstream gradient (Source: USACE and SFWMD 2010)	If in water shortage management band, proceed with LORS 2008. If in normal ranges, operate LO operations to meet flow requirements to achieve salinity range and zones Within approved Lake O schedule and utilizing C-43 and the FEB capacities, and other projects as appropriate, examine whether adjustments can be made to improve flows.	Adjust C-43 West Basin Storage Reservoir operations per ecological protocols in Water Control Plan	Optimize flows between C-43, Lake Okeechobee, the FEB complex, other projects as appropriate, and CEPP.	Increase water storage capability to continue to restore lower volumes of fresh water discharges to the estuaries;
NE-5: Oyster Recruitment and Water Quality; NE6: Predation pressure on oysters; NE-9: measures for oysters	**Oyster habitat** <u>MAP:</u> Benthic mapping and substrate characterization (every 5 years)	Increase by 20 acres every 5 years (Source: RECOVER 2005)	400 acres of suitable oyster habitat with at least 100 acres of living oyster reefs (Source: RECOVER 2007b); 500 acres of living oyster reefs with addition of artificial substrate (Source: RECOVER 2005)	Oysters will be measured after a minimum 4 year period of flows and salinity expected performance being achieved. Results will be compared to baseline and analyzed for incremental progress towards CEPP expected performance for both indicators.	528 acres of potential oyster substrate is found in lower CRE (Redfish cove south) Determine if salinity flow regime is being observed	Is predation limiting areal extent of oysters. If yes, are salinity goals being met? If yes, add additional substrate in zones of appropriate salinity.	inadequate of oyster substrate add suitable substrate such as oyster cultch (material such as oyster shells or concrete laid down on oyster areas to provide mobile oyster spat with places to attach)	
NE-11: Sustainable conditions for SAV and what additional measures are required to achieve restoration once flows have been restored.	Percent seagrass coverage and blade length <u>MAP:</u> SAV at 4 stations - patch scale percent-cover by species and canopy height (bimonthly); Landscape-scale aerial photos and in situ	<u>Mid-San Carlos Bay:</u> >30% (1.5 m) and >20% (1.75 m) with blade length >10 cm <u>Lower Pine Island Sound:</u> >65% (1.5 m) (Source: USACE and SFWMD 2010)	<u>*V. americana* in Beautiful Island:</u> ≥20% (1.0 m) with blade length ≥10 cm <u>Iona Cove:</u> ≥30% (1.0 m) <u>San Carlos Bay:</u> ≥20% (≥1.75 m) with blade length ≥10 cm (Source: RECOVER 2007c) SAV will be measured after a minimum 4 year period of flows and salinity expected performance being achieved.	<u>Short-term:</u> Significant decrease (or threat of adverse impacts) in current monitoring measures <u>Long-term:</u> No significant increase toward achieving targets within any of the sampling locations (Source: USACE and SFWMD 2010)	If there is an issue with water quality: provide the results as feedback to the implementing agencies to further optimize water quality using water quality features and State water quality projects/BMPs.	If desired salinity range is met, change operations to adjust flows based on new hypothesis	Implement seagrass plantings in coordination with state, USDOI, and NOAA	If there is an issue with lack of SAV seed source implement seagrass plantings (may be non-implementing agency effort).

Uncertainty ID	Indicator	Threshold (Interim/Project Restoration Goal)	Full Restoration Target (estimated time frame)	Trigger(s) for Management Action	Management Action Option 1	Management Action Option 2	Management Action Option 3	Management Action Option 4
	sampling (every 5 years) C-43 Project (proposed)[7]: Continuation of aerial photos (every 2 years); Additional 2 patch scale sites (above the 7 original MAP stations);)							
NE-11: Sustainable conditions for SAV; NE12: Storage and STAs Improve Water Color.	Water quality SFWMD water quality monitoring (grab) samples MAP: SAV at 4 stations*- patch-scale water quality parameters (bimonthly)	Iona Cove: <5 µg/l San Carlos Bay: < 4 µg/l Upstream estuary: 8 µg/l 24-hour average of ≥ 5.0 mg/l and instantaneous minimum of ≥4.0 mg/l **Secchi:** Tape grass area: median = ≥1.0 m Iona Cove: median = ≥1.2 m San Carlos Bay: median = ≥1.4 m As C-43 approaches target flows, trend toward 25th and 75th percentile (> 0.6 to > 1.0 m). **ADBL:** Tape grass area: >100 uE at 1.0 m Iona Cove: = 150 uE at 1.0 m San Carlos Bay: 150 uE at 1.0 m (Source: USACE and SFWMD 2010)	Iona Cove: <5 µg/l Secchi: Tape grass area: median = > 0.7 m Peppertree Pt: median = > 0.9 m San Carlos Bay: > 1.4 m PAR: Tape grass area: median = >-2.0 Peppertree Pt: median = >-1.6 San Carlos Bay: > -1.1 (Source: RECOVER 2007d TN: 0.80-0.85 mg/l TP: 0.079 mg/L S-79 loading: 190 mt/month (< 2000 cfs) (Source: RECOVER 2007d)	Increase in chl-a, especially upstream. Increase in bloom frequencies and chl-a concentrations that negatively impacts IWR standing. (Source: USACE and SFWMD 2010) Nutrients and total suspended solids will be compared in the same 4 year period to ensure these factors did not get worse from baseline.		If salinity expectations are met with CEPP but SAV and oyster performance is not, there could be an issue with nutrients or total suspended solids preventing proliferation of these species, which would clarify needs and opportunities for future projects and thus prevent misdirection of future efforts.		

[7] Monitoring is proposed as part of a CERP project monitoring plan, but has not yet been implemented.

3.6 Greater Everglades



Approximately fifty percent of the Everglades' habitat has been lost. The remaining portion of the Greater Everglades ecosystem includes a mosaic of inter-connected freshwater wetlands and estuaries located primarily to the east and south of the Everglades Agricultural Area. This area makes up most of the Greater Everglades wetlands reported on in this System Status Report. A ridge and slough system of patterned, freshwater peatlands extends throughout Water Conservation Area (WCA) 1 (which is within the Arthur R. Marshall Loxahatchee National Wildlife Refuge), WCAs 2, 3A and 3B into Shark River Slough (SRS) within Everglades National Park (ENP). The ridge and slough wetlands drain into tidal rivers that flow through mangrove estuaries into the Gulf of Mexico. Higher elevation wetlands that flank either side of SRS are characterized by marl substrates and exposed limestone bedrock. The marl wetland areas located to the east of SRS form the drainage basin for Taylor Slough, which flows through an estuary of dwarf mangrove forests into northeastern Florida Bay. The Everglades marshes merge with the forested wetlands of Big Cypress National Preserve to the west of WCA 3 and ENP. – **Table 3-6** identifies CERP and Non-CERP projects that will affect the Greater Everglades ecosystem. See more at: http://www.evergladesplan.org/pm/ssr_2014/mod_ge_2014.aspx#sthash.iykseb3t.dpuf

Table 3-6– CERP and Non-CERP Projects that Affect Greater Everglades Ecosystem Restoration

Time Period (Relative)	CERP Project/Component Affecting Caloosahatchee	Integrated Delivery Schedule (IDS) Timeframe (October 2010)
Period 1 – 2014-2018	C-111 South Dade	In effect
	Decomp Physical Model	In effect
	C-111 Spreader Canal Western Project	In effect
	State Restoration Strategies (Central)	2019
	Tamiami Trail Next Steps	2019
	Comprehensive Operating Plan[8]	2019
Period 2 – 2019-2028	Central Everglades Planning Project	?
	State Restoration Strategies (Western and Eastern)	2025
	Broward County Water Preserve Areas	?
Period 3 – 2029-2050	L-31 N Seepage	?
	DECOMP PIR 2 and 3	?
	Lake Okeechobee Watershed	?
	Flow to Central WCA 3A and Eastern WCA	?
	Big Cypress/L-28 modifications	?

[8] For the Modified Water Deliveries to Everglades National Park and C-111 South Dade projects.

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3.6.1 Greater Everglades Uncertainties

ID	Uncertainties (Source)	Uncertainty Details	Relevance	Knowledge - Level of understanding	Relevance (Actionable) - Level of confidence that actions can be taken	Risk - Level of risk to meeting goals	Strategy Characterization	Category of Uncertainty (Primary/ Secondary)	Potential Recommended Strategies
GE-1	What is the role of flow velocities and flow volumes in maintaining ridge-and-slough patterns?	>Sediment mobilization vs. distal feedback mechanisms in maintaining ridge-and slough. Topography had changed, which effects achieving flow targets (directionality/ magnitude). How difficult will it be to move water from one area to another, example relates to moving water from EAA where subsidence has occurred into WCA3A would like require pumping to lift water out of EAA.	Links to TS-1, SCS-1 and 8. Relates to YB PMs - GE1	Medium	High	Medium to High	1	Hydrologic/ Ecological	operational experiments that create directional flow (Decomp Physical Model); Project linkage using BACI or other design possible; Ridge and Slough monitoring contracts (FIU/UF); (Decomp Physical Model), monitor sediment movement, scouring, peat accretion
GE-2	What are the restoration targets (interim/full) for wading bird populations?	>Include Roseate Spoonbill (SCS)	Relates to - YB PMs - GE 21, 22, 23. IG - System-wide Wading Bird Nesting Patterns. Current targets are 3-yr running averages. We are more confident about nesting success, but moderately confident about predicting Super colonies and location of species over time.	High	High	High	2	Ecological	The challenge is linking what is capable with modeling tools to predict foraging suitability, location, and timing, as well as potential nesting success, with prior records of wading bird numbers, patterns, that are used as an assessment target would be helpful. Predicting future populations is likely too uncertain and exercise to address. Linking Wood Stork HSI, WADEM model output (Great Egret, White Ibis, Wood Stork) with monitoring efforts to identify thresholds of expected restoration performance from initial CERP projects would be helpful. Continued use of Wading Bird monitoring data in water management operations weekly decisions and periodic scientists calls. Refer to CEPP PIR Annex D part 1 - Section D.4.2.7.
		>Nesting Success		High	High	High	2	Ecological	
		>Supercolonies (frequency?)		High	High	High	2	Ecological	
		>Location overtime		Medium	High	High	1	Ecological	

ID	Uncertainties (Source)	Uncertainty Details	Relevance	Knowledge - Level of understanding	Relevance (Actionable) - Level of confidence that actions can be taken	Risk - Level of risk to meeting goals	Strategy Characterization	Category of Uncertainty (Primary/ Secondary)	Potential Recommended Strategies
GE-3	What are the targets for fish and crayfish densities that can sustain multiple wading bird species during the nesting season?	>Trophic interactions	Relates to YB PM - GE 20, and RECOVER PM GE Aquatic Trophic Levels of Small Fish. IG - Aquatic Fauna Regional Populations in Everglades.	Medium	High	High	2	Ecological	Prey production model and monitoring wet and dry season dynamics; Need Large fish model and performance measure.
		>What should large fish population dynamics be in a restored Everglades ecosystem?	Moderate understanding, low risk and relevance to CERP objectives	Medium	Low to Medium	Low	3	Ecological	Note- existing monitoring not conducted in canals.
GE-4	How will multiple endangered species respond to restoration efforts over time, and how can adverse effects be avoided, minimized, or counteracted?	>minimize impacts to CSSS in ENP while achieving restoration goals	Relates to YB PM - GE 15 Marl Prairie CSSS Habitat? Moderate understanding, high risk and relevance to CERP.	Medium	Medium to High	Medium to High	2	Ecological/ Engineering	hydrologic modeling and monitoring, operational strategies informed by monitoring, microtopography studies, habitat monitoring (Ross and Sah- non RECOVER work) and Julie Lockwood (non-RECOVER), models to assess potential CSSS habitat expansion
		>Are CSSS populations considered fixed or will they be allowed to move?	Moderate understanding, risk and relevance.	Medium	Medium	Medium to High	2	Ecological/ Policy	USFWS Multispecies Recovery Plan Strategies- policy issue, likely not addressed by RECOVER though we can provide data for discussion. Facilitate habitat transition with restoration: woody vegetation, exotic removal, prescribed burns. Other options might include translocation of subpopulations to rebuild populations.
		>How will snail kites respond?	Moderate understanding, risk and relevance. Models have been developed and used. Need test related to ERTP implementation.	Medium?	Medium	Medium to High	2	Ecological	Snail Kite and apple snail monitoring in response to ERTP. Development of Models to support predictions associated with project implementation. Test models and link to observed monitoring to water management operations.
		>How will Roseate Spoonbills and Wood Storks respond?	Relates to - YB PMs - GE 21, 22, 23. IG - System-wide Wading Bird Nesting Patterns. Need PM targets.	Medium-High -	High	High	2	Ecological	See Wading Bird Strategy above for Uncertainty GE-2

ID	Uncertainties (Source)	Uncertainty Details	Relevance	Knowledge - Level of understanding	Relevance (Actionable) - Level of confidence that actions can be taken	Risk - Level of risk to meeting goals	Strategy Characterization	Category of Uncertainty (Primary/ Secondary)	Potential Recommended Strategies
GE-5	Are their potentially conflicting habitat requirements for multispecies and what is to be restored? How should this be addressed?	As more water moves through the system due to restoration activities, habitats will shift across the system towards a restored system. Habitats important to endangered species will shift as well, and shouldn't be viewed as static. How do we best manage additional increments of water moving through the system to allow restoration results to be achieved, while allowing endangered species to recover and transition to new areas? Specifically, how do we monitor and manage CSSS habitat transition, wood stork nesting transition, and expansion of snail kites?	Links to TS-1, TS-7, GE-1, SCS-8. All PMs	Medium	High	Medium	2	Ecological/ Policy	EDEN, modeling, species requirements- note RECOVER does not collect data on many of the species of interest (T&E, etc). Not all of the information being gathered is available. Need to first id list of species of concern so we can determine what gaps exist. (and related habitat needs). Flexibility in operations and periodic scientist calls, using real world monitoring of previous year conditions to inform future year's water management recommendations (ERTP 's MSRP). Potentially consider PMs for T&E species to help inform moving forward with restoration.
GE-6	What are areas where restoration should occur quickly (decadal) or slowly (century-millennia), and are there locations where existing conditions are	>if hydrology is restored will ecology be restored?	Moderate understanding, high relevance, low to moderate risk	Low to Medium	Medium to High	Medium	2	Hydrologic/ Ecological	DECOMP Physical Model will provide some insight but this is a different habitat than other degraded regions (WCA2, WCA3A N). ? Experimental manipulations in dense sawgrass or areas of lost topography? DECOMP PIR 1 AM plan with Hydropattern Restoration Feature.
		>Do we need to restore a peatland in order to create a patterned peatland?	Moderate uncertainty, but moderate to low risk and relevance	Low to Medium	Medium	Low	3	Ecological	DECOMP Physical model: sediment movement, peat accretion, scouring.

ID	Uncertainties (Source)	Uncertainty Details	Relevance	Knowledge - Level of understanding	Relevance (Actionable) - Level of confidence that actions can be taken	Risk - Level of risk to meeting goals	Strategy Characterization	Category of Uncertainty (Primary/ Secondary)	Potential Recommended Strategies
GE-6	deteriorating along a trajectory where places which might be restored quickly today would shift into slow restoration condition within this decade? If so, where are these locations?	>Can ridge-and-slough patterns become re-established in degraded areas by simply restoring hydrologic conditions (including sheetflow)(this needs to be defined throughout as does volume-timing, depth, duration, and velocity details and variation)?	Low understanding, high risk and relevance	Low to Medium	High	High	1	Ecological	Ridge and Slough Maintenance Monitoring, modeling, and Decomp Physical Model (DPM) tests: sediment movement, peat accretion, scouring.
		>Is the system approaching a catastrophic "tipping point" where historic function and structure will become irretrievable? Is there a deadline for implementing restoration?	Moderate understanding, mod-high relevance, and high risk	Low to Medium	Medium	low	3	Ecological	Central Everglades Planning Project and DPM. Measure peat accretion, sediment movement, scouring.
		What vegetation community changes will occur with removal of invasive cattail/willow? Can they be directed towards healthy ridge-slough?	Low understanding, low to moderate risk and relevance	Low to Medium	Medium	Medium to High	2	Ecological	Cattail Habitat Improvement Project/ Active Marsh Improvement (AMI) - WCA2A cattail loss and existing condition provide some useful info.
GE-7	How do nutrients (Water Quality) interact with hydrology (Water Quantity, Timing, and Distribution) to achieve landscape and faunal restoration goals?	How should restoration projects be designed to implement restoration features and operations that deliver increments of clean water to priority restoration areas? Relates to questions about balancing water quantity and quality goals and optimizing performance of restoration projects.	CERP Planning Goal: 1, 2. Public Objectives: 1, 2, 4, 6.	Low to Medium	Medium	High	1	Ecological	Addressing this uncertainty requires a number of individual AM strategies involving: 1) field tests – DPM, G-3273, AMI, p-cycling in ridge and slough, and additional operational tests; 2) project/ system-wide monitoring (GRTS, Vegetation Transects, Hot Spot Monitoring, Trophic Web) of restoration and operational changes both short and long-term with clear treatment and reference areas; and 3) synthesis of field test and monitoring results to inform future operational planning, permitting, and implementation of new water management criteria to achieve ecological restoration goals

ID	Uncertainties (Source)	Uncertainty Details	Relevance	Knowledge - Level of understanding	Relevance (Actionable) - Level of confidence that actions can be taken	Risk - Level of risk to meeting goals	Strategy Characterization	Category of Uncertainty (Primary/ Secondary)	Potential Recommended Strategies
GE-9	What is the effectiveness of active marsh improvement?		Relates to YB PMs GE 6 - Wetlands TP, GE 7 TP loading, GE 10 TP conc. Soil,	Low	Low to Medium	Low	3	Ecological/ Policy	CHIP, effects of burns on soil and water column P (short and long-term). Take advantage of natural patterns of ire to determine effects on soils structure. Existing soil maps, etc provide background information on soil P distribution. New soil mapping strategy to address local and landscape change issues. Need to determine frequency for landscape and timelines for projects.
		Can cattails be used to rebuild peat as a bridge to patterned peatlands? If so, under what conditions?	Relates to YB PM GE 14 Vegetation mosaics	Low	Low to Medium	Low	3	Ecological	Measure surface elevation transects in cattail and compare to sawgrass habitats. Are we talking about R&S pattern or just peat buildup? Are we talking about experimental treatments (windrows out of cattail).
GE-10	How do flow, depth, velocities, durations, species, and nutrients interact in pattern generation/ maintenance?	> could we get good sawgrass ridge/water lily sloughs with the right hydropatterns even at slightly elevated P concentrations	Relates to YB PM GE 1, sheet flow in ridge and slough, GE 2, wet prairie, GE 3 number and duration of dry events; GE 4 Inundation Patter, GE 5 - Extreme High and Low Water levels, GE 6 - wetland TP, GE 7 TP loading, GE8 TN, GE 9 - TN loads, GE 10 TP soil GE 14 Vegetation mosaics, GE Marl Prairies, GE 16 Ridge and Slough Community Sustainability; GE 18 periphyton	Medium to High	medium	High	2	Ecological/ Chemical	Create directional flows (Decomp Physical Model), monitor sediment movement, scouring, peat accretion.. CEPP in NWCA 3A (Western HRF) and Eastern HRF.
		>What is the role of intraspecific competition/allelopathy in controlling landscape pattern development/ maintenance?	Moderate to high understanding, relevance and risk.	Medium to High	Medium to High	High	2	Ecological	Non-RECOVER SFWMD projects: Cattail Habitat Improvement Project and Active Marsh Improvement. Creating "sloughs" within cattail impacted areas of the Everglades.

