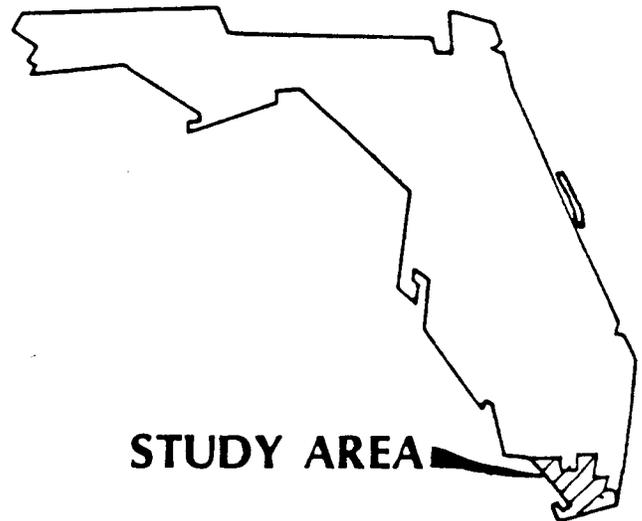

**GENERAL PLAN for Implementation of
an Improved Water Delivery System to
Everglades National Park , Florida**



**US Army Corps
of Engineers**
Jacksonville District

January 1985

GENERAL PLAN FOR IMPLEMENTATION OF AN IMPROVED
WATER DELIVERY SYSTEM TO EVERGLADES NATIONAL PARK

EXECUTIVE SUMMARY

This report was prepared to respond to Public Law 98-181, the Supplemental Appropriations Act, 1984. The Act authorized a 2-year field test of modified water deliveries to Everglades National Park (ENP). The Act further authorized acquisition of agricultural lands and construction of flood protection measures in residential areas impacted.

To provide necessary response to the Act, the following procedure was adopted. This General Plan was prepared:

- To assess alternative actions
- To develop the scope of a field test
- To propose options for water delivery
- To evaluate the feasibility of flood protection
- To define further studies

Secondly, a limited field test will be initiated that would not damage agricultural or residential owners. The third step, upon approval of this General Plan, would be preparation of a General Design Memorandum (GDM) to further evaluate those items in the General Plan. Subsequent to this, a recommended final course of action will be made to respond to PL 98-181.

This General Plan evaluates several preliminary flood protection options which include:

- A levee system for the residential areas
- A levee system for the residential and agricultural areas
- Floodproofing
- Acquisition/relocation

Water delivery options that deserve further evaluation include:

- A flow-through system for WCA No. 3
- Deliveries based on conditions in ENP
- Revised regulation schedule (Bridge 105)
- Structural modifications to support these management options

The conclusions of the General Plan are:

- Direct compliance with PL 98-181 is not possible due to the 2-year limit
- A change in water delivery is essential for preservation of the national treasure (ENP)
- The limited field test can provide data for use in the GDM
- Uniqueness of ENP is the basis for NED exception

Recommended actions:

- That the General Plan be approved
- That the GDM be prepared and submitted
- That the testing program extend beyond 2 years

GENERAL PLAN
EVERGLADES NATIONAL PARK, FLORIDA

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DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
P. O. BOX 4970
JACKSONVILLE, FLORIDA 32232-0019

REPLY TO
ATTENTION OF

SAJPD-F

January 1985

SUBJECT: General Plan for Implementation of an Improved Water Delivery System to Everglades National Park, Florida

Commander, South Atlantic Division

PURPOSE

1. Purpose. This report was prepared as a decision document to outline the planning necessary to implement authorizations contained in the Supplemental Appropriations Act, 1984 (Public Law 98-181) concerning a new water delivery schedule for Everglades National Park (ENP). The report contains conceptual descriptions of structural and operational modifications necessary for improved water deliveries to the Park from the Central and Southern Florida (C&SF) Project. Preliminary plans to protect potentially affected agricultural and residential areas from increased flooding risk due to water delivery modification are also presented. A schedule and estimate of funding requirements for detailed environmental and engineering studies to fully implement the requirements of PL 98-181 are also included. If a basis is found for proceeding, the detailed studies will be presented in a General Design Memorandum (GDM) and assessed in an Environmental Impact Statement (EIS). A limited field test will be conducted concurrently with preparation of the GDM and EIS. The field test will not significantly impact residential or agricultural interests.

AUTHORITY

2. Authority to Conduct a Field Test. The Supplemental Appropriations Act, 1984 (Public Law 98-181) authorized the Secretary of the Army to conduct an experimental program for delivering water to the Everglades National Park. This authorization allows modification of the current delivery schedule of water from the Central and Southern Florida Project. The pertinent section of the Act is quoted: " Sec. 1302. The Secretary of the Army is authorized, for a period of two years beginning with enactment of this Act with the concurrence of the Director of the National Park Service and the South Florida Water Management District, to modify the schedule for delivery of water from the central and southern Florida project to the Everglades National Park required by section 2 of the River Basin Monetary Authorization and Miscellaneous Civil Works Amendments Act of 1970 (Public Law 91-282) and to conduct an experimental program for the delivery of water to

the Everglades National Park from such project for the purpose of determining an improved schedule for such delivery.

The Secretary of the Army is further authorized to acquire such interest in lands currently in agriculture production which are adversely affected by any modification of schedule for water delivery to Everglades National Park under the preceding paragraph. The Secretary shall acquire any interest in land at the fair market value of such interest based on conditions existing after the construction of the project described in the preceding paragraph of this section and before any modification of such delivery schedule. The Secretary is also authorized to construct necessary flood protection measures for protection of homes in the area affected by any modification of such delivery schedule, at an estimated cost of \$10,000,000."

3. Authority for this Report. PL 98-181 was passed without the benefit of a feasibility report. Therefore this report was prepared to be a decision document for proceeding with implementation of the Act and is in response to direction contained in SADPD 1st Indorsement and DAEN-CWP-G 2nd Indorsement to SAJEN-HW letter, dated 22 December 1983, subject: Implementation of a Field Test of a New Water Delivery Schedule to Everglades National Park.

4. Implementation of PL 98-181. Direct compliance with the language and intent of the Act is not possible within the time frame provided. The time period allowed to conduct the experimental program is "... two years beginning with enactment of this Act." The Act specifically authorizes the Secretary of the Army to acquire interest in agricultural lands and to construct flood-protection measures for protection of homes in the area. The intent of this is to protect those private properties which might be damaged by a change in water levels as a result of the experimental water delivery program to ENP. Evaluation of changed water levels, design of flood-protection measures, acquisition of real estate, and construction would take all or most of the 2 years allowed and would preclude any time remaining for a meaningful field test. Further, complex real estate issues require resolution and clarification, and exception to National Economic Development (NED) criteria is needed.

5. Implementation Procedure. Given the flaws within the legislation, the following procedure has been determined to be responsive to the legislation and will also protect the interests of private landowners. A limited field test will be proposed that will not increase flooding within the agricultural or residential areas. In conjunction with this, a General Plan (this document) was prepared to describe the limited field test, describe options for water delivery, provide a preliminary feasibility for flood protection, and outline further study needs. If the General Plan is approved, a GDM and an EIS will be prepared. The GDM will address the need for flood-protection measures based on extrapolation from the limited field test and recommend a new delivery plan for water supply to ENP.

PROBLEM IDENTIFICATION

6. Existing Condition. The Everglades National Park (ENP) is located in south Florida, southwest of Miami (See Plate 1). The Park was authorized by Congress in 1934 and established in 1947. The purpose of establishing the Park was to preserve the area with its unique flora and fauna in an essentially primitive, natural condition. Acts of man outside the Park boundaries have had an impact on the vegetation and wildlife that was to be protected. Water control activities, including drainage, flood control, and water storage have substantially altered the natural flow of water that historically entered the Everglades.

Park biologists believe that changed water-flow patterns have caused ecological conditions within the park to deteriorate. Since impoundment of waters north of the Park in 1962 and the institution of various water-delivery schedules, certain wildlife populations within the Park have not fared well. ENP records on woodstorks show that there were 5 out of 9 successful nesting years prior to 1962, but only 3 in the 21 years since 1962. In addition, all other wading birds have shown a steady decline in nesting populations. Regulatory water releases for flood control purposes since 1962 have destroyed alligator nests through inundation. Fisheries within the Park have declined even with restrictions imposed on harvesting. Exotic plants have invaded the Park, becoming established partly due to changes in water levels. Additional information is contained in Appendix C.

Most of the surface flow entering the Park is through the Central and Southern Florida (C&SF) Project. This project, serves the multipurpose uses of flood control, water supply, prevention of salt water intrusion, recreation, navigation, and enhancement of fish and wildlife. The problem stems, in part, from water management operations of the C&SF Project required to ensure that its multiobjective functions are satisfied. At the present time, the only major conveyance pathway for release of flood waters from Water Conservation Area (WCA) No. 3A is through the S-12 (A-D) spillway structures leading into the Park. The suddenness with which the water must be released, the confinement of the water by Levee 67 Extension (L-67 Ext) into a relatively narrow corridor, and, at times, the unseasonable volume of water all contribute to adverse ecological impacts.

There is residential and agricultural development in the East Everglades area east of L-67 Ext which is concentrated, for the most part, within a 2-mile strip west of L-31N (See Plate 2). Although some roads exist beyond the developed area, few residences have been constructed beyond that depicted on Plate 2. These areas are subject to periodic flooding because of low ground elevations and the hydrologic regime. There are concerns that further structural or operational changes in the water-management system to benefit ENP will aggravate the current flooding.

7. Ecological Problems in ENP. The Superintendent of Everglades National Park states that "Since the Park's establishment in 1947, there have been significant declines of some of the area's most important natural resources" (Appendix C).

a. Ospreys. There has been a dramatic decrease in the osprey nesting population in Florida Bay. The present population is 60% below the levels documented a decade ago, and the reproduction rate may not be adequate to maintain the population. Kushlan and Bass^{1/} concluded that the nesting ospreys they studied in Florida Bay were food stressed, resulting in brood reduction. This is consistent with a decline in the Park's fishery discussed in the following paragraph.

b. Park Fishery. The water area presently included in Everglades National Park historically supported numerous fisheries, both commercial and recreational. In the late 1960's and early-to-mid 70's, the staff at Everglades National Park began to hear an increasing number of complaints from biologists and long-term fishermen that the fishing in Florida Bay was not what it used to be. Groups and individuals, particularly the recreational fishermen, began to question whether continued commercial harvest was consistent with Park Service policy, an increased demand for recreational resources, and a declining fishery. As these anecdotal reports of the decline in fishery resources in Florida Bay continued to grow, the National Park Service undertook a program of creel censuses and catch surveys. Using information generated by this program and acting on long-established Park Service policy, the Service, in January of 1979, prepared An Assessment of Fishery-Management Options in Everglades National Park, Florida. In March 1980, final regulations were promulgated to reduce pressures on the fishery resources and reallocate these resources among park wildlife, recreational fishermen, and commercial fishermen. Implementation is presently being withheld pending outcome of litigation. There is evidence that the fisheries decline is related to freshwater influence in Florida Bay. Over the past 18 to 24 months, unusually heavy rainfall throughout the year has coincided with a substantial resurgence in juvenile snook populations in the bay. Also, in the past two years, the amount of other fish production and harvest in parts of the Bay have increased by almost 30% (Gary Hendrix, pers comm.).

c. Wood Storks. ENP records on woodstorks show that there were 5 out of 9 successful nesting years prior to 1962. After waters were impounded north of the park in 1962, success dropped to 3 in 21 years (Hendrix, pers. comm.). It was found that nesting failed primarily because of desertion, which correlated with rising water levels, either a small water level rise

^{1/} Bass, O.L. Jr: and J.A. Kushlan. 1982: Status of the Osprey in Everglades National Park Rept M-679 National Park Service. Homestead, Florida.

early in the nesting season, or a large rise at the beginning of the rainy season. Since nesting by wood storks is initiated and sustained only through adequate food supplies, the key to nesting success lies in the production and timely availability of fish. It is hypothesized that, as water levels fall, fish emigrate ahead of progressively drying conditions. This eventually results in increased population densities and increased availability to wood storks. Hydrologic events that delay or temporarily reverse this trend have a potential adverse effect on wood stork nesting.

d. Alligators. A primary factor limiting alligator populations in South Florida is water management. The number of nests may be directly related to water levels occurring in spring, i.e. nesting effort is greatest in years of high water conditions. However, since nest heights are built in relation to water levels existing in the Spring, unusually high water levels resulting from water management practices during the incubation period will flood the nests and drown the eggs. In 1978, high spring releases resulted in a documented loss of 32% of the alligator eggs in Shark River Slough downstream of S-12 structures. This indicates the potentially severe impact of water management actions.

e. Periphyton. Periphyton is a collective name for a community of green and blue-green algae and diatoms complexed with calcium carbonate that is widely distributed within the freshwater marshes of the Park. Studies have indicated that total above-ground biomass of periphyton systems in the southern everglades may have substantially declined over the past decade. This is of concern because periphyton is an important base of the aquatic food web. Its biomass is about equal to the biomass that is available to higher trophic levels from all the vascular aquatic plants in the marshes. Also, as a result of its moisture-holding characteristics, it is known to provide a dry-season refuge for the eggs of one species of fish, and probably for other life stages of invertebrate species.

f. Exotic Plants. Several species of noxious exotic (non-native) woody plants have entered the Park as a result of reduced hydroperiod. Australian pine is invading the southern and southwest coastal areas of the Park, Brazilian pepper in the central Taylor Slough area, and Melaleuca in the western portions in and near the Big Cypress National Preserve. Once established, these species crowd out native plants and result in an altered and generally reduced quality habitat for wildlife.

