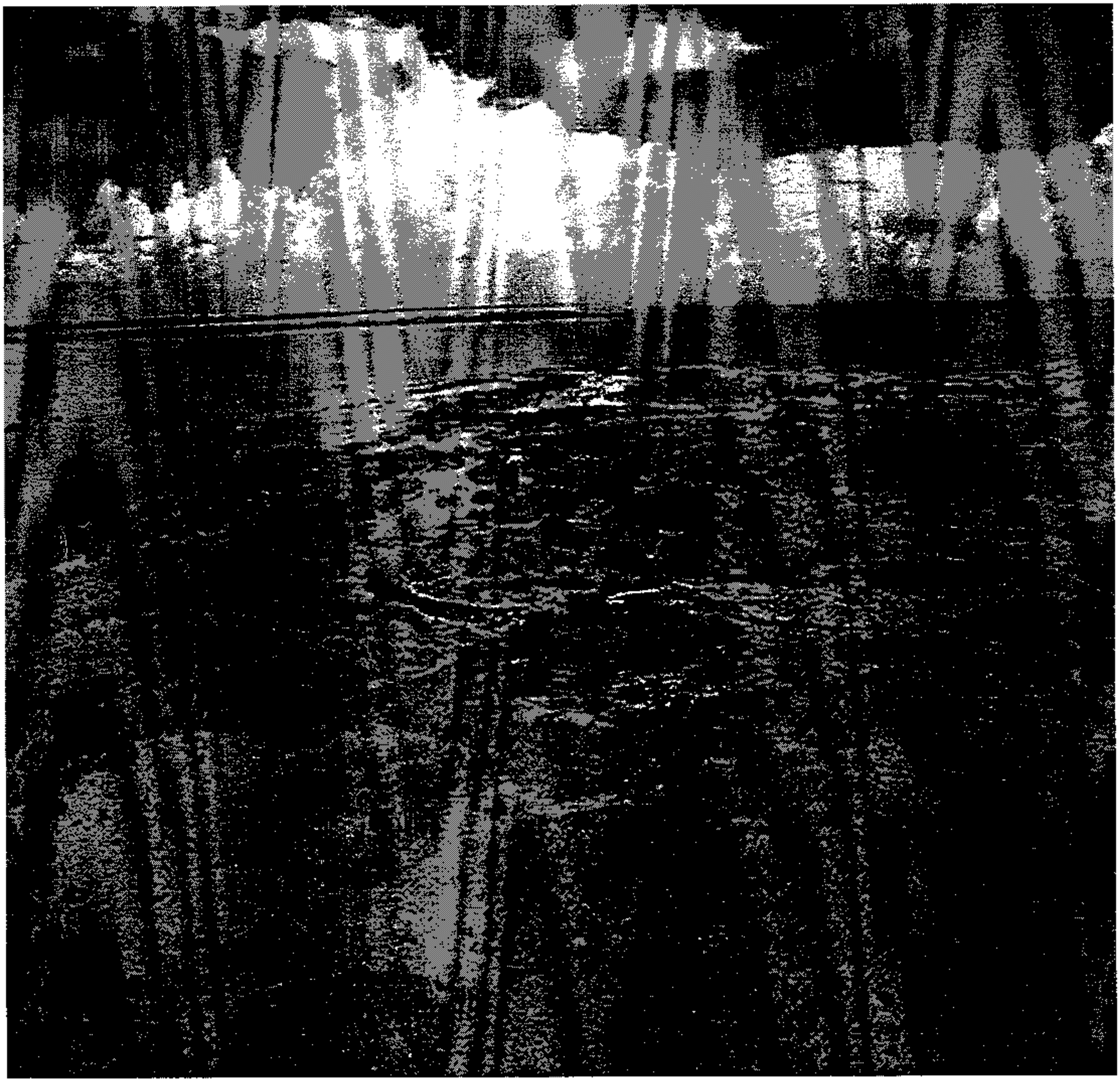
LAKE OKEECHOBEE REGULATION SCHEDULE STUDY

FINAL ENVIRONMENTAL IMPACT STATEMENT AND ANNEX A



Nov 1999

U.S. ARMY CORPS OF ENGINEERS
JACKSONVILLE DISTRICT

FINAL
ENVIRONMENTAL IMPACT STATEMENT

for

LAKE OKEECHOBEE REGULATION SCHEDULE STUDY

U.S. Army Corps of Engineers
400 West Bay Street, Room 980
Jacksonville, Florida
32232-0019

November 1999

FINAL
ENVIRONMENTAL IMPACT STATEMENT

for
LAKE OKEECHOBEE REGULATION SCHEDULE STUDY

Proposed Action: Five alternative lake regulation schedule alternatives are proposed to optimize environmental benefits to affected natural resources while causing little or no adverse impacts to existing project purposes.

Responsible Agencies: U.S. Army Corps of Engineers & South Florida Water Management District

Lead Agency: U.S. Army Corps of Engineers

Abstract:

Lake Okeechobee is the second largest freshwater lake within the contiguous United States, measuring over 720 square miles in area. It is a nationally renowned sport fishing venue and attracts thousands of seasonal tourists who come for the excellent fishing, as well as other recreational pursuits on and around the lake. Downstream, the St. Lucie and Caloosahatchee River estuaries possess among the largest diversity of fish and wildlife species in North America and their sensitive estuarine ecosystems are largely controlled by regulatory discharges from the lake and runoff from upstream basins. These resources have been imperiled due to the inability of the present water management system to adequately store, treat and convey clean water needed to supply the natural environment, agriculture and the urban areas. This problem is further compounded by the sensitivity of the receiving water bodies including the Everglades which is an oligotrophic environment that reacts quickly and poorly to nutrient laden waters, and the estuaries whose seagrasses and benthic fauna are adversely affected by freshwater infused with sediment and related pollutants. The proposed action allows for a lower overall lake regulation schedule with multiple operational zones in which discharges are controlled in part by climatological outlooks and meteorological forecasts and regular consultation with an interdisciplinary group of scientists, engineers and resource managers. The proposed action should improve conditions both within the lake and to a lesser extent, the St. Lucie Estuary for native vegetation including emergent and submergent vegetation and seagrasses. The proposed action is not expected to have substantial adverse effects on either the Caloosahatchee River Estuary or the Everglades Agricultural Area and only very limited short-term adverse effects to the Water Conservation Areas 3A and 2A. There are no significant adverse impacts to existing or future project purposes including water supply or flood control for the agriculture or urban areas or the natural environment. Some relatively very small positive economic effects are anticipated to result from improvements in agricultural water supply for the Everglades Agricultural Area and the Lower East Coast. Some relatively extremely minor increases in the incidence of water shortages for urban water users are anticipated based on modeling done to evaluate alternative regulation schedules in this study.

Note: The official closing date for the receipt of comments is ………………., 1999. This report is also available on our web site at: *http://www.saj.usace.army.mil/pd/env-doc.htm.*

For Further Information Contact: Mr. Martin Gonzalez/Mr. Olice Carter, U.S. Army Corps of Engineers, Jacksonville District, Planning Division P.O. Box 4970 PD-ES, Jacksonville, Florida 32232-0019, Tel: 904/232-1117/1140.

FINAL ENVIRONMENTAL IMPACT STATEMENT

for LAKE OKEECHOBEE REGULATION SCHEDULE STUDY

SUMMARY

The Central and Southern Florida (C&SF) Project was first authorized by Congress in 1948 and includes approximately 1,000 miles each of levees and canals, 150 water control structures and 16 major pump stations. At the heart of this system is Lake Okeechobee. Lake Okeechobee is a large, shallow lake located in the south central part of Florida. It comprises over 720 square miles of area and with a mean depth of about 9 feet the lake can store over five million acre-feet of water when the elevation is at the top of the conservation pool.

The lake serves a number of competing functions, including flood control, water supply, navigation, environmental protection and enhancement, and recreational purposes. Optimization of these competing project purposes is tied to the use of the regulation schedule. This schedule allows water to be stored during the wet season to provide adequate water supply during the dry season while simultaneously providing flood protection for surrounding areas. The lake has a limited discharge capacity. There are two major outlets, the St. Lucie and Caloosahatchee Rivers and four smaller agricultural canals; the West Palm Beach, North New River, Hillsboro and Miami Canals.

The entire C&SF Project originated during a time when flood control, water supply, and more prominently, "land enhancement" through drainage, were dominant objectives. Although environmental concerns were recognized, they were not considered urgent. Since the project was completed however, continually escalating demands due to increased agricultural output coupled with urban sprawl have resulted in the decline of what is now acknowledged to be an extensive, and highly significant ecosystem. The project is under intense review and study on both the Federal and State levels to determine the feasibility of both structural and operational modifications. A Final Integrated Feasibility Report and Programmatic Environmental Impact Statement for this very comprehensive study has recently been completed and is entitled the Central and Southern Florida Project Comprehensive Review Study; also referred to as the C&SF Restudy.

The purpose of the Lake Okeechobee Regulation Schedule Study (LORSS) is somewhat less complex and all encompassing. It is an attempt to fine-tune the existing regulation schedule to optimize environmental benefits at little or no impact to the competing purposes of flood control and water supply. This optimized schedule, if implemented, will be an interim operational change until such time as the recommendations of the more comprehensive C&SF Restudy can be implemented, somewhere within the next fifteen to twenty years. No alternative schedules that incorporated any structural modifications were studied as they were outside the scope of the LORSS.

There have been various schedules adopted since 1948. The current schedule is Run-25, which was a trial run in 1992 and recommended for implementation in 1994 upon completion of an Environmental Assessment prepared by the U.S. Army Corps of Engineers (USACE), Jacksonville District. The schedules studied in this report do not require structural modifications and were developed by the USACE and South Florida Water Management District (SFWMD). Performance measures and objectives were developed by an interagency group of concerned Federal and State agencies, scientists, researchers and resource managers. These performance measures and objectives were the "yardsticks" used to compare the various alternatives using the South Florida Water Management Model (SFWMM). In addition to the current regulation schedule, four other alternative regulation schedules were studied: 22AZE, HSM, Corps 2010, and WSE, which are described in some detail in section 5 of the main report.

The alternative regulation schedule recommended in this report represents the best operational compromise at the moment to improve the environmental health of certain major C&SF ecosystems, currently in decline. The proposed action, implementation of the WSE lake regulation schedule, incorporates the most up-to-date technical knowledge and tools currently available. When implemented, this schedule will be the first to use state of the art forecasting technology as part of the water management decision-making process for Lake Okeechobee. Extended periods of high water levels in Lake Okeechobee have resulted in significant loss of valuable habitat in the lakes' littoral zone and marsh communities. Exotic plant species are spreading rapidly as important fish and wildlife habitat has declined. Also, these high lake stages make it necessary to occasionally make large regulatory releases to the lakes' two major outlets, the St. Lucie and Caloosahatchee River Estuaries, resulting in additional, significant environmental damage to these ecosystems.

The rationale and impetus for action now, as opposed to waiting for the Restudy solution, is the continued environmental degradation suffered by the lake and both estuaries under the present lake regulation schedule. This study acknowledges the more extensive and comprehensive nature of the Restudy effort; the need for a structural solution, and greater storage capacity within the system, and the expectation of having better models, information and design details in the future. However, there will also be a significant time lag before the Restudy is implemented. The proposed action identifies an interim, if partial, solution which helps redress the ongoing environmental decline in the near term, at little or no cost to existing project purposes. This is, in essence, a form of adaptive assessment or adaptive management which has taken form under the C&SF Restudy.

Major Conclusions

An economic study was conducted to determine net regional and national benefits and impacts for the various alternatives. This is the first time the USACE has conducted a detailed socio-economics investigation for a regulation schedule action on Lake Okeechobee. Detailed results of the study are provided in ***Appendix D***. In brief, the study determined that the difference between the existing and future base conditions far outweighed any difference between the five alternatives. Implementation of the WSE lake regulation schedule will not adversely impact water supply, flood control, or existing local or regional economies and may in fact, enhance them through an improved and more sustainable natural ecosystem and the tourism and small business revenue it generates.

For the natural environment, the WSE schedule appears to provide substantial benefits for the lake littoral zone and marsh. Prolonged high lake stages, a distinct problem the past four out of five years in particular, are reduced under WSE, both under the near term and in the future base. Lake regulatory discharges, particularly high volume discharges, to the St. Lucie Estuary are somewhat reduced, improving, but not reversing the adverse affects on the estuary and Indian River Lagoon. High volume discharges to the estuaries resulting from a lack of resource management options under the current C&SF Project, have upset the natural ecology of the estuary and dumped nutrient and pollutant laden sediments which smother seagrasses, oyster beds and other benthos. Conditions within the Caloosahatchee are not substantially improved under the WSE alternative, and this estuary is either not improved or receives very little benefit from any of the alternatives. The EAA continues to act mostly as a pass through system for lake discharges south. Flows that are currently conveyed through the EAA in existing canals will continue under the WSE schedule unimpeded and without effecting current land use, remnant wetlands or protected lands. Water Conservation Area (WCA) 2A and WCA 3A will receive some additional flow, but relative to the size of these areas, it should not significantly affect regional hydroperiods or existing land or recreational uses. Some additional phosphorus loading to these WCAs may exacerbate existing cattail expansion in areas of sawgrass, but to a limited and relatively minor extent. This problem is expected to be an interim one, as STA (Stormwater Treatment Area) 3/4 will treat incoming flows to these areas beginning in late 2003. Modeling results strongly suggest that there will be essentially no hydrologic or ecological impacts in southern WCA 3A, WCA 3B or Everglades National Park from the proposed action.

Areas of Controversy and Issues to be Resolved

Almost any issue related to water management in a state with a high urbanization rate, and an unusually flat topography which is subject to seasonal wet and dry weather extremes, is bound to create controversy. Politics in Florida generally revolve around its water resources. Other than tourism, Florida derives large economic benefits from its agricultural and dairy industries. These industries not only require that adequate water supplies be available during periods of drought but they have also exacerbated the environmental damage of the State's water bodies due to heavy reliance on pesticides and fertilizers and the need for flood control through ditching and drainage. Other than this classic conflict between urban growth/human needs and the environment, the most controversial issue impacting this study is the phosphorous load that will still be sent to the WCAs. Excessive phosphorous loading to the WCAs will continue until such time as the proposed STA 3/4 recommended by the Everglades Construction Project is completed in late 2003. This loading will likely result in continued impacts to these areas in the form of cattail expansion into historical sawgrass areas, and unknown impacts to important periphyton communities throughout a much larger area. More importantly, these impacts may be irreversible, at least in the short-term, as nutrients deposited into the Everglades marsh sediment will not, in all likelihood, be economically recoverable in such a fragile and sensitive ecosystem without recovery efforts themselves causing equivalent damage.

Yet another area of controversy would be the level of uncertainty inherent in the use of computer models. Despite the use of the most technically advanced models, they are limited in the ability to account for all the numerous and complex biological, hydraulic and climate interactions. More advanced models are continually under development and will aid in improving our understanding of the relationship between hydrology and ecology in the future. Models are mostly useful to compare relative performance among the alternative plans based on past data over a period of record. That was their role in this study.

It is hoped that the regulation schedule alternative recommended by this study will result in an overall enhanced ecosystem at minimal or no cost to the economy, and that this represents the best possible use and management of our resources. It is important that this attempt be made now before the recommendations of the comprehensive C&SF Restudy are implemented. A decade or more spent waiting for a comprehensive solution is unacceptable to many who are currently impacted by the natural ecosystems upon which much of their economy, culture and lives are based. If an interim and improved regulation schedule is not implemented soon, many believe, continued decline in the lake's littoral zone and the estuaries is assured and may lead to significant long term damage from which the environment may never fully recover.

FINAL
ENVIRONMENTAL IMPACT STATEMENT

for
LAKE OKEECHOBEE REGULATION SCHEDULE STUDY

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Note: * delineates section is required for NEPA compliance

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1 Introduction

Lake Okeechobee is the second largest freshwater lake within the contiguous U.S.; measuring 730 square miles (476,000 acres) in area, with 150 square miles of littoral zone. The lake is shallow with a mean depth of 9 feet, subtropical, and eutrophic. Its storage capacity of 1.05 trillion gallons makes it the center of South Florida's water supply and flood control system. Lake Okeechobee provides water for a variety of consumptive demands, including urban drinking water, irrigation for agricultural lands, and recharge for wellfields. Habitat conditions inside and outside the lake also depend on this water supply. The lake's littoral zone supports a recreational sport fishery of noted importance, a commercial fishery, wading bird breeding and foraging, resident and migratory waterfowl, and endangered species. Lake Okeechobee is an important source of freshwater to the Everglades, and discharges influence the ecology of the St. Lucie and Caloosahatchee River estuaries.

1.1 Background and Previous Studies

Lake Okeechobee is one of the most critical components of the Central and Southern Florida Flood Control Project and achieving the right balance among the many, oftentimes competing demands on the lake has been, and continues to be, a difficult challenge. The lake is approximately 720 square miles in area and is now enclosed by approximately 140 linear miles of levees. Work on enclosing the lake was begun in the 1930's as a result of the disastrous 1928 hurricane that killed close to 2,000 people. Back then, the authorized project was known as the Caloosahatchee River and Lake Okeechobee Drainage Areas Project (CR&LODA) and the funding authority came from the 1930 Rivers and Harbors Act. This act essentially resulted in construction of the levees to completely surround the lake and enlarging the capacity of both major outlets to tide: the St. Lucie River to the East and the Caloosahatchee River to the West. With the passage of the Flood Control Act of 1948 (Public Law 858, 80th Congress, 2nd Session) the CR&LODA was expanded and enlarged into what is known today as the Central and Southern Florida (C&SF) Flood Control Project. The comprehensive plan for the C&SF Project was presented at that time and further modified by the Flood Control Act of 1954. It is this comprehensive plan which in essence converted the lake into a multi-purpose reservoir. What began in the 1930's as strictly a flood control endeavor with limited water storage as needed to supplement flood control capability, now also functioned to store even more water for both urban and agricultural use, navigation, fish and wildlife preservation, recreation, and salinity control. Historical lake stage elevations, including the maximum, mean, and minimum water surface elevations over the period of record 1931 – 1998 is shown in Figure 1.1-1. Table 1.1-1 contains the optimum water control elevations for Lake Okeechobee and the Okeechobee Waterway structures. Water levels above or below optimum water control elevations, and outside the regulation range, can occur. Additionally, temporary deviations from the operating criteria for Lake Okeechobee may be conducted from time to time.

Table 1.1-1

Optimum Water Control Elevations For Okeechobee Waterway and Lake Okeechobee (1)

Structure	Optimum Water Surface Elevation(ft) Headwater	Tailwater	Notes
S-77 Spillway and Moore Haven Lock	See Note 2	11.1	
S-78 Spillway and Ortona Lock	11.1	3.0	
S-79 Spillway and W.P. Franklin Lock	3.0	Tidal	
S-80 Spillway and St. Lucie Lock	14.0-14.5	Tidal	
S-308 Spillway and Port Mayaca Lock	See Note 2	14.0-14.5	
	Landside	Lake	
S-193 Lock	14.0	See Note 2	(3)
S-310 Lock	15.0	See Note 2	(4)

Notes:

(1) Optimum water control elevations have been developed through operating experience. All elevations are referenced to National Geodetic Vertical Datum 1929. Actual water levels can be above or below the optimum water levels.

(2) The current Lake Okeechobee regulation schedule ranges from 15.65 to 16.75 feet with multiple operation zones that vary flood releases over a wide range before reaching maximum release rates. The purpose of the 15.65 to 16.75 foot regulation schedule is to reduce damaging flows to the nearby St. Lucie Canal and Caloosahatchee River estuaries without sacrificing the flood control or water supply benefits derived from the Lake. In Zone D, discharges may be made to the estuaries for extended periods of time when the stage is rising. In Zone C, discharges are made at the same rate as Zone B of the current regulation schedule. In Zone B, discharges up to 6500 cfs at S-77 and 3500 cfs at S-80 can be made. When lake stages reach the levels defined for Zone A, maximum discharges are made through the major lake outlets after the removal of local runoff.

Regulatory releases occur at relatively high lake stages from 15.65 feet to 16.75 feet. The first zone of releases (Zone D) incorporates pulse releases to the estuaries. Pulse releases are low level releases that mimic the natural runoff from a rainstorm event. Lake stages can occur outside the regulation schedule. The minimum Lake elevation is 9.5 feet, NGVD. The maximum 30-day SPF average stage is 25.9 feet, NGVD.

(3) Both lock gates are opened full whenever the lake level is below 14.0 feet, NGVD. The lock is operated whenever the lake is above 14.0 feet, NGVD.

(4) When the lake stage is above 15.0 feet NGVD, the lock will be operated seven days a week from 5:30 am to 8:00 p.m. from October 1 through April 30; and from 5:30 am to 9:00 p.m. from May 1 through September 30. The lock will remain open at all times when the lake stage is below 15.0 ft NGVD. The optimum water level in the Industrial Canal is 15.0 ft NGVD when the lock is in operation.

Figure 1.1-1

Additional Flood Control Acts that refined the C&SF Project were passed in 1958, 1960, 1962, 1965 and 1968. Other than during the time frame wherein the C&SF Project works were being constructed, there existed only two authorized regulation schedules. One was a flat schedule of 16.4 feet, NGVD and the other was a seasonal 15.5 to 17.5 feet NGVD schedule with a one foot zone of variable releases that was approved in February 1959. In 1965 and 1966 this seasonal schedule was modified twice to allow storage to accumulate during the wet season and to deliver water to the Everglades National Park. The 1968 Flood Control Act authorized further raising of the surrounding levees to accommodate a proposed increase of four feet to the authorized regulation schedule. The prevailing lake regulation schedule at that time was then considered interim. During the early 1970's levee improvements were made so that the lake could safely handle the 15.5 to 17.5 foot authorized regulation schedule. In 1974 an interim schedule was put into operation to raise the schedule one-half foot to a range between 14.5 and 16.0 feet NGVD. This stayed in effect until 1978 when the schedule was raised to 15.5 to 16.5 feet NGVD. In December of 1991, the South Florida Water Management District, the Corps sponsor in managing the lake, requested that the Corps implement an interim 15.65 to 16.75 foot NGVD regulation schedule (known as "Run 25") for two years during which time a new regulation schedule would be considered. In 1994 an Environmental Assessment was prepared that recommended continued operation of Run 25 until such time as the C&SF Restudy and/or the results of the Lower East Coast Regional Water Supply Plan were known. These repeated attempts to raise the regulation schedule are largely attributed to increasing agricultural irrigation needs and the rapid urban development of the Lower East Coast of Florida, for which Lake Okeechobee functions as a back-up water supply source.

A socio-economics investigation was not conducted for this last study, which resulted in an Environmental Assessment, completed in 1994. The schedule most favorable to the environment at that time, 22AZE, was deemed to be too damaging to the water supply functions of the lake, and therefore by inference, economically damaging. However, because of the continued deterioration of both the lake's littoral zone and the two estuaries, then Governor of Florida, Lawton Chiles, requested that another study be conducted to determine a more environmentally friendly lake regulation schedule that would have minimal or no economic impact.

1.2 Study Authority

Authority to complete this study was granted under Section 310 of the 1990 Water Resources Development Act which reads in part: "… (1) CENTRAL AND SOUTHERN FLORIDA.- The Chief of Engineers shall review the report of the Chief of Engineers on central and southern Florida, published as house Document 643, 80th Congress, 2nd Session, and other pertinent reports, with a view to determining whether modifications to the existing project are advisable at the present time due to significantly changed physical, biological, demographic, or economic conditions, with particular reference to modifying the project or its operation for improving the quality of the environment, improving protection of the aquifer, and improving the integrity, capability, and conservation of urban water supplies affected by the project or its operation."

1.3 Study Purpose and Scope

This section describes the purpose of the Lake Okeechobee Regulation Schedule Study, what needs it is attempting to address and then develops a boundary around the myriad of issues and parties involved and the physical area anticipated to be effected by the alternatives identified.

1.3.1 Study Purpose and Need

The purpose of this study is to recommend for immediate implementation, a regulation schedule that will optimize environmental benefits at minimal or no impact to competing project (lake) purposes. The need for this study has been clearly established by the continued deterioration of Lake Okeechobee's littoral zone and both the Caloosahatchee and St. Lucie estuaries, after implementation of the current regulation schedule, Run 25. The solution is not clear. [redacted] The best scientific information currently available still cannot compensate for the unpredictability of Florida's subtropical climate. While there are some obvious alternative schedules that are of immediate benefit to the environment, concomitant adverse impacts to other project purposes are also very apparent.

1.3.2 Study Goals and Objectives

The objective of this study is to develop and select a new regulation schedule that will optimize environmental benefits with little or no impact to the competing purposes of flood control, water supply, navigation, salinity control and recreational purposes.

1.3.3 Study Scope

The work being performed for this study shall consist of identifying the impacts (both beneficial and adverse) associated with alternative Lake Okeechobee regulation schedules and the approved regulation schedule currently in place, 25. Studies and investigations shall be conducted to provide the basis for determining the environmental and socio-economic impacts of modifying the existing regulation schedule of Lake Okeechobee. Broadly, the effort will involve:

a. Identifying all environmental, fish and wildlife, cultural and recreational resources in the study area;

b. Assessing the impacts of the alternative regulation schedules on these resources;

c. Quantifying impacts to the competing lake management objectives such as flood protection, water supply, water quality, recreation and navigation;

d. Evaluating the socio-economic impacts associated with the alternative regulation schedules; and

e. Preparing the required documentation including graphics to present the study's findings and recommendations.

1.3.4 Study Area

The area that may be affected by the proposed alternative lake regulation schedules includes much of south Florida beyond the bounds of Lake Okeechobee proper. For the purposes of this study it has been determined that substantive effects may be regional in nature and importance, but perhaps due to the restricted operational changes being proposed, are not limitless in scope and effect. Hydrologic modeling, using the South Florida Water Management Model (SFWMM), strongly suggests that the southern Water Conservation Areas (WCAs), including Water Conservation Area (WCA) 3A below I-75 (Alligator Alley), WCA 2B, WCA 3B, and Everglades National Park are not significantly affected by the operational changes being proposed to the lake regulation schedule. An even more conservative estimate of hydrological impacts, is to conclude that regulatory discharges resulting from the lake under the array of alternatives, will not affect any areas downstream of Tamiami Trail (U.S. 41). The area considered to be affected and which shall receive the greatest scrutiny in terms of impact assessment therefore is within the lake itself, particularly within the littoral and marsh areas of the lake, in both major downstream estuaries including the St. Lucie and Caloosahatchee River Estuaries, within the Everglades Agricultural Area (EAA), and in the northern WCAs, including WCA 3A north of I-75, WCA 2A, and the Arthur R. Marshall Loxahatchee National Wildlife Refuge (WCA 1). WCA 3A south of I-75 and WCA 3B are also considered, although they are believed to be outside the area of hydrologic influence for any of the alternatives. See Figure 1.3.4-1 for an overall image of the study area including its proximity within the central and south Florida ecosystem and Figure 1.3.4-2 for a more detailed view

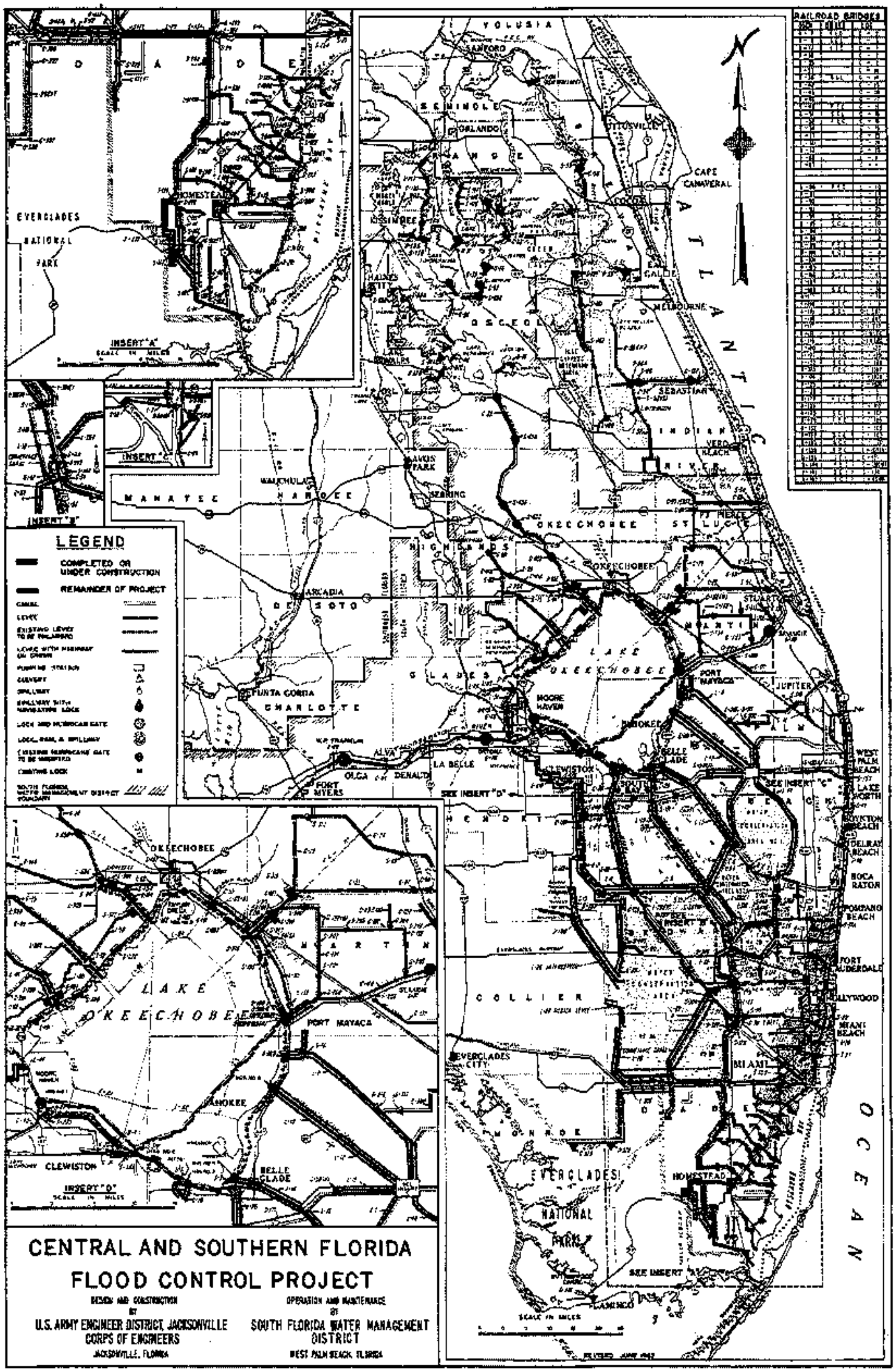


Figure 1.3.4-1 C&SF Project

of Lake Okeechobee, and its water control and conveyance features.

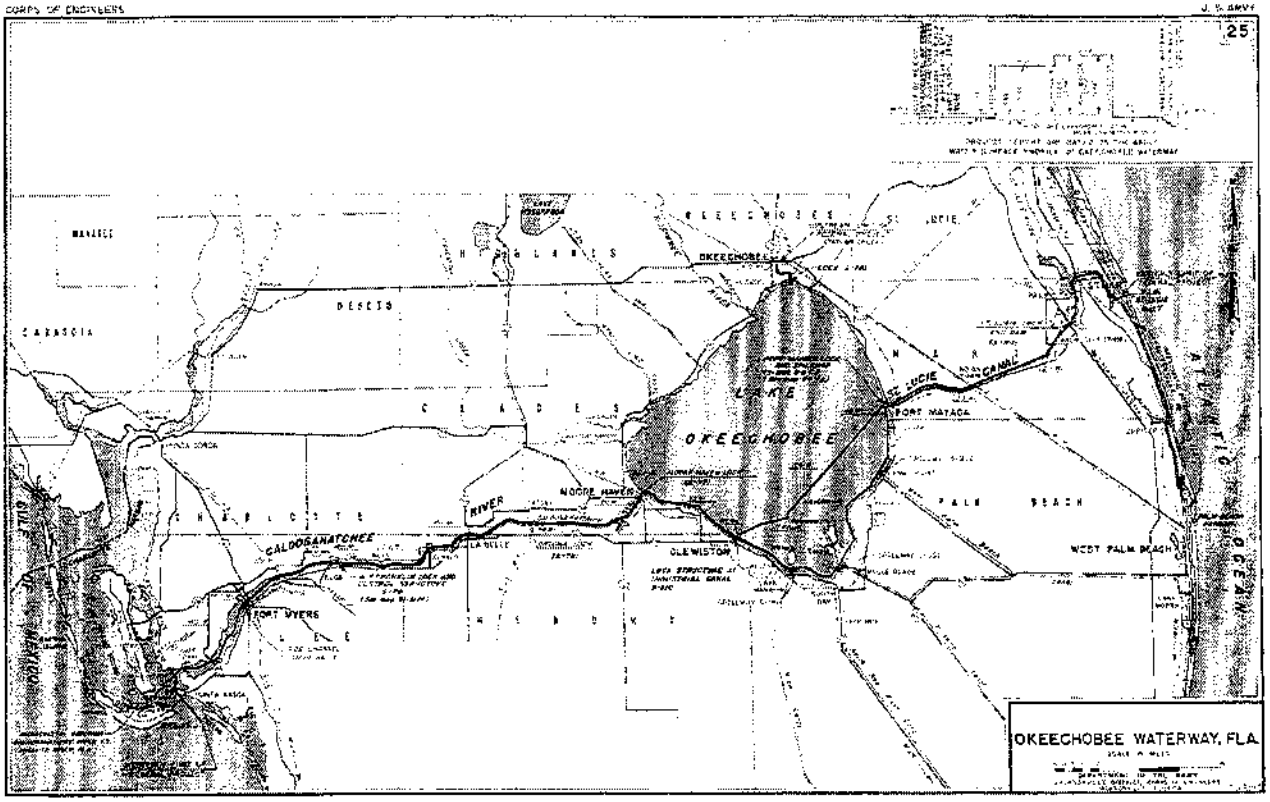


Figure 1.3.4-2 Map of Lake Okeechobee and Environs.

Lake Okeechobee is located in south central Florida, and occupies portions of, Glades, Hendry, Martin, Okeechobee, and Palm Beach Counties. The lake has an area of approximately 700 square miles with its approximate center near 26° 56′ 55″ north latitude, 80° 56′ 34″ west longitude.

The St. Lucie Estuary is located within portions of both Martin and St. Lucie counties on the southeast coast of Florida. The two forks of the St. Lucie Estuary, the North Fork and South Fork, flow together near the Roosevelt Bridge at the City of Stuart, and then flow eastward approximately six miles to the Indian River Lagoon (IRL) and Atlantic Ocean at the St. Lucie Inlet.

The Caloosahatchee River is the only flood-control outlet leading west from Lake Okeechobee, part of the Okeechobee Waterway, and the only navigable passage between the Gulf of Mexico and the Atlantic Ocean. The river extends approximately 70 miles from Lake Okeechobee, through the Caloosahatchee River Estuary, to the lower Charlotte Harbor Basin at San Carlos Bay. The Caloosahatchee River passes through parts of Glades, Hendry, and Lee counties.

The EAA, located south of Lake Okeechobee within eastern Hendry and western Palm Beach counties, encompasses an area totaling approximately 718,400 acres (1,122 square miles) of highly productive agricultural land comprised of rich organic peat or muck soils. A small portion of EAA mucklands is also found in western Martin County. Approximately 77 percent of the EAA (553,000 acres) is in agricultural production.

The area is considered one of Florida's most important agricultural regions. It extends south from Lake Okeechobee to the northern levee of WCA-3A. Its eastern boundary extends to the L-8 Canal. The L-1, L-2 and L-3 levees represent its westernmost limits.

The WCAs cover 1,372 square miles and are located south of the lake and EAA. WCA 1, also known as the Arthur R. Marshall Loxahatchee National Wildlife Refuge, includes 227 square miles of Everglades wetland habitat. Water Conservation Area 2, the smallest of the three WCAs, encompasses approximately 210 square miles. The area is divided into two cells by a levee constructed in 1961. The north cell, WCA-2A, Covers 173 square miles, and the south cell, WCA-2B, covers 37 square miles. Water Conservation Area 3, the largest of the WCAs covers an area of 915 square miles.

1.3.5 Report Organization

This report was initially presented in draft form as an Integrated Feasibility Report and Environmental Impact Statement. Subsequently the Corps has determined that a Feasibility Report was not entirely appropriate for authorization at the Division level, so the Final report is presented as a Final Environmental Impact Statement. Detailed results of the many independent studies and investigations conducted are attached as appendices. Interrelated summaries and important observations resulting from these independent studies and investigations are used and encapsulated throughout the main body of the report.

2 EXISTING CONDITIONS

The existing conditions are described below in either a regional or area specific context depending on the nature of the resource or the anticipated effect to that resource. For relatively uniform resources such as geology, soils, climate, air quality etc., it is assumed that the entire study area shares more or less similar qualities. They are therefore described in a regional or entire study area context. For more site specific resources and for those anticipated to be affected by the alternatives such as vegetation, water management, and fish and wildlife, the description of existing conditions is organized by specific area. These areas are organized based on physiographic region as was done for the alternatives modeling (***Appendix A***) and include: 1) within Lake Okeechobee or the Lake Okeechobee basin; 2) St. Lucie Estuary and Indian River Lagoon; 3) Caloosahatchee River and Caloosahatchee River Estuary; 4) Everglades Agricultural Area; and 5) Water Conservation Areas.

2.1 Topography, Geology and Soils

The topography of the lands surrounding Lake Okeechobee is flat to gently sloping with an elevation ranging from 10 ft to 20 feet above mean sea level (msl). The area can be divided into three physiographic regions: (1) the Sandy Flatlands to the west and north of the lake which slope gently towards the lake; (2) the Eastern Flatlands to the east of the lake which slope gently towards the lake; and (3) the Everglades Region to the south, southeast, and southwest of the lake which generally slope away from the lake. (Klein et al, 1964; Lichtler, 1960).

The mean Lake Okeechobee water surface elevation is 14.5 feet above msl, although this level varies from one side of the lake to another depending upon wind speed and direction. Lake depths within about a mile of the dike range from 1 to 11 feet below the mean water level in natural areas, and are approximately 38 feet below mean water level in the crest canal.

The geological formations underlying Lake Okeechobee can be divided into two distinct groups, one which occurs in the Sandy and the Eastern Flatlands region, and one which occurs in the Everglades region. In the Flatlands region, Pamlico Sand composed primarily of sand and limestone of the Late Pleistocene, occurs from 0 to 10 feet below land surface (bls). The Anastasia Formation occurs from 10 to 230 ft bls and consists of sand, limestone, and shell beds of the Pleistocene. The next layer of material is the Caloosahatchee Marl which occurs from 230 to 330 feet bls and is made up of shelly sands and shell marl of the Pliocene. Together, the Anastasia Formation and Caloosahatchee Marl comprise the water table or nonartesian aquifer of this region.

Underlying these porous layers, there are a series of formations with lower permeability which act as a confining layer. The uppermost of these layers is the Tamiami Formation which occurs from 330 to 400 feet bls and is comprised of marly sand, marl, and shell beds of the Miocene. The Hawthorn Formation occurs from 400 to

890 feet bls, and is composed of clayey and sandy marl of the Miocene. The Tampa Formation exists from 890 to 940 feet bls, and is made up of limestone and some marl of the early Miocene. The Tampa Formation exhibits somewhat higher permeability yielding some artesian water.

Within the St. Lucie and Caloosahatchee River regions drainage basins formed a variably shelly, sandy limestone on top of the Anastasia Formation. In the southwestern region, the higher elevation associated with the Immokalee Rise is an accumulation of sands overlying the Caloosahatchee Formation.

Lake Okeechobee is underlain by peat and muck (histosols of organic origin and entisols) although much of the peat has been altered to muck by oxidation processes. In surrounding drainage areas, soils range from fine sand and loamy material having poor natural drainage (predominantly alfisols and entisols with some histosols) to sandy and sandy-over-loamy soils with moderate natural drainage (spodosols and alfisols).

Martin and St. Lucie Counties are characterized by sandy and sandy-over-loamy soils with moderate natural drainage (spodosols and alfisols). In coastal areas, soils are predominantly sandy although some organic soils may be scattered throughout (entisols, histosols, and some alfisols).

The EAA is primarily underlain by peat and muck (histosols of organic origin and entisols) although much of the peat has been altered to muck by oxidation processes.

The WCAs are primarily underlain by peat and muck (histosols of organic origin and entisols) although much of the peat has been altered to muck by oxidation processes. Other soils in these areas include fine sand and loamy material that have poor natural drainage (predominantly alfisols and entisols with histosols).

2.2 Climate

The Study region is located in an area characterized by a humid subtropical climate. Summers are long and warm typified by frequent afternoon convection storms. Winters are mild with the temperatures rarely falling below freezing. The Summer months (May through October) constitute the wet season, the Winter months (November through April) the dry season. Prevailing winds in the Lake Okeechobee area vary from southeast to east-northeast, except during Winter when winds are from a northwesterly direction. The annual mean wind speed is 9.4 miles per hour (USDA, 1978).

The most significant factor affecting the climate of the Lake Okeechobee area is its proximity to large water bodies. Although located on a parallel occupied primarily by arid lands around the world, the maritimity effects of the Gulf of Mexico and the Atlantic Ocean on this area result in a significantly modified climate. The climate of lands immediately surrounding the lake are even further influenced by the lake itself. Because the lake stays cooler than the surrounding land during warm days, and warmer than the land at night, the pressure differences and consequent winds significantly affect the local environment. The cooler lake temperatures during the day have a suppression affect on cloud formation over and near the lake. On remote imagery, the lake often appears as a hole in the cloud cover, sometimes being cloud free when surrounding areas contain significant cloud cover. Consequently, there is generally up to a 30 percent reduction in annual rainfall over and west of the lake compared to surrounding areas (Henry et al, 1994). Climate data from points around Lake Okeechobee are presented in Table 2.2-1.

Table 2.2-1
Average Annual Temperatures and Rainfall
For Locations Surrounding Lake Okeechobee
1961 - 1990
(Southeast Regional Climate Center)

Annual Average:	Min Temp	Max Temp	Avg. Temp	Avg. Prcp
	(^{0}F)	(^{0}F)	(^{0}F)	(In)
Canal Point, USDA	62.5	83.7	73.1	50.1
Belle Glade, ExpStn	61.8	83.3	72.6	51.6
Clewiston, USACE 64.5	83.4	73.0	43.1	NA
Moore Haven, Lock 1 62.5	83.5	74.0	45.0	NA
Okeechobee, Gate 6	63.3	81.4	72.1	NA

NA = Not Available

2.3 Air Quality

Existing air quality in the affected environment is good to moderate. This project is in an area which has been designated by the Clean Air Act as a Prevention of Significant Deterioration (PSD) Class II area for U.S. Environmental Protection Agency (EPA) regulated air pollutants except ground level ozone. All of Palm Beach County is classified by the Florida Department of Environmental Protection (FDEP) as an Ozone Attainment/Maintenance Area.

Registered stationary emission sources include thirty stationary air point sources located in Martin County, and close to two hundred stationary air sources in Palm Beach County (FDEP, 1998). Notable registered sources include the local sugar processing plants. Namely, the Atlantic Sugar Association plant near Belle Glade, and the U.S. Sugar Corporation plant near Clewiston each contribute to the overall air quality of this area.

Additionally, short-term occurrences of elevated levels of airborne particulate matter may occur periodically from natural fires, controlled burns, and other sources. The potentially unaccounted for volatile organic compound emissions coming from nearby agricultural activities may affect the existing air quality as well.

2.4 Noise

Lake Okeechobee is located in a rural, largely agricultural environment and is not subject to noise levels generally associated with urban areas. Industry, where present, is often removed from the immediate area of the lake except in some instances where municipalities are situated adjacent to the landward side of the Herbert Hoover Dike (HHD). Around the lake there are a number of existing sources currently contributing to the overall ambient noise level. The more predominant of these sources include:

- vehicular traffic traveling along nearby highways
- railroad traffic along the Florida East Coast Railway
- aircraft utilizing local airports or traversing air space near the lake
- small industry (i.e., produce processing and distribution)
- boat and airboat traffic throughout the lake
- urban activities in municipalities adjacent to the lake shore
- agricultural equipment in nearby fields and on transportation arteries (tractors, trucks, cane harvesters etc.)
- pumping stations

Rural areas typically have noise levels of 35-55 decibels (dB). Sound levels along transportation arteries are typically in the range of 70 dB.

Within the rural municipalities and urban areas along the east and west coasts, sound levels may be expected to be of greater intensity, frequency, and duration. In general, urban emissions would not be expected to exceed about 60 dB, but may attain 90 dB or greater in busier urban areas or near to frequently used, high volume transportation arteries. Noise associated with urban areas such as highways, railroads, primary and secondary roads, airports, operation of landscaping and construction equipment, communication and industry all contribute to the existing ambient noise.

2.5 Vegetation

The below discussion of vegetation occurring within the study area is organized by physiographic area, beginning with the lake itself, the estuaries, EAA and concluding with the WCAs.

2.5.1 Lake Okeechobee Basin

The vegetation and cover types within the Lake Okeechobee region have been greatly altered during the last century. Historically, the natural vegetation was a mix of freshwater marshes, hardwood swamps, cypress swamps, pond apple forests, and pine flatwoods. The freshwater marshes were the predominant cover type throughout, but especially along the southern portion of the lake where it flowed into the Everglades. These marshes were vegetated primarily with sawgrass (*Cladium jamaicense*) and scattered clumps of carolina willow (*Salix caroliniana*), sweetbay (*Magnolia virginiana*), and cypress (*Taxodium* sp.). Hardwood swamps dominated by red maple (*Acer rubrum*), sweetbay, and sweet gum (*Liquidambar styraciflua*) occurred in riverine areas feeding the lake, while cypress swamps were found in depressional areas throughout the region. Pine flatwoods composed of slash pine (*Pinus elliottii*), cabbage palm (*Sabal palmetto*), and saw palmetto (*Serenoa repens*) were prevalent in upland areas especially to the north.

Lake Okeechobee has an extensive littoral zone that occupies approximately 400 km^2 (about 25 percent) of the lake's surface (Milleson 1987). Littoral vegetation occurs along much of the lake's perimeter, but is most extensive along the southern and western borders (Milleson 1987). The littoral zone plant community is composed of a mosaic of emergent, submergent and natant plant species. Richardson and Harris (1995) refer to a total of 30 distinguishable vegetative community types in their digital cover map study. Emergent vegetation within the littoral zone is dominated by herbaceous species such as cattail (*Typha* spp.), spike rush (*Eleocharis cellulosa*), and torpedo grass (*Panicum repens*) an invasive exotic species. Other emergent vegetation observed includes bulrush (*Scirpus californicus*), sawgrass, pickerelweed (*Pontederia cordata*), duck potato (*Sagittaria* spp.), beakrush (*Rhynchospora tracyi*), melaleuca (*Melaleuca quiquenervia*) an invasive exotic species, wild rice (*Zizania aquatica*), arrowhead (*Sagittaria latifolia*), button bush (*Cephalanthus occidentalis*), sand cordgrass (*Spartina bakeri*), fuirena (*Fuirena scirpoidea*), primrose willow (*Ludwigia peruviana*), rush (*Scirpus cubensis),* southern cutgrass (*Leersia hexandra*), maidencane (*Panicum hemitomon*) white-vine (*Sarcostemma clausum*), dogfennel (*Eupatorium capillifolium*), mikania (*Mikania scandens*) and carolina willow. Many of the native aquatic plant species have been eliminated, particularly on the north end of the lake, it is thought due to prolonged high water on the lake in the past five years (K. Havens, pers. comm.). Recently, awareness has increased of an organic berm formed apparently of dead, floating vegetation, along the interface of the open water zone of the lake and the littoral zone along the western shore.

The submergent vegetation is composed almost entirely of hydrilla (*Hydrilla verticillata*) an invasive exotic species, pondweed (*Potamogeton illinoensis*), bladderwort (*Utricularia* spp.), Chara (*Chara spp.*) and vallisneria, also known as wildcelery, eel grass, or tape grass (*Vallisneria americana*).

The natant, or floating, component of the littoral zone consists of lotus lily (*Nelumbo lutea*), fragrant water lily (*Nymphaea odorata* and *N. mexicana*), water hyacinth (*Eichhornia crassipes*), an invasive exotic species, water lettuce (*Pistia stratiotes*), duckweed (*Lemna* sp.), coinwort (H*ydrocotyle umbellata*), and ludwigia (*Ludwigia leptocarpa*).

The most recent vegetation mapping of the western littoral zone and marsh, conducted by the South Florida Water Management District (SFWMD), clearly depicts the dynamic state of vegetative succession within the littoral zone and the spread of less desirable and invasive exotic species into new areas. Results of this vegetation mapping show extensive areas of melaleuca along the rim canal, and nearshore, spike rush, particularly in the Moonshine Bay area, cattail, mostly interspersed in smaller stands, hydrilla, where large monotypic floating and submergent mats dominate in Fisheating Bay, and stands of torpedograss, some in large monocultures of thousands of acres.

Hydrilla is one of several problem species discussed below which occur on Lake Okeechobee. It seems to provide good fish habitat, although its prolific growth, as evidenced in Fisheating Bay, causes navigation and possibly water quality problems. There has also been observed a significant expansion of cattail in the littoral zone by FWC staff (M. Poole, pers. comm.).

Melaleuca, a resilient species, found in a variety of habitats, is one of the principal species of concern on the lake. Melaleuca is capable of displacing native vegetation, including sawgrass marsh (Hofstetter and Parsons 1983, Stocker and Sanders 1980, Laroche and Ferriter 1992), and has been observed to displace native species in other marsh types, cypress-hardwood forests, and pine savanna (Schmitz and Hofstetter 1994). Ewel (1990) described melaleuca sites in south Florida as having hydroperiods of 6-9 months. Shomer and Drew (1982) noted that melaleuca colonization rates appeared to be inversely proportional to the length of the hydroperiod. Melaleuca may be observed adjacent to the rim canal, on spoil islands peripheral to the HHD, in wetland pockets behind the dike, and in the western littoral zone, where it has penetrated into the marsh over a mile from the rim canal near Moore Haven.

Brazilian pepper (*Schinus terebinthifolius*), an invasive exotic species, is frequently associated with ditch banks (Barber 1994) and is commonly found along canal banks within the lake. Very little is known about its hydroperiod requirements, but Duever et al. (1986) found that it thrives in areas with three to four month hydroperiods, while Doren and Jones (1994) stated that it rarely grows on sites flooded longer than three to six months, and is absent from deeper wetland communities.

Australian pine (*Casurina* spp.), an invasive exotic species, is a major invader of short hydroperiod areas where it can be found in dense stands, which preclude establishment of native species. One of the species (*C. quinquenervia*) is intolerant of extended inundation, but another (*C. glauca*) invades sawgrass marsh and burned hardwood hammocks in the Everglades (Doren and Jones 1994). Australian pine is commonly found along the rim canal and in monotypic stands on the berm of the HHD and in areas behind the dike.

Other exotics that continue to plague resource managers throughout Lake Okeechobee include torpedograss, which is believed spreading rapidly into areas of spike rush, forms dense rooted mats and appears to be tolerant of a wide variety of hydroperiods. There was an estimated 14,000 acres of torpedograss within the marsh as of 1992 (Schardt and Schmitz 1992), although that figure may be too low according to recent empirical data (C. Hanlon, pers. comm.). Other species include water hyacinth, native to South America, and water lettuce, which clog waterways and are found primarily in canals and backwater areas as well as in the lake, and both may root in wet soil. These latter two species, along with hydrilla, pose navigation problems for boaters and fisherman, flood control and water supply challenges for water managers, and are among the principal species targeted by aquatic plant control efforts by the U.S. Army Corps of Engineers (USACE) (D. Kinard, pers. comm.).

2.5.2 Estuarine Vegetation

Seagrasses are undoubtedly among the most important vegetation of the St. Lucie and Caloosahatchee River Estuaries as well as the Indian River Lagoon. Seagrass meadows improve water quality by removing nutrients, dissipating the effects of waves and currents, and by stabilizing bottom habitats thereby reducing suspended solids. Seagrass beds support some of the most abundant fish populations in the Indian River Lagoon, with a large species diversity. Seagrass and macroalgae (collectively referred to as submerged aquatic vegetation, or SAV) are highly productive areas and are perhaps the most important habitat of the Indian River Lagoon (IRL CCMP, 1996). Pinfish (*Lagodon rhomboides*) and several species of mojarra (Gerreidae) are very abundant in the seagrass habitat. These species are known to feed on seagrasses and on the epiphytes and epifauna of the seagrasses, providing a critical link in the food chain between the primary producers and the higher level consumers such as the common snook (*Centropomus undecimalis*) and spotted seatrout (*Cynoscion nebulosus*).

In the St. Lucie Estuary, the predominant species of seagrass is shoal grass (*Halodule wrightii*). Shoal grass often occurs in shallower areas and is commonly used as an indicator species in ecosystem studies and in determining salinity tolerance ranges. Johnson's seagrass (*H. johnsonii*), recently listed as a threatened plant species by the National Oceanic and Atmospheric Administration, may also occur in the vicinity of the St. Lucie Estuary or Indian River Lagoon. In the Indian River Lagoon, turtlegrass (*Thalassia testudinum*) occurs in waters generally deeper than 1-2 feet and is often associated with manatee grass (*Syringodium filiforme*). Juvenile sea turtles have also been documented as foraging on turtle grass and other seagrasses in the Indian River Lagoon (Mendonca, 1981; Mendonca and Ehrhart, 1982).

In the Caloosahatchee River the primary species of importance is Vallisneria (*Vallisneria americana*), also known as tape grass and commonly found in still and fast flowing waters. Like the seagrasses of the St. Lucie Estuary and Indian River Lagoon, Vallisneria is used extensively as an indicator species as it has proven to be an excellent ecological representative for a wide variety of other biota for this area. Vallisneria is a valuable waterfowl food and is considered an excellent plant for fish spawning areas along the river margin. In some areas Vallisneria is declining due to competition with hydrilla and Eurasian watermilfoil (*Myriophyllum spicatum*), an invasive exotic species (USACE 1988). The seagrasses which occur are shoal grass, which is downstream in the estuary and extends beyond Shell Point. Shoal grass and turtle grass are in San Carlos Bay and the lower Charlotte Harbor.

The seagrass communities have experienced substantial declines in acreage and quality in recent years. An estimated 30 percent of the seagrass communities have been destroyed in Florida's estuaries since the 1940's. The Indian River Lagoon and Charlotte

Harbor have each lost about 30 percent of their seagrass beds. Since 1987, more than 59,000 acres of seagrasses have been affected by several factors including degraded water quality, dredging from boat propellers, freshwater management, severe temperature variability, and others; resulting in a massive die-off (Haddad and Sargent 1994). The relationship between seagrass growth and sustainability and light transparency has been well documented (Duarte, 1991; Kenworthy and Haunert, 1991; Goldsborough and Kemp, 1988; Stevenson et al., 1993; Dennison et al., 1993). It is therefore not surprising that in the opinion of many concerned citizens, discharges from lake Okeechobee, with its associated load of suspended and dissolved constituents such as sediments, chlorophyll and dissolved organic matter, may be impacting the riverine and estuarine seagrass communities and the animals that depend on this vital habitat.

2.5.3 Everglades Agricultural Area

The EAA, covering 1,122 square miles south of lake Okeechobee is the largest contiguous area of historic Everglades cover that has been converted by land use practices. The EAA historically consisted of several different plant communities. A dense swamp of pond apple, willow and elderberry formed broad bands along the southern rim of lake Okeechobee. The remainder of what is now the EAA was dominated by sawgrass marshes. The EAA today contains primarily agricultural cropland. Approximately 77 percent, or 553,000 acres, support crops including sugar cane, vegetables, sod, rice and citrus. Sugar cane is the primary crop of the EAA.

Several large tracts of land at the south end of the EAA were never directly converted to agricultural lands, although seasonal water patterns have been greatly altered by water management practices. These areas are known as the Holey Land and Rotenberger Wildlife Management Areas (WMAs), and the former Brown's Farm WMA (now converted to STA 2 (FWC, pers. comm.). These three areas comprise approximately 18 percent of the EAA and retain much of their historic sawgrass marsh and associated plant communities, although the plant cover has been altered by hydroperiod changes, fires, soil subsidence and invasion of exotic plant species and cattail. It is not expected that these areas will experience any modification to their existing in-flows under the lake regulation schedule alternatives and are thus not further discussed.

2.5.4 Water Conservation Areas

Almost all of the WCAs are graminoid wetlands interspersed with tree islands (hammocks) and willow strands. Tree islands are a unique feature of the Everglades ecosystem. Tropical hardwoods are found on some of the relatively unaltered tree islands in the southern portion of the area.