ID	Uncertainties (Source)	Uncertainty Details	Relevance	Knowledge - Level of understanding	Relevance (Actionable) - Level of confidence that actions can be taken	Risk - Level of risk to meeting goals	Strategy Characterization	Category of Uncertainty (Primary/ Secondary)	Potential Recommended Strategies
GE-11	How do exotic species affect restoration success and how restoration efforts are planned and implemented?	>How does the presence of exotic species (particularly Lygodium) affect restoration efforts	Links to SCS-7. moderate understanding, high relevance, moderate risk	Medium	Medium	low to Medium	3	Ecological	Tree island monitoring - non recover (I think Nungesser manages contract). Expectation for tree island community structure
		>What is the role of stochastic disturbances on exotics (e.g. hurricane events on the spread of Lygodium)?	Moderate understanding, high relevance, moderate risk	Medium	High	Medium	2	Hydrologic/ Ecological	
		>Effectiveness of biological control on exotics (e.g. Brazilian Pepper)	Moderate understanding, moderate risk and relevance. (update in 2014 SSR)	Medium	Medium	Medium	2	Ecological	Not a big issue in GE marshes, issue for tree islands and upland habitats. Wetting will remove Schinus in some habitats (see W side of the stretch where both Ardisia and Schinus disappear in wet habitat)- 2 inches downgrade from large stands.
		Will non-indigenous fish and animals species spread into new areas as a result of decompartmentalization activities?		Low to Medium	Medium	Medium	2		
		>Will DECOMP increase the spread of non-native aquatic organisms into newly connected habitats and are there any engineering features that could be included to diminish such spread? What will be impacts, if any, on ecosystem function in the recipient wetlands? How can we best document impacts, if present, and what definitions of 'impact' will we apply?	Moderate understanding, low risk and relevance, as DECOMP likely removes some conduits of exotics.	Medium	low	low	3	Engineering/ Ecological	Canal studies missing. Species life history studies to know if marsh conditions are suitable (hydroperiods may be too short). Can be coupled with existing RECOVER monitoring. Early Detection and Rapid Response Activities associated with CEPP Invasive and Nuisance Species Management Plan. Treatment could include clearing/scraping along areas where connection between areas will be made: treatment with herbicides, burning: electrofishing for fish,
		>What are the most effective strategies for the removal, degradation and stabilization of invasive vegetation (Lygodium, cattail), and are there regions of the Everglades where hydrologic restoration will enhance their expansion?	Moderate understanding, medium risk and relevance. 2014 SSR identified species that could increase due to hydrologic restoration. Napier grass and Primrose Willow were of most concern. CHIP underway.	Medium	Medium	Medium	2	Ecological	CHIP (to test tools to address cattail expansion), understand spatial distribution of elevated soil P and track cattail front (hotspot mapping) and distributed front (perhaps we need a specific study of cattails in unimpacted soils to know what is happening in more detail than long-term big maps)?

ID	Uncertainties (Source)	Uncertainty Details	Relevance	Knowledge - Level of understanding	Relevance (Actionable) - Level of confidence that actions can be taken	Risk - Level of risk to meeting goals	Strategy Characterization	Category of Uncertainty (Primary/ Secondary)	Potential Recommended Strategies
GE-12	Is complete backfilling of canals and removal of levees an ecological and hydrologic a necessity for restoration? Are partial backfilling and no backfilling of canals viable options? (Decomp Physical Model Science Plan, 2010)	Source: Decomp Physical Model Science Plan, 2010	The answer likely depends on the system and the objective. Effectiveness for various scenarios should be documented for planning assistance. Multiple GE PMs	Medium	High	High	1	Engineering/Ecological	DECOMP strategy, DPM, but no canal sampling is included for deep water effects on aquatic fauna.
GE-13	Are upward trends in alligator densities and body condition expected as a result of CERP-related projects?		YB PM - GE 24	Medium	High	High	2	Ecological	See CEPP AM Strategy,

ID	Uncertainties (Source)	Uncertainty Details	Relevance	Knowledge - Level of understanding	Relevance (Actionable) - Level of confidence that actions can be taken	Risk - Level of risk to meeting goals	Strategy Characterization	Category of Uncertainty (Primary/ Secondary)	Potential Recommended Strategies
Uncertainties considered by screened out									
	>What are realistic expectations for the restoration of former agricultural lands in terms of vegetation, nutrients, and elevation?		Policy question			Medium to High		Ecological/ Policy	Policy for now but important to understand, spatial extent, slope, land use issues for expectation and model boundary development. Removed from GE because most agricultural areas have already been dealt with from an Ag-Chemical remediation policy standpoint.
		>How effective will the continued use of BMPs be at reducing source concentrations of phosphorus	Relates to YB PMs GE 6 - Wetlands TP, GE 7 TP loading, GE 10 TP conc. Soil, and STA performance IG	High	Medium	High	2	Chemical	RECOVER does not address but this is critical. Removed from list because covered by other WQ and Quantity Questions.
GE-7	How does STA performance affect CERP restoration efforts (planning, design) and achievement of targets overtime?	>Given the range of observed STA performance, is operational flexibility a reasonably likely method for managing water insertion while limiting nutrient inflows?	Moderate uncertainty. High risk and relevance. Relates to Yellow Book - GE7 TP loading, GE 10 TP soil Conc., GE 11 - Tracer of STA Bypass of flows, IG - Increase STA Hydration, IG- Improve STA hydraulic loading,	Medium	Medium to High	Medium to High	2	Chemical/ hydrologic	CEPP FEB Strategy, State water quality strategies science plan.
		>Are eutrophic marshes (STAs) an alternative stable state for avian communities (i.e. wading birds vs. ducks)?	moderate understanding, low risk and relevance to CERP objectives	Medium	Low	Low	3	Ecological/ Chemical	While RECOVER does not collect wading bird data specifically from STAs, SFWMD and Audubon bird counts could be used to help understand what species are using STAs and population trends.

ID	Uncertainties (Source)	Uncertainty Details	Relevance	Knowledge - Level of understanding	Relevance (Actionable) - Level of confidence that actions can be taken	Risk - Level of risk to meeting goals	Strategy Characterization	Category of Uncertainty (Primary/ Secondary)	Potential Recommended Strategies
Uncertainties considered but screened out									
GE-8	What are the spatial and temporal trade-offs associated with getting the water quality right but not necessarily getting the water quantity right (and vice versa)?	>What are the relative benefits of restoring volumes of flow to overdrained areas vs. preventing nutrient loading?	Links to TS-5, SCS-4. Moderate understanding. High relevance and risk. Relates to all YB PMs GE 1-25	Medium	Medium to High	High	1	Ecological/ Policy	Existing Policy/Legal constraint, experimental protocols possible. Flume studies provide some evidence (non-drained areas). N WCA3A (existing hydroperiod distributions provide some insight, tied to loads), NWCA1 dries and gets direct flow input. (experimental strategy with DECOMP hydropattern restoration feature could be developed to address several related uncertainties)
		>What vegetation community changes will occur with removal of invasive cattail/willow? Can they be directed towards healthy ridge-slough?		Low	Medium	Medium	2	Ecological	CHIP, WCA2A cattail loss and existing condition provide some useful info.
		What are the ecological tradeoffs downstream of STA's between hard water vs. soft water inflows, and between nutrient loading and water quality?	moderate understanding, low to moderate relevance and risk	Medium	Low to Medium	low to Medium	2	Ecological/ Chemical	Determine volumes entering WCA1 and effects on stage and overall water budget. Experimental work initially conducted with periphyton communities. Further hydrologic analysis by Hagerthey. Water quality was not built into this model. We do see hardwater penetrating deeper into the refuge than P front (need to confirm).

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3.6.2 Greater Everglades AM Strategies

3.6.2.1 CERP AM Strategy GE-1, GE-6, GE-9, GE-10: Flow Velocities and Volumes to Restore Ridge and Slough Landscape Pattern

1. **CERP AM Uncertainty and ID#.** What is the role of flow velocities and flow volumes in maintaining ridge-and-slough patterns? (GE-1) What are areas where restoration should occur quickly (decadal) or slowly (century-millennia), and are there locations where existing conditions are deteriorating along a trajectory where places which might be restored quickly today would shift into slow restoration condition within this decade? If so, where are these locations? (GE-6) What is the effectiveness of active marsh improvement? (GE-9) How do flow, depth, velocities, durations, species, and nutrients interact in pattern generation/maintenance? (GE-10).

2. **CERP Objective or Constraint:** CERP Planning Goal: 1 and 2. Public Objectives:1-8.
3. **Location of Uncertainty and Ecosystem Indicator (Include Map):**
   a. **Habitat(s) and Region(s).** Greater Everglades**.**
   b. **Associated CERP Projects, Structures, and Operations:** Period 1 (2020) - Decomp Physical Model, Central Everglades Planning Project (CEPP); 2) Period 2 (2020-2030) –CEPP; Period 3 (2030-2050) rest of Decomp.
4. **What is expected to be learned by addressing this uncertainty and how will CERP benefit from addressing this uncertainty?** A better understanding is needed on how microtopography in the Greater Everglades will respond to increases in water flow across the system. The implementation of projects near term (Central Everglades Planning Project) and long-term (DECOMP part 2 and 3; flow to Central Water Conservation Area 3A) will be required to provide the necessary data. We know that flow is necessary to move floc and scour sloughs but what flow rates and volumes are required to maintain a healthy ridge and slough microtopography is unknown. Each restoration project will need to be examined and an appropriate "timing to response" will need to be determined. Some ecosystem characteristics will respond quickly, such as water quality, animal movement and reproduction, periphyton quality, etc. Some characteristics will take decades to centuries to show a measurable response such as landscape pattern restoration and the restoration of existing tree islands. In providing this information, realistic expectations can be achieved. Understand whether active marsh improvement methods (prescribed burns, herbicide, physical removal of vegetation or slough creation, Tree Island planting, etc.) work and are useful for jump starting restoration processes in degraded landscapes.
5. **Specific expectations and hypotheses to be tested to address each uncertainty, including the attribute(s).**

c. **Reference Existing Scientific Documents that Outline Approach to Address Uncertainty:**
   i. **RECOVER Performance Measures -** Slough Vegetation; Sheet flow in the Everglades Ridge and Slough Landscape (a) timing of flows, (b) distribution of flows, (c) flow continuity, and (d) flow volume; Inundation Pattern in Greater Everglades Wetlands; Wetland Landscape Patterns – Freshwater and Estuarine Vegetation Mosaics, and Ridge and Slough Community Sustainability; Extreme High and Low Water Levels in Greater Everglades Wetlands.
   ii. **MAP hypotheses name and number –** 9.2.5 Wetland Landscape and Plant Community Dynamics (RECOVER 2006): Hypothesis 1: Everglades Ridge and Slough Micro-topography in Relation to Organic Soil Accretion and Loss; Hypothesis 2: Everglades Ridge and Slough Landscape Pattern in Relation to Microtopography. Integrated Hydrology and Water Quality Hypothesis Cluster Hypothesis 1: Rainfall and Sheet Flow as Determinants of Natural System Hydrologic Characteristics in the Everglades.
   iii. **Landscape Models –** This performance measure does not attempt to predict optimal depth conditions for tree island restoration, nor is it applicable as a performance measure for lower-elevation islands. In the future, it should be possible to develop more precise tree island performance measures based on the results of ongoing research on the mechanisms of vegetation change on tree islands. At this time, this performance measure should not be used to conduct evaluations. 1.1 Predictive Metric and Target-1.1.1 Timing and distribution of flows: Natural System Model (NSM v4.62) Restore timing and distribution of flows throughout the Greater Everglades Wetlands, except in areas where deviations from NSM have been deemed to be environmentally beneficial.

d. **Specific ecosystem stressor (s), effect(s), or attribute(s) being measured:** Ridge and Slough pattern metrics, flow, particle movement.

e. **Time frame to begin to be able to measure change after a restoration action is taken:** Years to Decades

f. **When during CERP's life cycle should the AM strategy (modeling, monitoring, analysis, or test begin)?** Now to support operations and verify initial project implementation success. 1. Near-term Operational experiments are in design and/or are being conducted that create directional flow (Decomp Physical Model); Project linkage using Before and After Control Impact (BACI) or other design possible. 2. Mid-Term: Ridge and Slough monitoring contracts; projects to monitor sediment movement, scouring, peat accretion.

6. **Triggers/thresholds that indicate good CERP performance or need for adaptive management action.** Predictive metric and target are not available at this time. Development of targets based on empirical values or ranges, rather than model based targets, are needed that would support.
   a. Tree Island Species Richness: The general CERP target can be defined as the restoration of historic hydrologic patterns throughout the Everglades ridge and slough ecosystem such that vegetation communities on intact tree islands are protected and those on degraded islands are restored;

   b. Ridge and Slough Habitat Suitability: Conceptually, the general CERP target can be defined as restoration of the pre-drainage hydrologic patterns that originally maintained the Everglades ridge and slough landscape.

Referrences:

Nungesser M. (2011) Reading the landscape: temporal and spatial changes in a patterned peatland. Wetlands Ecology and Management 19(6):475-493

Wu Y, Wang N., Rutchey K. (2006) An analysis of spatial complexity of ridge and slough patterns in the Everglades ecosystem. Ecological Complexity 3(3):183-192

Yuan, J., M. J. Cohen, D. A. Kaplan, S. Acharya, L. G. Larsen, M. K. Nungesser. In review. Linking metrics of landscape pattern to hydrological process in a lotic wetland. Landscape Ecology.

3.6.2.2 CERP AM Strategy GE-2: Wading Bird Restoration Thresholds

1. **CERP AM Uncertainty and ID#.** What are the restoration targets (interim/full) for wading bird populations? GE-2
2. **CERP Objective or Constraint:** CERP Planning Goal: 1. Public Objectives: 2. and 3.
3. **MAP that Includes:**
   a. **Region(s).** Lake Okeechobee, Greater Everglades and Southern Coastal Systems
   b. **Associated CERP Projects, Structures, and Operations:** Period 1 (2020) - Modified Water Deliveries, Decomp Physical Model, C-111 South Dade/Spreader Canal, State Water Quality Strategies, Tamiami Trail Next Steps, Central Everglades Planning Project (CEPP); 2) Period 2 (2020-2030) – Broward County Water Preserve Areas, CEPP; Period 3 (2030-2050) L-31 N Seepage, rest of Decomp, Flows to Central WCA 3, Big Cypress/L-28 mods, Flows to Eastern WCAs.

4. **What is expected to be learned by addressing this uncertainty, i.e., how will CERP benefit from addressing this uncertainty?** Better understand how wading bird parameters are likely to respond not only to current operations across the system, but the implementation of projects near term and long-term. We know about long-term population numbers of wading birds from the 1930s, but are less certain about how many wading birds we will get with CERP implementation and operations. Models have been developed for habitat suitability, foraging, and in some cases nesting success based on data from 1999-2013. We also know that wading birds nested along the coast in ENP and haven't done so in large numbers since major changes to the system were implemented via the Central and Southern Project in the 1960s. In addition, one of the primary goals of CERP is to reestablish historic wading bird rookery numbers and locations. Favorable conditions for rookeries on the coast take into account salinity, water level, hydroperiod, and recession rates, all of which affect the production and availability of the birds' prey base.
5. **Expectations or hypotheses to be tested to address the uncertainty, and attribute(s) that will be measured to test each.**

Further development of wading bird modeling tools to link predictive parameters to assessment parameters will help inform operations, and both near term and long-term CERP implementation. Implement roseate spoonbill modeling combined with hydrology, water quality, SAV, and prey monitoring associated with C-111 Spreader Canal Operations and future operational changes related to Modified Water Deliveries.

a. **Reference Existing Scientific Documents that Outline Approach to Address Uncertainty:**
    i. **RECOVER Performance Measures -** GE Performance Measures Wetland Trophic Relationships - Wading Bird Foraging Patterns on Overdrained Wetlands, Wading Bird Nesting Patterns, and Roseate Spoonbill Nesting Patterns. Interim Goal 3.11 System-wide Wading Bird Nesting Patterns: Increase the total number of nesting pairs, the percentage of wading pairs nesting in estuarine locations, and the frequency of super colony evens, and establish conditions that encourage wood storks to initiate nesting earlier in the winter. Wading birds, SCS salinity, prey fish
    ii. **MAP hypotheses name and number –** Trophic Hypothesis Cluster MAP 2009 Section 3.3.8 Wading Bird Nesting in the Mainland and Coastal Everglades in Relation to the Aquatic Fauna Forage Base Hypothesis Cluster. Section 3.3.10 Ecosystem Characteristics of Everglades Coastal Wetlands in Relation to Freshwater Inflows Hypothesis Cluster salinity hypothesis cluster 3.4.5, predator-prey interactions of wading birds and aquatic fauna forage base hypothesis cluster 3.4.9, Native vegetation mosaic hypothesis cluster 3.4.10
    iii. **Wading Bird Models –** Several wading bird models are being evaluated as part of a NPS funded effort in collaboration with FAU (Summer 2014). The results of this workshop will identify which models can be used for different management purposes, including CERP RECOVER performance measures that currently lack predictive models. The results of this workshop will provide a path forward for updating the wading bird performance measures to link both modeling/evaluation to monitoring/assessment. Additional funds may be needed to run models using NSRSM to complete the wading bird PM. For example, if wading bird foraging models were run with NSRSM, a historical baseline of foraging habitat would be available, thus allowing a better understanding of the spatial configuration of foraging grounds that once supported larger populations.

b. **Specific ecosystem stressor (s), effect(s), or attribute(s) being measured:** 1. Wading Bird Foraging Distribution and Abundance, 2. Wading Bird Nesting Colony Location, Size, and Timing, 3. Wading Bird Super Colony Formation, 4. Wading Bird Nesting Success, and 5. Roseate spoonbill nesting success, breeding pair numbers and location.

c. **Time frame to begin to be able to measure change after a restoration action is taken:** 400 days

d. **When during CERP's life cycle should the AM strategy (modeling, monitoring, analysis, or test begin)?** Now to support operations and verify initial project implementation success. 1. Near-term - Roseate Spoonbills response to C-111 Spreader Canal, as well as wading bird foraging/nesting informing current operations of the C&SF water management system; 2. Mid-Term: Modified Water Deliveries project may improve wading bird foraging and nesting patterns, and CEPP is expected to improve these patterns.

6. **Triggers/thresholds that indicate good CERP performance or need for adaptive management action.** Current restoration targets for mainland nesting patterns are identified in the GE Performance Measures Wetland Trophic Relationships - Wading Bird Foraging Patterns on Overdrained Wetlands, Wading Bird Nesting Patterns, and Roseate Spoonbill Nesting Patterns. Further refinement is expected.

3.6.2.3 CERP AM Strategy GE-3: Aquatic Prey Targets to Sustain Successful Wading Bird Nesting

1. **CERP AM Uncertainty and ID #.** What are the targets for fish and crayfish that can sustain a successful wading bird nesting season?
2. **CERP Objective or Constraint:** CERP Planning Goal: 1. Public Objective: 3.
3. **MAP that Includes:**
   a. **Region(s).** Greater Everglades
   b. **Associated CERP Projects, Structures, and Operations:** Period 1 (2020) - Modified Water Deliveries, Decomp Physical Model, C-111 South Dade/Spreader Canal, State Water Quality Strategies, Tamiami Trail Next Steps, Central Everglades Planning Project (CEPP); 2) Period 2 (2020-2030) – Broward County Water Preserve Areas, CEPP; Period 3 (2030-2050) L-31 N Seepage, rest of Decomp, Flows to Central WCA 3, Big Cypress/L-28 mods, Flows to Eastern WCAs.