8. Study Area. The focus of this investigation is water delivery to the Everglades National Park. However, due to the sensitive hydrologic interconnection of all components of the Everglades, a large area outside the Park's boundaries can impact the flows available to the Park. A major portion of the remaining undeveloped Everglades is within the C&SF Project in the WCA's. Portions of the C&SF Project, as well as management strategies for the project, will be considered in this study. The major components considered in the study area are shown on Plate 1. The areas are the Everglades National Park, East Everglades, and Water Conservation Area Nos. 3A and 3B.

a. Everglades National Park is comprised of approximately 1.4 million acres set aside to preserve the unique ecological features of the Everglades. It is a subtropical wetland environment supporting diverse biological communities consisting of more than 1,000 species of plants and animals. Over 14 threatened or endangered species reside in the Park.

ENP is almost exclusively a biological park. Although areas and programs are provided for the enjoyment and education of the public, it has also been the field laboratory for many scientists and students attempting to understand the delicate balance of nature represented by this system. The Park's unique ecosystems developed when water flowed naturally through the area in a broad, shallow, slow, sheetflow pattern. The flows varied seasonally with large parts of the Park being permanently or seasonally inundated. Historically, a majority of water entering the Park came through the Shark River Slough. Natural flows have been altered in timing, location, and volume as a result of development in South Florida. Flows are now regulated by components of the C&SF Project and the timing of flows does not match natural hydrologic/meteorologic events under all conditions. To the extent possible, a return to more historic, natural flows is needed to improve ecological conditions within the Park.

b. East Everglades: The East Everglades includes the Northeast Shark River Slough (NESRS) and a developed area along the slough's eastward boundary. NESRS is a physiographic area within the East Everglades which is primarily an open wetland environment. It is adjacent to the eastern boundary of ENP and serves as a buffer between the Park and the urbanizing portion of Dade County. It is essentially a wetland which is privately owned, resulting from past real estate sales practices in the State. Water within the area is the most important factor affecting its physical character. The area has been drier than it was in its undisturbed condition as a result of the C&SF Project but much of it still remains a wetland. Ninety-five percent of the area is undeveloped.

Agriculture and residential land uses are predominant in the developed portion of the East Everglades and are concentrated along the eastern edge. The residential character is rural, with single-family houses and mobile homes. Much of the area is flood prone under current conditions and could be expected to be inundated more frequently and for longer periods of time if flows through the slough are drastically increased to the Park. Recognizing the wetland nature of the area, zoning restrictions have been imposed by Dade County to restrict further residential development.

Agriculture is the major use of the developed area. It is concentrated in the southeast portion of Shark River Slough. Approximately 4,300 acres are currently in agricultural production with fruits and vegetables the primary crops. Westward expansion of the agricultural area is doubtful because of higher economic costs associated with flooding of the lower ground elevations which exist to the west.

c. Water Conservation Area (WCA) No. 3 is a water storage area of the C&SF Project located north of the Park and is composed of WCA Nos. 3A and 3B. It is the source of water deliveries to ENP. Consequently, the operation of WCA No. 3A is a critical factor in the Park's water deliveries. The area is essential to the C&SF Project serving its multiobjective functions and maintenance of a wetland environment for Everglades plant and wildlife species.

9. Background - Water deliveries to Everglades National Park. This section provides background information concerning development of the current deliveries to the Park, the temporal and spatial distribution, and resultant problems. Historically, water entering Everglades National Park came through Shark River Slough in the form of slow moving sheet flow. This flow, below Tamiami Trail (US 41), is shown on Plate 3. As south Florida was developed, many of the headwater areas were originally drained by private or State interests for agricultural development. The need to control flood waters in these areas and provide water supply for the agricultural areas, and the growing population of the southeast coast, was a primary reason for construction of the C&SF project. As part of the project, the historic sheet-flow pattern was changed. Subsequent drought conditions in the Park during the early 1960's gave rise to the legislation for the current water deliveries.

a. Public Law 91-282 (91st Congress, H.R. 15166, dated June 19, 1970). PL 91-282 states, "...delivery of water from the Central and Southern Florida Project to the Everglades National Park shall not be less than 315,000 acre-feet annually, prorated according to the monthly schedule set forth in the National Park Service letter of October 20, 1967, to the Office of the Chief of Engineers, or 16.5 per centum of total deliveries from the project for all purposes including the park, whichever is less." The 20 October 1967 letter cited in the law specifies that minimum annual deliveries of 260,000 acre-feet to Shark River Slough, 37,000 acre-feet to Taylor Slough, and 18,000 acre-feet to the Eastern Panhandle area be supplied when possible. A monthly distribution of the 315,000 acre-feet minimum annual delivery is also provided in the letter. The general distribution of these flows is shown on Plate 4.

The requirements of the law were developed in response to extreme drought conditions which existed throughout the project in the early 1960's. This extended drought coincided with completion of WCA No. 3A and the initial impoundment of water. Throughout most of 1963, 1964, and 1965, virtually no water deliveries to the Park were possible, resulting in severe environmental damage. Consequently, the emphasis at that time was on securing assurance of maximum possible water deliveries to ENP. In fact, the National Park Service, in its 20 October 1967 letter, supported the Department of Interior's comment on the C&SF Project contained in HD No. 643 which stated, "...the question is not one of too much water but a guarantee that there shall not be too little."

During this period, the State, also concerned with maintaining adequate water supply for other project users, was reluctant to sacrifice water for the Park. Congress acknowledged the State's responsibility in Senate Report

No. 91-395, which accompanied PL 91-282, by stating that the law, " ...properly takes into account the Federal contribution to the central and southern Florida project while respecting the State's authority to allocate water or assign priorities among other water users, and that it will serve the national interest in the preservation of the Everglades National Park without impairing the position of other present water users and prospective users."

b. C&SF Project Water Deliveries to ENP. Water deliveries to ENP are currently made in compliance with the letter and the spirit of PL 91-282. Until this year, water from the C&SF Project to the Park was delivered only to Shark River Slough through S-12. Early in 1983, with construction of S-331 and the Howard Drive Bridge over L-31(N), the final features of the ENP-South Dade County Conveyance System, were completed. Water deliveries to Taylor Slough and the Eastern Panhandle area were then initiated.

(1) Water Conservation Area (WCA) No. 3A Regulation. A regulation schedule is utilized in the operation of WCA No. 3A, which is designed to maximize water supply storage while maintaining adequate flood control capabilities. This is accomplished by conserving as much water as possible when water levels are below schedule and discharging maximum volumes when above schedule. The regulation schedule is also designed to allow the continued growth of emergent wetlands vegetation in WCA No. 3A. Because of high seepage rates, it has not been practical to regulate WCA No. 3B.

(2) Shark River Slough Water Deliveries. PL 91-282 prescribes a minimum annual water delivery of 260,000 acre-feet to Shark River Slough when possible. This delivery is provided directly into the Park through S-12 (S-12 is made up of four large spillway structures designated as S-12A, 12B, 12C, and 12D (see plate 1)). These four spillway structures are located just north of Tamiami Trail spaced over about a 10-mile distance. When water levels in WCA No. 3A are below the regulation schedule, discharges through S-12 are maintained very close to the prescribed minimum monthly requirements to Shark River Slough. When water levels exceed the regulation schedule in WCA No. 3A, S-12 discharges are increased up to maximum rates in order to maintain the authorized flood control capacity. This method of delivering water to the Park results in a relatively uniform annual distribution of water supplies until the WCA No. 3A regulation schedule is exceeded, at which time maximum flood control releases are required. Depending on the season of the year, maximum flood control releases from WCA No. 3A can result in adverse ecological effects in the Park.

(3) Taylor Slough Water Deliveries. PL 91-282 prescribes a minimum annual water delivery to Taylor Slough of 37,000 acre-feet. Pumping Station 332 (S-332) pumps these water deliveries directly into the park from the L-31(W) borrow canal, which is a component of the ENP-South Dade County Conveyance System. Water deliveries to Taylor Slough were initiated in 1983 when construction of the final features of the conveyance system was complete.

(4) Eastern Panhandle Water Deliveries. PL 91-282 prescribes a minimum annual water delivery to the Eastern Panhandle of 18,000 acre-feet. This is supplied by flow through gaps in the southern levee along C-111 between S-18C and S-197. The water is discharged into C-111 through S-18C and water levels are maintained sufficiently to provide the necessary overflow into the park. These deliveries were also initiated in 1983 upon completion of the final works of the ENP-South Dade County Conveyance System. Water deliveries to the Eastern Panhandle are unique, because they do not flow directly across the Park's boundaries.

(5) Temporary Operating Permit for Lake Okeechobee. In 1971, the USGS published a report entitled, "Appraisal of Chemical and Biological Conditions of Lake Okeechobee, Florida" which identified Lake Okeechobee as being eutrophic. This report prompted the State to sponsor the Special Project to Prevent Eutrophication of Lake Okeechobee in 1973. The special project resulted in recommendations, which were published in 1976, for actions in each of the lake's tributary basins for the primary purpose of reducing nitrogen and phosphorous inflows. The Temporary Operating Permit (TOP) is an outgrowth of the State's efforts to implement the recommendations of the Special Project. The Corps' Kissimmee River Study was also requested, in part, as a result of this Special Project's recommendations.

The Florida Department of Environmental Regulation requires the South Florida Water Management District (SFWMD) to file for the TOP for Lake Okeechobee. As a part of the TOP, the SFWMD developed and is now implementing the Interim Action Plan (IAP) which calls for the maximum volume of excess water from the Everglades Agricultural Area to be pumped into the WCA's before pumping into Lake Okeechobee can be implemented. The IAP was implemented early in 1983 and will be continued for 5 years. If, after 5 years, it is considered to be effective, it will become the long-term operational strategy. SFWMD estimates that implementation of IAP will result in an average of between 200,000 to 300,000 acre-feet of additional water entering WCA No. 3A. This exacerbates already existing problems in ENP of unseasonal dry season discharges by increasing the frequency of such discharges. It should be noted, however, that under preproject conditions, this water would have flowed through WCA No. 3A. Therefore, the IAP is not inconsistent with the general goal of restoring water flows into the Park which match what occurred under natural conditions. Additionally, the importance of Lake Okeechobee to the water resources of South Florida validates the goal of the IAP to protect the lakes' water quality.

c. The Seven-Point Plan. The Park's assessment of ecological conditions following the extremely wet period experienced during the 1982/83 dry season, as well as many previous years of dry season floods, combined with the SFWMD's continuation of the IAP, prompted a request for immediate implementation of seven protective actions. This request, which has been referred to as the Seven-Point Plan, was received by the Jacksonville District on 15 March 1983. Prior to receipt of the Seven-Point Plan, the Jacksonville District was already addressing the issues raised in the Seven-Point Plan in two Survey Investigations; the Shark River Slough Study and

the Central and Southern Florida Water Supply Study. The Seven-Point Plan and the status of the Jacksonville District's response to each point is provided in Appendix A. Deliberations in this report concern some of the items in the Seven-Point Plan.

d. Prior Studies, Reports, and Existing Water Projects.

