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The Recover Team's Recommendations for Interim Goals and Interim Targets for the Comprehensive Everglades Restoration Plan

RESTORATION COORDINATION AND VERIFICATION (RECOVER)

COMPREHENSIVE EVERGLADES RESTORATION PLAN

CENTRAL AND SOUTHERN FLORIDA PROJECT

Executive Summary

The Comprehensive Everglades Restoration Plan (CERP or the Plan) was authorized by Congress in the Water Resources Development Act of 2000. This act introduced the concept of "Interim Goals", which was further developed in the Programmatic Regulations of 2003 defining Interim Goals as "a means by which the restoration success of the Plan may be evaluated throughout the implementation process". The regulations also required the development of "Interim Targets" for "evaluating the progress towards other water-related needs of the region provided for in the Plan…" This document provides RECOVER's recommendations for Interim Goals and Interim Targets as required by the Programmatic Regulations.

One of the first steps in the development of the Interim Goals and Interim Targets was the selection of indicators – aspects of the natural or urban systems that are related to the goals and purposes of the CERP and that we will keep track of (monitor) as CERP projects are constructed. The Interim Goals and Interim Targets are predictions of how the indicators will change as the CERP is implemented (by "implemented", we mean as projects are constructed or built, and become operational) and do not necessarily meet the desired restoration conditions, which are also described in this report. The indicators selected to be developed into Interim Goals and Interim Targets represent the full range of expected changes – from upstream to downstream, from short-term to long-term, from hydrological to biological. The predicted and desired restoration conditions contained in this report are based on the best available science applied within and alongside modeling tools.

The Programmatic Regulations require that Interim Goals and Interim Targets be developed for five-year increments beginning with the baseline and ending at full implementation. At this time, a full set of five-year modeling increments was not available. For all of the indicators, Interim Goals and Interim Targets were developed for the four simulations produced during the development of the CERP: 1995 Base, 2010, 2015, and D13R (full implementation). In some instances, scientists did think they had enough information to predict other increments of time (2020, 2025, and 2030.

The document has been organized geographically (from north to south) to explain not only the predicted status of each indicator, but the inter-dependencies of the indicators. Interim Goals are presented in four sections: Northern Estuaries, Lake Okeechobee, Everglades, and Southern Estuaries. The Interim Targets are presented in the fifth section, called Water Supply and Flood Protection.

The Northern Estuaries

The Northern Estuaries have been affected by three major factors, or stressors, that impact the estuaries: damaging high and low freshwater inflows, degraded water quality, and habitat loss (this is where plants and animals live in the natural system). The American oyster and submerged aquatic vegetation (plants that live under water) are important indicators that have been affected by these stressors. The CERP is expected to improve conditions for oysters and submerged aquatic vegetation by providing several water storage systems that will improve

the delivery of fresh water to the estuaries. The area of oyster habitat in the St. Lucie Estuary is expected to increase substantially as a result of the Indian River Lagoon-South Selected Plan (which is not yet authorized) and the area in the Caloosahatchee Estuary is expected to improve steadily from 2010 through full CERP implementation.

Lake Okeechobee

Currently, Lake Okeechobee is affected by two major stressors that significantly impact its ecology: unnatural water levels and excessive phosphorus. These stressors have contributed to an increase in invasive exotic plants and the frequency of harmful algal blooms and a loss of the diverse species of animals that use Lake Okeechobee to live or breed in, among other impacts. The CERP is expected to improve conditions in the lake primarily by constructing aquifer storage and recovery wells and by providing several reservoirs and stormwater treatment areas that both facilitate more natural lake water levels and reduce nutrient loads entering the lake. Interim Goals for the lake predict improvements in total phosphorus and reduction in the frequency of algal blooms, along with improvements in lake water levels.

The Everglades

The major freshwater flowway that historically went from Lake Okeechobee south to Florida Bay has been negatively affected by a reduction in the spatial extent or size of the Everglades, reduced water storage capacity due to drainage canals, poor water quality, and compartmentalization that came about because of the original Central and Southern Florida Project. The effects of these stressors can be seen in the numbers of marsh fish that are available for birds and other “high food chain” animals to eat, the number of wading birds and where and when they nest, healthy alligators, the expansion of cattail into the sawgrass plains, and numerous other impacts. The CERP includes a variety of projects that will improve conditions in the Everglades: storage reservoirs to provide needed dry season flows; allowing more water to stay in the natural system through seepage management; removing some of the barriers to sheet flow (this is the decompartmentalization project); increasing spatial extent of natural areas, including improving the quality of existing areas; and water quality improvements. Interim Goals for the Everglades include predictions of increased spatial extent from 2015 through full CERP implementation, increased quantities of water available to meet natural system needs, an increase in alligators in some areas with no change expected in others, and a general increase in the number of nesting wading birds.

The Southern Estuaries

Man-made changes to the quality, quantity, timing, and duration of freshwater inflows to the Southern Estuaries have changed circulation and salinity patterns in the estuaries. These stressors have altered how the estuarine ecosystems functioned to provide habitat for animals such as pink shrimp and the seagrasses upon which they depend. The CERP will primarily benefit the nearshore plant and animal communities of southern Biscayne Bay, including Barnes and Card Sounds, and the seagrass beds of Florida Bay by improving freshwater

inflows. However, improvements in most areas and for most indicators are small and generally not evident until full CERP implementation.

Other Water-Related Needs

Today's population of nearly six million people is three times more than the existing water management system was designed to serve. Drought-induced water supply shortages and storm-induced flooding combined with the significant population growth have increased demand on the water management system. The CERP will help meet these demands primarily by increasing storage capacity in the system, enabling water managers to make this water available to urban and agricultural users as well as the natural system, and, in some cases, to hold this water to reduce flooding impacts. The Interim Targets predict a reduced frequency of water shortages, increased protection of the Biscayne aquifer against saltwater intrusion, and maintained flood protection capacity.

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Foreword

The Comprehensive Everglades Restoration Plan (CERP) is a complex plan made up of many individual projects that will work together to restore the South Florida ecosystem. Along with the natural system of lakes, wetlands, forests, estuaries and bays, the South Florida ecosystem includes people, too. As such, the CERP is designed to benefit both the people and natural system of South Florida as a whole.

Building the CERP projects will require a significant public investment over many years. Because such a large investment will be made over such a long time, it is important that we set goals and track the CERP to ensure that the public's investment is being used wisely and that good progress is being made along the way.

In order for us to report on the public's investment and CERP's progress, the U.S. Army Corps of Engineers has adopted rules that will act as the roadmap for governing how the CERP projects will be built. The rules, called "Programmatic Regulations", require that we establish "Interim Goals" to provide a means of tracking success in restoring South Florida's natural areas, and "Interim Targets" to provide a means of tracking success in providing people's needs for water. The reason the goals and targets are called "interim" is that we will be measuring our progress along the way, not just when the last project is built. In this manner, we will be able to regularly check to make sure CERP is successfully restoring the South Florida ecosystem.

We have recommended Interim Goals and Interim Targets for a variety of "indicators". An indicator is something we think is important about the natural and human systems in South Florida, and something we intend to measure (or "monitor") and then evaluate (or "assess") to gauge success. These indicators were specifically chosen to show how well the CERP is doing in achieving its goals and purposes. An indicator can either be an animal, such as a wading bird, or something physical, such as the number of water supply restrictions. The Interim Goals and Targets are our predictions about how the indicators will change as we build the CERP projects. The Interim Goals and Targets do not necessarily say where we wish we could be but represent where we think we will be at different points during the implementation of the CERP. As projects are built, we will also be measuring the indicators to see how they are actually changing compared to the interim predictions.

The context: how we got here

The greater Everglades ecosystem historically included the Kissimmee River south of Orlando, through Lake Okeechobee, with the Caloosahatchee Estuary to the west, the St. Lucie Estuary to the east, and the Biscayne and Florida Bays to the south. The Everglades covered a vast area of many diverse habitats. Management of the Everglades and our estuaries and bays for human purposes began just over 100 years ago.

The size of the ecosystem has been substantially and irreversibly reduced, including an approximately 50 percent loss of the true Everglades. Before people intervened, most rainwater soaked into the ground in the region's vast wetlands. As South Florida developed,

the canal system built over the past 100 years worked very effectively and drained water off the land too quickly. As a result, approximately *1.7 billion gallons of water per day* on average is discharged to the gulf and the ocean.

One consequence is that not enough water, mostly during the dry season, is available for the environment and people. At other times, during the wet season, there is too much water. In addition, canals and highways that criss-cross the Everglades have interrupted the historic overland sheet flow. Further, water quality throughout South Florida has deteriorated as some untreated urban and agricultural storm water is sent directly to wetlands and estuaries.

An over-abundance or scarcity of water and degraded water quality affects plants and wildlife that require specific water levels and flows during different seasons. The remaining Everglades, and indeed the entire South Florida ecosystem, no longer exhibit the functions, richness, and area that historically defined the pre-drainage system.

The context: where we want to go

The goal of Everglades restoration in South Florida is to recover an Everglades-type of ecosystem. What made the Everglades unique was its large size and that water flowed through a single interconnected system. This created a wide variety of habitats needed by many plants and animals. A restored Everglades will be one that is defined by such characteristics as sheet flow across continuous interconnected wetlands, vast colonies of nesting wading birds, healthy and complex tree islands and seagrass meadows, a clean Lake Okeechobee, and ample habitat for endangered species such as the American crocodile and snail kite. The Everglades will not recover their defining characteristics if they continue to be treated as they have in the past; therefore, actions must be taken to restore the health of South Florida's ecosystem.

If the South Florida ecosystem and the Everglades are to be rescued, perhaps the first question we must answer is why. The answers to this question are overwhelming. Above all other reasons, the Everglades epitomize the region's sense of definition and place, both substantially by providing clean water and recreation, and spiritually by providing a sense of hope for the quality of the region's future. The Everglades are to South Florida as the Grand Canyon is the west, as the old growth forests are to the Pacific northwest, and as the Mississippi River is to the nation's heartland. The Everglades are in a national class with our most valued natural treasures – essential, unique, and fragile. The Everglades are unlike any other place. The Everglades attract the eyes of the world.

We know that South Florida's population will continue to grow. Balancing people's needs for water supply with the needs of the natural system presents a unique challenge. An adequate supply of clean fresh water is essential not only for the ecosystem but for South Florida's economy and its residents' quality of life.

The context: what we have done about it

In 1992 and again in 1996, Congress requested that the U.S. Army Corps of Engineers reexamine the Central and Southern Florida Project, which is the series of canals and water management structures built by the U.S. Army Corps of Engineers in the 1950s to 1970s, to determine the feasibility of modifying the project to restore the South Florida ecosystem and provide for other water-related needs of the region, including water supply and flood protection. This process is referred to as the Restudy. The result of this process was the CERP. The South Florida Water Management District, along with many other federal, state, and local agencies and tribal governments, was a partner with the U.S. Army Corps of Engineers in this planning effort.

Planning goals and study objectives were developed to sharpen the Restudy's intent and focus. These goals and objectives guided the development of the CERP and now its subsequent implementation, including the development of these recommendations for Interim Goals and Interim Targets. These goals and objectives are as follows:

Goal: Enhance Ecologic Values
- Increase the total spatial extent of natural areas
- Improve habitat and functional quality
- Improve native plant and animal species abundance and diversity

Goal: Enhance Economic Values and Social Well Being
- Increase availability of fresh water (agricultural/municipal and industrial)
- Reduce flood damages (agricultural/urban)
- Provide recreational and navigation opportunities
- Protect cultural and archeological resources and values

The CERP was designed to eliminate or substantially moderate hydrologic and certain water quality stresses that have degraded the natural system (the quantity, quality, timing, and distribution of water). Many environmental benefits are expected as a result of implementation of the CERP, although it was acknowledged that the currently approved CERP does not equate to a totally restored South Florida ecosystem. Other factors (e.g., proliferation of invasive exotic species) have an effect on the ecosystem that CERP was not designed to correct.

Through the enactment of a law called the Water Resources Development Act of 2000, Congress approved the CERP as a framework for modifications and operational changes to the Central and Southern Florida Project needed to restore the South Florida ecosystem and to provide water supply and flood protection.

The context: what we are doing now

The Programmatic Regulations tell us to set Interim Goals to measure the restoration success of the CERP as projects are built, and Interim Targets to assess the progress towards meeting South Florida's needs for water supply and flood protection. The multi-agency Restoration Coordination and Verification (RECOVER) team has developed these recommendations.

Interim Goals are defined in the Programmatic Regulations as "*a means by which the restoration success of the Plan may be evaluated throughout the implementation process.*" Interim Goals provide a means of tracking the performance of the CERP toward achieving expected environmental benefits, as well as a basis for reporting to Congress at five-year intervals on progress made towards restoration. Interim Targets are defined in the Programmatic Regulations as "*a means by which the success of the Plan in providing for other water-related needs of the region, including water supply and flood protection, may be evaluated throughout the implementation process.*" Interim Targets will also be reported to Congress at five-year intervals.

The Interim Goals and Targets are our predictions about how the indicators will change as the CERP projects are built. As projects are built, we will measure the indicators to see how they are actually changing compared to the interim predictions.

Interim Goals: what do we mean by historic conditions, desired restoration conditions, and what we expect from the CERP?

For the development of the Interim Goals, and for the evaluation of restoration success, we need to consider four "points of reference" in the process of ecosystem restoration:

1) The desired restoration condition for each indicator

2) The expected future condition (predicted performance) of each indicator due to the CERP

3) The condition of the indicator prior to CERP implementation ("pre-CERP condition")

4) The actual condition of the indicator as measured in the field during CERP implementation

In many cases the desired restoration condition for an indicator is the same as a certain historical condition. In others, the desired restoration condition is something different than the historical condition. For example, records show that 50 percent of the historic pre-drainage Everglades have been lost to urban and agricultural development. Increasing the spatial extent of the Everglades back to 100 percent of its historic size is not possible because our human civilization is now a permanent part of the South Florida ecosystem. Our desired restoration condition is, therefore, substantially lower than the historic condition, yet we believe it will be large enough to provide for a sustainable ecosystem. Given that few or no pristine, pre-drainage areas exist, the historical condition <u>and</u> the desired restoration condition are often described using historical accounts or computer models of the ecosystem without water management features.

The second point of reference along the path to restoration is the expected performance of the CERP. This point of reference is the actual Interim Goal. The Interim Goals are calculated (predicted) into the future using a number of tools including hydrologic and ecological computer models, and conceptual ecological models. Best available science is used within

and alongside the modeling tools to predict the condition of an indicator, given a particular schedule for construction of the CERP projects.

The two final points of reference are the "pre-CERP condition" and the actual measured condition of the indicator in the field during CERP implementation. The "pre-CERP condition" can be viewed as the starting point for each indicator. Monitoring of the indicators throughout CERP implementation will allow us to determine the status and trends in the hydrological and ecological characteristics of the natural areas we are trying to restore.

This document includes three of the points of reference listed above. For all indicators, a qualitative, and sometimes quantitative, description of the desired restoration condition was developed. For many indicators, but not all, predictions of the expected performance of the CERP at specific time intervals are given. This "expected performance" is the Interim Goal. It should be emphasized that these Interim Goals, even at full project build-out, are in most cases not equivalent to the desired restoration condition. Also included in this document is an analysis of the "pre-CERP condition" for each indicator.

The desired restoration conditions and the Interim Goals as stated here represent the best science available at the time of writing of this document. When our progress toward meeting both Interim Goals and Interim Targets is assessed in five years, we will compare actual field conditions to our predictions of expected performance to see if we are meeting those Interim Goals. At the same time, actual field conditions and updated model predictions can be compared to desired restoration conditions, as a way of measuring restoration success. The results of these analyses should illustrate where the CERP is working well, and where the CERP may need to be modified to seek continual improvement in the restoration of the South Florida ecosystem or whether the Interim Goals and Targets may need to be revised.

How accurately can we predict the Interim Goals and Interim Targets?

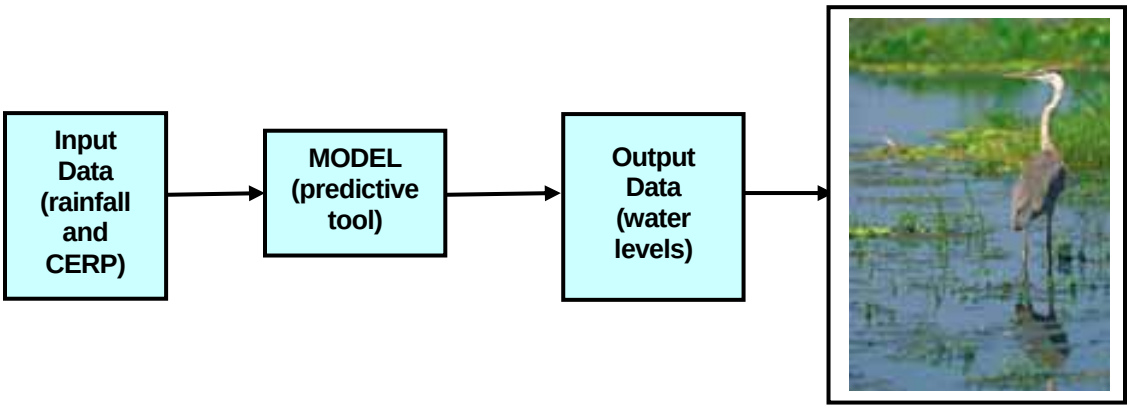
Predicting the number of nesting wading birds, the amounts of damaging phosphorus in the Everglades, or the amount of drinking water that will be available is a great challenge for scientists. In Florida, we know just how difficult it can be to predict the weather. We have all been caught, unprepared, after the weatherman predicted a mostly sunny day yet it rained. Predicting specific weather events with any certainty, for example where a particular hurricane might make landfall, is even more difficult. Furthermore, making predictions on how plants and animals might respond to weather and the hydrologic conditions in South Florida becomes an even more complex task. Plants and animals in the Everglades respond to their environment in ways that we do not always understand. Many factors that affect the Everglades are unpredictable, such as the invasion of exotic plants and animals, several of which have had profound effects on South Florida's environment.

The models we used to predict the Interim Goals and Targets are similar to those used by meteorologists to make weather predictions. CERP scientists routinely use the South Florida Water Management Model to describe water levels throughout South Florida. This model is useful for making general predictions about water levels, but it does not tell us how the important biological indicators (plants and animals) will respond. Some models have recently

been developed to predict biological indicators, but most are in the early stages of development. Given the challenges in predicting responses to the CERP, especially without fully developed models, the Interim Goals and Targets should be considered a work-in-progress that will evolve over time. As our understanding of the ecosystem improves and development of predictive models continues, the accuracy of the predictions of Interim Goals and Interim Targets will also improve.

Using these models, the current methods for predicting Interim Goals for many indicators produce results specific to the separate areas of the compartmentalized Everglades ecosystem. The South Florida ecosystem has been divided into these water management compartments for more than half a century. For example, the Everglades region is made up of five different Water Conservation Areas and Everglades National Park. These compartments have had distinctly different hydrology (i.e., some have tended to pool water, whereas others, like Everglades National Park, have been much drier than historical conditions). Therefore, the connected system produced by the CERP is likely to affect restoration indicators in these areas in different ways. New methods to characterize Interim Goals across the entire ecosystem are being developed.

Below is a generalized model used to predict Interim Goals for the CERP. Input data, such as rainfall and planned CERP projects, are used in a model to predict future conditions (output data), such as water levels. These predictions were used by scientists to produce the Interim Goals and Targets.



How and when will we revise the Interim Goals and Interim Targets?

In order to generate the data necessary to predict the Interim Goals and Interim Targets, scientists used the modeling that was generated during the Restudy phase of the CERP, referred to previously in this document. The specific model simulation was given the name "D13R". This modeling was completed in 1998 as the official CERP and was based upon the Restudy implementation schedule of CERP projects. It included modeled conditions that may occur after projects are implemented in the years 2010 and 2015. A "1995 Base" was completed to characterize conditions before CERP projects were built. A "2050 Base" was completed to characterize future conditions if the CERP was not implemented. In this

document you may also see predictions based on another model called the Natural System Model version 4.5. This model is our best characterization of historic hydrology in the South Florida landscape before the Everglades were drained. While the Programmatic Regulations call for using an update to the D13R model version and implementation schedule, updates were not available in time for use in establishing this initial set of Interim Goals and Targets. A new sequence for CERP projects, called the Master Implementation Sequencing Plan, is currently under development and likely to be different than the sequence used to predict Interim Goals and Interim Targets in this document. Accordingly, we expect our recommendations for Interim Goals and Interim Targets to change after the Master Implementation Sequencing Plan is fully developed and new modeling has been performed. The following table summarizes model simulations and descriptions used in predicting Interim Goals and Interim Targets.

Name of model simulation	**What does the model simulate?**
1995 Base	Hydrologic conditions before CERP projects are implemented ("pre-CERP condition")
2010	Hydrologic conditions in 2010 with CERP projects implemented
2015	Hydrologic conditions in 2015 with CERP projects implemented
D13R	Hydrologic conditions in 2050 with all CERP projects implemented
2050 Base	Hydrologic conditions in 2050 without any CERP projects
Natural System Model version 4.5	Hydrologic conditions before the Everglades were drained (historic conditions)

Within the next five years, and for the 2010 update of the Interim Goals and Interim Targets, we expect that our predictions of CERP performance will be more accurate than they are now. Unless there is a change in state water policy and law, the desired condition for Interim Targets for water supply (meeting demands in a 1-in-10 year drought event) should not change, although we recognize that as South Florida's population grows, so will the needs for urban water supply. We expect relatively little change in the fundamentals of desired restoration conditions throughout CERP implementation, though these desired conditions should become more quantitative as field research or better modeling improves our knowledge of historic conditions and the limitations of the current ecosystem. We do, however, expect substantial change in the predictions of CERP performance throughout implementation as our knowledge and tools improve and as a result of our efforts to improve the CERP. Especially for those indicators that show a large gap between expected CERP performance and desired restoration conditions, we expect our improved knowledge of the ecosystem to produce an updated plan whose predicted performance moves closer to the desired restoration condition.

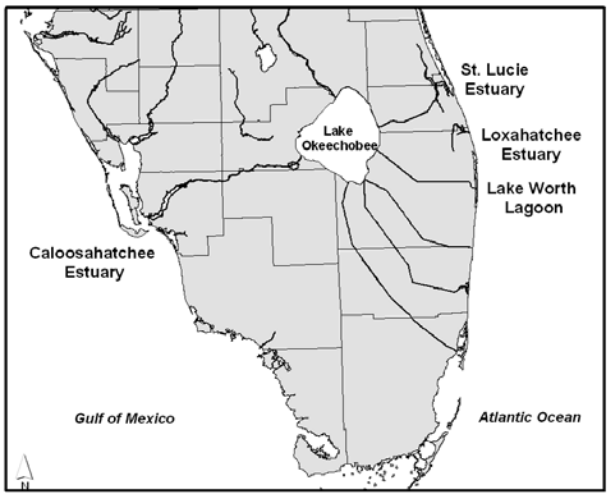
How this document is organized

Following this foreword are six sections. The first four – entitled Northern Estuaries, Lake Okeechobee, Greater Everglades, and Southern Estuaries – represent the Interim Goals and the predictions of restoration response of natural areas to CERP implementation. The fifth section – Water Supply and Flood Protection – represents the Interim Targets and progress towards meeting other water-related targets as the CERP is implemented. The last section is our conclusion for this initial set of Interim Goals and Interim Targets.

We have also prepared an appendix to this Interim Goals and Interim Targets report. The appendix contains detailed, technical and scientific information in support of this report. If you have questions about our conclusions or how we arrived at our predictions for the Interim Goals and Interim Targets, refer to the appendix in which you will find what we call "indicator documentation sheets" that explain the science and methodologies behind our predictions. The appendix also has a more lengthy introductory and background section as well. While we tried to keep the use of acronyms at a minimum in this main report, it was not as practical to do so in the appendix; therefore, an acronym list is provided. Lastly, the appendix includes a list of the people who helped develop the Interim Goals and Interim Targets.

Northern Estuaries

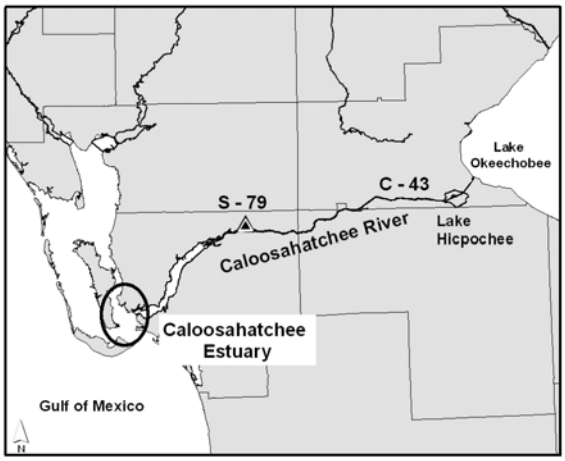
The Northern Estuaries include the Caloosahatchee, St. Lucie, and Loxahatchee Estuaries, and Lake Worth Lagoon. Within Florida, nearly 70 percent of recreational and commercial fisheries species (e.g., oyster, pink shrimp, blue crab, gray snapper, red drum, snook, stripped mullet, and spotted sea trout) rely on estuaries for at least part of their life span. Major stressors currently impacting these estuaries include damaging freshwater inflows, degraded water quality, and habitat loss.



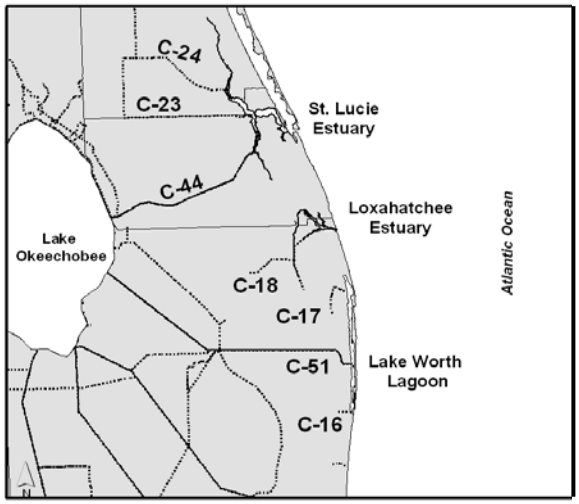
The eastern oyster and submerged aquatic vegetation are important indicators for the northern estuaries. Oyster bars and submerged aquatic vegetation provide important habitat for other animals such as fish that have a significant recreational and commercial value. Submerged aquatic vegetation beds provide habitat for many other plants and animals, stabilize sediments, and form the basis of food chains. The eastern oyster supported a subsistence fishery prior to European colonization of the United States and, throughout recent history, has provided an important economic and cultural resource to coastal inhabitants, though they were not commercially harvested in the northern estuaries. Oysters improve water quality by filtering particles from the water and serve as prey and habitat for many other animals.