4. **What is expected to be learned by addressing this uncertainty, i.e., how will CERP benefit from addressing this uncertainty?** Addressing this uncertainty provides information that will enhance the ability of CERP to improve and restore the availability of critical food-webs. The collapse of wading bird nesting colonies in the southern Everglades is attributed to declines in population densities and seasonal concentrations of marsh fishes (standard length ≤ 8 cm) and other aquatic prey organisms. Restoration of natural hydrologic conditions will re-establish distributions of prey densities and concentrations across the landscape that in turn will support the return of large, successful wading bird nesting colonies to the southern Everglades. The wet season density and size structure of aquatic prey organisms are directly related to the time since the last dry-down and the length of time the marsh is dry. The concentration of aquatic prey organisms into high-density patches where wading birds can feed effectively is controlled by the rate of dry season water level recession interacting with local topography and habitat heterogeneity. Large fishes (standard length ≥ 8.0 cm) affect trophic interactions by influencing abundances of various prey species through consumption or serve as prey for larger fauna such as crocodilians.
5. **Expectations or hypotheses to be tested to address the uncertainty, and attribute(s) that will be measured to test each.** The CERP AM plan will provide a way to determine more specifically, the values of hydrological parameters (hydroperiod, depth, frequency of dry downs) that are necessary to restore and sustain a healthy prey-base throughout the Greater

Everglades, as well as inform operations to maximize prey production under the current system given real world constraints.

a. **Reference Existing Scientific Documents that Outline Approach to Address Uncertainty:**
   i. **RECOVER Performance Measures –** GE Performance Measure Wetland Tropic Relationships – Regional Populations of Fishes, Crayfish, Grass Shrimp, and Amphibians and GE Performance Measure Prey-Based Freshwater Fish Density. Interim Goal 3.9 Aquatic Fauna Regional Populations in Greater Everglades Wetlands: Increase the abundance of fish to levels that approximate those predicted for pre-drainage conditions. Largemouth Bass Performance Measure to be developed.
   ii. **MAP hypotheses name and number –** Trophic Hypothesis Cluster MAP 2009 Section 3.3.8 Wading Bird Nesting in the Mainland and Coastal Everglades in Relation to the Aquatic Fauna Forage Base Hypothesis Cluster.
b. **Models –** Small-Sized Freshwater Fish Density and Largemouth Bass Models (Trexler et al. 2003) will be used to provide input for guiding strategies and determining expectations based on expected hydrologic improvements.
c. **Specific ecosystem stressor (s), effect(s), or attribute(s) being measured**: Attributes – 1. Aquatic prey density (small fish standard length ≤ 8 cm and prey invertebrates such as grass shrimp, and crayfish) 2. Large fishes (standard length ≥ 8.0 cm)
d. **Time frame to begin to be able to measure change after a restoration action is taken:** 3-5 years
e. **When during CERP's life cycle should the AM strategy (modeling, monitoring, analysis, or test begin)?** Now to support operations and verify initial project implementation success. 1. Near-term – Aquatic prey response to C-111 Spreader Canal; 2. Mid-Term: Modified Water Deliveries project may improve aquatic prey production, and CEPP is expected to improve these patterns.

6. **Triggers/thresholds that indicate good CERP performance or need for adaptive management action.** TBD based on further refinement of assessment parameters for the GE Performance Measure - Prey-Based Freshwater Fish Density and further development of the largemouth bass performance measure.

References:

Trexler, J., Loftus, W., Tarboton, K.C. 2003. Fish habitat suitability index. In SFWMD, Habitat Suitability Indices, South Florida Water management District, West Palm Beach, Florida. Chapter 6.

3.6.2.4 CERP AM Strategy GE4-5: Achieving Restoration and Endangered Species Goals

1. **CERP AM Uncertainty and ID#.** How will multiple endangered (listed) species respond to restoration efforts over time? How can adverse effects be avoided, minimized, or counteracted, and are their potentially conflicting habitat requirements between species and restoration efforts?
2. **CERP Objective or Constraint:** PG 1, PO 3.
3. **Location of Uncertainty and Ecosystem Indicator (Include Map):**
   a. **Habitat(s) and Region(s).** Greater Everglades
   b. **Associated CERP Projects, Structures, and Operations:**

i. Period 1 (2020) - Modified Water Deliveries, Decomp Physical Model, C-111 South Dade/Spreader Canal, State Water Quality Strategies, and Tamiami Trail Next Steps, Central Everglades Planning Project (CEPP), G-3273 Relaxation;
ii. Period 2 (2020-2030) - Broward County Water Preserve Areas, CEPP;
iii. Period 3 (2030-2050) L-31 N Seepage, rest of DECOMP, Flow to Central WCA 3A, Big Cypress/L-28 modifications, Flows to Eastern WCA, CEPP.

4. **What is expected to be learned by addressing this uncertainty and how will CERP benefit from addressing this uncertainty?** Increased understanding of how the listed species, such as Cape Sable seaside sparrow (CSSS), Everglades snail kite, wood stork and other species respond to restoration efforts and evaluating whether there are conflicting habitat requirements for various species and Everglades restoration is important in achieving restoration goals. It is expected that as more water moves through the system due to restoration activities, habitats will shift across the system towards restoration targets. Habitats important to endangered species will shift as well, and shouldn't be viewed as static. How do we best manage additional increments of water moving through the system to allow restoration results to be achieved, while allowing endangered species to recover and transition to new areas? The Service has developed a Multi-Species Transition Strategy (MSTS) which addresses the habitat needs of several species within Water Conservation Area 3A (WCA 3A). This strategy describes timeframes and water levels that are needed for the various species and provides trade-offs which allow management to rely on natural conditions. The MSTS has been included as part of the Everglades Restoration Transition Project (ERTP) and is being tested at this time. As more projects come online and operational flexibility increases it will be easier to manage flows to address the MSTS targets. If the MSTS is found to be useful management in WCA 3A it can be extended to other areas within the Everglades system.
5. **Specific expectations and hypotheses to be tested to address each uncertainty, including the attribute(s).** Species surveys, vegetation monitoring and hydrologic monitoring are important in addressing the response of species to restoration efforts. Much of this monitoring is associated with the MSTS and Biological Opinions (BO) for existing restoration projects such as Everglades Restoration Transition Plan (ERTP) and C-111 Spreader Canal Western Project. The data are necessary to determine how incremental changes in hydrology affect various species. The focus is on status and trends of habitat changes related to restoration efforts. Information gathered now can be used to inform future restoration efforts. If these guidelines are achieved it is expected that species such as Cape Sable seaside sparrow, Everglades snail kite and wood stork, and their habitats will benefit from restoration efforts. It is believed that as more restoration projects come online, the ability to meet the needs of these species will improve.
6. **Triggers/thresholds that indicate good CERP performance or need for adaptive management action.** The MSTS and ERTP BO provide good descriptions of levels and triggers for the CSSS, Everglades snail kite, wood stork, and their habitats including tree islands and wet prairie vegetation. These documents provide target water levels and appropriate dates for those levels in order to achieve beneficial recession and ascension rates for species and their habitats. Examples of some of the thresholds included in these documents are:
   a. Cape Sable seaside sparrow: a minimum of 60 consecutive dry days between March 1 and July 15 within 40% of the sparrow habitat and between 90 and 210 wet days for a

discontinuous annual hydroperiod. Both of these are beneficial for the development of suitable habitat which allows the CSSS to have successful breeding.

b. Wood stork: avoid two consecutive years where water depths at the 3-gauge average in WCA-3A exceeds 16 inches in depth between March 1 and May 31. Keeping water depths below 16 inches allows for successful foraging and fledging of chicks from the nest.

c. Everglades snail kite: avoid dry season recession rates in excess of 1.7 feet between January 1 and May 31 in two consecutive years and achieve dry season high water levels less than 9.2 feet by April 15. Both of these triggers are related to maintaining proper habitat for snail kites and their prey.

d. Tree Islands: hydrologic triggers include not exceeding a wet season high water level (June 1 to December 31) of 10.5’ NGVD for more than 60 days each year. This trigger was established to avoid drowning out tree islands.

References:

U.S. Fish and Wildlife Service, 2010. Biological Opinion for the Continuation of the Interim Operational Plan and the proposed Everglades Restoration Transition Plan, Phase 1. Vero Beach, FL: http://www.evergladesplan.org/pm/pm_docs/ertp/final_dec_2011/feis/102612_ertp_feis_vol_2_dec_2011_app_f.pdf

U.S. Fish and Wildlife Service, 2011. Biological Opinion C-111 Spreader Canal Western Project Final Project Implementation Report and Environmental Impact Statement – Annex A: Fish and Wildlife Coordination Act: http://www.evergladesplan.org/pm/projects/project_docs/pdp_29_c11/pir_final/012811_c111_final_pir_vol_2_annex_a5.pdf

3.6.2.5 CERP AM Strategy GE-7: Maximize Water Quality and Quantity Goals

1. **CERP AM Uncertainty and ID#.** How do nutrients (Water Quality) interact with hydrology (Water Quantity, Timing, and Distribution) to achieve landscape and faunal restoration goals? How should restoration projects be designed to implement restoration features and operations that deliver increments of clean water to priority restoration areas? GE-7.

2. **CERP Objective or Constraint:** CERP Planning Goal: 1, 2. Public Objectives: 1, 2, 4, 6.
3. **Location of Uncertainty and Ecosystem Indicator (Include Map):**
   a. **Habitat(s) and Region(s).** Greater Everglades.
   b. **Associated CERP Projects, Structures, and Operations:** Broward County Water Preserve Areas, C-111 and Spreader Canal, Central Everglades Planning Project, Decompartmentalization of Water Conservation Area 3A parts 2 and 3, Flow to Central Water Conservation Area 3A. Non-CERP projects include State of Florida Restoration Strategies, C-111 South Dade, and Modified Water Deliveries.

4. **What is expected to be learned by addressing this uncertainty and how will CERP benefit from addressing this uncertainty?** Achievement of water quality goals through the state restoration strategies will result in increments of clean water available to deliver to the GE landscape in an effort to then meet water quantity, timing and distribution goals. Areas that have lost peat and experienced soil oxidation (Northern and Eastern Water Conservation Area 3A, WCA 3B, Northeast Shark River Slough, Taylor Slough) are priority areas for receiving new increments of clean water. Preservation of peat in these areas is dependent upon maintaining stage and preventing excess nutrients from entering the Everglades and is critical to maintaining oligotrophy. However, these areas also have altered vegetation and nutrient concentrations in the soil and may require some additional management actions to ultimately meet restoration of landscape and trophic web goals. In addition, low level legacy nutrients may remain in the system's canals and soils for sometime after restoration and their long-term effects on vegetation, landscape maintenance and restoration, and trophic effects need to be understood to manage expectations about restoration response in different areas of the GE system. This coordinated effort will help ensure increments of new clean water and management of water through the system best meeting water quality, quantity, timing, and distribution goals to achieve restoration of landscape and trophic web goals.
5. **Specific expectations and hypotheses to be tested to address each uncertainty, including the attribute(s).**
   Addressing this uncertainty requires a number of individual AM strategies involving: 1) field tests – Decomp Physical Model, G-3273, active marsh improvement, p-cycling in ridge and slough, and additional operational tests; 2) project/system-wide monitoring (GRTS, Vegetation Transects, Hot Spot Monitoring, Trophic Web) of restoration and operational changes both short and long-term with clear treatment and reference areas; and 3) synthesis of field test and monitoring results to inform future operational planning, permitting, and implementation of new water management criteria to achieve ecological restoration goals
   a. **Reference Existing Scientific Documents that Outline Approach to Address Uncertainty:**
      i. **RECOVER Performance Measures –**Total Phosphorus Concentrations in Surface Water and Soil, Total Phosphorus Loading and Flow-Weighted Mean Concentration in Inflows, Nutrient Total Nitrogen Concentrations in Surface Water; Total Nitrogen Loads/Flow-Weighted Mean Concentration in Inflows; Sulfate Concentrations in Surface Water; Surface Water Conductivity; Sheet flow in ridge and slough landscape;
      ii. **MAP hypotheses name and number –**Landscape Patterns of Ridge and Slough Peatlands and Adjacent Marl Prairies in Relation to Sheet Flow, Water Depth Patterns and Euthrophication Hypothesis Cluster; Wading Bird Nesting in the Mainland and Coastal Everglades in Relations ot the Aquatic Fauna Forage Base Hypothesis Cluster.
      iii. **Models –** The methods used to apply a model or models for evaluation application are to be determined, pending selection of model(s) to simulate Greater Everglades water quality/ecology. The Everglades Landscape Model (ELM) (Fitz et al. 2003) has recently been approved for CERP use and may be used to evaluate net P accumulation and water column concentrations. Currently, structural flows into the Greater Everglades, as predicted by the SFWMM and RSM, are used as a surrogate

for nutrient loading, and spreadsheet models using formulas developed for STA design.

b. **Specific ecosystem stressor (s), effect(s), or attribute(s) being measured:**
   i. Stressors- Water Quality in water column marsh, structure, canals; Hydrology – flow quantity, velocity, hydroperiods, water depth and duration; Fire frequency
   ii. Effects - peat accretion, loss; Soil nutrient increase/decrease; periphyton community and TP concentrations, soil porewater;
   iii. Attributes - aquatic fauna and wading birds; vegetation diversity, cattail; landscape ridge, slough, and tree island

c. **Time frame to begin to be able to measure change after a restoration action is taken:** Months (periphyton), 1-5 Years – Predator, prey, vegetation; 5-10 years,-Tree island species, ridge and slough bi modality; Decades – Ridge, Slough, Tree Island Landscape structure

d. **When during CERP's life cycle should the AM strategy (modeling, monitoring, analysis, or test begin).** Immediately to prepare for additional restoration strategy water, additional flows from C-111 SC and Tamiami Trail bridges.

6. **Triggers/thresholds that indicate good CERP performance or need for adaptive management action**.
   TBD

3.6.2.6 CERP AM Strategy GE-11: Invasive Species Affects on Restoration Success

1. **CERP AM Uncertainty and ID#.** How do exotic species affect restoration success and how restoration efforts are planned and implemented? GE-11
2. **CERP Objective or Constraint:**
3. **Location of Uncertainty and Ecosystem Indicator (Include Map):**
   a. **Habitat(s) and Region(s).** WCA 1, 2, 3, and Everglades National Park.
   b. **Associated CERP Projects, Structures, and Operations:**
4. **What is expected to be learned by addressing this uncertainty and how will CERP benefit from addressing this uncertainty?** The potential impact of invasive species in further degrading the south Florida ecosystem and impeding restoration success has emerged as a high priority for CERP and south Florida ecosystem restoration. Invasive species are both drivers and stressors of ecosystem and can alter ecosystem patterns and processes at both small and large scales and disrupt successional trajectories, as Everglades restoration proceeds. A synthesis of south Florida invasive species issues and effects on restoration efforts and specific restoration performance criteria will support efforts to develop and prioritize programmatic strategies to address the most pressing invasive species issues balanced with restoration project implementation.
5. **Specific expectations and hypotheses to be tested to address each uncertainty, including the attribute(s).** *TBD*
6. **Triggers/thresholds that indicate good CEPP performance or need for adaptive management action.** *Triggers TBD*

3.6.2.7 CERP AM Strategy GE-12: Decompartmentalization

1. **CERP AM Uncertainty and ID #.** Is complete backfilling of canals and removal of levees an ecological and hydrologic necessity for restoration? Are partial backfilling and no backfilling of canals viable options? GE-12
2. **CERP Objective or Constraint:** CERP Planning Goal: 1. Public Objectives: 1, 2, 3, and 4.
3. **MAP that Includes:**
   a. **Region(s).** Greater Everglades
   b. **Associated CERP Projects, Structures, and Operations:** Period 1 (2020) - Decomp Physical Model, Central Everglades Planning Project (CEPP); 2) Period 2 (2020-2030) –CEPP; Period 3 (2030-2050) rest of Decomp.

4. **What is expected to be learned by addressing this uncertainty, i.e., how will CERP benefit from addressing this uncertainty?** Addressing this uncertainty will provide information that will enhance the ability of CERP to produce the velocities required to shape and maintain landscape patterns. Restoration of historic patterning of the Everglades landscape is predicated, in part, on the notion that the existing canal and levee system has significantly reduced the velocity of sheet flow. While the need for levee degradation to re-establish sheet flow is well founded, there remains much uncertainty and controversy over the need to backfill canals to marsh grade (complete backfill), particularly in canals that are oriented perpendicular to the direction of flow, to minimize hydraulic short-circuiting to marsh flow. This is primarily due to the fact that it is not known if a continuous physical surface connection is an absolute necessity to restore the ecological function of the ridge and slough system or ecosystem connectivity. The ecological rationale for the complete backfilling of canals is based on the hypothesis that the transport and redistribution of materials by flow is an important driver regulating the ridge and slough landscape pattern.
5. **Expectations or hypotheses to be tested to address the uncertainty, and attribute(s) that will be measured to test each.**
   a. **Reference Existing Scientific Documents that Outline Approach to Address Uncertainty:**
      i. **RECOVER Performance Measures –** GE Performance Measure Sheetflow in Everglades Ridge and Slough Landscape
      ii. **MAP hypotheses name and number –** Trophic Hypothesis Cluster MAP 2009 Section 3.3.5 Sheet flow and Water Depth Patterns Hypothesis cluster. Section 3.3.7 Landscape Patterns of Ridge and Slough Peat lands and Adjacent Marl Prairies in Relation to Sheet Flow, Water Depth Patterns and Eutrophication Hypothesis Cluster. Interim Goal 3.2 – Sheetflow in Natural Areas: Establish more historic magnitudes and directions of sheetflow in the natural areas of the Everglades. Interim Goal 3.7 Ridge and Slough Pattern: Restore the historical ridge and slough landscape directionality and pattern.

b. **Models –** The Decomp Physical Model (Decomp Physical Model Science Plan 2009) is a large-scale experiment designated to test hypotheses about how reintroducing historic flows through the wetland and across canals affect the redistribution of sediments and suspended particles. Results from the test will inform further plan formulation efforts for CERP.
c. **Specific ecosystem stressor (s), effect(s), or attribute(s) being measured**: See Decomp Physical Model Science Plan 2009.
d. **Time frame to begin to be able to measure change after a restoration action is taken:** 2 years
e. **When during CERP's life cycle should the AM strategy (modeling, monitoring, analysis, or test begin)?** Following completion of Decomp Physical Model testing to support plan formulation for future CERP projects and/or revisions to prior recommended plans.

6. **Triggers/thresholds that indicate good CERP performance or need for adaptive management action.** TBD.

References:

Decomp Physical Model Science Plan (October 2009). Sklar, F., Hagerthey, S., Engel, V., Harvey, J., Larsen, L., Legault, K., Newman, S., Noe, G., Redwine, J., Saunders, C., and Trexler, J.

3.6.3 *CERP AM Uncertainty and ID #. Are upward trends in alligator densities and body* **condition expected as a result of CERP-related projects? GE-13**

1. **CERP Objective or Constraint:** CERP Planning Goal: 1. Public Objective: 3.
2. **MAP that Includes:**

a. **Region(s).** Greater Everglades

b. **Associated CERP Projects, Structures, and Operations:** Period 1 (2020) - Modified Water Deliveries, Decomp Physical Model, C-111 South Dade/Spreader Canal, State Water Quality Strategies, Tamiami Trail Next Steps, Central Everglades Planning Project (CEPP); 2) Period 2 (2020-2030) – Broward County Water Preserve Areas, CEPP; Period 3 (2030-2050) L-31 N Seepage, rest of Decomp, Flows to Central WCA 3, Big Cypress/L-28 mods, Flows to Eastern WCAs.

3. **What is expected to be learned by addressing this uncertainty, i.e., how will CERP benefit from addressing this uncertainty?** Addressing this uncertainty provides information that will enhance the ability of CERP to improve the density and body condition of the American alligator. The American alligator plays a key ecological role in the Everglades by improving ecological diversity and function through creation of alligator holes, trails, and nests. Density and body condition of the American alligator in remaining Everglades wetlands are currently suppressed due to altered water depth patterns, salinity distributions, and prey abundance, which have resulted from compartmentalization and sheet flow. Canals further draw alligator populations from adjacent marshes and reduce the abundance and survival of juvenile alligators due to increased predation. Restoration of sheet flow and related water depth patterns, consistent with the understanding of the pre-drainage condition, in combination with the removal of canals, will result in a widespread increase in alligator density and body condition in the Everglades. The CERP AM plan will provide a way to determine more specifically, the values of hydrological parameters (hydroperiod, depth, frequency of dry downs) that are necessary to maintain healthy alligators and alligator populations at targeted levels.