The basin marsh community type develops in broad, shallow to intermediate depth basins with peat substrate. The dominant plant cover is sawgrass and/or buttonbush and/or mixed emergents. In general, there are three recognizable types of basin wetland communities present:

Sawgrass marsh, composed of sawgrass, with cattail, maidencane, arrowhead, pickerelweed, willow, button bush, wax myrtle (*Myrica cerifera*), and saltbush (*Baccharis glomeruliflora*).

Wet prairie, composed of beak rush, spike rush, maidencane, string lily (*Crinum americanum*), and white water lily.

Aquatic slough, composed of white water lily, floating heart (*Nymphoides aquatica*), spatterdock (*Nuphar luteum*), bacopa (*Bacopa caroliniana*), and bladderwort.

A strand is a broad, shallow channel with peat over a mineral substrate; seasonally inundated by flowing water; tropical or subtropical. Fire is occasional or rare. Vegetation is characterized by cypress and/or willow.

The following species are associated with this community: pond cypress (*Taxodium ascendens*), bald cypress (*Taxodium distichum*), willow, buttonbush, wax myrtle, sawgrass, and royal fern (*Osmunda regalis*).

A hydric hammock is a wetland forest community that occurs in lowlands over sandy, clay organic soil, often over limestone. Its water regime is mesic to hydric; climate is subtropical or temperate; and fire is rare or not a major factor. The following species are associated with this community: sweet bay (*Magnolia virginiana*), red bay (*Persea borbonia*), cocoplum (*Chrysobalanus icaco*), strangler fig (*Ficus aurea*), wax myrtle, willow, elderberry (*Sambucus simpsonii*), hackberry, cabbage palm (*Sabal palmetto*), red maple (*Acer rubrum*), false nettle (*Boehmeria cylindrica*), water oak (*Quercus nigra*), hornbeam, and needle palm (*Rhapidophyllum hystrix*).

Vegetation within the Arthur R. Marshall Loxahatchee National Wildlife Refuge (WCA-1), consists of a matrix of wet prairies, sawgrass prairies, and aquatic slough communities. Tree islands are interspersed throughout the area. Plant community cover within WCA-1 has shifted as a result of impoundment of the marsh by perimeter levees and alteration of hydroperiods by operation of the C&SF Project. The southern, lower elevation areas of WCA-1 have been flooded for long periods of time, while the northern portions of the area have experienced more frequent drying. Areas which have experienced shortened hydroperiods have experienced shifts to woody vegetation (wax myrtle and willow), while lower elevations have experienced shifts to more aquatic flora. In addition, WCA-1 currently includes approximately 6,000 acres (4 percent total cover) of cattail marsh that was not present prior to the early 1960's. A number of factors influence establishment of cattails in the Everglades. These include physical disturbance of underlying soil profile by canal construction activities, proximity to seed sources, fire, hydrologic changes and the availability of nutrients. Exotic vegetation that was uncommon prior to 1965 is a growing problem. Melaleuca and Brazilian pepper are both rapidly spreading along the perimeter and into the interior marsh. In 1988, total coverage of Melaleuca was estimated to be near 4,000 acres (2.8 percent). Old World climbing fern (*Lygodium microphyllum*) is also a major invasive exotic species in WCA 1.

Major plant communities in WCA 2A now consist of remnant drowned tree islands, open water sloughs and large expanses of sawgrass, and sawgrass intermixed with dense cattail (*T. domingensis*) stands. Remaining tree islands are found primarily at higher ground level elevations, located in the northwest corner of WCA 2A. Remnant (drowned) tree islands, dominated primarily by willow, are found scattered throughout the central and southern sections of WCA 2A. Cattail distribution in WCA 2 show 4,400 acres in which cattails represent more than 50 percent of the vegetation in coverage and 24,000 acres of mixed or scattered cattail (<50 percent coverage) present in the northeast portion of WCA 2A.

Several studies conducted within WCA 2A show that cattails out-compete sawgrass in their ability to absorb nutrients. There is increased cattail production during years of high nutrient inflows (Toth, 1988; Davis, 1991). Cattails are considered a high nutrient status species that is opportunistic and highly competitive, relative to sawgrass, in nutrient-enriched situations (Toth, 1988; Davis, 1991). Davis (1991) concluded that both sawgrass and cattail increased annual production in response to elevated nutrient concentrations, but that cattail differed in its ability to increase plant production during years of high nutrient supply.

The community structure and species diversity of Everglades vegetation located north of I-75 (WCA 3A North) is very different from the wetland plant communities found south of I-75 (WCA 3A South). Improvements made to the Miami Canal and impoundment of WCA 3A by levees have over-drained the north end of WCA 3A and shortened its natural hydroperiod. These hydrological changes have increased the frequency of severe peat fires that have resulted in loss of tree islands, aquatic slough, and wet prairie habitat that were once characteristic of the area. Today, northern WCA 3A is largely dominated by sawgrass and lacks the natural structural diversity of plant communities seen in southern WCA 3A.

Over drainage of the northwestern portion of WCA 3A has allowed the invasion of a number of terrestrial species such as salt bush (*B. halmifolia*), dog fennel, and broom sedge (*Andropogon* spp.). Melaleuca has become well established in the southeastern corner of WCA 3A North, and is spreading to the north and west.

Everglades vegetation located in the central and southern portion of WCA 3A probably represents some of the best examples of original, undisturbed Everglades habitat left in south Florida. This region of the Everglades appears to have changed little since the 1950's, and contains a mosaic of tree islands, wet prairies, sawgrass stands, and aquatic sloughs similar to those reported by Loveless (1959).

The majority of vegetation within WCA-3A south can be described as typical Everglades habitat with some exceptions due largely to the canalization and construction of levees which compartmentalize the WCAs.

2.6 Fish and Wildlife

As with the above discussion of existing vegetation, the below discussion of fish and wildlife resources inhabiting the study area is organized by physiographic area, beginning with the lake itself, the estuaries, EAA and concluding with the WCAs. For additional detail on fish and wildlife resources and results of recent biological sampling on Lake Okeechobee, reference ***Appendix E.***

2.6.1 Lake Okeechobee

The area around Lake Okeechobee includes a wide variety of habitat opportunities for wildlife, including wading and migratory birds, many mammals, amphibians, and reptiles, as well as prey species such as crayfish, prawns, apple snails (*Pomacea paludosa*), and aquatic insects. The U.S. Fish and Wildlife Service (USFWS) has designated five wildlife species as threatened or endangered and likely to occur in the vicinity of the Lake Okeechobee study area (reference Section 2.7). There are also state-listed species present within and around the lake, including several of the wading bird species that are not on the Federal list. The USACE has conducted a wildlife survey within the western littoral zone of the lake, for the past two years, gathering baseline data for key habitat types for reptiles, amphibians, and migratory and resident birds (see ***Appendix E***). The study results are briefly summarized in this section.

Lake Okeechobee is home to a large number of fish species, some of which are valued as commercial and sportfish, and others serving as part of the cornerstone of the littoral zone food web. As part of the wildlife utilization study, numerous small fish species, including the Cyprinodontids such as the golden topminnow (*Fundulus chrysotus*), the least killifish (*Heterandria formosa*), and the Florida flagfish (*Jordanella floridae*) have been collected and are known to be important food resources for wading birds, amphibians, and reptiles.

Additionally, Furse and Fox (1994) revealed that numerous sportfish occur in the littoral zone. The largemouth bass (*Micropterus salmoides*) is one of the most popular gamefish in the state of Florida, and is a major predator of small fish, amphibians, birds, and reptiles. Additionally, the black crappie (*Pomoxis nigromaculatus*), bluegill (*Lepomis macrochirus*), and redear sunfish (*L. microlophus*) are sportfish found in high numbers in the littoral zone.

Macroinvertebrate diversity in the western littoral zone provides yet another vital component to the food web. Macroinvertebrate species incidentally sampled during field investigations in the western littoral zone included the apple snail, an important food resource of the snail kite (*Rostrhamus sociabilis plumbeus*), crayfish (*Procambarus* spp.), grass shrimp (*Paleomonetus paludosus*), and Dytiscid beetles (Dytiscidae).

Lake Okeechobee supports a valuable commercial and sport fishery. Trawl samples taken by the FWC from 1987 to 1991 collected twenty-five fish species from the limnetic zone. Threadfin shad (*Dorosoma petenense*) were most abundant, and black crappie, most abundant in terms of biomass. These two species, and Florida gar (*Lepisosteus platyrhincus*), gizzard shad (*D. cepedianum*), white catfish (*Ameirus catus*), redear sunfish, and bluegill represented 98 percent of the total catch in terms of number and weight in the trawl study (Bull et al. 1995). Over a five year period (1987-1991) mean annual commercial harvest was 2,008 metric tons (Fox et al. 1992, 1993). Commercially important fish species included white catfish, bluegill, and redear sunfish.

In recent years significant changes have been observed on the lake. Valuable fish habitat including bulrush, spike rush and SAV has been lost and/or replaced by exotic species such as torpedograss and hydrilla. Reports of muddy, turbid water, and drowned vegetation are not uncommon among the public and fisherman. Fishing guides report fish spawning has been poor for the last five years. Others report that shiners (an important bait fish) are becoming increasingly difficult to find and more and more fisherman are forced to the same areas to fish for them (C. Head, pers. comm.). Pepper grass (*Potamogeton illinoensis*) a floating leafed aquatic species, important as fish habitat, occurs in deeper water and which was once abundant on the lake, has been severely impacted and is observed mostly in isolated parts of the south end of the lake, notably South Bay (C. Head, pers. comm.). In many peoples opinion, these adverse effects are largely due to the sustained high water events persistent on the lake.

A major area of concern to the life cycle of fish and wildlife species is the western littoral zone and marsh, thus the description below will focus on this area as a representative of similar littoral resources around the lake.

The western littoral zone provides tremendous foraging and nesting habit for a wide range of avifauna. Previous studies (Smith and Collopy, 1995; David, 1994) have documented birds including the endangered wood stork (*Mycteria americana*), the Federally and state endangered snail kite, great blue heron (*Ardea herodias*), white ibis (*Eudocimus albus*), pied-billed grebe (*Podilymbus podiceps*), great egret (*Casmerodius albus*), snowy egret (*Egretta thula*), little blue heron (*E. caerulea*), tricolored heron (*E. tricolor*), and common moorhen (*Gallinula chloropus*) have commonly been observed utilizing the study area.

Other birds that may utilize the littoral zone include the threatened bald eagle (*Haliaeetus leucocephalus*), black skimmer (*Rhyncops niger*), brown pelican (*Pelecanus occidentalis*), double-crested cormorant (*Phalacrocorax auritus*), and anhinga (*Anhinga anhinga*).

According to rangemaps presented in Conant and Collins (1991), herpetofaunal diversity should be quite high in littoral and marsh areas of the lake. Studied species on Lake Okeechobee include the American alligator (*Alligator mississippiensis*) (L. Hord, pers. comm.) and the Florida soft-shelled turtle (*Apalone ferox*) (P. Moler, pers. comm.). Currently, no published inventories are available on the diversity of herpetofauna inhabiting the western littoral zone of Lake Okeechobee.

During a USACE wildlife survey of the western littoral zone (***Appendix E***), species such as the greater siren (*Siren lacertina*) have been sampled in high numbers along with the green water snake (*Nerodia floridana*) and the banded water snake (*N. fasciata*). Additional common species sampled included frogs such as the southern leopard frog (*Rana utricularia*), the green tree frog (*Hyla cinerea*), and the squirrel tree frog (*H. squirrela*). The American alligator was the only listed species of reptile recorded in the study area and there are no listed species of amphibians currently known to utilize the study area.

Of additional interest is the possibility of colonization of exotic amphibians and reptiles within Lake Okeechobee. Several reports from local residents have confirmed sightings of non-native species of lizards, such as the green iguana (*Iguana iguana*), the spiny-tailed iguana (*Ctenosaura pectinata*), and the brown basilisk (*Basiliscus vittatus*). Established populations of such species could be extremely harmful to native herpetofaunal populations.

Lake Okeechobee also provides major resources for mammalian species. The Okeechobee Waterway, a designated channel that runs around the perimeter of the lake, as well as across the lake, provides habitat for the endangered West Indian manatee (*Trichechus manatus latirostris*). Additionally, river otters (*Lutra canadensis*), bobcats (*Felis rufus*), and the Florida water rat (*Neofiber alleni*), a species of special concern as listed by the Florida Committee for Rare and Endangered Plants and Animals, have been observed within the lake.

2.6.2 Estuarine Fish and Wildlife

The Indian River Lagoon system is a biogeographic transition zone, fed by the St. Lucie Estuary, rich in habitats and species, with the highest species diversity of any estuary in North America (Gilmore, 1977). Approximately 4,315 different plant and animal species have been identified in the lagoon system. Included are 2,965 species of animals, 1,350 species of plants, 700 species of fish and 310 species of birds (IRL CCMP, 1996). Species diversity is generally high near inlets and toward the south, and low near cities, where nutrient input, freshwater input, sedimentation, and turbidity are high and where large areas of mangroves and seagrasses have been lost. For biological communities and fisheries, seagrass and mangrove habitats are extremely important (Virnstein and Campbell, 1987). Much of the habitat loss has occurred as the result of the direct effects of shoreline development, navigational improvements, and marsh management practices.

Most of the predominantly freshwater fishes recorded from the Lagoon system, such as minnows (Cyprinidae), bullhead catfishes (Ictaluridae), and sunfishes (Centrarchidae) are found mainly or exclusively in the tributary streams including the streams feeding the St. Lucie. Examples of other species in this habitat include all of the ubiquitous forms mentioned above as well as Florida gar; gizzard shad; flagfish; bluefin killifish (*Lucania goodei*); mosquitofish (*Gambusia affinis*); least killifish; sailfin molly (*Poecilia* *latipinna*); inland silverside (*Menidia beryllina*); gulf pipefish (*Syngnathus scovelli*); leatherjack (*Oligoplites saurus*); gray snapper (*Lutjanus griseus*); Irish pompano (*Diapterus auratus*); silver jenny (*Eucinostomus gula*); fat sleeper (*Dormitator maculatus*); bigmouth sleeper (*Gobiomorus dormitor*); and lined sole (*Achirus lineatus*). Fish species that specialize in creek-mouth habitats include yellowfin menhaden (*Brevoortia smithi*); gafftopsail catfish (*Bagre marinus*); timucu, a needlefish (*Strongylura timucu*); gulf killifish (*Fundulus grandis*); striped killifish (*F. majalis*); mosquitofish; sailfin molly; lined seahorse (*Hippocampus erectus*); chain pipefish (*S. louisianae*); gulf pipefish; tarpon snook (*Centropomus pectinatus*); Atlantic bumper (*Chloroscombrus chrysurus*); gray snapper; Irish pompano; silver jenny; great barracuda (Sphyraena barracuda); gobies, sleepers, puffers, filefish (*Monacanthus* spp.) and many others.

In addition to finfish, the estuaries and Indian River Lagoon support a variety of shellfish. Blue crabs, stone crabs, hard clams and oysters are important estuarine commercial species. The blue crab accounted for approximately 80% of shellfish landings in the Indian River Lagoon between 1958 and 1988 (IRL CCMP, 1996). Oysters are an important indicator organism and are known to be sensitive to salinity changes in their environment.

2.6.3 Everglades Agricultural Area

Wildlife habitat within the EAA is mostly limited to the canal systems. Flooded and cultivated agricultural fields attract feeding birds, especially waders. The Holey Land and Rotenberger WMAs located at the south end of the EAA are wildlife management areas that support populations of wading birds, deer, hogs and waterfowl. Wading birds and some raptors also frequent the flooded fields and canals. Raptors find abundant food sources in small mammals, snakes and other reptiles which often inhabit sugar cane fields. The extensive canal system supports fish species that normally would not be common inhabitants of the Everglades marshes, but are typically found in lakes. These fish include black crappie, catfish, and shad. Oscars (*Astronotus* spp.), spotted tilapia (*Tilapia mariae*), walking catfish (*Clarias batrachus*), and the black acara (*Cichlasoma bimaculatum*) are examples of exotic fish species that have become established within the region.

2.6.4 Water Conservation Areas

The WCAs as a whole contain a number of important species whose existence, population numbers and sustainability are markedly influenced by water levels. The American alligator, a keystone Everglades species, has rebounded in terms of population numbers since the 1960's when the reptile was placed on the endangered species list by the USFWS. Alligators, it is believed, play an important ecological function by maintaining "gator holes", or depressions, in the muck which are thought to provide refuge for aquatic organism during times of drought and concentrates food sources for wading birds. High water during periods of nest construction which occurs from June to early July (Woodward et al., 1989) decrease the availability of nesting sites. If conditions become too dry, either naturally or through water management practices, water levels may fall too low to maintain gator holes, forcing the animal to seek other areas to survive.

Other important reptile species commonly encountered within the study area include a number of species of turtles, lizards, and snakes. Turtle species include the snapping turtle (*Chelydra serpentina*), striped mud turtle (*Kinosternon bauri*), mud turtle (*K. subruburm*), cooter (*Chrysemys floridana*), Florida chicken turtle (*Deirochelys reticularia*), and Florida softshell turtle (*Trionys ferox*). Lizards such as the green anole (*Anolis carolinensis*), are found in the central Everglades, and several species of skinks occur more commonly in terrestrial habitats. Numerous snakes inhabit the wetland and terrestrial environments. Drier habitats support such species as the Florida brown snake (*Storeria dekayi*), southern ringneck snake (*Diadophis punctatus*), southern black racer (*Coluber constrictor*), scarlet snake (*Cemophora coccinea*), and two rattlesnakes (*Sistrurus miliarius* and *Crotalus adamanteus*). The eastern indigo snake (*Drymarchon corais*), a Federally listed threatened species, and the Florida pine snake (*Pituophis melanoleucus mugitus*), a state species of special concern, may also exist in drier areas of the study area. Wetter habitats support more aquatic species such as the water snake (*Natrix sipedon*), the green water snake, mud snake (*Francia abacura*), eastern garter snake (*Thamnophis sirtalis*), ribbon snake (*T. sauritus*), rat snake (*Elaphe obsoleta*), and the Florida cottonmouth (*Agkistrodon piscivorus*) (McDiarmid and Pritchard, 1978).

Important amphibians, known to occur in south Florida, include the Everglades bullfrog, or pig frog (*R. grylio*), Florida cricket frog (*Acris gryllus*) and southern leopard frog, southern chorus frog (*Pseudacris nigrita*) and various tree frogs are common to tree islands and cypress forests. Salamanders inhabit the densely vegetated, still or slow-moving waters of the sawgrass marshes and wet prairies. They include the greater siren and the Everglades dwarf siren (*Pseudobranchus striatus*). Toads such as the eastern narrow-mouth toad (*Gastrophryne carolinensis*) also occur within the study area.

Colonial wading birds (Ciconiformes) are a conspicuous component of the wildlife communities that utilize the WCAs as both feeding and breeding habitat. These include 11 species of herons and egrets, two species of ibis, the wood stork, and the roseate spoonbill (Robertson and Kushlan, 1984). Historically, white ibis has been the most abundant colonial wading bird species within the WCAs. Surveys indicate that the great egret is the second most abundant species (Frederick and Collopy, 1988). The great blue heron, little blue heron, tricolored heron, green backed heron (*Butorides striatus*), snowy egret (*E. thula*), cattle egret (*Bubulcus ibis*), black crowned night heron (*Nycticorax nycticorax*), and yellow crowned night heron (*N. violacea*), are also common wading bird species found throughout the WCAs. The roseate spoonbill (*Ajaia ajaja*), a state listed species of special concern, and the wood stork, a Federally listed endangered species, both occur within the WCAs. The WCAs support additional aquatic avifauna, such as the limpkin (*Aramus guarauna*), two bitterns (*Ixobrycus exilis* and *Botarus lentiginosus*), the anhinga, as well as a number of resident and migratory waterfowl.

Aerial surveys (Systematic Reconnaissance Surveys or SRF flights) are being conducted to determine the foraging habitat requirements and to map the movement of colonial wading birds (herons, egrets, wood storks and ibis) within the WCAs. Results of these surveys have indicated that white ibis, great egrets, great blue herons, wood storks, little blue herons, snowy egrets, cattle egrets, and glossy ibis are the most common wading bird species utilizing the WCAs, with populations varying widely in relationship to seasonal water level fluctuations. Peak wading bird use of the WCAs often occurs in January in synchrony with receding water levels, with over 121,000 birds being observed at times. Lowest counts have occurred during August with less than 15,000 birds counted. The white ibis is typically the most abundant wading bird observed, with total monthly counts varying as the birds move in and out of the WCAs in response to changing water levels. Great egrets represented the second most abundant species of wading birds observed.

The Everglades fish community is composed of a variety of forage fish important in the diet of many wading birds, sport fish, native species and exotics introduced partly through aquacultural practices and the aquarium trade. Forage species include the Florida flagfish, bluefin killifish, least killifish, shiners, mosquito fish, and sailfin molly.

Generally, Everglades sport fish are harvested from the borrow canals that surround the marsh. As water levels in the canal and marsh rise, fish populations disperse into the interior marsh and reproduce with minimum competition and predation. As water levels recede, fish concentrate into the deeper waters of the surrounding canals, where they become available as prey for wildlife and fishermen. In some instances, the canal fishery has experienced major fish kills due to overcrowding and oxygen depletion. The WCAs provide a valuable sport fishery for south Florida. Many of the canals, notably along U.S. 41, I-75, and in the L-35B and L-67A provide valuable recreational fishing for largemouth bass, sunfish, oscar, gar, bowfin (*Amia calva*), catfish and other species.

Besides supporting a valuable recreational fishery for the region, WCA-fish communities provide a major food source for Everglades wading birds, alligators, and other carnivorous reptiles and mammals. Fish community structure and abundance is highly dependent on water levels. Consequently, fishing success by humans or wildlife is also dependent on water levels (Dineen, 1974). For a more complete listing of common Everglades fishes reference Gunderson and Loftus (1993).

Several game and non-game wildlife species occur within the WCA system including: white-tailed deer (*Odocoileus virginianus*), common snipe (*Capella gallinago*), and marsh rabbit (*Sylvilagus palustris*). Blue-winged teal (*Anas discors*), mottled ducks (*A. fulvigula*) and other game waterfowl are found in the sloughs of the northeast corner. Feral hogs (*Sus scrofa*) may also be present in drier areas or on tree islands.

2.7 Threatened and Endangered Species

The following section includes a brief description of the Federally listed species known or thought to occur within the study area and which may be affected by the lake regulation schedule alternatives. State listed species, although not protected under the Endangered Species Act, are considered under the Fish and Wildlife Coordination Act and are included in Table 2.7.1-1.

2.7.1 Fauna

The USFWS has determined that five listed faunal species are present in the study region of Lake Okeechobee and may be affected by alternative lake regulation schedules. These species include the West Indian manatee, snail kite, wood stork, bald eagle, and eastern indigo snake. On May 12, 1999 the USFWS informally suggested that the Cape Sable seaside sparrow (*Ammodramus maritimus mirabilis*) may be indirectly affected by the proposed action as well. The Corps agreed to investigate this possibility, and so this avian species is also addressed below. All state and Federally listed plant and animal species present within the effected area and which may be affected by regulation schedule alternatives are presented in Table 2.7.1-1. The western shore of the lake, and the entire littoral zone on this shore is designated as critical habitat for the snail kite. This includes the marshes located along the segment of the lake from the Hurricane Gate at Clewiston to the mouth of the Kissimmee River. Portions of the WCAs are also considered critical habitat for the snail kite. The USFWS has further determined that although critical habitat has been designated for the West Indian manatee in certain Florida waters, the waters of Lake Okeechobee are not included in that designation (USFWS 1996). For a complete species description, taxonomy, distribution, habitat requirements, management objectives, and current recovery status, reference the Draft Multi-Species Recovery Plan for the Threatened and Endangered Species of south Florida, Volume I (USFWS 1998) or the USFWS endangered species web site at *http://www.fws.gov/~r9endspp.*

2.7.1.1 West Indian manatee

The West Indian manatee has been recognized as an endangered species since 1967. Both the USFWS and FWC list it as an endangered species. Manatees are also protected under the provisions of the Marine Mammal Protection Act of 1972, as well as by Florida law. Manatees occur in both fresh and salt water habitats, and are believed to show preference to waters with salinity levels < 25 parts per thousand (ppt.). Waters colder than 20^0C increase the manatee's susceptibility to cold-stress and cold-induced mortality. Manatees therefore generally seek out warm water refuges in quiet areas in canals, creeks, lagoons or rivers. Manatees are also found throughout the waterways in south Florida, Lake Okeechobee and occasionally in the Florida Keys. In south Florida, manatees are most prominent year round in the Indian River, Biscayne Bay, Everglades and Ten Thousand Islands area, Estero Bay and Caloosahatchee River area and Charlotte Harbor. Manatees feed on a variety of submergent, emergent and floating vegetation and usually forage in shallow grass beds adjacent to deeper channels. The primary threats to manatees today are due to collisions with watercraft, degradation of seagrasses and accidents occurring at water control structures.

2.7.1.2 Snail kite

The snail kite is a wide ranging raptor, listed as endangered by the USFWS and FWC. Within the study area, critical habitat includes portions of the WCAs, and portions of Lake Okeechobee, as described above. Lake Okeechobee and surrounding wetlands are major nesting and foraging habitats, particularly the large marsh in the southwestern portion of the lake. The snail kite has a highly specific diet composed almost exclusively of apple snails, which makes the kite directly dependent on hydrology and water quality within these watersheds. Preferred habitat for the snail kite includes long hydroperiod wetlands, flooded for > 1 year, with marsh vegetation dominated by spike rush, beak rush, maidencane, sawgrass and/or cattails, and relatively clear and open areas in order to visually search for apple snails. Nesting almost always occurs over water, near suitable foraging habitat, but may occur in herbaceous vegetation during periods of low water when dry conditions prevail beneath willow stands. The principal threats to snail kites are related directly to water management activities which may contribute to the loss or degradation of wetlands, as well as degradation of water quality from agricultural and urban sources.

2.7.1.3 Wood stork

The wood stork is listed as an endangered species by the USFWS and the FWC. In a USFWS coordinated survey of wood stork colonies, conducted from 1991-1995, between 1,339 (1991) and 2,639 (1995) wood stork nests were surveyed in south Florida, approximately 35 percent of the total nesting effort in the southeast United States. In south Florida, breeding colonies of the wood stork occur throughout the study area, with particularly important colonies occurring at Corkscrew Wildlife Sanctuary, Cuthbert Lake, East River and Sadie Cypress. Wood storks forage in freshwater marshes, seasonally flooded roadside or agricultural ditches, narrow tidal creeks, shallow tidal pools, managed impoundments, and depressions in cypress heads and swamp sloughs. Wood storks feed almost entirely on fish between 2 and 25 cm in length (Kahl 1964, Ogden et al. 1976, Coulter 1987), and depend on prey species being concentrated in receding waters as they use a tactile feeding technique, using their stout beak as a probe. A key environmental concern is that of nesting failure due to water management practices currently in place. During wet years, fish are not sufficiently concentrated in shallow pools for the storks to forage effectively. In dry years, freshwater sloughs are overdrained, and thus unable to produce the fish on which storks feed.

2.7.1.4 Bald eagle

The bald eagle is listed as threatened by both the USFWS and the FWC. Bald eagles are known throughout the study area, where they typically are found near estuaries, large lakes, reservoirs, major rivers and particularly along the southwest coast and in the Kissimmee River region. Eagle numbers have responded positively to the banning of

DDT and other organochlorines and bald eagles have now been reclassified from an endangered to a threatened species. Eagles feed primarily on fish, water dependent birds, and mammals. Eagles are opportunistic feeders and will also eat carrion. Current threats to the bald eagle include habitat loss and fragmentation, collisions with cars and power lines (USFWS 1998).

2.7.1.5 Eastern indigo snake

The eastern indigo snake is a large, black, non-venomous snake and occurs throughout the study area. The USFWS and FWC list it as a threatened species. The eastern indigo snake, generally an upland species, occupies a wide variety of habitat, including pine flatwoods, scrubby flatwoods, dry prairie, tropical hardwood hammocks, along the margins of freshwater marshes, agricultural fields, coastal dunes, and human altered habitats. They are usually not found in abundance in the wetland complexes of the central Everglades region. In wetter habitats, eastern indigo snakes may take shelter in hollowed root channels, hollow logs, or the burrows of rodents, armadillo, or crabs (Lawler, 1977, Moler 1985b, Layne and Steiner 1996). Currently the greatest impact to the eastern indigo snake has been by the loss, degradation, and fragmentation of their habitat due to residential and commercial construction, agriculture and timbering. Pesticides, mortality from vehicles, and illegal trapping also pose a threat to recovery efforts of this species.

2.7.1.6 Cape Sable seaside sparrow

The Cape Sable seaside sparrow is listed as endangered by the USFWS and the FWC. Critical habitat for the Cape Sable seaside sparrow was designated in 1977. They have the most restricted range of any of the seaside sparrows, and occur only in the Everglades region of Miami-Dade and Monroe Counties in south Florida. Presently, the known distribution of the sparrow is restricted to two areas on the east and west sides of Shark River Slough and Taylor Slough in Everglades National Park. The preferred habitat of the sparrow are short-hydroperiod marl prairies, dominated by muhly grass (*Muhlenbergia filipes*) with open space for ground movement. Nesting occurs from late February through early August, with the majority of nesting occurring in the spring when the marl prairies are usually dry. Although far removed from Lake Okeechobee and not subject to any direct discharges from the lake, sparrows are highly sensitive to seasonal water level changes and have been adversely impacted in the past. The western sparrow sub-population is particularly sensitive to discharges originating from the S-12 structures when higher than normal water years coincide with the breeding season.

2.7.2 Flora

A Federally listed plant species, the Okeechobee gourd (*Cucurbita okeechobeensis*), described below, may also be affected by the lake regulation schedule alternatives.

2.7.2.1 Okeechobee gourd

The Okeechobee gourd is listed as endangered by the USFWS. There are several localized sites along the southeastern shore of Lake Okeechobee, where this vine is found within the study area, including: Torry Island, Ritta Island, Kreamer Island, Bay Bottom Dynamite Hole Island, South Shore Dynamite Hole Island, and the southern shore of the Lake Okeechobee Rim Canal (Walters et al. 1992; Walters and Deckers-Walters 1993).

The Okeechobee gourd is a fibrous-rooted, high-climbing vine with tendrils. Its leaf blades are heart- to kidney-shaped with five to seven shallow, angular lobes and irregularly serrated margins. The Okeechobee gourd is usually found in pond apple hammocks, heavily tangled woods, and willow and elderberry (*Sambucus canadensis*) thickets. The seeds of this gourd germinate on bare, exposed muck and especially on alligator nests where the soil has been disturbed.

Fluctuating lake levels are necessary for the continued survival and recovery of the gourd within and around Lake Okeechobee. High lake levels facilitate seed dispersal and inhibit proliferation of aggressive weeds and exotic plants in local habitats. As lake levels decrease, the cleared open habitats allow gourds to germinate and quickly climb onto adjacent trees. Prolonged high or low lake stages are detrimental to the gourd as well, affecting seed germination, plant survival, and encroachment by woody vegetation, eg. Melaleuca.

2.7.3 State Listed Species

Additional state listed species present within the effected area as reported by the FWC in correspondence dated March 19, 1999, and which may be affected by regulation schedule alternatives are presented in Table 2.7.1-1.

Table 2.7.1-1
Listed Species Present in the Study Area and Which May be Affected by Lake Regulation Schedule Alternatives

Scientific Name	Common Name	USFWS	FWC
Trichechus manatus	West Indian manatee	E	E
Rostrhamus sociabilis plumbeus	snail kite	E	E
Mycteria americana	wood stork	E	E
Haliaeetus leucocephalus	bald eagle	T	T
Ammodramus maritimus mirabilis	Cape Sable seaside sparrow	E	E
Drymarchon corais couperi	Eastern indigo snake	T	T
Alligator mississippiensis	American alligator		SSC
Ajaja ajaja	roseate spoonbill		SSC
Aramus guarauna	Limpkin		SSC
Egretta caerulea	little blue heron		SSC
Egretta rufescens	reddish egret		SSC
Egretta thula	snowy egret		SSC
Egretta tricolor	tri-colored heron		SSC
Eudocimus albus	white ibis		SSC
Grus canadensis pratensis	Florida sandhill crane		T
Pelecanus occidentalis	brown pelican		SSC
Rhynchops niger	black skimmer		SSC
Centropomus undecimalis	common snook		SSC
Cucurbita okeechobeensis	Okeechobee gourd	E	

E Endangered
T Threatened
SSC State Listed Species of Special Concern

2.8 Water Management & Water Supply

2.8.1 Water Management

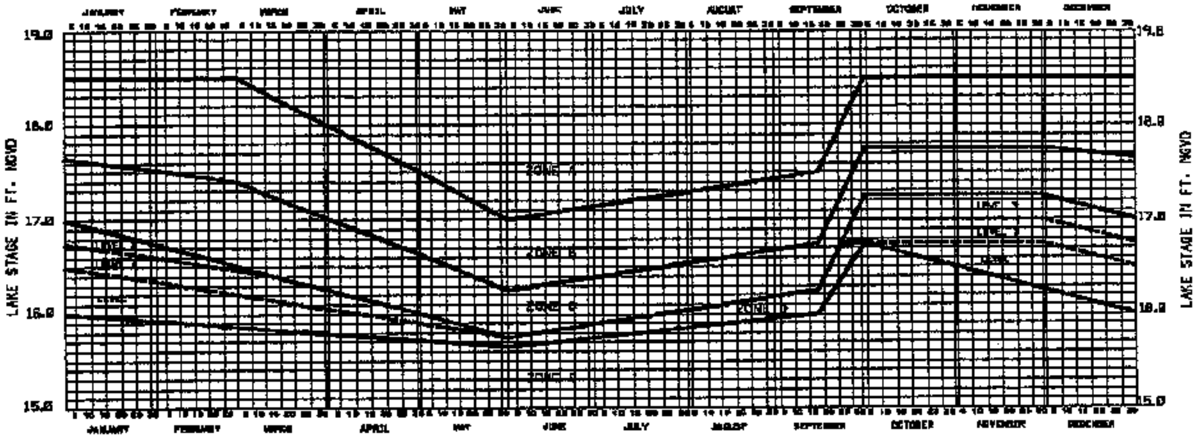
Lake Okeechobee is regulated to provide flood control; water supply for agricultural irrigation, municipalities and industry, and Everglades National Park; regional groundwater control and salinity control; enhancement of fish and wildlife; navigation and recreation.

Lake water levels in Lake Okeechobee are regulated by a complex system of pumps, spillways and locks. The regulation schedule attempts to achieve the multiple-use purposes mentioned above as well as provide seasonal lake level fluctuations. The schedule lowers the lake stage prior to the wet season to provide both storage capacity and flood protection for the surrounding areas during the wet season. After the peak of the hurricane season, lake levels are allowed to increase to store water for the upcoming dry season. The general plan of operation for Lake Okeechobee is based on the following: (1) flood protection from lake waters and hurricane-driven wind tides for lands adjacent to the lake; (2) maintenance of an 8-foot navigation channel across Lake Okeechobee, as part of the Okeechobee Waterway; and (3) storage of water to meet the requirements of the agricultural area south and east of the lake.

Flood control works on Lake Okeechobee consist of a system of about 1,000 miles of encircling levees designed to withstand a severe combination of flood stage and hurricane occurrence, plus the regulatory outlets of St. Lucie Canal and the Caloosahatchee River. The design discharge of Moore Haven Spillway is 9,300 cfs; that of St. Lucie Spillway is about 16,000 cfs. Following removal of local runoff from the agricultural areas south of the lake, an additional regulatory capability of several thousand cfs is available through the Miami, North New River, Hillsboro, and West Palm Beach Canals by pumping into the three Water Conservation Areas. The crest elevation of the levee system surrounding the lake ranges from 32 to 45 feet, NGVD. The likelihood of overtopping the levees from excess storage is almost non-existent. Possible flooding due to overtopping of levees within the Herbert Hoover Dike system is limited to short duration events involving wave runup in addition to hurricane-induced storm surge. The likelihood of such events is remote and the expected extent of flooding is minimal.

Trimble and Marban (1988) performed an analysis of the Lake Okeechobee regulation schedule which incorporated a trade off analysis framework and resulted in the recommendation of an improved schedule now in use (Figure 2.8-1). This recommended schedule reduced the frequency and distribution of regulatory discharges to the St. Lucie and Caloosahatchee estuaries to lessen the undesirable impacts to the natural ecosystems within these estuaries. This was accomplished without significantly impacting existing flood control, water supply and environmental benefits provided by the previous (15.5 – 17.5 feet) schedule approved in 1978. This schedule was approved by the District's Governing Board in December 1991 and approved on a two year interim basis by the USACE in May of 1992. This schedule was approved by the District's Governing Board in December 1991 and approved on a two year interim basis by the USACE in May of 1992. Regulatory releases are to occur at lower lake stage and at lower and more environmentally sensitive rates of discharge than the previous schedule. In Zone D discharges to the St. Lucie and Caloosahatchee Basins are made in a "pulse" fashion, which attempts to simulate a natural rainstorm event within the basins. The series of three pulse discharge levels was developed to control rising lake stages by starting off slow, meaning with the lowest rate of discharge required. If the lower rate of pulse did not bring the lake down to the desired level, then the subsequent releases would be at the next higher release rate, Each pulse takes 10 days to complete. This method was designed to allow estuarine biota to tolerate changes in salinity and to allow the discharges to remain within the natural range of freshwater flow to the estuary.

Run 25 Regulation Schedule



RELEASE THROUGH OUTLETS AS INDICATED

ZONE	AGRICULTURAL CANALS (2)	CALOOSAHATCHEE RIVER (2)	ST. LUCIE CANAL
A	PUMP MAXIMUM PRACTICABLE TO WCA'S	UP TO MAXIMUM CAPACITY AT S-77	UP TO MAXIMUM CAPACITY AT S-80
B (1)	MAXIMUM PRACTICABLE TO WCA'S	6500 CFS AT S-77	3500 CFS AT S-80 (3)
C (1)	MAXIMUM PRACTICABLE TO WCA'S	UP TO 4500 CFS AT S-77	UP TO 2500 CFS AT S-80 (3)
D	MAXIMUM PRACTICABLE TO WCA'S	MAXIMUM NON-HARMFUL DISCHARGES TO ESTUARY WHEN STAGE RISING	MAXIMUM NON-HARMFUL DISCHARGES TO ESTUARY WHEN STAGE RISING (3)
E	NO REGULATORY DISCHARGE	NO REGULATORY DISCHARGE	NO REGULATORY DISCHARGE

NOTES: (1) RELEASES THROUGH VARIOUS OUTLETS MAY BE MODIFIED TO MINIMIZE DAMAGES OR OBTAIN ADDITIONAL BENEFITS.
(2) SUBJECT TO FIRST REMOVAL OF LOCAL RUNOFF.
(3) EXCEPT WHEN EXCEEDED BY LOCAL INFLOW.

CENTRAL AND SOUTHERN FLORIDA
INTERIM REGULATION SCHEDULE
LAKE OKEECHOBEE
DEPARTMENT OF THE ARMY, JACKSONVILLE DISTRICT
CORPS OF ENGINEERS, JACKSONVILLE, FLORIDA
DATED: 27 DEC 1994

RUN 25

2.8.2 Water Supply

As one of its planned purposes, Lake Okeechobee supplies water for agricultural irrigation, municipalities, industry, and Everglades National Park, and for regional groundwater control and for salinity control.

A primary use of Lake Okeechobee is to provide water supply for adjacent urban and agricultural lands and a backup water supply for the lower east and west coast Florida counties. Currently, C-43 provides an important source of potable water for Lee County and the city of Ft. Myers and is also used as a source of water for irrigation by agriculture. The Caloosahatchee River is also considered a water user. During the dry months of April and May, the Caloosahatchee River flow may drop to near zero. When this happens, navigation lockages can allow a salt water wedge to move upstream. A short term high rate of discharge from Lake Okeechobee is then made to protect the potable water intakes for Ft. Myers and Lee County upstream of S-79. Short term high rates of discharge from Lake Okeechobee to the Caloosahatchee River are also required to break up severe algae blooms that develop during the dry months from December to April when the flow diminishes.

One of the primary functions of the C&SF Project is to provide a highly-efficient flood control system designed to keep urban and agricultural areas dry in the wet season by discharging excess water to tide or into the Water Conservation Areas and Everglades National Park. Rapid wet season flood releases, coupled with the lack of retention in Lake Okeechobee, the northern historical sawgrass plains, and the eastern peripheral wetlands and sloughs, have severely reduced storage within the system, causing excessive dry season demands on the regional system. The sawgrass plains, for example, once stored and slowly passed on much of the water that overflowed from Lake Okeechobee. Today, a large portion of the sawgrass plains habitat that was converted to agriculture within the Everglades Agricultural Area, quickly passes excess runoff to the Water Conservation Areas and the coast during the wet season. Releases of Lake Okeechobee water are then necessary to meet dry season demands. The lack of storage, not the lack of water, is a problem.

During years of normal rainfall, the 15.65 to 16.75 feet, NGVD, regulation schedule allows for an ample supply of water to be stored in Lake Okeechobee during wet season for use during the dry season. The fact that a similar regulation schedule was in effect during the 1980 – 1982 drought helped avoid large economic losses to agriculture during that period. However, south Florida's rapid growth produces ever-increasing water demands on the system each year.

During dry periods, increased water use and large dry season water losses due to evapotranspiration require an operational water allocation plan for Lake Okeechobee, especially when regional water supplies become low and may not meet anticipated service area demands. The SFWMD has developed a water supply management plan that requires various actions to be taken according to the severity of the conditions exhibited in the lake regulation schedule. The basis of this plan is an allocation scheme which parcels out lake water based on estimated water use for the remainder of the dry season. A target water level in Lake Okeechobee is established for the beginning of the wet season (June 1st) and allotments are computed such that lake water levels will not fall below the critical target stage, assuming average climatic conditions. Operational flexibility is built into the plan in order to make available the special actions that proved successful during the 1981 – 1982 drought.

2.9 Water Quality

Baseline water quality information is organized into existing water quality for the lake itself, followed by downstream areas including those canals and primary and secondary tributaries which convey lake waters to receiving water bodies. As before, receiving waters are considered the St. Lucie and Caloosahatchee River estuaries, including Indian River Lagoon and Charlotte Harbor, the EAA and the northern WCAs. For additional detailed information on water quality reference ***Appendix B.***

2.9.1 In-Lake Water Quality

Lake Okeechobee may be considered a naturally eutrophic water body that is tending to become hypereutrophic, due primarily from nutrient inputs from the Kissimmee River and the Taylor Creek basins. Water quality conditions in the upper Kissimmee River appear to be improving, primarily due to re-routing of wastewater flows from the river to reuse and ground-water discharge sites. However, large quantities of nutrients are still discharged from Lake Toho to Lake Kissimmee and other downstream areas. Water quality improves from Lake Kissimmee to near Lake Okeechobee, where the channel flows mostly through unimproved rangeland; however, pollutant loadings increase as cattle and dairies grow more numerous near the lake. Because the lake's phosphorus is internally recycled and a vast reservoir of the nutrient is stored in the lake sediments as well as wetland and canal sediments, phosphorus within the lake may not reach acceptable levels for many decades or even a century.

According to the 1996 305(b) report (FDEP, 1996) for Lake Okeechobee, the major pollution sources for the lake include runoff from ranch and dairy operations in the north where pollution has elevated phosphorus and coliform bacteria concentrations and created a large algal bloom. In the south, historic backpumping of runoff from row crops and sugar cane has elevated nutrient and pesticide levels. The backpumping has mostly ceased but still occurs when water in the primary canal of the EAA reaches 13 feet (flood-control levels). As a result, depending on location and seasonal rainfall or drought, the lake receives varying amounts of nutrients, substances creating high biological oxygen demand (BOD), bacteria, and toxic materials. A potentially very significant source of phosphorus loading to the lake is from atmospheric deposition. It could be on the order of 70 tons/year. Atmospheric loading is very difficult to quantify and efforts are underway to improve our understanding of this significant source of nutrient loading. Other potential problem sources that currently lack sufficient data to properly judge their impacts are sludge/waste disposal and stormwater runoff.

Biological sampling indicated variable but generally eutrophic conditions. In recent years, several widespread algal blooms (one covering about 100 square miles) and at least one major fish kill -- all of which were widely publicized -- launched the environmental community and governmental agencies into intense investigation and analysis of the lake's problems. The Lake Okeechobee Technical Advisory Committee, formed to assess the situation and recommend solutions, determined that phosphorus from dairies and agriculture was a major cause of the noxious algal blooms and that levels should be reduced by 40 percent. A few others contended that the secondary cause of increased phosphorus is the flooding of hundreds of acres of perimeter wetlands after the SFWMD decided in the late 1970's to raise the lake's water level. The higher level also reduced valuable fish-spawning grounds and waterfowl feeding and nesting habitat.

In general, the water quality trends for the lake are stable at six sites, improved at two sites, and degraded at two sites. The best water quality observations were noted for the flow entering Fisheating Creek and along the west near wetlands, while the worst water quality conditions occurred in the south by agricultural areas, and to the northeast by Taylor Creek, Nubbin Slough and the St. Lucie Canal. The reported major pollution sources in this basin were dairies and agriculture. According to a generalized assessment, the lake has fair water quality conditions, except for Myrtle Slough and the southwest region of the lake in the near shore area which were shown to have poor water quality (Havens and James, 1999, Decreased transparency due to mud sediment resuspension in the near-shore region of the Lake Okeechobee, Lake and Reservoir Management). The extreme south-southwest section of the lake has good water quality conditions which are described by the 305(b) report (FDEP, 1996).

2.9.2 Downstream Water Quality

Water quality conditions are degraded in the upper and lower areas of the Caloosahatchee River basin, due to agricultural and urban runoff, respectively. The channelized section of the river also shows degraded water quality conditions, due to agricultural inputs, as compared to tributaries lying in less developed areas of the basin. Problems associated with the degraded areas of the basin are typified by low dissolved oxygen levels, elevated conductivity, and decreased biodiversity. Conditions in the urbanized sections of the basin are influenced by non-point storm water flows, and are manifested in the river by elevated chlorophyll levels, algal blooms, periodic fish kills, and low dissolved oxygen levels. Although wastewater discharges remain a problem, the estuary is presently more seriously affected by high-nutrient waters from the river and tributaries, and storm water runoff from cities. Nutrient and chlorophyll levels are high, and small algal blooms occur regularly. The Orange River, a tributary entering the Caloosahatchee below the locks, is a favored wintering place for manatees because a nearby power plant discharges warm water. A fish kill and clam die-off occurred in 1990 because of high-temperature water discharges and low dissolved oxygen levels.

In general, good water quality conditions exist in the central portions of the basin. The best water quality indices are reported for Orange Creek. Water quality indices decline to fair in the easternmost area of the basin; specifically in the areas north and west of Lake Hicpochee; in the westernmost area of the basin, specifically around Trout Creek; and in the tidal areas of the Caloosahatchee River. Poor water quality indices were shown for the areas south and southeast of Lake Hicpochee, for the Daughtrey Creek sub-basin. Billy Creek, in the western portion of the basin, is reported as having the worst water quality in the basin. Overall, the monitoring stations were stable at three sites, and worse at one site. Major pollution sources were reported to be hydrologic modifications, agriculture, and urban areas, specifically Fort Myers.

The 1996 305(b) report (FDEP, 1996) for the EAA states that the L-8, West Palm Beach, Hillsboro, North New River, and Miami canals from Lake Okeechobee to the L4-L7 canals; which roughly define the EAA; have poor water quality with extremely high nutrient and low dissolved oxygen levels. Other problems include pesticides, BOD, bacteria, and suspended solids. Agricultural runoff and overflow or seepage from sugar mill retention ponds also contribute pollutants. Canals bordering the WCAs generally have very low dissolved oxygen levels typical of marsh waters. Nutrient levels at the marsh perimeter are elevated, probably from the breakdown of organic debris as well as agricultural drainage.

Agricultural BMPs have been implemented in the EAA however, this area remains a primary source of pollutants for the WCAs. The WCAs form the remnant wetland communities for the northern section of the Everglades system. These areas have been isolated from contiguous lands by a series of levees and pump stations. Water moving south from the lake and EAA is pumped through the WCAs, thereby making these areas nutrient filters for downstream basins. The highly altered hydroperiod, resulting from the levees and pump schedules, may exacerbate water quality conditions in the WCAs, as evidence by a general degradation of quality in the areas along the canals and pump stations, as compared to conditions in the central portions of the basins. The 1996 305(b) report (FDEP, 1996) generalizes the water quality conditions in the WCAs as ranging from poor to good. The conditions for WCA-1 are rated as fair throughout the basin, with the exception of the northern area, which is shown to have poor water quality.

The 1996 305(b) report classifies water quality conditions as good in the northernmost areas of WCA-2 transitioning to a fair condition throughout most of the remainder of the basin. Poor water quality conditions are shown to exist along the L-38E canal. Water quality in WCA-3A are rated as fair north of the county line, and are rated as good on the south side of the line. The ten-year trend does not show significant changes have occurred in the basin.

Water quality conditions along the St. Lucie River are rated as good in less developed areas of the basin. However, conditions are degraded in urbanized areas and along the extensive network of canals that drain this area. The worst water quality conditions in the Martin and St. Lucie County area are reported in the St. Lucie River and the canals leading from the EAA. Other major problem areas are found in Five Mile and Ten Mile creeks (in the areas near Port St. Lucie), the main channel of North Fork in Port St. Lucie, and Manatee Pocket, a small port on the St. Lucie Estuary. Although the Savannas State Preserve, a 15 mile long freshwater marsh between Ft. Pierce and Stuart, has fairly good water quality, mercury concentrations in fish tissue were high enough to warrant a no consumption advisory for Largemouth bass. As described above, the major sources of pollution in this basin are urban runoff, agriculture, rangeland runoff, boat discharge, and sewage overflows. Water quality in the south section of the Indian River Lagoon was rated as fair by a National Estuary Program technical report (Woodward-Clyde Consultants, 1994). The best water quality conditions were identified in the areas south of Ft. Pierce; the worst in Belcher Canal. The main water quality issues in this segment of the basin were urban runoff, sewage discharge, freshwater discharge, rangeland runoff, and citrus runoff.

2.10 Socio-Economics

The following discussion of socio-economic existing conditions focuses on the principal social and economic forces of the Lake Okeechobee region. They include:

commercial navigation via the Okeechobee Waterway, agriculture in the area immediately surrounding the lake, urban municipalities, recreation and sport fishing, and commercial fishing. More detailed information on the socio-economic conditions within the study area are presented in ***Appendix D***.

2.10.1 Commercial Navigation

The Lake Okeechobee Waterway connects Stuart on the Atlantic Ocean with Ft. Meyers on the Gulf of Mexico. It includes 154 miles of navigation channel and five lock and dam structures. The Port Mayaca and Moore Haven locks connect the lake to the St. Lucie canal and Caloosahatchee River respectively. Commercial navigation on this waterway has been stable over the past 10 years, with substantial year to year variation (USACE 1998). The Lake Okeechobee Waterway was used to transport 430,000 tons of freight in 1995. Petroleum products were the predominant commodities transported (USACE 1998). There are no commercial shipping lines that regularly pass through the waterway, rather traffic consists primarily of special barge traffic which takes advantage of the shortcut across the Florida peninsula, saving about 3-5 days of travel.

2.10.2 Agriculture

The immediate area surrounding Lake Okeechobee is largely rural, with agriculture being critical to the local and regional economy. There are estimated to be over 700,000 irrigated acres of farm land in the lake Okeechobee Service Area (LOSA), which includes the Everglades Agriculture Area. The EAA alone, accounted for over $750 million in agricultural production, and provided employment for over 20,000 full time workers in 1989 (Snyder and Davidson, 1994). Agricultural production consists predominantly of sugarcane, as well as rice, row crops, and sod. There is also extensive improved and unimproved pastureland, particularly west and north of the lake. The St. Lucie and Caloosahatchee basins, which also receive irrigation water from the lake, also cultivate an estimated 138,000 and 49,000 acres, respectively of citrus crops, sugarcane, vegetables, sod, and ornamentals (USACE 1998). During prolonged droughts, significant volumes of water are also required by the agricultural community in the Lower East Coast. Row crops such as truck vegetables, are the predominant crop type in the Lower East Coast.

2.10.3 Urban

The urban landscape surrounding Lake Okeechobee includes the incorporated municipalities of Belle Glade, Clewiston, Moore Haven, Okeechobee City, Pahokee, and South Bay. These communities range in population from approximately 1,439 (Moore Haven) to 16,656 (Belle Glade). Residential and commercial water users depend on lake water supply for wellfield recharge, drinking water, and industrial processes.

In addition to the area immediately surrounding the lake, the populations of the Caloosahatchee and St. Lucie Basins, and of the Lower East Coast, can be affected by Lake Okeechobee operations. Martin and St. Lucie Counties had a population of just over a quarter of a million in 1990. The 1990 population of the Caloosahatchee Basin counties of Lee, Glades, and Charlotte was just over 450,000. The LEC counties of Palm Beach, Broward and Miami-Dade had a 1990 population of just over 4 million. The combined population of these areas, along with the rural areas adjacent to the lake, accounts for just under 40% of the State's population. The economy of South Florida is based on services, agriculture, and tourism. The LEC counties' economies are strongly oriented to the services industry, while the counties surrounding the lake are heavily agricultural.

2.10.4 Recreation and Sport Fishing

Lake Okeechobee is the largest recreational resource in the region. The lake provides a wide variety of water based recreation including fishing, boating, picnicking, sightseeing, camping, swimming, hunting, airboating, and hiking. The littoral zone, along the lake's western shore, provides valuable habitat for the lake's popular sport fishery. Lake Okeechobee is recognized as supporting one of the best recreational fisheries in the nation. A variety and abundance of sport fish, including largemouth bass, black crappie, bluegill, and redear sunfish are targeted by sportfishermen from around the country. Consequently, sport fishing is a major activity on the lake. There are also several major sportfishing tournaments held on Lake Okeechobee annually, which bring significant revenues to the marinas, fishing guides, hotels, and support industries along the lake. It should be noted that the lake supports several commercial finfishing endeavors, including fisheries for bullhead catfish, gizzard shad, striped *mullet (Mugil cephalus*), and gar (*Lepisosteus* spp.).

Heavy seasonal waterfowl utilization of the lake attracts tourists and recreational enthusiasts, such as hunters. Common waterfowl species include ring-necked duck (*Aythya collaris*), American wigeon (*Anas americana*), Northern pintail (*Anas acuta*), green-winged teal (*Anas crecca*), blue-winged teal (*Anas discors*), lesser scaup (*Aythya affinis*), and Florida duck (*Anas fulvigula*).

The lake has also been a historic tourist destination for purely aesthetic reasons. Airboat rides are popular tourist activities on the lake. In 1996 recreation levels at Lake Okeechobee were estimated at over 64,000 visitor-hours, with an annual value of over $78,000,000 (USACE 1998).

2.10.5 Commercial Fishing

The commercial fishing industry in Lake Okeechobee utilizes primarily haul seines to catch bluegill, redear sunfish, and catfish. Catfish are also caught by trot lines, and wire traps. Bullhead, shad, gar, mullet, and tilapia are also caught, although since the net ban, mullet are no longer considered a commercial species. There are also reports of commercial turtle trapping on the lake, mostly in the canals (FWC pers. comm.). The annual wholesale value of the commercial fishery was estimated in 1998 (USACE) to be approximately $2,326,932, employing about 210 fisherman and landside workers.

There are also commercial fisheries on the lake, which harvest the American alligator and the Florida soft-shell turtle (Diemer and Moler, 1995). Alligators are harvested from the lake population to supplement the stock in alligator farming operations. Soft-shell turtles are harvested by commercial fishermen, with some individual yields in excess of 13,640 kilograms (30,000 pounds) annually. The majority of the harvest is prepared for shipment to Japan, or sold locally, primarily to the Miccosukee tribe.

2.11 Land Use

The following section will address the general land use within the general area of the lake. The area is rural in character, with most lands dedicated to agriculture, generally speaking sugar cane is the predominant crop in the south, row crops and sugar cane in the east and pastureland with dairy production in the north. Urban areas, which are generally few and modest in population, service the agriculture sector, as well as the tourists who come to the lake to fish, hunt, and enjoy other recreational pursuits.

2.11.1 Agriculture

There is an abundance of agricultural lands surrounding Lake Okeechobee and throughout the affected area. The section below discusses the existing agricultural conditions by physiographic region, beginning with the largest area, the EAA, immediately south and east of the lake.