What has been causing the decline of ecosystem health in the Northern Estuaries?

The Caloosahatchee Estuary is located on the southwest coast of Florida. Most of the fresh water flowing into the estuary comes from the Caloosahatchee River. Historically, the Caloosahatchee River was a meandering system with numerous oxbows, flowing from its headwaters at Lake Hicpochee to the Gulf of Mexico. Activities that led to its degradation, beginning in the1890s, include channelization, connection to Lake Okeeechobee, and construction of an extensive canal network associated with agricultural development in the watershed. The channelized portion of the Caloosahatchee River (C-43 canal), as well as this canal network, has changed the timing, quantity, and direction of runoff within the watershed and led to abnormal



salinity fluctuations. The tidally influenced portion of the estuary has been reduced by the operation of the S-79 control structure, which allows periodic large regulatory (flood) releases from Lake Okeechobee. Prior to these impacts, the Caloosahatchee Estuary was a highly productive system with an abundance of aquatic plants and animals. Today, the abundance, health, and functionality of these species have been greatly reduced. Submerged aquatic vegetation and the eastern oyster have been reduced from a widespread distribution to a sparse occurrence.



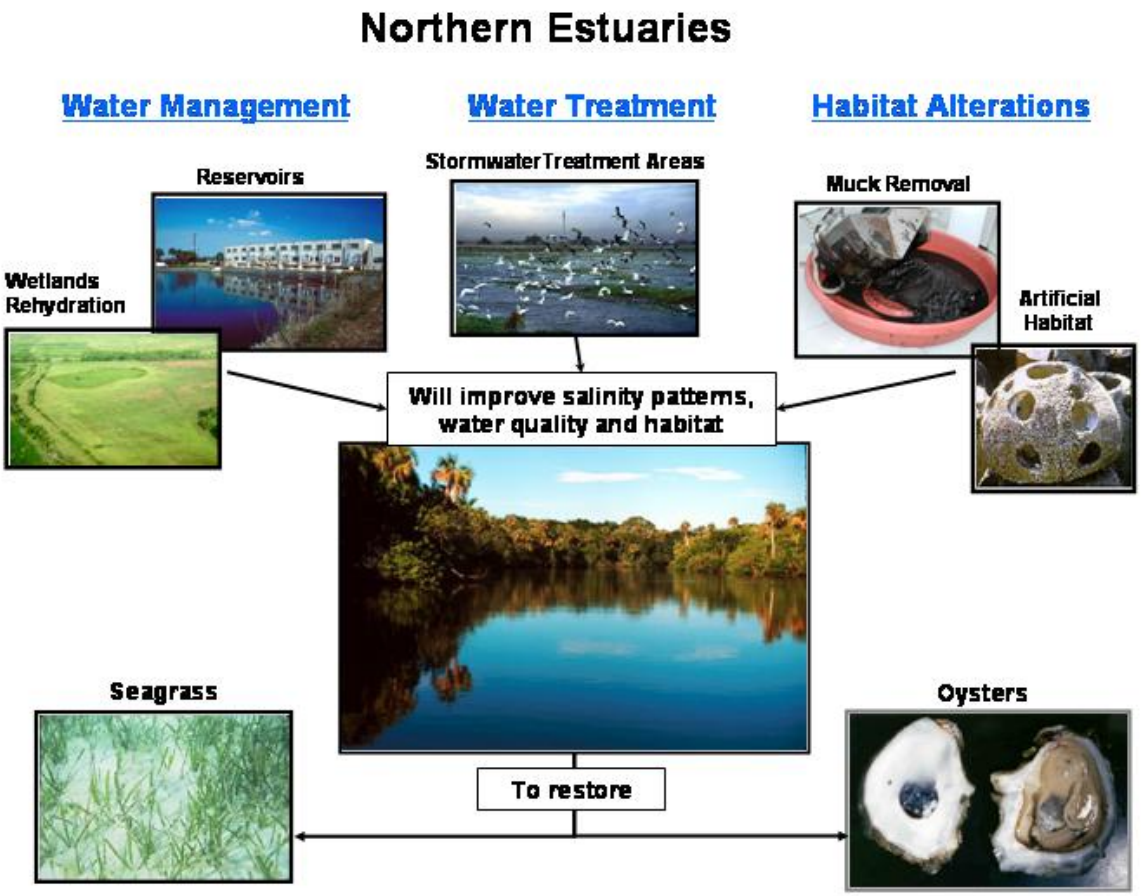
The St. Lucie Estuary, located on the southeast coast of Florida, flows into the Indian River Lagoon and the Atlantic Ocean. Historically, this estuary was a freshwater system influenced by ephemeral ocean inlets. When the St. Lucie Inlet was permanently established in 1898, the system became an estuary, characterized by abundant mangroves, oyster bars, and submerged aquatic vegetation. Agricultural and urban drainage projects, beginning in the 1910s, expanded the area that now drains into the estuary. The historic watershed was approximately one-third of its present size of almost 775 square miles. Major drainage canals constructed in the watershed include the C-23 and C-24 canals. The St. Lucie Estuary is connected to Lake Okeechobee by the C-44 canal, which is used for navigation and regulatory releases from Lake Okeechobee. As a result, freshwater flow into the estuary tends to be excessive in the wet season and occasionally insufficient in the dry season. The estuary has also been degraded by thick deposits of mucky silt that cover large portions of the bottom and make it unsuitable for submerged aquatic vegetation and oysters. These sediments also become resuspended by wind, current, and boat traffic resulting in diminished light penetration through the water column.

The Loxahatchee River is also located on the southeast coast of Florida. The Loxahatchee basin has been extensively altered by construction of canals, channelization of natural waterways, drainage and/or impoundment of wetlands, and stabilization of the Jupiter Inlet. Construction of the C-18 canal resulted in the disconnection of the Northwest Fork from its headwaters, the Loxahatchee Slough. This has resulted in periodic shortages of water for the Northwest Fork and increased flows into the Southwest Fork during storm events. Saltwater intrusion upstream into the Northwest Fork has resulted in the loss of six river miles of cypress swamp and freshwater floodplain vegetation. Oysters and seagrass beds currently exist in a limited area of the estuary.

Lake Worth Lagoon, also located on the southeast coast of Florida, was historically a freshwater lake receiving water from wetlands along its western edge. Creation of permanent inlets to the lagoon changed it to an estuarine environment. Although regionally important natural resources remain, the cumulative impact of human activities over the past 100 years significantly altered the lagoon environment. Changes affecting the hydrology include

construction of major drainage canals (C-51, C-17, and C-16), shoreline bulkheads, a causeway, channels, and port development. Discharges from the C-51 canal produce excessive periodic releases of fresh water that adversely impact estuarine biological communities. Limited numbers of oysters remain in the lagoon and submerged aquatic vegetation populations are unhealthy and reduced in number.

Water management activities within the watersheds of these estuaries resulted in significant alterations in the timing and volume (excess wet season and insufficient dry season water flows), distribution (water now flows through canals instead of overland), and quality of water flowing into these estuaries. Channelization and water control structures have reduced the ability of these systems to filter nutrients and have further degraded water quality. These impacts reduce the ability of the watershed to provide water storage, dry season flows, water quality treatment, and fish and wildlife habitat. The objectives of many Comprehensive Everglades Restoration Plan (CERP) projects are focused on reducing these impacts.



What are the effects these stressors are having on the ecology?

Pre-drainage estuarine systems received freshwater inflow primarily from direct rainfall and basin runoff that resulted in low nutrient inputs. These natural patterns of freshwater inflow sustained an ecologically appropriate range of salinity conditions with fewer salinity extremes. Water management and dredging practices have major impacts on the presence of oysters and submerged aquatic vegetation within these estuaries. CERP projects that will restore more natural freshwater inflows into the estuaries will provide beneficial salinity conditions, a reduction in nutrient concentrations and loads, and improved water clarity that will promote the reestablishment of healthy oyster bars and submerged aquatic vegetation communities. This will also benefit fish health and other aquatic populations (such as manatees). These stressors and attributes are described in the simplified conceptual ecological models in the *CERP Monitoring and Assessment Plan: Part 1, Monitoring and Supporting Research* (RECOVER 2004).

How will the CERP help to restore the Northern Estuaries?

The CERP goal for the northern estuaries is to enhance habitat conditions while providing for economic and recreational opportunities. CERP projects are expected to moderate the stressors (freshwater discharges, diminished water quality, and habitat loss) and enhance the natural attributes (submerged aquatic vegetation and oysters) of the northern estuaries. This will be accomplished through habitat enhancement, as well as water storage and treatment projects. A detailed description of these projects can be found in the *Central and Southern Florida Project Comprehensive Review Study Final Integrated Feasibility Report and Programmatic Environmental Impact Statement* (USACE and SFWMD1999). A general description of the CERP projects that will benefit the Northern Estuaries are as follows:

- **C-43 Basin Aquifer Storage and Recovery and C-43 Basin Storage Reservoir** - This project will provide water management and water quality benefits by reducing salinity and nutrient impacts to the Caloosahatchee Estuary.
- **Caloosahatchee Backpumping with Stormwater Treatment** - This project will benefit the estuary and Lake Okeechobee by capturing, storing, and treating excess basin runoff.
- **Lake Okeechobee Aquifer Storage and Recovery -** This project will provide water storage that will directly benefit Lake Okeechobee and reduce regulatory discharges to the St. Lucie and Caloosahatchee Estuaries.
- **Lake Okeechobee Watershed Project** - This project will provide water storage and treatment in the watershed and result in more beneficial flows to the estuaries.
- **Indian River Lagoon South** - This project will provide water storage, treatment of watershed runoff, and wetland rehydration; remove silt and muck; and provide artificial habitat in the St. Lucie Estuary.

- **Everglades Agricultural Area Storage Reservoirs -** These reservoirs are expected to provide water storage and treatment and reduce Lake Okeechobee regulatory releases to the estuaries.
- **North Palm Beach County -** These projects will provide direct and indirect benefits to Lake Worth Lagoon and Loxahatchee River and Estuary with habitat restoration and water storage and treatment.
- **Acme Basin Discharge -** This project will provide water storage and treatment and reduce regulatory discharges to Lake Worth Lagoon.
- **Palm Beach County Agriculture Reserve Reservoir -** This project will capture, store, and possibly treat excess water currently discharged to Lake Worth Lagoon.

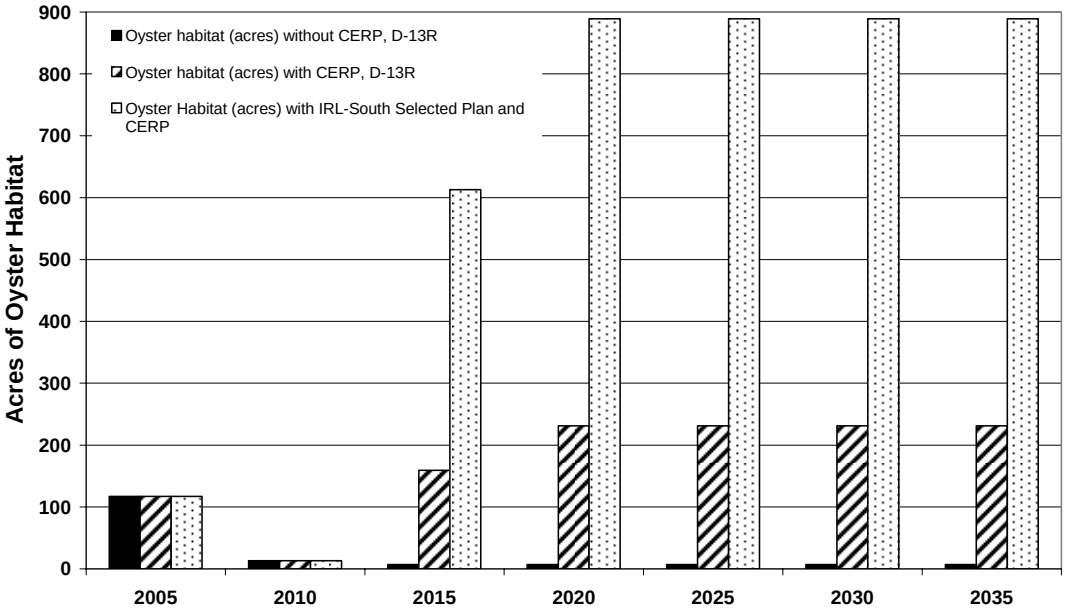
What types of tools were used to make the predictions?

Although each estuary uses different models to predict hydrologic and biological changes, the basic concept applies to all Northern Estuaries. Watershed models predict the amount of surface- and groundwater entering the system. Salinity models predict the change in salinity as the flow (amount of water) changes. Ecological models predict the change in oyster and seagrass acreage in relation to salinity change and other pertinent factors (such as response times to the changes in flow, salinity, etc.). The models used in each estuary are described in more detail in the indicator documentation sheets in the technical appendix.

What are the predictions for Interims Goals for the Northern Estuaries?

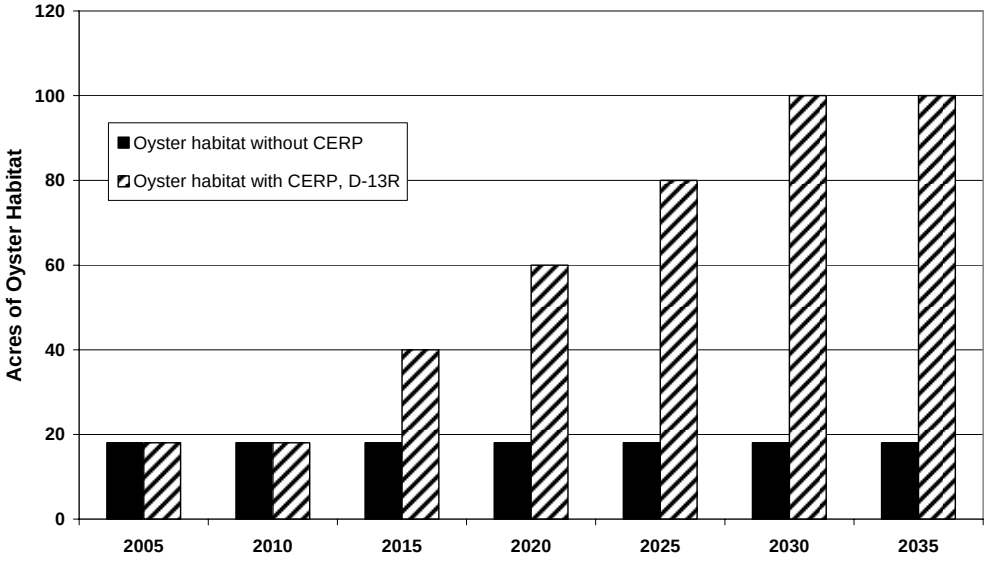
Oyster beds in the St. Lucie Estuary are expected to respond to CERP projects over time. This analysis shows the damaging effects of periodic high freshwater regulatory releases from Lake Okeechobee that result in a severe loss of oysters (with an approximate five-year recovery period) until all projects that influence the St. Lucie Estuary are completed. Two different responses are presented here. One analysis, labeled “CERP-only”, includes storage reservoirs in the St. Lucie Estuary. A second analysis, labeled “IRL-South”, includes water management (storage reservoirs), treatment, wetland rehydration, and habitat enhancement features that were identified as the selected plan benefiting the St. Lucie Estuary. The “IRL-South” analysis indicates that up to four times as much additional oyster habitat may be expected over what CERP alone would produce. The “CERP-only” analysis indicates that oyster habitat in the middle estuary from the Roosevelt Bridge downstream to the A1A Bridge would increase from less than 25 acres in 2010 (when CERP projects are coming on line), to approximately 160 acres in 2015, to approximately 230 acres in the period 2020 through 2035. The “IRL-South” analysis indicates up to four times as much habitat could be expected: habitat may increase from less than 25 acres in 2010, to approximately 600 acres in 2015, to approximately 900 acres in the period from 2020 through 2035.

Comparison of Oyster Habitat (acres) in the St. Lucie Estuary "Without" and "With" CERP, and with IRL-South Selected Plan



With changes in freshwater inflows into the Caloosahatchee Estuary resulting from CERP projects, salinities in the riverine portion (north of Shell Point) of the Caloosahatchee Estuary may increase and result in estuarine salinities suitable for the growth and enhancement of oyster reefs in areas north of Shell Point. In the next 10 to15 years, oyster reef coverage will increase up to five fold (approximately 100 acres), with an annual increase of approximately 10 to 20 percent. It is expected that approximately 40 acres of reef will develop north of Shell Point while 60 acres of oyster reef will be in the San Carlos Bay.

Comparison of Oyster Habitat (acres) Change in the Caloosahatchee Estuary "With" and "Without" CERP (D-13R)



Predictions for oysters and submerged aquatic vegetation in the Lake Worth Lagoon and Loxahatchee Estuary are not currently available. Hydrological and ecological models needed to make these predictions are under development and should be available for the next reporting period.

How do we know we have achieved success through the CERP?

Changes in oyster distribution and abundance will be monitored according to the *CERP Monitoring and Assessment Plan: Part 1, Monitoring and Supporting Research* (RECOVER 2004) at a variety of sites on both the east and west coasts of Florida, including St. Lucie, Caloosahatchee, and Loxahatchee Estuaries, and Lake Worth Lagoon. This long-term monitoring program for the eastern oyster will focus on four aspects of oyster ecology: spatial and size distribution patterns of adult oysters, distribution and frequency patterns of the oyster diseases, reproduction and recruitment, and juvenile oyster growth and survival. Data will be analyzed to determine if the health and spatial extent of oysters is improving with time as CERP projects are implemented. Maps of oyster bed location, density, and health will also be produced.

Submerged aquatic vegetation communities will be restored by restoring hydrology. Monitoring will determine if restoration of submerged aquatic vegetation beds is achieved with the modification of freshwater inflows, salinity regimes, and water quality (RECOVER 2004). Long-term monitoring programs for submerged aquatic vegetation will be established in the Caloosahatchee River and Estuary and San Carlos Bay on the south west coast, and St. Lucie Estuary and southern Indian River Lagoon on the southeast coast.

Literature Cited

RECOVER. 2004. CERP Monitoring and Assessment Plan: Part 1, Monitoring and Supporting Research. Restoration Coordination and Verification Team (RECOVER), c/o United States Army Corps of Engineers, Jacksonville District, Jacksonville, FL, and South Florida Water Management District, West Palm Beach, FL.

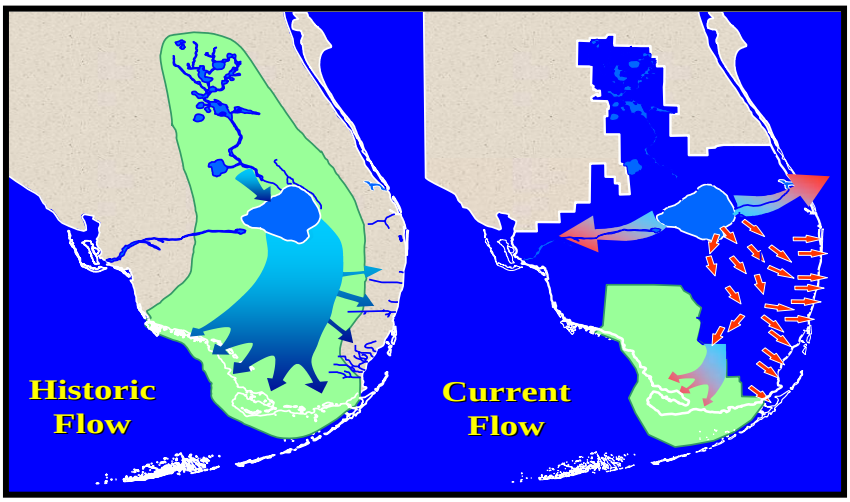
USACE and SFWMD. 1999. Central and Southern Florida Project Comprehensive Review Study Final Integrated Feasibility Report and Programmatic Environmental Impact Statement. United States Army Corps of Engineers, Jacksonville District, Jacksonville, FL, and South Florida Water Management District, West Palm Beach, FL.

Lake Okeechobee

Lake Okeechobee is the "liquid heart" of South Florida. It is the second largest freshwater lake within the contiguous United States, measuring 730 square miles in area. Lake Okeechobee provides many vital functions on a regional level including natural habitat for fish, wading birds and other wildlife; essential water for people, farms, and the environment; flood protection; recreation; navigation; and is home to a multimillion dollar sport and commercial fishery. Lake Okeechobee is an important source of fresh water to the Everglades, and discharges from the lake influence the ecology of the St. Lucie and Caloosahatchee Estuaries. Therefore, the Comprehensive Everglades Restoration Plan (CERP) is critical to achieving the right balance among the many competing demands in Lake Okeechobee.

What has been causing the decline in Lake Okeechobee's ecosystem health?

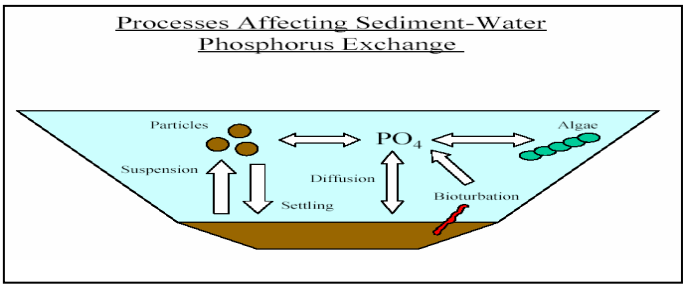
Currently, Lake Okeechobee is plagued with two major stressors that significantly impact its ecology: unnatural water levels and excessive phosphorus. In the 1890s, Hamilton Disston constructed a canal connecting Lake Okeechobee with Lake Hicpochee, the headwaters of the Caloosahatchee River. This provided the lake's first outlet to tidewater (the Gulf of Mexico) via the Caloosahatchee River. In the early 1900s, the Everglades Drainage District constructed several other canals that impacted Lake Okeechobee. The St. Lucie, Hillsboro, North New River, West Palm Beach, and Miami Canals were constructed from the lake to tidewater (the Atlantic Ocean). These canals provided a slow, continuous drainage from Lake Okeechobee and the Everglades. The goal was to drain the northern Everglades for agriculture to prevent the crops from flooding. Construction of the Herbert Hoover Dike in the early to mid-1900s reduced the size of the lake's open-water zone by nearly 30 percent. This resulted in a



considerable reduction in average water levels, and produced a new littoral zone within the dike that is only a fraction of the size of the natural one. Also, variations in rainfall, water supply deliveries from the lake, regulation schedules, and supply-side management have the potential to affect the lake's water levels.

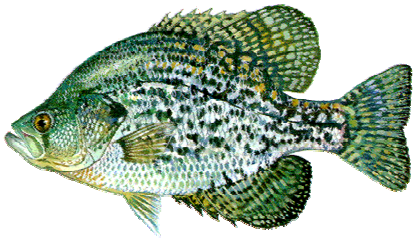
During the Twentieth Century, much of the land around Lake Okeechobee was converted to agricultural use. To the north, dairy farms and beef cattle ranching became the major land uses, while in the south, sugar cane and vegetable farming increased rapidly. Associated with the land use changes were large increases in the rate of nutrient (nitrogen and phosphorus) inputs to the lake, and detrimental changes occurred in the lake's water quality. Phosphorus inputs from the northern watershed have increased dramatically, with loads of total phosphorus nearly tripling in the open-water region of the lake, between the early 1970s and mid-1980s. Blooms of blue-green algae became more common, with particularly large blooms covering more than 40 percent of the lake surface in the 1980s.

Most recently, scientists have discovered that one of the greatest challenges in reversing harmful trends caused by excessive phosphorus may be controlling sources within the lake itself. Because high phosphorus loads have occurred for over 60 years, more than 30,000 tons of phosphorus accumulated at the bottom of the lake in the form of soft organic mud. Due to the lake's shallow depth (9 feet), this mud is mixed into the water column every time strong wind blows across the lake surface. This keeps water column phosphorus concentrations high, which eventually prevents submerged plants from getting the light they need to grow. It may stimulate the growth of cattail along the edge of the littoral zone.



What effects are these stressors having on the lake's ecology?

When Lake Okeechobee was diked in the 1900s, the littoral zone was comprised of a diverse mosaic of native plants, including spikerush, beakrush, and willow. These plants provided important habitat for fish, birds, and other wildlife, as they continue to do so today. However, today, a large percentage of the native plant habitat in the lake's littoral zone (about 20 percent or over 20,000 acres) has been lost to exotic plants, most notably melaleuca and torpedograss. The spread of these plants seem to be due to extreme low water levels in the lake.



On the other hand, high lake levels are the probable cause of cattail expansion in the marsh, high phosphorus levels particularly in the open-water areas, and loss of aquatic vegetation. Lake Okeechobee's nearshore region has lost most of its submerged plant community due to these high water levels, and a ridge, or berm, of organic material has accumulated along the western lake shore. It is anticipated that if high water levels continue, future berms can be

expected to form. The increase of berms and the decrease in submerged vegetation may have a grave impact on the sport fishery, particularly black crappie.

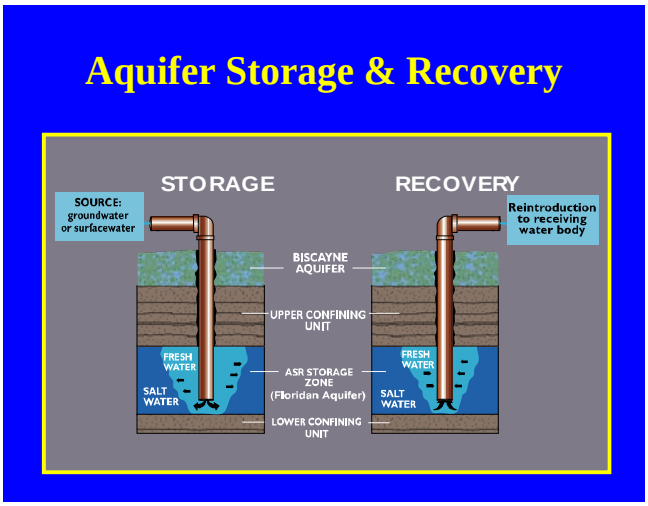
Concentrations of total phosphorus in the lake's water column has more than doubled in the last 30 years, from 40 to 50 parts per billion in the early 1970s to over 100 parts per billion in 2001. High phosphorus in the lake results in the loss of macro-invertebrate diversity, impacts to drinking water, occurrence of blue-green algal blooms, and impacts to downstream ecosystems including the St. Lucie and Caloosahatchee Estuaries and the Everglades.

Algal blooms can represent a significant risk to the human population that depends on this water resource for drinking water and other uses. Algal blooms can cause problems with taste and odor of drinking water, they can contribute to the formation of carcinogenic chemicals in water that must be chlorinated, and some bloom-forming algae have the ability to produce toxins that kill or cause disease in fish, wildlife, and domestic animals if they drink the water.