4. **Expectations or hypotheses to be tested to address the uncertainty, and attribute(s) that will be measured to test each.**
   a. **Reference Existing Scientific Documents that Outline Approach to Address Uncertainty:**
      i. **RECOVER Performance Measures –** GE Performance Measure Wetland Tropic Relationships – American Alligator Abundance, Body Condition, Hole Occupancy, and Production Suitability Index. Interim Goal 3.10 American Alligator: Restore more natural numbers and distribution patterns for alligators across South Florida's major freshwater and estuarine landscapes.
      ii. **MAP hypotheses name and number –** Trophic Hypothesis Cluster MAP 2009 Section 3.3.9 American Alligator Density and Body Condition in Relation to the Hydrologic Patterns and Artificial Canal Habitats in the Everglades Hypothesis Cluster.
   b. **Models –** The Alligator Production Suitability Index Model (Shinde et al. 2013) will be used to provide input for guiding strategies and determining expectations based on expected hydrologic improvements.

c. **Specific ecosystem stressor (s), effect(s), or attribute(s) being measured**: Attributes – 1. Alligator Body Condition 2. Alligator Relative Density.
d. **Time frame to begin to be able to measure change after a restoration action is taken:** 4-6 years
e. **When during CERP's life cycle should the AM strategy (modeling, monitoring, analysis, or test begin)?** Now to support operations and verify initial project implementation success. 1. Near-term – Alligator body condition and relative density response to C-111 Spreader Canal; 2. Mid-Term: Modified Water Deliveries project may improve alligator body condition and relative density, and CEPP is expected to improve these patterns.

5. **Triggers/thresholds that indicate good CERP performance or need for adaptive management action.** Assessment parameters for alligators are relative abundance (based on encounter rate), body condition, and alligator hole occupancy (Mazzotti et al. 2009). Also see GE Performance Measure Wetland Tropic Relationships – American alligator Abundance, Body Condition, Hole Occupancy, and Production Suitability Index. Results will be reported in the context of what is expected given the improvements to hydrology (estimated using the Alligator Production Suitability Index Model (Shinde et al. 2013)) and in comparison to established targets (Mazzotti et. al. 2009).

References:

Mazzotti, F.J., G.R. Best, L.A. Brandt, M.S. Cherkiss, B.M. Jeffery and K.G. Rice. 2009. Alligators and crocodiles as indicators for restoration of Everglades ecosystems. Ecological Indicators 9S, Indicators for Everglades Restoration, Pp. S137-S149.

Shinde, D., L. Pearlstine, L. A. Brandt, F. J. Mazzotti, M. Parry, B. Jeffery and A. LoGalbo. 2013. Alligator Production Suitability Index Model (GATOR-PSIM v. 2.0). Ecological and Design Documentation. http://www.cloudacus.com/simglades/alligator.php

3.6.4 Greater Everglades Management Options Matrices

Uncertainty ID	Indicator	Threshold (*Incremental Project/ Incremental Goal Performance)*	Full Restoration Target	Trigger(s) for Management Action	Management Action Options 1	Management Action Options 2	Management Action Options 3
GE-1, GE-6, GE-9, GE-10 Combined GE-1: Flow velocities, volumes, and stages Landscape; GE-6: Restoration trajectories locations; GE-9: active marsh improvement; GE-10: pattern maintenance	Ridge:Slough area approximately 50:50 Increase in vertical differences between slough bottom, ridge top and tree island top. Healthy sawgrass monoculture on ridges, healthy/diverse tree stand and understory on tree islands.	Increase in slough area within WCA-3AN and WCA-3B.	Ridge: Slough area approximately 50:50 Ridge elevation at about 0.5 m above slough bottom Tree Island elevation at least 1.0 m above slough bottom	Increase in ridge area Degradation of ridge sawgrass, invasion by shrub species (willow) Degradation of tree island vegetation (loss of species and species diversity) Filling of sloughs-increase in emergent plants, loss of floating leaf plants.	Adjustments to current C&SF water management operations Implement Period 1 CERP and Non-CERP Projects (2020) Modified Water Deliveries, Decomp Physical Model, C-111 South Dade/Spreader Canal, State Water Quality Strategies, Tamiami Trail Next Steps, Central Everglades Planning Project (CEPP)Maintain appropriate stages Maintain flow velocity and directionality	Adjustments to current C&SF water management operations Implement Period 2 CERP Projects (2020-2030) – Broward County Water Preserve Areas, CEPP. Increase flow velocities	Adjustments to current C&SF water management operations Implement Period 3 CERP (2030-2050) L-31 N Seepage, rest of Decomp, Flows to Central WCA 3, Big Cypress/L-28 mods, Flows to Eastern WCAs. Tree planting on degraded tree islands
GE-2 *What are the restoration targets (interim/full) for* wading *bird populations?*	Wading bird foraging distribution Wading bird nesting locations Wading bird nesting success Super colony formation	Threshold TBD. Observance of foraging distributions and nesting patterns consistent with expectations for pre-drainage distributions. Observable shift of nesting to southern Everglades. Observed shifts in the timing of nesting November/December	Increase and maintain total number of pairs of nesting birds in mainland colonies to minima of 4,000 pairs of Great Egrets, 10,000 to 20,000 combined pairs of Snowy Egrets and Tricolored Herons, 10,000 to 25,000 pairs of White Ibis, and 1,500 to 2,500/3,000 pairs of Wood Storks* Shift timing of nesting (Wood storks to initiate nesting no later than January in most years (as early as December in some years), and for ibis, egrets, and herons to initiate nesting in February-March in most years) * Return of major Wood Stork, Great Egret, and ibis/small egrets and herons nesting colonies from the Everglades to coastal areas and headwaters of mangrove estuary of Florida Bay and Gulf of Mexico* *Current restoration targets for mainland nesting patterns are identified in the GE Performance Measures Wetland Tropic Relationships –Wading Bird Foraging Patterns on Overdrained Wetlands, Wading Bird Nesting Patterns, and Roseatte Spoonbill Nesting Patterns. Further refinements to these PMs are expected within near future.	Observance of decrease in aquatic prey fauna densities. Observance of decrease or unstable trends in wading bird foraging distribution, nesting locations and/or nesting success.	Adjustments to current C&SF water management operations Implement Period 1 CERP and Non-CERP Projects (2020) Modified Water Deliveries, Decomp Physical Model, C-111 South Dade/Spreader Canal, State Water Quality Strategies, Tamiami Trail Next Steps, Central Everglades Planning Project (CEPP)	Adjustments to current C&SF water management operations Implement Period 2 CERP Projects (2020-2030) – Broward County Water Preserve Areas, CEPP	Adjustments to current C&SF water management operations Implement Period 3 CERP (2030-2050) L-31 N Seepage, rest of Decomp, Flows to Central WCA 3, Big Cypress/L-28 mods, Flows to Eastern WCAs.)

Uncertainty ID	Indicator	Threshold (*Incremental Project/ Incremental Goal Performance)*	Full Restoration Target	Trigger(s) for Management Action	Management Action Options 1	Management Action Options 2	Management Action Options 3
GE-3 Prey Targets for wading birds	Aquatic prey density (small fish standard length ≤ 8 cm and prey invertebrates such as grass shrimp, and crayfish) Large fishes (standard length ≥ 8.0 cm)	Threshold TBD. Observance of increases of aquatic prey fauna prey base following improvements in observed hydroperiods.	Maximize densities of small-sized freshwater fish densities. * Target for large fishes TBD. *See GE PM Wetland Prey Based Freshwater Fish Density – Greater Everglades Aquatic Trophic Hypothesis. Full restoration targets TBD based on further refinement of PM.	Observance of decrease in aquatic prey fauna densities in the context of what is expected given improvements to hydrology.	Adjustments to current C&SF water management operations Implement Period 1 CERP and Non-CERP Projects (2020) Modified Water Deliveries, Decomp Physical Model, C-111 South Dade/Spreader Canal, State Water Quality Strategies, Tamiami Trail Next Steps, Central Everglades Planning Project (CEPP)	Adjustments to current C&SF water management operations Implement Period 2 CERP Projects (2020-2030) – Broward County Water Preserve Areas, CEPP	Adjustments to current C&SF water management operations Implement Period 3 CERP (2030-2050) L-31 N Seepage, rest of Decomp, Flows to Central WCA 3, Big Cypress/L-28 modificationss, Flows to Eastern WCAs.)
GE-4 , GE-5 Combined GE 4: How will multiple endangered (listed) species respond to restoration efforts over time? How can adverse effects be avoided, minimized, or counteracted, and are their potentially conflicting habitat requirements between species and restoration efforts?	CSSS, Everglades snail kite, wood stork abundance, distribution, and nesting patterns.	Avoid decreases in population numbers Achieve 60+ consecutive dry days or 90-210 wet days during 8 out of 10 years Achieve appropriate water depths at the 3-gauge average in WCA 3A in 8 out of 10 years Achieve appropriate recession/ascension rates for Everglades snail kites in 8 out of 10 years See Multi-Species Transition Strategy (MSTS), ERTP and CEPP Biological Opinions for descriptions of levels and triggers for the CSSS, Everglades snail kite, wood stork, and their habitats including tree islands and wet prairie vegetation. These documents provide target water levels and appropriate dates for those levels in order to achieve beneficial recession and ascension rates for species and their habitats.	Achieve sustainable and increasing populations for CSSS, Everglades snail kite and wood stork, as well as other indicator species within the system. Cape Sable seaside sparrow: a provide at least 100 consecutive dry days between March 1 and July 15 within 100% of the sparrow habitat and between 90 and 210 wet days for a discontinuous annual hydroperiod. Both of these are beneficial for the development of suitable habitat which allows the CSSS to have successful breeding. Wood stork: avoid years where water depths at the 3-gauge average in WCA-3A exceeds 16 inches in depth between March 1 and May 31. Keeping water depths below 16 inches allows for successful foraging and fledging of chicks from the nest. Everglades snail kite: avoid dry season recession rates in excess of 1.7 feet between January 1 and May 31 in any years and achieve dry season high water levels less than 9.2 feet by April 15. Both of these triggers are related to improving proper habitat for snail kites and their prey.* Tree Islands: hydrologic triggers include not exceeding a wet season high water level (June 1 to December 31) of 10.5’ NGVD for more than 30 days each year. This trigger was established to avoid drowning out tree islands.	Observed decreases in population estimates for select species Failure to meet identified triggers/thresholds as outlined in current USFWS MSTS and project BOs.	Caveat: No management action option is being proposed for the Programmatic CERP AM Update. RECOVER MAP monitoring may be used to develop and/or refine risk assessment tools to direct species management decisions. Listed species management is required by the project BOs for each monitoring plan developed for projects of the CERP. Typical actions include utilization of operations flexibility, monitoring, periodic science calls, and habitat restoration. Potential tie-backs to CERP projects may include optimizing design features of CERP Projects to potentially increase habitat quality, breeding success and foraging potential.		

Uncertainty ID	Indicator	Threshold (*Incremental Project/ Incremental Goal Performance)*	Full Restoration Target	Trigger(s) for Management Action	Management Action Options 1	Management Action Options 2	Management Action Options 3
GE-7 Maximizing Water Quality and Quantity Goals	Water quality (Water Column and Marsh) Hydrology (flow, velocity, hydroperiods, water depth and duration, fire frequency) Expansion of cattail areas within the marsh	Threshold TBD. Observed decrease in expansion or rate of expansion of cattail areas within the marsh as projects are implemented.	Returning Everglades to historic vegetation communities	Observed increase in expansion or rate of expansion of cattail areas within the marsh as projects are implemented. Observed increase in soil concentrations of TP > 500 mg/KG (Impacted Soils/Peat) Increases above 10 to 12 ppb TP within the water column.	Adjustments to current C&SF water management operations Optimization of design features of CERP Projects Active marsh improvement (removal of cattail) during prior to project implementation/ construction.	Adjustments to current C&SF water management operations Optimization of design features of CERP Projects Active marsh improvement (removal of cattail) during prior to project implementation/ construction.	
GE-11 Exotics species effects on restoration	Distribution and abundance of invasive species	Threshold TBD Observed decrease in abundance and distribution of invasive species relative to base conditions prior to implementation of CERP project	Restoration of pre-drainage conditions or complete removal of invasive species is impractical. Target should be restoration of ecological structure and function of ridge and slough landscape.	Observed increase in abundance and distribution of invasive species relative to base conditions	Caveat: No management action option is being proposed for the Programmatic CERP AM Update. RECOVER MAP monitoring may be used to develop and/or refine risk assessment tools to direct species management decisions. Invasive species management is required to be included in each monitoring plan developed for projects of the CERP. Typical actions include utilization of biological, physical, mechanical, and chemical control methods to manage invasive species, use of construction methods that minimize ground disturbance, and vehicle and equipment decontamination protocols. Potential tie-backs to CERP projects may include optimizing design features of CERP Projects to potentially decrease establishment and spread of invasive species (*i.e.* removal of levees without backfilling canals may continue to provide warm water refugia for invasive fish species as well as continue to provide conveyance routes to the open marsh).		
GE-12 Best Canal Design to Meet Sheetflow Restoration Goals	Flow velocities* Particle transport* Periphyton composition* Small-sized freshwater fish density* Vegetation* *See Decomp Physical Model Science Plan for indicators being measured	Threshold TBD	Threshold TBD	Threshold TBD	Implement Period 1 CERP Projects (2020) Decomp Physical Model	Implement Period 2 CERP Projects (2020-2030) – CEPP	
GE-13 *Are upward trends in alligator densities and body condition expected as a result of CERP-related projects?*	Alligator relative abundance Alligator body condition Alligator hole occupancy	Threshold TBD Desired restoration condition with more natural patterns of hydrology, alligators will repopulate and resume nesting in areas where hydrology is restored including northwestern WCA 3A, the Rocky Glades, and the freshwater reaches of tidal rivers in the mangrove estuaries, and will increase in relative abundance, and body condition throughout most of the GE wetlands.	Relative abundance target is to meet or exceed 1.70 alligators/km and/or have a stable (if abundance exceeds 1.70 alligators/km) or increasing trend* Body condition target is to meet or exceed Fulton's K value (calculated using snout-vent length and mass) of 2.27 and have a stable or increasing trend* Alligator hole occupancy target is > 70% occupancy of holes with stable or increasing trend* *See GE PM Wetland Trophic Relationships – American Alligator Abundance, Body Condition, Hole Occupancy and Production Suitability Index	Decrease or unstable trend in relative alligator abundance, body condition, and/or hole occupancy in the context of what is expected given improvements to hydrology (estimated using the Alligator Production Suitability Index Model (Shinde et al. 2013)) and in comparison to established targets (Mazzotti et. al. 2009).	Adjustments to current C&SF water management operations Implement Period 1 CERP and Non-CERP Projects (2020) Modified Water Deliveries, Decomp Physical Model, C-111 South Dade/Spreader Canal, State Water Quality Strategies, Tamiami Trail Next Steps, Central Everglades Planning Project (CEPP)	Adjustments to current C&SF water management operations Implement Period 2 CERP Projects (2020-2030) – Broward County Water Preserve Areas, CEPP	

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3.7 Southern Coastal Systems

The Southern Coastal System (SCS) region encompasses a large ecologically and economically important area that includes Biscayne Bay; Florida Bay and the Lower Southwest Coast; and the Upper Southwest Coast and Ten Thousand Islands coastal environments. This report is organized by each of these three subregions, which are distinguished by regional hydrology and monitoring program design. Over the past century, water management practices and agriculture/urban development have disrupted the availability, timing, and distribution of fresh water to the SCS, which has significantly altered the structure and function of the regional ecosystem. A primary goal of the Comprehensive Everglades Restoration Plan (CERP) for the SCS is to restore and sustain the highly productive estuaries and adjacent coastal wetlands of the SCS via the restoration of freshwater flows to the extent practical. Reestablishing more natural flows will restore estuarine salinity conditions, resulting in improved habitat for fish and wildlife resources. – **Table 3-7**and **Table 3-8** identify CERP and Non-CERP projects that currently are or will affect Southern Coastal System restoration indicators. See more at: http://www.evergladesplan.org/pm/ssr_2014/mod_scs_2014.aspx#sthash.ZX6sLSMj.dpuf.

Table 3-7– CERP and Non-CERP Projects Affecting Florida Bay

Time Period (Relative)	CERP Project/Component Affecting Florida Bay	Project Schedules (April 2014)
Period 1 – 2014-2018	C-111 Spreader Canal Western Project	In effect
	Biscayne Bay Coastal Wetlands (Portions)	In effect
	Modified Water Deliveries	2017
Period 2 – 2019-2028	Central Everglades Planning Project	TBD
	Tamiami Trail Next Steps	TBD
	Biscayne Bay Coastal Wetlands (PIR 1 rest of components)	TBD
Period 3 – 2029-2050	Decompartmentalization PIRs 2 and 3	TBD
	C-111 Spreader Canal Eastern PIR	TBD
	Biscayne Coastal Wetlands PIR 2	TBD
	L-31 Seepage Management	TBD
	Flow to Central WCA 3A	TBD
	Flows to Eastern WCA	TBD
	Big Cypress L-28 modifications	TBD

Table 3-8– CERP and Non-CERP Projects Affecting Biscayne Bay

Time Period (Relative)	CERP Project/Component Affecting Biscayne Bay	Project Schedules (April 2014)
Period 1 – 2014-2018	C-111 Spreader Canal Western Project	In effect
	Biscayne Bay Coastal Wetlands (Portions)	In effect
	Modified Water Deliveries	2017
Period 2 – 2019-2028	Central Everglades Planning Project	TBD
	Tamiami Trail Next Steps	TBD
	Biscayne Bay Coastal Wetlands (PIR 1 rest of components)	TBD
Period 3 – 2029-2050	Decompartmentalization PIRs 2 and 3	TBD
	C-111 Spreader Canal Eastern PIR	TBD
	Biscayne Coastal Wetlands PIR 2	TBD
	L-31 Seepage Management	TBD
	Flow to Central WCA 3A	TBD
	Flows to Eastern WCA	TBD

3.7.1 Southern Coastal Systems Uncertainties

ID	Uncertainties (Source)	Uncertainty Details	Relevance	Knowledge - Level of understanding	Relevance (Actionable) - Level of confidence that actions can be taken	Risk - Level of risk to meeting goals	Strategy Characte rization	Category of Uncertainty (Primary/ Secondary)	Existing and Potential Recommended Strategies
SCS-3	What are the volumes and patterns of flow required to restore Submerged Aquatic Vegetation (SAV), oysters, and fish communities in coastal estuaries/bays? (Notes from Southern Everglades Adaptive Management Strategy Session, 2008)	What are the responses of SAV and fish communities that would result in restoration?	Information would help set ecological attribute targets. Also could establish targets based on function (i.e. water quality improvement, prey-base)	Medium	High	High	1	Ecological	Continued research and monitoring to determine the freshwater needs. Finalize performance measures and setting of targets (for freshwater flows).
SCS-4	How can we reasonably and accurately quantify the volume of water required for restoration of Biscayne Bay (BB), Florida Bay (FB) and the SW Coast acknowledging real-world constraints?	Reliable models currently do not exist. However, even if reliable models were available, conflicts between what models may predict as needed for restoration and constraints on water volume dictated by political / and policy issues need to be resolved	These issues must be resolved before a clear picture of what is possible can be used to guide restoration implementation.	Medium	high	Medium	2	Ecological/ policy	Political and policy constraints need to be resolved.
SCS-5	To what degree will sea level rise affect restoration efforts? Based upon how Sea-Level Rise (SLR) will affect restoration efforts, what spatially sustainable areas should restoration afford a priority focus and how is that priority determined?	Affects the water budget, fresh groundwater supply, extents of tidal influence on floral and faunal communities in the ENP and northern estuaries.	Programmatic uncertainties that has implications for all projects	Low	High	High	1	Ecological/ Policy	Continue ongoing SLR research (i.e., Climate Change Technical Reports, other SLR research in south Florida).
SCS-6	How will SLR affect coastal soils?	Will there be a smooth transition between brackish, oligohaline, to mangrove communities? To what extent are coastal wetlands vulnerable via peat collapse?	SLR could counteract restoration progress and potentially increase salinity in soils. (we can take actions, just not sure if those actions would work)	Medium/ Low	High	High	1	Ecological/ Policy/ Hydrology	Continue ongoing SLR research (i.e., Climate Change Technical Reports, other SLR research in south Florida) with focus on SLR effects to soil
SCS-10	What is the effect of exotics on the southern coastal systems? How will the spread and costs associated with the control, and success of the control of Exotic Species impact restoration?	How effective will exotics control actually be within the system? How do we control them?	Links to GE-11: spread of exotics could significantly impair the extent of restoration	medium	medium	undefined	2	Ecological	Ensure that adverse impacts from exotic invasion are adequately controlled. Relates to ongoing exotic/invasive species monitoring and control efforts.