(1) The Central and Southern Florida (C&SF) Project covers an area of about 16,000 square miles including all or part of 18 counties. It consists of 6 main components, the Kissimmee River Basin, Lake Okeechobee, the Water Conservation Areas (WCA's), the Everglades National Park (ENP) - South Dade County Conveyance System, the lower east coast canals and structures, and the Upper St. Johns River Basin. With the exception of the Upper St. Johns River Basin, all components of the project are hydrologically connected. The project is a complex water management system that serves the multiobjective functions of flood control; municipal, industrial, and agricultural water supply; prevention of salt water intrusion; water supply for ENP; and enhancement of fish and wildlife resource.

The area being addressed in this report (WCA Nos. 3A and 3B, ENP, and East Everglades) is at the southern extreme of the project. Consequently, the project works and operation have a very significant impact on the study area.

(2) Shark River Slough Survey Review was authorized in 1978. The purpose was to investigate the feasibility of structural modifications to provide a redistribution of surface water flow through the northeast Shark River Slough to ENP. The objectives included in the study are: to improve wildlife habitat in ENP and in NESRS on the eastern Park boundary; aquifer recharge and protection of water supply for the densely populated lower east coast of Florida; protection against coastal saltwater intrusion; improved water quality in Florida Bay; and protection of existing land use activities as necessitated by implementation of any study alternatives. The Shark River Slough investigation addresses essentially the same area and problem as the current study addressed in the General Plan. The major distinguishing feature is that PL 98-181 authorizes an experimental program for water delivery to ENP which will provide much better data on which to base a decision for future water deliveries to ENP. To allow for incorporation of these data, completion of the Shark River Slough Study has been delayed until response to PL 98-181 is completed.

(3) Southwest Dade County Project is an authorized flood protection plan for southwest Dade County. It is currently inactive. The project addresses essentially the same area as this study. The report presents a plan that would provide only dry season protection for agriculture in the area.

(4) C&SF Water Supply Study is an ongoing effort to analyze the water resources within the C&SF Project area (excluding the Upper St. Johns River Basin) to determine if existing water supplies can meet the future

needs of south Florida. The study will further address alternatives to meet any shortages that may be identified. A change in the deliveries of water to ENP will impact the C&SF water supply and will have to be taken into account.

(5) Biscayne Bay Management Program. This program is a cooperative effort between Dade County, State, Local, and Federal agencies (including the Corps of Engineers) to analyze problems and restore Biscayne Bay. This program could be affected should flood protection measures for the East Everglades area include routing storm water east through existing C&SF project works. Work elements of the Biscayne Bay Management Program include evaluation of freshwater inflows to Biscayne Bay as a result of C&SF Project operations.

ALTERNATIVE ACTIONS CONSIDERED

10. The No Action Alternative. A change in the water delivery system to ENP from the C&SF Project is essential for the welfare of the Park. Given that condition, and the language and intent of PL 98-181, the no action alternative is not feasible. However, for comparison purposes, the no action alternative and its impacts are described. The no action alternative would be the situation as it currently exists. Water deliveries to the Park would be made in accordance with existing criteria prescribed in PL 91-282. Some of the water may also be discharged through NESRS via S-333 under the Interim Operating Criteria. The risk from flooding due to local rainfall will be the same as currently exists. Given the hydrological condition experienced over the past 21 years, ecological conditions within ENP will continue to decline since the temporal and spatial distribution, as well as the volume, of water deliveries will remain essentially the same. Regulatory releases during the dry season will be required whenever WCA No. 3A exceeds its regulation schedule and therefore untimely and damaging flows into the Park will be experienced. Some of these releases may be even more severe as a result of the Interim Action Plan under which SFWMD is operating Lake Okeechobee. This alternative would also restrict further action on four items in the Seven-Point Plan. The specific items are:

a. Item 2 - Filling in L-67 Extension and removing its levee. Structure S-346 and S-347 are being installed to effectively plug the canal. However, the levee would remain, separating NESRS from the Park.

b. Item 3 - Restoration of WCA No. 3B to the Everglades System. Currently, S-151 discharges water from WCA No. 3A to 3B. The Park has requested additional capacity. This alternative would preclude additional outlet capacity.

c. Item 4 - Distribution of water supply along the full length of the Tamiami Canal from L-28 to L-30. The current interim operating criteria for S-333 is very conservative. Without further study, it is anticipated little water would be discharged to the Park through NESRS.

d. Item 7 - Field test a new delivery system. The no action alternative would preclude further testing beyond the limited work done to this point.

11. Changing the System. To improve water deliveries to ENP, the sequential actions discussed in the following paragraphs are necessary.

a. Conducting the Field Test. Public Law 98-181 authorizes a 2-year field test. A description of a limited test to be conducted without causing damage to residential and agricultural interests is presented later in this report. Further refinement of the scope and execution of the test will depend on future climactic conditions as well as institutional constraints.

b. Developing Options for Water Delivery. Several different options to modify the existing delivery system for water to Everglades National Park exist. Basically, they would fall into two categories; timing of the flows and location. These categories are not mutually exclusive and would have to account for quantity delivered as well. Some structural modifications to existing C&SF Project works should be anticipated.

c. Feasibility of Flood Protection. Analysis of several options to protect the residential and agricultural areas are explored. The engineering feasibility and cost to protect these areas under several options are discussed. The impact of NED criteria as prescribed by the Principles and Guidelines is addressed.

PLAN FORMULATION

12. Study Objectives. Objectives of this study were derived to be responsive to the requirements of PL 98-181 and conform to current planning regulations, directives, and procedures. More specifically, the objectives of this study are:

a. To define the water resource problem in relation to Everglades National Park to include determination whether a change in the current water delivery will mitigate the problem.

b. Identify alternative structural modifications to project works to optimize water deliveries to ENP.

c. Conduct an experimental program of new alternative water-delivery plans.

d. Identify potential effects of providing water deliveries to ENP through Northeast Shark River Slough.

e. Develop preliminary plans to protect or compensate private property owners for potential impacts of altered water delivery plans.

f. Define GDM studies necessary to provide sufficient design, cost, and benefit data for decision-making concerning a new water-delivery schedule.

13. National Objectives. The Principles and Guidelines require selection of the plan with the greatest net economic benefit consistent with protecting the Nation's environment. In this particular case, the main objective is to improve the ecological condition of Everglades National Park without inflicting damages to private landowners. Thus, many of the benefits of resultant action which may be proposed by the study are environmental, while the costs can be expressed in monetary units. At this time, there is no accepted methodology to convert environmental gains and losses, even when applied to a national treasure such as ENP, into monetary terms. Consequently, an exception to the NED criteria will be required.

14. Exception to NED Criteria. The Everglades National Park has been designated ecologically unique and worth preserving as stated in legislation establishing and authorizing the Park. This legislation infers that, not only preservation, but active intervention to restore and preserve the Park from actions outside its boundaries and adversely affecting it can be considered as being taken in the National interest. Further, international recognition of the qualities of the Park should be considered (see paragraph 17). Most recently, the passage of Public Law 98-181 provided further commitment that preservation of ENP is in the National interest. Language contained in the Senate report (No. 98-275) and conference report (No. 98-551) preceding enactment of PL 98-181 indicates Congressional concern for preserving the ecological integrity of the Park and recognizes the need for action to restore and preserve it. This concern was manifest in the authorizations provided in the Act to change water-delivery schedules and to protect private landowners from adverse results of those actions. The Principles and Guidelines provide that the Secretary of a department can select a plan other than the NED alternative when there is some overriding reason based on other Federal, State, local and/or international concerns. This exception is necessary if the corrective actions are to be taken to protect and restore the Everglades National Park.

15. Everglades National Park: A Significant National Resource. Everglades National Park is the largest remaining subtropical wilderness in the coterminous United States. This region has been classified as the only example of its type found in the United States based on climate, geology, soils, and vegetation. It is approximately 1,400,000 acres, roughly the size of the State of Delaware. Everglades National Park was initially authorized by Congress in 1934 due to the efforts of a prominent group of south Florida citizens. On December 6, 1947, President Truman, at Everglades City, dedicated the Park to the use of the people of the United States. The purpose of the Park was clearly articulated in the legislation establishing the Park, which stated, "The said area... shall be permanently reserved as a wilderness and no development of the project or plan for the entertainment of visitors shall be undertaken which will interfere with the preservation

intact of the unique flora and fauna and essential primitive natural conditions now prevailing in the area." This is the same premise on which the National Park Service was established in 1916; "... purpose to conserve the scenery and the natural and historic objects and the wildlife therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations..."

The unique ecological significance of Everglades National Park has received national and international recognition. In 1976, Everglades National Park was designated as a Biosphere Reserve of United Nations Educational Scientific and Cultural Organization's (UNESCO) Man and Biosphere Program; in 1978, 2,030 square miles of the Park (92.9 percent) was placed in the National Wilderness Preservation System; and in 1979, the Park was designated by UNESCO as a World Heritage Site for outstanding universal value to mankind. The diverse ecosystems form a combination found only in Everglades National Park and include: sawgrass prairies, cypress forests, pine uplands, subtropical hardwood (such as mahogany) hammocks, marl and limestone flatlands, freshwater streams and sloughs, spring-fed lakes, mangrove estuaries, and marine bays. These ecosystems provide habitat for rare or endangered species of plants and animals found only in south Florida, such as: Everglade kite, Everglades mink, Florida panther, Cape Sable seaside sparrow, American crocodile, and a number of orchids and bromeliads. In general, there are 25 native mammals, over 300 species of birds, 60 known species of reptiles, and at least 45 species of plants endemic to the Park. Of these, there are 14 known federally-listed endangered or threatened species which may be found in Everglades National Park. Such species as the Cape Sable seaside sparrow, Florida panther, and the American crocodile have substantial portions of their remaining breeding populations within Park boundaries.

Although the Park was initially established for biological reasons, it has become a popular tourist attraction, not only for Floridians, but for visitors from all over the United States and foreign countries. The recent average attendance is approximately 600,000 visitors per year and had been as high as 1.2 million per year in the late 1970's. This would represent a recreation value of about \$15 million to \$30 million.

Because of the unique ecosystems found in the Park, the largest field research center in the National Park Service is located at Everglades National Park, the South Florida Research Center.

The State of Florida is also extremely concerned about the future of Everglades National Park. The Governor has initiated a Save-Our-Everglades program with a goal of returning the Everglades to the ecological conditions of the early 1900's by the year 2000.

16. Planning Constraints. A number of possible constraints must be considered:

a. Competing uses for the water resources in south Florida may provide the largest challenge. Flood control, water supply (municipal and industrial as well as agricultural), water supply for ENP, prevention of salt water intrusion, fish and wildlife, recreation, and navigation all compete for available water.

b. Interaction of proposals from this study on other projects and programs, both physical and institutional.

c. The requirement to limit the water delivery field test to non-damaging levels and resulting necessity to project conditions for an ultimate future delivery plan.

d. Time constraints contained in PL 98-181.

17. Water Delivery Alternatives for Everglades National Park.

a. Objectives of a Water-Delivery Plan. Generally, the goal of the water-delivery plan is to establish conditions in the Park which match, as closely as possible, those existing prior to construction of canals, levees, and structures in the area. This general goal can be accomplished by satisfying the following specific objectives.

(1) Timing. Two approaches to defining the timing of water deliveries appear to have merit. One approach would call for the rate of water deliveries to vary in response to changes in hydrologic/meteorologic conditions upstream of the Park. A second approach would call for the rate of water deliveries to be manipulated in an attempt to maintain ecologically desirable water level fluctuations within the Park. It should be noted that these approaches may not be mutually exclusive.

(2) Transitions. Transitions between wet and dry conditions should approximate what occurred under preproject conditions. Abrupt changes caused by water management actions should be avoided.

(3) Spatial Distribution. Areal extent and location of water deliveries should closely match preproject flow regimes. The hydrologic conditions in the Northeast Shark River Slough should be in balance with hydrologic conditions within the Park.

(4) Volumes. The volumes of water deliveries should be conducive to desirable ecological conditions in the Park with respect to area and depth of inundation. They should be responsive to existing meteorologic events with delivery matching preproject conditions as far as possible.