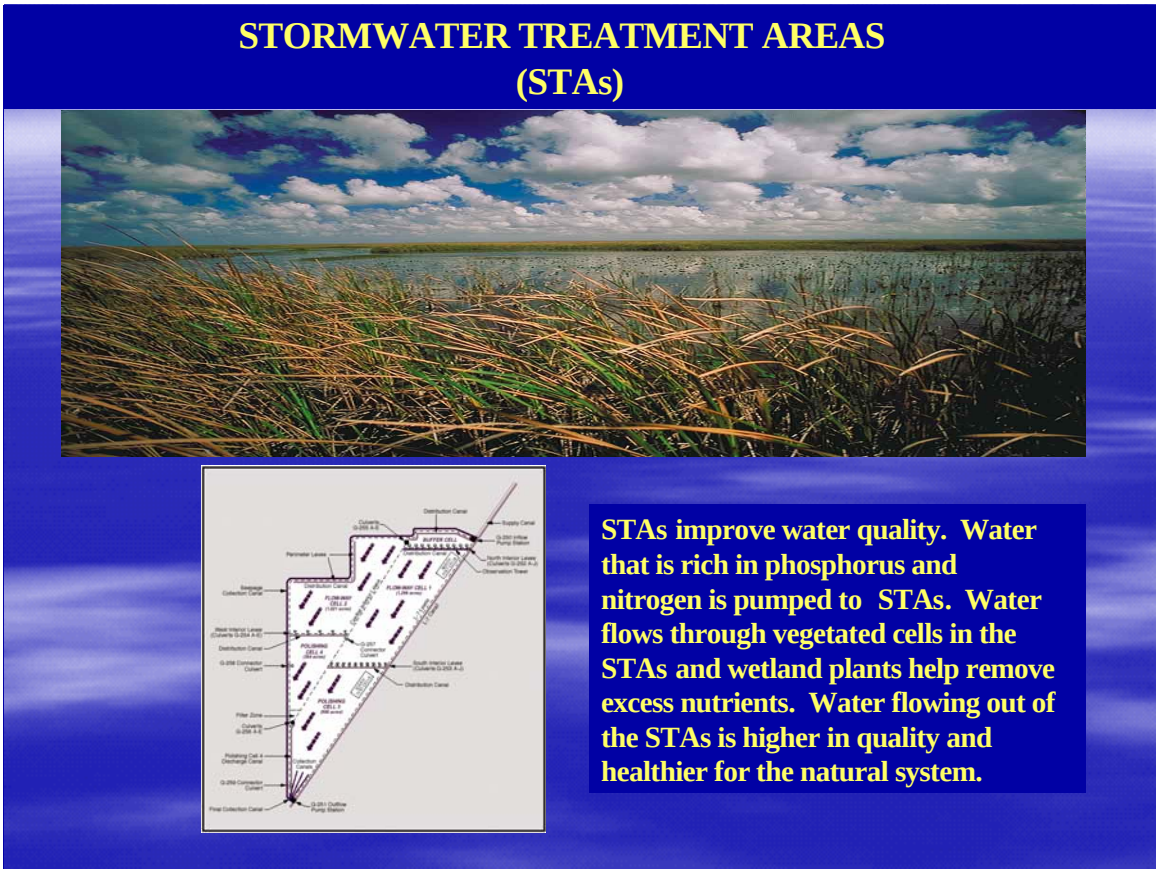
How will the CERP help to restore Lake Okeechobee?

The CERP goals and targets for Lake Okeechobee are to enhance economic values, social well being (maintaining current level of flood protection), and environmental attributes. Specifically, Lake Okeechobee restoration goals involve 1) reducing open-water total phosphorus concentrations in the lake to 40 parts per billion; 2) substantially reducing the frequency of blue-green algal blooms in the open water; 3) restoring and maintaining healthy communities of submerged aquatic vegetation, littoral zone vegetation, and shoreline bulrush; and 4) eliminating harmful high and low water levels that cause adverse impacts to plants, fish, and wildlife, while still providing for a beneficial seasonal range of water levels. The goal also defines a desired gradual recession of water from a winter high near 15.5 feet to a spring low of near 12.5 feet above mean sea level. Several ways to accomplish these goals are through the CERP projects discussed in the following paragraphs.

The **Lake Okeechobee Aquifer Storage and Recovery Pilot Project** includes a series of aquifer storage and recovery wells adjacent to the lake. Aquifer storage and recovery projects provide underground water storage and would help to minimize high-volume water releases to the St. Lucie and Caloosahatchee Estuaries. During dry periods, water recovered from the aquifer storage and recovery wells would be used to help maintain the surface water levels within the lake.

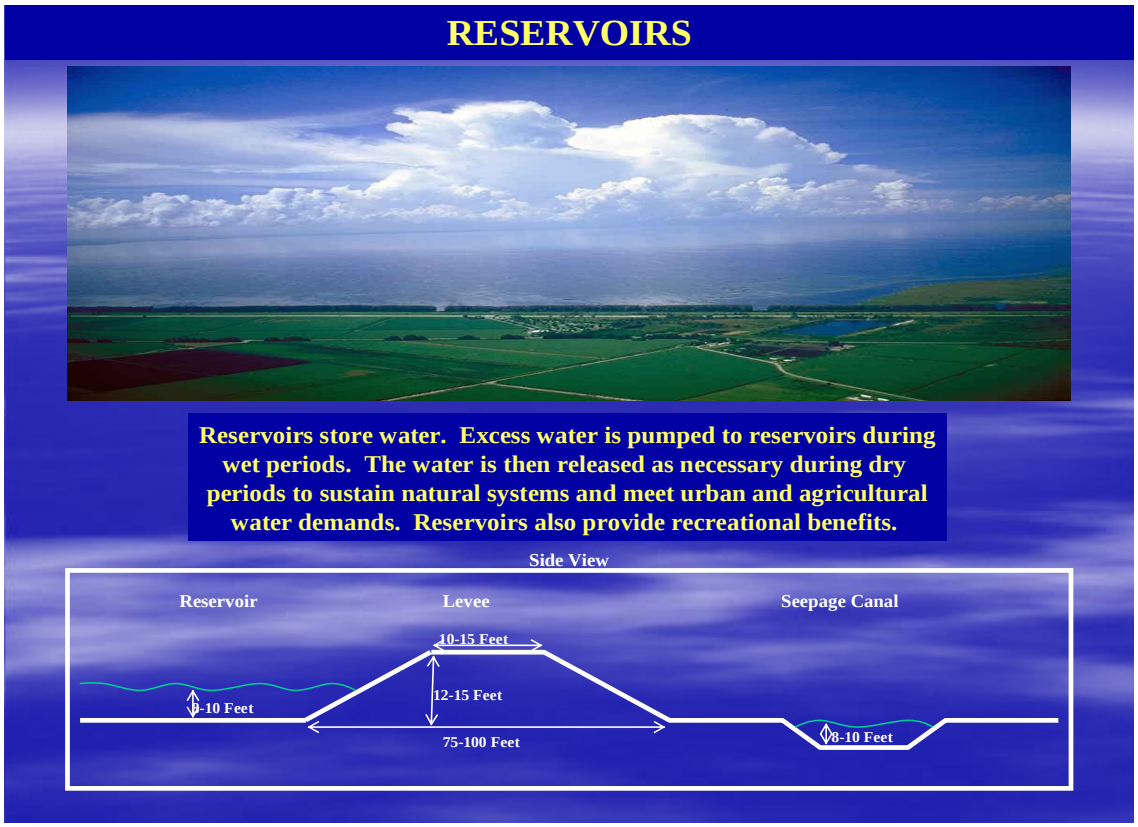


The C-43 Basin Plan includes three projects: 1) **C-43 Basin Storage Reservoir**, 2) **C-43 Basin Aquifer Storage and Recovery**, and 3) **Caloosahatchee Backpumping with Stormwater Treatment**. These projects include in-ground reservoirs and a stormwater treatment area to help store water that might otherwise damage Lake Okeechobee.



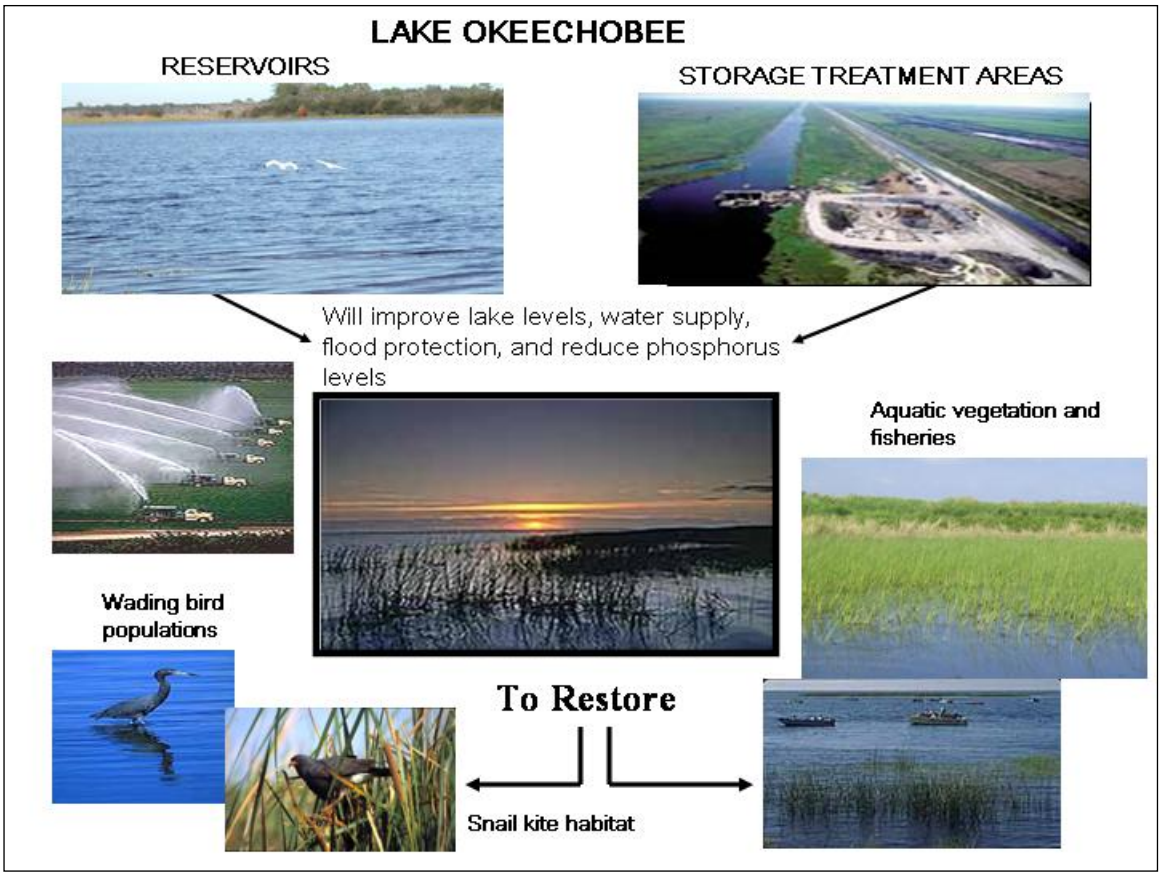
The **Everglades Agricultural Area Storage Reservoir** project is located in western Palm Beach County. The additional storage will relieve pressure on Lake Okeechobee to store water by providing for irrigation requirements in the Everglades Agricultural Area, environmental deliveries of water to the Water Conservation Areas, storage of regulatory releases from Lake Okeechobee, and increased flood protections within the Everglades Agricultural Area.

The **Lake Okeechobee Watershed Project** will improve water quality in Lake Okeechobee, provide for better management of lake water levels, reduce damaging releases to the estuaries downstream of the lake, and reduce phosphorus loading. These goals will be accomplished by 1) a 17,500-acre reservoir in the lower Kissimmee Basin; 2) a 5,000-acre stormwater treatment area in the Taylor Creek/Nubbin Slough Basin; and 3) smaller reservoir assisted stormwater treatment areas and restoration of isolated wetlands.



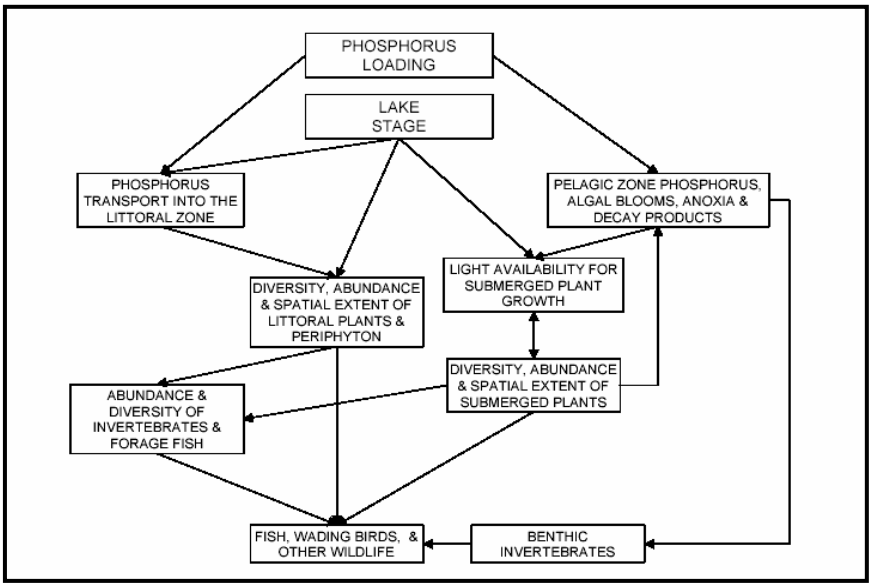
The two most important restoration achievements expected from these CERP projects are phosphorus concentration reductions and improved management of lake levels. These projects should help reduce open-water total phosphorus concentration in the lake to 40 parts per billion, reducing the occurrence of blue-green algal blooms; reverse the trend in loss of macro-invertebrate diversity in the lake sediments; and ameliorate impacts of phosphorus on the downstream ecosystem when water is released from the lake. Improvements in the management of lake levels will promote an increase in the amount of aquatic vegetation such as eelgrass, peppergrass, and southern naiad. Improvements are also

expected in littoral zone vegetation, which should lead to increasing forage fish populations and should also improve conditions for wading birds and threatened and endangered species such as the wood stork and snail kite.



What types of tools do we use to predict the CERP success?

We can predict the changes in Lake Okeechobee's physical characteristics such as lake levels, phosphorus concentrations, and algal bloom frequency by applying the most updated scientific information available, lessons learned from research programs, and tools such as geographic information systems, which capture, store, and display data and models. In recent years, researchers have developed numerous models to predict or evaluate the benefits the CERP will provide to ecological and societal conditions, particularly in Lake Okeechobee and its watershed.

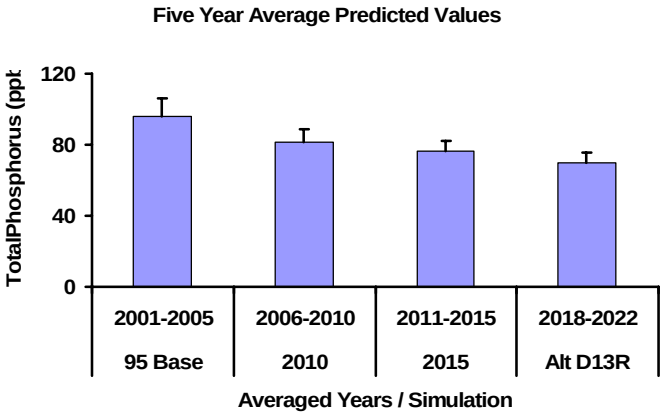


One model that is frequently used for CERP planning purposes, and to better understand the relationship between phosphorus loading, lake stages, wildlife, and plants is the Lake Okeechobee Conceptual Ecological Model developed by South Florida Water Management District.

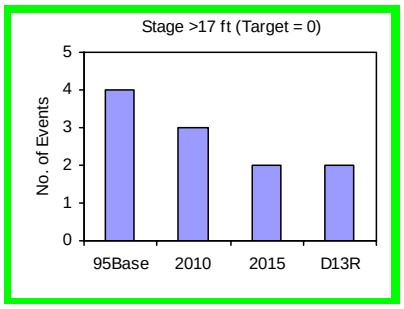
Other models being used to help predict interim performance include both the Lake Okeechobee Water Quality Model and the South Florida Water Management Model. Recently, the South Florida Water Management District has completed the development of a submerged vegetation model, the Lake Okeechobee Environment Model, that links with an existing hydrodynamic (movement of water) model of the lake. This combined hydrodynamic-water quality-vegetation model will go through a review process and should be ready for use for CERP applications in late 2005. It then will be possible to display predicted maps showing the abundance of submerged plants under different water level management and nutrient loading scenarios.

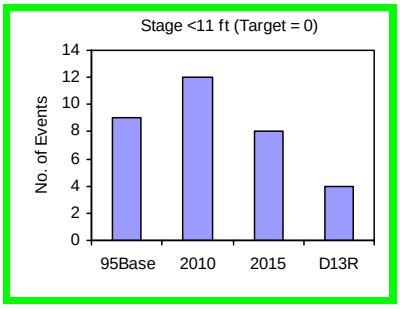
What are the predictions for Interim Goals for Lake Okeechobee?

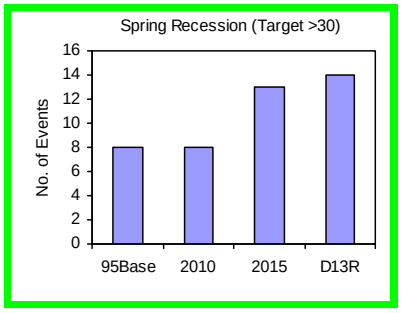
Today, scientists can predict whether the desired restoration goal for Lake Okeechobee can be met using models and other tools. We can show such achievements in five-year increments for water levels and phosphorus. For instance, by using the Lake Okeechobee Water Quality Model, we can predict or be certain that we can achieve lower phosphorus concentrations in the lake.



Water Levels







A CERP restoration goal is to eliminate harmful high and low water levels (above 17 feet or below 11 feet) in the lake, in addition to a gradual recession of water from a winter high near 15.5 feet to a spring low of near 12.5 feet above mean sea level. Using the modeling tools at hand, researchers predict that lake levels in excess of 17 feet declines by 50 percent in 2015 and in the completed CERP (D13R). The predicted occurrence of lake levels in excess of 15 feet for 12 months or more duration drops by over 70 percent in 2010, 2015, and in the completed CERP (D13R).

Algal Blooms

A CERP restoration goal is to substantially reduce the frequency of blue-green algal blooms in the open-water region of the lake. Results from the Lake Okeechobee Water Quality Model suggest that in-lake phosphorus concentrations will decline. Given these predictions, it is likely that the frequency of algal blooms will also decline throughout the implementation of the CERP.

Aquatic Vegetation

A CERP restoration goal is to restore and maintain healthy communities of submerged aquatic vegetation (at least 40,000 acres), vascular submerged aquatic vegetation (at least 20,000 acres), littoral zone vegetation, and shoreline bulrush (at least 5,000 acres). At the present time, it is not possible to predict interim performance for littoral vegetation and shoreline bulrush, but the Lake Okeechobee Environment Model, discussed above, is expected to be ready in late 2005. With this model, it will be possible to display predicted maps showing the spatial distribution of submerged plants under different water level management and nutrient loading conditions. Even though at this time, we do not have models to predict aquatic vegetation performance, we can determine a general sense of success based on other on-going Lake Okeechobee programs such as sampling and monitoring research.

How do we know we have achieved success through the CERP?

The success of the CERP is dependent on four important considerations: 1) identifying the problems that plague Lake Okeechobee's ecological and societal values, 2) identifying the corrective measures, 3) designing and implementing appropriate restoration projects through the CERP, and 4) monitoring or tracking improvements or shortfalls towards the desired goals and targets, which can be used to make adjustments to the restoration plan. CERP managers will use the Restoration Coordination and Verification (RECOVER) program's system-wide

set of performance measures (RECOVER 2004a) and *CERP Monitoring and Assessment Plan: Part 1, Monitoring and Supporting Research* (RECOVER 2004b) as the primary tools to evaluate the performance of the CERP. Performance measures will help assist managers, planners, and researchers in evaluating the success of the CERP. In the Monitoring and Assessment Plan, protocols for data collection, data management, data analysis, reporting, and quality assurance were established. We monitor water levels daily. Phosphorus and other nutrients are measured both in the lake and at the inflows and outflows to the lake. Littoral zone emergent vegetation is mapped using aerial photography and submerged aquatic vegetation is monitored by regular sampling.

How is the CERP addressing "uncertainties"?

So far, we have presented Lake Okeechobee's history, ecological, and economic issues; measures to improve the lake's condition through the implementation of CERP projects; and tools to track the success of the CERP; however, there is one other important component of the CERP that still must be considered. The CERP scientists and resource specialists have come a long way in their understanding of how CERP will work, but many "uncertainties" remain as well as gaps in the research and modeling. Lake Okeechobee is a complex ecosystem with a myriad of influences, and therefore it is not unexpected that we have a number of questions requiring additional research. Also new models will be developed and existing models refined to help predict CERP's success. With continuing hard work, Lake Okeechobee researchers will be able to more fully address key uncertainties regarding water quality, lake levels, phosphorus, algal blooms, fish and aquatic fauna, snail kites, wading birds, and aquatic vegetation.

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Everglades

The Everglades encompasses the major water flowway of the historic South Florida ecosystem, the original "River of Grass" that flowed south from Lake Okeechobee to the mangrove zone edging Florida Bay. The Everglades as defined in this document includes all of the Water Conservation Areas (WCAs on map), and the freshwater marshes of Everglades National Park.

The essence of the Everglades is the large expanse of freshwater marsh along this flowway, an area that, when allowed enough water and freedom to flow, produces a seasonal abundance of fish that supports populations of alligators, enormous colonies of wading birds, and a multitude of other wildlife species. In this watery ecosystem, very small differences in elevation produce different habitats, such as the deep, central ridge and slough system, and the slightly higher marl prairies that flank either side of Shark Slough in Everglades National Park. In the pre-drainage system, higher levels of water during the wet season allowed fish to multiply and disperse out over these slightly higher prairies. As the water receded toward the deeper slough during the dry season, fish were concentrated in steadily shrinking pools of water along the edges, providing an abundant source of food for wading birds during their nesting season. Tree islands dispersed along the "River of Grass" contain one of the only species-rich tropical forests in the country.

The values of the Everglades lie in its unique ability to produce abundant life, and in its ability to maintain a large supply of high quality water for the people of South Florida. Most marshes and wetlands throughout the world receive their nutrients from rivers that seasonally overflow their banks. The Everglades is unique in that the extremely low levels of nutrients that support the ecosystem come almost entirely from the atmosphere via rainfall. No other place in the world has such potential to closely link abundant nature with a thriving human population living side-by-side.

What has been causing the decline in the Everglades ecosystem health?

The Everglades ecosystem has suffered due to changes introduced by the water management infrastructure and associated human activities. Several major stressors have been identified that negatively affect overall ecosystem function and the plants and animals that live there. Four of these stressors are addressed by the Comprehensive Everglades Restoration Plan (CERP): reduced spatial extent, reduced water storage capacity, poor water quality, and the division of the "River of Grass" into compartments (Davis 2004, Ogden 2004).

Due to agriculture and urban expansion, the natural ecosystem area is much smaller and less functional than the original (reduced spatial extent). It is estimated that the central part of the Everglades ecosystem, called "ridge and slough", has lost more than a quarter of its original area. The large area of the original system was essential to capture and store large amounts of rainfall, ameliorating the variability in water extent and depth that occurred between years. Historically, all of the land south of Lake Okeechobee was part of the original system, which, coupled with other natural factors such as fire, tropical storms, and keystone animal species meant that a variety of different habitats for plant and animal populations could exist simultaneously (Craighead 1968, Davis et al. 1994, Ogden et al. 1999, Ogden 2004). Because of the large size of the original system, these habitats also covered extensive areas, allowing for ecological functions such as high productivity of aquatic fauna including animals like small fish and crayfish, and the persistence of populations of highly specialized species, such as the snail kite and Cape Sable seaside sparrow.

The Everglades no longer stores the amount of water that it did in pre-drainage times. The sponge-like peat soils in the sawgrass plain south of Lake Okeechobee that held large quantities of water and released it slowly over the dry season no longer exist since the land has been converted to agricultural land use, resulting in soil subsidence. The Everglades sometimes has too much water and sometimes too little. Canals and pumps of the Central and Southern Florida Project efficiently remove water from the system before and after storms and heavy rains, sending much of it out to the estuaries, and putting the rest into the marshes of the Water Conservation Areas. These changes mean that the central part of the Everglades can be "stacked" with water to unnatural depths, and at other times is much drier than it should be. Water levels in the Everglades also rise and fall faster than they did in the pre-drainage system, when slow drying allowed the fish and aquatic invertebrates to concentrate in seasonal

pools that served as the primary food source for larger animals like alligators and wading birds.

The Everglades was originally one large, connected system, where water flow was slow but unrestricted. The construction of the Tamiami Trail, and the Central and Southern Florida Project created compartments by building canals and levees throughout the system. Under the current system, the hydrology of each of these compartments is managed nearly independently; some marshes are shallow at the same time that adjacent marshes are deep. Levees and canals have diverted the flow of water from its original path, and reduced the extent to which a large horizontal expanse of water can flow slowly through the system (called "sheet flow".) Canals have created unnatural deep water habitat in the midst of shallow water marshes. The fact that canals move water quickly has increased the rates of change in water depths of marshes adjacent to canals, and altered the timing and the duration of flooding and dry outs in the marshes.

The quality of the water entering the Everglades is degraded from its pre-drainage condition. Very low levels of nutrients are a vital precursor to the clear, clean water of the Everglades, and to the natural distribution of plant communities. Today, water with high levels of nutrients comes into the system from urban and agricultural sources. In addition, the unnatural drying of marsh plants and soils over the last century has allowed a chemical process called "oxidation" to occur. When this happens, nutrients that are normally held in soil and plant tissue are released into the environment during oxidation and can have harmful effects on desirable plant communities.

The CERP was designed and approved to relieve these stressors on the ecosystem by creating a water management system that allows the natural ecosystem to regain its original health and strength while providing for the needs of the people of South Florida. The intent of the CERP is to reverse the trends of loss of water and natural areas, to reduce barriers to the flow of water in the Everglades, and to protect the quality of the water flowing through the ecosystem. These changes in the physical environment will provide the foundation for restoration of Everglades landscapes, and the return of populations of abundant wildlife to the ecosystem.

Another major stressor on the Everglades is the presence of introduced exotic species, including plants, and freshwater and terrestrial animals. Although the CERP was not designed to specifically address this problem, exotic species can have effects on the restoration success of the CERP, including the indicators chosen for Interim Goals, and they can in turn be affected by CERP implementation. In future assessments of progress toward Interim Goals, exotic species will need to be considered.