ID	Uncertainties (Source)	Uncertainty Details	Relevance	Knowledge - Level of understanding	Relevance (Actionable) - Level of confidence that actions can be taken	Risk - Level of risk to meeting goals	Strategy Characterization	Category of Uncertainty (Primary/ Secondary)	Existing and Potential Recommended Strategies
SCS-11	How will Threatened & Endangered species issues vs. hydrologic restoration requirements be resolved within the confines of existing Federal laws?	Currently some T&E species are a constraint on hydrologic restoration needs to the system.	Links to GE- 4 and 5. constraints due to federal laws has potential to affect restoration outcomes	High	High	High	2	Ecological/ Policy	Political and policy constraints need to be resolved.
SCS-12	What controls the input and methylation rates that affect accumulation rates by coastal fauna?	How methylmercury bioaccumulation is influenced by watershed management, particularly with regard to methylation in upstream wetlands, sulfate inputs to these areas, and transport to the coast.	Methylmercury affects achievement of predator-prey ecosystem function.	Med	Low	High	2	Chemical/ Ecological	We need to understand what is being done and what still needs to be done, who should do it and where RECOVER Science efforts might fit in vs. where the South Florida Ecosystem Restoration Task Force Science efforts fit in.
SCS-14	Other human activities - how will further development on the coast, e.g. power plants effect coastal salinity and restoration efforts?	For example, how will Turkey point upgrade and potential unit 6&7 construction affect Biscayne Bay.	Any project affecting the CERP footprint could counteract restoration benefits	Medium/Low	Medium	Medium	2	Policy	Need to be diligent about how large scale projects affect CERP benefits. Coordinate with those parties as deemed appropriate to minimize benefit loss.
Uncertainties considered but screened out									
	What are the flooding effects associated with various C-111 spreader canal discharge rates?							Engineering	
	What is the current and historical pre-canal distribution of oyster buildups in the Southern Estuaries? (BBCW AM Plan, 2010)		Information would help set ecological attribute targets. Establish targets based on function (i.e. water quality improved, reefs as habitat)					Ecological	
	Will achieving salinity targets in the tidal wetlands ensure an increase in crocodile populations? What are target population metrics? (BBCW AM Plan, 2010)		Information would help set ecological attribute targets					Ecological	
	How much groundwater can be conserved in the freshwater Glades through seepage management before flows to estuaries are detrimentally reduced?							Ecological/ Engineering	

ID	Uncertainties (Source)	Uncertainty Details	Relevance	Knowledge - Level of understanding	Relevance (Actionable) - Level of confidence that actions can be taken	Risk - Level of risk to meeting goals	Strategy Characterization	Category of Uncertainty (Primary/ Secondary)	Existing and Potential Recommended Strategies
	If water quality policy issues continue, CERP restoration water targets will be unable to be met.	can't send more water south if it doesn't meet consent decree phosphorus levels							
SCS-8	What is the shared vision between and among SCS and GE as regards restoration goals?	Is restoration target pre-development or is it constrained by current realities and policies?	Relates to SERES efforts.	high	high	medium or low	2	Ecological/ policy.	Clear definition of restoration goals needs to be defined and implemented. Decision must come from upper-level managers among the involved stakeholders.
SCS-7	Getting water south requires meeting WQ standards. Will the additional water for restoration meet those standards, or will/can the standard be revised? Will the WQ standards be met in time to allow for waters to flow prior to a permanent loss in the already declining ecosystem characteristics?	If policy mandated water quality is not met, will water still be sent through the Everglades and into FL Bay and BB? If it does get through with poor water quality, does that then help or hurt the ecosystem?	key element potentially defining quantity of water available for restoration	Medium/Low	High	Medium	2	Ecological/ Policy	Political and policy constraints need to be resolved.
SCS-8	How does restoration affect nutrient availability from internal and external sources and results in ecological responses?	For example, will increased freshwater flow to FL Bay increase nutrient availability in the Bay?	Do we risk sending more freshwater to the Bay to meet salinity targets with the risk of nutrient effects	High	Medium	Medium/ High	2	Policy/ Hydrology	Implement and give high priority to CERP projects that will clean water.
SCS-9	How will delays in implementation due to funding constraints affect the final outcome (irreversible adverse changes)?	How would delays in implementation affect restoration goals (ecosystem be beyond repair?)	funding drives all aspects of both monitoring and Project implementation	Low	Low (we can't force the funding)	High	2	Policy	Political and policy constraints need to be resolved. Funding needs to be provided.
SCS-1	What are our limits on evaluating the system as a whole?	We need to have more of a system approach to modeling. (salinity, SLR, changing hydrology and coastal conditions) Hydrodynamic modeling	Desirable to have the ability to evaluate the system as a whole.	High	High	High	2	system-wide (all)	Refine existing system-wide models to be more accurate and reliable. Or develop new models.
SCS-2	Will the SCS be provided the water it needs for restoration from upstream (timing, distribution, quality and quantity)?	The amount of water provided from upstream due to CERP may or may not meet SCS restoration targets. Much is known about SCS targets and CERP water generated, but need synthesis developed.	Related to TS-1: key element determining whether restoration has been successful	med	high	high	1	hydrological / ecological	GE needs to define restoration goals in terms of stages at the southern boundary, which would define the water available to the SCS. CERP needs to implement those elements necessary to achieve those stage goals.

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3.7.2 Southern Coastal Systems AM Strategies

3.7.2.1 SCS-3 – Water Quantity, Timing and Distribution to Restore Ecology

1. **CERP AM Uncertainty and ID#.**
   What are the volumes and patterns of flow required to restore SAV, oysters, and fish communities in coastal estuaries/bays? What are the responses of SAV and fish communities that would result in restoration?
2. **CERP Objective or Constraint:**
   Public objectives #2, 3, and 4, Planning Goal #1, Planning Constraint #2
3. **Location of Uncertainty and Ecosystem Indicator (Include Map):**
   a. **Habitat(s) and Region(s).** SCS
   b. **Associated CERP Projects, Structures, and Operations:** Any CERP project and/or operations affecting southern coastal systems
4. **What is expected to be learned by addressing this uncertainty and how will CERP benefit from addressing this uncertainty?**
   Information gained would help set ecological attribute targets. We could also establish targets based on function (i.e., water quality improvement, prey-base).
5. **Specific expectations and hypotheses to be tested to address each uncertainty, including the attribute(s).**
   A combined hydrologic and ecological modeling effort with monitoring of actual restoration project results is needed to address this uncertainty. Testing of projects such as the C-111 Spreader Canal would allow the continuation of refining existing models to give more accurate target setting capabilities. In addition, Testing of C-111 Spreader Canal and/or Biscayne Bay Coastal Wetlands projects will provide information on the incremental benefit of restoration projects and amount of hydrological improvement needed to generate measureable ecological responses in epifauna, oysters, SAV, fish, and crocodiles.
   a. **Reference Existing Scientific Documents that Outline Approach to Address Uncertainty:**
      i. **RECOVER Performance Measures –** Fish communities, oysters, juvenile pink shrimp and associated epifauna, and SAV
      ii. **MAP hypotheses name and number –** SAV 3.4.6, nursery habitat 3.4.7, oysters 3.4.8, predator prey interactions 3.4.9
      iii. **Models –** Using the paleo-adjusted NSM salinities, RSM hydrologic modeling of water quantity, timing, and distribution (volumes and patterns of flow) would be estimated. The paleo-adjusted NSM salinities would also be used to estimate ecological response for SAV, Seatrout, and crocodile species using those ecological planning tools.
   b. **Specific ecosystem stressor (s), effect(s), or attribute(s) being measured:** Fish, SAV, oysters, epifauna, and salinity
   c. **Time frame to begin to be able to measure change after a restoration action is taken:** Salinity responses could be observed within hours/days from project implementation but require 5 years to capture climate variability. Initial response in fish, SAV, epifauna, and oysters could be observed within months but would take up to 5 years to confirm consistent trends given climate variability. Crocodiles could take up to 10 years before detections in population increases could be confirmed.

d. **When during CERP's life cycle should the AM strategy (modeling, monitoring, analysis, or test) begin?** Now, to support operations and verify initial project implementation success for C-111 Spreader Canal Western Project and Biscayne Bay Coastal Wetlands. Pilot field studies or mesocosm studies to determine the responses of SAV and fish communities. For SAV, implement pilot field studies to determine methods for overcoming limitation of recovery by grazers and predation on oysters and fish.

6. **Triggers/thresholds that indicate good CERP performance or need for adaptive management action.**
TBD

3.7.2.2 SCS-4 – Restoration Flows within Real-World Constraints

1. ***CERP AM Uncertainty and ID#.*** (Similar to CEPP Uncertainty #67: Will CEPP improve flows to Florida Bay and the Lower Southwest coast resulting in more natural salinity patterns (magnitude, spatial distribution, and timing)? Will results be consistent with the expectations from the CEPP scenario model predictions?) How can we reasonably and accurately quantify the volume of water available for restoration of Biscayne Bay, Florida Bay and the southwest Coast acknowledging real-world constraints?
2. **CERP Objective or Constraint:**
Public objectives #4, Planning Goal #1, Planning Constraint #1, 2, and 3
3. **Location of Uncertainty and Ecosystem Indicator (Include Map):**
   a. **Habitat(s) and Region(s).** Southern Coastal Systems, Bays and estuaries
   b. **Associated CERP Projects, Structures, and Operations:** Any CERP project affecting southern coastal systems
4. **What is expected to be learned by addressing this uncertainty and how will CERP benefit from addressing this uncertainty?** Information gained from addressing this uncertainty would determine how close we can come to achieving restoration targets given the constraints in the system. The model information would also help inform field tests in real world conditions. This would also inform operational efforts once all projects are built. Constructed features of CEPP are designed to yield a more natural distribution of water towards the southeastern Everglades and northeast Florida Bay. The CEPP operational plan focuses primarily on operational changes to the S-356 pump station and G-211 structure to actively move water to the west of the L-31N to compensate for seepage concerns along the L-31N and requires the integration of operations of the Lower East Coast Service Area (LECSA) 2 & 3 South Florida Water Management District (SFWMD) Canal System to achieve the predicted salinity regimes in at the Little Madeira Bay, Joe Bay, Trout Cove, Long Sound, Little Black water Sound, and Barnes Sound Marine Monitoring Network stations. Operations of the LECSA 2 & 3 SFWMD Canal System can affect the flows in Taylor Slough and the lower C-111 basin and subsequently, salinities in Little Madeira Bay, Joe Bay, Trout Cove, Long Sound, Little Blackwater Sound, and Barnes Sound Marine Monitoring Network stations. CEPP water deliveries south of Tamiami Trail are predicted to improve flows to Florida Bay and the Lower Southwest coast resulting in a more natural salinity pattern (magnitude, spatial distribution and timing). CEPP and LECSA 2 & 3 SFWMD Canal System operations and constructed features will result in: 1) a more natural

flow distribution, 2) a more natural timing regime and 3) a greater magnitude of flows to Florida Bay and the lower Southwest coast.

5. **Specific expectations and hypotheses to be tested to address each uncertainty, including the attribute(s). (state upfront what we're doing)**
   a. **Reference Existing Scientific Documents that Outline Approach to Address Uncertainty:**
      i. **RECOVER Performance Measures –** GE hydrologic PMs, all SCS PMs
      ii. **MAP hypotheses name and number –** Water quality hypothesis cluster 3.4.4
      iii. **Models –** Real-time analyses of operational changes to the S-12 structures, S333, and the LECSA 2 & 3 SFWMD Canal System and their subsequent affect on surface and ground water flows to the southern coastal creeks and salinity in Florida Bay and the Lower Southwest Coast prior to construction, during construction, and into Operations and Maintenance for CEPP should be pursued to provide feedback to water managers on operational decisions and their subsequent effect on the estuaries. Focus of the analyses are on the distribution, magnitude, and timing of surface and groundwater flows at water management structures, select wetland stage/flow gages, select coastal creek flow gages, and salinity at the Marine Monitoring Network stations. Preferably, refinement of the existing hydrologic and hydrodynamic models in the southern coastal wetlands, Florida Bay, and the Lower Southwest coast is necessary to better forecast the effects of operational changes prior to actual implementation and avoid irreversible negative impacts through a trial and error approach. This refined modeling analysis will help identify specific quantifiable hypotheses (CEPP performance expectations) to be confirmed with CEPP implementation.
   b. **Specific ecosystem stressor (s), effect(s), or attribute(s) being measured:** modifications to the quantity, timing, and distribution of freshwater delivery in the region south of Tamiami Trail (Shark River and Taylor Sloughs, Florida Bay, and the Lower Southwest Coast). These attributes were selected based on existing knowledge of the surface/groundwater connectivity in Shark River and Taylor Sloughs and adjacent estuaries. Many of the attributes listed are currently monitored by other agencies or USACE projects and may provide, in part, input to the testing of this uncertainty's hypothesis. For example, the ENP Marine Monitoring Network (MMN) is a primary tool for evaluate salinity in Florida Bay and should be maintained to continue to inform decision makers on the progress and potential improvements needed with adaptive management. It is anticipated additional monitoring will be necessary for the Project, to be determined during Design. Costs for the additional monitoring have been included in the Monitoring Cost Table. The timeframe in which the attributes listed below will be able to measure changes as function of the Project range from a minimum of 7 days (wetland and canal/creek stage, surface and groundwater flow) to a maximum of 2 years (estuarine salinity). Estimated timeframes to begin perceiving changes are listed below in parentheses.

      The attributes to be measured and time needed to begin perceiving changes are the following (these time frames are indications of speed of response, not limits on the monitoring to be conducted):

      1. Estuarine Salinity (2 years)

2. Wetland and Canal/Creek Stage (7 days)
3. Surface and Groundwater Flow (7 days)

c. **Time frame to begin to be able to measure change after a restoration action is taken:** In some cases, immediate changes could be seen, such as changes in salinity. In other cases, it is dependent on which stressor or attribute is being addressed, change could take days to years.

d. **When during CERP's life cycle should the AM strategy (modeling, monitoring, analysis, or test begin)?** Now to support operations and verify initial project implementation success and help plan and implement future CERP projects.

6. **Triggers/thresholds that indicate good CERP performance or need for adaptive management action.**

CEPP Restoration Target Triggers:

- RECOVER Southern Coastal Systems Performance Measure: Salinity in Florida Bay (http://www.evergladesplan.org/pm/recover/recover_docs/perf_measures/062812_rec_pm_scs_salinity_flbay.pdf) metrics less than those predicted for the selected alternative (4R2) or exhibits a negative long-term trend at each of the 17 NPS Marine Monitoring Network stations in Florida Bay
- Stage/flow distribution inconsistent to those predicted for the selected alternative (4R2)

Baseline Thresholds:

- Salinity exceeds the 90th percentile of the recorded salinity values at the NPS Marine Monitoring Network in NE Florida Bay zone and near shore Florida Bay stations for the entire period of record for the equivalent rainfall years
- Violation of the Minimum Flows and Levels for Florida Bay

3.7.2.3 SCS-5 and SCS-6 – Sea-Level Rise Effects on Restoration Success

1. ***CERP AM Uncertainty and ID#.*** To what degree will sea level rise and climate change affect restoration efforts? (SCS-5) How will SLR affect coastal soils? SCS-6 (Similar to CEPP Uncertainty #64). Based upon how SLR will affect restoration efforts, what spatially sustainable areas should restoration afford a priority focus and how is that priority determined?
2. **CERP Objective or Constraint:** Public objectives #2, Planning Goal #1 and 2, Public Constraints #3
3. **Location of Uncertainty and Ecosystem Indicator (Include Map):**
   a. **Habitat(s) and Region(s).** Southern Coastal Systems, Bays and estuaries
   b. **Associated CERP Projects, Structures, and Operations:** Any CERP project affecting southern coastal systems
4. **What is expected to be learned by addressing this uncertainty and how will CERP benefit from addressing this uncertainty?** SLR affects the water budget, fresh groundwater supply, extents of tidal influence on floral and faunal communities in the SCS. Sea-level change could affect the setting of restoration targets if salinity zones/ranges shift more upstream. Information gained would allow us to understand what areas are vulnerable to sea-level rise, what degree are restoration benefits affected, and what areas are likely to be sustained with restoration. This information could support refinements of CERP expected restoration benefits, prioritization of restoration projects to address sea-level rise effects, and/or development and implementation of adaptation plans to ensure the system changes in

a sustainable way. Reference CEPP Uncertainty #64, information learned from CEPP will support understanding how effective hydrologic restoration is at addressing sea-level rise effects.

5. **Specific expectations and hypotheses to be tested to address each uncertainty, including the attribute(s). (state upfront what we're doing)**
   Conduct a risk and vulnerability assessment of South Florida Ecosystem and how it affects restoration benefits or restoration efforts mitigate effects using CEPP and CERP scenarios. Implement monitoring associated with CEPP AM plan implementation, as stated in CEPP AM Strategy addressing Sea-Level Rise
   a. **Reference Existing Scientific Documents that Outline Approach to Address Uncertainty:**
      i. **RECOVER Performance Measures –** All RECOVER performance measures
      ii. **MAP hypotheses name and number –** Salinity Hypothesis Cluster 3.4.5, SAV Hypothesis Cluster 3.4.6, Estuarine Nursery Habitat Hypothesis Cluster 3.4.7, Native Vegetation Mosaic Hypothesis Cluster 3.4.10
   b. **Models –** Use a series of linked hydrodynamic/salinity models that drive ecological models of SAV and oysters to evaluate effects of CERP projects under various sea level rise scenarios. **Specific ecosystem stressor (s), effect(s), or attribute(s) being measured: Salinity,** SAV, Estuarine habitat
   c. **Time frame to begin to be able to measure change after a restoration action is taken:** Once restoration projects are constructed and begin to produce more freshwater flow to the southern coastal systems, we hope to have improved conditions in the ecosystem. Monitoring will show what increase in sea level has occurred and if the freshwater flow is enough to counteract it, or if different actions need to take place to produce more freshwater flows than we thought was needed.
   d. **When during CERP's life cycle should the AM strategy (modeling, monitoring, analysis, or test begin)?** Now to include sea level rise analysis in design of the projects.
   6. **Triggers/thresholds that indicate good CERP performance or need for adaptive management action.**
      TBD based on SLR analysis.

3.7.2.4 SCS-10 – Invasive Species Effects on SCS

1. ***CERP AM Uncertainty and ID#.***
   What is the effect of exotics on the southern coastal systems? How will the spread and costs associated with the control, and success of the control of Exotic Species impact restoration? If we raise stages to keep wetlands higher/longer then there may be more easy access for exotic fishes to disperse into the system from canals.
2. **CERP Objective or Constraint:** Public objectives #2 and 3, Planning Goal #1
3. **Location of Uncertainty and Ecosystem Indicator (Include Map):**
   a. **Habitat(s) and Region(s).** SCS
   b. **Associated CERP Projects, Structures, and Operations:** All CERP projects
4. **What is expected to be learned by addressing this uncertainty and how will CERP benefit from addressing this uncertainty?**
   Information gained should help control adverse impacts from exotic invasion. This will be related to the invasive species management plans for each project, however, as a system we

would need to see how certain areas are responding to the influx of more water, and whether invasives are increasing in the areas we are trying to restore.