2.11.1.1 Everglades Agricultural Area

More than 600,000 acres are farmed in Palm Beach County (UFBEBR, 1995), and sugarcane was harvested from about half of that acreage in 1996 (FASS, 1996d). Much of this acreage is likely categorized as unique farmland based upon its location, growing season, and high value crops, including sugarcane and vegetables. Sugarcane receipts accounted for 68 percent of total field crop sales in Florida in 1996 (FASS, 1996c). The EAA is known for its sugarcane production and sugar processing, but Palm Beach County also ranks 15th among Florida counties for acres of citrus (FASS, 1996b). This region is characterized by mid-size farms averaging 690 acres each with high productivity of more than $1300 per acre (UFBEBR, 1995). More than 18,000 people are employed in agricultural production and services representing a payroll of more than $26 million (UFBEBR, 1995). Total market value of agricultural products in Palm Beach County is almost $900 million, ranking it first among counties in the state of Florida (UFBEBR, 1995) and third among U.S. counties (FDACS, 1994).

The EAA is highly dependent upon the system of canals running through the region to provide necessary drainage of excess water during the wet season as well as supplemental water supplies for irrigation during the dry season. Approximately two thirds of the land farmed in the EAA is irrigated, totaling more than 400,000 acres (UFBEBR, 1995). The EAA has traditionally relied upon Lake Okeechobee for its water supply during drier periods, and looked to the WCAs to the south to receive their excess drainage.

Continued agricultural production in the EAA has become increasingly controversial. Some of the factors that may affect EAA agriculture include water quality concerns, soil subsidence, and urban encroachment. The water quality concerns, particularly phosphorus loading, are being addressed through best management practices, storm water treatment areas, and growing use of organic farming practices and rice cultivation in rotation with sugarcane production. Although sugarcane cultivation in the EAA has come under some sharp criticism in recent years, sugarcane is recognized as the most appropriate crop for this region. Sugarcane requires less phosphorus fertilizer than other crops grown in the EAA (Sanchez, 1990), and sugarcane has been found to remove 1.79 times more phosphorus than was applied as fertilizer (Coale et al., 1993). Florida sugarcane only requires small amounts of pesticides due to disease resistant and tolerant cultivars, and cultivation instead of herbicides for weed control. Sugarcane also tolerates greater variability in water table levels, allowing for more flexible water management strategies (Glaz, 1995).

Soil subsidence has become a potential threat to long-term crop production in the EAA. The average historic rate of subsidence of 1 inch per year has slowed to 0.56 inches per year since 1978 (Shih et al., 1997). They attributed the lower rate to several factors including higher water tables and an increased proportion of land planted to sugarcane. Surveys conducted by Shih et al. (1997) found an average of 1.62 feet to 4.36 feet of soil remaining over 11 transects. Prevention of continued soil subsidence will depend on maintaining high ground water levels to prevent further oxidation of the soil profile. This, in turn, will require development of more water-tolerant sugarcane varieties and/or increased rice cultivation. This research is currently underway and showing promising results (Glaz, 1997). A strong agricultural economy in the EAA based on profitable crop production is the best defense against conversion of agricultural land to urban land.

2.11.1.2 Kissimmee River Basin

Immediately north of the lake, Osceola, Polk, Highlands, and Okeechobee Counties surround the Kissimmee River Basin. More than two million acres in these counties are farmed, with more than half of this area devoted to pastureland (UFBEBR, 1995). Much of this acreage is likely categorized as unique farmland based upon its location, growing season, and high value crops, including citrus. Almost a quarter of a million acres in the Kissimmee River Basin are irrigated (UFBEBR, 1995), requiring a dependable water supply. This region is characterized by large farms with relatively low productivity per acre. These four counties are among the top five counties in Florida for cattle production, both beef and dairy (FASS, 1996a). More than 200,000 acres are used for citrus production. Approximately 11,000 people are employed in agricultural production and services representing a payroll of approximately $21 million. The market value of all agricultural products in this region totals approximately $575 million (UFBEBR, 1995).

2.11.1.3 Martin and St. Lucie Counties (Upper East Coast)

At present, The dominant land use in the basin is agriculture (covering approximately 45 percent of the basin). Agricultural activities include 228,000 acres of citrus, 211,000 acres in range and citrus, and 9,500 acres of vegetable crops (SCS, 1994). The present urban land use (17 percent of the basin) is concentrated along the coast and the lagoon shorelines. Urban growth is rapidly extending westward, replacing agricultural land. Future land use patterns indicate that this trend will continue as urbanization intensifies along the coast, especially in the southern counties (Swain and Bolohassen, 1987). Present forested uplands and wetlands comprise 11 and 18.8 percent of the basin, respectively.

2.11.1.4 Caloosahatchee River Basin

Almost one half million acres are farmed in the Caloosahatchee River Basin, and approximately three-fourths of that area is pastureland. The region is characterized by large farms averaging 1800 acres, with relatively low productivity per acre (UFBEBR, 1995). Glades County ranks eighth in the state of Florida for cattle production (FASS, 1996a). Citrus production in the Caloosahatchee River Basin covers more than 20,000 acres (FASS, 1996b) and is currently increasing. Much of this acreage is likely categorized as unique farmland based upon its location, growing season, and high value citrus crops.

Almost 5,000 people are employed in agricultural production and services, and the payroll totals approximately $5 million. Agricultural products in this region have a total market value of more than $135 million (UFBEBR, 1995).

More than 77,000 acres of farmland are irrigated in the Caloosahatchee River Basin (UFBEBR, 1995). Reliable water supply is a big concern in this region which has traditionally relied upon water deliveries through the Caloosahatchee River from Lake Okeechobee. Irrigation demands can be expected to increase as additional land is used for citrus production.

2.11.2 Urban Land Use

A significant use of land outside the agricultural context is for urban development. Six incorporated communities are situated around the lake and range in population from approximately 1,400 to 16,000 (Table 2.11.2-1).

Table 2.11.2-1 1996 Population Estimates For Communities Surrounding Lake Okeechobee (USBC, 1997)		
Community	Population	County
Belle Glade	16,656	Palm Beach
Clewiston	6,645	Hendry
Moore Haven	1,439	Glades
Okeechobee City	4,831	Okeechobee
Pahokee	6,993	Palm Beach

The Brighton Seminole Indian Reservation occupies a large area of land west of the lake in Glades County. The southern end of this reservation is near the HHD just north of Lakeport.

Major transportation corridors around the perimeter of Lake Okeechobee include several highways and railroads. County Road 78 parallels the lake along its western and northern shores from Moore Haven to Okeechobee. From Okeechobee, State Highway 98/441 follows the northern and eastern portion of the lake to Pahokee. County Road 715 then follows the HHD from Pahokee to Belle Glade, where State Highway 27 follows the southern lake area back to Moore Haven and County Road 78.

The municipalities of Stuart at the mouth of the St. Lucie Estuary, Fort Pierce, to the north of Stuart, and Jupiter to the south, are the three principal urban centers nearest the outlet of the C-44 within Martin and St. Lucie Counties.

On the west side of the lake, along the Caloosahatchee River and on Charlotte Harbor, urban areas include the cities of LaBelle, Alva, Olga, Fort Myers, and Cape Coral. Land use adjacent to the Caloosahatchee River Estuary is largely residential and urban with the city of Cape Coral on its northern bank and the highly urbanized city of Fort Myers on its south bank. Both of these communities have experienced rapid growth with even more growth anticipated in the near future (SFWMD, 1997).

2.12 Recreation Resources

Recreation resources in the Lake Okeechobee region are primarily water based within Lake Okeechobee and include boating, fishing, and nature interpretation. Lake Okeechobee provides approximately 40 miles of navigable waterway for commercial navigation and many more for recreational boating. Twenty-five USACE built land and water-based recreational facilities are located along the lake. The Florida National Scenic Trail encompasses Lake Okeechobee atop the HHD (approximately 140 miles long). Approximately 94 percent of the recreation lands available to the public in this region are owned by the state or Federal government (SCORP, 1994). Bike riding, hiking, picnicking, camping, and nature interpretation are popular land based recreation activities in the region. Substantially altered water deliveries to this region could result in flooding and have a detrimental affect on many natural and recreation resources in the area. The ample water based recreation resources in the Lake Okeechobee region receive extensive use and future demand is anticipated to increase.

The St. Lucie Canal provides approximately 34 miles of navigable waterway with four USACE/County recreation facilities that include boating, fishing, camping and day-use facilities (USACE, 1991). The approximately 44 miles of Intracoastal Waterway, within the Upper East Coast, provides many coastal recreational navigation opportunities.

Public beaches in the Upper East Coast are the most popular forms of recreation in the region. Four State of Florida Aquatic Preserves, and four State Parks and Recreation Areas are within the Upper East Coast. Five artificial coastal reefs provide popular diving and fishing spots. The region also includes high quality recreation opportunities within the Dupuis Reserve State Forest and Wildlife and Environmental Area and the St. Lucie Inlet Preserve. Overall, existing recreation resources in the region receive heavy annual usage that is expected to increase in the future.

Recreation resources in the WCA region are inland water and upland resources that include the Arthur R. Marshall Loxahatchee National Wildlife Refuge, and Rotenberger and Holey Land WMAs (SCORP, 1994). These areas provide high quality boating, fishing, and nature interpretation activities. The Miccosukee State Indian Reservation is within the WCA region boundary. Hunting, boating, and fishing occur within the Everglades WMA, including the Miccosukee State Indian Reservation.

The Caloosahatchee River provides approximately 67 miles of navigable waterway with ten USACE recreation facilities that include boating, fishing, picnicking, and camping. The J.N. "Ding" Darling National Wildlife Refuge, a popular birding area, administers Caloosahatchee, Matlacha Pass, Island Bay National Wilderness area and Pine Island National Wildlife Refuge, all located near the region's western edge. Boca Grande Pass is world renowned for record tarpon, and Sanibel and Captiva Islands are reported among the top shelling destinations in the Western Hemisphere.

Caloosahatchee State Park and Recreation Area is located near Alva on the Caloosahatchee River. Estero River and Hickory Creek State Canoe Trails are within the region and provide excellent recreation resources. Cayo Costa State Park, Sanibel Island State Park, and State Aquatic Preserves are located in the region.

2.13 Aesthetics

This section attempts to describe the visual aesthetics of the study area, or how it is perceived by a variety of people including casual observers, resource users, tourists, and the local communities. The focus is firstly on the lake itself and immediate area around the lake, and secondarily on the downstream water bodies where aesthetics would be expected to be less affected.

2.13.1 Lake Okeechobee Basin

The Lake Okeechobee region is characterized by two types of scenery: open lake views, characterized by a vast expanse of water with a vanishing horizon, and littoral zone viewsheds, characterized by various types of marshes, serving as a backdrop for wildlife. Hardwood swamps are found landward of the HHD, primarily on the west side of the lake. Significant exotic and invasive vegetation species (melaleuca, Australian pine, torpedograss, cattail) are intruding into stands of native species that tends to diminish biological diversity and existing aesthetics in those areas. In the Indian Prairie region of the lake, expansion of torpedograss and cattail particularly have affected aesthetic qualities of the lake.

Some remnants of the historical willow swamp vegetation still can be found (Lodge, 1994). The HHD sideslopes are generally well grassed but contain some exotic and or dead vegetation that degrades the distant uniform appearance. However, the dike affords a panoramic view of the lake from its crest, which can be magnificent during a sunset or sunrise. Shoreline trees generally enhance the rim canal aesthetics when viewed from a distance.

Melaleuca control programs have left hundreds of acres of dead melaleuca forest standing, which effects the overall aesthetic north of the Old Moore Haven Canal. Substantially altered water levels could have a detrimental effect on many aspects of the region's viewable resources. Development is a nominal aesthetic impact to this region's aesthetics at the present.

2.13.2 Downstream Aesthetics

Along the St. Lucie Canal, much of the interior region is ditched for farming or range practices that have altered the natural vegetation and aesthetic resources of those areas. Many of the rural areas possess good scenic quality on a small scale. Orange groves, combined with scattered trees and forests provide a tranquil backdrop to this rural agricultural setting.

The visual landscape of the WCAs is overwhelmingly flat. Landscape features include typical canals, levees and prairie wetland communities. Access points to the interior of the areas are limited. Water Conservation Area 1 is operated as a wildlife refuge and offers opportunities for observation of migratory game birds during winter months. Although some of the marshlands have been degraded in visual quality by over-flooding and loss of tree islands, other areas, such as the south-central region of WCA 3A, still preserve good examples of original, undisturbed Everglades communities, with a mosaic of tree islands, wet prairies, sawgrasss expanses, and deeper sloughs. From the elevated viewpoint of the Eastern Perimeter Levee system, the view westward to the marshes is panoramic, though mostly homogenous.

Immediately south of the lake, in the EAA, the aesthetic overview is one of an extensively altered landscape that is nearly flat with most of the land in agricultural production. Few areas, if any, have retained any of the historical pond apple or sawgrass marsh plant communities that comprised their natural state. The region is extensively ditched for water supply and flood control to farm sugarcane and appears lush and green when the cane is ready for harvest. Minimal aesthetic resources exist in the EAA however some non-farmed pocket areas do possess better aesthetic quality.

The Caloosahatchee River Basin regional aesthetic overview is characterized by the Caloosahatchee River corridor, the Gulf of Mexico coastal plain, and surrounding uplands. The Caloosahatchee River is a linear body of water whose width allows observation of shoreline vegetation that includes texture, color, and wildlife varieties of interest and beauty. Minor urban impacts exist along the Caloosahatchee until the Fort Myers area where impacts increase noticeably. The coastal segments of the region possess a higher degree of aesthetic quality within the visual environment. State Parks, Wildlife Management Areas, and Wilderness Areas secure natural resources of prominent aesthetics. Much of the region's interior aesthetics are comprised of forested wetlands and irrigated pasturelands of moderate aesthetic quality. Many of the regional rural areas possess scenic quality on a small scale. Rural areas are largely pine forested with some oak, hickory and gum associations. Air traffic noise is an increasing adverse aesthetic impact. Development pressures are an increasing concern to natural and aesthetic resources.

2.14 Cultural Resources

The earliest widely accepted date of occupation of Florida dates from around 12,000 years ago. This earliest cultural period is termed the Paleo-Indian period and lasted until about 7500 B.C. Few Paleo-Indian archeological sites are recorded in Florida, and none are identified by the Florida Master Site Files (FMSF) near Lake Okeechobee or its downstream basins. The Archaic period, (ca. 7500 B.C. – ca. 500 B.C.), is thought to be a reflection of man's adaptation to the changing environment at the start of the Holocene, when our basically modern climate and biota were established. Archaic Indians exploited a wider range of resources than Paleo-Indians, probably utilized a more restricted territory, and may have led a more sedentary existence. Seasonally available food resources, including deer and small game, hardwood nuts, freshwater snails, and marine shellfish were used during the Archaic (Milanich 1994). The Archaic is further subdivided into the Early Archaic (7500B.C. to 5000 B.C.), Middle Archaic (5000 B.C. to 3000 B.C.) and Late Archaic (3000 B.C. to 500 B.C). Few Early or Middle Archaic period archeological sites are recorded in south Florida, and known sites are clustered along the northern Florida Atlantic and Gulf coasts and inland waterways (Milanich 1994). Foraging and hunting are the main subsistence activities throughout the archaic period, with Late Archaic people exploiting a larger territory and wider range of aquatic and terrestrial food resources (Milanich 1994). Archaic sites become more numerous during the Late Archaic period, when essentially modern climatic conditions had been established. Crude fiber-tempered pottery first appears in the Late Archaic. No Archaic period sites are located near Lake Okeechobee, as recorded in the FMSF. Late Archaic sites do cluster along the Gulf coast of southwest Florida from Charlotte Harbor south into the Ten Thousand Islands. Large Late Archaic period shell midden sites containing fiber-tempered pottery and shell tools are recorded in the mouth of the Caloosahatchee River basin.

Regional cultural diversity becomes apparent in the archeological record by 500 B.C. The clearest indication is that distinctive styles of pottery were made in different parts of the state (Piper Archaeology/Janus Research 1992). In the Okeechobee Basin, the Belle Glades culture sequence (ca. 500 B.C. – A.D. 1500) is subdivided into four periods. Ceramic technology progresses from fiber tempered to fiber and sand tempered to sand tempered ceramics, with St. Johns ceramic types also being used during the Belle Glades culture sequence. Black earth middens, low sand mounds and circular and linear earthworks are Belle Glade site types located near Lake Okeechobee, as recorded in the FMSF. The Caloosahatchee River Basin is considered a culture area separate from the Okeechobee and Glades regions, but the river, acting as a canoe highway, connected the regions and fermented close contact between the groups. There is a concurrence of ceramic technologies, and it is likely that cultural and political relationships between the Okeechobee and Caloosahatchee regions were close.

During the early historic period, beginning with the first Spanish colonial period (1513 – 1763), the Calusa inhabited southern Florida. Their population was decimated by European-introduced diseases, warfare, enslavement, and migration out of Florida (Archaeological Consultants Inc 1991). The Miccosukee and the Seminole migrated into Florida in the 18th and 19th centuries from Georgia and Alabama. Throughout the mid 1800's the U.S. relentlessly pursued a policy of Indian removal in Florida, and the Seminole, resisting removal, eventually establishing themselves in the Everglades, Big Cypress Swamp, and the Ten Thousand Islands. Several important battles of the Seminole Wars occurred around Lake Okeechobee including the largest and bloodiest battle of the Second Seminole War, the Battle of Okeechobee on Christmas Day in 1837 (Carr et. al. 1995). The Okeechobee Battlefield site is located at the north end of Lake Okeechobee and is a National Historic Landmark site. Other Seminole battle and habitation sites, predominantly on tree islands, are located near the lake and the downstream basins.

American settlement around Lake Okeechobee began in earnest in the late 19th century when efforts to drain and reclaim the Everglades began. Agriculture began in the Everglades, south of Lake Okeechobee after drainage projects of the 1906-1927 era (Milano 1995). During this period, the first settlements, Okeelanta and Glade Crest were established just south of the lake. By 1921, there were 16 settlements on or near Lake Okeechobee, with a total estimated population of 2,000. Settlement and agricultural activities escalated during the subsequent decades. The West Palm Beach Canal opened in 1917 and the town now known as Canal Point was established (Archaeological Consultants, Inc. 1991). In 1918 a school was built in Pahokee. By 1920 mercantile and commercial buildings were springing up along the lake. As early as 1917 sugar cane was being produced, and quickly became a flourishing industry in the region. The mid 1920's saw the south Florida real estate boom, which was crippled by the great hurricane of 1926. The 1928 hurricane devastated the recovery from the earlier storm with tremendous property damage and the loss of an estimated 1,800 to 2,000 lives

(Archaeological Consultants, Inc. 1991). South Florida benefited from the civic and administrative works of Franklin D. Roosevelt's New Deal programs in the 1930's, including the Canal Point School, a structure determined eligible for inclusion on the National Register of Historic Places. After the hurricanes, work was begun locally to build a series of dikes around Lake Okeechobee. In 1935 the Army Corps of Engineers assumed responsibility for the on-going construction. The dike was completed in 1937 and named after President Herbert Hoover. The Herbert Hoover Dike structure may be eligible for inclusion on the National Register of Historic Places for its historical significance.

2.15 Hazardous, Toxic and Radioactive Waste

The preliminary assessment indicated no evidence of hazardous, toxic or radioactive waste (HTRW) on the project lands. During land procurement and project construction further HTRW awareness should be practiced.

A large portion of the property considered for this project, is adjacent to agricultural land. Agricultural activities are exempt from Resource Conservation Recovery Act (RCRA) as section 40 CFR 261.4 (b)(2)(ii) provides an exclusion. Therefore, the handling, storage and reporting requirements established by RCRA are not applicable. Farm chemical storage and mixing sites are regulated by Federal Insecticide, Fungicide and Rodenticide ACT (FIFRA). The chemicals typically used by farmers are pesticides, fuels and herbicides. Spills or problems associated with farm spill sites are not documented or the HTRW database search conducted during this assessment did not reveal their existence.

3 FUTURE WITHOUT PROJECT CONDITION

This section discusses the assumptions used in forecasting a future scenario in terms of anticipated population growth/recession, water use by agriculture, urban areas and the environment, and future land use and socio-economic changes anticipated to occur in the affected environment. This information is then used in comparing the anticipated benefits and impacts expected to result from the proposed action, and alternative actions, compared to not implementing the recommended plan.

3.1 Planning Horizon

It was decided for the purposes of this study, not to use the typical fifty-year planning horizon because this regulation schedule change will be an interim operational change until such time as the more comprehensive Restudy is implemented. Since many major changes are anticipated to the entire C&SF Project, it would be unsound to base the selection of an interim schedule on a planning horizon with such an unpredictable physical (and operational) future scenario. The 2010 scenario assumed 2010 land use and associated water use demands as estimated by the SFWMD and used data from the Lower East Coast Regional Water Supply Plan. These demands and land use parameters were already available and had been incorporated into the selected hydraulic model. The 2010 scenario also assumed the following features, that are part of the overall C&SF Project, would be in place and operational:

a. Kissimmee River restoration
b. Everglades Construction Project
c. Modified Water Deliveries to Everglades National Park
d. The C-111 General Re-evaluation Report Project
e. A new interim regulation schedule for WCA 1

3.2 Future Without Project Assumptions

The future "Without Project" condition would involve continued operation of the current regulation schedule, known as Run 25, until such time as the C&SF Project Restudy effort is well under way and another regulation schedule (resulting from Restudy efforts) is implemented. Even with the above listed and expected structural improvements to the C&SF Project that will be in place before 2010, continued deterioration of both the lakes' littoral zone and the two estuaries will likely occur. Concomitant declines in water quality, valuable habitat for juvenile fisheries, and recreational benefits will also occur.

3.2.1 Population and Socio-Economic Conditions

Florida's population is anticipated to grow by just over 40% between 1990 and 2010. The LEC counties' projected growth during this period is anticipated to be about the same, with about 31% of the State's population in the LEC during the period bounded by this study's planning time horizon. The much smaller populations of the rural areas making up the EAA and the rest of the area surrounding the lake are anticipated to experience greater percentage growth during this period (50% to 60%), based on long term forecasts available from Florida's Bureau of Economic and Business Research. But with the smaller populations of these areas, their resulting share of the State's population would only grow from about 7.6% in 1990 to 8.6% in 2010. The general economic profile of the study area is not expected to change dramatically during these years, with the counties surrounding the lake tending to remain heavily agriculturally oriented and relatively sparsely populated, and the LEC tending to remain primarily a services-based economy and more heavily populated.

3.2.2 Water Quality

Modeling of the future without project condition, predicts minor negative impacts to the estuaries due to a predicted higher number of undesired high fresh water discharges to the estuaries which will cause more salinity imbalances. Furthermore, marsh hydroperiods may be somewhat adversely affected in the future, as they are predicted to receive less water. Slight positive benefits to marsh water quality may be accrued as a minor amount of undesired nutrients from the lake will be directed to the estuaries until STA 3/4 is on line in 2003. The relatively small amount of nutrients (proportionate to the total quantity) diverted to the estuaries from the marsh areas will have a slight negative impact on the estuaries. No measurable impact to the water quality of the lake is anticipated due to the current schedule being maintained.

3.2.3 Estimated Water Use

Future agricultural and urban water use is an important part of the water budget in the study area. Future agricultural uses are estimated as a part of the SFWMM simulation process. Evapotranspiration, or ET, is simulated by the SFWMM based on a number of relevant variables, including land cover (which in agricultural areas is reflective of crop type). Agricultural water use is not estimated for use as SFWMM input; differences in agricultural area ET estimated through model simulation (SFWMM output) were used to estimate the consequent effects of the alternative regulation schedules on crop yields (since crop growth is functionally related to ET). Urban water use by residential users, businesses, industrial and government users in the study area is required as input for the SFWMM, the principal analytical tool used to simulate hydrologic, and to the extent possible by extension, ecological and economic consequences of the different alternatives examined in this study. Urban water use was estimated using a software tool called IWR-MAIN. IWR-MAIN estimates urban water use based on the relationship between use and a number of demonstrated relevant economic and demographic variables. Over 90% of the urban water use in the study area occurs in the LEC. The urban uses occurring in the rural, agricultural areas immediately surrounding the lake do not have a significant affect on the comparison of alternative regulation schedules. 1990 urban use in the LEC is a little over 900 MGD, and for purposes of this study, in 2010 this use was projected to grow to a little over 1100 MGD. Estimates using IWR-MAIN were made for Service

Areas 1, 2 and 3, roughly corresponding to southern Palm Beach County, Broward, and Miami-Dade Counties, respectively, and the North Palm Beach Service Area. The relative distribution of overall use by area does not change much during the period of analysis covered by this investigation, 1990-2010. The area-wide urban annual use was translated or reaggregated into monthly wellfield withdrawals, the necessary format required as SFWMM input data.

4 PROBLEMS AND OPPORTUNITIES

The sections below describe the problems that the alternatives are attempting to resolve, concerns and needs of the affected public, and opportunities for which the project could address these problems and needs and provide benefits to the natural and human environment.

4.1 Public Concerns

Public sentiment surrounding Lake Okeechobee and the issues involved in this study have always been controversial and not far removed from the conflict between encroaching human development and the natural environment. The lake plays a very important role as a primary source of water supply for nearby urban areas, the Lake Okeechobee Service Areas and the productive Everglades Agricultural Area that lies to the immediate south of the lake. The lake also continues to grow in importance as a backup water supply source for the already heavily populated, and continually growing, urbanized areas of the Lower East Coast of Florida. Increased heavy rainfall over the past several years has contributed to higher lake stages, resulting in impacts to the lake littoral zone. This has also resulted in more frequent freshwater discharges to the Caloosahatchee River and St. Lucie estuaries, which can impact their ecosystems. Public concern over these environmental impacts is increasing as these important diverse and productive ecosystems continue to decline. Some environmentalists and scientist advocate lower lake stages to protect the lake littoral zone, an important habitat for fish and wildlife. This study has attempted to address all of these concerns.

4.2 Ecological Problems and Opportunities

Broadly speaking there are several ecosystems currently suffering adverse impacts as a result of existing water management of the lake, and the need to respond to water supply and flood protection needs. Other than the two estuaries and Lake Okeechobee, there are occasions when water is discharged to the Everglades (i.e. WCAs 1, 2, and 3) with adverse impacts to the flora and fauna of the WCAs.

For the lake littoral zone, the more stabilized and higher water levels do not allow for the periodic wetting and drying necessary for the germination of several vegetative communities, such as willows, which provide nesting substrates for snail kites and wading birds. Fish will suffer adverse impacts due to loss of aquatic vegetation and other beneficial plant life that serves as breeding ground and affords protection for their juveniles. Plants hold sediments in place and compete with algae for nutrients. In this way, they can help to maintain better water quality through reduced turbidity, fewer nutrients and fewer phytoplankton. Ecosystem damage extends beyond the loss of beneficial plant life to include continued growth and colonization by melaleuca, torpedo grass and other exotic plants. These exotics aggressively and successfully compete with native species since prolonged high water levels often promote an environment that stresses native vegetation, providing the aggressive and highly adaptive exotics an opportunity to invade areas previously occupied by native species.

Ecological damage occurs at both the Caloosahatchee River and St. Lucie Estuaries due to the large freshwater releases made from the lake when, in an effort to maintain the flood control capability of the lake, it becomes necessary to lower high lake stages. These large freshwater releases upset the salinity envelope characteristic of estuaries. Species that have adapted over years to this particular environment suffer adversely. As an indicator of damage done, the amount of shoal grass found in the St. Lucie Estuary has declined substantially despite its having a wide salinity tolerance (approximately 3.5 ppt. to 44 ppt.). Oysters have a narrower range and will die if exposed to freshwater for only a few days; these have become almost non-existent in the estuary. At flows from the lake exceeding 1,500 cfs the estuary becomes increasingly fresher until the whole system is freshwater at flows near 3,500 cfs. The larger increases from the current regulation schedule, Zone A releases as high as 7,000 cfs, not only quickly make the estuaries freshwater, but also transport large quantities of sediment, further destroying the shoal grass and oyster habitat and other estuarine biota as well. At the Caloosahatchee River estuary, a similar situation exists, the submerged aquatic vegetation species found in this estuary are diverse and spread throughout the ecosystem. Those species include the shoal grass found at St. Lucie as well as other species eg. turtle grass. These species suffer significantly when exposed to lower salinity regimes. Again, a good indicator of the damage caused by large freshwater releases is the decline in numbers for the American oyster as well as declines in submerged aquatic vegetation. Studies have shown that mean monthly flows of a minimum of 500 cfs during the dry season are needed. Specifically, mean monthly flows above 2,500 cfs should not be promoted because: (1) salinity downstream of the Cape Coral bridge approaches oligohaline conditions, (2) optimum salinity for shoal grass and oysters at the bridge cannot be maintained, and (3) sub-optimum conditions develop for turtle grass in San Carlos Bay.

Prior to the C&SF Project, the EAA, WCAs, and ENP, were all one massive wetland area comprised of sawgrass wet prairies, aquatic sloughs, and tree island communities, all of which benefited from the expansive sheet flows of water from Lake Okeechobee. While specific water management issues and problems within each WCA differ to varying degrees the prolonged hydroperiods and increased nutrient levels within WCA 2A has resulted in the loss of tree island communities and conversion of once wet prairies into aquatic sloughs. The Water Conservation Areas created as part of regional drainage efforts suffer from prolonged hydroperiods and increased nutrient loadings from the lake that encourage the expansion of cattails into sawgrass, wet prairie communities.

4.3 Water Quality Problems and Opportunities

Lake Okeechobee is designated as a Class I waterbody according to the Florida Administrative Code. This means that it is used as a potable water supply source and must meet the most stringent surface water quality and pollution control criteria in Florida. However, the lake was never as eutrophic historically as it is today. Significant quantities of nutrients (most notably phosphorous derived from agricultural practices) have been carried into the lake by the Kissimmee River basin, the Taylor Creek/Nubbin Slough basin and backpumping from the EAA. The FDEP in 1998 prepared a list of waterbody sites where water quality was not adequate to sustain its designated uses. Lake Okeechobee had eight different monitoring stations wherein excessive nutrients, low levels of dissolved oxygen and high concentrations of unionized ammonia, iron, chlorides and coliform bacteria were found. It is expected that several ongoing restoration efforts, coupled with best management practices of the agriculture industry will result in improved water quality for the lake regardless of which regulation schedule is in place.

Water quality aspects associated with management of the lake acquired greater importance as the study progressed. The lake has very large deposits of sediments that have accumulated from the various pollution sources over the years. These nutrient deposits are so substantial that they are a significant cause of turbidity. Based on current modeling, even if all existing external loads were discontinued immediately, a significant time period (at least 20-25 years) would pass before the nutrient concentration outflows from the lake would start to show a response (concentration levels falling). This is due to the buffering effect of these large sediment deposits of nutrients. The continuing eutrophication of the lake is caused by polluted waters entering the lake from the Kissimmee, Nubbin-Slough basins and the back-pumping and runoff from agricultural interests near the lake. During the period of time before the downstream STA is on line (approximately four years), the different regulation schedules are not anticipated to have significant differences in phosphorus outflows from the lake under similar volumetric outflows from the lake. However, the schedules that tend to keep the lake stages lower will reduce nutrients being transported from the center of the lake (with the existing phosphorus-rich mud sediments) to the lower nutrient near shore areas. This will provide a clear and demonstrable benefit to the lake littoral zones by keeping water transparency higher and total phosphorus lower in these areas than would occur with higher lake stages. The WSE schedule showed the most benefit in achieving this effect because it takes into account the climatological forecasting. Ongoing major project works such as the Kissimmee Restoration effort coupled with continued, specific, regulatory and non-regulatory activities are being required by the local sponsor, the SFWMD, are expected to help reduce the current nutrient loading into the lake. More activities will be needed to meet established targets.

4.4 Economic and Social Well-Being

Almost the entire region surrounding Lake Okeechobee, and in particular the very large EAA located immediately south of the lake is productive cropland, dairy and/or cattle range. As a result, the economy and well-being of residents within this entire region is tied into the availability of, and access to, clean water to sustain a close to eight billion dollar (annual) industry. The lake is also significant to the heavily populated Lower East Coast since this is one of their alternate sources for water, during dry periods and after having exhausted local groundwater supplies and allocations from the WCAs. Social well-being extends beyond the very basic need for potable water, water for industrial, commercial and residential use, and water to protect the surficial aquifer from salt water intrusion. The need for water is not taken lightly by a state that has seen more than its' fair share of water restrictions resulting from prolonged periods of drought. There exists a strong psychological need to feel that a handy and large source of water is readily available for the next drought.

5 DESCRIPTION AND EVALUATION OF ALTERNATIVES

The sections below describe how the various alternatives were formulated, how each alternative functions in terms of regulating lake levels and downstream discharges to various parts of the system, and concludes with a summary evaluation of the performance of each of the alternatives.

5.1 Plan Formulation Methodology

While the issues that surround the implementation of a regulation schedule for the lake are very complex, as are the various scientific models used, the planning process is relatively straightforward and simple. Various alternative lake regulation schedules were developed and proposed to replace the existing schedule identified herein as alternative 25, or Run 25. Performance measures were developed to quantify specific objectives and thereby determine the effectiveness of each regulation schedule studied in meeting study goals and objectives. A socio-economic study was conducted to gauge the efficiency (in terms of monetary impacts to the regional and national economy) of the schedules. Extensive coordination with all involved governmental agencies (Federal and State) and the public was made to determine the acceptability of the schedules being considered.

Because the study considered only operational changes and none of the schedules allowed for higher water levels than previously authorized, there were no structural features to consider except for those already embedded within the SFWMM and which were common to all alternative schedules. There were also no real estate concerns since the lake is self contained and no higher lake stages were considered. This further simplified the planning process.

The team decided on using the 2010 demands and model runs as the base, without project condition since it represents the most likely scenario during implementation of the schedule. The Kissimmee River Restoration project has already begun construction and the Central and Southern Florida Restudy report has been finalized and approved for implementation. All efforts to have the structural features assumed by the hydraulic models to be in place before the year 2010 are moving forward.

5.2 Description of Lake Regulation Schedule Alternatives

The section below describes, both in text and graphically, the proposed alternative lake regulation schedules. Included is the "no action" alternative ("Run 25") which is the existing lake regulation schedule and the schedule which would be implemented should no action be taken. Also included is the "preferred alternative" (WSE), which is the one believed to best meet the objectives of this study and is therefore carried forward as the future with project condition. The term "regulation schedule" refers to a compilation of operating criteria, guidelines, rule curves and specifications that govern basically the storage and release functions of a reservoir. In general, schedules indicate limiting rates of releases required during various seasons of the year to meet all functional objectives of the particular project. In general, the regulation schedule consists of 5 zones, as described below. The zones will vary according to the specific schedule.

Zone A – maximum releases necessary for flood protection

Zone B and Zone C – releases through various outlets that may be modified to minimize adverse effects or obtain additional benefits

Zone D – discharges made through various outlets for extended periods of time that may be modified to minimize adverse effects to the littoral zone and the estuarine environment – may include pulse releases

Zone E – no regulatory releases

5.2.1 Run 25 (No Action)

The Run 25 regulation schedule ranges from 15.65 to 16.75 feet with multiple operation zones which vary flood releases over a wide range before reaching maximum release rates. The purpose of this schedule is to reduce damaging flows to the nearby St. Lucie Canal and Caloosahatchee River estuaries without sacrificing the flood control or water supply benefits derived from the lake. When the stage is rising in Zone D, pulse releases, described in the following paragraph, are made to the estuaries. These multi-level releases are the least harmful method for releasing lake water to the estuaries when trying to avoid larger required discharges. In Zone C, discharges are first made through the EAA to the WCAs if water conditions in the area permit. However, when more substantial releases are needed during the wet season, or local runoff conditions do not allow discharges through the EAA, the Caloosahatchee River and the St. Lucie Canal are used as primary outlets. Environmental restrictions on the amount of water released in Zone C to these downstream estuaries are 2,500 cfs at S-80 to the St. Lucie Estuary, and 4,500 cfs at S-77 to the Caloosahatchee Estuary. In Zone B, discharges up to 6500 cfs at S-77 and 3500 cfs at S-80 can be made. When lake stages reach the levels defined for Zone A, maximum discharges are made through the major lake outlets after the removal of local runoff.

This schedule does not significantly impact water supply or lake stages, and was designed to reduce the occurrence of large discharges to the estuaries. Regulatory releases occur at relatively high lake stages from 15.65 to 16.75 feet. Regulatory releases to the estuaries occur in a graduated fashion. The first zone of releases (Zone D) incorporates pulse releases to the estuaries. Pulse releases are low level releases that mimic the natural runoff from a rainstorm event. Even though these pulse releases are low in volume compared to other flood control releases, they may cause problems in the estuaries if used too frequently. However, it is still an environmentally sensitive approach to release of water to these ecosystems and provides a compromise that can possibly avoid more harmful larger releases. See Figure 2.8-1on page 33.

5.2.2 Run 22 AZE

The Run 22AZE schedule ranges between a high of 15.6 ft. and a low of 13.5 ft. The stage ranges offer improved potential for wading bird use of Lake Okeechobee marshes while retaining other fish and wildlife values for the lake. In Zone D, pulse release discharges may be made to the estuaries for extended periods of time when the stage is rising to lessen undesirable impacts of large volumes of fresh water. In Zone C, discharges up to 4500 cfs at S-77 and 2500 cfs at S-80 may be made. In Zone B, discharges up to 6500 cfs at S-77 and 3500 cfs at S-80 can be made. When lake stages reach the levels defined for Zone A, flood protection becomes the chief concern. Maximum discharges that will not cause local flooding are made through the major lake outlets.

This schedule was designed to discharge water from the lake during the dry season to lower lake levels for the perceived benefit of enhancing the littoral zone of the lake. Regulatory discharges begin at relatively low lake stages. The pulse release zone (Zone D) is narrow, at one low level of release, and provides a minimal buffer to larger releases. Significant levels of regulatory releases occur at relatively low lake stages.

Zone E allows low level discharges at the low lake stages of 13.5 to 15.60 ft. while including the advantages of gradual increases in releases at higher lake stages. In Zone E, discharges can only be made southward to the WCAs. As in Run 25, in Zone D, there are three levels of pulse releases to the estuaries.

This schedule incorporates a large jump at the beginning of the wet season. This allows for the capture of large regional rainfall events, which frequently occur in Florida in the month of June, for potential water use during the following dry season. See Figure 5.2.2-1.

5.2.3 HSM

The HSM regulation schedule's lowest zone ranges from 14.0 feet to 16.75 feet, with multiple operation zones. The theme of this schedule is to increase the operational flexibility of meeting the objectives of managing Lake Okeechobee water levels and discharges. Recent breakthroughs made in the understanding of the nature of climate variations on monthly to interannual scales make the time right for the introduction of this flexibility. This is accomplished in two ways: The first is by recommending that discharges in Zones B, C and D be based on hydrologic and climatological forecasts: and the second is by allowing discharges from the lake to be initiated at lower lake water levels, under special conditions.

In Zone D pulse releases may be made to the estuaries for extended periods when very large inflows are expected. Pulse releases are low level releases that mimic natural runoff from a rainfall event and minimize adverse impacts to the estuaries. In Zone C, discharges up to 4500 cfs at S-77 and 2500 cfs at S-80 can be made when necessary to prevent larger discharges required from Zone A or B. However, smaller pulse releases are the preferred mode of discharges to the estuaries in this zone. Under drier than normal hydrologic and climatologic conditions, releases may be limited to the Everglades only. In Zone **B** under normal to wet conditions, releases up to 6500 cfs at S-77 and 3500 cfs at S-80 may be made. In Zone B, C, and D, coordination with Everglades and estuarine biologists are encouraged to minimize adverse effects to downstream ecosystems. When lake water levels reach Zone A, up to maximum discharges may be made through the major outlets after removal of local runoff to control lake water levels. See Figure 5.2.3-1.

5.2.4 Corps 2010

This schedule represents an alternative to the Run 25 schedule for the conditions likely to occur by the year 2010. The lowest zone, Zone E, ranges from 14.5 to 16.0 feet, NGVD. The highest zone, Zone A, is identical to Run 25 Zone A. Unlike any zones in Run 25, the Zone E is characterized by releases only southward (i.e. not to the estuaries) to the extent practicable. If the canals in the EAA are full, then there are no releases. The pulse releases to the estuaries (both Caloosahatchee and St. Lucie) begin in Zone D, and are similar to those in Run 25. Zones B, C, and D are slightly higher than the comparable Run 25 zones, but not more than 0.25 feet higher.

This schedule is intended to lower the lake in high water years to prevent multi-year flooding to the existing littoral zone. The schedule also passes less to the estuaries and moves more water to the WCAs without significantly reducing the amount of water available for water supply.

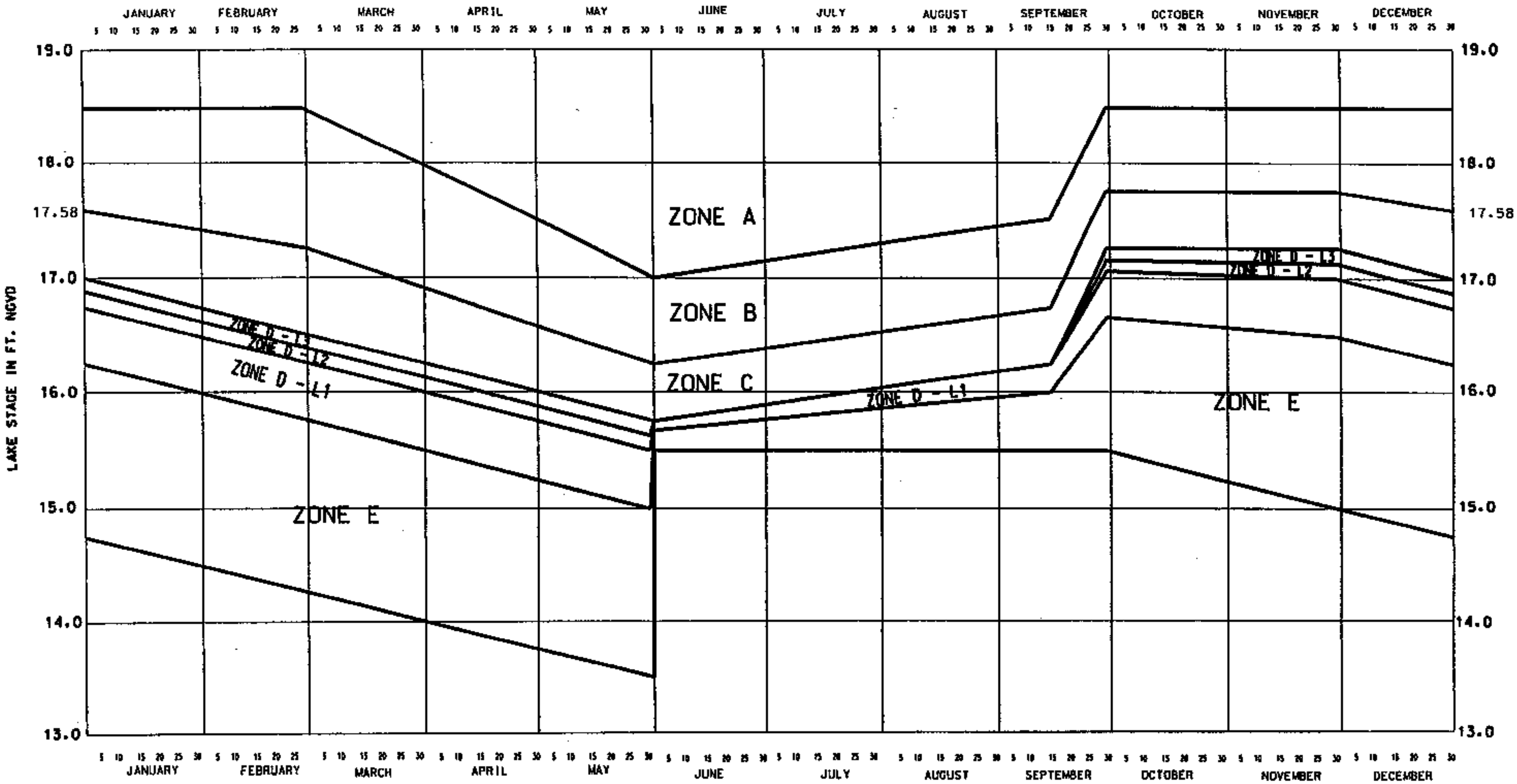
This regulation schedule is very similar to Run 25, but includes the lower zone introduced by Run 22AZE. The schedule includes an allowance for a potential increase in storage over Run 22AZE immediately after the peak of the hurricane season. Also, discharges to the Everglades in the lowest zone of the schedule are discontinued at a higher water elevation than Run 22AZE except during June and July. See Figure 5.2.4-1.

5.2.5 WSE (preferred alternative)

This schedule incorporates increased operational flexibility in the intermediate zones and permits excess water to be discharged from the lake at lower water levels when large inflows are expected, based on current and projected hydrologic conditions. The National Climate Prediction Center official climate and ENSO outlooks are applied to estimate expected inflow to the lake. With the recent advances in the diagnostics and predictability of prolonged climate shifts, it is clearly appropriate that this new information should be assimilated into the operational rules of the south Florida regional hydrologic system. Lake Okeechobee, with its large tributaries and water use basins, is ideal for this application. The most substantial value of the implementation of a climate-based operational schedule is to alert water managers of the increased likelihood of extreme regional hydrological events, so performance may be improved for such events. Improved overall performance during less extreme hydrologic events may also occur. Regional water management systems that include large lakes and reservoirs with extensive tributary and water use basins require longer lead forecasts so that operators can make significant adjustments early enough to minimize adverse impacts to sensitive ecological systems, while maintaining adequate levels of flood protection and water supply. For Lake Okeechobee, even small deficits or surplus in rainfall are accentuated due to the large areal expanse that directly contributes to fluctuations in the lake storage. This amplification of the lake hydrologic response significantly narrows the window of opportunity for operational decisions. With the significant advances in climate research in recent years, climate forecasting has emerged as a plausible mechanism for improved water management. Climate forecasts predict shifts in atmospheric conditions that may persist for months, years or even decades. Vital research being completed by a number of NOAA and international research centers has allowed great strides to be made in the field of climate forecasting. These efforts have tremendous potential for increasing the efficiency of water management.

Recent lake operational schedules (1971-1997) contain a clause indicating that adjustments to the operational rules may be implemented for the purpose of increasing benefits and minimizing impacts to the hydrologic system. The 1970 schedule, and most of those prior to 1970, allowed adjustments for discharges based on weather forecasts. However, rarely in the last 25 years have outflows differed from those explicitly stated on the operational schedule. With the recent strides made in the understanding of climate variations on different time scales, the proposed lake operational schedule offers guidelines for refined water management practices for Lake Okeechobee. Adjustments to discharges for each zone of the schedule are based on climate forecasts and hydrologic conditions. These volumes include surface inflows and rainfall that falls directly into the lake.

A key feature of the WSE schedule is the lower operational zone, labeled Zone D. This zone allows the operational flexibility to deliver water to the Everglades at lower lake water levels, which minimizes adverse impacts to the lake littoral zone. If very wet conditions exist or are expected over the next six months, pulse releases may be initiated to tidewater in Zone D. The WSE schedule allows dry season discharges to tidewater to be gradually increased as necessary (up to the discharge rate recommended for the specific zone) to control water levels. This practice does not impact flood protection since there is no threat of hurricane surge during the dry season. The large outlet capacity virtually assures the ability to lower the water levels before the arrival of the hurricane season. This practice will allow more water to be kept in the regional system for water supply and hydroperiod restoration. See Figure 5.2.5-1.



LAKE OKEECHOBEE RELEASES

ZONE	AGRICULTURAL CANALS (2)	CALOOSAHATCHEE RIVER (2)	ST. LUCIE CANAL
A	Maximum Practicable Releases to Water Convervation Areas	Up to Maximum Capacity at S-77	Up to Maximum Capacity at S-80
B		6500 CFS	3500 CFS (3)
C		4500 CFS	2500 CFS (3)
D Level 3 Level 2 Level 1		10-day Pulse with a Mean Discharge of: Level 3 = 3000 CFS Level 2 = 2300 CFS Level 1 = 1600 CFS	10-day Pulse with a Mean Discharge of: Level 3 = 1170 CFS Level 2 = 900 CFS Level 1 = 730 CFS
E		No Releases	No Releases

NOTES: (1) RELEASES THROUGH VARIOUS OUTLETS MAY BE MODIFIED TO MINIMIZE DAMAGES OR OBTAIN ADDITIONAL BENEFITS.
(2) SUBJECT TO FIRST REMOVAL OF LOCAL RUNOFF.
(3) EXCEPT WHEN EXCEEDED BY LOCAL INFLOW.

CENTRAL AND SOUTHERN FLORIDA
PROPOSED REGULATION SCHEDULE

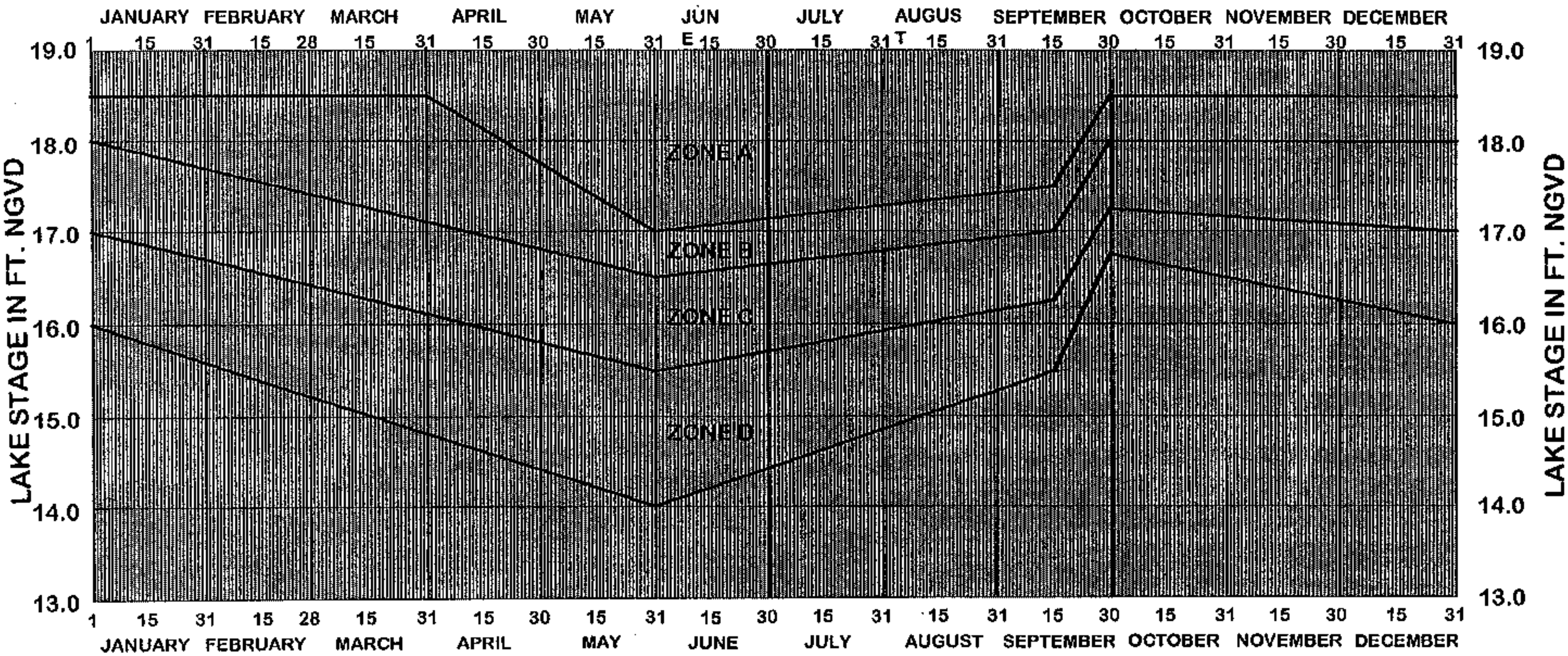
LAKE OKEECHOBEE

DEPARTMENT OF THE ARMY, JACKSONVILLE DISTRICT
CORPS OF ENGINEERS, JACKSONVILLE, FLORIDA

R22AZE

Figure 5.2.2-1

Insert Run 22AZE Regulation Schedule here



RELEASE THROUGH OUTLETS AS INDICATED

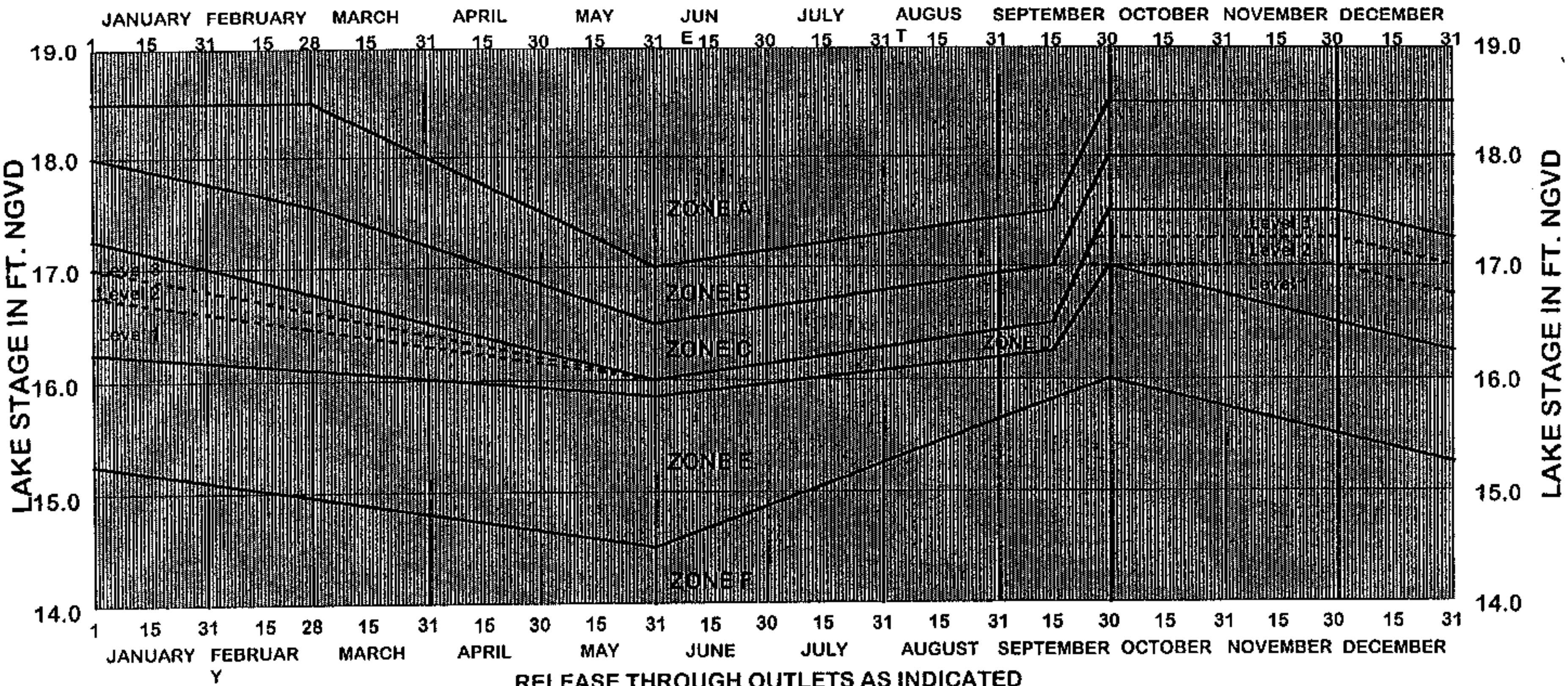
ZONE	AGRICULTURAL CANALS TO WCAs (1)	CALOOSAHATCHEE RIVER AT S-77 (1,2,4)	ST. LUCIE CANAL AT S-80 (1,2,4)
A	PUMP MAXIMUM PRACTICABLE	UP TO MAXIMUM CAPACITY	UP TO MAXIMUM CAPACITY
B (3)	MAXIMUM PRACTICABLE RELEASES	NORMAL TO WET: UP TO 6500 CFS DRY: UP TO MAXIMUM PULSE RELEASE	NORMAL TO WET: UP TO 3500 CFS DRY: UP TO MAXIMUM PULSE RELEASE
C (3)	MAXIMUM PRACTICABLE RELEASES	WET: UP TO 4500 CFS NORMAL: UP TO MAXIMUM PULSE RELEASE DRY: NONE	WET: UP TO 2500 CFS NORMAL: UP TO MAXIMUM PULSE RELEASE DRY: NONE
D (3)	AS NEEDED TO ENHANCE NATURAL HYDROPERIODS IN THE EVERGLADES	VERY WET: PULSE RELEASE OTHERWISE: NONE	VERY WET: PULSE RELEASE OTHERWISE: NONE

NOTES:
(1) SUBJECT TO FIRST REMOVAL OF RUNOFF FROM DOWNSTREAM BASINS
(2) GUIDELINES FOR WET, DRY AND NORMAL CONDITIONS ARE BASED ON: 1) SELECTED CLIMATIC INDICES AND TROPICAL FORECASTS AND 2) PROJECTED INFLOW CONDITIONS
(3) RELEASES THROUGH VARIOUS OUTLETS MAY BE MODIFIED TO MINIMIZE DAMAGES OR OBTAIN ADDITIONAL BENEFITS. CONSULTATION WITH EVERGLADES AND ESTUARINE BIOLOGISTS IS ENCOURAGED TO MINIMIZE ADVERSE EFFECTS TO DOWNSTREAM ECOSYSTEMS. RELEASES SHOULD BE PUMPED WHEN NECESSARY FOR THE ENHANCEMENT OF THE EVERGLADES NATURAL HYDROPERIOD
(4) PULSE RELEASES ARE MADE TO MINIMIZE ADVERSE IMPACTS TO THE ESTUARIES

DRAFT PROPOSED REGULATION SCHEDULE
LAKE OKEECHOBEE
SOUTH FLORIDA WATER MANAGEMENT DISTRICT
WEST PALM BEACH, FLORIDA
DATED: 14 FEBRUARY 1997
HSM

Figure 5.2.3-1

Insert HSM Regulation Schedule here.