What effects are these stressors having on the ecology?

These hydrologic and water quality stressors have affected the biology of the system in a number of ways, including degradation of the entire landscape and individual species. Reduced spatial extent has reduced the number of options for animals with large feeding ranges (e.g., wading birds and snail kites), lowered the overall amount of aquatic production, and eliminated large areas of long-hydroperiod habitat.

Reduced water storage capacity and the consequent extreme high and low fluctuations of water levels in the Everglades have degraded the central "ridge and slough" system. Tree islands have been affected by flooding in some areas and by fire in others. Former aquatic slough habitat has been altered by the expansion of sawgrass ridges. This is an important factor in the reduction of total production of aquatic fauna, and of feeding habitat for wading birds. Alligator reproduction has been affected; sometimes marshes are too dry for courtship behavior, and at other times what looked like a good dry nesting spot suddenly becomes fatal as marsh water levels are artificially increased.

Reduced sheet flow due to compartmentalization has contributed to the leveling of ridge and slough habitats, again reducing the potential for production of aquatic fauna. The managed mosaic of compartments has changed the timing and distribution of pools where wading birds feed, and the birds have moved away from their traditional nesting sites near the estuaries.

Addition of nutrients from outside the natural system, and the increase in soil oxidation in the Everglades, has increased phosphorus in the ecosystem and contributed to the expanse of large areas of cattail and to changes in periphyton, which are important algal communities. Increased phosphorus levels in the Everglades may eventually translate into higher levels of phosphorus and nitrogen in downstream estuaries, affecting the frequency of algal blooms in bays and nearshore lakes.

What are the indicators of Everglades restoration?

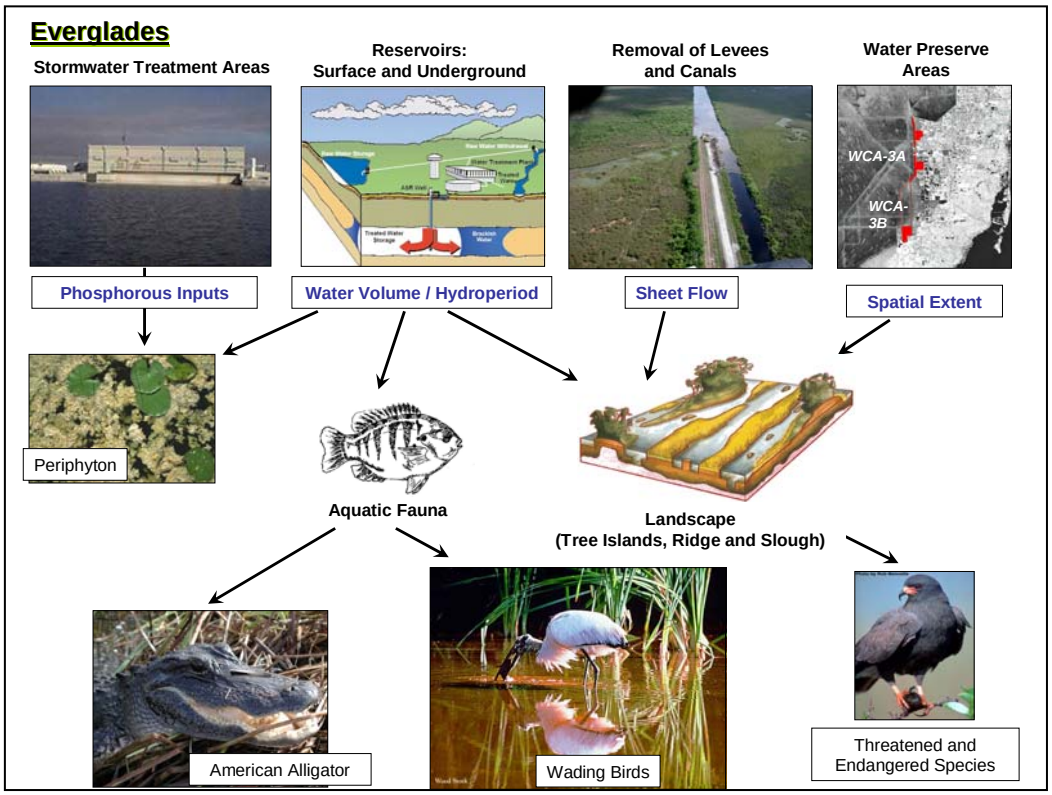
Improvements in hydrology and water quality are essential to alleviate the adverse effects of past water management practice in the Everglades. When making these essential changes to the physical part of the ecosystem, we expect landscapes and vegetation communities to respond positively, followed by restoration of healthy wildlife populations. What then constitutes a restored Everglades, and what critical elements of the ecosystem should we use to predict CERP effects on the Everglades? Desired restoration conditions for the hydrology of the Everglades involve increasing the amount of water captured and stored by the system, and distributing sufficient amounts of this water to meet the needs of the natural system. Timing and spatial distribution of the water should reflect as closely as possible the historic ecosystem, allowing natural sheet flow to occur along the original route of the "River of Grass", and restoring the seasonal patterns of flooding and drying that supported abundant wetland wildlife. Desired conditions for water quality include maintaining historic levels of phosphorus in surface waters and soils, and reducing the amount of phosphorus entering the natural system, thus supporting healthy periphyton communities and appropriate ridge and slough vegetative communities. The desired hydrologic and water quality restoration conditions described above support the development and maintenance of natural ecological communities, including a natural pattern and composition of tree islands, increases in the abundance and size of marsh fish, increases in alligator population density, and improvements in wading bird numbers and distribution across the landscape.

The restoration indicators for the Everglades were chosen because of their importance to this part of the ecosystem, and because of their potential positive response to CERP projects. Interim Goals are calculated for twelve restoration indicators of the Everglades (see table to the right). These indicators reflect ecosystem characteristics identified in the Ridge and Slough and Southern Marl Prairies Conceptual Ecological Models (Ogden 2004, Davis 2004), and cover hydrology, water quality, landscapes, species groups, individual keystone species, and threatened and endangered species. The indicators include different levels in the food chain as a way of tracking the functionality of the system.

Everglades Restoration Indicators	
3.1.	Water Volume
3.2.	Sheet Flow
3.3.	Hydropattern
3.4.	Spatial Extent
3.5.	Everglades Phosphorus
3.6.	Periphyton
3.7.	Ridge and Slough Pattern
3.8.	Tree Islands
3.9.	Aquatic Fauna
3.10.	Alligators
3.11.	Wading Birds
3.12.	Snail Kite

How will the CERP help to restore the Everglades?

Almost all CERP projects are designed to work together to benefit the Everglades ecosystem, working toward the overall goals of increasing the total spatial extent of natural areas, improving habitat and functional quality, and improving native plant and animal species abundance and diversity. Most CERP projects are multi-purpose, including several objectives such as increasing water storage, reducing seepage, and improving the quality of water to be released into natural areas.



Furthermore, no single CERP project can be said to significantly improve the Everglades ecosystem by itself. The environmental benefits to the Everglades result from the group of projects as a whole. For example, removing barriers to sheet flow will have little benefit unless sufficient water is actually flowing from storage, flow, and seepage management projects. In addition, environmental benefits of water flow depend on the quality of the water. Therefore, the CERP implementation schedule must be included in predictions for Interim Goals that estimate environmental benefits for the Everglades.

The major CERP projects or project categories that affect the Everglades ecosystem follow. A detailed description of these projects can be found in the *Central and Southern Florida Project Comprehensive Review Study Integrated Feasibility Report and Programmatic Environmental Impact Statement* (USACE and SFWMD 1999). These projects represent the original design of the CERP approved in 2000. While the original concepts and intent of the CERP should not change, as knowledge of the natural and built systems grows over the lifetime of the CERP, the suite of projects, their detailed design, and the timing of their implementation should change to improve the benefits to the natural system.

Storage Reservoirs

Water storage facilities will allow us to manage for more natural conditions in the Everglades while providing for other water-related needs, such as water supply. While all of the aquifer storage and recovery (belowground storage) and surface reservoirs (aboveground storage) will contribute to our ability to better manage water in South Florida, the following two projects should impact the Everglades most directly:

- The **Everglades Agricultural Area Storage Reservoir** project is located in west Palm Beach County. Environmental benefits of this new reservoir capacity for the Everglades include the delivery of water to the Water Conservation Areas.

- The **Central Lake Belt Storage Area** project increases storage capacity for release of water into Everglades National Park when needed.

Seepage Management

Water seepage through levees can cause desirable water to leave important areas of the Everglades. A series of CERP projects will reduce the amount of seepage lost from the Everglades including the following:

- The **Broward County Water Preserve Areas** project is primarily for water supply but also includes seepage management within Water Conservation Area 3.

- The **Everglades National Park Seepage Management** project reduces the seepage of water out of Everglades National Park by modifying the levee that borders the eastern side of the park.

Sheet Flow Enhancement

Many projects will increase amounts of water into the Everglades and enhance sheet flow including **Flow to Northwest and Central Water Conservation Area 3A**, **Flows to Eastern Water Conservation Area**, **Water Conservation Area 2B Flows to Everglades National Park**, and **South Miami-Dade Reuse**. However, the following two projects may have the largest effect on restoring sheet flow:

- The **C-111 Spreader Canal** project includes modifications to the C-111 canal in the southern Everglades and Model Lands, allowing for rehydration of this area and more natural sheet flow.

- **Water Conservation Area 3 Decompartmentalization and Sheet Flow Enhancement**, referred to as simply Decomp, is implemented in stages, and is coordinated to complement a non-CERP project, Modified Water Deliveries to Everglades National Park. The first part of Decomp supports elevating a section of eastern Tamiami Trail to increase the potential for sheet flow. Later phases of the Decomp project include moving the main conveyance for urban water supply out of the central Everglades. Canals and levees inside Water Conservation Area 3 are modified or removed, and the North New River Canal is improved to take water to the urban areas on the coast. These changes increase the potential for natural sheet flow through the central Everglades (Water Conservation Area 3 and Everglades National Park) and reduce unnatural discontinuities in the landscape.

Increase Spatial Extent

Some projects will acquire natural lands and restore them to increase the spatial extent of the Everglades. These include **Southern Corkscrew Regional Ecosystem Watershed (CREW) Project Additional Imperial River Flowway**, **Winsburg Farms Wetland Restoration**, **Restoration of Pineland and Tropical Hardwood Hammocks in C-111 Basin**, **Protect Wetlands Adjacent to Loxahatchee National Wildlife Refuge**, **Bird Drive Recharge Area**, and four Indian River Lagoon projects: **North Fork**, **Cypress Creek**, **Pal Mar Complex**, and **Allapattah**. Many of these projects also perform functions with respect to water flow and water quality, as well as spatial extent.

Protect Water Quality

Protection of water quality in South Florida is under the jurisdiction of the State of Florida (Everglades Forever Act, Florida Statute 373.4922), which has taken steps such as the implementation of the Everglades Construction Project, independent of the CERP to improve the quality of water in the natural system. Nevertheless, the CERP contributes to protecting water quality by means of the construction of stormwater treatment areas. For the Everglades region, the following CERP projects include construction of stormwater treatment areas: **C-11 Canal Impoundment**, **C-9 Impoundment**, **Central Lake Belt Storage Areas**, **Big Cypress/L-28 Interceptor Modifications**, **Miccosukee Water Management Plan**, **ACME Basin B Discharge**, **Seminole Tribe Water Conservation Plan**, and **C-111 North Spreader Canal**.

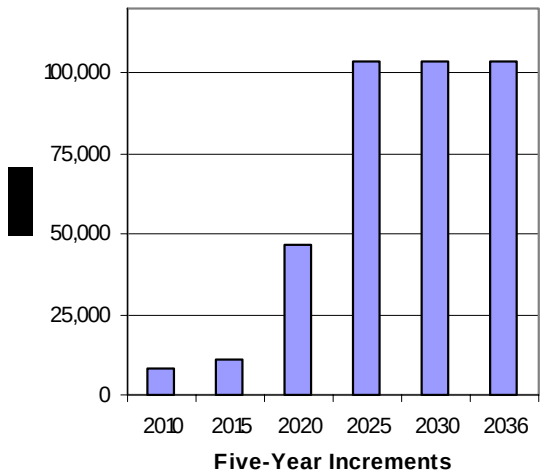
What types of tools were used to predict CERP success in the Everglades?

The desired restoration conditions for the Everglades are developed using knowledge of the historical system, both from scientific studies and layperson accounts, and in the case of some indicators, are estimated using the Natural System Model. Interim Goals for hydrology are based on the South Florida Water Management Model, version 3.5. Interim Goals for landscape features, vegetation, and wildlife communities are based on a number of models that use the information from the hydrology models to figure out what is expected to happen to species and biotic communities. In some cases, such as the spatial extent and phosphorus Interim Goals, a simple calculation of number of acres of land to be acquired as natural areas or put to specific use as a water quality treatment area was used.

What are the predictions for Interim Goals for the Everglades?

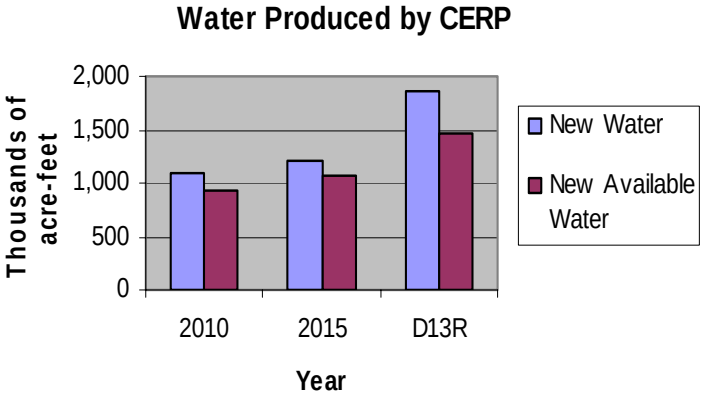
Spatial Extent

The CERP includes land purchases and the development of water preserve areas to increase the spatial extent and functionality of natural wetlands. The interim goal for spatial extent includes purchases of wetlands over the entire South Florida ecosystem before 2025, and will increase the total spatial extent of natural areas by 103,709 acres. Increased functional value of natural areas is a desired restoration condition for the Everglades; however, an interim goal for functional value was not predicted at this time because the method has not yet been developed.

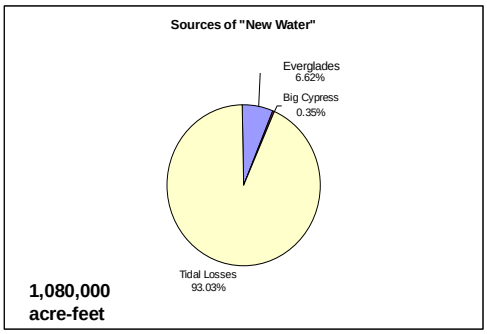


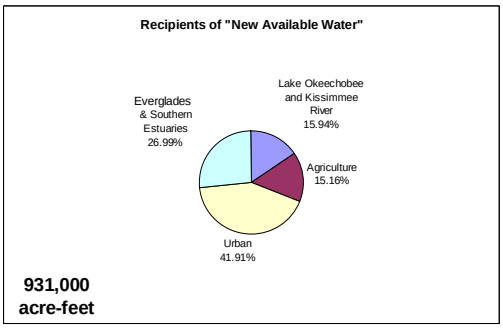
Hydrology

Water Volume. CERP is designed to capture water. In the interim goal for water volume, we track the amount of water captured by the CERP, where it comes from, and where it goes. The accompanying graph shows the cumulative volume of "new" water captured by the CERP over time, and the quantity of water to be distributed among stakeholders. In 2010, we are capturing 1,084,000 acre-feet, and by the end of CERP implementation (D13R), 1,871,000 acre-feet of "new" water has been captured by the CERP. Note that the amount of water captured ("new water") is always more than what is

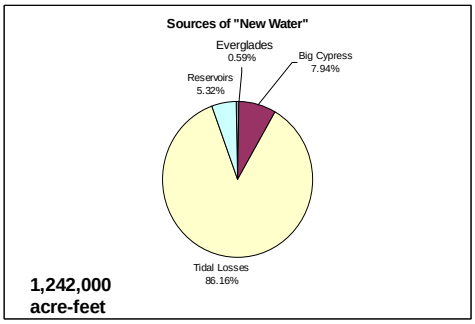


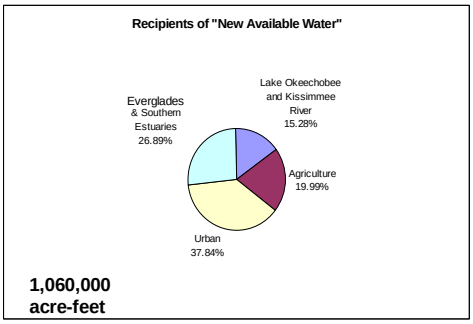
2010



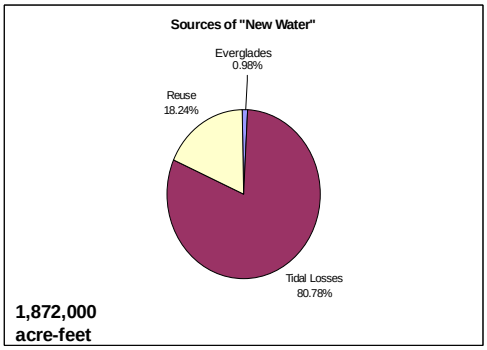


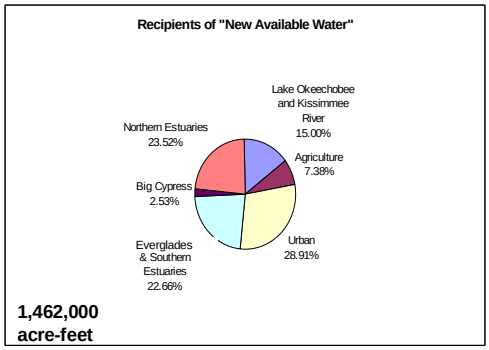
2015





Full Implementation (D13R)





distributed to recipients ("new available water). The difference remains in aboveground or belowground reservoirs and can be viewed as a "cost" of maintenance of the water management system. The figure below shows where that "new" water comes from, and where it goes, in terms of percentages of the total amount. In the year 2010, almost all of the "new water" comes from capturing water previously sent to the estuaries ("tidal losses"), and about 7 percent comes from the Everglades and Big Cypress. None yet comes from wastewater reuse. By the end of CERP implementation, wastewater reuse projects are producing nearly 18 percent of the "new water", and the contribution made by capturing water previously lost to tide is still the most significant source. Recipients of "new available water" in 2010 include

the urban system and agriculture (57 percent), and the natural system made up of the Kissimmee/Lake Okeechobee headwaters, and the Everglades and Southern Estuaries (43 percent). The model output of the D13R alternative (full implementation) indicates that by the end of CERP implementation, urban uses and agriculture receive about 36 percent of the new water, the Northern Estuaries are receiving nearly a fourth, and the headwaters, Everglades/Southern Estuaries, and Big Cypress are receiving 40 percent.

Sheet Flow. The interim goal for sheet flow in the Everglades looks at the amount of water flowing across a set of imaginary lines drawn across a map of the region. It also looks at the direction the water is flowing. These two items - amount of water flow and where it is going - are critical to measuring progress toward reestablishing the natural course of the "River of Grass."

By 2010, sheet flow in the Everglades will be increased in volume, and the north to south flow pattern will be shifted toward the Atlantic Ridge in the eastern part of the system. These changes move the system closer to the historic pattern. Much of this early change in sheet flow is a result of the Modified Water Deliveries Project, and part can be attributed to early phases of CERP projects to remove barriers to flow. Another shift in the system, due to the CERP, is noted between 2015 and full implementation (D13R), when greater amounts of water are flowing into Everglades National Park, especially through Northeast Shark Slough.

Hydropattern. Hydropattern is a term that describes the inundation of a landscape. The concept of hydropattern encompasses the depth of water, the area of flooded lands, and the rate at which the water extends and recedes across the landscape. Therefore, there are many ways to measure hydropattern. The interim goal chosen for hydropattern is a simple estimate of the average percent of the landscape that is inundated within the Everglades. The hydropattern interim goal is further divided into three major components: ridge and slough (the deepest and naturally most inundated), marl marsh, and sawgrass (both of which are less inundated naturally than ridge and slough.)

Patterns of inundation of the Everglades landscape should be sensitive to the implementation of the CERP. The model simulations of the percent of landscape inundated show an increase in inundation by 2010, and, in some habitats, another increase by full CERP implementation. The early increase in inundation may include the effects of the Modified Water Deliveries Project, whereas the later increases may be attributed to the CERP.

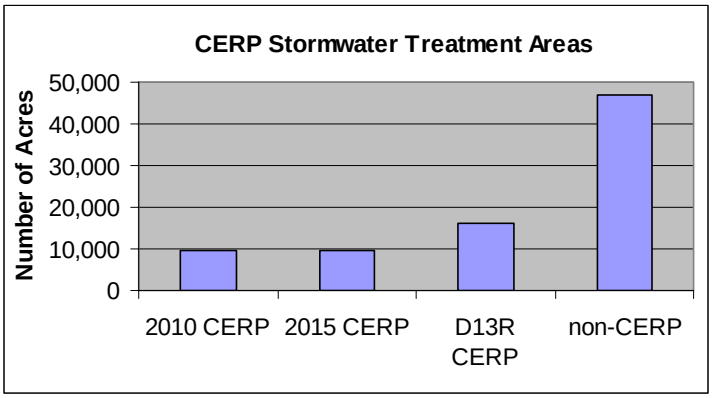
The hydropattern interim goal is currently calculated as an average, using indicator regions in different parts of the Everglades landscape. This method, based on indicator regions in different water management compartments, has limitations in terms of its ability to reflect benefits of changes in hydropattern over the Everglades landscape as a whole. Future improvements to the statistical methods used to calculate this Interim Goal may make it a more useful tool in the assessment of progress toward restoration.

Water Quality

CERP projects will have a variety of effects on the water quality of the Everglades. Some projects will directly improve surface water quality through new stormwater treatment areas. Other projects that enhance water storage (such as reservoirs) should allow stormwater

treatment areas to increase their ability to clean the water of excess nutrients. CERP changes in the quantity and timing of water flow into the Everglades can also alter water quality. For instance, longer hydroperiods produced by the CERP should reduce the extent to which overdrained soils oxidize and release stored phosphorus to the water column. Water quality restoration indicators include periphyton and the total phosphorus in the ecosystem.

Periphyton. Periphyton is a widespread feature of Everglades marshes. It is an algal mat made up of a number of species of algae and diatoms. Periphyton is important in the formation of marl soils and is likely to be an important food web component. Periphyton grows differently depending on the water regime. In areas with short hydroperiods it grows in a mat on the ground, and in longer-hydroperiod areas it floats or grows attached to aquatic plants. Periphyton also is very sensitive to water quality, as higher levels of nutrients change the composition of species that make up the mat and therefore change the periphyton function in terms of marl soil formation and food web importance. These characteristics make it a good indicator of changes in the amount and quality of water in the system. Currently, the method for evaluating the impact of the CERP on Everglades periphyton is in development.



Phosphorus. Two methods were used to estimate Interim Goals for phosphorus in the Everglades. First, the number of acres of new stormwater treatment areas was calculated for each five-year time period of CERP implementation. For the Everglades region, the Everglades Construction Project is building nearly three-fourths of the total acreage of stormwater treatment areas, with the CERP making up the remaining fourth. Although the Everglades Construction Project is independent of the CERP, the physical interrelationship between the projects is unavoidable, and must be considered throughout the planning and management of both projects.

Second, in the absence of a water quality model for the Everglades, an analysis was done of how CERP affects the performance of stormwater treatment areas built under the authority of the Everglades Construction Project. This stormwater treatment area performance analysis looked at the results of the South Florida Water Management Model to see how increased flow and hydroperiods should affect the ability of the treatment areas to clean water from the Everglades Agricultural Area. Not all of the Everglades Construction Project treatment areas did better under full D13R implementation. However, during CERP implementation less water is routed around the stormwater treatment areas, which means that a greater percentage of the water is at least partially cleaned by traveling through a stormwater treatment area.

Landscape Effects

Interim Goals for landscape characteristics of the Everglades include a Ridge and Slough Pattern Index and a Tree Island Habitat Suitability Index.

Ridge and Slough Pattern Index. The Ridge and Slough indicator is an index that combines four characteristics of water in the Everglades - depth, fluctuation, velocity, and flow direction - to estimate how good the physical environment is for the development and maintenance of ridge and slough habitat. In this model, the "perfect" habitat would score a 1, and the worst would score 0. Averages (and ranges) of these scores for the northern Everglades (Loxahatchee National Wildlife Refuge and Water Conservation Area 2) and for the central Everglades (Water Conservation Areas 3A and 3B, and Shark Slough in Everglades National Park) are shown in the table below.

Average (and Range) of the Ridge and Slough Pattern Index for Indicator Regions in the Northern and Central Everglades

	NSM	95base	50base	2010	2015	D13R
Northern	**.53** (.51-.54)	**.30** (.21-.38)	**.31** (.26-.35)	**.29** (.23-.34)	**.29** (.23-.35)	**.29** (.23-.34)
Central	**.60** (.52-.82)	**.45** (.34-.59)	**.54** (.48-.62)	**.65** (.36-.71)	**.66** (.57-.71)	**.58** (.57-.74)

These different areas of the original ridge and slough landscape are separated out because the northern Everglades originally formed part of a separate flowway. The index shows that we expect little change over the course CERP implementation in the northern Everglades potential for ridge and slough habitat, compared to current conditions, as well as compared to the future without CERP implementation. For the central Everglades, however, ridge and slough potential improves with CERP implementation compared to current conditions.

Tree Island Habitat Suitability Index. Tree islands in the Everglades are important landscape components. Contributing much to the plant species diversity of the Everglades, they are nesting sites for birds and reptiles and important refuges for animals during periods of high water, as well as important archaeological sites. The species composition and soils of tree islands are sensitive to drought (they may be damaged by fire), and to prolonged flooding (some high-ground species of trees suffer when their roots are wet for long periods of time). The tree island habitat suitability index looks at the suitability of hydrology (drought, flooding) and at the relationship between hydrology and tree species diversity to estimate the potential for maintenance and diversity of tree island vegetation.