5. **Specific expectations and hypotheses to be tested to address each uncertainty, including the attribute(s). (state upfront what we're doing)**
   Invasive species management plans are now required for each "planned" CERP project, but not all projects have invasive species management plans. There is also information about the effects of invasives and what each project is doing to address invasive species issues can be found in the 2014 SSR and CERP project implementation reports.
   a. **Reference Existing Scientific Documents that Outline Approach to Address Uncertainty:**
      i. **RECOVER Performance Measures –** No RECOVER PMs for exotics.
      ii. **MAP hypotheses name and number –** N/A
      iii. **Models –** We do not have invasive species models
   b. **Specific ecosystem stressor (s), effect(s), or attribute(s) being measured:** Water quality and attributes affected by water quality (e.g., SAV) should be measured.
   c. **Time frame to begin to be able to measure change after a restoration action is taken:** Water quality could change in hours to days to months after restoration action is taken. Significant temporal trends may take years to detect.
   d. **When during CERP's life cycle should the AM strategy (modeling, monitoring, analysis, or test) begin?** Now to support operations and verify initial project implementation success and help plan and implement future CERP projects.
6. **Triggers/thresholds that indicate good CERP performance or need for adaptive management action.**
   TBD.

3.7.2.5 SCS-11 – Achieving Restoration and Threatened and Endangered Species Goals

1. ***CERP AM Uncertainty and ID#.***
   How will Threatened & Endangered species issues vs. hydrologic restoration requirements be resolved within the confines of existing Federal laws? Currently some T&E species are a constraint on hydrologic restoration needs to the system.
2. **CERP Objective or Constraint:**
   Public objectives #2, 3, and 4, Planning Goal #1, Planning Constraint #1
3. **Location of Uncertainty and Ecosystem Indicator (Include Map):**

a. **Habitat(s) and Region(s).** SCS

b. **Associated CERP Projects, Structures, and Operations:** All project linkages upstream of SCS.

4. **What is expected to be learned by addressing this uncertainty and how will CERP benefit from addressing this uncertainty?**
   Information would be used to inform policy and protect T&E species, while also providing the freshwater flows needed to restore the Everglades.
5. **Specific expectations and hypotheses to be tested to address each uncertainty, including the attribute(s). (state upfront what we're doing)**
   System-wide planning and evaluation of full restoration flows and endangered species effects compared to partial restoration with endangered species considerations as a constraint (similar to SCS-4) using CEPP modeling will help inform which species are vulnerable and in what areas of the system. In addition, operational tests of C-111 SC, as described in the

PIR adaptive management approach should be implemented to understand how much of project restoration goals can be achieved while avoiding impacts to endangered species (e.g., Cape Sable Seaside Sparrow).

a. **Reference Existing Scientific Documents that Outline Approach to Address Uncertainty:**
   i. **RECOVER Performance Measures –** No RECOVER performance measures, however, there is the ERTP/FWS performance measures as well as the MSTP from FWS.
   ii. **MAP hypotheses name and number –** N/A
   iii. **Models –** Models currently exist for seatrout and crocodiles, and the salinity threshold is known for what these species need. Perhaps run some more models to see where water could be moved to provide the southern coastal systems more freshwater without flooding out T&E species in the Greater Everglades (e.g., Cape Sable Seaside Sparrow). Since CERP will provide flows in increments, gauge how species are responding to increased water within the Greater Everglades to inform their progress on relocating to drier areas or not.

b. **Specific ecosystem stressor (s), effect(s), or attribute(s) being measured:** Threatened and endangered species, hydropatterns (water levels, hydroperiods)
c. **Time frame to begin to be able to measure change after a restoration action is taken:** The amount of water needed for southern coastal systems restoration could be reduced or halted due to differing needs of endangered species upstream. The timeframe may depend on status of the species prior to restoration efforts.
d. **When during CERP's life cycle should the AM strategy (modeling, monitoring, analysis, or test begin)?** Begin operational test now for C-111 Spreader Canal using RECOVER and project monitoring for restoration objectives and project monitoring for endangered species objectives (e.g., population changes, relocating, etc.).. Implement System-wide Planning and Evaluation to support future increments of CERP.

6. **Triggers/thresholds that indicate good CERP performance or need for adaptive management action.**
   TBD.

3.7.2.6 SCS-12 – Methylmercury Effects Related Restoration Goal

1. **CERP AM Uncertainty and ID#.** What controls the input and methylation rates that affect accumulation rates by coastal fauna? We are uncertain how methylmercury bioaccumulation is influenced by watershed management, particularly with regard to methylation in upstream wetlands, sulfate inputs to these areas, and transport to the coast.
2. **CERP Objective or Constraint:** Public Objective #4, Public Constraint #2
3. **Location of Uncertainty and Ecosystem Indicator (Include Map):**
   a. **Habitat(s) and Region(s).** All CERP projects
   b. **Associated CERP Projects, Structures, and Operations:** All project linkages upstream of SCS.
4. **What is expected to be learned by addressing this uncertainty and how will CERP benefit from addressing this uncertainty?**
   Everglades' ecosystem services and achievement of restoration success for predator-prey performance measures are diminished by widespread methylmercury contamination in virtually all upper trophic level fauna; such as wading birds, alligators, crocodiles, sportfish, and other fauna. In addition, methylmercury is likely also affecting endangered species

recovery rates. A synthesis report of methylmercury areas of risk with respect to CERP performance measures and South Florida threatened and endangered species, trajectories, and restoration actions effects will help inform future south Florida management actions, water management, and restoration expectations. The strategy would be to understand the effects of such an action to then inform other actions if necessary or determine the issue has been addressed. We need to understand what is being done and what still needs to be done, who should do it and where RECOVER Science efforts might fit in vs. where the South Florida Ecosystem Restoration Task Force Science efforts fit in.

5. **Specific expectations and hypotheses to be tested to address each uncertainty, including the attribute(s). (state upfront what we're doing)**
   a. **Reference Existing Scientific Documents that Outline Approach to Address Uncertainty:**
      i. **RECOVER Performance Measures –** Fish communities, juvenile pink shrimp and associated epifauna, American crocodiles, wading birds, alligators
      ii. **MAP hypotheses name and number –** water quality and phytoplankton hypothesis cluster 3.4.4, estuarine nursery habitat hypothesis cluster 3.4.7 Not sure these are all the clusters we need to include
      iii. **Models – Not sure if there is a mercury model, but we probably need one if we don't have it**
   b. **Specific ecosystem stressor (s), effect(s), or attribute(s) being measured: Mercury methylation,** Coastal fauna including wading birds, crocodiles, alligators, sportfish
   c. **Time frame to begin to be able to measure change after a restoration action is taken:** Unsure of how fast methylation occur.
   d. **When during CERP's life cycle should the AM strategy (modeling, monitoring, analysis, or test begin)?** Now to detect and determine severity of mercury accumulation in the attributes noted above, and determine corrective actions if necessary.
6. **Triggers/thresholds that indicate good CERP performance or need for adaptive management action.**
   TBD.

3.7.2.7 SCS-14 – Non-CERP Effects on Water Budget and Restoration

1. **CERP AM Uncertainty and ID#.** Other human activities - how will further development on the coast, e.g. power plants affect coastal salinity and restoration efforts? For example, how will Turkey Point Upgrade and Unit 6&7 construction/operation affect the greater Biscayne Bay.
2. **CERP Objective or Constraint:** Public objective #1-7, Planning Goals 1&2, Public constraints 1-8
3. **Location of Uncertainty and Ecosystem Indicator (Include Map):**
   a. **Habitat(s) and Region(s).** All SCS projects plus upstream CERP projects
   b. **Associated CERP Projects, Structures, and Operations:** All CERP projects.
4. **What is expected to be learned by addressing this uncertainty and how will CERP benefit from addressing this uncertainty?**
   Any project affecting the CERP hydrologic footprint could counteract or reduce restoration benefits. RECOVER needs to know what projects are being constructed and intended to be constructed that might affect water and/or water quality, and try to predict their effects in order manage any negative effects it may have on restoration efforts. When permitting is done, make sure CERP projects are taken into account.

5. **Specific expectations and hypotheses to be tested to address each uncertainty, including the attribute(s). (state upfront what we're doing)**
   a. **Reference Existing Scientific Documents that Outline Approach to Address Uncertainty:**
      i. **RECOVER Performance Measures –** All Biscayne Bay performance measures, specifically salinity for the power plant example.
      ii. **MAP hypotheses name and number –** All Biscayne Bay MAP hypotheses
      iii. **Models –** There are no models predicting how future development would affect the bays.
   b. **Specific ecosystem stressor (s), effect(s), or attribute(s) being measured:** Includes all stressors and attributes identified within the system.
   c. **Time frame to begin to be able to measure change after a restoration action is taken:** Dependant on which stressor or attribute is being addressed (days to years).
   d. **When during CERP's life cycle should the AM strategy (modeling, monitoring, analysis, or test begin)?** Now to support operations and verify initial project implementation success and help plan and implement future CERP projects. We need to be diligent about how large scale projects affect CERP benefits and coordinate with those parties as deemed appropriate to minimize benefit loss.
6. **Triggers/thresholds that indicate good CERP performance or need for adaptive management action.**

   TBD.

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3.7.3 Southern Coastal Systems Management Options Matrices

3.7.4 Florida Bay Management Options Matrix

Uncertainty ID	Indicator	Threshold (Interim/Project Restoration Goal)	Full Restoration Target (estimated time frame)	Trigger(s) for Management Action	Management Action Option(s) 1	Management Action Option(s) 2	Management Action Option(s) 3
4, 5, 6, 14	Algal bloom (surface water quality) water quality, monthly	Minimize bloom intensity, spatial extent and duration (Reference the stoplight indicator report and the Southern Estuaries Module – Water Quality (2014 SSR))	Current nutrient concentrations of surface water inputs from the Everglades and Florida Keys should not be exceeded so the oligotrophic conditions of the bay are maintained. Decrease or cause no net increase in the frequency, duration, intensity or spatial extent of algal blooms relative to conditions documented since 1991. Light penetration should be sufficient to support net production by seagrasses. Algal bloom threshold targets for Florida Bay are 2 parts per billion (ppb) of chlorophyll *a* in eastern Florida Bay and 3 ppb of chlorophyll *a* in central and western Florida Bay	Alteration of current surface water nutrient spatial distribution or concentrations relative to current conditions Increased frequency of yellow and red conditions for the algal bloom system-wide indicator report	Adjust operations to change *spatial* and /or *temporal* distribution of water Model refinement and coupling to improve ability to forecast effects of operations and adaptive operational changes	Decrease overall inputs of nutrients into water.	
SCS-10[9]	Cattail (vegetation change) - vegetation transects, annually; aerial landscape analysis every 5 years Not monitored through MAP, may have project monitoring or invasive species management plan			Alteration of current spatial distribution relative to current conditions Increase of cattail expansion above current rate (or increased rate of expansion).			
SCS-10	Soil nutrients (transport & availability); Soil and vegetation nutrient transects, bi-annually;soil P, quarterly Not currently monitored			Movement of spatial nutrient front or increase in nutrient rate of release from soils			
SCS-4	Salinity (estuarine) Salinity, continuously	Lower the average salinity in the bay; Reduce the frequency, duration, magnitude, and spatial extent of hypersaline (>40 psu) conditions throughout the bay; and Restore seasonal deliveries of freshwater more typical of the natural system,(e.g., extension of water deliveries into the dry season.) At a minimum, trend in salinity moves towards target.	Predrainage regime as predicted by the paleo adjusted regression models using the NSM output.	Salinity exhibiting a long-term increasing trend at the MMN Florida Bay stations. Salinity exceeds the 90th percentile of the recorded salinity values at the MMN NE Florida Bay and Florida Bay stations for the entire period of record for the equivalent rainfall years. Violation of the Minimum Flows and Levels for Florida Bay			
SCS-4	Flow Creekflow, continuous	Increase in duration of positive creek flows to Florida Bay.		Violation of the Minimum Flows and Levels for Florida Bay.			

[9] Rows shaded in gray are not covered by the MAP and/or proposed as project monitoring

Uncertainty ID	Indicator	Threshold (Interim/Project Restoration Goal)	Full Restoration Target (estimated time frame)	Trigger(s) for Management Action	Management Action Option(s) 1	Management Action Option(s) 2	Management Action Option(s) 3
SCS-10	Mangrove and white zone (vegetation change); vegetation transects, annually aerial landscape analysis 5 yrs			White zone expansion rate exceeds Ross rate (3 km/50 yr west of US1, 1 km/50 yr east of US1); mangrove zone expansion rate exceeds current rate of expansion	Adjust operations to change *spatial* and /or *temporal* distribution of water Model refinement and coupling to improve ability to forecast effects of operations and adaptive operational changes		
SCS-10	Soil elevation soil elevation and depth, annually			Reduction in elevation Increase in rate of coastal soil loss over the existing rate.			
SCS-4 [10](CEPP 67)	Salinity - wetland surface water conductivity, continuously; groundwater conductivity, monthly; porewater conductivity; and below ground resistivity, quarterly			Change in spatial extent of wetland surface water or groundwater salinity relative to two similar rainfall years from the period of record Salinity magnitude exceeds equivalent rainfall conditions for the past 2 years from the period of record) and/or saltwater wedge movement inland.			
SCS-3	Seagrass seagrass densities and community diversity, quarterly	At a minimum, trend moves toward target	Increase seagrass cover and diversity in Florida Bay Reduce the region of *Thalassia* overdominance, and increase both *Halodule* and *Ruppia* cover	5% decrease in seagrass coverage and/or species specific densities from existing conditions as a function of upstream hydrologic changes.			
SCS-13 (systemwide)	Spoonbills Spoonbill system-wide ecological indicator parameters, annually			Increased frequency of 'yellow' and 'red' status for the Roseate Spoonbill in the system-wide indicator report. 5% decrease in spoonbill densities from existing conditions as a function of upstream hydrologic changes.			
SCS-3	Fish Juvenile Seatrout system-wide ecological indicator parameters, annually	Baywide increase in fish diversity and density, and an increase in the abundance of FL Bay seatrout and mangrove fish assemblages	Increase diversity and density of fish assemblages along the mainland mangrove shorelines of Florida Bay. Increase distribution, abundance, growth and survival of juvenile spotted seatrout in north-central and western FL Bay.	Increased frequency of yellow and red for the fish and macroinvertebrates system-wide indicator report for Florida Bay Salinity exceeds the 90th percentile of the recorded salinity values at the MMN Florida Bay stations for the entire period of record for the equivalent rainfall years In Florida Bay, 5% decrease in juvenile seatrout spatial coverage and/or species specific densities from existing conditions as a function of upstream changes.			
SCS-3	Pink Shrimp and other epifauna Pink Shrimp system-wide ecological indicator parameters, annually	At a minimum, trend moves toward target	Semi-annual density targets for Florida Bay Pink Shrimp: Zone 3: $\geq 5/m^2$ Zone 4: $\geq 17/m^2$ Zone 5 $\geq 5/m^2$ Zone 6: $\geq 7/m^2$ Zone 16: $\geq 17/m^2$	Increased frequency of yellow and red for the juvenile pink shrimp system-wide indicator report for Florida Bay Salinity > 90th percentile of the recorded salinity values at the MMN Florida Bay stations for the entire period of record for the equivalent rainfall years In Florida Bay, 5% decrease in juvenile pink shrimp spatial coverage and/or species densities from existing conditions as a function of upstream hydrologic changes.			Adjust operations to change *spatial* and/or *temporal* distribution of water Model refinement and coupling to improve ability to forecast effects of operations and adaptive operational changes

[10] Rows shaded in gray are not covered by the MAP and/or proposed as project monitoring

Uncertainty ID	Indicator	Threshold (Interim/Project Restoration Goal)	Full Restoration Target (estimated time frame)	Trigger(s) for Management Action	Management Action Option(s) 1	Management Action Option(s) 2	Management Action Option(s) 3
SCS-3,[11]	Juvenile Crocodiles Juvenile growth and survival system-wide ecological indicator parameters, annually		Restore habitat for the endangered American crocodile	Increased frequency of yellow and red for the crocodilians system-wide indicator report for Florida Bay 5% decrease in juvenile crocodile growth and survival from existing conditions as a function of upstream hydrologic changes.			
SCS-10	Invasive exotic vegetation and animals • Vegetation, monthly or seasonally • Animals, daily or seasonally *Per Invasive Species Monitoring Plan			No new introductions of invasive exotic species into area Suppression of established invasive species to the lowest feasible level such that ecosystem impacts are minimized Management decisions based on Florida Weed Risk Assessment Tool, biological profiles and risk assessments (animals) using ECISMA and FWC approach. Trigger is a function of K vs. R-selection by the invasive species.			Refinement or development of Invasive Species Risk Assessment Tools Implement CEPP Invasive Species Management Plan measures CEPP invasive and nuisance species management team may provide information to reduce future species management costs by redesigning or retrofitting project features. If the suggestions are beyond the scope of the CEPP Plan, additional authorization would be required.
SCS-6	LEC Stage/Flow stage and/or surface/groundwater flow monitoring, continuous			Violation of the Minimum Flows and Levels for Florida Bay; greater than 1% decrease in canal flow and/or stages compared to existing April conditions and/or in dry years violation of existing consumptive use permit requirements Increase of 1% or greater in canal or groundwater stage compared to ECB October average water table.			Operational tests Develop/refine operational plans Model development/refinement
SCS-6	LEC Water Quality (ground and surface) water quality, monthly			Violation of FAC 62-160 for various water quality parameter increased frequency or magnitude of exceedances in surface water monitoring segments that would lead to designation of "impaired" Declining trend compared to prior condition Detection of indicators of surface water influence in groundwater monitoring wells.			Adjust operations to change *quantity* of water delivered

[11] Rows shaded in gray are not covered by the MAP and/or proposed as project monitoring

Uncertainty ID	Indicator	Threshold (Interim/Project Restoration Goal)	Full Restoration Target (estimated time frame)	Trigger(s) for Management Action	Management Action Option(s) 1	Management Action Option(s) 2	Management Action Option(s) 3
SCS-6	Periphyton (nutrient availability) - periphyton tissue nutrient content, quarterly soil nutrient, every 2 years			Alteration of current spatial distribution relative to current conditions Increased frequency of yellow and/or red conditions for the periphyton nutrient content system-wide indicator report	Adjust operations to change *spatial* and /or *temporal* distribution of water Model refinement and coupling to improve ability to forecast effects of operations and adaptive operational changes		
SCS-6	LEC Wetland Vegetation vegetation transects, annually aerial landscape analysis every 5 years during construction and into O/M.			Violation of the Minimum Flows and Levels for Florida Bay greater than 1% decrease in canal flow and/or stages compared to existing April conditions and/or in dry years violation of existing consumptive use permit requirements Increase of 1% or greater in canal or groundwater stage compared to ECB October average water table 5% reduction in spatial coverage and/or species specific densities from existing conditions as a function of upstream hydrologic changes.			Operational tests Develop/refine operational plans Model development/refinement

- Shaded rows indicate monitoring that is not currently funded by the RECOVER Monitoring and Assessment Program (MAP).