RELEASE THROUGH OUTLETS AS INDICATED

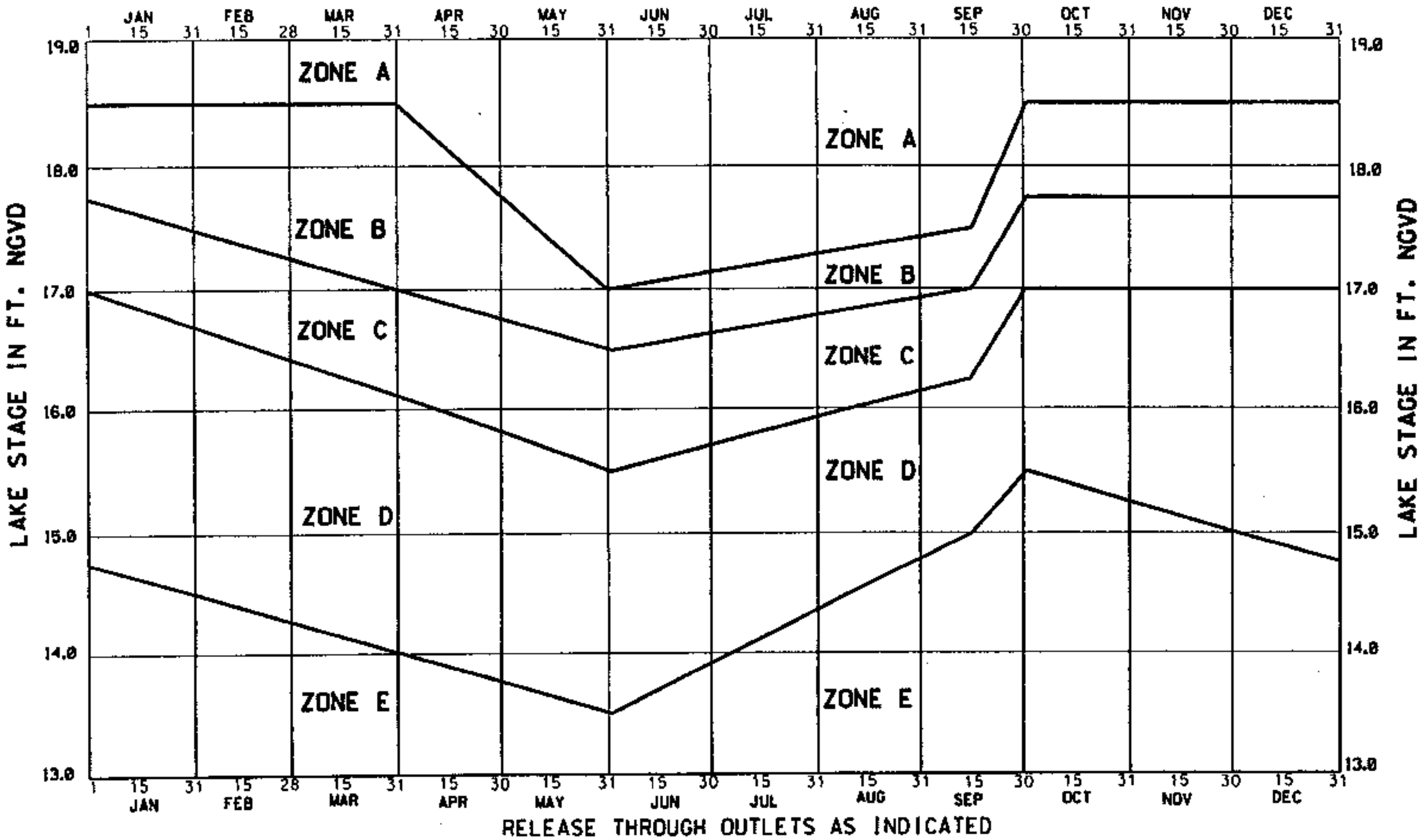
ZONE	AGRICULTURAL CANALS (2)	CALOOSAHATCHEE RIVER (2)	ST. LUCIE CANAL
A	PUMP MAXIMUM PRACTICABLE TO WCAs	UP TO MAXIMUM CAPACITY AT S-77	UP TO MAXIMUM CAPACITY AT S-80
B (1)	MAXIMUM PRACTICABLE TO WCAs	6500 CFS AT S-77	3500 CFS AT S-80 (3)
C (1)	MAXIMUM PRACTICABLE TO WCAs	UP TO 4500 CFS AT S-77	UP TO 2500 CFS AT S-80 (3)
D	MAXIMUM PRACTICABLE TO WCAs	MAXIMUM NON-HARMFUL DISCHARGES TO ESTUARY WHEN STAGE RISING	MAXIMUM NON-HARMFUL DISCHARGES TO ESTUARY WHEN STAGE RISING (3)
E	MAXIMUM PRACTICABLE TO WCAs (4)	NO REGULATORY DISCHARGE	NO REGULATORY DISCHARGE
F	NO REGULATORY DISCHARGE	NO REGULATORY DISCHARGE	NO REGULATORY DISCHARGE

NOTES:
(1) RELEASES THROUGH VARIOUS OUTLETS MAY BE MODIFIED TO MINIMIZE DAMAGES OR OBTAIN ADDITIONAL BENEFITS
(2) SUBJECT TO FIRST REMOVAL OF LOCAL RUNOFF
(3) EXCEPT WHEN EXCEEDED BY LOCAL INFLOW
(4) SUBJECT TO CANAL CAPACITY; NO RELEASES WHEN IN ZONE A IN WCAs
(5) PULSE RELEASES LEVEL 1,2, AND 3 AS DESCRIBED IN RUN25

DRAFT PROPOSED REGULATION SCHEDULE
LAKE OKEECHOBEE
DEPARTMENT OF THE ARMY, JACKSONVILLE DISTRICT
CORPS OF ENGINEERS, JACKSONVILLE, FLORIDA
DATED: 4 FEBRUARY 1997
CORPS 2010

Figure 5.2.4-1

Insert Corps 2010 Regulation Schedule here



RELEASE THROUGH OUTLETS AS INDICATED

ZONE	AGRICULTURAL CANALS To WCAs (1)	CALOOSAHATCHEE RIVER AT S-77 (1,2,4)	ST. LUCIE CANAL AT S-80 (1,2,4)
A	PUMP MAXIMUM PRACTICABLE	UP TO MAXIMUM CAPACITY	UP TO MAXIMUM CAPACITY
B (3)	MAXIMUM PRACTICABLE RELEASES	NORMAL TO WET: UP TO 6500 CFS DRY: UP TO MAXIMUM PULSE RELEASE	NORMAL TO WET: UP TO 3500 CFS DRY: UP TO MAXIMUM PULSE RELEASE
C (3)	MAXIMUM PRACTICABLE RELEASES	WET: UP TO 4500 CFS NORMAL: UP TO MAXIMUM PULSE RELEASE DRY: NONE	WET: UP TO 2500 CFS NORMAL: UP TO MAXIMUM PULSE RELEASE DRY: NONE
D (3,5)	AS NEEDED TO MINIMIZE ADVERSE IMPACTS TO THE LITTORAL ZONE WHILE NOT ADVERSELY IMPACTING THE EVERGLADES. (SEE NOTE 5.)	VERY WET: UP TO MAXIMUM PULSE RELEASE OTHERWISE: NONE	VERY WET: UP TO MAXIMUM PULSE RELEASE OTHERWISE: NONE
E	NO REGULATORY DISCHARGE	NO REGULATORY DISCHARGE	NO REGULATORY DISCHARGE

NOTES: (1) SUBJECT TO FIRST REMOVAL OF RUNOFF FROM DOWNSTREAM BASINS
(2) GUIDELINES FOR WET, DRY AND NORMAL CONDITIONS ARE BASED ON: 1) SELECTED CLIMATIC INDICES AND TROPICAL FORECASTS AND 2) PROJECTED INFLOW CONDITIONS
(3) RELEASES THROUGH VARIOUS OUTLETS MAY BE MODIFIED TO MINIMIZE DAMAGES OR OBTAIN ADDITIONAL BENEFITS. CONSULTATION WITH EVERGLADES AND ESTUARINE BIOLOGISTS IS ENCOURAGED TO MINIMIZE ADVERSE EFFECTS TO DOWNSTREAM ECOSYSTEMS.
(4) PULSE RELEASES ARE MADE TO MINIMIZE ADVERSE IMPACTS TO THE ESTUARIES
(5) ONLY WHEN THE WCAs ARE BELOW THEIR RESPECTIVE SCHEDULES

DRAFT PROPOSED REGULATION SCHEDULE
LAKE OKEECHOBEE
SOUTH FLORIDA WATER MANAGEMENT DISTRICT
WEST PALM BEACH, FLORIDA
PROPOSED: 15 APRIL 1998
REVISED: 10 DECEMBER 1998
WSE

Figure 5.2.5-1

Insert WSE Regulation Schedule here

5.3 Evaluation of Lake Regulation Schedule Alternatives

The section below provides a brief assessment of the alternative regulation schedules from the perspective of how they will affect the natural environment, the human environment, including local and regional economic conditions, water quality, water management and water supply. A summary of key performance measure results for all of the lake regulation schedule alternatives is included at the end of section 5.3 (see Table 5.3-1). For additional detail and modeling results of performance measures for the various alternatives, reference ***Appendices A and C.***

5.3.1 Environmental

Both alternatives HSM and Corps 2010 were determined to be, at a minimum, no improvement for the lake ecosystem, and at worst, an exacerbation of already existing adverse conditions within the littoral zone and marsh. HSM produced several more extreme high lake stages than the existing Run 25 using the 2010 base (***Appendix A***). Neither alternative allows the lake the opportunity to recede sufficiently to levels thought to encourage regeneration of the littoral zone as does the WSE and 22 AZE alternatives. Although both alternatives HSM and Corps 2010 perform reasonably well in diverting existing regulatory discharges away from the estuaries, southward towards the WCAs, it is not known what impact these may have on existing water quality and cattail expansion in these areas since this was not included in the modeling. By and large, it is reasonable to conclude that since neither of these alternatives improves in any real way, and may in fact adversely impact Lake Okeechobee, then they do not meet the study goals of optimizing environmental benefits to the natural areas. Under the WSE schedule, there is a small (about 5%) reduction in the frequency of high lake stage events (>15 feet), but no significant increase in lows (>12 feet), as compared to Run 25. In other words, the WSE schedule takes a small step towards fixing the problem with high lake stages, without doing it at the expense of creating more lows. Furthermore, WSE should actually perform better as climate forecasting abilities evolve. These two alternatives are henceforth not considered any further for the purposes of this study.

5.3.1.1 Lake Okeechobee

Alternative 25 appears to be slightly better for the lake littoral zone given conditions assumed under the 2010 base. This may be attributable to the increased demands on water supply from the lake expected in the future, which results in lower overall lake stages. Alternative 25 has fewer low stage events than the other alternatives under the 2010 base. WSE has four low stage events, one more than Run 25, and one low stage event less than 22AZE. Alternative 25 performs about the same as WSE in terms of mimicking "historical" (defined as that period from 1953-1972) lake stage conditions. WSE has shorter flooding events (duration above 15 feet NGVD) compared to Run 25, although not as good as 22AZE. While there is no significant difference between the alternatives for prolonged low lake stages (<12 feet for >1 year), WSE performs slightly poorer in terms of the number of occurrences of extremely low lake stage events (<11 feet for >100 days), although the duration below 11 feet was longer with both Run 25 and 22AZE.

Water Quality modeling of Lake Okeechobee regulation schedule alternatives, using a one-box version of the Lake Okeechobee Water Quality Model (LOWQM) was done to evaluate the response of in-lake total phosphorus and chlorophyll a concentrations. The one-box model treats the entire lake as one modeling unit, which researchers know to be an oversimplification. The one-box LOWQM is thought to provide a relatively simple assessment of water quality responses to lake regulation at this time. A five-box model is under development by the SFWMD. Alternatives were compared to the base case (Run 25; 2010 base), and ranked as to the total number and relative percentage of years, over the 31 year simulation period, that the alternatives outperformed the base case. Results appear to indicate that lake regulation schedules producing intermediate scores eg. 22AZE are preferred. In 26 of 31 years alternative 22AZE (2010) simulated conditions with lower total phosphorus concentrations within the lake than Run 25 (2010). WSE (2010) also performed better than Run 25 (2010) with 71% of the 31 year simulation period total phosphorus concentrations below the base. Chlorophyll a concentrations for 22AZE (2010) were only slightly better than 25 (2010), resulting in just 19% less time with lower chlorophyll a concentrations, or 6 events in 31 years. WSE performed the best of the three alternatives, with 18 years during the simulation period (58%) demonstrating lower chlorophyll a concentrations. The report noted that actual differences of total phosphorus and chlorophyll a never exceeded 10 and 20 percent, respectively, on a yearly basis and because of model uncertainty, values should be viewed with caution. These preliminary results seem to indicate, at a minimum, that lower lake levels produce conditions which may be better for water quality. The limited modeling available over the period being simulated (31 years) shows that there is a slight advantage to Run 22AZX over Run 25 and WSE. However, given the uncertainty/accuracy of the available modeling, there appear to be no significant differences for overall water quality in the lake between the different schedules. Yet, it should be noted that lower lake stages are desirable for the health of the lake in the littoral zones. The WSE schedule is anticipated to best achieve this effect (lower lake stages) because it uses climatological forecasting.

5.3.1.2 St. Lucie Estuary

Results are somewhat mixed for the St. Lucie Estuary. On the whole, WSE appears the best for the St. Lucie Estuary, with the least number of flood control releases above 2500 cfs of the three alternatives. WSE had two fewer releases than 22AZE and six fewer than 25. Although WSE had approximately 10% more discharges at the lower volume of 1600 cfs than 22AZE, and performed better than Run 25, the larger discharge volume events are of greater concern for the health of the estuary. 22AZE exhibits 11 fewer such events than Run 25 and 3 fewer than WSE. 22AZE also demonstrated the best performance of the 3 alternatives, in reducing the number of times (24x for 22AZE, relative to 30x for WSE, and 37x for Run 25) in which average flows exceeded 1600 cfs for > 14 days from lake regulatory releases. Finally, mean annual flood control releases from Lake Okeechobee, shows 22AZE as having the least flow to the St. Lucie and

Caloosahatchee River Estuaries (73.5 k acre-feet and 170.6 k acre-feet respectively), followed by WSE (85.9 k acre-feet, and 228 k acre-feet respectively) and Run 25 (108.5 k acre-feet and 254.4 k acre-feet respectively). Overall, the model simulations seem to indicate that WSE provides only marginal benefits to the St. Lucie Estuary

5.3.1.3 Caloosahatchee River Estuary

Performance for the Caloosahatchee River Estuary is somewhat more clear than for the St. Lucie Estuary. 22AZE performs slightly better than WSE and significantly better than Run 25 for maintaining desirable salinity envelopes and in minimizing the number of times high discharge criteria were exceeded. Flows resultant from the C-43 basin or from a combination of the C-43 basin and lake releases, which exceed the discharge criteria (on either the low or high end) occur about the same for each alternative. WSE actually had the fewest number of low flow events (107; lake and basin flows <300 cfs from November to May), followed by Run 25 (110 events) and 22AZE (111 events). Run 25 appears to show far fewer months (19) of flows >2800 cfs resultant from lake releases than does WSE with 28 months, although this performance measure does not accurately portray large releases. A more detailed examination of simulated flows was necessary because pulse releases up to 3000 cfs are considered environmentally friendly for the Caloosahatchee basin, and the model allows discharges up to the 3000 cfs level. At volumes greater than 3000 cfs, WSE performed better than Run 25. 22AZE however, demonstrates better performance for reducing high volume discharges to the estuary (>2800 cfs and 4500 cfs from lake and basin flows combined). Model results show just 56 occurrences of >2800 cfs mean monthly flow and 25 events of >4500 cfs mean monthly flows for 22AZE, fewer by 16 and 2 events respectively than WSE, and 7 and 3 events respectively than Run 25.

5.3.1.4 Water Conservation Areas

A review of stage hydrographs, stage duration curves for various areas within the WCAs, and graphical plots of mean NSM hydroperiod matches for the alternatives, shows no significant difference, and in many instances, no differences at all between alternatives. Achievement of NSM like hydroperiods in the WCAs is apparently not affected by operational changes to Lake Okeechobee alone. Limited improvements (about 5%) in hydroperiod are noted in north WCA 3A due to alternative 22AZE. Attainment of NSM-like hydroperiod targets (as a percentage of total area) are similar, or the same for WSE and Run 25 in all of the WCAs.

Alternatives WSE and 22AZE deliver significantly more water to the WCAs, as opposed to sending water to tide via the St. Lucie and Caloosahatchee River Estuaries, as is currently the case under Run 25. Lake Okeechobee, under alternative WSE, would deliver roughly 157 k acre-feet of water (on a mean annual basis) to the WCAs, which is about 1.4 times more water than the approximately 109 k acre-feet (mean annual) delivered under Run 25 (actual amounts may vary depending on climatic conditions eg.

particularly wet years, or drought years and the need to make regulatory flood control releases). Alternative 22AZE delivers even more water to the WCAs than the other alternatives, about 299 k acre-feet (mean annual), 2.7 times more than Run 25 and about 53% more than would be delivered under WSE.

These alternatives likely would carry higher additional phosphorus loads to the WCAs which are higher than background receiving water levels. Output from the Everglades Phosphorus Gradient Model (EPGM) comparing the alternatives demonstrate that the additional phosphorus loading to the WCAs associated with alternatives WSE and 22AZE poses a potential negative environmental impact. These impacts are defined in terms of the area affected by increased phosphorus concentrations in the receiving water column and underlying soils. Output is defined as number of acres which could result in cattail growth (due to phosphorus accretion in the receiving soils) and number of acres where water column phosphorus concentrations are greater than 10 ppb (suggesting a change in native periphyton communities).

Assuming, in light of performance measure results, there would be minimal hydroperiod benefits to the WCAs due to the alternatives, and WCA stages are minimally affected if at all, impacts due to increased phosphorus loading become an important variable in assessing impacts. These impacts are thought to be important because they would occur in a nutrient limited (oligotrophic) system, one which is not subject to regular flushing action, and impacted soils and resultant plant growth could reasonably be determined to be irreversible. Furthermore, increased phosphorus accretion in the soils, may actually impact limited areas of the Everglades, prior to any visible cattail expansion, resulting in soil conditions which could later foster further expansion of cattails.

Output from the EPGM of a comparison of alternatives for the period January 1999 to December 2004 (W.W. Walker, 1998), demonstrates that (assuming 100 ppb phosphorus inflow from the lake) implementation of alternative WSE could result in a net expansion of cattails in WCA 1 of about 400 acres, in WCA 2A by about 50 acres, and in WCA 3A by about 85 acres above and beyond the rate of expansion which would occur under Run 25. Considering the large area of the WCAs, this represents a fairly modest impact of about 0.3% for WCA 1, 0.007% for WCA 2A, and 0.02% for WCA 3A. Dr. Fontaine, in a memorandum dated June 4, 1998, noted that STA1-West and STA-2 will become fully operational on July 2000 and August 2000 respectively. The EPGM analysis does not account for the STAs becoming operational during the simulation period, therefore impacts to WCA 1 and WCA 2 may be over estimated. The area expected to be impacted by water column phosphorus concentrations in excess of 10 ppb (thus potentially affecting native periphyton communities) is much higher. According to the EPGM, over 3,800 acres in WCA 1 (2.6% of total area) would be impacted by WSE flows, while 395 acres (0.4% of total area) would be impacted in WCA 2A, and nearly 5,700 acres (1.2% of total area) in WCA 3A (assuming 100 ppb phosphorus lake inflow).

The modeling performed, and use of an assumed 100 ppb inflow total phosphorus concentration, describes a "worst case scenario". It further assumes that the water will be uniformly distributed over the WCAs. The more likely scenario according to Barry Rosen, Ph.D. (pers. comm. 1998), is a plume effect in a much smaller area. In addition, once the STAs are constructed and functioning, water released from the lake will be treated to Phase I and later Phase II water quality standards. STA 3/4 are scheduled to be completed by 2003 and will treat the water expected from the regulation schedule releases if the timing of releases is appropriate. WSE is the only regulation schedule alternative with the flexibility to move the water into the STAs when they are best able to handle the additional water.

Purely from a water quality perspective, it may be argued that the lake regulation schedule discharging the least amount of relatively high phosphorus laden water to the WCAs would be better in terms protecting periphyton and minimizing cattail expansion.

5.3.1.5 Everglades National Park

Review of stage duration curves, hydrographs, and graphical plots of overland flow to ENP, show minimal differences between alternatives Run 25 and WSE, and only limited improvements with 22AZE in hydroperiod and overland flow across the Tamiami Trail, east and west of the L-67 extension. Reasonably, one may conclude that there would be no environmental effect associated with the various lake regulation schedules on ENP.

5.3.2 Socio-Economics

An economic evaluation investigation, examining the economic consequences of the alternative regulation schedules, is presented in ***Appendix D***, the Socio-Economics Final Report. The effects of the alternative schedules were estimated by comparing conditions expected with the new schedule in place, with conditions without the new schedule. Run 25 was used to represent without-project conditions. The economic evaluation focus was on agricultural and urban water supply, recreation, navigation, and commercial fishing.

In summary, the effects of the alternative regulation schedules, based on SFWMM output and its economic interpretation, range from relatively small to nearly insignificant. For agricultural water supply, the average annual difference between no water restrictions, and water shortages experienced over time with the current Run 25 regulation schedule in place, translated into average revenue effects for the entire EAA and LEC, whose annual agricultural output approaches $4 billion, is a little over $10 million (see Table 5.3.2-1). That is, if the system were to be operated so that there would never be a shortage of agricultural water, estimated annual revenues would be about ¼ of one percent higher than they are now. This estimated "shortfall" of about $10 million per year would be a little bit higher with 2 of the alternatives, and a little bit lower with the other two, as outlined below. These numbers are very small in terms of either a national or regional context. The analysis suggests that WSE would result in a small improvement for agriculture.

Table 5.3.2-1[1/] Estimated Agricultural Impacts for LEC and EAA		
Schedule	Change in Annual "Shortfall"[2/]	Comparison of Shortfall With Total Annual Revenues[3/]
25	N/A	-.251%
22AZE	+12.9%	-.283%
Corps 2010	+5.1%	-.263%
HSM	-6.3%	-.235%
WSE	-1.9%	-.245%

1/ Based on 2010 conditions scenario
2/ This is the difference in water supply delivery "shortfall" (shortfall = difference between perfectly timed water deliveries in needed quantities, and simulated deliveries, and is expressed as an estimated change in net farm income in the region) between Run 25 and each alternative regulation schedule. E.g., estimated average annual shortfall for Run 22AZE = $11,318,683, and for Run 25, = $10,024,086 (Table 2-7, Appendix D). [22AZE shortfall] / [25 shortfall] = 1.129; so the shortfall with 22AZE is 12.9% higher (worse) than with Run 25.
3/ This is the difference in average annual agricultural revenues between perfectly timed water supply deliveries in the needed quantities and simulated deliveries for each of the regulation schedules, expressed as a percentage of total average annual agricultural regional revenues (estimated to be approximately $4 billion). E.g., for Run 22AZE, the estimated annual shortfall of $11,318,683 = .283% of total annual revenues of $4 billion for agriculture in the region (i.e., 11,318,683 / 4,000,000,000 = .00283).

For the St. Lucie and Caloosahatchee Basins, as well as other areas around the lake that are not part of the EAA (or the LEC), data constraints did not allow for an evaluation of revenue effects. The relative difference in unmet demands, compared with total demands, did not differ significantly between alternatives.

The methodology used for computing the annual urban water unmet demand is analogous to that used for agricultural water supply. There is no meaningful measure for the effects of the plan on urban water users (comparable to agricultural revenues). The change in shortfall or unmet annual demands is even less significant than agricultural effects (in the range of plus or minus 1% to 2%, as compared with a range of about +2% to -13% for agriculture).

The potential for impacts on commercial navigation are based on the number of times the SFWMM simulation shows undesirably low lake stages (<12' for >1 year, and <11'for >100 days). The estimated economic impacts are expected to be quite small, if measurable at all. The model simulations show no change in the 12' low stage criterion for any of the alternatives. For the 11' low stage criterion, there are some very small differences between alternatives, as compared with Run 25. Since the economic impacts of any one event are likely to be small or insignificant at most, the difference between Run 25 (3 events during the 31-year simulation period) and the alternatives (ranging from 2 to 5 events during the 31-year simulation period), are not likely to be significant.

Effects of alternative regulation schedules can be short term and long term. Short term oriented effects are based on the concept that low lake stages negatively affects boater access, mobility of boaters/fishermen around the lake, and safety. Model simulations suggest that very slight decreases in the total value of Lake Okeechobee oriented recreation would occur with Run 22AZE and WSE, very small increases with HSM, and no change with Corps 2010. These short term view changes would likely be less than +/- 1%. Probably the more important long term effects would be related to the important role of a healthy littoral zone in maintaining the long-term health of the fishery.

There are no significant differences expected between Run 25 and the alternative schedules for commercial fishing in Lake Okeechobee. Alternative regulation schedules could result in improvements for commercial and recreational fishing for the St. Lucie and Caloosahatchee estuaries, relative to Run 25. But the alternative schedules will not meet the salinity-based goals for high fresh water releases to these estuaries.

The potential effects on the regional economy of any of the alternative regulation schedules are insignificant. No significant measurable impacts on regional employment, income, or sales are anticipated to result from any of the schedule changes being considered.

Although the impacts are relatively small, it is important to recognize the significance of Lake Okeechobee as a fishing, recreational, and navigation resource. It has a high economic value, but it is unlikely that the proposed operational changes would result in any significant economic change.

5.3.3 Water Quality

WSE is an incorporation of the desired features of the schedules known as Run 22, HSM, and the Corps 2010 proposal.

So for purposes of water quality analysis the comparison is done between Run 25 and WSE as there are no real significant differences in terms of water quality issues for the other schedules.

None of the operational schedules are anticipated to impact existing nutrient concentration levels of waters being discharged from the lake. This is due to the fact that the very large sediment load in the lake, which is essentially acting as a buffer, will maintain a near constant output of nutrient concentrations for a very long time, regardless of what schedule is used. During the period of time before the downstream STA is on line (approximately four years), the alternative regulation schedules are not anticipated to have significant differences in phosphorus outflows from the lake under similar volumetric outflows from the lake. However, the schedules that tend to keep the lake levels lower will reduce nutrients being transported from the center of the lake (with the existing phosphorus-rich mud sediments) to the lower nutrient concentration near shore areas. This will provide a clear and demonstrable benefit to the lake littoral zones by keeping water transparency higher and total phosphorus lower in these lower nutrient areas than would occur with higher stages. The WSE schedule is anticipated to best achieve this effect (lower lake stages) because it uses climatological forecasting. Therefore none of these schedules are expected to cause any measurable affect on the water quality of the lake. The nutrient discharges from the lake are very closely linked to the quantity of water discharged from the lake. Therefore, for purposes of analysis, nutrient output from the lake can be considered directly related to the volume discharged from the lake. Discharges from the lake are weather driven and over the long term the different schedules end up releasing essentially similar amounts of water. The major differences in the alternative schedules' downstream effects are in the timing and direction of the discharge flows.

Run 25 discharges more water to the estuarine system than the WSE schedule during wet periods. Adding more freshwater during periods of high rainfall to the estuaries stress the plant and animal life by decreasing the desired salinity levels that are considered optimum. WSE modeling has shown that shifting more water southward instead of discharging it to the estuaries will reduce these types of undesired events. Page 21, Table 6, of ***Appendix A***, shows results of modeling to demonstrate this. Run 22AZE, Corps 2010, HSM and WSE are all improvements over the base condition of Run 25 in terms of reducing the number of undesirable high freshwater discharge events to the estuaries. WSE does not have a significant difference from the other alternatives when compared to the base condition for this aspect.

Generally, during periods of water scarcity, the Run 25 schedule will put more water into the estuaries when compared to the WSE schedule. When there is water scarcity, the estuaries tend to become too salty. This is stressful to the plant and animal life of the estuarine systems. The general consensus is that the wet season benefits to the affected estuarine systems under the WSE schedule outweigh the negative benefits of the dry season possibility of hypersalinity in the affected estuarine systems.

WSE shifts more water towards the WCAs away from the estuarine systems. This would occur during a 3 to 4 year period when the STAs will not be built yet and therefore not able to remove the nutrients to desired levels. This nutrient load problem will exist during this interim period regardless of what regulation schedule is used. It can be effectively argued that both the WCAs and the estuarine systems are very sensitive and are adversely impacted by any additional nutrient loading. However the goal of hydrologic restoration is better achieved by the WSE schedule. This is because the WSE schedule moves more water southward at the appropriate times per the NSM. The hydrological targets for these areas have been developed using the NSM. There is a clear consensus that the Everglades need more water of proper timing and duration. WSE will incrementally move towards that goal for the 1990 condition. An analysis by Wm. Walker, Ph.D. (1999) summarized the comparison of loading impacts between WSE and Run 25. This analysis showed no significant difference between the two schedules in terms of loading reduction.

5.3.4 Water Management and Water Supply

The management of alternative 22AZE and the Corps 2010 regulation schedules would be very similar to the existing Run 25 schedule. Schedules WSE and HSM would include more in-depth coordination with environmental experts in the field of estuarine biology, the Lake Okeechobee littoral zone, and the Everglades, and would rely more heavily on the available climate forecasting information. See the Implementation Plan for WSE (Section 6.3) for more details. To further increase the multiple benefits for managing the lake, other water management components, such as storage areas, are necessary. This issue has been addressed in the Final Integrated Feasibility Report and Programmatic EIS for the Restudy. The regulation schedule is an important tool for managing the resource, but it has its limitations.

The objective of the water supply performance measure was to maximize the water supply capability of the lake. This was accomplished by quantifying the percentage of Lake Okeechobee Service Area irrigation demands that were met over the 31-year simulation period. (See Table 5.3.4-1 below.) Baseline simulations are referred to as the 1990 Base and the 2010 Base, and they represent, respectively, "current (circa 1990)" infrastructure and operations, and future (without project) infrastructure and operations. The 2010 Base can be interpreted as the condition that would result if the LORSS recommended no-action, or no-change from current operations. Therefore, Run 25 is assumed as part of the 2010 Base condition." For the 1990 condition, it can be seen that schedule HSM ranks highest, followed by WSE and alternative Run 25, which are tied, and then Corps 2010 and alternative 22AZE, in that order. For the 2010 condition, the superior schedule is HSM, followed by Run 25, WSE, Corps 2010, and 22AZE, in that order. It is important to note that the difference between the percentages is small. It is also important to recognize that the difference in performance between the schedules is relatively small when comparing the differences between the 1990 and 2010 conditions.

Table 5.3.4-1.
Summary of Water Supply Performance Measure for 1990 and 2010 Condition

	Run 25	**22AZE**	**HSM**	**Corps 2010**	**WSE**
1990 CONDITION					
WATER SUPPLY	91.9%	89.4%	95.3%	91.4%	91.9%
2010 CONDITION					
WATER SUPPLY	81.6%	77.2%	83.8%	80.1%	80.9%

Following the initial comparison of the first four schedules, the SFWMD developed the WSE schedule to combine the most desirable features of those four schedules to better achieve a desired balance among the competing objectives for managing the lake. Since HSM produced a greater number of undesirable high lake stage events and provided no improvement for the lake ecosystem, it was dropped out of the final comparisons. In addition, the Corps 2010 schedule lacked a zone low enough to benefit the littoral zone. For these reasons, comparisons were performed again between the remaining three alternatives: WSE, Run 22AZE and Run 25. For 1990 condition, alternative Run 25 and WSE were slightly ahead, followed by alternative 22AZE. For 2010 condition, alternative Run 25 was slightly better than WSE, followed by alternative 22AZE. The increase in demands expected for 2010 conditions would produce lower lake stages and fewer occurrences of high stage events. Thus there are fewer flood release events as compared with 1990 conditions. In 1990 conditions, for the drought years of 1971, 1975, 1981, and 1989, within the 1965 – 1995 simulation period, the water supply performance of WSE was slightly better than that for alternative Run 25. For the 2010 condition, alternative Run 25 was slightly better than WSE.

Because of the small differences in the performance of the alternatives in regard to water supply, and in view of the results of the other parameters, it would appear that the recommendation of any of the top three schedules would be satisfactory.

Although 2010 conditions assume increased demands on the lake, the simulations also assume the same historical (1965 – 1995) climate regime will re-occur. If the future climate regime is wetter than it has been during the past 30 years, then the relative performance of the schedules may be more like that shown for the 1990 conditions. Certain global-scale climate indicators suggest that south Florida may be currently entering into a much wetter climate regime that may last for several decades.

Table 5.3-1 Summary Matrix of Key Performance Measure Results for Alternative Lake Regulation Schedule Alternatives.

	NUMBER OF UNDESIRABLE LAKE STAGES > BASE	MAXIMIZE WATER SUPPLY CAPABILITY LOSS (-) OR GAIN (+) FROM BASE	NUMBER HIGH DISCHARGES TO ST. LUCIE LOSS (-) OR GAIN (+)	NUMBER OF HIGH DISCHARGES TO CALOOSAHATCHEE RIVER ESTUARY	NSM MATCHING EVERGLADES/ WCA 30 - 90 days longer/shorter	PHOSPHOROUS CONCENTRATIONS avg. yearly % difference from base	AVERAGE ANNUAL ECONOMIC EFFECTS (relative to base)
Run 25	BASE	BASE	BASE	BASE	54%	BASE	BASE
22AZE	> 17 ft > 50 days = 0 < 12 ft > 1 year = 0 < 11 ft > 100 days = 2 TOTAL = 2	DNM EAA = 615 acft DNM LOSA=395 acft	MMF > 1600 cfs = -7 MMF > 2500 cfs = -4 TOTAL = -11	MMF > 2800 cfs = 56 MMF > 4500 cfs = 25 TOTAL = 81	57%	-1.63%	($3,055,875)
WSE	> 17 ft > 50 days = 0 < 12 ft > 1 year = 0 < 11 ft > 100 days = 1 TOTAL = 1	DNM EAA = 67 acft DNM LOSA= 76 acft	MMF > 1600 cfs = -2 MMF > 2500 cfs = -6 TOTAL = -8	MMF > 2800 cfs = 72 MMF > 4500 cfs = 27 TOTAL = 99	66%	-0.18%	$5,144,909
HSM	> 17 ft > 1 year = 3 < 12 ft > 1 year = 0 < 11 ft > 100 days = -1 TOTAL = 2	DNM EAA = -323 acft DNM LOSA= -178 acft	MMF > 1600 cfs = -2 MMF > 2500 cfs = -6 TOTAL = -8	MMF > 2800 cfs = 63 MMF > 4500 cfs = 25 TOTAL = 88	55%	-0.43%	$1,703,018
Corps 2010	>17 FT > 50 days = 1 < 12 ft > 1 year = 0 < 11 ft > 100 days = 0 TOTAL = 1	DNM EAA = -198 acft DNM LOSA= 139 acft	MMF > 1600 cfs = -6 MMF > 2500 cfs = -2 TOTAL = -8	MMF > 2800 cfs = 58 MMF > 4500 cfs = 25 TOTAL = 83	56%	55.62%	($1,189,085)

5.4 Identification of the Recommended Plan

The WSE schedule was designed to increase operational flexibility. Considering the dynamic shifting of priorities for managing the lake, it is desirable to design flexible operating rules that give water managers some latitude to utilize best available multi-disciplinary information, and adjust operations as necessary to achieve a better balance of the competing objectives. Considering the potential benefits from recent lake inflow forecasting tools, and the rapid increase in state-of-the-art forecasting technology, it makes good sense to establish more flexible rules that allow water managers to utilize supplementary information and apply their sound judgement in making operational decisions.

The recommendation to adopt the WSE schedule as the new Interim Schedule should be viewed as one step in the longer process of developing a Lake Okeechobee regulation schedule optimized to best serve all of the C&SF Project purposes. Adjusting the schedule changes the way the system is operated, but there's only so much adjusting that can be done without the benefit of structural changes. The larger problems now existing in the system can only be solved by water storage on a regional scale which has been addressed in the Final Integrated Feasibility Report and Programmatic EIS for the Restudy.

6 RECOMMENDED PLAN

6.1 WSE Operational Features

Figure 6.1-1 illustrates the WSE Operational Schedule. This schedule promotes the amalgamation of the knowledge of the south Florida regional hydrologic system with that of the state and trends of the current global climate for operational proficiency. Figures 6.1-2 and 6.1-3 delineate detailed operational decision trees that will enable the successful implementation of the WSE schedule. Due to the approximate nature of extended climate forecasts, the extent of their application is proposed to be constrained by hydrologic conditions existing within the vast tributary basins. For example, it would not usually be deemed appropriate to only make minimum pulse releases in Zone B of the WSE Operational Schedule based on extended dry climate forecasts while very wet conditions exist in tributary basins and large inflows to the lake are occurring. There will be times for 'hedging' or shifting from the basic WSE Operational Schedule implementation guidelines as unique hydrologic and/or environmental conditions present themselves in the future. However, even if no such hedging occurred, the WSE Operational Schedule is designed to lead to advancement in operational proficiency by directly incorporating tributary hydrologic conditions and climate forecasts into the operational guidelines. In the following sub-sections the decision criteria (the "diamonds" in the decision tree: Figure 6.1-2 and Figure 6.1-3) are discussed in detail. These criteria may be considered the starting point from which to 'hedge' the operational decisions as unique hydrologic or environmental events present themselves.

6.1.1 Lake Okeechobee Water Level Criteria

Lake Okeechobee water levels, as with all features of the C&SF Project, are managed and monitored throughout each day by staff at the SFWMD and the Corps. The Corps uses the Water Control Decision Support System (WCDSS) to collect and exchange real-time and historic hydrologic and meteorological data with the Corps Area Offices, the State Water Management Districts, and other agencies. At the heart of water management is an effective decision support system. The WCDSS is an integrated system of computer hardware and software packages readily usable by water managers and operators as an aid for making and implementing decisions. Real-time hydrometeorologic data is also obtained from the five spillway/locks located on the Okeechobee Waterway. These sites record headwater, tailwater, rainfall, wind speed and direction, barometric pressure, gate settings, and discharge parameters. Workstations at the sites are connected to the District wide area network and data collection is done automatically on an hourly basis. Lake Okeechobee water levels will continue to be managed and monitored as is procedure with the current operational schedule.

6.1.2 Tributary Hydrologic Conditions

The majority of the Lake Okeechobee regulatory schedules prior to 1978 (USACE, Rules and Operating Criteria Master Regulation Manuals, 1978) included operational flexibility. This allowed for adjustments to be made in the timing and magnitude of Lake Okeechobee regulatory discharges based on conditions in the lake tributary basins and extended meteorological outlooks. The implementation of the WSE Operational Schedule suggests that such considerations be re-emphasized. These conditions will be especially valuable for determining whether the appropriate window of opportunity exists to 'hedge' water management practices in order to take advantage of the recent advances in climate forecasting. Two measures of the tributary hydrologic conditions are included within the design of the operational decision tree: (1) regional excess or deficit of net rainfall (rainfall minus evapotranspiration) during the past four weeks and, (2) the average S-65E inflow for the past two weeks. Each measure should be updated each week.

(((Figure 6.1-1 WSE)))

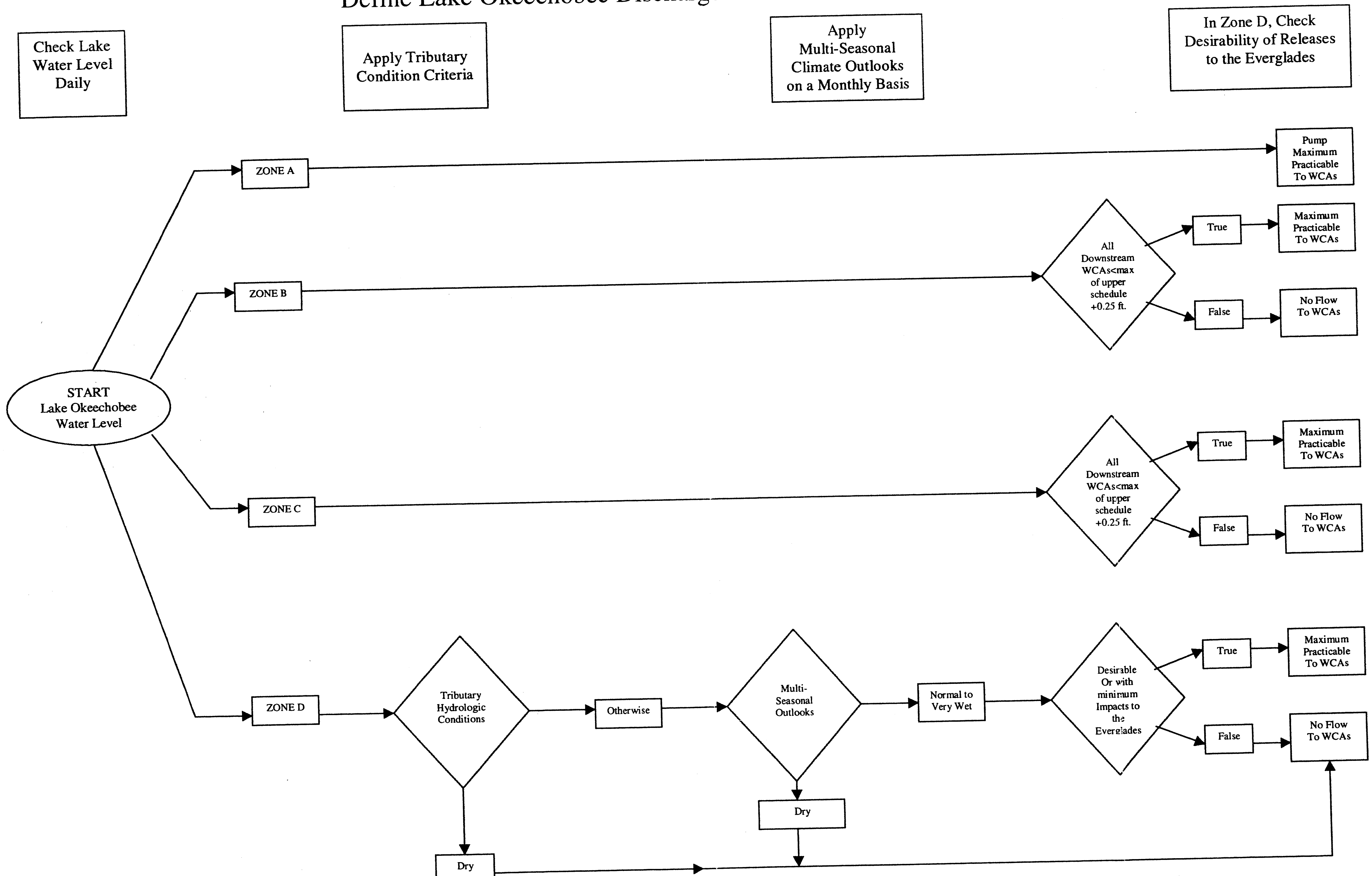
(((Figure 6.1-2 WSE Operational Tree)))

WSE Operational Guidelines Decision Tree

Part 1

Define Lake Okeechobee Discharges to Water Conservation Areas

Note: This Decision Tree provides essential supplementary information to be used in conjunction with the WSE regulation schedule.



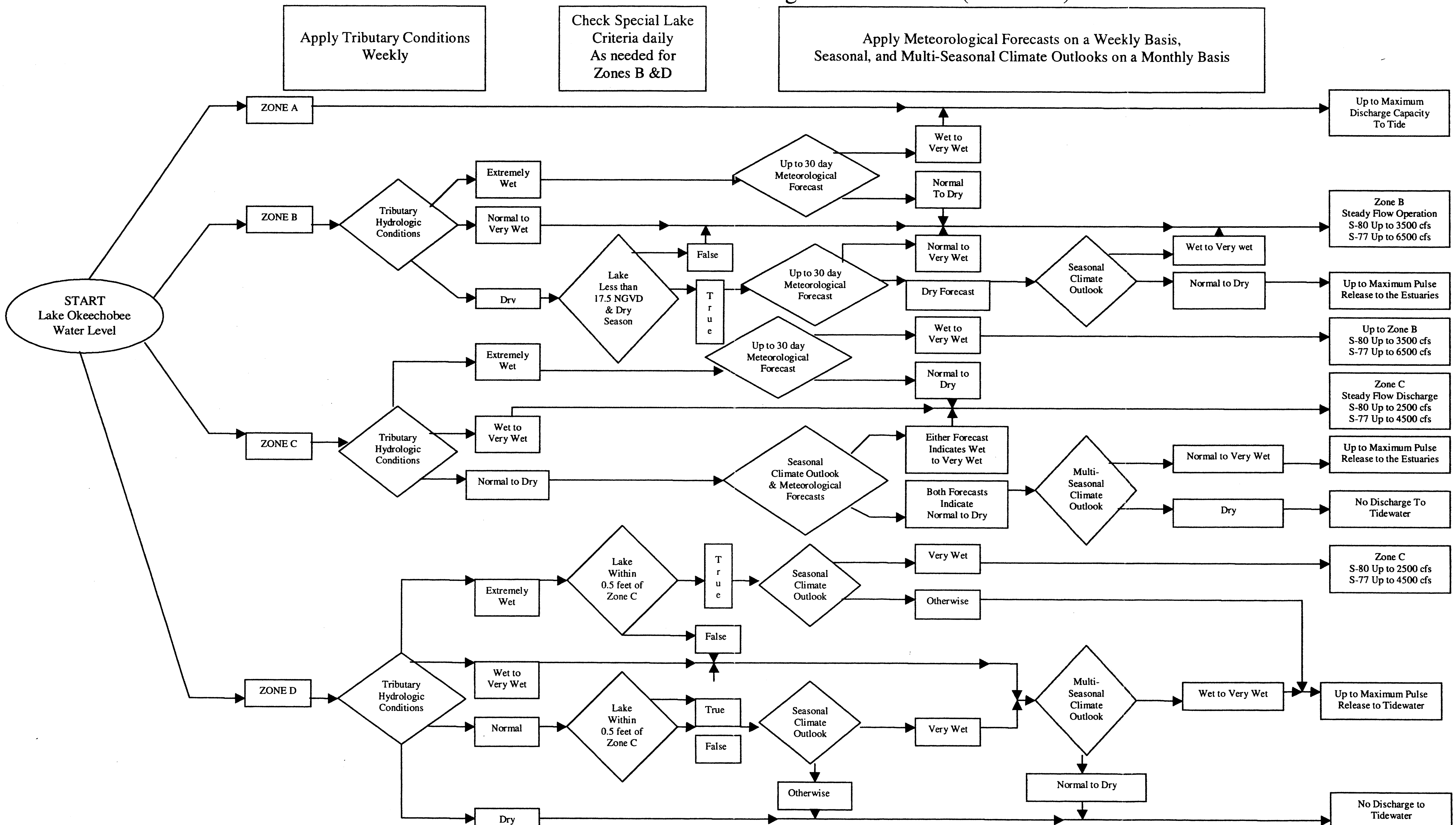
...f identifying and evaluating operational alternatives to unique regional hydrologic and/or environmental conditions that may occur.

WSE Operational Guidelines Decision Tree

Part 2

Define Lake Okeechobee Discharges to Tidewater (Estuaries)

Note: This Decision Tree provides essential supplementary information to be used in conjunction with the WSE regulation schedule.



Hydrologic analysis will be performed as needed for the purpose of identifying and evaluating operational alternatives to unique regional hydrologic and/or environmental conditions that may occur.

(((Figure 6.1-3 WSE Operational Tree)))

6.1.3 Thirty-Day Net Rainfall

The merit of the regional net rainfall may be derived from the following data sets:

(1) The monthly rainfall record from the National Climatic Data Center (NCDC) for the period 1895-1998, and
(2) The monthly evapotranspiration which was estimated as being 75% of the standard project storm ET for the Kissimmee River Basin (USACE, 1978).

The net rainfall was computed by subtracting the monthly ET from the monthly rainfall for the period 1895 through May of 1998. The maximum, minimum, quartiles and 90th percentile of the net rainfall for each month is illustrated in Figure 3a in ***Appendix C***. Figure 3b in ***Appendix C*** delineates the rainfall exceedance curve with all the months of the year being considered collectively. In the implementation of the WSE schedule, it is recommended that the tributary rainfall data may be represented by averaging the upper and lower Kissimmee basins for the previous 30-day rainfall as made available in the South Florida Water Management District's (SFWMD) daily weather report. The tributary basin ET may be represented as 60% of the long term daily average pan evaporation estimated at the Lake Alfred experimental station (on an annual average basis 60% of Lake Alfred Pan evaporation is equivalent to 75% of the standard project storm or about 44 inches per year). The net rainfall provides a valuable indicator of the regional hydrologic trends within the tributary basin during the past four weeks.

Two-Week Average S-65E Flow

The S-65E flow factors in the rainfall excesses or deficits that have accumulated within the Kissimmee tributary basins over periods of the past few days to periods for as long as several months. On average, S-65E flow represents between 35 to 50 percent of the structural inflows to Lake Okeechobee and thus is an additional effective regional hydrologic indicator of conditions in the tributary basin. Figures 4a and 4b in ***Appendix C*** summarize the statistics for the 14-day running average S-65E flow (the summary statistics consist of the maximum 14-day flow that occurred within each month) with a similar convention as was used for net rainfall. The period of record included in this analysis extends from 1930 through June of 1998. Sequential and ranked net rainfall and S-65E flows as computed for Figure 3 and Figure 4 are included in ***Appendix C***.

6.1.4 Identifying Various Hydrologic Regimes

Table 6.1.4-1 summarizes the ranges of the net rainfall and two-week average flow as they were selected to represent the various hydrologic regimes. These ranges were based on: (1) an extensive review of the available hydrologic record for the period beginning in 1930 and extending through the El Nino period of 1997-1998 and, (2) testing with the application of the South Florida Water Management Model to determine the best threshold values for meeting the regional hydrologic performance measures. In this respect, each hydrologic classification is not specifically related to the mean or variances of the regional hydrologic indicator.

The wettest classification of the two regional hydrologic indicators is selected to represent the hydrologic conditions in the tributary basin to ensure that flood protection criteria are being met. Therefore, if net rainfall indicates wet conditions but S-65E flow indicates normal conditions, the operational condition will be taken to be 'wet'. During extreme wet conditions it is desirable to check regional hydrologic conditions every day. When conditions become extremely wet, there may be significant advantages for flood protection and environmental considerations to increase flows above the maximum flow rates defined for a given zone. This type of action should be taken only after the appropriate consideration has been given to all the primary water management objectives. When considering drier than normal conditions, both measures of tributary moisture should indicate dry conditions before tributary hydrologic conditions are defined to be 'dry'. The tributary hydrologic indicators should be updated weekly with a new value being computed for net rainfall and for average S-65E inflow each week.

Table 6.1.4-1. Classification of Tributary Hydrologic Regimes (Check weekly)*

Tributary Condition	Net Rainfall (inches past 4 weeks)	S-65E Flows (cfs - 2 week average)
Very Dry	less than -3.00	Less than 500
Dry	-3.00 - -1.01	500 - 1499
Normal	-1.00 - 1.99	1500 - 3499
Wet	2.00 - 3.99	3500 - 5999
Very Wet	4.00 - 7.99	6000 - 8999
Extremely Wet	Greater than 8.0	greater than 9000

* Wet conditions are defined by the wettest of these two indicators.

6.1.5 Summary of Historical Rankings

Table 6.1.5-1 summarizes the percentage of time that historical rainfall and S-65E flow indicated that tributary hydrologic conditions were classified within various hydrologic regimes depicted in Table 6.1.4-1. Also listed in 6.1.5-1 are the net rainfall, S-65E flow, and the total net inflow that includes the effect of net rainfall on the lake. During periods that normal hydrological conditions exist in the tributary basin, the lake water levels can most often be successfully regulated by low impact pulse releases to tidewater. This relationship is established by comparing the average net Lake Okeechobee inflow under normal conditions in Table 6.1.5-1 to the sum of the mean Level 2 pulse releases through the St. Lucie and Caloosahatchee estuaries to tidewater. The sum of the mean impulse releases through the St. Lucie and Caloosahatchee outlets is equal to 3,200cfs/day, which approximately equals the average net inflow when the tributary conditions are in the normal range. During these normal to dry tributary conditions, the majority of the lake inflow would be required for water supply and natural ecosystem enhancement. For wet to very wet tributary conditions, normally larger steady flow discharges to tidewater will be required to control the lake level. While for extremely wet conditions, larger flows, up to maximum capacity, may be required to control the lake water levels. The exact magnitude of discharge required to tidewater is dependent on the lake water level, whether the seasonal lake operational schedule is rising or falling, the conveyance capacity for delivering excess water to the WCAs, the desirability or impact such releases would have on the Everglades, and finally, the temporal and spatial distribution of the rainfall.

Table 6.1.5-1. Percentage of weeks that fall within each of the hydrologic regimes (based on the period of January 1930 through June 1998)

Tributary Conditions	Percent Occurrence	Average Net Rainfall (inches past 4 weeks)	Average S-65E Flow (cfs - 2 week average)	Average Net Lake Inflow (cfs - 2 week average)
Dry	21%	-2.2	580	1463
Normal	47%	0.1	1324	3236
Wet	19%	2.4	2344	5952
Very Wet	11%	4.7	3664	10007
Extremely Wet	2%	8.1	7929	16427

6.1.6 Hydrologic Conditions during the 1997-1998 El Nino

The WSE operational guidelines were designed in part based on the events of the 1997-1998 El Nino. This period includes by far the wettest dry season in the 103 years of record available for the lake tributary basin. Areal average net rainfall of about 22 inches occurred over the lake's vast tributary basin during the period of November 1, 1997 through March 31, 1998. This excess rainfall was more than twice as large as the second largest event that occurred during the 1982-1983 El Nino (November-March period). The 1982-1983 event had a net rainfall that was equivalent to about 10 inches of rain averaged over the lake tributary basin. The current operational schedule was designed to lessen the impacts of an El Nino event such as that which occurred during the dry season of 1982-1983 with the tools available at that time, but not a dry season rainfall as extreme as the 1997-1998 event. Complicating matters for water management in south Florida was the fact that the last moderately strong El Nino (1991-1992) did not produce greater than normal rainfall. The WSE Operational Schedule would not recommend discharges during the 1991-1992 El Nino condition since the tributary basin remained relatively dry during this period. It does, however, allow for an earlier response at lower lake levels during the 1997-1998 El Nino since the tributary conditions met the criteria of being 'very wet' by December 1997.

Figure 5 in ***Appendix C***, illustrates the lake water levels relative to the WSE Operational Schedule during the 1997-1998 El Nino event. As the water levels in the lake rose above the lowest line of the schedule in late November, net rainfall conditions already indicated the tributary basins were 'wet' and quickly becoming 'very wet'. This information, when combined with the Climate Prediction Center forecast for the likelihood of above normal rainfall, would have recommended the initiation of pulse releases to tidewater. Within the month of December of 1997, both net rainfall and S-65E flow conditions were indicative of 'extremely wet' conditions. During this period, when lake water levels were in Zone D, it would have been desirable to initiate steady flow releases. Hydrologic conditions in the tributary basins remained extremely wet until the end of March. These conditions suggest that larger than the standard discharges in both Zones C and B would have been desirable in an attempt to decrease the duration of Zone A discharges. By mid-April, the tributary basins were in a drying state so that steady flow discharges were allowed to be reduced to pulse releases during the remainder of the dry season. A forecast of below normal rainfall for June of 1998 by the Climate Prediction Center and an increased potential for dry climate conditions for the 1998-1999 dry season suggested that it may be advantageous to discontinue releases to tidewater during May, 1998. However, the passing of tropical storm Mitch in early November of 1998 eliminated potential advantages gained from this last action.