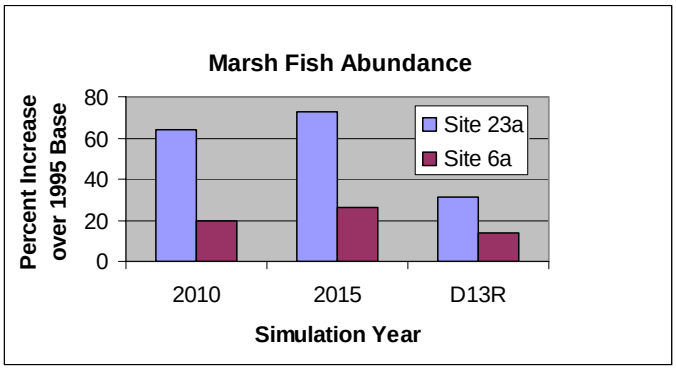
The Everglades has been divided into compartments for more than half a century (i.e., the five different Water Conservation Areas and Everglades National Park) and these compartments have had distinctly different hydrology (i.e., some have tended to pool water, whereas others like Everglades National Park have been much drier than historical conditions). Therefore, the connected system produced by the CERP is likely to affect tree islands in these areas in different ways. Some will get wetter and some will get drier. As time passes, the species composition of these islands will reflect those changes.

One trend for tree islands is clear using this measure: drought stress on tree islands in all compartments of the Everglades shows mixed results by 2010, but is reduced in all areas by 2015, and further reduced by the end of CERP implementation. Flooding stress and tree island species richness, as calculated with the tree island index, show mixed results for the different compartments throughout CERP implementation; in some areas, these indices show

improvement but in others they do not. Changes in the calculation method for this indicator, by taking a regional approach rather than one based on compartments, may in future predictions of Interim Goals help to clarify the expected impacts of CERP implementation on this important landscape component.

Wildlife

Aquatic Fauna. Marsh fishes and other aquatic fauna are critical sources of food for Everglades predators (e.g., alligators and wading birds). Calculation of the expected benefits of the CERP regarding increased abundance of marsh fishes come from a relationship of fish abundance to hydroperiod (time since the site was last dried out) that has been determined from field studies in the Everglades. Predictions were made for two sites located in Everglades National Park. Both of these sites show increasing abundances of marsh fishes with 2010 and 2015 CERP conditions compared to the ecosystem in 1995 without CERP. Both sites also show that fish abundance decreases from 2015 to full CERP implementation, although the system still produces more fish than the ecosystem in 1995 without CERP.



Alligators. Alligators are a symbol of the Everglades, and are a keystone species in the South Florida wetlands, in that they play a major role in influencing the overall health and ecological patterns of the region. Overdrained wetlands and reductions in numbers of alligators have caused the loss of many small ponds ("holes") that were essential for the survival of small aquatic animals during dry seasons.

Click here for alligator figure:

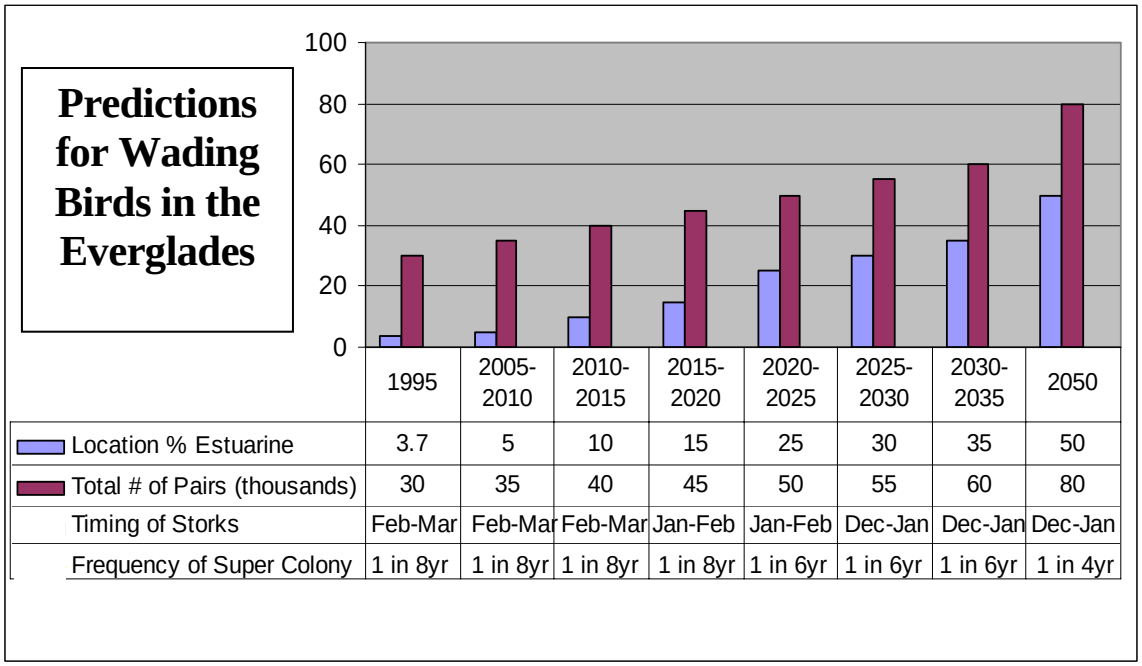
alligator figure.gif

The full implementation of the CERP is expected to increase the density of alligators in large areas of the Everglades, including the north and western parts of Water Conservation Area 3 and the edges of Shark Slough in Everglades National Park (green areas in adjacent map), whereas the central part of Shark Slough and the southeastern part of Water Conservation Area 3 are not expected to change much (reddish areas).

Changes expected by 2010 include general improvements to alligator conditions in Water Conservation Area 3, and improvements to selected characteristics (like density and body condition) in Water Conservation Area 2 and Everglades National Park.

Wading Birds

Wading birds are also a symbol of the Everglades and, perhaps even more than the alligator, demonstrate the impact that people have had on this environment. The wading bird Interim Goal looks at system-wide patterns of nesting, including measurements of numbers of birds, locations of colonies, and timing and the frequency of "super colonies".



	1995	2005-2010	2010-2015	2015-2020	2020-2025	2025-2030	2030-2035	2050
Location % Estuarine	3.7	5	10	15	25	30	35	50
Total # of Pairs (thousands)	30	35	40	45	50	55	60	80
Timing of Storks	Feb-Mar	Feb-Mar	Feb-Mar	Jan-Feb	Jan-Feb	Dec-Jan	Dec-Jan	Dec-Jan
Frequency of Super Colony	1 in 8yr	1 in 8yr	1 in 8yr	1 in 8yr	1 in 6yr	1 in 6yr	1 in 6yr	1 in 4yr

Threatened and Endangered Species: Snail Kite

The snail kite is an endangered species characteristic of the Everglades, living in wet prairie habitats with tree islands. The desired restoration condition for snail kites is a substantial mosaic of wet prairie habitat over the area that includes the Everglades and the Lake Okeechobee littoral zone, with marginal or good habitat for snail kites found in about 50 percent of this area. Because the CERP will change hydrology in the Everglades, snail kite habitat is likely to be affected. Interim goals were based on 1) the potential for habitat to support optimal feeding conditions for the snail kite and 2) optimal reproductive conditions for their primary prey species, the apple snail.

Model output shows that the potential of habitat to support snail kites appears to improve beginning in 2010, especially in the Shark Slough and Loxahatchee areas. This pattern is maintained and optimal snail kite habitat is predicted for western and northern Water Conservation Area 3B and the Pennsucco Wetlands in the D13R simulation. Conditions for apple snails gradually improve over 1995 results in the 2010, 2015, and D13R simulations. These improvements reflect slightly improved conditions for apple snails over the 2050 simulation. Overall, we expect increased suitability for snail kites in Southern Water Conservation Area 3A and Shark River Slough as hydrologic restoration progresses. Additional work in the field of model refinement and development may allow predictions of population size, growth rates, and spatial distribution of the snail kite population.

How do we know we have achieved success through the CERP?

The success of restoration is measured in several ways. The first is to compare what is actually happening in the ecosystem with the Interim Goal. That is, are the changes in the ecosystem reflecting what we expect from the CERP plan? The second is to compare what is happening in the ecosystem with the desired restoration condition. Are we moving closer to our definition of restoration? Both of these comparisons can be used to assess CERP's progress, and to work toward changes to the CERP that improve the potential for achieving desired restoration conditions.

The primary tool for measuring what is happening in the ecosystem is the *CERP Monitoring and Assessment Plan: Part 1, Monitoring and Supporting Research* (RECOVER 2004). This plan includes projects to monitor hydrologic characteristics, water quality, and the ecological components of the Everglades. Hydrologic monitoring includes keeping track of the depth of water, groundwater levels, and the movement of quantities of water from one area to another, over the entire spatial extent of the CERP. The detailed hydrologic monitoring plan is still being finalized, and some components may be added. Water quality gradients will be monitored within the Everglades, including nutrients in the water column and in the soil. Periodic vegetation mapping will follow landscape pattern changes and changes in the number and size of tree islands. Aquatic fauna, alligators, and wading birds are specifically identified as components for monitoring programs. Some of these monitoring components have begun to get baseline data in 2004 and 2005. The snail kite is monitored by the U.S. Fish and Wildlife Service. As CERP implementation progresses, assessments will be done every five years to determine progress toward the Everglades Interim Goals and progress toward restoration.

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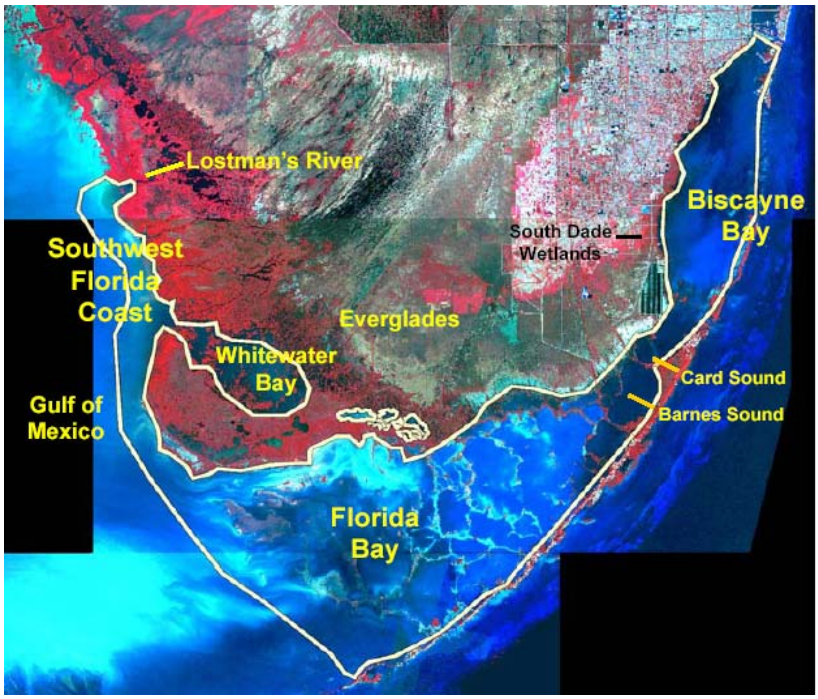
The Southern Estuaries

Estuaries and the lands surrounding them are places of transition from land to sea, and from fresh to salt water. Estuaries are critical for the survival of many species and are among the most biologically productive ecosystems on our planet. Tens of thousands of birds, mammals, fish, and other wildlife depend on estuarine habitats as places to live, feed, and reproduce. Estuaries provide ideal spots for migratory birds to rest and refuel during their journeys. Many species of fish and shellfish rely on the sheltered waters of estuaries as protected places to spawn, giving them the nickname "nurseries of the sea." More than two-thirds of the fish and shellfish we eat spend some part of their lives in estuaries.

Besides serving as important habitat for wildlife, the wetlands that fringe many estuaries also perform other valuable functions. Water draining from the uplands carries sediments, nutrients, and other pollutants. As the water flows through fresh and salt marshes, much of the sediments and pollutants are filtered out. This filtration process creates cleaner and clearer water, which benefits both people and marine life. Wetland plants and soils also act as a natural buffer between the land and ocean, absorbing flood waters and dissipating storm surges. This protects upland organisms as well as valuable real estate from storm and flood damage.

Seagrass beds are a key component of South Florida estuarine ecosystems, providing critical food and habitat for shrimp, fish, and other organisms. Seagrass beds also stabilize sediments, thus promoting clear water and helping to minimize algal blooms. Freshwater inflow patterns (quantity, timing, and spatial distribution) affect salinity, nutrients, and light, which in turn, influence seagrass species composition, abundance, and spatial distribution.

The southern estuaries include Biscayne Bay, Florida Bay, and the southwestern mangrove coast. These estuaries are a connected system of wetlands and lagoons where fresh water leaving the Everglades mixes with salt water.



Florida Bay covers a triangular area of 2,200 square kilometers at the southern tip of Florida, between the Everglades and the Florida Keys. About 80 percent of this

estuary is within the Everglades National Park and it is classified as an Outstanding Florida Water. The bay is shallow, with an average depth of about 3 feet and most of the bay's bottom is covered by seagrass, which is habitat for many invertebrate and fish species.

Biscayne Bay is located along the southeastern coast of Miami-Dade County, Florida. It varies considerably in width, depth, water quality, and degree of connectedness to the open marine waters of the Atlantic Ocean. The central and southern portions of Biscayne Bay comprise much of Biscayne National Park, and Card Sound and Barnes Sound are part of the Florida Keys National Marine Sanctuary. All of these areas are designated as Outstanding Florida Waters. Biscayne Bay varies in width from several hundred meters in the northern end to over nine miles in the south-central regions and in depth from less than 3 feet in tidal areas to over 40 feet in dredged ship channels.

What has been causing the decline of ecosystem health in Florida and Biscayne Bays?

Man-made changes to the quality, quantity, timing, and duration of freshwater inflows to the Southern Estuaries have changed the circulation and salinity patterns. These changes in circulation and salinity patterns have altered the structure and function of estuarine ecosystems.

Starting in the late 1980s, a series of ecological changes to Florida Bay were apparent, including widespread seagrass die-off, the occurrence of algal booms and high turbidity in what had been clear waters, widespread mortality of sponges, and decreases in some other invertebrates and fish species. It is generally thought that historical decreases in freshwater inflow from the Everglades and resultant increases in salinity have contributed to these ecological changes.

Florida Bay is currently plagued by the occurrence of turbid water in many parts of the bay. In the eastern bay, most of this turbidity is caused by resuspended sediments, while in the central and western bay, turbidity is caused by both resuspended sediments and algal blooms. Sediment resuspension and associated turbidity is strongly affected by seagrass density. The dense monoculture of turtle grass that existed in Florida Bay prior to die-off in the 1980s resulted in clear water, but this condition is not considered to be natural and is not a restoration target. Rather, the target of moderate and diverse seagrass cover will likely be associated with moderate turbidity and light penetration.

Historically, fresh water flowed eastward overland from the Everglades to the bay through natural sloughs and rivers and as groundwater through the Biscayne Aquifer. During the last century, this pattern has been altered by regional drainage, canal construction and operation,

and urban development, as well as by construction of roads, levees, and other barriers to surface flow. Based upon these alterations, the bay currently receives freshwater inflow from canals, minor overland flows, and groundwater.

In general, water quality within Biscayne Bay varies from poor in deep areas with heavy pollutant loading and little mixing, to good in the east-central areas where there is little overland pollution and high exchange with marine waters. Parts of the bay are subject to extremely rapid shifts in salinity and nutrients from canal flows. As the rapid pulse of fresh canal water moves into the bay it can harm or even kill plants bottom dwelling invertebrates and fish and shrimp.

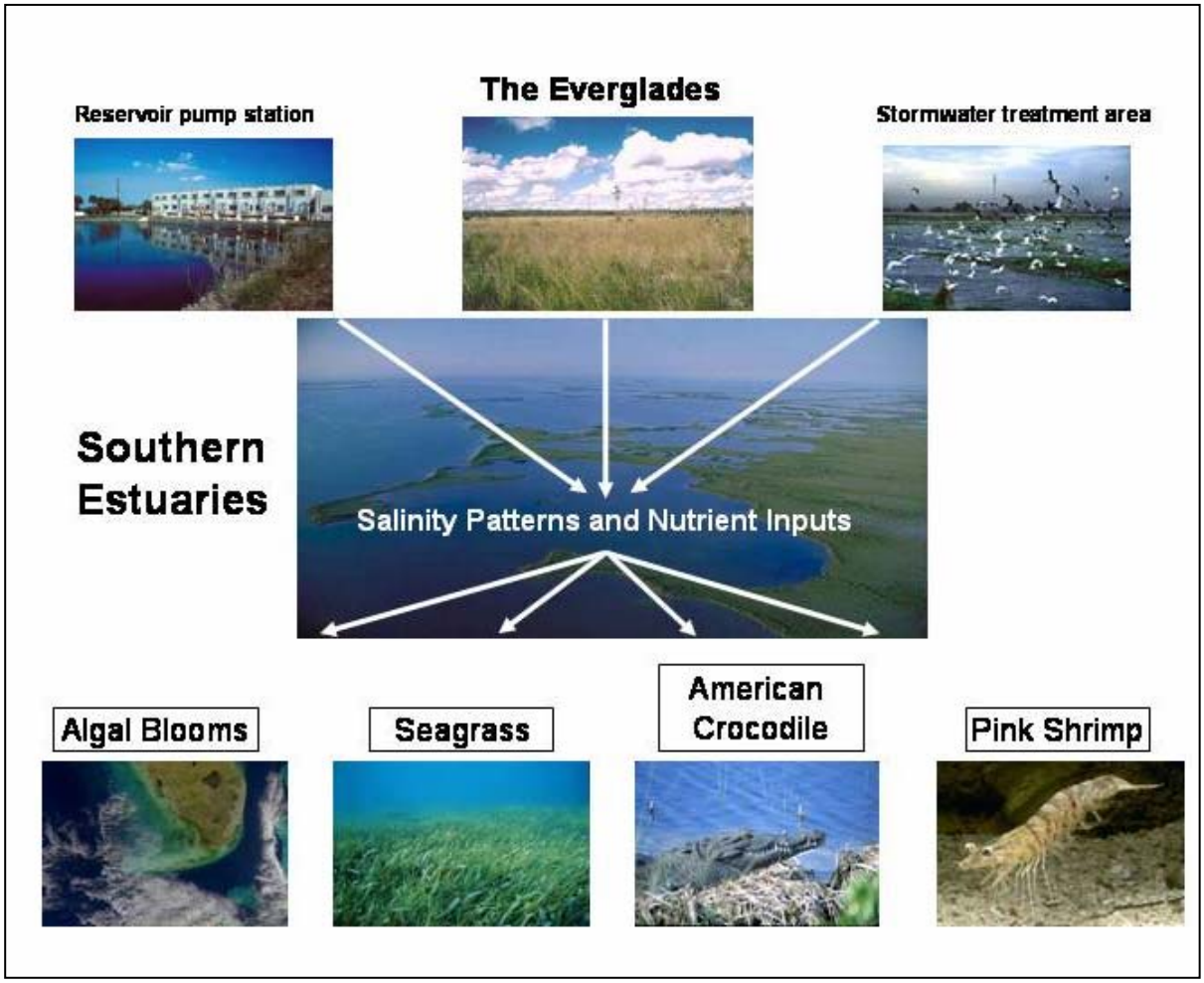
How will CERP help to restore the Southern Estuaries?

The restoration of a natural volume, distribution, and timing of freshwater inputs to Florida Bay is expected to provide salinity patterns that will sustain seagrass beds covering most of the bay bottom. The northeast portions of the bay are expected to experience less abrupt and less extreme decreases in salinity, while hypersaline conditions are expected to be less frequent, less extreme, and less extensive in the central and western parts of the bay. Seagrass recovery is expected to include decreased dominance by turtle grass and more cover by a mix of turtle grass and shoal grass through most of the bay and the expansion of widgeon grass near the northern coastline. The recovery of seagrass beds in combination with restored salinity regimes is expected to enhance nursery ground habitat values, as indicated by increased populations of juvenile pink shrimp, juvenile spotted seatrout, and other fish species that inhabit seagrass beds. Recovery of seagrass beds should also sequester nutrients and stabilize sediments to reduce algal blooms and turbidity in areas of Florida Bay that have experienced seagrass die-off.

The Comprehensive Everglades Restoration Plan (CERP) will primarily benefit the nearshore plant and animal communities of southern Biscayne Bay, including Barnes and Card Sounds. Increased freshwater inflows to the bay through the tidal creeks and herbaceous marshes of the South Dade Wetlands are expected to lower salinity at mouths of the creeks to levels favorable for establishment of more estuarine salinity patterns supporting seagrass beds and oyster beds in nearshore areas that presently do not support seagrasses or oysters. The delivery of fresh water to the bay across the South Dade Wetlands should reduce the accompanying nutrient inputs and establishment of more natural inflow patterns is expected to restore oyster bars and estuarine fish communities and to increase densities of juvenile pink shrimp in the nearshore environment of southern Biscayne Bay.

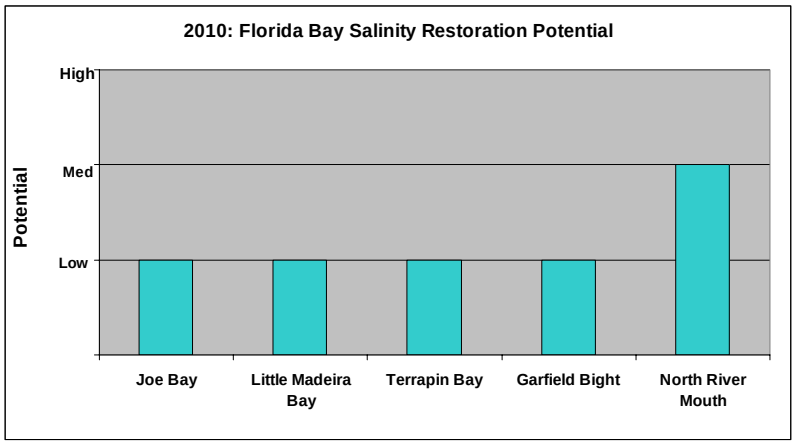
What are the predictions for Interim Goals for the Southern Estuaries?

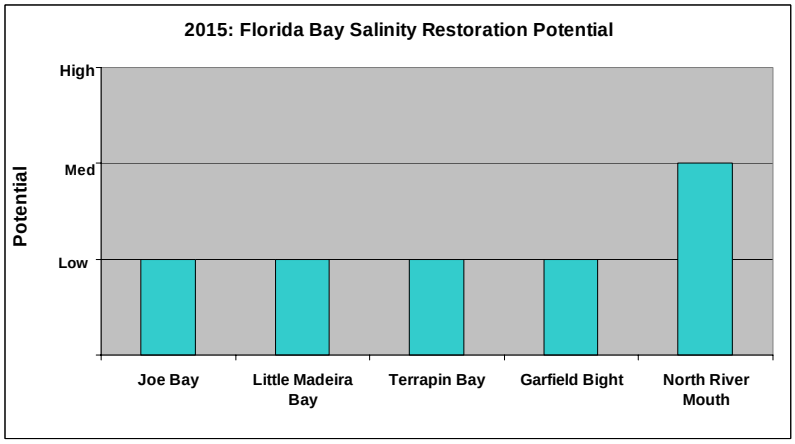
Five indicators are being used to judge the restoration progress and success of the restoration for the southern estuaries: salinity patterns, juvenile pink shrimp densities, American crocodile habitat, and algal blooms. The relationship between freshwater and nutrient inputs to the southern estuaries and the indicators is shown in the figure below. For Biscayne Bay, no interim goals are available at this time.

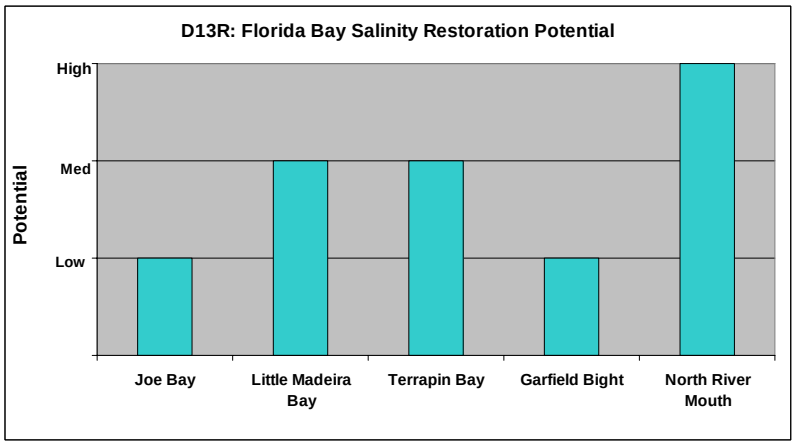


Salinity Patterns

The desired restoration condition for salinity patterns in the southern estuaries is to reduce the intensity, frequency, duration, and spatial extent of hypersaline events; reestablish common mesohaline conditions in mainland nearshore zones; and reduce the frequency and rapidity of salinity fluctuations derived from pulse releases of fresh water from canals. Currently, progress toward restoration of appropriate salinity patterns seems assured for the Shark River Slough estuaries, however there is less certainty regarding the prospects for Florida Bay nearshore waters. Salinity predictions generally show little improvement until full CERP implementation in 2036 and in some cases show no improvement even with the CERP. Evaluating the adequacy of the CERP for Florida Bay restoration is an explicit goal of the Florida Bay and Florida Keys Feasibility Study and models being created for this study should provide much better predictive power for these salinity indicators.