(5) Justification. Any modifications to implement a new water delivery plan should be justified on the basis that the expected beneficial environmental and economic impacts exceed the direct and indirect economic costs. Furthermore, incremental levels and locations of flow modification must be justified by the incremental benefits they produce.

b. Management Alternatives. As described above, the objectives of a water delivery plan for ENP are relatively straight forward and are generally agreed upon. However, the development of a water delivery plan which will satisfy these objectives, without impacting the ability of the C&SF Project to perform its multiobjective functions, has not been accomplished to date. A lack of preproject data makes it extremely difficult to define the natural hydrologic conditions within ENP with an adequate degree of specificity. Additionally, the construction of an extensive and complex water management system that controls overland flows into the Park, makes it necessary that a water delivery plan include a strategy which accounts for the needs of all users while defining the hydrologic requirements of ENP in specific terms. Several alternative water delivery plans have been proposed for consideration in conceptual form only. A clearly favored alternative has not surfaced. Therefore, additional studies are being conducted to develop the alternatives in more detail and to predict the resulting potential impacts. To support the management alternatives presented below, certain structural modifications will be required.

(1) WCA No. 3 - Flow-through System. This alternative water-delivery plan would call for all gates at S-12A, 12B, 12C, 12D, and S-333 to be fully opened at all times. WCA No's. 1 and 2 would continue to be operated according to regulation schedules. This would provide water deliveries that would fluctuate in response to changing hydrologic/meteorologic conditions. Transitions between wet and dry conditions would not be directly influenced by water-management operations. Northeast Shark River Slough would be hydrologically balanced with ENP. A number of structural modifications to WCA No.'s 3A and 3B would be required to ensure that water flows would not be detrimentally impacted by project works. These structural modifications are discussed later in this report. A major concern with this alternative is that the volume of water discharged to the Park might be detrimental to the Park and to the ability of WCA No. 3A to satisfy its functions. A variation of this alternative might be to maintain the structures fully open during the wet season and then to control water deliveries during the dry season, possibly based on optimal water recession rates within ENP.

(2) Water Deliveries Based Upon Conditions Within ENP. Attempts would be made to deliver water to ENP at rates that would maintain water levels within acceptable ranges based upon optimal ecological needs at indicator gages inside the Park. Indicator gages would be selected to provide reasonably representative descriptions of conditions in key habitat areas. In this manner, acceptable conditions could be maintained most of the time. However, if water levels in WCA No. 3 become unacceptably high, regulatory releases would be required regardless of conditions within the Park. This factor would have to be accounted for in some way as a part of a water delivery schedule. Possibly, this water delivery plan could be combined with a strategy that would call for water deliveries to vary based on conditions in WCA No. 3 under extreme conditions,

(3) Bridge 105 Water-Delivery Plan. Water deliveries to ENP would be based on concurrent conditions within Big Cypress National Preserve as

measured at Tamiami Trail Bridge 105. This alternative is based on the premise that the Big Cypress basin is relatively undisturbed and it responds to rainfall in a manner similar to the Everglades under preproject conditions. The rate of water deliveries to ENP would be based on a relationship between the stage at Bridge 105 and discharge at S-12 and S-333. This would provide water deliveries to ENP that would fluctuate in response to hydrologic/meteorologic conditions. However, under some conditions, large discharges into the Park could be prescribed by the Bridge 105 stage at a time when water levels within the Park are already too high. This alternative might be modified to include consideration of conditions within ENP. For example, Bridge 105 stages could be utilized to prescribe water deliveries until water levels at key indicator gages in the Park are outside an ecologically desirable range. At that time, a multiplier could be applied to the Bridge 105 deliveries to reduce or increase discharges until conditions in the Park are acceptable.

c. Field Test of New Water Delivery Plan for ENP. As previously stated, authority has been provided to conduct a field test of a new water delivery plan for ENP. The field test will be designed so that residential and agricultural interests in the East Everglades are not significantly impacted. The purpose of the field test is to enable the collection of hydrologic data during a period of modified water deliveries. These data would assist in the development of an optimum water delivery plan for the Park. Based on information obtained during the field test, better estimates of relationships between surface and groundwater in Shark River Slough, direct rainfall, and water levels in adjacent canals will be possible. Additionally, the information will enable better prediction of the impacts of specific hydrologic variables throughout the study area. A computer model developed by SFWMD under contract to the Corps, the South Florida Water Management Model (SFWMM), can be verified under a modified condition and can then be used to predict the impacts of additional modifications with greater confidence.

(1) Current Operational Strategy. Since 9 June 1983, all gates at S-12A, 12B, and 12C have remained fully open. S-12D has been closed during this period. Water deliveries to the Park have been well above the minimum required by PL 91-282 during this period, as shown in Table 1.

This operation was agreed to by the Corps, ENP, and SFWMD. As indicated above, monthly volumes of water delivered to the Park have been well above the minimums required by PL 91-282 and, furthermore, deliveries during this dry season have remained abnormally high. However, several objectives have been accomplished. Excess releases from WCA No. 3A have reduced water levels in the area, thereby reducing the probability of sharp variations in releases being necessary during this dry season. Although the rate of water deliveries has been very high, to date, the rate of water-level recession in the Park has been smooth and uninterrupted through the dry season. By keeping S-12D closed, the volume of water entering the Park down the L-67 Ext. borrow canal has been reduced. More water has entered the Park through overland flow across the marsh. Some observable benefits that might be

attributable, in part, to this operation have already been realized. For example, this is the first time in 10 to 15 years that large numbers of small snook have been observed in the estuary of Florida Bay. The large volumes of fresh water flowing into the Bay since about June 1982, including the current high flows, are believed by fisheries biologists to have produced improved conditions for snook propagation.

TABLE 1
Water Deliveries to ENP via S-12

(Volumes in Acre-Feet)

	<u>Min. Deliveries required by PL 91-282</u>	<u>Actual Deliveries</u>	<u>Excess of Actual over Min. Req'd.</u>	<u>% of Minimum Actually Delivered</u>
June 1983	5,000	31,008	26,008	620
July	7,400	37,266	29,866	504
Aug	12,200	42,302	30,102	347
Sept	39,000	62,282	23,282	160
Oct	67,000	90,190	23,190	135
Nov	59,000	85,092	26,092	144
Dec	32,000	86,639	54,639	271
Jan 1984	22,000	86,877	64,877	395
Feb	9,000	51,670	42,670	574
Mar	4,000	40,440	36,440	1,011
April	<u>1,700</u>	<u>34,785</u>	<u>33,085</u>	2,046
Total	258,300	648,551	390,251	251

*The volume of water released from WCA No. 3A in excess of the minimum required by PL 91-282 between June 1983 and January 1984 (390,251 acre-feet) accounts for a total of about a 0.8-foot reduction in water level in WCA No. 3A.

Because of the availability of water throughout the C&SF Project, it was possible to continue this operation through the dry season. However, water levels in WCA No. 3A have been steadily receding and are now well below regulation schedule. An operational strategy for this wet season is in the process of being coordinated.

On 10 January 1984, the Jacksonville District provided authority to SFWMD for the operation of S-333 according to revised operating criteria. This operating criteria allows S-333 to be utilized to discharge water to ENP through Northeast Shark River Slough if two conditions are satisfied. These conditions are that the S-333 tailwater stage must be below 7.5 feet NGVD;

and the water level in the developed portion of the East Everglades, as recorded at gage G596, must be below a seasonally varying operation schedule. The S-333 Interim Operation Schedule is very conservative.

Gage G596 was incorporated into the operating criteria because it is the only gage in the area with an adequate period of record. It is recognized that gage G596 is greatly influenced by stages in the nearby L-31N borrow canal. As stated in the Environmental Assessment for "Utilization of S-333 to Redistribute Water Releases to ENP through Northeast Shark River Slough," operation of the structure would be closely monitored to determine if another gage could be utilized which would reflect the impacts of S-333 discharges. Use of another gage might allow greater flexibility in the S-333 operation without impacting developed areas. Efforts will continue toward this goal. The above EA provides a basis for issuing a Finding of No Significant Impact (FONSI) for this action.

(2) Future Field Test. When conditions in WCA No. 3A become such that water supply is critical and S-12 discharges must be altered, a new water-delivery method will be required. This water delivery method has not been formulated. The strategy for development of the water-delivery plan is to identify the one or two current best estimates of what the water delivery plan should ultimately be and, then to design a field test to match these delivery plans as closely as possible within the current constraints. Coordination has been initiated and hydrologic modeling is being conducted toward the goal of identifying potential optimum water delivery plan(s). A new EA may be required for the future field test if its scope exceeds that discussed in the previous EA for operation of S-333.

(3) Hydrologic Monitoring. Development of an optimum plan to include NESRS in the conveyance of water from WCA No. 3 would benefit from a trial period to assess effects of changes in the area's hydrology. An extensive network of gages in the East Everglades and the adjacent areas will be utilized to evaluate hydrologic impacts of the field test in specific areas. In some areas, new gages have been recently installed to ensure the capability to fully evaluate the hydrologic effects of operating S-333 according to the proposed criteria. Areas to be monitored would be ENP west of and adjacent to the East Everglades, Northeast Shark River Slough, the developed portion of the East Everglades, the adjacent area east of L-31N, WCA No. 3A, and WCA No. 3B. Specific gages would generally be utilized to evaluate effects in each of these areas. The location of some gages would enable them to be used in evaluating more than one area. Data from individual gages are available from a variety of sources and in a variety of forms. Therefore, an annual report would be prepared and published which will present a compilation of all pertinent gage data and provide analyses of impacts produced by the operation of S-333. The data could be utilized in the South Florida Water Management Model to further calibrate the model's results and then to identify specific effects produced by the operation of S-333 versus the numerous other variables which affect the area's hydrology.

d. Structural Modifications for Improved Water Deliveries to ENP.
Several structural modifications would be required to implement or optimize the management options discussed above. Although other alternatives may be evaluated, modifications addressed in this preliminary analysis include:

1. S-345 and C-310. A culvert structure, S-345, would be located in L-67A to pass water from WCA No. 3A into WCA No. 3B via a discharge canal, C-310. This would provide a means of diverting additional water into WCA No. 3B. This is proposed to respond to item number 3 of ENP's Seven-Point Plan (Appendix A), which calls for discharging as much flood water into WCA No. 3B as is environmentally acceptable. This would reduce the need for large, untimely flood releases to the Park. Structure S-345 would be a four-barrel, 96-inch corrugated metal pipe culvert with four manually operated, standard slide gates. Canal 310 would have a 30-foot bottom width and extend about 7,200 feet southwest from S-345. The canal was designed to develop a water surface profile which would insure uniform overbank dispersion of flows over the southerly 1,000 feet. This was considered to be more environmentally desirable than a point discharge into WCA No. 3B. The structure and canal could pass 1,000 cfs. First cost of this option would be about \$1,089,000.

(2) S-349 and Tieback Levee. This option consists of a gated spillway structure located in the L-67A borrow canal between S-151 and S-333. A tieback levee would extend roughly northward from S-349 for about 2,000 feet. The purpose of this option is to reduce the conveyance of water down the L-67A borrow canal except when water supply deliveries are required. This canal currently passes water to the south end of WCA No. 3A very efficiently relative to marsh conveyance resulting in overdrainage of the area to the north and pooling of water in the south end above S-12. By plugging L-67A borrow canal, a sloping pool would be created with higher water levels in the north and lower levels in the south. When WCA No. 3A is above schedule and all S-12 gates are fully open, this will allow S-12 discharges into ENP to fluctuate with variations in marsh flow through the area rather than with the more rapid variations in conveyance down the L-67A borrow canal. Structure 349 would include four 10-foot-high by 12-foot-wide gates and steel-sheet-pile tieback walls. The structure would pass 1,250 cfs. Cost of the structure and tieback levee would be about \$909,000.

(3) WCA No. 3B Seepage Levee. A small seepage levee would be constructed across the southeastern corner of WCA No. 3B from S-334 to S-335. Other structural modifications being considered to improve water deliveries to ENP include alternatives to divert more water into WCA No. 3B. The resulting higher water levels will produce greater seepage out of the area both to the south through L-29 and to the east through L-30. The southward seepage will supplement water deliveries to ENP through NESRS. Eastward seepage, however, will enter the L-30 borrow canal. Above S-335, the increase in seepage rates will be minor because the head across L-30 is relatively small. Below S-335, the optimum water level in the L-30 borrow canal is 1.5 feet lower. Seepage rates through the roughly 1.5-mile section of L-30 borrow canal between S-335 and Tamiami Trail can aggravate problems

during wet conditons. The purpose is to reduce seepage out of WCA No. 3B. The levee would have a 10-foot crown width at elevation 12.0 and a base width of at least 30 feet. The cost of the levee would be about \$194,000. An outlet structure may be necessary to maintain the ecological viability of WCA No. 3B and/or to supplement input to the ENP-South Dade County Conveyance System.