Another useful example of combining tributary hydrology with climate forecasts is the case of the spring and summer prior to a forecasted La Nina Year. During wet season months, based on the net rainfall computations for the tributary basins, conditions are normally classified as approaching or being wet during the period of June through September. However, during certain years the wet season may get a late start and/or never reach the normal wet conditions as defined in Table 6.1.5-1. Such a combination of factors may lead to increased potential for drought, especially if the following dry season is a La Nina year. Therefore, it may, at times, be desirable to discontinue or reduce regulatory discharges during the late spring months until the selected indicators suggest that a normal rainy season has begun. If conditions stay dry in the tributary basins, the lake will decline to the desired levels by ET and water demands alone as the tropical season approaches. This will minimize impacts to the estuaries during a period of the year when large freshwater inflows are not normally desirable. This type of operational action should only be implemented in a way that ensures that lake water levels do not exceed critical water levels during the peak of the hurricane season.

6.1.7 Special Lake Okeechobee Water Level Criteria

Three special Lake Okeechobee water level criteria are included in the operational decision tree. These criteria are as follows:

(1) Pulse releases are only permitted to replace steady flow releases during the dry season and when the lake is below 17.5 feet.

(2) When lake water levels are in the upper portion of Zone D, within .5 feet of Zone C, and normal conditions exist in the tributary basin, the decision to make pulse releases should be based on multi-seasonal forecasts.

(3) While water levels are in Zone D, steady flow discharges due to extremely wet tributary basins are only suggested if the lake water levels are within .5 feet of Zone C.

Higher than desirable water levels in the WCAs should allow pulse releases to be made to tidewater at lower lake levels, while lower than desired water levels in the WCAs may preclude or lessen regulatory discharges being made to tidewater. This is particularly true while water levels are in Zone D.

Three levels of 10-day pulses are defined for the St. Lucie and Caloosahatchee estuaries under the WSE Operational Guidelines. These pulse release hydrographs are listed in Table 6.1.7-1. The level of pulse release selected at a particular juncture of the operational decision tree will depend on a number of factors including, but not limited to: (a) the ecological status of the lake's littoral zone; (b) the ecological status of the downstream estuaries; (c) the current tributary hydrologic conditions; (d) the seasonal and multi-seasonal climate based hydrological conditions: (e) water levels in the WCA's. The benefits of pulse releases can be best realized if desired lake water level targets are identified for future months and hydrologic position analysis is applied for determining the likelihood of being within a particular range of these target levels. Recognizing climate shifts and associated hydrologic events is a crucial part of position analysis. The level of pulse should be selected to best follow the future targets while not taking unnecessary risk towards meeting any of the major objectives for managing the lake water levels. In general, pulse releases should not exceed Level 3 when pulse releases are called for in the operational decision tree.

Table 6.1.75-1. Pulse Release Hydrographs for Three Levels of Pulse (units = cfs/day)

Day	St. Lucie Estuary			Caloosahatchee Estuary		
	I	II	III	I	II	III
1	1,200	1,500	1,800	1,000	1,500	2,000
2	1,600	2,000	2,400	2,800	4,200	5,500
3	1,400	1,800	2,100	3,300	5,000	6,500
4	1,000	1,200	1,500	2,400	3,800	5,000
5	700	900	1,000	2,000	3,000	4,000
6	600	700	900	1,500	2,200	3,000
7	400	500	600	1,200	1,500	2,000
8	400	500	600	800	800	1,000
9	0	400	400	500	500	500
10	0	0	400	500	500	500

6.1.8 Seasonal Climatic and Meteorologic Outlooks

Due to the intricate and vast nature of the C&SF Flood Control Project and the complex interactions of tropical and extra-tropical weather systems that affect Florida's weather, it should not be expected that extended forecasts could be made to a very precise level of accuracy. However, with recent advances in climate prediction, it is now possible to predict with some level of confidence whether the upcoming season is likely to have above, below or near normal rainfall. Changnon (1982) indicated that certain longer term regional water resources operational planning decisions can be enhanced by applying climate forecasts that are classified into three such categories. It is at this level of detail that the official seasonal forecasts from the National Center of Environmental Predictions, Climate Prediction Center (CPC) are to be referenced in this application.

The year is partitioned into two seasons:

(1) Wet season (May-October) and
(2) Dry season (November-April)

The 3 to 6 month climate forecasts should be applied to make probabilistic hydrologic forecasts for the remainder of the current season. In addition to climate forecasts, when lake water levels are in Zone C or higher, one to two week meteorologic forecasts should also be considered.

6.1.9 Multi-seasonal Climate Outlooks

Multi-seasonal outlooks are applied to determine when an increased possibility of extended periods of abnormal rainfall may occur either in the form of large inflows to the lake or increased potential for drought. When applying multi-seasonal climate forecasts for operational planning, it is important that the cumulative hydrologic effects be considered.

6.1.10 Tables of Additional Tools and Measures for WSE Implementation

There are several useful measures and tools that are currently available for Lake Okeechobee operational decisions. One of the most valuable sets of tools may be the regional hydrologic models that are available within the Hydrologic Systems Modeling Division of the Planning Department of the SFWMD. These models are summarized in Table 6.1.10-1. Table 6.1.10-2 lists additional meteorological and climate forecasts that may be considered.

Table 6.1.10-1 Regional Hydrologic Models

Object-Oriented Routing Model (ORM) This model is initialized with current water levels and simulates water levels for a period of several months up to two years into the future considering climatological events that have occurred in the past. It is most useful in making probabilistic forecasts of expectation and setting confidence levels for these hydrologic projections when the climatology of the current year can be identified with a select class of past climatological years. For example, the 1998-1999 projected La Nina conditions may suggest that only the past La Nina years be considered when determining the expected value and confidence levels of these projections. This type of application is often referred to as 'position analysis'. Contacts are Cary White, Dr. Luis Cadavid, Dr. Jayantha Obeysekera and Randy Vanzee. South Florida Water Management Model (SFWMM) This is the most well known regional hydrologic model. Its model domain includes Lake Okeechobee, the Caloosahatchee River and the St Lucie River Basins, southward through the Everglades and into the Lower East Coast Developed Region. Currently this model is only applied for continuous simulation but may also be a valuable tool if applied in the framework of position analysis. Contacts are Dr. Luis Cadavid, Paul Trimble, and Ray Santee. South Florida Regional Simulation Model (SFRSM) This is the newest of the regional models that currently may be applied for the Everglades. Contact is Randy Vanzee. Upper Kissimmee Lakes Model (UKISS) This model simulates the Upper Kissimmee Lakes and may be useful for projecting flows through S-65 that will make their way through the Kissimmee River Basin to the lake. Contact is Randy Vanzee.

Table 6.1.10-2. Additional Climate Based Tools

Converting NOAA Climate Forecasts to Statistical Hydrologic Forecasts Thomas Croley (1996) presents an approach that applies historical hydrologic data together with the new long-lead climate forecasts, for making statistical hydrologic forecasts. The potential use of this methodology is currently under investigation by the Hydrologic Systems Modeling Division. Croley's paper appears in ***Appendix C***. Contacts are Dr. Luis Cadavid and Dr. Jayantha Obeysekera
Atlantic Ocean Thermohaline Current Ongoing research of Colorado State University and the Atlantic Oceanographic and Meteorological Laboratory, have reported on cyclic decadal shifts of the Atlantic Ocean currents that significantly affect Climate regimes within the Atlantic Ocean Basin. The most recent indicators of the phase of this ocean current indicates that Florida may expect much wetter conditions from June through October during the next few decades similar to those that were experienced during the decades of the 1930s, 1940s, 1950s and the 1960s. Contact is Paul Trimble.
Meteorological and Climatological Forecasts SFWMD's Meteorological Forecasts. Contacts are Geoff Shaughnessy and Eric P. Swartz.
Solar Eruptive Activity and Secular Trends Rainfall Activity seasonal to multi-seasonal prediction of shifts. Contact is Paul Trimble.
Artificial Neural Networks, Intelligent Systems and Other Pattern Recognition Technology Pattern recognition technology such as neural networks has provided another valuable tool for forecasting regional climate shifts for Florida that may best be explained by considering the state of El Nino, the Atlantic Ocean Thermohaline and solar activity together. Contacts are Beheen Trimble and Paul Trimble.

6.2 Climate Based Forecasting

Recent breakthroughs in the diagnostics of climate variability on seasonal to decadal time scales provide a valuable mechanism for the advancement of the level of proficiency of regional water management. This potential for advancement results from increased lead times of forthcoming climate anomalies that may persist for extended periods. These anomalies may occur in the form of long term departures from average climate conditions and/or a distinct change in the likelihood of occurrence of extreme events. When these anomalies are recognized as being associated with larger scale prolonged climate phenomena, the advantages of an adaptable operational schedule are significant. This opportunity for increasing the efficiency of the regional hydrologic system is very timely considering the challenges that we face in managing our future water resources in south and central Florida.

The WSE operational schedule incorporates a six month lead inflow forecast. In addition to the increased flexibility incorporated into the operational rules of the intermediate zones, the proposed schedule permits excess water to be discharged from the lake at lower water levels when large inflows are expected, based on current and projected hydrologic conditions. The National Climate Prediction Center official climate and ENSO outlooks are applied to estimate expected inflow to the lake.

With the recent strides made in the understanding of climate variations on different time scales, the proposed lake operational schedule offers guidelines for refined water management practices for Lake Okeechobee. Adjustments to discharges for each zone of the schedule are based on climate forecasts and hydrologic conditions.

By integrating the effects of large atmospheric and oceanic processes on Florida's climate, the accuracy and certainty of climate forecasts can be significantly increased. This type of system is a powerful tool for pattern recognition. With this new tool that estimates Lake Okeechobee 6-month inflows, guidelines are established for the WSE schedule to improve the proficiency of water management.

Due to the intricate and vast nature of the C&SF Flood Control Project and the complex interactions of tropical and extra-tropical weather systems that affect Florida's weather, it should not be expected that extended forecasts could be made to a very precise level of accuracy. However, with recent advances in climate prediction, it is now possible to predict with some level of confidence whether the upcoming season is likely to have above, below or near normal rainfall. Changnon (1982) indicated that certain longer term regional water resources operational planning decisions can be enhanced by applying climate forecasts that are classified into three such categories. The year is partitioned into two seasons:

wet season (May – October) and
dry season (November – April)

The 3 to 6 month climate forecasts should be applied to make probabilistic hydrologic forecasts for the remainder of the current season. In addition to climate forecasts, when lake water levels are in Zone C or higher, one to two week meteorologic forecasts should also be considered.

Multi-seasonal outlooks are applied to determine when an increased possibility of extended periods of abnormal rainfall may occur either in the form of large inflows to the lake or increased potential for drought. When applying multi-seasonal climate forecasts for operational planning, it is important that the cumulative hydrologic effects be considered.

There are several useful measures and tools that are currently available for Lake Okeechobee operational decisions. One of the most valuable sets of tools may be the regional hydrologic models that are available within the Hydrologic Systems Modeling Division of the SFWMD Planning Department. These models are summarized in Table 6.1.11-1. Table 6.1.11-2 lists additional meteorological and climate forecasts that may be considered.

6.3 Implementation of WSE Schedule

The section below explains the technical details underlying the implementation of the WSE lake regulation schedule, including the modeling tools used and references for more detailed information available on various web sites.

6.3.1 Introduction

The Internal Operational Planning Core (OPI) team has developed a decision tree for implementation of the WSE Operational Schedule (Operational Planning Team, 1999). The operational decision tree has been separated into two schematic diagrams. One diagram depicts the decision tree for discharges from the lake to the WCAs, while the second diagram depicts discharges from the lake to tidewater. If discharges to the WCAs are not large enough to control the lake levels at the desired level, then the WSE operational guidelines would allow releases to tidewater. The WSE Operational Schedule was developed with the primary intention of relieving stress on the lake littoral zone. By incorporating additional information (such as tributary basin hydrologic conditions, and meteorologic and climatic forecasts) directly into the operational guidelines, it was determined that it is possible to relieve the stress on the littoral zone while also improving the other objectives for managing the lake levels and discharges. This has become possible because of the very recent advances in understanding climate variability.

The additional water management objectives include: (1) flood protection, (2) water supply and (3) Everglades hydro-pattern enhancement. The WSE Operational Schedule decision trees were developed to act as a decision support system. The WSE operational guidelines and the decision support schematics are included in Figures 6.1-2 and 6.1-3. If one of the major ecosystems has experienced a large level of stress in recent months and/or years, it may be appropriate to hedge the operational guidelines in a direction that would allow for the recovery of that particular ecosystem. This type of action should be taken only with the support of hydrologic analysis, which documents the benefits that would be achieved and the risks that may occur due to such an action. These results should be reviewed by the Internal Operational Planning Core (OPI) team which should include environmental experts for the Lake Okeechobee littoral zone, the downstream estuaries, and the Everglades, to review any proposed deviations. The OPI will meet on a regular basis.

6.3.2 Lake Water Level and Tributary Hydrologic Conditions

Climatological and meteorological forecasting are far from perfect sciences. Therefore, a set of operational guidelines has been developed so these forecasts can be applied in a safe manner. This is accomplished by directly incorporating the tributary hydrologic conditions as inputs into the decision support system. While this inclusion may limit the full potential benefits that may be realized from climate forecasts, it also safeguards against extreme adverse conditions occurring in the case of an inaccurate forecast. The forecast that is applied depends on the zone the lake water level is in and the hydrologic conditions in the tributary basin. The "diamonds" are the essence of the decision support schematics. These diamonds determine the most appropriate decision criteria to be applied within each operational zone of the WSE schedule. The current operational zone, followed by the moisture conditions in the tributary basin (tributary hydrologic conditions are only considered in Zone D for the discharges to the WCAs), are the first two criterion considered. The current zone that the lake level falls within can be accessed on the USACE Water Management and Meteorology URL:

[http://www.saj.usace.army.mil/h2o/plots/okehp.gif].

The hydologic net rainfall moisture parameter is posted on the SFWMD Hydrologic Systems Modeling Division URL:

[http://141.232.1.11/org/pld/hsm/opr/TRIBUTARY/Kiss_netRF_0430.pdf]

This parameter is similar to the Palmer Z index but is not normalized for each month of the year. The South Florida Water Management District is responsible for keeping this value updated. Table 6.1.4-1 indicates the classification of the hydrologic regimes. Normally the wettest of the two parameters is used to classify the hydrologic regime.

6.3.3 Meteorological and Climate Forecasts in Zones B & C

The season of the year and the lake water level determine the most appropriate forecast to use. For example, when water levels are in Zone B, shorter-range meteorologic and climatological forecasts (a few days up to 1 month) would be the most appropriate forecasts to utilize. The SFWMD meteorologists have a wealth of additional material at hand for making their forecast. To completely understand the complexity of making reliable meteorological forecasts, a walk-through of the meteorological "war room" is suggested. On an active day, a meteorological forecast sometimes will need to be checked on "time steps" less than an hour long, while other days may allow time for documenting the effect of past storms and preparing for the next one. A sampling of the information that must be interpreted appears at the URL site:

http://xweb/curre/2_weather.html

Of course, the information that the meteorologist must analyze will be much more detailed and complex. Generally, the forecasters of the SFWMD Operational Department will interpret the forecasts for operational purposes.

6.3.4 Climatological Forecasts look at an Extended Period

Understanding the impacts of climate variation is as important as being able to predict global scale variations. [redacted] The Climate Diagnostic Center (CDC) provides excellent tools to determine expected mean rainfall and chances of extreme events if El Nino or La Nina are present during a particular month of the year. The URL for the mean (composite conditions) is:

http://www.cdc.noaa.gov/ENSO/enso.climate.html#compos

While the URL for extreme conditions is:

http://www.cdc.noaa.gov/~cas/atlas.html

In the lower portion of Zone C (with falling water levels) and Zone D, priorities shift to a larger time window. The water level may be very healthy for the littoral zone at the current time. However, this may not be good for the littoral zone or the other water management objectives if the climate forecasts predict an extended dry period during the next several seasons. Since Zone D is a wider zone with no immediate flood or drought implications [redacted] If an extended dry period is forecasted it would be wiser to keep the water in the system. There are a large spectrum of credible, though experimental, forecast models that may be used for this decision making process. A summary of these model forecasts was formally published by NOAA's Climate Prediction Center. However, this publication is now published by the Center for Ocean-Land-Atmospheric Studies, which is supported by NOAA, NSF and NASA. Several forecasts are made by highly respected research institutes, although they don't necessarily agree with each other or the CPC forecasts. These include: (1) The Columbia University, (2) the Bureau of Meteorological Research, Melbourne, Australia, (3) Scripts Institution of Technology and Max Plank Institute for Meteorology, Germany, (3) Center for Ocean- Land-Atmospheric studies, and many other credible resources. The URL for this publication is:

http://grads.iges.org/ellfb/.

Click on contents to review individual forecasts. A Forecast Forum is provided by NOAA, which exists at the URL:

http://nic.fb4.noaa.gov/products/analysis_monitoring/bulletin/forecast.html

This forum summarizes the results of several forecasts and makes a general prediction.

The artificial neural network predictions are currently under review at this time. The results should be posted on the Operational Planning URL only after a satisfactory peer review is completed. The Environmental Research Laboratory is currently reviewing important predictors for seasonal variations of the Florida climate. When this information becomes available it will also be applied as a decision making tool.

6.3.5 Estuary

Leading experts from the SFWMD will determine the needs of the estuaries. Although maintaining certain ranges for the salinity envelopes is desirable during lake discharges, they still need to be checked on a case-by-case basis to determine the status of the individual estuarine ecosystems. Estuaries can also be impacted by hypersalinity. From an environmental standpoint, during these times the estuaries would benefit from freshwater releases to attain the preferred salinity envelope.

6.3.6 Object Oriented Regional Routing Model (ORM)

The regional routing model is currently used to insure that the choices made by the Operational Planning Team won't lead to an unwarranted increase in the chances of an adverse occurrence. This model is used for position analysis in which the current water levels are input to the model each day of the year of the 31 years that the ORM executes. The meteorological conditions that occurred from 1965 to 1995 that were included in the model are allowed to repeat themselves. This allows the water levels to be simulated for the next 12 months to generate probability percentiles for each month. These results may be found at the following URL:

http://141.232.1.11/org/pld/hsm/opr/index.html

When all years are considered equally, there is quite a spread of possibilities. However, during particular climate scenarios, the range of possible outcomes narrows significantly. For the initial implementation of the WSE Operational Schedule, it is envisioned that the ORM will continue to be used just as it has been. In the future, as the climate forecasting capabilities increase and the period of record of the ORM is extended, it is envisioned that this tool may prove to be very valuable for operational planning.

6.3.7 New Available Tools

As new forecasting tools become available, they should be posted on the operational planning page. If the methodology is a significant improvement, it should be written in "Currents" or for the local newspapers. The NOAA Environmental Research Laboratory in Miami is working on one improvement that may occur within the next year. This group has had much success in down scaling global ocean and atmospheric variability for useful predictions for regional water management. Their work goes well beyond the application of the El Nino-Southern Oscillation, but considers variabilities that occur across the globe. In addition, further refinements are being made to include the application of neural networks for down scaling global scale climate variability for regional water management.

6.3.8 Documentation

For the time being, as crucial decisions are made, the logic and reasoning behind those decisions should be noted. The forecast tools that were used should also be listed. This should be an integral part of the WSE schedule.

6.3.9 Rapid Response

Rapid response should not be as necessary under the WSE Operational Schedule since much of the operational flexibility is built directly into the schedule guidelines. However, it would be valuable in certain emergency situations to have a procedure that initiates a quick response from the Governing Board Members in a systematic way.

7 ENVIRONMENTAL EFFECTS

The environmental effects of the array of alternatives are presented below. Attention is focused on those issues considered ripe for discussion and that have been determined, through environmental analyses and coordination with resource managers and scientists, to be of particular concern or expected to be impacted proportionally greater than others. A brief synopsis of the environmental effects are summarized in Table 7, on the following pages.

7.1 Topography, Geology and Soils

Effects to the regions topography, geology and soils are discussed below. Topography and geology are distinguished from soils as there are no impacts expected to the regions' topography or geology and only minimal impacts to soils.

7.1.1 Topography and Geology

The scope of the proposed action, as well as any alternative actions, is limited to operational changes, with no proposed structural features, no proposed construction of any nature, and outflow from the lake will be conveyed through existing channels and structures. This is not expected to result in any impacts to the topography or geology of the study area.

7.1.2 Soils

The lake regulation schedule alternatives are not expected to have a substantial affect on soils within the study area. Despite the fact that under some alternatives more water is discharged from the lake to the WCAs, modeling shows that there is minimal, if any, difference in the amount of time marsh areas are flooded throughout the year. Longer hydroperiods in the WCAs would help retard soil subsidence which results from soil that is too dry for much of the year. The peat is then oxidized and subsides or diminishes in content, often forming a depression where water can pond. The difference between alternatives under existing conditions and in the future without project condition in retarding soil subsidence, is likely to be minimal. All of the alternatives, including the existing schedule, result in significantly less flooding of the marsh in northern WCA 3A, where drier than normal hydroperiods are a problem, than that predicted by the Natural Systems Model (NSM).

All of the alternatives are predicted to discharge less water from the lake to the estuaries than Run 25 under the future base. Soil erosion, along the bank of the St. Lucie Canal, in particular, may be somewhat reduced by lower average flood control releases which would result under alternatives HSM, WSE, 22AZE and Corps 2010. However, it is likely that occasional high volume (Zone A) discharges cause the most damage to canal banks and sluffing of adjacent soils. This scenario, whereby large amounts of water would need to be quickly released from the lake when lake stages surpass Zone A of their regulation schedule, would still occur under any of the alternatives. Therefore, it is reasonable to assume that there would be only minor differences between any of the alternatives in protecting soils adjacent to or within existing conveyance canals.

TABLE 7
SUMMARY OF ENVIRONMENTAL CONSEQUENCES

Environmental Components	Run 25	WSE	22AZE	Corps 2010	HSM
Topography and Geology	No adverse effects expected (0)	No adverse effects expected (0)	No adverse effects expected (0)	No adverse effects expected (0)	No adverse effects expected (0)
Soils	No adverse effects expected (0)	Possible minor benefits due to less oxidation of soils (+)	Possible benefits due to less oxidation of soils (++)	No adverse effects expected (0)	No adverse effects expected (0)
Climate	No adverse effects expected (0)	No adverse effects expected (0)	No adverse effects expected (0)	No adverse effects expected (0)	No adverse effects expected (0)
Air Quality	No adverse effects expected (0)	No adverse effects expected (0)	No adverse effects expected (0)	No adverse effects expected (0)	No adverse effects expected (0)
Noise	No adverse effects expected (0)	No adverse effects expected (0)	No adverse effects expected (0)	No adverse effects expected (0)	No adverse effects expected (0)
Vegetation	Continued degradation of littoral vegetation in lake and estuarine seagrasses (3)	Benefits to littoral vegetation (++) and seagrasses (+), minor adverse impacts (cattail expansion) to WCAs 2A/3A (1)	Benefits to littoral vegetation (+) and seagrasses (+), possible adverse impacts to sawgrass in WCAs (2)	Not a significant improvement over existing Run 25, continued degradation of lake, and especially, estuarine vegetation (2)	Particularly adverse effects to lake vegetation due to sustained high lake stages (3), not a significant improvement over existing schedule for estuarine seagrasses (2)
0 = No Consequences **(+) = Limited Benefits**	**1 = Minimal Adverse Effects** **(++) = Substantial Benefits**	**2 = Moderate Adverse Effects** **(+++) = Extensive Benefits**	**3 = Extensive Adverse Effects**		

Environmental Components	Run 25	WSE	22AZE	Corps 2010	HSM
Fish and Wildlife	Short-term = continued degradation of lake and estuarine F&W habitat (3) Long-term = improvements to hydroperiod due > water supply demands and lower overall lake levels. Potential cumulative adverse effects (2)	Improvements to lake (++) and St. Lucie Estuary (+) hydroperiods and F&W habitat. No effect on Caloosahatchee River and WCAs (0)	Improvements to lake, although too many prolonged low lake stages (+). Improvements to estuarine F&W conditions, through reduced regulatory discharges (+). Potential adverse effects to Everglades habitat through > amt. Lake water discharged to WCAs (2)	No significant improvements over existing condition for fish and wildlife habitat (2), continued degradation of already adversely impacted fish and wildlife species and habitat (3)	Particularly adverse to lake resident species and their habitat due to continued, and possibly exacerbated, high water conditions (3), no significant improvement over existing schedule for estuarine species (2)
Threatened & Endangered Species	No significant impacts to T & E species expected beyond present adverse condition (1)	Slight improvement for some species (+)	No significant impacts to T & E species expected (1)	No significant impacts to T & E species expected (1)	Possible adverse impacts to some species (wood storks, Okeechobee gourd) due to extreme high and prolonged high lake levels
Water Management	No significant adverse impacts expected (0)	No significant adverse impacts expected (0)	No significant adverse impacts expected (0)	No significant adverse impacts expected (0)	No significant adverse impacts expected (0)
Water Supply	No significant impacts to water supply expected (0)	No significant impacts to water supply expected (0)	Only minor impacts to water supply expected (1)	No significant impacts to water supply expected (0)	No significant impacts to water supply expected (0)
Water Quality					
SocioEconomics	No adverse effects expected (0)	Insignificantly small mixed positive and adverse impacts (0)	Very small adverse water supply impacts (1)	Insignificantly small adverse water supply impacts (0)	Insignificantly small positive water supply impacts (0)
0 = No Consequences **(+) = Limited Benefits**	**1 = Minimal Consequences** **(++) = Substantial Benefits**	**2 = Moderate Consequences** **(+++) = Extensive Benefits**	**3 = Extensive Consequences**		

Environmental Components	**Run 25**	**WSE**	**22AZE**	**Corps 2010**	**HSM**
Land Use	No adverse effects expected (0)	No adverse effects expected (0)	No adverse effects expected (0)	No adverse effects expected (0)	No adverse effects expected (0)
Recreation Resources	Continued degradation of lake (3) and estuarine (3) recreation resources until/unless future water demand lowers lake levels	Improvements to lake (++) and St. Lucie estuarine (+) fishing and wildlife observation. No significant effects to WCAs or Caloosahatchee River (0)	Improvements to lake (+) and St. Lucie estuarine (+) fishing and wildlife observation. Potential adverse effects from prolonged low lake levels (2)	Little, if any, overall improvements to existing and expected future declining recreational conditions for lake and estuaries (3)	Possibly an acceleration of declining recreational condition in lake (3), little, if any improvement for estuarine recreational conditions (2)
Aesthetic Resources	Continued degradation of lake and estuarine water quality/clarity, emergent and SAV and decline in observable fish and wildlife (3)	Improvements to lake (++) and St. Lucie estuarine (+) water quality/clarity, aquatic vegetation and improvements to observable fish and wildlife	Probably greater improvements to aesthetics, due periodic low water conditions than recreation as lake will experience occasional extreme low water events (++), modest improvements to estuaries and Everglades (+)	Little, if any, change in overall aesthetics for any of the effected resources (0)	Probably a continued decline in existing aesthetics around the lake as native vegetation declines and dies out, continued high turbidity in lake and estuary etc. (3)
Cultural Resources	No adverse effects expected (0)	No adverse effects expected (0)	No adverse effects expected (0)	Minimal, non-adverse effects (1)	No adverse effects expected (0)
HTRW	No adverse effects expected (0)	No adverse effects expected (0)	No adverse effects expected (0)	No adverse effects expected (0)	No adverse effects expected (0)
0 = No Consequences **(+) = Limited Benefits**	**1 = Minimal Consequences** **(++) = Substantial Benefits**	**2 = Moderate Consequences** **(+++) = Extensive Benefits**	**3 = Extensive Consequences**		

7.2 Climate

None of the alternatives would be expected to affect the local or regional climate directly or indirectly, either in the short or long term.

7.3 Air Quality

The proposed action, as well as the alternative actions, are completely operational in nature, do not propose any construction features, nor any physical modifications to existing structures. Therefore there is not expected to be any affect on air quality, either directly, indirectly, or cumulatively by any of the alternatives.

7.4 Noise

There is not expected to be any affect on existing or future noise levels, as there are no construction features associated with the proposed action or the alternative actions, nor any physical or mechanical changes to existing operational systems.

7.5 Vegetation

Vegetative species within the study area are site specific and it is highly probable that there will be effects to plant communities, due to the proposed action and alternatives. These effects are expected to be largely beneficial, but in certain areas may be locally detrimental due to the lake's existing water quality.

7.5.1 Vegetation Within Lake Okeechobee

Over the course of several performance measure workshops and study team meetings, it was generally accepted by lake researchers and resource managers that extreme low lake stage events (<11 feet for >100 days), prolonged low lake stages (<12 feet for >1 year), extreme high lake stages (>17 feet for >50 days) and prolonged high lake stages (>16 feet for >1 year or >15 feet for >2 years) are undesirable in terms of their affect on aquatic and marsh vegetation around the lake. For instance, when lake levels exceeded 17 feet NGVD in 1995, large sections of bulrush (*Scirpus californicus* and *S. validus*) were lost. These plants, which occur at the interface between the pelagic and littoral zone, where they are exposed to wave action, are a prime habitat for largemouth bass and black crappie, two of the most important recreational fishes in the lake (Furse and Fox 1996). Prolonged high lake stages can cause wind and wave damage to near shore plant communities, and facilitate the resuspension and transport of phosphorous laden sediment into the lake water column, which facilitate algae blooms. At the opposite end of the spectrum, extreme and prolonged low lake stages may allow for conditions favoring the spread of exotic and nuisance vegetation leading to the displacement of natives. Thayer (pers. comm.) for instance, observed a dramatic increase in the areal extent of Melaleuca seedlings in the marsh following the 1989 drought, when lake stage fell below 11 feet NGVD and over 95 percent of the marsh was exposed.

Over the past several years, lake levels have been maintained at a relative high level which is believed by some to have resulted in damage to native vegetation which may have allowed exotic vegetation to gain a stronger foothold in areas previously occupied by natives. A notable exception would be the spring of 1997, when the lake receded to just below 13.0 feet NGVD. Recent research and empirical data seem to suggest that there is a relationship between lake hydroperiods and vegetation assemblages. At present however, there is insufficient data to definitively determine a direct correlation between lake levels and changes to vegetation or the spread of exotics. Richardson and Harris (1995) showed that melaleuca and cattail, both problematic species, were increasing in abundance in the marsh. Panicum (torpedograss) is also commonly thought to be expanding within the marsh (C. Hanlon, pers. comm.). Richardson et al. (1995) found that vegetation distribution in Lake Okeechobee is largely controlled by hydroperiod. Many lake users, particularly within the fishing community, believe that conditions within the lake have regressed at an accelerated rate since 1995 and that high lake levels may be partly responsible for the demise of littoral vegetation which is important fish and wildlife habitat. Steinman et al. (1997) showed that high lake stage is negatively correlated with Chara abundance, and mechanistically that light is the causitive agent. Further suggesting that prolonged high lake levels may have adversely affected native aquatic vegetation, is recent empirical evidence that several native plant communities appear to be regenerating in areas previously heavily impacted. Bulrush, Vallisneria, pepper grass and other native species have been observed by USACE operations field personnel as reestablishing communities in areas previously decimated, it is thought, due to sustained high water (A. Charles, pers. comm.). At the time of these observations, the lake had experienced a prolonged spring lake level recession, descending to below 14.0 feet NGVD.

Modeling results indicate that hydrologic conditions within Lake Okeechobee under existing (1990 base) conditions are improved by the WSE regulation schedule as well as that of alternative 22 AZE. The HSM alternative results in twice as many extreme high lake stage events (>17 feet for > 50 days) than alternative Run 25, which may result in long term damage to the littoral and marsh zone vegetation. The Corps 2010 alternative under existing conditions is similar to alternative Run 25, with the same number of high and low lake stage events predicted for both.

Under the future base (year 2010), the no action alternative (Run 25) performs better with one third fewer undesirable lake stage events, than it does under existing conditions (1990 base), mostly due to low lake stages. This would seem to suggest that future water supply demand placed on the lake will lower overall lake levels, inadvertently benefiting the lake ecosystem. With just 6 undesirable events over the 31 year period of record, alternative Run 25 actually performs the best of the alternatives, followed be WSE, Corps 2010, and 22 AZE with 1, 1 and 2 more events respectively than Run 25 (see ***Appendix A***). Lower lake stages with fewer prolonged high lake stage events, as would be the case under all of the alternatives except HSM for the future base, may help to protect and reinvigorate willow trees, whose loss has been documented to be connected to higher lake levels (Aumen, 1995; Richardson and Harris, 1995). Prolonged moderately high lake levels (> 15 ft NGVD for > 2 years) where nearly 100 percent of the marsh areas are flooded, also can be harmful because they bring about changes in the extent of nutrient transport within the lake, as well as losses of benthic plants due to light limitation. Run 25 also has fewer low stage events than the other alternatives under the 2010 base. The difference is that both the proposed action (WSE) and alternatives Corps 2010 and 22 AZE result in more extreme low lake stages than alternative Run 25. WSE has four extreme low lake stage events, one more than both Run 25 and Corps 2010, and one event less than 22AZE. Although high lake stages are generally considered more detrimental to marsh and littoral zone aquatic vegetation (K. Havens, pers. comm.), prolonged low lake stages may result in adverse impacts through the spread of melaleuca, and torpedograss. The HSM alternative simulation performed poorly in terms of protecting the lakes littoral and marsh vegetation, with substantially more occurrences of extreme high lake stage events predicted to occur over the simulation period.

Run 25 performs about the same as WSE in terms of mimicking "historical" (defined as that period from 1953-1972) lake stage conditions. Alternative WSE has shorter flooding events (duration above 15 feet NGVD) compared to Run 25, although not as good as 22AZE. While there is no significant difference between the alternatives for prolonged low lake stages (<12 feet for >1 year), WSE performs slightly poorer in terms of the number of occurrences of extremely low lake stage events (<11 feet for >100 days), although the duration below 11 feet was longer with both Run 25 and 22AZE.

A more detailed assessment, done during the preparation of the WSE Implementation Plan (see ***Appendix C***) utilizes 1995 as the base for existing conditions. The 1995 base provides a somewhat more realistic and comprehensive description of actual water resource management conditions in the vicinity of the study area (B. Rosen, pers. comm.). It may be argued that the 1995 base provides a more appropriate assessment "snapshot" of short-term environmental effects due to the interim nature of the proposed action and short-term effects to certain resources, notably WCA 3A, which will begin receiving "treated" lake water from STA 3/4 in 2003. As mentioned in section 5.1, this detailed information and analyses was unavailable during plan selection, and is used herein primarily as supplemental information for assessing the preferred alternative relative to the existing schedule. Using the 1995 base, WSE simulations demonstrate better performance for the lake littoral zone, with a total of only 5 undesirable lake stage events, compared to 8 for alternative Run 25. More particularly the WSE simulation results in one fewer extreme high lake stage event than alternative Run 25 and no events of prolonged high lake stages of >15 feet for >2 years compared to 2 such events for the existing schedule. Assuming that high water conditions have played a role in adversely impacting native littoral zone and marsh vegetation, algal blooms, the spread of cattail, and exotic plant species, then this differential represents a promising opportunity to enhance protection of these important vegetative communities.

In conclusion, assuming future water supply demand predictions used in modeling the various alternatives are accurate to within reason, there should be a substantial benefit to the lake littoral zone and marsh vegetation due to improved lake hydroperiods. This would likely be true for each of the alternatives including Run 25, WSE, Corps 2010, and 22 AZE. However, based on the most current modeling results using the 1995 base, it appears WSE would result in the greatest enhancement to marsh and littoral plant communities and overall lake ecological conditions.

7.5.2 Estuarine Vegetation

The following paragraphs are a description of the possible impacts to aquatic vegetation of the St. Lucie and Caloosahatchee River Estuaries due to the array of alternatives.

7.5.2.1 St. Lucie Estuary

There may be limited affects on downstream aquatic vegetation within the estuary and Indian River Lagoon. Although results are somewhat mixed, on the whole, using both base conditions, WSE appears the best for the St. Lucie Estuary, with the least number of flood control releases above 2500 cfs of the three alternatives. Alternative WSE had two fewer damaging releases than 22AZE and six fewer than Run 25. Although WSE had approximately 10% more discharges at the lower volume of 1600 cfs than 22AZE, and performed better than Run 25, the larger discharge volume events are of greater concern for the health of the estuary. Alternative 22AZE exhibited 11 fewer such events than Run 25 and 3 fewer than WSE. Alternative 22AZE also demonstrated the best performance of the 3 alternatives, in reducing the number of times (24x for 22AZE, relative to 30x for WSE, and 37x for Run 25) in which average flows exceeded 1600 cfs for > 14 days from lake regulatory releases. Finally, mean annual flood control releases from Lake Okeechobee, shows 22AZE as having the least flow to the St. Lucie and Caloosahatchee River Estuaries (73.5 k acre-feet and 170.6 k acre-feet respectively), followed by WSE (85.9 k acre-feet, and 228 k acre-feet respectively) and Run 25 (108.5 k acre-feet and 254.4 k acre-feet respectively) (***Appendix A***).

Under the 1995 base, both the no action alternative and the proposed action fall far short of the target number of allowable regulatory discharges, which demonstrates the limited capacity of operational only changes to affect downstream conditions. Under the proposed action, the St. Lucie Estuary will receive about 14,000 acre-feet on a mean annual basis less than it would under the existing schedule. This translates into seven less events over a 31 year period of record wherein the estuary suffers from regulatory discharges >2500 cfs. To the extent that WSE is able to reduce damaging regulatory discharges to the estuary and Indian River Lagoon system, it will benefit seagrasses and SAV which are currently in a declining state from sediment and nutrient deposition from upstream sources. Clearer water and more stable salinity is expected to foster re-colonization of the bottom by benthic plants, especially shoal grass. This, in turn, should support the furtherance of two of the three goals put forward in the IRL SWIM Plan (improved water and sediment quality and support of listed species and fish and wildlife), although it will in no way fulfill them.

7.5.2.2 Caloosahatchee River Estuary

Performance for the Caloosahatchee River Estuary is somewhat more clear than for the St. Lucie Estuary. Alternative 22AZE performs slightly better than WSE and significantly better than Run 25 for maintaining desirable salinity envelopes and in minimizing the number of times high discharge criteria were exceeded. Flows resultant from the C-43 basin or from a combination of the C-43 basin and lake releases, which exceed the discharge criteria (on either the low or high end) occur about the same for each alternative. Alternative WSE actually had the fewest number of low flow events (107; lake and basin flows <300 cfs from November to May), followed by Run 25 (110 events) and 22AZE (111 events). Maintaining flows of at least 300 cfs mean monthly discharge from S-79 is required to maintain Vallisneria beds (Bierman, 1993), a critically important indicator species. Alternative 25 appears to show far fewer months (19) of flows >2800 cfs resultant from lake releases than does WSE with 28 months, although this performance measure does not accurately portray large releases. A more detailed examination of simulated flows was necessary because pulse releases up to 3000 cfs are considered environmentally friendly for the Caloosahatchee basin, and the model allows discharges up to the 3000 cfs level. At volumes greater than 3000 cfs, WSE performed better than Run 25. Alternative 22AZE however, demonstrates better performance for reducing high volume discharges to the estuary (>2800 cfs and >4500 cfs from lake and basin flows combined). Model results show just 56 occurrences of >2800 cfs mean monthly flow and 25 events of >4500 cfs mean monthly flows for 22AZE, fewer by 16 and 2 events respectively than WSE, and 7 and 3 events respectively than Run 25 (***Appendix A***).

Under the 1995 base and the proposed action, the Caloosahatchee River Estuary would receive slightly more water volume through regulatory discharges than under the existing schedule, resulting in two more occurrences each when high discharge criteria (>2800 and >4500 cfs) were exceeded. This is probably within the margin of error for the model and would not be expected to significantly impact Vallisneria beds or seagrasses. None of the alternatives, including the proposed action, approach restoration of more natural flows or salinity regimes within the Caloosahatchee River Estuary as defined by the target levels in Chamberlain and Doering (1999 draft). The proposed action, at best, allows for the status quo to continue with regard to the health and sustainability of plant communities in the Caloosahatchee.

7.5.3 Everglades Agricultural Area

Under any of the alternatives, regulatory discharges from the lake will be confined to existing canal systems and flow through the EAA without impacting existing agricultural vegetation. Furthermore, native vegetation, within remnant wetlands and within the Roterberger and Holey Land WMAs, will not be impacted as no additional flows beyond those expected in the future without project condition are expected to be diverted to those areas.

7.5.4 Water Conservation Areas

Under all of the alternatives, greater flow than is currently the case will be directed southward into the WCAs. This water was previously stored in the lake or diverted to the estuaries. As lake water contains nutrient concentrations higher than WCA background levels, and is relatively high in phosphorus in particular (around 70 ppb [P] for each of the 3 major canals discharging into WCAs 3A and 2A, with about 135 ppb [P] in the West Palm Beach Canal), changes to existing plant communities would be expected. Phosphorus loading to the WCAs prior to any additional STA treatment is expected to affect plant communities within WCA 3A and WCA 2A. Flows to WCA 1 are actually less under the proposed action than under existing or future without project conditions, so no net environmental impact is expected. As the total load of phosphorus to WCA 2A and WCA 3A is relatively modest (see ***Appendix B***) impacts to plant communities are expected to be relatively minor, limited in scope and occur over a period of several years. In all likelihood, the additional loading to the WCAs due to WSE, would contribute to an already existing cattail problem in the northern WCAs, expanding the range wherein cattail have outcompeted sawgrass by an unknown, but relative to the area affected, modest number of acres. Possible impacts to periphyton may also occur over a larger area, although the ability to quantify with any precision the number of acres of either periphyton or cattail spread is rather imprecise.

7.6 Fish and Wildlife

As was the case with vegetation (Section 7.5), the study area is site specific with regard to fish and wildlife resources and it is highly probable that there will be affects on these resources due to the proposed action and alternatives. These effects are expected to be largely beneficial, but in certain areas may be locally detrimental due to the lake's existing water quality.

7.6.1 Lake Okeechobee

To date, there has not been sufficient research enabling investigators to explicitly link water level variations in Lake Okeechobee with its fisheries ecology. However, a general understanding of how fisheries respond to changes in habitat structure and resource availability leads to a consensus among experts that Lake Okeechobee's fishery may be harmed by extreme high and low lake stage events (Havens et al. 1998). When lake stage declines below 11 ft NGVD for instance, the stage considered to be extreme on the low end, 95 percent of the littoral zone is exposed land without standing water. In that condition, it no longer can function as habitat for fish or wildlife that depend on local fish populations as a food resource. Spike rush and bulrush are almost completely dry at this lake level, and can no longer support the fish and bird communities that depend on them for foraging and nesting (Havens et al. 1998).

Both the preferred (WSE) and no action (Run 25) alternatives appear to perform well under the 2010 (future) base. As stated earlier, alternative performance under the 2010 base is largely due to the increased water supply demands expected to be imposed on the lake in the future. That is to say, the impact on lake levels due to the difference between existing conditions under the 1990 base and the future without project condition (2010 base) is substantially greater than the impacts expected to result from the array of alternatives. The future base would produce lower lake stages and fewer occurrences of prolonged high and extreme high lake stage events. Although there is no alternative that demonstrates superior performance under the 2010 base, the no action alternative actually appears to perform slightly better for fish and wildlife resources that utilize the littoral zone and marsh as spawning, feeding, roosting and nesting habitat. Alternative 25 has fewer low lake stage events than the other alternatives under the 2010 base. WSE has four low stage events, one more than Run 25, and one low stage event less than 22AZE.

An analysis of existing (1995 base) conditions used in modeling alternatives WSE and Run 25, produced somewhat different results. It is reasonable to present these results as well given the relatively short term, interim basis for implementation of a new regulation schedule, and the changing future conditions which will affect downstream impacts (eg. completion of STA construction). Using the 1995 base, WSE demonstrates clearly better performance than the existing schedule in terms of reducing extreme and prolonged high lake stages, although there is no observable difference in lower stages. Prolonged high lake stages have been shown to limit light penetration to bottom dwelling benthic plants, algae and invertebrates (Havens et al. 1998). Many invertebrate species are phototropic, responding positively to light. Moreover, increased light penetration is positively correlated to benthic vegetation and algae production, which provides food and cover for invertebrates. Alternative WSE experiences only about two-thirds the number of undesirable lake stage events than does alternative 25. This would seem to indicate that, at least in the short term, WSE may improve conditions within the lake for native fish and wildlife due primarily to a reduction in high lake stages.

Maintaining the heterogeneous native plant communities which are intrinsic to a healthy lake littoral zone may also facilitate an improvement in fish stocks and wading birds under conditions brought about by WSE. By improving lake hydroperiods, including a lowering of overall lake stages, and reductions in both prolonged high and extreme high lake stages, conditions for both emergent and submergent aquatic vegetation, as well as for wading bird foraging, nesting and spawning and feeding habitat for fish should be improved.

Lake stages, as predicted by stage hydrographs, will not differ substantially between the WSE and Run 25 alternatives. A key difference between no action and the proposed action (WSE) is the lake regulation schedule elevation below which no regulatory discharges are made (line between zones D and E; reference Figures 2.8-1 and 5.2.5-1). For WSE, the low end of the regulation schedule allows the lake to recede to 13.5 feet NGVD, while under Run 25, the low end of the regulation schedule is at 15.65 feet NGVD. The proposed action therefore allows for more frequent lower lake levels than would occur under Run 25. Periodic dry downs have been shown to be important for the marsh and littoral plant communities to regenerate, providing optimal habitat for fish and wildlife, enhancing foraging conditions for wading birds and reducing nutrient and sediment influxes into the littoral zone from the open waters of the lake. There should not be any adverse effects to other related biota as a result of WSE, including macro-invertebrates, upon which wading birds and fishes depend for food. Water levels in the rim canal or principal navigation canals should not be significantly affected, and will continue to offer refuge to animals such as manatees, alligators, turtles and predator fish known to use this habitat.

7.6.2 Estuarine Fish and Wildlife

Under the 2010 base, performance of the alternatives is somewhat mixed. On the whole, WSE appears the best for the St. Lucie Estuary. Results of the 1995 base comparison are similarly suggestive of the WSE alternative. While alternative 25 shows slightly fewer incidences where mean monthly flows exceeded 1600 cfs than did WSE (79 events compared to 82 for the 31 year period of record), WSE is predicted to result in seven fewer incidences of high volume discharges of >2500 cfs than alternative 25. Number of months of low flow (<350 cfs) during the period of record were the same for both alternatives. Alternative 22 AZE was not modeled using the 1995 base.

The WSE alternative is expected to improve, to a limited extent, estuarine conditions through portions of the St. Lucie Estuary, benefiting oysters and seagrass, and fish and wildlife. These benefits would be principally during the wet season when high water flows to the estuary would be reduced. Dry season flows would not be appreciably affected. Both oysters and seagrass have a number of invertebrate and fish species associated with them that are currently either absent from the estuary or present in very low numbers. Once the habitats are restored, fish and invertebrates that depend on these substrates should recolonize the area quickly. Past high discharge events have caused fish kills, fish lesions, invertebrate kills, and probably impacted spawning of a number of species. By reducing freshwater flow events outside the natural salinity envelope, WSE should reduce stress on fish and wildlife of the estuary. A number of species utilize the area as a spawning, nursery, or juvenile rearing area. Restoring the St. Lucie to estuarine conditions should incrementally improve spawning and nursery grounds for a number of important commercial and recreational species, including snook, red drum, spotted seatrout, tarpon, mangrove snapper and mullet.

As the health of the St. Lucie estuary improves as a result of the proposed action, a number of endangered species may benefit. Restored seagrasses may provide some additional forage areas for the manatee. Improved fisheries may also be beneficial to the wood stork and bald eagle.

7.6.3 Everglades Agricultural Area

Increased flows southward from the lake proposed under WSE, are not expected to impact agricultural fields, existing flood control, or remnant wetlands where wildlife may occur. WSE flows should pass through the region within the existing canal system, much as they do at present, leaving fields and any natural wildlife habitat unaffected. Although canal stages may be slightly higher at certain times of the year, this is not expected to be of a magnitude that may affect existing fish and wildlife foraging areas.

7.6.4 Water Conservation Areas

Benefits to fish and wildlife habitat resulting from the array of alternatives would likely be due to restoration of more natural hydroperiods within the marsh ecosystem, unless and until said rehydration itself caused plant community shifts due to the introduction of additional nutrients from upstream. Under the future base there is no perceptible hydroperiod restoration benefit to any of the WCAs due to the array of alternatives. Each of the alternatives falls to within about one percentage of the other (in terms of approaching NSM levels) which is certainly within the error of the 2 mile by 2 mile grid of the SFWMM. Under the most realistic (1995 base), near term scenario, WSE by increasing flows to WCA 3A, through the S-8, results in somewhat improved hydroperiods in WCA 3A north of I-75. This area, which receives about 20,000 acre-feet per year more lake water under WSE than under alternative 25, increases by about 6% the amount of area which matches conditions predicted under the NSM. That is, the area would benefit to a degree, hydrologically, which may produce benefits by restoring longer hydroperiods in the overdrained marsh and restoring fish and wildlife habitat. These benefits would most likely be of minor magnitude, localized to the general vicinity (such as the point of discharge and surrounding areas) of northern WCA 3A nearest the Miami canal, and benefit mostly water dependent species such as wading birds, fish, macroinvertebrates, alligators and other herptiles.

Discharges to the North New River canal are expected to increase by about 7,000 acre-feet per year of additional lake water. This water will be conveyed to either WCA 3A or WCA 2A through the S-7 until STA 3/4 is completed, when they will be treated there prior to discharge into the WCAs. These additional discharges are not expected to adversely affect terrestrial species such as white-tailed deer, feral hog, and small mammals to any great degree. Normalized stage hydrographs and stage duration curves, show nearly identical hydroperiods for both WSE and alternative 25 in all areas except WCA 3A, north of I-75. Although slightly more water will be conveyed to WCA 2A, stage hydrographs actually show a slight modification of extreme high and low water depths. At the scale available in the modeling of performance measures (***Appendix A***), there is no distinguishable difference between WSE and Run 25 stage duration curves to indicate any hydroperiod benefits as a result of the proposed action. Water Conservation Area 1 will receive about 7,700 acre-feet per year less water under the 1995 base, but shows no distinguishable difference in stage or stage duration compared to alternative 25. Therefore, there are no real hydrologic restoration benefits, nor adverse impacts expected which may impact Everglades fish and wildlife or their habitat as a result of WSE in WCA 1, WCA 2A, WCA 2B, WCA 3A south of I-75 or WCA 3B.

Lake waters discharged into the WCAs are currently estimated to contain between 70 and 100 ppb phosphorus concentration, which is considerably above that present in the receiving waters. These are the values used in assessing water quality impacts by the Everglades Phosphorus Gradient Model. Actual values are reported in ***Appendix B***. In the long term, such additional loading of phosphorus would be expected to have significant and long lasting adverse affects on the fish and wildlife habitat of the area. Existing cattail stands would probably expand rapidly into areas currently and historically occupied by sawgrass, displacing one cover type for another. This action would be expected, if allowed to persist, to displace whole animal species associated with the more open stands of sawgrass such as species of egret, heron and ibis with those of cattail such as red-winged blackbird (*Agelaius phoeniceus*), boat tailed grackle (*Quiscalus major*), and common gallinule (*Gallinula chloropus*) among others. Since any additional Lake Okeechobee regulatory releases will be treated by STA 3/4, once it is completed and on-line, any adverse affects to receiving water bodies occasioned in the interim, would be expected to be short-term, localized and of relatively minor magnitude.

7.7 Threatened and Endangered Species

The USACE requested of the USFWS, by letter dated August 29, 1996, information on listed species or their critical habitat that may be present in the study area. The USFWS determined that five listed faunal species and one plant species were present in the study area and may be affected by alternative lake regulation schedules. The FWC confirmed the five federally listed animal species and identified twelve additional state listed species which may also be affected by lake regulation schedule alternatives. For a complete listing of these plant and animal species reference Table 2.7.1-1. The entire littoral zone and western shore of Lake Okeechobee, and parts of the WCAs, are designated as critical habitat for the snail kite. For a complete species description, taxonomy, distribution, habitat requirements, management objectives, and current recovery status, reference the Draft Multi-Species Recovery Plan for the Threatened and

Endangered Species of south Florida, Volume I (USFWS 1998) or the USFWS endangered species web site at *http://www.fws.gov/r4eao/wildlife/vbms.html*.

Implementation of the WSE alternative is expected to improve conditions within the Lake Okeechobee littoral zone, reduce prolonged and extreme high lake stages and enhance protection of water quality within the marsh/littoral zone area. These improvements would be expected to improve, or have no adverse impact on snail kites and wood storks which require a fairly specific hydrologic regime to flourish. Although, water depths in the marsh area will be somewhat lower overall under WSE, the magnitude of change is not of such an extent as to impede movement of animals, or access to foraging or breeding areas. A review of normalized lake stage hydrographs indicate that under both the 1995 and 2010 bases, WSE is only slightly lower (0.5 feet maximum) during parts of the year than alternative 25 (***Appendices A and C***). Although the proposed action will allow lake levels to recede to 13.5 feet NGVD before discontinuing regulatory releases (except under drought conditions), water levels are not expected to adversely impact habitat for the West Indian manatee which utilizes extensively the canal system for foraging and moving about. Nor would it be expected to adversely impact the bald eagle which is largely dependent on the abundant fish stocks from the lake as a primary food source. The eastern indigo snake would also not be adversely affected as there would be no effects to upland areas either within the lake (canal banks, spoil areas, islands etc.) where snakes may be present. The Okeechobee gourd is expected to benefit somewhat due to a reduced occurrence of high water events and flooding of its habitat on the south shore of Lake Okeechobee.

Reduced freshwater flows to the St. Lucie Estuary may also modestly improve water quality within the estuary, and improve conditions for seagrasses and the animals which depend on them for food and cover. Flows under WSE to the Caloosahatchee River and south to the WCAs, are not expected to affect any listed species. As stage duration and stage hydrograph model output from the SFWMM clearly shows, there are no significant hydrologic effects as a result of WSE realized within the WCAs below WCA 3A north. There is no evidence to suggest that additional regulatory flows of the magnitude proposed under WSE would in any way affect hydrological or ecological conditions within ENP, including the Cape Sable seaside sparrow, their nesting range or other listed species critical habitat.

7.8 Water Management & Water Supply

The WSE regulation schedule incorporates the recent advances in the reliability of climate forecasts by including a six month lead inflow forecast into its operational rules. The most substantial value of the implementation of a climate-based operational schedule is to alert water managers of the increased likelihood of extreme hydrological events, so performance may be improved for such events. During periods of more active and severe tropical activity and a lower drought frequency, it would be advantageous to make releases from the lake to tide-water at lower water levels. This would not only improve flood protection, but would minimize the impact to the lake littoral zone and downstream estuaries. A key feature of the schedule is the lower operational zone, labeled Zone D. This zone allows the operational flexibility to deliver water to the Everglades (WCAs 2A and 3A in particular) at lower lake water levels which serves to relieve stress on the lake littoral zone. The schedule allows dry season discharges to tide-water to be gradually increased as necessary (up to the discharge rate recommended for the specific zone) to control water levels. This practice does not impact flood protection since there is no threat of hurricane surge during the dry season. The large outlet capacity virtually assures the ability to lower the water levels before the arrival of the hurricane season. This practice will allow more water to be kept in the regional system for water supply.

Furthermore, the WSE operational schedule allows for the water supply requirements to be satisfied at least as effectively as the current operational schedule (Run 25) while reducing the stress of prolonged high water levels on the littoral zone. Additionally, in a comparison of the 1995 base condition to that of the proposed WSE schedule, the trend showed an increase by approximately 4 percent of the Lake Okeechobee Service Area water supply needs being met during drought years.

7.9 Water Quality

There are minor positive impacts to the St. Lucie Estuary due to the reduction in the number of undesired high regulatory discharges from the lake under the proposed plan. Additionally, there are very minor negative impacts, due to the proposed plan, to the receiving marsh areas in WCA 2A and WCA 3A, north of Alligator Alley. This is due to the addition of higher nutrient concentrations associated with lake water being discharged to the WCAs, which will remain in effect until STA 3/4 is on line (scheduled completion is October 2003). The proposed plan will provide minor hydroperiod benefits to marsh areas in WCA 2A and WCA 3A, north of Alligator Alley as they will be receiving more water primarily through the Miami Canal and also through the North New River Canal. There is no measurable impact to Lake Okeechobee outflow nutrient concentrations from any of the schedules being considered. This is due to the limitations of regulation schedule adjustments and the coarseness of the modeling tool. Reference Appendix B for more detailed results. However, the schedules that tend to keep the lake stages lower will reduce nutrients being transported from the center of the lake (with the existing phosphorus-rich mud sediments) to the lower nutrient concentration near shore areas. This will provide a clear and demonstrable benefit to the lake littoral zones by keeping water transparency higher and total phosphorus lower in these lower nutrient concentration areas than would occur with higher stages. Reference ***Appendix B*** for more detailed results.