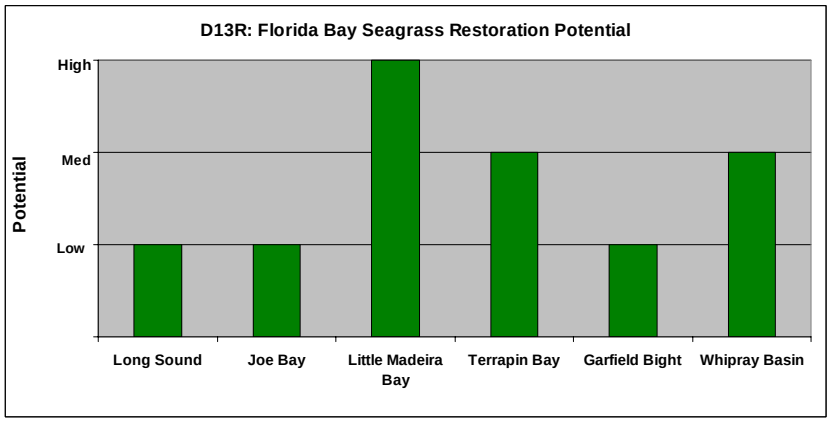


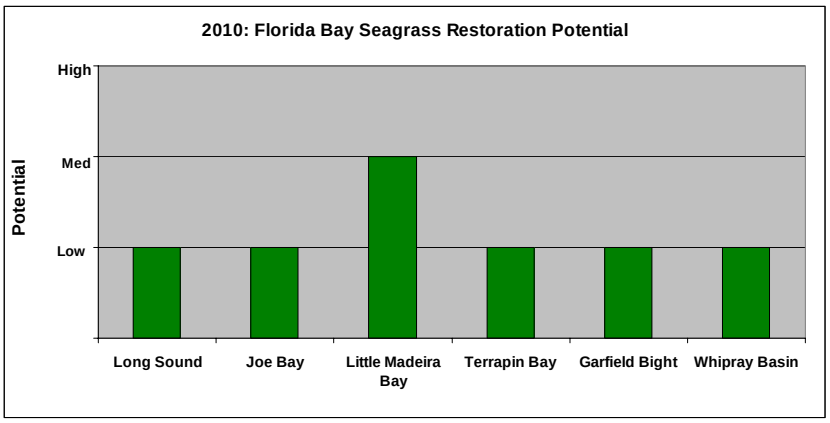


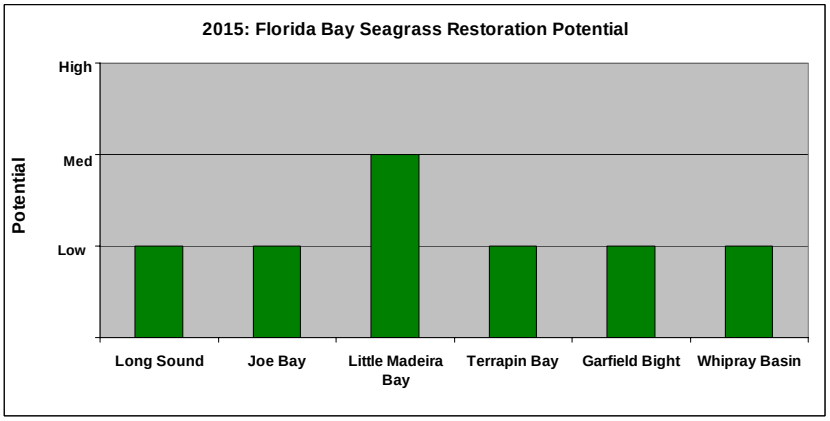


Submerged Aquatic Vegetation

The desired restoration condition for submerged aquatic vegetation in southern estuaries is to establish and sustain diverse Florida Bay seagrass communities, with moderate plant densities and more natural seasonality, covering 65-70 percent of suitable bay habitat. Certain models for salinity and nutrients that are critical to predicting the restoration progress are still being developed. Thus, the predictions for restoration of submerged aquatic vegetation presented here are the best professional judgment of several marine ecologists with experience and expertise in the southern estuaries. CERP implementation will result in less seasonal variation in the northeastern part of Florida Bay, which will likely achieve the restoration targets for this area. In the central part of the bay, hypersalinity events will be less probable and the chance of seagrass die-off will decrease as compared to the 1965-1995 period. Little change in submerged aquatic vegetation is expected in the areas of Long Sound, Joe Bay, and Garfield Bight.

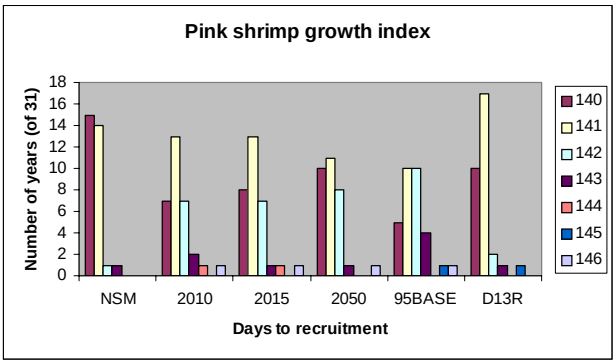






Juvenile Shrimp

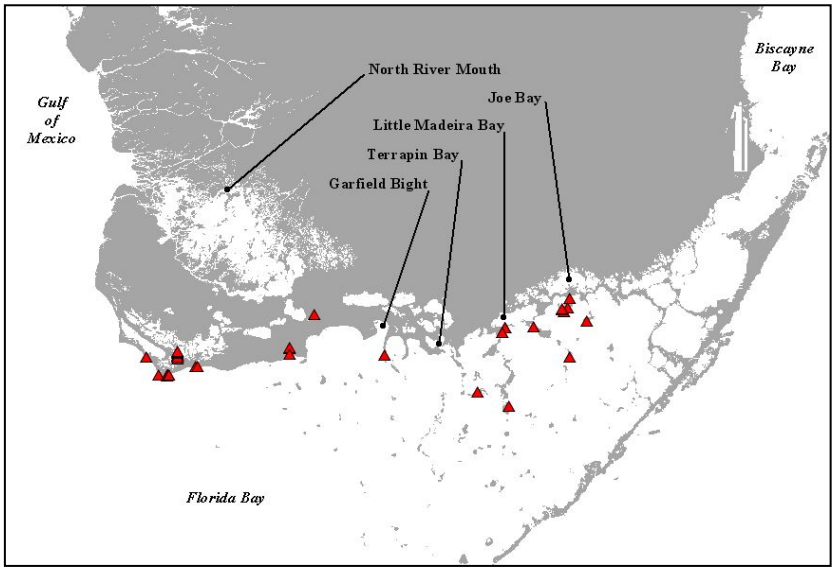
The desired restoration condition for juvenile shrimp densities in Florida and Biscayne Bay is an increase juvenile pink shrimp density at peak abundance during August-October in optimal habitat (seagrass) in three regions of Florida Bay: Ponce de Leon Bay, lower southwest mangrove coast, and western nearshore southern Biscayne Bay. Specific restoration goals include 17 shrimp per square meter in Johnson Key Basin; 7 shrimp per square meter in south central Florida Bay (when western monitoring area exceeds 15 shrimp per square meter); at least 5 shrimp per square meter in Whipray Basin (when western monitoring area exceeds 15 shrimp per square meter); 7 shrimp per square meter in Ponce de Leon Bay (when western monitoring area exceeds 15 shrimp per square meter); and 2 shrimp per square meter in nearshore optimal habitat from Shoal Point to Turkey Point (in south Biscayne Bay).



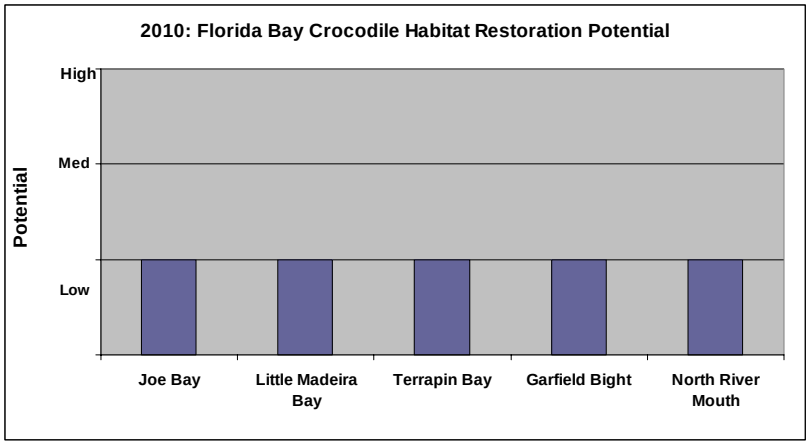
Shrimp predictions for the first five-year evaluation interval were prepared for only the north-central interior of Florida Bay because daily salinity predictions for western Florida Bay were lacking for the scenarios. Thus, the values of density and days to recruitment in these simulations are relative values among years and scenarios, rather than attempts to represent actual values. Density at 1,212 days (from settlement) is highest (2.3-2.4 shrimp per square meter) for the most number of years with the 2050 with CERP. Growth rate is fastest for the most years using the Natural Systems Model version 4.5 scenario. More realistic values await calibration to observed juvenile densities in optimum habitat in Johnson Key Basin, which cannot be fully accomplished until modeled daily salinity data for Johnson Key Basin are available.

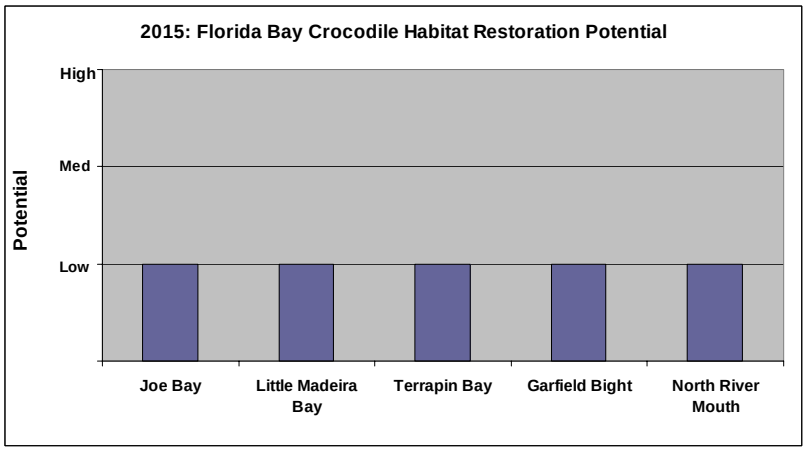
American Crocodiles

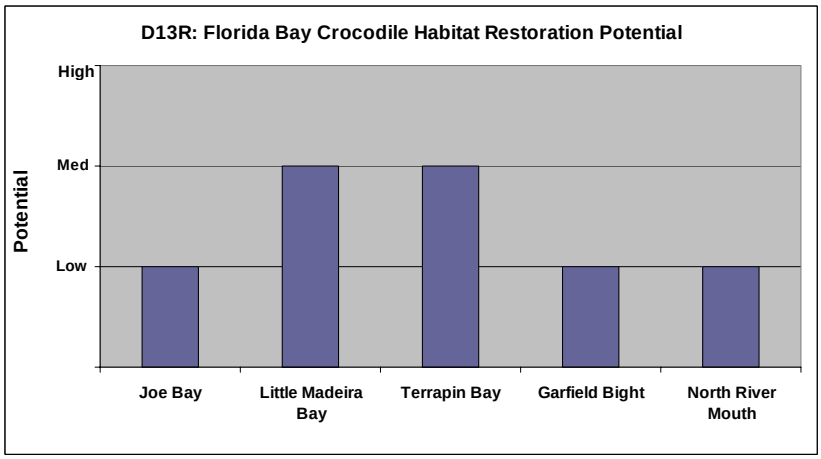
The desired restoration condition for American crocodiles is to establish appropriate salinity regimes for optimal growth and survival of juvenile crocodiles. The known nesting sites of the American crocodile are indicated by the red triangles in the figure to the right.



The frequency of optimal salinities in Terrapin Bay between the 1995, and the 2010, 2015, and 2050 with CERP model simulations increases and should provide improved conditions for growth and survival of juvenile crocodiles. Overall, the interim and full CERP simulation may only provide very small benefits versus the 2050, or future without CERP. The model simulations do not show any differences in the frequency of optimal salinities at the North River Mouth, Joe Bay, or Garfield Bight. For Little Madeira Bay, small improvement in the frequency of optimal salinities were predicted. In summary, some reductions in the frequency of months with high salinities were observed in the 2010, 2015, and full CERP implementation model predictions. Though any improvement may be expected to result in small, incremental improvements in habitat suitability, it is unlikely that such small increases will result in measurable increases in juvenile growth and survival.







Algal Blooms

The desired restoration condition for algal blooms is to sustain good water quality in Florida Bay, minimizing the magnitude, duration, and spatial extent of algal blooms in the bay such that light penetration is sufficient to sustain healthy and productive seagrass habitat. The Interim Goal for Florida Bay algal blooms is prevent any increase in the intensity, duration, or spatial extent of such blooms in Florida Bay or adjacent waters within the Florida Bay and Florida Keys Feasibility Study boundaries. Causes of algal blooms in Florida Bay are complex, involving multiple sources of nutrient supply, the extent of bay water exchange with adjacent marine waters, grazing of algal cells, and other processes.

Successful predictions of the relationship between CERP actions and bay water quality require synthesis of existing data (through modeling) and provision of new data on processes that influence algal blooms. A predictive water quality model is under development and not yet functional. This model is being developed as part of CERP's Florida Bay and Florida Keys Feasibility Study and will have the capability of predicting the magnitude, duration, and spatial extent of algal blooms and assess their relationship to freshwater flow and nitrogen associated with this flow. Water quality models of other estuaries have successfully predicted algal bloom dynamics, but Florida Bay modeling is particularly challenging because of the bay's physical and chemical complexity. Thus, successful water quality predictions for Florida Bay depend on successful hydrodynamic modeling and provision of data on critical ecological processes (particularly regarding organic nitrogen bioavailability) by CERP's Restoration Coordination and Verification team (RECOVER), National Oceanic and Atmospheric Administration's Coastal Ocean Program, and other research programs.

How do we know we have achieved success after implementing the CERP?

CERP managers will use the *CERP Monitoring and Assessment Plan: Part 1, Monitoring and Supporting Research* (RECOVER 2004) as the primary tool to determine if we are successful throughout the implementation of the CERP. The CERP Monitoring and Assessment Plan calls for monitoring salinity in Biscayne Bay, and in the Garfield Bight, Joe Bay, Little Madeira Bay, North River Mouth, and Terrapin Bay sites in Florida Bay. Monitoring of seagrass, pink shrimp, juvenile crocodiles, and indicators of algal blooms will occur alongside salinity monitoring so we can see if the CERP has affected salinity patterns and if those salinity patterns have affected wildlife.

It is important to note that scientists are still evaluating the adequacy of the current CERP for Florida Bay restoration. The final report (USACE and SFWMD1999) of the Central and Southern Florida Project Comprehensive Review Study, referred to as the Restudy, acknowledged that additional work was necessary to determine what actions were necessary to restore water quality and ecological conditions in Florida Bay. Therefore, the Florida Bay and Florida Keys Feasibility Study was established. Models being built for this study should provide much better predictive power for these salinity indicators and help to define restoration targets for Florida Bay. The study is also evaluating restoration targets for the bay and this effort will help guide a revised set of Interim Goals in the future. As the CERP improves, we will continue to identify the problems that harm the Southern Estuaries and monitor the system to determine if restoration is occurring.

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USACE and SFWMD. 1999. Central and Southern Florida Project Comprehensive Review Study Final Integrated Feasibility Report and Programmatic Environmental Impact Statement. United States Army Corps of Engineers, Jacksonville District, Jacksonville, FL, and South Florida Water Management District, West Palm Beach, FL.

Water Supply and Flood Protection

Almost six million people live in South Florida, making it more populous than 39 states. Most people live in a narrow band along the lower east coast. The South Florida Water Management District provides regional water supply to the people of South Florida by storing water in canals, the Water Conservation Areas located west of the developed lower east coast, and Lake Okeechobee. Primarily, the lower east coast counties of Palm Beach, Broward, Miami-Dade, and Monroe are collectively referred to as the Lower East Coast Service Area for the purposes of water supply. In addition to its urban population, South Florida supports almost one million acres of agricultural lands, mainly sugar cane, citrus, vegetables, and plant nurseries. A large, mostly agricultural service area, called the Lake Okeechobee Service Area because it is centered around Lake Okeechobee, provides water supply to the Everglades Agricultural Area (see picture to right), the Caloosahatchee and St. Lucie basins, and the Seminole Tribe of Florida's Brighton and Big Cypress Reservations. The system of canals and water management structures, known as the Central and Southern Florida Project, also provides flood protection for people and farms.

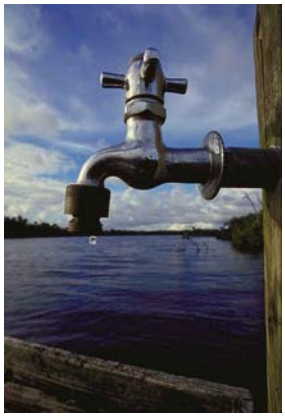
What has been causing problems with water supply and flood protection?

Over fifty years ago, the U.S. Congress authorized the Central and Southern Florida Project to help protect the roughly 500,000 people who were then living in South Florida from the effects of hurricanes, floods, droughts, and fires. The massive water management system was built to address flood protection and provide water to people and agricultural lands. When the project was designed in the early 1950s and built in the late 1950s to early 1970s, it was estimated that by 2000 two million people may be living in South Florida. Today's population of nearly six million people is three times more than the project was designed to serve.

From 1971 to 2001, South Florida experienced eight years of drought caused by too little rainfall; in six of these years, water shortage restrictions were declared. Water shortage restrictions can cause economic hardship to people living in cities as well as on farms. Conversely, storm events like the No-Name Storm and Hurricane Irene in 1999 caused extensive flood damage to some people. During the 2004 hurricane season, four hurricanes struck South Florida and Lake Okeechobee water levels rose by 5.5 feet in only six weeks. These events have reinforced the need for upgrades to the aging infrastructure of the Central and Southern Florida Project.

South Florida's growth, enabled by the drainage system, has impacted the natural environment and forever changed the region's landscape. The rapid increase in population has intensified demands for water supply and changed historical land uses as open areas (uplands, wetlands, and agricultural areas) are converted to development. The loss of open areas to soak up and store South Florida's normally abundant rainfall means more water is shunted off to tide to provide flood protection to new development and less water remains stored in the system for use in dry times. These factors have strained the project's ability to perform its intended functions of flood protection; water supply for people, agriculture, and industry; preventing saltwater from seeping into the fresh groundwater of the Biscayne aquifer; supplying water to Everglades National Park; and protecting fish and wildlife.

How will the CERP help water supply and flood protection?



As Comprehensive Everglades Restoration Plan (CERP) projects are built, they will store water in reservoirs and underground wells that is now discharged to tide. Ultimately, this will increase the amount of fresh water available for all water users, including people and the environment. By increasing the storage capacity through the CERP, we can expect to see fewer water restrictions for the people of South Florida and less competition for water between people and the natural system. The State of Florida's planning goal for people's needs is to meet existing and future municipal, industrial, and agricultural water supply requirements in the region during a 1-in-10 year drought event; the CERP will help to meet these needs.

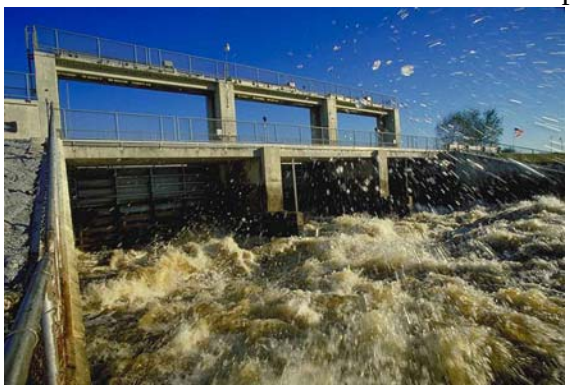
More water storage capacity will provide water managers with more flexibility in how water can be moved through the Central and Southern Florida Project. Not only will water supplies be enhanced, but flood protection will be maintained, and in some situations, will be improved.

What types of tools do we use to predict progress of the CERP towards meeting Interim Targets?

The tools employed in predicting progress towards meeting Interim Targets are numerical or computational models, which allow forecasting how the water supply and flood protection indicators will respond to changes brought about by the CERP. In order to generate the data necessary to predict the Interim Targets, the South Florida Water Management Model simulated conditions for the South Florida ecosystem for 1995, 2010, 2015, and 2050 with all CERP projects built. Based upon the implementation plan in Section 10 of the *Central and Southern Florida Project Comprehensive Review Study Final Integrated Feasibility Report and Programmatic Environmental Impact Statement* (USACE and SFWMD 1999), CERP components expected to be constructed within each timeframe were added as input data to the model. By evaluating the output of each timeframe, predictions of CERP's progress have been established.

Conclusions drawn from models, such as the setting of Interim Targets, must be understood in the context of the limits of applying predictive models, model uncertainty, and appropriateness of scale. The hydrologic predictive models cannot predict what will actually happen to the South Florida ecosystem between now and 2010, 2015, or any other time frame. Rainfall amounts, their spatial and temporal distribution (in other words, variability), are completely unknown. What the simulation models do is provide a greater understanding of how the system may respond under a variety of circumstances (e.g., projects constructed by 2010) using a predetermined rainfall pattern. Therefore, the numeric output from the simulation models reflects conditions over an historical 31-year period of record. We use these outputs to guide predictions for the years between 1995, 2010, 2015, and 2050 with CERP projects built.

Predicting the outcome of some indicators (i.e., flood protection indicators) is expected to have an inherent level of uncertainty because current models have a margin of error associated with the output that is within a range that could indicate impacts in specific locations. The results will be useful to look at trends and the potential effects of CERP-related regional system operational changes in tribal, urban, and agricultural areas. As more is learned about system responses to the CERP through monitoring and adaptive assessment, predictions of responses will become more informed. Information from the monitoring program will be used to refine and revise the predictive models, incrementally reducing the uncertainty that surrounds their use. Contained within the appendix is a further discussion of the specific methodology and tools used in the



prediction of each Interim Target indicator. The discussion includes the uncertainty associated with each method.

What are the predictions of Interim Targets for Water Supply and Flood Protection?

Six indicators for water supply and flood protection are being reported here. Below is a list of the indicators with a brief description of each:

- **Water Volume** - This indicator is identical to the volume indicator in the Everglades section. We predict the amount of water that is captured and stored by CERP projects, and where that "new" water goes. The distribution of the new water is provided in the Everglades section, and so is not repeated here.
- **Water Supply for the Lower East Coast Service Area** - The characteristics of water supply that are predicted include how often and for how long water supply restrictions are imposed. The cause of the water restrictions, such as whether the restriction is due to low Lake Okeechobee levels, dry season criteria, or a local trigger, is also calculated.
- **Water Supply for the Lake Okeechobee Service Area** - The characteristics of this indicator are similar to the Lower East Coast Service Area in that it tracks when water shortage restrictions are imposed, including the severity of the water restrictions.
- **Ability to Protect the Biscayne Aquifer from Saltwater Intrusio**n - In selected canals that flow into the ocean, stages (levels) at certain structures are evaluated to see if the stages are high enough to prevent saltwater from intruding into and significantly harming the Biscayne aquifer.
- **Ability to Protect the Southern Biscayne Aquifer from Saltwater Intrusion** (South Miami-Dade County) - This indicator is for the protection of the Biscayne aquifer in south Miami-Dade County and is based on coastal canal stages.
- **Flood Control: Root Zone Groundwater Levels in the South Miami-Dade Agricultural Area East of L-31N** - In order to get a relative feel for flood risk in this area, several points of data are analyzed. Changes in stage (levels) in several "cells" of the model and how long the stages remain at certain levels are two of these points.

Although additional indicators for flood control were developed, these being "Groundwater Stages for Miami-Dade, Broward, Palm Beach, and Seminole Tribe Surface Water Management Basins" and "Flood Water Removal Rate for the Everglades Agricultural Area", data were not available to make predictions for this initial set of Interim Targets for these two indicators. We do expect to make predictions for these indicators when this document is revised. It should be noted that due to the use of the South Florida Water Management Model and its coarse resolution, relative trends in flood protection are reported. A table is presented

on the next page that characterizes the stages (levels) at the high end for each of the areas of interest (or "cells") in the model.

The predictions for water supply are based on the future population growth and increased demand for water supply that was generated during the Central and Southern Florida Comprehensive Review Study, referred to as the Restudy, and flood protection indicators are presented in the following table. More technical documentation for each indicator is provided in the appendix.

Indicator	1995	2010	2015	D13R
1.1 Water Volume	No CERP projects yet built	931,000 acre-feet of new water available	1,060,000 acre-feet of new water available	1,462,000 acre-feet of new water available
1.2 Water Supply for Lower East Coast Service Area	1-in-2 year Return Frequency for declared water shortages	1-in-3 year return frequency for declared water shortages	1-in-5 year return frequency for declared water shortages	1-in-10 year return frequency for declared water shortages
1.3 Water Supply for Lake Okeechobee Service Area	1-in-3 year return frequency for declared water shortages	1-in-2.5 year return frequency for declared water shortages	1-in-4 year return frequency for declared water shortages	1-in-6 year return frequency for declared water shortages
1.4 Ability to Protect Biscayne Aquifer from Saltwater Intrusion	Potential inability to protect aquifer during severe drought in Miami-Dade County	Highly likely will be able to protect aquifer during severe drought	Highly likely will be able to protect aquifer during severe drought	Highly likely will be able to protect aquifer during severe drought
1.5 Ability to Protect Southern Biscayne Aquifer from Saltwater Intrusion	Low potential ability to protect aquifer during severe drought	Low potential ability to protect aquifer during severe drought	Potentially able to protect aquifer during severe drought	Highly likely will be able to protect aquifer during severe drought
Flood Control: Root Zone Groundwater Levels in South Dade	Reasonably matches target in most areas of interest	Flood protection levels are acceptable; some areas decrease while others increase, compared to 1995 levels	Closely matches 2010 performance	Closely matches 2010 performance

The following table represents high stages in the five cells analyzed for the flood protection indicator.

Simulated Ground Water Stages (feet in NGVD[1])
(at the 10 percent line, high stage, of the stage duration curve)

	Cell 1	Cell 2	Cell 3	Cell 4	Cell 5
1995 Base	3.8	4.9	5.6	5.05	5.9
2010	3.65	5.1	5.8	4.8	5.8
2015	3.65	5.1	5.8	4.8	5.8
D13R	3.65	5.1	5.8	4.8	5.8
Target	3.65	4.75	5.4	5.1	5.85

How do we know we have made progress towards meeting Interim Targets through the CERP?

The actual number of times and duration when water supply restrictions are imposed will be analyzed to determine if water supply demands were met for the water supply indicators. For protection of the Biscayne aquifer, the number of times (frequency) the coastal canal stages and the number of consecutive days (duration) the criterion is not met for each event will be monitored and analyzed to determine if it was related to drought conditions or other causes. The monitoring data at the control structures will also be compared to historical conditions and the ability to meet operating criteria. The Interim Target for flood protection may be measured by using parameters such as water stage; duration and frequency; and canal operating levels, flow volumes, and timing.

[1] NGVD – National Geodetic Vertical Datum

Summary of CERP Indicators and Interim Goals

This section provides a summary of the Restoration Coordination and Verification Team's (RECOVER's) recommended indicators for CERP Interim Goals, and the initial set of predictions of performance for these indicators during CERP implementation. CERP interim goal indicators are organized by region and each indicator is underlined below. Current predictions for the indicators are presented in narrative format, either quantitatively or qualitatively, and are often separated by subregion under each heading. The information provided is taken from the main report as well as the indicator documentation sheets found in the appendix. Page numbers following each region reference the main report. The numbers following each indicator reference the indicator documentation sheet in the appendix where additional details can be found.

This summary is not intended to be a stand-alone document. The justification of indicator use and Interim Goals predictions, including methods, limitations, assumptions, and uncertainty, is provided in the appendix. These initial predictions carry a high degree of uncertainty associated with them that reflects current gaps in understanding of the natural systems and limitations in current capacities to predict the performance of the selected indicators.