(4) Other Modifications. After more detailed investigation, other modifications may prove to be more effective and/or economical. These might include a series of small structures in L-67A or partial filling of L-67A borrow canal in lieu of S-349.

e. An Example Water Management System. One combination of a water management option and structural modification would be the WCA No. 3-Flow through system with construction of S-349. This system would provide water deliveries that fluctuate in response to changing hydrologic/meteorologic conditions. This would go far in providing the Park a water supply that is tied to natural conditions more than the current regulation schedule. The provision of S-349 would negate the current effect of L-67A borrow canal on water delivery to the Park. The slower flow of water through WCA No. 3A would tend to approach the historic natural condition. Also, S-349 would allow use of L-67A borrow canal for one of its intended purposes, as a part of the South Dade County Conveyance System, during low flow times. The most significant cost of this plan would be construction of S-349 and its associated tieback levee. Initial cost would be about \$909,000. The cost to distribute the water south of Taimiami Trail would not be significant, i.e., the cost difference between routing water through S-12 versus S-333 is negligible. Annual added cost to operate and maintain the new structures and operating plan would be about \$86,000.

18. Flood Protection Measures - Alternative Plans. PL 98-181 states that the Secretary of the Army is authorized to construct necessary flood-protection measures for homes in the area affected by any modification of the water-delivery schedule to ENP. The intent of this section is to provide a reasonable estimate of the magnitude of various alternative flood-protection measures which cover varying areas.

a. Degree of Flood Protection. There is no indication that project failure in the East Everglades would constitute a risk to many lives. The developed portion of the East Everglades is sparsely populated and is predominantly agricultural rather than urban. Consequently, SPF protection would not be warranted. The least costly option for flood-protection measures would be to provide protection against the increment of increased flooding or risk of flooding produced by a modified water-delivery plan for ENP. However, this may provide a false sense of security to residential and agricultural interests who, without improved conditions, would still be subject to periodic flooding. Existing development in the area was possible, in part, as a result of a false sense of security caused by dry conditions through most of the 1970's.

The area adjacent to the East Everglades, east of L-31N, is provided protection from a storm roughly equivalent to a 1 in 10-year event. This has been a standard degree of protection for agricultural areas throughout development of the C&SF Project. For the purposes of this report only, this level of protection was assumed for the preliminary flood-protection alternatives discussed below. Further analysis would include a range of water delivery scenarios (including differing distributions and quantities of water), several flood events, other flood protection measures that may be developed, and an incremental analysis that would provide for the best trade-off between environmental enhancement, flood protection, and cost.

b. Hydrology.

(1) Biscayne Aquifer. The Biscayne Aquifer is a highly permeable wedge-shaped formation that is more than 200 feet thick in coastal Broward County and thins to a feather edge 35 to 40 miles inland. The aquifer provides water for all municipal water-supply systems from Palm Beach southward, and for agricultural irrigation in Dade and Broward counties. Over much of its extent, the limestone of the aquifer is covered by only a few inches of soil. In the project area, the rock which emerges at the land surface is the upper surface of the aquifer. Because there are no natural impermeable formations between the aquifer and the surface, surface water infiltrates directly into the groundwater system. This relatively rapid infiltration allows the groundwater supply to be replenished quickly by precipitation and allows the groundwater level to rise freely. In times of heavy rainfall, the aquifer simply fills up and the water table rises above the land surface. This phenomenon contributes to the seasonal inundation patterns throughout the region.

In addition to being one of the most porous aquifers in the world, the Biscayne is also one of the most productive. High yields are obtained from wells penetrating solution-riddled sections of the aquifer. The direct connection between the ground and surface-water systems does make the aquifer susceptible to pollution and disruption from activities at the land surface. Many contaminants are rapidly diluted in the large volumes of water contained in the aquifer, and the porous limestone acts as a filter. However, high concentrations of pollutants can overload and incapacitate the natural cleansing action. Because of its importance to the urban and agricultural ecosystems of south Florida, as well as its sensitivity to the activities of these systems, the Biscayne Aquifer has recently been designated a "sole source" aquifer by the U.S. Environmental Protection Agency.

The project area lies within a physiographic province identified as the Rocky Glades. This is a poorly defined drainage area between Northeast Shark River Slough and Taylor Slough. Surficial-flow patterns are indeterminate due to relatively high variability in topography. The soil is marl and peat with extensive outcrops of limestone.

(2) Seepage from Northeast Shark River Slough. Alternative flood-protection measures described herein were designed to protect from seepage into the area from Northeast Shark River Slough under conditions that would

be expected about once in 10 years, concurrent with local runoff from a 1-in-10 year rainfall event. The South Florida Water Management Model (SFWMM) was utilized to estimate the stage frequency relationship at gage G1502, located at Chekika State Park, under existing conditions. The incremental increase in 10-year water levels produced by diversion of 50 percent of ENP's water deliveries into the East Everglades was estimated to be about 0.2 feet adjacent to the developed area. Additional studies will be necessary to verify this assumption. The 10-year peak stages in the slough varied from a high of 8.0 feet, NGVD at the northern edge of the developed area to about 7.5 feet, NGVD at the west edge of the agricultural area to the south. The specific flood stages along the perimeter of the developed area were estimated from correlation curves developed from the SFWMM output at 2-mile intervals over a grid network which includes the East Everglades. Flood protection works for the developed areas were designed to maintain peak flood levels at, or below, ground levels. However, in small areas adjacent to the westerly perimeter levees, peak water levels might rise about 0.2 feet above natural ground because of westerly-sloping ground elevations.

The methods utilized to estimate seepage rates into the protected area are described in Appendix B. Seepage rates are an extremely important factor in designing an adequate flood-protection system. The lack of pumping tests within the project and the relatively high degree of variability indicated by existing information, require that pumping tests be performed prior to development of detailed designs.

(3) Runoff. Alternative flood-protection measures were designed to protect from a 1-in-10 year rain event concurrent with seepage into the area expected with 1-in-10 year stages in Northeast Shark River Slough. A rate of runoff of 46.4 cfs/square mile, or 1.75 in/day, was utilized for the project area.

(4) Other Factors. ENP-South Dade County Conveyance System, the Interim Action Plan, and other modifications and/or operational changes made to the C&SF project since its initial construction are part of the overall synergistic effects of the project on this area. These effects will be included in the flood protection analysis.

c. Plan A - Residential Area with Detention Area. This alternative would provide for a double levee around the 8.5-square-mile residential area. The actual area encompassed by the levee would be about 10.3 square miles due to levee location (See Plate 5). The levee would tie into L-31N. The double levee would reduce seepage inflow. The elevation of the external levee would be to 11 feet, NGVD and the elevation of the internal levee would be at 9 feet, NGVD. Approximately 14.4 miles of canals would be constructed within the protected area to convey groundwater seepage and storm runoff out of the area. Excess water from the protected area would be pumped into a 1.7-square-mile detention area with perimeter levees constructed to elevation 15. Excess water will be temporarily stored in the detention area for the purpose of removing nutrients and other contaminants

before it enters ENP. Water will evaporate or seep out of the detention area. Culverts will be provided for emergency discharges if the design capacity of the area is exceeded. A pump station will be provided to move the water to the detention area. It will have a total capacity of 1,580 cfs. Of the pump capacity total, 480 cfs would be to remove runoff and 1,100 cfs of seepage. Preliminary estimate of first cost for construction of this alternative is \$16.4 million with about \$10 million additional required for land acquisition and easements. This estimate includes about \$2 million for flowage easements on affected croplands.

d. Plan B - Residential and Agricultural Area with Retention Area.

This plan incorporates all of the features of Plan A for the residential area and adds protection for the agricultural area immediately south (See Plate 6). It protects about 6.4 square miles. The plan has an additional 7.2 miles of double levee from the residential area (in Plan A) that ties into L-31N further south. The plan would also call for an additional detention area that would be about 1 square mile in size. About 9 miles of canals would be constructed in the protected agricultural area. An additional pump station will be located in the agricultural area. It will be designed to remove 300 cfs of runoff and 850 cfs of seepage for a total capacity of 1,150 cfs. Preliminary estimate of first cost to construct this option is about \$31.2 million plus \$11 million required for land acquisition and easements.

e. Plan C - Residential Area - Eastward Pumping. This option is similar to Plan A except that the water is pumped into L-31N borrow canal for conveyance eastward to the ocean (See Plate 7). To accommodate the additional storm waters, 3.6 miles of new canal would be constructed from L-31N borrow canal to C-103N. All of C-103N would be enlarged and that portion of C-103 from S-179 to the ocean would also be enlarged. Approximately 13.7 miles of interior canals would be constructed to convey excess water to L-31N borrow canal. The pump for this plan would remove 480 cfs of runoff and 290 cfs of seepage for a total capacity of 770 cfs. This plan would cost about \$27.6 million to construct with an additional \$10 million required for real estate acquisition.

f. Plan D - Residential and Agricultural Areas - Eastward Pumping.

This option is similar to Plan B, in that the same areas are protected (See Plate 8). Storm water is pumped eastward via L-31N borrow canal and C-103 as in Plan C with similar type of modifications to C&SF structures. Pumping capacity for this plan would be designed to remove 780 cfs of runoff and 710 cfs of seepage for a total capacity of 1,490 cfs. Construction of this plan would cost about \$54 million plus \$11 million for lands and easements.

g. Flood Proofing. This alternative would consist of construction of the necessary works to avoid damages in the residential area. Agricultural development could not be protected in this manner. Flood proofing measures might include raising houses, improving septic tanks, and raising access roads. However, Dade County's zoning restrictions have required all houses and septic tanks constructed in the East Everglades to be built at elevations which would only be flooded during extremely rare events. Only those

structures constructed without the necessary permits or any structures which might have been constructed prior to implementation of stringent zoning requirements would require flood proofing. It would be anticipated that owners of unpermitted structures would have to bear all costs for flood proofing of such structures, assuming further action by Dade County is not taken against them. Roads in the area are generally built on grade and are overtopped rather frequently. Therefore, improvement of the access roads would be necessary. Even with all flood proofing measures in place, however, homes in the area would frequently be literally surrounded by water for long periods of time. Many of the residents who already are adequately flood proofed, have expressed dissatisfaction with this situation. Additionally, local agencies (i.e., Dade County and SFWMD) have been actively attempting to curb increases in development in the East Everglades. Improvement of access roads in the area and other flood proofing measures would serve to encourage additional development and increase the associated problems such as water quality degradation and potential flood damages. Consequently, this alternative has not been pursued in detail in this report. Subsequent studies, if approved, will address the feasibility of flood proofing measures in more detail.

h. Miccosukee Indians - Flood Proofing. Several members of the Miccosukee Tribe of Indians live in a relatively low area immediately north of Tamiami Trail between L-67 and L-30. Water levels in the L-29 borrow canal can be raised as high as 7.5 feet, NGVD without damaging these residences. However, depending on how high water levels must be raised to provide ENP with optimum water deliveries through NESRS, it may be necessary to flood proof 7 to 10 chickees (thatched-roofed raised pole structures used as residences and work areas). This could be accomplished by filling an area of about 0.6 acres where the structures are located. The approximate cost is \$65,000.

i. Acquisition/Relocation. This alternative would provide for acquisition of lands in East Shark River Slough in lieu of construction of flood protection measures. There are several institutional issues involved with this option. Public Law 98-181 specifically addresses acquisition of interest in agricultural land. It also addresses flood protection measures for the residential area which could include acquisition and relocation. However, the Act is silent with respect to the undeveloped land further west in the Slough which is held in private ownership. This undeveloped area covers about 80,000 acres held in approximately 7,000 ownerships and represents about 90 percent of the study area. Both the Senate Report No. 98-275 and Conference Report No. 98-551 (which preceded enactment of PL 98-181) express the need to treat fairly private landowners whose properties may be adversely affected as a result of water delivery modifications necessary to protect the Federal park. However, although more general in language than PL 98-181, they both focus on the agricultural and residential areas. One could assume the intent was to consider all private landowners in Shark River Slough in the same way as the agricultural and residential areas. However, this real estate matter needs clarification.