7.10 Socio-Economics

The measured economic effects, based on this study's modeled simulation, are relatively negligible. While generally, these effects were analyzed as not being large, the recommended plan's relatively positive environmental effects would most likely translate into a socio-economic enhancement, particularly for the residents, recreation, and fishing in the estuary basins, and also for fishing and recreation in and around Lake Okeechobee. Adverse impacts to commercial navigation and recreational access (boat landings and watercraft navigation within the lake or channel) within the Lake Okeechobee Waterway are expected to be minimal due to a very small difference in the frequency of extreme low lake stages between the alternatives (reference ***Appendix D***, Sections 4 and 5). Tables 4-1 and 5-6 of ***Appendix D***, suggest that there is only one additional extreme low lake stage event (<11 feet NGVD for >100 days) associated with the proposed plan relative to the existing schedule under both the 1990 and 2010 base. Additional detailed information on the socio-economic effects of the alternative plans is available in ***Appendix D.***

7.11 Land Use

The WSE alternative is strictly operational in nature and contains no structural features such as water control or conveyance structures, reservoirs, levees, canals, culverts etc. beyond which are present today under existing operations. The WSE alternative is also not expected to convey flows from the lake, or flood any lands which are not today receiving lake water or flooded as functional wetlands, rivers or estuaries. Moreover, implementation of the WSE regulation schedule will not result in adverse impacts to existing or future water supply, beyond that predicted under the 2010 base, which potentially could impact urban and agricultural land use. As a result, there are no affects on existing or future land use anticipated due to the implementation of WSE.

7.12 Recreation Resources

Improvements to the lakes' hydroperiod should reduce the occurrence of prolonged high lake stage events in particular, that have adversely impacted native aquatic and marsh vegetation around the lake. The littoral and marsh habitat provides important nesting, breeding and feeding areas for fish and wildlife and the health and sustainability of these vegetation communities is crucial to the recreation resources, particularly fishing, hunting, and wildlife viewing. The WSE alternative, by allowing for lower lake levels, would protect and enhance fish and wildlife habitat within the lake, to a certain degree, by reducing over inundation of emergent and floating vegetation and improving light penetration to SAV, components of which are important habitat throughout the life cycle of fishes, wading birds, raptors, waterfowl, and other animals which make up the food chain. Moreover, lower lake levels may also contribute to a reduction in sediment and nutrient transport into the back water marsh areas and littoral zone and reduce resuspension of nutrients which contribute to algae bloom production. These improvements to hydroperiod, aquatic vegetation, and water quality should translate into better opportunities for fish and wildlife reproduction, foraging and cover, and allow for larger, more sustainable populations for fishing, hunting, and wildlife observation.

Reduced freshwater releases to the St. Lucie Estuary in particular will improve fish and wildlife habitat and improve conditions for the fishery. Although Zone A releases would still be necessary on occasion, the reduced volume of lake water sent to the estuary would improve overall salinity regimes, water clarity and color, reduce turbidity and probably the oxygen demand of deposited silts. Any conditions which favor growth and expansion of seagrasses and improved water quality, will enhance the fishery and opportunities for commercial and sport fishing. Wildlife viewing may also be enhanced with healthy and sustainable seagrass beds. Habitat for prey species such as invertebrates and forage fishes which are food sources for eagles, wading birds, marine mammals and other watchable species will enhance opportunities to view these animals. Manatees, which feed directly on seagrasses will also benefit through improved conditions for their primary food source. It is worth highlighting the fact that due to the limitations of an operations-only regulation schedule change, and the present restricted capacity of the C&SF Project to regulate water levels originating from the lake, benefits to the St. Lucie estuary and IRL would be expected to be incremental in nature, occur over several years and would not, in and of themselves, result in wide-spread restoration of the estuary.

Recreation within the EAA should not be materially affected by the WSE alternative. While additional flows from the lake are sent southwards through the EAA, these additional flows will be conveyed within existing canals and not impact existing agricultural fields or wetlands. Once into the WCAs, under high stages, lake flow will spread out across the landscape and should provide some rehydration of north WCA 3A. Rehydration of the overdrained areas of WCA 3A may provide additional opportunities to view wading birds, waterfowl, alligators, and other water dependent animal species. Access via small watercraft or airboat may be improved during part of the year in localized areas due to somewhat greater water depths. Flows to WCA 1, 2A and the Caloosahatchee River and Estuary will not be altered to the point of significantly affecting recreation opportunities such as fishing, boating, hunting and viewing wildlife.

7.13 Aesthetic Resources

Aesthetics within the study area will probably not be affected in the short-term. Since there will not be any structural modifications to the existing operations system, no visible impediments to existing landscapes will be present. While plant communities may change over time through varying water management practices, succession, and competition, among other factors, significant (observable) changes to plant communities *usually* require a few to several years to occur. Over the longer term, improved hydroperiods within Lake Okeechobee and the St. Lucie Estuary are expected to benefit native plant communities which should support enhanced numbers of native fish and wildlife. A reduction in the occurrence of prolonged and extreme high lake stages within the lake for instance should reduce excessive turbidity, and enhance wading and foraging conditions and nesting success for wading birds, two components of the ecosystem which contribute greatly to the visual aesthetic/appeal. Healthier seagrass beds in the St. Lucie and Indian River Lagoon will provide better habitat for fish stocks which, although not easily seen by the casual observer, also act as food sources and support bald eagles and other fish eating raptors whose presence may enhance the wilderness aesthetic of the estuary.

There are not expected to be any affects on existing or future aesthetics within the EAA, nor to the Caloosahatchee River. Neither area benefit greatly from the proposed action in terms of improved hydroperiods and flows through these areas will not affect related resources, existing land use or other variables that may enhance or detract from current appearances.

7.14 Cultural Resources

The Herbert Hoover Dike (FMSF #8PB2028) is historically significant and may be eligible for inclusion on the National Register of Historic Places. All alternatives, including the No Action Alternative and the WSE will have no affect on the historic significance of the Dike. A number of historic structures and significant archeological resources are located near Lake

Okeechobee, although none are located within the area of potential impact. The Corps has determined that implementation of the proposed WSE regulation schedule at Lake Okeechobee will not adversely affect significant historic properties. This determination is made according to the guidelines established in 36 CFR Part 800 and in compliance with Section 106 of the National Historic Preservation Act. This determination is being coordinated with the Florida State Historic Preservation Officer.

7.15 Hazardous, Toxic and Radioactive Waste

The preliminary assessment indicated that no hazardous, toxic, radioactive, or other harmful substances are present within the project area. However, if contaminants are found during property procurement or project construction, the site will be remediated.

These chemicals if not detected during the site assessment, may be disturbed or released by increasing the water level and hydroperiod or by removing unnatural structures or features from the landscape. However, our experience has shown that residual HTRW levels when flooded would be difficult to detect because of dispersion and biological activity. Lowering the water elevation would expose undetected contaminants to air, promoting oxidation, especially effective in hydrocarbon remediation process.

7.16 Unavoidable Adverse Environmental Effects

As the proposed action is completely operational, and does not contain any physical features, construction, or addition or removal of structures, and the action is designed to enhance conditions within the natural environment, there are very few, if any, adverse impacts anticipated to the natural and human environment. Due to the limited discharge capacity of the Lake Okeechobee water management system, relative to the large volume of water in the lake, operational modifications alone result in relatively modest impacts downstream. As there is no additional storage capacity built into the system as a result of any of the alternatives, lake water with relatively high (between 70 ppb and 100 ppb [P]; Reference ***Appendix B***) concentrations of phosphorous are redistributed from one part of the system to another. In other words, there is not a substantial *net* environmental gain as a result of any of the alternatives for all of the affected ecosystems. In any effort to enhance protection of the St. Lucie Estuary and the Lake Okeechobee littoral zone, additional lake water is conveyed south, through the Miami and North New River Canals and ultimately into WCA 2A and WCA 3A. The increased phosphorous loading into northern WCA 3A is predicted to result in a vegetative change from sawgrass to cattail in at least 3 and at most 13 acres (depending on [P] in-flow assumptions) and from 9 to 31 acres in WCA 2A. Furthermore, this additional loading is predicted to result in an area of over 2100 acres in WCA 3A and about 790 acres in WCA 2A which is expected to exceed 10 ppb [P] a concentration which has been determined may affect periphyton communities (***Appendix B***). These values are over and above what would be predicted for the future without project condition (alternative 25, 2010 base). As these numbers are based on numerous assumptions, and are subject to a wide variety of environmental factors unrelated to the LORSS, they should be interpreted with some caution. It is reasonable to conclude that the additional loading of phosphorus to WCAs 2A and 3A as a result of the proposed action, will contribute to the spread of cattail that already exists, further exacerbating, albeit to a limited and relatively minor extent, an existing ecological problem.

Conditions within the Caloosahatchee River Estuary as well, are not predicted to be improved. Under the 2010 base, the WSE alternative results in 28 additional number of months wherein flows exceed 2800 cfs due to regulatory releases from the lake. This is 9 more than if no action were taken (alternative 25, 2010 base), and 16 more events than predicted to occur under alternative 22 AZE. Of the three alternatives (Run 25, WSE, and 22 AZE) WSE exhibits the poorest performance for the Caloosahatchee River Estuary in terms of the predicted number of times high discharges (>2800 cfs) would be experienced. Alternative WSE experiences 9 more such events than if no action were taken and 16 more than alternative 22 AZE ***(Appendix A).***

In the short to intermediate term, under 1995 existing conditions, WSE performs considerably better, but still not as good as alternative 25. Alternative WSE exhibits just 2 more events each where mean monthly flows exceed 2800 cfs and 4500 cfs, relative to alternative 25. Both alternatives were far short of the target of 22 and 6 events respectively (***Appendix C***).

7.17 Relationship Between Short Term Uses and Long Term Productivity

In one sense, conveyance of additional lake water to the WCAs, and to a lesser extent the Caloosahatchee River, may represent a "trade-off" for the benefit of the lake littoral zone primarily and secondarily the St. Lucie Estuary. Ordinarily, rehydration of overdrained areas within the WCAs would be environmentally positive in terms of restoring more natural hydroperiods, reducing fire periodicity, and oxidation and subsidence of peat soils. However, unless and until the STAs, notably STA 3/4 which will treat lake water prior to entering WCA 3A and WCA 2A are on-line and able to reduce nutrient concentrations down to acceptable levels, the WSE alternative is predicted to result in additional phosphorus loading to northern WCA 3A and WCA 2A. This will manifest itself by converting several acres of native sawgrass to cattail and potentially impacting periphyton communities over a much larger area. Stormwater Treatment Area 3/4 is expected to be constructed and on-line within about 4 years (year 2003) when theoretically, this short-term "use" should be invalidated due to treatment of lake water inflows.

7.18 Irreversible and Irretrievable Commitments of Resources

As there is no proposed construction or alternation of existing features or landscape, there should be no irretrievable or irreversible commitment of resources as a result of this project. Conversion of a minimum of 12 and a maximum of 44 total acres of existing sawgrass to cattail due to an increase, albeit temporary, in phosphorous loading to northern WCA 3A and WCA 2A may be considered an irreversible impact, at least in the short-term, as there are currently no cost effective means to "reverse" an established community change of this nature without incurring significant environmental and financial costs. It should be noted that this acreage represents only between 0.001 and 0.003% of the total WCA 3A area and 0.01 and 0.03% of the total area of the smaller WCA 2A (***Appendix B***).

7.19 Cumulative Effects

Cumulative impacts are impacts likely to occur due to the proposed action or alternatives in combination with other past, present and reasonably foreseeable future actions. As stated previously, the impact on the natural and human environment of the proposed action and alternatives is relatively minor in magnitude compared to that which is expected to occur as a result of future water demands projected to be placed on the lake. Moreover, this study has been designed to identify an *interim* lake regulation schedule which would be in effect until a more comprehensive solution to the water regulation and management challenges is implemented by the C&SF Restudy. A key feature to restoring the lake and the estuaries under the Restudy is the construction of several large (on the order of 5000-20,000 acres) storage reservoirs, reservoir assisted STAs and STAs which would attenuate and treat flows to the lake and downstream receiving water bodies. These are the type of structural features which will likely be necessary to fully resolve the environmental problems inherent in the present system. As the WSE lake regulation schedule is expected to operate only in the short to intermediate timeframe, additional flows south to WCA 3A and WCA 2A will be treated by STA 3/4 as of October 2003, and the action proposes no construction, no land acquisition, and no physical modifications to existing operational features, there is little reason to expect cumulative impacts to result.

8 PUBLIC INVOLVEMENT AND COORDINATION

The section below explains how the USACE has and will, in future, involve the public at large in the planning process for this project.

8.1 Public Involvement Program

Prior to developing the recommended solution, a number of public information meetings were held. The first meeting was utilized for developing environmental performance measures and was attended by an interagency group of experts. Next, an information meeting was held on April 7, 1998 in West Palm Beach. The attendees were provided a project overview, modeling results for several environmental performance measures, and economic impacts for the proposed alternatives.

The local sponsor, SFWMD, was actively involved in the Public Involvement Program. The SFWMD hosted a Public Workshop on April 15, 1998 to present a new alternative, WSE. The Workshop was attended by approximately 400 stakeholders from a variety of interest groups. Due to the novelty of this alternative, SFWMD conducted several meetings with the individual interest groups, eg., utilities, agricultural, environmentalist, and fishermen. The purpose for implementing an active public involvement program was to ensure that the public was well informed of the proposed alternatives prior to receiving the recommendation and the decision document.

8.2 Scoping

A Notice of Intent to prepare an Environmental Impact Statement for the study was published in the Federal Register, Volume 60, Number 119, on June 21, 1995. The Notice of Intent outlined in summary form the project purpose and objective; described the study area; project scope; and laid out the Scoping process utilized to involved Federal, state and local agencies, affected Native American Tribes and interested private organizations and parties.

A Scoping Letter, dated June 14, 1995, was sent out by the Corps to over 500 recipients, including Federal, state, and local agencies, Native American Tribes, and private organizations and parties, soliciting their views, comments, and information about resources, study objectives, alternatives, and important features within the study area. The record was held open for a 45 day comment period. Forty-two written responses were received within the comment period, representing a myriad of issues. Of the forty-two, six expressed a preference for a lower lake stage, nine preferred to maintain the existing schedule, nineteen preferred a higher lake stage, and eight expressed no preference. These issues were compiled and infused into the plan formulation process over the next several years.

Some of the key issues resulting from the Scoping process included:

- Water supply to urban and agricultural areas
- Flood control for urban and agricultural areas outside the HHD
- Hurricane preparedness
- Economic effects of lower regulation schedule on agriculture
- Effects of prolonged high water on littoral zone, fishing and related industries
- Need to lower lake levels in order to improve conditions in the littoral zone/marsh for aquatic vegetation, fish and wildlife
- Need to stop damaging regulatory discharges to the St. Lucie and Caloosahatchee River Estuary

8.3 Public Meetings

Water control plans are developed in concert with all basin interests which are or could be impacted by or have an influence on project implementation. Close coordination is maintained with all Federal, state, regional, and local agencies in the development and execution of water control plans. The Corps of Engineers, along with SFWMD, will sponsor public involvement activities to apprise the general public of development or modification of the water control plan in accordance with Section 310 of the Water Resources Development Act (WRDA) of 1990.

9 COMPLIANCE WITH ENVIRONMENTAL REQUIREMENTS

The alternative plans were considered in relation to compliance with Federal environmental review and consultation requirements.

9.1 NATIONAL ENVIRONMENTAL POLICY ACT of 1969

Environmental, socio-economic, hydrologic and water quality information on the project has been compiled and a Final Environmental Impact Statement (FEIS), for the Lake Okeechobee Regulation Schedule Study, was prepared from April to June 1999. A systematic interdisciplinary approach to planning has been utilized; all reasonable alternatives have been studied, developed and described, and all pertinent information, including hydrologic, environmental and water quality modeling and ecological field studies have been developed, carried out and utilized. The FEIS will be coordinated with state, Federal and local agencies, native American Tribes, non-governmental agencies, and the public for a period of not less than thirty days.

9.2 FISH AND WILDLIFE COORDINATION ACT of 1958

In response to the requirements of this Act, the USACE has and will continue to maintain continuous coordination with the USFWS and the FWC during all stages of the planning and implementation of this project. The FWC has prepared a Fish and Wildlife Coordination Act Report (CAR), dated April 16, 1999, which is included as ***Annex A***. The USFWS and USACE have a Scope of Work for preparation of a CAR which called for a draft CAR by April 15, 1999 and a final CAR commensurate with the final EIS. Due to the development of a new alternative later in the planning phase, and new information eg. the WSE Implementation Plan, which also became available in May 1999, this date was unattainable. The USFWS has indicated by letter dated June 4, 1999, that a draft CAR and biological opinion will be prepared and delivered to the Corps by July 30, 1999. This document will then be reviewed by the Corps, its recommendations fully considered under the NEPA process. Furthermore, the CAR will be included in its entirety as an appendix in the final EIS.

9.2.1 U.S. Fish and Wildlife Service, final Fish and Wildlife Coordination Act Report Recommendations

Comment # 1 - Refine the WSE Schedule. Further refinement of climate forecasting should be investigated, and incorporated, into revisions of the WSE Schedule.

Response - The Corps and SFWMD agree with this recommendation. Climate forecasting is a dynamic science and evolving quickly as our technology and understanding of global weather increases. Refinements to the climate forecasting methodology will be incorporated, as appropriate and feasible, into future iterations of the climate forecasting tool. For the purposes of the existing WSE schedule, the climate forecasting methodology, as presented in the LORSS draft EIS, is not expected to change prior to implementation of the WSE schedule.

Comment # 2 - Conduct Additional Studies. Additional documentation is needed to confirm and quantify the relationships between stressors and responses in the Lake Okeechobee Conceptual Model. The Service recommends that the Corps assist in funding field studies and statistical analyses to quantify the relationship between spring water recession characteristics and wading bird foraging and/or nesting success in the lake. Additional research is needed on the degree to which extended periods of high water stages increase penetration of phosphorus-laden water into Moonshine Bay. Monitoring of the benthic invertebrate fauna in the littoral zone should accompany this effort. Research is lacking on the effect of lake stage on the fish fauna in the littoral zone.

Response - The Corps agrees that there are a myriad of scientific questions which need to be addressed in order to better understand the ecological function of Lake Okeechobee. The request for additional studies, monitoring and scientific research is however, beyond the scope of authority used in funding the Lake Okeechobee Regulation Schedule Study. For these kinds of efforts there are state and Federal agencies with the necessary expertise, experience and authority to carry out ecological studies whose research the Corps and SFWMD would then apply in better managing the lake for all users.

Comment # 3 - Implement habitat restoration. The Service continues to support the recommendation to plan and carry out restoration of wetlands at Torry, Kreamer, and Ritta islands within the lake, provided that follow-up contaminant sampling indicates that pesticide residues in those areas have degraded to safe levels for fish and wildlife. The Service recommends that the Corps re-evaluate the omission of this component from the C&SF Restudy.

Response - As described in the LORSS draft EIS, this study is authorized to consider only operational changes to the current lake regulation schedule, and is not authorized to study alternatives requiring structural modifications such as would be required for environmental restoration of Torry, Kraemer and Ritta Islands (removal of exotic vegetation, possible removal of surface soils, modification of existing, or construction of new structures eg. canals, berms, levees etc.). The Corps generally agrees that the aforementioned initiative would represent a worthwhile restoration project, assuming a systematic and thorough hazardous and toxic waste investigation documenting that the area was free of pesticides and other hazardous materials. There is little evidence however that pesticide residues are degraded to safe levels for fish and wildlife at this time. We suggest that the USFWS pursue this initiative along alternative channels such as through the Restudy Comprehensive Plan adaptive management process or other authorities which are specifically set up for environmental restoration of C&SF Project features.

Comment # 4 - Take Advantage of Improved Management Flexibility. As those components of the C&SF Restudy that most directly influence water management in Lake Okeechobee are implemented, additional management flexibility should be available to further modify the lake's regulation schedule. Continued re-evaluation of opportunities to refine the regulation schedule will be necessary to achieve benefits in the lake, the estuaries, and the Everglades. The Service supports implementation of WSE on an interim basis, to be evaluated annually by a multi-agency and multi-disciplinary technical review panel. Formal re-evaluation of the schedule, including another Fish and Wildlife Coordination Act Report, will likely be necessary several years after implementation of WSE.

Response - The Corps agrees with the concept of adaptive assessment in order to monitor the performance of WSE with a view to improving the overall management of Lake Okeechobee. The concept of a multi-agency, multi-disciplinary technical review panel presupposes that there will be new and sufficiently ample amount of data to review and upon which to base recommendations. The Corps has no authority, and therefore no funding, to conduct new field investigations or monitoring which might support such a review. However, the SFWMD does have investigations both planned and ongoing through their Okeechobee Systems Research Division which may prove useful during said review. Information resulting from these studies, along with empirical data, may be beneficial in assessing WSE performance in the short term. Recommendations from a technical review panel would not be expected to result in a new regulation schedule, rather they would assist the Corps and SFWMD water managers in interpreting the effects of the WSE schedule on the lake, affected communities and downstream natural resources. The Corps would welcome the opportunity to partner with other interested agencies in assessing conditions within the lake, and affected areas downstream, during the proposed technical review panel. Details for establishing this review will need to be worked out between the concerned agencies. However, it is expected that it would be supported equally between the Corps, SFWMD, the USFWS and other participating state and Federal agencies. Furthermore, it is envisioned that such a panel would be informal in nature, would require minimal additional work outside of the annual review, and may be based entirely on existing data and/or empirical observations over the previous year.

Interpretation of Lake Okeechobee regulation schedule operational guidelines is ultimately the responsibility of the SFWMD and the Corps. While this responsibility cannot be shared with or assumed by entities outside of these two agencies, the SFWMD and the Corps welcome input of a policy or technical nature at any time by interested agencies through informal channels. The SFWMD and Corps possess extensive technical expertise, of a multi-disciplinary background, to effectively conduct the day to day water management operations of the Central and Southern Florida Project. Moreover, we are cognizant of the limitations of the present system, and the delicate balance among the communities and resources served by this water allocation. In the past, when emergency situations arose which could potentially affect communities or resources under other agencies authority, the Corps and SFWMD called upon the expertise of those agencies to assist us with assessing the problem, formulating solutions and mitigating potential impacts. Under such an emergency situation, this close collaboration would be beneficial and would continue. The Corps does not concur with the need to carry out a complete NEPA review process within five years on an as yet unspecified and undefined action. NEPA review, an expensive and time consuming process, will occur at an appropriate time, if and when the Corps and/or the SFWMD considers implementing another alternative lake regulation schedule.

9.2.2 Florida Fish and Wildlife Conservation Commission, preliminary Fish and Wildlife Coordination Act Report Comments

Comment #1 – The FWC had several comments in a previous Planning Aid Letter regarding suggested improvements to model output including re-scaling certain performance measures so all alternatives could be viewed using similar scales and enlargements of select stage hydrographs and "wading bird windows" so more detailed assessments can be conducted.

Response – The above suggested improvements to the subject model output was done and results posted to an ftp site for display. This information was made available to Biologists at the USFWS and FWC on May 14, 1999.

Comment #2 – The FWC suggests that performance measures be based on selected indicator regions as was done for the Restudy and not on individual grid cells for the Water Conservation Areas.

Response – The WSE alternative was run using the indicator region concept as was done during the C&SF Restudy and results were posted to an ftp site as per above, and made available to USFWS and FWC Biologists.

Comment #3 – The draft EIS should contain a section that clearly explains the rationale for decreasing the amount of water, and therefore the phosphorus load, that WCA 1 would receive under WSE, while increasing it to the other WCAs.

Response – The below paragraph is provided to explain the proportion of regulatory releases allocated to each of the WCAs:

A major theme of the WSE schedule is to reduce the stress on the littoral zone of Lake Okeechobee by releasing water southward to the WCAs during periods when such releases would be of minimum impact to, and in most cases, beneficial for Everglades hydroperiods. During periods when additional flows would benefit Everglades hydroperiods, the WSE schedule pumps water at the S-7 and S-8 structures southward into WCA 2A and WCA 3A. In the base condition, releases from the lake to WCA 2A and WCA 3A are normally by gravity unless the lake water levels enter Zone A of the regulation schedule. The additional water sent to WCA 2A and WCA 3A under the proposed action is due to this additional pumping through the S-7 and S-8 structures. By way of comparison, nearly all releases from Lake Okeechobee to WCA 1 through the Hillsboro (S-6 pump station) and West Palm Beach Canals (S-5A pump station) are pumped. This leaves a disproportionately large amount of regulatory releases entering WCA 1 as compared to WCA 2A and WCA 3A under the base condition. While the original intention of WSE was to get more water to the Everglades for improved hydroperiod, this additional pumpage also had the effect of distributing water more evenly between the WCAs.

In addition it should be noted that one-third of the simulated regulatory releases from Lake Okeechobee to WCA 3A may never leave the Miami Canal. This because, under the simulation, Service Area 3 of the LEC imposed an equal or greater demand for water the same day that the regulatory releases were made. In the base condition, these demands were satisfied directly from WCA 3A until its water level reached its minimum level. In effect, WCA 3A receives the volumetric benefits of 24.8 k acre-feet of additional flow on an average annual basis from the lake, but only receives 16.6 k acre-feet of this water actually would overflow the canal bank and enter the wetlands.

Comment #4 – Should WSE be implemented, the FWC recommends that a standing, interagency team of biologists be formed to consult with the USACE and SFWMD to interpret the operational guidelines.

Response – An interagency group of biologists, hydrologists, engineers and water management modeling experts already exists and coordinates regularly on lake management issues. This group coordinates via meetings and teleconference calls which are open to all. Relevant experience, particularly on Lake Okeechobee fishery resources, would be of benefit to the group and the FWC is encouraged to participate. It should be noted that management of Lake Okeechobee regulatory issues are inherently time sensitive, based in part on climatalogical and near term storm event data, and require swift decision making, often by ad hoc members.

9.2.3 Florida Fish and Wildlife Conservation Commission, final Fish and Wildlife Coordination Act Report Comments

Comment # 1 - The FWC requests clarification as to why less phosphorus loading would occur under the WSE schedule in WCA-1 than in WCA-2 and WCA-3.

Response – See Reference ,"South Florida Water Management District. 1999. Phosphorus issues associated with the Lake Okeechobee regulation schedule, Unpublished report, March 1999. West Palm Beach, Florida"

Comment # 2 - We request clarification as to the nature of the reduction in cattail spread. Specifically, does this represent a reduction in the rate of spreading, or to an anticipated actual reduction in the acres of existing cattails.

Response - In the final US Fish and Wildlife Service CAR this issue was not discussed.

Comment # 3 – We request that the U.S. Environmental Protection Agency and the Florida Department of Environmental Protection examine the water quality analysis very carefully to determine if the excess loading would violate water quality standards.

Response – Concur

Comment # 4 – We recommend that the decision-making trees presented as Figures 6.1-2 and 6.1-3 be explicitly incorporated as a part of the regulation schedule for WSE.

Response – Figures 6.1-2 and 6.1-3 have been revised to be incorporated as part of the regulation schedule for WSE.

Comment # 5 - Because WSE attempts to provide an unprecedented level of balance among the competing uses of the lake, we recommend that the SFWMD appoint an advisory group, operating under the Florida Sunshine Act, to its in-house team. We recommend that the advisory group meet with the in-house team of experts quarterly.

Response – The US Fish and Wildlife Service stated in the Executive Summary making a recommendation that a multi-agency and multi-disciplinary technical review panel meet annually to reassess how effective climate forecasting has been in improving the performance of the WSE schedule. This will provide an opportunity to review ecological conditions in the lake, the estuaries, and the Everglades and to explore opportunities for further refinement of WSE.

9.3 ENDANGERED SPECIES ACT of 1973

Informal consultation was initiated by letter on August 29, 1996 requesting a list of threatened and endangered species known or thought to occur within the study area. The USFWS, through inter-agency coordination, transmitted information to the Corps regarding listed species likely to be present in the study area and which may be affected by LORSS alternatives. The Corps issued a determination of effect, by letter, to USFWS on February 16, 1999 stating that listed species and their critical habitat were not likely to be adversely effected as a result of the WSE alternative. This determination was made based on an assessment of hydrologic modeling of environmental performance measures, contained in ***Appendices A and C***, scientific field data collected by the Corps during the study (***Appendix E***), and coordination with USFWS biologists throughout the study. Written concurrence by USFWS concluded Informal consultation on July 30, 1999. Informal consultation does not require issuance of a biological opinion. The USFWS concluded that expected improvements on habitat conditions due to WSE would likely be beneficial to the Okeechobee gourd, bald eagle, wood stork, and the snail kite in the vicinity of Lake Okeechobee.

Coordination with the National Marine Fisheries Service (NMFS) regarding federally listed threatened and endangered marine mammal and sea turtle species is ongoing. The Corps, in a letter to NMFS dated June 24, 1999, provided a biological assessment indicating that, in the opinion of the Corps, the project is not likely to adversely effect listed species known to occur within the study area. The Corps will provide NMFS with copies of this draft report and appendices for their review and consideration, and seek their concurrence with this determination of effect. This project is therefore in partial compliance with the Act.

9.4 NATIONAL HISTORIC PRESERVATION ACT of 1966

The study is in partial compliance at this stage. Consultation with the Florida State Historic Preservation Officer has been initiated.

9.5 CLEAN WATER ACT of 1972

The study is in full compliance at this stage. Because the proposed action is strictly of an operational nature, and does not involve any construction activity at all, water quality certification from the State of Florida is not required. Furthermore, as there are no structural components contained in the proposed action and no dredge and fill operations being considered, a Section 404(b) Evaluation is not appropriate.

9.5.1 CONSENT DECREE – U.S. vs. South Florida Water Management District, et al. Case No. 88-1886-CIV-Hoeveler

In 1988, the United States sued the State of Florida over the state's failure to deliver water meeting state water quality standards to the Loxahatchee National Wildlife Refuge (Refuge) and Everglades National Park (Park). United States v. South Florida Water Management District, et al., Case No. 88-1886-Civ-Hoeveler (S.D. Fla.). The parties entered into a settlement agreement in 1991, which the Court entered as a Consent Decree in 1992. United States v. South Florida Water Management District, 847 F. Supp. 1567, 1569 (S.D. Fla. 1992), affirmed in relevant part, 28 F.3d 1563 (11^{th} Cir. 1994). Among other things, the Consent Decree requires the state to implement Best Management Practices (BMPs) in the Everglades Agricultural Area (EAA); construct Stormwater Treatment Areas (STAs) to remove phosphorus from surface water discharged to the Refuge and the other Water Conservation Areas (WCAs); and to achieve long-term state water quality standards in the Refuge and Park by July 2002.

The 1992 Consent Decree also requires that phosphorus loads to the Refuge and other WCAs be reduced. Generally, the decree prescribes a schedule of remedial measures, the timely implementation of which is expected to provide progressive reduction in loads. Further, the decree numerically quantifies the load reductions expected from completion of the remedial measures. ¶ 8A; App. C. These numerical reductions are expressed in terms "relative to the amount of phosphorus that was historically discharged from the EAA into the EPA." App. C.3.

In 1995, the settling parties moved to modify the Consent Decree to incorporate an expanded technical plan authorized by Florida's Everglades Forever Act, F.S. §373, 4592. The requested modifications would require the construction of more acres of STAs and postpone deadlines by several years. Under the proposed modifications to the Consent Decree, "Phosphorus loads discharged from the EAA will be reduced by approximately 80% to the EPA by October 1, 2003, and will be reduced by approximately 85% to the Refuge by February 1, 1999, as compared to mean levels measured from 1979 to 1988." ¶ 8(A). The Court has not yet ruled on the motion to modify the Consent Decree.

The proposed WSE regulation schedule for Lake Okeechobee will not cause a violation of the phosphorus load provisions of the proposed modifications to the Consent Decree. The phosphorus load reduction provisions in the decree require load reductions consistent with the expected benefits of the mandated technical plan. Under the technical plan being implemented by state and federal agencies (the Everglades Construction Project Conceptual Design, dated Feb. 15, 1994), phosphorus loads delivered to the Refuge and other WCAs are expected to be reduced through a combination of BMPs, STAs, and other measures. Over the past several years, the BMP's and STA's have been operating far more effectively than assumed in the technical plan. So long as phosphorus loads to the Refuge and other WCAs are equal to or below the cumulative phosphorus loads assumed under the technical plan, then the load reduction requirements will be met. An analysis of total projected phosphorus loads to the WCAs with the WSE schedule indicates that total loads would be less than those assumed under the technical plan. The WSE schedule would add only a negligible amount to phosphorus loads sent to the WCAs and the effect of those loads would be mitigated once STA 3/4 is completed in the year 2003. Accordingly, the WSE schedule would not cause a violation of the load reduction provisions of the Consent Decree.

9.6 CLEAN AIR ACT of 1972

This Act is not applicable to this study.

9.7 COASTAL ZONE MANAGEMENT ACT of 1972

The study is in partial compliance at this time. Full compliance would be achieved with receipt of comments from the Florida State Clearinghouse. A Federal consistency determination in accordance with 15 CFR 930 Subpart C is included in this report as ***Annex B***.

9.8 FARMLAND PROTECTION POLICY ACT of 1981

This project will not affect agricultural lands within the study area. The proposed action recommends operational changes only to the existing lake regulation schedule and will not impact existing or future agricultural or associated urban water supply. This Act is therefore not applicable.

9.9 WILD AND SCENIC RIVER ACT of 1968

The Northwest Fork of the Loxahatchee River is designated a Wild and Scenic River. This resource is not expected to be adversely impacted by the proposed action. The study is in full compliance.

9.10 ESTUARY PROTECTION ACT of 1968

The study is in full compliance. The proposed action takes into account the restoration of all the estuaries in the project area. While the Caloosahatchee River Estuary does not greatly benefit from the proposed action, it's current ecological health should not be significantly effected either. The St. Lucie Estuary should be marginally improved from its current condition to the extent that operational changes alone can affect lake releases to the estuary, without adversely impacting authorized project purposes or other areas of the natural system.

9.11 FEDERAL WATER PROJECT RECREATION ACT of 1965

The project is in full compliance at this stage. The effects of the proposed action on outdoor recreation have been considered. Benefits to fishing, boating and wildlife viewing should be accrued by implementation of the proposed action.

9.12 RESOURCE CONSERVATION AND RECOVERY ACT of 1976

This law has been determined to be not applicable, as there are no items regulated under this act either being disposed of or affected by this project.

9.13 TOXIC SUBSTANCES CONTROL ACT of 1976

This law has been determined to be not applicable, as there are no items regulated under this act either being disposed of or affected by this project.

9.14 MARINE PROTECTION, RESEARCH, AND SANCTUARIES ACT of 1972

This Act is not applicable. Ocean disposal of dredged material is not proposed as a part of the Lake Okeechobee Regulation Schedule Study.

9.15 RIVERS AND HARBORS APPROPRIATION ACT of 1899

The study is in full compliance. The proposed work would not obstruct navigable waters of the United States.

9.16 COASTAL BARRIER RESOURCES ACT

This Act is not applicable. The study area is not in a designated Coastal Barrier Resources Act unit.

9.17 Section 904 of the 1986 WATER RESOURCES DEVELOPMENT ACT

Section 904 of the 1986 Water Resources Development Act requires that the plan formulation and evaluation process consider both quantifiable and unquantifiable benefits and costs of the quality of the total environment, and preservation of cultural and historical values. The study and report are in full compliance.

9.18 Section 307 of the 1990 WATER RESOURCES DEVELOPMENT ACT

Section 307 of the 1990 Water Resources Development Act establishes, as part of the water resources development program, an interim goal of no overall net loss of the Nation's remaining wetlands, and a long-term goal of increasing the quality and quantity of the Nation's wetlands. The proposed action is in full compliance.

9.19 E.O. 11988, FLOODPLAIN MANAGEMENT

The study is in full compliance. The considered alternatives support avoidance of development in the flood plain, continue to reduce hazards and risks associated with floods and to minimize the impact of floods on human safety, health and welfare, and restores and preserves the natural and beneficial values of the base flood plain.

9.20 E.O. 11990, PROTECTION OF WETLANDS

The study is in full compliance. Losses and degradation to the beneficial values of wetlands are minimized, and such values are preserved and enhanced. The public has been involved in early planning.

9.21 E.O. 12114, ENVIRONMENTAL EFFECTS ABROAD OF MAJOR FEDERAL ACTIONS

This executive order is not applicable to this study.

9.22 E.O. 12898, ENVIRONMENTAL JUSTICE

Executive Order 12898 requires the Federal government to achieve environmental justice by identifying and addressing disproportionately high adverse effects of its activities on minority and low-income populations. It also requires the analysis of information such as the race, national origin, and income level for areas expected to be impacted by environmental actions. Executive Order 12898 also requires Federal agencies to identify the need to ensure the protection of populations relying on subsistence consumption of fish and wildlife, through analysis of information on such consumption patterns, and communication to the public of associated risks.

This project is not expected to pose any adverse impacts to minority or low income populations. In fact, benefits to Lake Okeechobee and the estuaries and their fishery and natural resources in particular, will act to enhance and sustain populations around the lake and estuaries who depend on a healthy natural ecosystem. These populations would include minority populations who participate in local economies as owners and/or employees, notably in commercial fishing ventures, sport fishing guide services, bait and tackle operators, resorts and campgrounds, motel and hotel operations, restaurants and other related businesses. Those minority individuals or groups active in sustainable harvest of fish, shellfish, turtles and other plants and animals would also see their activity improved through a healthier lake and estuarine ecosystem.

10 LIST OF PREPARERS

Table 10.00-1
Final Environmental Impact Statement
List of Preparers

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MIKE ZIMMERMAN EVERGLADES NATIONAL PARK 40001 STATE ROAD 9336 HOMESTEAD, FL 33034-6733	PETE MILAM USACE, AREA ENGINEER SOUTH FLORIDA AREA OFFICE 525 RIDGE LAWN ROAD CLEWISTON, FL 33440-5399 (3 CYS)	U.S. DEPARTMENT OF AGRICULTURE ATTN: MS. DIANE CONWAY 450 NW HWY 98 OKEECHOBEE, FL 34972
STATE AGENCIES	EXECUTIVE DIRECTOR SOUTH FLORIDA WATER MANAGEMENT DISTRICT P.O. BOX 24680 3301 GUN CLUB ROAD WEST PALM BEACH, FL 33416	LINDA LOOMIS SHELLEY, SECRETARY INTERGOVERNMENTAL AFFAIRS POLICY UNIT THE CAPITOL, ROOM 1603 TALLAHASSEE, FL 32399-0001
LEWIS HORNUNG SOUTH FLORIDA WATER MGMT DISTRICT P.O. BOX 24680 WEST PALM BEACH, FL 33416-4680	FLORIDA STATE CLEARINGHOUSE ATTN: CHERIE TRAINOR DEPARTMENT OF COMMUNITY AFFAIRS 2555 SHUMARD OAK BLVD TALLAHASSEE, FL 32399-2100 (16 CYS)	MR. ERNIE BARNETT, DIRECTOR OFFICE OF ECOSYSTEM PLANNING FLORIDA DEPT OF ENVIRON. PROTECTION 3900 COMMONWEALTH BLVD MS 45 TALLAHASSEE, FL 32399-3000
MR. HERBERT H. ZEBUTH SOUTHEAST DISTRICT FLRORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION P.O. BOX 15425 WEST PALM BEACH, FL 33416	EXECUTIVE DIRECTOR FLORIDA FISH AND WILDLIFE CONSERVATION COMMISSION 620 S. MERIDIAN STREET TALLAHASSEE, FL 32399-1600	MS. MARY ANN POOLE EVERGLADES PROTECTION AND RESTORATION PROGRAM FLORIDA FISH AND WILDLIFE CONSERVATION COMMISSION 255 154TH AVENUE VERO BEACH, FL 32968-9041
ENVIRONMENTAL OFFICE (MS-37) FLORIDA DEPARTMENT OF TRANSPORTATION 605 SUWANEE STREET TALLAHASSEE, FL 32399-0450	MS. JANET SNYDER MATTHEWS, PH.D. STATE HISTORIC PRESERVATION OFFICER DIVISION OF HISTORICAL RESOURCES R.A. GRAY BUILDING 500 SOUTH BRONOUGH STREET TALLAHASSEE, FL 32399-0250	MS CAROLINE DECKLE SOUTH FLORIDA REGIONAL PLANNING COUNCIL 3440 HOLLYWOOD BLVD. SUITE 140 HOLLYWOOD, FL 33021
MR. MIKE BUSHA TREASURE COAST REGIONAL PLANNING COUNCIL 301 SE OCEAN BLVD. SUITE 300 STUART, FL 34994-2236	MR. WAYNE DALTRY SOUTHWEST FLORIDA REGIONAL PLANNING COUNCIL P.O. BOX 3455 NORTH MYERS, FL 33918	MR. DOUGLAS LEONARD CENTRAL FLORIDA REGIONAL PLANNING COUNCIL P.O. DRAWER 2089 BARTOW, FL 33830
JANET G. LLEWELLYN, DIRECTOR OFFICE OF WATER POLICY FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION 3900 COMMONWEALTH BLVD MS 46 TALLAHASSEE, FL 32399-1600	BRIAN BARNETT FLORIDA GAME & FRESH WATER FISH COMMISSION 620 S MERIDIAN TALLAHASSEE, FL 32399-1600	BONNIE KRANZER GOVERNOR'S COMMISSION FOR A 1550 MADRUGA AVENUE, SUITE 220 CORAL GABLES, FL 33146

DON FOX FLORIDA GAME AND FRESH WATER FISH COMMISSION OKEECHOBEE BIOLOGICAL FIELD STA 3991 SE 27TH COURT OKEECHOBEE, FL 34973	COMMISSIONER BOB CRAWFORD DEPARTMENT OF AGRICULTURE AND CONSUMER SERVICES 3125 CONNER BLVD. ROOM 269 TALLAHASSEE, FL 32399-1650	AL STEINMAN, PH.D. SOUTH FLORIDA WATER MANAGEMENT DISTRICT P.O. BOX 24680 3301 GUN CLUB ROAD WEST PALM BEACH, FL 33416
WILLIE HORTON, DIRECTOR DEPT OF NAT RESOURCE PROTECTION 218 SW 1ST AVENUE FORT LAUDERDALE, FL 33301		PAUL TRIMBLE SOUTH FLORIDA WATER MANAGEMENT DISTRICT P.O. BOX 24680 3301 GUN CLUB ROAD WEST PALM BEACH, FL 33416
CAL NEIDRAUER OPERATIONS OFFICE SOUTH FLORIDA WATER MANAGEMENT DISTRICT P.O. BOX 24680 3301 GUN CLUB ROAD WEST PALM BEACH, FL 33416	TOMMY STROWD OPERATIONS OFFICE SOUTH FLORIDA WATER MANAGEMENT DISTRICT P.O. BOX 24680 3301 GUN CLUB ROAD WEST PALM BEACH, FL 33416	SOUTH FLORIDA WATER MANAGEMENT DISTRICT REFERENCE LIBRARY – B50 ATTN: MS. CYNTHIA PLOCKELMAN POST OFFICE BOX 24680 WEST PALM BEACH, FL 33416-4680 (2 CYS)
SOUTH FLORIDA WATER MANAGEMENT DISTRICT OKEECHOBEE SERVICE CENTER ATTN: NISSIE BARLETTO 205 E. PARK STREET OKEECHOBEE, FL 34972	ROBERT CHAMBERLAIN, PH.D. OKEECHOBEE SYSTEMS RESEARCH DIVISION SOUTH FLORIDA WATER MANAGEMENT DISTRICT P.O. BOX 24680 WEST PALM BEACH, FL 33416-4680	DAN HAUNERT, PH.D. OKEECHOBEE SYSTEMS RESEARCH DIVISION SOUTH FLORIDA WATER MANAGEMENT DISTRICT P.O. BOX 24680 WEST PALM BEACH, FL 33416-4680
COUNTY AGENCIES	LEIGH E. DUNSTON, CHAIR ECONOMIC COUNCIL, PALM BEACH COUNTY 1555 PALM BEACH LAKES BLVD SUITE 400 WEST PALM BEACH, FL 33401-2375	BEVIN A BEAUDET, P.E. UTILITY DIRECTOR PALM BEACH COUNTY BOX 16097 WEST PALM BEACH, FL 33416-6097
MR. JIM THREEWITS COUNTY COORDINATOR GLADES COUNTY ADMINISTRATION P.O. BOX 1018 MOORE HAVEN, FL 33471	MR. LESTER B. BAIRD COUNTY ADMINISTRATOR HENDRY COUNTY ADMINISTRATION P.O. BOX 1760 LABELLE, FL 33935-1760	MR. CARL COOL COUNTY ADMINISTRATOR HIGHLANDS COUNTY ADMINISTRATION P.O. BOX 1926 SEBRING, FL 33871-1926
MR. DONALD STILWELL COUNTY ADMINISTRATOR LEE COUNTY ADMINISTRATION 2401 SE MONTEREY ROAD STUART, FL 34996	MR. GEORGE LONG COUNTY ADMINISTRATOR OKEECHOBEE COUNTY ADMINISTRATION 304 NW 2ND STREET OKEECHOBEE, FL 34972	MR. ROB MAGNAGHI COUNTY MANAGER OSCEOLA COUNTY ADMINSTRATION 17 S. VERNON AVE., ROOM 117 KISSIMMEE, FL 34741-5488
MR. ROBERT WEISMAN COUNTY ADMINISTRATOR PALM BEACH COUNTY ADMINSTRATION 301 N. OLIVE AVE. WEST PALM BEACH, FL 33401-4705	MR. JIM KEENE COUNTY MANAGER POLK COUNTY ADMINISTRATION DRAWER CA01 P.O. BOX 9005 BARTOW, FL 33831	MR. DOUGLAS M. ANDERSON COUNTY ADMINISTRATOR ST. LUCIE COUNTY ADMINSTRATION 2300 VIRGINIA AVE. FORT PIERCE, FL 34982

MR. DENNIS L. CARTER ASSISTANT COUNTY MANAGER METRO-DADE CENTER OFFICE OF THE CITY MANAGER SUITE 2910 111 NW 1ST STREET MIAMI, FL 33128	MR. RUSS BLACKBURN COUNTY ADMINISTRATOR MARTIN COUNTY ADMINISTRATION 2401 SE MONTEREY ROAD STUART, FL 34996	GUILERMO OLMEDILLO PLANNING DIRECTOR MIAMI-DADE COUNTY PLANNING DEPT 111 NW FIRST STREET SUITE 1220 MIAMI, FL 33128-1972
BOB HOWARD LEE COUNTY 1500 MONROE STREET-3RD FL. FT. MYERS, FL 33901	THE HONORABLE WILLIAM PETERSON GLADES CITY BOARD OF COUNTY COMM P.O. BOX 10 MOORE HAVEN, FL 33471	THE HONORABLE MARLENE YOUNG POLK COUNTY BOARD OF COUNTY COMMISSIONERS P.O. BOX 60 BARTOW, FL 33830
FRANK MARSOCCI ECONOMIC COUNCIL OF OKEECHOBEE COUNTY INC. P.O. BOX 718 OKEECHOBEE, FL 34973	MS. DORIS CUTSHALL HEAD LIBRARIAN BARRON LIBRARY 461 N. MAIN STREET LABELLE, FL 33935-5179	MS. SUSAN E. KILMER, DIRECTOR ST. LUCIE COUNTY LIBRARY SYSTEM 124 N. INDIAN RIVER DRIVE FORT PIERCE, FL 34950
COUNTY LIBRARIES	MS. MARY ELLEN FULLER, DIRECTOR CHARLOTTE COUNTY LIBRARY SYSTEM 18400 MURDOCK CL PORT CHARLOTTE, FL 33948-1094	JOHN FRASER, DIRECTOR HENDRY COUNTY LIBRARY SYSTEM 120 W. OSCEOLA AVE. CLEWISTON, FL 33440
MS. PHYLLIS LILLEY BRANCH MANG. BELLE GLADE BRANCH PUBLIC LIBRARY 530 S. MAIN STREET BELLE GLADE, FL 33430	MS. DOROTHY M. SCHIRTZINGER DIRECTOR LEE COUNTY LIBRARY SYSTEM 2050 LEE STREET FORT MYERS, FL 33901	MS. GRETCHEN CUFFE, DIRECTOR MARTIN COUNTY LIBRARY SYSTEM 701 E. OCEAN BLVD. STUART, FL 34994
MS. MARY MYERS, DIRECTOR HIGHLANDS COUNTY LIBRARY SYSTEM 319 W. CENTER AVE. SEBRING, FL 33870	MR. BILL JOHNSON,DIRECTOR OSCEOLA COUNTY LIBRARY SYSTEM 211 E. DAKIN AVE. KISSIMMEE, FL 34741	MR. JERRY BROWNLEE, DIRECTOR PALM BEACH COUNTY LIBRARY SYSTEM 3650 SUMMIT BLVD. WEST PALM BEACH, FL 33406-4198
	MR. EDWARD KILROY, DIRECTOR OKEECHOBEE COUNTY LIBRARY 50 SE SECOND AVENUE OKEECHOBEE, FL 34972-2990	
MS. LINDA CHANCEY, DIRECTOR POLK COUNTY BARTOW PUBLIC LIBRARY 315 E. PARKER STREET BARTOW, FL 33830		

ASSOCIATIONS	PAUL N. GRAY, PH.D., MANAGER NATIONAL AUDUBON SOCIETY ORDWAY-WHITTELL KISSIMMEE PRAIRIE SANCTUARY 17350 NW 203RD AVENUE OKEECHOBEE, FL 34972	MAX QUACKENBOS, BOARD MEMBER ST. LUCIE RIVER INITIATIVE P.O. BOX 2082 STUART, FL 34994
FLORIDA BIODIVERSITY PROJECT ATTN: BRIAN SCHERF 1060 TYLER STREET HOLLYWOOD, FL 33019	MR. MARK KRAUS NATIONAL AUDUBON SOCIETY 444 BRICKELL AVE. #850 MIAMI, FL 33131	FLORIDA AUDUBON SOCIETY ATTN: CHARLES LEE 1331 PALMETTO AVE., SUITE 110 WINTER PARK, FL 32789
DR. PAUL PARKS FLORIDA WILDLIFE FEDERATION 1549 LIVE OAK DRIVE TALLAHASSEE, FL 32301	MR. DAVID BALMAN EVERGLADES COORDINATING COUNCIL 3845 SW 103RD AVENUE APT 101 MIAMI, FL 33165	MS. ROSA DURANDO AUDUBON SOCIETY OF THE EVERGLADES 10308 HERITAGE FARMS LAKE WORTH, FL 33467
MR. KARSTEN A RIST TROPICAL AUDUBON SOCIETY, INC. 5530 SUNSET DRIVE MIAMI, FL 33143	MR. DENNIS OLLE TROPICAL AUDUBON SOCIETY 201 S. BISCAYNE BLVD (SUITE 1402) MIAMI, FL 33131	
MR. JOSEPH PODGOR FRIENDS OF THE EVERGLADES 244-A WESTWARD DRIVE MIAMI SPRINGS, FL 33166	ELAINE USHERSON CONSERVATION CHAIR LOXAHATCHEE GROUP SIERRA CLUB 410 BENNINGTON LANE LAKE WORTH, FL 33467	MS. SHANNON ESTENOZ WORLD WILDLIFE FUND P.O. BOX 19630 PLANTATION, FL 33318
MS. MARY MUNSON CO-CHAIRPERSON DEFENDERS OF WILDLIFE 1101 14TH STREET, NW SUITE 1400 WASHINGTON, DC 20005	MR. DOUG COWARD 1000 FRIENDS OF FLORIDA 1833 SE HIDEAWAY CIRCLE PORT ST LUCIE, FL 34952	MR. JIM HAGGART CALOOSAHATCHEE RIVER CITIZENS ASSOCIATION 12491 COCONUT CREET COURT FORT MYERS, FL 33908
MR. FRAN STALLINGS SAVE THE MANATEE P.O. BOX 8776 NAPLES, FL 34101-8776	MR. ROBERT BENDICK, STATE DIRECTOR THE NATURE CONSERVANCY 222 S. WESTMONTE DRIVE (SUITE 300) ALTAMONTE SPRINGS, FL 32714-4269	MS. PATTI WEBSTER ENVIRONMENTAL COALITION OF BROWARD COUNTY 10400 GRIFFIN ROAD, SUITE 304 COOPER CITY, FL 33328
MR. TIMOTHY SEARCHINGER ENVIRONMENTAL DEFENSE FUND 1875 CONNECTICUTT AVE. NW WASHINGTON, DC 20009		MS. HELEN HIRSCHFELD LEAGUE OF WOMEN VOTERS, BROWARD 202 SW 63RD AVENUE PLANTATION, FL 33317

NATIONAL PARKS AND CONSERVATION ASSOC. ATTN: MS. KIM SWATLAND 1546 POLK STREET HOLLYWOOD, FL 33020-5426		MS. LUCIE P. ANDERSON RIDGE AUDUBON SOCIETY 1122 CIRCLE DRIVE LAKE WALES, FL 33853
MR. MANLEY FULLER, III FLORIDA WILDLIFE FEDERATION P.O. BOX 6870 TALLAHASSEE, FL 32314-6870	HERBERT W. KALE II, PH.D. FLORIDA AUDUBON SOCIETY 460 HWY 436 SUITE 200 CASSELBERRY, FL 32707-4939	MR. JOHN RAINS, JR. IZAAK WALTON LEAGUE 5314 BAY STATE ROAD PALMETTO, FL 32561-9712
MR. CARROL HEAD, PRESIDENT FRIENDS OF LAKE OKEECHOBEE 2252 SOUTHWEST 22ND CIRCLE OKEECHOBEE, FL 34974	MS. BRENDA H. MARSHALL TRUST FOR PUBLIC LANDS 7900 RED ROAD SUITE 25 MIAMI, FL 33143	THE ARTHUR R. MARSHALL FOUNDATION & THE FLORIDA ENVIRONMENTAL INSTITUTE, INC. P.O. BOX 2621 PALM BEACH, FL 33480
J. RICHARD HARRIS EXECUTIVE DIRECTOR 100 BLACK MEN OF PALM BEACH CO. 1897 PALM BEACH LAKES WEST PALM BEACH, FL 33407		
NATURAL RESOURCES DEFENSE COUNCIL ATTN: BRAD SEWELL 40 WEST 20TH STREET NEW YORK, NY 10011	MR. WAYNE NELSON FADE P.O. BOX 16061 WEST PALM BEACH, FL 33416	MR. ANDREW SCHOCK NATIONAL WILDLIFE FEDERATION 1330 WEST PEACHTREE ST (SUITE 475) ATLANTA, GA 30309
AGRICULTURAL INTERESTS	ELIZABETH S. JOHNSTONE STITT RANCH INC. ROUTE 2 BOX 170 CLEWISTON, FL 33440-9747	DR. SEYMORE GOLDWEBBER DADE COUNTY AGRICULTURAL COUNCIL 7900 SW 126TH TERRACE MIAMI, FL 33156
MR. ART DARLING DAIRY FARMERS INC. 166 LOOKOUT PLACE SUITE 100 MAITLAND, FL 32751	MS. BARBARA MIEDEMA SUGAR CANE GROWERS COOPERATIVE P.O. BOX 666 BELLE GLADE, FL 33430-5556	VEE PLATT FRIERSON FARM P.O. BOX 1686 CLEWISTON, FL 33440
MR. JOHN W. DUNCKELMAN FLORIDA SUGAR CANE LEAGUE, INC. P.O. DRAWER 1208 CLEWISTON, FL 33440-1208	MR. TOM JONES SOUTH FLORIDA AGRICULTURAL COUNCIL P.O. BOX 68 LABELLE, FL 33935	FLORIDA CITRUS MUTUAL P.O. BOX 89 LAKELAND, FL 33802