Northern Estuaries (pages 9-16)

American Oysters in Northern Estuaries (1.1)

The desired restoration condition for the American oysters is 834 acres of living oyster beds in the St. Lucie Estuary and 500 acres in the Caloosahatchee Estuary. Desired restoration conditions for the Loxahatchee Estuary and Lake Worth Lagoon are being developed.

St. Lucie Estuary. Results from a 2003 survey indicate that approximately 117 acres of live oyster beds are present in the St. Lucie Estuary. American oyster habitat is expected to decrease to less than 25 acres by 2010. By 2015, oyster habitat is expected to increase to approximately 159 acres. At full D13R implementation, approximately 231 acres of oyster habitat was predicted.

Caloosahatchee Estuary. A 2004 survey estimated approximately 18 acres of live oyster beds. American oyster habitat is expected to increase to approximately 20 acres of suitable habitat by 2010. By 2015, approximately 40 acres of oyster habitat was predicted. At full D13R implementation, approximately 100 acres of oyster habitat was predicted.

Loxahatchee Estuary. Approximately 10 acres of oyster habitat were found in 2004. No predictions are available.

Lake Worth Lagoon. Existing acreage of oysters is not available. No predictions are available.

Submerged Aquatic Vegetation in Northern Estuaries (1.2)

The desired restoration condition for submerged aquatic vegetation in Northern Estuaries is to increase the spatial extent and improve the functionality of submerged aquatic vegetation. Predictions are not available for submerged aquatic vegetation at this time.

Lake Okeechobee (pages 17-26)

Lake Okeechobee Phosphorus (2.1)

The desired restoration condition for Lake Okeechobee phosphorus is 40 parts per billion (ppb). Model-based 1995 estimates suggest phosphorus concentrations of 95 (± 10 standard error) ppb in Lake Okeechobee. Phosphorus in Lake Okeechobee is expected to decrease to approximately 81 (± 8) ppb in 2010. In 2015, phosphorus concentrations were predicted to be 76 (± 6) parts per billion and full D13R implementation should result in 70 (± 6) ppb.

Water Levels in Lake Okeechobee (2.2)

The desired restoration condition for water levels in Lake Okeechobee is 0 events above 17 feet, 0 events under 11 feet, and a spring recession nearly every year.

Harmful High Stages Above 17 feet. Model-based 1995 estimates result in 4 events over a 31-year period of record. Under 2010 conditions, 3 events were predicted over a 31-year period of record. Under 2015 and full D13R implementation conditions, 2 events were predicted over a 31-year period of record.

Harmful Low Stages Below 11 feet. Model-based 1995 estimates result in 9 events over a 31-year period of record. Under 2010 conditions, 12 events were predicted over a 31-year period of record. Under 2015, 8 events were predicted over a 31-year period of record. Under full D13R implementation conditions, 4 events were predicted over a 31-year period of record.

Spring Recession. Model-based 1995 estimates result in 8 events over a 31-year period of record. Under 2010 conditions, 8 events were predicted over a 31-year period of record. Under 2015, 13 events were predicted over a 31-year period of record. Under full D13R implementation conditions, 14 events were predicted over a 31-year period of record.

Lake Okeechobee Algal Blooms (2.3)

The desired restoration condition for Lake Okeechobee algal blooms is for no algal blooms to occur in Lake Okeechobee. The frequency of algal blooms is expected to decline when concentrations of phosphorus are reduced; however, no quantitative predictions are available at this time.

Lake Okeechobee Aquatic Vegetation (2.4)

The desired restoration condition for Lake Okeechobee aquatic vegetation is to maintain at least 65,000 acres of aquatic vegetation. Estimates, based on a 2004 survey, suggest that approximately 55,000 acres of aquatic vegetation were present in Lake Okeechobee. Predictions are not available for aquatic vegetation at this time.

Everglades (pages 27-42)

Water Volume (3.1)

The desired restoration condition for water volume is to distribute water across the ecosystem in a manner that reflects natural conditions while providing for other water-related needs of the region. Interim Goals are South Florida Water Management Model (SFWMM) characterizations of "new" water made available by the CERP above and beyond 1995 conditions.

Between 1995 and 2010, 93,000 acre-feet of fresh water is available for redistribution and is shared by the following recipients: 41.9 percent to urban basins, 27.0 percent to the Everglades and Southern Estuaries, 15.9 percent to Lake Okeechobee and the Kissimmee River, and 15.2 percent to agricultural basins.

Between 1995 and 2015, 1,060,000 acre-feet is available for redistribution and the shares shift as follows: 37.8 percent to urban basins, 26.9 percent to the Everglades and Southern Estuaries, 20.0 percent to agricultural basins, and 15.3 percent to Lake Okeechobee and the Kissimmee River.

Between 1995 and full D13R implementation, the total water available for redistribution is 1,462,000 acre-feet, which is predicted to be distributed according to the following percentages: 28.9 percent to urban basins, 23.5 percent to the Northern Estuaries, 22.6 percent to the Everglades and Southern Estuaries, 15.0 percent to Lake Okeechobee and the Kissimmee River, 7.4 percent to agricultural basins, and 2.5 percent to Big Cypress Basin.

Sheet Flow (3.2)

The desired restoration condition for sheet flow is to establish more historic magnitudes and directions of sheetflow in the natural areas of the Everglades. Interim Goals are SFWMM characterizations of changes relative to 1995 conditions.

Sheet flow vector diagrams for 2010 indicate significant changes in magnitude in the vicinity of the Everglades Agricultural Area and a shift of the flowway to the east in Water Conservation Area 3 and at the northern boundary of Everglades National Park due to the Modified Water Deliveries Project.

In general, minor changes in sheet flow distribution are predicted between 2010 and 2015.

Additional improvements in the magnitude of flow in lower Water Conservation Area 3 and across the northeastern boundary of Everglades National Park are predicted for the D13R simulation.

Hydropattern (3.3)

The desired restoration condition for hydropattern is to restore the natural timing and pattern of inundation throughout the ecological communities of South Florida. Interim Goals are SFWMM characterizations of changes relative to 1995 conditions.

Sawgrass Plains. In 2010, approximately 10 percent to 20 percent more of the landscape is predicted to be inundated throughout the year, but further changes are expected to be minimal.

Ridge and Slough. Minimal changes are predicted in 2010 and 2015, but the full D13R simulation predicts an increase in inundation of about 5 percent of the landscape during dry season months.

Marl Marshes. In 2010, up to 10 percent more of the landscape is inundated during the late wet season and early dry season. In 2015 and full D13R, increases of up to 12 percent and 20 percent are predicted in the early dry season.

System-Wide Spatial Extent of Habitat (3.4)

The desired restoration condition for system-wide spatial extent of habitat is to increase the spatial extent of lands to be managed as natural areas and to increase the functional values of native habitat.

In 2010, it is expected that 8,232 acres of public lands will be acquired to increase the spatial extent of natural habitat. In 2015, a total of 11,109 acres are expected to be acquired, with a total of 103,709 acres acquired with full D13R implementation.

Everglades Total Phosphorus (3.5)

The desired restoration condition for water column phosphorus concentrations in the Everglades is 10 micrograms/liter.

A quantitative method for predicting total phosphorus in the Everglades marshes is not available, so a related measure, the acreage of CERP stormwater treatment areas that flow into the Everglades, is being reported. By 2010, 9,680 acres of these stormwater treatment areas will be constructed. By 2015, no additional acreage of stormwater treatment areas are planned to be built. With full D13R implementation, a total of 16,320 acres of stormwater treatment areas should be constructed.

Periphyton Mat Cover, Structure and Composition (3.6)

The desired restoration condition for periphyton mat cover, structure, and composition is to restore periphyton communities that were characteristic of the spatially-distinct hydroperiods (short and long hydroperiod) and low nutrient conditions in the greater Everglades wetland communities.

Currently, the methodology for evaluating the impact of the CERP on Everglades periphyton is in development; predictions are not available at this time.

Ridge and Slough Pattern (3.7)

The desired restoration condition for ridge and slough pattern is to restore the ridge and slough landscape directionality and pattern. An index value of 1.0 is optimal.

North Ridge and Slough. Model-based estimates of current hydrologic suitability, averaged over the subregion, indicate an index value of 0.29. Suitability is predicted to remain in this state from 2010 through D13R implementation.

Central Ridge and Slough. Model-based estimates of current suitability indicate an index value of 0.45. In 2010 suitability is predicted to improve to 0.65. In 2015, no change is expected and a slight decrease in suitability (0.58) may be expected upon full implementation of D13R.

Everglades Tree Islands (3.8)

The desired restoration condition for Everglades tree islands is to improve tree island health and maintain healthy islands. Three sub-indices, based on a scale of 0-1.0, are used to predict tree island health. These are drought, flooding, and species richness. An index value of 1.0 is optimal.

North Tree Islands. Model-based 1995 characterizations for drought, flooding, and species richness predict average values of 0.85, 0.80, and 0.88. Drought stress does not change throughout CERP implementation, nor does flood stress. Species richness is predicted at 0.86 for 2010, 0.83 for 2015, and 0.81 at full D13R implementation.

Central Tree Islands. Model-based 1995 characterizations for drought, flooding, and species richness predict average values of 0.80, 0.44, and 0.61. Predicted results for drought stress are 0.81 for 2010, 0.84 for 2015, and 0.89 for full D13R implementation. Results for flood stress are 0.36 for 2010, 0.40 for 2015, and 0.41 for D13R. Species richness is predicted to be 0.71 in 2010, 0.73 in 2015, and 0.83 when D13R is fully implemented.

Aquatic Fauna Regional Populations in Everglades Wetlands (3.9)

The desired restoration condition for aquatic fauna regional populations in Everglades wetlands is to increase the abundance of fish to levels that approximate those predicted for pre-drainage conditions, but a quantitative estimate is not available. Interim Goals are expressed as changes relative to 1995 conditions.

Northeastern Shark River Slough (Site 23). An increase in fish abundance, relative to 1995 conditions, of 64.4 percent is expected by 2010 and an increase of 73 percent is expected by 2015. With full D13R implementation, a 31 percent increase in fish abundance over 1995 conditions is predicted.

Western Shark River Slough (Site 6A). An increase in fish abundance, relative to 1995 conditions, or 20.3 percent is expected by 2010 and an increase of 25.5 percent is expected by 2015. With full D13R implementation, a 14.4 percent increase in fish abundance over 1995 conditions is predicted.

American Alligator (3.10)

The desired restoration condition for American alligators is to restore more natural numbers and distribution patterns for alligators across South Florida's major freshwater and estuarine landscapes. Predictions are relative to 1995 and only available for 2010.

Loxahatchee National Wildlife Refuge. In 2010, no improvements in alligator density, body condition, nesting, or clutch size are expected over model-based 1995 characterizations.

Water Conservation Area 2. In 2010, alligator density, nesting, and clutch size is not expected to improve, but body condition should improve.

Water Conservation Area 3. In 2010, alligator density, body condition, and clutch size should increase while nesting should not.

Shark Slough. In 2010, no improvement in alligator density, body condition, nesting, or clutch size is expected.

Rocky Glades/Marl Prairies. In 2010, alligator density and hole occupancy are expected to improve and nesting and clutch size are expected to remain stable.

System-Wide Wading Bird Nesting Pattern (3.11)

The desired restoration condition for wading birds is to have over 50 percent of 80,000 pairs nesting in estuarine locations. Wood stork nesting initiation should occur in the December/January time period. Wading bird super colony events should to occur once every 4 years.

Total Number of Nesting Pairs. Recent surveys indicate that approximately 30,000 pairs of wading birds nest in the Everglades. In 2010, 2015, and with full D13R implementation, totals of 35,000, 40,000, and 60,000 pairs, respectively, are predicted.

Percent of Pairs Nesting in Estuarine Locations. Recent surveys indicate that 3.7 percent of nests are found in estuarine locations. In 2010, 2015, and with full D13R implementation, approximately 5 percent, 10 percent, and 35 percent of the nests are predicted to be in estuarine locations.

Timing of Wood Stork Nest Initiation. Recent surveys suggest that wood storks initiate nesting in February and March. In 2010 and 2015, the timing of nest initiation is not expected to change. With full D13R implementation, nest initiation is expected in December and January.

Frequency of Super Colony Events. Surveys suggest that super colony events occur at an average frequency of once every 8 years. This frequency does not increase until full D13R implementation (once every 6 years).

Snail Kite (3.12)

The desired restoration condition for snail kite is for at least 50 percent of the area to be marginal or optimal snail kite foraging habitat. The desired restoration condition for apple snail habitat are under development.

Snail Kite Foraging Habitat. Model-based characterizations of 1995 conditions suggest that 34 percent of the indicator regions have marginal habitat and no indicator regions have optimal habitat. Approximately 31 percent of the indicator regions are expected to be marginal with no optimal habitat in 2010. In 2015, 38 percent of the indicator regions are expected to be marginal snail kite foraging habitat, with 3 percent of the indicator regions having optimal habitat. With full D13R implementation, 31 percent of the indicator regions

are expected to have marginal habitat and 10 percent of the indicator regions should have optimal snail kite foraging habitat.

Apple Snail Habitat. Model-based characterizations of 1995 conditions suggest that only 43 percent of the indicator regions are suitable apple snail habitat. By 2010, 67 percent of the indicator regions are expected to be suitable as high quality apple snail habitat. Expectations for 2015 and full D13R implementation indicate an increase in suitability with 70 percent and 77 percent of the indicator regions predicted to be suitable.

Southern Estuaries[1] (pages 43-52)

Salinity Patterns in Florida and Biscayne Bays (4.1)

The desired restoration condition for salinity in Florida and Biscayne Bays are to re-establish mesohaline to oligohaline conditions of 0-15 parts per thousand (ppt) in mainland nearshore zones.

Joe Bay. Model-based characterizations of 1995 salinities indicate that salinities of approximately 35 ppt are common. No reductions in high salinity levels are predicted throughout CERP implementation.

Little Madeira Bay and Terrapin Bay. Model-based characterizations of 1995 salinities indicate that salinities of approximately 35 ppt are common. Small reductions in high salinity levels are predicted for 2010 and 2015. At full D13R implementation, substantial reductions in high salinity levels are expected.

Garfield Bight. Model-based characterizations of 1995 salinities indicate that salinities of approximately 50 ppt are common. No reductions in high salinity levels are predicted throughout CERP implementation.

North River Mouth. Model-based characterizations of 1995 salinities indicate that salinities of approximately 20 ppt are common. In 2010 and 2015, high salinity levels are expected to decline. With full D13R implementation, high salinity levels are expected to decline substantially.

Submerged Aquatic Vegetation in Southern Estuaries (4.2)

The desired restoration condition for submerged aquatic vegetation in Southern Estuaries is a diverse seagrass community with moderate plant densities and more natural seasonality, and with 65-70 percent of Florida Bay having suitable habitat for seagrass growth. Current submerged aquatic vegetation community types are ephemeral and not as diverse as required for full restoration of Florida Bay. The following comparisons are relative to current conditions.

[1] Predictions for Biscayne Bay are not available for this initial set of Interim Goals.

Long Sound, Joe Bay, and Garfield Bight. No changes in the restoration of desirable submerged aquatic vegetation communities are expected throughout the D13R implementation.

Terrapin Bay. No changes in the restoration of desirable submerged aquatic vegetation communities are expected in 2010 and 2015. With full D13R implementation, there may be a lower probability of *Halodule* die-offs.

Whipray Basin. No changes in the restoration of desirable submerged aquatic vegetation are expected in 2010 and 2015. With full D13R implementation, the probability of hypersalinity events may be lower and thus the probability of seagrass die-offs may be lower.

Little Madeira Bay. In 2010, a slight decrease in *Thalassia* and increase in *Halodule* and *Ruppia* is expected. In 2015, this trend is expected to continue. With full D13R implementation, substantial decreases in *Thalassia* are expected along with corresponding increases in *Halodule* and *Ruppia*. Full restoration should be achieved.

Juvenile Shrimp Densities in Florida and Biscayne Bays (4.3)

The desired restoration condition for juvenile shrimp densities in Florida and Biscayne Bays is a range of densities from 2 to 17 juvenile shrimp per square meter. Predictions are only available for one basin in Florida Bay at this time.

Whipray Basin. Model-based estimates of 1995 shrimp densities indicate 2.2 – 2.5 juvenile shrimp per square meter. No increase in the density of pink shrimp is expected throughout the implementation of D13R.

American Crocodile (4.4)

The desired restoration condition for the American crocodile is to maintain high frequencies of salinities below 20 ppt for optimal survival and growth of juvenile crocodiles.

Terrapin Bay. Model-based simulations for 1995 conditions indicate low frequencies of optimal salinities for growth and survival of juvenile crocodiles. The frequency of optimal salinity conditions for growth and survival of juvenile crocodiles is expected to improve slightly throughout CERP implementation.

North River Mouth. Model-based simulations for 1995 conditions indicate high frequencies of optimal salinities for growth and survival of juvenile crocodiles. No improvement in the frequency of optimal salinities is expected throughout the D13R implementation.

Little Madeira Bay. Model-based simulations for 1995 conditions indicate low frequencies of optimal salinities for growth and survival of juvenile crocodiles. In 2010 and 2015, no improvements in the frequency of optimal salinities were predicted. With full D13R implementation, a moderate improvement in the frequency of optimal salinities is expected.

Joe Bay and Garfield Bight. Model-based simulations for 1995 conditions indicate low frequencies of optimal salinities for growth and survival of juvenile crocodiles. No

improvement in the frequency of optimal salinities is expected throughout D13R implementation.

Florida Bay Algal Blooms (4.5)

The desired restoration condition for Florida Bay algal blooms is to minimize the magnitude, duration, and spatial extent of algal blooms in Florida Bay. No predictions were available for algal blooms at this time.

Summary of CERP Indicators and Interim Targets

This section provides a summary of the Restoration Coordination and Verification Team's (RECOVER's) recommended indicators for CERP Interim Targets, and the initial set of predictions of performance for these indicators during CERP implementation. CERP interim target indicators are organized by water supply and flood protection. Each indicator is underlined below. Current predictions for the indicators are presented in narrative format, either quantitatively or qualitatively, and are often separated by subregion under each heading. The information provided below is taken from the main report as well as the indicator documentation sheets found in the appendix. The water supply and flood protection section of this main report can be found on pages 53-58. The numbers following each indicator reference the indicator documentation sheet in the appendix where additional details can be found.

This summary is not intended to be a stand-alone document. The justification of indicator use and Interim Targets predictions, including methods, limitations, assumptions, and uncertainty, is provided in the appendix. These initial predictions carry a high degree of uncertainty associated with them that reflects current gaps in understanding and limitations in current capacities to predict the performance of the selected indicators.

Water Supply

Water Volume (5.1)

The target for water volume is to distribute water across the ecosystem in a manner that reflects natural conditions while providing for other water-related needs of the region. Interim Targets are South Florida Water Management Model (SFWMM) characterizations of "new" water made available by the CERP above and beyond 1995 conditions.

Between 1995 and 2010, 93,000 acre-feet of fresh water is available for redistribution and is shared by the following recipients: 41.9% to urban basins, 27.0% to the Everglades and Southern Estuaries, 15.9% to Lake Okeechobee and the Kissimmee River, and 15.2% to agricultural basins.

Between 1995 and 2015, 1,060,000 acre-feet is available for redistribution and the shares shift as follows: 37.8% to urban basins, 26.9 % to the Everglades and Southern Estuaries, 20.0% to agricultural basins, and 15.3% to Lake Okeechobee and the Kissimmee River.

Between 1995 and full D13R implementation, the total water available for redistribution is 1,462,000 acre-feet, which is predicted to be distributed according to the following percentages: 28.9% to urban basins, 23.5% to the Northern Estuaries, 22.6% to the Everglades and Southern Estuaries, 15.0% to Lake Okeechobee and the Kissimmee River, 7.4% to agricultural basins, and 2.5% to Big Cypress Basin.

Water Supply for the Lower East Coast Service Area (5.2)

In 2010, the Lower East Coast Service Area simulation performs slightly better overall (9 years, on average, of simulated cutbacks over the 31-year period of record) than the 1995 Base (14 years on average) in providing a 1-in-10 level of service and in minimizing the number of

months with water supply cutbacks. The water shortages that do occur are Phase 1 water shortages. Service Area 3 is the exception, with the frequency and duration of water shortages increasing slightly in 2010.

The 2015 performance shows improvement in the Lower East Coast Service Area (7 years of cutbacks on average). The number of locally-triggered Phase 1 water restrictions was similar to the 1995 Base and 2010 performance, while both the number of lake-triggered and dry season criteria-triggered restrictions decreased by five months each.

The 2050 performance with all CERP projects implemented (full D13R) shows improvement in the Lower East Coast Service Area (3 years of cutbacks on average). No locally-triggered Phase 1 water restrictions occur in either North Palm Beach or Service Area 1, while those that occur in Service Area 2 and 3 are most likely a result of local conditions and not changes in regional water supplies. These locally triggered restrictions are short (one or two months) in duration.

Water Supply for the Lake Okeechobee Service Area (5.3)

In the Lake Okeechobee Service Area, the pattern of water shortages changed from the 1995 Base to the 2010 interim period. The number of years with predicted cutbacks increases (from 9 years in 1995 to 12 years in 2010 out of the 31-year period of record), as does the severity and duration of the cutbacks. Some of the increases in cutbacks can be expected due to a projected increase in acreages requiring irrigation in some of the service area basins.

While cutbacks increased in the Lake Okeechobee Service Area predictions for 2010, it is not expected that this will occur in all of its basins. By 2010, a reservoir is expected to be constructed in the Everglades Agricultural Area basin that will reduce water demand by reducing the amount of acreage requiring irrigation. A similar situation occurs in the Seminole Tribe's Big Cypress Reservation basin where the irrigation demands remain constant from 1995 to 2010 due to Compact requirements.

The pattern of water shortages in the Lake Okeechobee Service Area in the 2015 interim period (8 years of cutbacks) improves over the 2010 interim period, and performs similar to the 1995 base. The 2015 predictions have one less year of cutbacks than 1995 and 4 years less than 2010. One of the major drought events is predicted to be slightly shorter in the 2015 interim period. Overall, the severity and duration of the 2015 cutbacks are improved over the 1995 base.

The pattern of water shortages in the Lake Okeechobee Service Area continues to improve as the CERP is implemented. By full implementation, the frequency of water restrictions declines to 5 years with a total of 21 months having restrictions. The volume of water supply restricted is cut in half compared to 2015. Also, the frequency, duration, and severity of restriction events improves compared to 2015.

Protect Biscayne Aquifer from Saltwater Intrusion (5.4)

Predictive modeling in 1995 indicates a potential inability to protect the Biscayne aquifer during severe drought in Miami-Dade County. Model evaluations for 2010, 2015, and full D13R implementation indicate a high likelihood of being able to protect the aquifer during a severe drought.

Protect Southern Portion of Biscayne Aquifer from Saltwater Intrusion (5.5)

Predictive modeling in 1995 indicates a low ability to protect the southern portion of the Biscayne aquifer during severe drought in Miami-Dade County. Model evaluations indicate the same in 2010, a potential ability to protect the aquifer in 2015, and a high likelihood of being able to protect the aquifer during severe drought after full D13R implementation.

Flood Protection

Flood Control: Root Zone Groundwater Levels in the South Miami-Dade Agricultural Area East of L-31N (5.6)

In 2010, flood protection levels in the South Miami-Dade County Agricultural Area are acceptable, although some areas analyzed decreased and some increased. 2015 and 2050 predictions closely matched performance seen in 2010.

Flood Control: Groundwater Stages for Miami-Dade, Broward, Palm Beach, and Seminole Tribe Surface Water Management Basins (5.7)

Predictions were not available for this indicator at this time.

Flood Control: Flood Water Removal Rate for the Everglades Agricultural Area (5.8)

Predictions were not available for this indicator at this time.

Appendix to the Recommendations for Interim Goals and Interim Targets for the Comprehensive Everglades Restoration Plan

Prepared by Restoration Coordination and Verification (RECOVER)

Introduction

This document presents the appendix to the technical recommendations of the Restoration Coordination and Verification (RECOVER) Team for a set of Interim Goals and Interim Targets for the implementation of the Comprehensive Everglades Restoration Plan (CERP or the Plan). This appendix provides more detailed and technical information than that provided in the main Interim Goals and Interim Targets report. As called for in the CERP Programmatic Regulations (§ 385.38) (DOD 2003), RECOVER's technical recommendations are provided to the U.S. Army Corps of Engineers, the Department of the Interior, and the South Florida Water Management District for their consideration in developing an Interim Goals Agreement. RECOVER's technical recommendations for Interim Targets are provided to the U.S. Army Corps of Engineers and the South Florida Water Management District (§ 385.39). The complete CERP Programmatic Regulations can be downloaded from the following web page: http://www.evergladesplan.org/pm/progr_regs_final_rule.cfm

This appendix provides background and technical information for the Interim Goals and Interim Targets. The sections include a brief history and authority for the development of the Interim Goals and Targets, a brief description of the revision process, descriptions and definitions of both the Interim Goals and Interim Targets, tables summarizing the indicators for each, a discussion of the uncertainty associated with indicator predictions, responses to peer review comments, a list of acronyms used, and a list of preparers. The remainder of the appendix contains the indicator documentation sheets describing the technical aspects of each Interim Goal and Target.

History and Authority

The Central and Southern Florida (C&SF) Project Comprehensive Review Study, known as the Restudy, was authorized by Section 309(l) of the Water Resources Development Act (WRDA) of 1992. Section 528 of WRDA 1996 provided additional direction and guidance for the Restudy.

The Restudy's purpose was to reexamine the C&SF Project to determine the feasibility of modifying the project to restore the South Florida ecosystem and provide for other water-related needs of the region, including water supply and flood protection.

Planning goals and study objectives were developed to sharpen the Restudy's intent and focus. It is these goals and objectives that guided the development of the CERP and now guide its

implementation, including the development of these recommendations for Interim Goals and Interim Targets. These goals and objectives are as follows:

Goal: Enhance Ecologic Values
- Increase the total spatial extent of natural areas
- Improve habitat and functional quality
- Improve native plant and animal species abundance and diversity

Goal: Enhance Economic Values and Social Well Being
- Increase availability of fresh water (agricultural/municipal and industrial)
- Reduce flood damages (agricultural/urban)
- Provide recreational and navigation opportunities
- Protect cultural and archeological resources and values

The final feasibility report for the Restudy (USACE and SFWMD 1999) was transmitted to Congress on July 1, 1999. Through the enactment of WRDA 2000, Congress approved the CERP as a framework for structural modifications and operational changes to the C&SF Project needed to restore the South Florida ecosystem.

Section 601(h) of WRDA 2000 represents the assurances provision for CERP implementation and called for Programmatic Regulations to be developed to ensure that the goals of the CERP are achieved. The goals and purposes of the CERP are defined in the Programmatic Regulations as "the restoration, preservation, and protection of the South Florida ecosystem while providing for other water-related needs of the region, including water supply and flood protection." Restoration is further defined as the "recovery and protection of the South Florida ecosystem so that it once again achieves and sustains those essential hydrological and biological characteristics that defined the undisturbed South Florida ecosystem."