3.7.5 Biscayne Bay Management Options Matrix

Uncertainty ID	Indicator	Threshold (Interim/Project Restoration Goal)	Full Restoration Target (estimated time frame)	Trigger(s) for Management Action	Management Action Option(s) 1	Management Action Option(s) 2	Management Action Option(s) 3
3, 4,6,5, 14 Similar to CEPP 67	Salinity (estuarine); Continuous salinity monitoring	Maximize frequency of salinities in mesohaline range; at a minimum, trend should show increased frequency in mesohaline range from existing conditions[12]	Pre-drainage regime as predicted by AdH model Oysters – Stable salinity range of 10-25 at mouth of creeks SAV, epifauna, and mangrove fish – Stable mesohaline salinity (5-18) through most of year	Wet season: average bottom salinity >20 in a zone extending 500 m from shore Dry season: average bottom salinity >20 in a zone extending 500 m from shore (RECOVER, 2006) Post-project salinity less desirable than AdH-predicted salinity for project	Adjust operations of BBCW Expedited Project to change *spatial* and /or *temporal* distribution of water Adjust operations of C&SF system -related water management structures to improve quantity, timing, and distribution of water Model refinement and coupling to improve ability to forecast effects of operations and adaptive operational changes	Adjust operations of Period 2 projects Review and revise salinity target (if deemed appropriate) Plug or fill mosquito ditches in BBCW project area to improve distribution	Adjust operations of Period 3 projects System-wide/Regional Performance Issue Analysis (send more water)
3,4,,5,6 Similar to CEPP 67	Stage; continuous monitoring	Use RSM or TIME models to predict stage change resulting from any given CERP project affecting Biscayne Bay At a minimum, trend in water level and hydroperiod moves toward the target	Stage as predicted by RSM or TIME under pre-drainage conditions Water level and hydroperiod in coastal wetlands -0.5 to +2.0 feet and 28-32 weeks, respectively	Water level and/or hydroperiod less than predicted by RSM or BISECT for given CERP project Water level and/or hydroperiod less than existing condition		Adjust operations of Period 2 projects Review and revise targets and triggers (if deemed appropriate) Possibly change operations to meet a different point of the target range	Adjust operations of Period 3 projects System-wide/Regional performance issue analysis (more water)
3, 4, 5, 6	Flow; continuous monitoring	At a minimum, trend in flow should move towards target	According to Biscayne Bay salinity PM: Wet season: average daily flow of 2,104 ac-ft Dry season: average daily flow of 687 ac-ft RSM or BISECT determined under pre-drainage condition	As predicted by RSM or BISECT for given CERP project No increase in flow as predicted for given CERP project preferred alternative		Adjust operations of Period 2 projects Review and revise targets (if deemed appropriate) Plug or fill mosquito ditches in BBCW project area to improve distribution	• Adjust operations of Period 3 projects
3,4	Seagrass seagrass densities and community diversity	At a minimum, trend in occurrence, abundance and diversity moves toward the target	Increased occurrence and abundance of Halodule and Ruppia in nearshore area Decreased occurrence and abundance of Thalassia in nearshore area Increase in species diversity	No increase in seagrass habitat diversity and coverage as predicted for given CERP project preferred alternative 5% decrease in seagrass coverage and/or species specific densities from existing conditions function of upstream hydrologic changes.		Adjust operations of Period 2 projects Review and revise SAV targets (if deemed appropriate) Refine salinity estimates	Adjust operations of Period 3 projects System-wide/Regional performance issue analysis (more water)
3, 4, 5, 6	Fish Mangrove fish	Threshold determined by plugging AdH salinity output from CERP project affecting Biscayne Bay into mangrove fish HSIs (gray snapper, mojarras, etc.) Trend in species composition, occurrence, density, delta density moving toward Joe Bay conditions	Target determined by plugging in pre-drainage AdH salinity output into fish HSIs Alternately, species composition, occurrence, density, delta density very similar to Joe Bay conditions	Species composition, occurrence, density, delta density less than predicted by mangrove fish HSIs for given CERP project affecting Biscayne Bay Trend in species composition, occurrence, density, delta density moving toward target		• Adjust operations of Period 2 projects • Review and revise targets (if deemed appropriate)	Adjust operations of Period 3 projects

[12] Determined by AdH-predicted salinity for given CERP project affecting Biscayne Bay

Uncertainty ID	Indicator	Threshold (Interim/Project Restoration Goal)	Full Restoration Target (estimated time frame)	Trigger(s) for Management Action	Management Action Option(s) 1	Management Action Option(s) 2	Management Action Option(s) 3
4, 5, 6, 14	Pink Shrimp and other epifauna Pink Shrimp system-wide ecological indicator parameters, annually	Pink shrimp threshold determined by plugging AdH salinity output from given CERP project affecting Biscayne Bay into shrimp HSI At a minimum, pink shrimp abundance moving toward target Other epifauna indicators (e.g., grass shrimp) increase in abundance	Juvenile pink shrimp HSI values as predicted using predicted pre-drainage salinity conditions (those salinity conditions not yet available)	Juvenile Pink Shrimp HSI is less than what is predicted for any given CERP project preferred alternative Juvenile pink shrimp exhibits a negative long-term trend (i.e., increased frequency of yellow and red for the juvenile pink shrimp system-wide indicator report) 5% decrease in juvenile pink shrimp spatial coverage and/or species specific densities from existing conditions as a function of upstream hydrologic changes.	Adjust operations of BBCW Expedited Project to change *spatial* and /or *temporal* distribution of water Adjust operations of C&SF system -related water management structures to improve quantity, timing, and distribution of water Model refinement and coupling to improve ability to forecast effects of operations and adaptive operational changes	• Adjust operations of Period 2 projects • Review and revise targets (if deemed appropriate)	Adjust operations of Period 3 projects to change *spatial* and/or *temporal* distribution of water Model refinement and coupling to improve ability to forecast effects of operations and adaptive operational changes
4, 5, 6, 14	Salinity (wetland surface and groundwater) surface water salinity/conductivity, continuously groundwater conductivity, monthly porewater conductivity and below ground resistivity, quarterly Indicator currently not monitored by MAP.	Threshold determined by AdH prediction of salinity resulting from any given CERP project affecting Biscayne Bay At a minimum, salinity regime should show trend moving toward the target for any given CERP project affecting Biscayne Bay	Salinity in wetlands as predicted by AdH model under pre-drainage condition (will provide target only in wetlands within AdH domain)	Observed salinity in wetlands within AdH domain less favorable than AdH-predicted salinity for given CERP project Change in spatial extent of wetland surface water or groundwater salinity relative to two similar rainfall years from the period of record Salinity magnitude exceeds equivalent rainfall conditions for the past 2 years from the period of record) and/or saltwater wedge movement inland.		Adjust operations of Period 2 projects Review and revise targets (if deemed appropriate) Plug or fill mosquito ditches in BBCW project area to improve distribution	Adjust operations of Period 3 projects
4, 5, 6, 14	Juvenile Crocodiles Juvenile growth and survival system-wide ecological indicator parameters, annually (Indicator currently not monitored by MAP.)	At a minimum, juvenile crocodile growth and survival exhibits trend moving toward target Juvenile crocodile HSI values using salinity conditions predicted by given CERP project preferred alternative	Juvenile crocodile HSI output using predicted pre-drainage salinity conditions in Biscayne Bay (those salinity conditions not yet available) Alternately, nesting density similar to natural areas (e.g., Crocodile Lakes National Wildlife Refuge	Juvenile Crocodile HSI is less than what is predicted for any given CERP project preferred alternative Juvenile crocodile survival and growth exhibits a negative long-term trend Increased frequency of yellow and red for the crocodilians system-wide indicator report for Biscayne Bay 5% decrease in juvenile crocodile growth and survival from existing conditions as a function of upstream hydrologic changes.		Adjust operations of Period 2 projects Remove dense woody vegetation on the berms associated with drainage ditches and creeks to improve nesting habitat Review and revise targets (if deemed appropriate)	Adjust operation of Period 3 projects Increase berm elevation using fill (marl or sand) to improve nesting habitat
4, 5, 6, 14	Mangrove and white zone (vegetation change); vegetation transects, annually; aerial landscape analysis every 5 years (Indicator currently not monitored by MAP.)	At a minimum, white zone footprint decreases in response to any project providing improved quantity, timing and/or distribution of fresh water	Footprint of white zone delineated from earliest aerial photographs. (as per Ross 2000, and Egler 1952 studies) Graminoid marsh spatial area similar to that as per Davis (1943) vegetation map.	White zone expansion rate exceeds Ross rate (3 km/50 yr west of US1, 1 km/50 yr east of US1) mangrove zone expansion rate exceeds current rate of expansion. Graminoid spatial extend decreases or exhibits no change		Adjust operations of Period 2 projects Physically remove forested wetland vegetation to promote growth and establishment of graminoids Provide more natural fire regime to promote and maintain graminoid marsh community	Adjust operation of Period 3 projects

Uncertainty ID	Indicator	Threshold (Interim/Project Restoration Goal)	Full Restoration Target (estimated time frame)	Trigger(s) for Management Action	Management Action Option(s) 1	Management Action Option(s) 2	Management Action Option(s) 3
						Review and revise targets (if deemed appropriate)	
4, 5, 6, 14	Soil elevation and depth, annually (Indicator currently not monitored by MAP.)			Reduction in elevation Increase in rate of coastal soil loss over the existing rate.	Adjust operations of BBCW Expedited Project to change *spatial* and /or *temporal* distribution of water Adjust operations of C&SF system -related water management structures to improve quantity, timing, and distribution of water Model refinement and coupling to improve ability to forecast effects of operations and adaptive operational changes	Adjust operations of Period 2 projects Review and revise targets (if deemed appropriate)	Adjust operation of Period 3 projects
4, 5, 6, 14	Periphyton (nutrient availability) - periphyton tissue nutrient content, quarterly; soil nutrient, every 2 years (Indicator currently not monitored by MAP.)			Alteration of current spatial distribution relative to current conditions Increased frequency of yellow and/or red conditions for the periphyton nutrient content system-wide indicator report		Adjust operations of Period 2 projects Plug or fill mosquito or drainage ditches as needed to obtain desired freshwater distribution and hydropattern	Adjust operations for Period 3 projects System-wide/Regional performance issue analysis (more water)
4, 5, 6, 14	Algal bloom (surface water quality); monthly sampling (Indicator currently not monitored by MAP.)			Alteration of current surface water nutrient spatial distribution or concentrations relative to current conditions Increased frequency of yellow and red conditions for the algal bloom system-wide indicator report		Adjust operations of Period 2 projects Improve and enforce best Management Practices Review and revise targets (if deemed appropriate)	Adjust operations of Period 3 projects
4, 5, 6, 14	Soil nutrients (transport & availability); Soil and vegetation nutrient transects, bi-annually; soil P, quarterly (Indicator currently not monitored by MAP.)			Movement of spatial nutrient front or increase in nutrient rate of release from soils		Adjust operations of Period 2 projects Review and revise targets (if deemed appropriate)	Adjust operation of Period 3 projects
10, 14	Invasive exotic vegetation and animals • Vegetation, monthly or seasonally • Animals, daily or seasonally *Per Invasive Species Monitoring Plan (Indicator currently not monitored by MAP.)	Dependent on invasives removal activities tied to project	No invasive plants or animals in Biscayne Bay area	No new introductions of invasive exotic species into area Suppression of established invasive species to the lowest feasible level such that ecosystem impacts are minimized Management decisions based on Florida Weed Risk Assessment Tool, biological profiles and risk assessments (animals) using ECISMA and FWC approach. Trigger is a function of K vs. R-selection by the invasive species.		Adjust operations of Period 2 projects Review and revise targets (if deemed appropriate)	Adjust operations of Period 3 projects Refinement or development of Invasive Species Risk Assessment Tools Implement CEPP Invasive Species Management Plan measures CEPP invasive and nuisance species management team may provide information to reduce future species management costs by redesigning or retrofitting project features. If the suggestions are beyond the scope of the CEPP Plan, additional authorization would be required.
3, 4, 5, 6, 14	LEC Stage/Flow; stage and/or surface/groundwater flow monitoring, continuous	•	•	Exceed a 1% reduction in flow to Biscayne Bay relative to current conditions Violation of the Minimum Flows and Levels for Florida Bay; greater than 1% decrease in canal flow		Adjust operations of Period 2 projects Review and revise targets (if deemed appropriate)	Adjust operations of Period 3 projects Operational tests Develop/refine operational plans Model development/refinement

Uncertainty ID	Indicator	Threshold (Interim/Project Restoration Goal)	Full Restoration Target (estimated time frame)	Trigger(s) for Management Action	Management Action Option(s) 1	Management Action Option(s) 2	Management Action Option(s) 3
	(Indicator currently not monitored by MAP.)			and/or stages compared to existing April conditions and/or in dry years violation of existing consumptive use permit requirements Increase of 1% or greater in canal or groundwater stage compared to ECB October average water table.			
? (CEPP)	LEC Water Quality (ground and surface); water quality, monthly (Indicator currently not monitored by MAP.)	•	•	Violation of FAC 62-160 for various water quality parameters increased frequency or magnitude of exceedences in surface water monitoring segments that would lead to designation of "impaired" Declining trend compared to prior condition Detection of indicators of surface water influence in groundwater monitoring wells.	Adjust operations of BBCW Expedited Project to change *spatial* and /or *temporal* distribution of water Adjust operations of C&SF system -related water management structures to improve quantity, timing, and distribution of water Model refinement and coupling to improve ability to forecast effects of operations and adaptive operational changes	Adjust operations of Period 2 projects Review and revise targets (if deemed appropriate)	Adjust operations of Period 3 projects to change *quantity* of water delivered
4, 5, 6, 14	LEC Wetland Vegetation; vegetation transects, annually; aerial landscape analysis every 5 years during construction and into O/M. (Indicator currently not monitored by MAP.)	•		Exceed a 1% reduction in flow to Biscayne Bay relative to current conditions Violation of the Minimum Flows and Levels for Florida Bay greater than 1% decrease in canal flow and/or stages compared to existing April conditions and/or in dry years violation of existing consumptive use permit requirements Increase of 1% or greater in canal or groundwater stage compared to ECB October average water table 5% reduction in spatial coverage and/or species specific densities from existing conditions as a function of upstream hydrologic changes.		Adjust operations of Period 2 projects Review and revise targets (if deemed appropriate)	Adjust operation of Period 2 projects Operational tests Develop/refine operational plans Model development/refinement

3.8 Total System

The south Florida Everglades ecosystem that is to be restored by the Comprehensive Everglades Restoration Plan projects and other restoration and best management practice actions is the sum of the regions (Northern Estuaries, Lake Okeechobee, Greater Everglades, and Southern Coastal Systems) and how water will move through these regions to meet natural system goals in addition to existing project goals for water supply and flood damage risk reduction. There are global uncertainties that relate to getting the quantity, quality, timing and distribution of water right to restore the defining characteristics of the south Florida Everglades ecosystem, and are contained in this section. Specific AM strategies related to projects and activities in each region that were identified in the previous sections, so no specific Total System adaptive management strategies are yet described in this section. Ultimately, the CERP Program-Level AM process described in Appendix A – Section 4.0, is the approach for addressing larger programmatic uncertainties that the CERP program faces in implementing the plan and ensuring its success.

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3.8.1 Total System Uncertainties

ID	Uncertainties (Source)	Uncertainty Details	Relevance	Knowledge - Level of understanding	Relevance (Actionable) - Level of confidence that actions can be taken	Risk - Level of risk to meeting goals	Strategy Characterization (Tier 1, 2 or 3)	Category of Uncertainty (Primary/ Secondary)	Existing and Potential Recommended Strategies
TS-1	What are the hydrological needs of the total Everglades (natural) and Human (Urban and Agricultural) systems? How much of this need is provided by CERP and how much more storage is needed?	There are a number of facets to this uncertainty. Each region's questions about hydrologic needs and amount met by CERP all link to this Total System (TS) question. In addition, there are questions about how these scenarios can be addressed in the USACE planning process. Much is Known about individual regions needs (e.g., SCS salinity, GE NSM) and restoration indicators, but an integrated synthesis is not yet available. In addition, an integrated suite of models and planning scenarios is not yet available.	Affects the availability of adequate water supply, after future agricultural and urban demands, to fulfill CERP program and project needs; i.e. reservoirs and STAs	Medium	High	High	1	Ecological/ Socio-economic	Synthesize existing information about individual regions. Refine existing system-wide models for accuracy and reliability, or develop new models. Conduct a technical system-wide review of projected CERP performance given new information about restoration and human system hydrologic needs, as well as the validity of CERP technologies/ projects in meeting those needs in addition to what was originally planned for in CERP. Confirm how GE targets (stage and flow) relate to SCS targets, as well as LO and NE targets relate to each other. Identify viable options to incrementally move towards hydrologic needs.
TS-2	What system changes could be affected by uncertain future agricultural and urban water demands and changes to the system from climate change (e.g., rainfall, evapotranspiration, temperature, and sea-level rise)? How well will CERP perform under a variety of different scenarios compared the 2000 scenario?	Subset of number TS-1. SERES, Tom Smith (USGS), and planners from MIT also looking at this.		Medium	High	High	1	Ecological/ hydrological	Characterize uncertainty levels for changes in sea-level rise, evapotranspiration, temperature, and rainfall. Update CERP formulation assumptions for these parameters. Do scenario analysis to evaluate robust project plans to allow for adaptation increase habitat resilience. Review results of SERES (Tom Smith, USGS); 4 county compact analysis; MIT and FAU/USGS work on this question.
TS-3	How will climate change affect the regional water balance? How will the hydrologic assumptions used for CERP projects be affected?	Subset of number TS-1, TS-2.	Affects water budget for environment and human systems. There is a need for a regional climate model that can project precipitation and temperature regimes under global warming scenarios.	Medium	High	High	1	Ecological/ hydrological	A regional climate model should be developed to project precipitation and temperature regimes under climate change scenarios to support water budget scenario analysis.
TS - 4	If the lake stage in Lake Okeechobee is achieved for LO indicators, will the rest of CERP NE projects be able to address NE and its effects on downstream water bodies.	Assuming we have determined the appropriate lake stage for Lake O plants and animals, and we can achieve that stage, does CERP do enough to relieve Lake O discharge problems to the northern estuaries? How much of the estuarine problems is CERP expected to remedy? For example, if the IRL-S, LOWP and C-43 reservoir projects are constructed, and the estuaries do not respond as expected, should CERP do more? From an estuary perspective, which is more damaging – volume and timing of Lake O water releases, or the nutrients in that water?	Related to nutrients and peak freshwater discharges from Lake O and their duration. Performance measure targets needed and used to evaluate during watershed planning.	Medium	High	High	1	Hydrological	Continued review of CERP-related water storage projects and strategies and evaluation of the feasibility of these projects. Existing related monitoring includes that done as part of Lake Okeechobee stage monitoring; LO Water Quality and Phytoplankton Hypothesis Cluster; NE SAV Hypothesis Cluster (water quality); NE Benthic Infaunal Invertebrates (water quality) and NE Oyster Health and Abundance (water quality). Additionally, LO Stage PM could be updated to reflect need for targets.

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4 APPENDIX A - CERP PROGRAMMATIC AM COMPONENTS IN PLACE

This section describes the components of each AM activity at the program-level, along with the documents and responsible parties. This section is not intended to discuss these activities in detail, but rather provide a short synopsis with links to existing documents for further information. Additionally, this section summarizes the current status of these activities as well as any planned next steps.

4.1 Activity 1 – Stakeholder Engagement and Interagency Collaboration

4.1.1 Non-Governmental Stakeholder Engagement

There are several guidance documents available to CERP teams for identifying and engaging non-governmental stakeholders, which are listed below:

- USACE Planning Manual (Yoe and Orth, 1996) – Guidance on identifying stakeholders and techniques for public involvement in the USACE planning process.
- USACE Planning Guidance Notebook (USACE, 2000) – Guidance on when to engage stakeholders and requirements for public involvement in USACE Civil Works planning
- USACE EC on Planning in a Collaborative Environment (USACE, 2005) – Encourages collaborative planning with other Federal, State, and local agencies and Tribes, as well as collaborative monitoring and adaptive management efforts.
- CERP Guidance Memorandum (CGM) 011.02: Federal Advisory Committee Act (FACA) Requirements for CERP Teams (USACE and SFWMD, 2003a) – Provides CERP-specific guidance on FACA that requires public comment periods during CERP meetings, and prohibits two-way dialogue.[13]
- CERP AM Integration Guide (RECOVER, 2010a) and CGM 056.00: Guidance for Integration of AM into CERP Program and Project Management (USACE and SFWMD, 2011) – Outline existing venues for two-way dialogue with non-governmental stakeholders (i.e., public workshops, South Florida Ecosystem Restoration Task Force Working Group or Science Coordination Group meetings, and WRAC meetings).