To provide a comparison of alternative ways to deal with the added flooding, preliminary costs to acquire interest in the lands in Northeast Shark River Slough were developed. The preliminary cost to acquire sufficient interest to ameliorate the potential damages due to increased flows through the NESRS area would be about \$111 million. This preliminary value is based on purchase and relocation of the residential area and a flowage easement in the agricultural and undeveloped areas. Acquisition of only the undeveloped area would cost about \$50 million.

j. General Environmental Impacts of Flood Protection Plans. Construction of a flood-protection system of levees, canals, and detention basins would result in the following impacts. Within the considered protective levee, a residential build-out to a density of at least one house per 5 acres is expected, based on current zoning. Agriculture would also build out to the confines of the levee. This would result in an, as yet, undefined loss of existing marsh habitat. A portion of the impact area lies within the designated Critical Habitat for the Cape Sable seaside sparrow - a species listed as endangered under the Endangered Species Act. A conflict with the Act would be avoided by conducting a redesignation survey of Critical Habitat or seeking an exemption. If excess water is pumped eastward and eventually enters Biscayne Bay, water quality problems resulting from the current fresh water inflows from the C&SF Project might be made worse. The severity of the existing problem, if one exists, and potential future impacts of additional fresh water inflows will require additional investigations. Eastward pumping flood protection plans have the potential for overdraining the Northeast Shark River Slough which is in conflict with the general intent of spreading the park's water deliveries over a wider area.

k. Economic Considerations.

(1) Real Estate Values. The real-estate values used in this report are based on information and data collected for a report covering the study area dated May 1983. A real estate issue requiring further consideration is based on the fact that the Act was quite specific addressing acquisition of agricultural lands and construction of flood protection measures for the residential area. However, the Act was silent as to intent with respect to the remainder of the East Everglades. More than 90 percent of the affected area is undeveloped land held in private ownership. This land is essentially wetland in nature and covers about 80,000 acres. This land is largely undevelopable under the current hydrologic regime. Environmental regulations further restrict the ability of owners to develop most of the area. Although the area is essentially wetlands, the Act's requirements to consider protection and/or acquisition of some of the affected area seem to dictate recognition of any damages which may occur and constitute a taking. Any further congressional consideration should address this issue.

Based on the information available, the value of land and improvements protected by flood-control Plans A and C is \$47.6 million. The costs to acquire lands for construction of flood-control works and flowage easements

for agricultural lands would be \$10 million. The value of lands protected by plans B and D would be \$74.4 million. Costs to acquire lands for construction of flood-control works and flowage easements for agricultural lands would be \$11 million.

In considering potential damages in the residential areas, the duration of flooding, as well as depth, is important. The assumed duration of 2 months essentially renders the area unsuitable for residential purposes. Although the floor elevations of many of the structures in the flooded area exceed the flood level, roads are well below this level and become impassable. Few people can be expected to tolerate such a long period of nonuse of their residence under these circumstances.

(2) East Everglades Crops. There are approximately 6,000 acres of agricultural land in the East Everglades study area, of which an estimated 4,300 acres are under cultivation. Virtually all cultivated acreage exists along a 2-mile-wide stretch of land along the west side of L-31N. Primary crops are winter and tropical vegetables, tropical fruits, citrus and ornamental plants. The cropland consists generally of small plots of row crops and groves. About 200 acres of noncultivated land is utilized for raising horses, cows, chickens, and other animals on a small scale.

The damages considered in this paragraph assume a modification to the current water delivery schedule to ENP, specifically routing more water through NESRS. The current schedule, to include releases through S-333 under the Interim Operating Criteria, are not the source of these damages. They would occur only if a change, as anticipated as a result of full implementation of PL 98-181, was instituted. A 10-year flood event raising water levels to 8 feet, NGVD with a 2-month duration would cause flooding over approximately 1,960 acres of agricultural land. A flood event of this magnitude is estimated to cause approximately \$2.6 million in crop damages. The flooding would impact 820 acres of lime groves and other tree crops, causing nearly \$1.2 million in damages. These damages would be primarily to lime groves. In computing these damages it was assumed only the fruit crop was lost and that the trees did not suffer reduced yields or mortality in subsequent production years. Under this same flood event, the damages to the vegetable row crops, covering nearly 1,100 acres, are estimated to exceed \$1.4 million.

(3) Summary. Given the time and data available for this report, a comparison of costs and potential damages is presented. Several items complicate the analysis and will require additional work and some policy decisions.

(a) Definition of benefits and assignment of costs are not readily handled due to the complexity of the situation. One of the predicate assumptions is that the action of changing the flows to ENP through Northeast Shark River Slough will be to reflood this area to some degree of its historic pattern. However, since construction of the C&SF project, agricultural and residential development has taken place in the area. Thus,

an increment of flooding risk will be that added to the existing situation as a result of water management operations. This is more for mitigation of damage to the Park than to protect lands from floods, per se. Because of this, environmental benefits could well be the dominant factor in evaluating a course of action. This would require an exception to NED criteria as discussed in paragraph 16 (Exception to NED Criteria).

(b) Public Law 98-181 requires that the fair market value of land, specifically agricultural but also presumably residential, will be based on conditions existing after construction of the C&SF project but prior to a change in water deliveries to the Park. Given actions by local authorities and market conditions influenced by such governmental actions, analysis of real estate values will be quite complex.

(c) Establishing the specific frequency and range of flooding risk to be expected in the agricultural and residential areas could not be accomplished given the time limit for this report. A best estimate for a conceptual design for the flood protection works was made for the 10 percent event, based on higher water levels in the Slough. This provided a flood elevation and duration which was used to identify the likely impacted area. Should further effort be extended, the level of increased flood risk due to water management operations would be specified. Any additional flood protection beyond this increment would have to be justified by the standard NED criteria.

Based on the above, the following impacts may be expected. These show only the costs and areas protected, based on the limited data, and should not be viewed as the standard type of analysis which would be presented in a G&DDM. Preliminary estimates are on the following table.

TABLE 2
COSTS AND LAND VALUES PROTECTED

<u>PLAN</u>	CONSTRUCTION FIRST COST (<u>\$000</u>)	LAND PROTECTED (<u>\$000</u>)
A	16,398	47,606
B	31,398	74,396
C	27,613	47,606
D	54,065	74,396

NOTE: Land and easement costs for Plans A and C are \$10 million and for Plans B and D are \$11 million.

FUTURE STUDIES

19. General Work Description. The work elements described in this section will provide sufficient detail to analyze the several courses of action available to restore more historic flows to the Everglades National Park. Additionally, the expected ecological benefit to the Park will be described with concomitant impacts on the developed parts of Northeast Shark River Slough. Sufficient engineering, economic, and environmental information should be generated to allow a decision to be made regarding the water-delivery plan for the Park along with the structural modifications and operational strategies required for its implementation. At the conclusion of the GDM studies, an optimum water delivery plan and detailed designs and cost estimates of all associated works will be presented.

a. Engineering Studies. The following work will be needed. Topographic surveys for the East Everglades area and sites in WCA No. 3A and 3B in sufficient detail for design analysis. Hydrology and hydraulics work will include seepage studies, analysis using the South Florida Water Management Model (SFWMM), evaluation of selected hydraulic designs. Geotechnical studies to provide sufficient data for structure design will be needed.

b. Environmental Studies. Studies would be conducted to contribute to a benefit analysis for the Park and for impact assessment of flood-protection plans for the East Everglades. The studies will be planned so that the results can be used to predict the incremental impacts of changes in delivery schedules and locations.

(1) Park Benefits

(a) Vegetational Responses to Hydrologic Changes. Monitoring studies are not appropriate for quantifying change in vegetational communities and associated wildlife because of the short duration of the field test relative to the period over which ecological changes take place, and the small changes in hydrology predicted from model runs (0.1 to 0.2 feet). An alternative consists of evaluating existing ecological conditions in the four-corners region of the Everglades (WCA No. 3A, WCA No. 3B, NESRS, and the northern portion of ENP) as predictors of alternative futures for the Park. This region, lying within Shark River Slough, was ecologically similar before completion of Water Conservation Areas Nos. 3A and 3B. Since that time, the four areas (corners) have evolved under quite different water regimes, ranging from very wet in WCA No. 3A to relatively dry in Northeast Shark River Slough. Each can be considered to represent the ecological product of a 20-year experiment in water management, and as such, would be used in the study as the basis for interpolation or extrapolation of possible future habitat conditions in ENP under different water-delivery scenarios. This would include mapping existing vegetation within the four corners defined by the intersection of L-67A/L-67 Ext and L-29 and simulating changes brought about by differing water regimes. A Landsat data base would be developed to interface with computerized thematic mapping to evaluate, in

particular, changes in hardwood hammocks. Ground-truthing over an expanded geographical area would be accomplished under a Corps of Engineers contract. Transfer of interagency funds to the NPS would be required to augment Landsat data evaluation.

(b) Vegetational Changes and Patterns. A detailed analysis of changes in plant species diversity and quantity would be conducted by re-surveying the sites within the Park that were intensively studied by Alexander and Crook (1975)*. This would statistically document the magnitude of any decline in these parameters over the past 10 years.

(c) Wading Bird Feeding Habitat, Exotic (noxious) Plant Distribution, Water Drying Patterns. This would be a cooperative effort with an ongoing ENP aerial survey study to establish baseline conditions for contributing to better understanding of the relationship of wading bird feeding concentrations to hydrologic conditions. There is a potential for this to document improvement in habitat utilization in response to the field test.

(d) Topographic Information. Transect line surveys would be conducted throughout the four corners to establish a series of topographic reference stations. ENP has a method of using water-level data in conjunction with such stations to develop detailed topographic maps showing water depths over large areas. This is a necessary complementary study to the wading bird feeding habitat survey.

(2) Impact Assessment. The following studies would be needed for impact assessment of flood-protection plans for the East Everglades:

(a) Septic-tank Study. Studies would be conducted to determine the hydraulics of pollutant migration for residential septic systems.

(b) Cape Sable Seaside Sparrow Survey. Field survey of singing male sparrows conducted within the area of influence of the flood-protection levee system that intersects the designated Critical Habitat of this endangered species would be conducted. Surveys would have to be accomplished during the period between April and June.

c. Economic and Real Estate Studies. Work to be accomplished to provide data for the economic analysis will include gathering further data on potential crop damage. The major area of emphasis will be definition of groundwater levels that cause root damage. Further work will be required on floor elevations of existing residential structures and potential relocation/evacuation costs. Additional real estate cost data will be needed, especially in view of the fair market value reference point required in PL 98-181. More detailed data on current transactions will be required to establish equitable land values.

* Alexander, T. R. and A. G. Crook 1975. Recent and long-term vegetation changes and patterns in South Florida.

d. Public Involvement and Coordination. Early inclusion of public participation will be needed. Identification of interested and affected publics will be a priority action at the outset of the study. Such publics will include residents of the East Everglades, agricultural interests, other land owners, environmental groups, and others. Coordination with Federal, State, and local interests will be initiated. Public meetings, workshops, and work groups will be utilized. This will be a continuous effort throughout the study process.

20. Schedule and Cost Estimates. Studies necessary for preparation of a GDM addressing the issues described herein in the manner described in this section would required about 26 months and would cost approximately \$1.7 million, see Table 3.

TABLE 3

GDM STUDIES

Engineering		
Topographic	\$390,000	
Hydrology/hydraulics	205,000	
Geotechnical	231,000	
Design and Cost Estimates	80,000	
Subtotal		\$ 906,000
Environmental		
Vegetative Patterns	200,000	
Vegetative Response	100,000	
Topographic	200,000	
Other	140,000	
Subtotal		640,000
Economics		25,000
Real Estate		120,000
Public Involvement/Coordination		65,000
		<u>\$1,756,000</u>

CONCLUSIONS

21. Conclusions. The timeframe provided in PL 98-181 makes direct compliance difficult at best. The procedure outlined in this report provides a mechanism to comply with the law, albeit, not strictly within the 2 years. A limited field test can be run while design and evaluation of necessary flood prevention measures for an ultimate delivery plan for ENP is prepared. This limited test can provide much data on the interaction of groundwater and surface flows in the area.

The limited testing program is projected to extend beyond the 2-year time limit set in the Act for modification to the PL 91-282 requirements. Since the continued testing program may require water deliveries below the minimums specified in PL 91-282, a letter of agreement between the Jacksonville District, SFWMD, and ENP would be required so that the test can continue after expiration of PL 98-181.

A change from current water deliveries to the Park should reverse its ecological decline. This decline has been demonstrated by ENP and the scientific community. The need and impetus for corrective action is contained in PL 98-181 and antecedant committee reports. Development of water supply plan for the Park will need to consider preserving the multiobjective functions of the C&SF Project.

Inasmuch as existing C&SF Project works have an enormous impact on water flows to the park, structural modifications will be necessary to realize the full benefits of any operational changes. Some structural modifications alone have potential for greatly improving water deliveries to ENP under any operational strategy.