MR. ED ENGLISH GULF CITRUS GROWERS P.O. BOX 1319 LABELLE, FL 33975	MR. PHIL STRAZZULLA INDIAN RIVER CITRUS LEAGUE 4102 SABLE PALM DRIVE VERO BEACH, FL 32963	MR. JOE PEARCE FLORIDA CATTLEMAN'S ASSOCIATION P.O. BOX 421929 KISSIMMEE, FL 34742-1929
UNITED STATES SUGAR CORP. ATTN: MR. FRANKLYN JONES, P.E. DIRECTOR, ENGINEERING PLANNING P.O. DRAWER 1207 CLEWISTON, FL 33440	BRYAN BEER GUTWEIN GROVES, INC. P.O. BOX 158 LABELLE, FL 33935	LEWIS FRIEND FARMS, INC. ATTN: LEWIS FRIEND 460 STATE MARKET ROAD PAHOKEE, FL 33476
DAVE QUIRING BERRY GROVE CORPORATION P.O. BOX 459 LABELLE, FL 33935	PRESIDENT ATLANTIC SUGAR ASSOC., INC. P.O. BOX 1570 BELLE GLADE, FL 33430	BUBBA WADE 111 PONCE DE LEON CLEWISTON, FL 33440
ALBERTO S. RECIO OSCEOLA FARMS CO. RAW SUGAR FACTORY P.O. BOX 679 INTERSECTION U.S. 98 & HATTON HWY. PAHOKEE, FL 33476	MARY ANN GOSA FLORIDA FARM BUREAU 222 SW 77TH TERRACE OKEECHOBEE, FL 34974	BRIAN MCMAHON LYKES BROTHERS INC. AGRICULTURAL GROUP 7 LYKES ROAD LAKE PLACID, FL 33852
LAWRENCE D. WORTH DIRECTOR OF ENGINEERING U.S. SUGAR CORPORATION P.O. DRAWER 1207 CLEWISTON, FL 33440	LOUIS E. LARSON, SR., PRESIDENT LARSON DAIRY, INC. P.O. BOX 1242 OKEECHOBEE, FL 34973	WAYNE ZAHN LYKES BROTHERS INC. 7 LYKES ROAD LAKE PLACID, FL 33852
NATIVE AMERICAN TRIBES	MICCOSUKEE TRIBE OF INDIANS ATTN: GENE DUNCAN P.O. BOX 440021 TAMIAMI STATION MIAMI, FL 33144	MR. CRAIG TEPPER SEMINOLE TRIBE OF FLORIDA 6073 STIRLING ROAD HOLLYWOOD, FL 33024
OTHER	JOHN W. DRAKE ROUTE 2 BOX 173 CLEWISTON, FL 33440	LESLY S. SMITH TOWN COUNCIL PRESIDENT TOWN OF PALM BEACH 360 SOUTH COUNTY ROAD PALM BEACH, FL 33480
LEE CHAMBERLAIN, PRESIDENT EVERGLADES COORDINATING COUNCIL 7901 WEST 25TH COURT HIALEA, FL 33016	CATHY HILLIARD LADIES OF THE LAKE, U.S.A. P.O. BOX 1686 CLEWISTON, FL 33440	EMILY DRAKE ROUTE 2 BOX 173 CLEWISTON, FL 33440

	WILLIAM T. STITT, P.E. ROUTE 2 BOX 170 CLEWISTON, FL 33440	ARDIS HAMMOCK P.O. BOX 1928 CLEWISTON, FL 33440
DWIGHT R. GRAYDON GENERAL MANAGER PAHOKEE WATER CONTROL DISTRICT P.O. BOX 896 BELLE GLADE, FL 33430	KATHY FEDERICO, UTILITY DIRECTOR WATER UTILITIES DEPARTMENT PALM BEACH COUNTY BOX 16097 WEST PALM BEACH, FL 33416-6097	
CAROL A. ROBERTS, DISTRICT II COUNTY COMMISSIONER 301 NORTH OLIVE AVENUE 12TH FLOOR WEST PALM BEACH, FL 33401	MR. THOMAS MACVICAR MACVICAR, FREDERICO & LAMB, INC. 4524 W. GUN CLUB ROAD SUITE 201 WEST PALM BEACH, FL 33415	PAUL W. LARSEN LARSEN & ASSOCIATES LIMESTONE MINING COALITION 200 SOUTH BISCAYNE BLVD SUITE 2940 MIAMI, FL 33131
MR. PHILLIP PARSONS LANDERS & PARSONS P.O. BOX 271 TALLAHASSEE, FL 32302-0271	CITY OF PAHOKEE ATTN: KENNETH N. SCHENCK CITY MANAGER 171 N. LAKE AVE. PAHOKEE, FL 33476	DR. PETER ROSENDAHL FLO-SUN, INC. 316 ROYAL POINCIANA PLAZA PALM BEACH, FL 33480
OKEECHOBEE WATERWAY ASSOCIATION ATTN: GAIL A BYRD P.O. BOX 2756 CLEWISTON, FL 33440	LEO GILLIS COQUINA WATER CONTROL DISTRICT 17205 NW 240TH STREET OKEECHOBEE, FL 34972	PAHOKEE MARINA ATTN: SUSAN SELTNER 190 NORTH LAKE DRIVE PAHOKEE, FL 33476
THE HONORABLE JOSEPH SPRATT HENDRY COUNTY BOARD OF COUNTY COMMISSIONERS P.O. BOX 1760 LABELLE, FL 33935-1760	RON HAMEL GULF CITRUS GROWERS ASSOCIATION P.O. BOX 1319 LABELLE, FL 33935	PALMER TUTHILL INDIANTOWN DRAINAGE DISTRICT P.O. BOX 806 INDIANTOWN, FL 34956
M. KENT BOWEN MCARTHUR FARMS INC. 1550 NE 208TH STREET OKEECHOBEE, FL 34972	THE HONORABLE CHARLES W. HARVEY OKEECHOBEE COUNTY BOARD OF COUNTY COMMISSIONERS 304 NW 2ND STREET ROOM 106 OKEECHOBEE, FL 34972	JOHN ED BURDESHAW OKEECHOBEE CHAMBER OF COMMERCE 55 SOUTH PARROTT AVENUE OKEECHOBEE, FL 34972
LACE K. VITUNAC CONSERVATION ALLIANCE ST LUCIE COUNTY 810 KITTERMAN ROAD PORT ST LUCIE, FL 34952-9017	MR. MIKE BUSHA TREASURE COAST REGIONAL PLANNING COUNCIL 301 SE OCEAN BLVD. SUITE 300 STUART, FL 34994-2236	JEFF KRAUSKOPF MARTIN BOARD OF COUNTY COMM 2401 SE MONTEREY ROAD STUART, FL 34996

PAUL GRAY WATERFOWL MGMT SECTION FL GAME & FRESHWATER FISH COMM 3991 SE 27TH COURT OKEECHOBEE, FL 34974	LORI ROZSA MIAMI HERALD 139 N. COUNTY RD. #35 PALM BEACH, FL 33480	EDWARD FILO STUART NEWS 1939 S. FEDERAL HWY STUART, FL 34997
T.L. RICE FIU 7700 N. KENDALL DRIVE, SUITE 303 MIAMI, FL 33516	NATHANIEL REED BOX 375 HOBE SOUND, FL 33455	PAT GLEASON MONTGOMERY WATSON 2328 10TH AVENUE NORTH, 5TH FLOOR LAKE WORTH, FL 33462
DAVID G. CUFFE PALM BEACH COUNTY ENGINEERING DEPT. 160 AUSTRAILIAN AVENUE, RM. 302 WEST PALM BEACH, FL 33406	CHARLES SCHOECH HIGHLANDS GLADES DRAINAGE DIST P.O. BOX 2775 PALM BEACH, FL 33480-4306	RICAARDO A. LIMA OKEELANTA CORPORATION P.O. BOX 86 SOUTH BAY, FL 33493
F. D. JORDAN ST LUCIE RIVER INITIATIVE INC. P.O. BOX 2471 STUART, FL 34995	ANTHONY J. CLEMENTE, P.E., DIRECTOR MIAMI-DADE WATER AND SEWER DEPT 4200 SALZEDO STREET CORAL GABLES, FL 33146	RICAARDO A. LIMA OKEELANTA CORPORATION P.O. BOX 86 SOUTH BAY, FL 33493
STEVE BAUMGARTNER CHAMBER OF COMMERCE 115 E. MAIN STREET PAHOKEE, FL 33476	ANTHONY J. CLEMENTE, P.E., DIRECTOR MIAMI-DADE WATER AND SEWER DEPT 4200 SALZEDO STREET CORAL GABLES, FL 33146	
LARS LARSEN OKEECHOBEE WATERWAY ASSOC, 1402 SW 54 TERRACE CAPE CORAL, FL 33914	MS. JEAN FERRERA WRAGGS AND CASAS 1000 BRICKELL, SUITE 400 MIAMI, FL 33131	DEBRA FRUTH 964 COUNTY RD. 721 LOT 174 LORIDA, FL 33857
PALM BEACH POST ATTN: BOB KING 2751 SOUTH DIXIE HWY WEST PALM BEACH, FL 33416	DAVID MILLER & ASSOCIATES, INC. SUITE 350 130 PARK STREET, SE VIENNA, VA 22180	SUN SENTINEL ATTN: NEIL SANTANIELLO 3333 SOUTH CONGRESS AVE. DELRAY BEACH, FL 33445
DEBRA FRUTH 964 COUNTY RD. 721 LOT 174 LORIDA, FL 33857	MR. WILLIAM KEITH 301 E. ATLANTIC BLVD. POMPANO BEACH, FL 33034	GEORGE DALRYMPLE 21425 SW 368TH STREET HOMESTEAD, FL 33034

MOYE BISHOP P.O. BOX 865 CLEWISTON, FL 33440	ROBERT E. CLARK SR. P.O. BOX 2426 CLEWISTON, FL 33440	BRYON MAHARREY 329 EMERSON CR. PALM SPRINGS, FL 33461
JOE CARROL 1160 38TH AVENUE VERO BEACH, FL 32960	DERICK PRIDGEN 119 BALBOA PLACE CLEWISTON, FL 33440	WILLIAM WALKER, JR. PH.D. 1127 LOWELL ROAD CONCORD, MA 01742
RON ARIETTA 2622 MONROE STREET HOLLYWOOD, FL 33020	THOMAS L. BUCK C&T SEAFOODS 5824 MARINA ROAD BOKEELIA, FL 33922	ROBERT L. YODER 8291 NW 19TH STREET PEMBROKE PINES, FL 33922
TERRY GARRELS 622 SABAL AVE CLEWISTON, FL 33440	BISHOP WRIGHT, JR. 15439 94TH STREET NORTH CAPE CORAL, FL 33914	EDWIN CONNERS 3914 SW 11TH AVE CAPE CORAL, FL 33914
RONALD BENENATI 24 OAKWOOD ROAD WINTERHAVEN, FL 33880	GARY M. ELLIS 1550 OLO 27 LOT 282 CLEWISTON, FL 33440	ALAN ADAMS 337 KILPATRICK LOOP CLEWISTON, FL 33440
LYDIA WALKER 6236 HOMELAND ROAD LAKE WORTH, FL 33467	JIM HAZLETT 1861 WILLOW BEND PALM CITY, FL 34990	CLAYTON ESTILL 4425 441 S #10 OKEECHOBEE, FL 34974
RENNIE BERRY 647 SE 26TH DRIVE OKEECHOBEE, FL 34974-3202	JOHN A. COLLIER RT 6B 797 OKEECHOBEE, FL 33974	LARRY HARRIS 12836 LONGFORD ROAD NORTH PALM BEACH, FL 33408
BRUCE WALDRON BOTCHA BAIT TACKLE 8591 HWY 78 WEST OKEECHOBEE, FL 34974	LAWRENCE R. STERLING 2105 SE 35TH LANE OKEECHOBEE, FL 34974	DAVID MULLINS 614 8TH AVE OKEECHOBEE, FL 34974

NOEL CHENDLE 1007 SW 6TH AVENUE OKEECHOBEE, FL 34974	DAVID HAZELLIEF 1200 SOUTH PARROT AVENUE OKEECHOBEE, FL 34974	DONALD JONES 7740 SW 13TH SE OKEECHOBEE, FL 34974
JOHN BURTON 9951 SW 40TH TERRACE OKEECHOBEE, FL 34974	BEN BOLAN 823 SE 4TH STREET OKEECHOBEE, FL 34974	KEN ZODY 1716 SW 35TH CIRCLE OKEECHOBEE, FL 46239
HANK BOHLMAN 13450 NE 18TH AVENUE OKEECHOBEE, FL 34972	GENE WOODS 5283 NW 20TH STREET OKEECHOBEE, FL 34972	JEAN ELLIOTT BROWN 3339 PINE HILL TR PALM BEACH GARDENS, FL 33418
DALLAS MCKIM 4128 SE 24TH ROAD OKEECHOBEE, FL 34974	HARABEL KIEFER 2730 SE 25TH DRIVE OKEECHOBEE, FL 34974	CHARLES HOLTZHOWER P.O. BOX 966 INDIANTOWN, FL 34956
MARDEN H. WARREN 1410 SE 8TH DRIVE OKEECHOBEE, FL 34974	ARZA D. HEINY P.O. BOX 282 OKEECHOBEE, FL 34973	HOSEA GIRTMAN RT. 6 BOX 666 OKEECHOBEE, FL 34974
ALANA EDWARDS 3206 PALM DRIVE DELRAY BEACH, FL 33483	ANDREW STYKA, P.E. 23380 CAROLWOOD LANE #3301 BOCA RATON, FL 33428	REV. J. RICHARD HARRIS 1897 PALM BEACH LAKES BLVD. WEST PALM BEACH, FL 33409
PALM BEACH POST ATTN: BOB KING 2751 SOUTH DIXIE HWY WEST PALM BEACH, FL 33416	ROBERT M. NORTON 4200 HWY 441 SE OKEECHOBEE, FL 34974	JEAN FERRERA WRAGGS AND CASAS 1000 BRICKELL, SUITE 400 MAIMI, FL 33131
DANNY MALLIN 2319 SW 21ST STREET OKEECHOBEE, FL 34974	FRANKIE JOHNSON 3122 SE 28TH STREET OKEECHOBEE, FL 34974	JANET STAINES 2301 MCREGER BLVD. FORT MYERS, FL 33901

12 GLOSSORY OF TERMS, ACRONYMS AND ABBREVIATIONS

12.1 Glossary of Terms

A

Acre-foot—The quantity of water required to cover 1 acre to a depth of 1 foot. Equal to 43,560 cubic feet (1,233.5 cubic meters).

Affected environment—Existing biological, physical, social, and economic conditions of an area subject to change, both directly and indirectly, as a result of a proposed human action.

Air quality—Measure of the health-related and visual characteristics of the air, often derived from quantitative measurements of the concentrations of specific injurious or contaminating substances.

Aquatic—Living or growing in or on the water.

Aquifer—An underground geologic formation in which water can be stored.

B

Base—The "base case" simulations estimate what the regional hydrologic conditions would have been during the 1965 – 1995 rainfall sequence if the facilities, operational policies and water use levels were in place that are most consistent with those of the 1990 existing conditions or those projected for 2010 conditions. Best Management Practices for the EAA and the Everglades Construction Project are assumed to be in place for the 2010 simulations. The comparison of the base case and NSM outputs can also be used as a preliminary technique for identifying areas where restoration may be needed.

Benthic—Bottom of rivers, lakes, or oceans; organisms that live on the bottom of water bodies.

Best Management Practice—(BMP) The best available technology or process that is practical and achieves the desired goal or objective.

Biodiversity—The number of different species inhabiting a specific area or region.

Biological opinion—Document issued under the authority of the Endangered Species Act stating the U.S. Fish and Wildlife Service and/or the National Marine Fisheries Service (NMFS) finding as to whether a Federal action is likely to jeopardize the continued existence of a threatened or endangered species or result in the destruction or adverse modification of critical habitat. This document may include:

Critical habitat—A description of the specific areas with physical or biological features essential to the conservation of a listed species and which may require special management considerations or protection. These areas have been legally designated via Federal Register notices.

Jeopardy opinion—The U.S. Fish and Wildlife Service or NMFS opinion that an action is likely to jeopardize the continued existence of a listed species or result in the destruction or adverse modification of critical habitat. The finding includes reasonable and prudent alternatives, if any.

No jeopardy opinion—U.S. Fish and Wildlife Service or NMFS finding that an action is not likely to jeopardize the continued existence of a listed species or result in the destruction or adverse modification of critical habitat.

C

Candidate species—Plant or animal species not yet officially listed as threatened or endangered, but which is undergoing status review by the U.S. Fish and Wildlife Service or the National Marine Fisheries Service.

Channel—Natural or artificial watercourse, with a definite bed and banks to confine and conduct continuously or periodically flowing water.

Conveyance capacity—The rate at which water can be transported by a canal, aqueduct, or ditch. In this document, conveyance capacity is generally measured in cubic feet per second (cfs).

Cubic feet per second—A measure of the volume rate of water movement. As a rate of streamflow, a cubic foot of water passing a reference section in 1 second of time. One cubic foot per second equals 0.0283 meter /second (7.48 gallons per minute). One cubic foot per second flowing for 24 hours produces approximately 2 acre-feet.

D

Dissolved oxygen (D.O.)—A commonly employed measure of water quality.

Dry Season—Hydrologically, for south Florida, the months associated with a lower incident of rainfall, November through April.

E

Ecosystem—A functional group of animal and plant species that operate in a unique setting that is mostly self-contained.

Endangered species—Any species or subspecies of bird, mammal, fish, amphibian, reptile, or plant which is in serious danger of becoming extinct throughout all, or a significant portion of its range. Federally endangered species are officially designated by the U.S. Fish and Wildlife Service or the National Marine Fisheries Service and published in the Federal Register.

Enhancement—Measures which develop or improve the quality or quantity of existing conditions or resources beyond a condition or level that would have occurred without an action; i.e., beyond compensation.

Environmental consequences—The impacts to the Affected Environment that are expected from implementation of a given alternative.

Environmental Impact Statement (EIS)—An analysis required by the National Environmental Policy Act for all major federal actions, which evaluates the environmental risks of alternative actions.

Estuary—A water passage where the tide meets a river current; an arm of the sea at the lower end of a river.

Eutrophic—Referring to a body of water which is naturally or artificially enriched in dissolved nutrients, and often shallow with a seasonal deficiency in dissolved oxygen due to high primary production.

Evaporation—The change of a substance from the solid or liquid phase to the gaseous (vapor) phase.

Evapotranspiration (ET)—Evapotranspiration is part of the hydrologic cycle that is a combination of evaporation and transpiration. Solar energy induces evaporation, causing water vapor to condense and fall as precipitation. A portion of this precipitation seeps into the ground and is consumed by plants. It is then recycled back into the atmosphere in the form of transpiration.

Exotic species—Introduced species not native to the place where they are found.

F

Flow—The volume of water passing a given point per unit of time.

> ***Instream flow requirements***—Amount of water flowing through a stream course needed to sustain instream values.
>
> ***Minimum flow***—Lowest flow in a specified period of time.
>
> ***Peak flow***—Maximum instantaneous flow in a specified period of time.

H

Habitat—Area where a plant or animal lives.

Heterogeneity—Unlike, dissimilar, not uniform

Hydrologic response—An observed decrease or increase of water in a particular area.

Hydroperiod—For non-tidal wetlands, the average annual duration of flooding is called the *hydroperiod*, which is based only on the presence of surface water and not its depth.

I

Indicator species—Organism, species, or community which indicates presence of certain environmental conditions.

Irrigation water—Water made available from the project which is used primarily in the production of agricultural crops or livestock, including domestic use incidental thereto, and the watering of livestock. Irrigation water also includes water used for domestic uses such as the watering of landscaping or pasture for animals (e.g., horses) which are kept for personal enjoyment.

J

Juvenile—Young fish older than 1 year but not having reached reproductive age.

L

Limnology—Scientific study of the physical, chemical and biological characteristics of freshwater including lakes, streams, and ponds.

Littoral zone—The shore of land surrounding a water body that is characterized by periodic inundation or partial saturation by water level. Typically defined by species of vegetation found.

M

Marl—Soil comprised of clays, carbonates and shell remains.

Marsh—An area of low-lying wetland.

Mercury—Heavy metal that is toxic to most organisms when converted into a byproduct of inorganic-organic reaction. Distributed into the environment mostly as residual particles from industrial processes.

Mitigation—One or all of the following: (1) Avoiding an impact altogether by not taking a certain action or parts of an action; (2) minimizing impacts by limiting the degree or magnitude of an action and its implementation; (3) rectifying an impact by repairing, rehabilitating, or restoring the affected environment; (4) reducing or eliminating an impact over time by preservation and maintenance operations during the life of an action; and (5) compensating for an impact by replacing or providing substitute resources or environments.

Model—A tool used to mathematically represent a process which could be based upon empirical or mathematical functions. Models can be computer programs, spreadsheets, or statistical analyses.

Muck lands—Fertile soil containing putrid vegetative matter.

N

No Action Alternative—The planning process by which the action agency decides to not carry forth any planned action to alter existing conditions

O

Oxygen demand—The biological or chemical demand of dissolved oxygen in water. Required by biological processes for respiration.

P

Peat—Soil rich in humus or organic (exerts of oxygen demand) and is highly porous.

Phosphorus—Element or nutrient required for energy production in living organisms. Distributed into the environment mostly as phosphates by agricultural runoff (fertilizer) and life cycles. Frequently the limiting factor for growth of microbes and plants.

Preferred alternative—The alternative plan which is preferred by the action agency, sponsor, or other entity, among the array of alternatives being considered in the NEPA document.

Proposed action—Plan that a Federal agency intends to implement or undertake and which is the subject of an environmental analysis. Usually, but not always, the proposed action is the agency's preferred alternative for a project. The proposed action and all reasonable alternatives are evaluated against the no action alternative.

Public involvement—Process of obtaining citizen input into each stage of the development of planning documents. Required as a major input into any EIS.

R

Release—For this report, release is an intentional opening up of water control structures to allow stored water to flow out for 2 reasons. First, to lower water stage to acceptable levels. Second, to make available water for water supply demand (e.g., ecological, agricultural, or urban).

Reservoir—Artificially impounded body of water.

S

Scoping—The process of defining the scope of a study, primarily with respect to the issues, geographic area, and alternatives to be considered. The term is typically used in association with environmental documents prepared under the National Environmental Policy Act.

Seepage—Water that escapes control through levees, canals or other holding or conveyance systems.

Slough—A depression associated with swamps and marshlands as part of a bayou, inlet or backwater.

Spillway—Overflow structure of a dam.

Stream—Natural water course.

Subsidence—A local mass movement that principally involves the gradual downward settling or sinking of the earth's surface with little or no horizontal motion. It may be due to natural geologic processes or mass activity such as removal of subsurface solids, liquids, or gases, ground water extraction, and wetting of some types of moisture-deficient loose or porous deposits.

T

Threatened species—Legal status afforded to plant or animals species that are likely to become endangered within the foreseeable future throughout all or a significant portion of their range, as determined by the U.S. Fish and Wildlife Service or the National Marine Fisheries Service.

W

Wetland—A zone periodically or continuously submerged or having high soil moisture, which has aquatic and/or riparian vegetation components, and is maintained by water supplies significantly in excess of those otherwise available through local precipitation.

Wet season—Hydrologically, for south Florida the months associated with a higher than average incident of rainfall, May through October.

Wildlife habitat—An area that provides a water supply and vegetative habitat for wildlife.

12.2 Glossary of Acronyms and Abbreviations

BOD	biological oxygen demand
bsl	below sea level
C	Canal
cfs	Cubic feet per second
C&SF	Central and Southern Florida
Co.	County
Corps	U.S. Army Corps of Engineers
Corps 2010	Lake regulation schedule alternative
dB	Decibels
ET	Evapotranspiration
°F	degrees Fahrenheit
EAA	Everglades Agricultural Area
EPA	Environmental Protection Agency
EPGM	Everglades Phosphorus Gradient Model
FDEP	Florida Department of Environmental Protection
FMSF	Florida Master Site File
FWC	Florida Fish and Wildlife Conservation Commission
HHD	Herbert Hoover Dike
HSM	Lake regulation schedule alternative
HTRW	Hazardous, Toxic and Radioactive Waste
I-75	Interstate 75
IRL	Indian River Lagoon
k	one thousand
km	Kilometer
L	Levee
LOWQM	Lake Okeechobee Water Quality Model
mgd	Million gallons per day
mg/l	Milligrams per liter
msl	Mean sea level
NGVD	National Geodetic Vertical Datum
NHPA	National Historic Preservation Act of 1966
NSM	Natural Systems Model
ppb	Parts per billion
ppt	Parts per thousand
S	Structure
SFWMD	South Florida Water Management District
SFWMM	South Florida Water Management Model
SHPO	State Historic Preservation Officer
SR	State Route
STA	Stormwater Treatment Area
USACE	U.S. Army Corps of Engineers

USFWS	U.S. Fish and Wildlife Service
WCA	Water Conservation Area
WCDSS	Water Control Decision Support System
WMA	Wildlife Management Area
WSE	Water Supply & Environment alternative
22AZE	Lake regulation schedule alternative

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E – Wildlife Survey and Habitat Utilization Study of Western Littoral Zone, Lake Okeechobee, Florida, Final Report

ANNEX A

FISH and WILDLIFE COORDINATION ACT REPORT

United States Department of the Interior

FISH AND WILDLIFE SERVICE
South Florida Restoration Projects
P.O. Box 2676
Vero Beach, FL 32961-2676
(561) 778-0896

October 6, 1999

Mr. James C. Duck
Chief, Planning Division
U.S. Army Corps of Engineers
P.O. Box 4970
Jacksonville, Florida 32232-0019

Re: Lake Okeechobee Regulation
Schedule Study
Service Log No: R-1-99-I-859

Dear Mr. Duck:

The attached report is submitted in accordance with the Scope of Work for the Lake Okeechobee Regulation Schedule Study (LORSS) in which a final Fish and Wildlife Coordination Act (FWCA) Report is to be provided for your review. This report is provided in accordance with the FWCA (48 Stat. 401, as amended; 16 U.S.C. 661 *et seq.*) and the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531 *et seq.*).

The Fish and Wildlife Service (Service) concurred on July 30, 1999, with the Corps of Engineers' (Corps) determination that implementation of the Water Supply and Environmental (WSE) water regulation schedule is not likely to adversely affect federally listed threatened or endangered species or result in destruction or adverse modification of designated critical habitat. We have assigned Service Log Number 4-1-99-I-859 to this consultation; please refer to this number in any future correspondence regarding this consultation. Although this does not constitute a Biological Opinion described under section 7 of the ESA, it does fulfill the requirements of the Act, and no further action is required. If modifications are made to the regulation schedule or if additional information involving potential impacts on listed species becomes available, re-initiation of consultation may be necessary.

Although the Corps has broad authority to modify the Central and Southern Florida (C&SF) Project, the Service understands that the intent of the LORSS was to explore alternatives to the present Lake Okeechobee regulation schedule that could be implemented immediately, without changes to infrastructure. Nevertheless, the Service is obliged to provide recommendations to conserve and enhance fish and wildlife resources both in the short term and the long term. While recognizing the Corps' and South Florida Water Management District's logic in seeking a short-term alternative to the present regulation schedule, the Service's recommendations take a longer range view, consistent with the adaptive assessment strategy presented in the Comprehensive Plan for the C&SF Project. Lake Okeechobee's regulation schedule will clearly be linked to implementation of the structural and operational changes needed to realize the ecosystem restoration goals of the Comprehensive Plan.

This report constitutes the Secretary of the Interior's views and recommendations for the LORSS, in accordance with section 2(b) of the FWCA. On August 31, 1999, the Florida Fish and Wildlife Conservation Commission (FWC) provided a separate final FWCA report. Section 2(b) of the FWCA requires the Corps to "give full and equal consideration to the report and recommendations of the Secretary of the Interior and any report of the State agency on the wildlife aspects of such projects." Both of the FWCA reports should be included in the Final Environmental Impact Statement (EIS) for the LORSS.

Please contact Robert Pace at (561) 778-0896, extension 11, regarding the findings and recommendations contained in this report. The cooperation of your staff and the staff of the local sponsor, the South Florida Water Management District, is greatly appreciated.

Sincerely yours,

David L. Ferrell
Supervisor
South Florida Restoration Projects

Attachment

cc:
FWS, Atlanta, Georgia (Attention: Linda Kelsey, GARD, Area III)
FWS, Vero Beach (Attention: Steve Forsythe, State Supervisor)
FWS, Vero Beach (Attention: Jay Slack, Project Leader)
FWS, Loxahatchee NWR, Boynton Beach (Attention: Mark Musaus, Refuge Manager)
FWC, Vero Beach, Florida (Attention: Mary Ann Poole)
SFWMD, West Palm Beach, Florida (Attention: Lewis Hornung)
EPA, West Palm Beach, Florida (Attention: Richard Harvey)
FDEP, West Palm Beach, Florida (Attention: Herb Zebuth)

FINAL

FISH AND WILDLIFE COORDINATION ACT REPORT

ON THE

LAKE OKEECHOBEE
REGULATION SCHEDULE STUDY

Prepared by:

Robert Pace
U.S. Fish and Wildlife Service
South Florida Restoration Office
Vero Beach, Florida

October 1999

EXECUTIVE SUMMARY

The Fish and Wildlife Service (Service) has a long history of coordination with the Corps of Engineers (Corps) and the South Florida Water Management District (SFWMD) on regulatory schedules for Lake Okeechobee. The present re-evaluation was initiated in 1996. Although the Corps has broad authority to modify the Central and Southern Florida (C&SF) Project, the Corps and the SFWMD have elected to confine the scope of the Lake Okeechobee Regulation Schedule Study (LORSS) to explore alternatives to the present Lake Okeechobee regulation schedule that could be implemented immediately, without changes to infrastructure. Initially, several alternatives were considered and compared to the current regulation schedule. Since the spring of 1998, the study has shifted from the analysis of several alternatives to the refinement of an alternative called Water Supply and Environmental (WSE) that incorporates climate forecasting to improve the response of water managers to rising or falling water levels in the lake.

Analysis of the ecological and water supply effects of the alternatives has covered the entirety of south Florida, in recognition of the central importance of Lake Okeechobee to water management throughout the C&SF Project. Improvement in all of the multiple objectives for Lake Okeechobee cannot be achieved by any single regulation schedule given the physical and societal constraints of the present water management system. All evaluated alternatives show trade-offs between ecological goals and water supply goals, and even among competing ecological goals without consideration of water supply issues. The resource concerns of the Service include the ecological health of the lake as a whole, which includes the central open water portion of the lake (pelagic zone), and especially the extensive marshes (littoral zone) around the periphery of the lake. The study also evaluated the effects of the proposal on the St. Lucie and Caloosahatchee estuaries and the hydrology and water quality of the Everglades.

Current simulations indicate that although the WSE schedule demonstrates moderate improvements in overall ecological performance relative to the existing schedule, it holds promise as an approach to slightly reduce the duration of ecologically damaging high water levels without extending periods of extreme drought. The WSE schedule should slightly improve the spring water recession in the lake, which would be beneficial for foraging by wading birds and the endangered Okeechobee gourd. The Service believes that the simulations do not indicate significant changes overall to the St. Lucie and Caloosahatchee estuaries; some performance measures show slight improvement, while others are slightly less favorable than under the present regulation schedule. No major changes were observed between WSE and Run 25 in the Everglades. Stage duration curves for nearly all indicator regions of the Everglades were identical for the two schedules, except for a slight increase (1 to 2 percent) in the percentage of time that indicator regions in northern Water Conservation Area (WCA) 3A remain flooded during drier periods. Depending on rainfall conditions between implementation of the WSE schedule and operation of Stormwater Treatment Area (STA) 3/4, a slight increase in total loading of phosphorus may occur in northern WCA 3A, but this increase would be negligible and would not violate the consent decree arising from the Everglades water quality lawsuit.

The Service concurred with the Corps' determination that implementation of the WSE regulation schedule is not likely to adversely affect federally listed threatened or endangered species. If modifications are made to the regulation schedule or if additional information involving potential impacts on listed species becomes available, re-initiation of consultation may be necessary.

The degree to which the climate forecasting elements of WSE will improve ecological conditions in Lake Okeechobee depends on the ability to correctly predict changes in climate and on the rainfall trend (overall increase or decrease in total rainfall, relative to the 1965-1995 period of simulation) through the next decade. We believe implementation of WSE will allow empirical testing of climate prediction in lake regulation decisions, and will be better suited to take advantage of the increasing management flexibility as components of the Comprehensive Plan for the C&SF Project.

The Service supports implementation of the WSE regulation schedule on an interim basis. We recommend that a multi-agency and multi-disciplinary technical review panel meet annually to reassess how effective climate forecasting has been in improving the water regulation in the lake. This will provide an opportunity to review ecological conditions in the lake, the estuaries, and the Everglades and to explore opportunities for further refinement of WSE. Formal re-evaluation of the schedule, including preparation of another Fish and Wildlife Coordination Act (FWCA) report, will likely be necessary several years after implementation of WSE.

The Service has provided recommendations involving refinement of the application of climate forecasting to the Lake Okeechobee regulation schedule, improved scientific support for the Lake Okeechobee conceptual model, restoration of islands within the lake, and the need for continued review of the lake's regulation schedule as components of the Comprehensive Plan for the C&SF Project are implemented.

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LIST OF ACRONYMS USED IN THE TEXT

ASR	Aquifer Storage and Recovery
C&SF	Central and Southern Florida
EAA	Everglades Agricultural Area
EIS	Environmental Impact Statement
FDEP	Florida Department of Environmental Protection
FTP	File Transfer Protocol (on the Corps' Jacksonville District internet server)
FWC	Fish and Wildlife Conservation Commission
FWCA	Fish and Wildlife Coordination Act
HSM	(An alternative regulation schedule; not the preferred alternative)
LEC	Lower East Coast (Service Area)
LOLZTG	Lake Okeechobee Littoral Zone Technical Group
LORSS	Lake Okeechobee Regulation Schedule Study
LOSA	Lake Okeechobee Service Area
NGVD	National Geodetic Vertical Datum
PAL	Planning Aid Letter
SFWMD	South Florida Water Management District
SFWMM	South Florida Water Management Model
STA(s)	Stormwater Treatment Area(s)
SWIM	Surface Water Improvement and Management
TP	Total Phosphorus
WCA	Water Conservation Area
WSE	Water Supply and Environmental (the preferred alternative regulation schedule)

I. IDENTIFICATION OF PURPOSE, SCOPE, AND AUTHORITY

A. Purpose and Scope of the Project

The purpose of the LORSS is to determine if an alternate regulation schedule can better balance the multiple, and sometimes competing, objectives for managing water levels in, and discharges of water from, Lake Okeechobee. These multiple objectives have been listed by Neidrauer *et al.* (1998) as follows:

1. Provide adequate flood protection for the regions surrounding the lake.
2. Meet the water use requirements of the agricultural and urban areas that are dependent on Lake Okeechobee for water supply.
3. Preserve the biological integrity of the estuaries (St. Lucie and Caloosahatchee) downstream of the lake's two outlets to tide.
4. Supply water to the remnant Everglades to restore natural hydroperiods[1].
5. Preserve and enhance the lake's littoral zone, which provides a natural habitat for fish and wildlife.
6. Meet the recreational needs of south Florida.
7. Navigation.

The Service must add to this list of objectives the improvement of water quality, particularly reduction in phosphorus concentration in the lake, which the SFWMD (1989, 1997) has identified as one of the principal goals for the Lake Okeechobee Surface Water Improvement and Management (SWIM) Plan. Water levels in Lake Okeechobee have a direct influence on the amount of phosphorus suspended in the water column, which in turn affects ecological conditions in the pelagic zone, and most likely the littoral zone of the lake (Havens 1997). In addition to the importance of nutrient concentrations on the intrinsic ecological health of the lake and the volume and concentration of phosphorus within the lake, water discharged from the lake affects fish and wildlife habitat in the St. Lucie and Caloosahatchee estuaries and the Everglades. However, it should be noted that the greatest source of nutrients to the Everglades is south of Lake Okeechobee in the Everglades Agricultural Area (EAA), and nutrient inputs from within the St. Lucie and Caloosahatchee drainage basins are major stressors on those ecosystems.

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[1]The Service suggests substituting the term "hydroperiod" with "hydropattern," which includes consideration of the depth of water, duration of inundation, and the quantity, timing, and distribution of freshwater flows into and through the Everglades (SFWMD and Florida Department of Environmental Protection [DEP] 1997).

To allow expeditious development and implementation of a superior regulation schedule, the Corps and the SFWMD have decided to limit the scope of the evaluated alternatives to those regulation schedules that are feasible without changes to the physical infrastructure of canals, levees, pumps, and water control structures around Lake Okeechobee. The geographic scope of the analysis of ecological effects of the alternatives includes Lake Okeechobee itself, the St. Lucie and Caloosahatchee estuaries, the WCAs, and Everglades National Park.

B. Authority

Authority to complete this study was granted under Section 309(l) of the Water Resources Development Act of 1992, which reads in part:

> "... (1) CENTRAL AND SOUTHERN FLORIDA. - The Chief of Engineers shall review the report of the Chief of Engineers on central and southern Florida, published as House Document 643, 80th Congress, 2nd Session, and other pertinent reports, with a view to determining whether modifications to the existing project are advisable at the present time due to significantly changed physical, biological, demographic, or economic conditions, with particular reference to modifying the project or its operation for improving the quality of the environment, improving protection of the aquifer, and improving the integrity, capability, and conservation of urban water supplies affected by the project or its operation."

The above authorizing language was cited in the Corps' Draft Environmental Impact Statement (EIS) for the LORSS, which is identical to the broad authority that launched the feasibility phase of the C&SF Restudy. The Service believes that Congress has not imposed a specific limitation on the authority to address the ecological and water supply issues associated with Lake Okeechobee. Rather, the Service believes that the Corps and the SFWMD limited the scope of the LORSS to only operational changes, thereby allowing more expeditious development and implementation of a superior regulation schedule. Nevertheless, the Service is obliged to provide in this report both long-term and short-term recommendations to conserve and enhance fish and wildlife resources in Lake Okeechobee, consistent with the restoration goals of the C&SF Comprehensive Plan.

II. PREVIOUS SERVICE INVOLVEMENT IN THE LAKE OKEECHOBEE REGULATION SCHEDULE (1978-PRESENT)

The Service has a long history of involvement in reviewing and providing recommendations on the effects of water regulation in Lake Okeechobee, beginning in 1957. The following chronology includes only major milestones, since 1978, leading up to and through the present study. Many additional meetings and correspondence are not included in this summary.

On March 8, 1978, the Service issued a Biological Opinion on the Corps' proposal to raise the Lake Okeechobee regulation schedule from a 14.5 to 16.0 ft schedule[2] to a 15.5 to 17.5 ft schedule (the 1978 schedule). The Biological Opinion was limited to consideration of effects on the endangered snail kite (*Rostrhamus sociabilis plumbeus*), and concluded that the action was not likely to jeopardize the continued existence of the snail kite. However, the Biological Opinion expressed concern that it was difficult to predict the exact response of apple snail (*Pomacea paludosa*) populations to the new regulation schedule, and the Service recommended that the Corps initiate an apple snail monitoring program in the lake's littoral zone, which is designated as critical habitat for the snail kite.

On June 19, 1978, the Service provided an FWCA report in response to the proposed 1978 schedule. The Service did not oppose implementation of the 1978 schedule, but called for monitoring of apple snails, the vegetative composition in the littoral zone, the fisheries in the marsh, and bird rookeries and other breeding areas. The Service also recommended management of water levels within the levees at Torry, Kreamer, and Ritta islands in the southeastern portion of the lake to create additional marsh habitat.

On September 5, 1985, the Service provided a Planning Aid Letter (PAL) to the Corps regarding the potential adverse environmental effects of raising the lake's regulation schedule from the 15.5 to 17.5 ft schedule, then in effect, to a 19.5 to 21.5 ft schedule, as part of an effort to increase water supply in south Florida. In 1968, Public Law 90-483 gave the Corps authority to raise the regulation schedule to the 19.5 to 21.5 ft range. Although the Corps had stated that it would be unlikely to implement such a schedule, this alternative was being considered under the C&SF Water Supply Plan. The PAL cited evidence suggesting that the 1978 schedule, which had at that time been in effect for nearly six years, was causing adverse effects on the littoral marsh and its associated fish and wildlife resources. The PAL recommended long-term monitoring of the effects of the 1978 schedule, and recommended against the 19.5 to 21.5 ft schedule, which the Service predicted would eliminate about 55,600 acres of littoral wetlands, including willow-vegetated bars used by wading birds and the snail kite for nesting. The PAL also noted that the Corps had not carried out the Service's 1978 recommendation to mitigate adverse effects caused by the 1978 schedule through restoration of marshes at Torry, Kreamer, and Ritta islands.

On June 10, 1987, the Service sent a letter to the SFWMD, requesting re-evaluation of the 1978 schedule, based on the observed stress on the vegetation in the littoral zone.

In 1988, the Lake Okeechobee Littoral Zone Technical Group (LOLZTG), a technical group of wetland and wildlife scientists (including the Service), recommended adoption of a lower lake regulation schedule, known as Run 22, which would operate in zones between 13.5 ft and 15.5 ft.

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[2]Regulation schedules for Lake Okeechobee are referenced to feet above Mean Sea Level. For consistency with Corps' documents and ease of description, the Service has retained this convention for all references to lake stage, but all other units of measure in this report are metric.

The LOLZTG noted, in addition to adverse changes in vegetation, drastically reduced populations of wading birds in Lake Okeechobee as evidence to support a lower regulation schedule.

In 1992, Run 25 was implemented for a two-year trial period.

On March 18, 1993, the Corps, responding to a request from the SFWMD, called for comments on the Run 22 schedule.

On May 14, 1993, the Service sent a letter to the Corps stating that Run 22 or a similar schedule would apparently be preferable to the Run 25 schedule for protection of the littoral zone. The letter requested that the Service and the Corps develop a Scope of Work to prepare a draft FWCA report on Run 22. Although our files contain copies of a draft Scope of Work, we believe this was never finalized and that the Service never prepared an FWCA report on Run 22.

In May 1994, the Corps held two public hearings on the continued use of Run 25 as the lake's regulation schedule. One of the alternatives considered in that review was Run 22AZE, a modification of Run 22 that involves a large Zone E in the regulation schedule allowing low level discharges at lake stages between 13.75 ft and 15.60 ft. Following the 1994 public hearings, the Corps extended use of Run 25, and it is in effect to the present.

Although the preceding items in this chronology demonstrate a nearly continuous process of re-evaluation of the lake's regulation schedule since 1978, the current study (LORSS) began with a June 14, 1995, public notice requesting comment on the alternatives that were then under consideration.

On September 24, 1997, the Florida Fish and Wildlife Conservation Commission (FWC) and the Service jointly sent a PAL to the Corps, based on the results of the draft simulations (Neidrauer *et al.* 1998). The PAL noted that none of the simulated alternatives was consistently superior to any of the others, in keeping with the findings of previous studies (Trimble and Marban 1988, Otero and Floris 1994) that found inevitable trade-offs among the objectives for evaluated alternatives. The FWC and the Service disagreed with the conclusion by Neidrauer *et al.* (1998) that the HSM schedule had strong advantages over the others, noting that the principal advantage in the performance of HSM was an increase in the percentage of time in the simulation when water supply demands could be met. In terms of reducing the period of time that high water stages would adversely affect the lake's littoral zone, HSM performed less favorably than all other evaluated alternatives, and Run 22AZE performed best. Although Run 22AZE was not favorable in terms of the period when base flows of fresh water could be supplied to the St. Lucie estuary, the FWC and the Service preferred Run 22AZE overall among the alternatives then under consideration. Evaluation of the alternatives' implications on phosphorus loading to the Everglades Protection Area was not included in the Neidrauer *et al.* (1998) report and was not discussed in the 1997 PAL.

On April 15, 1998, the Service attended a meeting of the SFWMD's Governing Board dealing with the LORSS. Staff of the SFWMD presented preliminary results of a simulation of a newly devised alternative, named WSE. That analysis was the first by the SFWMD that included consideration of phosphorus loading to the Everglades Protection Area through changes to Lake Okeechobee's regulation schedule. Lacking adequate time to fully evaluate the newly introduced WSE alternative, both the FWC and the Service stated to the Governing Board that Run 22AZE remained their preferred alternative.

In a June 19, 1998, letter, the SFWMD notified the Corps that the Governing Board had found that among the currently evaluated alternatives, WSE ". . . most effectively balances competing water resource objectives."

On September 23, 1998, the Service provided a PAL in response to discussions at a meeting on September 11, 1998, involving development of an implementation strategy for the WSE schedule. The Service provided recommendations for evaluation of the phosphorus loading to the Everglades Protection Area and provided recommendations for presentation of a summary of results in an evaluation matrix to be included in the Draft EIS for the LORSS.

On February 9, 1999, the Operational Planning Core Team, composed of Corps and SFWMD employees, issued a report on implementation strategies for the WSE schedule, including additional modeling of WSE, based on updated assumptions in the South Florida Water Management Model (SFWMM) regarding 1995 infrastructure and water use.

On February 16, 1999, the Corps officially notified the Service that the WSE schedule would be the preferred alternative in the Draft EIS for the LORSS. That letter also stated the Corps' determination that the WSE schedule was not likely to adversely affect federally listed threatened or endangered species.

On May 14, 1999, the SFWMD posted additional analysis of WSE on the Corps' file transfer protocol (FTP) site. This included hydrologic data compiled according to the indicator regions used in the C&SF Restudy, and the stage hydrographs at a suitable scale to allow comparison of spring water recession rates as indicators of foraging conditions for wading birds.

In July 1999, the Service received a copy of the Draft EIS for the LORSS. The draft FWCA report had not been completed prior to issuance of the Draft EIS.

On July 30, 1999, the Service issued the draft FWCA report on the LORSS.

III. AREA SETTING

A. Introduction

The Service has provided summaries of the hydrologic and biological resource values of Lake Okeechobee in several previous FWCA reports. Extensive scientific literature and other publications intended for the layman are available, and we need not repeat the contents of these. Aumen and Wetzel (1995) edited a thorough compendium of scientific papers that were assembled as a special issue of *Archiv für Hydrobiologie* (45) dedicated exclusively to Lake Okeechobee. In that compendium, Aumen (1995) provides an excellent general description of Lake Okeechobee and the resource issues in the lake. The Corps (1999b) issued a final report entitled "Wildlife Utilization and Habitat Utilization Study of Western Littoral Zone, Lake Okeechobee, Florida." The following sections provide only sketches of the hydrologic and biological characteristics of Lake Okeechobee.

B. Hydrologic Description

Lake Okeechobee, measuring 1,732 km^2, is the central feature of south Florida's interconnected Kissimmee River/Lake Okeechobee/Everglades watershed. Lake Okeechobee is a shallow (mean depth of 2.7 m) subtropical lake that supplies water to the remnant Everglades, Florida Bay, and the St. Lucie and Caloosahatchee estuaries. Lake Okeechobee is now completely surrounded (except for Fisheating Creek) by the Herbert Hoover Dike, and the inflows and outflows are controlled by an extensive system of levees, canals, water control structures, and large pump stations. The 12,000 km^2 Kissimmee River drainage basin lies north of the lake, and is dominated by dairy and beef operations. The 2,800 km^2 EAA lies immediately south of the lake, where water from the lake supports the sugar, rice, and winter vegetable crops. Figure 1 shows some of the more prominent natural features of Lake Okeechobee and the location of surrounding cities.

C. Fish and Wildlife Resources

Lake Okeechobee provides habitat for fish and wildlife resources of direct monetary value (commercial and recreational fisheries, waterfowl hunting, alligator hunting) and of inestimable indirect value in terms of tourism, quality of life, and the survival of many threatened, endangered, and rare species. Furse and Fox (1994) estimated the value of five different vegetative communities in the lake in supporting the commercial and recreational fisheries, which they then estimated to have a "total economic value" in excess of $480 million. The economic effect of a healthy lake ecosystem on non-consumptive recreational activities in the lake may be more difficult to measure, but it is becoming more significant. Airboat tours and internationally marketed birding expeditions are increasing.

The marsh and swamps that once surrounded the lake are now converted to urban and agricultural land uses outside the Herbert Hoover Dike. Today's 400 km^2 littoral zone is a unique wetland that has been formed since impoundment of the lake. Lake Okeechobee is a critical concentration point for winter waterfowl along the Atlantic flyway and supports feeding and nesting of wading birds. The southwestern littoral zone of the lake comprises part of the critical habitat of the endangered snail kite. The section of this report entitled "Resource Concerns" provides an updated summary of factors affecting fish and wildlife in Lake Okeechobee.

IV. EVALUATION METHODOLOGY

A. Lake Okeechobee Performance Measures Recognize the Physical Constraint Imposed by the Herbert Hoover Dike

Recognition of the limitations imposed by Lake Okeechobee's confinement within the Herbert Hoover Dike, and the fact that extreme fluctuations in lake stage will occur despite attempts to reduce them, is essential to understanding the foundation for the performance measures for Lake Okeechobee. Water stage fluctuations are generally of lesser amplitude in lakes subject to regulation for water supply and flood control than in their historic condition. For the majority of Florida's lakes that are not surrounded by a dike, the Service would recommend that ecological restoration include a return to the natural amplitude and timing of water stage fluctuations. When restoration of water stage fluctuation is not considered feasible (due to flooding, water supply, or navigational constraints), the Service has supported periodic extreme drawdowns as a management strategy to counteract the adverse ecological effects of unnaturally static water levels in Florida's lakes. Extreme drawdowns have been an effective management technique in the Kissimmee Chain of Lakes, short of full restoration of lake stage fluctuations. However, extreme drawdowns are not considered practical for Lake Okeechobee, not only due to the size of the lake, but also in terms of the unacceptable level of risk to this pivotally important, centrally located large volume of water (to supply agricultural and urban consumers and to sustain the natural areas of south Florida).

Lake Okeechobee presents particular characteristics that call for a reduction in the present range of lake stage fluctuation as a goal in the performance measures. First, Lake Okeechobee is almost entirely surrounded (except for the Fisheating Creek drainage) by the confining Herbert Hoover Dike. Under natural conditions, high water stages temporarily or seasonally inundated wetlands around the periphery of Lake Okeechobee across a much broader littoral fringe that has today been converted to agricultural and urban uses outside the Herbert Hoover Dike. Fish and wildlife populations were able to adjust to and use these extensive habitats as they were flooded and exposed by drying. Today, water stages above 15 ft only increase water depths in the littoral zone above those most desirable to sustain littoral marsh vegetation, without the opportunity for expansion of wetland habitat during high water stages. Second, the history of water fluctuation in Lake Okeechobee indicates that the present system of water control structures, levees and canals around the lake is still unable to eliminate water stage fluctuation. In most of Florida's managed lakes, reduced stage fluctuations are maintained to a narrow range considered to be ecologically adverse. However, natural cycles of flood and drought still produce adequate water stage fluctuations in Lake Okeechobee to avoid excessively static conditions that would extend over periods of several years. Therefore, the ecological performance measures call for reduction in the present level of lake stage fluctuation, particularly the amplitude and duration of high water stages that rise against the immovable barrier of the Herbert Hoover Dike.

B. Development and Refinement of Performance Measures

The performance measures for Lake Okeechobee have evolved since Trimble and Marban's (1988) analysis of multi-objective trade-off plots that led to selection of Run 25, which has been the operational schedule for the lake from 1992 to the present. Otero and Floris (1994) used similar performance measures to re-evaluate regulation schedule options, but this study did not lead to a change in the regulation schedule. Both of these studies used the South Florida Regional Routing Model to produce hydrologic simulations and demonstrated the trade-offs that severely constrain selection of a water regulation schedule; these constraints largely remain in effect, although climate forecasting appears to be a promising improvement to previously considered alternatives.

The SFWMD's Lower East Coast (LEC) Regional Water Supply Plan (1996) started the development and refinement of performance measures based on hydrologic simulations from the SFWMM. The Corps and the SFWMD assembled a multi-agency group of experts on August 20-21, 1996, to further develop these performance measures for use in the LORSS. That meeting produced performance measures that were circulated for review on September 13, 1996; that document included a description of each measure, its objective, a rationale supporting its use, and lists of supporting citations.

The C&SF Restudy and other ecological restoration projects in south Florida prompted a series of workshops between October 1996 and August 1997 to develop conceptual ecological models for the landscapes of south Florida, including Lake Okeechobee. The most recent version of the Lake Okeechobee model (Havens and Rosen 1999) is found on pages D-A-9 through D-A-23 of the Final Programmatic EIS for the C&SF Restudy. The conceptual model lists several attributes and societal values as representative of the ecological health of the lake: (1) quality and quantity of urban and agricultural water supply, (2) quality and quantity of water in the ecosystems of south Florida, (3) ecotourism and recreation, (4) sport and commercial fisheries, (5) wading birds and waterfowl, (6) establishment and maintenance of a diverse mosaic of native vegetation, and (7) the lake's importance in recovery of the snail kite. Figures 2 and 3 are simplified excerpts of portions of the complete Lake Okeechobee conceptual model that deal with low water and high water stressors, which are the most pertinent to evaluation of the lake regulation schedule.

A separate draft conceptual ecological model has been developed for the St. Lucie and Caloosahatchee estuaries (Gray and Haunert 1999). The conceptual model includes a generalized stressor "altered hydrology," which leads to changes in the salinity envelope for the estuaries. Excess wet season flows and insufficient dry season flows are the principal characteristics of altered hydrology under the managed system that cause detrimental ecological conditions. The performance measures used here to assess the regulation schedules (Table 1) include two levels of excessively high volumes of flow known to cause ecological damage to the estuaries and the number of months in the simulation when base flows of fresh water cannot be delivered to the estuaries, which leads to damaging levels of hypersalinity. Empirical measurements of salinity distribution in the estuaries during periods of high flow and drought, combined with estimates of the salinity requirements of two indicator species in the estuary, shoal grass (*Halodule wrightii*) and American oyster (*Crassostrea virginica*), support the selection of thresholds for the performance measures used in this evaluation (Haunert and Chamberlain 1994).

The performance measures for the Everglades were originally derived from those used in the LEC Regional Water Supply Plan. The earlier evaluations of the alternatives looked at the hydrology of single cells in the SFWMM corresponding in location to selected water gauges in the Everglades. The C&SF Restudy found that averaging hydrologic parameters over several cells in the SFWMM within an indicator region of the Everglades was more reliable than evaluations based on single cells in the model. The analysis according to the indicator regions was posted electronically only for the WSE and Run 25 schedules on May 14, 1999.

The Service has participated throughout the process of development of performance measures for Lake Okeechobee. Our evaluation of the alternatives for the LORSS has relied principally on those versions of the performance measures appearing in reports on the results of model simulations (Neidrauer *et al.* 1998, Operational Planning Core Team 1999).

V. FISH AND WILDLIFE RESOURCE CONCERNS

A. Introduction

Because Lake Okeechobee is central to water management strategies throughout the C&SF Project, the lake's water regulation schedule has implications for fish and wildlife values throughout south Florida. Nevertheless, the strongest effects are exerted within Lake Okeechobee itself, which has high intrinsic habitat value for fish and wildlife. Adverse effects of drought or extreme high water can affect the lake for either short periods or for durations of one or two years. Regulatory releases from the lake can have dramatically adverse consequences in the St. Lucie and Caloosahatchee estuaries, but as explained below, water management in the drainage basins of the estuaries also contributes to ecological problems in the estuaries. The influence of water management in the lake can also be significant to hydropatterns in the Everglades. The Lake Okeechobee conceptual model (Havens and Rosen 1999) demonstrates the complex interactions among various environmental stressors affecting the lake. Therefore, division of the discussion into the following subsections of the report describing the Service's resource concerns is somewhat artificial, due to the high level of interaction among many of these factors.

B. Direct Effects of Lake Stages on the Littoral Zone

Although the pelagic zone of Lake Okeechobee is important in supporting commercial and recreational fisheries, the littoral zone of the lake is highly productive, sustains a greater diversity of fish and wildlife, and is the area most affected by changes to the lake's regulation schedule. Changes in water depth and duration of inundation control the vegetative communities of the littoral zone, the total area of the lake available as habitat for aquatic animals, and the availability of aquatic prey for higher consumers, particularly wading birds. Havens *et al.* (1996b) found that the littoral zone had a greater trophic complexity. Many of the additional species in the littoral zone that are not found in the pelagic zone are large predators (14 species of adult fish and 14 species of birds), but the majority of additional taxa (54) are macroinvertebrates. The effects of water regulation in the lake on phytoplankton, periphyton, and benthic invertebrates are passed through the food web to readily observable losses in biodiversity at higher trophic levels.

During periods of extreme high lake levels (>17 ft), wind and erosion cause emergent and submerged plants to be torn loose from their substrates, resulting in a loss of important fish and wildlife habitat. When lake levels exceeded 17 ft in 1995, large sections of bulrush (*Scirpus californicus* and *S. validus*) were lost. These plants, which occur at the interface between the pelagic and littoral zones where they are exposed to wave action, are a prime habitat for largemouth bass (*Micropterus salmoides*) and black crappie (*Pomoxis nigromaculatus*), two of the most important recreational fishes in the lake (Furse and Fox 1994).

Extreme low lake levels (<11 ft) expose 95 percent of the littoral zone to desiccation, rendering the majority of the area unavailable as habitat for fish and waterfowl. One of the aquatic communities that becomes dry when the lake is at 11 ft is one dominated by spike rush (*Eleocharis cellulosa*). This community is of particular concern because it supports a large population of apple snails, the primary food resource for the endangered snail kite.