In addition, a draft white paper entitled "Options for Stakeholder Engagement and Collaborative Process" outlines four potential options to achieve two-way dialogue with non-governmental stakeholders within the requirements of FACA for CERP implementing agencies to consider (Meridian Institute, 2010).

[13] National Federal Advisory Committee Act guidance can be found at http://www.iwr.usace.army.mil/Missions/CollaborationandConflictResolution/CPCX/Law,PolicyandGuidance.aspx

4.1.2 Interagency Collaboration and Consultation with Native American Tribes

There are several forums for interagency collaboration that include Tribal participation, including RECOVER teams, PDTs, the WRAC, and the South Florida Ecosystem Restoration Task Force (RECOVER, 2010). RECOVER and PDT meetings are the primary forum for interagency collaboration to exchange information and address restoration related issues, but have limited opportunities for non-governmental and public engagement. In addition, USACE Policy Guidance Letter No. 57 on Indian Sovereignty and Government-to-Government Relations with Indian Tribes guides consultation with the Miccosukee Tribe of Indians of Florida and the Seminole Tribe of Florida for CERP (USACE, 1998).

4.2 Activity 2 – Establish/Refine Restoration Goals and Objectives

The "Yellow Book" (USACE and SFWMD, 1999) outlined the broad, system-wide goals that are the basis of CERP and its component projects related to enhancing ecologic values, economic values and social well-being (see **Error! Reference source not found.**).

Table 4-1 CERP Goals (Table 5-1 of Yellow Book)

Goal: Enhance Ecologic Values	Goal: Enhance Economic Values and Social Well Being
• Objective 1 (O1) Increase the total spatial extent of natural areas	• Objective 4 (O4) Increase availability of fresh water (agricultural/municipal & industrial)
• Objective 2 (O2) Improve habitat and functional quality	• Objective 5 (O5) Reduce flood damages (agricultural/urban)
• Objective 3 (O3) Improve native plant and animal species abundance and diversity	• Objective 6 (O6) Provide recreational and navigation opportunities
	• Objective 7 (O7) Protect social and cultural resources and values

In addition to these broad goals, the "Yellow Book" outlined the intended objectives of each of the CERP components (i.e., projects). These are the goals and objectives that each project uses to specify its project-level objectives during the planning phase. There was a recognition in the "Yellow Book" that "…the point at which restoration is achieved, and the precise characteristics of that 'restored' system, represent questions that are not completely answerable at present" (USACE and SFWMD, 1999, p. 5-37) and that consensus on what a restored ecosystem should be will emerge over time, as more information becomes available. More information on CERP goals and objectives as described in the Yellow Book can be found at: http://www.evergladesplan.org/about/rest_plan_pt_03.aspx.

To improve clarity on the definition of CERP success, the implementing agencies prepared a more focused vision statement along with a set of guiding principles (USACE and SFWMD, 2003b) in 2003. One of the principles states that "Definitions of overall plan success will be refined through time as new knowledge provides improved understandings of natural and human systems in south Florida" (USACE and SFWMD, 2003b). In 2009 an effort known as the 2010 Shared Definition of Everglades Restoration was initiated by the implementing agencies and RECOVER to better define the attributes of a restored Everglades in order to provide enhanced information for planning, design, implementation and operation of restoration projects (USACE and SFWMD, 2010a). The Shared Definition effort involves refining CERP goals and targets in light of new information and opportunities, and using the refinements to specify measurable short-term goals and targets.

4.3 Activity 3 – Identify and Prioritize Uncertainties

The "Yellow Book" noted that one of the major hurdles to complete restoration is that few of the quantitative, ecological characteristics of the pre-drainage wetlands of south Florida are known (USACE and SFWMD, 1999). In addition to hydrological and ecological uncertainties, there were considerable uncertainties related to the technologies proposed to achieve Everglades restoration (e.g., aquifer storage and recovery [ASR], seepage management, (see Appendix O: Uncertainty Analysis in USACE and SFWMD, 1999). As a result of these scientific/technical uncertainties, pilot projects were authorized to obtain information about the feasibility of these new technologies (DOD, 2003 §385.12), and RECOVER was required to develop a system-wide monitoring plan (i.e., the MAP), as part of the AM program, to provide information on hydrological and ecological uncertainties (DOD, 2003 §385.20 (e) (1)). The MAP provides the most comprehensive list of scientific/technical uncertainties to date, including both global (e.g., climate change, sea level rise) and regional uncertainties (RECOVER, 2004; 2009). In addition to scientific/technical uncertainties, there are also policy/management uncertainties with the potential to impact the ability to achieve CERP goals and objectives. While informed by scientific/technical information, policy/management uncertainties require resolution by CERP managers and once identified are brought to the DCT to be addressed.

Until development of this Programmatic AM Plan, there has never been an attempt to systematically identify and prioritize CERP uncertainties, including both scientific/technical and policy/management. Section 4 of this plan describes the process by which the uncertainties were identified and prioritized, and Appendix 1 shows the complete list, organized by region and by those that apply to the total system.

Another component of this activity is the development of AM strategies to address prioritized uncertainties, such as sensitivity analyses, modeling tests, data mining, monitoring pre/post-restoration responses, physical models/field tests or policy/management decisions. Some uncertainties have strategies already in place; however, the uncertainties and strategies have not been linked together in one document until this plan (see Section 4). Other uncertainties do not have strategies in place and those gaps have been identified in this plan, along with potential strategies for management to consider (see Section 4).

4.4 Activity 4 – Apply Conceptual Models and Develop Hypotheses and Performance Measures

4.4.1 Conceptual Ecological Models and Hypothesis Clusters

Conceptual ecological models (CEMs) provide a broad understanding of the existing factors and assumptions that have resulted in stressed or diminished natural characteristics of the south Florida and Everglades ecosystems (RECOVER, 2004; Wetlands, 2005). CEMs provide the scientific foundation to develop testable system-wide hypotheses (RECOVER, 2006b), grouped as hypothesis clusters, such as oyster or submerged aquatic vegetation hypothesis clusters (RECOVER, 2009). These system-wide hypotheses describe the current understanding of how the defining characteristics of the ecosystem can be restored and are the basis for MAP monitoring and are used to verify CERP's progress and performance, as well as recommend potential adjustments. Conceptual ecological models for CERP can be found at: http://www.evergladesplan.org/pm/recover/cems.aspx.

4.4.2 Performance Measures and Interim Goals/Interim Targets

Performance measures in CERP are standards of how to measure restoration success that ideally, have two main components: 1) the standard of success toward which restoration should strive, which is sometimes species or area-specific, or sometimes applied system-wide, and 2) predictive modeling tools that can indicate whether proposed restoration plans and operations will help to achieve the standards of success. Performance measures are derived from the stressors and attributes (restoration indicators) defined in the CEMs, and should be coordinated with ecological monitoring that measures achievements of the standards. RECOVER has developed total system performance measures, as well as those pertaining to the four geographic regions of the MAP (i.e., Lake Okeechobee, Northern Estuaries, Greater Everglades, and Southern Coastal Systems)[14], which are used as the basis for project-specific performance measures. RECOVER performance measures can be found at: http://www.evergladesplan.org/pm/recover/eval_team_perf_measures.aspx.

As required by the Programmatic Regulations, interim goals and targets, which most are subsets of system-wide performance measures, were developed by RECOVER to evaluate performance of successive groups of projects in five-year increments (RECOVER, 2005). Interim goals assess CERP progress toward regional hydrologic performance targets, improvements in water quality, and anticipated ecological responses (DOD, 2003 §385.38). Interim targets assess CERP progress towards the other water-related needs of the region, including water supply and flood protection (DOD, 2003 §385.39). The interim goals and

[14] RECOVER total system and regional performance measure documentation sheets are located at http://www.evergladesplan.org/pm/recover/eval_team_perf_measures.aspx

targets agreements were approved in 2007 and are scheduled to be reviewed at least every five years and revised as needed (DOA et al. 2007; DOA and State of Florida, 2007). The most recent review is documented as part of the 2014 System Status Report.

4.4.3 Using Performance Measures

Predictive tools, such as hydrological and ecological models, are used to conduct system-wide evaluations with respect to performance measures by simulating outcomes of proposed actions in the ecosystem such as operational changes and/or new restoration projects. Hydrologic models commonly used include the South Florida Water Management Model or 2x2, the Regional Simulation Model RSM, and the Natural System Model (NSM). Performance measures and associated hypotheses and predictive tools are refined and updated based on new information provided by the MAP, in accordance with the principles of AM.

4.5 Activity 5 – Integrating AM Principles into Program Implementation

Adaptive management principles were built into CERP from its inception as part of the "Yellow Book," WRDA 2000, and the Programmatic Regulations. The "Yellow Book" provided a mechanism to integrate new information into decision-making processes to allow for further adjustments to the Plan, as necessary, and WRDA 2000 established the initial sequencing of CERP components and projects (i.e., management actions) such that uncertainties could be reduced and new information could be incorporated in a cost-effective, timely manner. In 2005, the Master Implementation Sequencing Plan (MISP) was completed and defined the order in which CERP projects would be planned, designed, and constructed, based on the banding or grouping of projects within five-year time periods (USACE and SFWMD, 2005b). Ultimately, the MISP was incorporated into an overall schedule for restoration (CERP and non-CERP initiatives) known as the Integrated Delivery Schedule (IDS)[15]. The IDS is focused on prioritizing and sequencing both CERP and non-CERP restoration projects to achieve restoration objectives consistent with appropriate predecessor-successor relationships and funding constraints.

One missing component of this activity is the development of regional management options matrices that outline potential adjustments to projects and operations based on results from monitoring and assessment. These matrices are developed by linking hypothesized performance of projects or regional groupings of projects to monitoring and identifying corresponding targets. They support future decision making by providing a range of potential management actions (i.e., contingencies) to be considered if adjustment is required. Section 4 of this plan describes the process used for developing the matrices and Appendix 3 contains the matrices themselves.

[15] The Integrated Delivery Schedule is located at http://www.evergladesplan.org/pm/progr_int_schedule.aspx

In addition, the AM principle of robust and flexible planning, design, construction, and operations can be incorporated into the CERP project plans, as stated in CGM 056.00, and for CERP through the Comprehensive Plan Modification Report (see RECOVER, 2011). CGM 016.00 requires that future sea level rise be a plan formulation and performance consideration for all CERP components and features and provides guidance on how this is to be accomplished (USACE and SFWMD, 2004) to ensure robust performance in light of climate change uncertainty. Additionally, the Programmatic Regulations require that CERP develop a system operating manual and individual project operating manuals to provide potential operational flexibility (through the application of AM within the context of authorized Central and Southern Florida project purposes) (see RECOVER, 2010a for more details). A draft of the Initial System Operating Manual has been developed, as a precursor to the System Operating Manual (USACE and SFWMD, 2005a).

4.6 Activity 6 – Monitoring

The development and execution of scientifically rigorous monitoring plans are essential components of the CERP AM process because they allow for an assessment of the progress toward reaching CERP goals and objectives by documenting pre-CERP conditions and comparing that information to actual ecological conditions after implementation. This has been done at the programmatic level through the implementation of the CERP MAP, the goals of which are to establish a pre-CERP reference state (i.e., baseline) for key system-wide performance measures, increase understanding of ecological cause-and-effect relationships in the Everglades, and assess the system-wide responses to CERP project implementation (RECOVER, 2004; 2009).

Project-level monitoring fills gaps specific to project effects not covered by the MAP supported monitoring and to address project specific uncertainties. Part of the monitoring program is to maintain all of the data collected, through both the system-wide and project-level monitoring, in a central location and conduct quality assurance/quality control. There are several CERP teams and processes in place to guide data management and quality assurance/quality control for MAP and project monitoring data, including the CERP Information Data Management (IDM) Team and the CERP Quality Assurance and Oversight Team (QAOT) (USACE and SFWMD, 2008; RECOVER, 2010a). In addition, the Quality Assurance Systems Requirements (QASR) Manual for CERP has been developed to ensure all project-level monitoring is scoped and entered into the common databases using comparable standards, as appropriate (USACE and SFWMD, 2010b).

Associated with the performance measures and the monitoring are decision criteria, which are thresholds and time, used to determine whether restoration success has been met or adjustments are needed, as required by USACE (2009a). More specifically, thresholds are a point, range, or limit that signifies when restoration performance is on track for a particular set of projects or veering away from expectations and is trending toward an unintended outcome. For CERP the formally recognized decision criteria are the interim goals and targets. In some cases, thresholds have not yet been defined, and RECOVER performance measures restoration targets are used instead. Thresholds are described per stressor/attribute (restoration indicator) to be monitored because each should result in an outcome that informs management decisions, as described in management option matrices in Section 4 and Appendix 3.

4.7 Activity 7 – Assessment

RECOVER coordinates system-wide/regional assessment of CERP performance using monitoring data from the MAP, CERP projects, as well as other applicable monitoring information. There are two assessment reporting cycles: annual reports from principal investigators and the System Status Report (SSR), which has been produced twice every five years (RECOVER, 2006c; 2007; 2010b, 2012, 2014). The SSR is an overview of ecosystem status, including whether interim goals and targets are being met as required for the RECOVER Technical Report (DOD, 2003 §385.31(b)(4)). The SSR also provides the potential management relevance and recommendations related to its findings to facilitate adaptive management. In addition to these two reports, restoration performance data and recommendations are also delivered to decision makers via the annual South Florida Environmental Report (e.g., SFWMD and FDEP, 2011), the annual South Florida Wading Bird Report (e.g., Cook and Kobza, 2010), reporting through the U.S. Environmental Protection Agency's Everglades Ecosystem Assessment Program (R-EMAP) (e.g., Scheidt and Kalla, 2007). The CERP AMIG outlines the process by which programmatic performance issues are identified, validated, and elevated for managers to address (RECOVER, 2010a). There are several other programmatically-required reports providing scientific assessment of the CERP which inform and/or are informed by the SSR, such as the biennial peer review reports produced by the National Research Council's (NRC) Committee on Independent Scientific Review of Everglades Restoration Progress (CISRERP) (NRC, 2007; 2008; 2011, 2012, 2014), the South Florida Ecosystem Restoration Task Force's System-wide Ecological Indicators Report (SFERTF, 2010, 2012), and the Five-Year Report to Congress (USDOI and USACE, 2005; 2010) (see RECOVER, 2010a for more details).

Other efforts have been initiated to provide new information to aid adaptive management of CERP. The Scientific Knowledge Gained (SKG) document summarizes new information from monitoring and research, engineering advances, and modeling pertinent to the Everglades and south Florida ecosystem gained since CERP's authorization (RECOVER, 2011). The SKG document, as part of the 2010 Shared Definition of Everglades Restoration effort, provides updated information to be incorporated into CERP planning, design, implementation and operations. Additionally, the Decomp Physical Model (DPM) is being undertaken as a prime example of active adaptive management for CERP (Sklar et al., 2010). The DPM is a large-scale field study to address scientific, hydrologic, and water management issues specific to uncertainties regarding the ecological need to completely backfill canals and the ecological benefit of sheetflow. New information gained from the DPM will be used to inform the Decomp project, although it will have broader application and relevance.

4.8 Activity 8 – Feedback to Decision Making

The CERP AMIG outlines the process by which RECOVER presents performance issues identified through the SSR to the DCT or QET[16] (RECOVER, 2010a). An issue team is created to identify and develop potential solutions by:

1. scoping the extent of the issue(s) and developing a common interpretation of the relevant scientific and technical information;
2. developing options, beginning with the management options matrix (see Section 4); and
3. analyzing the options and developing potential management actions. From the options analysis, one of two reports may be prepared: an Options Report and/or an Assessment Report.

The concept of an Options Report was developed as a potential venue for presenting options for resolving an issue to managers (RECOVER, 2010a). The Assessment Report is described in the Programmatic Regulations and is a formal decision document (DOD, 2003 §385.31 (b)(4)(i); RECOVER, 2010a). Both reports contain the findings from the options analyses including various potential solutions to the performance issue(s) being addressed. Options are presented by the issue team to the DCT or QET for evaluation and agreement on a recommended corrective action, following the decision-making process described in the CERP AMIG (RECOVER, 2010a).

In addition to assessment-generated performance issues, necessary updates may be identified through periodic CERP updates and system-wide evaluation, as required by the Programmatic Regulations (DOD, 2003 §385.31 (b)(4)(c)). These updates provide an evaluation of the Plan using new or updated modeling that includes the latest scientific, technical, and planning information. According to the Programmatic Regulations, periodic CERP updates should be conducted whenever deemed necessary or at least every five years. The Initial CERP Update (ICU) Report was produced by RECOVER in 2005 to re-simulate the CERP using updated models (CERP-A instead of CERP-0) and input data. The ICU report recommended developing new operational scenarios referred to as CERP-A refinement to further improve restoration performance. (RECOVER, 2005b). In 2010 RECOVER completed the Technical Report on System-wide Performance of CERP 2015 Band 1 Projects (Band 1 Report), which simulated the ten initial CERP projects (i.e., “Band 1”) and their operations to see their contribution to overall restoration (RECOVER, 2010c). Results revealed that regional

[16] Note – QET (Quarterly Executive Team) replaces the JPRB (Joint Project Review Board), and QAT (Quarterly Agency Team) replaces the QRB (Quality Review Board).

groupings of projects provide measurable, predicted benefits, and the report recommended that programmatic AM strategies be developed as part of the System Operating Manual Study.

Finally, this activity involves bringing scientific information about competing ecological demands to CERP managers to help inform decision making to resolve these issues. In their third biennial report, the CISRERP clearly states that rigorous scientific analyses of these competing demands (e.g., water quantity vs. quality) should be conducted by RECOVER in collaboration with water managers and then communicated to managers (NRC, 2011). RECOVER recognizes the need to conduct an inventory and develop scientific background information on these competing demands.

4.9 Activity 9 – Adjustment

As described by the Programmatic Regulations, if new information resulting from assessment indicates the need for an adjustment to ensure that CERP goals and purposes are achieved, decision makers may consider the following management actions to implement the adjustment (DOD, 2003 §385.31 (d)):

1. modifying operations,
2. modifying the design or operational plan for a project yet to be implemented,
3. adding new components or deleting components not yet implemented,
4. removing or modifying a component of the Plan already in place, or
5. a combination of these.

These actions are implemented through revisions to the SOM (operations), the IDS (sequencing), project modifications, or a Comprehensive Plan Modification Report (major changes to the Plan) (see RECOVER, 2010a for more details). If the USACE and SFWMD determine that major changes to the Plan (e.g., revisions to CERP goals and objectives, the deletion or addition of actual projects to the plan, or major changes in policies or procedures) are necessary to achieve the goals and objectives of the plan, then a Comprehensive Plan Modification Report will be prepared following the process in the Programmatic Regulations. Other adjustments to CERP implementation that are required of RECOVER include updating CERP technical information (models, performance measures, monitoring), reprioritizing uncertainties and refining system-wide hypotheses in the MAP about how the system would respond to CERP adjustments.

Project-level adjustments with additional cost that were included and budgeted in the approved project-level AM plan can be implemented, but those that were not included may require Congressional authorization (RECOVER, 2010a). The costs of AM adjustments should be explicitly described and the reasonableness of those costs will be reviewed (USACE, 2009a). If monitoring results indicate the need for adjustments, the costs of those changes will be cost-shared by the implementing agencies (USACE, 2009a). As CERP goals and objectives are achieved and indicator targets are met, monitoring and assessment may be adjusted and refined to focus on measuring the next set of projects, operations, and expected responses. Also, as new information reduces uncertainty about how the natural system will respond to the Plan it may provide opportunities to refine and clarify CERP goals, objectives, and desired endpoints (restoration targets) (see Activity 2 for discussion of 2010 Shared Definition of Everglades Restoration).

5 APPENDIX B - REFERENCES

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