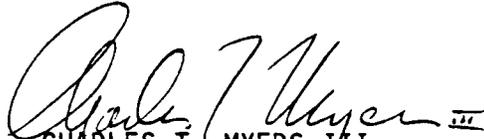
The water supply needed for ENP in volume, timing, and spatial distribution should be related to historical flows and flow patterns. If this is to be done and correlated to current hydrologic events, then a return to use of NESRS as a flow-way is needed. However, to do this requires protection or evacuation of some of the existing agricultural and residential development as well as disposition of the undeveloped lands. This is a complex problem, especially given the local and State restrictions placed on these landowners in recent years. The problem is aggravated by the nature of the real estate authorities contained in PL 98-181.

An exception to NED criteria prescribed in the Principles and Guidelines is probably needed. The focus of actions required to comply with PL 98-181 is enhancement of ENP. Most benefits derived from this action are environmental and thus do not contribute to NED benefits in developing the standard benefit-cost analysis.

RECOMMENDATIONS

The following recommendations are submitted:

- a. That this General Plan be approved.
- b. That a General Design Memorandum and an Environmental Impact Assessment be prepared for modifications necessary to effect a change in water deliveries to ENP and required flood protection. The studies outlined in this report should be approved and funded.
- c. That the testing program extend beyond the 2-year time limit specified in PL 98-181 based upon written agreement between the Jacksonville District, South Florida Water Management District, and Everglades National Park.


CHARLES T. MYERS III
Colonel, Corps of Engineers
Commanding

APPENDIX A

ENP's SEVEN-POINT PLAN AND THE STATUS OF THE JACKSONVILLE DISTRICT'S RESPONSES

GENERAL. On March 15, 1983, the Jacksonville District received ENP's request that seven protective measures be immediately implemented. The District has been addressing six of the seven requests (one request is strictly a local responsibility) in long-term planning studies, Shark River Slough and C&SF Water Supply. Pending completion of the necessary planning studies, interim responses to the park's requests are being implemented as described below:

ENP Request No. 1

"Fill in L-28 canal and remove substantial segments of the levee. L-28 canal is over-draining the eastern Big Cypress during the dry season and the levee prevents high water from moving into Big Cypress as it traditionally did. Removal of the levee will provide some flood relief to Everglades National Park and restore high water flow through several historical drainages."

Construction of modifications to L-28 in response to this request is expected to be complete by the end of March 1984. Three gaps in the L-28 tieback will restore overland flow into a portion of Big Cypress; a culvert structure, S-344, in L-28 will enable regulatory releases from WCA No. 3A and water supply releases under dry conditions into Big Cypress; six plugs in the L-28 borrow canal will prevent overdrainage of eastern Big Cypress; two structures, S-343A, and S-343B, will enable regulatory releases from WCA No. 3A to be made into Big Cypress via the Tamiami Trail borrow canal.

ENP Request No. 2

"Fill in L-67 extended canal and completely remove its levee. Water deliveries to the park through this canal at times cause abnormal flooding of the park during the dry season, and the levee prevents the historical hydrological connection with deeper water areas of Northeast Shark Slough."

Construction of two structures, S-346 and S-347, in the L-67 Extension borrow canal is expected to be complete by the end of March 1984. These structures will serve as plugs to reduce flows into ENP down the L-67 Extension borrow canal. The proportion of overland flow into the park will be increased and water will be spread more evenly west of L-67 Extension. Complete removal of the levee and filling the borrow canal is being proposed for consideration in the General Plan for Improved Water Deliveries to ENP.

ENP Request No. 3

"Restore Water Conservation Area No. 3B (WCA 3B) to the Everglades system. Specifically, divert as much flood waters as are environmentally acceptable into WCA No. 3B."

Currently, S-151 is being utilized, when necessary, to pass regulatory discharges from WCA No. 3A into 3B. The General Plan for Implementing an Improved Water Deliveries to ENP is proposing that structural modifications to enable diverting more water into WCA No. 3B be considered in a GDM. A new structure, S-345, and canal (C-310) from WCA No. 3A into 3B are being considered. Additionally, the park has suggested that an outlet from WCA No. 3B be considered.

ENP Request No. 4

"Distribute water deliveries from Water Conservation Area No. 3A along the full length of the Tamiami Canal from L-28 to L-30. Northeast Shark Slough contains the center of the drainage to Everglades National Park and the prevention of flow through the upper reaches of this drainage has severely stressed the park."

After extensive studies and coordination, the Jacksonville District revised the S-333 operating criteria in January 1984 to allow the discharge of water into Northeast Shark River Slough. The operating criteria is conservative enough to avoid increasing flooding potential in the developed portion of the East Everglades. An extensive monitoring system has been implemented to insure the system is operated to avoid or reduce flood damage to the greatest extent possible and to provide data for the assessment of the impacts of S-333 discharge. This operating criteria will be incorporated into a Field Test of a new water delivery schedule to ENP which will be conducted concurrently with the preparation of a GDM, if approved. The GDM would address all potential means of improving water deliveries to ENP.

ENP Request No. 5

"Establish whatever rigorous water quality monitoring program necessary to provide an early alert to degradation of delivery waters to Everglades National Park."

In January 1979, the Corps of Engineers, National Park Service, and South Florida Water Management District entered into a Memorandum of Agreement (MOA) to ensure that the quality of waters delivered to Everglades National Park (ENP) is not degraded. This MOA included a water quality sampling program which requires the Corps to test the delivery water quarterly and sediment semi-annually. This established water quality monitoring program serves as an early alert to degradation of delivery waters to Everglades National Park. In April 1983, SFWMD presented a proposal for an expanded water quality monitoring plan to ENP and the Corps that has now been fully coordinated and agreed to by all parties. The revised MOA is now being implemented.

ENP Request No. 6

"Defer any implementation of new drainage districts such as that proposed in the East Everglades, until the full impact of any potential flood discharges to Everglades National Park are thoroughly thought out and all possible mitigations to the park are considered."

Establishment of local drainage districts is completely a responsibility of the State, and the Corps of Engineers has no authority to affect such actions. However, implementation of flood protection measures being considered in the General Plan would impact this request.

ENP Request No. 7

"Starting as soon as possible, field test a new delivery schedule to Everglades National Park. The delivery schedule will be based upon a reference station in the Big Cypress that predicts what the Shark Slough should be receiving based upon current rainfall and normal runoff, not upon upstream water management. Any quantities above that predicted will be considered "flood discharges" and all efforts should be made to divert those excess waters. We feel this method of determining what to deliver to the park is the best current solution. The present delivery schedule is not working and must be replaced immediately for the health of the park."

In November 1983, PL 98-181 was enacted. Section 1302 of this law authorized a field test of a new water delivery schedule to ENP. The Secretary of the Army was authorized to construct flood protection measures and acquire interest in real estate currently under agricultural production for areas adversely impacted by the field test. The field test is limited to a 2-year period from enactment of the law. This authorization is being implemented as follows: A General Plan has been prepared which will address alternatives, feasibility determinations, cost analyses, and estimates for continued engineering. If authorized and funded, a GDM will be prepared to design in detail the necessary works and identify an optimum water delivery schedule. In conjunction with these studies, a new water delivery schedule will be field tested. The field test will be limited so that no damages to developed areas are incurred.

APPENDIX B

SEEPAGE CONSIDERATION IN EAST EVERGLADES

In 1972, a pumping test was conducted at a site 0.7 mile northeast of S-331. That site is adjacent to the Rocky Glades study area. The pumping test is described in C&SF, Part V, Supplement 52 -- the GDM for Conveyance Canals to ENP and South Dade County. The transmissivity of the shallow nonartesian aquifer was found to be 40 cfs/ft. Figure 1 (inclosed) displays a map with contour lines of equal depth to the base of the Biscayne Aquifer. The aquifer depth is about 60 feet at the pumping test site, but only about 50 feet in the area of interest. Accordingly, we use for transmissivity a value of 33 cfs/ft. In the study area, seepage through a levee -- being very much smaller than seepage beneath it -- can reasonably be ignored. Pool-to-pool seepage beneath a levee can be calculated with formulas from the footnote on p. 212 of The Flow of Homogeneous Fluids through Porous Media by Morris Muskat. For levees with heights of 10 feet and 3 feet (base widths of 70 feet and 28 feet) the underseepage rates in cfs per mile of levee per foot of head would be 1,550 and 2,510, respectively. Data obtained at five pumping tests along the southern and eastern boundaries of Conservation Area No. 3 indicated that flow in the limestone aquifer can become turbulent.

Using the average velocity found at the onset of turbulence, seepage predictions were adjusted to the values tabulated below by the method used in C&SF, Part I, Supplement 7 -- Permeability Investigations by Well-pumping Tests.

<u>Levee Height ft.</u>	<u>Head (H) ft.</u>	<u>Underseepage cfs per mile of levee per ft. of head</u>
10	>0.144	590 \sqrt{H}
3	>0.090	750 \sqrt{H}

Seepage between parallel canals (assumed to penetrate through the aquifer) can be calculated from Darcy's Law. For canals D miles apart, the seepage rate would be:

$$\frac{33}{D} \text{ cfs per mile of canal per ft. of head.}$$

Only laminar flow would be expected as gradients are not likely to reach 6.7 feet per mile.

Seepage under levees at the rates tabulated above would make flood protection impractical. There are, however, good reasons for suspecting that those figures could be unrealistically large. At the site of the 1972 pumping test, there was no evidence of a stratum of low-permeability rock or soil near the ground surface. In some parts of our study area -- which lies farther west -- it is possible that such a stratum could exist. It would retard seepage loss from a pool behind a levee. The results of the 1972 pumping test are representative of the test site, which is rather small and which could fail to typify our study area. In 1973, the USGS published a map, Figure 2 (inclosed), showing lines of equal transmissivity of the Biscayne Aquifer. Much of the information therein was obtained by analyzing water-table contours adjacent to canals and in well fields. Results obtained in that way tend to be more representative of extended areas. Transmissivity information taken from Figure 2 probably provides the best currently available basis for our seepage estimates. From the figure, it appears that 10 m.g.d./ft. would be a good figure to use for aquifer transmissivity in the study area.

$$T = 10 \frac{\text{m.g.d.}}{\text{ft.}} = 15.5 \frac{\text{c.f.s.}}{\text{ft.}}$$

For laminar flow, seepage rates would be proportional to transmissivities. Levees with heights of 10 feet and 3 feet would have revised underseepage rates, in cfs per mile of levee per foot of head, of:

$$\frac{15.5}{33} \times 1550 = 728 \text{ and } \frac{15.5}{33} \times 2510 = 1180,$$

respectively. Proceeding as before, we get for turbulent flow the seepage predictions tabulated below:

<u>Levee Height</u> <u>ft.</u>	<u>Head (H)</u> <u>ft.</u>	<u>Underseepage</u> <u>cfs per mile of levee per ft. of head</u>
10	>0.307	404 \sqrt{H}
3	>0.190	514 \sqrt{H}

Pool-to-pool seepage beneath a levee could be reduced by using parallel levees to step down the water level. If the two levees were alike, and the water level between them controlled by seepage, the heads across the two levees would be equal. With levees sufficiently separated to prevent significant interference of their seepage patterns, the seepage loss would be equal to that for a single levee with half the head. A levee separation of 300 feet should prove adequate. For turbulent flow -- the case of practical interest -- using two levees, instead of one, would reduce seepage loss by about 30 percent.

Figure 2 shows that, as one proceeds west from L-31, the aquifer transmissivity diminishes. This is due, at least in part, to thinning of the aquifer. By locating levees farther west, it may be practical to protect more area without having to deal with increased amounts of seepage.

DECLINING NATURAL RESOURCES IN EVERGLADES NATIONAL PARK*

Since the Park's establishment in 1947, there have been significant declines of some of the area's most important natural resources. Extensive manmade alterations to the natural water-flow pattern for the purposes of flood control, land reclamation, and water storage have greatly altered the hydrological regime north of Everglades National Park. The once unregulated, slow-moving "sheetflow" regime is now a complex system of levees, canals, water-storage impoundments, and water control structures, which influence the quantity, quality, and the timing of water entering the Park. Severe drought conditions in a major portion of the park, which threatened to cause significant, long-term ecological damage to the area, led the National Park Service to petition for surface-water delivery guarantees. A 6-year period of negotiations between the Department of the Interior, Department of the Army, and the Central and South Florida Flood Control District followed. Finally, in 1970, Congress passed the Monetary Authorization Act (Public Law 91-282) which authorized construction of additional water-conveyance facilities and established the current guaranteed minimum deliveries to the Park. For Shark River Slough, 260,000 acre-feet of water distributed on a fixed monthly schedule is now guaranteed annually.