The Programmatic Regulations require the establishment of an Interim Goals Agreement to "facilitate interagency planning, monitoring, and assessment so as to achieve the overarching objectives of the Plan," and that RECOVER shall recommend a set of Interim Goals for implementation of the Plan. The regulations also require that RECOVER shall recommend a set of Interim Targets for evaluating progress towards other water-related needs.

Description and Definition of Interim Goals

The CERP was designed to eliminate or substantially moderate hydrologic and certain water quality stressors that have degraded the natural system (quantity, quality, timing, and distribution of water.) Significant and substantial environmental benefits are expected as a result of CERP implementation, although it was acknowledged that the predicted performance of the currently approved Plan does not equate to a totally restored South Florida ecosystem. The Interim Goals are designed to measure progress toward those environmental benefits expected through CERP implementation. Through more detailed planning and design, and the adaptive management program, it is thought that the environmental benefits expected from the CERP will increase and bring us closer to our desired restoration condition. Additionally,

other factors have an effect on the ecosystem (e.g., proliferation of invasive exotic species) that the CERP was not designed to correct.

Interim Goals are defined in the Programmatic Regulations as "*a means by which the restoration success of the Plan may be evaluated throughout the implementation process.*" Interim Goals provide a means of tracking the performance of the Plan toward achieving expected environmental benefits, as well as a basis for reporting at specified intervals of time on progress made towards restoration of the South Florida ecosystem. Furthermore, Interim Goals allow for periodic evaluation of the accuracy of predictions of system responses to the effects of the Plan.

The Interim Goals are predictions of ecosystem response to the implementation of CERP projects, and reflect incremental accomplishments towards achieving CERP goals. Evaluations of the anticipated hydrologic and water quality changes in the South Florida ecosystem brought about by CERP implementation, with the attendant ecological responses, provided the basis for the RECOVER recommendations for Interim Goals.

Description and Definition of Interim Targets

Interim Targets are predictions of system response to the implementation of CERP projects, and reflect progress towards achieving CERP goals. Evaluations of the anticipated hydrologic changes in South Florida brought about by CERP implementation provided the basis for the RECOVER recommendations for Interim Targets.

Interim Targets are defined in the Programmatic Regulations as "*a means by which the success of the Plan in providing for other water-related needs of the region, including water supply and flood protection, may be evaluated throughout the implementation process.*" Interim Targets provide a means of tracking Plan performance, as well as a basis for reporting on the progress made at specified intervals of time towards providing for other water-related needs, and for periodically evaluating the accuracy of predictions of system responses to the effects of the Plan.

Revision Process

As stated in the Programmatic Regulations, the agreed upon Interim Goals and Targets will be reviewed at least every five years to determine if they should be revised. Any revisions will undergo the same development and agreement process as the initial Interim Goals and Targets. Revisions will incorporate new information, improved prediction capabilities, and improved understanding of the ecosystem and its relationships, resulting in a set of goals that improve over time and a refinement of the expected benefits of the Plan. This process will also permit new Interim Goals and Targets to be incorporated as warranted. Revisions to the Interim Goals and Targets will also be made in response to changes in implementation sequencing, changes in the design and operation of the Plan, and changes resulting from adaptive management.

Indicators of CERP Restoration Success

Interim Goals are designed to establish incremental milestones to evaluate progress toward the expected level of performance of the Plan. Interim Goals represent predictions of achievements in the natural system during the implementation of the CERP and are defined by indicators that are assessed using measurable parameters with quantitative targets, or they may be assessed as trends, i.e., directions of change. The list of indicators for Interim Goals has been grouped by three general categories: hydrologic, water quality, and biological indicators. Interim Goal indicators are listed in Table A-1.

Table A-1. List of Recommended CERP Interim Goal Indicators

1.1 American Oysters in Northern Estuaries
1.2 Submerged Aquatic Vegetation in Northern Estuaries
2.1 Lake Okeechobee Phosphorus
2.2 Water Levels in Lake Okeechobee
2.3 Lake Okeechobee Algal Blooms
2.4 Lake Okeechobee Aquatic Vegetation
3.1 Water Volume
3.2 Sheet Flow in Natural Areas
3.3 Hydropattern
3.4 System-wide Spatial Extent of Habitat
3.5 Everglades Wetlands Total Phosphorus
3.6 Periphyton Mat Cover, Structure, and Composition
3.7 Ridge and Slough Pattern
3.8 Everglades Tree Islands
3.9 Aquatic Fauna Regional Populations in Greater Everglades Wetlands
3.10 American Alligator
3.11 System-wide Wading Bird Nesting Patterns
3.12 Snail Kite
4.1 Salinity Patterns in Florida and Biscayne Bays
4.2 Submerged Aquatic Vegetation in Southern Estuaries
4.3 Juvenile Shrimp Densities in Florida and Biscayne Bays
4.4 American Crocodile
4.5 Florida Bay Algal Blooms

The team selected indicators from a broad set of stressors and attributes found in the set of South Florida conceptual ecological models that are described in Appendix A of the *CERP Monitoring and Assessment Plan: Part 1 Monitoring and Supporting Research* (RECOVER 2004a). Each regional conceptual ecological model identifies the major hydrologic and chemical stressors in a landscape type within South Florida (e.g., St. Lucie Estuary, Everglades Ridge and Slough) and describes the major effects of these stressors on a set of

biological attributes. Because the CERP will modify hydrology and water quality (stressors), indicators that pertain to each ecological region were included for both stressors and attributes. A primary criterion for the selection of indicators was whether that indicator is expected to be highly responsive to the CERP, that is, the indicator is a component of the natural system that the CERP is designed to influence. In addition, indicators that represent short-term, intermediate, and long-term responses are represented as they are based on the variable response time to changes in hydrology and water quality. Physiological variables represent short-term indicators, population variables are considered intermediate indicators, and community-level variables are considered long-term indicators.

Evaluating Progress Towards Other Water-Related Needs of the Region

Interim Targets are designed to establish incremental milestones to evaluate progress toward the expected level of performance of the Plan. Interim Targets represent predictions of achievements of other water-related needs of the region due to CERP implementation and are defined by indicators that are assessed using measurable parameters with quantitative criteria. The list of indicators for Interim Targets fall into three general categories: hydrologic, water supply, and flood protection. Interim Target indicators are listed in Table A-2. Together, the Interim Targets represent the expected benefits of the Plan for other water-related needs and are consistent with the goals and purposes of the CERP as described above.

Table 1. List of Recommended CERP Interim Target Indicators

5.1 Water Volume
5.2 Water Supply for Lower East Coast Service Area
5.3 Water Supply for Lake Okeechobee Service Area
5.4 Protect Biscayne Aquifer from Saltwater Intrusion
5.5 Protect Southern Portion of Biscayne Aquifer from Saltwater Intrusion
5.6 Flood Control: Root Zone Groundwater Levels in South Miami-Dade Agricultural Area East of L -1N
5.7 Flood Control: Groundwater Stages for Miami-Dade, Broward, Palm Beach, and Seminole Tribe Surface Water Management Basins
5.8 Flood Control: Flood Water Removal Rate for Everglades Agricultural Area

Current Uncertainty Associated with Indicator Predictions

The Interim Goals and Targets presented in this initial RECOVER report must be viewed as a preliminary set of expectations for performance by a key group of CERP indicators. These Interim Goals and Targets will be substantially revised and improved as better understandings of the relationships among hydrological conditions and ecological responses are achieved over the coming years of CERP monitoring, and as improved tools for predicting system responses

are developed. It is particularly difficult during this early stage of CERP implementation for the RECOVER technical teams to estimate or predict responses by a set of key indicators in the absence of developed and tested ecological models, and while lacking an adequate representation of predictions of hydrological responses at five-year intervals during the full extent of CERP implementation.

Under these circumstances, the RECOVER teams consider it important that the users of this report understand the limitations of this initial set of Interim Goals and Targets. In striving to maintain high standards of science in supporting the CERP, the RECOVER teams have been careful to not exceed the boundaries of good science by creating predictions that are not supported by adequate understandings of ecological and biological relationships in the natural system, or that lack appropriate model outputs that can provide a temporal and spatial framework for predicting or estimating indicator responses at specific intervals during CERP implementation.

In the absence of models, the RECOVER teams have relied heavily on the best science that is currently available to the teams of experts for developing many of the Interim Goals and Targets for the initial report. The initial predictions and expectations in most cases are based on considerations of the direction of ecological and biological changes that are necessary for meeting the desired restoration endpoints called for by the CERP performance measures, and on current understandings of potential response patterns associated with improved hydrological patterns. Predictions of response patterns by the selected indicators are largely derived from the working hypotheses used to create the conceptual ecological models of the major natural system landscapes of South Florida (Appendix A of RECOVER 2004a). For those indicators where current hypotheses are weakest, and therefore do not provide for confident estimates of the rates and patterns of indicator responses, the initial Interim Goals may be more theoretical than real. These initial goals should be considered as placeholders for the refined and improved predictions of Interim Goals and Targets that will emerge as improved understandings accumulate between now and the next Interim Goal and Target reporting period.

Although the ability to develop many of the Interim Goals and Targets is limited at this time for the reasons presented above, the RECOVER team recommends the inclusion of the full set of recommended biological and ecological indicators in the initial report, as a means for focusing attention on the indicators that may be most useful for tracking progress towards the system-wide ecosystem restoration objectives of the CERP, and for identifying those attributes of the natural and human systems that should receive priority for ongoing and future monitoring, research, and modeling. The RECOVER view is that while it may not be possible in the initial report to confidently provide quantitative predictions of performance at specific intervals, all indicators should be included as a means for providing an initial perspective on the performance of the suite of indicators that collectively will show progress by the CERP, and also to show where RECOVER stands in being able to develop predictions for each of the key indicators.

Several general types of uncertainty can affect predictions of Interim Goals and Interim Targets. The sources of uncertainty discussed here are associated with 1) modeling, 2) scheduling, 3) environmental variability, and 4) geopolitical change.

Model Uncertainty

Although the uncertainty of the landscape-scale models currently used for CERP Interim Goals and Targets can be large, it has been well documented (Sklar and Hunsaker 2001, Lall et al. 2002). A generalized understanding of different landscape models suggests that despite a diversity of approaches, uncertainty resides within five components of the modeling exercise. These "errors" can be traced to problems associated with 1) data collection, 2) model structure, and 3) natural variability. Reducing these uncertainties may be as simple as taking multiple environmental samples for better calibration, or as complex as running a simulation a thousand times to better understand the impacts of stochastic events such as hurricanes or fires (Sklar and Hunsaker 2001).

Every landscape model requires a map of initial conditions: a point in time and a description of the space where the model begins. However, it is rare to find a situation where a complete set of appropriately scaled landscape maps can be found for initialization. A very heterogeneous Everglades landscape represented by only a few data points are the ingredients for extreme initialization error. All models used for predicting Interim Goals and Targets have an uncertainty associated with spatial interpolation of point data, the number and distribution of point data, the complexity of the landscape, and the basic lack of understanding of ecological relationships.

Model structure also has an uncertainty such that the scale of simulated events do not always match the scale of events of the data used by the model or the information needed by the user to make predictions (Sklar et al. 1990). This mismatching of scales will most often produce uncertainties associated with model conclusions. Unfortunately, errors associated with mismatching of scales are not easy to identify. These types of uncertainties can only be avoided by careful peer review and clearly defining and bounding the model objectives.

In general, the more complex the model structure, the greater the total variation of both observational and simulated data, and the less accurate (more uncertain) the predicted Interim Goals (Costanza and Sklar 1985). The real effectiveness or explanatory power of a model is a function of both how much it attempts to explain (complexity) and how well it explains what was attempted (accuracy). There is an optimum size or complexity beyond which the "benefits" of additional complexity are outweighed by the "costs" of lowered accuracy (Costanza and Sklar 1985).

CERP Scheduling

The uncertainties associated with the CERP schedule, things that can alter project start and end dates, may include unanticipated legal constraints and lawsuits, construction delays,

contractual bottlenecks associated with land purchases, feasibility studies and new technologies, and the overall bureaucratic complexity associated with the management of a very large restoration program that is shared by several government agencies. Interim Goals and Targets will assume a particular sequence of CERP projects (i.e., Alternative D13R), as well as, a construction period for each project and a specific "benefit" associated with each project. Any change in any one of these can alter the timing and effectiveness of restoration. This will, in turn, affect the five-year intervals of predicted Interim Goals and Targets. Unfortunately, it is unknown just how much an Interim Goal or Target may shift when sequencing is altered. Clearly, any schedule change to a project that is directly influencing the volume, flows, or quality of the water to the natural system, will noticeably alter any predictions associated with hydrologic and water quality Interim Goals and Targets. However, schedule shifts may also noticeably alter predictions associated with the indirect biological Interim Goals.

Environmental Variability

The stochastic nature of nature is probably the largest source of any uncertainty that is associated with Interim Goals and Targets. As with CERP scheduling, Interim Goals and Targets will assume a particular weather and rainfall pattern. Since the ecosystem is affected by rainfall, runoff, hurricanes, freezing temperatures, droughts, and floods, it is very certain that our predicted Interim Goals and Targets will not exactly match reality. To account for this uncertainty, every five years we will rerun all the models used to predict the Interim Goals and Targets with the currently approved or updated CERP and all the real, updated weather and rainfall data. These "new" Interim Goals and Targets will then be compared with observations in the ecosystem to see if it is responding as expected and to make sure that restoration is proceeding in the appropriate direction.

Geopolitical Change

Very few people would argue that large-scale economic and social, or geopolitical, events will not influence large-scale projects such as the CERP. The majority would agree that war, terrorists, bankruptcies, and recessions may alter resource allocations and the political will to design, construct, and complete all 50, or so, CERP projects. These realities will need to be tracked and accounted if they are found to influence our ability to schedule and complete projects, particularly those that influence predicted goals and targets. Of all the uncertainties, geopolitical change is the most unknowable. However, to produce Interim Goals and Targets we must assume geopolitical stability.

Responses to Peer Review Comments

After indicators and predictive methods were selected for Interim Goals and Targets, the U.S. Army Corps of Engineers contracted Battelle Memorial Institute to facilitate an independent scientific peer review of the April 19, 2004 draft document entitled *Recommendations for*

Interim Goals for the Comprehensive Everglades Restoration Plan (RECOVER 2004b). A panel of seven scientists reviewed the document and provided oral comments during a workshop on May 3, 2004, and written comments as a follow up to that meeting (Swiecichowski 2004). All review comments were compiled into a document that is available on the CERP web page http://www.evergladesplan.org/pm/recover/recover_docs/igit /122804_rec_igit_peer_report.pdf The scientific peer review panel will conduct a final review of the Interim Goals and Targets in 2005 and recommendations will be incorporated during future efforts to develop and revise the Interim Goals and Targets.

The following is a summary of the peer review comments and responses:

Linkage between goals and targets

Do not separate Interim Goals and Targets

We could not fully integrate the Interim Goals and Interim Targets because separate agreements are required by the Programmatic Regulations (33 CFR 385.38). However, with the intention of describing that CERP will provide benefits for both ecological and other water resource-related needs, we discussed indicators for Interim Goals and Interim Targets in the Foreword section of this document.

Describe trade-offs between Interim Goals and Targets

The Interim Goals and Targets were produced through the use of hydrologic simulations based on one plan for restoration of the South Florida ecosystem. No alternative hydrologic simulations were made to quantify potential trade-offs. Trade-off analyses were not performed as part of this effort because the CERP was purposefully designed to provide benefits for the natural system and human-related needs. Therefore, we did not include a discussion of trade-offs between Interim Goals and Interim Targets.

Maintain consistency between Interim Goals and Targets

The document was revised to maintain consistency between Interim Goals and Interim Targets.

Tell a comprehensive "story"

Develop a storyline

Authors of the Interim Goals and Interim Targets document took these comments very seriously and attempted to "tell the story" by revising the document's structure and language. This was primarily accomplished by organizing the document into regional modules that provide brief summaries of their respective regions, including information on the important indicators of restoration success and description of how regional CERP projects were likely to improve those indicators. In addition, the introduction of the document was revised to increase readability for a non-technical audience. At the same time, the document maintains a high level of scientific and technical specificity through inclusion of a scientific appendix.

Include project level objectives

Each regional module includes a list and brief description and list of objectives for the projects affecting that region.

Add Master Implementation Sequencing Plan (MISP) and link to individual CERP projects

We used modeling from the initial development (Restudy) of the CERP to predict Interim Goals and Interim Targets. These model results used the initial sequence of CERP projects that is described in Section 10 of the Restudy final feasibility report (USACE and SFWMD 1999) (http://www.evergladesplan.org/docs/comp_plan_apr99/sect10.pdf); therefore, the MISP (http://www.evergladesplan.org/pm/misp.cfm) was not used for predicting goals and targets in this document. Interim Goals and Targets will be based on the MISP after new model simulations become available.

Tie the indicators to broad classes of system functions

Generally, the regional modules describe how the major hydrologic stressors affect specific indicators and why the indicators are important. The appendix includes indicator documentation sheets that provide more specific information on the importance of each indicator and why each indicator is representative of a specific ecosystem function.

Include working hypotheses

While not always explicitly stated, working hypotheses are found in the indicator documentation sheets for each indicator.

Provide a better big picture view

We attempted to bring this "big picture" view to the document in the new Foreword and following regional module sections. These sections describe the entire South Florida ecosystem and the various ways that humans, stochastic environmental events, and water management affect the ecosystem.

Group indicators to help form a story

Each regional module was organized to describe how hydrologic changes were expected to affect each of the indicators. Effects to indicators were described together. For example, salinity-based indicators were described relative to their potential to affect oysters and seagrasses.

Include human demands and population growth as part of the story

This information was included in the water supply module of this document.

Better define terms and concepts and reformat document

Include a summary table of the Interim Goals and Targets

A summary table for Interim Goals and Interim Targets is provided as part of the Executive Summary.

Clearly define all terms in the document

All acronyms have been clearly defined, but defining all terms was beyond the scope of the document. We attempted to minimize the use of acronyms and define confusing terminology.

Assure consistency of justification, goal statements, etc. in documentation sheets

Indicator documentation sheets have been reviewed and revised to provide as much consistency as possible between indicators.

Rewrite the document so that it can be read by a scientist or layperson

The document has been revised to be readable by a scientist or layperson.

Provide all necessary documentation within (appendix) the document

The scientific appendix includes all relevant documentation.

Recommendations regarding indicators

Provide baseline historical data and variability for each indicator

Whenever possible, scientists provided historical baseline data and variability for indicators. For some indicators, these data were not always available. Moreover, appropriate baseline data, associated with restoration targets, were sometimes not available because significant impacts to the South Florida ecosystem occurred before thorough ecological investigations were implemented. All of the indicators used for Interim Goals and Interim Targets are discussed in the *CERP Monitoring and Assessment Plan: Part 1 Monitoring and Supporting Research* (RECOVER 2004a) and additional baseline data and estimates of parameter variability can be found there. In other cases, scientists did not have predictive models for use in developing Interim Goals and Interim Targets; therefore, predictions were not based on the actual indicator, but on some aspect of hydrologic suitability for the indicator.

Review and use US Environmental Protection Agency criteria for indicator selection

We did not use US Environmental Protection Agency criteria for indicator selection. Indicators for Interim Goals and Interim Targets were developed as a subset of indicators that were previously screened by other CERP planning teams for use in a predictive manner for project planning and in for assessment through the *CERP Monitoring and Assessment Plan: Part 1 Monitoring and Supporting Research* (RECOVER 2004a). Moreover, the scientific relevance of Interim Goals and Interim Targets indicators was previously established through the development of conceptual ecological models. These models were established using a consensus-based process with the collective knowledge and understanding of many established ecologists in South Florida. Other factors were used for selection such that the indicators should fulfill the following criteria:

- Be consistent with the goals and purposes of the CERP
- Address the physical and biological aspects of the Plan

- Be consistent with the *CERP Monitoring and Assessment Plan: Part I Monitoring and Supporting Research* (RECOVER 2004a) and the draft *CERP System-wide Performance Measures* (RECOVER 2004c)

- Be predictable and easily interpreted

In addition to these criteria, the subteam also considered other factors including the following:

- The need to maintain balance among physical stressor-based indicators and biological attribute-based indicators

- The need to have indicators from all regions of South Florida affected by the Plan

- The need to have enough indicators to adequately track representative responses for the major goals of the Plan without having so many as to be duplicative of the key goals

- The need to have indicators that represent different response times (i.e., both short-term and long-term responses to the affects of CERP implementation)

The RECOVER team considered many more indicators than have been included in these final recommendations. Some of these indicators were excluded because they were not considered to represent a broad class of ecosystem functions or because an alternative indicator was considered to be a better representative. Others were considered to be good representatives of ecosystem health generally, but were thought to be too dependent on non-CERP efforts. Still others that satisfied these tests and were considered to be good indicators of CERP success had no available prediction methods and scientists did not anticipate having these prediction methods in the near future. The Programmatic Regulations permit the Interim Goals and Targets to be reviewed at least every five years. When new prediction methods are available, some of these indicators may be added to the lists of Interim Goals and Targets.

<u>Choose poster children indicators and bring them to the forefront</u>

We did not deliberately choose "poster children" to report on at this time. Instead, we reported on all indicators while stressing Interim Goals and Interim Targets for indicators that the public would be most familiar with and likely to understand. We will work on future development of potential "poster children" indicators. For this document, we focused on telling several stories that illustrate CERP expectations in different regional areas. Thus, the readers can concentrate on reading about "their backyard" as opposed to one or two indicators found throughout South Florida.

<u>Provide more documentation/justification for hydrologic indicators</u>

Hydrologists provided additional justification for the hydrologic indictors in the indicator documentation sheets.

Document and sufficiently justify the importance of less obvious indicators

Each indicator documentation sheet provides substantial justification for each indicator. For brevity, and to hold the reader's attention, little justification is provided in the main portion of the document.

Too many indicators - use a short list of indicators for developing goals

We were not able to find a more parsimonious set of indicators for this round of Interim Goals and Interim Targets predictions. Because the indicators were developed to reflect a comprehensive set of key components identified in the conceptual ecological models, they were all included.

Include socioeconomic indicators

Socioeconomic indicators other than those for water supply and flood protection are being considered for the next version of Interim Goals and Interim Targets predictions. However, routine methods for predicting system-wide effects on socioeconomic indicators have not been developed for the CERP. As these methods are developed, socioeconomic indicators will be considered if effects on them can be attributed to the CERP.

Modeling Issues and Process of Predicting Goals

Describe natural indicator variability and the expected response relative to variability

When data for a specific indicator were available, summaries of natural variability and expected responses relative to that variability were discussed. Overall, we included an uncertainty section to manage expectations and highlight stochastic environmental processes that are certain to thwart our ability to meet all Interim Goals and Targets and confound our ability to attribute the CERP implementation to specific ecological responses.

Consider climate change when predicting goals

Hydrologic simulation modeling did not account for climate change; therefore, in most cases, it was not considered.

Discuss the cumulative uncertainty when using the South Florida Water Management Model (SFWMM) for drive secondary models

This is discussed in the uncertainty section of the document.

Use stochastic modeling simulations instead of the deterministic South Florida Water Management Model (SFWMM)

Development of an entirely new stochastic hydrologic simulation model was not possible for predicting Interim Goals and Interim Targets.

Screen models using specific model acceptability criteria

Predictive models were not screened. For this effort, we considered the process of choosing, including, and assuring sufficient monitoring plans to be the principal task. If indicator experts determined that a predictive model was useful for setting Interim Goals and Interim Targets, then the model may have been used entirely or only to guide the predictions. In most cases, all available models were run; as such, the Interim Goals and Interim Targets document represents a current disclosure of all available predictive methods with an indication of uncertainty and future needs to improve predictive power. A series of criteria for model acceptability has not been developed for the CERP, but this process is in development. Future predictions will include these criteria to screen and accept models.

Use and justify best professional judgment and provide assumptions

Best professional judgment was used in the development of Interim Goals and Interim Targets. Each indicator documentation sheet includes justification for predictions based on best professional judgment and available science.

Discuss the Natural Systems Model (NSM)

The Natural System Model (NSM) was often used as a reference point to show how simulation models might perform before much of South Florida was impacted through development. Additional details on the NSM can be found at the following web site: http://www.sfwmd.gov/org/pld/hsm/models/nsm/index.html.

Itemize sources of uncertainty when predicting Interim Goals

In most cases it was not possible to itemize all sources of uncertainty in the development of Interim Goals and Interim Targets. Any known sources of uncertainty in predictions were outlined in the indicator documentation sheets. This appendix also includes a discussion on uncertainty and outlines several general sources of uncertainty relative to the primary simulation model, the SFWMM.

Use flow diagrams to explain data flow and models used for making predictions

A general flow diagram was included in the document to show how data were used to make predictions. Some indicator documentation sheets also included the logic processes for predictive models. However, it was beyond the scope of this document to include flow diagrams for all predictive models. Sufficient reference were provides such that a reader can refer to citations for additional model detail.

Manage expectations of long-term responses by being explicit

This was done, particularly for those indicators that are likely to respond during the late phases of CERP implementation and beyond.

Use reference sites for establishing targets

To the extent that the *CERP Monitoring and Assessment Plan: Part 1 Monitoring and Supporting Research* (RECOVER 2004a) utilizes reference sites, the Interim Goals and

Interim Targets do as well. Specific reference sites were not established for Interim Goals and Interim Targets.

Do not use models to do assessments

In some cases it may be absolutely critical that models are used, in addition to real data, to perform assessments. For example, we cannot control the weather in South Florida and may need to use models to reconcile unexpected responses over short time frames (5 years) that may be due to random weather events.

Use an uncertainty classification system – red, yellow, green

All predictions for Interim Goals and Interim Targets are uncertain. The degree to which predictions are uncertain is unknown in many cases and can also be the topic of scientific debate. A method for developing a classification system was not developed because it was thought to be viewed as highly subjective and limited in value.

Keep and set Interim Goals for indicators that do not have models

In some cases, predictive models were not available to make indicator predictions, yet Interim Goals were set.

Assure that Interim Goals are quantifiable

Interim Goals were made as quantifiable as possible, but this was difficult in cases where predictive models were not available.

Human demands should be considered

Human demands are considered and Interim Targets are designed to showcase the extent to which the CERP can meet those demands throughout its implementation.

Use graphics to display goals

In most cases, graphics were used to display Interim Goals.

Achieve widespread buy-in for the predictive models

Far too many predictive models are used to achieve widespread buy-in. Indicator experts consulted with colleagues to choose the best predictive models.

List of Acronyms

List of Preparers

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Indicator Sheets

The indicator sheets for Interim Goals and Interim Targets make up the remainder of this document.