In addition to the detrimental effects that occur from the short-term extreme events described above, the lake was subjected to the 15.5 to 17.5 ft water regulation schedule between 1978-1992. This regulatory period demonstrated the deleterious effects of a prolonged period of moderately high lake stages. Milleson (1987) documented vegetation changes along the Moore Haven and Indian Prairie transects in the littoral zone, as compared with conditions found by Pesnell and Brown (1977). Milleson found a loss of spikerush, expansion of cattail (*Typha domingensis*), and invasion by the exotic torpedo grass (*Panicum repens*). Torpedo grass is very poor habitat and cannot support the fish and wildlife populations that are found in native vegetation. Milleson attributed these changes to prolonged inundation of the littoral zone by stages over 15 ft under the 15.5 to 17.5 ft schedule, that had then been in effect since 1978. He predicted that reduced diversity of the marsh vegetation would adversely affect waterfowl, wading birds, reptiles, fish, and other species that depend on a diverse marsh.

On the basis of Milleson's observations and subsequent evaluations of littoral zone vegetation (Richardson and Harris 1995, Richardson *et al.* 1995), the Service believes that prolonged periods of lake stages over 15 ft favor less diverse, more permanently flooded wetland communities, rather than the more diverse vegetation produced in alternately flooded and exposed portions of the littoral marsh. The reduction in the proportion of the littoral zone vegetated by willow (*Salix caroliniana*) in the early 1970s has been attributed to higher lake stages (Richardson and Harris 1995, Richardson *et al.* 1995). Willows are important nesting sites for the endangered snail kite and several species of wading birds. David (1994a, 1994b) found that by 1988 wading birds no longer nested in the willows at the King's Bar colony, which contained nearly 10,000 nests in 1974 and 6,000 nests in 1978 (excluding cattle egret [*Bubulcus ibis*]). He attributed this loss of the larger nesting colonies to the 1978 regulatory schedule. In addition to the adverse effects on wading bird nesting habitat through changes in vegetation, several studies indicate additional adverse effects of sustained high lake stages on feeding by wading birds. Zaffke (1984) found that successful wading bird feeding in the littoral zone depended on receding lake stages below 15 ft and suggested that the 15.5 to 17.5 ft schedule, which had then been in effect since 1978, was detrimental to feeding and nesting wading birds. This observation has been supported in subsequent studies by Smith *et al.* (1995) and Smith and Collopy (1995). Bull *et al.* (1995) found significant negative correlations between water depth at sample sites in the lake's pelagic zone and the abundance of threadfin shad (*Dorosoma petenense*) and bluegill (*Lepomis macrochirus*), while increased depth was positively correlated with abundance of white catfish (*Ameiurus catus*) and black crappie. Additional study is needed on the effect of lake stage on the standing stock and reproductive success of fish in the littoral zone.

C. Effects of Lake Stage on Water Quality in the Lake

Havens (1997) provides a review of ecological changes in Lake Okeechobee caused by cultural eutrophication and discusses hypotheses on the causal relationships for the correlation between higher lake stages and increased total phosphorus concentrations in the pelagic zone of the lake. Janus *et al.* (1990) and Maceina (1993) hypothesize that higher lake stages increase the incidence of algal blooms. An algal bloom in August 1986, covering 300 km^2, caused the death of thousands of apple snails in the western littoral zone of the lake, part of the designated critical habitat for the endangered snail kite, which feeds almost exclusively on apple snails.

The concentration of total phosphorus in the lake doubled from 49 ppb in 1973 to 98 ppb in 1984 (Janus *et al.* 1990). Despite progress in reducing phosphorus loading rates to the lake through implementation of Best Management Practices in dairies north of the lake, the phosphorus loading exceeds the legally-mandated SWIM target. The water column phosphorus concentration goal for the lake is 40 ppb. At present, concentrations of phosphorus in the lake average 100 ppb, largely due to the high inputs from lake sediments. Even with reduction of phosphorus loading from external sources, internal phosphorus loading from resuspension of phosphorus-rich sediments that have built up in the lake may affect water quality in the lake for several decades (Havens *et al.* 1996a, Steinman *et al.* 1998).

Warren *et al.* (1995) found that the benthic invertebrate communities of Lake Okeechobee's sublittoral zone are of relatively poor quality and that shifts toward dominance of more undesirable species (indicative of highly eutrophic conditions) have occurred at a rapid rate. Higher lake stages are likely to increase the transport of nutrient-rich water from the pelagic zone to the littoral zone, which would ultimately reduce the diversity of the invertebrate community in the littoral zone, which has a higher diversity of benthic invertebrates than the sublittoral zone (Havens *et al.* 1996b). Havens and James (1999) suggest that observed declines in water transparency could be explained by the migration of mud sediments from mid-lake towards the littoral zone along the southwestern shore. This migration of sediment would be more likely to occur under extended periods of high water and could have severe impact on the primary productivity of the littoral zone.

D. Spread of Exotic Vegetation in the Littoral Zone

The conceptual model for Lake Okeechobee indicates that extremely low water stages may favor expansion of exotic vegetation. The Service finds that although water regulation certainly is one of several variables influencing spread of exotic vegetation, the magnitude of this variable relative to others has not been clearly demonstrated.

The spike rush habitat in Moonshine Bay (preferred foraging habitat for the snail kite) is encircled by torpedo grass, which may overtake the region if low water levels suppress the growth and survival of the native plants. Torpedo grass is tolerant of a much wider range of hydroperiods, and appears to thrive under both wet and dry conditions (Sutton 1996). Torpedo grass is poor habitat and cannot support the fish and wildlife populations that are found in native vegetation. However, Smith *et al.* (1995) suggest that once every several years, allowing the lake stage to drop to 10 to 12 ft in the dry season would be beneficial to wading bird populations, "to expose prey-rich submerged beds, invigorate essential willow stands, and to allow fires to burn away cattail and *Panicum* wrack, recycle nutrients, and encourage establishment of attractive successional vegetation complexes." The current set of performance measures produce unfavorable scores when lake stages drop below 11 ft. The Service would not agree at this time with Smith *et al.* (1995) regarding the recommendation to drop water levels below 11 ft on a regular basis, but we would encourage controlled burning in the littoral zone during the dry season when stages descend below 12 to 13 ft. Research is needed to determine the consequences of such a management policy relative to expansion of exotic vegetation and overall diversity and productivity of the littoral zone.

Smith *et al.* (1995) state that *Melaleuca* expanded its range in Lake Okeechobee following the 1989-90 drought, displacing some areas of more productive spike rush and beak rush (*Rhynchospora*) flats. However, based on experiments in mesocosms subjected to varied hydroperiods, Lockhart *et al.* (1999) found that a lower lake regulation schedule may not stimulate expansion of *Melaleuca*. They found that although *Melaleuca* is affected by hydroperiod, it is highly adaptable to a wide range of environmental conditions, and that water management is not the most effective management alternative to control this exotic species.

They recommend continuation of the ongoing chemical treatment of *Melaleuca*, with introduction of biological controls, as a more effective management strategy.

E. Effects of the Lake Okeechobee Regulation Schedule on the St. Lucie and Caloosahatchee Estuaries

The performance measures for the St. Lucie and Caloosahatchee estuaries indicate the degree to which a regulation schedule can prevent damaging high volume discharges during periods of high rainfall and can eliminate periods of a damaging lack of freshwater flow during drought.

Recent ecological harm to the St. Lucie estuary during the 1997-1998 winter-spring El Niño event caused public concern. The North Fork of the St. Lucie River, which normally averages 18 ppt salinity decreased to 0 ppt during peak flows. Portions of the St. Lucie estuary that normally average 24 ppt decreased to 5 ppt, and the Indian River Lagoon, which normally averages 30 ppt, decreased to approximately 20 ppt. The high volume freshwater discharges coincided with a high incidence of fish with lesions.

Soon after this ecologically damaging event, the South Florida Ecosystem Working Group called for establishment of the St. Lucie Issue Team to immediately accelerate progress toward improving water and habitat quality in the St. Lucie estuary. Their Interim Report (October 1998) correctly points out that there are two sources of excess water causing the observed ecological problems:

Problem 1 *Excess fresh water entering the estuary from regulatory releases from Lake Okeechobee has direct and powerful adverse impacts on the water, sediment, and habitat quality of the estuary by not only reducing salinity but also carrying silts, sediments and other pollutants to the estuary.*

Problem 2 *Due to stormwater releases and water use from agricultural and urban development, even in the absence of Lake Okeechobee discharges, the desirable salinity envelope goal of the estuary is often violated by too much, or too little, fresh water entering the estuary from its own 827 square mile watershed.*

Similar ecological problems are present in the Caloosahatchee estuary and San Carlos Bay, caused by excessive pulses of freshwater flow from Lake Okeechobee regulatory releases and runoff from the C-43 drainage basin. The upstream portions of the Caloosahatchee River support submerged aquatic vegetation (primarily *Vallisneria*) that requires low salinity conditions, pointing out the need to maintain base flows during droughts is important in addition to buffering extreme high flow events.

The lake's regulation schedule is only one element in the strategy to restore the St. Lucie and Caloosahatchee estuaries. The Indian River Lagoon Feasibility Study is under way to provide additional storage of water released from Lake Okeechobee and excessive runoff from the drainage basins of the St. Lucie estuary. The Comprehensive Plan for the C&SF Project outlines the components in the C-43 basin now considered necessary to restore the Caloosahatchee estuary, but feasibility planning is not yet as advanced as for the St. Lucie estuary.

F. Hydropattern Restoration in the Everglades, Consistent With Water Quality Goals

The Everglades Program (SFWMD and FDEP 1997) involves completion of the STAs included in the Everglades Construction Project, improvement in delivery of flows from the STAs to the Everglades, and other elements. The regulation schedule for Lake Okeechobee must be compatible with these plans. Until facilities (particularly STA 3/4) to remove phosphorus are completed, additional volumes of water from Lake Okeechobee will increase the total phosphorus load to the Everglades Protection Area. This presents a dilemma to water managers in the short term (at least until 2003, when the STAs are due to be completed) in balancing the desire to provide adequate water flows to the Everglades Protection Area while not violating the 1992 consent decree (United States v. South Florida Water Management District, 847 F. Supp. 1567, 1569 [S.D. Fla. 1992], affirmed in relevant part, 28 F.3d 1563 [11th Cir. 1994]).

G. Restoration of Torry, Kreamer, and Ritta Islands

Torry, Kreamer, and Ritta islands are located within the Herbert Hoover Dike in the southeastern corner of the lake, close to Belle Glade. These islands are surrounded by wetlands, but their interior portions are abandoned agricultural lands that could be restored to native vegetative communities supporting fish and wildlife resources.

The Service has recommended restoration of these islands for several years. In the past, the Service's emphasis has been primarily the opportunity to establish water management practices favorable to waterfowl. Although dedicating a portion of these islands for such a purpose is still open to consideration, the emphasis of the Service is now the opportunity to re-establish the pond apple (*Annona glabra*) swamp that was historically the dominant habitat type along the southern shore of Lake Okeechobee. Pond apple swamp is a rare and unique habitat type in Florida which has nearly been eliminated. In addition to its habitat value for fish and wildlife, the pond apple swamp was the original habitat of the endangered Okeechobee gourd (U.S. Fish and Wildlife Service [FWS] 1999).

The Science Subgroup Report (1993) included a recommendation to "integrate the islands at the southern end of the lake into an overall management plan for the lake," and mentioned the pond apple swamp as among the "landscape remnants" that needed to be addressed in a comprehensive restoration plan for south Florida. Restoration of these islands was included among the "40 Preferred Options" by the Governor's Commission for a Sustainable South Florida (1996). The Service supported including the restoration of these islands as an Other Project Element in the Comprehensive Plan for the C&SF Project (FWS 1998). However, this was not among the Other Project Elements selected by the Corps to be included in the Comprehensive Plan.

Soil samples from Torry and Kreamer islands in 1977 contained DDT, DDD, and DDE levels ranging from 2,200 to 110,000; 580 to 10,000; and 1,300 to 9,300 µg/kg, respectively (Pfeuffer 1985). A single sample was collected from southern Torry Island in 1985; this contained DDD and DDE residues at 4,900 and 300 µg/kg, respectively (Pfeuffer 1991). None of the parent compound, DDT, was found, suggesting that degradation or biotransformation of the pesticides may be occurring. Samples collected in 1992 from six sites on Ritta Island showed all analyzed pesticide compounds below the detection limit of 5 µg/kg (Pfeuffer, unpublished data 1998). Additional sampling is needed to confirm that contaminant levels are low enough in particular areas to safely attract additional wildlife use by restoring hydrology and native vegetation.

Provided that contaminant residues on former agricultural lands are now degraded to safe levels, the Service continues to recommend restoration of these islands, with an emphasis on restoration of pond apple swamp, which would enhance overall fish and wildlife habitat conditions and could be designed to promote recovery of the endangered Okeechobee gourd.

VI. FISH AND WILDLIFE RESOURCES WITHOUT THE PROJECT

Without selection and implementation of the proposed WSE schedule, the Service believes that the current regulation schedule, Run 25, would likely be maintained for an indefinite period. No single schedule has been demonstrated to improve performance across the full range of performance measures, even if we limit consideration to ecological performance measures, excluding water supply measures. The Run 25 schedule has proven to strike a more acceptable balance in environmental trade-offs than its predecessor, the 1978 schedule, which had stronger adverse effects on the littoral zone. Under the present regulatory constraints, extreme high and low water stages, as occurred during the extended 1994 rainy season (SFWMD 1995) and the winter-spring 1998-1999 El Niño event, can not be entirely prevented regardless of which alternative is selected. The damages to the lake's littoral zone are likely to be of slightly greater amplitude and/or duration with continuation of Run 25, as compared to implementation of the WSE schedule.

VII. DESCRIPTION OF SELECTED PLAN AND OTHER ALTERNATIVES

The Service believes that the development of alternatives and the selection of a preferred alternative for the LORSS can most accurately be characterized as a two-step process. The first step, from 1995 through 1997, involved a broader screening of alternatives in initial SFWMM simulations. The second period, from the spring of 1998 to the spring of 1999, involved refinement and development of operational guidelines for the WSE schedule.

The scope of the LORSS was restricted to operational rules feasible within the capability of the existing physical infrastructure controlling water inflows and outflows around Lake Okeechobee. These alternatives are described in detail and illustrated in Neidrauer *et al.* (1998).

The initial set of alternatives included Run 22AZE, which did not use climate forecasting, and the HSM and Corps' schedules, which included climate forecasting. After the initial analysis found none of those alternatives to perform adequately for all performance measures, the SFWMD devised the WSE schedule by combining selected aspects of the previous alternatives. Further refinement of the first version of WSE (Neidrauer *et al.* 1998) led to its selection as the preferred alternative and to its comparison to Run 25 (Operational Planning Core Team 1999). The latter document and the Corps' Draft EIS (Corps 1999a) contain detailed descriptions of the refined WSE schedule evaluated below.

VIII. EVALUATION OF THE PREFERRED ALTERNATIVE

A. Introduction

The following sections of this report discuss the anticipated effects of the Corps' preferred alternative (WSE), and are organized for consistency according to the resource concerns described above. As with the presentation of the Service's resource concerns, many of these effects interact, making clear demarcation into distinct categories somewhat artificial.

Until components of the Comprehensive Plan for the C&SF Project are built and enter into operation, the present infrastructure lacks the water storage and treatment capacity to approach performance targets in all areas. The current water management system has limited latitude to optimize performance in one area without trading off an adverse reaction in other aspects of performance.

The September 24, 1997, joint FWC/Service PAL provided an analysis of the initial set of alternatives, finding that none of the alternatives was superior in all performance areas, even if water supply performance measures were not considered. The HSM schedule, then preferred by the SFWMD, used the forecasting in a way that mainly benefitted water supply, showed slight improvement to the estuaries, but did not reduce the duration of high water stages that are damaging the littoral zone. The position of the FWC and the Service at that time was to implement Run 22AZE, which would best reduce the duration of high water stages in the lake. However, as with all analyzed alternatives, some trade-offs in overall performance would be inevitable. The adverse ecological consequences of Run 22AZE involved extension of the duration of extremely low lake levels during periods of drought and the inability to supply base flows of fresh water to the St. Lucie estuary during drought.

Table 1 summarizes the performance of the proposed WSE schedule, relative to the current Run 25 schedule. The information was derived from the latest simulation of the WSE schedule (Operational Planning Core Team 1999) and analysis of phosphorus loading by Walker (1999).

B. Direct Effects of Lake Stages on the Littoral Zone

The principal benefit of WSE derives from its use of climate forecasting to alleviate high water stages (both the duration of stages over 15 ft and the number of times stages reach 17 ft) during periods when inflows to the lake are anticipated to be above average. This allows reduction in the high water stages that adversely affect the littoral zone, without extending the severity and duration of low water stages that dry out the littoral zone. This is the first regulation schedule in many years of hydrologic modeling to demonstrate this favorable combination of characteristics.

In contrast, previous simulations indicated that although Run 22AZE would be effective in reducing high water stages, it also would extend periods when the littoral zone becomes completely dry, which is not ecologically desirable. WSE would also be more acceptable than Run 22AZE in terms of water supply. The climate prediction incorporated into WSE allows reduction of extreme high water stages, while slightly improving water supply deliveries to the EAA and the LEC during five drought years in the simulation period.

Reduction in the duration and severity of high water stages is expected to be more favorable for maintenance of more diverse vegetative communities in the littoral zone, which in turn should provide more favorable habitat conditions for fish and wildlife. The percentage of time in the simulation when lake stages exceed 15 ft would decrease from approximately 32 percent under Run 25 to about 26 percent under WSE. The simulation indicates that water stages would exceed 15 ft for a period of 2 years or more twice in 31 years under Run 25, and no years out of 31 under WSE. The anticipated overall increase in diversity of littoral zone vegetation is expected to include larger areas vegetated by willow, which we know was adversely affected during implementation of the 1978 schedule. Willow is important as nesting substrate for wading birds and the snail kite. More extreme high water stages (>17 ft) would also be reduced from about 4 percent of the simulation under Run 25 to about 2 percent under WSE, thereby decreasing the likelihood of erosion of bulrush from the deep water edge of the littoral zone.

Another performance measure (not summarized in Table 1) for the lake's littoral zone is the spring recession, which looks at the behavior of the stage hydrograph in the months of January through May. The ideal pattern for foraging by wading birds is considered to be an uninterrupted decline in lake stage from around 15 ft to around 12 ft without reversals (rising water stages) of greater than 0.5 ft. To date, a numerical scoring procedure has not been devised to rank schedules relative to this "wading bird window" performance measure. We have visually compared stage hydrographs for WSE and Run 25 over the 31-year simulation. In most years, no significant differences are observed between the two schedules. However, in five years (1965, 1966, 1967, 1974, and 1981) the WSE schedule had a slightly more favorable spring recession than Run 25. Figure 4 shows the improved performance of the WSE schedule for 1967 and 1981. Notice that in both years the WSE schedule exhibits a greater total descent in stage and more days within the desirable window. WSE performed slightly worse than Run 25 in only one year (1968). Although we can not predict the climatological conditions over the next several decades, over the wide-ranging conditions in effect in the simulation from 1965 through 1995, it appears that on average, the WSE schedule is likely to slightly improve the spring water recession across the littoral zone, relative to Run 25.

C. Effects of Lake Stage on Water Quality in the Lake

In accordance with the hypothesis (Havens 1997) that high lake stages increase the resuspension of phosphorus-rich sediments from the central pelagic portions of the lake, the reduction of high lake stages under the WSE schedule is likely to be slightly favorable, relative to Run 25, for water quality within the pelagic zone of the lake. By reducing the percentage of time lake stages exceed 15 ft, WSE should also decrease the transport of phosphorus-rich water from the lake's pelagic zone to the littoral zone; this should result in a slight improvement in water quality in the littoral zone, which in turn should be less favorable for continued expansion of cattail and other more nutrient-tolerant vegetation. The oligotrophic interior portions of Moonshine Bay, dominated by *Eleocharis* flats, supports the most favorable feeding conditions for the endangered snail kite; this habitat type should be somewhat less subject to invasion by nutrient-tolerant species of plants and invertebrates under WSE.

D. Spread of Exotic Vegetation in the Littoral Zone

The Service agrees with the findings of Lockhart *et al.* (1999) that potential concern about the spread of *Melaleuca* in the littoral zone under a lower lake regulation schedule should not dictate selection of the preferred regulation schedule. Aggressive removal and chemical treatment to combat the spread of *Melaleuca* appear to be the most effective management strategy. Likewise, the Service does not believe that adoption of the WSE schedule will significantly affect the spread of torpedo grass in the littoral zone; experimental control methods need to be implemented on a large scale for that species.

E. Effects of the Lake Okeechobee Regulation Schedule on the St. Lucie and Caloosahatchee Estuaries

According to the performance measures used in the simulations to date, the WSE schedule can not be considered as universally beneficial relative to Run 25 for the estuaries. Table 1 illustrates that some aspects of WSE are more favorable, while others are less favorable than Run 25 for the estuaries.

WSE would decrease the frequency of the most damaging high volume discharges (>2,500 cfs) to the St. Lucie estuary, but would slightly increase periods of moderately high volume discharges (>1,600 cfs), which are also considered detrimental to the estuary. The Service's evaluation is based on the performance measures provided in the 1999 simulation of WSE and Run 25. At a meeting in West Palm Beach on September 22, 1999, we were informed that SFWMD scientists have proposed modification of the performance measures for future evaluations of the St. Lucie estuary. They apparently have concluded that flow exceeding 2,000 to 3,000 cfs may be the more appropriate threshold for harm to the St. Lucie estuary, but the

Service has not yet reviewed the scientific basis for this conclusion. If this change in the performance measures for the St. Lucie estuary is accepted, it would support the Corps' conclusion on page 102 of the Draft EIS that the desirable reduction in the frequency of flows greater than 2,500 cfs outweighs the undesirable increase in the frequency in flows greater than 1,600 cfs in the simulation of WSE. Nevertheless, the Service is not certain, based on the current simulation, that the difference between Run 25 and WSE in the St. Lucie estuary is substantial enough to support the Corps' conclusion (also on page 102 of the Draft EIS) that, "Clearer water and more stable salinity is expected to foster re-colonization of the bottom by benthic plants, especially shoal grass." Although we agree this is an appropriate ecological goal for the St. Lucie estuary, we are not convinced that implementation of WSE alone will produce a substantial increase in the coverage of submerged aquatic vegetation. Implementation of WSE can be considered as a first step in developing a compatible regulation schedule for Lake Okeechobee as the water storage facilities of the Indian Lagoon Feasibility Study are designed, constructed, and operated, which we believe will substantially benefit submerged aquatic vegetation in the St. Lucie estuary.

The simulation suggests that WSE would slightly **increase** the number of times high volume discharges (> 2,800 cfs and > 4,500 cfs) are sent to the Caloosahatchee estuary, although the performance is quite close to that of Run 25.

F. Hydropattern Restoration in the Everglades, Consistent With Water Quality Goals

In the Everglades, the performance of WSE is nearly identical to that of Run 25, except at indicator regions in northern WCA 3A. Stage duration curves show a slight increase (1 to 2 percent) in the percentage of time that indicator regions in northern WCA 3A remain flooded during drier periods. WSE would slightly increase the average annual hydroperiod in northern WCA 3A, an area that is known to be drier now than under historic conditions.

The simulation indicates that prior to STA 3/4 coming on line, WSE would, **on average,** slightly reduce the concentration of phosphorus entering the Everglades Protection Area, but would also slightly increase the total mass of phosphorus entering the Everglades Protection Area due to WSE's increased volume of flow to the Everglades. However, one should remember that this finding is based on averaging throughout the climatic conditions that occurred during the years 1965-1995. The climatic conditions between the date of implementation of the WSE schedule and completion of the STAs will determine whether the proposed change in lake regulation will truly increase total phosphorus loading to the Everglades Protection Area. If rainfall is less than average over the interim period prior to 2003, the Service finds that changing the regulation schedule to WSE will not result in increased phosphorus loading to the Everglades relative to Run 25. If rainfall is above average, WSE would slightly increase total phosphorus loading, relative to Run 25, for about three years. Analysis by the SFWMD (1999) suggests that the slight increase in total phosphorus loading would be limited to WCAs 3A and 2A. The slight differences in hydrology observed in the northern portions of the WCAs are not discernible in

Everglades National Park, and no significant effect is anticipated on the loading of phosphorus in the Everglades Protection Area south of Alligator Alley (including Everglades National Park). Under the water routing in WSE, Loxahatchee National Wildlife Refuge would not receive increased flows or phosphorus loads. Once the full complement of STAs are completed, the flow of water from the lake and from the EAA could be adjusted to increase flow to Loxahatchee National Wildlife Refuge and other areas without increasing phosphorus loading. Not only would WCAs 3A North and 2A buffer the southern Everglades from hydrologic differences between the schedules, but those portions of the Everglades would also absorb any ecological effects (such as increased rate of cattail expansion) of potential increased loading of phosphorus prior to completion of the STAs. The STAs, when completed, are designed to handle much greater increases in total flow to the Everglades than the slight increase that would occur in changing the Lake Okeechobee regulation schedule to the proposed WSE. Therefore, the potential increased phosphorus loads to the Everglades (depending on the rainfall conditions in the intervening years) would only occur until the STAs are completed. STA 3/4 is currently scheduled to be fully operational by October 2003.

In 1988, the United States sued the State of Florida over the state's failure to deliver water meeting state water quality standards to Loxahatchee National Wildlife Refuge and Everglades National Park. On May 12, 1999, the affected Federal agencies (Department of Justice, Department of the Interior solicitors, Corps of Engineers, Environmental Protection Agency, National Park Service, and the Fish and Wildlife Service) met in the Corps' Jacksonville District office to discuss the potential effects of the WSE schedule on compliance with the 1992 consent decree that settled that lawsuit (United States v. South Florida Water Management District, 847 F. Supp. 1567, 1569 [S.D. Fla. 1992], affirmed in relevant part, 28 F.3d 1563 [11th Cir. 1994]). The participants concluded that the WSE schedule would add only a negligible amount to phosphorus loads to the WCAs, and the effect of those loads would be mitigated once STA 3/4 is completed in 2003. They concluded that the WSE schedule would not cause a violation of the load reduction provisions of the consent decree.

IX. THREATENED AND ENDANGERED SPECIES

A. Federally Listed Species

The Corps has informally consulted with the Service regarding potential impacts of the LORSS since 1995. The following federally listed species have been addressed in that consultation:

COMMON NAME	SCIENTIFIC NAME	STATUS
Snail kite	*Rostrhamus sociabilis plumbeus*	E(CH)
Wood stork	*Mycteria americana*	E
West Indian manatee	*Trichechus manatus*	E(CH)
Bald eagle	*Haliaeetus leucocephalus*	T[3]
Cape Sable seaside sparrow	*Ammodramus (=Ammospiza) maritimus mirabilis*	E(CH)
Eastern indigo snake	*Drymarchon corais couperi*	T
Okeechobee gourd	*Cucurbita okeechobeensis* ssp. *okeechobeensis*	E

E=Endangered; T=Threatened; CH=Critical Habitat has been designated

On February 16, 1999, the Corps provided a determination to the Service that the proposed WSE schedule was not likely to adversely affect any of the considered species. The Service has reviewed the analysis of the hydrologic changes predicted for the WSE schedule and the best scientific information available on these species in the areas to be affected by the project, and we are able to concur with the Corps' determination. The Service believes that the effect of implementation of WSE on the West Indian manatee, the Cape Sable seaside sparrow, and the eastern indigo snake is negligible. We find that implementation of WSE is likely to slightly benefit the health of the lake's littoral zone, which is likely to have slight positive effects on four of the above species: the snail kite, the wood stork, the bald eagle, and the Okeechobee gourd. The following paragraphs provide a brief rationale for our findings for each species.

The project will not likely affect the indigo snake, which primarily inhabits uplands. The project does not include any changes to the water regulation infrastructure around the lake, such as the Herbert Hoover Dike, where the snake might be found.

The West Indian manatee inhabits the open waters of Lake Okeechobee and the surrounding canals, but the Service does not anticipate any significant effect on habitat conditions for the manatee within the lake as a result of this project. Outside of the lake, the project demonstrates mixed results for the Caloosahatchee and St. Lucie estuaries, and the Service is not convinced that the WSE schedule would significantly improve conditions in the estuaries (such as increased growth of seagrasses) that would be beneficial to the species. Lake Okeechobee is not included in the designated critical habitat for the manatee, and the critical habitat outside the lake should not be significantly affected.

The simulations indicate that the hydrology of the indicator regions of the Everglades corresponding to occupied Cape Sable seaside sparrow habitat is not significantly affected by WSE. Therefore, neither the species nor its designated critical habitat is likely to be affected.

Several active bald eagle nests are located around the edge of Lake Okeechobee. To the extent that the WSE schedule may contribute to enhanced productivity of fish in the lake, foraging

[3] At the date of this report, the bald eagle has been proposed for de-listing, but during the consultation on this project, it was listed as threatened, and was evaluated accordingly.

conditions for these eagles may be slightly enhanced by implementation of WSE. We do not believe that the proposed action will have a significant effect on bald eagles nesting adjacent to the St. Lucie and Caloosahatchee estuaries.

Wood storks nest in small numbers around the lake (Zaffke 1984, David 1994a), and they are regularly seen foraging in the area. However, wood storks are attracted to the lake in large numbers only when the lake stage descends below 14 ft. Large flocks are present during severe drought years, such as 1981 and 1990, when water stages descended below 10.5 ft (Zaffke 1984, Smith *et al.* 1995). WSE does not extend periods of extreme low water stages. Therefore, the attraction of large flocks of wood storks to feed in the lake would not be increased by implementation of WSE. However, the slight improvement in the spring recession under WSE should benefit a variety of wading birds, including the wood stork.

The Service believes that the two species most likely to benefit from implementation of WSE are the Okeechobee gourd and the snail kite, which are sensitive to the ecological health of the lake's littoral zone. The known range of the Okeechobee gourd is limited, in south Florida, to Lake Okeechobee. The Okeechobee gourd is adversely affected by extended periods of high water, because drying portions of the littoral zone are not available to allow germination. The reduction of extreme high water conditions under WSE should be beneficial to the species (U. S. Fish and Wildlife Service [FWS] 1999). Lake Okeechobee is central to the range of the snail kite and is consistently used by the species for nesting and foraging. Rodgers (1996) suggests that a stage of 14 ft during the snail kite breeding season would be favorable to inundate suitable woody vegetation that can support snail kite nests. The WSE schedule would equal or exceed 14 ft for 45 percent of the time, as opposed to 48 percent of the time under Run 25. According to Rodgers' recommended criterion, this shift might be slightly unfavorable for nesting snail kites in the short term, but presumably the distribution of woody vegetation would adjust to this small change in inundation frequency. This potentially adverse effect is mitigated by the reduction of stages exceeding 15 ft, which should reduce the threat of more turbid and phosphorus-laden water entering the interior portions of Moonshine Bay, which is the most suitable portion of the designated critical habitat for feeding of the snail kite. Turbid water is more likely to enter interior portions of the littoral zone during high lake stages, cutting down on light penetration and productivity of periphyton. Phosphorus-laden waters change the species composition of periphyton and invertebrates to more nutrient-tolerant species and foster the expansion of more nutrient-tolerant plants, such as cattail. The displacement of spikerush-dominated vegetation by cattail is adverse to foraging by the snail kite, because it is less successful in visually locating prey in dense vegetation. On balance, the Service believes that the WSE schedule would be beneficial to habitat conditions in the littoral zone and would contribute in a small way to recovery of the snail kite.

The Service cannot support the Corps' conclusion in the Draft EIS (Corps 1999a, p. 108) that WSE would enhance habitat conditions for the West Indian manatee and the bald eagle in the St. Lucie estuary. We find that the proposed action is not likely to affect those species in any significant way in either the St. Lucie or Caloosahatchee estuaries.

B. State Listed Species

The Corps' Draft EIS (Corps 1999a, Table 2.7.1-1, p. 30) includes a list of 12 additional species listed by the State of Florida that are not also federally listed. The FWC has found this list to be accurate for the project area (M. A. Poole, FWC, personal communication 1999). However, the Draft EIS does not include a determination whether or not the project is likely to affect those 12 additional species. Based on our discussion with the FWC, we believe that the American alligator, brown pelican, and black skimmer (all species of special concern) may be slightly benefitted by improved fish production in the lake, which those species consume. We also believe that seven species of wading birds (roseate spoonbill, limpkin, little blue heron, reddish egret, snowy egret, tricolored heron, and white ibis), which are all listed as species of special concern, may be slightly benefitted by the improved spring water recession under WSE.

X. RECOMMENDATIONS/CONSERVATION MEASURES

A. Introduction

While recognizing the influence of water management in Lake Okeechobee throughout south Florida, we have limited our recommendations below to those most directly associated with the effects of the regulation schedule on the lake itself. The Service is providing planning guidance and recommendations in many studies in south Florida, with the understanding that these must consider the effects on the total C&SF system. Among the many related efforts for which we will provide recommendations in additional FWCA reports, we can mention a few that will be most directly associated with the LORSS: Lake Okeechobee Action Plan, Taylor Creek/Nubbin Slough water treatment and storage areas, Indian River Lagoon Feasibility Study, Caloosahatchee water storage/Aquifer Storage and Recovery (ASR), Lake Okeechobee ASR Pilot Project, water storage in the EAA, and the Comprehensive Water Quality Reconnaissance Study. We also assume that the Everglades Construction Project will be constructed and operated by 2003 to limit the potential interim effect of phosphorus loads on the Everglades.

B. Recommendations

The Service provides the following recommendations:

1. **Refine the WSE Schedule.** Further refinement of climate forecasting should be investigated and incorporated, as appropriate, into revisions of the WSE schedule. Continued evaluation is needed to determine how accurately the forecasting predicts the observed hydrologic regime and how far into the future the forecasting proves to be useful.

2. **Conduct Additional Studies.** Additional documentation is needed to confirm and quantify the relationships between stressors and responses in the Lake Okeechobee Conceptual Model. In particular, the Service recommends that the Corps assist in

funding field studies and statistical analyses to quantify the relationship between spring water recession characteristics and wading bird foraging and/or nesting success in the lake. Additional research is needed on the degree to which extended periods of high water stages increase penetration of phosphorus-laden water into Moonshine Bay. Monitoring of the benthic invertebrate fauna in the littoral zone should accompany this effort, because these organisms are sensitive indicators of the expansion of eutrophic conditions. Bull *et al.* (1995) found a correlation between fish distribution patterns and lake stage in the pelagic zone of the lake, but research is lacking on the effect of lake stage on the fish fauna in the littoral zone. These activities are essential components of the adaptive assessment strategy that the Corps has endorsed in the Comprehensive Plan for the C&SF Project.

3. **Implement Habitat Restoration.** The Service continues to support its long-standing recommendation to plan and carry out restoration of wetlands at Torry, Kreamer, and Ritta islands within the lake, provided that follow-up contaminant sampling indicates that pesticide residues in those areas have degraded to safe levels for fish and wildlife. The Service now believes a greater emphasis should be placed on restoration of hydrology and planting of pond apple forest.

   Because the pond apple forest that once bordered the southern shore of the lake has virtually disappeared, these islands may offer an opportunity to re-establish this lost habitat type in a portion of its historic range. In addition to enhancement of habitat conditions for fish and wildlife, appropriate design of this restoration could also promote recovery of the endangered Okeechobee gourd.

   The Service recommends that the Corps re-evaluate the omission of this component from the Comprehensive Plan for the C&SF Project. A multi-agency workshop to produce a conceptual design for this restoration could provide adequate information to justify inclusion of this component either under the programmatic authority for the Comprehensive Plan for the C&SF Project or under a separate project authorization.

4. **Take Advantage of Improved Management Flexibility.** As those components of the Comprehensive Plan for the C&SF Project that most directly influence water management in Lake Okeechobee are implemented, additional management flexibility should be available to further modify the lake's regulation schedule. Continual re-evaluation of opportunities to refine the regulation schedule will be necessary to achieve benefits in the lake, the estuaries, and the Everglades.

XI. SUMMARY OF SERVICE POSITION

The Service supports implementation of the WSE regulation schedule on an interim basis. We recommend that a multi-agency and multi-disciplinary technical review panel meet annually to reassess how effective climate forecasting has been in improving the performance of the WSE schedule. This will provide an opportunity to review ecological conditions in the lake, the estuaries, and the Everglades and to explore opportunities for further refinement of WSE. Formal re-evaluation of the schedule, including preparation of another FWCA report, will likely be necessary several years after implementation of WSE.

The Service has provided recommendations involving refinement of the application of climate forecasting to the Lake Okeechobee regulation schedule, improved scientific support for the Lake Okeechobee conceptual model, restoration of islands within the lake, and the need for continued review of the lake's regulation schedule as components of the Comprehensive Plan for the C&SF Project are implemented.

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Table 1. Comparison of WSE and Run 25 water regulation schedules through simulation of their performance, based on 1965-1995 climate conditions (Page 1 of 4)

Preferred Performance | Less Preferred Performance | Alternatives Roughly Equal

ECOLOGICAL PERFORMANCE MEASURE	WSE	RUN 25
Lake Okeechobee Littoral Zone		
Duration of Stages > 17 ft	slightly better	slightly worse
Duration of Stages < 11 ft	even	even
Duration of Stages > 15 ft	slightly better	slightly worse
Number of Undesirable Lake Stage Events (occurrences in 31-year simulation; lower number is more desirable)		
Stages < 11 ft for >100 days	2	2
Stages < 12 ft for > 1 year	1	1
Stages > 15 ft for > 2 years	0	[illegible]
Stages > 16 ft for > 1 year	0	0
Stages > 17 ft for > 50 days	2	[illegible]
St. Lucie Estuary		
Flow < 350 cfs (number of months in the 31-year simulation; lower number is more desirable)	153	153
Flow > 1600 cfs for ≥ 14 days, from local basins (number of occurrences in 31-year simulation)	87	87
Flow > 1600 cfs for ≥ 14 days, Lake Okeechobee releases (number of occurrences in 31-year simulation)	41	42
Mean monthly flow > 1600 cfs (number of months in the 31-year simulation; lower number is more desirable)	[illegible]	79
Mean monthly flow > 2500 cfs (number of months in the 31-year simulation; lower number is more desirable)	35	[illegible]

Table 1. Comparison of WSE and Run 25 water regulation schedules through simulation of their performance, based on 1965-1995 climate conditions (Page 2 of 4)

Preferred Performance | Less Preferred Performance | Alternatives Roughly Equal

ECOLOGICAL PERFORMANCE MEASURE	WSE	RUN 25
Caloosahatchee Estuary		
Flow < 300 cfs (number of months during dry season in the 31-year simulation; lower number is more desirable)	106	107
Flow > 2800 cfs from C-43 basin (number of months in 31-year simulation)	44	[illegible]
Flow > 2800 cfs due to Lake Okeechobee releases (additional number of months in 31-year simulation)	[illegible]	24
Mean monthly flow > 2800 cfs (number of months in the 31-year simulation; lower number is more desirable)	[illegible]	70
Mean monthly flow > 4500 cfs (number of months in the 31-year simulation; lower number is more desirable)	[illegible]	31
Everglades Hydroperiods (Percent of model cells with hydroperiod matches to the Natural System Model; higher number is more desirable)		
Loxahatchee National Wildlife Refuge	68.4	68.4
Water Conservation Area 2A	92.7	92.7
Water Conservation Area 3A North	55	[illegible]
Water Conservation Area 3A South	64.6	64.6
Everglades National Park	55.3	55.8
Overland Flow to Everglades National Park (acre-feet/yr X 10^3; greater flow east of L-67E is desirable)		
Wet season flow east of L-67E	76	76
Dry season flow east of L-67E	70	69

Table 1. Comparison of WSE and Run 25 water regulation schedules through simulation of their performance, based on 1965-1995 climate conditions (Page 3 of 4)

Preferred Performance | Less Preferred Performance | Alternatives Roughly Equal

ECOLOGICAL PERFORMANCE MEASURE	WSE	RUN 25
Everglades Water Quality		
Phosphorus concentration (ppb)[1]		
Flow-weighted mean at all inflows to the Everglades Protection Area, Pre-STA3/4	73	[illegible]
Flow-weighted mean at all inflows to the Everglades Protection Area, Post-STA3/4	65	66
Phosphorus load (metric tons/yr)[1]		
Total load to Everglades Protection Area, Pre-STA3/4	[illegible]	6.1
Total load to Everglades Protection Area, Post-STA3/4	14.71 [2]	14.46

[1]Data from Walker (1999).

[2]Total load projected to increase following operation of STA3/4, based on modeling assumption that the Everglades Forever Act-mandated 28 percent average annual increase in flow is achieved.

Table 1. Comparison of WSE and Run 25 water regulation schedules through simulation of their performance, based on 1965-1995 climate conditions (Page 4 of 4)

Preferred Performance | Less Preferred Performance | Alternatives Roughly Equal

WATER SUPPLY PERFORMANCE MEASURE	WSE	RUN 25
Lake Okeechobee Service Area (LOSA)		
Mean annual demands not met throughout simulation (acre-feet/yr X 10^3)		
Everglades Agricultural Area	51	51
Other LOSA Sub-Areas	34	33
Total water supply cutback percentage throughout simulation		
Everglades Agricultural Area	12	12
Other LOSA Sub-Areas	16	16
Mean annual demands not met in five drought years (acre-feet/yr X 10^3)		
Everglades Agricultural Area	76	[illegible]
Other LOSA Sub-Areas	46	[illegible]
Total water supply cutback percentage in five drought years		
Everglades Agricultural Area	14	[illegible]
Other LOSA Sub-Areas	16	[illegible]
Lower East Coast Service Areas		
Mean annual water deliveries in five drought years, sum of three LEC Service Areas (acre-feet/yr X 10^3)	366	[illegible]

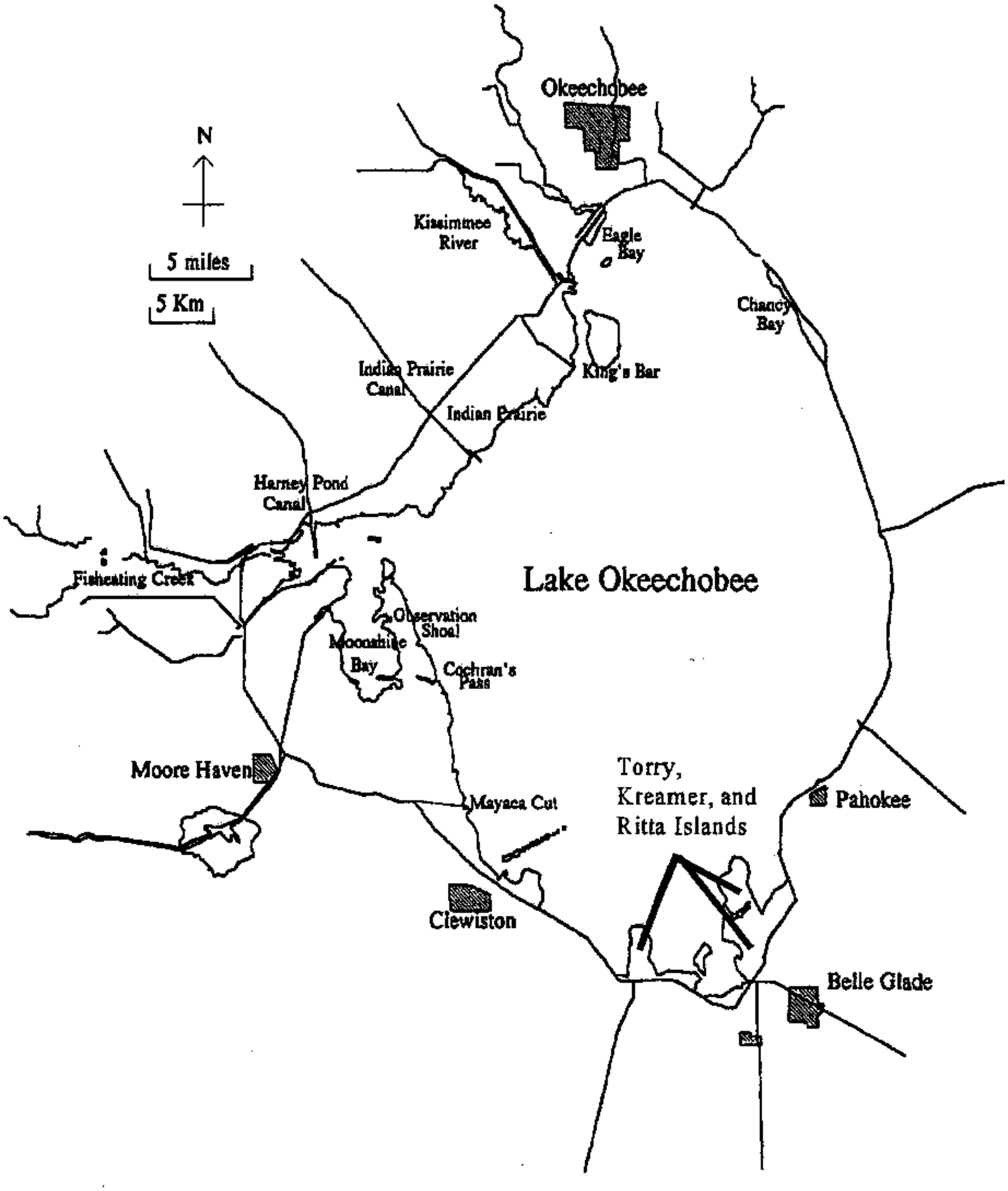

Figure 1. Selected natural features of Lake Okeechobee and principal surrounding cities.

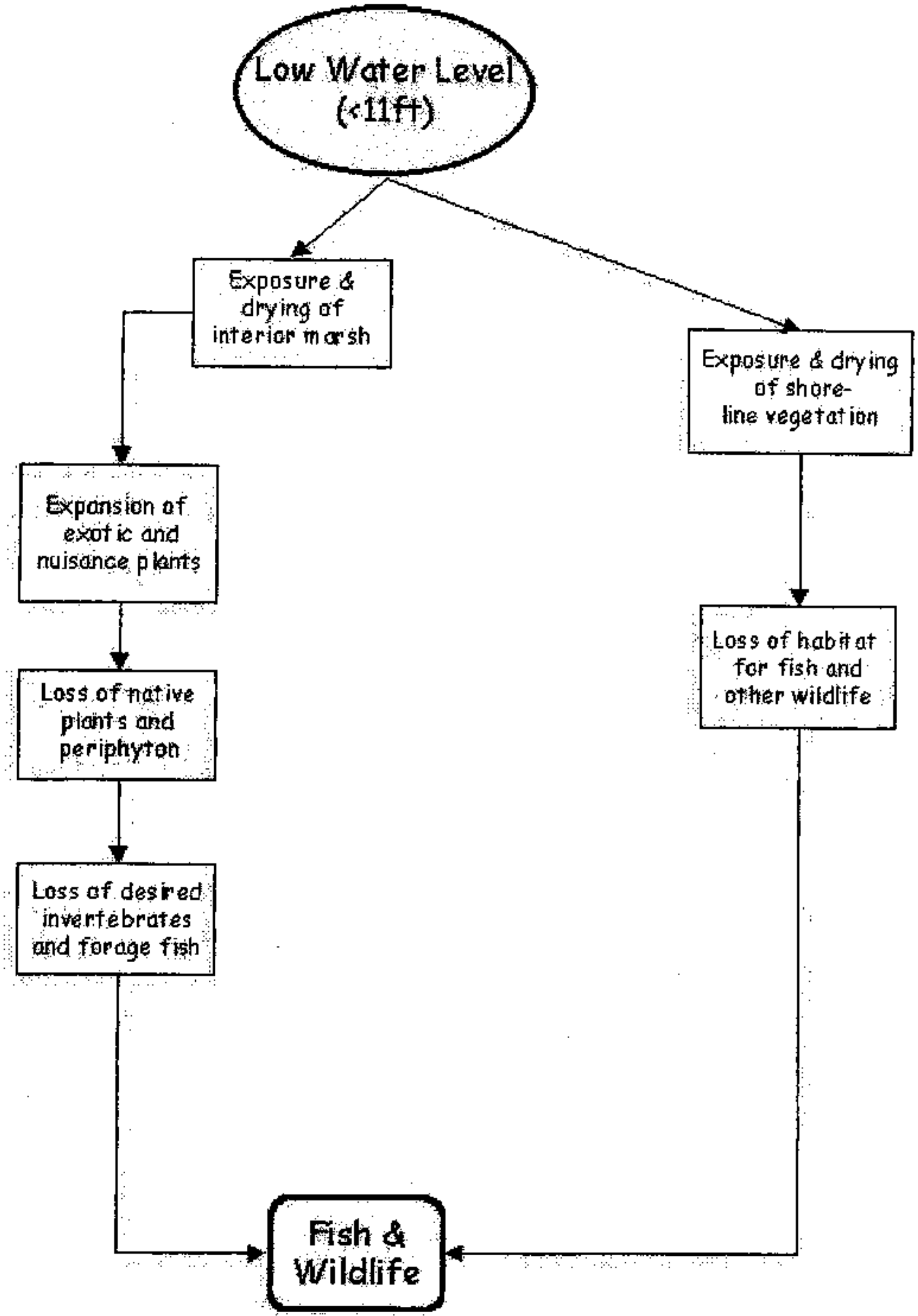

Figure 2. The portion of the Conceptual Model for Lake Okeechobee dealing with the low water stressor (from Karl Havens, SFWMD)

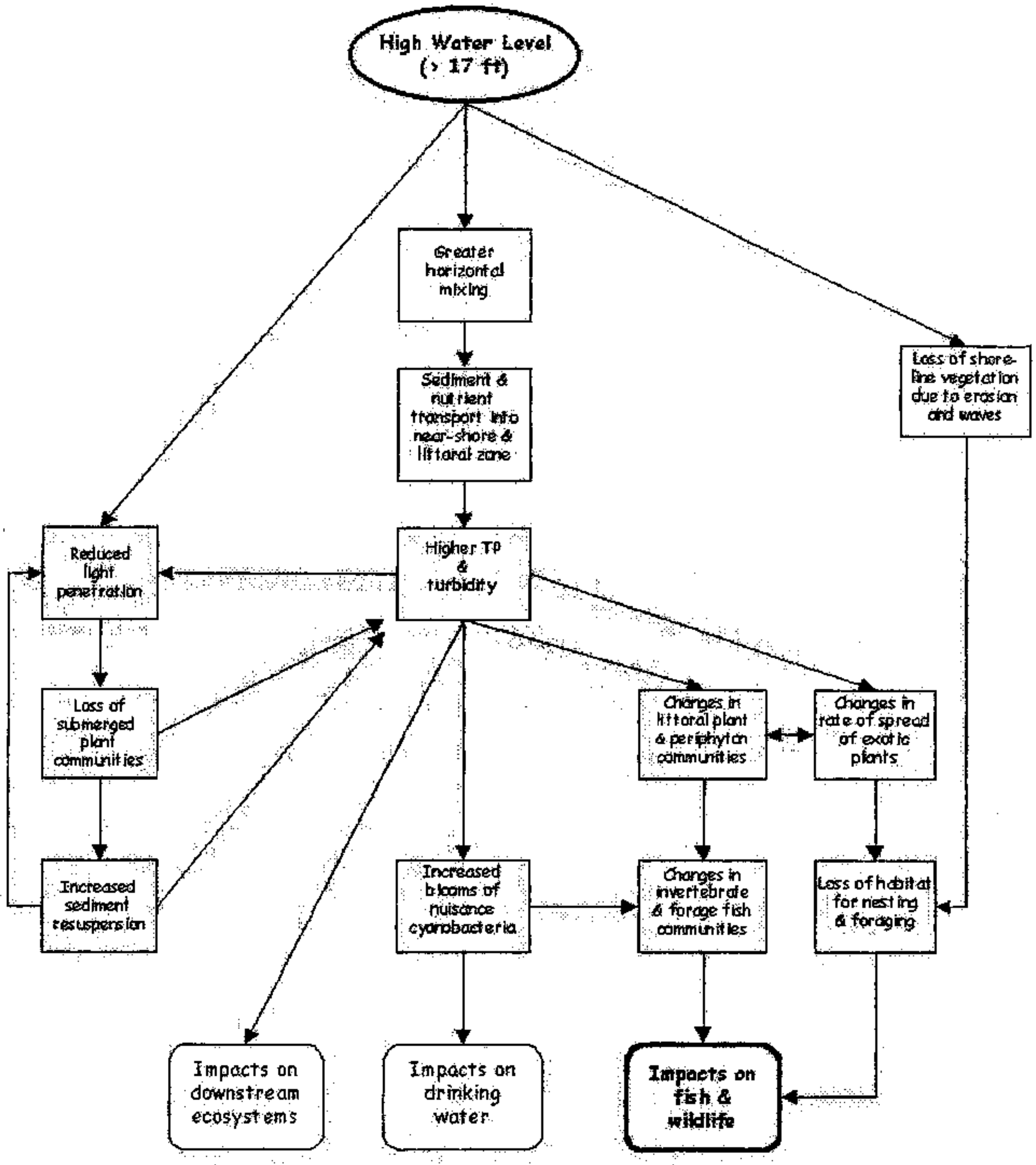

Figure 3. The portion of the Conceptual Model for Lake Okeechobee dealing with the high water stressor (from Karl Havens, SFWMD)

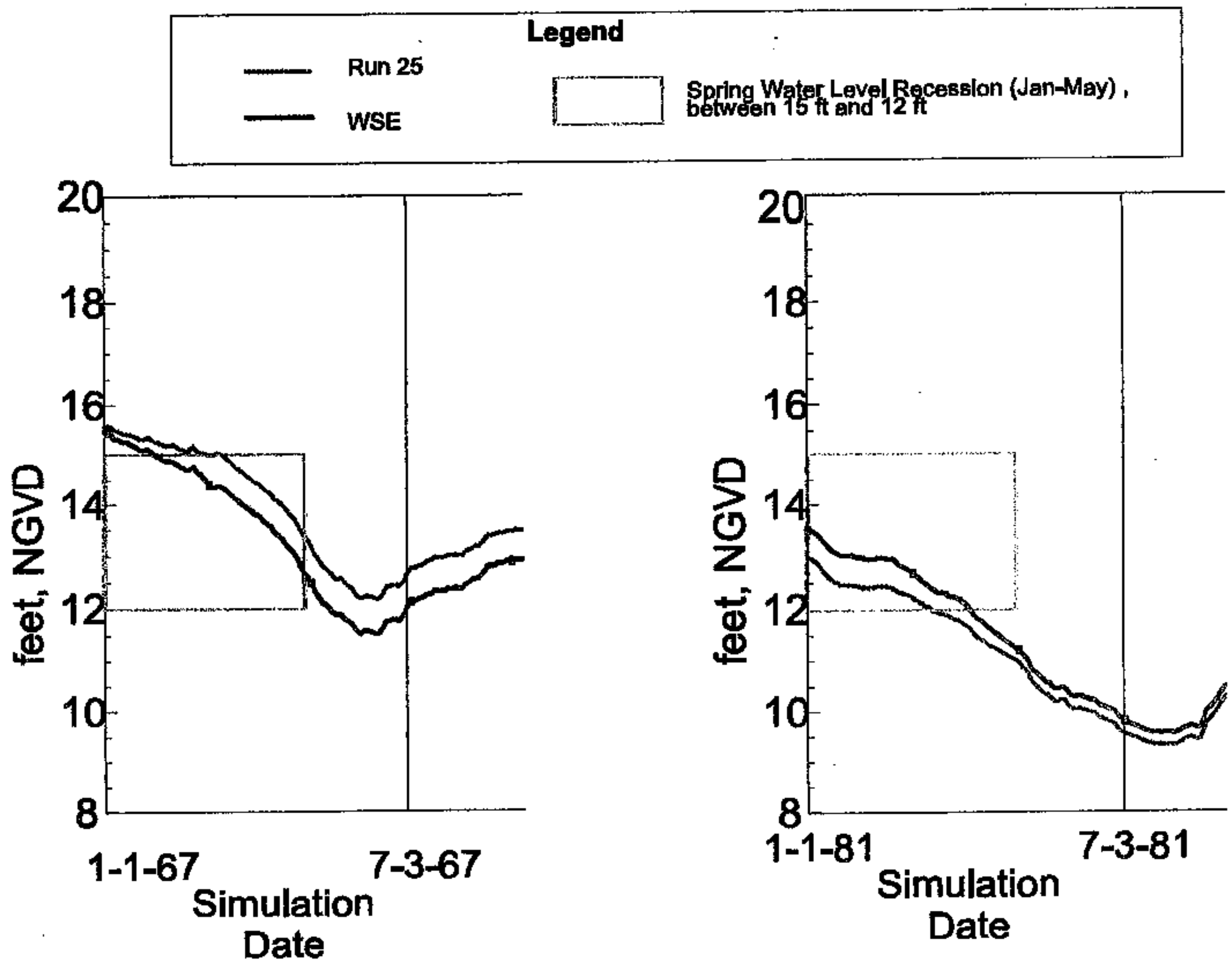

Figure 4. Comparison of portions (1967 and 1981) of stage hydrographs for WSE and Run 25, with spring recession windows.