While an understanding of the changes that have occurred in the hydrological regime is hampered by a lack of documentation of historic conditions, the Park feels that the present water-delivery schedule has probably resulted in a reduction of total water quantity and, perhaps more importantly, has definitely caused a disruption of the natural timing and contrasted volumes of wet versus dry periods. In effect, the existing schedule has reduced the magnitude of both the occasional extremes of high and low water levels of the past and has severely disrupted the duration and timing of the normal annual drying-out period in the marsh system.

The trend since 1970 has been toward modulation of the normally varied hydroperiod which, in turn, has affected the water-dependent biology. The Park fears that, in time, such modulation will reduce natural plant and animal diversity and will biologically favor only those few species that happen to be adapted to the modulation. In an ecosystem like the Everglades marsh -- one that is not particularly diverse in species to begin with -- reduction in population and loss of species can happen dramatically and rapidly. This may already be occurring.

* Excepted from: Morehead, J. M. ca 1983. "Everglades National Park, U.S.A. Attempts to Modify significant deterioration of a park's natural resources." Unpub paper. Homestead, Fl.

Decline in Park's Bird Population. The dwindling populations of colonial, fresh-water wading birds within the Park serves as a dramatic illustration of the decline of a significant natural resource. While documentation is largely lacking, the best estimate is that there may have been upward of 2.5 million colonial wading birds nesting in southern Florida in the 1870 period. Since 1934, however, there has been a steady, and perhaps statistically accelerating, decline. It is believed that less than 10 percent of the historic colonial wading bird numbers can now be found in the Park. The most probable causes of the decline after 1934 are a general loss of habitat plus the disruption of the natural water quantity and schedule. With increased research efforts and improved accuracy of resource monitoring, this continuing decline has been more accurately observed and documented. Since 1967, regional counts have been conducted yearly that provide reliable data. Within the Park, a series of monthly surveys were performed between 1977 and 1981 that provide the most accurate statistical information available to date.

Decline of Park Fishery. The water area presently included in Everglades National Park historically supported numerous fisheries, both commercial and recreational. In the enabling legislation of the park, the National Park Service was specifically mandated to permit no activities or developments which would detract from the essential wilderness character of the area. Subsequent legislation and designations have underscored the intent of the act to preserve the natural resources. Even before the Park was formally established, however, the question of commercial fishing was raised. Commitments were made to the commercial fishermen that have resulted in intense political and personal conflicts, as it appeared to most that fishery resources of the Park were declining.

In the late 1960's and early-to-mid 70's, the staff at Everglades National Park began to hear an increasing number of complaints from biologists and long-term fishermen that the fishing in Florida Bay was not what it used to be. Groups and individuals, particularly the recreational fishermen, began to question whether continued commercial harvest was consistent with Park Service policy, an increased demand for recreational resources, and a declining fishery. As these anecdotal reports of the decline in fishery resources in Florida Bay continued to grow, the National Park Service undertook a program of creel censuses and catch surveys. Using information generated by this program and acting on long-established Park Service policy, the Service, in January of 1979, prepared An Assessment of Fishery-Management Options in Everglades National Park, Florida. In March 1980, final regulations were promulgated to reduce pressures on the fishery resources and reallocate these resources among park wildlife, recreational fishermen, and commercial fishermen. The commercial fishing interests claim that the National Park Service, in light of prior commitments and a lack of conclusive scientific data to statistically quantify a decline in the fishery, must change or retract the regulations. The National Park Service,

on the other hand, contends that the opinions of the overwhelming majority of knowledgeable fishermen and biologists provide adequate reason for taking measures to preserve the resource, even though these opinions are not, as yet, backed by adequate statistical data.

Conclusions. Changes in the volume and timing of water flow into Everglades National Park have caused disruption to the area's ecosystem. Declining populations of several species of birds, declining fish and crustacean populations, changes in bay and estuary salinity, and invasion by exotic plant species all serve as indicators of this ongoing disruption. While a major research program is now underway, detailed scientific data to document the extent of the various changes is limited. Lacking such support data, however, opinions of knowledgeable persons are so overwhelmingly in agreement that the National Park Service has already taken management action to halt, and hopefully reverse, some of the existing trends.

It is obvious that water is the keystone of the Everglades ecology. Surface-water flow into the Park from the north has now been completely altered by man, and decisions for water release or retention are based upon factors such as flood control, drought prevention, draining land to provide areas for farming or urban development, agricultural water needs, urban water needs, and others. Ecological needs for water have been considered, but usually practice has favored those uses which more immediately benefit man's comfort and economic well being.

The National Park Service is now in the process of working with all the other agencies and organizations involved in an effort to change the water-delivery schedule for the Park. It is hoped that an adequate quantity of water, delivered on a schedule that is driven by natural rainfall events, will eventually restore a portion of the diversity and quantity of the original Everglades flora and fauna.

Federally Listed Endangered and Threatened Species that may occur in Everglades National Park (U.S. Department of Interior, Fish and Wildlife Service).

Manatee (Trichechus manatus) - Endangered.
Florida panther (Felis concolor coryi) - Endangered
Bald eagle (Haliaeetus leucocephalus) - Endangered
Everglade kite (Rostrhamus sociabilis plumbeus) - Endangered
Arctic peregrine falcon (Falco peregrinus tundrius) - Endangered
Brown pelican (Pelecanus occidentalis) - Endangered
Cape Sable seaside sparrow (Ammospiza maritima mirabilis) - Endangered
Wood stork (Mycteria americana) - Endangered
Peregrine falcon (Falco peregrinus) - Endangered
American alligator (Alligator mississippiensis) - Threatened
Loggerhead sea turtle (Caretta caretta) - Threatened
Green sea turtle (Chelonia mydas) - Endangered
Eastern indigo snake (Drymarchon corais couperi) - Threatened

Designated critical habitat for the following endangered or threatened species is found in ENP: manatee, Everglade kite, American crocodile, and Cape Sable seaside sparrow.

State of Florida Listed Endangered, Threatened, Rare, and of Special Concern that may occur in Everglades National Park (from Rare and Endangered Biota of Florida, P.C.H.-Pritchard, Series Editor, 1978).

MAMMALS

Florida panther (Felis concolor coryi) - Endangered
Florida black bear (Ursus americanus floridanus) - Threatened
Everglades mink (Mustela vison evergladensis) - Threatened
West Indian manatee (Trichechus manatus latirostris) - Threatened
Round-tailed muskrat (Neofiber alleni) - Special Concern

BIRDS

Wood stork (Mycteria americana) - Endangered
Everglade kite (Rostrhamus sociabilis plumbeus) - Endangered
Brown pelican (Pelecanus occidentalis carolinensis) - Threatened
Rothschild's magnificent frigate bird (Fregata magnificiens rothschildi) - Threatened
Bald eagle (Haliaeetus leucocephalus) - Threatened
Osprey (Pandion haliaetus) - Threatened
Southeastern American kestrel (Falco sparverius paulus) - Threatened
Florida sandhill crane (Grus canadensis pratensis) - Threatened
American oystercatcher (Haematopus pulliatus) - Threatened
Least tern (Sterna albifrons) - Threatened
White-crowned pigeon (Columba leucocephala) - Threatened

Reddish egret (Dichromanassa rufesiens) - Rare
 Roseate spoonbill (Ajara ajaja) - Rare
 White-tailed kite (Elanus caeruleus majusculus) - Rare
 Short-tailed hawk (Buteo brachyurus) - Rare
 Mangrove cuckoo (Coccyzus minoi) - Rare
 Black-whiskered vireo (Vireo altiloguis) - Rare
 Cuban yellow warbler (Dendrocia petechia qundlachi) - Rare
 Florida great white heron (Ardea herodias occidentalis) - Special Concern
 Little blue heron (Florida caerulea) - Special Concern
 Common white egret (Casmerodius albus) - Special Concern
 Snowy egret (Egretta thula) - Special Concern
 Louisiana heron (Hydranarsa tricolor) - Special Concern
 Glossy ibis (Plegadis falcinellus) - Special Concern
 Least bittern (Ixobrychus exilis exilis) - Special Concern
 White ibis (Eudocimus albus) - Special Concern
 Cooper's hawk (Accipiter cooperii) - Special Concern
 Limpkin (Aramus guarauna) - Special Concern
 Piping plover (Charadrius melodus) - Special Concern
 American avocet (Pecurvirostra americana) - Special Concern
 Royal tern (Sterna maxima) - Special Concern
 Black skimmer (Rynchops niger) - Special Concern
 Florida prairie warbler (Dendroica discolor paludicola) - Special Concern

REPTILES

American crocodile (Crocodylus acutus) - Endangered
 Atlantic hawksbill sea turtle (Eretmochelys imbricata) - Endangered
 Atlantic ridley sea turtle (Lepidochelys kempii) - Endangered
 Atlantic loggerhead sea turtle (Caretta caretta) - Threatened
 Mangrove terrapin (Malaclemys terrapin rhizophorarum) - Rare
 Atlantic leatherback sea turtle (Dermodochelys coriacea) - Rare
 American alligator (Aligator mississippiensis) - Special Concern
 Eastern indigo snake (Drymarchon corais couperi) - Special Concern

FISH

Rivulus (Rivulus marmoratus) - Threatened
 Sheepshead minnow (Cyprinodon variegatus) - Special Concern
 Southern Gulf killifish (Fundulus grandis saguanus) - Special Concern
 Mangrove gambusia (Gambusia rhizophorae) - Special Concern

PLANTS

Fragrant maidenhair fern (Adiantum melanoleucum) - Endangered
 Bird's nest spleenwort (Asplenium serratum) - Endangered
 Dollar orchid (Encyclia boothiana) - Endangered
 Wild cotton (Gossypium hirsutum) - Endangered
 Hand fern (Ophioglossum palmatum) - Endangered
 Everglades peperomia (Peperomia floridana) - Endangered
 Slender spleenwort (Asplenium dentatum) - Threatened

Powdery catopsis (Catopsis berteroniana) - Threatened
Prickly apple (Cereus gracilis) - Threatened
Cow-horn orchid (Cyrtopodium punctatum) - Threatened
Night-scent orchid (Epidendrum nocturnum) - Threatened
Manchineel (Hippomane mancinella) - Threatened
Inkwood (Hypelate trifoliata) - Threatened
Krug's holly (Ilex krugiana) - Threatened
Pineland jacquemontia (Jacquemontia curtssi) - Threatened
Florida thatch palm (Thrinax floridana) - Threatened
Twisted air-plant (Tillandsia flexuosa) - Threatened
Worm-vine orchid (Vanilla barbellata) - Threatened
Golden leather fern (Acrostichum aureum) - Rare
Florida royal palm (Roystonea elata) - Rare
Tropical curly-grass (Schizaea germanii) - Rare
Blackmangrove (Avicennia germinans) - Special Concern
Red mangrove (Rhizophora mangle) - Special Concern

EVERGLADES NATIONAL PARK AND THE POPULAR PRESS

Everglades National Park has been the focus of national attention since its conception in 1947. The park has been the subject of many books, notably Majory Stoneman Douglas' River of Grass and Archie Garrs' The Everglades.

Newspapers, with national readership, have published numerous articles concerning the Park's scenic beauty and also about the Parks's controversies. These newspapers include the New York Times, Wall Street Journal, Washington Post, Los Angeles Times, and Christian Science Monitor.

Popular national magazines featuring articles on Everglades National Park include: Newsweek, Time, U.S. News and World Report, Sports Illustrated, National Geographic, Science, House and Garden, Sierra Club, Horticulture, American Heritage, National Parks and Conservation, Mademoiselle, Backpacker, Home Garden and Flower Grower, National Wildlife, Trailer Boats, Petersen's Photographic, Southern Living, Sports Afield, Modern Maturity, Flying, Off Road, Oceans, American Forests, Boy's Life, Yachting, Popular Gardening, Living Wilderness, and Motor Boating and Sailing.

In addition to the Park's popularity in national publications, it is also the focus of a great amount of scientific research. Because of the diverse ecosystems found in Everglades National Park, these resources have been the subject of scientific research studies and published scientific journal articles. There are over 120 professional papers and published scientific journal articles that have studied the various components of the Everglades ecosystem. A bibliography of some of these publications follows:

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